Mongolia
The Air Pollution Reducing Department of Capital City
(APRD)

Capacity Development Project
for
Air Pollution Control
in Ulaanbaatar City Phase 2
in Mongolia

Final Report

June 2017

Japan International Cooperation Agency (JICA)

SUURI-KEIKAKU CO., LTD

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Final Report Summary

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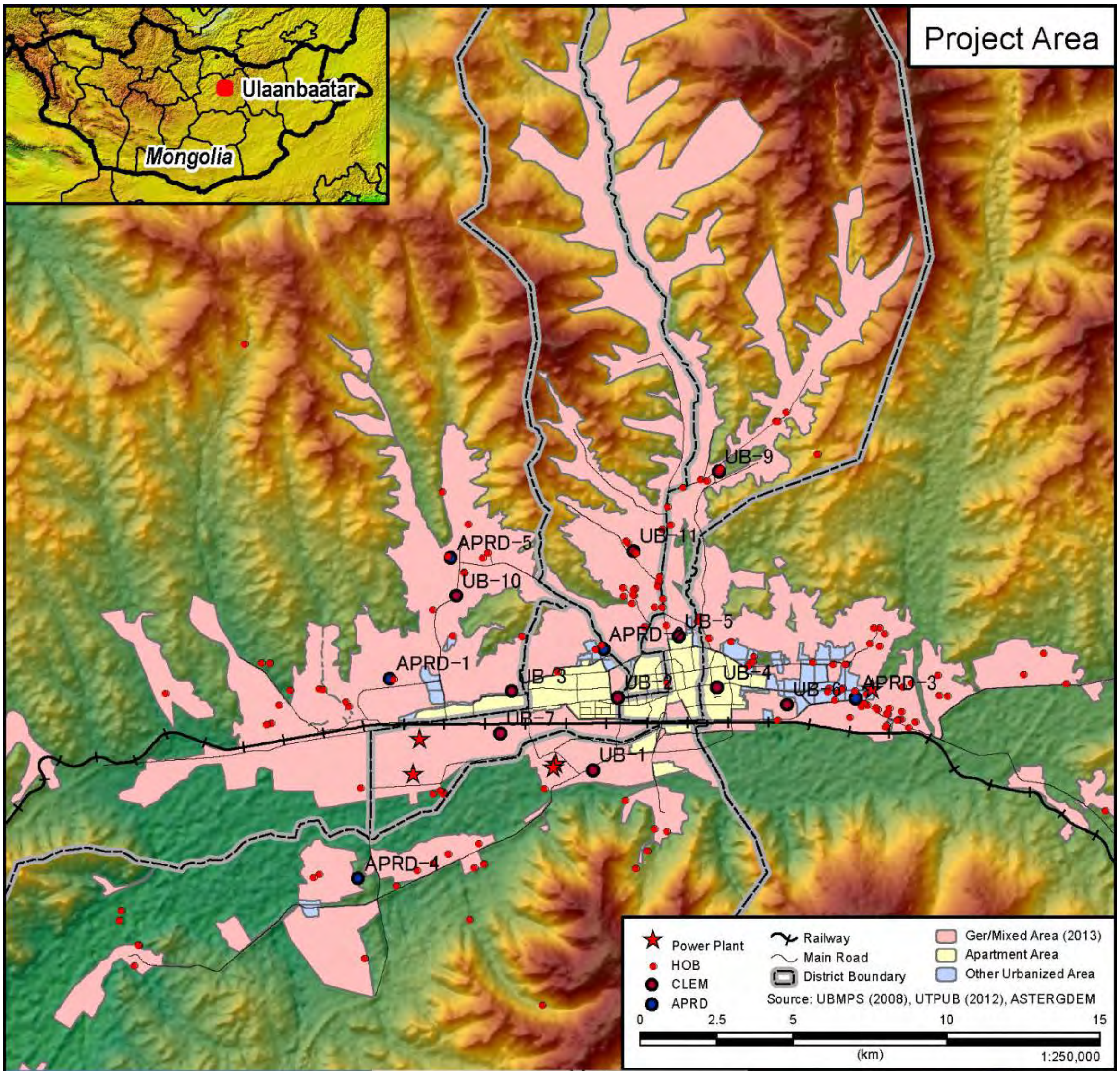
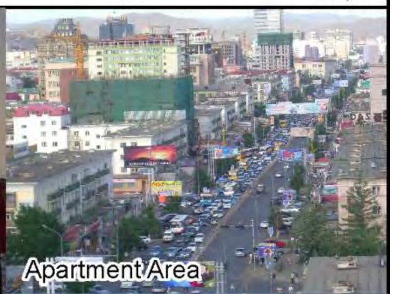
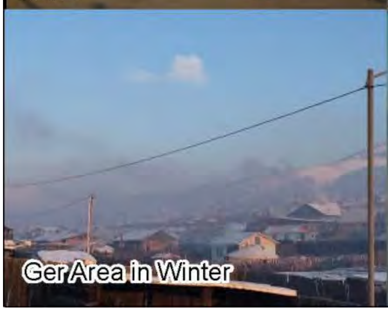
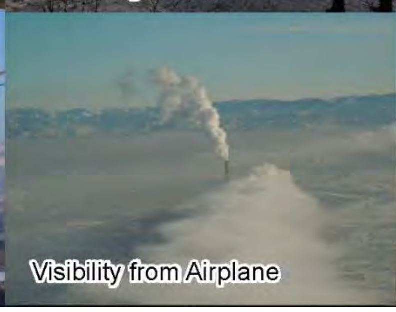

Project Area
Ulaanbaatar
Mongolia
UB-9
UB-11
APRD-5
UB-10
UB-5
UB-3
UB-4
APRD-1
APRD-3
UB-7
UB-1
APRD-4
Power Plant
HOB
CLEM
APRD
Railway
Main Road
District Boundary
Ger/Mixed Area (2013)
Apartment Area
Other Urbanized Area
Source: UBMPS (2008), UTPUB (2012), ASTERGDEM
0 2.5 5 10 15
(km)
1:250,000


HOB


Bayankhoshuu
Monitoring Station


Apartment Area


Ger Area in Winter


Visibility from Airplane


Smoke from Power Plant

Contents

1 Outline

1.1 Back Ground, Project Activities, and Implementation Polities

Mongolia is a coal rich country with limited options for energy sources, heavily dependent on the coal which contains a great amount of water and ash resulting in dust-emitting characteristics. The major emission sources are coal combustion at the 3 old coal fired power plants (the Power Plant No.4, No.3 and No.2) for power and heat generation, about 200 Heat Only Boilers (hereinafter HOBs), about 1,000 small boilers such as Coal Fired Water Heaters (hereinafter CFWHs), and numerous Ger stoves and wall stoves at more than 130,000 families in Ger areas.

The air pollution at Ulaanbaatar (hereinafter UB) city has been severe, especially in the winter season. Major pollutants have been particulate matters including dust, PM10 and PM2.5. In addition to the coal combustion, increasing vehicle emissions, wind-blown dust from ash ponds of the power plants and other fugitive sources are also contributing to the severe air pollution.

According to NAMEM, the highest monthly average value of PM10 ambient concentration showed as much as 1,000 µg/m3 during the winter of 2011 and all monitoring sites showed high concentration of PM10 exceeding the Mongolian ambient air quality standards (100 µg/m3 for daily average and 50 µg/m3 for annual average) posing serious health risks to the citizens. Also other parameters such as SO2 and NO2 are problematic throughout the year, occasionally exceeding the Mongolian air quality standards.

In UB city, Air Quality Division was established within Nature Environment Agency of Capital City in year 2006 to promote air pollution control. Later in February 2009, the division was upgraded to Air Quality Department of the Capital City (hereinafter AQDCC), but the knowledge and experiences of the staffs were not enough to deal with complicated issue of air pollution. At this time, the influences of each pollutant to the ambient air were unclear. Even to consider the cause and control measures of air pollution, almost no data existed in scientific bases.

Under the circumstances, based on the request by the Government of Mongolia, the Government of Japan provided technical assistance through JICA ‘Capacity Development Project for Air Pollution Control in UB City’ during 2010 to 2013, which focused on the capacity development of the AQDCC and other relevant agencies at city and national level especially to control the emission sources. Major activities included technical transfer for credible emission inventory elaboration, air pollution simulation model, on-site emission measurements of boilers including dust among other pollutants, establishment of the boiler registration system, diagnostic and proposal of a control measures of power plants and HOBs, elaboration of emission control measures and improvement of their technical evaluation of emission reduction as well as air quality. Also, for data management and accuracy improvement of ambient air monitoring which was not included in Phase1, problems are still remaining to be solved. Having these backgrounds, the Government of Mongolia requested the Phase2 of the Project in 2012. The Government of Japan approved the Project for 2013 implementation.

1.2 Overall Goal, Project Purpose, and Outputs

Overall goal, Project purpose, and outputs are shown in Table 1.2-1.

Table 1.2-1 Overall Goal, Project Purpose, and Outputs

Items	Contents
Duration of the Project	December, 2013 to June, 2017
Overall Goal	Measures for emission reduction of air pollutants will be strengthened in Ulaanbaatar City.
Project Purpose	Capacity for air pollution control in Ulaanbaatar City is strengthened, paying special attention to the development of human resource and coordinating mechanism of the APRD and other relevant agencies among other aspects of the capacity development.
Output 1	Capability of emission source monitoring is strengthened.
Output 2	Capability of ambient air quality monitoring is strengthened.
Output 3	Capability to evaluate pollution structure is strengthened by integrating emission inventory, simulation model and ambient air quality monitoring.
Output 4	Decision making process for air pollution control is improved, by utilizing technical abilities of APRD and the relevant agencies.
Output5	APRD and the relevant agencies promote public awareness program and implement advisory system for citizen in Ulaanbaatar city on air pollution.
Output 6	Capability of technical evaluation of air pollution control measures is strengthened.
Output 7	Capability of APRD and the related agencies to regulate and to control emission sources is strengthened.
Output 8	Emission control measures at major polluters are enhanced by APRD and the related agencies.
Output 9	Coordinating mechanism by APRD and the related agencies for output 1 to 8 are developed.

1.3 Implementation Structure of the Project

APRD is counterpart (C/P). Other related organization is counterpart working group (C/P-WG). The project implemented emphasizing capacity development for human resources.

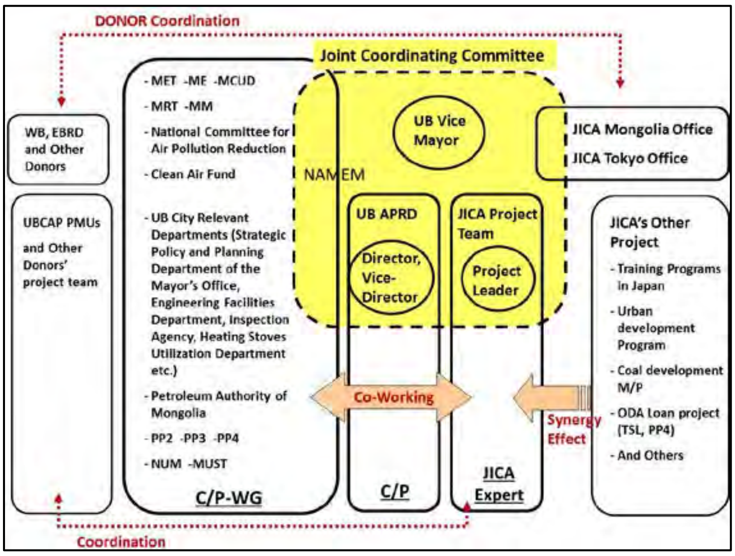


Figure 1.3-1 Implementation Structure of the Project

2 Activities and Outcomes

2.1 Air Quality Monitoring

2.1.1 Rehabilitation and Status of Monitoring Stations

Air quality monitoring network consisted of APRD Network and NAMEM/CLEM Network. APRD Network was established by the German grant-aid in 2008 and was maintained by APRD. NAMEM/CLEM Network was established by French loan in 2010 and is maintained by CLEM. Since number of malfunction of APRD monitoring equipment increased, APRD monitoring equipment has been rehabilitated through Activity 2-2 of this Project. Table 2.1-1 shows the condition of monitoring devices in February 2017. Almost all devices work well.

Table 2.1-1 Operational Conditions of Five Stationary Monitoring Stations managed by APRD as of February 2017

Station / Analyzer Type	Tolgoit (APRD1)	MNB (APRD2)	Amgalan (APRD3)	Nisekh (APRD4)	Bayankhoshuu (APRD6)
SO2 APSA370	○	○	○	○	○
NOx APNA370	○	○	○	○	
CO APMA360	○	○	○	○	
O3 APOA370	○	○	○	○	
PM Model180	○	○	○	○	
PM APDA371					○
Calibration Devices MCC1000	CO Line inoperative				○
Weather Monitors	○	○	○	○	○

○ : Operational


Figure 2.1-1 Stationary Air Quality Monitoring Station

2.1.2 Evaluation of Monitoring Data and Monthly and Annual Report

In the beginning of this project, APRD's data was not validated almost. Therefore, APRD's data was not used as official data even in the monthly statistics report issued by Statistics Department of the Capital City. Throughout the capacity development of this project, APRD and NAMEM validate their monitoring data of all stations, compile monthly and yearly reports using the data of both organizations, and publish them.

2.1.3 Establishment of a New AQMS

There was no continuous air monitoring system built in outskirts of Ulaanbaatar city especially in Ger area, though AQMS networks cover the major central area in Capital City. Air pollution status in Ger area was not identified in details however inhabitants have experienced severe air pollution in winter season. So, one district has been selected as new monitoring site based on examination result of the proper location study for AQMSs. A new AQMS has been established in Bayankhoshuu district. Measurement devices and a Shelter were provided by Japan, meanwhile AQDCC supplied land, fence and power supply line. A new AQMS is operative from the end of April 2016, working in good condition.

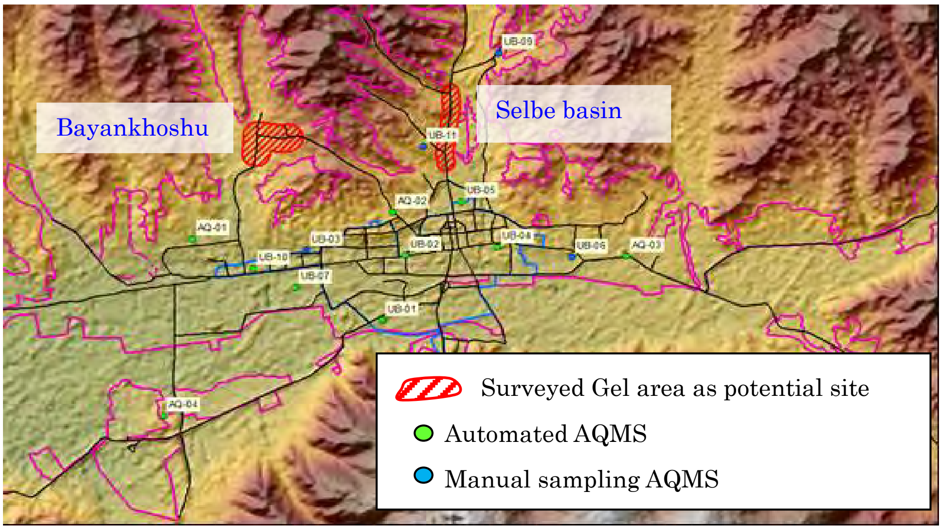
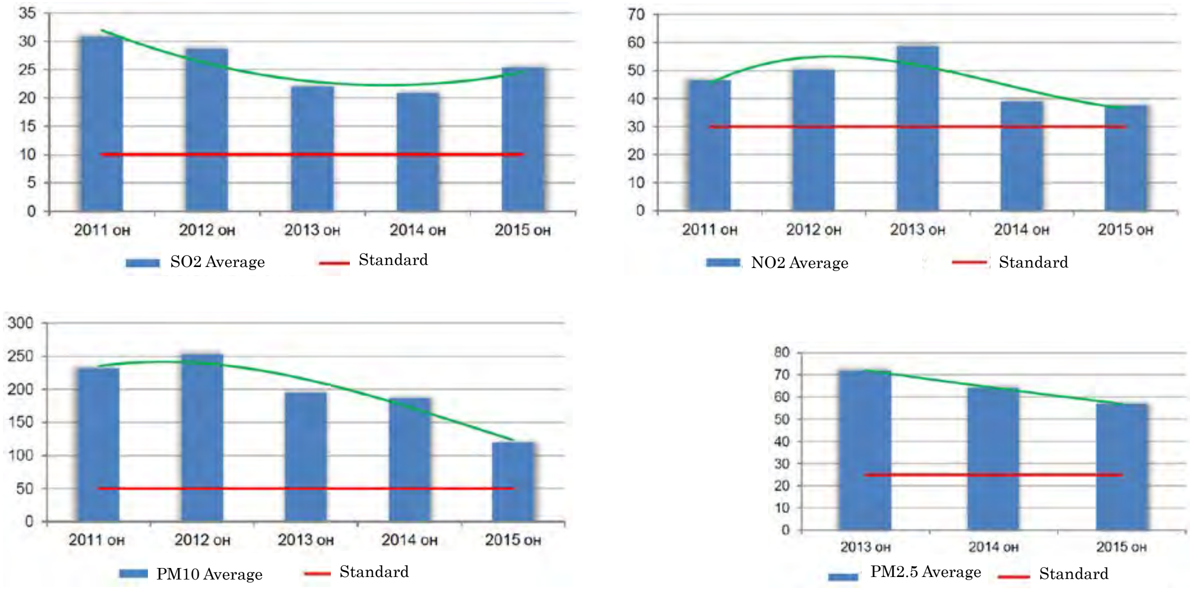


Figure 2.1-2 Location of a Newly Established Air Monitoring Station (Bayankhoshuu)

Figure 2.1-3 Established New AQMS

2.1.4 Preliminary Analysis of Air Quality Monitoring Data

Annual trend of air pollution condition in UB City are indicated in Figure 2.1-4. The annual average of SO2 was decreasing since 2011, but the concentration in 2015 was higher than that of 2014. The annual average of NO2 increased from 2010 to 2013, and then decreased until 2015. Especially, the concentration in 2013 was 2 times higher than the air quality standard (indicated as red line). The concentration of PM10 has decreased gradually since 2012, but is still 2 times higher than the air quality standard. The annual average of PM2.5 has been decreasing every year since 2018. However, it is still almost 2 times higher than the air quality standard, causing severe air pollution.



Source: NAMEM Annual report 2016

Figure 2.1-4 Annual Trend of Air Pollutants in UB City

2.2 PM Emission Source Contribution Analysis

2.2.1 PM Emission Source Contribution Analysis through PM Composition Analysis

Although establishment of CMB model was difficult under the situation of UB City, it was concluded that the contribution of coal combustion is dominant in PM pollution in winter season. Also, regarding contribution of secondary particle in UB city, it was found that the contribution of condensed dust is larger than other countries.

Therefore, generating process of PM is separated as follows.

1. Generating Process of Primary Particle
   A. Generating Process by combustion of sources etc.

      These particles are generated by fuel combustion or fugitive dust.

   B. Generating Process by Condensation of Gas in stack

      This indicates the process that the particle is generated through condensation in stack after moisture in the stack gas reacts with SO2 or NO2 and generates sulfuric acid or nitric acid.

2. Generating Process of Secondary Particle
   A. Generating Process of Condensed Dust

Condensed Dust is produced through gas or liquid (volatile matter or vapor etc.) in the stack is condensed into particles by rapid cooling and/or mixing in the air after the stack gas is emitted.

B. Generating Process by Chemical Reaction

For the sources by fuel combustion, secondary particles are generated by chemical reaction in the air after the stack gas is emitted.

On the other hand, fugitive dust from road was the most contributing source in the result of previous simulation model. Considering the ground surfaces in winter season freezes and little fugitive is expected, it is suggested that the fugitive dust from road emission source in the simulation model needs to be revised. The result of PMF model agreed with the observed value very well, thus the simulation model was revised considering this result.

2.2.2 PM10 Emission Considering Condensed Dust

PM10 emission considering condensed dust is shown in Table 2.2-1. PM10 emission of condensed dust was about 26% for the total emission of PM10.

Table 2.2-1 Emission by Source before and after considering Condensed Dust

	PM10			SO4			NO3			Total of PM10,SO4,NO3		
	1.A	2.A	Total	1.B	2.A	Total	1.B	2.A	Total	1	2	Total
Power Plant	21,215.45	6,810.16	28,025.61	989.35	447.19	1,436.54	14.85	37.75	52.60	22,219.65	7,295.10	29,514.75
HOB	924.16	296.65	1,220.81	115.04	52.00	167.04	1.66	0.63	2.29	1,040.86	349.28	1,390.14
CFWH	192.42	61.77	254.19	23.03	10.41	33.44	0.08	0.40	0.48	215.53	72.58	288.11
Small stove for household (Traditional stove)	3,747.87	1,203.07	4,950.94	107.67	48.66	156.33	3.00	6.29	9.29	3,858.54	1,258.02	5,116.56
Small stove for household (Improved stove)	1,026.96	329.66	1,356.62	149.83	67.72	217.55	0.82	1.73	2.55	1,177.61	399.10	1,576.71
Vehicle exhaust gas (Major road)	235.04	1,990.52	2,225.56	22.54	10.18	32.72	0.00	0.00	0.00	257.57	2,000.71	2,258.28
Vehicle exhaust gas (Minor road)	36.72	311.00	347.72	3.52	1.59	5.11	0.00	0.00	0.00	40.24	312.59	352.83
Fugitive road dust	2,860.51		2,860.51							2,860.51		2,860.51
Fugitive ash from ash pond of power plant	409.64		409.64							409.64		409.64
Total	30,648.77	11,002.81	41,651.58	1,410.97	637.76	2,048.73	20.41	46.80	67.21	32,080.15	11,687.37	43,767.52

Unit: ton

Source: JICA Experts

1.A: Emission by combustion of sources, 1.B: Emission by condensation of gas in stack, 2.A: Emission by generating process of condensed dust

1: Generating process of primary particle (1.A + 1.B)、2: Generating process of secondary particle (2.A + 2.B)

In secondary particle, the emissions of generating process by chemical reaction are not calculated because the particle by this process is generated during spreading.

2.2.3 Source Contribution Analysis by Simulation Model Considering Condensed Dust

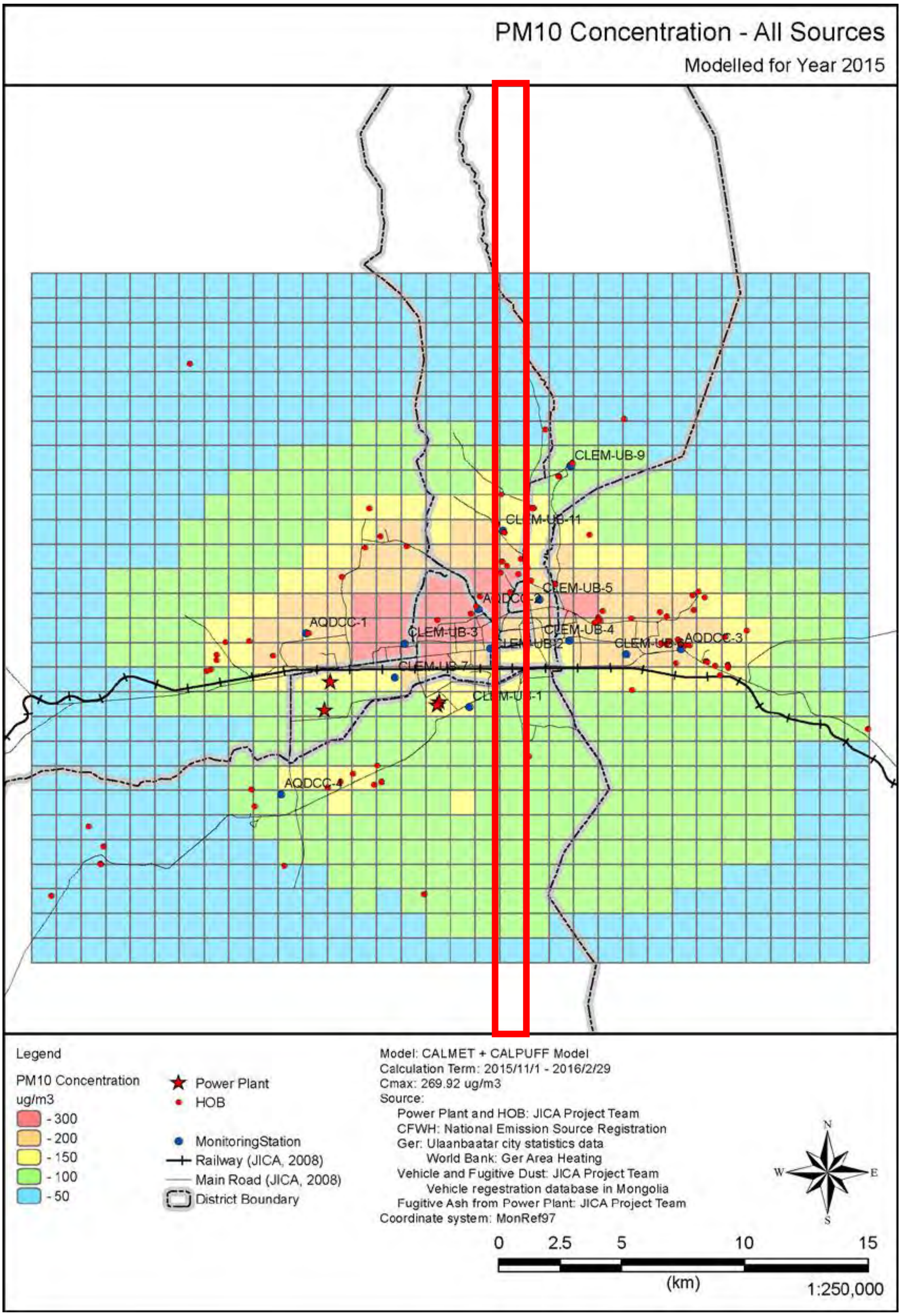
Using emission inventory for 2015 and the dispersion simulation model developed above, SO2 and PM10 concentration by grid was calculated.

Average concentration of PM10 for 4 months winter season exceeded 150ug/m3 in the central and Ger area. Annual average concentration of PM10 in this area is predicted to exceed 50ug/m3 that is the air quality standard of PM10. The concentration of PM10 for 4 months of winter season exceeded 200ug/m3 in the Ger area of Bayangol and Songinokhairkhan district.

Regarding the cross-section diagram of PM10 ambient air concentration (Figure 2.2-2) and PM10 contribution ratio at the monitoring station in Ger area (UB-05) (Figure 2.2-3), small stove had the largest contribution and then, contribution by fugitive dust from road and vehicle exhaust gas in order. Power plant is the largest source of PM10 emission, however, since PM10 spread widely, the contribution ratio of ambient air concentration is totally small. On the other hand, the contribution in the south of UB city is relatively large.

Sulfate and Nitrate indicate the particle generated through condensation in stack after moisture in the stack gas reacts with SO2 or NO2 and generates sulfuric acid or nitric acid, and the particle by generating process of secondary particles by chemical reaction during spreading in air. The contribution to sulfate of small stove occupies more than 80% and the contributions to nitrate of small stove and vehicle exhaust gas occupy about 45% respectively (Figure 2.2-4).

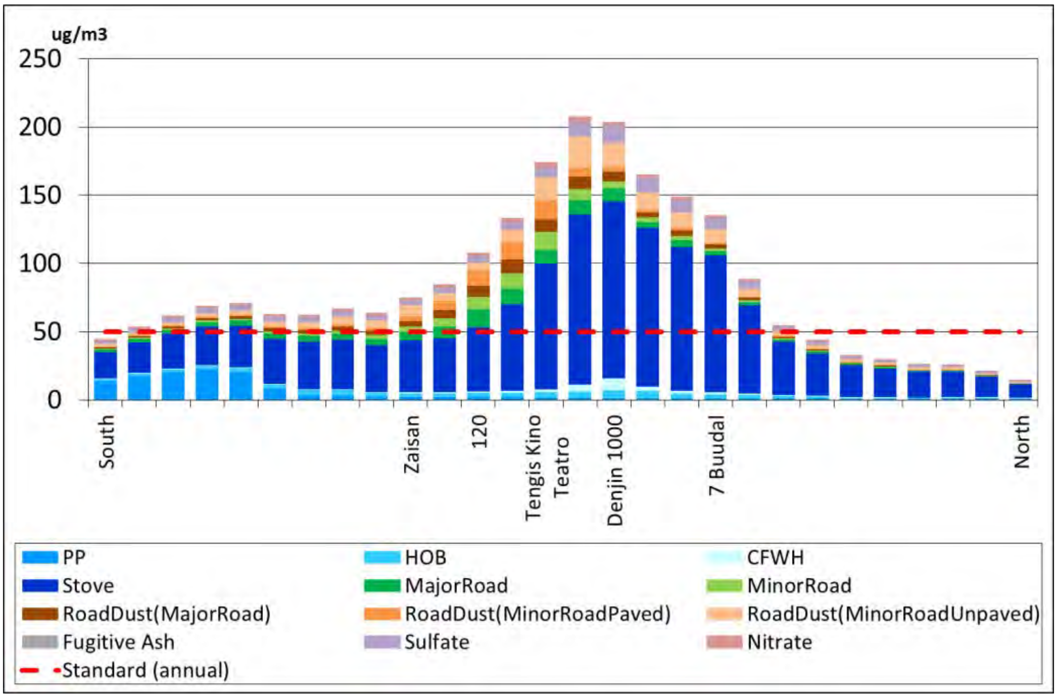
Therefore, in order for PM10 concentration to satisfy the air quality standard, air pollution control measure that will reduce PM10 concentration in the Ger area, which is surrounds the central area, to less than one-third of the current concentration is necessary. In addition, air pollution control measures to reduce vehicle exhaust gas and fugitive dust from road are necessary for the reduction of traffic volume. Since power plant is the largest source of PM10 emission, monitoring, the maintenance of the effort of current control measure and strength of future control measure are necessary.



Red rectangle shows the range of cross-section diagram of Figure 2.2-2

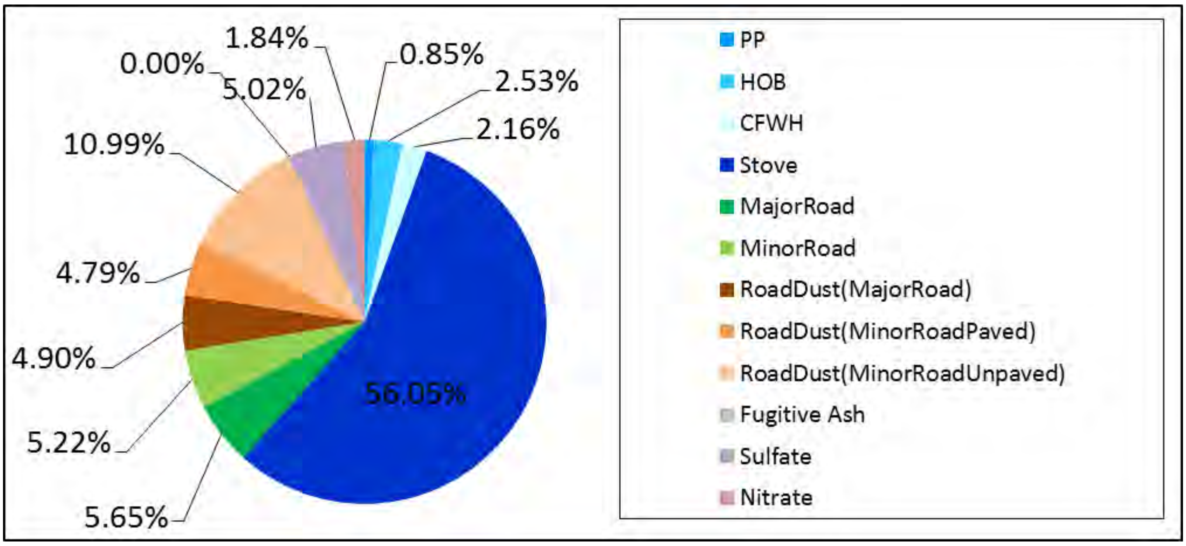
Source: JICA Experts

Figure 2.2-1 PM10 Concentration Distribution (2015)



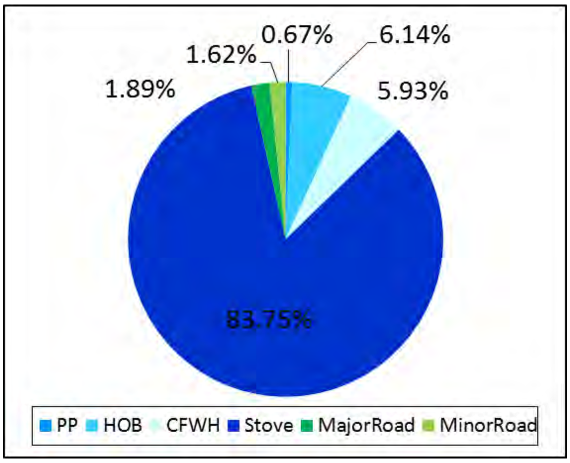
Source: JICA Experts

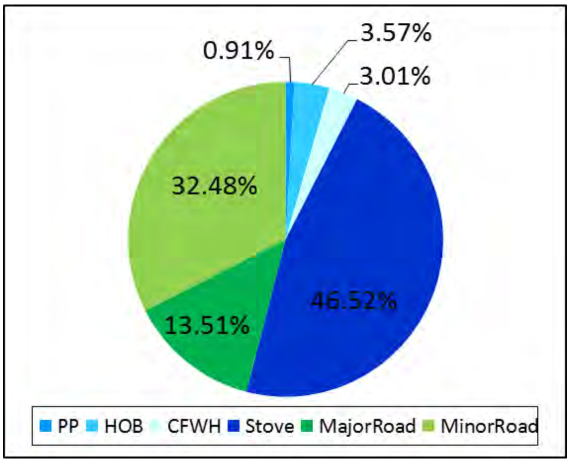
Figure 2.2-2 PM10 Cross Section Diagram by Source



Location of this monitoring station refer to Figure 2.1-2
Source: JICA Experts

Figure 2.2-3 PM10 Contribution Ratio at UB-05





Left: Sulfate、Right: Nitrate
Source: JICA Experts

Figure 2.2-4 Sulfate and Nitrate Contribution Ratio at UB-05

2.3 Capacity Development for Administration through Development of Boiler Management and Registration

2.3.1 Protocol for HOB Inspection

JICA Expert Team, C/P, and C/P-WG discussed on all of the target pollutants of emission measurement for boiler inspection. As an output, "The Protocol for HOB Inspection" was elaborated. Then, "The Protocol for Boiler Inspection (Administrative Instruction of Boiler Inspection and Certification)" was approved by Vice Mayor in September 28th, 2015. Based on "Administrative Instruction of Boiler Inspection and Certification", the emission measurement has been performed from October 2015, compliance rate for MNS standard was estimated based on the emission measurement results, then, HOB improvement orders and audit has been performed. "Administrative Instruction of Boiler Inspection and Certification" represents "The Protocol for HOB Inspection".

The Protocol for HOB Inspection

1. Implement the boiler inspection without the flue gas measurement
2. Implement boiler registration
3. Implement the flue gas measurement using JIS method
4. Issue improvement order and inspection results based on the result of the flue gas measurement
5. Confirm the performance of an improvement order

2.3.2 Flue Gas Measurement on Boiler Inspection and Certification

The progress of the flue gas measurement on the Boiler Inspection and Certification is shown in Table 2.3-1. In actual winter season of the year 2015, flue gas measurement team performed the flue gas measurement at 41 boilers, which was less than the original plan. The flue gas measurements at 22 boilers are performed during the winter season of the year 2016, and so total of 63 boilers were able to be performed through the project (Note: The boiler facilities are 170 in 2016). The flue gas measurement will continue to be performed even after the termination of this project for the Boiler Inspection and Certification. In the case of the current 1 flue gas measurement team continuous, 55 boilers facilities will have flue gas measurement in 1 year because total number of boilers will be decreased by an admonishment which is to change HOB to the hot water system, and 3 years will be necessary in order to perform the flue gas measurement at all boiler facilities.

Table 2.3-1 Progress of the Flue Gas Measurement on the Boiler Inspection and Certification

Original plan (September 2015)			Actual performance		
Schedule	**The number of team**	**The number of measurement**	**Schedule**	**The number of team**	**The number of measurement**
2015/10/1 ～ 2015/11/30	1	12	2015/10/1 ～ 2016/3/31	1	41
2015/12/1 ～ 2016/2/29	2	40			
2016/10/1 ～ 2017/2/28	2	106	2016/12/1 ～ 2017/2/28	1	15
			2017/3/1 ～ 2017/3/31	1	7
Sub-Total		158			63

Source: JICA Expert Team

The result of measurement on the Boiler Inspection and Certification from October 2015 to March 2017 is shown in Table 2.3-2. All parameters in 4 boilers (7.1%) have met the emission standard. The boiler of 42.9% met the emission standard of SO2, 100% for NOx, 31.7% for CO, and 36.5% for dust. Actual performance as above plan is necessary to calculate the representative achievement rate which achieved the emission standard because measured rate of 63 boilers is 22.0 % against total 287 boilers.

As the result of performed flue gas measurement at 63 HOB, knowledge as overtaken previous common is had been acquired. For example, even though a lot of boilers which were considered low–impact for environment were installed, many of them were not met the emission standard and boilers which were installed by fund of Clean Air Fund did not have met the emission standard. Regarding replacement of HOB in the future, it is expected that the flue gas measurement data as described in final report will be able to be utilized.

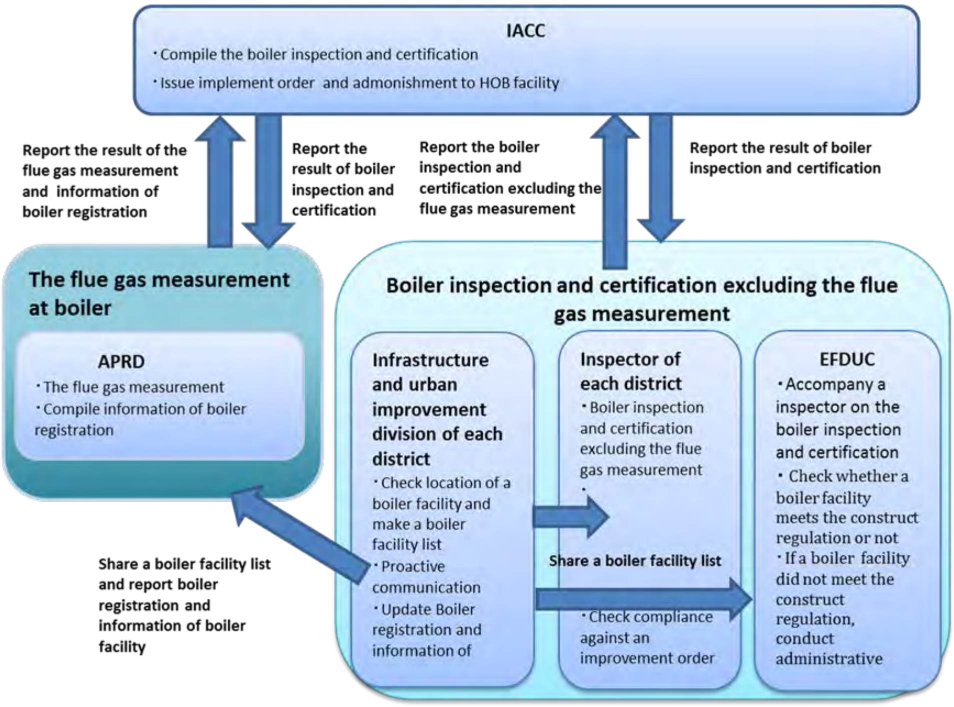
Table 2.3-2 Result of the Flue Gas Measurement on the Boiler Inspection and Certification (2015/10～2017/03)

	SO_2	NOx	CO	Dust
The number of boilers which measured by each parameter	63	63	63	63
The number of boilers which meet emission standard by each parameter	27	63	20	23
The achievement rate which achieved the emission standard by each parameter (%)	42.9	100.0	31.7	36.5

Source: JICA Expert Team

2.3.3 Full Implementation of Boiler Management and Registration

The achievement of the Boiler Inspection and Certification of 2015 was the establishment of full implementation of boiler management and registration. The details of achievements were 1) The Boiler inspection without the flue gas measurement, 2) Registration of boiler, 3) The flue gas measurement, 4) Notification of emission measurement results and improvement orders and 5) Confirmation of performance of improvement orders. As a result of coordination between APRD, IACC, UECC, EFDUC, infrastructure and Urban Improvement Division of each district, Inspector of each district and JICA Expert Team, the related activities were implemented. Task of each organization is shown in Figure 2.3-1.



Source: JICA Expert Team

Figure 2.3-1 Task of Each Organization

From Phase 1 of the project, which began in 2010, to the year 2014, not few numbers of non-registered boilers existed, and the improvement of registration rate was becoming an every year issue for the boiler registration. The boiler registration team visited all HOBs and steam boilers in the year 2015. However, while visiting HOBs, stacks were searched by the district officers in charge of boiler registration. If non-registered stacks were found, the inspection agency has authority to enter the facilities and confirm the existence of the facilities. As a result, many non-registered boilers and new HOBs were found. The registration status of the boiler in the year 2014 and 2015 is shown in Table 2.3-3.

Table 2.3-3 Number of Boiler Facility and Boiler Registration by District

District	2014		2015	
	Number of boiler facilities	Number of boiler	Number of boiler facilities	Number of boiler
Bayangol	10	14	13	14
Songinokhairkhan	28	59	28	58
Khan-Uul	28	69	33	54
Chingeltei	23	43	22	30
Sukhbaatar	14	25	15	26
Bayanzurkh	54	120	57	105
Total	157	330	168	287

Source: JICA Expert Team

IACC issued admonishment for suspension to 6 boilers facilities, ordered penalties to 11 boilers facilities and 73 improvement orders based on the result of the boiler inspection of the year 2015.

2.3.4 Utilization of Air Pollution Control Measures

Throughout HOB site survey, the Project Team found problems in air pollutants emission reduction. For examples, there are dust reduction equipment models of which not only cost but also effect was minimized. It is not rare that HOB user does not maintain dust reduction equipment by which dust reduction effect was minimized. This information became to be used in IACC's recommendations to HOB operators, such as improvement and appropriate maintenance of cyclone and/or scrubber, and operator trainings.

2.4 Control Measures for Mobile Sources

2.4.1 Mobile Emission Source Monitoring

From August 2014 to January 2017, the total of 20 vehicles with 2 sets of on-board emission measurement system were measured (non-winter seasons: 9 gasoline passenger cars (including 1 LPG car), 5 diesel trucks, and 4 motor coaches in , and winter season: 1 gasoline passenger car and 1 motor coach).

Figure 2.4-1 Measurement Using On-board Emission Measurement System

Although the number of measured emission is limited, using on-board emission measurement system, the emission factor was updated and the emission was recalculated by compiling measured result from vehicles that was actually traveling through UB city. Regarding air pollution control measures, such as introduction of DPF to buses for public transportation, introduction of EURO IV buses, transition into low emission vehicle, and promotion of NANO fuel, the effects of control measures were estimated based on the emission factor, and the mobile source inventory by control measures was created.

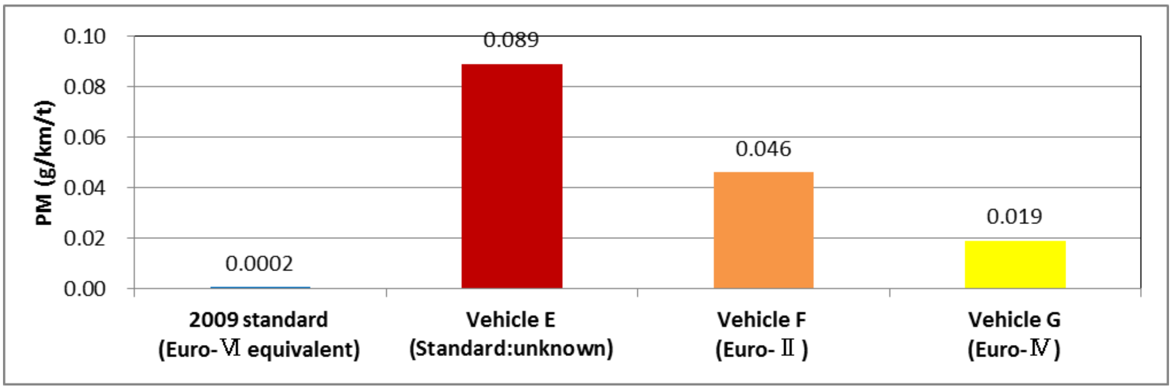
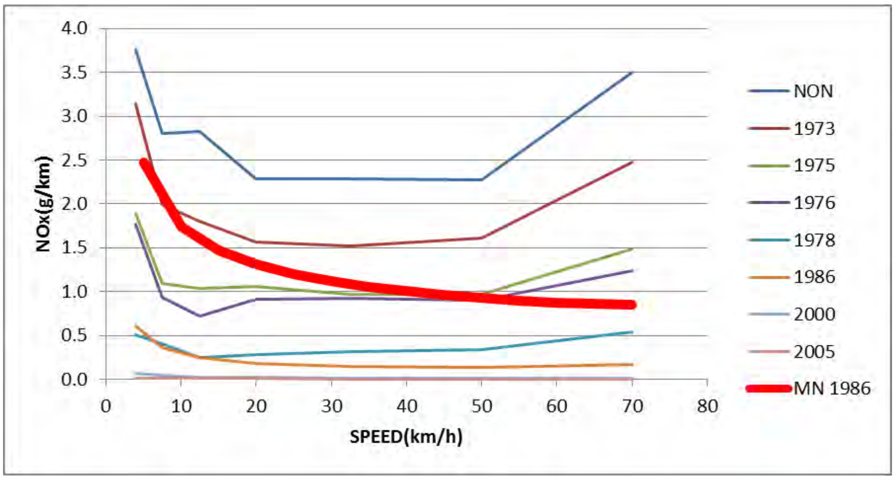


Figure 2.4-2 Emission Difference (A Sample of Outcome of On-board Emission Measurement System)

The example of emission factors by speed after classifying the measured result by the exhaust gas regulation year are shown in Figure 2.4-3. This example is based on the emission factor using the result of exhaust gas measurement with on-board equipment for 2 gasoline vehicles that correspond to NOx exhaust gas regulation in 1986. The emission factors of travelling in Mongolia (Red line) were nearly 5 times of the ones of Japan (Orange line). The determination of the formula of emission factor by speed was conducted same as other groups and emission factors were updated.



Thick line: Emission factor by the result of exhaust gas measurement by using on-board equipment

Thin line: Emission factor by vehicle gas regulation in Japan

Source: JICA Experts

Figure 2.4-3 Comparison of NOx Emission Factor by Speed

2.4.2 Control Measures for Vehicle Exhaust Gas

As shown in Table 2.8-1, the Project Team proposed 7 control measures for vehicle exhaust emission reduction. One measure was already realized, and 5 measures are listed in the “Activity Plan” for “National Program on Air and Environment Pollution Reduction” approved on 28th April 2017. Regarding DPF, working group was organized and then elaborated a plan to introduce DPF. Pilot project was carried out in UB as another new JICA Project, by which the selected model of DPF was confirmed as suitable measure for UB. Since 5 measures are listed in the Activity Plan, appropriate implementation supports are going to be required.

2.5 Monitoring of Flue Gas Measurement at PP4 by CEMS

Dust analyzer and flue gas measurement analyzers were supplied to PP4. Entire measurement system is shown below. Dust analyzer was installed at aggregate stack, and flue gas measurement analyzers were placed in a room inside boiler buildings. One unit of flue gas analyzer measures exhaust gas of 4 boilers with switching system.

The Project Team, including APRD, MET, PP4 and Ministry of Energy, proposed an institutional coordination mechanism on CEMS data sharing and evaluation. Although it requires time to be authorized, it would be authorized by MET, and the system would be used mainly by IACC.

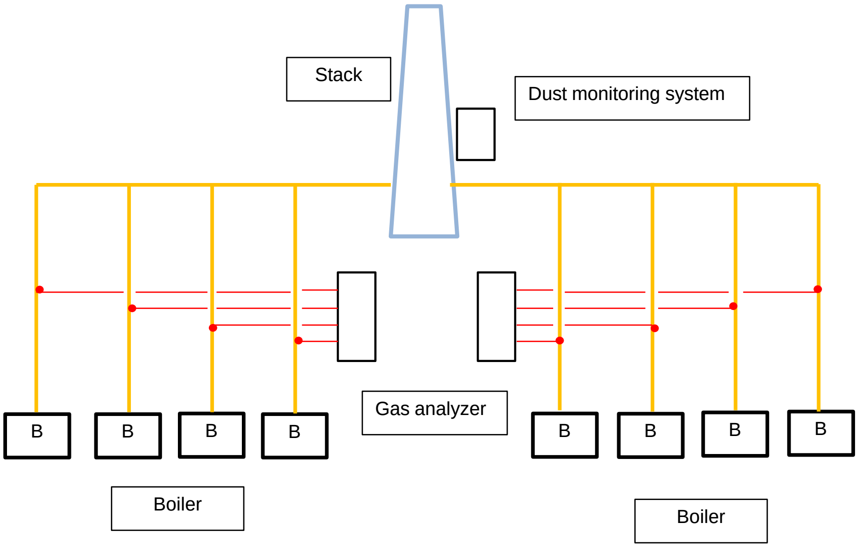


Figure 2.5-1　CEMS System inside PP4

Figure 2.5-2　Flue Gas Measurement Analyzers and Dust Analyzer

2.6 Public Relations and Public Awareness

Under the support of this project, air quality information was started to be issued by NAMEM and APRD according to Order A-131 of Minister of Nature Environment and Tourism in 2011. Advisory services were started to be issued also via Air Quality Smart Control System and related systems. Originally, order A-53 of Minister of Nature Environment and Tourism in 2011 was defined for advisory services of air quality information. According to a suggestion of JICA Expert, C/P-WG member of NAMEM proposed to amend it. It was realized as Order A-327 of Minister of Nature Environment and Green Development in 2014, and applied to the systems above.

APRD, with JICA Expert, prepared and carried out the public awareness seminars at schools regarding on the air quality information reading from 2015 until 2016.

Source: JICA Project Team

Figure 2.6-1 LCD Displaying Air Quality Information and Public Awareness Seminar for Schools

Seminars and symposium were organized for 19 times. Total 704 people attended those seminars.

Access count to the websites of APRD and NAMEM related to the project was 211,914 in 2014, and increased to 393,752 in 2016, increased by 86%.

2.7 Cooperation between Organizations

As reported in PR4, coordinating mechanism of APRD (AQDCC) and NAMEM for Integrated Air Quality Monitoring Network at UB city area was realized by the end of 2014, and it was documented and signed on 30th December 2015.

NCAPR was held in November 2016, and then continued as working group elaborating National Program on Air and Environment Pollution Reduction. APRD provided information such as emission measurement data, emission inventory, air quality simulation output and control measures evaluated using capacities developed by this project. This proved out that coordinating mechanism between APRD and NCAPR has been strengthened.

APRD, IACC, UB energy coordinating committee, JICA Experts and related organizations discussed boiler inspection and certification, and "the administrative instruction of boiler inspection and certification", which describe roles and activities of related agencies for boiler inspection and certification was drafted. The administrative instruction of boiler inspection and certification was approved by Vice Mayor in September 2015. The flue gas measurement was conducted from October to March 2016. Summary on boiler inspection and certification from September to March 2016 was submitted to Vice Mayor in May 2016. Boiler audit results from November 2016 to March 2017 were submitted to Vice Mayor in May 2017.

Technology to evaluate control measures by using emission inventory and dispersion simulation was used to discuss “National Program on Air and Environment Pollution Reduction”. Technology for air pollutant control measure that Production and Innovation Bureau in UB city evaluated highly was checked by flue gas measurement of APRD. The new cooperation between organizations with a focus on the utilization of transferred technology to APRD is occurring.

2.8 Evaluation of Air Pollution Control Measures and Concentration Reduction Effect

JICA Experts prepared and verified 15 plans of air pollution control measures and reduction effect of emission and concentration.

Table 2.8-1 Setting of Air Pollution Control Measure

No	Control measure	Target source	Setting of reduction of pollutant
1-1	Introduction of improved fuel to whole UB city (Semi-coke briquette)	Small stove for household	The result of combustion test is applied; Fuel consumption: 82% when using coal SO2 emission factor: 25% when using coal PM emission factor (kg/ton): 0.93(traditional stove),0.27(improved stove)
1-2	Introduction of improved fuel to partial area in UB city (Semi-coke briquette)	Small stove for household	Target area is khoroos where calculation concentration from small stove was high. Fuel consumption in this area is corresponding to about 160 thousand ton. Others are the same as 1-1.
2	Installment of DPF to large size bus	Vehicle exhaust gas	Based on the result of vehicle exhaust gas measurement with/without, PM emission from large size bus reduces by 80%.
3	Introduction of EURO-IV emission standard bus	Vehicle exhaust gas	Emission factor of EURO-IV emission standard bus measured in UB city by on-board equipment is applied.
4	Abolishing HOBs around Amgalan Heat Supply Facility	HOB	HOBs in area described master plan in 2013 are abolished and these emission change to 0ton.
5	Installation of Appropriately-Designed Multi-Cyclone	HOB	Dust collection efficiency is 60%.
6	Installation of Appropriately-Designed Scrubber	HOB	Dust collection efficiency is 70%.
7	Introduction of low sulfur fuel	Vehicle exhaust gas	Sulfur content in gasoline and diesel change to respectively 1/20 and 1/100[1]. As this setting, SO2 emission reduces to 1/20 and 1/100 and catalysts don't damaged by high-sulfur fuel.
8	Recommendation of eco-driving	Vehicle exhaust gas	Based on the result in Japan, fuel consumption and SO2 of gasoline vehicle reduces by 12% and fuel consumption and SO2 of diesel reduces by 21%, NOx reduces by 35%, and PM reduces 45%.
9	Fuel Conversion from Coal to Coal Gas	HOB	Gas amount is as much calorie as the case of using coal. Emission factor applied the result of flue gas measurement of HOB using coal gas.

[1] Sulfur content of gasoline: Settings to improve to 10ppm from 200ppm that is considerable substantial sulfur contents of EURO4 fuel
Sulfur content of diesel: Settings to improve to 10ppm from 1000ppm that is considerable substantial sulfur contents of EURO4 fuel

10	Improvement of Dust Collection System for PP2 and PP3	Power plant	Dust collection efficiency by power plant based on improving proposal of dust collection system in Table 2.8-1 is applied.
11	Introduction of low emission gas vehicle	Vehicle exhaust gas	Vehicle that was manufactured before 2005 is changed to the one that apply exhaust gas regulation in 2005 (New Long Term).
12	Ignition Material for a Ger and Wall Stove	Small stove for household	With implementing No1 (Introduction of improved fuel), the result of combustion test apply as emission factor.
13	Construction of apartments in Ger area	Small stove for household	Number of Ger and building in target area for air pollution control measure is 0.
14	Improvement of signal control system	Vehicle exhaust gas	Travel speed less than 30km/h increases by 5km/h.
15	Introduction of RSD	Vehicle exhaust gas	Since vehicle exceeded exhaust gas standard is found by RSD and the regular inspection and maintenance are promoted, degradation of vehicle is suppressed.

Source: JICA Expert Team

Table 2.8-2 Cost-Effectiveness for PM Reduction Amount of Air Pollution Control Measures

No	Control Measures		PM10 reduction amount (ton/year)	Maximum ground concentration(μg/m3)			Initial cost of control measures		Control measures cost per ton (Million MNT)	Durable year	Control measures annual cost per ton (Million MNT)	
				Before control measures	After control measures	Capacity of variation	Million MNT	Million Yen			Million MNT	Million Yen
1-1	Introduction of improved fuel (Whole Area)	Household small stove	3,758.62	184.77	137.86	46.91	17,044.9	811.7	4.53	1	4.53	0.21
1-2	Introduction of improved fuel (a part of UB)	Household small stove	549.18	184.77	121.35	63.42	2,913.8	138.8	5.31	1	5.31	0.24
2	Introduction of DPF to Buses	Vehicle exhaust gas	75.90	72.13	46.89	25.24	30,245.4	1,440.3	398.49	10	39.85	1.81
3	Introduction of EURO-IV Buses	Vehicle exhaust gas	77.05	72.13	46.67	25.46	465,403.6	22,162.1	6,040.28	10	604.03	27.43
4	Abolishment of HOB by operating of Amgalan heating facility	HOB	336.75	12.99	10.47	2.52	7,885.8	375.5	23.42	30	0.78	0.04
5	Introduction of cyclone to HOB	HOB	477.23	12.99	8.17	4.82	974.2	46.4	2.04	10	0.20	0.01
6	Introduction of wet scrubber to HOB	HOB	556.94	12.99	5.57	7.42	6,015.0	286.4	10.80	10	1.08	0.05
7	Introduction of low sulfur fuel	Vehicle exhaust gas	154.82	72.13	30.93	41.2	16,195.2	771.2	104.61	1	104.61	4.75
8	Recommendation of eco-drive	Vehicle exhaust gas	122.29	72.13	40.72	31.41	53.0	2.5	0.43	10	0.04	0.00
9	Fuel conversion of coal gas	HOB	364.06	12.99	12.57	0.42	3,791.1	180.5	10.41	30	0.35	0.02
10	Dust collector improvement of PP2 and PP3	Power Plant	12,051.72	32.84	14.06	18.78	25,620.0	1,220.0	2.13	30	0.07	0.00
11	Introduction of low emission vehicle	Vehicle exhaust gas	56.98	72.13	54.12	18.01	932,264.0	44,393.5	16,361.25	10	1,636.12	74.30
12	fire materials of low dust emission	Household small stove	4,052.38	184.77	38.87	145.9	80,844.0	3,849.7	19.95	1	19.95	0.91
13	promotion of apartment construction in Ger Area	Household small stove	2,762.51	184.77	93.85	90.92	1,996,800.0	95,085.7	722.82	30	24.09	1.09
14	Improvement of traffic signal system	Vehicle exhaust gas	20.74	72.13	65.84	6.29	73.7	3.5	3.55	10	0.36	0.02
15	Introduction of RSD	Vehicle exhaust gas	78.07	72.13	51.35	20.78	630.0	30.0	8.07	10	0.81	0.04

PM reduction potential of control measures on coal fuel and vehicle is shown in Figure 2.8-1 and Figure 2.8-2. Control measures of coal fuel such as cyclone, coal gas, wet scrubber and Amgalan Heat Facility, improved fuel, and duct collector of PP2 and PP3 would be implemented by 61,331 million MNT (2,785 million Yen) as initial cost, PM10 of 17,545 ton would be reduced.

Control measures of vehicle such as traveling speed increase by traffic signal improvement, introduction of low emission vehicle, installation of DPF to buses, introduction of EURO-IV Buses, introduction of RSD, recommendation of eco-drive and introduction of low sulfur fuel would be implemented by 1,444,865 million MNT (65,611 million Yen) as initial cost, PM10 of 585.85 ton would be reduced.

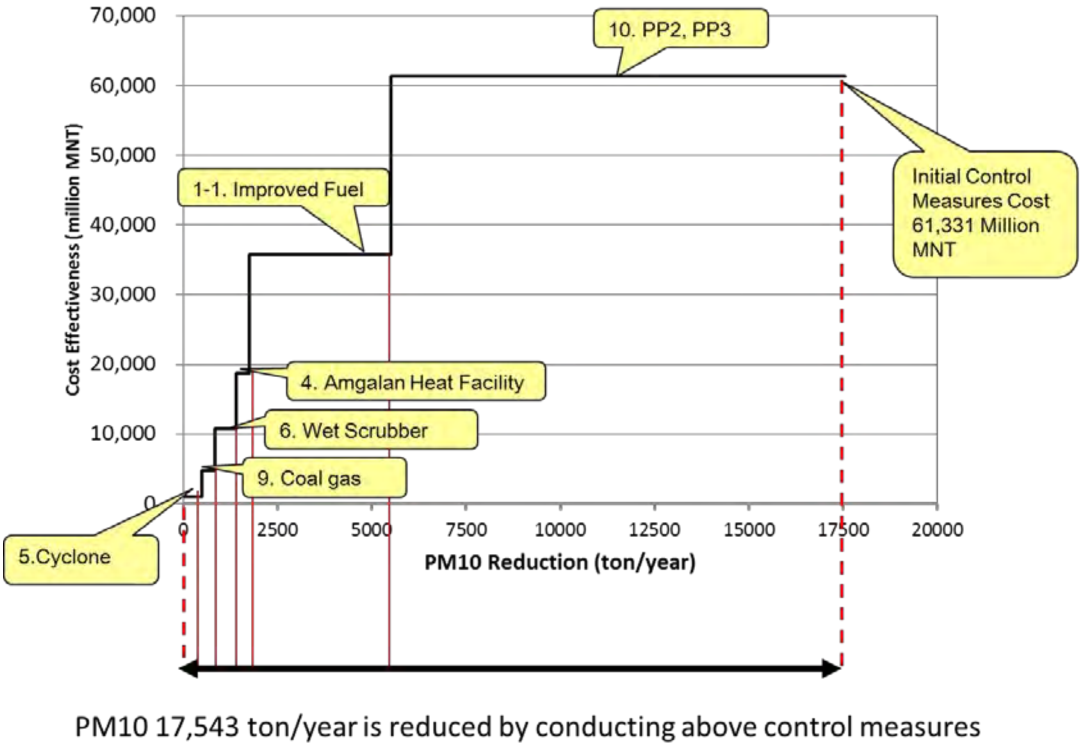


Figure 2.8-1 PM Reduction Potential by Control Measures for Coal Combustion Sources

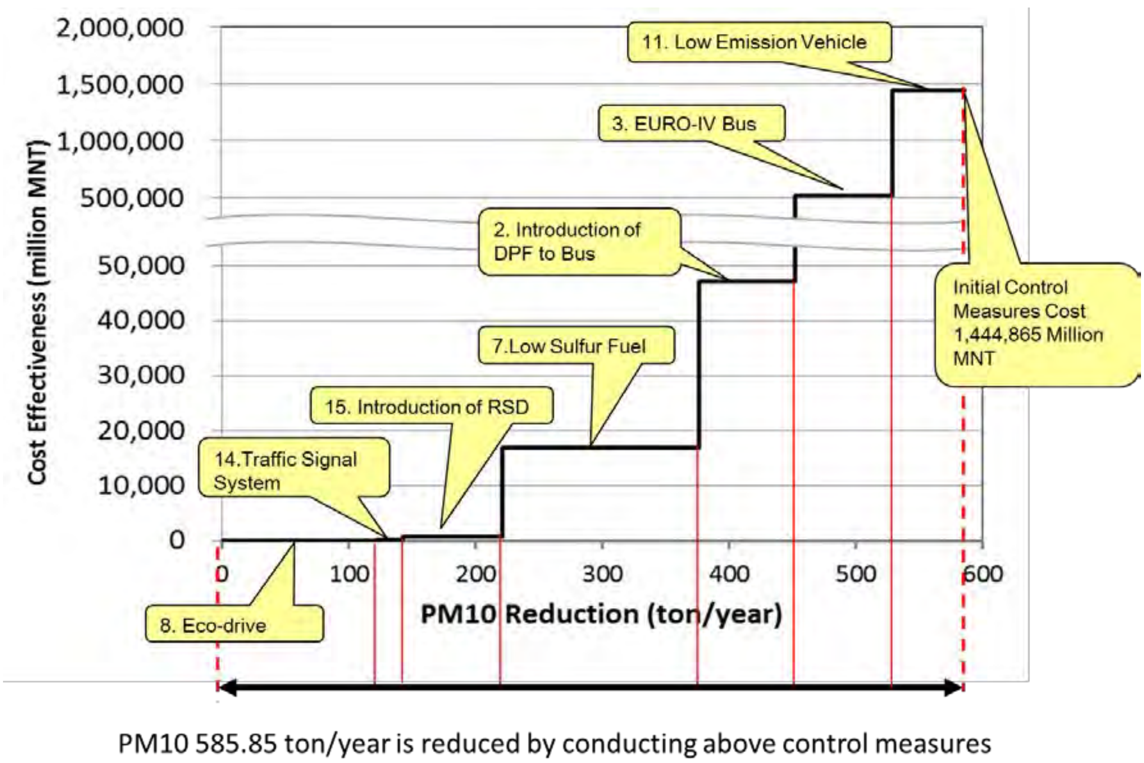


Figure 2.8-2 PM Reduction Potential by Control Measures for Vehicle Exhaust Gas

3 Future Assignment on Air Pollution Control

Future assignment on air pollution control is described below, mainly based on the discussion of last Joint Coordinating Committee (JCC).

(1). Air Quality Monitoring and Citizen's Awareness Activities

Air quality monitoring network has been rehabilitated. Continuous monitoring has contributed to stability of air quality information to citizens. This achievement has raised citizen's concern, and has led to a situation that the whole country works toward solving air pollution problems actively. Sustaining and maintaining stable data supply is a big responsibility of municipality and government, and it is important to allocate necessary budget and human resources. Mayor and decision makers understand this condition, which made the normal maintenance continuous. However, equipment in air quality station has become old including data transfer system, and the instruments renewal is necessary. In addition, new tasks are being recognized. The tasks are the things that monitoring stations established by another organization in 2015 are still not operating normally as of May 2017, and there are few human resources who can convey how to read air pollution information.

(2). Identification of Emission Sources

Both introduction of technology and professional training of Mongolian experts have strengthened a capacity to identify emission sources. Trained experts can process data and arrange them as information, and this situation makes it possible that this information has formed a big cycle connected to measures determined by decision makers. To date, measures have not been prioritized corresponding to their effectiveness, and therefore this effectiveness has not been visible. However strengthening of these capacities has made them visible, and prioritization has become possible.

(3). Air Pollution by Vehicles

Agendas for evaluation and implementation of effective and viable measures for mobile emission sources were discussed. It is known that DPF has 80 to 90% pollution reduction effect and RSD also has the same level of effect. However, for example, introduction of RSD has the feature to require standard such as MNS standard in order to compare measured results. Vehicle is one of the major air pollution sources and there are further measures to be studied. It is emphasized that these works and studies need more cooperation with JICA experts.

(4). Air Pollution by Ger Stoves

Improved fuel supply is the important measure as mid-term measures. In order to realize it, subsidy is indispensable to promote improved fuel, and improved fuel standard, including emission standard, is necessary to keep the fuel quality suitable for air pollution reduction. Currently, quality of improved fuel is not defined in air pollutant emission, and decision makers sometimes don't distinguish even the differences between briquette and semi-cokes briquette. Supports by JICA experts are important to solve these issues.

(5). Air Pollution from HOBs and Power Plants

It is summarized that stationary sources such as HOB and power plants, flue gas was measured and technology to be evaluated was built, effective control measures were evaluated. For maintaining technology and operating continuous monitoring, NAMEM, PP4 and APRD secure budget and human resources, and also interstitial training for human resources to be secured is important. Especially, PP4 and other power plants on CEMS operation support are necessary.

(6). Future Assignments and Prospects for Air Pollution Control Measures

Following future assignments and prospects for air pollution control measures presented in the summary seminar were discussed, and discussion result was wrapped up as M/M.

・Air quality monitoring and citizen's awareness

・Identification of emission sources

・Necessity of technology transfer on PM component analysis

・Air pollution control measures for vehicles

・Air pollution control measures for Ger stoves

・Air pollution control measures for HOB and thermal power plants

・Assignments for future implementation measures and their solutions

(7). Summary

Further capacity development on planning, preparation and implementation for air pollution control is important for Mongolia. Distinct air pollution reduction may be realized by pilot projects with high priority and high technical validity, and then expanding the project by mobilizing Mongolian budget including the budget of polluters' tax and ADB loan. For implementing capacity development on planning, preparation and implementation for air pollution control, it is premise that capacity development to Mongolian side by Phase 1 and Phase 2 will be maintained and improved.

Mongolia
The Air Pollution Reducing Department of Capital City (APRD)

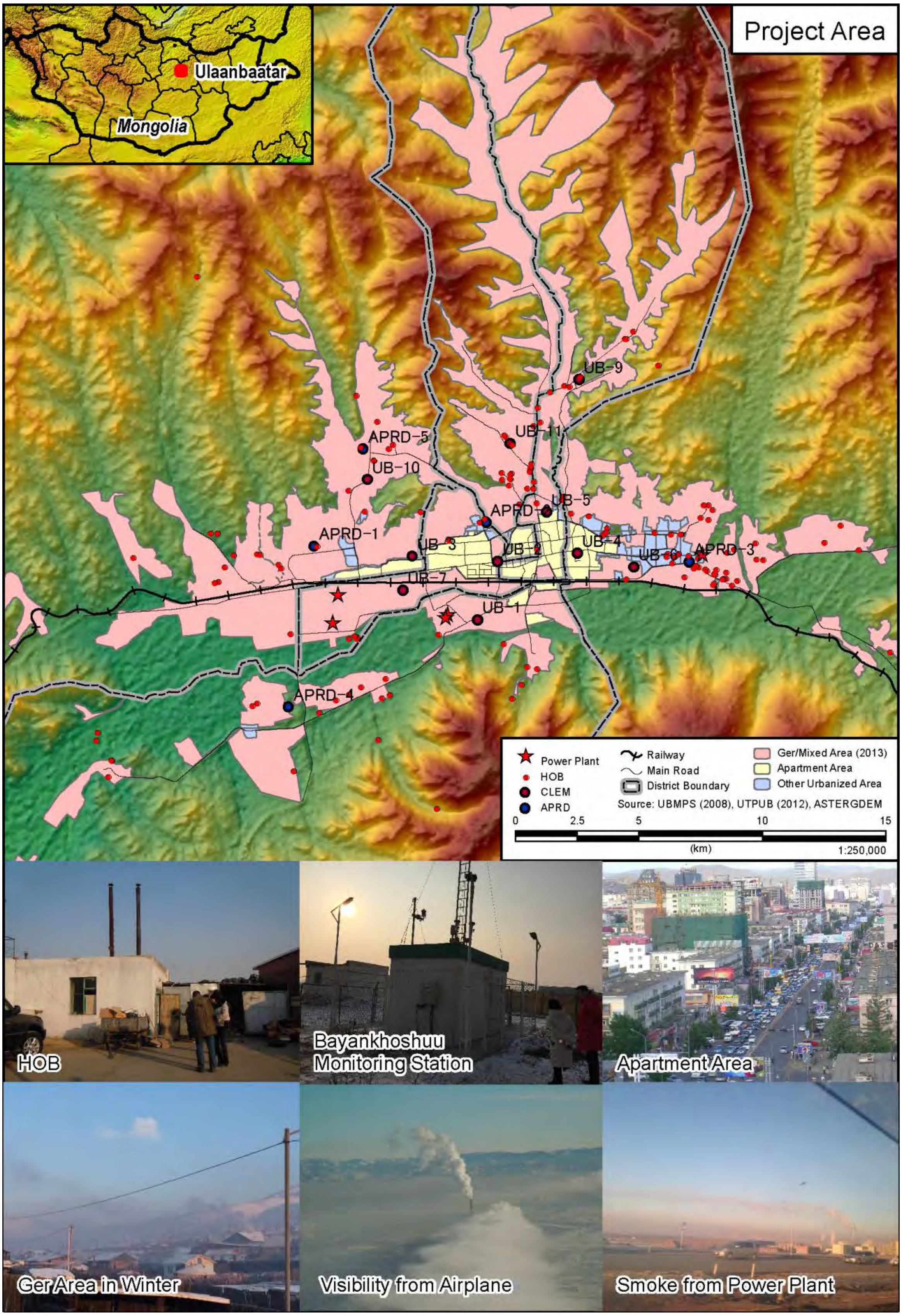
Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia

Final Report

June 2017

Japan International Cooperation Agency (JICA)

SUURI-KEIKAKU CO., LTD



Project Area
Ulaanbaatar
Mongolia
UB-9
UB-11
APRD-5
UB-10
UB-5
APRD-1
UB-3
UB-2
UB-4
APRD-3
UB-7
UB-1
APRD-4
Power Plant
HOB
CLEM
APRD
Railway
Main Road
District Boundary
Ger/Mixed Area (2013)
Apartment Area
Other Urbanized Area
Source: UBMPS (2008), UTPUB (2012), ASTERGDEM
0 2.5 5 10 15
(km)
1:250,000
HOB
Bayankhoshuu Monitoring Station
Apartment Area
Ger Area in Winter
Visibility from Airplane
Smoke from Power Plant

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Abbreviation

Abbreviation	English
ADB	Asian Development Bank
APRD (Originally AQDCC)	Air Pollution Reduction Department (Originally as Air Quality Department of the Capital City)
CA	Capacity Assessment
CAF	Clean Air Foundation
CD	Capacity Development
CEMS	Continuous Emission Monitoring System
CFWH	Coal Fired Water Heater
CLEM	Central Laboratory of Environment and Metrology
CMB	Chemical Mass Balance
C/P	Counterpart
C/P-WG	Counterpart Working Group
CO	Carbon monoxide
DPF	Diesel Particulate Filter
EFDUC	Engineering Facilities Department of the Ulaanbaatar City
EIC	Education, Information and Communication
EPWMD	Environment Pollution and Waste Management Department
GIS	Geographic Information System
GM	General Manager
GOJ	The Government of Japan
GOM	The Government of Mongolia
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HOB	Heat Only Boiler
HSUD	Heating Stoves Utilization Department
IACC	Inspection Agency of the Capital City
IMHE	Institute of Meteorology, Hydrology and Environment
ISO	International Organization for Standardization
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
ME	Ministry of Energy
MET (Originally MEGDT)	Ministry of Environment and Tourism (Originally as Ministry of Environment, Green Development and Tourism)
MNS	Mongolian National Standard

MM	Ministry of Mines
NAMEM	National Agency for Meteorology and Environment Monitoring
NCAPR	National Committee for Air Pollution Reduction
NIA	National Inspection Agency
NO2	Nitrogen dioxides
NOx	Nitrogen oxides
NUM	National University of Mongolia
OJT	On the Job Training
O_2	Oxygen
PAM	Petroleum Authority of Mongolia
PCM	Project Cycle Management
PDM	Project Design Matrix
PMF	Positive Matrix Factorization
PMU	Project Management Unit
PM10	(Particulate Matter with a diameter of 10 micrometers or less)
PM2.5	(Particulate Matter with a diameter of 2.5 micrometers or less)
PO	Plan of the Operation
PTDCC	Public Transportation Department of the Capital City
RDCC	Road Department of the Capital City
R/D	Record of Discussions
SCDM	Sustainable Capacity Development Matrix
SO2	Sulfur dioxides
SOx	Sulfur oxides
TPD	Traffic Police Department
UB	Ulaanbaatar
USEPA	United States Environmental Protection Agency
WB	The World Bank

1 Outline

1.1 Back Ground, Project Activities, and Implementation Polities

1.1.1 Back Ground of the Project

Mongolia is a coal rich country with limited options for energy sources, heavily dependent on the coal which contains a great amount of water and ash resulting in dust-emitting characteristics. The major emission sources are coal combustion at the 3 old coal fired power plants (the Power Plant No.4, No.3 and No.2) for power and heat generation, about 200 Heat Only Boilers (hereinafter HOBs), about 1,000 small boilers such as Coal Fired Water Heaters (hereinafter CFWHs), and numerous Ger stoves and wall stoves at more than 130,000 families in Ger areas.

The air pollution at Ulaanbaatar (hereinafter UB) city has been severe, especially in the winter season. Major pollutants have been particulate matters including dust, PM10 and PM2.5. In addition to the coal combustion, increasing vehicle emissions, wind-blown dust from ash ponds of the power plants and other fugitive sources are also contributing to the severe air pollution.

According to NAMEM, the highest monthly average value of PM10 ambient concentration showed as much as 1,000 μg/m3 during the winter of 2011 and all monitoring sites showed high concentration of PM10 exceeding the Mongolian ambient air quality standards (100 μg/m3 for daily average and 50 μg/m3 for annual average) posing serious health risks to the citizens. Also other parameters such as SO2 and NO2 are problematic throughout the year, occasionally exceeding the Mongolian air quality standards.

In UB city, Air Quality Division was established within Nature Environment Agency of Capital City in year 2006 to promote air pollution control. Later in February 2009, the division was upgraded to Air Quality Department of the Capital City (now re-organized as Air Pollution Reduction Department, APRD), but the knowledge and experiences of the staffs were not enough to deal with complicated issue of air pollution. At this time, the influences of each pollutant to the ambient air were unclear. Even to consider the cause and control measures of air pollution, almost no data existed in scientific bases.

Under the circumstances, based on the request by the Government of Mongolia, the Government of Japan provided technical assistance through JICA "Capacity Development Project for Air Pollution Control in UB City" during 2010 to 2013, which focused on the capacity development of the APRD and other relevant agencies at city and national level especially to control the emission sources. Major activities included technical transfer for credible emission inventory elaboration, air pollution simulation model, on-site emission measurements of boilers including dust and PM10 among other pollutants, establishment of the boiler registration system, diagnostic and proposal of a control measures of power plants and HOBs, elaboration of emission control measures and improvement of their technical evaluation of emission reduction as well as air quality. Also, for data management and accuracy improvement of ambient air monitoring which was not included in Phase1, problems are still remaining to be solved. Having these backgrounds, the Government of Mongolia requested the Phase2 of the Project in 2012. The Government of Japan approved the Project for 2013 implementation.

1.1.2 Activity of the Project

Target area is UB City of Mongolia and relevant agencies are as follows.

Relevant agencies and institutions of Mongolian side

Counterpart (C/P)		Air Pollution Reduction Department (APRD)
Counterpart Working Group(C/P-WG)	National Level	・ National Committee for Air Pollution Reduction (NCAPR) ・ Ministry of Environment and Tourism (MET) (reorganized in august 2016, from Ministry of Environment and Green Development and Tourism) ・ Clean Air Foundation ・ Ministry of Energy ・ Ministry of Construction and Urban Development ・ Ministry of Road and Transportation ・ Ministry of Mining ・ National Agency for Meteorology and Environment Monitoring (NAMEM) ・ Petroleum Authority of Mongolia
	City Level	・ Strategic Policy and Planning Department of the Mayor's Office ・ Engineering Facilities Department ・ Inspection Agency ・ Heating Stoves Utilization Department ・ Nature, Environment and Green Development Department ・ Traffic Police Department ・ Road Department ・ Police Agency
	Industry, University etc.	・ No.2, No.3 and No.4 Power Plants ・ National University of Mongolia ・ Mongolian University of Science and Technology

1.1.3 Basic Policy of Project Implementation

1.1.3.1 Emphasis on Capacity Development

The common concept of JICA technical cooperation project and capacity developments of Mongolian human resources and organizations was emphasized in the project.

The Project was conducted stationary emission source monitoring to be conducted by the Phase 1, and provided technology transfer such as on-board emission monitoring by vehicle, air quality monitoring

Implementing researches in Mongolia by Japanese experts, submitting reports of the results and recommending air pollution control proposals were not the purpose. Instead, the purpose was to strengthen human resources and organizations of Mongolian sides and develop capability of elaborating air pollution control proposals by themselves. Although it was inevitable that Japanese experts implemented and showed specific technology to Mongolian staff for instructions at the beginning of technology transfer, technology was gradually transferred to the Mongolian staff to be implemented by themselves, and institutional arrangement of Mongolian side will be also supported.

1.1.3.2 Considerations to Characteristic Conditions of Ulaanbaatar

From the viewpoint of air pollution, characteristic conditions of Ulaanbaatar city were as follows.

(1) Severe meteorological conditions with temperature of minus 30 to 40 degrees C in winter

(2) Small and medium sized hot water boilers not used in Japan recently

(3) Economic and social conditions for inevitable use of coal

Severe low temperature due to meteorological conditions seemed to affect especially the feasibility of stack gas measurement of the project. Possible countermeasure against severe conditions was included in technical proposal in this report.

In Japan, high cost investment like De-SOx and De-NOx devices during economic boom and fuel switching from coal to oil or natural gas were very effective as air pollution control measures. However, coal can be easily mined and price was cheaper, and the option of switching to oil and natural gas was considered not feasible in short-term basis in Mongolia. Practical and feasible measures for Ulaanbaatar city were examined.

1.1.3.3 Project Operation by Establishment of Counterpart Working Group (C/P-WG)

C/P is APRD and other related organizations are C/P-WG, the project implemented mainly capacity development for human resources. Also the project has strengthened capacity development of human resources to be developed by phase 1. The project will be implemented mainly focusing on development of organization structures for air pollution control implementation. National Committee for Air Pollution Reduction (NCAPR), Clean Air Foundation and road related agencies, etc. are participating as C/P-WG. To enhance the organizational cooperation for air pollution control measures, just after starting of project, appropriate applicants of for technical transfer by output and by activity were selected from the Mongolian members. The project was implemented for providing technology transfer to the decided members of C/P-WG.

Implementation system of the project is shown in Figure 1.1-1.

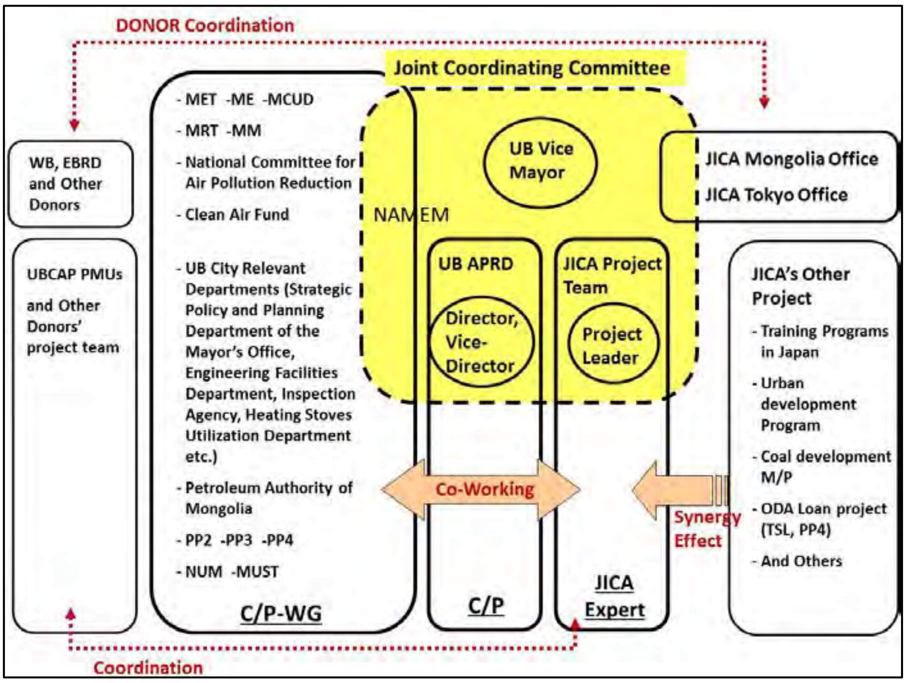


Figure 1.1-1 Implementation Structure of the Project

Desirable air quality management cycle in the project, and air quality management cycle and Fields of JICA Experts are shown in Figure 1.1-2 and Table 1.1-1.

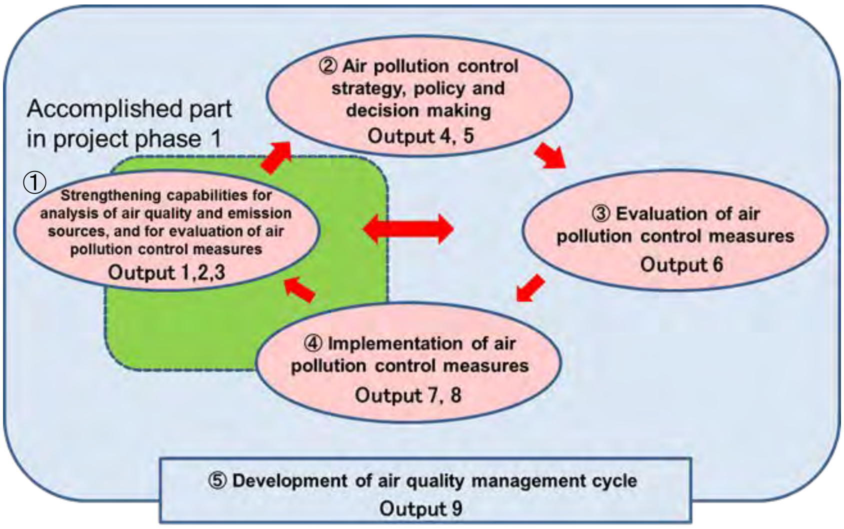


Figure 1.1-2 Desirable Air Quality Management Cycle in the Project

Table 1.1-1 Air Quality Management Cycle and JICA Expert's Fields

Items	Mainly Output and Activity	Agencies	JICA Expert's Fields
① Analysis of air quality and emission sources and evaluation of air pollution control measures	1. Emission source monitoring (stack gas emission measurement etc.) 2. Ambient air quality monitoring 3. Emission inventory and simulation model	・ APRD ・ NAMEM ・ Inspection Agency etc.	・ Chief Adviser ・ Sub-chief Adviser / Air Pollution Control Measures 1 ・ Emission Measurement for Stationary Sources 1 / Ambient Air Quality Monitoring 1 / PM_{10} and $PM_{2.5}$ measurement and composition analysis 2 ・ Emission Measurement for Stationary Sources 2 ・ Emission Measurement for Stationary Sources 3 ・ Mobile Emission Measurement 1 / Mobile Source Control ・ Mobile Emission Measurement 2 ・ Mobile Emission Measurement 3 ・ Other Emission Source Monitoring ・ Ambient Air Quality Monitoring 2 ・ Data Analysis for Ambient Air Quality Monitoring ・ PM_{10} and $PM_{2.5}$ measurement and composition analysis 1 ・ Emission Source Inventory / Ambient Air Quality Monitoring 3 / Evaluation of Air Pollution Control Measures 2 / Public awareness and advisory system ・ Air Pollution Simulation Modeling ・ Boiler Registration System
② Air pollution control strategy, policy and decision making	4. Review or decision making reasonable measurement based on technical justification 5. Public awareness program for citizens and establishment of advisory system	・ APRD ・ NAMEM ・ NCAPR ・ relevant ministries and agencies	・ Chief Adviser ・ Sub-chief Adviser / Air Pollution Control Measures 1 ・ Emission Measurement for Stationary Sources 1 / Ambient Air Quality Monitoring 1 / PM10 and PM2.5 measurement and composition analysis 2 ・ Emission Source Inventory / Ambient Air Quality Monitoring 3 / Evaluation of Air Pollution Control Measures 2 / Public awareness and advisory system ・ Air Pollution Simulation Modeling ・ Air Pollution Control Measures 2 ・ Power Plant Control Measures 1

			・ Power Plant Control Measures 2 ・ Industry and HOB Control Measures ・ Coal Combustion Technology 1 ・ Coal Combustion Technology 2 ・ Coal Combustion Technology 3 ・ Evaluation of Air Pollution Control Measures 1
③ Evaluation of air pollution control measures	6. Evaluation based on technical evaluation of air pollution control measures	・ MET ・ CAF ・ APRD ・ NAMEM	・ Chief Adviser ・ Sub-chief Adviser / Air Pollution Control Measures 1 ・ Air Pollution Simulation Modeling ・ Air Pollution Control Measures 2 ・ Power Plant Control Measures 1 ・ Power Plant Control Measures 2 ・ Industry and HOB Control Measures ・ Coal Combustion Technology 1 ・ Coal Combustion Technology 2 ・ Coal Combustion Technology 3 ・ Evaluation of Air Pollution Control Measures 1
④Implementation of air pollution control measures	7. Regulation and control for emission source (Compliance of MNS emission standard / full implementation boiler registration system etc.) 8. Enhancement for emission control measures at major polluters	・ APRD ・ Relevant departments in UB city ・ NAMEM ・ Inspection Agency ・ Industries	・ Chief Adviser ・ Sub-chief Adviser / Air Pollution Control Measures 1 ・ Emission Measurement for Stationary Sources 1 / Ambient Air Quality Monitoring 1 / PM_{10} and $PM_{2.5}$ measurement and composition analysis 2 ・ Emission Measurement for Stationary Sources 2 ・ Mobile Emission Measurement 1 / Mobile Source Control ・ Emission Source Inventory / Ambient Air Quality Monitoring 3 / Evaluation of Air Pollution Control Measures 2 / Public awareness and advisory system ・ Air Pollution Simulation Modeling ・ Air Pollution Control Measures 2 ・ Power Plant Control Measures 1 ・ Power Plant Control Measures 2 ・ Industry and HOB Control Measures ・ Coal Combustion Technology 1 ・ Coal Combustion Technology 2 ・ Coal Combustion Technology 3

			・ Evaluation of Air Pollution Control Measures 1 ・ Boiler Registration System
⑤ Development of air quality management cycle	9. Development of desired air quality management cycle in UB city	・ Above all agencies	・ All JICA Experts

1.1.3.4 Cooperation with Other Donors and Other JICA Projects

Before this project, several projects by the other donors like the World Bank (WB), EBRD, and GTZ were implemented for air pollution control in Ulaanbaatar city.

We had to communicate with the other donors at all time and take it into considerations in order to avoid overlapping and smooth cooperation. However, we also had to keep viewpoints of our positions and attitudes to air pollution control in Ulaanbaatar city when necessary in the cooperation.

As international staffs of the other donors did not always stay in Ulaanbaatar city, we had to make contacts with local staffs and also effectively communicate with each other by e-mail and/or TV conference if necessary.

We actively cooperate with the other JICA projects like urban development and waste management etc. in Ulaanbaatar city during the implementation of this project. We received and utilized population distribution data prepared by the existing urban development project for estimation of averaged concentrations exposure of population during the 2nd Detailed Planning Survey.

Furthermore, we investigated the utilization of the environmental program grants and the environmental two-step loans for air pollution control measures proposed in this project as much as possible. We examined the possible arrangements of outputs form so that this project can be utilized and realized.

1.1.3.5 PDM, Joint Coordinating Committee, Mid-Term Review and Terminal Evaluation

PDM was usually used as the base of project making/planning and project monitoring/evaluation for JICA technical cooperation project from project formation stage, and as tools for consensus building with counterpart organization and related organizations. PDM was also used as tools for project management and was revised if necessary.

Joint Coordinating Committee (JCC) was generally established for JICA cooperation project and the Vice Mayor of Ulaanbaatar city in charge of industry and ecology became the chairman of the JCC. JCC was expected to take the role of securing the activities of C/P-WG that consisted of several related organizations.

Mid-term review was usually conducted at around middle of the project and terminal evaluation was conducted around six months before the end of the project. Review and evaluation teams were dispatched from

JICA headquarter. Joint evaluation by Mongolian evaluators in addition to Japanese evaluators was agreed on the R/D.

1.1.3.6 Utilization of Training Course in Japan

(1). **Training Course of the Project in Japan**

Training course was implemented in Japan for 7 trainees from 9th to 22th of Nov. 2014, in the title "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia, Air Pollution Control (FY2014)" (Training course ID was J14-22116). The trainee compiled an action plan for the training subject "to improve the process how to select air pollution counter measures".

Training course was implemented in Japan for 4 trainees from 6h to 12th of Dec. 2015, in the title "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia, Air Pollution Control (FY2015)" (Training course ID was J1522239). The trainee compiled an action plan "to develop reduction plan on vehicle air pollution in UB, and to make vehicle emission measurement plan for developing reduction plan".

Training course was implemented in Japan from 4th to 10th of September 2016, in the title "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia, Air Pollution Control (FY2016)" (training course ID was J1621925). One trainee did not attend owing to poor health, and 5 trainees attended the training course in Japan. The trainees repeated practicing of calculation method several times for a training theme which is to understand the calculation method of the air pollutant emission concentration with the use of the flue gas measurement data on small boiler and the combustion test laboratory, and then the trainees have successfully completed calculation method.

Training course was implemented in Japan from 1st to 10th of December 2016, in the title "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia, Air Pollution Control (FY2016)" (training course ID was J1621969). 5 trainees attended the training course in Japan. The trainees studied the coordination mechanism between company and government, law system and CEMS utilization in Japan, and then elaborated action plan to use CEMS under the legal system in Mongolia.

Participants list is shown in Attachment 5.4.

(2). **Other Training Course in Japan**

B. Munkhkhand of NCAPR and S. Nansalmaa of Ministry of Road and Transportation attended to JICA training course "Countermeasure against Automobile Pollution in Urban Area" (from 3rd October 2014 until 21st November 2014). JICA Expert team suggested them the outcome of Phase 1 and Phase 2 that ultra-low sulfur gasoline and diesel oil are necessary because ultra-low emission vehicles are continuously imported and there is no suitable fuel for them. They made their action plan to promote ultra-low sulfur fuels including preparing necessary standards. Although they were selected without paying attention on this project, the project team supported the training course and they supported this project.

M. Otgonbayar, a member of C/P of this project, and S. Enkhmaa, a member of C/P-WG of this project attended to another JICA training course “Capacity Building towards Air Quality Management” (NO. J14-04193, ID=480864, from 5th October 2014 until 7th November 2014), and made their action plans via discussion with Mr. YAMADA, the advisor of this project. The action plan of M. Otgonbayar was titled as “To Improve Air Quality Control by Strengthening System of Ulaanbaatar City”, proposing to change air pollution related organizations in Ulaanbaatar. The action plan of S. Enkhmaa was titled as “Improve of Air Law”, proposing legal reform to revising the definition of large scale stationary sources which is not clearly defining them.

D. Gantuya (APRD) and S. Munkhsaikhan (NAMEM) participated in a JICA training course titled as “Capacity Building towards Air Quality Management”, from 19th October 2015 until 18th November 2015. They studied lectures and trainings including to develop emission inventory and to utilize air quality simulation models instructed by 2 experts of this JICA project, and then presented their action plans. They participated in the training course actively throughout discussions with lecturers and other attendants.

L. Narmandakh (AQDCC) and B. Bayarmagnai (NAMEM) attended to another JICA training course “Capacity Building towards Air Quality Management” (from 6th July 2016 until 11th August 2016). L. Narmandakh developed an action plan to evaluate air pollution reduction plan by emission reduction and air quality improvement simulated by emission inventory and air quality model, and realized it throughout this project described in 2.10. It was applied by the working group to develop “Air and Environment Pollution Reduction Plan” authorized in 20th March 2017. B. Bayarmagnai developed an action plan to elaborate “Air Quality Monitoring Data Validation Guideline”, and realized in this project described in (2).

G. Tsatsral (APRD) participated to JICA training course “Countermeasure against Automobile Pollution in Urban Area” (from 2nd October 2016 until 19th November 2016), and elaborated “An Action Plan to Reduce PM Emissions from Motor Vehicles in the City of Ulaanbaatar”. It plans how to solve air pollution utilizing the experts trained by this project, including emission factor revising based on measurement by on-board emission measurement system and revising emission regulations.

1.2 Goal of Project

Overall goal, purpose, outputs of the Project, and expected outputs and objectively verifiable indicators of each activity are as follows. Based on the verifiable indicator decided in February 2015, the Indicator of PDM was updated. In August 2016, name of AQDCC was changed into APRD.

Table 1.2-1 Overall goal, purpose outputs of the project, and outputs and objectively verifiable indicators of expected each activity

Items	Project Purpose / Output/ Indicator	
1. Overall goal	Measures for emission reduction of air pollutants will be strengthened in UB City. Indicator 1: Most of major stationary emission sources like around 200 HOBs and 3 power plants in UB City will be under control to comply with emission standards.	
2. Purpose of the project	Capability for air pollution control in UB City is strengthened, paying special attention to the development of human resource and coordinating mechanism of the APRD and other relevant agencies among other aspects of the capacity development. Indicator 1: APRD elaborates annual air quality reports including emission inventory, air quality monitoring results and emission measurements at least three times during the Project, and present them to decision makers. Indicator 2: Decision makers evaluate at least more than fifteen (15) air pollution control measures based on technical consultation with the professional agencies (APRD and NAMEM). Indicator 3: At least four inter-institutional agreements necessary for air quality management cycle are accomplished.	
3. Outputs	1	Capability of emission source monitoring is strengthened. Indicator 1: Stack gas measurements are implemented at least twenty five times during the Project. Indicator 2: Exhaust gas measurements are implemented for at least twenty auto-vehicles selected by using in-vehicle exhaust gas measurement equipment during the Project. Indicator 3: 80% of the registered boilers is inspected by using stack gas measurement protocol for boiler inspection. Indicator 4: CEMS is adequately operated and maintained, and CEMS data is shared among related organizations.
	2	Capability of ambient air quality monitoring is strengthened. Indicator 1: Out of the 8,760 hours in-total for air quality monitoring, reliable data are obtained for more than 6,000 hours. Indicator 2: At least more than eighteen monthly reports and two annual reports are presented by using corrected data from the AQMSs (air quality monitoring stations) network. Indicator 3: PM10 and PM2.5 sampling and composition analyses are executed at least twenty times, of which results are shared among the concerned authorities. Indicator 4. At least one air quality monitoring station is newly established and adequately operated and maintained.
	3	Capability to evaluate pollution analysis is strengthened by integrating emission

		inventory, simulation model and ambient air quality monitoring. Indicator 1: The existing emission inventory is revised at least twice during the Project based on emission measurement results of boilers and auto-vehicles, boiler registration data and other related statistics information. Indicator 2: Evaluation of pollution structure for base year is revised at least two times during the Project reflecting revised emission inventory and simulation model. Indicator 3: Based on PM10 simulation model, results of air quality monitoring and composition analyses of PM10 and PM2.5, PM10 control measures are developed and/or air quality monitoring methodology for PM10 and PM2.5 is revised.
	4	Decision making process for air pollution control is improved, by utilizing technical abilities of APRD and the relevant agencies. Indicator 1: Air quality management reports are presented to decision makers at least three times during the Project. Indicator 2: Technical consultation meetings between the decision makers and professional agencies are organized at three times during the Project.
	5	APRD and the relevant agencies promote public awareness program and implement advisory system for citizens in UB city on air pollution. Indicator 1: System for air quality monitoring results dissemination for public and for advisory service is started. Indicator 2: Corrected air quality monitoring data is published monthly no later than from year 2016. Indicator 3: Seminars for disseminations and symposium are implemented at least three times during the Project. Indicator 4: Numbers of access to the homepages of APRD and NAMEM increase by more than thirty percent at completion compared with the first year of the Project.
	6	Capability of technical evaluation of air pollution control measures is strengthened. Indicator 1: At least 60% percent of available funds at CAF is allocated for air pollution control related projects by applying technical appraisal guideline elaborated in the Project.
	7	Capability of APRD and the related agencies to regulate and to control emission sources is strengthened. Indicator 1: Compliance rate of MNS emission standards (dust concentration) for Boiler with 100 kW or more become more than 80% at the Project completion. Indicator 2: At least three pollution control measures by relevant authorities for mobile sources and other sources including regulatory measures are proposed.

	8	Emission control measures at major polluters are enhanced by APRD and the related agencies. Indicator 1: For more than ten times, the technical consultation by the JICA Experts for the entities (power plants, HOB, industries, and others) of pollution sources are executed to elaborate the air pollution control measures. Indicator 2: More than five pollution control measures for mobile sources and other sources at owners are proposed.
	9	Coordinating mechanism by APRD and the related agencies for output 1 to 8 are developed. Indicator 1: For institutional coordination by relevant agencies in air quality management, official papers are issued at least during the Project 3 times such as Mayor’s orders, Ministry orders, laws and regulations and inter-institutional agreements.

1.3 Project Management by Utilization of SCDM and Capacity Assessment

Based on C/P-WG members’ assignment by output and by activity, through discussion with Mongolian members, JICA Expert Team prepared SCDM (Sustainable Capacity Development Matrix) explained it to Mongolian side at the 4th JCC. SCDM matrix can evaluate how C/P-WG member matrix contributes to the achievement by outputs of the project, through process of the project activity, how strengthening of capacity development implements visibly, operation management of the project and each step of capacity assessment can be implemented by time series. Also, role-sharing between Mongolian side and JICA Experts can be clarified for field level.

The matrix consists of the following two types of matrixes.

1. Identification matrix on requirements for sustainability by each project output

2. Investigation matrix on ideal state of role-sharing and cooperation among the related organizations by each project output

Examples of the matrixes are shown in Table 1.3-1 and Table 1.3-2. All the matrixes are shown in Appendix 1.3-1.

In the identification matrix, practical targets and activities of technology transfer are summarized. Respective requirements such as skills, equipment, information base, manuals, human resources, budget, and institutional arrangement of inside and outside of the organizations and establishment of decision making and implementation mechanism are described.

In the latter matrix, current conditions and action plans on cooperation, such as which Mongolian organization cooperates or must cooperate in which activities are described.

Table 1.3-1 Identification Matrix on Requirements for Sustainability by each Project Output

Output 1

Steps of Capacity Development (Requirements for Sustainability)	Output 1 1. Capability of emission source monitoring is strengthened.
	Objectively Verifiable Indicators 1.1 Stack gas measurements are implemented at least twenty five times during the Project. 1.2 Exhaust gas measurements are implemented for at least twenty auto-vehicles selected by using in-vehicle exhaust gas measurement equipment during the Project. 1.3 80% of the registered boilers are inspected by using stack gas measurement protocol for boiler inspection. 1.4 CEMS is adequately operated and maintained, and CEMS data are shared among related organizations.
	Activity 1: Emission source monitoring 【Stationary emission sources monitoring】 1-1 Self-sustained emission measurement is reinforced. 1-2 Capacity for emission measurement required for boiler registration system is developed. 1-3 Capabilities for emission measurement at power plants are strengthened. 1-4 Emission measurement protocol for boiler inspection is developed. 1-5 QA/QC (Quality Assurance/ Quality Control) capabilities on CEMS data are developed at PP4. 1-6 Dedicated unit for maintenance and calibration of CEMS is established by PP4. 1-7 Transmission system of CEMS data from PP4 to related organizations (Ulaanbaatar City, Ministry of Environment, Green Development and Tourism, Ministry of Energy) is developed. 1-8 Related organizations evaluate CEMS data from PP4. 【Mobile emission sources monitoring】 1-9 In-vehicle equipment for automobile emission measurement is introduced, and appropriate methodology at Ulaanbaatar City and its manual are elaborated. 1-10 Related training for automobile emission measurement is implemented. 1-11 Self-sustained emission measurement operation using in-vehicle equipment is initiated. 【Other emission sources monitoring】 1-12 Monitoring system for ash ponds and road fugitive dust etc. is established. 【Application to technical evaluation for air pollution control measures】 1-13 Effectiveness of air pollution control measures are verified by emission

		measurement.
	Securing target human resources for technology transfer	【Main Members】 Stationary Source Emission Monitoring: Mr. S. BATSAYA (APRD), Ms. G. URANSETSEG (APRD), Ms. Sh.ENKHTVUSHIN (APRD), Mr. M. OTGONBAYAR (APRD) Mobile Source Emission Monitoring:: Mr. O. ALTANGEREL (APRD), Ms. S. ENKHMAA (CLEM) Other Emission Source: Ms. Orkhon (APRD), Ms. S. ENKHMAA (CLEM) Air Pollution Control Evaluation: Ms. L. NARMANDAKH (APRD), Ms. S. ENKHMAA (CLEM), Mr. S. MUNKHSAIKHAN (NAMEM), Mr. BUTANTOGTOKH (IMHE) 【Members】 Detailed members are shown in table of member list by organization
	Technology transfer(Lecture, OJT, Training course in Japan	【Seminar】 ○Stationary source emission monitoring Progress report of boiler inspection including the results of flue gas measurements (Mid-term Seminary) : 9 December 2015 HOB gas measurement results (Summary Seminar) : 25 April 2017 ○Mobile source emission monitoring Mobile source emission measurement seminar: 27 May, 2014 Expert awareness seminar regarding vehicle emission measurement using in-vehicle measurement equipment: 2 October, 2014 Mobile source emission measurement results and preparation of mobile source emission measures: 5 May 2015. ○Other Emission Source Nothing in particular ○Evaluation for air pollution control measures Explanatory meeting regarding combustion test measurement method on new coal fuels: 24 September, 2014 First explanatory meeting regarding combustion test measurement results using new coal fuels: 16 December, 2014 First explanatory meeting regarding combustion test measurement results using new coal fuels: 11 June., 2015 Conference on air pollution control measures: 20 May 2016 【Training】 Experts workshop on compiling measurement results of in-vehicle emission measurement equipment: 3 October, 2014 【Training in Japan】

		"Training to develop reduction plan on vehicle air pollution in UB, and to make vehicle emission measurement plan for developing reduction plan" , November 2015 Training to stationary emission measurement" , September 2016 【OJT】 OJT implementation on stationary source emission monitoring: 8 , 11 and 12 January 2014, 27 February, 3, 4, 6, 7, 10, 12 March, from end of August to September, 8 March 2015, October 2015 - March 2016, December 2016 to March 2017 Necessary equipment maintenance training on stationary source emission monitoring: September 2014, September 2015, December 2015, January 2016. Training on flue gas measurement from stationary sources : October 2015 Development of simple measurement method reading emission measurement: November to December 2014, March 2015 Preparation emission measurement by in-vehicle emission monitoring equipment 20 to 23 December,2013 Traveling survey by in-vehicle emission monitoring equipment: 11 to 29 August 2014, 6 to 10 October 2014, 13 April to 5 May 2015,24 August to 11 September 2015, April 2016, January 2017 RSD survey: 17 to 21 April 2017 Monitoring of ash pond in power plants and roads: 14 to 25 April 2014, 13 to 24 April 2015, 21 and 27 August 2015 Combustion test on coal fuels: 28 September 2014 to 28 October 2014, 11 to 29 May 2015, 21 to 30 September 2015 Performance test of combustion improver: January 2016 【Textbook】 Preparation textbook on compiling measurement results of in-vehicle monitoring equipment: October 2014 【Training in Japan】 Air pollution administration training: 9 to 22 November 2014 Stationary measurement training: 4 to 9 September 2016 CEMS training: 1 to 10 December 2016
	Maintaining skills and securing utilization	The number of members for each stationary source emission monitoring was increased to 5. Four of them are in charge of on-site measurement and another one member is in charge of processing of measured data, and all of them are improving their capacity. On-site measurement member can keep flue gas monitoring utilizing their skills, even when one of them is absent. It is planned that they will be separated into individual two teams for flue gas monitoring after October 2016. For in-vehicle monitoring equipment, members of C/P-WG shared the tasks

		according to their advantages, and near to carry out their own tasks using their skills developed in the project.
	Maintenance and management of equipment and facilities	Stationary source emission monitoring: One set of emission measurement equipment was provided. APRD experts replace expendables, and record them into their maintenance record. Two sets of in-vehicle mobile emission measurement equipment and two sets of vehicle emission measurement inspection equipment were provided. MET proposed CEMS provision in 2014. Provision of CEMS to PP 4 as additional equipment was officially requested in Feb. 2015, and details were discussed after JCC. Based on the discussion, responsibility of Mongolian side was decided in May 2015 and R/D was revised to add CEMS provision and new monitoring station. CEMS was installed October 2016, and has been operated from January 2017.
	Maintenance and management of information base	Boiler information and flue gas measurement data are processed, which were obtained from boiler inspection from October and March 2015 for people and companies utilizing large stationary emission source. Also, 2015 annual report for flue gas measurement of stationary source was made. Teams of stationary emission source monitoring, mobile source emission monitoring and other emission source manage information, compiled Annual Report 2014. They are compiling Annual Report 2015 Annual report was completed April, and was reported to Vice Mayor.
	QA/QC QA/QC (Preparation of technical manuals and SOP)	【Stationary Source Emission Monitoring】 Manuals prepared in Phase 1 project were revised according to actual measurement operation. 【Mobile Source Emission Monitoring】 Manuals for installation of in-vehicle emission equipment (October 2014) Data arrangement and analysis manual (preparation of emission factors estimation) by in-vehicle monitoring equipment (October 2014) 【Other Emission Sources】 Manuals to be prepared by Phase1 project The following manual will be prepared in Phase2 project ; Stack Gas Measurement Protocol (Automobile emission gas) Stack Gas Measurement Protocol for Boiler Inspection Air Quality Monitoring Manual for Rehabilitation, Operation and Maintenance Air Quality Monitoring Manual for Integrated Network and Public Dissemination Manual for PM10 and PM2.5 measurement and composition analysis Manual for Making and Updating Emission Source Inventory Manual for Implementing and Revision Simulation Model

		Technical Guidelines to Appraise Air Pollution Control Measures Boiler Registration System Guidelines Manual for Operation of CEMS Guidelines for Sharing and Utilization of CEMS data Teaching Materials of Workshops, Seminars, and Training in Japan made in this Project Public Relation Materials of the Project
	Securing human resources in the organization (increase number of staff or out sourcing)	PP4 support to HOB emission gas measurement in JCC on 9 June 2015.Discussion with JICA Experts and PP4, they agreed two engineers of PP4 supported to APRD. One engineer of PP4 supported to HOB emission gas measurement in October, but he did not support from November. Therefore, APRD and PP4 discussed the support of engineers, APRD need to pay labor cost on HOB emission measurement for PP4. APRD did not have budget of labor cost, PP4 did not support to APRD from November 2015. Number of members on stationary source emission monitoring is 5. (Number of acquisition skill including field activity among the members is 5.) All of them belong to APRD. Number of members on mobile source emission monitoring is 12. (Number of acquisition skill including field activity among the members is 5.) Number of members on other emission sources emission monitoring is 7. (Number of acquisition skill including field activity among the members is 3.)
	Budget preparation	Procurement system to overhaul and repair of necessary equipment and consumables will be developed for the project period. As for stationary emission source monitoring, fuel charge became to be prepared enough by Mongolian side, and flue gas monitoring vehicle are in operation without delaying. Also, budget for overhaul of equipment are being requested. JICA Experts will keep assisting C/P to prepare budget for modification of flue gas monitoring vehicle, standard gas and other consumables, overhaul of equipment.
	Establishing system in the organization	New technology not to have existing responsibility is so many, role-sharing to be appropriately modified based on ideal situation of organization and acquisition status of technology is desirable. APRD is change implement organization of each administration and one by one role institutional system into team system which has 3 divisions such as stationary source emission monitoring, mobile source emission monitoring and ambient air quality monitoring. NAMEM and CLEM assigns members among existing organization system, utilization depends on manager decision.
	Establishment	As for stationary source monitoring, cooperation was established among Inspection

	of cooperation among organizations	Ministry, APRD, EFDUC and Inspection Agency, and boiler inspection become to be operated smoothly. Cooperation framework of organization is appropriately modified in accordance with technology acquisition status of each member, Based on inspection Ministry, APRD, Traffic department of Ulaanbaatar city and existing responsibility role, cooperation on among organizations is developing.
	Establishment of mechanism of decision making and implementation on air pollution control	Director of APRD ordered to measure evaluation of air pollution control measures effect by exhaust gas measurement to evaluate DPF in Ulaanbaatar which is trained to director of APRD etc. is evaluated in Ulaanbaatar. The measurement results examine utilization method for decision making of air pollution control measures and implementation mechanism. Effective measurement can be implemented for acquisition data to contribute selection of effective measures, target measurements are selected and necessary expenses should be acquired.

Table 1.3-2 Investigation Matrix on Ideal State of Role-Sharing and Cooperation among the Related Organizations by each Project Output

Output 1

C/P-WG organizations and the related organizations	Output 1 1. Capability of emission source monitoring is strengthened.
	Objectively Verifiable Indicators 1.1 Stack gas measurements are implemented at least twenty five times during the Project. 1.2 Exhaust gas measurements are implemented for at least twenty auto-vehicles selected by using in-vehicle exhaust gas measurement equipment during the Project. 1.3 80% of the registered boilers are inspected by using stack gas measurement protocol for boiler inspection. 1.4 CEMS is adequately operated and maintained, and CEMS data are shared among related organizations.
	Activity 1: Emission source monitoring 【Stationary emission sources monitoring】 1-1 Self-sustained emission measurement is reinforced. 1-2 Capacity for emission measurement required for boiler registration system is developed. 1-3 Capabilities for emission measurement at power plants are strengthened. 1-4 Emission measurement protocol for boiler inspection is developed. 1-5 QA/QC (Quality Assurance/ Quality Control) capabilities on CEMS data are developed at PP4. 1-6 Dedicated units for maintenance and calibration of CEMS are established by PP4. 1-7 Transmission system of CEMS data from PP4 to related organizations (Ulaanbaatar City, Ministry of Environment, Green Development and Tourism, Ministry of Energy) is developed. 1-8 Related organizations evaluate CEMS data from PP4. 【Mobile emission sources monitoring】 1-9 In-vehicle equipment for automobile emission measurement is introduced, and appropriate methodology at Ulaanbaatar City and its manual are elaborated. 1-10 Related training for automobile emission measurement is implemented. 1-11 Self-sustained emission measurement operation using in-vehicle equipment is initiated. 【Other emission sources monitoring】 1-12 Monitoring system for ash ponds and road fugitive dust etc. is established.

		【Application to technical evaluation for air pollution control measures】 1-13 Effectiveness of air pollution control measures are verified by emission measurement.	
	APRD	Activity 1.1～1.13 (Main)	Each activity is implemented.
	NAMEM /IMHE	Activity 1.1～1.13 (Main)	Each activity is implemented.
	CLEM	Activity 1.1～1.13 (Main)	Each activity is implemented.
	NCAPR		
	Clean Air Foundation		
	MNEGDT	Activity 1.3～1.8 (Main)	CEMS data on power plant is utilized.
	ME	Activity 1.5～1.8 (Main)	CEMS data on power plant is utilized.
	MM		
	MCUD (Ministry of Construction, and Urban Development)		
	MRT (Ministry of Road, Transportation	Activity 1.9～1.13 (Sub)	Professional organizations are utilized for mobile source emission monitoring.
	PAM		
	NIA	Activity 1.1～1.4 (Sub)	Professional organizations are utilized for stationary source emission monitoring.
	Strategic Policy and Planning Department of Mayor's Office		
	Nature, environment and greed development of Department of UB		

	Engineering Facility Department of UB city		
	PTDCC	Activity 1.9～1.13 (Sub)	Professional organizations are utilized for mobile source emission monitoring.
	EFDUC		
	UB city Inspection Agency	Activity 1.1～1.4 (Sub)	Professional organizations are utilized for stationary source emission monitoring.
	NUM		
	MUST (Mongolian University of Science and Technology)		
	CHP2	Activity 1.3 (Sub)	Regular data providing to measurement data
	CHP3	Activity 1.3 (Sub)	Public announcement of CEMS data to public agencies
	CHP4	Activity 1.3 (Main)	Promotion of utilization for CEMS data
	Others		

1.4 Project Output regarding to Verifiable Indicators

Project status by objectively verifiable indicators is summarized in Table 1.4-1 and Table 1.4-2.

Table 1.4-1 Summary of Achieved Status for Project Purposes

No	Indicators	Achievements (as of April 2017)	Summary of Achieved Status
Proj.-1	3 annual reports	High Potential	Annual reports on emission inventory, air quality monitoring results, stack gas measurement and mobile emission measurement for 2014 and 2015 were completed. 2nd annual report for emission measurements 2015 is ready in spring 2016. Annual reports for 2016 would be ready and report by May

			2017. Completion period of annual reports ・Annual reports for 2014 Emission inventory: September 2016 Air quality monitoring: October 2015 Stack gas measurement: May 2015 Mobile emission measurement: October 2014 Report on annual reports: middle of October 215 ・Annual reports for 2015 Emission inventory: Preparation to be concluded end of November 2016, Publication of web version: December 2016 Air quality monitoring: November 2016 Stack gas measurement: March 2016 Mobile emission measurement: October 2016
Proj.-2	15 control measures evaluated by decision makers	High Potential	12 control measures have been proposed until Conference on Air Pollution Reduction Proposals held on 20th May. 3 additional control measures would be developed and requested for decision maker's evaluation. - Mobile control measures: Introduction of DPF for public buses, introduction of low sulfur fuel, introduction of low emission vehicle, conduction of eco-drive and NANO fuel - Improved fuel: Promotion of improved fuel, bio-coal briquette, firing materials - HOB control measures: Cyclone, Scrubber and Appropriate maintenance and management for existing dust collection facilities 6 control measures on staged introduction of improved fuel in Ger area was prepared in January 2017, preparation meeting for national security conference was explained and audited.
Proj.-3	4 inter-institutional agreements	Achieved	4 are ready by new agreement on air quality monitoring between APRD and NAMEM. Ministry order of MET on CEMS maintenance and data usage is in discussion.

Table 1.4-2 Summary of Achieved Status for Project Outputs

No	Indicators	Achievements (as of April 2017)	Summary of Achieved Status
1-1	25 times stack gas measurement	Achieved	41 times stack gas measurement from 2015 to winter of 2016 was completed.
1-2	20 times exhaust gas measurement by on-board analyzer	High Potential	As of January 2017, 20 times mobile emission measurement was completed.
1-3	Inspection on 80% or more of the HOBs	High Potential	Measurement protocol was revised from 2015 to winter of 2016, 168 HOB facilities were audited. Although JICA Expert Team and APRD have been preparing for 2nd emission measurement team, it would be delayed because new municipality tries to improve the organization.
1-4	CEMS maintenance and data sharing	Preparing	CEMS was installed in October 2016. Maintenance and data sharing system for CEMS was developed and CEMS data sharing with related agencies has conducted.
2-1	6000 hours reliable data	Achieved	In 2016, 6000 hours were achieved by 49 out of a total of 57 analyzers.
2-2	18 monthly reports and 2 yearly report based on validated air quality data	High Potential	24 monthly reports and yearly report 2014 and 2015 were issued.
2-3	Sampling and laboratory analysis for 20 or more samples and its report	Achieved	284 times PM sampling and composition analysis were conducted, Final data and analysis output was shared with related agencies.
2-4	One new air quality monitoring station and its adequate operation and maintenance	Achieved	The new station of Bayankhoshuu was installed; monitoring is well maintained from April 2016.
3-1	2 times updates of emission inventory	Achieved	Twice emission inventory were updated.
3-2	2 times revision on pollution structure	High Potential	Pollution structure on 2014 is evaluated. Pollution structure evaluation is scheduled to be revised using

	evaluation		2015 emission inventory.
3-3	Based on PM simulation model or composition analysis, control measures are developed or monitoring is revised.	Achieved	PM10 and PM2.5 air pollution control measures were modified based on PM10 simulation results and analysis of air quality monitoring. NAME supported to collect air pollution sources data, adjust monitoring and simulation based simulation results, and simulation model was improved
4-1	Three air quality management reports presentation	High Potential	Twice air quality management report reported to decision makers. Third annual report for 2016 had prepared from January 2017, and would be completed April 2017.
4-2	Three technical consultation meetings between the decision makers and professional agencies	Achieved	Technical conference of NCAPR was conducted September and December 2014, and June 2015.
5-1	System for air quality monitoring results dissemination	Achieved	Dissemination system of citizens on air quality monitoring results has developed from 2014 through combined air quality monitoring network. Totally 3 web sites such as air quality smart management system of NCAPR, APRD, and NAMEM was opened.
5-2	Monthly report on corrected air quality monitoring data	Achieved	Air quality monthly monitoring data by CLEM has issued from March 2000. APRD monthly report is unified the CLEM format from 2015.
5-3	3 times seminars and symposiums	Achieved	19 times of seminars and symposium organized. Total 704 people attended those seminars.
5-4	Web site access count increase by 30 %	High Potential	Access count of five web sites including APRD is 399,752. Web site access count of January to December in 2016 is increased by 86% to January to December in 2015.
6-1	60% of CAF budget is allocated by technical appraisal guideline elaborated	Un-estimable	As mid-term evaluation, existing of CAF is not clear by political change. CAF budget of 2016 is allocated based on technical advises by professional agencies and JICA Expert

	in the Project		Team. CAF budget of 2017 is expected to be allocated by MET based on technical appraisal guideline elaborated in the Project. New CAF fund was approved by MET/NCAPR in February 2017. Establishment of working group on preparation of technical guideline issued in January 2017. The technical guideline will be prepared to decided allocation of CAF budget from technical point of view. Therefore, first working group will be held in May 2017, and technical guideline will be approved by related agencies in June 2017.
7-1	80% of HOBs comply with dust emission standard	Tough to realize	41.5%, or 17among 41, according to the inspection of 2015 until the end of March 2016.
7-2	3 pollution control measures	Achieved	9 have been proposed until Conference on Air Pollution Reduction Proposals held on 20th May. 6 cases are mobile, 3 cases are improved fuel.
8-1	10 times technical consultation to entities (power plants, HOB, industries, and others)	Achieved	10 cases technical consultation were conducted. - Proposals on dust collector for PP2 and PP3 and combustion management: 4 cases - Cyclone and Scrubber for HOB control measures: 2 cases - Technical advice to each HOB company for HOB improves order: 4 cases.
8-2	5 proposals to owners of mobile sources and other sources	Achieved	6 presented in Conference on Air Pollution Reduction Proposals held on 20th May, were also proposed to owners of mobile sources or other sources. DPF, mobile emission control, reuse of combustion ash, introduction of improved fuel, eco-drive and NANO fuel
9-1	3 times official papers for institutional coordination	Achieved	4 are ready by new cooperation agreed in the end of 2015. Also Mayor order, proposal of national security conference and cooperation document between UB city and ME was officially announced. One or two more institutional cooperation are expected

			via improvement of HOB registration and cooperation for CEMS

1.5 Amendments of PDM

1.5.1 Clarification of Indicator

In JCC in February 2015, indicators of PDM, such as XX% and X times, were discussed. They were approved as below.

Indicator 1-3: 80% of the registered boilers are inspected by using stack gas measurement protocol for boiler inspection.

Indicator 6-1: At least 60% percent of available funds at CAF are allocated for air pollution control related projects by applying technical appraisal guideline elaborated in the Project

Indicator 8-1: Compliance rate of MNS emission standards (dust concentration) for Boiler with 100 kW or more become more than 80% at the Project completion.

Indicator 9-1: For institutional coordination by relevant agencies in air quality management, official papers are issued at least during the Project 3 times such as Mayor's orders, Ministry orders, laws and regulations and inter-institutional agreements.

1.5.2 Revision of PDM for Installation of CEMS at CHP4 and Establishment of AQMS

Mongolian side and Japanese side agreed on installation of one unit of new CEMS and establishment of one new AQMS station in May 2015 as below. Based on the agreement, PDM was revised. The revised PDM is shown in Table 1.5-1.

Installation of one unit of new CEMS at CHP4

One unit of new CEMs at CHP4 will be installed; exhaust gas data will be able to share with ME, MET, APRD.

Establishment of one unit of new AQMS

One new AQMS station for APRD will be established. JICA will provide monitoring equipment; Mongolian side will cover cost of maintenance and operation.

1.5.3 Change of Organization Name in PDM

Government party was changed in June 2016, organization structure of Mongolian agencies was implemented, but agencies name in PDM is not changed from AQDCC to APRD.

Table 1.5-1 Project Design Matrix (PDM)

Date: 11 May, 2015 (Ver.3)

Project Title: Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase2
Duration of the Project: December, 2013 to June, 2017 (3 years and 7 months), Target Area: Ulaanbaatar City
Target Group: Air Quality Department of the Capital City (AQDCC), the other relevant agencies included in Counterpart Working Group (C/P-WG) and Polluters
Implementing Organizations: AQDCC, and C/P-WG members

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal Measures for emission reduction of air pollutants will be strengthened in Ulaanbaatar City.	1. Most of major stationary emission sources like around 200 HOBs and 3 power plants in Ulaanbaatar City will be under control to comply with emission standards.	1. Survey on status of MNS emission standards compliance	
Project Purpose Capacity for air pollution control in Ulaanbaatar City is strengthened, paying special attention to the development of human resource and coordinating mechanism of the AQDCC and other relevant agencies among other aspects of the capacity development.	1. AQDCC elaborates annual air quality reports including emission inventory, air quality monitoring results and emission measurements at least three times during the Project, and present them to decision makers. 2. Decision makers evaluate at least more than fifteen (15) air pollution control measures based on technical consultation with the professional agencies (AQDCC and NAMEM). 3. At least four inter-institutional agreements necessary for air quality management cycle are accomplished.	1. Annual air quality reports issued 2. Materials submitted by professional agencies for meetings of decision makers such as conferences of NCAPR 3. Official papers issued such as Mayor's order and inter-institutional agreements 4. The Project reports	
Outputs **《Strengthening capabilities for analysis of air quality and emission sources, and for evaluation of air pollution control measures》**			1. Legal and political framework for air quality management is maintained, which defines decision making mechanism such as NCAPR, CAF and professional agencies like AQDCC and NAMEM.
1. Capability of emission source monitoring is strengthened.	1. Stack gas measurements are implemented at least twenty five times during the Project. 2. Exhaust gas measurements are implemented for at least twenty auto-vehicles selected by using in-vehicle exhaust gas measurement equipment during the Project. 3. 80% of the registered boilers are inspected by using stack gas measurement protocol for boiler inspection. 4. CEMS is adequately operated and maintained, and CEMS data is shared among related organizations.	Emission measurement reports Stack gas measurement protocol for boiler inspection The Project reports Boiler registration database CEMS data	
2. Capability of ambient air quality monitoring is strengthened.	1. Out of the 8,760 hours in-total for air quality monitoring, reliable data are obtained for more than 6,000 hours. 2. At least more than eighteen monthly reports and two annual reports are presented by using corrected data from the AQMSs (air quality monitoring stations) network. 3. PM10 and PM2.5 sampling and composition analyses are executed at least twenty times, of which results are shared among the concerned authorities. 4. At least one air quality monitoring station is newly established and adequately operated and maintained.	Air quality monitoring monthly reports and annual reports The Project reports	

3. Capability to evaluate pollution structure is strengthened by integrating emission inventory, simulation model and ambient air quality monitoring.	1. The existing emission inventory is revised at least twice during the Project based on emission measurement results of boilers and auto-vehicles, boiler registration data and other related statistics information. 2. Evaluation of pollution structure for base year is revised at least two times during the Project reflecting revised emission inventory and simulation model. 3. Based on PM10 simulation model, results of air quality monitoring and composition analyses of PM10 and PM2.5, PM10 control measures are developed and/or air quality monitoring methodology for PM10 and PM2.5 is revised.	1. The Project reports 2. "Air quality management reports" by AQDCC and NAMEM	
《Air pollution control strategy, policy and decision making》			
4. Decision making process for air pollution control is improved, by utilizing technical abilities of AQDCC and the relevant agencies.	1. Air quality management reports are presented to decision makers at least three times during the Project. 2. Technical consultation meetings between the decision makers and professional agencies are organized at three times during the Project.	Minutes of Discussion The Project reports	
5. AQDCC and the relevant agencies promote public awareness program and implement advisory system for citizen in Ulaanbaatar city on air pollution.	1. System for air quality monitoring results dissemination for public and for advisory service is started. 2. Corrected air quality monitoring data is published monthly no later than from year 2016. 3. Seminars for disseminations and symposium are implemented at least three times during the Project. 4. Numbers of access to the homepages of AQDCC and NAMEM increase by more than thirty percent at completion compared with the first year of the Project.	1. Minutes of seminars and symposium 2. The Project repots 3. Homepages of AQDCC and NAMEM	
《Evaluation of air pollution control measures》			
6. Capability of technical evaluation of air pollution control measures is strengthened.	1. At least 60% percent of available funds at CAF is allocated for air pollution control related projects by applying technical appraisal guideline elaborated in the Project.	CAF operational reports	
《Implementation of air pollution control measures》			
7. Capability of AQDCC and the related agencies to regulate and to control emission sources is strengthened.	1. Compliance rate of MNS emission standards (dust concentration) for Boiler with 100 kW or more become more than 80% at the Project completion. 2. At least three pollution control measures by relevant authorities for mobile sources and other sources including regulatory measures are proposed.	Boiler registration database The Project reports	
8. Emission control measures at major polluters are enhanced by AQDCC and the related agencies.	1. More than ten times technical consultation by AQDCC and the related agencies for the entities (power plants, HOB, industries, and others) of pollution sources are executed to elaborate air pollution control measures. 2. More than five pollution control measures for mobile sources and other sources at owners are proposed.	Minutes of discussion by JICA Experts and entities for air pollution control measures elaboration The Project reports	

《Development of air quality management cycle》			
9. Coordinating mechanism by AQDCC and the related agencies for output 1 to 8 are developed	1. For institutional coordination by relevant agencies in air quality management, official papers are issued at least during the Project 3 times such as Mayor's orders, Ministry orders, laws and regulations and inter-institutional agreements.	1. The Project reports 2. Official papers issued	

Activities	**Input of the Project**		
《Strengthening capabilities for analysis of air quality and emission sources, and for evaluation of air pollution control measures》 Activity 1: Emission source monitoring 【Stationary emission sources monitoring】 1-1 Self-sustained emission measurement is reinforced. 1-2 Capacity for emission measurement required for boiler registration system is developed. 1-3 Capabilities for emission measurement at power plants are strengthened. 1-4 Emission measurement protocol for boiler inspection is developed. 1-5 QA/QC (Quality Assurance/ Quality Control) capabilities on CEMS data are developed at PP4. 1-6 Dedicated unit for maintenance and calibration of CEMS is established by PP4. 1-7 Transmission system of CEMS data from PP4 to related organizations (Ulaanbaatar City, Ministry of Environment, Green Development and Tourism, Ministry of Energy) is developed. 1-8 Related organizations evaluate CEMS data from PP4. 【Mobile emission sources monitoring】 1-9 In-vehicle equipment for automobile emission measurement is introduced, and appropriate methodology at Ulaanbaatar City and its manual are elaborated. 1-10 Related training for automobile emission measurement is implemented. 1-11 Self-sustained emission measurement operation using in-vehicle equipment is initiated. 【Other emission sources monitoring】 1-12 Monitoring system for ash ponds and road fugitive dust etc. is established. 【Application to technical evaluation for air pollution control measures】 1-13 Effectiveness of air pollution control measures are verified by emission measurement. Activity 2: Ambient air quality monitoring. 【Development of integrated ambient air quality monitoring network for Ulaanbaatar City Area】 2-1 Operational status of existing ambient air quality monitoring stations is reviewed. 2-2 Rehabilitation of existing monitoring stations is implemented. 2-3 QA/QC (Quality Assurance/ Quality Control) capabilities are developed at NAMEM. 2-4 Integrated ambient air quality monitoring information system for AQDCC and NAMEM is developed. 2-5 Dedicated unit for maintenance and calibration of equipment is established by AQDCC and NAMEM. 2-6 Necessary technical manuals for monitoring network are elaborated. 2-7 Ambient air quality monitoring network design is developed and the network design manual is elaborated. 2-8 At least one monitoring station is newly established abased on the network design manual. 【PM10 and PM2.5 measurement and composition analysis】 2-9 Capability for PM10 and PM2.5 measurement is developed at AQDCC and NAMEM. 2-10 Capability for PM10 and PM2.5 composition analysis is developed at NAMEM, related training for AQDCC is implemented. 2-11 Necessary technical manuals and SOPs for PM10 and PM2.5 measurement and composition analysis are elaborated.	Japanese Side 1.JICA Experts (necessary field) (1) Chief Advisor (Air Pollution Control) (2) Air Pollution Control Planning and Policy (3) Emission Measurement for Stationary Sources (4) Emission Measurement and Boiler Technology for Power Plants (5) Automobile Emission Measurement (6) Other Emission Source Monitoring (7) Ambient Air Quality Monitoring (8) Data Analysis for Ambient Air Quality Monitoring (9) PM10 and PM2.5 Measurement and Composition Analysis (10) Emission Source Inventory (Stationary, Mobile and Other) (11) Air Simulation Modeling (12) Boiler Registration System (13) Evaluation of Air Pollution Control Measures (14) Clean Coal Technology for Air Pollution Control Measures (15) Public Awareness (16) Project Coordinator 2. Training	Mongolian Side 1. Counterpart (1) Assignment of C/P and C/P-WG staff 2. Facility (1) Provision of necessary office space (2) Laboratory 3. Local costs (1) Counterpart expenses for personnel travel and accommodation (2)Project administrative expenses	1. There are no frequent leaves, transfers or resignations of C/P and C/P-WG.

Activity 3: Evaluation of pollution structure by integrating emission inventory, simulation model and ambient air quality monitoring 【Self-reliant and sustained update of emission source inventory/ simulation by Mongolian side】 3-1 Plan for emission inventory continuous update is elaborated. 3-2 Emission inventory is updated using related information such as emission measurement data, boiler registration, automobile registration and relevant statistics. 3-3 Emission estimation of PP4 is refined with CEMS data. 3-4 Reliabilities for ambient air quality monitoring data and emission inventory is reviewed. Preliminary analysis of pollution structure is implemented. Guidelines for these processes are developed. 3-5 Reliabilities of the simulation model are examined by elaborating simulation model for SO2, CO and NOx based on the related data such as updated emission inventory and ambient air quality monitoring data. 【Analysis on discrepancy between PM10 air quality monitoring result and simulation model】 3-6 PM10 simulation model is restructured by taking into account of secondary particles originated from SO2, NOx based on updated emission inventory. 3-7 Mechanism for PM10 formation at Ulaanbaatar City is studied. 3-8 PM10 pollution sources are identified by taking into account of dust emission and precursors such as SO2, NOx and others. 【Application for technical evaluation of air pollution control measures】 3-9 Air pollution control measures are reviewed and developed for PM10 and other pollutants which are not achieving ambient air quality standards, based on discussion with the Mongolian side and Japanese experts. 3-10 Those pollution control measures are technically evaluated based on updated emission inventory, simulation model, and ambient air quality monitoring.	(1) Holding of local seminars and workshop (2) Training course implementation in Japan 3. Provision of necessary equipment 4. Local costs (1) Personnel expenses of project office staff (office staffs and interpreters) (2) Necessary expenses for activity of Japanese experts (3) Local survey costs of Japanese experts for XX	
《Air pollution control strategy, policy and decision making》 Activity 4: Decision making process improvement for air pollution control 4-1 Decision making process in air pollution control utilizes improved information and technical capabilities of AQDCC, NAMEM and the relevant agencies. 4-2 Communication between decision makers, AQDCC and NAMEM is strengthened by establishing periodical air quality reports. 4-3 Members of C/P and C/P-WG study legal and administrative framework for air pollution control by comparing Japan and Mongolia in training program in Japan and seminar in Ulaanbaatar City. 4-4 AQDCC and NAMEM provide technical advices on air pollution control measures for decision makers.		
Activity 5: Public awareness program and advisory system for citizen in Ulaanbaatar city on air pollution 5-1 Dissemination of air quality information and advisory services are provided through operation of integrated air quality monitoring network. 5-2 AQDCC and C/P-WG implement public awareness program for citizens. 5-3 Communication between citizens and AQDCC on air pollution is strengthened. 5-4 AQDCC and C/P-WG implement seminars and symposium for professionals on status of air pollution and project activities. 5-5 Newsletters, publication, and media are utilized for disseminating project activities.		**Pre-conditions** 1. Appropriate facilities at AQDCC and NAMEM are prepared to receive equipment.
《Evaluation of air pollution control measures》 Activity 6: Technical evaluation of air pollution control measures. 6-1 On-going process for appraising air pollution control measures at CAF and the relevant agencies is reviewed. 6-2 Technical guideline to appraise air pollution control projects is developed. 6-3 Technical abilities of AQDCC, NAMEM, scholars and professionals are utilized in the appraisal process of air pollution control projects.		

《Implementation of air pollution control measures》		
Activity 7: Regulation and control for emission reduction [Full implementation of the boiler registration system] 7-1 Obligatory emissions measurement at HOB and other boilers is phased in. 7-2 MNS emission standards compliance at HOBs and other boilers is reviewed through boiler inspection based on the developed protocol (see Activity1-4). 7-3 “Permissions to operate” (or “good boiler certifications”) are issued to the boilers which satisfy conditions. [Proposal for MNS revision] 7-4 Appropriateness and relevance of MNS including parameters and values for regulation, and measurement methods are examined. If necessary, revision of MNS is proposed. 7-5 Draft MNS revision for improved fuel is elaborated. [Mobile sources and other sources] 7-6 Control measures including regulation for mobile emission sources and other sources are elaborated. [Utilization of CEMS data] 7-7 Related organizations compile and utilize CEMS data from PP4 and enhance air pollution control measures by power plants.		
Activity 8: Enhancement for emission control measures at major polluters 8-1 JICA Experts assist entities (power plants, HOB, industries, and others) of pollution sources to elaborate air pollution control measures. 8-2 Emission source monitoring for power plants (boilers and ash ponds) No.4, No.3 and No.2 are strengthened. Air pollution control measures are discussed. 8-3 PP4 investigate operation improvement and draft air pollution control measures, and share the information among power plants. 8-4 Air pollution control measures for mobile sources and other sources are enhanced.		
《Development of air quality management cycle》		
Activity 9: Development of air quality management cycle 9-1 Agreement on responsibilities of professional agencies (AQDCC and NAMEM) related to emission inventory and simulation is concluded. 9-2 Coordinating mechanism of AQDCC and NAMEM for integrated air quality monitoring network at Ulaanbaatar City Area is established. 9-3 Coordinating mechanism of professional agencies and NCAPR is established. 9-4 Coordinating mechanism of professional agencies and CAF is established. 9-5 Coordinating mechanisms of professional agencies and relevant authorities for inspection of emission sources are established 9-6 Coordinating mechanism of Ulaanbaatar City, Ministry of Environment, Green Development and Tourism, Ministry of Energy and power plants is developed.		

C/P：Counterpart, C/P-WG：Counterpart Working Group
AQDCC: Air Quality Department of the Capital City
NAMEM: National Agency for Meteorology and Environment Monitoring
NCAPR: National Committee for Air Pollution Reduction
CAF：Clean Air Foundation
HOB：Heat Only Boiler
CEMS: Continuous Emission Monitoring System

1.6 JCC Meetings

JCC meetings were held seven times and the dates and main contents of the meetings were shown in Table 1.6-1. Minutes of Meeting (MM) of each were shown in Appendix 1.6-1.

Table 1.6-1 Records of JCC Meetings

JCC Meetings	Date	Main Contents
1st JCC Meeting	January 2014	Work plan for the first year was approved. Also 1-perfect implementation of boiler registration, 2-issues of PDM, 3-Laboratory of PM10 First JCC (Joint Coordinating Committee) was implemented on 21 January 2014. JCC discussed on the 7 contents below, in addition to the approval of outline of first year of work plan draft. The details of the agreement of the meeting were compiled as minutes of meeting. 1: Full Implementation of the Boiler Registration and Management System 2: Issues of PDM (Project Design Matrix) 3: Experimental laboratory for PM10 and PM2.5 Analysis 4: Provision of Equipment by the Project for Vehicular Emission Measurement 5: Selection of Trainees for the Training Course in Japan 6: Coordination between UBCAP (Ulaanbaatar Clean Air Project) and the Project 7: Allocation of Multiple Staff Members
2nd JCC Meeting	August 2014	JCC approved Progress Report 1.
3rd JCC Meeting	February 2015	Third JCC approved Progress Report 2, and Mongolian requested establishment of one unit of new AQMS and installation of one unit of new CEMS at CHP4. R/D revision will be discussed based on the request.
4th JCC Meeting	June 2015	Fourth JCC approved Progress Report 3, and preparation regarding installation of new AQMS and CEMS in CHP4 will be discussed.
5th JCC Meeting	September 2015	Fourth JCC approved work plan for the second year.
6th JCC Meeting	November 2015	Sixth JCC in November 2015, the Project Mid-Term Evaluation results was explained and discussed.

7th JCC Meeting	May 2016	Seventh JCC approved Progress Report 4, and review of air pollution control and training in Japan were discussed.
8th JCC Meeting	October 2016	Eighth JCC approved Progress Report 4, and PDM revision based on reorganization of structure of Mongolian side and change of name will be conducted
9th JCC Meeting	January 2017	Terminal evaluation results were explained and approved in Ninth JCC. Attendants from JICA headquarter proposed to reemployed for emission gas measurement team, coordination between city level agencies such as APRD and national level organization
10th JCC Meeting	April 2017	Draft Final Report was explained and JCC approved Draft Final Report and discussed issues of future air pollution control measures.

1.7 Records of Reports Submission and Approvals

Timings of reports submissions and approvals are shown in Table 1.7-1.

Table 1.7-1 Records of Reports Submissions and Approvals

Name of Reports	Submission	Approval
Work plan First Year	2014 January	2014 January
Progress Report 1	2014 June	2014 August
Progress Report 2	2015 February	2015 February
Progress Report 3	2015 June	2015 August
Work plan Second Year	2015 August	2015 September
Progress Report 1	2016 April	2016 May
Progress Report 2	2016 October	2016 October
Draft Final Report	2017 April	2017 April
Final Report and technical Guidelines	2017 June	2017 June

1.8 Technical Guidelines and Manuals

Technical guidelines and manuals prepared by the project were shown as follows.

Technical guidelines and Manuals

- Stack Gas Measurement Protocol (Automobile emission gas)
- Stack Gas Measurement Protocol (Boiler Inspection)
- Air Quality Monitoring Manual for Rehabilitation, Operation and Maintenance
- Air Quality Monitoring Manual for Integrated Network and Public Dissemination
- Manual for PM10 and PM2.5 measurement and composition analysis
- Manual for Making and Updating Emission Source Inventory
- Manual for Implementing and Revision Simulation Model
- Technical Guidelines to Appraise Air Pollution Control Measures
- Boiler Registration System Guidelines
- Manual for Operation of CEMS
- Guidelines for Sharing and Utilization of CEMS data
- Teaching Materials of Workshops, Seminars, and Training in Japan made in this Project
- Public Relation Materials of the Project

2 Activities and Outputs

2.1 Emission Source Monitoring: Output 1

2.1.1 Stationary Source Emission Monitoring except CEMS

2.1.1.1 Flue Gas Measurement

(1). Technical Capability Improvement of Members of C/P

In the beginning of the Phase 2 project, technical guidance was given to the two personnel in charge of the stationary emission source monitoring, sequentially from Phase 1. However, those charged with the flue gas measurement changed frequently due to personal and employment issues, such as studying abroad, relocation according to the restructuring of the organization of the APRD in March 2015, and organizational changes in UB City in August 2016.

An increase in the number of measurement staff has been sought; JICA Expert Team has requested that C/P-WG cooperate on human resources. The JICA Expert Team also requested that NAMEM cooperate on human resources. However, NAMEM rejected the request because NAMEM is not a measurement institution; it is a policy-making and research institution. In addition, APRD discussed cooperating on human resources with PP4, and was unable to obtain an agreement.

Temporarily, flue gas measurements were stopped because the three trained personnel in charge of flue gas measurements were discharged in November 2016. The supervisor from Phase 1, who is core personnel of the flue gas measurement, tried to perform the flue gas measurement. However, they could not remember how to operate apparatus, and the flue gas measurements repeatedly failed because the manuals were not read. As the result, the number of the flue gas measurement, including failed measurement, was less than half the targeted number.

In December 2016, the JICA Expert Team confirmed the reason that those in charge of measurements were discharged. They made recommendations to APRD to prevent similar misdeeds and advised on the restructuring of the flue gas measurement team. APRD appealed to the upper administrative of the UB City for new employment and re-employment of prior discharged personnel. Finally, although discharged personnel received an informal job offer to return, the upper administrative of UB City has not approved the employment of the staff as of the end of March 2017. The personnel in charge of the stationary source monitoring and their work schedules are shown in Table 2.1-1.

Table 2.1-1 Schedule of Personnel in Charge of Stationary Source Monitoring

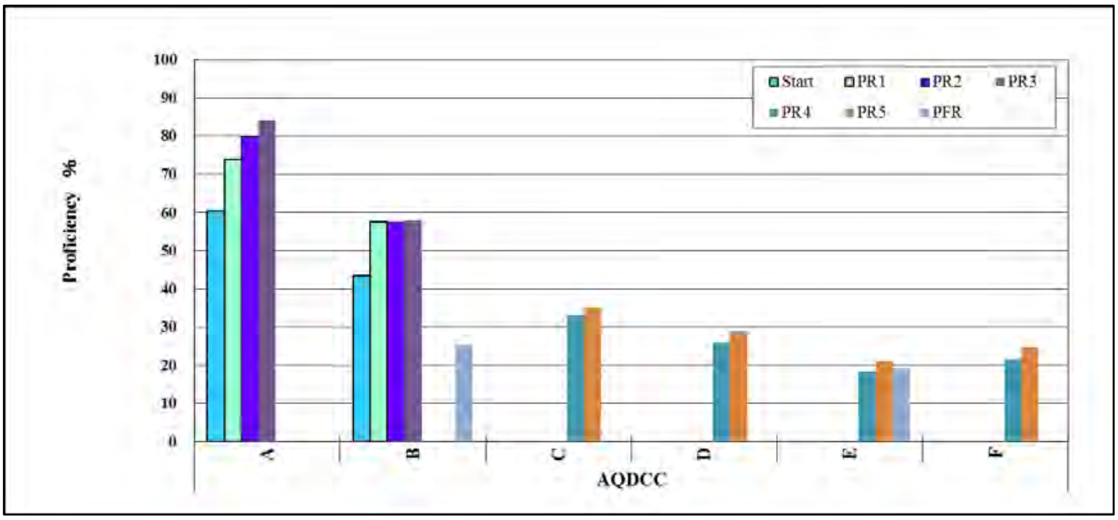
	Name	2014												2015												2016												2017			Remarks
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
1	G. Davaajargal	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					Studying abroad from August 2015
2	M. Otgonbayar	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					■	■	■	■	■	
3	S. Batsaya																						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
4	Kh.Gerelchuluun															■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					■	re-employment of discharged from March 2017
5	O.Tuvshinjargal															■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						Discharge on November 2016
6	L.Tugsbayar																						■	■	■	■	■	■	■	■	■	■	■	■	■						Discharge on November 2016
7	D.Gantuya															■	■	■	■	■	■	■	■	■	■																Discharge on November 2016
8	Sh. Enkhtuvshin																						■	■	■	■	■	■	■	■	■	■	■								1 year leave of absence from September 2016
9	G.Urantsetseg																														■	■	■	■	■	■	■	■	■	■	returned work after maternity leave from June 2016

Legend: ■ Period of person in charge □ Period of no person in charge

Source: JICA Expert Team

The flue gas measurement team has two roles, flue gas measurement and subsequent data processing. The role of the person in charge of the flue gas measurement is preparation of equipment, measurement at HOB facilities, and equipment maintenance. The role of the person in charge of data organization is to calculate the gas concentration based on the measured data and organize the results.

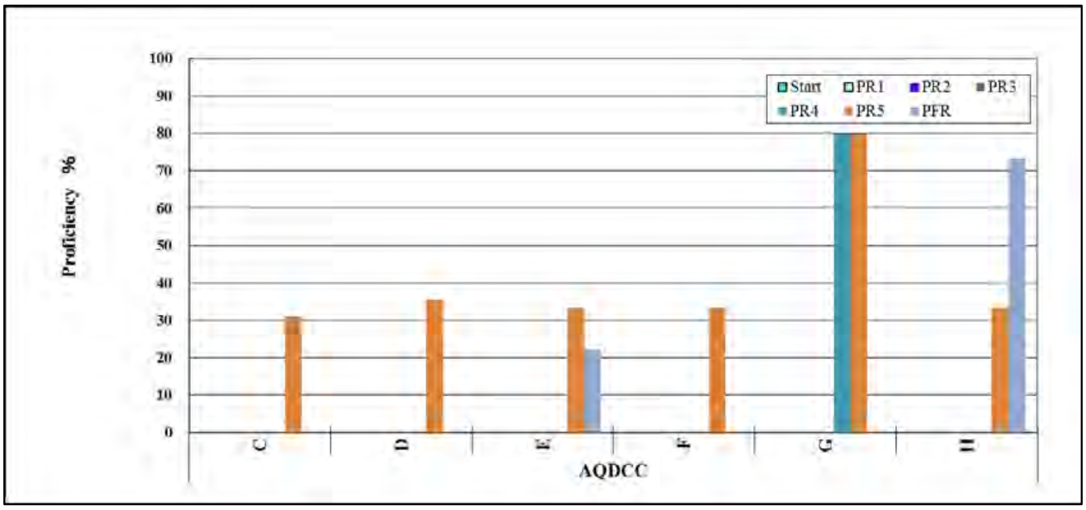
Presently C/Ps, the personnel in charge who organize the flue gas measurements perform the flue gas measurements themselves. However, the number of C/Ps is too small and there will be a manpower shortage because there are large numbers of flue gas measurements needed for Boiler Inspection and Certification and evaluation of improved fuel. Re-employment of discharged staff and staff returning to work after studying abroad in August 2017 is necessary; with the additional personnel, C/Ps will be able to train them to perform the required work. Their technical level is shown in Figure 2.1-1.



Source: JICA Expert Team

Figure 2.1-1 Technical Capability Progress in Stationary Source Emission Monitoring (Flue Gas Measurements)

In September 2016, a training course for data processing measured results was implemented in Japan. As the result, the capability of C/Ps improved; they can now input data into the calculation sheet, determine the range of measured data, remove unnecessary data, create graphs, and draw comparisons between measured data and emission standards. Three supervisory personnel who participated the training course in Japan were discharged in November 2016. Presently, one supervisory person who participated in the training course Japan has the capability of data processing the measured results. The C/P will train other supervisors independently after the termination of this project. Their technical level is shown in Figure 2.1-2.



Source: JICA Expert Team

Figure 2.1-2 Technical Capability Progress in Stationary Source Emission Monitoring (Data Processing of Measured Results)

(2). Flue Gas Measurement Results from Boiler Inspection and Certification

The measurement results from Boiler Inspections and Certifications from October 2015 to March 2017 are shown in Table 2.1-2. All parameters in four boilers (7.1%) met the emission standard. Of the remaining boilers, 42.9% met the emission standard for SO_2, 100% for NOx, 31.7% for CO, and 36.5% for dust.

Table 2.1-2 Flue Gas Measurements During Boiler Inspection and Certification (2015/10～2017/02)

Unit (mg/m^{3}N)

No.	Year	Day	Measured site	Type of boiler	Capacity	Item	SO_2	NOx	CO	Dust
1	2015	10-20	Bitsamo LLC	DZH	2 t/h	*c	1,261	170	236	181
2	2015	10-21	MCS Coca Cola LLC	DZH	6 t/h	*c	1,243	110	**11,534**	1,382
3	2015	10-22	CassTown LLC	Carborobot 300	0.3 MW	*b	**2,545**	224	**6,243**	**634**
4	2015	10-27	Bgd-Uulsuwilal	Kiturami KCR240	0.3 MW	*b	233	187	**20,526**	**501**
5	2015	10-28	No.34 School	DZL-07-07/95	0.7 MW	*b	**2,793**	161	2,040	280
6	2015	10-29	Han-Uul General Hospital	Carborobot 300	0.3 MW	*b	**3,058**	128	**10,504**	**1,715**
7	2015	11-03	Tavin-Us	HP-16	0.16 MW	*b	**1,382**	86	**14,148**	**741**
8	2015	11-04	Bayasakh Foods LLC	DZH-2-1.25	2t/h	*c	**3,380**	229	**3,378**	631
9	2015	11-05	Shar Doktor LLC	DZH	2t/h	*c	303	38	**4,734**	5,367
10	2015	11-11	Tushigt Khangai	MUHTt-1	1.4 MW	*a	**671**	176	**5,888**	**1,906**
11	2015	11-13	No.63 School	BNEB	0.35 MW	*b	719	102	**7,767**	352
12	2015	11-18	Mogul Town	Eco-Effect	0.6 MW	*b	**1,971**	116	**7,423**	351
13	2015	11-24	No.134 Kindergarten	Carborobot 300	0.3 MW	*b	**1,524**	198	**29,699**	**1,118**
14	2015	11-25	Diplomat Hothon	Carborobot 300	0.3 MW	*b	**1,350**	151	**19,702**	**1,274**
15	2015	12-03	No.118 School	Carborobot 300	0.3 MW	*b	**1,704**	178	**4,549**	**1,114**
16	2015	12-08	No.105 School	Eco-Effect	0.6 MW	*b	**1,641**	146	**6,149**	281
17	2015	12-09	SHD Tsagdaagiin 2-r Heltes	Euro Zigi Star-kom-350	0.35 MW	*b	438	142	**3,335**	**4,158**
18	2015	12-10	No.67 School	Carborobot 300	0.3 MW	*b	**1,433**	204	2,305	**3,289**
19	2015	12-11	KhTs-0151	HP-60	1.4 MW	*a	**624**	225	**5,041**	**2,941**
20	2016	01-21	Khan tushee	CDZL 2.8-85/60-AII	2.8 MW	*a	571	186	433	**1,762**
21	2016	01-26	Enkhjin	DZL-2.8	2.8 MW	*a	**763**	190	**2,845**	211
22	2016	01-28	No.42 School	Carborobot 300	0.3 MW	*b	**1,599**	255	419	**1,512**
23	2016	02-02	No.107 School	Carborobot 300	0.3 MW	*b	**986**	166	**6,843**	218
24	2016	02-03	No.106 School	Kiturami KCR240	0.3 MW	*b	453	121	**6,549**	**1,060**
25	2016	02-04	SHD Mon Laa	SL	0.18 MW	*b	321	145	**3,894**	223
26	2016	02-16	English garden Hothon	CDZL 1.4	1.4 MW	*a	**962**	204	63	**517**
27	2016	02-17	No.46 School	Eco-Eco	0.7 MW	*b	599	135	1462	234
28	2016	02-18	Voltam	Eco-Eco	1.4 MW	*a	**983**	166	**9,013**	238
29	2016	02-24	Lion Tower	Eco-Eco	0.7 MW	*b	**1,833**	204	1918	121
30	2016	02-25	Nuht Amralt	Carborobot 300	0.3 MW	*b	**1,342**	158	**4,130**	**4,439**
31	2016	03-02	SBD Tsagdaagii 2-r Heltes	Kiturami KCR240	0.3 MW	*b	180	260	151	205
32	2016	03-04	KhTs 0253 Angi	Kiturami KCR240	0.3 MW	*b	295	27	**12,716**	317
33	2016	03-09	Monhjilchin	CLSG0.7-85/60A	0.7 MW	*b	**1,057**	46	**5,984**	**490**
34	2016	03-10	Monopole Farmatseutikali	DZH	4t/h	*c	322	29	**1,094**	529
35	2016	03-11	SBD Doloon Buudal	Carborobot 300	0.3 MW	*b	**876**	84	**4,312**	**4,419**
36	2016	03-16	SBD Sanjit	Odcon NR-2-85	0.17 MW	*b	306	31	2,395	**692**
37	2016	03-17	HUD No.114 School	Kiturami KCR	0.35 MW	*b	573	49	1,721	**11,774**
38	2016	03-18	Elbeg dulaan 103 Kindergarten	MGL zuuh E-1.4	1.4 MW	*a	**1,522**	73	1,216	**437**
39	2016	03-22	Avrah Tusgai Angi	HP-4.5	0.6 MW	*b	**1,165**	50	**6,568**	**789**
40	2016	03-23	ChD No.61 School	Kiturami KCR	0.35 MW	*b	546	56	1,073	**457**
41	2016	03-24	Khanburgedei	SL	0.1 MW	*b	173	59	**14,598**	**498**
42	2016	12-22	Go Ord LLC	CLC	2.5 MW	*a	**633**	153	**6,384**	**873**
43	2017	01-04	No.72 School	Carborobot 300	0.3 MW	*b	**1,451**	199	**3,312**	287
44	2017	01-13	Zag LLC Khiimori Apartment	Termorobot	0.4 MW	*b	524	257	180	**633**
45	2017	01-19	Green City	Fulton	0.7 MW	*b	587	82	2,460	167
46	2017	01-20	Max Super	HP-16	0.16 MW	*b	616	76	**14,018**	**461**
47	2017	02-02	MCS Coca Cola	DZH	6t/h	*c	**1,712**	220	283	264
48	2017	02-03	No.35 School	Carborobot 300	0.3 MW	*b	**1,871**	177	1,864	**509**
49	2017	02-08	Ih Sunder Constructuion	CWNG	2.8 MW	*a	272	283	**12,378**	**4,517**
50	2017	02-09	Zevsegt huchnii 303 angi	HP-18-54	0.6 MW	*b	**1,845**	218	1,198	**2,460**

51	2017	02-10	SH.A.B" LLC_Belkh zakh	Carborobot 300	0.3 MW	*b	**1,893**	196	1,819	**545**
52	2017	02-15	No.104 School	SHC	0.35 MW	*b	**1,471**	109	**6,080**	**525**
53	2017	02-16	Sansar	Kiturami KCR	0.35 MW	*b	656	110	**6,835**	**200**
54	2017	02-17	Sansar-32	Odcon	0.1 MW	*b	546	209	**4,604**	**860**
55	2017	02-21	No.49 School	Carborobot 300	0.3 MW	*b	**948**	198	**3,383**	**1,382**
56	2017	02-22	No.107 School	Kiturami KCR	0.35 MW	*b	703	49	**79,725**	**1,708**
57	2017	03-07	No.58 School	MUHT	1.2 MW	*a	**1,113**	114	**6,550**	**4,400**
58	2017	03-14	Hamgaalaltiin II gazar 5 angi	Hp-2-85	0.5 MW	*b	499	149	**7,463**	**4,437**
59	2017	03-15	No.81 Kindergarten	CLHS	0.35 MW	*b	524	140	**13,079**	180
60	2017	03-16	OBEG HU angi	HP-30	0.3 MW	*b	**1,200**	167	**10,688**	354
61	2017	03-22	Nuur Am Sudlaliin Surguuli	DOd	0.42 MW	*b	546	157	**5,887**	**749**
62	2017	03-23	No.124 School	MUHT	0.4 MW	*b	**1418**	123	2,242	**1,444**
63	2017	03-24	Monlaa	CDZL	1.4 MW	*a	**941**	224	**3,780**	**2,477**
The number of boilers which meet emissions standard, separated by parameter							27	63	20	23
The percentage of boilers that achievement the emission standard, separated by parameter (%)							42.9	100.0	31.7	36.5

(shaded) : Exceeds emission standard

Item	Target	MNS Emission Standard (mg/Nm³)			
		SO_2	NOx	CO	Dust
*a	HOB： 0.8MW＜Boiler Capacity ≦3.15MW（MNS 5457:2005）	600	400	2,000	300
*b	HOB： Boiler Capacity ≦0.8MW（MNS 5457:2005）	800	450	2,500	400
*c	Steam Boiler： Steam Boiler Capacity ≦10t/h（MNS 5919:2008）	1,500	680	940	8,000

Note: Regarding the MNS 5919:2008, boilers were divided into 15 categories based on boiler capacity, and prescribed standard. However, only the necessary standard is quoted in this table.

Source: Based on the APRD report and modified by the JICA Expert Team

The progress made in measuring flue gas during the Boiler Inspections and Certifications is shown in Table 2.1-3. In the 2015 winter season, the flue gas measurement team measured flue gas at 41 boilers, which was less than the original plan. The flue gas was measured at 22 boilers during the 2016 winter season; a total of 63 boilers have been inspected through the project. Flue gas measurements will continue after the termination of this project during Boiler Inspections and Certifications. Given the current team and their expected progress, 55 boilers facilities will have flue gas measured in one year, and three years will be necessary to measure flue gas at all boiler facilities.

Table 2.1-3 Flue Gas Measurement Progress during Boiler Inspection and Certification

Original plan (September 2015)			Actual performance in winter season of the year 2015			Actual performance in winter season of the year 2016		
Schedule	The number of team	The number of measurement	Schedule	The number of team	The number of measurement	Schedule	The number of team	The number of measurement
2015/10/1～2015/11/30	1	12	2015/10/1～2016/3/31	1	41			
2015/12/1～2016/2/29	2	40						
2016/10/1～2017/2/28	2	106				2016/12/1～2017/2/28	1	15
						2017/3/1～2017/3/31	1	7
Sub-Total		158			41			22
Total	158		63					

Source: JICA Expert Team

(3). <u>Activities Related to Developing Capabilities for Sustainable Flue Gas Measurements</u>

Since September 2015, C/Ps began using a budget to purchase consumable supplies and materials to continuously perform the flue gas measurement after the project is completed. Because developing sustainable flue gas measurements is necessary for Boiler Inspection and Certification, the JICA project has performed the following activities.

- The JICA Expert Team revised the calculation format for data organization of the flue gas measurement in consultation with the C/Ps.
- The JICA Expert Team revised the field-recording sheet for flue gas measurements in consultation with C/Ps.
- The JICA Expert Team created the “Draft of the flue gas measurement manual on small coal-fired boiler”, “Draft of the flue gas measurement manual on the Ger stove”, and “Draft of the flue gas measurement manual on fuel combustion test laboratory” as technical manuals for stationary source monitoring; the JICA Expert Team consulted with C/Ps regarding the necessary technical manuals. The C/Ps and JICA Expert Team agreed on the contents of those manuals. Finally, all necessary technical manuals for stationary source monitoring (technical deliverables) produced from the JICA project were completed.
- C/Ps prepared the list of equipment for flue gas measurements.

- In the presence of the JICA Expert Team, C/Ps were able to perform maintenance on the automatic isokinetic dust sampler and pump for dust sampling, and were able to replace consumable supplies and material for the HORIBA PG250 and HODAKA HT-3000.
- The JICA Expert Team provided technical guidance to the C/Ps using the list, and assisted in adding necessary consumable supplies and materials for the flue gas measurements to the budget.
- C/P developed the flue gas measurement training plan to train other personnel to work independently.
- Although C/Ps were unable to purchase supplies until 2014 due to the small budget, subsequently, the C/Ps had a larger budget and purchased winter clothes and winter boots in 2015.
- In 2014, the flue gas measurements were not performed due to lack of a budget for drivers and fuel expenses. However, from the year 2015, C/Ps secured fuel expense funds for the measurement vehicle, and the flue gas measurements were performed without delay.
- The C/Ps purchased 71 boxes of filters and two sets of standard gas. The C/P has begun to purchase, repair, and has performed maintenance using their budget.

(4). <u>Others</u>

The activities performed other than the flue gas measurement and capability development for sustainable flue gas measurements are as follows:

- The C/Ps published the progress report on results from flue gas measurements from the Boiler Inspections and Certifications in the mid-term seminar. The JICA Expert Team provided content support for the presentation, which was prepared by the C/Ps.
- The C/Ps and JICA Expert Team prepared the 2015 annual report on flue gas measurements from stationary emission sources using the data organized by the C/Ps; the C/Ps prepared the 2016 annual report in April 2017.
- The flue gas results are being used for Boiler Inspections and Certifications, as noted in “2.7.1 Full Implementation of Boiler Management and Registration”. The IACC has issued an implement order to the HOB facility based on the Boiler Inspections and Certifications. Finally, these results have contributed to a reduction in air pollution, which is noted in “2.8.4 HOB and Steam Boiler”.
- In addition, the flue gas results were utilized to implement an emission factor, as noted in “2.3.1.2 Updating Emission Inventory”.

(5). <u>Recommendations</u>

One to seven years are required for personnel to reach a level of expertise in flue gas measurements; the time required depends on each person due to their different capabilities. To evaluate the improved fuel and continue performing the Boiler Inspections and Certifications after September 2017, personnel are needed. They will be drawn from three sources: (1) the re-employment of the person discharged in November 2016;

(2) the return of personnel after studying abroad in August 2017; and (3) training of successors from the APRD by the remaining supervisors. The JICA Expert team recommends that the deputy mayor is encouraged to increase the budget for the organization in charge of human resources; the APRD has no authority to regulate human resources or increase the budget.

2.1.1.2 Protocol for HOB Inspection

A comparison of the simplified dust and emission measurement results using the JIS method was made for 2014 and 2015. The Mongolian regulators decided they are unable to accept HOB inspections using the simplified dust measurement, and requested a policy that inspects all HOBs within two years. Therefore, the JICA Expert Team, C/P, and C/P-WG discussed all the target pollutants for emission measurements during boiler inspections from August to September 2015. The product of this discussion was the development of "The Protocol for HOB Inspection". Then, "The Protocol for Boiler Inspection (Administrative Instruction of Boiler Inspection and Certification)" was approved by the Vice Mayor on September 28, 2015. Based on "Administrative Instruction of Boiler Inspection and Certification," emission measurements have been performed since October 2015. The compliance rate for the MNS standard was estimated based on the emission measurement results, and HOB improvement orders and audit were subsequently performed. The "Administrative Instruction of Boiler Inspection and Certification" represents "The Protocol for HOB Inspection."

Protocol for HOB Inspection

1. Implement boiler inspections without flue gas measurements
2. Implement boiler registration
3. Implement flue gas measurements using the JIS method
4. Issue improvement instructions and inspection results based on the flue gas measurements
5. Confirm the performance of the improvements

In 2015, Boiler Inspections and Certifications were conducted by the JICA Expert team, C/Ps, and C/P-WG based on the protocol for HOB inspection. The five steps were as follows. 1) Implementation of the boiler inspection without flue gas measurements. 2) Implementation of boiler registration. 3) Implementation of the flue gas measurement using the JIS method. 4) Issue improvement instructions and inspection results based on the flue gas measurements. 5) Confirm the performance of the improvements. The "Administrative Instruction of Boiler Inspection and Certification of the Year 2016" was approved by the Mayor in November 2016. The APRD, Inspection Agency for the Capital City (IACC), UB Energy Coordinating Committee (UECC), Engineering Facilities Department of the UB City (EFDUC), and Infrastructure and Urban Improvement Division from each district and Inspector from each district cooperated and worked together to conduct the Boiler Inspections and Certifications. The related activities have been implemented. It is expected that boiler registration, boiler inspection, and improvement directives will be implemented continuously after the termination of this project.

2.1.1.3 Measurement of Pollution Abatement Measures for HOB

The following measurement was conducted to study pollution abatement measures for HOB.

(1). **Air Ratio Adjustment to Improve HOB Efficiency**

To study the effect of air ratio adjustment on HOB efficiency, measurements of HOB heat balance were conducted. However, the results were unclear.

(2). **Evaluation of HOB Scrubber Dust Removal Efficiency**

The dust removal efficiency from scrubbers was evaluated using dust measurements before and after scrubber installation in January 2015. Scrubbers had efficiencies between 60 and 80%, which are comparatively high values.

Table 2.1-4 Dust Measurement Results Before and After Installing Scrubbers

Locations			No.41 School	Police Academy	Nairamdal Camp	No.39 School
Type of HOB			MUHT	DZL	DZL	DZL
Dust concentration	Before Scrubber	$g\ m^{-3}N^{-1}$	3.75	0.88	0.84	0.22
	After Scrubber	$g\ m^{-3}N^{-1}$	0.85	0.32	0.32	0.04
	Dry waste gas volume	$Nm^3\ h^{-1}$	1,329	10,646	11,705	20,400
	Dust removal efficiency	%	77.3	63.6	61.9	81.8

Injection of limestone was studied to prevent the scrubbing water to decrease pH. To protect equipment from corrosion, scrubbing water pH must remain higher than 5, which requires approximately 0.02 kg-limestone/kg-coal.

(3). **Measurement of Electrical Resistivity of HOB Fly Ash to Evaluate the Applicability of Electrostatic Precipitators**

A Japanese company, which specializes in this field and possesses qualifications for Japanese measurement activities, analyzed the electrical resistivity of the HOB fly ash sampled at locations in Table 2.1-5 selected by the APRD. The HOB load affects the applicability of the electrostatic precipitator, the waste gas temperature decreases at low load, and the boiler combustion appliance. However, the electrical resistivity of the HOB fly ash indicates that electrostatic precipitator is applicable for almost all HOBs.

Table 2.1-5 Results of Electrical Resistivity of HOB Fly Ash

No	Facility	Coal type	Load factor	Electrical resistivity of fly ash (ω cm /120 = 150degC)	Applicability
1	BAGD #2	Nalaikh	70-75%	$4.6 \times 10^{10} – 5.5 \times 10^{10}$	○
2	Khan UUL	Nalaikh	60-70%	$1.6 \times 10^{12} – 5.5 \times 10^{12}$	△
3	No.63 School	Tavantologoi	70%	$7.3 \times 10^{8} – 1.1 \times 10^{9}$	○
4	No.34 School	Nalaikh	40-50%	$8.2 \times 10^{11} – 3.4 \times 10^{11}$	△
5	No.41 School	Baganuur	-	$1.2 \times 10^{6} – 9.2 \times 10^{5}$	×
6	AGGAT No.2	Baganuur	31-45%	$1.1 \times 10^{10} – 1.0 \times 10^{10}$	○

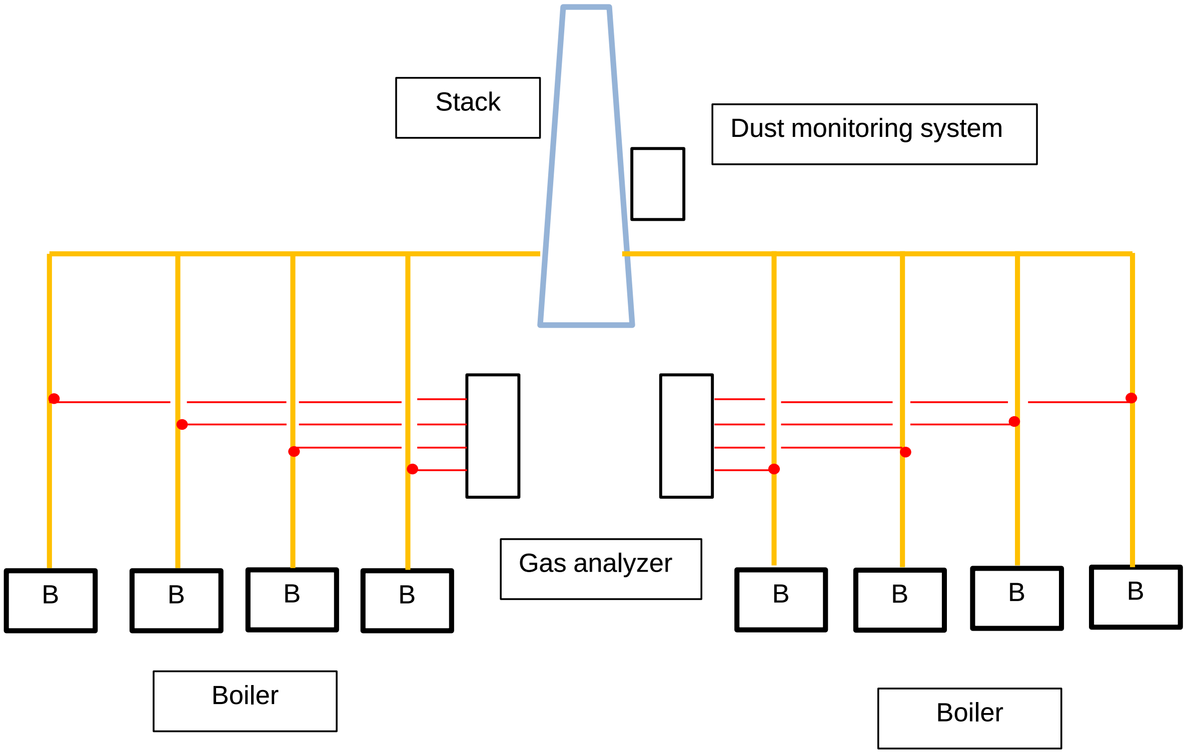
; Operators estimated Load factor because of no load instruments Water content in Waste gas condition is presumed to be 10%

2.1.2 CEMS Installation and Utilization for PP4

2.1.2.1 Installation of CEMS

The dust analyzer (one unit from the Tanaka Electric laboratory) and flue gas measurement analyzers (two units from Horiba) were supplied to PP4.

The entire measurement system is shown below. The dust analyzer was installed at the aggregate stack, and the flue gas measurement analyzers were placed in a room inside boiler buildings. One flue gas analyzer unit measures exhaust gas from four boilers with a switching system.



Specification and photographs of these instruments are shown below.

Dust analyzer

(1) Type	DDM- fC
(2) Structure	Wall mount outdoor installation type
(3) Principle	90° backward light scattering method
(4) Light source	Halogen light
(5) Measurement range	0 – 500 mg $m^{-3}N^{-1}$ relative density output (range is variable)
(6) Display	Digital panel meter, 0 - 100%

Flue gas measurement analyzer

(1) Type	ENDA-5800
(2) Application	NOx, SO2, CO, CO2, O2
(3) Principle	Cross flow modulation method for NOx, SO2, CO, CO2
	Magneto-pneumatic detection for O2
(4) Measuring range	NOx: 0-5,000 ppm
	SO_2: 0-5,000 ppm
	CO: 0-5,000 ppm
	CO_2: 0-20 vol%
	O_2: 0-25 vol%

Measurement equipment departed Japan in mid-August 2016, arrived at PP4 in mid-September, and was stored in a warehouse. Engineers from the manufacturers were dispatched to the site in October 2016, and they set and adjusted the measurement equipment. In mid-December 2016, the PP4 staff finished their work on the measurement equipment, and both measurement and monitoring was placed into operation in the central control room. One example of the CEMS measurement is shown in Figure 2.1-3. Since April 2017, CEMS has been successfully conducting exhaust gas measurements.

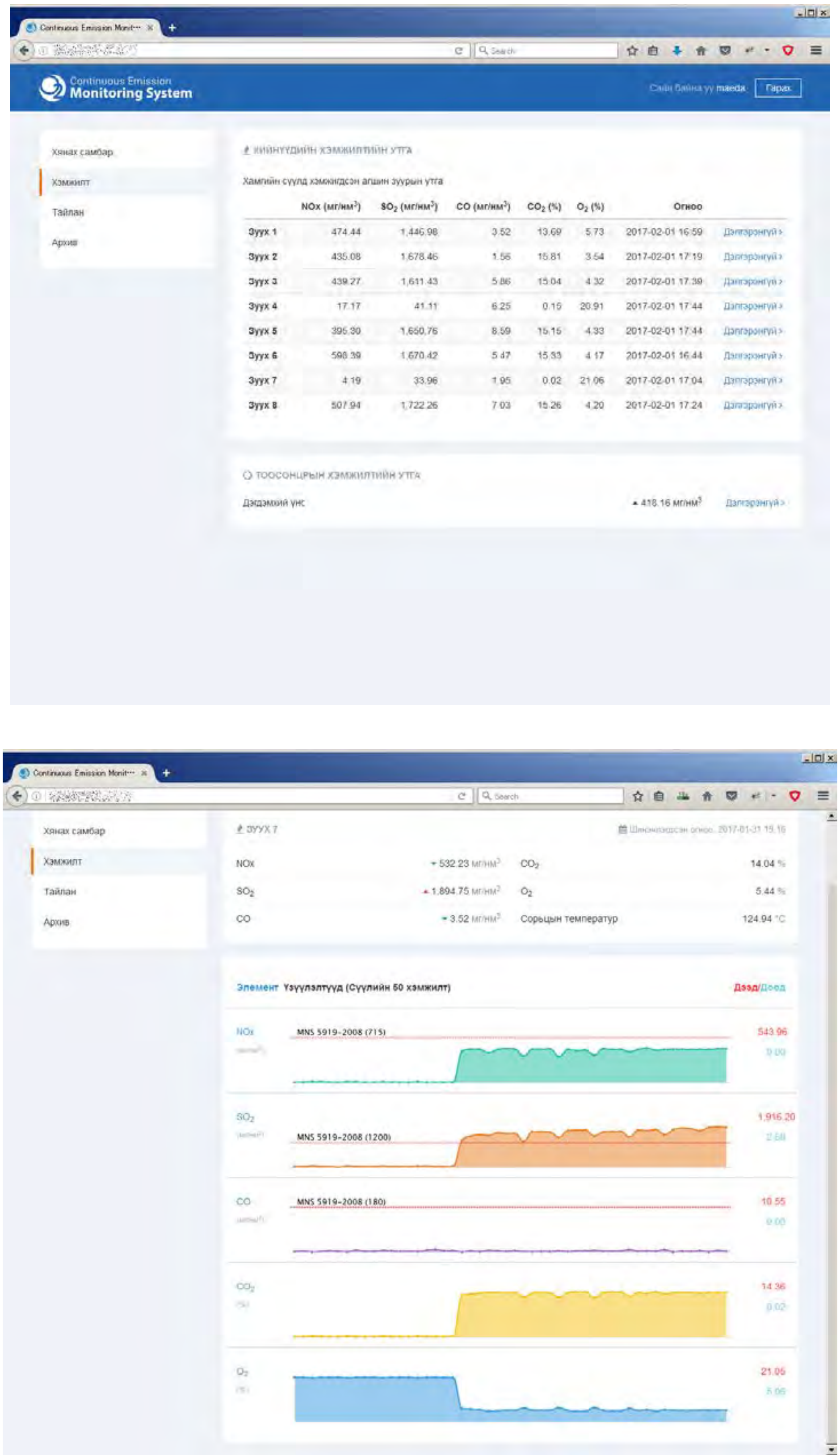


Figure 2.1-3 Example of Measurement by CEMS

2.1.3 Mobile Emission Source Monitoring

2.1.3.1 Purpose

To examine the future vehicle control measures in UB City, it is necessary to understand the precise emission from vehicles. Therefore, various vehicles travelling in UB City must be measured, and using the result, emission factors must be estimated.

To estimate emission factors, the emissions were measured from vehicles travelling in UB City using an on-board emission measurement system.

The on-board emission measurement system for this survey was installed in vehicles selected from motor coaches that had large emission ratios in the estimation result in Phase 1 and the most commonly own vehicles in UB City. Measurements necessary to develop vehicle control measures were conducted.

In addition, a measurement workshop using the portable exhaust gas analyzer on a vehicle that was not moving was conducted to improve vehicle emission inspections and maintenance. This unit is generally used by the Inspection Agencies of UB City for conducting vehicle emission inspections and regular maintenance. For concentration, exhaust gas is measured by inserting a probe into the exhaust pipe.

2.1.3.2 Activities

The contents of the activities are shown in Table 2.1-6 and Figure 2.1-4.

Table 2.1-6 Mobile Source Monitoring Activity Report

Date	Details of Main Activity
20-23 Dec, 2013	Visited three companies (explained survey content for on-board emission measurement system) Preliminary examination of traveling route for on-board emission measurements
26-30 May, 2014	Conducted an awareness seminar for experts Interviewed to decide on company to install on-board emission measurement system
11-29 Aug, 2014	Installed on-board emission measurement system (two passenger cars and one motor coach), conducted traveling survey, and uninstalled on-board emission measurement system Conducted a meeting with a fuel company
2-17 Oct, 2014	Conducted an awareness seminar for experts Conducted a workshop for experts Installed on-board emission measurement system (two passenger cars and two motor coaches), conducted traveling survey, and uninstalled on-board emission measurement system Conducted training to process on-board emission measurement data Conducted a meeting with fuel company and arranged transportation to Japan
13 Apr - 5 May, 2015	Conducted an awareness seminar for experts Installed on-board emission measurement system (three passenger cars, one freight car, and one bus (installed DPF)), conducted traveling survey, and uninstalled on-board emission measurement system Requested fuel analysis from fuel company in Mongolia
23 Aug - 12 Sep, 2015	Installed on-board emission measurement system (one freight car and two micro buses), conducted traveling survey, and uninstalled on-board emission measurement system
11 - 29Apr, 2016	Installed on-board emission measurement system (two passenger cars and one freight car), conducted traveling survey, and uninstalled on-board emission measurement system
5 - 8Aug, 2016	Held a workshop on the portable exhaust gas analyzer
12- 25 Jan, 2017	Installed on-board emission measurement system (one passenger car and one motor coach), conducted traveling survey, and uninstalled on-board emission measurement system for winter season

May 2014: Awareness seminar

August 2014: Installed on-board emission measurement system (passenger car)

October 2014: Awareness seminar

October 2014: Workshop

October 2014: Training to process on-board emission measurement data

October 2014: Obtain fuel from warehouse

April 2015: Installation of DPF (bus)

May 2015: Awareness seminar

August 2015: Traveling survey

April 2016: Data analysis

August 2016: Workshop on the portable exhaust gas analyzer

January 2017: Traveling survey

Figure 2.1-4 Photos of Mobile Source Monitoring Activities

2.1.3.3 Output

(1). **<u>Activity 1-9: In-vehicle equipment for automobile emission measurement is introduced, and appropriate methodology at Ulaanbaatar City and its manual are elaborated.</u>**

The JICA Expert Team created various manuals (the details are shown in Appendix 2.1-1 and 2.1-2) for the supervising personnel to lead and conduct a traveling survey independently. These manuals were based on the traveling survey of representative vehicles based on the number of registered vehicles in UB City. In addition, JICA Experts conducted a winter season traveling survey in January 2017. Based on their results, the notes related to measurement in the winter season were added and the manual was revised.

(2). **Activity 1-10: Related training for automobile emission measurement is implemented.**

The JICA Expert Team conducted awareness seminars (the details are shown in Appendix 2.1-3) for experts to develop a shared understanding regarding theory and equipment for mobile emission measurement in May and October 2014.

In addition, based on the manual, the traveling surveys for the on-board emission measurement system were conducted by the supervising personnel from August 2014 to January 2017.

As a result, the supervising personnel obtained enough skill, knowledge, and operation ability to independently measure mobile emission using the on-board emission measurement system.

(3). **Activity 1-11: Self-sustained emission measurement operation using in-vehicle equipment is initiated.**

According to Output 1 from Indicator 2, the vehicle exhaust gas measurement using an on-board emission measurement system should have been conducted on at least 20 vehicles. The actual survey was conducted using 20 vehicles (18 vehicles in spring-summer-fall and two in winter), satisfying the policy suggestion.

Based on the manual, traveling surveys were conducted using an on-board emission measurement system by the supervising personnel from August 2014 to January 2017. As a result, advice from experts decreased, and support from the JICA Experts was unnecessary for vehicle emission measurement.

In addition, the PTDCC and fuel company requested that the APRD conduct emission measurements of the regular route bus retrofitted with a DPF and potential reduced emissions due to fuel additives (the details are shown in Appendix 2.1-4). Considering the situation, the assistance of a self-sustained emission measurement operation will be achieved and the supervising personnel will be able to conduct measurements independently.

2.1.3.4 Summary

From August 2014 to January 2017, a total of 20 vehicles with an on-board emission measurement system were measured. In spring-summer-fall, nine gasoline passenger cars (including one LPG car), five diesel trucks, and four motor coaches were measured. In the winter season, one gasoline passenger car and one motor coach were measured.

Although the number of vehicles with measured emission is limited, using on-board emission measurement system, the emission factor was updated. Then, the total emissions were recalculated using compiling measurement result from vehicles that were traveling through UB City and the method indicated in 2.3.2.1(4).

In addition, for air pollution control measures, such as introduction of DPF to buses for public transportation, introduction of EURO IV buses, transition to low emission vehicles, and promotion of

NANO fuel, the effects of control measures were estimated based on the emission factor. A mobile source inventory using control measures was created. The details are shown in Activity 3-2.

From the measurement made with the on-board emission measurement system, the supervising personnel who compiled the vehicle exhaust gas results is hypothesized to obtain the knowledge and experience to create quantitative outcomes that consider the current and future specific control measures in UB City.

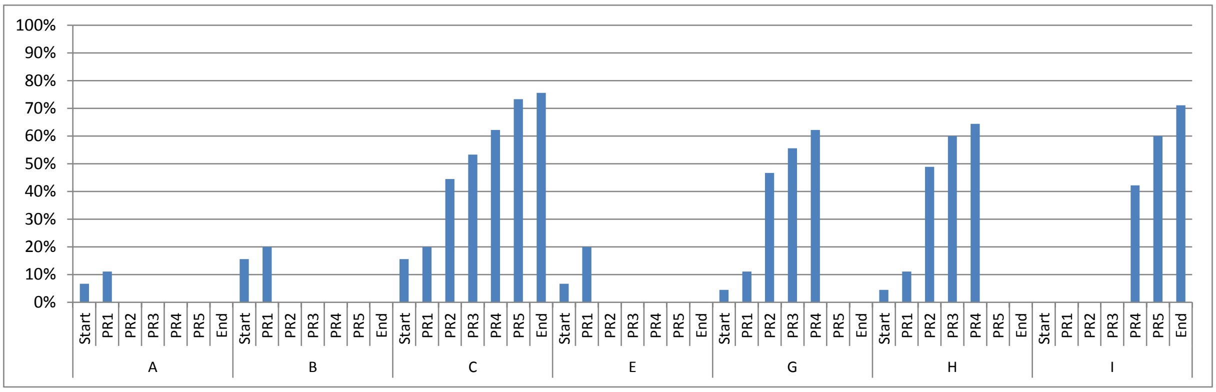


Figure 2.1-5 Technical Progress on Mobile Emission Monitoring (APRD Members)

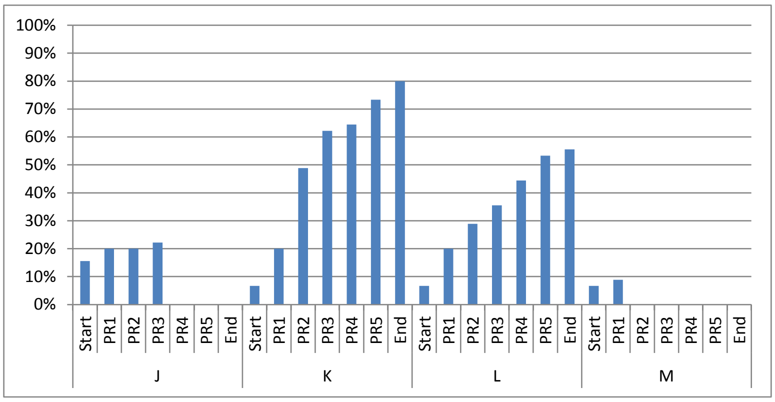


Figure 2.1-6 Technical Progress on Mobile Emission Monitoring (NAMEM and CLEM Members)

2.1.4 Other Emission Source Monitoring

The activity of the other emissions source monitoring was implemented as follows and the capacity of monitoring other emission sources were improved.

- Activities Related to Monitoring Fugitive Dust from Ash Ponds of Power Plant
- Activities Related to Monitoring Fugitive Road Dust
- Activities Related to Monitoring Emissions from Factories and Business Establishments

2.1.4.1 Activities Related to Monitoring Fugitive Dust from Power Plant Ash Ponds

The JICA Expert and the supervisors of the "C/P – WG members" (hereafter "C/P – WG members") supported activities to monitor fugitive dust from ash ponds of power plants NO.2 (PP2), NO.3 (PP3), and NO.4 (PP4) from April 2014 to September 2016. The "C/P – WG members" were Ms. Enkhmaa (NAMEM), Ms. Erdenetsetseg (NAMEM), and Ms. Sanchirbayar (APRD); Ms. Orkhon (APRD) was exchanged with Ms. Sanchirbayar (APRD) in August 2015.

In April 2016, the JICA Expert and "C/P – WG members" visited each PP ash pond. Then, the JICA Expert instructed and supported the "C/P – WG members" to create a monitoring plan. The JICA Expert led the "C/P – WG members" in preparing for the monitoring activities. The monitoring plan is shown in Appendix 2.1-5. This monitoring plan includes the activity supervisor, implementation structure, monitoring method, preparation equipment, draft schedule, and safety considerations. The monitoring method uses iron poles set vertically on the ash ponds; the length of iron poles above the ash surface is measured to estimate the amount of scattered fugitive dust. The quantity of scattered fugitive dust from the ash ponds was measured using the difference between the previous and current lengths.

By developing the monitoring plan, the "C/P – WG members" carried out the monitoring activities independently, even in the absence of the JICA Expert. The monitoring report documents the results of the monitoring activity. The form of the monitoring report was decided in discussions with the JICA Expert and "C/P – WG members." The flow of activity was such that the "C/P – WG members" generated this monitoring report themselves and reported to the JICA Expert after it was established.

In April 2015, using the monitoring report, the JICA Expert and the "C/P – WG members" considered the estimation method for fugitive dust from each PP ash pond. The "C/P – WG members" provided the variables, such as rainfall and bulk density of coal ash. They tried to determine how to estimate these variables through the discussion with the JICA Expert. In April 2016, activities, such as the preparation of the monitoring plan, implementation of monitoring activity, generating the monitoring report, and calculating the emissions of air pollutants, were established.

Based on these activities, the structure for monitoring the fugitive dust from each PP ash pond was almost completely developed. In the future, if the budget can be obtained to monitor the ash ponds in UB City, it is hypothesized that the monitoring activity can be conducted.

The activities required to estimate fugitive dust from each PP ash pond are shown in Table 2.1-7. The detailed results from monitoring activities and quantities of fugitive dust from ash ponds are shown in Appendix 2.1-5.

Table 2.1-7 Monitoring Activities to Estimate Fugitive Dust From the Ash Ponds of Each PP

The fugitive dust from ash ponds scattered very little due to control measures, such as covered soil and afforestation. Densely grown forests or bushy trees/grasses provide soil cover surfaces that minimizes dust scattering.
Ash will not scatter from surfaces that contain enough moist or are covered by water. In addition, this condition is very dangerous and monitoring activity must not be carried out in such an ash pond.
In the scenario in which water flows at the surface of ash ponds, the difference in the measured length of the iron poles increases at the same monitoring point because the surface of the ash pond around iron pole hollows. In addition, it is difficult to estimate the difference between the amount of the fugitive dust from wind and the movement of ash from water flow. Therefore, in this situation, the quantification of fugitive dust amount was challenging.
Large amounts of fugitive dust from ash pond were emitted when the ash pond dried and strong wind blew across it during the spring season.

2.1.4.2 Activities Related to Monitoring Fugitive Road Dust

The JICA Expert and supervisors of the "C/P – WG members" began to discuss the activities required to monitor fugitive road dust in October 2014. The "C/P – WG members" are Ms. Nyamdavaa (NAMEM), Mr. Munkhsaikhan (NAMEM), and Mr. Altangerel (APRD).

The JICA Expert generated the monitoring plan for fugitive road dust with "C/P – WG members" in October 2014. The "C/P – WG members" have been conducting this monitoring activity since November 2014 according to the monitoring plan. Therefore, the monitoring framework has been constructed. In the future, the "C/P – WG members" will continually conduct this monitoring activity.

In October 2014, the JICA Expert and the "C/P – WG members" generated a draft monitoring plan to monitor fugitive road dust. This monitoring plan includes the supervising personnel, implementation structure, monitoring method, preparation equipment, draft schedule, and safety considerations.

The monitoring activity calculates the silt loading (sL) based on AP-42 from the U.S. EPA. First, a 1 m square measurement area was set on the road using a length scale. The dust was then collected in this area using a vacuum or broom. Then, the ratio of silt was measured in each sample.

The monitoring activities began in October 2014, and the monitoring plan was improved using the results. Since then, the monitoring activity has been conducted without the JICA Expert because the monitoring plan was developed.

Initially considering safety, the monitoring point was set as the edge of each road. The emission of the fugitive road dust was calculated using the results of the monitoring activity, and this emission was estimated using a model simulation. In addition, this emission was investigated further using PM10 and PM2.5 sampling and composition analyses. As a result, repeated calculation results were not obtained.

The JICA Expert and the "C/P – WG members" reconsidered the sampling plan and the monitoring point was changed to 1 m from the edge of the road. In addition, it was confirmed that the first priority is safety.

The results from the monitoring of fugitive road dust are shown as Table 2.1-8.

Table 2.1-8 Parameters for Setting Fugitive Road Dust Emission Factors

Paved Road					
	Method	Equation (2), AP-42, 13.2.1			
	k	Particle size multiplier	Whole Year	0.62	g/VKT
	sL	Silt Loading	Whole Year	1.01	g/m2
	sL	Winter Baseline Multiplier	April - October	1	
			November - March	0.25	
	W	Average weight (tons) of vehicles traveling		1.48	Mg
	P	Number of Wet Day	April - October	37	days
			November - March	120	days
	N	Number of days in the averaging period	April - October	214	days
			November - March	151	days
	Eext	Long-term average emission factor	April - October	0.892897	g/vehicle/km
			November - March	0.211799	g/vehicle/km

The calculation equation of Table 2.1-8 shown below is from "13.2.1 Paved Roads" of AP42 of US EPA.

$$E_{ext} = [k \times (sL)^{0.91} \times (W)^{1.02}] \times (1 - P/4N)$$

Where:

E_{ext}	Particulate emission factor
k	Particle size multiplier
sL	Road surface silt loading (g/m^2)
W	Average weight (tons) of the vehicles traveling the road
P	Number of "wet" days
N	Number of day in the averaging period

In the future, it will be necessary to collect more data and increase the accuracy of the emission factor. The structure for monitoring fugitive road dust is almost fully developed. If a budget from UB City or Mongolian government can be acquired, it is hypothesized that this monitoring activity can be conducted.

2.1.4.3 Activities Related to Monitoring Emissions from Factories and Business Establishments

The JICA Expert and supervisors of the "CP - WG members" began to study the activities to monitor emissions from factories and business establishments in April 2015. The "C/P – WG members" are Ms.

Enkhmaa (NAMEM), Ms. Erdenetsetseg (NAMEM), Ms. Delgermaa (NAMEM), and Ms. Orkhon (APRD).

Ms. Erdenetsetseg and Ms. Delgermaa provided the lists of factories and business establishments. The JICA Expert and “C/P – WG members” discussed the lists and decided that brick factories, concrete facilities, and waste disposal sites were the optimal targets.

The JICA Expert and “C/P – WG members” went on site visits to some concrete factories in UB City. Because these factories have already applied some control measures, such as “Hoods,” “Curtains,” and “Shrouds,” the fugitive dust from these factories was expected to be very small. In addition, the data collection from the statistical information on concrete production was difficult, and then the dust from concrete factories could not be estimated.

The JICA Expert and “C/P – WG members” went on site visits to some brick factories in UB City. The economic stagnation and relocation plan to the suburbs caused the suspension of operation of large-scale brick factories. Small brick factories were operating, and thus the potential for air pollutants from the process of grinding and screening operations at the coal-fired kiln was confirmed.

The number of bricks pieces was obtained from the statistical database of UB City. The MNS on bricks was obtained, the measurement survey was conducted regarding the mass of brick pieces, and the mass per one piece was estimated. The emission factors for brick factories were obtained from the AP-42 from the U.S. EPA. Because environmental countermeasures are different between large-scale and small-scale factories, the emission factors were hypothesized to be different. Therefore, the JICA Expert and “C/P-WG members” developed estimation methods for activity data from large-scale and small-scale factories. Through these activities, an emissions estimation method for air pollutants from bricks factories was established. In the future, monitoring of the number of bricks pieces will lead to estimates of air pollutant emissions from brick factories.

The waste disposal data was collected from the waste management authority in UB City. According to the supervisor of the waste management authority, a waste incinerator does not exist in UB City. Therefore, the air pollutant emissions from open burning landfill sites were considered. According to a satellite image taken on September 1, 2015, open burning in the landfill site is evident. However, the frequency of open burning based on satellite photos was small.

The emission factors from waste combustion were obtained from “The Global Atmospheric Pollution Forum Air Pollutant Emission Inventory Manual version 5.0”. This manual describes the method for estimating the fraction of total MSW that is incinerated. Some country-specific data are also included in Annex 2A.1 of the draft 2006 IPCC guidelines and a default of 5% would seem appropriate for most developing countries unless country specific data are provided. Therefore, it was assumed that 5% of waste was subject to open burning. As a result, the air pollutant emissions from open burning in solid waste disposal sites were calculated. In the future, monitoring activities, such as data collection on the number of solid waste disposal sites from the waste management authority in UB City, will be conducted. With that data, estimates of air pollutant emissions from the solid waste disposal sites can be calculated.

2.2 Ambient Air Quality Monitoring: Output 2

2.2.1 Ambient Air Quality Monitoring Network

2.2.1.1 Rehabilitation and Status of Monitoring Stations

Air Quality Monitoring Stations (AQMSs) are in operation in UB City, continuously monitoring air pollutants. There are two monitoring networks: the APRD and CLEM Networks. The APRD Network was built using the German grant-aid in 2008 and is maintained by APRD. The CLEM Network was built using the French loan cooperation fund in 2010 and is maintained by CLEM.

Status of Project Activities 1

Project Activities	Achievement
Activity 2-1 Operational status of existing ambient air quality monitoring stations is reviewed.	Accomplished
Activity 2-2 Rehabilitation of existing monitoring stations is implemented.	Almost reached

The JICA Expert and supervising APRD personnel performed routine inspections and confirmed the working condition of the Air Quality Monitoring Stations (AQMS) at the beginning of the project period. Project Activity 2-1 in PDM has been adequately executed (see Table 2.2-1). Analyzers are working properly, as shown in Table 2.2-1; it proves that rehabilitation, repair, and replacement, have been corrected for failed equipment. The calibration system is operable for ordinary operation; however, one of the functions is partially inoperative. Project Activity 2-2 in PDM has almost reached its goal. The progress in these activities is shown below.

(1). **APRD Stationary Monitoring Stations**

The symbols in Table 2.2-1 indicate the working condition of monitoring devices in February 2017. Proper working conditions are observed in almost all devices. New monitors were installed for renewal or to establish a new air monitoring station during the project period.

Table 2.2-1 Five Stationary Monitoring Stations Managed by APRD and Operational Conditions as of February 2017

Analyzer Type \ Station	Tolgoit (APRD1)	MNB (APRD2)	Amgalan (APRD3)	Nisekh (APRD4)	Bayankhoshuu (APRD6)
SO_2 APSA370	○ *1	○ *1	○ *1	○ *1	○ *4
NOx APNA370	○ *1	○ *1	○ *1	○ *1	
CO APMA360	○	○	○	○	
O_3 APOA370	○ *2	○ *2	○ *2	○ *2	
PM Model180	○	○	○ *3	○	
PM APDA371					○ *4 (2sets)
Calibration Devices MCC1000	CO Line inoperative				○ *4
Weather Monitors	○ *5	○	○ *5	○	○ *4

○ : Operational

*1: Monitors renewed in January 2014 with APRD budget.

*2 : Monitors renewed in March 2015 as part of JICA project.

*3 : Monitors renewed in January 2016 with APRD budget.

*4 : New monitoring station built in April 2016 as part of JICA project.

*5 : Monitors renewed in August 2016 with World Bank funds.

NOTE : The calibration system worked for ordinary operation; however, one of the functions was partially inoperative. Failed devices were fixed and Project Activity 2-2 in PDM has almost reached its goals.

Figure 2.2-1 Stationary Air Monitoring Station

< Past History >

Since the start of operations in 2008, consumables were not adequately replaced and periodical health checks were rarely performed, degraded parts caused frequent poor working conditions with inadequate sensitivities of the equipment. This situation was caused by poor management of the maintenance system due to budgetary or maintenance issues. Consequently, we did not have confidence in the collected data in 2010. However, APRD began repair/replacement activities on some devices in 2012, the readings track the environmental concentration on many analyzers. Therefore, reliable data were observed from a few monitors.

Although this project began in November 2013, we were unable to start technical support until later because there was a question of ownership from APRD. The possibility existed that the monitoring station ownership might have been transferred from APRD to NAMEM, and APRD might not have chosen C/P as the organization that JICA personnel were going to train.

JICA Technical Support started in Mongolia in August 2014 after the future of the APRD was confirmed. At that time, APRD had a large budget due to the strong support from the newly appointed deputy mayor, thus we were excited about the projects. The initial assessment of the monitoring stations is shown in Table 2.2-2. Many troubles were discovered, the JICA Experts began activities targeting initial normal operations at the stations for completion in September 2014.

Table 2.2-2 Four Stationary Monitoring Stations Managed by APRD and Operational Conditions as of August 2014

Station / Analyzer Type	Tolgoit (APRD1)	MNB (APRD2)	Amgalan (APRD3)	Nisekh (APRD4)
SO_2 Sensitivity	× 3/10	△ 9/10	△ 12/10	△ 11/10
NOx Sensitivity	○ 10/10	△ 9/10	△ 6/10	△ 10/10
CO Sensitivity	× 4/9	× 5/9	△ 7/9	× 3/9
O3	× Failed			
PM	○	○	○	○
Calibration Devices	CO Line inoperative	○	CO Line inoperative	○
Weather Monitors	× Wind Direction	○	× Wind Direction	○
Air conditioner	—	—	Failed	—
UPS/AVR	Not installed			

○ : Operational △ : Not completely operational but the readings track environmental concentrations

× : Abnormal operation.

NOTE 1: The measured sensitivity of an analyzer in the table is indicated by the ratio compared to the target concentration, e.g., 3/10 indicates that the analyzer only had 30 % sensitivity.

NOTE 2: APRD installed UPS and AVR backup power sources to mitigate the unstable power supply in the city and protect the measurement equipment from its effects.

Analyzers were brought back into good condition in September 2014 after replacing major consumables and conducting maintenance, as shown in Table 2.2-3. The power supply for the Air Monitoring Stations was improved with UPS installations in December 2014. Some devices in failed conditions have been repaired or gradually replaced since then.

Table 2.2-3 Four Stationary Monitoring Stations Managed by APRD and Operational Conditions as of December 2014

Station / Analyzer Type	Tolgoit (APRD1)	MNB (APRD2)	Amgalan (APRD3)	Nisekh (APRD4)
SO2 Sensitivity	○ 10/10	△ 10/10	△ 10/10	△ 11/10
NOx Sensitivity	○ 10/10	△ 10/10	△ 6/10	△ 10/10
CO Sensitivity	○ 10/10	○ 10/10	△ 10/10	○ 10/10
O3	× Failed			
PM	○	○	○	○
Calibration Devices	CO Line inoperative	○	CO Line inoperative	○
Weather Monitors	× Wind Direction	○	× Wind Direction	○
Air conditioner	—	—	Failed	—
UPS/AVR	○ Installed by APRD funding			

Additional analyzer issues have been encountered since August 2015, and have been repaired as detected. The list of the issues is shown in Table 2.2-4.

Table 2.2-4 APRD Measurement Analyzer Issues since August 2015

SO2 Analyzer for each station	High concentrations of dust get stuck in the flow path during the winter season and the analyzers automatically stop measurement due to the low flow rate. Repaired.
O3 Analyzer for MNB Station	Filter was accidentally not installed by the maintenance person in February 2016, which caused an automatic shutdown. Repaired.
PM Analyzer for Amgalan Station	Operational malfunction caused by moisture condensation dripping within the analyzer caused an electricity circuit short. Replaced with a new device purchased by APRD.
Entire Amgalan Station	Due to an air-conditioning malfunction at the station, the entire station operation halted in summer, 2015. Replaced by APRD.

(2). **APRD's Mobile Station**

APRD purchased a Mobile Air Monitoring Station in 2008, and it has been used for short term ambient air monitoring in many places in UB City, especially in the winter season.

Figure 2.2-2 Image of APRD Mobile Air Monitoring Station and View Inside

Table 2.2-5 below shows the operational condition of monitors in the mobile station, based on several inspections conducted directly after project initiation. Considering the low frequency of their use, far fewer issues have been discovered in comparison to analyzers at Fixed Stations.

Table 2.2-5 Operational Status of APRD Mobile Station as of September 2014

Analyzer Type	Operational Condition	
SO_2 EC9850A	×	The concentration indicator remains at zero during air measurements.
NOx EC9841A	○	Apparent operation is normal.
CO EC9830	○	
CO_2 EC9830	○	
O_3 EC9801A	○	Measurement readings appear normal, although it has not been calibrated since delivery.
PM10 BAM1020	Unknown	Yet to be investigated.
Calibration Device GasCal1100	×	Alarm sounds at the O3 generation screen and the sequence stops.
Weather Monitors	×	Wind speed / Wind direction sensor failure. To be replaced.
Others	—	Measured data from analyzers cannot be collected in Data Logger.

○：Operational ×：Abnormal operation. Readings do not reflect the environmental conditions

In the summer of 2015, APRD fixed two old analyzers on the shelf, an SO_2 Analyzer (APSA360) and NOx Analyzer (APNA360), by carrying out the maintenance and calibration themselves. A spare APRD PM analyzer Model 180 is being used as necessary, the JICA Expert helped improve the PC data collection method. These analyzers in the Mobile Station improved its working condition.

A weather meter and data logger needs replacements due to severe failures. However, the lack of funding from APRD has prevented the replacement. Nevertheless, the Mobile Station is in use and measure SO_2 and NOx in many places, such as roadside.

(3). **CLEM AQMSs**

The maintenance Section in the CLEM, NAMEM-affiliated laboratory, performs maintenance activities throughout the year on six Air Monitoring Stations in UB City.

Figure 2.2-3 Images of the CLEM Stationary Monitoring Station

Table 2.2-6 CLEM Five Stationary Monitoring Stations and One Mobile Station

Analyzer Type \ Station	UB1	UB2	UB4	UB5	UB7	UB8
SO_2 AF22M	□	□	□	□	□	□
NOx AC32M	□	□	□	□	□	□
CO CO12M	□	□	□	□	□	□
O_3 O3 42M	□	－	□	□	－	□
HC AC51M	□	□	－	－	－	－
PM2.5 MP101M	－	□	□	－	－	－
PM10 MP101M	□	□	□	□	□	□
PM Sampler PM162M	□	－	－	－	－	－
Calibration Device MGC101 / ZAG7001	□	□	□	□	□	□
Weather Monitors	□	□	□	□	□	□

□ Denotes equipment operative　　－ Denotes lack of equipment

The JICA Expert accompanied the CLEM personnel on inspection rounds to the CLEM AQMSs, and verified the analyzer operational conditions. Many of the analyzers were working normally; aid from the French loan fund cooperation was still available when the JICA project had just started and CLEM was able to obtain consumables and technical support from a French manufacturer. The expert also concluded that the characteristics of the measured data provided from NAMEM reflected proper operation; therefore, the measurements are considered accurate. The expert also witnessed the replacement of a major part of the measurement equipment. The replacement work indicated that the staff was familiar with equipment handling. There were only three failed analyzers in 2014, which ceased working for a long time due to lack of parts to make repairs.

Table 2.2-7 Failed Equipment at CLEM Monitoring Stations (as of November 2014)

Equipment	Operational Condition
(Qty 1) NOx Analyzer	The concentration indicator remains at zero during air monitoring. Failure likely at the amplifier circuit.
(Qty 1) NOx Analyzer	Unknown cause. CLEM is investigating the cause.
(Qty 1) CO Analyzer	A small circuit card may be inoperative.

After the French loan fund cooperation ended, the number of analyzers in failed conditions increased every year, and the number of stocked parts gradually decreased each year because they were used for maintenance. Every year CLEM has been requesting a NAMEM budget allocation for parts procurement, but often their requests have been turned down from upper policy-makers, but their requests have been partially approved for maintenance and repair.

While the JICA project was not intended to provide repair parts to CLEM, small consumables for the PM monitor were a priority for parts provision from JICA support because the repair of PM monitors is essential for obtaining PM measurement data from all monitoring locations in UB City on this project.

It is challenging for CLEM to obtain highly accurate data due to the lack of replacement parts, however the experienced staff have excellent maintenance skills.

2.2.1.2 Maintenance Management Organization

Achievements regarding maintenance management organizations are shown in Table 2.2-8.

Table 2.2-8 Status of Project Activities 2

Project Activities	Achievement
Activity 2-5 Dedicated unit for maintenance and calibration of equipment established by APRD and NAMEM.	Established Take care if action will be executed as planned.
Manual generation of monitors for rehabilitation/operation and maintenance.	Completed

To continuously obtain good quality measurement data, it is essential to strengthen some of the main tasks systematically, such as the securing of personnel, personnel supervision and training, securing the budget in advance, and rules for task management. These items have been gradually improved throughout the project. However, the APRD changes in monitoring personnel plagued the project, especially in such areas as the improving equipment maintenance and skill levels. The progress was very slow for Activity 2-5 until the end of the project, delaying systematic organization and personnel technical improvement. Table 2.2-9 shows the change in maintenance management structure.

Table 2.2-9 Change in Maintenance Management Structure in the APRD

	Changes in Maintenance System	
	Beginning of Project	Termination Period of Project
Monitoring Personnel Maintenance Skill	Only one staff with little knowledge and experience was assigned.	Two staff members form a team who trained from new procedures, assigned for Data Management and Station Maintenance. Another experienced staff member will be assigned for emergencies.

		Organizational restructuring occurred four times throughout this project, and a total of eight persons participated in technical training.
Budget		
Consumables Purchasing	There is no specific plan to purchase parts and spares.	Parts lists were created (see Appendix 2.2-1-3). C/P can now determine the name and quantities of necessary items.
Timing of File Applications	Delayed or Forgotten	An Annual Schedule was created (see Appendix 2.2-1-2), and the actual timing is described in Maintenance Manuals to file applications on time (see Appendix 3).
Electricity Charges	Entire stations were without power for a long time due to delays in monthly payments.	There are no longer power outages due to late payments.
Telecommunication fees	Data was not transmitted from AQMSs due to delays in monthly payments.	Transmission issues no longer occur due to late payments.
Rules		
Maintenance Rules	Work contents were not broken down and identified.	Task items and frequency of maintenance are clearly described in the Maintenance Task Table. Working condition of analyzers is verified every morning using a data check from AQMSs via the internet.
Maintenance Schedule	Work contents are not scheduled	Task items mentioned above are marked on the Annual Schedule table (see Appendix 2.2-1-1). Care is taken that the actual schedule is adhered to as planned.
Parts Inventory Control	There was no record for consumables	Stocked parts are recorded using a personal computer from APRD.
Other Document	Nothing	Maintenance record form is created and used to record actual maintenance tasks. (see Appendix 2.2-1-4)
Vehicles	No own car APRD has to go to AQMS for scheduled maintenance or emergency action.	Not improved

Anxiety issues in the APRD reinforce maintaining the current maintenance system. The supervising APRD personnel have been changed multiple times by organizational restructuring. The upper organization took it for granted that the budget allocation for consumables could be cut down to half in some cases. Furthermore, the APRD cannot secure the exact day for AQMS maintenance because APRD does not own a car.

The budget is the controversial point for CLEM to support a management system for maintenance. Once an analyzer breaks down with large repairs required, it will remain out of operation for a long time due to lack of parts and the measurement accuracy reduces, despite the capabilities of the maintenance staff. Attention must be paid to maintenance rules so that the activity log shows that the periodical maintenance has been performed.

< Past History >

At the beginning of this project in November 2013 one person was assigned as maintenance staff. APRD only weakly supported maintenance as indicated by the lack of knowledge and experience of the personnel required, the unplanned purchase of expendable supplies, difficulty in securing a budget, irregular maintenance schedule, and lack of work records.

Although four personnel were assigned as maintenance staff in August 2014, on the first time assignment the staff assignment was unstable. Therefore, the expert and an experienced personnel employed in the Phase 1 project were obliged to perform maintenance until the second organizational restructuring in March 2015.

Once the AQMS staffs were able to devote themselves only to the AQMS maintenance and management, the organizational rules began to emerge gradually as shown in Table 2.2-10. Technical trainings were performed intensively and new personnel experienced actual maintenance on site.

Table 2.2-10 Operational Maintenance Rules as of March 2015

1	Make the station building keys available to all maintenance personnel.
2	Four people will maintain four stationary monitoring stations; however, assigning only one individual to a station should be avoided.
3	Limit the equipment operators within each station to those who have been authorized after receiving training and demonstrating sufficient experience.
4	Filter replacement once every two weeks. Equipment calibration using standard gas should be performed once a month.
5	Practical use of maintenance records for each station. Log all monitoring activities within a station.
6	Record the station visits. Note the name, arrival, and departure times for each visit.

However, the supervising personnel were changed a third time, and the trained staff left and another new staff member joined the team. The JICA Expert performed technical training starting with a beginner course at the request of the Director of APRD.

The expert performed on-the-job personnel training for maintenance of the monitoring stations as requested; the expert maintained the proper operational and accuracy conditions of the equipment by providing the equipment maintenance in August and December 2015 and March 2016. Consequently, the maintenance skills have improved gradually.

The expert asked APRD to replace the consumables. Although APRD performed the filter replacements as the main activity, APRD did not perform other consumable replacements despite the requests. In particular, no parts were replaced for two years on the SO_2 and NOx analyzers that were newly acquired using APRD funding in January 2014. Therefore, there is a concern that the measurement accuracy has suffered.

Thus, under expert guidance in March 2016, four maintenance personnel tackled the replacement of major consumables in analyzers, and cleaned and performed the measurement accuracy maintenance tasks that should have been done periodically. Newer personnel were also trained to understand the usage and function of the inner parts in the analyzers, and began to perform sensitivity calibrations. One common problem is caused by highly concentrated dust in winter that plugs the flow path to the analyzers. Now the newly trained personnel have sufficiently learned the internal structure of the equipment, they can repair them independently.

JICA and APRD separately purchased and stored major consumables, but they are almost all depleted. APRD has made purchase arrangements for new consumables, securing the budget for 2017. The consumables supply is being used as planned.

Figure 2.2-4 Images of Analyzer Major Part Replacement (Periodic Maintenance)

Maintenance manuals were generated by the supervising personnel and JICA Expert based on the knowledge and experience acquired from on-the-job training and the expert's advice (see Appendix 2.2-3). The creation of the document formed part of the technical training activities. The manuals are not yet finished currently, but they will be completed after revising the following points during the expert's next visit.

Personnel assignment changed again for a fourth time due to directives from the UB City office, and we lost an experienced staff member in November 2016. During the project, personnel changed four times in total. Once trained and confirmed to have increased skill and knowledge levels, the local staff repeatedly left their positions. Consequently, we had to keep training new people, which resulted in severe inefficiencies and large delays in building the maintenance management structure.

Nevertheless, the personnel supervising APRD and the expert have inspected the working conditions of AQMSs every month, although staff has changed many times.

A total of eight persons participated in training sessions during the project. Currently, three personnel are assigned to supervise the AQMS. As a new government took over in 2016 in the capital city, it adopted a new rule that a task is strictly to be managed by one person. Thus, the new rule forced multiple people to not share the same tasks. Figure 2.2-5 shows the technical proficiency of the eight trainees.

Table 2.2-11 APRD Monitoring Station Personnel as of January 2017

No.	Trainees Name (Gender)	Duty
1	Muuguu Otgonbayar (Male)	Experienced technician employed from Phase 1 project Troubleshooting of AQMS and stack monitoring
2	Dashzeveg Sanchirbayar (Female)	Maintenance staff for AQMSs
3	Luvsandorj Narmandakh (Female)	Data collection and management
4	Silam Mart (Female)	Improved fuel *(from November to December 2016)
5	Namsrai Orkhon (Female)	- *(from March 2015 to October 2016)
6	Battur Bayarmaa (Female)	- *(from March to June 2015)
7	Nasanjargal Naranbat (Female)	- *(from August to October 2014)
8	Erdenesambuu Erdenebaatar (Male)	- *(from August to October 2014)

*: They have been transferred to another division, and are not trainees now; however, they received technical training in AQMS maintenance. Training period is shown in brackets.

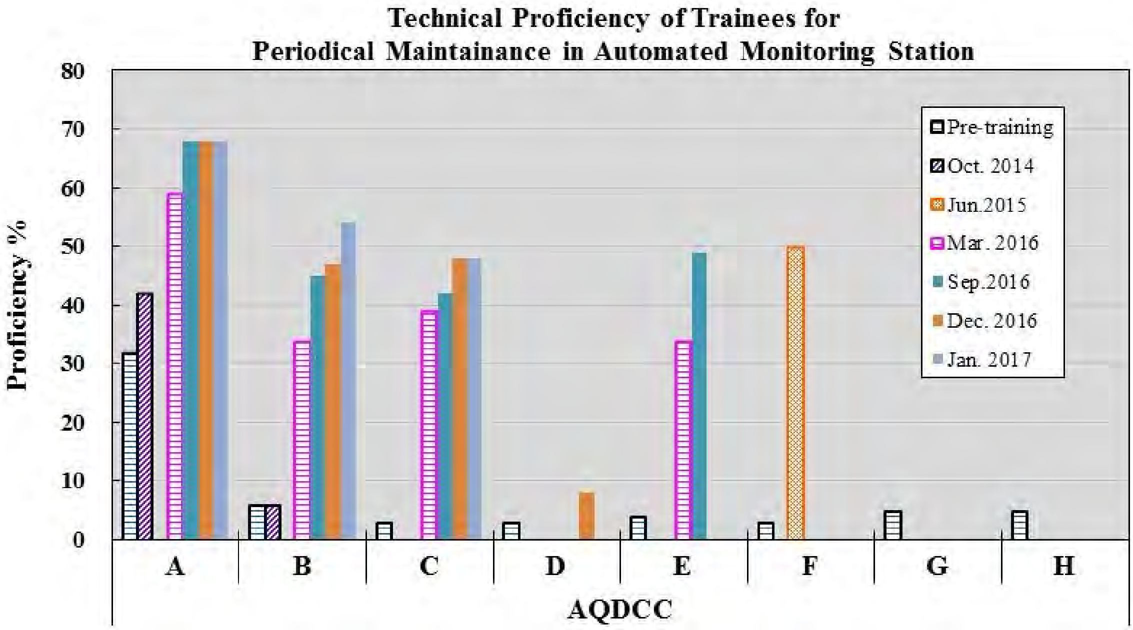


Figure 2.2-5 Technical Proficiency of Trainees for Periodical Maintenance in Automated Air Monitoring Station

2.2.1.3 QA/QC

On-site maintenance work, such as the periodical exchange of consumables and calibration of analyzers using the standard gas, is necessary to maintain accurate working conditions. Moreover, the maintenance schedule and record sheet are useful documents for the quality control system, to perform maintenance on schedule.

(1). **<u>QA/QC in APRD AQMSs</u>**

We performed quality control tasks for the APRD AQMSs as shown below.

1) Replacement of major consumables

We replaced major maintenance analyzer parts in March 2016 as shown in Chapter 2.2.1.2. Consequently, analyzers in five AQMSs are currently working in good measurement accuracy. Before replacing consumables, some analyzers had worked in poor sensitivity due to degraded parts after years of use. Because this trouble was caused by delaying of replacing consumables, we marked the timing of replacing parts on the annual maintenance schedule to prevent.

2) Calibration of O3 Analyzer

Four new O_3 analyzers were delivered from Japan in March 2015, and they have been operating at the four APRD AQMSs. We performed calibrations on the four O_3 analyzers using a standard O_3 gas generator in March 2016; we confirmed that these analyzers have been operating well. Parts replacement and a second O_3 calibration were performed in January 2017 with satisfactory results.

Figure 2.2-6 Images of O_3 Analyzer Periodic Maintenance at CLEM Reference Laboratory

3) Calibration of Other Types of Gas Analyzers

High-accuracy standard gasses (SO_2, NO, and CO) were delivered from Japan in June 2016. They were used to accurately calibrate the gas analyzers at the APRD Monitoring Stations, enabling confidence in the calibration. Calibration tasks are much easier for maintenance staff because gas cylinders have being installed in each AQMS.

4) Maintenance Record Sheet

The staff generated a maintenance record sheet, and APRD now maintain the records of maintenance tasks at Monitoring Stations. This record sheet is retained as a quality control document and provided by the APRD.

(2). QA/QC in CLEM AQMSs

We began quality control activities after obtaining high-accuracy standard gasses. Activities 2-3 developed the QA/QC capabilities for the AQMSs from CLEM, a NAMEM-affiliated laboratory.

Table 2.2-12 Status of Project Activities 3

Project Activities	Achievement
Activity 2-3 QA/QC (Quality Assurance/ Quality Control) capabilities are developed at NAMEM.	Improved

The CLEM AQMS's have analyzer problems that are unrelated to managing accuracy. There are more than a few analyzers that are not operational due to the lack of replacement consumables or available repair parts. Such funding or activities are outside of our responsibility for this project. Therefore, JICA technical support concentrated its effort with CLEM on the measurement accuracy and sensitivity verification of the analyzers.

This project provides devices for quality control to the CLEM Reference Laboratory. These devices enable CLEM to perform different types of inspections for measurement accuracy, which CLEM could not make without support. Table 2.2-13 shows the usage and status of the quality control devices.

Table 2.2-13 Usage, Status, and Schedule of Quality Control Devices

Name/Model Number	Usage, Using Status & Schedule
Standard gas dilutor with zero gas unit (fixed type) GASCAL1100, 8301LC	A standard device for gas dilution. It has been used since the summer of 2015 for sensitivity check of analyzers brought into the CLEM laboratory.
Standard gas dilutor with zero gas unit (portable type) * SG-741	When questionable conditions were observed in the diluter of the monitoring station, this device is used as standard diluter to check conditions. It has been used since the 2016 winter season; it has been repaired once due to damage received in the spring of 2016.
High precision O_3 standard gas generator with zero gas unit * 49i-PS, 94-1	Standard calibrator for the O_3 analyzer; it is used to calibrate the four O_3 analyzers in the AQMSs.
Ambient SO_2 analyzer * APSA370	These units have been used since March 2016 to check the working condition of the diluter or analyzers brought from the AQMSs.
Ambient NOx analyzer * APNA370	
Ambient CO analyzer * APMA370	
Data recorder KR3121-NOA	
19 in rack	Racks are used to accommodate the equipment listed previously.
Standard flow meter ML-500-B	This is used as the flow standard to check the flow rate of air samplers, such as the PM sampler.
Standard flow meter RK1400	This is used for check the analyzer flow rates in the AQMSs.
Mass flow meter CMS95000	Used to check the low flow rate of analyzers in the CLEM AQMSs.
Flow meter for low flow rate GLF-1000	Also used to check the low flow rate of analyzers in the CLEM AQMSs.
Standard Barometer PTB330TS	This was used and registered as a pressure standard in the CLEM laboratory.
Temperature and humidity testing chamber (portable type) * RHCL-2	This was used and registered as a temperature and humidity standard in the CLEM laboratory.
Weather meter (portable type) PRMET-100	This used this for field air measurements by the CLEM group, who are planning the running schedule.

*: The CLEM staff has experience and technical; they learned to operate many devices by reading the attached operation manuals on their own. For other devices (*) that require instruction, CLEM staff learned to operate from explanations from the experts in field use.

CLEM staff has independently conducted the inspection of calibration accuracy on the CLEM AQMS network since the end of 2016 using a portable type standard gas dilutor. This is one outcome of technical support, because it contributes to strengthening the quality control of CLEM.

CLEM did not previously keep maintenance records of the maintenance work performed at the AQMS. No record form was prepared until the end of 2016, and CLEM could not trace and confirm the past results of calibration regarding quality control. Therefore, CLEM generated record sheets for project generated maintenance records at the beginning of 2017; they will be used in the future.

2.2.1.4 Annual Validated Monitoring Data

To verify the progress of Output 2-1 "Out of the 8,760 hours in-total for air quality monitoring, reliable data are obtained for more than 6,000 hours.", the reliable hours of monitoring data from APRD and NAMEM were counted. The hours of validated monitoring data in 2016 at continuous monitoring stations in UB City are shown in Table 2.2-14. In addition, the result may be different from the numbers of hours published by APRD or NAMEM, because JICA Experts decided to exclude some hours of monitored data as missing data.

Table 2.2-14 Hours of Validated Monitoring Data during 2016

(APRD: 2016/1/1~2016/12/31、CLEM: 2016/1/1~2016/12/31)

Hours of Validated Monitoring Data from Continuous Monitoring Stations in UB City (hours)

	NO	NO2	NOx	CO	O3	SO2	PM10	PM2.5	PM1
CLEM-1	36	36	36	0	4557	2137	8246	-	-
CLEM-2	8033	8033	8033	4901	-	7840	8232	8251	-
CLEM-4	8570	8570	8570	8558	7774	7961	8495	8415	-
CLEM-5	8605	8605	8605	7331	8629	7937	8619	-	-
CLEM-7	5003	5003	5003	8093	-	7547	7197	-	-
CLEM-8	6983	6983	6983	4208	6472	4672	6767	-	-
APRD-01	8284	8292	8293	8331	8537	8046	8431	8431	8431
APRD-02	8630	8631	8631	8647	7784	8352	8606	8606	8606
APRD-03	7791	7799	7798	7823	7662	7673	6890	6890	6890
APRD-04	6440	6440	6440	6607	6599	6321	6692	6692	6692
APRD-06	-	-	-	-	-	5266	5283	5260	-

Hours of Missing Monitoring Data from Continuous Monitoring Stations in UB City (hours)

	NO	NO2	NOx	CO	O3	SO2	PM10	PM2.5	PM1
CLEM-1	8748	8748	8748	8784	4227	6647	538	-	-
CLEM-2	751	751	751	3883	-	944	552	533	-
CLEM-4	214	214	214	226	1010	823	289	369	-
CLEM-5	179	179	179	1453	155	847	165	-	-
CLEM-7	3781	3781	3781	691	-	1237	1587	-	-
CLEM-8	1801	1801	1801	4576	2312	4112	2017	-	-
APRD-01	500	492	491	453	247	738	353	353	353
APRD-02	154	153	153	137	1000	432	178	178	178
APRD-03	993	985	986	961	1122	1111	1894	1894	1894
APRD-04	2344	2344	2344	2177	2185	2463	2092	2092	2092
APRD-06	-	-	-	-	-	926	909	932	-

Ratio of Validated Monitoring Data from Continuous Monitoring Stations in UB City (%)

	NO	NO2	NOx	CO	O3	SO2	PM10	PM2.5	PM1
CLEM-1	0.4	0.4	0.4	0.0	51.9	24.3	93.9	-	-
CLEM-2	91.5	91.5	91.5	55.8	-	89.3	93.7	93.9	-
CLEM-4	97.6	97.6	97.6	97.4	88.5	90.6	96.7	95.8	-
CLEM-5	98.0	98.0	98.0	83.5	98.2	90.4	98.1	-	-
CLEM-7	57.0	57.0	57.0	92.1	-	85.9	81.9	-	-
CLEM-8	79.5	79.5	79.5	47.9	73.7	53.2	77.0	-	-
APRD-01	94.3	94.4	94.4	94.8	97.2	91.6	96.0	96.0	96.0
APRD-02	98.2	98.3	98.3	98.4	88.6	95.1	98.0	98.0	98.0
APRD-03	88.7	88.8	88.8	89.1	87.2	87.4	78.4	78.4	78.4
APRD-04	73.3	73.3	73.3	75.2	75.1	72.0	76.2	76.2	76.2
APRD-06	-	-	-	-	-	85.0	85.3	84.9	-

(shaded): < 68.31% at present (6000/8784 = 68.31%)

Output 2-1 was accomplished as hours of validated monitoring data exceeded 6,000 hours at all four APRD stations for all target pollutants.

The hours of validated monitoring data at APRD-06 (Bayankhoshuu) did not reach 6,000 hours as the monitoring started in April 2006. However, the ratio of validated monitoring data was around 85%, which was much higher than the 68.31%, the ratio of hours for 6,000 annual monitoring hours.

Some analyzers maintained by CLEM did not continuously monitor air quality because of analyzer malfunctions or lack of periodically replaced parts. For example, the air quality monitoring hours ratio for NOx and CO analyzers from CLEM-1 were less than 1% in 2016. According to the analyzer manuals, the CLEM experts claimed necessary costs to NAMEM every year. However, the government and/or MET failed to allocate the required budgets, which caused difficulties in air quality monitoring. To continue air quality monitoring by NAMEM/CLEM, State Great Khural, MET, and NAMEM must allocate full budgets for periodically replaced parts and standard gasses calculated by the JICA Experts and additional budgets for unexpected expenses, which are necessary to repair malfunctioned analyzers quickly.

2.2.1.5 Evaluation of Monitoring Data and the Monthly and Annual Reports

The JICA Expert Team assisted APRD and NAMEM to accomplish Output 2-2 “At least more than eighteen monthly reports and two annual reports are presented by using corrected data from the AQMSs (air quality monitoring stations) network.” and output 4-1 “Air quality management reports are presented to decision makers at least three times during the Project.”

Hourly monitoring data from APRD stations are reported to NAMEM every week and issued and published from NAMEM based on the Mongolian domestic rule. However, monitoring data from APRD stations were not referred to in the previous reports, because they contained many missing values and were unreliable.

JICA Experts implemented assistance as indicated, as follows, in addition to the rehabilitation of monitoring stations, to implement activity 4-2 “Communication between decision makers, APRD and NAMEM is strengthened by establishing periodical air quality reports.”

(1). Validation by APRD

Hourly monitoring data from APRD stations are reported to NAMEM every week, which NAMEM issues and publish based on the Mongolian domestic rule. Therefore, the role of APRD in the validation process is the validation of hourly data.

APRD was validating air quality data using only data saved in the data logger, and did consider any maintenance information at the sites. As the result, the APRD sometimes reported analyzer output during a calibration period or from damaged equipment as validated data in 2015. The site work team began to compile the site work reports and submit to the validation team in February 2016. The JICA Experts and APRD discussed the organization of workflow to utilize the maintenance information in the validation process. The experts also corrected programs for the hourly data calculation, which uses raw data. As a result, an APRD Officer became able to validate and report monitoring data to NAMEM independently, and their continuous reporting ability has been established.

(2). Validation by NAMEM

The roles of NAMEM are to collect monitoring data from both APRD and CLEM stations, and to calculate and validate the statistic values, such as daily and annual averages. However, the NAMEM officer was including abnormal monitoring data based on an individual's subjective judgment, and there was no obvious decision guidelines used.

NAMEM and JICA Experts discussed creating monitoring data validation guidelines. NAMEM drafted a version of the Monitoring Data Validation Guideline in May 2016. JICA Experts advised on making improvements to the guidelines based on Japanese Continuous Monitoring Manual of Ambient Air (Japanese Ministry of Environment, 2010, ver. 6). As a result, the guidelines were finalized in November 2016.

In addition, the NAMEM officer in supervising the guidelines joined the training course in Japan. Based on the content learned from the training course, they presented an action plan for issuing guidelines during the training.

(3). Monthly and Annual Report

By rehabilitation of air quality monitoring stations and training on maintenance, APRD established workflow to provide more reliable monitoring data to NAMEM every week. As a result, the monitored data from APRD station has become published in the monthly report from January 2015, in which only monitoring data from CLEM stations were reported before. Also, the monitoring data from the new station (Bayankhoshuu) has been added in monthly report since December 2016. After January 2015until present (February 2017), the monthly reports were published 25 times, and will be published continuously, accomplishing the output 2-2.

Table 2.2-15 Example of Monthly Report including Monitoring Data from APRD stations (December 2016)

Сум, дүүрэг 2016 оны 12 дугаар сарын байдлаар

Үзүүлэлт		Улаанбаатар														
		УБ-1	УБ-2	УБ-3	УБ-4	УБ-5	УБ-6	УБ-7	УБ-8	УБ-9	УБ-10	АББГ-1	АББГ-2	АББГ-3	АББГ-4	АББГ-6
Хүхэрлэг хий SO_2	Дундаж		0.052	0.045	0.060	0.102	0.045	0.039	0.044	0.047	0.035	0.033	0.133	0.170	0.095	0.159
	Хамгийн их		0.076	0.098	0.089	0.157	0.074	0.058	0.070	0.103	0.098	0.047	0.209	0.257	0.149	0.286
	ХА-с давсан хувь Хэ		65	26	61	97	39	16	39	30	14	0	100	100	96.4	100
	мжилтийн тоо		31	31	31	31	23	31	31	30	28	19	31	31	28	25
Азотын давхар исэл NO_2	Дундаж		0.116	0.042	0.102	0.072	0.035	0.069	0.064	0.043	0.033	0.038	0.083	0.074	0.054	
	Хамгийн их		0.156	0.066	0.160	0.086	0.068	0.102	0.103	0.063	0.064	0.049	0.117	0.092	0.087	
	ХА-с давсан хувь Хэ		100	16	87	97	17	87	71	20	7	0	94	100	57.1	
	мжилтийн тоо		30	31	31	30	24	31	31	30	28	19	31	31	28	
Нүүрстөрөгчийн дутуу исэл CO	Дундаж				2.292	3.506		1.486				1.731	4.705	5.259	2.435	
	Хамгийн их				5.850	8.963		4.388				3.183	10.594	10.811	6.762	
	ХА-с давсан хувь Хэ				0	0		0				0	1	4	0	
	мжилтийн тоо				92	53		93				61	93	93	85	
Тоос, PM10	Дундаж	0.113	0.194	0.217	0.179	0.443		0.218	0.097			0.158	0.386	0.301	0.158	0.578
	Хамгийн их	0.237	0.456	0.451	0.401	0.872		0.491	0.209			0.252	0.685	0.420	0.292	1.096
	ХА-с давсан хувь Хэ	48	81	94	84	97		94	45			100	100	100	92.9	100
	мжилтийн тоо	29	31	18	31	31		31	31			22	31	31	28	25
Тоос, PM2.5	Дундаж		0.153		0.130							0.148	0.368	0.287	0.136	0.567
	Хамгийн их		0.366		0.232							0.238	0.641	0.403	0.246	1.065
	ХА-с давсан хувь Хэ		97		97							100	100	100	100	100
	мжилтийн тоо		31		31							22	31	31	28	25
Озон O_3	Дундаж				0.006	0.004			0.033			0.008	0.011	0.012	0.019	
	Хамгийн их				0.030	0.022			0.057			0.027	0.032	0.030	0.048	
	ХА-с давсан хувь Хэ				0	0			0			0	0	0	0	
	мжилтийн тоо				93	92			93			61	93	93	85	

Тайлбар: Улаанбаатар хотын агаар дахь бохирдуулах бодис SO_2, NO_2, PM10, PM2.5-г 24 цагийн дундаж, CO, O_3-г 8 цагийн дундаж,
Дархан, Эрдэнэт хотын SO_2, NO_2-ийг 20 минутын дундаж, PM10-г 24 цагийн дундаж агууламжаар тус тус тодорхойлсон болно.
ХА- Хүлцэх агууламж
ХА-с давсан хувь- ХА-аас давсан тохиолдлын тоог хувиар илэрхийлсэн

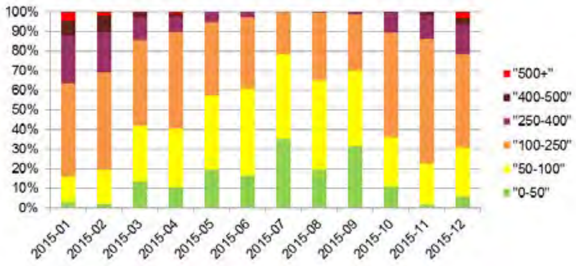
The 2015 annual report was published in October 2015, based on 2014 monitoring data. The JICA Experts and NAMEM together added new analyses in the report to better understand the air pollution conditions; the analyses were implemented in the seminar held in April 2015.

The annual report based on monitoring data from 2015 was published in October 2016. The monitoring data from APRD stations were newly added to the report in this year, the same as monthly reports, indicating that the workflow to publish monitoring data in UB City has been integrated. In addition, the NAMEM officer integrated the analyses into the 2016 annual report independently; these were added to annual report from 2015 based on documents and programs provided by JICA Experts.

Although the annual reports have improved over these two years, the reports were published in October of the year after the last data were measured; this is too late to utilize these reports for air pollution management in the following year. To discuss air pollution management policy in summer, the air pollution condition of previous year should be published before spring of the next year. Thus, the JICA Experts and NAMEM officers created a schedule to issue the next annual report by spring, 2017 based on monitoring data from 2016. Currently, the JICA Experts are assisting NAMEM to implement analyses according to the schedule.

Examples of analyses implemented by NAMEM and assisted by JICA Experts are provided in Figure 2.2-7. Also, the improvements to the annual report are listed in Table 2.2-16.

Annual Change of PM10 (daily average)



Monthly AQI Histogram of PM10

Figure 2.2-7 Examples of Analyses Added in the Annual Report (Obtained from the Annual Report issued in October 2016)

Table 2.2-16 Improvement of Annual Reports

Data year	Issued year and month	Improvement
2014	2015.10	- JICA Experts and NAMEM together added new analyses.
2015	2016.10	- New monitoring data from APRD stations were added ・NAMEM officer implemented analyses for annual report 2016 himself
2016	2017.4 (in progress)	・Annual report will be published earlier to contribute to air pollution management policy for next winter ・NAMEM officer implemented analyses himself

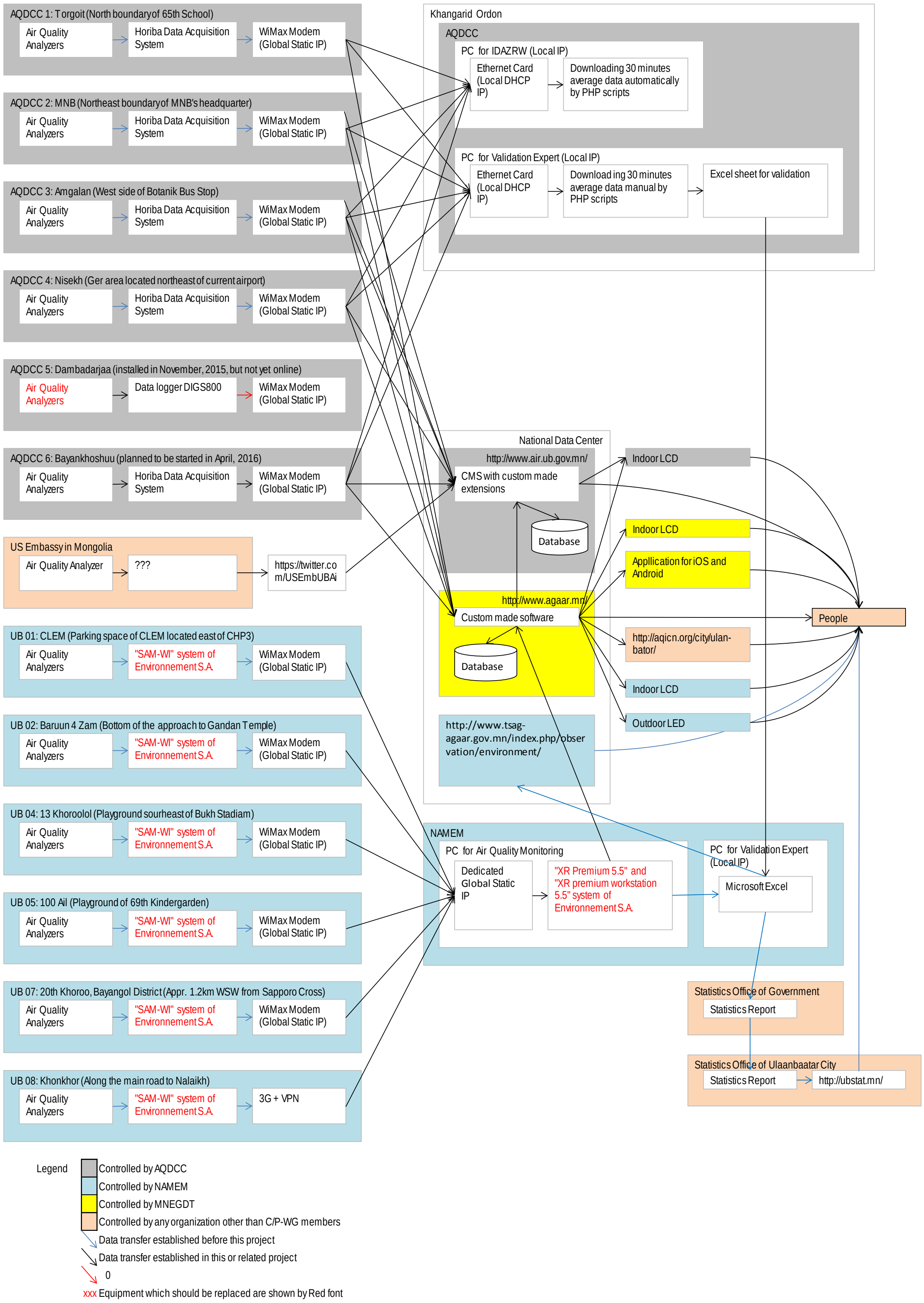
Output 2-2 “At least more than eighteen monthly reports and two annual reports are presented by using corrected data from the AQMSs (Air Quality Monitoring Stations) network.” has been accomplished with the activities above. Output 4-1 “Air quality management reports are presented to decision makers at least three times during the Project.” will be accomplished by issuing NAMEM annual report, which will be issued in April 2017 and published in May 2015.

2.2.1.6 Integrated Ambient Air Quality Monitoring Information System

System diagram of developed Integrated Ambient Air Quality Monitoring Information System is shown in Figure 2.2-8. The air quality data of 5 APRD stations are downloaded directly, separately in parallel by the station maintenance team of APRD, the data validation team of APRD, the website of APRD, and the Air Quality Smart Control System.

The air quality data of 6 NAMEM stations are downloaded by the data server managed by and located in NAMEM. The data in this data server is used by the data validation team of NAMEM, and the Air Quality Smart Control System.

There is another air quality monitoring station in UB which only monitors PM2.5, owned by and located in USA Embassy. It was installed in summer 2015 and the data became open to public from October 2015. From January 2016, with support of JICA Expert, APRD started to show air quality data of NAMEM and USA Embassy based on permissions from the organizations.



Source: JICA Expert Team

Figure 2.2-8 System Diagram of Developed Integrated Ambient Air Quality Monitoring Information System

(1). Organizational Structure

Organizational Structure is shown below.

Table 2.2-17 Organizational for Integrated Ambient Air Quality Monitoring Information System

Coordination	MET
Server	National Data Center
Technical Support in IT	The consultant that developed the system (ASTVISION Company)
Technical Support in Air Quality Monitoring Contents	NAMEM, CLEM, APRD
Technical cooperation via NAMEM, CLEM, APRD	JICA Expert

Source: JICA Expert Team

January 2016, data logging PC in UB05 of NAMEM/CLEM station was damaged. The expert of CLEM substituted the PC, and recovered the software and necessary configuration.

PM analyzers bought by APRD in 2015 had not been used because data logger could not receive data from new analyzers. JICA Expert studied the handshake between analyzer and data logger and discussed with the engineer of the manufacturer. Since software bug was found in the latest firmware, and older version firmware may solve this problem. The experts of CLEM and APRD, without JICA Expert, succeeded to change the firmware of one analyzer on 4^{th} May 2016, and data transfer was started. As the result, new PM analyzers became fully online on 21th June 2016, by changing the firmware of other 3 PM analyzers.

In September 2016, APRD received new weather sensors for Amgalan and Tolgoit stations by the budget of UBCAP Project. APRD, under the support of Interscience Company, connected these sensors to Integrated Ambient Air Quality Monitoring Information System.

Accordingly, the project team concluded that Mongolian organizations have basic capacity to maintain and replace the system.

(2). Manuals for Integrated Ambient Air Quality Monitoring Information System

In order to keep the websites online even after the JICA Project, APRD, NAMEM and MET must train any new personnel in future. Manual is required for this training. Following plan was proposed in PR4, and approved by JCC.

1) Manuals supplied by manufactures are the basic training materials for each part of the system.
2) The manual on Air Quality Smart Control System was prepared by the system developer ASTVISION Company, and was submitted to NCAPR, and handed to MET. The manual will not be included into

the manual of JICA Project because the manual was prepared under the contract between NCAPR and ASTVISION Company.

3) Any missing information from the manuals 1) and 2) above, JICA Expert, APRD and/or NAMEM have prepared manuals, which are combined as “Air Quality Monitoring Manual for Integrated Network and Public Dissemination”. Since this combined manual contains confidential information such as user name and password, it will be shared directly with the persons in charge instead of the final report that will be publicly available.

(3). **Issues Remained for Integrated Ambient Air Quality Monitoring Information System**

Following issues recommended by JICA Expert are not scheduled to be realized. It is recommended to be discussed again by Mongolian stakeholders to realize.

1. PM air quality data from NAMEM stations are shown in 1 hour delay. The system is suggested to be configured and/or updated to show correctly.
2. O2 is not air pollutant. Icon of Air Quality Smart Control System is recommended to be changed any other icon and not use O2.
3. Air pollution depends on local life cycles. The data is suggested to be saved with local time stamp.
4. Whenever IT Expert of NAMEM has any issue which is not solved by himself, he consulted with IT consultants who developed Air Quality Smart Control System. Support contract for this is recommended to be extended.
5. APRD’s system transfers analyzer status and error information with air quality data. APRD is recommended to use the status and error information in order to improve the station maintenance quality.

2.2.1.7 Ambient Air Quality Monitoring Network Design for Future

In April 2015, according to the discussion between APRD and JICA Expert Team, the future ambient air quality monitoring network was designed based on the following standards.

1. Regulation of Ministry of Environment, Japan. It is a standard to operate automated air quality monitoring based on Article 22 of Air Pollution Control Act (last amendment on 31st March, 2010)
2. “Chapter 6: Monitoring Network Design” of Quality Assurance Handbook for Air Pollution Measurement Systems Volume II Ambient Air Quality Monitoring Program, issued by USEPA

Appropriate area for additional monitoring station was examined for issuing advisory service, inspecting air quality and studying air pollution control measures. As the result, the following 2 areas were recommended.

3. Ger area which is inside the valley of Selbe River, far from Selbe River riverbed and far from hill slopes. In details, approximately 300m from the main road from 4-n Buudal to 7-n Buudal.
4. Central area of Bayankhoshuu Ger Area. In details, approximately 500m from the main intersection of Bayankhoshuu.

Following areas are proposed as additional areas if more maintenance and operation budget will be secured.

5. A station to monitor actual background air quality because current background air quality stations are largely affected by human activities. UB-08 (Urgakh Naran) is largely affected by vehicle and APRD-04 (Nisekh) is largely affected by Ger Area.
6. The station for observing actual background would be difficult to maintain because of unstable electricity, unstable data communication, too far to visit the station frequent for maintenance, and security. As an alternative, semi-background station is proposed. Any urbanized area where least effect of air pollution from Ger area, vehicle, railway and construction is expected. For examples, area around national park institute where far from road, railway and construction works.
7. Additional Ger area air quality monitoring stations in order to upgrade advisory service and inspect air quality. For examples, Sharkhad, Uliastai and Yarmag.
8. New air quality monitoring where vehicle affect most and Ger area effect is least. For examples, along Enkhtaiwan Avenue between Mongolian State University of Education and Central Post Office.

In May 2015, JICA Expert Team discussed with NAMEM and agreed as follows.

9. MEGDT secured budget for 1 additional air quality monitoring station by 2015 budget of CAF. Adjustment is necessary between CAF and JICA Project not to locate 2 stations near each other.
10. Although NAMEM considered that background air quality monitoring station is important, it is not appropriate to set the station now because damage risk caused by power failure and communication system risk are high. NAMEM agreed with proposal to set 2 stations this year, one at Selbe River Area and the other at Bayankhoshuu

According to the discussion and design above, the project team and the related organizations made the following progress by April 2016.

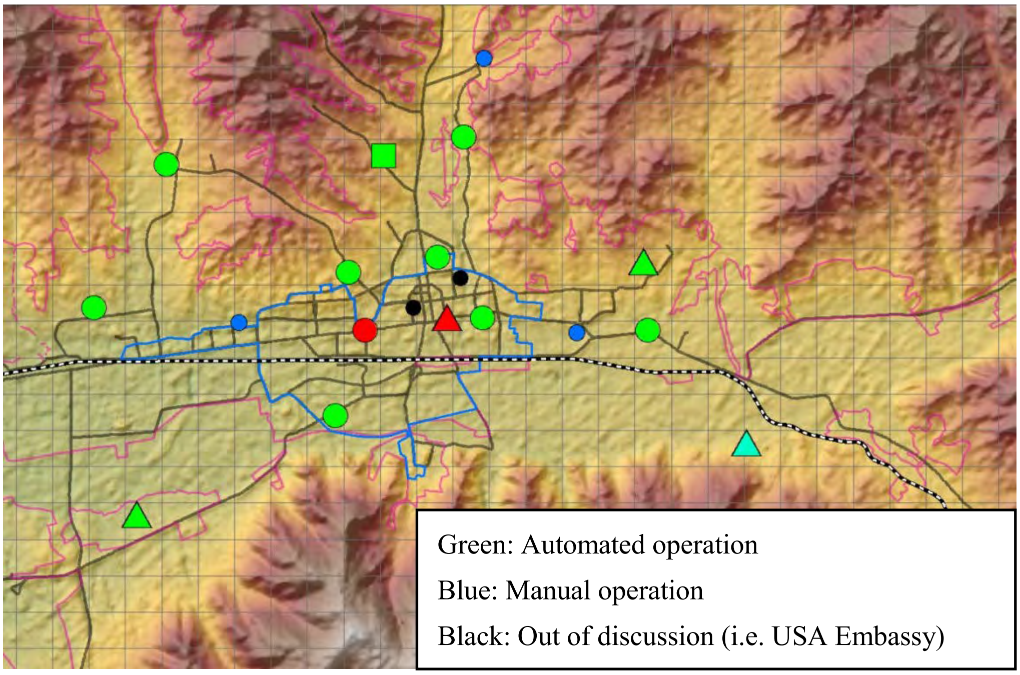
For the Ger area inside the Valley of Selbe River, APRD settled a new air quality monitoring station in November 2015, using the second hands analyzers and related equipment donated by Seoul Municipality of Korea.

For the Ger area of the central area of Bayankhoshuu, APRD and JICA Expert Team established a new air quality monitoring station in April 2016, using the new analyzers and related equipment donated by JICA.

The JICA Expert Team is currently connecting the station to the Integrated Ambient Air Quality Monitoring Information System, operated by APRD and NAMEM.

The process to buy 2 sets of analyzers by budget 2015 of CAF was cancelled. In April 2016, NAMEM is attempting to install 1 air quality monitoring station by UBCAP budget. JICA Expert recommended NAMEM to install the station in any of the additional areas proposed above. However, NAMEM prefers to upgrade any of existing manual monitoring stations to automatic. UBCAP requested NAMEM for higher security of the new station. Takhilt Meteorological Station is being nominated and with Takhilt Meteorological Station, one more automated air quality station will be installed along the boundary between Ger and apartment area. Therefore, Takhilt is not a suitable location in terms of air quality monitoring defined above.

Figure 2.2-9 shows the last proposal based on JICA Expert and APRD discussion.



Source: JICA Expert Team

Figure 2.2-9 Distribution of Air Quality Monitoring Stations Proposed

2.2.1.8 Establishment of a New AQMS

There is no continuous air monitoring system built in the outskirts of UB City, in particular the Ger area compared to the AQMS network coverage across the major central area in the capital city. The air pollution status in Ger area has not been identified in detail; however, inhabitants have experienced severe air pollution in the winter season. Therefore, one district was selected as a new monitoring site based on examination result of the proper study location for AQMSs, Bayankhoshuu district.

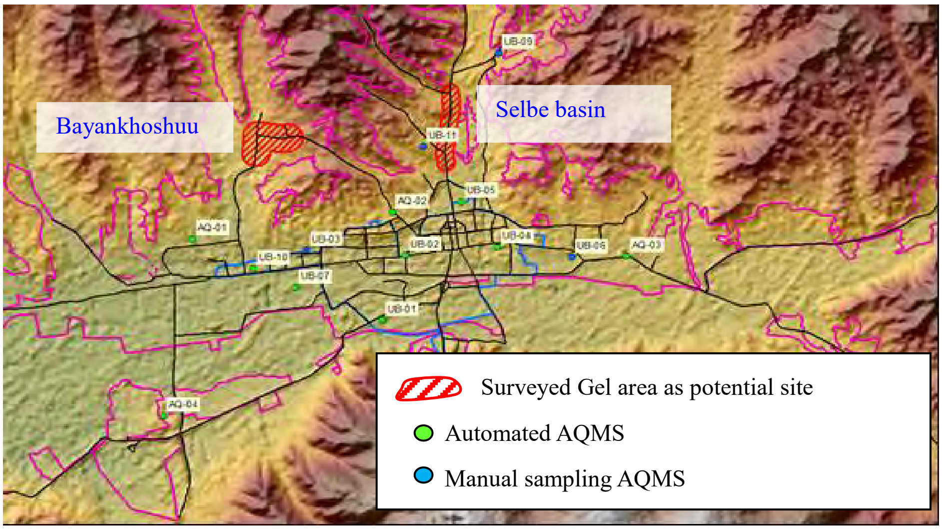


Figure 2.2-10 Location of a Newly Established Air Monitoring Station (Bayankhoshuu)

Together, APRD and the expert verified the appropriateness of the installation site for a new AQMS using our own investigation and preliminary survey. APRD finally decided to select Bayankhoshuu as a new site. Measurement devices and a shelter were provided by Japan; the APRD supplied the land, fence, and power supply line. A new AQMS has been operative and in good working condition since the end of April 2016.

Figure 2.2-11 Images of Newly Established AQMS

The room layout for the new AQMS is almost identical to the four existing AQMSs. Considering the weather impact and structural change, the expert requested an indigenous housing vendor to provide one-year of service in the agreement with JICA.

Table 2.2-12 Major Equipment Installed at the Bayankhoshuu Air Monitoring Station

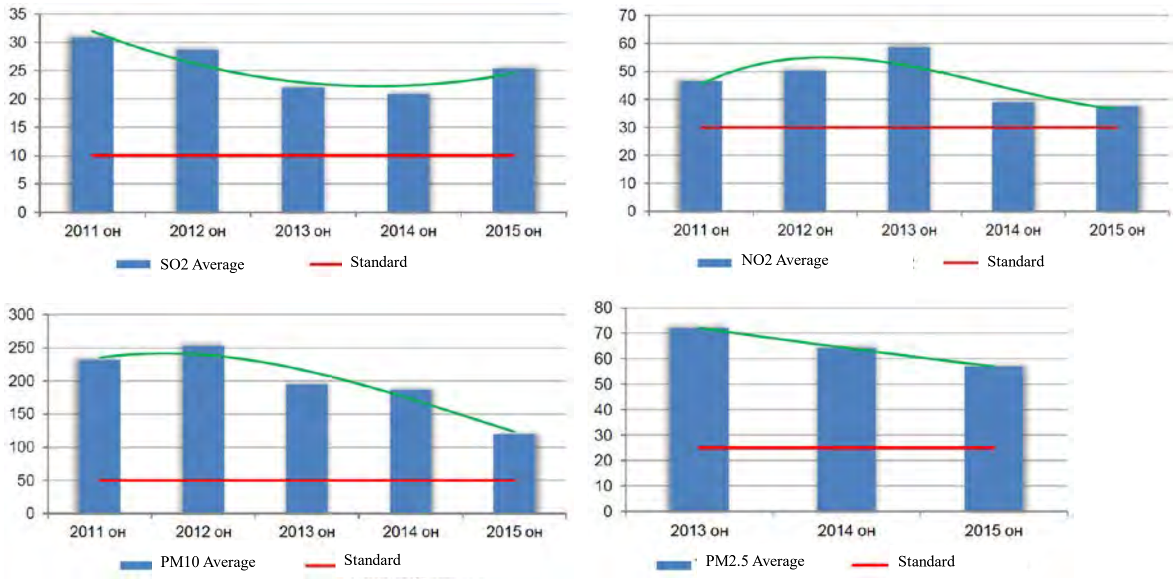
Equipment	Name
Monitors	Ambient SO_2 monitor Ambient PM10 monitor, Ambient PM2.5 monitor Weather monitors for wind direction/speed, temperature, relative humidity, and solar radiation
Peripheral Devices	Standard gas dilutor, data acquisition system, air conditioner, air sampling system, 19 in rack, and gas cylinder stand
Furniture	Desk, chair, and fire extinguisher

2.2.1.9 Preliminary Analysis of Air Quality Monitoring Data

According to activity 3-4 “Reliabilities for ambient air quality monitoring data and emission inventory is reviewed.” A preliminary analysis of the pollution structure was implemented. The current air pollution condition in UB City is reported below. These preliminary analyses were reported in the annual report published by NAMEM in September 2016, based on monitoring data from 2015.

(1). **Annual trend**

Annual trends in air pollution in UB City are provided in Figure 2.2-12. The mean annual SO2 has decreased since 2011, but the concentration in 2015 was higher than that in 2014. The mean annual NO2 increased from 2010 to 2013, and then decreased until 2015. In particular, the concentration in 2013 was two times higher than the air quality standard (indicated with a red line). The concentration of PM10 has decreased gradually since 2012, but is still two times higher than the air quality standard. The mean annual PM2.5 has been decreasing every year since 2013. However, it is still almost two times higher than the air quality standard, causing severe air pollution.



Source: NAMEM Annual report 2016

Figure 2.2-12 Annual Trends in UB City Air Pollutants

(2). Values in Excess of Air Quality Standards

Air quality standard excesses in 2015 are provided in Table 2.2-18. The SO_2, NO_2, PM10, and PM2.5, both daily and annual averages, were in excess of the standard at every monitoring station. There were stations with annual SO_2 averages reached five times the standard, four times the standard for PM, and double the standard for NO_2. In contrast, eight-hour averages of O_3 and CO met the standard at some stations, suggesting the pollution from these air pollutants was relatively light compared with other pollutants.

Daily means of air pollutants at each station are shown in Figure 2.2-13. For SO_2 and PM in particular, it is clearly that severe pollution occurs in winter. Pollution from NO_2 increases significantly in winter. The concentrations at UB-2 and UB-4 stations were in excess of the standard all year, while SO_2 and PM concentrations decreased to lower than the standard during summer. UB-2 and UB-4 stations are located at roadsides, indicating that vehicle emissions drive NO_2 pollution.

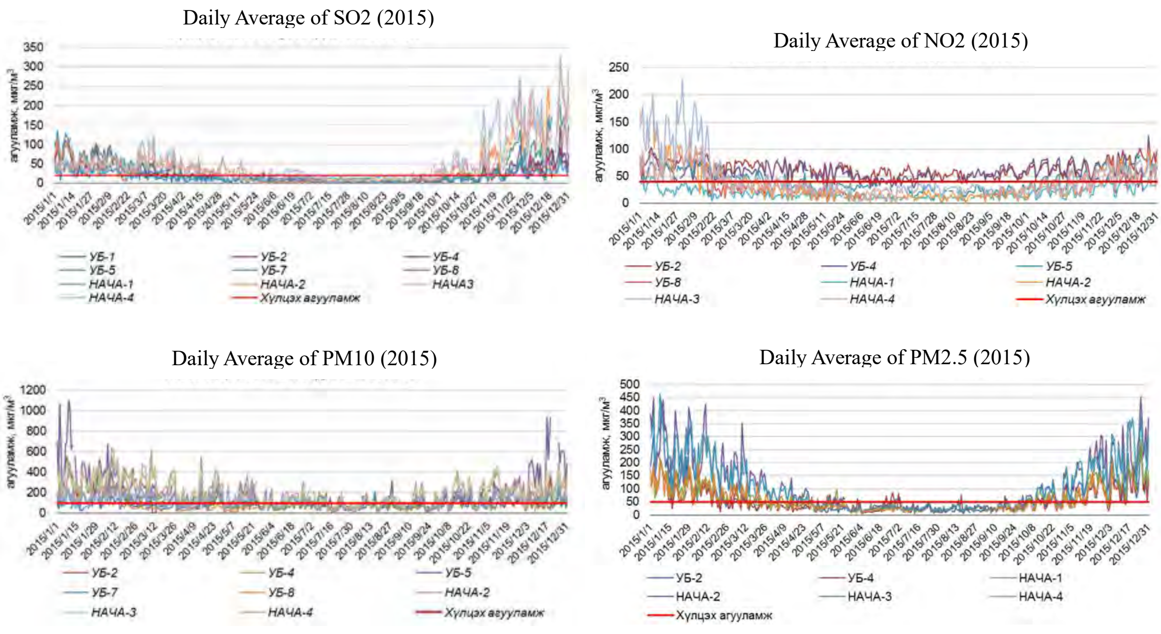
Table 2.2-18 Comparison of Data to Air Quality Standards

Station	SO2					NO2					PM10				
		24 hrs Average					24 hrs Average					24 hrs Average			
	Annual Average (μ g /m^3)	Max Conc. (μg/m3)	Validated Monitoring Data (days)	Excess of the standard (days)	Excess of the standard (%)	Annual Average (μ g /m^3)	Max Conc. (μg/m3)	Validated Monitoring Data (days)	Excess of the standard (days)	Excess of the standard (%)	Annual Average (μ g /m^3)	Max Conc. (μg/m3)	Validated Monitoring Data (days)	Excess of the standard (days)	Excess of the standard (%)
Standard	10	20				30	40				50	100			
UB-1		58	75	39	52%						74	302	323	64	20%
UB -2	25	97	344	159	46%	65	118	342	326	95%	124	546	342	173	51%
UB -4	27	148	333	147	44%	58	124	349	323	93%	198	1101	352	237	67%
UB -5	33	293	346	142	41%	41	92	336	150	45%	113	538	308	162	53%
UB -7	14	74	339	87	26%										
UB -8		77	49	25	51%		87	153	26	17%					
APRD-1	17	68	348	93	27%		52	348	10	3%	132	382	348	225	65%
APRD -2	42	317	338	187	55%	33	191	343	98	29%	205	643	352	268	76%
APRD -3	53	331	353	228	65%	47	230	359	135	38%	191	510	359	269	75%
APRD -4		236	278	219	79%		120	278	102	37%		326	267	181	68%

Station	PM2.5					CO					O3				
		24 hrs Average					8 hrs Average					8 hrs Average			
	Annual Average (μ g /m^3)	Max Conc. (μg/m3)	Validated Monitoring Data (days)	Excess of the standard (days)	Excess of the standard (%)	Annual Average (μ g /m^3)	Max Conc. (μg/m3)	Validated Monitoring Data (days)	Excess of the standard (days)	Excess of the standard (%)	Annual Average (μ g /m^3)	Max Conc. (μg/m3)	Validated Monitoring Data (days)	Excess of the standard (days)	Excess of the standard (%)
Standard	25	50				–	10000				–	100			
UB-1												119	811	2	0.20%
UB -2	63	436	337	126	37%	1498	23250	1059	7	0.70%					
UB -4	53	284	343	133	39%	873	5163	1049	0	0.00%		109	672	2	0.30%
UB -5							10138	827	1	0.10%	20	115	1060	1	0.10%
UB -7						706	4525	1028	0	0.00%					
UB -8							2275	471	0	0.00%		95	478	0	0.00%
APRD-1	62	286	348	157	45%	759	3589	1038	0	0.00%		75	798	0	0.00%
APRD -2	115	453	351	213	61%	1773	12511	1072	6	0.60%		137	794	22	2.80%
APRD -3	106	466	359	196	55%	2026	11615	1082	8	0.70%		139	827	5	0.60%
APRD -4		293	267	124	46%		5326	853	0	0.00%		101	568	1	0.20%

: items meeting standard

Source: JICA Experts (based on the NAMEM annual report published in September 2016)



Source: NAMEM Annual Report 2016

Figure 2.2-13 Air Pollutant Daily Means at Each Station

(3). Air Quality Index (AQI)

Because acceptable concentrations of air pollutants vary according to the pollutants, concentration comparisons between multiple air pollutants cannot indicate the most severe air pollution. Therefore, the ratios of air pollutant concentration to air quality standard are published as AQI (based upon A-327 in the order of Minister of Nature Environment and Green Development Act in 2014). AQI is calculated as follows:

$$Air\ Quality\ Index\ (\mathrm{AQI}) = \frac{Concentration\ of\ air\ pollutant}{Air\ Quality\ Standard\ of\ air\ pollutant} * 100$$

In addition, the pollution severity is classified into six categories, provided in Table 2.2-19. For example, an AQI larger than 100 (orange) indicates that the concentration exceeds the standard, while red indicates that the concentration reaches five times the standard.

Table 2.2-19 Air Quality Index (AQI) Classification

AQI	Classification	Color	Effects on Health
0 - 50	Good		No harmful effect on health
51 - 100	Normal		Although the concentration is below the air quality standard, there may be harmful effect to some sensitive people.
101 - 250	Polluted Light		There are harmful effects to sensitive people including those who have chronic diseases in cardiovascular or respiratory organs.
251 - 400	Polluted Middle		There are harmful effects to all people and the effects are severe to sensitive people.
401 - 500	Polluted Heavy		There are obvious hazardous effects to all people who stay outside for long periods of time.
501 <	Polluted Severe		There are obvious severe effects to all people who stay outside for long periods of time.

Source: A-327 of the order of Minister of Nature Environment and Green Development Act in 2014

According to this classification, AQI histograms are shown in Figure 2.2-14. In winter, and particularly for SO_2 and PM2.5, most are ranked as orange or worse, including red. The pollution categories indicate that winter pollution is the most severe. In contrast, orange or worse categories almost disappear during the summer season for SO_2 or PM, while the orange category remains around 20 % for NO_2, even in summer.

PM10 tends to exceed the standard even in summer, compared to PM2.5. As soil particles have relatively large sizes compared to all possible particle sources, this suggests that soil particles contribute to PM10 concentration in summer.

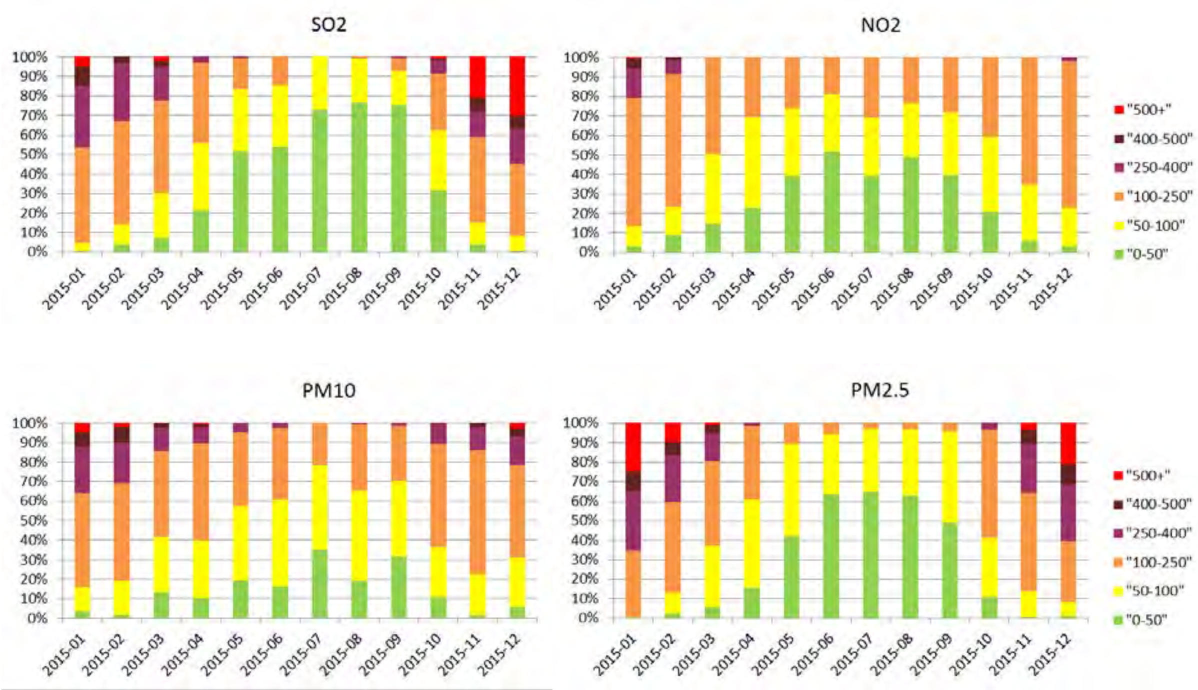


Figure 2.2-14 Monthly AQI Histogram

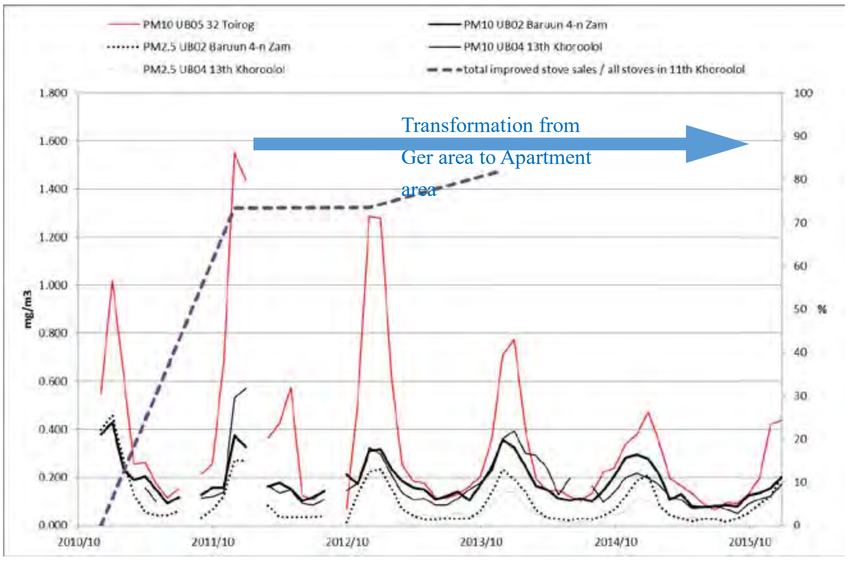
(4). <u>Example of Ambient Air Monitoring Data Analyses</u>

As an example of analyses, annual trends in PM at each station are shown in Figure 2.2-15.

UB05 station is located near the boundary between the Ger area and north side of UB City. PM10 concentration was much higher than other stations in the city. PM10 concentration increased from 2010 to 2011, and then decreased until 2014.

The relationship between UB05 stations and sales of improved stoves was analyzed. The ratio of the sales of improved stoves to all existing stoves (Table 2.2-20) was 73.3% before 2011, increasing only 8.8% after 2011. In contrast, the mean monthly PM concentration increased over 50% from January 2011 to December 2011. Then, the monthly average gradually declined to 30% of December 2011 values in January 2015. From these results, no relationship was observed between the sales of improved stoves and PM concentration.

Next, the relationship between reconstruction around the monitoring station and PM concentration was surveyed. The satellite image around station UB05 is shown in Figure 2.2-16. Around station UB05, Gers and houses were continuously replaced with apartments between 2011 until 2014. The decrease in emission sources near the UB05 stations may affect the PM10 concentration. To investigate this possibility, more detailed analyses of monitoring data taking wind condition into consideration should be added or simulation model to reveal the air pollution condition should be analyzed.



Source: Issued by JICA Experts (using preliminary CLEM data)

Figure 2.2-15 Annual Trends at CLEM Stations (Preliminary Data)

Table 2.2-20 Ratio of Improved Stove Sales / All Stoves Around UB05

	Khorool Number (Small District)	Total Stoves	Improved Stoves(%)		
			2011	2012	2013
Sukbaatar District	9	1550	76.2	76.3	81.0
	10	0	—	—	—
	11	**1954**	**73.3**	**73.5**	**82.1**
	12	1938	73.8	73.9	77.3
	13	2646	66.8	66.8	72.7
	14	1448	62.1	62.2	73.5
	15	1622	60.1	60.1	69.4
	16	2919	65.3	67.1	71.4
	17	1808	73.5	73.6	76.5

Source: Issued by JICA Experts (using data from the Statistics Bureau of UB City)

Source: Google Earth, Left: 9/23/2010, Right: 10/10/2015, Green pin indicates UB05.

Figure 2.2-16 Satellite Images of the UB05 Surroundings

2.2.1.10 Next Issues

Next issues are identified as follows;

1. Works in order not to stop air quality monitoring. In healthy condition, payment for electricity, payment for data communication, spare parts to be replaced periodically (including standard gases for calibration), human resources and transportation for operation and maintenance are necessary. In damaged condition, budget and process to repair the damaged equipment, and spare equipment to continue measurement until the damaged equipment will be repaired are necessary. In addition, many of tasks can be done by one expert only. APRD and NAMEM/CLEM should develop spare experts which will be necessary for the period when the original expert will have training abroad and/or vacation. Since the members of C/P and C/P-WG does not allowed to allocate spare experts, head of APRD and NAMEM/CLEM or any other high position person are recommended to allocate. These works should be started immediately because new problems are starting, such as PM monitor of Tolgoit Station and analyzers of UB01 Station.
2. To renew equipment. Equipment should be renewed in 7 to 10 years interval, even if they are maintained perfectly. New equipment must be compatible with the current data transfer system and/or data transfer system must be updated to manage new equipment. Since the equipment of NAMEM/CLEM stations have been used for 7 years, it is necessary to be renewed soon.
3. To add missing equipment. Since PM2.5 analyzer is not installed in 4 of 6 NAMEM/CLEM stations, 4 sets of PM2.5 analyzers are recommended to be prepared and installed.
4. To relocate air quality monitoring stations, as shown in Figure 2.2-9

2.2.2 <u>PM10 and PM2.5 Measurement and Composition Analysis</u>

In this project, PM10 or PM2.5 in the atmosphere over the UB area was collected on filters every season. Various chemical compositions in PM were quantitatively determined from the obtained filter samples. Based on the chemical analyses, the contribution concentrations of the major sources were estimated using receptor models, such as Chemical Mass Balance (CMB) analysis and Positive Matrix Factorization (PMF). Objective PM emission sources are clarified to provide countermeasures to reduce heavy air pollution in the winter season. The purpose of this project is to obtain knowledge, which contributes to such policy making.

2.2.2.1 PM Sampling (Plan and Execution)

In this project, filter samples for PM10 or PM2.5 were planned for collection at observation sites in the UB area, a total of 120 sites for three years from 2014 to 2016 every season. The obtained filter samples were analyzed chemically. Considering the security of electric power and safety, several sites for PM sampling were selected from 10 air pollution measurement stations（six CLEM stations and four APRD stations）in

UB City. In the observations after the 2014 winter season, the sample collection was also conducted at the site of a private house in Chingeltei in the northern city. The collection sites where samples were conducted during the period are shown in Figure 2.2-17.

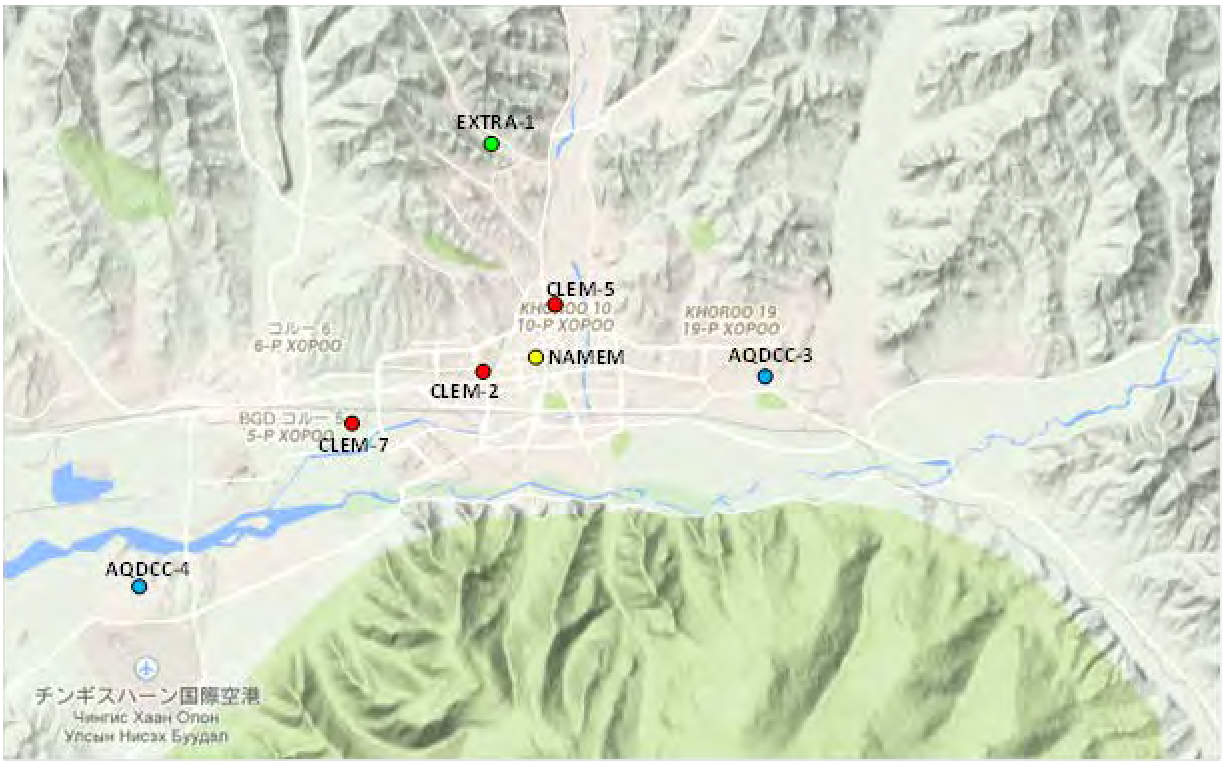


Figure 2.2-17 Location Map Showing the Collection Points of Filter Samples During the Project Period

Four FRM-2000 type samplers, from NAMEM, were used for the sampling the PM filter samples. This FRM (Federal Reference Method)-2000 type sampler is the standard equipment regulated by the U.S. EPA for measuring PM2.5 mass concentrations.

In the U.S.A., the particle size separation characteristics of the PM collection sampler, particle collection efficiency, performance characteristics, such as the hygroscopicity of the PM collection filter, and filter weighing condition around the collection are regulated in detail as a standard measuring method for mass concentrations of PM10 and PM2.5. In particular, detailed regulations consider the effects of semi-volatile material and humidity to obtain a concentration measurement error of 10% or less. In addition, the PM samples for chemical analysis were collected using the chemical speciation sampler. This collects different types of filter samples using the same conditions. After the spring of 2015, PM samples were collected using a chemical speciation sampler (MCAS-SJ) supplied by JICA at the NAMEM site.

PM samples obtained every season during the project duration are tabulated in Table 2.2-21. Preliminary PM collection was attempted in the 2013 winter season (January 17-23, 2014). PM collection over 24 h was attempted using FRM samplers, the standards used by the U.S. EPA, and five sets of PM2.5 filter samples were obtained. Based on this sampling campaign, continuous PM collection for 24 h was deemed impossible because the pressure drop of the filter exceeds the tolerance during heavy pollution in the winter.

Since then, PM sample collection has been conducted with an FRM sampler in the 2014 summer (June 20 - July 6, 2014), 2014 winter (December 15, 2014 - January 6, 2015), 2015 spring (April 18 - May 2, 2015), 2015 autumn (September 17 - October 7, 2015), and 2015 winter (January 9 – February 2, 2016), and 97 sets of PM2.5 and 103 sets of PM10 filter samples were obtained. In addition, after the 2015 spring, 45 sets of size segregated PM filter samples were also obtained using a CAS-SJ sampler supplied by JICA. Intermittent sampling at 30 min intervals is possible using the MCAS-SJ sampler and this function is extremely useful for observations in the winter season in which the air pollution is often severe in the UB area. For the 2015 winter observations, PM collection for all days was possible using intermittent sampling.

Two kinds of filters, PTFE and quartz fiber, were used for the PM sample collection. The Teflon (PTFE) filter was used for PM mass concentration measurement by the filter weighing method and elemental concentration measurement by fluorescent X-ray spectroscopy analysis. It is a stretched Teflon filter with a ring (Whatman product) that meets the U.S. EPA standards. The quartz fiber filters (Pallflex product), which is used for carbon component analysis, were preheated at 900°C prior to use for more than three hours to remove carbon. Two sheets of quartz fiber filters were used for one sampling, one filter on top of the other. The lower one is for monitoring adsorption of gaseous carbon. The mass of particulate carbon is calculated as the difference between the upper and lower filters.

2.2.2.2 Mass Measurement

a. Measuring Mass and Comparison with Automated Analyzer Outputs

The samples on PTFE filters, on which PM was collected, were used to determine mass concentration by the weighing method. Before and after sampling, filters are placed in regulated conditions (20-23°C, 30-40% relative humidity) more than 24 h and subsequently weighed. Then, each PM mass concentration is calculated based on the increase in mass after sampling. The samples collected for measurement are listed in Table 2.2-21. The PM mass concentrations measured using filter weighing method are tabulated in Table 2.2-22, and shown in Figure 2.2-18.

Table 2.2-21 Obtained PM samples in Every Season during the Project Duration

Sampling season	Observation period	No. of samples			
		FRM		M-CAS	
		PM2.5	PM10	PM2.5	PM10-25
1: Winter 2013	Jan.17, '14 - Jan. 23, '14	5	-	-	-
2: Summer 2014	Jun.20, '14 - Jul. 6, '14	11 (2)*	25 (4)*	-	-
3: Winter 2014	Dec.15, '14 - Jan. 6, '15	26	20	-	-
4: Spring 2015	Apr.18, '15 - May 2, '15	10	15	10	10
5: Autumn 2015	Sept.17, '15 - Oct. 7, '15	19 (6)*	19 (2)*	13	13
6: Winter 2015	Jan. 9, '16 - Feb. 2, '16	26	24	22	22
: Sum		97 (8)*	103 (6)*	45	45

*: No. of quartz filter sampling failure

Table 2.2-22 Mass Concentration Measurement Results from PM2.5 And PM10 Samples Using the Filter Measurement Method (mg/m^3)

Part 1

Date/Site	CLEM-2		CLEM-5		CLEM-7		AQDCC-3		AQDCC-4		EXTRA-1	
	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10
2014/1/17			103									
2014/1/18			130.5									
2014/1/20					174.2							
2014/1/21					101.1							
2014/1/23	146.4											
2014/6/20		95.8		75.7								
2014/6/21		79.2		72.7								
2014/6/22		68.9		50								
2014/6/23	66.3			91								
2014/6/24	20.1											
2014/6/25	21.7			117.1								
2014/6/26	28.5			150.3								
2014/6/27	51.2			102.2								
2014/6/28	29.4			69.3								
2014/6/29		105.2		87.7								
2014/6/30		130.9							42.5	160.2		
2014/7/1		114.3								78.7		
2014/7/2						61.7				92.8		
2014/7/3						62.2			13.9			
2014/7/4						180.7			16.7			
2014/7/5						147.6			24.2	229.3		
2014/7/6						60.3			10.1	72.5		
2014/12/15	55.1				106							
2014/12/16	149.4				166.7							
2014/12/17	198.9				243.6							
2014/12/18	38.3				51.2							
2014/12/19	115.5				135.7							
2014/12/20	46.4				101.8							
2014/12/21		260.1				261.1						
2014/12/22		182.3				230.8						
2014/12/23		165.5								84.9		
2014/12/24								280.9		237.2		
2014/12/25								88.9		212.7		
2014/12/26							183.8		140.9			
2014/12/27							126.4		184.5			
2014/12/28							142.2		87.9			
2014/12/29				130.7		144.5						
2014/12/30				187.5								163.4
2014/12/31				401.8								389.8
2015/1/1				241.3								378.9
2015/1/2				269.6								305.5
2015/1/3			321.5								304.3	
2015/1/4			62.7								36.2	
2015/1/5			141.1								149	
2015/1/6			209.9								153.6	

Part 2

Date/Site	CLEM-2		CLEM-5		CLEM-7		AQDCC-3		AQDCC-4		EXTRA-1		NAMEM	
	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM2.5-10
2015/4/18		70.8												
2015/4/20		93.4												
2015/4/21		106.7											64	9.1
2015/4/22		122.1											48.4	6.7
2015/4/23	24		66.5										56.7	8
2015/4/24	1		84.9										69.8	9.8
2015/4/25	49.8		108.3										84.9	13.1
2015/4/26		1		265.7									84.7	12.3
2015/4/27		191.7		182.3									71	10.1
2015/4/28		132.7		154.8									53.7	8.7
2015/4/29	40.7			147.5									42.1	7.5
2015/4/30	20.1			27.6										
2015/5/1	53.5			81.2										
2015/5/2	29.5			70									24.2	10.2
2015/9/17						170.8		100.2						
2015/9/18						183.6		116.6						
2015/9/19						157.5		109.5						
2015/9/20					38.7									
2015/9/21						24								
2015/9/22				36.8				21.2						
2015/9/23				35.9			18.1							
2015/9/24			19.8										36.7	3.3
2015/9/25			34.7										32	5.5
2015/9/26			43.9										25.1	4.4
2015/9/27			65.3						35.8				35	5.8
2015/9/28				192.6					72.9				46.9	8.2
2015/9/29				123.5						40.8			19.5	4
2015/9/30										25.6			35.4	6
2015/10/1		147								44.4			34.6	6.4
2015/10/2	59.3								44.1				42.4	7.2
2015/10/3	76.8								67.7				53.8	7.3
2015/10/4	89.8										44.4		66.2	11.5
2015/10/5	80.9										50.9		62.3	10.9
2015/10/6	69.1										40.7		86.5	7.6
2015/10/7												22.1		
2015/10/8												18.7		
2015/10/9		114										42.9		
2016/1/9			210.2		132.3									
2016/1/10			221.5		65.6									
2016/1/11			243.1		93.1									
2016/1/12				576.3		338							361.1	16.2
2016/1/13				189.7		88.8							119.5	5.1
2016/1/14				203		144.3							255.8	8.9
2016/1/15			276.4		185.6								117	8.1
2016/1/16					61.3						76.5		83	3.4
2016/1/17						49.3						127.3	102.6	4
2016/1/18						170.2						245	202.9	7.7
2016/1/19										179.9		297	181	8.6
2016/1/20										153.2		154.2	109.4	5.5
2016/1/21									35.9		32.4		30	3
2016/1/22									36.5		32.5		42.6	3.6
2016/1/23									52.3		206		209.8	8.1
2016/1/24	367.7								351.8				279.3	15
2016/1/25		243.1								196.4			173.6	6.6
2016/1/26		116.5								90			166.5	7.6
2016/1/27		183.5						212.3					168.9	6.5
2016/1/28		303.1						339.2					192.3	10.2
2016/1/29		151.7						207					111.1	6.6
2016/1/30	105.3						88.5						114.3	6.4
2016/1/31	104.9						123.8						219.9	11
2016/2/1	169.3						121.6						196.9	13.6

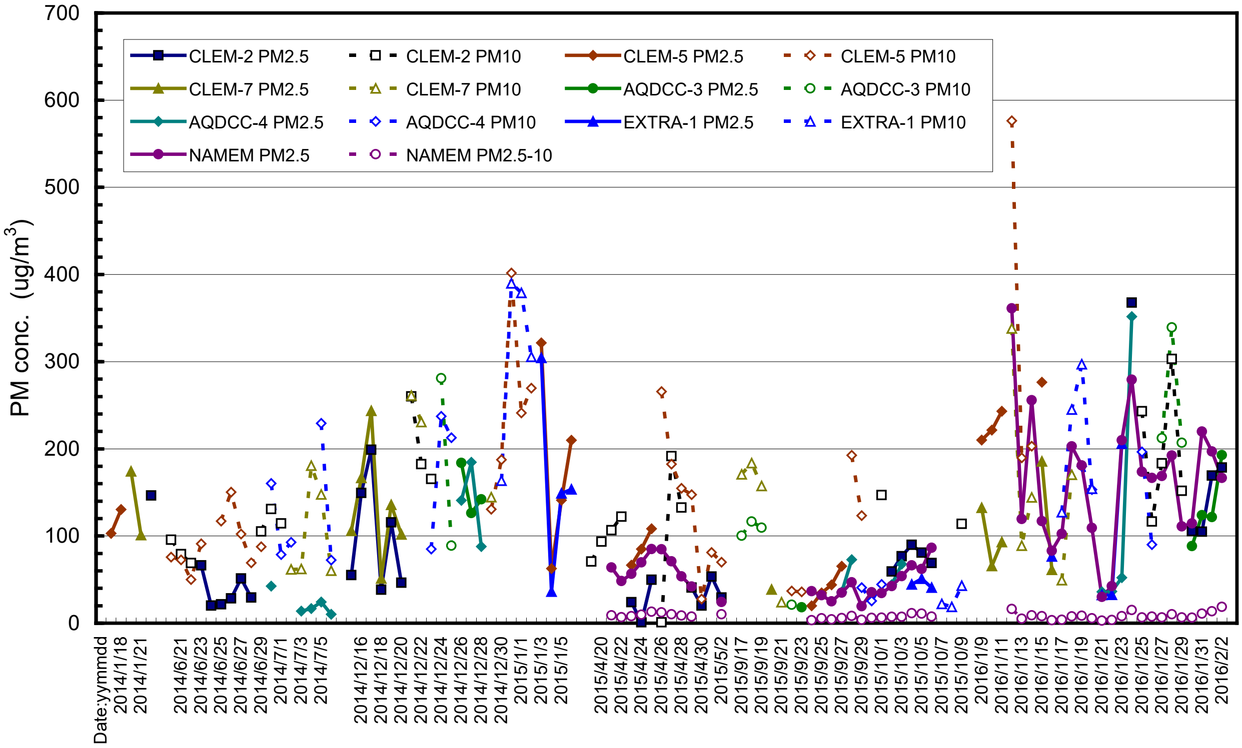


Figure 2.2-18 Mass Concentration Variation in PM2.5 and PM10 Observed At All Sites

The sum of the major emission source category concentrations, namely RCFM, should provide a reasonable estimate of the ambient dry PM2.5 mass concentration in the atmosphere. Here, the major emission sources are $(NH_4)_2SO_4$, particulate organic matter (POM), EC, crustal particles (soil), biomass aerosol, Sea salt, NH_4NO_3, and NH_4Cl. Therefore, contradictions in filter weighing mass concentration and chemical composition measurement results can be judged by comparing PM2.5 mass concentration from the filter method with the RCFM. The mass concentration of PM2.5 and RCFM calculated from the chemical composition concentrations in PM2.5 were compared (see Table 2.2-23). This result indicated that there was no contradiction in the filter weighing and analytical results of chemical composition in PM2.5.

Table 2.2-23 Comparison of PM2.5 Concentrations and RCFM at Each Observation Site Percentages of Emission Source Category Concentrations in RCFM Are Also Shown

(Part 1)

Site : CLEM-2 (%)

Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20140623	66.3	34.2	2.9	20.9	10.7	15.5	0.3	0.7	0.0	0.6	X
20140624	20.1	20.8	6.1	38.7	27.8	25.4	0.6	0.8	2.4	1.5	
20140625	21.7	24.6	4.7	58.5	18.5	26.0	0.9	0.8	2.5	1.7	
20140626	28.5	31.5	7.4	47.9	21.1	28.4	0.7	0.6	3.1	1.5	
20140627	51.2	25.0	2.7	23.0	9.1	11.3	0.2	0.5	1.5	0.6	
20140628	29.4	28.1	4.5	37.2	25.3	24.0	0.5	0.6	2.3	1.0	
20141215	55.1	35.3	13.6	33.3	8.6	5.4	0.3	0.1	1.7	1.0	X
20141216	149.4	91.4	13.2	37.7	5.9	1.4	0.1	0.1	1.5	1.4	X
20141217	198.9	180.1	13.8	60.1	9.4	1.3	0.1	0.1	3.8	1.9	
20141218	38.3	36.2	16.0	53.1	13.2	5.5	0.3	0.8	2.8	2.8	
20141219	115.5	102.1	16.8	53.7	10.2	2.6	0.2	0.4	1.5	3.0	
20141220	46.4	39.2	14.0	42.6	13.3	8.3	0.3	0.6	2.6	2.8	
20150423	24.0	28.6	5.5	56.6	19.9	28.3	1.1	1.3	3.5	3.0	
20150425	49.8	47.1	4.9	30.6	9.6	42.0	1.6	1.0	2.6	2.2	
20150429	40.7	29.0	3.8	18.5	6.3	38.3	1.4	0.5	1.3	1.0	
20150430	20.1	17.8	10.6	34.8	24.2	10.8	0.3	0.3	5.5	2.0	
20150501	53.5	36.8	3.4	15.3	6.5	40.3	1.2	0.4	1.1	0.6	
20150502	29.5	21.1	7.2	22.7	8.2	28.6	1.1	0.5	2.0	1.2	
20151002	59.3	29.2									X
20151003	76.8	75.6	5.8	31.6	11.6	43.9	1.4	0.3	1.9	1.8	
20151004	89.8	87.2	5.9	30.9	11.1	43.3	1.5	0.3	1.6	2.5	
20151005	80.9	41.4									X
20151006	69.1	62.3	4.4	12.6	6.9	63.2	1.7	0.2	0.9	0.2	
20160124	367.7	376.9	26.0	60.3	8.7	1.7	0.1	0.1	4.3	1.2	
20160130	105.3	105.5	24.8	56.6	10.0	2.3	0.2	0.7	3.1	2.5	
20160131	104.9	53.3									X
20160201	169.3	155.6	22.1	48.9	8.8	3.7	0.2	0.4	5.9	1.9	
20160202	178.6	173.6	24.1	50.4	11.1	2.6	0.1	0.2	7.3	1.5	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

(Part 2)

Site : CLEM-5 (%)

Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20150103	321.5	331.6	12.9	73.6	8.8	1.1	0.1	0.1	4.2	2.3	X
20150104	62.7	63.3	13.4	71.5	10.6	0.7	0.2	0.2	1.6	2.5	
20150105	141.1	141.1	12.7	71.3	10.6	0.5	0.1	0.1	2.0	2.6	
20150106	209.9	204.5	10.8	72.7	8.2	0.5	0.1	0.1	2.2	2.8	X
20150423	66.5	50.1	4.3	22.3	4.6	38.8	1.3	0.8	1.2	2.0	
20150424	84.9	76.7	3.7	20.4	3.8	57.3	1.8	0.7	1.3	1.4	
20150425	108.3	86.0	3.7	17.7	3.3	49.6	1.9	0.7	1.2	1.4	
20150924	19.8	18.9	7.4	50.3	15.4	15.1	1.1	0.5	1.5	4.2	
20150925	34.7	34.0	7.8	42.6	13.0	25.4	1.2	0.4	3.8	3.9	
20150926	43.9	41.4	8.4	33.9	9.8	36.0	1.4	0.4	1.9	2.5	
20150927	65.3	64.0	7.2	36.2	10.7	37.2	1.5	0.5	1.9	3.0	
20160109	210.2	254.8	20.9	79.4	9.7	3.9	0.2	0.2	3.4	3.5	X
20160110	221.5	398.9	25.0	129.2	14.5	2.7	0.2	0.1	4.0	4.4	X
20160111	243.1	222.3	24.7	48.6	7.0	4.7	0.2	0.1	4.3	1.9	
20160115	276.4	197.6	24.7	34.7	5.6	2.5	0.2	0.0	2.9	0.9	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

(Part 3)

Site : CLEM-7 (%)

Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20141215	106.0	52.9	22.1	2.6	0.4	2.0	0.1		0.0	8.5	X
20141216	166.7	198.1	17.7	83.8	9.8	2.4	0.2	0.1	2.2	2.6	X
20141217	243.6	243.0	15.5	66.3	9.2	2.3	0.1	0.1	4.0	2.3	
20141218	51.2	44.2	14.4	49.7	9.4	7.9	0.3	0.4	2.6	1.5	
20141219	135.7	125.9	19.5	57.8	8.7	2.4	0.2	0.2	1.7	2.2	
20141220	101.8	87.7	23.3	41.5	9.9	5.8	0.3	0.3	1.9	3.1	
20160109	132.3	135.7	21.5	59.8	8.0	6.5	0.4	0.1	5.3	0.9	
20160110	65.6	89.0	27.6	80.0	11.9	2.1	0.6	0.1	10.0	3.4	
20160111	93.1	131.5	31.8	82.9	10.0	3.7	0.4	0.1	11.8	0.5	
20160115	185.6	198.0	27.6	60.5	9.6	2.2	0.2	0.0	5.8	0.7	
20160116	61.3	63.5	21.3	65.3	10.0	1.3	0.5	0.3	3.3	1.5	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

(Part 4)

Site : AQDCC-3 (%)

Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20141226	183.8	155.3	12.0	55.4	9.4	3.1	0.1	0.2	2.4	1.8	
20141227	126.4	112.0	13.4	55.7	10.6	1.8	0.1	0.1	4.4	2.4	
20141228	142.2	125.3	12.5	53.7	10.5	4.9	0.2	0.3	3.6	2.4	
20150923	18.1	7.6	7.7	0.0	0.0	33.1	1.0	0.0	0.0	0.0	X
20160130	88.5	88.8	17.9	57.3	10.8	7.4	0.2	0.6	3.2	3.0	
20160131	123.8	128.9	19.0	60.6	11.0	5.6	0.2	0.9	3.5	3.3	
20160201	121.6	141.2	21.9	72.0	10.4	2.1	0.2	0.4	6.1	3.0	
20160202	192.9	218.8	21.8	69.1	11.3	3.0	0.2	0.2	5.7	2.3	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

(Part 5)

Site : AQDCC-4 (%)

Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20140630	42.5	10.0	3.4	0.0	0.0	19.6	0.7	0.0	0.0	0.0	X
20140703	13.9	15.1	7.6	51.7	6.5	40.4	0.9	1.2	0.0	0.0	
20140704	16.7	18.8	9.0	43.9	8.4	43.5	1.1	1.7	3.2	2.0	
20140705	24.2	37.1	5.0	68.8	12.0	56.8	1.4	2.5	4.4	2.3	
20140706	10.1	5.1	9.2	0.0	0.0	40.5	1.0	0.0	0.0	0.0	X
20141226	140.9	129.4	13.7	60.4	9.1	2.5	0.2	0.1	4.3	1.6	
20141227	184.5	170.6	12.3	60.7	9.1	3.3	0.2	0.1	5.0	1.9	
20141228	87.9	87.8	15.3	64.0	11.2	3.1	0.2	0.1	4.7	1.2	
20150927	35.8	14.1	9.7	0.0	0.0	28.4	1.3	0.0	0.0	0.0	X
20150928	72.9	65.5	1.5	18.4	2.7	63.7	2.0	0.3	0.8	0.3	
20151002	44.1	42.0	7.0	39.3	13.3	28.9	1.2	0.2	3.1	2.3	
20151003	67.7	37.9	4.9	0.0	0.0	49.3	1.8	0.0	0.0	0.0	X
20160121	35.9	38.0	15.4	64.6	8.8	12.9	0.5	0.4	2.5	0.7	
20160122	36.5	37.4	17.6	64.7	11.1	5.1	0.3	0.4	2.2	1.1	
20160123	52.3	47.1	16.9	59.2	7.6	2.4	0.2	0.1	2.8	0.8	
20160124	351.8	404.8	26.5	75.0	6.7	1.7	0.1	0.0	4.1	0.9	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

(Part 6)

Site : EXTRA-1 (%)

Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20150103	304.3	314.1	13.6	74.7	8.0	1.0	0.1	0.0	4.3	1.6	
20150104	36.2	36.6	13.4	71.0	12.2	1.7	0.1	0.2	1.2	1.2	
20150105	149.0	148.9	13.1	76.0	7.5	0.3	0.1	0.0	1.3	1.5	
20150106	153.6	160.6	10.1	80.7	8.2	0.4	0.1	0.1	3.0	2.0	
20151004	44.4	41.8	7.7	36.4	7.2	37.3	1.4	0.2	2.5	1.4	
20151005	50.9	20.4	7.1	0.0	0.0	31.8	1.2	0.0	0.0	0.0	X
20151006	40.7	32.8	4.5	18.0	3.7	50.5	1.7	0.3	1.6	0.3	
20160116	76.5	70.8	22.7	55.5	8.1	3.2	0.2	0.1	1.6	1.0	
20160121	32.4	26.1	16.3	44.1	6.7	11.0	0.5	0.4	0.8	0.8	
20160122	32.5	25.7	15.6	49.7	7.4	3.6	0.2	0.2	1.6	0.7	
20160123	206.0	202.3	21.4	62.9	7.7	1.5	0.1	0.0	3.0	1.6	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

(Part 7)

Site : NAMEM (%)

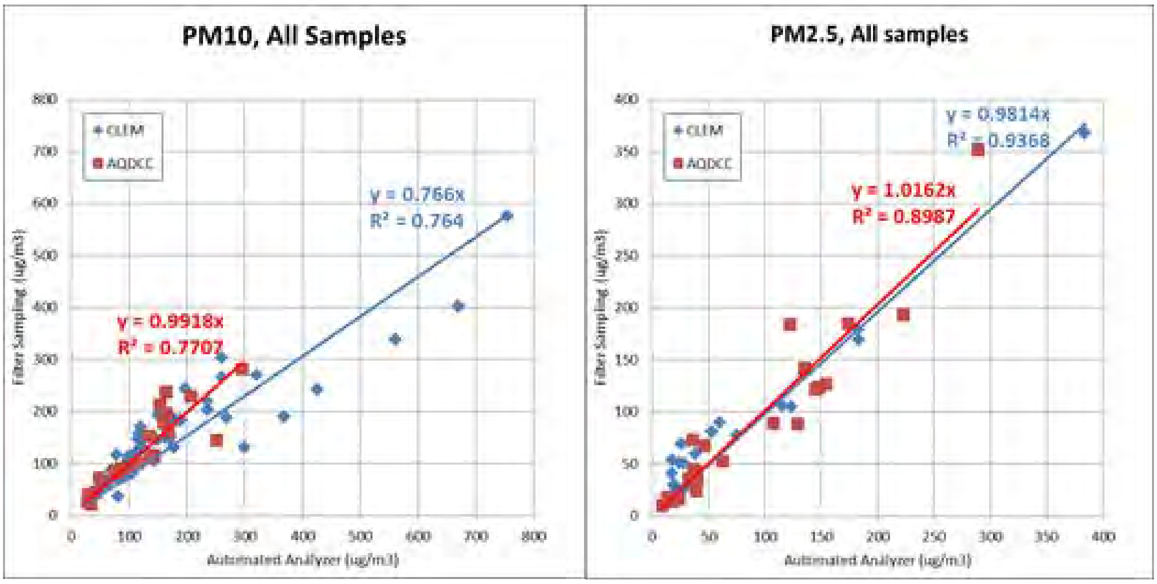
Date:yymmdd	PM (ug/m^3).	RCFM (ug/m^3)	[Sulfate]*	[POM]**	[EC]	[Crustal]	[Biomas]***	[S.Salt]	[Nitrate]	[NH4Cl]	
20150421	64.0	50.0	4.6	24.8	7.2	36.1	1.3	0.5	2.2	1.5	
20150422	48.4	36.5	5.3	21.7	5.3	38.4	1.4	0.5	1.9	1.0	
20150423	56.7	42.6	3.9	21.4	6.5	38.0	1.4	0.4	2.0	1.4	
20150424	69.8	50.5	3.2	19.3	5.3	39.9	1.2	0.4	1.7	1.3	
20150425	84.9	58.4	2.9	15.3	4.0	42.9	1.2	0.4	1.1	0.8	
20150426	84.7	52.3	2.8	13.6	2.5	39.8	1.2	0.4	1.0	0.5	
20150427	71.0	50.8	3.1	15.9	4.8	44.5	1.0	0.3	1.1	0.8	
20150428	53.7	46.8	4.5	17.5	2.8	58.9	1.6	0.4	1.0	0.3	
20150429	42.1	35.5	4.1	19.0	4.5	52.6	1.6	0.5	1.1	0.9	
20150502	24.2	17.1	11.7	18.9	7.2	30.9	1.0	1.2	0.0	0.0	
20150925	32.0	28.3	7.7	33.8	13.7	27.2	1.0	0.3	2.8	1.8	
20150926	25.1	20.7	12.3	30.4	12.5	20.8	0.8	0.4	3.1	2.3	
20150927	35.0	31.9	9.8	35.7	13.6	25.7	1.0	0.4	2.1	2.7	
20150928	46.9	37.2	4.0	18.0	8.0	45.4	1.4	0.4	1.2	0.8	
20150929	19.5	16.5	9.6	26.1	13.0	30.6	1.0	0.4	2.6	1.5	
20150930	35.4	31.4	5.6	31.3	14.5	32.2	1.0	0.3	1.9	1.8	
20151001	34.6	28.8	5.1	26.0	13.5	34.5	0.9	0.2	2.1	1.0	
20151002	42.4	37.8	7.5	33.7	14.8	27.5	0.9	0.2	2.3	2.2	
20151003	53.8	47.5	6.3	29.7	12.3	34.3	0.9	0.2	2.4	2.1	
20151004	66.2	62.6	6.2	29.9	11.8	40.9	1.4	0.2	2.0	2.3	
20151005	62.3	58.1	7.0	25.1	11.8	44.1	1.4	0.2	1.9	1.7	
20151006	86.5	46.1	2.5	8.3	2.2	38.3	0.8	0.3	0.6	0.3	X
20160112	361.1	368.7	31.7	55.9	5.4	4.0	0.2	0.0	4.1	0.8	
20160113	119.5	118.3	25.7	54.2	9.0	4.7	0.2	0.1	3.8	1.2	
20160114	255.8	320.7	25.4	83.2	9.1	2.8	0.1	0.1	3.0	1.7	
20160115	117.0	97.3	27.0	36.8	6.4	7.0	0.2	0.2	4.6	0.9	
20160116	83.0	75.7	24.2	51.5	6.8	3.0	0.2	0.7	3.0	1.7	
20160117	102.6	98.1	26.5	53.7	7.2	3.2	0.2	0.3	3.1	1.4	
20160118	202.9	208.6	25.1	62.6	7.5	3.1	0.2	0.2	2.8	1.3	
20160119	181.0	179.3	23.4	59.3	7.3	3.8	0.2	0.3	3.2	1.7	
20160120	109.4	106.3	24.3	54.4	8.2	4.8	0.2	0.3	3.5	1.5	
20160121	30.0	24.2	16.4	39.3	7.3	11.4	0.4	0.9	3.4	1.6	
20160122	42.6	38.3	18.4	47.2	8.2	8.9	0.2	0.8	4.2	1.9	
20160123	209.8	269.0	24.9	84.0	8.9	3.7	0.2	0.6	3.7	2.3	
20160124	279.3	275.6	25.9	55.1	6.2	5.1	0.2	0.0	4.7	1.4	
20160125	173.6	167.9	27.6	53.3	7.4	3.1	0.2	0.1	4.1	1.1	
20160126	166.5	170.7	26.0	60.4	7.7	4.0	0.2	0.2	2.7	1.4	
20160127	168.9	179.1	25.8	65.0	7.3	3.0	0.2	0.3	2.9	1.6	
20160128	192.3	195.2	25.7	58.4	6.8	4.7	0.2	0.5	3.4	1.9	
20160129	111.1	101.1	25.3	47.6	7.4	4.7	0.2	0.3	4.5	1.2	
20160130	114.3	107.3	24.5	51.5	7.3	5.2	0.2	0.4	3.1	1.7	
20160131	219.9	221.9	22.8	61.1	7.1	5.1	0.2	0.4	2.3	1.9	
20160201	196.9	190.1	21.5	54.7	6.5	6.4	0.3	0.7	4.4	2.0	
20160202	166.7	165.4	22.9	52.6	6.7	8.6	0.2	0.4	6.4	1.4	

* : [Sulfate]=4.125*S, ** : POM=1.6*OC '* : [Biomas]=1.4*(K-0.18*Fe

b. Evaluation of the Automatic Measuring Machine

At certain observation sites, consecutive observations of PM mass concentration with the automatic monitoring system were carried out. Scatter diagrams are shown in Figure 2.2-19 to compare the PM mass concentration using the automatic monitoring system and results from the filter method. There are few observation results. However, from the scatter diagram with all observation data for PM2.5 or PM10, the PM10 mass concentrations indicate a difference in CLEM and APRD.

The PM masses were measured automatically at APRD observation sites using the light scattering method and at CLEM sites using the beta-ray absorption method. The difference in measurement technique may be the reason for the difference in results. Freezing of water on the sampling filter results in inconvenience for normal sampler operating because it increases the pressure loss; it also leads to overestimating the PM mass on a filter using the beta-ray absorption method. However, because of the few observation data, a detailed examination evaluation is difficult. It is necessary to continue to compare measurements regularly with the filter method, in particular in the winter season.



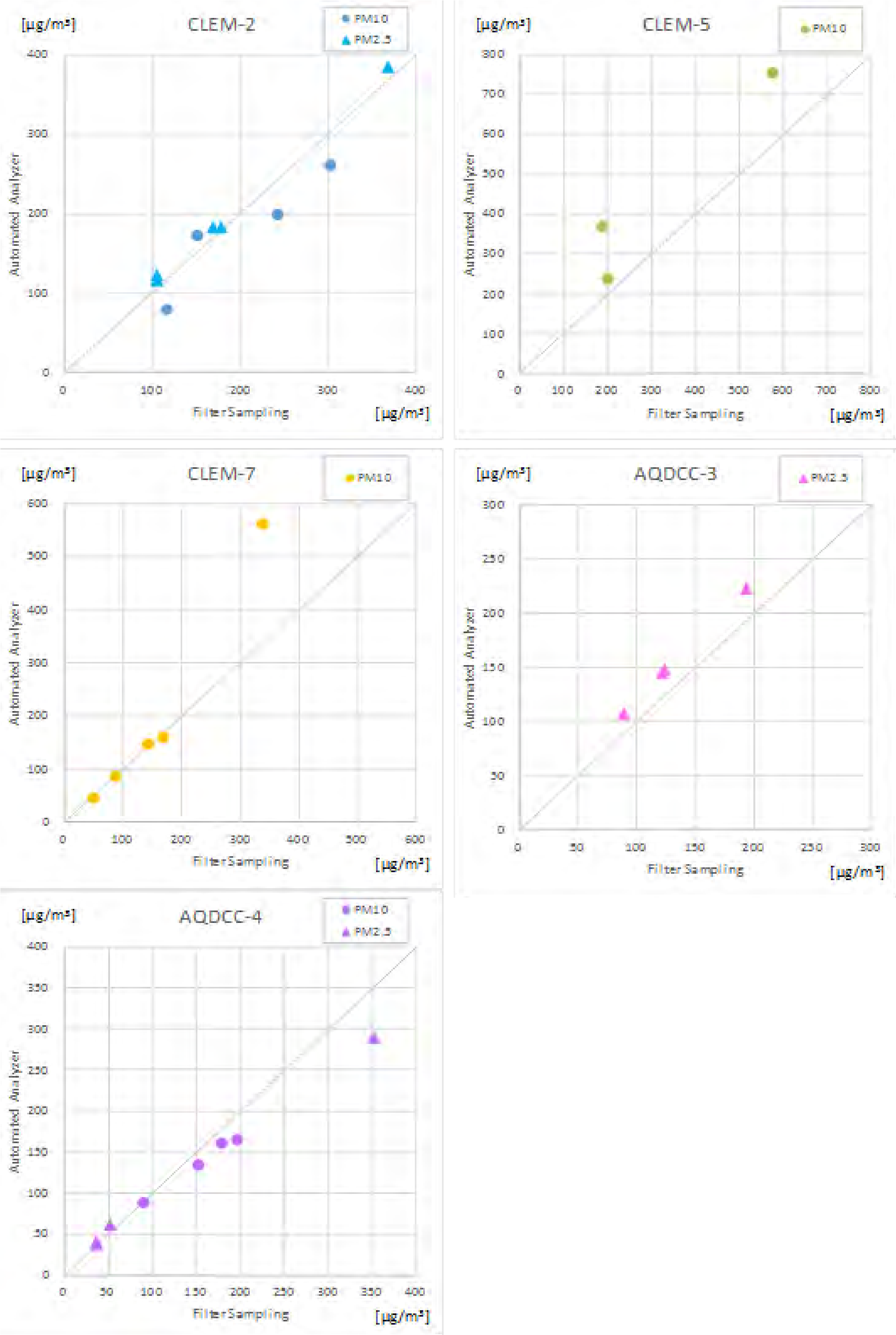


Figure 2.2-19 Scatter Diagrams Comparing the Concentrations Measured Using the Filter Method with Those from the Automatic Measuring Machine

2.2.2.3 PM Composition Analysis and Source Contribution Analysis

Major chemical compositions in PM include various elements, carbon components, and water-soluble ionic species. The filter samples described in Section 1.2.2.1 were analyzed chemically to obtain the major chemical composition concentrations in PM. Concentrations of various elements (Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Br, Rb, Sr, Mo, Sn, Sb, Ba, and Pb) in PM were analyzed non-destructively by applying energy-dispersible X-ray fluorescence spectroscopy (ED-XRF) to the PTFE filter sample after weighing. The thermal optical reflectance method (TOR) with the IMPROVE-A procedure, the U.S. EPA standard method and adopted globally widely, was applied for carbon component analysis. The punch (8 mm ϕ) of PM sample collected on the quartz fiber filter was provided to analyze carbon components, OC and EC, using TOR with the IMPROVE-A procedure. In this method, depending on the difference between temperature conditions in the analytical atmosphere, the organic carbon is classified into four fractions (OC1～OC4) and the elemental carbon into three fractions (EC1～EC3). The quantity organic matter that was charred in pyrolysis (OCpyro) is corrected based on the change in reflectivity from monitoring the sample surface. The water-soluble ionic species were analyzed using ion chromatography (IC). The water-soluble ionic species were extracted ultrasonically from half of each PM sample collected on the quartz fiber filter with 10 mL of deionized distilled water. The filtrate was analyzed by IC to determine the concentration of anions (NO_3^-, SO_4^{2-}, and others) and cations (NH_4^+ and others).

(1). <u>PM Composition Analysis Results</u>

The results of chemical composition analysis on all PM samples are provided in Appendix 2.2-6. In addition, the 14 major chemical component concentrations in PM2.5 are shown in Figure 2.2-20. Using these analytical results, the contribution concentrations of the major emission sources are estimated using the receptor model technique for the UB area.

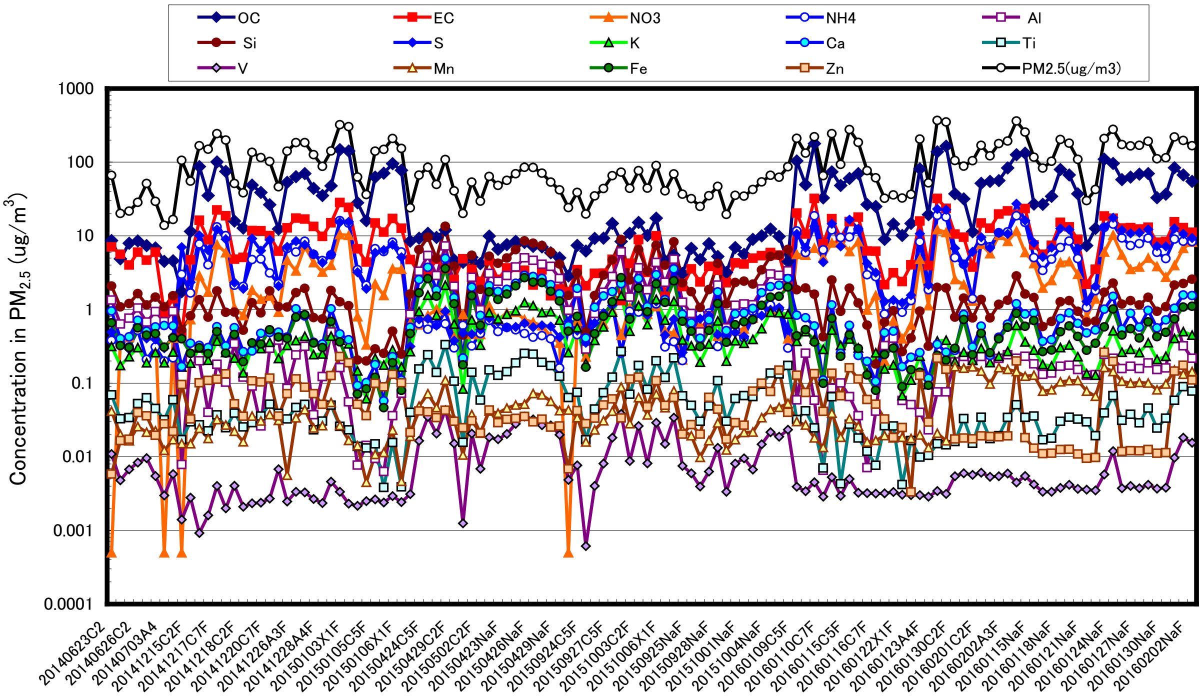


Figure 2.2-20 14 Major Chemical Component Concentrations in PM2.5 Observed during This Project Period

(2). Results and Analysis of PM Emission Source Contributions

a. Major Emission Source Category Analysis

The mass concentration of the fine particle PM2.5 is equivalent to the sum of the major source category contribution concentrations calculated from the chemical composition concentrations. That is, the reconstructive fine mass (RCFM) can be calculated using the following equation.

$$RCFM = (NH_4)_2SO_4 + NH_4NO_3 + POM + EC + Soil + Sea\ Salt + 1.4*KNON$$

Here, KNON is non-crustal potassium exhausted with biomass combustion.

Therefore, by comparing the PM2.5 mass concentration with the RCFM concentration, no discrepancy was found between the filter mass concentration and chemical composition analysis result. The chemical composition, which constitutes PM, clarifies the major source categories.

All measurement results from each observation site, RCFM concentrations and various emission source category concentrations are shown in comparison with the PM2.5 concentration in Table 2.2-23.

Except for the case that sample collection was challenging (marked with an X mark in the Table), these results indicate that most RCFM concentration were in the 85-115% range of the PM2.5 concentration.

Therefore, there was no discrepancy between the PM mass concentration and chemical compositions.

In addition, as an example, calculation results of contribution concentrations from various emission source categories at the observation site NAMEM are shown in Figure 2.2-21.

The mean concentration of PM2.5 at the observation site in the spring, autumn, and winter season was 60 μg/m^3, 41 μg/m^3, and 164 μg/m^3, respectively, and the PM2.5 concentration in the winter season was 3-4 times higher than in the other seasons.

In addition, the major emission source category concentrations have distinct seasonal characteristics. Winter season particles were 56% particulate organic matter (POM), 25% $(NH_4)_2SO_4$, 7% EC, and 5% crustal particles (5%); the POM was remarkably high in concentration in PM2.5 and crustal particles were low in concentration in winter. In the spring season, crustal particle concentrations increase to 42% and POM concentration decreases to around 20%.

The high concentration volatile organic compound condensed as POM in the winter season. Based on this characteristic, it was hypothesized that coal combustion exhaust particles caused the high PM concentration in the winter season.

The heavy PM concentration was observed to suddenly decrease after the clean and very cold atmosphere flowed in from the Siberian region in the winter season（Date: 1/21/2016 and 1/22/2016）. In addition, RCFM concentrations in spring tended to be lower than detection capability. In addition, it is hypothesized that the contribution concentration of crustal particles was slightly underestimated because the transformation coefficient for the crustal particles differs considerably from literature data.

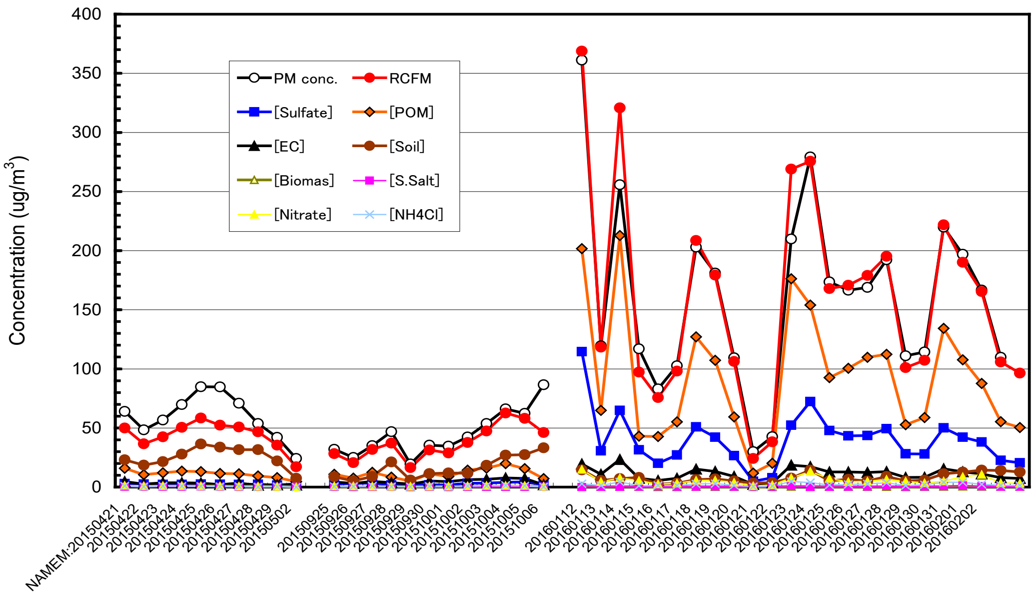


Figure 2.2-21 Concentration Variation of Various Emission Source Category in PM2.5 Observed at NAMEM

b. PMF Analysis

i. PMF Analysis of PM2.5

The receptor model deriving emission source contribution concentration includes a CMB model and multivariate analysis model. The PMF method is a representative multivariate model for PM source assignment, and this method was applied to the measured data to simultaneously derive emission source factors and contribution concentrations. That is, the data matrix, which consists of 14 lines of 124 rows prepared from the chemical composition of the 124 PM2.5 samples, was applied to the PMF analysis. Then, the contribution concentrations of seven emission source factors for each sample were derived.

The chemical component percentages in each major emission source factor derived from the PM2.5 samples are provided in Table 2.2-24 and shown in Figure 2.2-22. From their characteristics, these factors originated from the each source as follows, factor F7-2: motor vehicle exhaust, factor F7-3: coal combustion exhaust particles, factor F7-4: refuse incineration, factor F7-5: sulfate and nitrate particles, and factor F7-7: crustal particles. Sources for factors F7-1 or F7-6 were not found. As shown in Figure 2.2-22, the PM2.5 concentration in the winter season was high, with factors F7-3 (blue line) and factor F-5 (purple line) having significantly high contributions. In contrast, in the other seasons, the PM2.5 concentration was low, and the contribution from factor F7-7 was high.

Table 2.2-24 Chemical Component Percentage in Each Major Emission Source Factor Derived for PM2.5 Samples using PMF Analysis (%)

(Unit: %)

Factor	OC	EC	NO_3^-	NH_4^+	Al	Si	S	K	Ca	Ti	V	Mn	Fe	Zn
F7-1	0.05	2.58	0.00	0.01	0.0007	0.05	5.89	0.26	0.14	0.012	0.000	0.394	0.23	0.000
F7-2	54.40	53.20	6.94	1.62	0.0007	0.03	0.00	0.26	0.00	0.036	0.001	0.070	0.49	0.001
F7-3	50.99	12.19	0.00	4.94	0.0000	0.02	5.89	0.05	0.00	0.000	0.000	0.000	0.00	0.000
F7-4	2.20	0.00	0.00	0.35	0.0005	0.46	0.14	0.45	0.02	0.029	0.000	0.001	0.00	0.348
F7-5	39.78	0.01	10.81	9.51	0.0005	0.92	8.64	0.09	0.24	0.000	0.001	0.001	0.13	0.019
F7-6	0.04	19.89	0.00	0.00	0.0202	24.90	1.99	1.91	22.88	0.839	0.121	0.000	13.46	0.051
F7-7	8.37	0.00	0.00	0.00	9.1846	11.66	0.00	2.12	2.40	0.297	0.040	0.116	2.42	0.043

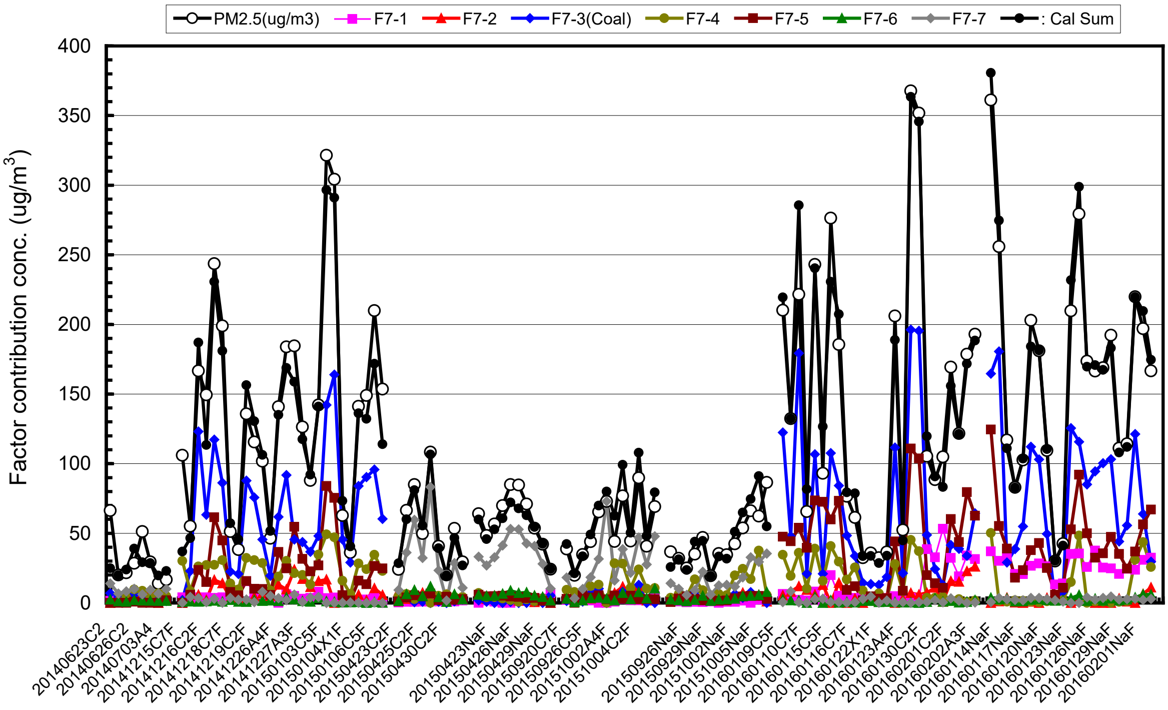


Figure 2.2-22 Contribution Concentration of Each Emission Source Factor Derived for the PM2.5 Sample Using PMF Analysis

The mean contribution concentration of each emission source factor in each observation period is summarized in Table 2.2-25. The PM2.5 concentration in the winter season was on average approximately triple the concentration in the other seasons. The exhaust particles, which contained abundant volatile carbon emitted with coal combustion, were dominant in the winter. In contrast, crustal particles were dominant in the other seasons.

Table 2.2-25 Mean Contribution Concentration of Each Emission Source Factor in PM2.5 Summarized in Each Observation Period

Source Profile : Season (Sampling period)		F7-1: ?	F7-2 Motor vehicles	F7-3 Coal combustion	F7-4 Refuse incineration	F7-5 NH_4NO_3 $(NH_4)_2SO_4$	F7-6 ?	F7-7 Crustal	Observed (ug/m^3)
Sampled by FRM (Jan.09,'16 - Feb.02,'16)	(ug/m^3)	13.0	7.7	64.8	17.1	42.3	1.1	1.4	145.7
	(%)	8.9	5.3	44.5	11.7	29.0	0.8	1.0	
Sampled by MCAS (Jan.12,'16 - Feb.02,'16)	(ug/m^3)	27.0	2.0	80.1	10.9	43.5	2.9	2.4	165.9
	(%)	16.2	1.2	48.3	6.6	26.2	1.7	1.5	
Mean	(ug/m^3)	19.4	5.1	71.8	14.3	42.8	1.9	1.9	154.9
	(%)	12.5	3.3	46.3	9.2	27.6	1.2	1.2	
Summer in 2014 (Jun.23,'14 - July04,'14)	(ug/m3)	1.6	4.6	4.2	4.9	0.3	1.5	8.9	31.0
	(%)	5.1	15.0	13.4	15.7	1.1	5.0	28.7	
Winter in 2014 (Dec.12,'14 - Jan.06,'15)	(ug/m3)	4.1	7.8	66.4	24.7	25.0	1.2	2.1	140.5
	(%)	2.9	5.5	47.2	17.5	17.8	0.9	1.5	
Spring in 2015 (Apr.23,'15 - May02,'15)	(ug/m3)	1.5	3.6	1.2	3.5	3.7	5.5	34.0	56.7
	(%)	2.6	6.3	2.1	6.2	6.6	9.7	60.0	
Autumn in 2015 (Sept.20,'15 - Oct.06,'15)	(ug/m3)	1.4	4.9	4.2	12.9	3.2	3.7	22.9	48.7
	(%)	2.9	10.0	8.7	26.6	6.6	7.7	47.2	

ii. PMF Analysis of PM10

Similarly, the data matrix prepared from the chemical analysis results of 96 PM10 samples was analyzed using analysis, and the contribution concentrations for the six emission source factors for each sample are provided in Table 2.2-26 and shown in Figure 2.2-23. In addition, the contribution concentrations of each emission source factor in the winter season are summarized in Table 2.2-27. The mean concentration of observed PM10 was 207 $\mu g/m^3$, and the contributions of the six emission source factors were, factor F6-6: 120 $\mu g/m^3$ (58%), factor F6-4: 40 $\mu g/m^3$ (19%), factor F6-3: 24 $\mu g/m^3$ (12%), factor F6-1: 12 $\mu g/m^3$ (6%), factor F6-5: 7 $\mu g/m^3$ (3%), and factor F6-2: 6 $\mu g/m^3$ (3%). Factor F6-6 was categorized as derived from coal combustion, and factor F6-4 was from refuse incineration; however, the contribution from the latter factor was low compared to the other factors and identification of these emission sources was challenging.

In the winter season and non-winter season, emission source with remarkable influence is different. So, in the case of PM2.5, it is delicately different in multivariate analysis such as PMF in PM10, because the deflection of data set.

Table 2.2-26 Chemical Component Percentage in Each Major Emission Source Factor Derived for PM10 Samples Using PMF Analysis (%)

(unit: %)

Factor	OC	EC	NO_3^-	NH_4^+	Al	Si	S	K	Ca	Ti	V	Mn	Fe	Zn
F6-1	0.07	26.07	22.68	0.53	0.00	6.81	0.00	0.95	5.13	0.25	0.05	0.16	4.37	0.00
F6-2	0.07	0.01	0.00	0.00	2.16	5.88	1.30	0.00	18.68	0.11	0.01	0.00	1.44	0.18
F6-3	40.27	10.94	0.00	1.22	0.00	2.23	3.91	0.51	1.36	0.10	0.02	0.21	1.31	0.00
F6-4	36.35	17.68	0.00	0.91	0.00	0.01	0.01	0.39	0.38	0.03	0.00	0.00	0.07	0.24
F6-5	5.31	0.00	0.00	0.00	10.00	15.87	0.05	2.71	2.21	0.43	0.06	0.13	4.37	0.00
F6-6	40.39	3.11	1.91	6.59	0.00	0.65	7.50	0.05	0.06	0.00	0.00	0.00	0.06	0.00

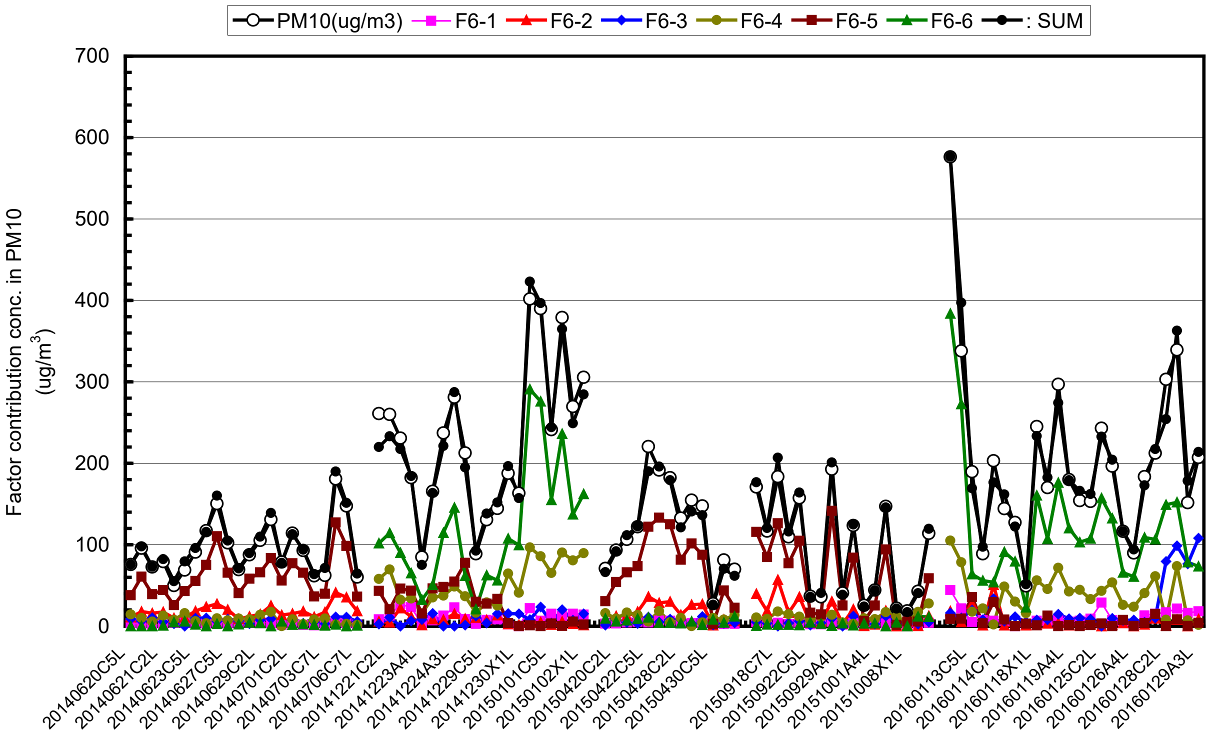


Figure 2.2-23 Contribution Concentration of Each Emission Source Factor Derived for the PM10 Samples Using PMF Analysis

Table 2.2-27 The Contribution Concentration of Each Emission Source Factor Derived for PM10 Samples Observed in the Winter Season

Source Profile :		F6-1	F6-2	F6-3	F6-4	F6-5	F6-6	Observed
Season (Sampling period)		MV + NH_4NO_3	?	$(NH_4)_2SO_4$	Refuse incineration	Crustal	Coal combustion	(ug/m^3)
Sampled by FRM	(ug/m^3)	11.7	6.4	23.8	39.7	6.6	120.1	206.6
(Jan.09,'16 - Feb.02,'16)	(%)	5.7	3.1	11.5	19.2	3.2	58.1	

c. CMB Analysis

Major emission source contribution concentrations can be derived from one set of observation data, but *a priori* information on the major emission sources, such as profiles, is necessary for CMB analysis. In the UB area, neither the major emission sources nor their profiles were clear. Therefore, based on information provided from the PMF analyses, we attempted to identify major emission sources and derive their profiles in the UB area.

The major emission sources in the UB area were clearly identified in the PMF analyses; sources from coal combustion, sulfate particles, refuse incineration, and motor vehicles were dominant in the winter season. In the other seasons, those contributions significantly decreased and crustal particles became important. The seasonal variations in contribution concentrations from coal combustion exhaust and crustal particles were significant.

The Matrix 19, 79-type, was prepared from chemical composition data from the PM2.5 observations in UB area. Here, the Matrix 19 includes 5 organic carbon fractions, OC1, OC2, OC3, OC4, and OCpyro, and 13 chemical components, EC, NO_3^- NH_4^+, Al, Si, S, K, Ca, Ti, V, Mn, Fe, and Zn. The term 79-type indicates the selected sample number in which the difference between RCFM value and PM2.5 concentration was within 15%. From the prepared matrix, a correlation matrix between 19 components was calculated. In addition, eigenvalues and eigenvectors were calculated from the correlation matrix. The eigenvalue larger than two factors accounted for 94% of the data, and that larger than four factors accounted for 97%. This calculation indicates that there were two dominant source factors, and these factors with the following two factors account for most of the samples.

The derivation of the major emission source profiles:

Based on PM2.5 observation data in the UB area and derived emission factors from PMF analysis, the emission source profiles of the coal combustion exhaust and crustal particles, the factors with the largest seasonal variability, were derived.

In PMF analysis, the derived factors and their contribution concentrations depend on the number of factor assumed. Therefore, PMF analysis was applied to each case using factor numbers 3 to 7 in the 79 samples described previously. For each factor number, Figure 2.2-24 shows a comparison with the chemical composition concentration of the factor for coal combustion exhaust. The geometric mean for the composition concentration of each factor was taken as the mean value. Similarly, Figure 2.2-25 shows a comparison with chemical composition concentration of the factor for crustal particles.

The chemical composition was not used for PMF analysis; the concentration ratio with the chemical composition provided from PMF analysis was calculated from observation data, and this ratio was adopted for calculating the concentration by CMB analysis. .

The profiles for motor vehicle exhaust particles and refuse incineration emission particles were created from existing data adjusted for the UB. The derived emission source profiles for CMB analysis are shown in Table 2.2-28.

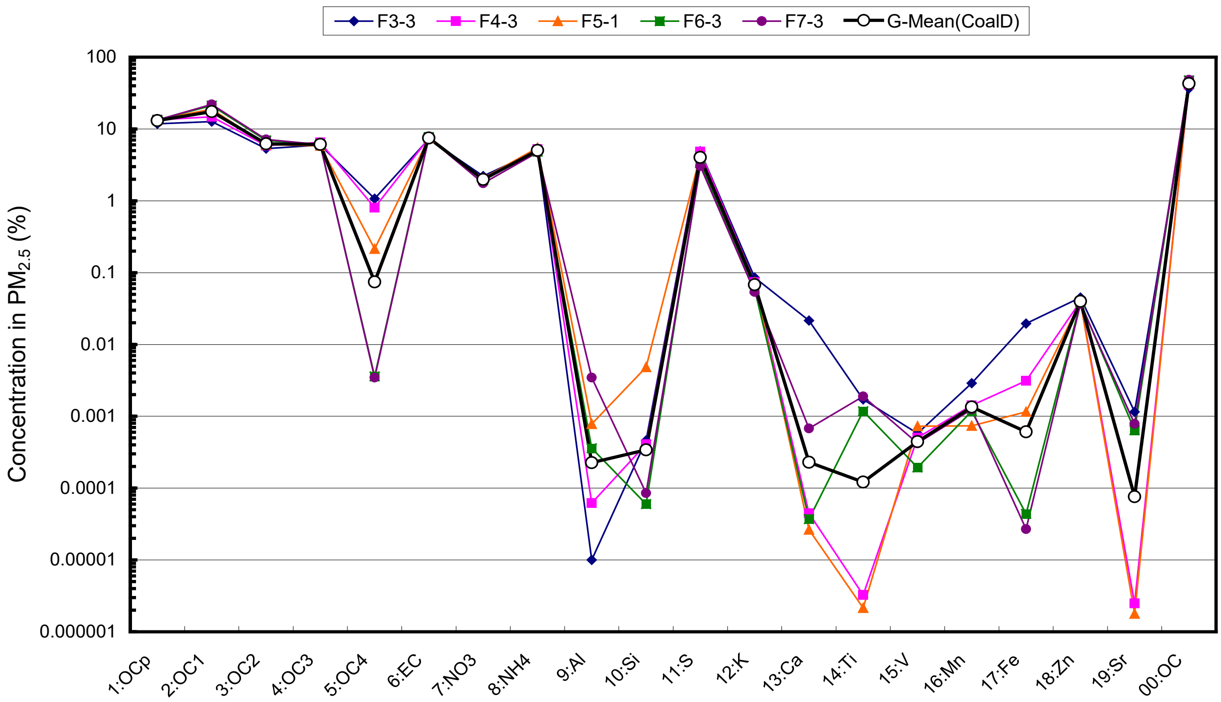


Figure 2.2-24 Comparison of the Chemical Composition Concentrations of the Factor from Coal Combustion

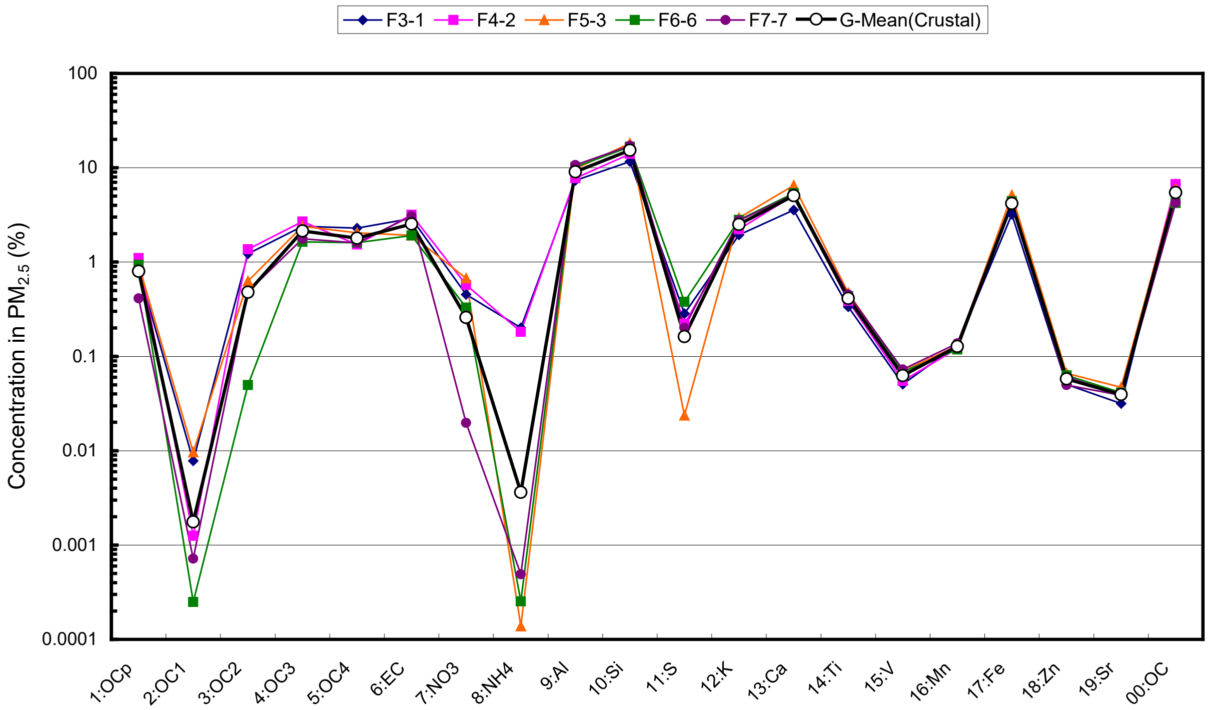


Figure 2.2-25 Comparison of the Chemical Composition Concentrations of the Factor from Crustal Particles

Table 2.2-28 Emission Source Profiles for CMB Analysis

(unit: %)

	Crustal	STD	W-Coalcom	STD	RefuseInc	STD	MVExhaus	STD
OC	1.01E+01	1.01E+00	4.48E+01	3.50E+00	1.00E+00	5.00E-01	2.47E+01	2.47E+00
EC	3.49E-01	3.49E-02	8.12E+00	1.06E+00	5.00E+00	2.50E+00	4.94E+01	4.94E+00
OCp	1.64E+00	1.64E-01	1.27E+01	2.47E+00			0.00E+00	0.00E+00
OC1	6.51E-01	6.51E-02	1.59E+01	1.43E+00			4.03E+00	4.03E-01
OC2	2.41E+00	2.41E-01	7.05E+00	1.17E+00			1.03E+01	1.03E+00
OC3	3.13E+00	3.13E-01	6.81E+00	1.29E+00			5.33E+00	5.33E-01
OC4	2.29E+00	2.29E-01	1.96E+00	1.79E+00			3.31E+00	3.31E-01
NO3-	1.16E-01	1.16E-02	2.51E+00	1.03E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SO4-	2.42E-03	2.42E-04	6.59E+00	1.35E+00	0.00E+00	0.00E+00	2.16E+00	2.16E-01
NH4+	8.41E-02	8.41E-03	4.56E+00	7.65E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na	1.12E+00	1.74E-01	3.11E-01	1.71E-01	1.20E+01	1.20E+00	7.64E-03	7.64E-04
Mg	5.47E-01	1.11E-01	1.10E-01	2.98E-02				
Al	5.51E+00	2.59E+00	3.77E-02	1.56E-02	4.20E-01	8.40E-02	1.57E-01	1.57E-02
Si	1.49E+01	1.70E+00	5.58E-01	2.92E-01				
P	9.18E-02	2.06E-02	4.06E-02	1.24E-02				
S	1.63E+00	5.58E-01	3.99E+00	1.59E+00				
Cl	5.43E-01	5.55E-01	8.26E-01	2.39E-01	2.70E+01	2.70E+00	2.00E-02	2.00E-03
K	2.47E+00	3.00E-01	1.10E-01	3.11E-02	2.00E+01	2.00E+00	1.97E-02	1.97E-03
Ca	5.50E+00	7.74E-01	7.50E-02	7.50E-02	1.10E+00	2.20E-01	1.46E-01	1.46E-02
Ti	4.34E-01	5.79E-02	3.35E-03	3.35E-03	9.00E-02	4.50E-02	1.46E-02	1.46E-03
V	6.06E-02	7.59E-03	9.00E-04	5.09E-04	2.70E-03	1.35E-03	7.25E-04	7.25E-05
Cr	1.52E-02	1.92E-03	1.38E-03	1.57E-03	8.50E-02	8.50E-02	1.16E-03	1.16E-04
Mn	1.40E-01	1.63E-02	2.18E-03	2.18E-03	3.30E-02	3.30E-02	1.93E-03	1.93E-04
Fe	4.41E+00	5.11E-01	5.45E-02	5.45E-02	6.10E-01	6.10E-01	9.89E-02	9.89E-03
Ni	2.55E-03	1.76E-03	8.05E-04	4.18E-04	0.00E+00	0.00E+00	9.89E-04	9.89E-05
Cu	3.10E-02	1.11E-02	2.45E-03	1.67E-03	3.60E-01	7.20E-02	1.13E-02	1.13E-03
Zn	4.53E-02	4.53E-03	4.94E-02	1.05E-02	2.60E+00	1.30E+00	6.24E-02	6.24E-03
As	0.00E+00	2.26E-03	8.07E-03	2.76E-03	1.50E-02	1.50E-02	3.69E-04	3.69E-05
Se	6.09E-02	3.61E-02	1.58E-02	1.01E-02	0.00E+00	0.00E+00	1.67E-04	1.67E-05
Br	9.86E-03	1.20E-02	4.44E-03	3.09E-03	8.30E-02	1.66E-02	2.45E-03	2.45E-04
Rb	6.32E-03	4.60E-03	1.12E-03	5.85E-04	2.60E-02	2.60E-02	4.90E-05	4.90E-06
Sr	3.95E-02	9.01E-03	1.71E-03	1.18E-03				
Mo	2.32E-02	1.34E-02	6.48E-03	3.51E-03	0.00E+00	0.00E+00	5.91E-04	5.91E-05
Sn	2.03E-02	1.17E-02	5.62E-03	2.97E-03				
Sb	2.22E-02	1.37E-02	6.24E-03	3.25E-03	9.52E-02	4.80E-02	1.96E-03	1.96E-04
Ba	7.06E-02	3.53E-02	1.98E-02	9.69E-03	3.90E-02	3.90E-02	9.89E-03	9.89E-04
Pb	2.34E-02	1.32E-02	1.96E-02	5.53E-02				
Mass	100	0	100	0	100	0	100	0

d. **Selection of Major Emission Sources and Index Chemical Species**

In CMB analysis for the UB area, the PM emitted from coal combustion, soil, refuse incineration, and motor vehicles were selected as major emission source particles, and their contribution concentrations were derived.

For the analysis calculation, it is necessary to select index chemical species, and 12 chemical species, OC, EC, Na, Si, S, K, Ca, Ti, V, Mn, Fe, and Zn, were selected first. Originally, it was necessary to select an index that does not change in the process of advection and diffusion in the atmosphere after emission from the source. However, in UB area, the PM2.5 concentration is extremely high in the winter season and it is common that the POM is >50% of the PM mass concentration. During the winter, the outside temperature is often lower than -10°C all day, therefore, it is hypothesized that semi-volatile organic carbon condensed on particles is stable under this atmospheric environment. Therefore, OC can be used as an index chemical species for CMB analysis for the winter season, but there is a concern about selecting the element S.

e. The example of the analysis result

From the PM2.5 observation data using for the PMF analysis, one set of chemical composition concentration data was calculated for the trial analysis（see Table 2.2-29）. The obtained major source contribution concentrations from CMB analysis are tabulated in Table 2.2-30. It was estimated that approximately 100% of the observed concentrations was accounted for using four selected major emission sources. However, the contribution from condensable matter was incorporated in the profile of the coal combustion exhaust particles, and a negative value was observed in OC, which appeared in V-C. The deficit applied to POM accounts for at least 7 $\mu g/m^3$. In addition, it is hypothesized that estimated results for contribution concentrations from motor vehicle and refuse incineration exhaust particles were also related to the coal combustion exhaust particle profile.

Major emission source contribution concentration can be apportioned from one set of observation data, however, *a priori* knowledge, such as emission source profiles of major emission sources is necessary for the CMB analysis. In addition, the emission source profile data shown as examples here are not finalized, and should be further improved by accumulating observation data in the future. The emission source profile should be determined from chemical analyses of emitted particle samples collected directly from emission sources. In addition, the CMB analysis is a source-apportion method, which derives the contribution concentrations of primary particles but not secondary products from major emission sources selected *a priori*. Based on principle, the profile data should be reexamined in more detail based on PM observation data already obtained.

Table 2.2-29 Trial Data Set of Chemical Composition Concentrations in PM2.5 Calculated for CMB Analysis.

Mean−79sAll	Con(ng/m3	Err(%)
Mass	1.20E+05	10
OC	4.38E+04	12
EC	1.04E+04	10
OCp	1.29E+04	15
OC1	1.37E+04	15
OC2	7.02E+03	10
OC3	7.80E+03	10
OC4	3.59E+03	10
NO3−	3.38E+03	15
SO4−	8.30E+03	10
NH4+	5.27E+03	15
Na	5.53E+02	10
Mg	2.00E+02	10
Al	7.06E+02	25
Si	1.93E+03	15
P	6.23E+01	10
S	5.61E+03	15
Cl	1.06E+03	10
K	3.76E+02	10
Ca	8.00E+02	15
Ti	4.92E+01	15
V	6.63E+00	15
Cr	3.39E+00	10
Mn	2.01E+01	10
Fe	5.73E+02	15
Ni	1.43E+00	10
Cu	7.68E+00	10
Zn	7.63E+01	10
As	8.83E+00	15
Se	2.67E+01	10
Br	7.93E+00	15
Rb	2.24E+00	10
Sr	6.82E+00	20
Mo	1.10E+01	50
Sn	9.47E+00	50
Sb	1.04E+01	50
Ba	3.53E+01	50
Pb	9.21E+01	50

Table 2.2-30 Result of Emission Source Apportionment Obtained From CMB Analysis

(ug/m^3)

Sample	UB-79Sample-Mean		
	Fine*		
PM Conc.	120.0		
Coal combustion exhaust	104.1	±	11.9
Crustal particles	10.7	±	0.8
Motor vehicle exhaust	4.1	±	3.2
Refuse incineration	0.2	±	0.2
Sum of Primary Particle	119.1		
NO_3^-	0.8		
SO_4^{2-}	1.3		
Cl^-	0.0		
NH_4^+	0.5		
OC : OM (=1.4xOC)	-5.0		-6.9
Sum Total of derived	114.8		

*：SD less than 2.5μm

2.3 Emission Inventory and Simulation Model: Output 3

2.3.1 Frame of Emission Inventory

2.3.1.1 Framework of Emission Inventory

(1). Holding a Seminar on the Emission Source Inventory and Dispersion Simulations

The second expert seminar on emission inventory and dispersion simulations was held on April 16, 2014. From Mongolia, 32 participants attended. The JICA Experts explained the schedule and issues involved in updating the emission inventory, and discussed the dispersion simulation, future activity plan for the target emission sources, and updating emission inventory with Mongolian representatives. The handout from this seminar is shown in Appendix 2.3-1.

In addition, the personnel supervising the “emission source for updating emission inventory” were selected from NAMEM and APRD in this seminar. The list of these personnel is shown in Table 2.3-1.

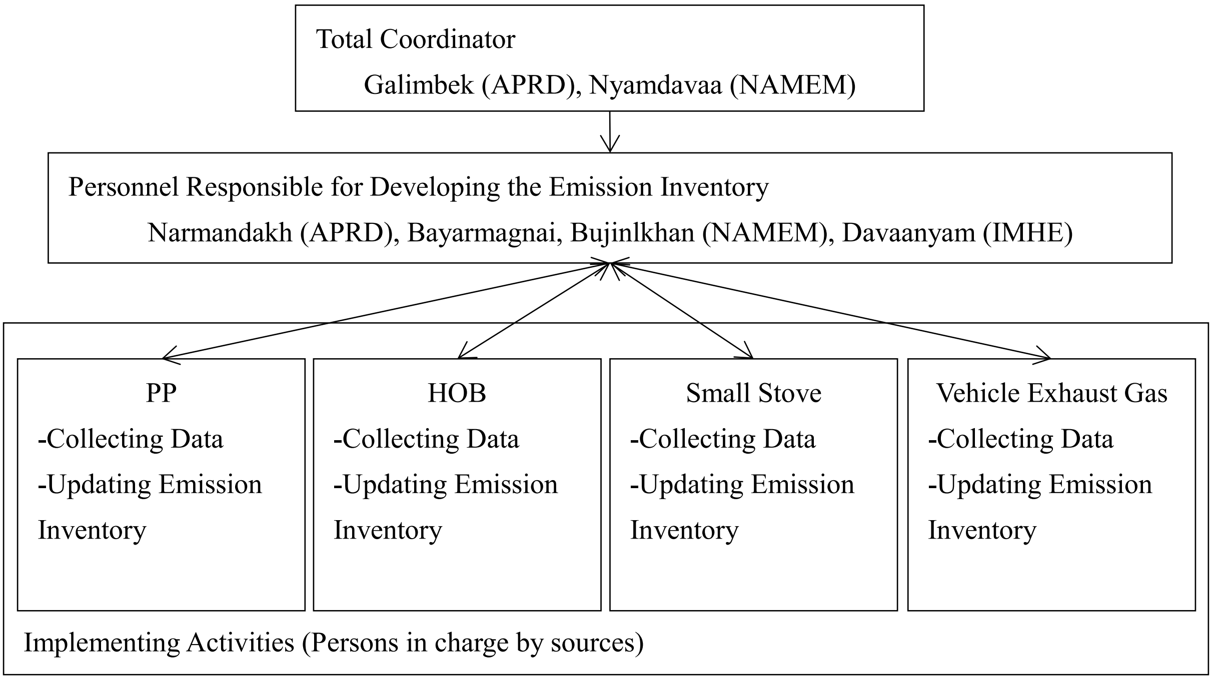
Table 2.3-1 List of People in Charge of Updating the Emission Inventory as of April 2014

	NAMEM, IMHE	APRD
Power Plant	Mr. Buyantogtokh, Mr. Munkhsaikhan, Mr. Gansukh, Ms. Nyamdavaa, and Mr. Davaanyam	Ms. Narmandakh and Ms. Bayarmaa
HOB		Mr. Batsaya
CFWH		Ms. Urantsetseg
Industrial factory	Mr. Buyantogtokh and Ms. Tsatsral	Mr. Erdenebaatar
Small stove (Ger stove etc.)		Ms. Bayasgalan
Exhaust gas by vehicle	Mr. Buyantogtokh and Ms. Enkhmaa	Mr. Altangerel
Fugitive dust by vehicle	Ms. Enkhmaa and Mr. Gansukh	Ms. Nasanjargal and Mr. Altangerel
Fugitive ash from ash pond		Ms. Sanchirbayar

(2). Change in Framework for Emission Inventory after the Seminar in April 2015

After the seminar, because personnel changes at APRD occurred due to maternity leave and study abroad, APRD reviewed those supervising the emission inventory. Therefore, JICA Experts conducted training candidates responsible for the emission inventory at APRD in April 2015 and reviewed their progress with tasks. As the result, JICA Experts selected Ms. Narmandakh as the primary supervisor of the emission inventory at APRD.

Furthermore, the JICA Experts reviewed the participation during previous training events, and selected Mr. Munkhsaikhan as the primary supervisor of the emission inventory at NAMEM. However, due to NAMEM policy, Mr. Bayarmagnai and Ms. Bujinlkhan decided to continue with this technology, and the technical transfer was conducted within NAMEM. Organizations for updating the emission inventory and list of personnel involved are shown in Figure 2.3-1 and provided in Table 2.3-2.



Source: JICA Experts

Figure 2.3-1 Revised Organization for Updating the Emission Inventory

Table 2.3-2 Revised List of Persons That Update the Emission Inventory

	NAMEM, IMHE	**APRD**
Total coordinator	Ms. Nyamdavaa	Mr. Galimbek
Personnel responsible for developing emission inventory	Mr. Bayarmagnai, Ms. Bujinlkhan, Mr. Davaanyam	Ms. Narmandakh
PP		Ms. Narmandakh, Ms. Odonbileg
HOB		
CFWH		
Small stoves for households		
Large facility in factory	Ms. Erdenetsetseg, Ms. Delgermaa	
Vehicle exhaust gas		Ms. Tsatsral, Mr. Altangerel
Fugitive dust from road	Mr. Bayarmagnai	
Fugitive ash from ash pond in PP	Ms. Erdenetsetseg	
Dispersion simulation	Mr. Bayarmagnai, Mr. Davaanyam, Mr. Buyantogtokh	Ms. Narmandakh, Ms. Odonbileg

Note: The data is current as of February, 2017

Source: JICA Experts

(3). **Conducting the Training on Emission Inventory and Dispersion Simulation**

Records of the lecture and training on emission inventory and dispersion simulation are shown in Table 2.3-3. The main participants of these training events were the officers in APRD, NAMEM, and IMHE.

Table 2.3-3 Record of Lectures and Practical Experience for Emission Inventory and Dispersion Simulations

Term	Contents	Participants
April 2014	Updated the emission inventory for 2013 and conducted dispersion simulations	Galimbek, Narmandakh, Nyamdavaa, Munkhsaikhan, and others
December 2014	Attended a lecture on, and practiced methods for air pollution control using the results from the dispersion simulation	Munkhsaikhan and Buyantogtokh
April 2015	Explanation to new person in charge at APRD on the updated method for inventorying emissions	Bayarmaa, Nasanjargal, Tsatsral, and Narmandakh
October 2015	Discussed the framework for updating the emission inventory for 2015	Galimbek, Narmandakh, Enkhmaa, and Munkhsaikhan
January to February 2016	Attended a lecture on, and practiced methods for conducting dispersion simulations using CALPUFF	Narmandakh, Munkhsaikhan, Buyantogtokh, and Davaanyam
February 2, 2016	Attended a seminar on developing the dispersion simulation model	Galimbek, Narmandakh, Nyamdavaa, Munkhsaikhan, Buyantogtokh, and others
June 2016	Attended a lecture on, and practiced methods for conducting dispersion simulation using CALPUFF	Narmandakh, Munkhsaikhan, and Davaanyam
September 2016	Attended a lecture on, and practiced methods for updating the emission inventory based on air pollution control measure	Narmandakh, Tsatsral, Munkhsaikhan, and Davaanyam
December 2016	Provided an explanation of the estimation methods for PM10 emissions considering condensed dust	Galimbek, Narmandakh, Odonbileg, Tsatsral, Batbayar, Bayarmagnai, and Davaanyam
December 2016	Attended a lecture on, and practiced methods for updating the emission inventory based on air pollution control measures	Narmandakh, Odonbileg, Tsatsral, Bayarmagnai, and Davaanyam
February 2017	Updated the emission inventory and conducted dispersion simulations based on air pollution control measure	Narmandakh, Odonbileg, Tsatsral, Bayarmagnai, Bujinlkhan, Davaanyam, and Buyantogtokh

Source: JICA Experts

(4). **Technical Capacity Progress on the Mongolian Side**

In this project, the member involved with Output 3 at the beginning of this project was changed due to personnel relocation in APRD and NAMEM. The responsibilities and schedule of each member are shown in Table 2.3-4.

Table 2.3-4 Terms that Members of Mongolian Side Were Engaged for Output

Member	Start (2013.12)	PR1 (2014.06)	PR2 (2015.01)	PR3 (2015.06)	PR4 (2016.04)	PR5 (2016.09)	Final (2017.05)
Stationary Source Emission Inventory and Dispersion Simulation							
A	■	■			■	■	■
B		■	■	■			
C	■	■					
D	■	■					
E	■	■	■	■			
F	■	■	■	■	■	■	
G	■	■	■	■	■	■	■
H	■	■	■	■	■	■	
I	■	■	■	■	■	■	■
J	■	■	■	■			
K					■	■	■
M							■
N							■
O							■
Mobile Source Emission Inventory							
A	■	■	■	■	■	■	
B	■	■	■	■	■	■	■
C	■	■	■	■	■	■	
D	■	■	■	■	■	■	■
E						■	■

Source: JICA Experts

The officer supervising the emission inventory and dispersion simulation in APRD dramatically has an increase in responsibilities due to the technical transfer in this project. Although this officer joined in the middle of the project, they can operate a PC proficiently and has contributed significantly to building capabilities in organizing the calculated emissions and conducting the dispersion simulation. In addition, since joining, the officer has calculated emissions and conducted dispersion simulation independently based on air pollution control measures and has gained enough knowledge and skill to have discussions with the JICA Experts.

The officer supervising the emission inventory and dispersion simulation in NAMEM steadily acquired technical ability after aggressively joining training events. This supervising officer departed from this project in February 2017 based on the reallocation of supervisors in NAMEM. Therefore, the supervisor transferred the acquired technology to the subsequent supervisor.

The officer in charge of mobile source emission inventory in APRD was named during the discussion of framework on emission inventory in October 2016. The previous person responsible for the mobile source emission inventory was dedicated to mobile source monitoring and the new member was supposed to play a role in data analysis and developing the mobile source emission inventory. Because the new member is still new to their position, they are improvising their understanding with support from their predecessor and colleagues.

The officers in IMHE already had used the dispersion simulation technique. Therefore, in project training, the officers focused on methods for developing/updating emission inventory and applying the simulation results to improve air pollution control measures. Based on this experience, effective applications of emission inventory and dispersion simulations are expected in the future.

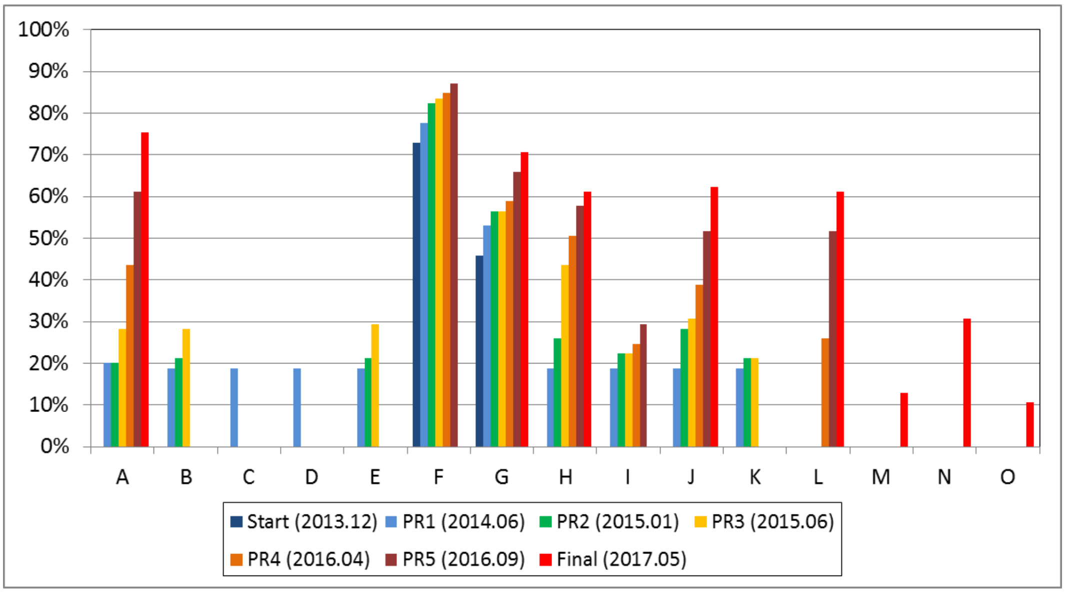
Because each current supervisor is knowledgeable and skilled, some are also in charge of other activities. To reduce the burden on each member, structuring the emission inventory and dispersion simulation should be discussed in each agency, and the technique that C/P previously achieved should be maintained. The progress in technical capacity for stationary source inventory, mobile source inventory, and dispersion simulations is shown in Proficiency rate of 100% indicates that a person can implement the output goal of each field alone, handle troubleshooting, and instruct co-workers

Source: JICA Experts

Figure 2.3-2 to Proficiency rate of 100% indicates that a person can implement the output goal of each field alone, handle troubleshooting, and instruct co-workers

Source: JICA Experts

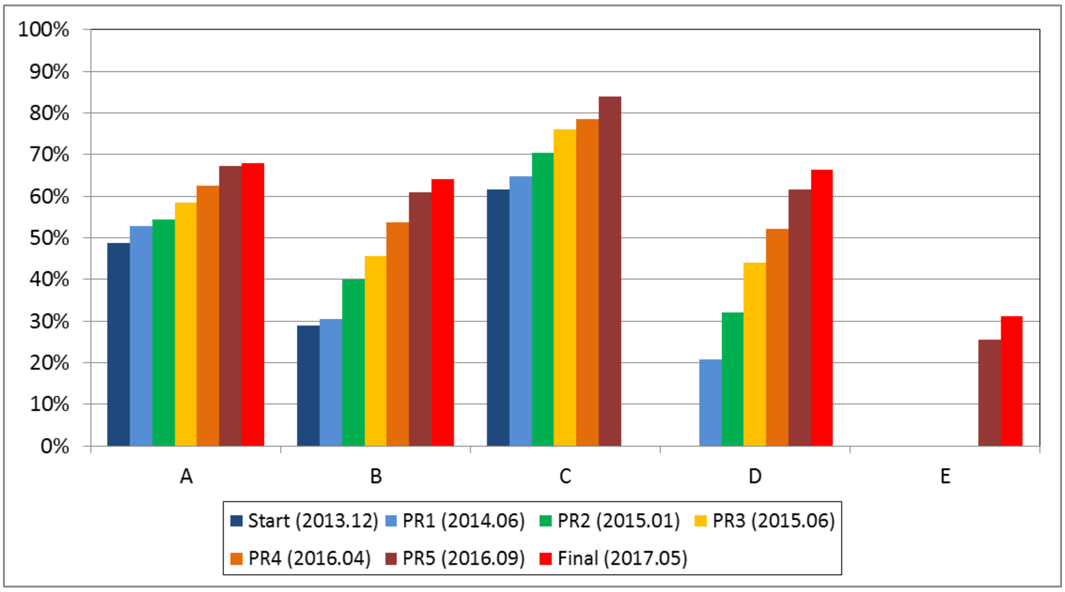
Figure 2.3-4. The scenario where the supervising personnel leave this project, such as by resignation, is not evaluated.



Proficiency rate of 100% indicates that a person can implement the output goal of each field alone, handle troubleshooting, and instruct co-workers

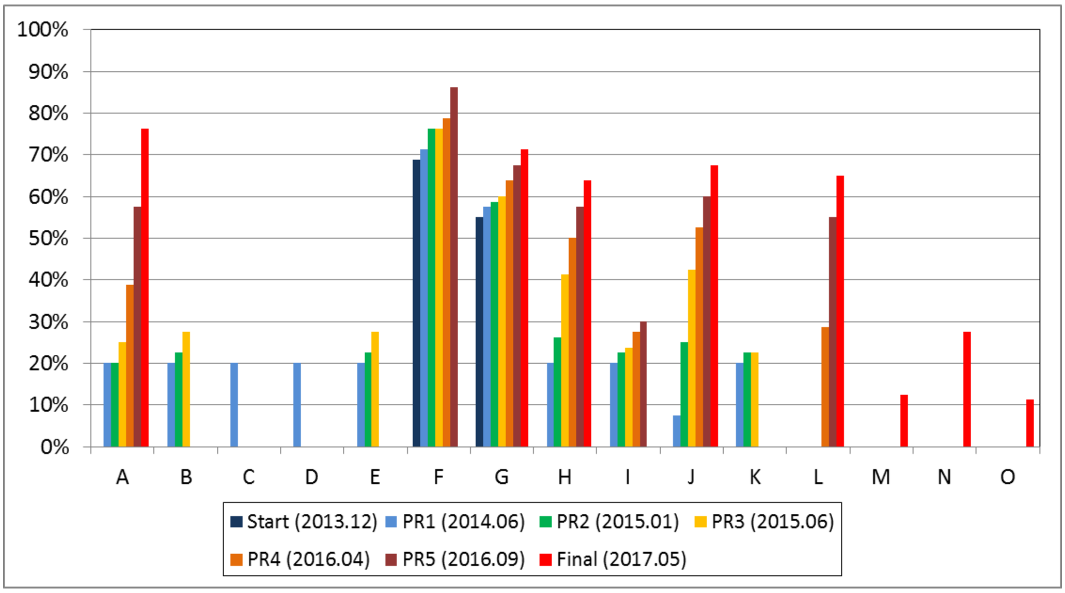
Source: JICA Experts

Figure 2.3-2 Technical Capacity Progress for Stationary Source Inventory



Proficiency rate 100%: Person can implement the output goal of each field by oneself, handle troubleshooting, and instruct co-workers
Source: JICA Experts

Figure 2.3-3 Progress of Technical Capacity Level on Mobile Source Inventory



Proficiency rate of 100% indicates that a person can implement the output goal of each field alone, handle troubleshooting, and instruct co-workers
Source: JICA Experts

Figure 2.3-4 Progress of Technical Capacity Level on Dispersion Simulation

2.3.1.2 Updating Results and Plan for Emission Inventory

(1). Updating the Emission Inventory for 2014 and 2015

The emission inventory for 2014 was updated by C/P and JICA Experts in September 2015. In addition, the emission inventory for 2015 was updated by C/P and JICA Experts in December 2016. The 2015 annual report of emission inventory was uploaded to the APRD website. The annual report is shown in Appendix 2.3-1. Additionally, a manual for updating the emission inventory was expanded; the practical knowledge used to develop the emission inventory so far was described.

(2). Updating the Emission Inventory for 2016

The APRD supervisor is using the manual described in 1.3.1.2 (1) to update the 2016 emission inventory. In addition, the APRD supervisor developed the annual report for this emission inventory result and uploaded this report to the APRD website after the approval by the responsible personnel.

(3). Methods for Calculating the Emission Inventory

The settings for activity data and emission factors of each source are shown in Table 2.3-5; future plans for each source are also shown. The detailed calculation method is described in the annual report of the emission inventory.

Table 2.3-5 Settings for Activity Data and Emission Factors of Each Source

Source	Item	Setting
Power plant	Activity data	Monthly coal consumption of each boiler, reported for each power plant. Additionally, each power plant's coal consumption based on energy statistics from Mongolia published by the Energy Regulatory Commission was referenced and variations between the reported and statistic value were verified.
	Emission factor	The emission factor was the maximum flue gas measurement at each power plant.
	Future plans	It is desirable that APRD continuously obtains coal consumption from power plants in the future. While the emission factor is based on flue gas measurements, this result was the measurement from Phase 1. Subsequent flue gas measurements should be conducted appropriately for current conditions. In addition, measured data was crosschecked with data from CEMS.
HOB	Activity data	Coal consumption, boiler, and stack by boiler inspection information were used. Additionally, operational conditions, such as new construction and cessation of operations, were incorporated.
	Emission factor	For HOBs with measurement results from the same boiler type, the average of the measured boiler type using the same coal type was applied. For HOBs without measurement results from the same boiler type, the average of the measured HOB by coal type was applied. These values reflected the results from flue gas measurements each time.
	Future plans	HOB information can be obtained from the boiler registration inspection; however, the boiler type filling method and the units of value are not unified. Therefore, verification, such as rechecking at the time of inventory updates is necessary. The boiler inspection team must further consider efficient investigation methods, such as unifying the description method in the survey form and establishing the survey form creation system to reflect data from the previous year.
		The boiler type emission factor includes data from the measurement in Phase 1. Further measurements will be carried out in the future and the accuracy of the emission factor is expected to improve.
CFWH	Activity data	The list of extracted boilers corresponding to CFWH from the national source registration data carried out in 2014 was applied. In addition, the survey commissioned by NAMEM in 2016 on the number of boilers from khoroo was implemented in UB City and each county in Mongolia.
	Emission factor	The emission factor reflects the results of flue gas measurements from this project.

	Future plans	The number of boilers in each khoroo in the national source registration survey and the number of boilers in each khoroo in the UB City and county survey in 2016 were significantly different. The reason for the discrepancy appears to that investigators did not sufficiently understand the definition of CFWH. Increasing the authority for counting charge and implementation of a teaching program are being considered in Mongolia in the future.
		The emission factor is based on flue gas measurement results, but the number of measurements is small. Therefore, the accuracy of the emission factor needs to be improved by increasing the number of measurements.
Small stoves for households	Activity data	Fuel consumption values were applied as follows. Coal [1]: 3.88 ton/unit/year (Ger stove), 4.84 ton/unit/year (wall stove), 3.45 ton/unit/year (improved stove) Wood: 0.49 ton/unit/year (all stoves)
		The number of stoves was applied as follows. In the case of the estimation using the number of households in each khoroo based on UB City statistics, the number of stoves is estimated from the number of households and setting the households with multiple stoves to 20.5%[2]. The survey of number of stoves in each khoroo was implemented under the direction of NAMEM for UB City and all counties in 2016.
	Emission factor	The emission factor was updated with the results from flue gas measurements in the Ger stove and combustion testing using coal and wood in the APRD laboratory.
	Future plans	Fuel consumption is based on literature values. Coal consumption varies by household and the accuracy of fuel consumption is expected to be improved after conducting seasonal fuel consumption surveys in multiple sample houses. With regard to the number of stoves, because there only a slight difference between the estimation method prior to 2015 and survey result in 2016, it is appropriate to calculate future activity data based on surveys of the number of stoves in each khoroo by stove type.
		The emission factor is based on flue gas measurement results, but the number of measurements is small. Therefore, the accuracy of the emission factor needs to be improved by increasing the number of measurements.
Vehicle exhaust	Activity data	The traffic count on the major roads was calculated by multiplying the traffic survey data in Phase 1 conducted in 2010 with the increasing number of registered inspected

[1] MONGOLIA: HEATING STOVE MARKET TRENDS IN POOR, PERI-URBAN GER AREAS OF LAANBAATAR AND SELECTED MARKETS OUTSIDE ULAANBAATAR, WB, 2013

[2] Data source is household count statistics (Ulaanbaatar municipality, 2010) and satellite image (2010). One khoroo was selected from each district, Ger were counted and divided by Ger household count.

gas		vehicles from 2010. In addition, travel regulations based on vehicle plate numbers have been implemented every weekday since 2011, so we set the traffic count estimated from the traffic survey to 4/5 from 2011. The major road distance was updated based on confirming newly constructed roads and updating the GIS data. The traffic count on minor roads was calculated using the ratio of the traffic volume of major road and minor road in the previous year.
	Emission factor	Emission factors were calculated using weighted averaging emission factors from Japan; these were based on the travelling ratio of vehicle exhaust gas regulation type to vehicle type calculated using 2015 vehicle inspection registration data.
		The deterioration of the catalyst due to high sulfur fuel etc. was considered and the deterioration was set for all cars that had been imported more than two years previously.
	Future plans	A traffic count survey has not been implemented since 2010 and the traffic situation in UB City has changed significantly, so a traffic count survey should be conducted.
		Exhaust gas measurements with on-board equipment was conducted for 20 vehicles in this project, but in spite of the same exhaust gas regulation year, the differences in the emission factors between measured vehicles varied by more than a factor of two. Therefore, by increasing the number of measurements in the future, the accuracy of the emission factor will be improved and an emission factor specific to Mongolia will be developed.
Fugitive dust from roads	Activity data	The settings for paved and unpaved road are as follows: minor roads in apartment areas are all paved; 30% of minor roads in other areas are paved and 70% are unpaved. Traffic volume is calculated in the same manner as vehicle exhaust gas
	Emission factor	Emission factors for paved and unpaved roads using AP-42 were calculated. Silt ratio: 1.01 g/m^2 (Major road), 1.8% (Minor road) The time period with wet ground was set to the sum of the number of rainy days plus the number of days the ground was frozen in winter.
	Future plans	Fugitive dust from roads was calculated using the emission factor method established in AP-42. Therefore, in the future, considering a method for reducing road dust is necessary.
Fugitive ash from ash pond of power plant	Activity data	The area where fugitive ash can be scattered was estimated using the results from satellite images and interviews with each power plant.
	Emission factor	The emission factor was calculated taking into consideration the density of ash from fugitive ash monitoring, which was carried out from spring to autumn every year. Because the ash landfill froze in winter, the amount of fugitive ash was considered to

		be 0.
	Future plans	Fugitive ash monitoring is affected by ash outflow and influx due to rainfall. Therefore, the accuracy of the fugitive ash measurements will improve from verifying the weather conditions before and after the measurement and shortening the measurement interval. Taking control measures to prevent scattering is necessary.

Source: JICA Experts

2.3.2 Updated Emission Inventory

2.3.2.1 Review of Emission Inventory

To improve the accuracy of emission inventory, the following reviews were conducted based on the comments from C/P and JICA Experts and a literature search.

(1). **Usage of the Information on HOB Registration System**

HOB information, such as newly established, abolition, location, boiler type name, and fuel consumption was updated using the annual data from the HOB registration survey. The boiler type emission factor was updated using the results from flue gas measurements.

(2). **Review of Estimation Method of Emission Factor from TSP to PM10**

Based on Mr. Endo’s advice, the amount of wood used to cold start before coal ignition was 500 g with a correlated coal consumption of about 4 kg. Therefore, the annual consumption ratio between wood and coal was set as 500 g to 4 kg. The annual wood consumption for stoves, which was calculated from coal consumption in 2015, was 0.49 t.

Table 2.3-6 shows the result of a combustion test using only 500 g wood as ignition material in October 2014 using an improved stove from DULL. The average of these results was updated as the new wood emission factor.

Table 2.3-6 Combustion Results from Wood

	Dust	SO2	NOx	CO
No 1	8.84	0.75	1.15	21.25
No 2	3.85	0.65	1.50	21.32
No 3	5.39	1.56	0.81	30.23
No 4	3.95	0.68	1.05	18.56
No 5	7.57	1.27	2.29	31.57
No 6	2.89	2.42	2.23	43.31
Average	5.42	1.22	1.50	27.71

Unit: kg/ton

Source: JICA Experts

(3). Review of Methods to Estimate Emission Factors from TSP to PM10

The PM10/TSP ratio that has been used is the UB value provided in Gattikunda (2007); however, the source of this ratio was not described in Gattikunda (2007).

To review the PM10/TSP ratio, measured data and cited studies were considered. To collect appropriate data during flue gas measurements, it is necessary to separate the flue gas collected during isokinetic sampling by particle size with an impactor. Then, the weight of all collected particles is compared to the weight of the collected PM10 particles. However, because the flue gas measurements for boiler inspection were prioritized, measuring surveys for PM10/TSP ratios were challenging. In the future, flue gas will be collected from combustion facilities and particle size distribution will be determined; the accuracy of the emission factor will be improved after obtaining measured values of PM10/TSP and PM2.5/TSP ratios. Furthermore, the literature values for PM10/TSP ratios in UB after 2007 have not been found. Therefore, the literature for neighboring countries was researched; PM10/TSP ratio results before and after installation of a treatment facility for a power plant in China was obtained.

However, because PM10/TSP ratios for small boilers and stoves in neighboring countries, such as China were not found in the literature, values from the EMEP/EEA Guidebook 2016 were applied.

A detailed explanation of each source follows.

a. Power Plant

The PM10/TSP ratios for a power plant with ESP in China[3] were found in the literature. The average PM10/TSP, PM2.5/TSP, and PM2.5/PM10 ratio after ESP were 91.57%, 46.14%, and 50.45%, respectively.

However, the PM10/TSP ratios for power plants equipped with scrubbers and bag filters were not found in the literature. Therefore, PM10/TSP ratios for all power plants were set to 91.57%. The emission factor before and after the update is shown in Table 2.3-7.

Table 2.3-7 Updated PM10 Emission Factors for Power Plants

	Before		After	
	TSP	PM10	TSP	PM10
PP2	23.37	15.19	23.37	21.40
PP3-1	10.47	6.81	10.47	9.59
PP3-2	5.13	3.33	5.13	4.69
PP4	2.87	1.87	2.87	2.63

Unit: kg/ton

Source: JICA Experts

b. Small Boiler (HOB and CFWH)

The PM10/TSP ratio values for small boilers were not found in the literature. The emission factors set in 1.A.4 Small combustion in the EMEP/EEA Guidebook 2016 were as follows.

For a HOB with a capacity < 1 MW, Table 3-26 of the Guidebook 2016 is applied;

Emission factor of PM10 / Emission factor of TSP = 190/200 = 0.95

For a HOB with a capacity > 1 MW, Table 3-27 of Guidebook 2016 is applied;

Emission factor of PM10 / Emission factor of TSP = 76/80 = 0.95

For a CFWH using coal, Table 3-16 of Guidebook 2016 is applied;

Emission factor of PM10 / Emission factor of TSP = 225/261 = 0.862

For a CFWH using wood, Table 3-18 of Guidebook 2016 is applied;

Emission factor of PM10 / Emission factor of TSP = 480/500 = 0.96

[3] EMISSION CHARACTERISTICS OF FINE PARTICLES FROM COAL-FIRED POWER PLANTS https://www.researchgate.net/publication/237613273_EMISSION_CHRACTERISTICS_OF_FINE_PARTICLES_FROM_COAL-FIRED_POWER_PLANTS

However, these values are from Europe. Therefore, in the future, the values will be updated to reflect measurements from Mongolia and neighboring countries. The emission factor before and after the change is shown in Table 2.3-8.

Table 2.3-8 Updated of PM10 Emission Factors for CFWH

	TSP	PM10
Before	8.92	5.798
After	8.92	7.689

Unit: kg/ton

Source: JICA Experts

c. Small Stoves

The values for PM10/TSP ratios of small stoves were not found in the literature. The emission factors set in 1.A.4 Small combustion in the EMEP/EEA Guidebook 2016 were as follows.

For using coal, Table 3-15 of Guidebook 2016 is applied;

Emission factor of PM10 / Emission factor of TSP = 450/500 = 0.90

For using wood, Table 3-17 of Guidebook 2016 is applied;

Emission factor of PM10 / Emission factor of TSP = 760/800 = 0.95

However, these values are from Europe. Therefore, in the future, the values will be updated to reflect measurements from Mongolia and neighboring countries. The emission factors before and after change is shown in Table 2.3-9.

Table 2.3-9 Updated PM10 Emission Factors for Small Stoves for Households

	Before		After	
	TSP	PM10	TSP	PM10
Ger stove (Coal)	6.23	4.05	6.23	5.61
Ger stove (Wood)	5.42	3.57	5.42	5.15
Wall stove (Coal)	9.77	6.35	9.77	8.79
Wall stove (Wood)	5.42	3.52	5.42	5.15
Improved stove (Coal)	1.23	0.80	1.23	1.10
Improved stove (Wood)	5.42	3.57	5.42	5.15

Source: JICA Experts

Unit: kg/ton

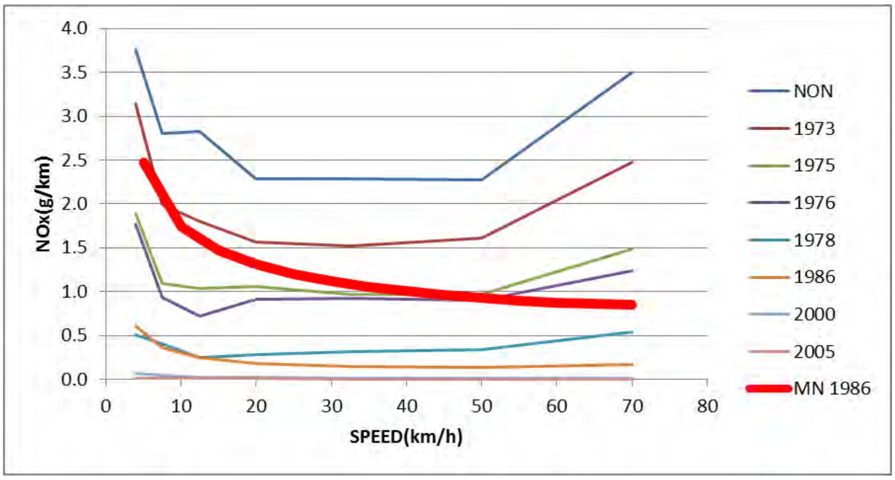
(4). Updated Mobile Source Emission Inventory Using the Exhaust Gas Measurements from On-board Equipment

The results from exhaust gas measurements using on-board equipment in Activity 1-11 were used to update the emission inventory, and the results were compared to the previously used emissions.

The procedure for updating data is as follows:

1. Select the target year for exhaust gas regulation by manufactured year, fuel, and total weight of each survey data
2. Classification of each survey data based on the selected exhaust gas regulation year
3. Determine the regression coefficients between travel speed and emission factor in respective classified group
4. Update the regression coefficients in the table in the emission inventory database
5. Re-calculate the PM and NOx emission using the updated table

Examples of emission factors by speed after classifying the measured result using the exhaust gas regulation year are shown in Figure 2.3-5. This example is based on an emission factor using the result of exhaust gas measurement with on-board equipment for two gasoline vehicles that correspond to NOx exhaust gas regulations in 1986. The emission factors for travelling in Mongolia (red line) were nearly five times the ones for Japan (orange line). Determining the emission factor by speed was conducted in the same manner as for the other groups and the emission factors were updated.



Thick line: Emission factor using the exhaust gas measurements from on-board equipment
Thin line: Emission factor by vehicle gas regulation in Japan
Source: JICA Experts

Figure 2.3-5 Comparison of NOx Emission Factors by Speed

Emissions updated using the measurements from on-board equipment and the method described are provided in Table 2.3-10.

Table 2.3-10 Comparison of Emissions before and After Applying the Exhaust Gas Measurement Results from the On-board Equipment

	PM		NOx	
	Major Road	**Minor Road**	**Major Road**	**Minor Road**
Emission before applying the measurement result	235.04	36.72	3,872.84	605.08
Emission after applying the measurement result	232.87	36.38	5,543.16	851.99

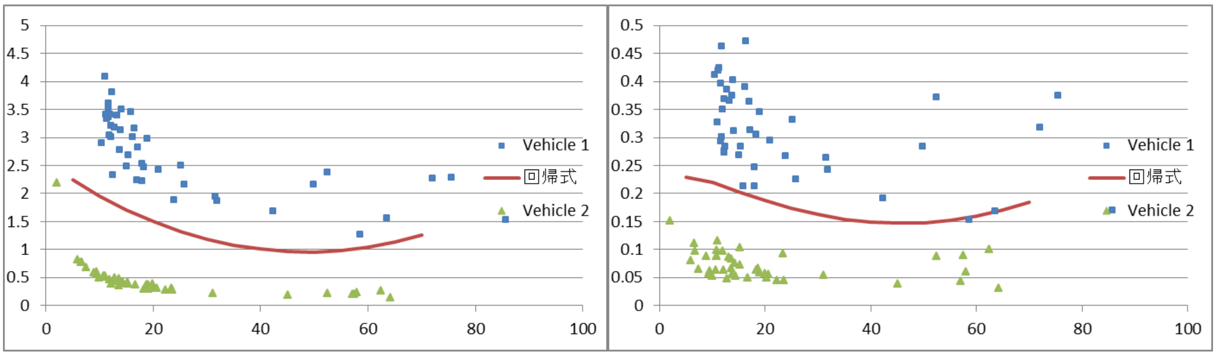
Unit: ton

Source: JICA Experts

After updating the emission factors, the PM emission changed little. However, the change in NOx emission was large because the emission factor in Mongolia was originally estimated based on Japan's emission factor; the value in Mongolia had not been previously measured. Therefore, the original NOx emission factor was underestimated. Furthermore, within all vehicles exhaust gas measurements, there were regulation years for which we had measured only one vehicle within a vehicle type class. In addition, despite having the same exhaust gas regulation year, differences in emission factors between measured vehicles were nearly eight fold (Figure 2.3-6). The JICA Experts explained to the C/P that, in the future, continued exhaust gas measurement using on-board equipment are necessary and as a result, the accuracy of emission factor should improve.

In addition, when setting the control measure plan for vehicle exhaust gas, the emission factor applied must be discussed.

Using the results from the bus with a EURO4 engine that runs in UB (Activity 1-11), the emission reduction effect from introducing the EURO4 engine to all large size bus was evaluated.



The measurement result of two diesel vehicles that were modified to meet the 1992 exhaust gas regulation
Left: NOx, Right: PM
Source: JICA Experts

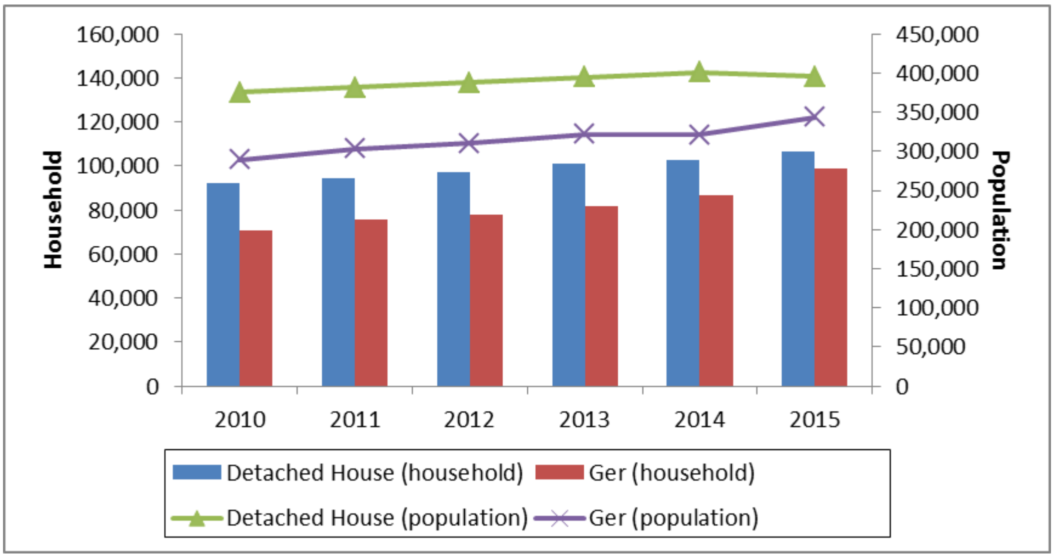
Figure 2.3-6 Comparison of the Result for the Same Vehicle in the Year of Exhaust Gas Regulation

2.3.2.2 Results from Emission Inventory Calculations

The trends in emission by sources from 2010 to 2015 are shown in Table 2.3-13 to Table 2.3-17 and Figure 2.3-10 to Figure 2.3-21. The annual report for emission inventory for 2016 was completed in April 2017 and was uploaded to the APRD website in May 2017.

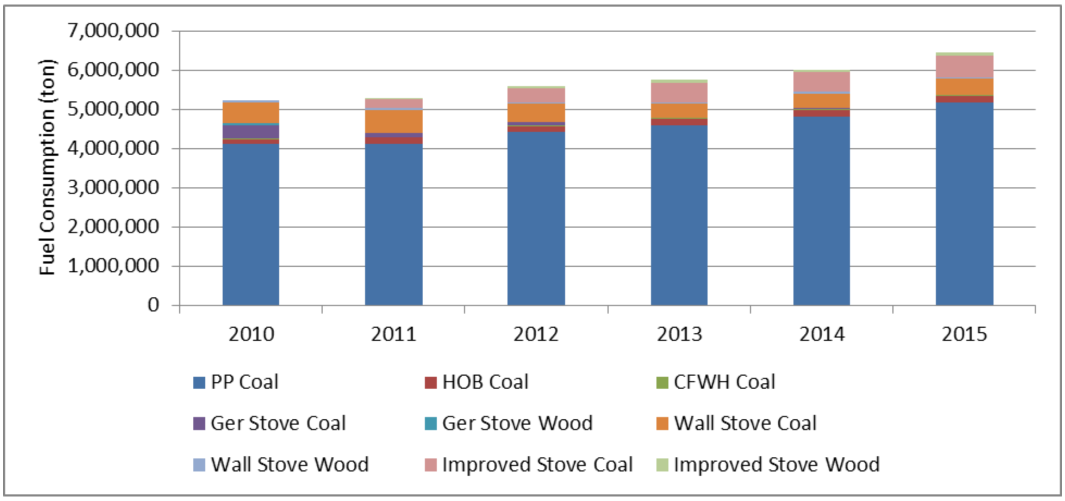
(1). <u>Trends in Activity Data</u>

The trends in population and households in the six central districts in UB from 2010 to 2015 are shown in Figure 2.3-7 and the trends in fuel consumption for stationary sources are shown in Figure 2.3-8 and Table 2.3-11. For the past five years, fuel consumption has increased as the population of the entire city and Ger area has increased.



Source: JICA Experts

Figure 2.3-7 Trends in Population and Households in the Ger Area in the Six Central Districts of UB City



Source: JICA Experts

Figure 2.3-8 Trends in Fuel Consumption of Stationary Sources

Table 2.3-11 Trends in Coal Consumption of Stationary Sources

	2010	2011	2012	2013	2014	2015
PP	4,105,209.62	4,126,456.16	4,424,844.69	4,603,087.57	4,823,254.95	5,159,910.00
HOB	133,975.11	148,742.40	148,742.40	149,284.00	154,061.00	175,059.00
CFWH	19,857.00	22,438.41	22,895.12	23,669.54	24,512.38	25,025.85
Ger Stove	331,295.20	97,077.45	76,629.01	13,631.99	19,441.17	17,686.05
Wall Stove	552,344.33	560,417.43	457,682.16	352,602.28	382,522.60	390,542.04
Improved Stove	0.00	218,325.12	349,279.59	496,758.93	497,833.77	560,222.75
Total	5,142,681.26	5,173,456.96	5,480,072.98	5,639,034.32	5,901,625.88	6,328,445.70

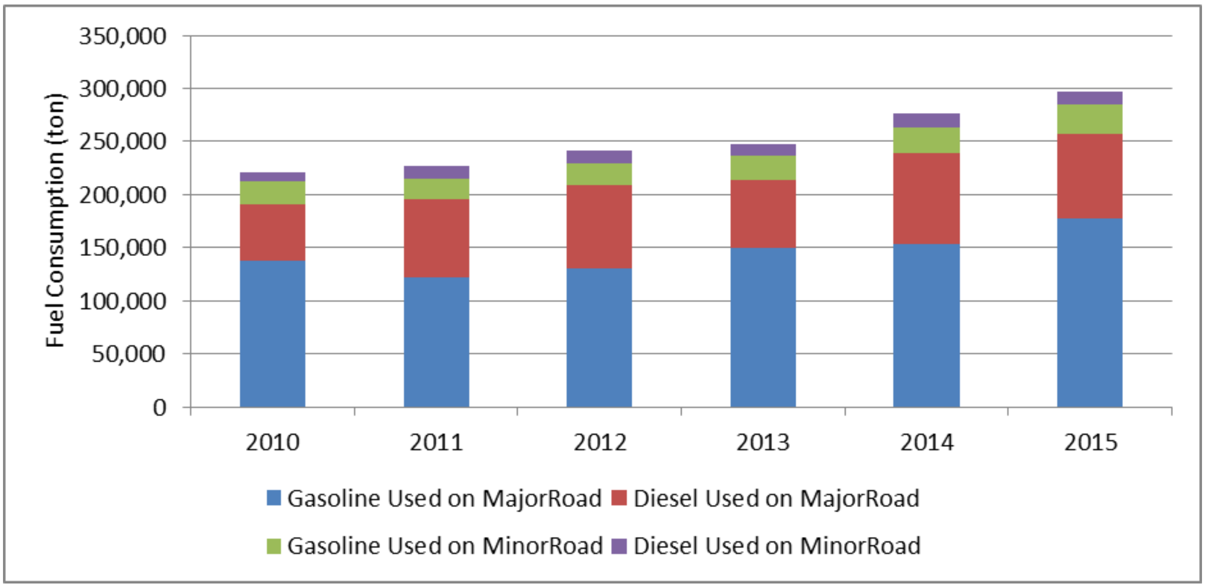
Unit: ton
Source: JICA Experts

The trends in number of inspected vehicles in UB City from 2010 to 2015 are shown in Table 2.3-12 and the trends in fuel consumption of mobile sources are shown in Figure 2.3-9. The annual traffic census and traffic volume were estimated from multiplying the traffic numbers from the traffic census survey conducted in 2010 and 2011 by the increasing number of inspected vehicle after 2012. The fuel consumption was estimated as increasing similarly.

Table 2.3-12 Number of Inspected Vehicles in UB City

	2010	2011	2012	2013	2014	2015
Total	188,100	205,596	218,204	257,783	293,892	294,902

Unit: vehicle number
Source: Vehicle inspection and registration center in Mongolia



Source: JICA Experts

Figure 2.3-9 Trends in Fuel Consumption for Mobile Sources

(2). Trends in SO_2 Emissions

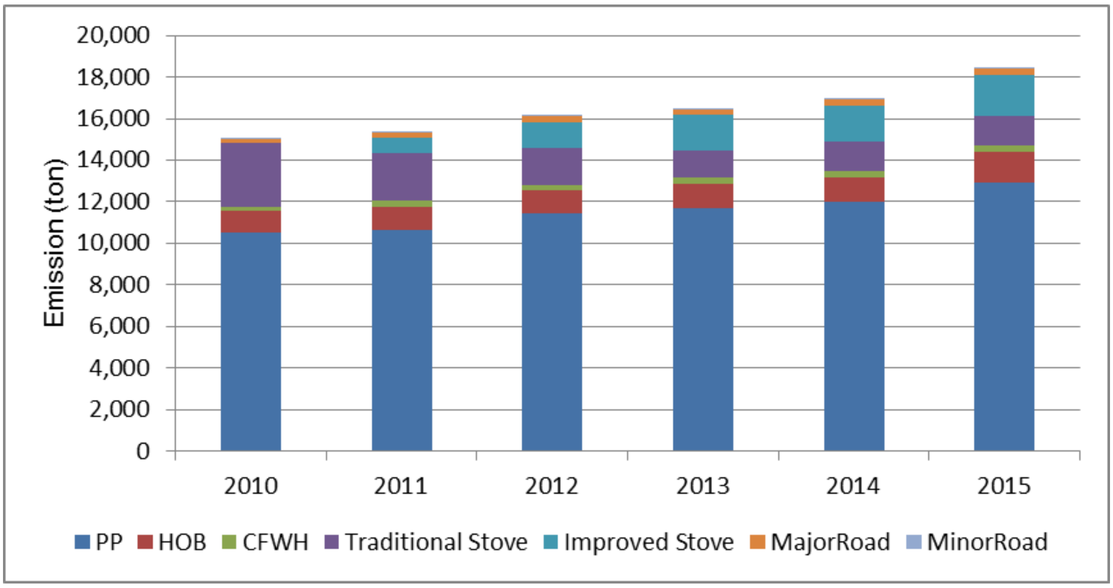
The trends in SO_2 emission by sources from 2010 to 2015 are shown in Table 2.3-13 and Figure 2.3-10, and the distribution map of SO_2 emission for 2015 is shown in Figure 2.3-12. The emission each year was calculated using the emission factor modified in 2.3.2.1. Because coal consumption in PPs and small stoves in households are increasing with the population and households in UB City, SO_2 emissions are also increasing. From 2014 to 2015, emissions from power plants decreased, but the emissions from HOB and small stoves for households increased, leading to an increase in coal consumption. SO_2 emission contributions by source for 2015 are shown in Figure 2.3-11. In increasing order, power plants, small stoves for households, and HOB had the largest emissions.

Table 2.3-13 Trends in SO_2 Emissions by Source

	2010	2011	2012	2013	2014	2015
PP	10,544.72	10,666.97	11,444.76	11,668.15	12,002.58	12,922.12
HOB	991.31	1,109.08	1,084.79	1,204.53	1,165.62	1,502.55
CFWH	238.19	269.15	274.63	283.92	294.64	300.81
Small stove for household (Traditional stove)	3,051.46	2,265.95	1,808.11	1,294.32	1,415.10	1,406.28
Small stove for household (Improved stove)	0.00	761.91	1,222.44	1,737.20	1,740.50	1,956.92
Vehicle exhaust gas (Major road)	204.25	256.90	273.69	237.95	301.71	294.33
Vehicle exhaust gas (Minor road)	31.91	40.14	42.76	37.18	47.14	45.99
Total	15,061.84	15,370.09	16,151.19	16,463.25	16,967.29	18,429.00

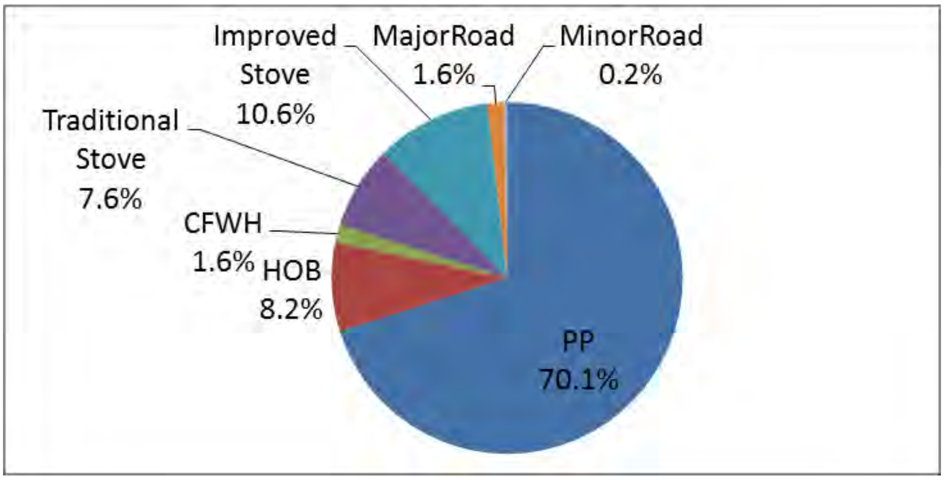
Source: JICA Experts

Unit: ton



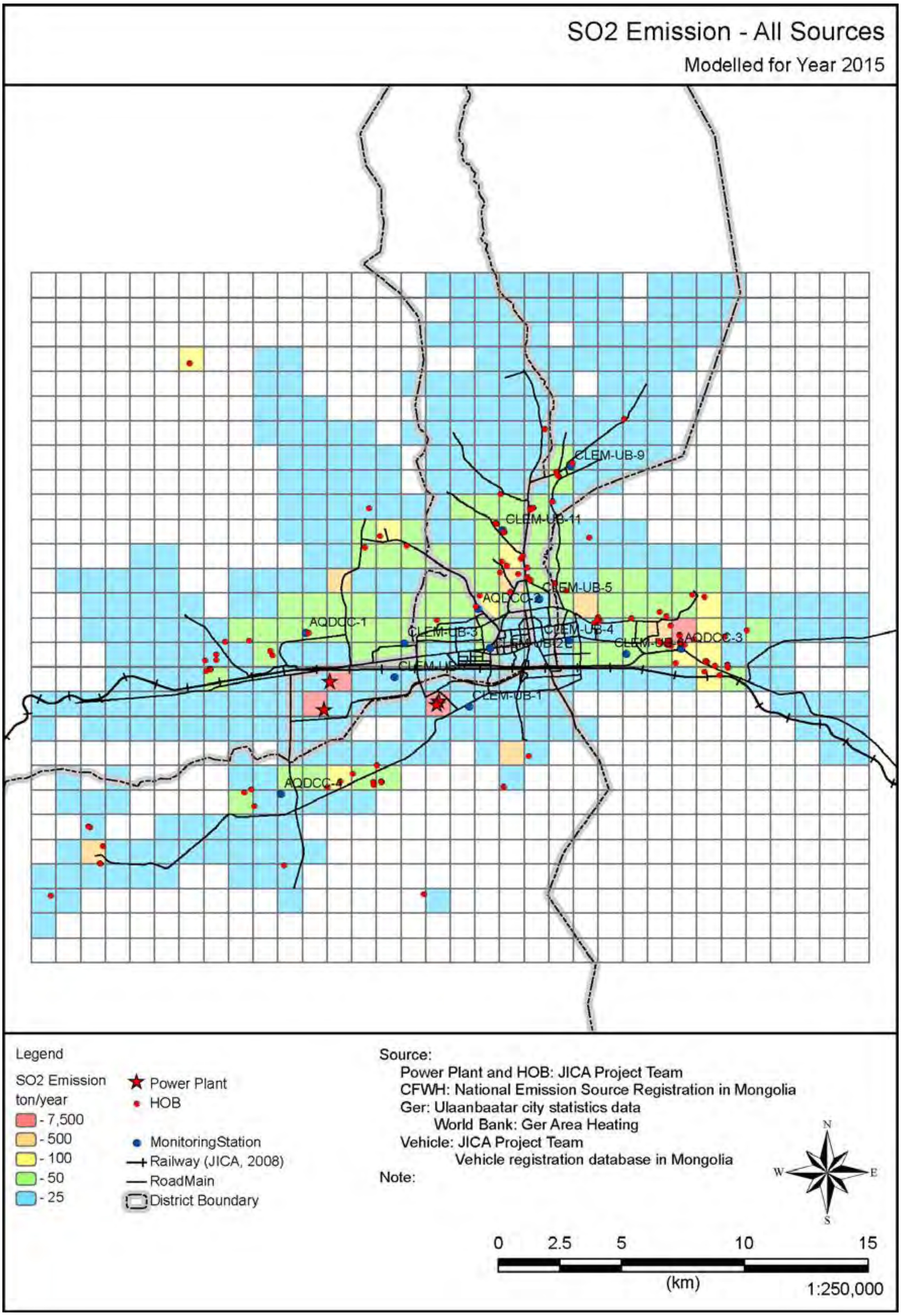
Source: JICA Experts

Figure 2.3-10 Trends in SO_2 Emissions by Source



Source: JICA Experts

Figure 2.3-11 SO2 Emission Contributions by Source for 2015



Source: JICA Experts

Figure 2.3-12 SO2 Emission Distribution

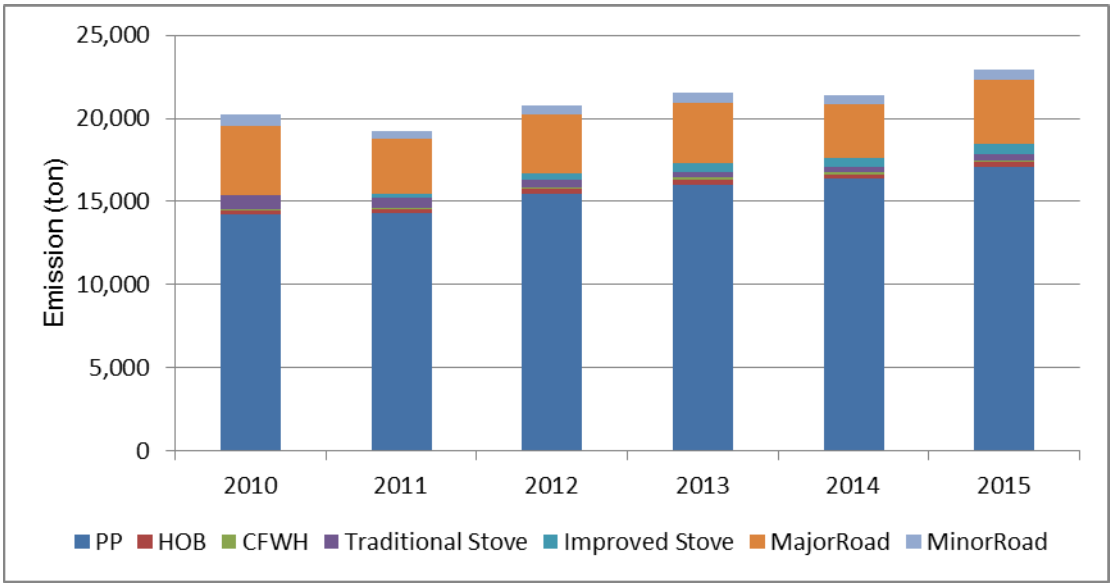
(3). Trends in NOx Emissions

The trends in NOx emission by sources from 2010 to 2015 are shown in Table 2.3-14 and Figure 2.3-13. The emissions each year were calculated using the emission factor modified in 2.3.2.1. The traffic count is estimated using the increasing number of inspected vehicles based on the traffic count survey in 2010 and 2011. Although it is clear that the increase in number of inspected vehicles is leading to an increase in vehicle exhaust gas, new traffic surveys are necessary. Currently, new roads are being constructed and existing roads are being renovated, so calculating emissions using updated traffic counts are desirable. From 2014 to 2015, emissions from power plants decreased, but emissions from vehicle exhaust gas increased due to increasing traffic volume. The NOx emission contributions by sources for 2015 are shown in Figure 2.3-17. The emissions from power plant and vehicle exhaust gas accounted for about 90% of total emissions.

Table 2.3-14 Trends in NOx Emissions by Source

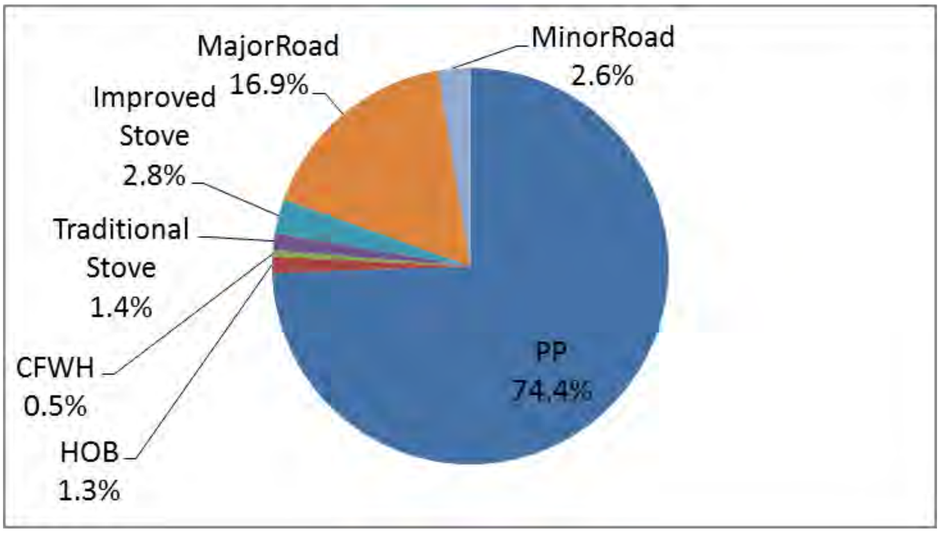
	2010	2011	2012	2013	2014	2015
PP	14,251.02	14,274.63	15,465.37	16,032.89	16,362.47	17,070.92
HOB	184.20	255.78	279.62	296.70	280.69	304.73
CFWH	92.14	104.12	106.24	109.84	113.98	116.37
Small stove for households (traditional stove)	864.94	556.97	443.95	294.18	324.23	321.10
Small stove for households (improved stove)	0.00	247.82	398.55	566.37	567.45	639.69
Vehicle exhaust gas (major road)	4,186.38	3,303.29	3,518.09	3,652.19	3,213.81	3,872.84
Vehicle exhaust gas (minor road)	654.07	516.10	549.66	570.61	502.12	605.08
Total	20,232.74	19,258.70	20,761.47	21,522.78	21,364.75	22,930.72

Source: JICA Experts
Unit: ton



Source: JICA Experts

Figure 2.3-13 Trends in NOx Emission by Source



Source: JICA Experts

Figure 2.3-14 NOx Emission Contributions by Source for 2015

(4). Trends in TSP Emissions

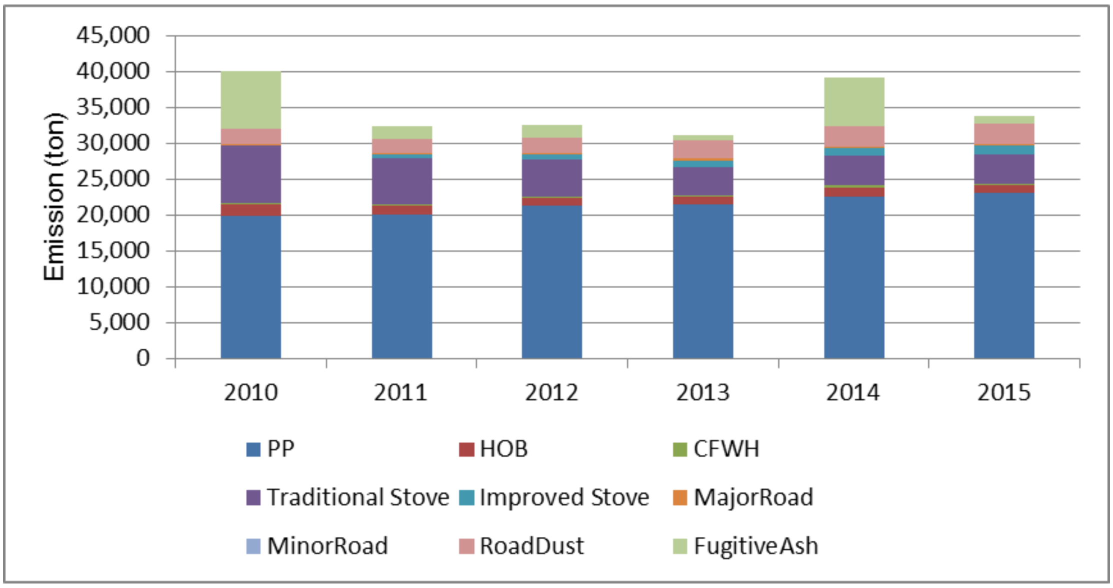
The trends in TSP emission by source from 2010 to 2015 are shown in Table 2.3-15 and Figure 2.3-15. The emissions each year were calculated using the emission factor modified in 2.3.2.1. The trends in number of small stoves for households by types are shown in Figure 2.3-17. Replacing traditional stove with improved stoves decreased emission from small stoves for households before 2013, however, emissions increased after 2014 as a result of increasing coal consumption. From 2014 to 2015, fugitive ash from PP ash ponds decreased, leading to a reduction in total emissions of TSP. Because fugitive ash from PP ash ponds is influenced by the condition of cover soil in the ash pond, annual emissions vary widely. TSP emission contributions by source for 2015 are shown in Figure 2.3-16. Emissions from PPs were the largest, followed by small stoves for households and fugitive road dust.

Table 2.3-15 Trends in TSP Emission by Source

	2010	2011	2012	2013	2014	2015
PP	19,826.11	20,107.94	21,236.59	21,481.09	22,605.88	23,168.56
HOB	1,647.86	1,159.81	1,120.35	1,100.47	1,271.72	972.80
CFWH	176.76	199.74	203.80	210.70	218.65	223.23
Small stove for household (Traditional stove)	7,989.48	6,453.34	5,152.33	3,832.31	4,174.08	4,151.72
Small stove for household (Improved stove)	0.00	435.14	697.85	991.70	993.59	1,117.13
Vehicle exhaust gas (Major road)	195.33	212.14	225.69	255.76	216.27	235.04
Vehicle exhaust gas (Minor road)	30.52	33.14	35.26	39.96	33.79	36.72
Fugitive dust from road	2,068.35	2,032.78	2,169.63	2,413.93	2,850.65	2,860.51
Fugitive ash from ash pond in PPs	8,135.16	1,673.82	1,673.82	812.03	6,693.00	1,069.00
Total	40,069.57	32,307.85	32,515.33	31,137.95	39,057.64	33,834.70

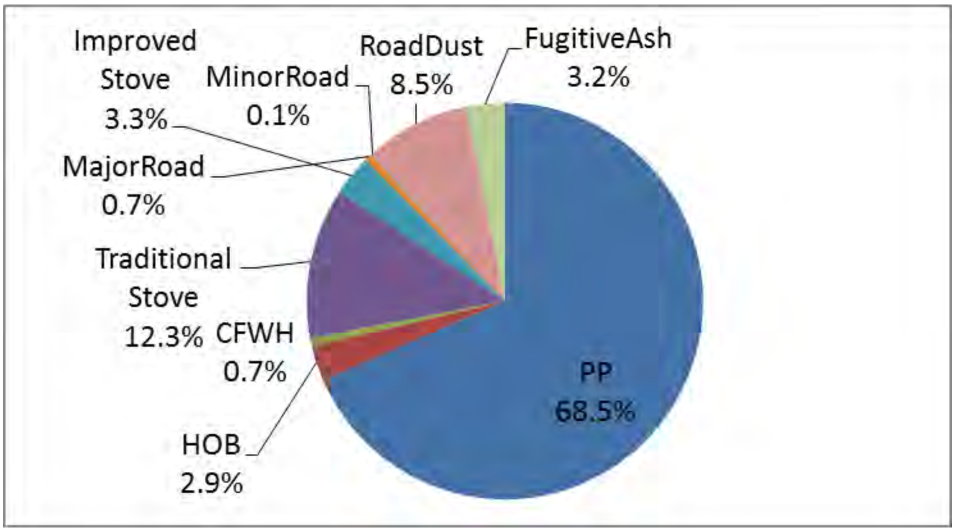
Source: JICA Experts

Unit: ton



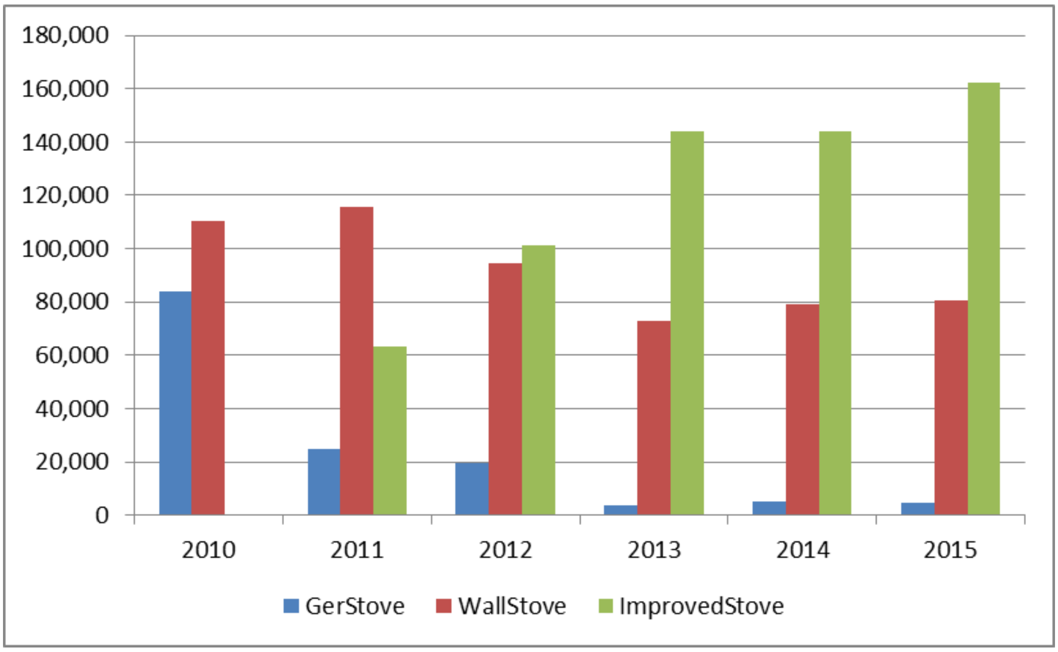
Source: JICA Experts

Figure 2.3-15 Trends in TSP Emissions by Source



Source: JICA Experts

Figure 2.3-16 TSP Emission Contributions by Source for 2015



Source: JICA Experts

Figure 2.3-17 Trends in the Number of Small Stoves for Households by Type

(5). Trends in PM10 Emissions

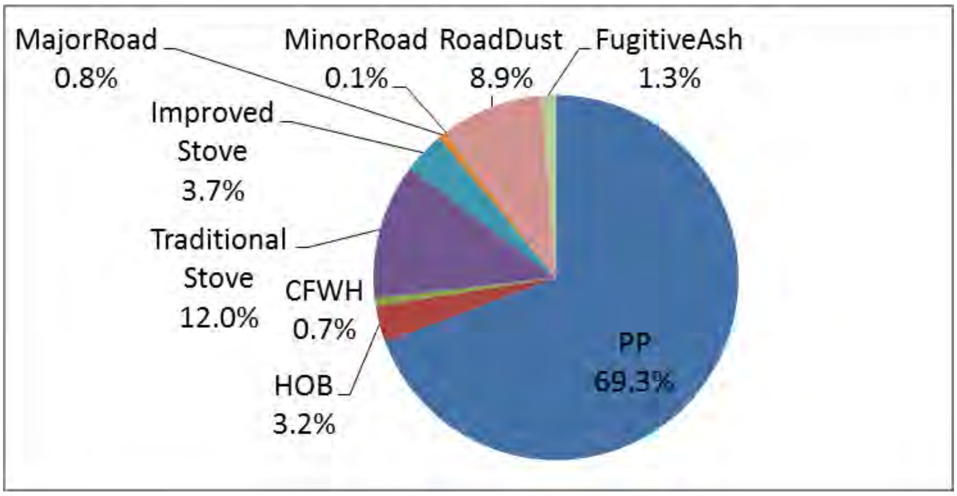
The trends in PM10 emissions by sources from 2010 to 2015 are shown in Table 2.3-16 and Figure 2.3-19, and the distribution map of PM10 emission for 2015 is shown in Figure 2.3-20. The emissions each year were calculated using the emission factor modified in 2.3.2.1. The trends in number of small stoves for households by type are shown in Figure 2.3-17. Similar to TSP, the PM10 emission from small stoves for households decreased before 2013 from replacing traditional stoves with improved stoves; however, the emissions increased after 2014 due to increasing coal consumption. From 2014 to 2015, total emissions of PM10 increased as emissions from small stoves for households increased. Because fugitive ash from PP ash ponds is influenced by the condition of cover soil in the ash pond, annual emissions vary widely. PM10 emission contributions by source for 2015 are shown in Figure 2.3-18. Emissions from PPs were the largest, followed by small stoves for households and fugitive road dust.

Table 2.3-16 Trends in PM10 Emissions by Source

	2010	2011	2012	2013	2014	2015
PP	18,974.81	19,242.42	20,336.20	20,577.34	21,633.64	22,219.65
HOB	1,644.18	1,188.71	1,149.31	1,139.55	1,299.55	1,040.86
CFWH	170.66	192.85	196.77	203.43	211.11	215.53
Small stove for household (Traditional stove)	7,456.42	6,004.85	4,794.17	3,561.35	3,879.44	3,858.54
Small stove for household (Improved stove)	0.00	457.32	735.62	1,045.39	971.61	1,177.61
Vehicle exhaust gas (Major road)	210.97	231.81	246.65	273.98	239.37	257.57
Vehicle exhaust gas (Minor road)	32.96	36.22	38.54	42.81	37.40	40.24
Fugitive dust from road	2,068.35	2,032.78	2,169.63	2,413.93	2,850.65	2,860.51
Fugitive ash from ash pond in PPs	1,950.15	515.31	515.31	328.30	498.63	409.64
Total	32,508.51	29,902.27	30,182.20	29,586.08	31,621.41	32,080.15

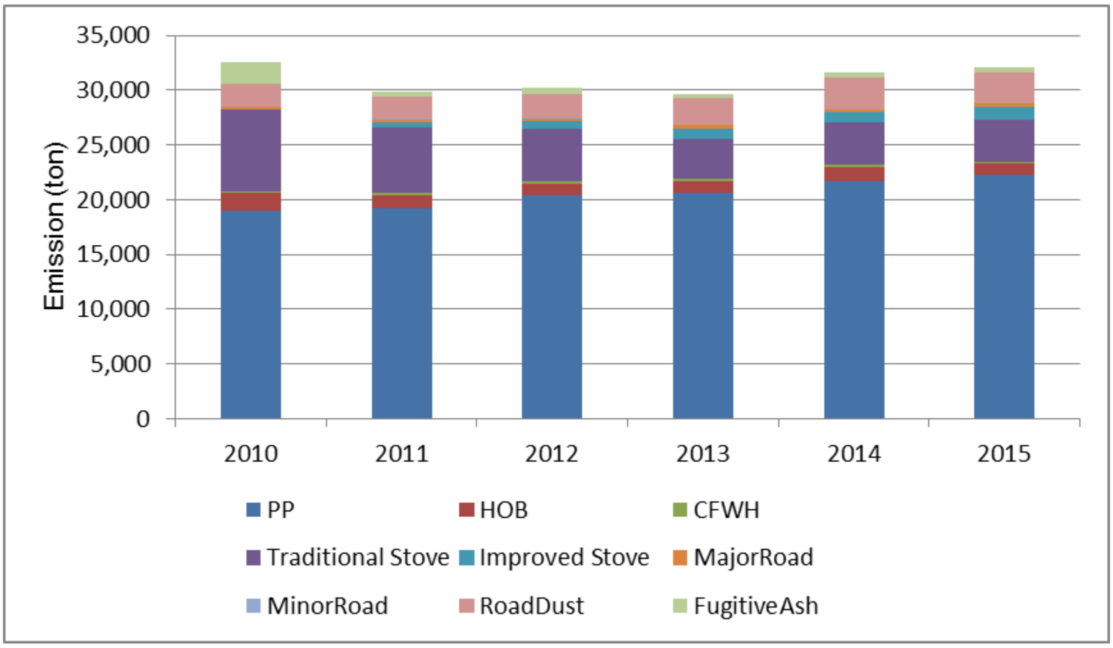
Source: JICA Experts

Unit: ton



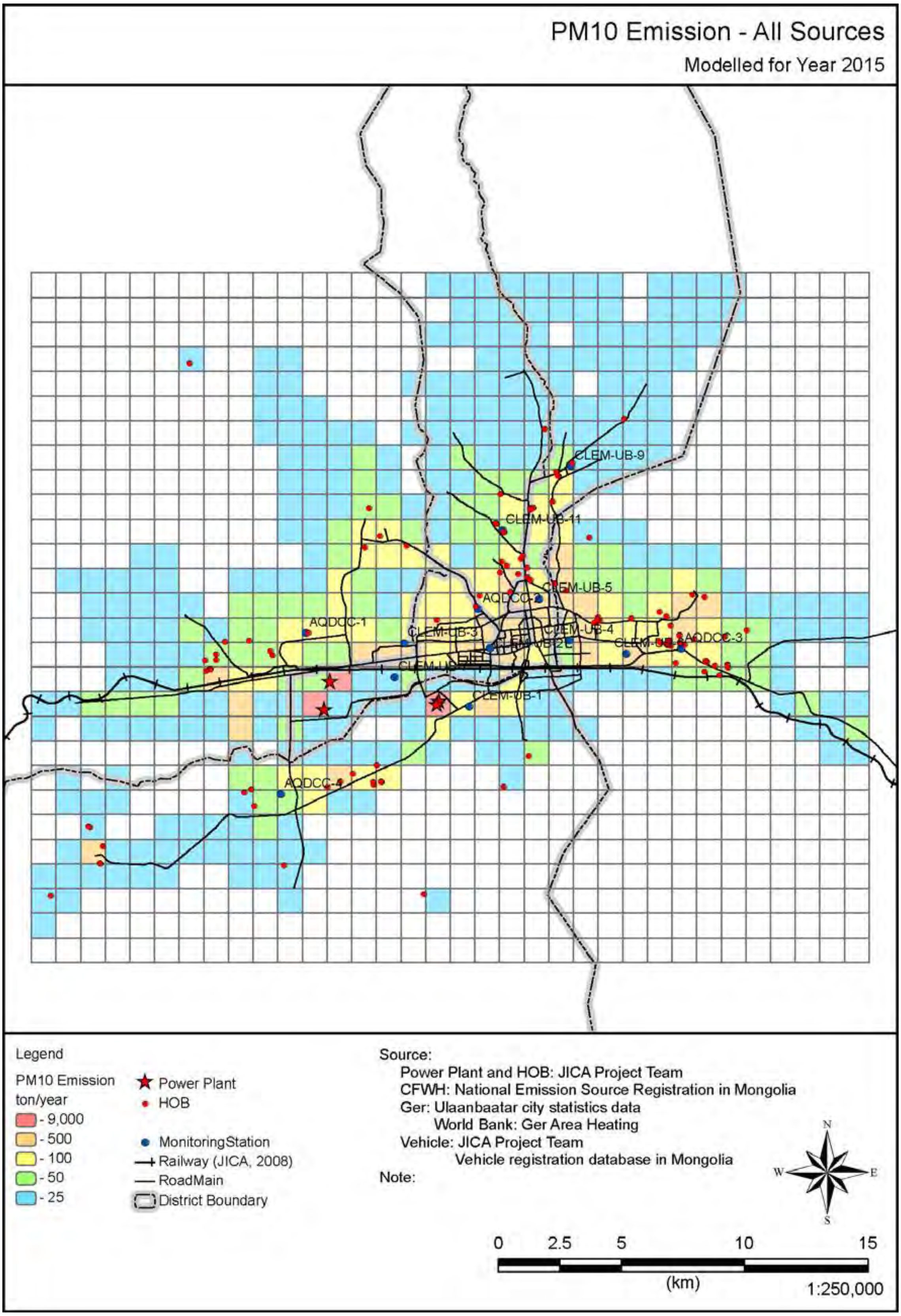
Source: JICA Experts

Figure 2.3-18 PM10 Emission Contributions by Source for 2015



Source: JICA Experts

Figure 2.3-19 Trends in PM10 Emissions by Source



Source: JICA Experts

Figure 2.3-20 PM10 Emission Distribution

(6). Trends in CO Emissions

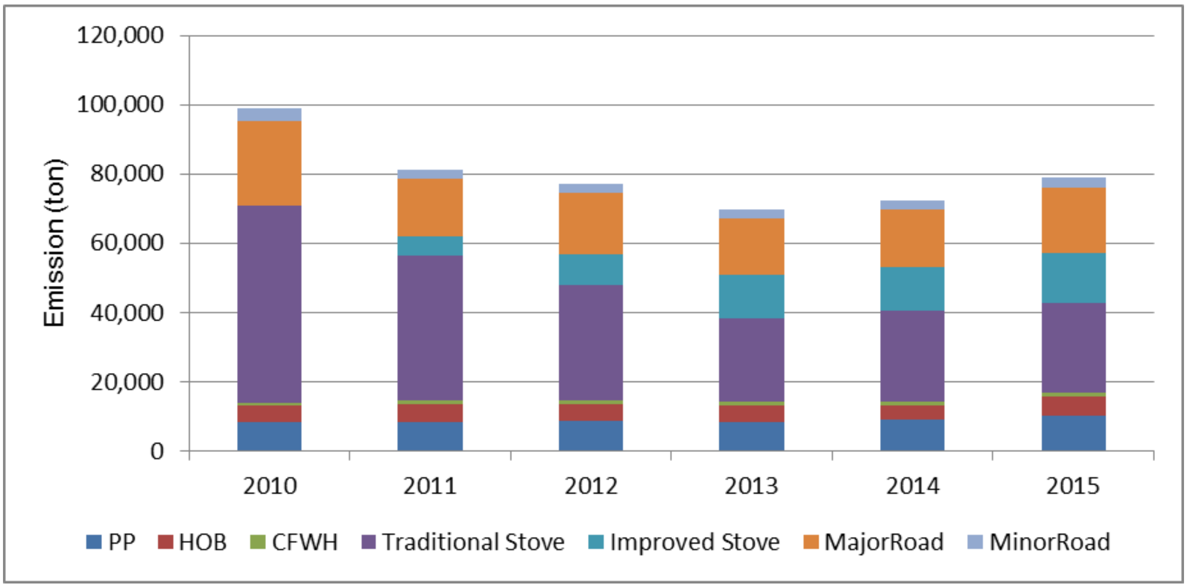
The trends in CO emission by sources from 2010 to 2015 are shown in Table 2.3-17 and Figure 2.3-21. Emissions each year were calculated using the emission factor modified in 2.3.2.1. The overall CO emissions decreased; however, emissions increased in 2014 due to the increase in emissions from small stoves for households. CO emission contributions by source for 2015 are shown in Figure 2.3-22. The emissions from small stoves for households were the largest, followed by vehicle exhaust gas. These two sources accounted for about 75% of total emissions.

Table 2.3-17 Trends in CO Emission by Source

	2010	2011	2012	2013	2014	2015
PP	8,480.55	8,484.45	8,647.03	8,483.07	9,088.64	10,067.82
HOB	4,596.04	5,166.05	5,038.03	4,846.17	4,260.11	5,846.16
CFWH	905.39	1,023.09	1,043.92	1,079.23	1,119.97	1,143.43
Small stove for household (Traditional stove)	56,830.04	41,833.30	33,378.67	23,792.04	26,023.47	25,844.69
Small stove for household (Improved stove)	0.00	5,551.29	8,825.58	12,541.92	12,565.77	14,128.24
Vehicle exhaust gas (Major road)	24,292.66	16,461.59	17,542.23	16,497.39	16,631.30	19,001.35
Vehicle exhaust gas (Minor road)	3,795.42	2,571.92	2,740.75	2,577.51	2,598.43	2,968.72
Total	98,900.12	81,091.69	77,216.21	69,817.32	72,287.70	79,000.43

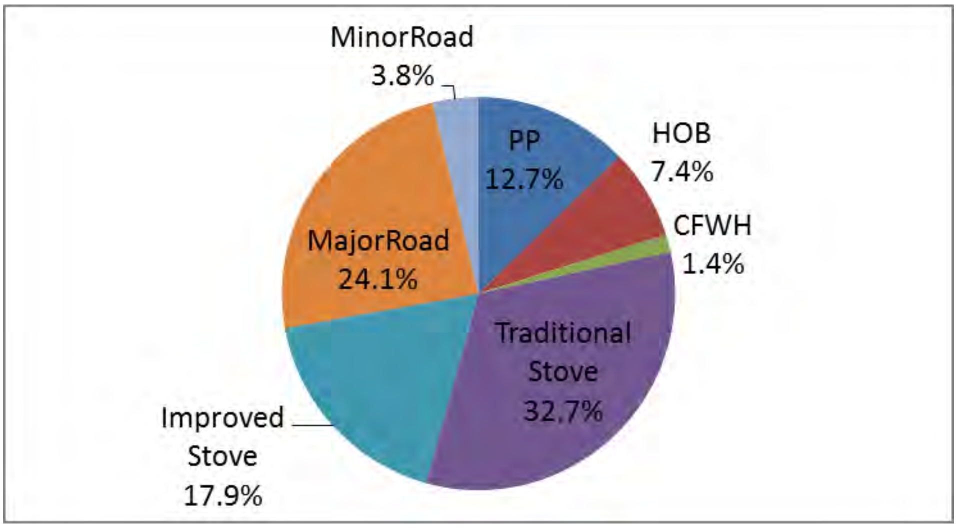
Source: JICA Experts

Unit: ton



Source: JICA Experts

Figure 2.3-21 Trends in CO Emissions by Sources



Source: JICA Experts

Figure 2.3-22 CO Emissions Contribution by Source for 2015

2.3.3 PM10 Source Contribution Analysis Trials Using the CMB Model

As activity 3-7, the CMB model was implemented using the chemical component data obtained in UB City, reported in previous progress reports, to reveal the mechanism of PM10 formation.

2.3.3.1 Analyses Using the CMB Method

The CMB method is a receptor model, which statistically estimates the contribution of emission sources to PM using PM chemical components both at sources and receptors.

According to the results from the air diffusion simulation model established in Phase 1 of this project, the calculated concentration of PM10 was much lower than the observed concentration. As a result of the PM component analyses implemented in Phase 2 of this project, it was revealed that this difference was caused by PM from unburnt fuel, which is a vapor at high temperature and could not be considered as PM in the emission source measurement. Therefore, CMB analysis was implemented to reveal the PM10 formation mechanisms.

The analysis using the CMB model did not agree with the observed weight; in winter, the CMB weight was generally heavier than the observed value. This was hypothesized as due to OC, which accounts for the major component of coal combustion. OC changes its phase between gas/particle according to the equilibrium condition in the atmosphere. The CMB model is based on the premise that the index component is stable between the source and receptor. Even if the index components used for CMB calculation are stable, the difference between the calculated and observed concentration of total mass can be large if unstable components, such as OC, occupies most of the mass in ambient air. In addition, there are other problems, such as insufficient number of samples, or revision of source sampling method.

2.3.3.2 Analyses Using the PMF Method

To address the CMB problems, the PMF model was implemented due its lower cost. PMF is a receptor model based on multivariate analysis utilized to analyze contributions of major emission sources of PM. It can estimate emission sources and their contributions simultaneously and does not require source information. The results from PMF were reasonable, as indicate by the results that follow.

- In PM2.5, the contributions from the carbon component, including volatile carbon emitted from coal combustion, were dominant in the winter season. In contrast, contributions from soil particle dominated in the other seasons.
- Contributions from vehicles; waste combustion, including old tires; and secondary particles, including nitrate ion and ammonia ion were indicated as the other sources.
- The possibility of multiple soils types, which have different components, was suggested.

2.3.3.3 Overview of Receptor Model Analysis

As described previously, although establishing the CMB model was difficult given the conditions in UB City, it was concluded that contributions from coal combustion were the dominant PM pollution in the winter season. In contrast, fugitive road dust was the largest contributing source in results from the simulation model. Considering ground surfaces in the winter season freeze, and little fugitive dust is expected, this result suggests that fugitive road dust as an emission source in the simulation model needs to be revised. The PMF model results agreed with the observations very well, thus the simulation model was revised based on this result.

In addition, the ratio of element components in particles differed by seasons based on the analysis of monitoring data from January and February 2016. This suggests that profiles of emission sources should also vary seasonally.

Table 2.3-18 Summary of Each Model and Its Results

CMB	**Model Characteristics** ・ Contribution of each emission source types can be calculated, using both emission and ambient data. ・ It does not incorporate secondary and condensed dust. **Results** ・ The result did not agree well with observations due to large impact of condensed or secondary dust. ・ Differences between coal combustion facilities types were not detected from component analyses of source samples, thus the contribution from each source type could not be calculated.
PMF	**Model Characteristics** ・ The contribution from each emission source types needs to be assumed. Only ambient data is used. ・ Secondary dust and condensed dust are taken into consideration. **Results** ・ The contribution from coal combustion dominates PM pollution in the winter season. ・ Contributions between coal combustion facility types could not be separated, due to the similarity of their components.
Air Diffusion Simulation	**Model Characteristics** ・ The contribution from each emission source type can be calculated. ・ Secondary and condensed dust need to be estimated. **Results** ・ The simulation model was reconstructed based on the problem revealed from condensed dust in the PMF and CMB model results.

2.3.4 Development of PM10 Simulation Model

2.3.4.1 Selected Simulation Model

Until now, JICA Experts have been utilizing the ISC-ST3 model, which cannot consider generation processes for secondary particles, such as chemical transformation. To solve this issue, CALPUFF was implemented for modeling. CALPUFF was reconstructed as an air dispersion simulation model because CALPUFF can consider chemical transformations.

CALPUFF was developed by Scire et al. (1995) to model advection and dispersion of pollutant by non-steady-state change in an air current in a maritime area with complex geometry. In an air current field, generated using a three-dimensional air flow model, the advective and dispersion calculation of a pollutant is conducted using the advective puff.

The model consists of three components: (1) CALMET, which generates the three-dimensional air flow model, (2) CALPUFF, which models air quality dispersion using the puff model, and (3) CALPOST, which outputs or analyzes the calculated result. In addition, this model contains some sub-modules, such as MAKEGEO.

The basic equation for CALPUFF is as follows.

$$C = \frac{Q}{2\pi\sigma_x\sigma_y} \cdot g \cdot exp\left[-{d_a}^2/(2{\sigma_x}^2)\right] \cdot \exp\left[-{d_c}^2/\left(2{\sigma_y}^2\right)\right] \quad \text{(2-1)}$$

$$g = \frac{2}{(2\pi)(2\pi)^{1/2}\sigma_z} \cdot \sum_{n=-\infty}^{\infty} exp\left[-(H_e + 2nh)^2/(2{\sigma_z}^2)\right] \quad \text{(2-2)}$$

Where,

C: ground-level concentration (g/m3)

Q: pollutant mass contained in the puff (g)

σx: standard deviation of Gaussian distribution in the along-wind direction (m)

σy: standard deviation of Gaussian distribution in the cross-wind direction (m)

σz: standard deviation of Gaussian distribution in the vertical direction (m)

da: distance from the puff center to the receptor in the along-wind direction (m)

dc: distance from the puff center to the receptor in the cross-wind direction (m)

g: vertical term of the Gaussian equation (m)

He: effective height above the ground of the puff center

h: height of the mixed-layer (m)

The summation of the vertical term *g* expresses multiple reflections of the mixing layer and ground surface. The term *g* converges to the uniformly mixed limit of 1/h for σ_z > 1.6 h. In general, puffs within the convective boundary layer meet this criterion a few hours after release.

For a horizontal symmetric puff with $\sigma_x = \sigma_y$, the equation (2-1) reduces to:

$$C = \frac{Q(s)}{2\pi{\sigma_y}^2(s)} \cdot g(s) \cdot exp\left[-R^2(s)/\left(2{\sigma_y}^2(s)\right)\right] \quad \text{(2-3)}$$

Where, *R* is the distance from the center of the puff to the receptor (m) and *s* is the distance traveled by the puff (m). The distance dependent variables in Equation (2-3) are terms such as *C(s)* and $\sigma_y(s)$.

2.3.4.2 Evaluation Based on CALPUFF Calculation Result and Improvement of Simulation Model

In the seminar in February 2016, the PM10 source contribution ratio in winter using the dispersion simulation was different from the ratio using PMF. Therefore, the source contribution ratio using the dispersion simulation and PMF were evaluated and the following improvements were suggested:

・Improvement of the emission inventory

・Improvement of the generating process for PM10

The improvement of the emission inventory has already been reported in 2.3.2.1. The improvement of the generating process for PM10 is reported hereinafter.

(1). Outline of Process for Generating PM10

A schematic outlining the generating processes for PM10 is shown in Figure 2.3-23. The processes for generating PM10 include the following:

1. Process for Generating Primary Particles

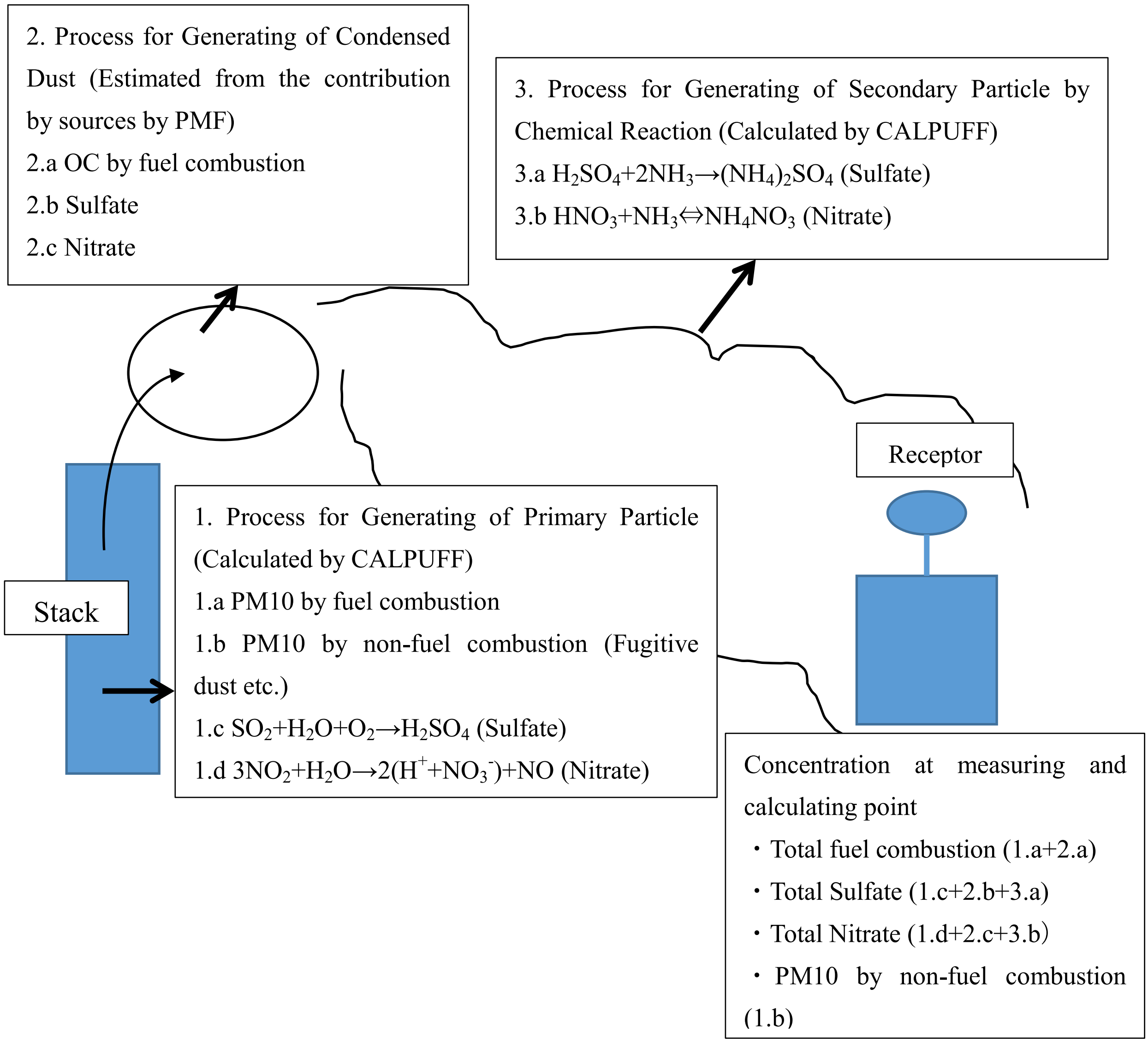
Primary particles are generated from fuel combustion or fugitive dust. Particles generated through condensation from moisture in the stack gas reacting with SO_2 or NO_2 are included as primary particles.

2. Process for Generating Condensed Dust

Condensed dust is produced through gas or liquid (volatile matter or vapor etc.) in the stack condensing into particles from rapid cooling and/or mixing in the air after the stack gas is emitted.

3. Process for Generating Secondary Particles by Chemical Reactions

Secondary particles are generated from chemical reactions in the air after the stack gas is emitted.



Source: JICA Experts

Figure 2.3-23 Schematic for the PM10 Generating Process

(2). Method for Estimating PM10 Emission Considering Condensed Dust

Calculating PM10 emission can only be accomplished using the emission factor calculated from flue gas measurements and monitoring surveys described previously in 1.a and 1.b. In CALPUFF, the generating process for condensed dust is not considered. Therefore, to estimate PM10 emissions considering condensed dust, the processes in 1.c, 1.d, and 2.a to 2.c are set as follows:

1. PM10 emissions are calculated using the emission factor calculated from flue gas measurements and monitoring surveys (1.a, 1.b)

PM10 emissions by source were calculated from multiplying activity data, such as coal consumption, by the emission factor.

2. The gas condensation process results in particles in the stack (1.c, 1.d)

PM10 emissions generated from the chemical reaction from SO_2 to SO_4 (1.c) and NO_2 to NO_3 (1.d) in the stack were calculated.

The conversion ratio for the reaction from SO_2 to SO_4 in stack was set as 5.0[4], and SO_2 and SO_4 emissions were estimated from the following formulas

SO_4 Emission after reaction = SO_2 Emission in the emissions inventory * 5/100 * 98/64

SO_2 Emission after reaction = SO_2 Emission in the emissions inventory * (1-5/100)

In addition, NO_3 emissions included in PM10 were estimated using the NO_3 ratio from the component analysis of the source samples (Table 2.3-19). These calculated results were added to the PM10 concentration.

NO_3 Emission = PM10 Emission * NO_3 Ratio of each source / 100

Table 2.3-19 NO3 Ratio of Each Source from Component Analysis

Source	Ratio (%)
Power plant	0.07
HOB	0.18
CFWH	0.04
Small stove for household	0.08
Vehicle exhaust gas	0.00

Source: JICA Experts

3. Generating process of condensed dust (2.a~2.c)

To estimate the emissions from each source, considering the process for generating condensed dust, 1) the calculated concentration considering the process for generating primary and secondary particles, 2) average concentration of PM10 at the monitoring station, and 3) the PM10 contribution ratio of each source estimated using the PMF were utilized.

The calculated concentration, considering the process for generating primary and secondary particle, is set as C1, the average PM10 concentration at the monitoring station is set as C_{AQ}, and the PM10 contribution ratio from each source estimated using the PMF is set as A. Then, the average PM10 concentration of each source at the monitoring station, Cs, and the ratio to estimate emissions considering the process that generates condensed dust, R, are calculated using the following formula. PM10 emissions considering

[4] Prediction Manual of SPM Committee of SPM Control Measure 1997 (in Japanese)

condensed dust were estimated from multiplying R by the PM10 emissions from every source in the emission inventory (Figure 2.3-24 and Figure 2.3-25).

$C_S = C_{AQ} \times A/100$

$R = C_S/C_1$

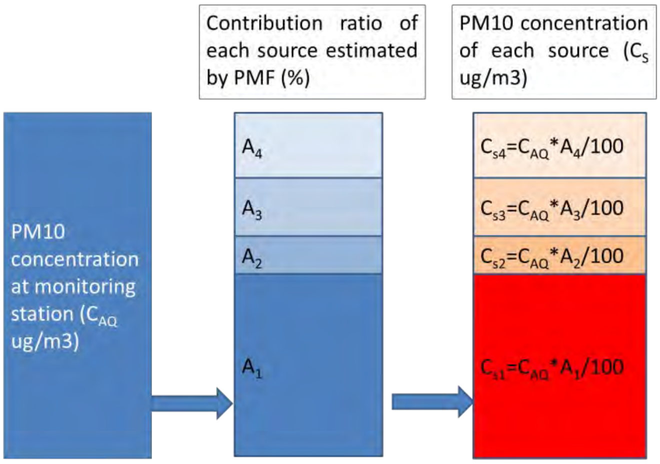
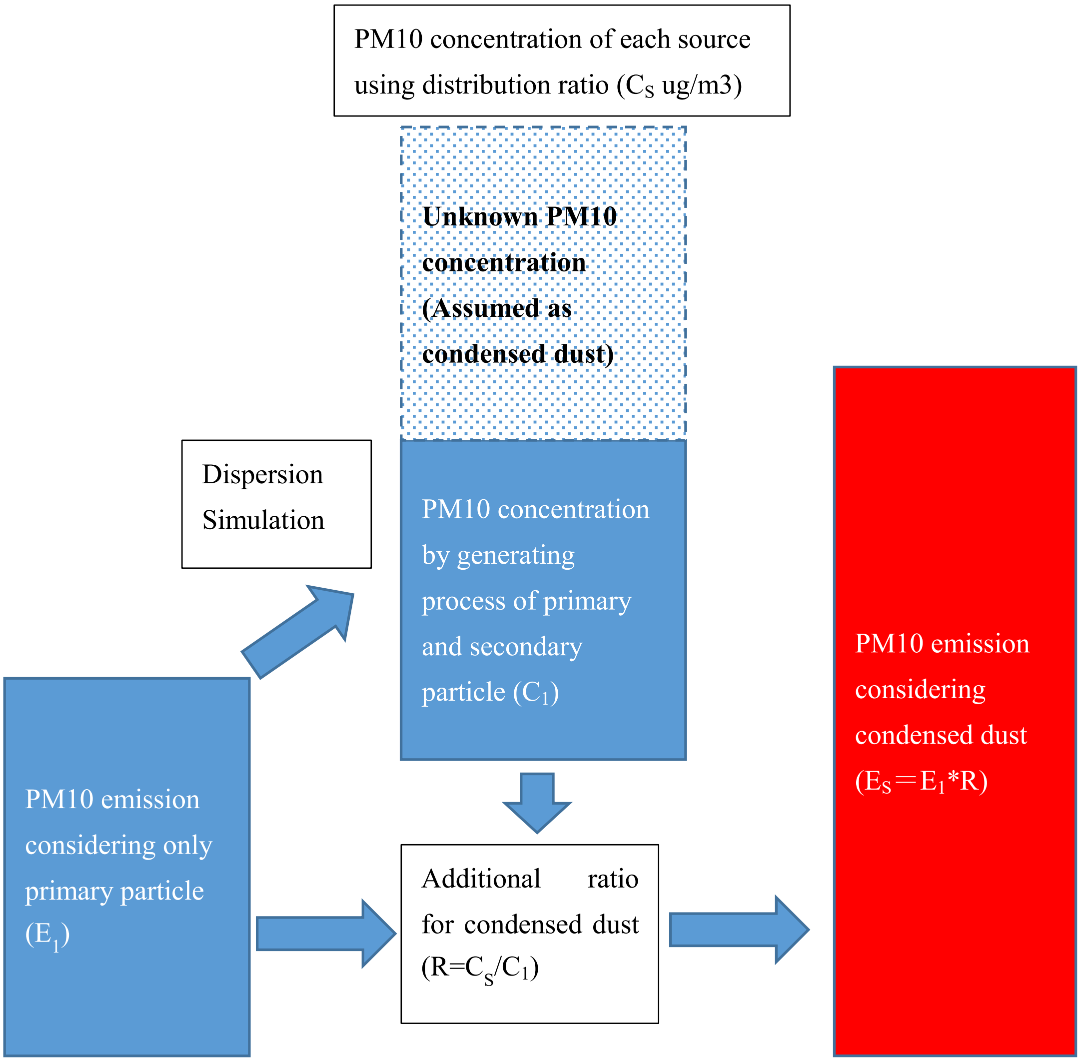


Figure 2.3-24 Schematic for Estimating PM10 Concentrations from Each Source at Monitoring Stations Using PMF Results



Source: JICA Experts

Figure 2.3-25 Schematic for Estimating PM10 Emissions Considering Condensed Dust

The PM10 contribution ratio from each source estimated using PMF in the winter was presented by Dr. Mizohata in the seminar on February 2, 2016, as shown in Table 2.3-20. The emission Es (the emission with added condensed dust) was estimated from multiplying E_1 (each source emission in emission inventory) by R.

In Table 2.3-21 , LF7-3 and LF7-7 are particulate matter and do not generate condensed dust, and the contributions of LF7-2 and LF7-3 are low, therefore, these source factors were excluded from the source of condensed dust. Regarding LF7-2, UB City does not incinerate refuse and general waste is burned in the open air. However, LF7-2 may include tire combustion in Ger stoves, but further discussion of this source is needed.

Dr. Mizohata pointed out that there are many buildings under construction and the contribution from cement may increase. However, because the contribution is low (1.6%), this source factor is also excluded from the source of condensed dust.

Accordingly, the sources of condensed dust were set to coal combustion, vehicle exhaust gas, sulfate, and nitrate.

Table 2.3-20 Concentration and Ratio of Each Source Factor Estimated Using PMF

Source Factor by PMF	Concentration	
	µg/m3	%
LF7-4: Motor Vehicle	30.3	13.1
LF7-1: Coal Combustion	146.3	63.6
LF7-2: Refuse Incineration	3.6	1.6
LF7-3: Cement	3.4	1.5
LF7-7: Crustal	20.6	9.0
LF7-5: Sulfate	10.9	4.8
LF7-6: Nitrate	15.2	6.6
Total	230.3	100.0

Source: JICA Experts

Sums of the ratios do not become the total values because each value is rounded in the first decimal place

Table 2.3-21 Concentration by Source Factor and Ratio of Generation Process for Condensed Dust

	Coal Combustion	Vehicle Exhaust Gas	Crustal	Sulfate	Nitrate	Refuse Incineration	Cement
Averaged PM10 concentration at the monitoring station (C_{AQ})	161.34						
PM10 distribution ratio of source estimated using PMF (A, %)	63.60	13.10	9.00	4.80	6.60	1.60	1.50
PM10 concentration of each source ($Cs=C_{AQ}*A/100$, ug/m3)	102.61	21.14	14.52	7.74	10.65	2.58	2.42
Concentration by CALPUFF (C1, ug/m3)	58.51	2.23	31.81	5.15	2.81		
R=Cs/C1	1.754	9.469		1.503	3.791		

Source: JICA Experts

The condensed dust, considering PM10 emissions is provided in Table 2.3-22 and shown in Figure 2.3-26. . PM10 emissions increased 35% from considering condensed dust.

The contributions by source before and after considering condensed dust are shown in Figure 2.3-27. The contributions from power plants were highest in all cases. However, considering condensed dust resulted in higher contributions from vehicle exhaust gas.

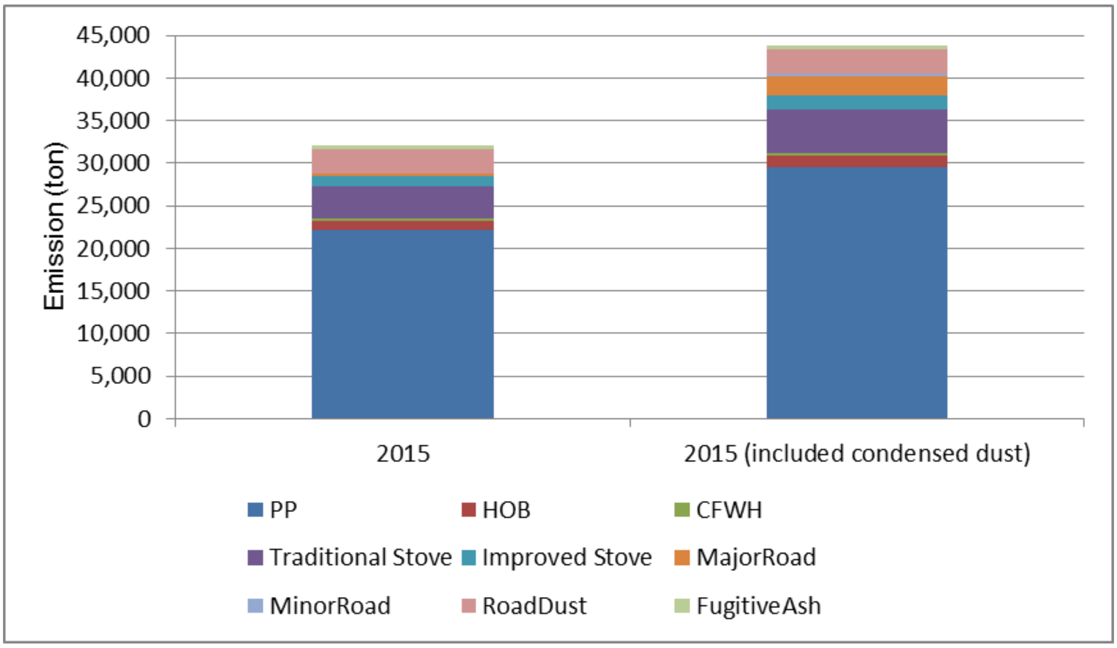
Studying condensed dust in Japan is progressing and uncertainty remains. Determining the processes for generating condensed dust in Mongolia in the future is expected to improve the accuracy of PM10 and PM2.5 emission calculations.

Table 2.3-22 Emission by Source Before and After Considering Condensed Dust

	PM10			SO4			NO3			Total of PM10, SO4 and NO3		
	Primary particle	Condensed dust	Total	Primary particle	Condensed dust	Total	Primary particle	Condensed dust	Total	Primary particle	Condensed dust	Total
PP	21,215.45	6,810.16	28,025.61	989.35	447.19	1,436.54	14.85	37.75	52.60	22,219.65	7,295.10	29,514.75
HOB	924.16	296.65	1,220.81	115.04	52.00	167.04	1.66	0.63	2.29	1,040.86	349.28	1,390.14
CFWH	192.42	61.77	254.19	23.03	10.41	33.44	0.08	0.40	0.48	215.53	72.58	288.11
Small stove for household (Traditional stove)	3,747.87	1,203.07	4,950.94	107.67	48.66	156.33	3.00	6.29	9.29	3,858.54	1,258.02	5,116.56
Small stove for household (Improved stove)	1,026.96	329.66	1,356.62	149.83	67.72	217.55	0.82	1.73	2.55	1,177.61	399.10	1,576.71
Vehicle exhaust gas (Major road)	235.04	1,990.52	2,225.56	22.54	10.18	32.72	0.00	0.00	0.00	257.57	2,000.71	2,258.28
Vehicle exhaust gas (Minor road)	36.72	311.00	347.72	3.52	1.59	5.11	0.00	0.00	0.00	40.24	312.59	352.83
Fugitive dust from road	2,860.51		2,860.51							2,860.51		2,860.51
Fugitive ash from ash pond in PPs	409.64		409.64							409.64		409.64
Total	30,648.77	11,002.81	41,651.58	1,410.97	637.76	2,048.73	20.41	46.80	67.21	32,080.15	11,687.37	43,767.52

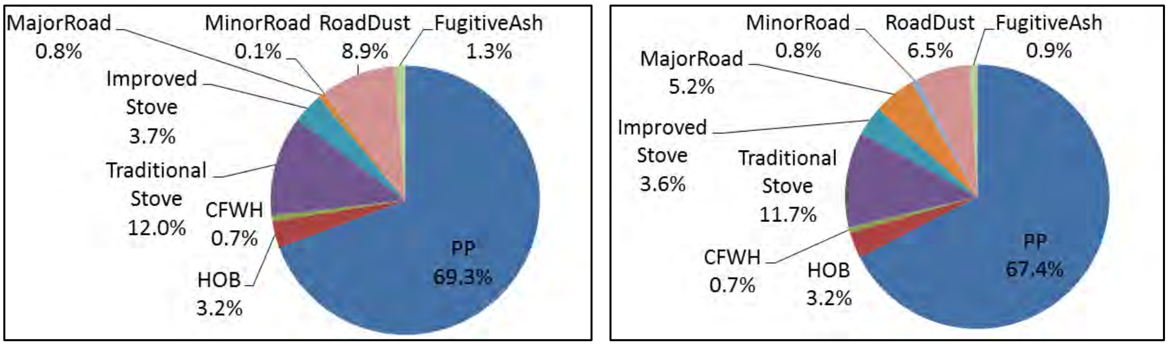
Unit: ton

Source: JICA Experts



Source: JICA Experts

Figure 2.3-26 PM10 Emission by Source Before and After Considering Condensed Dust



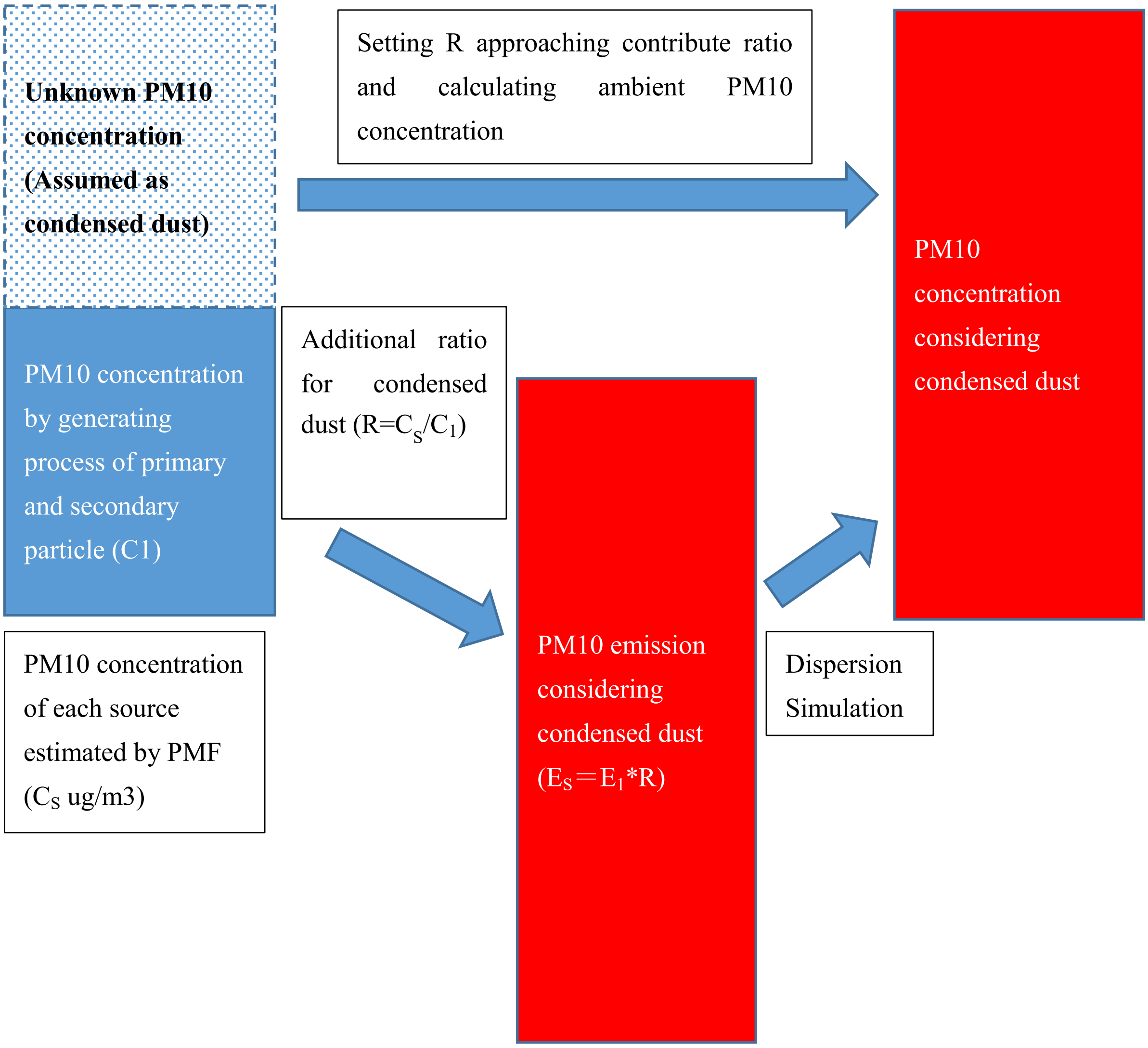
Source: JICA Experts

Figure 2.3-27 Contribution by Source Before and After Considering Condensed Dust

(3). Method for Estimating PM10 Concentration

1. The Process of Generating Primary Particles Considering Condensed Dust (1.a to 1.d and 2.a to 2.c)

Based on the previous discussion, the dispersion simulation with CALPUFF was conducted using the emission considering the process for generating condensed dust as input data. Concentrations of primary particles generated from SO_4 and NO_3 emissions were added to PM10 concentration (Figure 2.3-28).



R is the ratio for multiplying the inventory of emissions to estimate PM10 emission considering the generating process for condensed dust.
Source: JICA Experts

Figure 2.3-28 Estimating PM10 Concentration Considering Condensed Dust

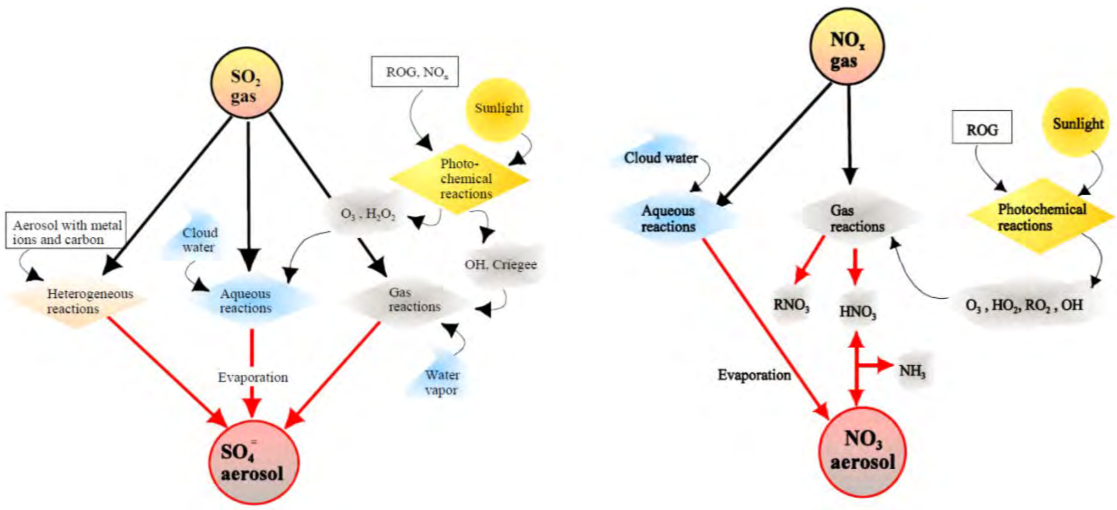
2. Process for Generating Secondary Particles by Chemical Reaction

A pseudo-first-order chemical reaction model was applied as a chemical reaction model in CALPUFF. This chemical model considers the generating process from SO2 to SO4, and from NOx to NO3 and HNO3.

After reactant SO2 is emitted into the air, SO4 ion is generated from the reaction with moisture, ozone and hydrogen peroxide etc. in the air, and product particle of ammonium sulfate is produced from the reaction of SO4 ion and ammonia.

After reactant NOx is emitted to the air, NOx reacts in two different processes. The first process is NO_3 generating process from the reaction between NOx and moisture in the air. The second process is an ammonium nitrate generating process from the reaction between ammonia and nitric acid gas generated from the reaction with OH radicals through ozone or photochemical reactions. In addition, because this reaction is reversible, depending on temperature and relative humidity, nitric acid gas and ammonium nitrate are in equilibrium.

The image of each generating process is shown in Figure 2.3-29. SO_4^-, NO_3, and HNO_3 concentration were calculated from the CALPFF dispersion simulation using SO_2 and NOx emissions as input data, and were added to the PM10 concentration.



Source: A User's Guide for the CALPUFF Dispersion Model (Ver 5)

Figure 2.3-29 Generating Process for SO4 and NO3

2.3.5 Source Contribution Analysis Using a Simulation Model

Using the emissions inventory for 2015 and described dispersion simulation model, SO_2 and PM10 concentrations were calculated by grid. The settings of the dispersion simulation model are shown in Table 2.3-23 and simulation results are shown in Figure 2.3-30 to Figure 2.3-34. However, the air pollution structure between the winter and other seasons, so coal consumption for heating is reduced. Furthermore, the wind is strong in spring, so contributions of fugitive ash from ash ponds and fugitive road dust are large. Therefore, simulations in seasons other than winter should be conducted in the future.

(1). SO2

Average concentration of SO_2 for four months in the winter season exceeded 60 $\mu g/m^3$ in the north and east of the Ger area. Mean annual concentrations of SO_2 in this area are predicted to exceed 20 $\mu g/m^3$, which is the air quality standard for SO_2. SO_2 concentrations in the Ger area of Bayangol and Chingeltei district exceeded 80 μg/m^3, these are high pollutant concentration areas (Figure 2.3-30).

Regarding the SO_2 cross-section diagram (Figure 2.3-32), small stoves had the largest contributions in most areas. Therefore, for SO_2 concentrations to satisfy the air quality standard, air pollution control measures are necessary that reduce SO_2 concentration in the Ger area, which surrounds the central area, to less than one-third of the current concentration.

In contrast, Zaisan is located in the southern area, next to the National Park, and the residential area has been developing in recent years. The concentration in this area is lower than the central area and the northern Ger area, only slightly exceeding the air quality standard. However, the contribution from power plant in this area is larger than other areas. This is caused by the high stack height of the power plant, causing pollutants to spread farther and land in the southern mountain region. Therefore, because there are some areas highly influenced by power plants, the installation of desulfurization equipment should be considered to reduce pollution.

(2). **PM10**

The average concentration of PM10 for four months in the winter season exceeded 150 μg/m^3 in the central and Ger areas. Mean annual concentration of PM10 in this area is predicted to exceed 50 μg/m^3, the air quality standard for PM10. The concentration of PM10 for four months in the winter season exceeded 200 μg/m^3 in the Ger area of Bayangol and Songinokhairkhan district (Figure 2.3-31).

Regarding the PM10 cross-section diagram (Figure 2.3-33) and PM10 contribution ratio at the monitoring station in the Ger area (CLEM-5) (Figure 2.3-34), small stoves contributed the most, followed by fugitive road dust and vehicle exhaust gas. In addition, small stoves contributed the most to sulfate and vehicle exhaust gas contributed the most to nitrate (Figure 2.3-35).

Therefore, for PM10 concentration to satisfy the air quality standard, air pollution control measures are necessary that will reduce PM10 concentration in the Ger area, which is surrounds the central area, to less than one-third of the current concentration. In addition, air pollution control measures to reduce vehicle exhaust gas and fugitive road dust are necessary, which may come from a reduction in traffic volume.

Similar to SO_2, the PM10 concentrations in Zaisan are lower than in the central and northern Ger areas, and only slightly exceeding the air quality standard. However, the contribution from power plant in this area is larger than other areas. This is caused by the high stack height of the power plant, causing pollutants to spread farther and land in the southern mountain region. Therefore, because there are some areas highly influenced by power plants, the installation of dust removal equipment should be considered to reduce pollution.

Table 2.3-23 Settings for the Dispersion Simulation Model

Item	Contents
Using model	CALPUFF Ver5.8.4 (USEPA recommended model)
Geography	SRTM30/GTOPO30 Global Data (0 to 900 m, 30 arc-sec)[5]
Land use data	USGS Land Use/Land Cover Scheme Eurasia (optimized for Asia)[6]
Surface meteorology data	NCDC TD3505 Integrated Surface Hourly Data[7]
Aero logical data	NOAA/ESRL Radiosonde Database[8]
Target area	34 km × 28 km including the central area
Resolution	1 km × 1 km
Target Pollutant	SO2, NOx, TSP, PM10, SO4, NO3, HNO3, CO
Source	Emission inventory for 2015 Power plant, HOB, CFWH, small stove for household, major road, minor road, fugitive dust from road, and fugitive ash from ash pond of PP
Period	From 2015/11/1 to 2016/2/28
Concentration calculation point	Center point in 1 km × 1 km grid

[5] http://dds.cr.usgs.gov/srtm/version2_1/SRTM30/
[6] http://edc2.usgs.gov/glcc/tablambert_euras_as.php
[7] http://rda.ucar.edu/datasets/ds463.3/
[8] http://www.esrl.noaa.gov/raobs/

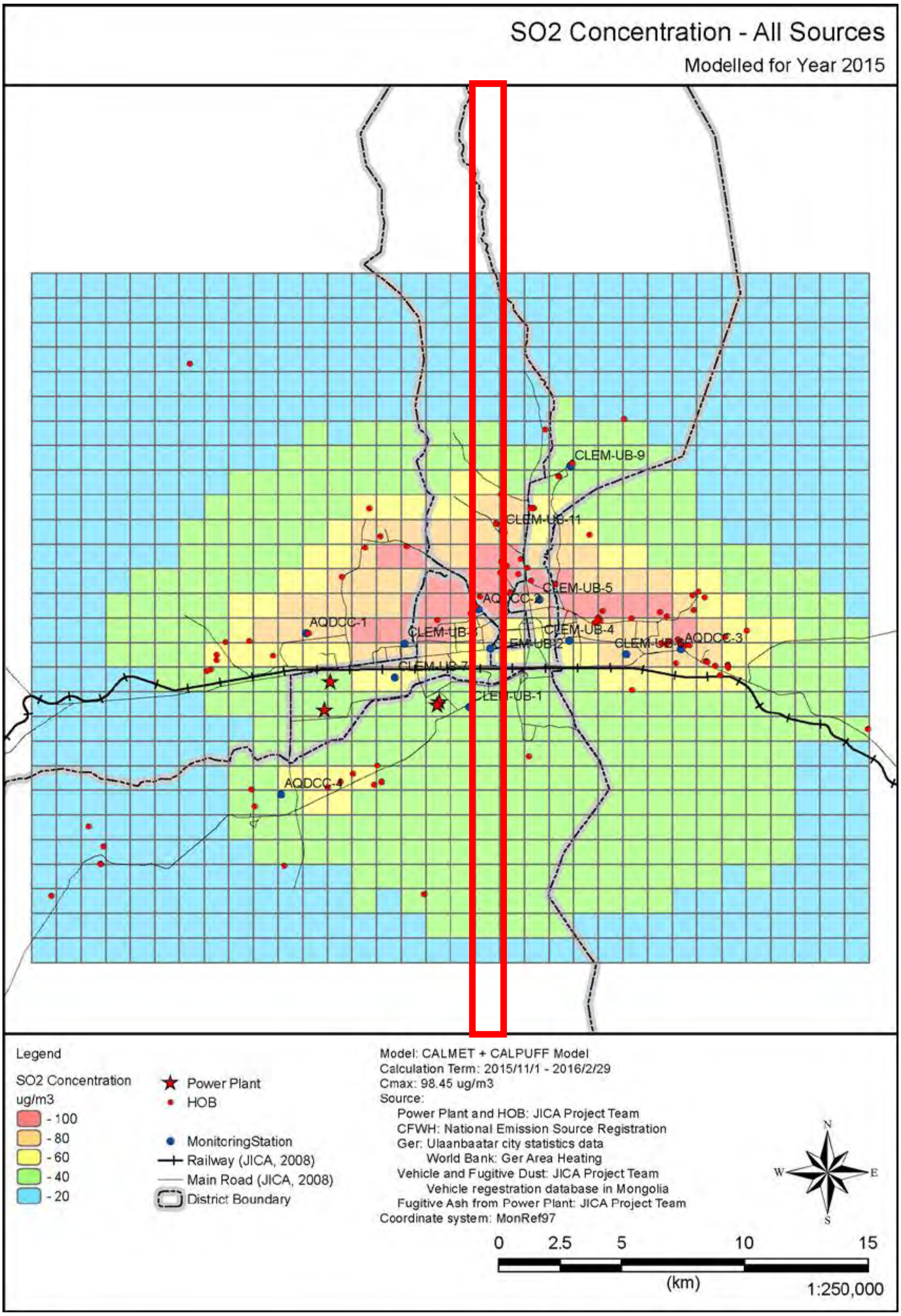


Figure 2.3-30 SO2 Concentration Distribution (2015)

Red rectangle shows the range of the cross-section diagram in Figure 2.3-32.
Source: JICA Experts

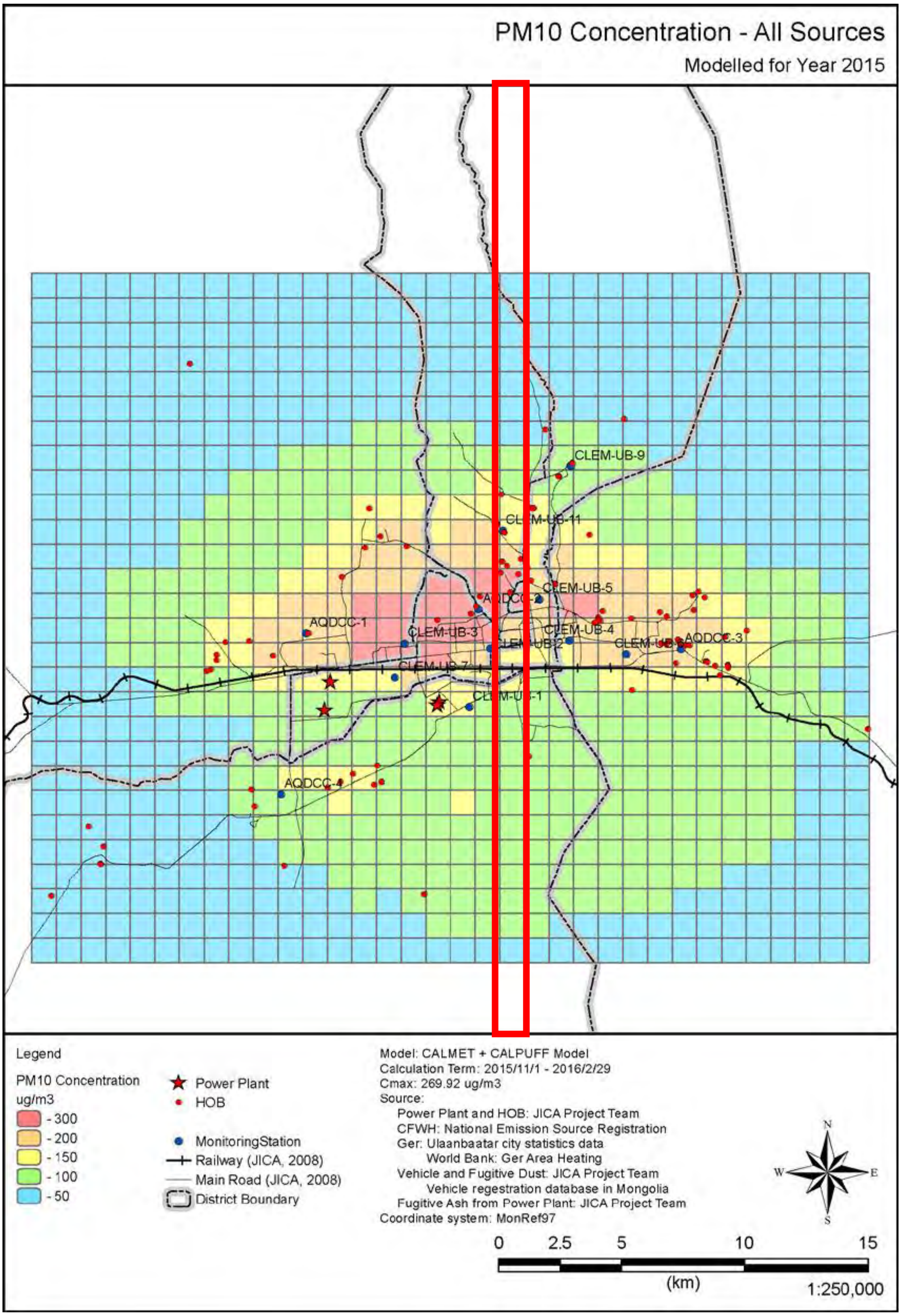
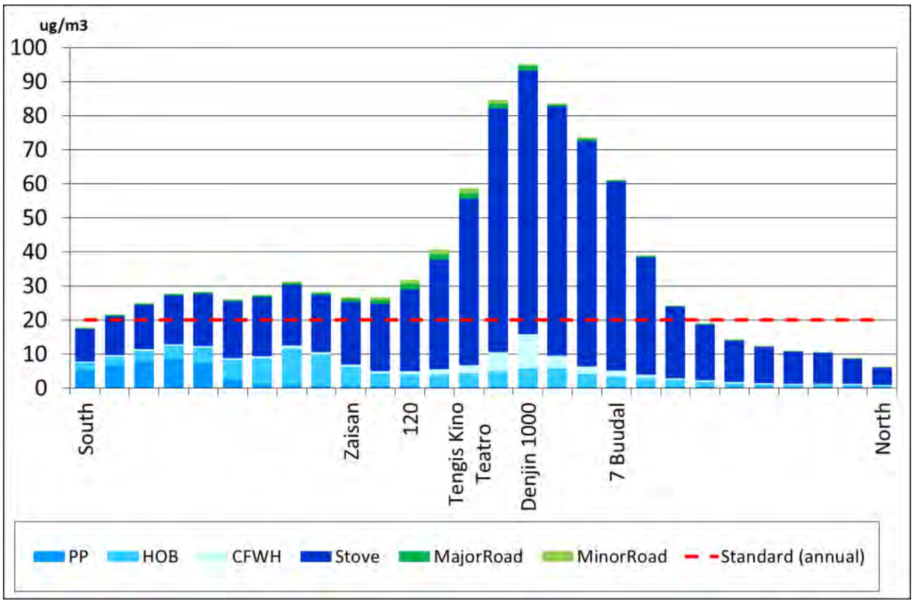


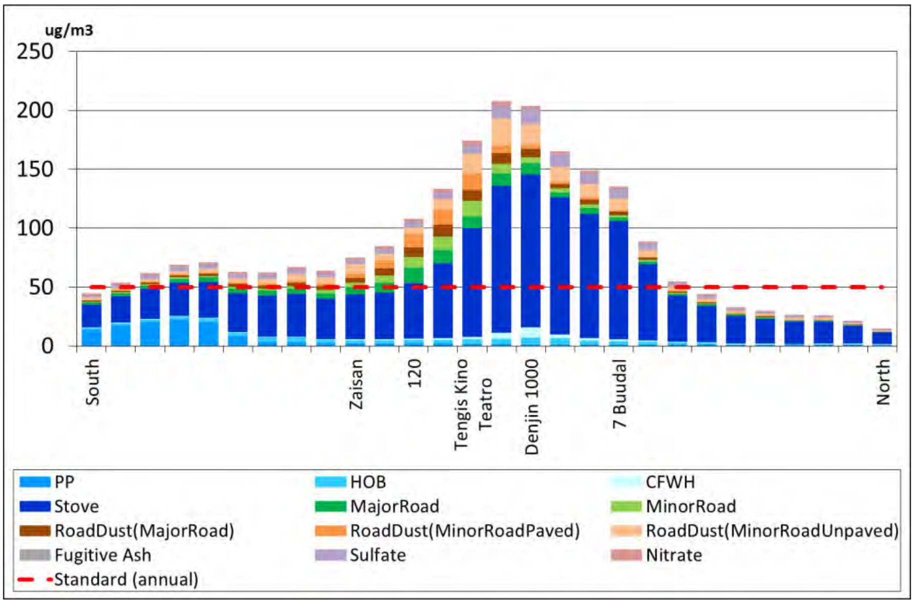
Figure 2.3-31 PM10 Concentration Distribution (2015)

Red rectangle shows the range of the cross-section diagram in Figure 2.3-33.
Source: JICA Experts



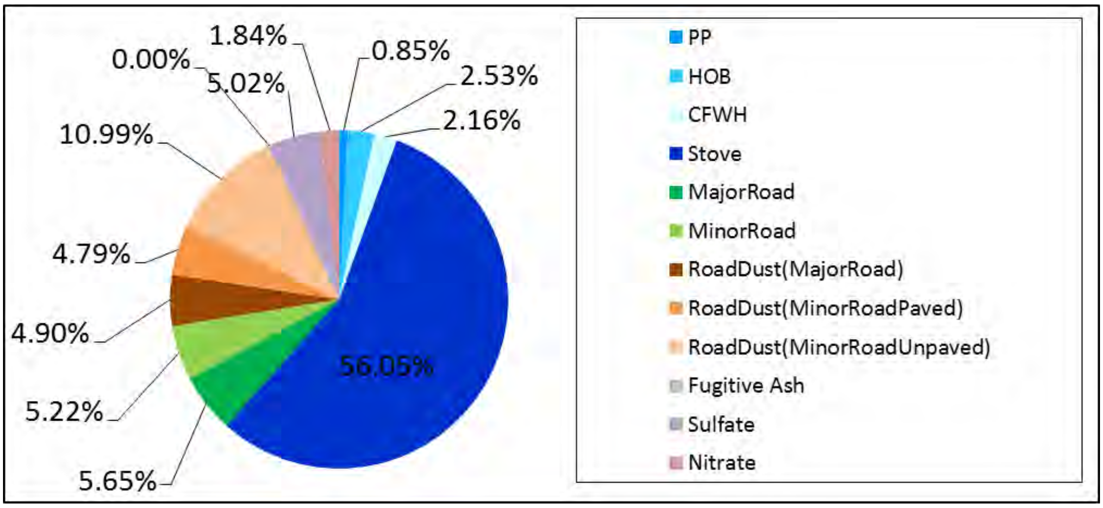
Source: JICA Experts

Figure 2.3-32 SO2 Cross Section Diagram by Source



Source: JICA Experts

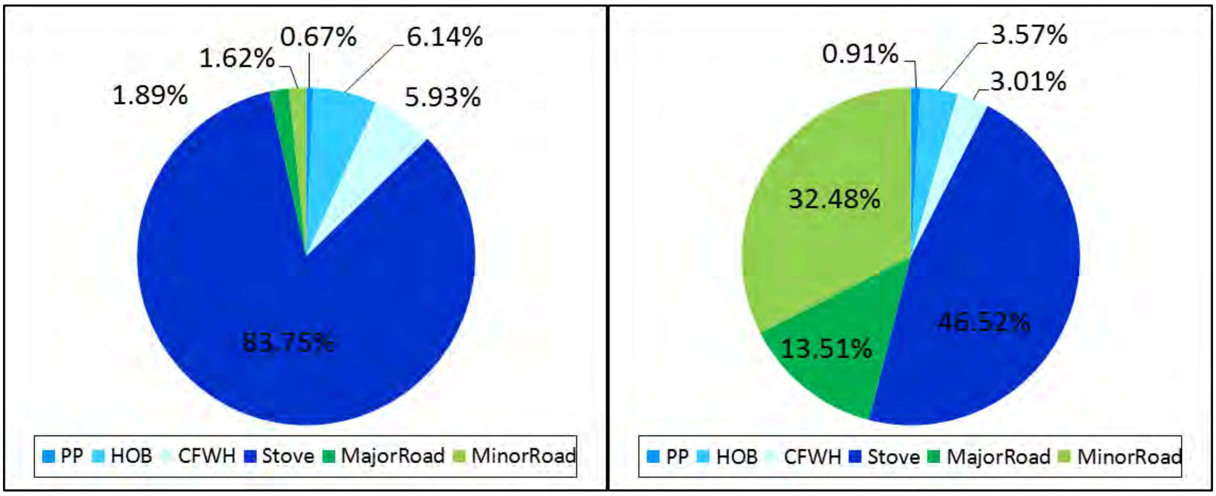
Figure 2.3-33 PM10 Cross Section Diagram by Source



Location of this monitoring station refer to 2.2

Source: JICA Experts

Figure 2.3-34 PM10 Contribution Ratio at CLEM-5



Left: Sulfate, Right: Nitrate

Source: JICA Experts

Figure 2.3-35 Sulfate and Nitrate Contribution Ratio as CLEM-5

2.3.6 Evaluation of Exposure

To evaluate the influence on citizens in UB City, the exposure from PM10 concentration was weighted by population (PWE; Population-Weighted Exposure). Using PWE, the averaged concentration considered the size of population can be calculated. The method in WB (2011)[9] was used as calculation method of PWE.

[9] Air Quality Analysis of Ulaanbaatar Improving Air Quality to Reduce Health Impacts, WB 2011

Since citizens are interested in health effect, PWE expects to be used to comparing control measure plan in the future. PWE of Figure 2.3-31 was 151.15μg/m3.

$$\text{PWE} = \frac{\sum(C_i \times P_i)}{P_{total}}$$

Ci: Concentration in grid i (ug/m3)

Pi: Population in grid i

P_{total}: Total population in calculation area

2.3.7 Developing Manuals for Emission Inventory and Dispersion Simulation

JICA Experts have improved the manual for emission inventory and dispersion simulation. This manual was used for updating the 2016 emission inventory, and contents that were lacking in the manual were identified; in agreement with the C/P, the manual will be continually updated and improved.

2.3.8 Application in Evaluation of Air Pollution Control Measures

Figure 2.3-36 shows flow diagram for evaluating air pollution control measures. First, determine the emissions based on the current air pollution control measures, which were developed in 2.3.2. Next, when estimating the emissions considering condensed dust, two estimation methods were set. Two methods are considered because the effect of condensed dust is different depending on air pollution control measures.

1. The case that the reduction of condensed dust in PM10 emissions is proportional to the reduction of PM10 emissions of primary particles (Figure 2.3-37)
2. The case that the reduction of condensed dust in PM10 emissions is not proportional to the reduction of PM10 emissions of primary particles (Figure 2.3-38)

In example 1, the processing of activity data and updating of emission factors are assumed. In example 2, the installation of equipment targeted at dust collection, and a reduction in volatile matter due to changing fuel are assumed.

Using emissions considering condensed dust, as applied in the previous process, the dispersion simulation is conducted and cross-section diagram and distribution map for concentration are drawn. Then, the maximum concentration and distribution of changing concentration and exposure, before and after control measures, are compared.

Furthermore, dividing the cost of implementing control measures by the reduction in emissions or concentration, results in an estimated cost to reduce 1 ton or 1 μg/m^3, and the cost-effectiveness is analyzed by comparing the result of each control measure.

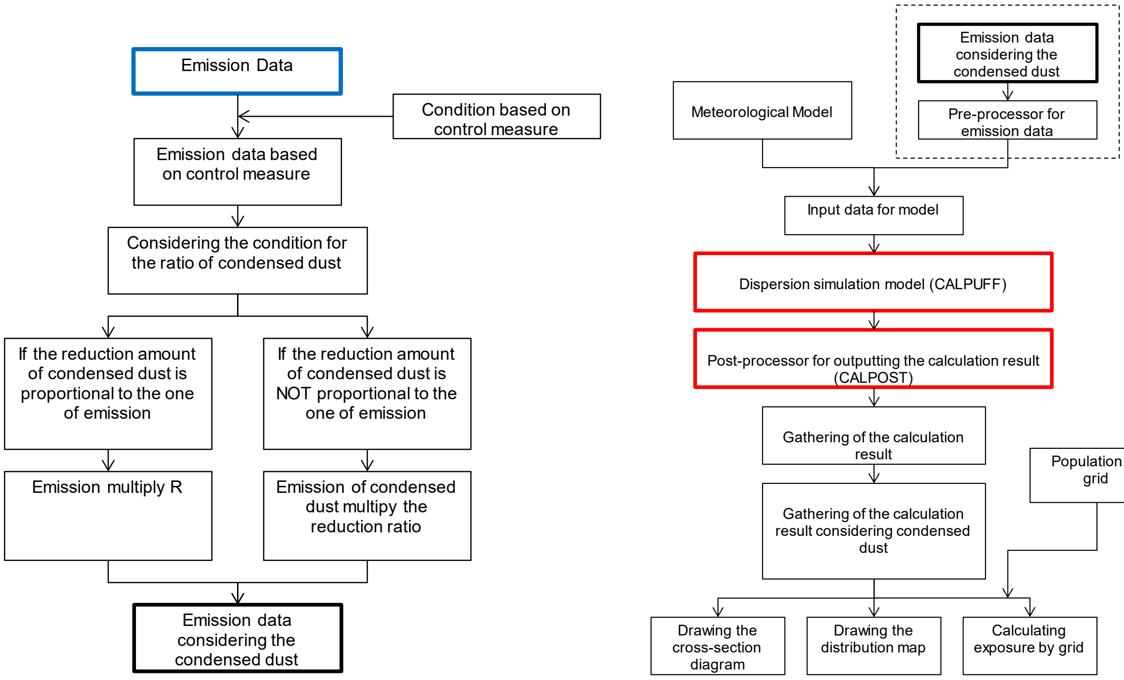


Figure 2.3-36 Flow Diagram for the Method to Evaluate Air Pollution Control Measures

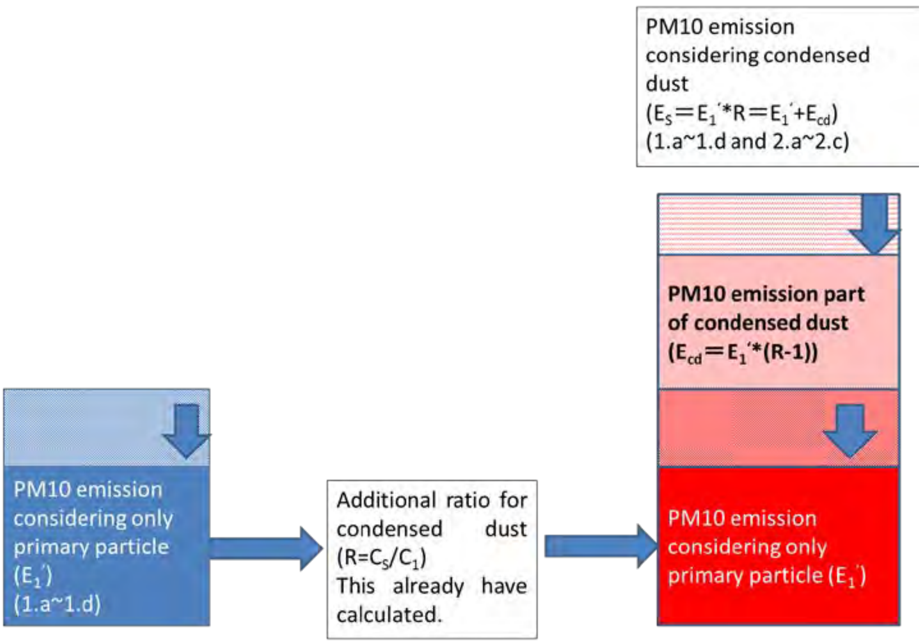


Figure 2.3-37 Emission Estimation Method Based on Draft Air Pollution Control Measures (1)

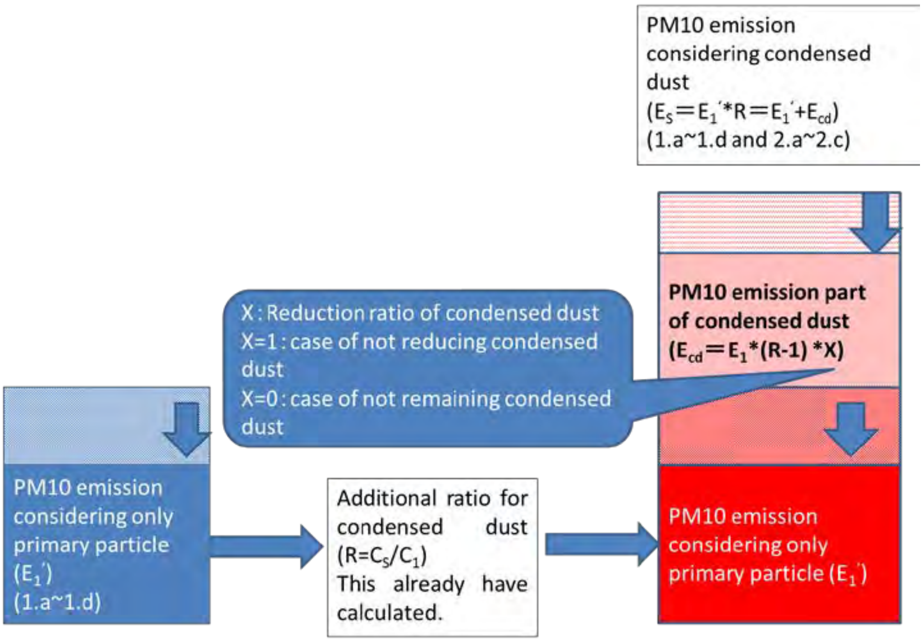


Figure 2.3-38 Emission Estimation Method Based on Draft Air Pollution Control Measures (2)

2.4 Decision Making Process Improvement for Air Pollution Control: Output 4

2.4.1 NCAPR

NCAPR was under direct control of Mongolian president at the beginning. Subsequently, the structure under Prime Minister Altankhuyag was changed, and the members of NCAPR were changed. As a result, NCAPR became to be able to conduct activities independently through arrangements with the related agencies. Detailed activities such as development of air quality smart management system had very rapid progress in 2014. The NCAPR activities overlapped the JICA activities such as boiler registration and integrated system for monitoring data. The JICA Expert Team implemented coordinating activities effectively with NCAPR.

However, Prime Minister Altankhuyag was dismissed in November 2014, and according to re-organization structuring, Prime Minister Saikhanbileg was appointed. Accordingly, the secretary office of NCAPR, which was an isolated agency, was dissolved on 1 January 2015. Mr. Nyamdavaa, a Director in MET, double as secretary general. After Mongolian re-organization structure, since the NCAPR is positioned as a national committee by the Air Law, members of NCAPR were only changed, budget of air pollution control measures were decreased, and as a result, NCAPR had only one meeting in 2015. The National Permanent Committee is a different agency from NCAPR, and has small committee on environment, and the members of national permanent committee will be changed after election in June 2016. In addition, the roles of the committee will be changed and performance of the content of the agreement is not being promised before election.

Thus, re-organization structuring in Mongolia after November 2014, it is not clear that NCAPR act as the decision maker. The APRD and the JICA Expert Team discussed and adopted the reviewing method as following. For the reviewing process for air pollution control measures relating to JICA project activities, the emission measurement results by APRD and the air pollution control measures will be discussed in JCC and agreed air pollution control measures will be approved by upper organization, the decision maker. For example, discussion of DPF introduction to public buses was held at JCC in September 2015 and setting of the organization of working group was agreed. Based on the agreement, working group which consists of APRD, Ministry of road and traffic, and UB city traffic bureau, was organized, and the working group reviewed DPF introduction to public buses.

The government party was changed by the national election in June 2016 which leads to the reorganization of the administrative agencies of Mongolian side from July 2016. NCAPR participating agencies are decided, therefore, NCAPR was held November 2015. The NCAPR meeting implemented member of NCAPR and revised and approval of operation implementation rule, and effective countermeasures for air pollution control were discussed. Operation implementation rule is shown in Appendix 2.4-1.

2.4.2 APRD

Decision making process is supposed to be conducted by NCAPR, MET and Vice Mayor J. Batbayasgalan in charge of ecology and green development in UB city. Vice Mayor manages APRD of the project C/P, and is formally inaugurated as the Vice Mayor in August 2016, and is a chairman of JCC.

In the first quarter of 2015, it has been discussed that APRD was to be integrated to Agency of Nature, Environment and Green Development of UB city. However, APRD was decided to stay as an organization for exhaust gas measurement for stationary source, ambient air quality monitoring, and mobile exhaust gas measurement by in-vehicle monitoring equipment. Therefore, the JICA Expert Team is continuing the project activities. In August 2016, AQDCC was reorganized to APRD for focusing on air pollution control activities, and a new director of APRD was inaugurated. Contents of APRD activities will not be changed.

The annual reports on HOB emission measurement results in 2014, mobile emission results by mobile emission monitoring equipment, prepared air quality monitoring and emission inventory, which were contained in Progress Report No.3, were approved by APRD. In October 2015, the APRD reported the 2015 annual report to the Vice Mayor.

The second training course in Japan was organized in Dec. 2015. The training included vehicle emission control for working-level experts, and comparison of air pollution control administration for vehicles in Mongolia and Japan.

In May 2016, administrative agencies, university, company and JICA Expert Team and so on participated in the conference related to draft of air pollution control measures. The conference contained presentation theme such as 1) Air pollution reduction modification between geography and meteorological factor, 2) air pollution reduction by automobile, 3) air pollution reduction of fuel policy arrangement, and 4) air pollution reduction by improvement of electric power and heat supply. The demonstration of DPF installation on bus was conducted; the JICA Expert Team introduced 12 cases of air pollution control measures and presented on air quality monitoring network design.

The third training course in Japan was organized in September 2016. In the training, stationary source monitoring for working-level experts and field survey of Isogo power plant of J-power were conducted. The next training course in this year is planned to include utilization of CEMS and stationary emission monitoring. In addition, comparison of institutions between Mongolia and Japan related to CEMS and stationary emission monitoring are being planned.

2.4.3 NAMEM

NAMEM approved the draft report for ambient air quality management in the Progress Report No.3, and reported to MET. The first training course in Japan was implemented in November 2014. The output presentation for the training showed proposals of policy goals and plan on air pollution control as a draft of process improvement for air pollution control selection. The presentation was made on selection process of air pollution control, based on the proposals at a meeting on air pollution reduction method, and possibility study in UB city. In the presentation, the necessity of the quantity evaluation for air pollutants was strengthened to Mongolian side. Based on the first training course in Japan, the second training courses in Japan will focus on the engineering training for persons in charge of exhaust gas measurement and PM composition analysis.

2.4.4 Pilot Activity to Improve Decision Making Process

In order to evaluate air pollution reduction plans proposed by Mongolian and JICA Experts, based on the proposal by the Deputy Mayor on Ecology and Green Development, conference on Air Pollution Reduction Proposals was carried out on 20th May 2016 at Freshwater Ecosystem Management and Natural Resource Protection Conservation Center.

The purpose of the conference was as follows;

1. In order to develop coordination of governmental, municipal and non-governmental organization, international organization, researchers, privates and private companies that work for air pollution reduction of the capital city.
2. In order to evaluate air pollution reduction plans scientifically, to select effective plans, to compile the selected plans for technical evaluation document, and to submit it to decision making organizations such as NCAPR.

In the conference, air pollution reduction plans proposed by Mongolian and JICA Experts were presented and discussed. Plans were classified into the following groups; (1) Air pollution reduction by changing topography and weather, (2) Air pollution reduction by vehicle emission control, (3) Air pollution reduction by fuel policy control, (3) Air pollution reduction by improving electricity and fuel supply. The plans were discussed mainly by Mongolian experts, and reviewed by feasibility by Mongolian budget.

Proposed plans were summarizes as Appendix 2.4-2.

Following 12 air pollution control measures were evaluated based on technical consultation with the professional agencies (APRD and NAMEM). NANO fuel measure was checked by JICA Expert Team in response to APRD's request. Other 11 measures were proposed by JICA Experts.

<<Vehicle>>

(1) DPF installation to public transportation buses
(2) Introducing EUVO IV emission standard buses to public transportation buses
(3) Introducing ultralow sulfur fuels
(4) Introducing low pollutant emission vehicles
(5) Introducing ECO-Driving
(6) Introducing NANO fuel to vehicles

<<Improved Fuels>>

(7) Promoting improved fuel by subsidy
(8) Promoting "bio coal briquette"
(9) Promoting low emission ignition materials

<<HOB>>

(10) Dust emission reduction by cyclone
(11) Dust emission reduction by scrubber
(12) Dust emission reduction by improving operation of existing equipment

The Result of the conference was issued as a document which has 96 pages, and distributed to attendants and those who concerns. The title page is shown below.

Нийслэлийн Засаг Даргын Тамгын газар

Нийслэлийн Агаарын чанарын алба

Японы Олон улсын хамтын ажиллагааны байгууллага

Улаанбаатар хотын агаарын бохирдлыг бууруулахад хэрэгжүүлэх арга хэмжээний саналын талаар зөвлөлдөх уулзалтын эмхэтгэл

Улаанбаатар хот
2016 оны 05 сарын 20-ны өдөр

Figure 2.4-1 Transactions of the Conference on Air Pollution Reduction Proposals

2.5 Public Relations and Public Awareness: Output 5

2.5.1 Dissemination and Advisory Services of Air Quality Information

Under the support of this project, air quality information was started to be issued by NAMEM and APRD according to Order A-131 of Minister of Nature Environment and Tourism in 2011. Advisory services were started to be issued also via Air Quality Smart Control System and related systems.

Table 2.5-1 is the list of systems in operation.

Table 2.5-1 Dissemination Systems for Air Quality Information in Operation

http://agaar.mn/	Air Quality Smart Control System owned by MET. Un-validated data.
http://tsag-agaar.gov.mn/observation/environment-monitoring/air	System operated by NAMEM. Validated data.
http://www.air.ub.gov.mn/	System operated by APRD. Validated data.
http://ubstat.mn/Report	System operated by Statistic Department of UB City. Validated air quality monitoring data of all NAMEM and APRD stations are reported every month.

Source: JICA Expert Team

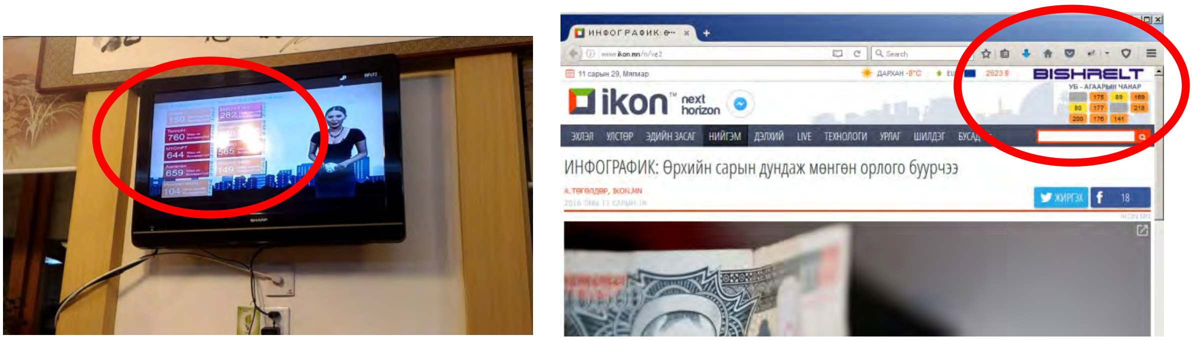
Originally, order A-53 of Minister of Nature Environment and Tourism in 2011 was defined for advisory services of air quality information. According to a suggestion of JICA Expert, C/P-WG member of NAMEM proposed to amend it. It was realized as Order A-327 of Minister of Nature Environment and Green Development in 2014, and applied to the systems above. Its summary is shown in Table 2.5-2.

Table 2.5-2 Summary of Advisory Services of Air Quality Information (Order A-327 of Minister of Nature Environment and Green Development in 2014)

Concept	Advisory level is defined as air pollutant concentration level to air quality standard	
Levels	Less than half of air quality standard	Clean
	Less than air quality standard	Normal
	Less than 2.5 times of air quality standard	Weakly Polluted
	Less than 4 times of air quality standard	Medially Polluted
	Less than 5 times of air quality standard	Strongly Polluted
	More than 5 times of air quality standard	Extraordinary Polluted
Remarks	➢ Air quality standard for hourly average is basically used for this calculation. For any pollutants for which hourly average standard is not defined, 8 hours or 24 hours average standard is used. ➢ Index to air quality standard is calculated hourly for 6 pollutants separately, and then maximum index among 6 pollutants is used to define air pollution level	

Source: JICA Expert Team

Air quality information became to be quoted by TV news and news website.



Source: JICA Expert Team

Figure 2.5-1 Samples of Air Quality and Advisory Services Information Quoted

As the result of Activity 7-4, Air Quality Standard was updated as MNS 4585:2016, which was approved on 23rd June 2016 and activated on 8th July. Accordingly, dissemination and advisory services systems, such as Air Quality Smart Control System and http://air.ub.gov.mn/, were updated.

Maintenance level of dissemination and advisory services systems has been improved.

For example, data of all the 11 stations were not updated in the dissemination and advisory services systems were not updated approximately 24 hours from 16th June 2016 10:00.

The reason was internet routing change of NAMEM for the 6 stations of NAMEM. The data transfer was recovered by NAMEM's requested to the IT consultant that developed the air quality smart control system. The air quality information will be sustainable for dissemination and advisory services if NAMEM continues for the good relationship with the consultant.

The reason was subscription renewal failure for the 5 stations of APRD. Among the 4 Experts of APRD, the trouble was found by one of the 2 Experts in summer vacation, instead of the other 2 Experts attending the office. The Project Team proposed 4 Experts for the station maintenance because 1 or 2 Experts were not enough for station maintenance while they are off to a summer vacation. In addition, when the Expert who was turning the on/off switch of the air quality information LCD of the main municipality building left for a summer vacation, the other 3 Experts did not turn on the LCD every day. Although these issues were not serious issues, these incidents proved that the air quality monitoring team of APRD has not yet developed as proposed. The 2 Experts of 4 have reached to some level and content of the trouble solution manuals have been accumulated. Thus, the trainings by higher level Experts of APRD to other APRD Experts will be necessary after the completion of this JICA Project, and shall be recommended to be practiced from now. For examples, turning ON/OFF switch of the 1st floor LCD should be able to be done by the other APRD Experts before instructions are given by the managers and/or JICA Experts.

Although APRD agreed with the suggestion of JICA to allocate multiple officers for each task, APRD seems to allocate single officer for each task from September 2016, which causes a risk in sustainability. Simple tasks, such as turning ON/OFF the air quality dissemination LCD, should be done by any person who finds issue. APRD should organize education schedule from one officer to the other officers, which will be necessary for the period when the person will attend training courses abroad and/or holidays.

Air quality display of LCD and websites often became to show error status, "Error displaying the error page: Application Installation Error: Could not connect to MySQL". Its reason is the overload of MySQL in the shared server hosted by National Data Center of Mongolia. As the primary solution, JICA Expert suggested 2 options to APRD. The first option is to request National Data Center by justifying configuration or enhancing hardware. The second option is to move to another hosting server. APRD tried the first option because the second option requires additional budget. Meanwhile, for a temporary solution, the project team improved the system, thus web client will be able to reload the contents whenever the error message is displayed.

2.5.2 Public Awareness Program for Citizens

APRD, with JICA Expert, prepared and carried out the public awareness seminars at schools regarding on the air quality information reading from 2015 until 2016.

APRD continued this activities using UNICEF's budget.

2.5.2.1 Activity Planning

Attendants to public awareness program for citizens of APRD in past years were biased because they were mobilized by Khoroo Offices[10]. As less biased approach, APRD proposed to have a seminar at schools. It can reach equally to any families which have school students. Students are expected to deliver seminar materials to their homes.

Public awareness purpose is concluded as "how to read air quality data for your health" based on the proposal of APRD. The project team has planned to prepare the brochure and presentation. The pilot schools were selected with district offices. The seminar for all the students of any schools is difficult because each school has many students and the scientific contents appropriate for both of grade 1 to 12 could not be designed. Ecology club or equivalent group was nominated as the target groups because they can be expected to redistribute the seminar contents and the size of 50 students are suitable for any lecture rooms.

2.5.2.2 Public Awareness Program for Schools

The schedules, working group, and photos are shown below. The brochure and presentation is shown in Appendix 2.5-1.

Although APRD arranged the schedule with districts and schools in advance, 3 issues arose. When the working group visited the school for the seminar, 1 school did not know about the seminar. The 2 schools requested to change the time. APRD tried to improve schedule arrangement with schools. For examples, 2 or 3 shifts school is common in UB city. Higher grade students, which are expected as core members of the seminar, generally study in the morning shift. APRD changed the schedule from "one in the morning and the other in the afternoon" to "one in the early morning and the other in the late morning".

Since arrangement issues were found in the beginning of the program, APRD changed human resource allocation. As the result, APRD carried out the program smoothly and schools evaluated the program highly.

[10] An administrative division that is subdivisions of districts, up to 20,000 population, and administrative organization in charge of the division

Source: JICA Expert Team

Figure 2.5-2 Outlook of and Seminar at School #34

Table 2.5-3 Schedule of School Seminars

District	School	Seminar Date	Pre-coordination Meeting Date
Khan-Uul	School #34	2015/12/23	2015/12/22
Chingeltei	School #72	2016/2/1	2016/1/27
	School #49	2016/2/1	2016/1/27
	School #24	2016/2/29	(unknown)
	School #39	2016/3/22	(unknown)
Songinokhairkhan	School #65	2016/2/4	2016/1/27
	School #9	2016/2/4	2016/1/27
Bayangol	Setgemj School	2016/2/5	2016/2/2
	School #113	2016/2/5	2016/2/2
Sukhbaatar	School #58	2016/2/22	2016/2/16
	School #35	2016/2/22	2016/2/16
Bayanzurkh	School #120	2016/2/18	2016/2/15
	School #85	2016/2/18	2016/2/15

Source: JICA Expert Team

Table 2.5-4 Working Group for of School Seminars

Responsibility	Original	Last
Team Leader	APRD - Ms. G. Tsatsral	APRD - Ms. N. Naasanjargal
Preparing Contents	APRD - Ms. G. Tsatsral	
Updating Contents		APRD - Ms. N. Naasanjargal
Lecturer	APRD - Ms. T. Tumennaast	APRD - Ms. N. Naasanjargal APRD - Ms. T. Tumennaast
Coordination	APRD - Ms. E. Battsetseg	APRD - Ms. E. Battsetseg
Material Design	Technician of local design company	Technician of local design company
Support	JICA Expert /MAEDA/	JICA Expert /MAEDA/

Source: JICA Expert Team

2.5.3 Communication between Citizens and APRD on Air Pollution

In autumn of 2015, in order to respond to complaint and inquiry of citizens, and to help citizens for better understandings of air pollution, methodology on capacity development for APRD was discussed. The number of complains, proposal and comments in 2015 was decreased by 94% from 2013. The major portion of the number in 2013 was related to the distribution of new coal fuels and recommended stoves which are being promoted. In 2015, these were no longer major problems of APRD.

Triggered by the Doctor of School #49, the project started to conduct the continuous monitoring of CO at School #49. However, the monitoring started in a spring season where no students complained about headache, the Project Team was not able to evaluate the relationship between headache and CO concentration. In order to supply the air quality information to the school students, in spring 2016, the project installed air quality information display to 5 pilot schools. This system is shown at the air quality information display website of APRD.

Table 2.5-5 List of Schools where Air Quality Information Display was Installed

District	Count of Schools Installed	School Number or Name
Khan Uul	5	7, 15, 18, 60, 118
Chingeltei	6	17, 24, 39, 49, 57, 72
Songinokhairkhan	9	9, 42, 62, 65, 67, 76, 81, 82, 105
Bayangol	6	21, 48, 68, 84, 92, Amgalan Tsogtsolbor
Sukhbaatar	5	4, 6, 16, 29, 58
Bayanzurkh	4	28, 96, Shine Erin, Setgemj

Source: JICA Expert Team


Discussion on Installation Location


Ceremony on Installation

Source: JICA Expert Team

Figure 2.5-3 Installation on Air Quality Information Display

Lessons learned are as follows;

- Schools welcome the information display because schools can supply air quality information continuously to students and local citizens.
- Some schools did not accept the information display because they did not have Internet connection. In addition, some schools suspend Internet connection in night, Tsagaan Sar Holiday and/or any other school holidays. Some of the schools have not yet recovered its Internet after holidays. Internet connection (including budget allocation) is necessary to be improved.
- Since the LCD was generally installed along the entrance hall, some schools requested to use the LCD for some other educational purposes such as traffic safety, environment and/or health care. They are generally permitted whenever they promised to show air quality information after educational programs. LCD seems have been used for school educational program prepared by Mongolian National Office for Children or UNICEF.

2.5.4 Seminars and Symposium for Professionals

APRD and C/P-WG had implemented seminars and symposium for the Experts regarding the air pollution and project activities for 19 times. The seminars and symposium to be held in the future are listed in Table 2.5-6, and the photos are shown in Figure 2.5-4. The attendants list is shown in Appendix 2.5-2.

Table 2.5-6 Seminars and Symposium for Professionals

1st	**Seminar on Project Outline**
Date	21st January 2014
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ Introduction by Head of APRD ➢ Introduction by Leader of JICA Advisory Team ➢ Introduction and discussion on the project work plan ➢ Introduction and discussion on issues to startup the project
Count of Participants	40
2nd	**Seminar on Emission Inventory**
Date	16th April 2014
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center
Contents	➢ Introduction of “Output 3” of this Project Phase 2 ➢ Introduction of emission inventory and dispersion model for Ulaanbaatar developed in the Project Phase 1 and their issues ➢ Discussion on establishing team to start the Project Activity 3-2 titled as updating emission inventory
Count of Participants	38
3rd	**Symposium on PM10 and PM2.5**
Date	22nd April 2014
Venue	MNEGD
Contents	➢ PM10 and PM2.5 in the air pollution of Ulaanbaatar ➢ Composition of PM2.5 in Ulaanbaatar ➢ Plan of this project on PM10 and PM2.5 analysis
Count of Participants	41

4th	**Seminar on Mobile Source Emission Measurement**
Date	27th May 2014
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center
Contents	➢ Vehicle emission measurement method which is to be introduced newly into Ulaanbaatar ➢ Methodology to use on-board emission analyzer ➢ Schedule and Personnel of on-board emission measurement
Count of Participants	36
5th	**Seminar on Vehicle Emissions Countermeasures**
Date	2nd October 2014
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center
Contents	➢ Vehicle emission countermeasures which is to be introduced into Ulaanbaatar ➢ Methodology to calculate emission factor
Count of Participants	25
6th	**Seminar on Emission Test Result of New Coal Fuels' Combustion**
Date	16th December 2014
Venue	"Khangarid Ordon" of Ulaanbaatar Municipality
Contents	➢ Emission test result of new coal fuel's combustion ➢ Proposal based on emission test result
Count of Participants	34
7th	**Seminar on Boiler and Technology of Air Pollution Control Measures for CHP**
Date	11th March 2015
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ Boiler and technology of air pollution control measures for CHP
Count of Participants	20
8th	**Symposium on PM and Air Quality Monitoring**
Date	16th April 2015
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ Analysis Results of Ambient Air Quality Data in UB ➢ Chemical Composition of PM10 and PM2.5 in UB ➢ Activity Plan and Schedule of the Project
Count of Participants	37

9th	**Seminar on Improvement Order and Air Pollution Control Measures for HOB**
Date	22nd April 2015
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center
Contents	➢ Improvement Orders and their implementation schedule for HOB Operators ➢ Operation Management and Air Pollution Control Measures for HOB
Count of Participants	69
10th	**Seminar on Measurement and Control Measures of Vehicle Exhaust Emissions**
Date	5th May 2015
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center
Contents	➢ Importance of on-board emission measurement ➢ Outputs of on-board emission measurement ➢ Discussion of vehicle exhaust emission control ➢ Activity Plan and Schedule of the Project
Count of Participants	30
11th	**Seminar on Emission Test Result of New Coal Fuels' Combustion**
Date	11th June 2015 14:00 ~ 17:00
Venue	"Khangarid Ordon" of Ulaanbaatar Municipality, Room 15B
Contents	➢ Emission test result of new coal fuels' combustion ➢ Proposal on fuel combustion test ➢ Proposal on fuel evaluation method ➢ Proposal on fuel combustion test MNS Proposal on new coal fuels promotion
Count of Participants	25
12th	**Seminar on PM10 and PM2.5 Composition sampled in UB**
Date	3rd November 2015
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ Composition of PM10 and PM2.5 sampled in UB
Count of Participants	33
13th	**Mid-term Seminar**
Date	9th December 2015
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ Report on Mid-term review, and project activities remained ➢ For the use of SCDM (Sustainable Capacity Development Matrix) in the project ➢ Intermediate Report of HOB Registration and Inspection, including emission gas measurement results of HOB
Count of Participants	15

14th	**Seminar on Source Apportionment by Air Quality Simulation Model and Receptor Modelling**
Date	2nd February 2016
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ Developing Air Quality Simulation Model for UB for Source Apportionment ➢ Source Apportionment by Receptor Modelling
Count of Participants	35
15th	**Conference on Air Pollution Reduction Proposals**
Date	20th May 2016 8:30 to 18:00
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center, Main Hall on 1st Floor
Contents	➢ Air pollution reduction by topography and climate effects (4 Presentations) ➢ Air pollution reduction by vehicles emission reduction (4 presentations and 1 demonstration) ➢ Air pollution reduction by fuel policy adjustment (5 presentations) ➢ Air pollution reduction by electricity and heat supply improvement (5 presentations)
Count of Participants	94
16th	**PM Source Apportionment Analysis by Receptor Models**
Date	15th September 2016
Venue	Mongolia-Japan Center for Human Resources Development
Contents	➢ PM Source Apportionment Analysis by Receptor Models
Count of Participants	17
17th	**Seminar for Promoting Gas Supply**
Date	22nd March 2017
Venue	Main Meeting Room, Ministry of Mining and Heavy Industry
Contents	➢ Coal Gasification by Grand Power ➢ Gas usage and safety system in Japan by JICA Expert
Count of Participants	37
18th	**Summary Seminar**
Date	25th April 2017
Venue	Freshwater Ecosystem Management and Natural Resource Protection Conservation Center, Main Hall on 1st Floor
Contents	➢ Overall Output of the Project ➢ Demonstration of DPF evaluated by the project
Count of Participants	58

19th	**PM Source Apportionment Analysis by Receptor Models**
Date	25th May 2017
Venue	Mongolia-Japan Center for Human Resources Development
Contents	PM Source Apportionment Analysis by Receptor Models
Count of Participants	20

Source: JICA Expert Team

Seminar on Project Outline (21st January 2014)

Seminar on Emission Inventory (16th April 2014)

PM10 and PM2.5 (22nd April 2014)

Seminar on Mobile Source Emission Measurement (20th May 2014)

Vehicle Emissions Countermeasures (2nd October 2014)

Emission Test Result of New Coal Fuels' Combustion (16th December 2014)

Boiler and Technology of Air Pollution Control Measures for CHP (11th March 2015)

PM and Air Quality Monitoring (16th April 2015)

Improvement Order and Air Pollution Control Measures for HOB (22nd April 2015)

Measurement and Control Measures of Vehicle Exhaust Emissions (5th May 2015)

New Coal Fuels' Combustion (11th June 2015)

PM10 and PM2.5 Composition sampled in UB (3rd November 2015)

Mid-term Seminar (9th December 2015)

Source Apportionment by Air Quality Simulation Model and Receptor Modelling (2nd February 2016)

Conference on Air Pollution Reduction Proposals (20th May 2016)

 PM Source Apportionment Analysis by Receptor Models (15th September 2016)	 Seminar for Promoting Gas Supply (20th March 2017)
 Summary Seminar (25th April 2017)	 PM Source Apportionment Analysis by Receptor Models (25th May 2017)

Source: JICA Expert Team

Figure 2.5-4 Photos of Seminars and Symposium

2.5.5 Dissemination of Project Activities by Newsletters, Publication and Media

2.5.5.1 Activity Outline

Project Newsletters were issued three times. Three language versions (Mongolian, Japanese and English) were prepared, and then distributed through JICA Mongolia Office and seminars, and uploaded at APRD's website. Newsletters are shown in Appendix 2.5-3, and their titles are listed below.

Project dissemination by mass media, by any other mass medias and by any other medias are also listed below.

Table 2.5-7 Project Newsletters

Volume	Title	Date
1	Project Outline	February 2014
2	New Technology to Measure Automobile Emission	January 2015
3	Emission Differences of New Coal Fuels by Ger Stoves Combustion Tests	February 2015

Source: JICA Expert Team

Table 2.5-8 Project Dissemination by News Paper

Date	Article	Name of paper
11th October 2013	JICA Project was introduced in an interview to the head of APRD in the campaign “Saving Life in Warm and Healthy Environment”	Zuunii Medee
21st January 2014	Seminar on Project Outline (21st January 2014) was introduced.	Several papers
28th October 2015	Interview in SATO (Chief Representative of JICA Mongolia), SATO (JICA Expert), NAKATA (JICA Expert) were reported in a featured article titled "Can UB become green: air”	Unuudur
7th December 2015	PM2.5 air quality data of APRD-02 station was referred from APRD’s website developed in this project	UBPOST
23rd March 2016	Opening ceremony for air quality information LCD at School #39 on 22nd March 2016 was reported.	Mongolian Medee, Zasgiin Gazrin Medee

Source: JICA Expert Team

Table 2.5-9 Project Dissemination by Other Mass Medias

Date	Contents	Name of Media
18th December 2013	Project start-up discussion by APRD and JICA was reported by news program.	NHK TV
12th January 2014	Project was introduced in "NHK Abroad Network" Program	NHK TV
21st January 2014	Seminar on Project Outline (21st January 2014) was introduced by news programs of several channels	Eagle TV, etc.
27th April 2015	On-board emission measurement for a vehicle emission countermeasure is reported by news programs of few channels.	Bloomberg Mongol, etc.
29th October 2015	Baterdene Deputy Mayer introduced measurement and dissemination of air quality monitoring to UBS TV. Maintenance activities by C/P were on air as a part of introduction of measurement.	UBS-1 TV
23rd March 2016	Opening ceremony for air quality information LCD at School #39 on 22nd March 2016 was reported.	UBS-1 TV TM TV
2nd May 2016	Newspapers and TV stations collected information at New Air Quality Monitoring Station Donation Ceremony, and reported via mass media.	ECO TV, C1 TV, etc.
20th May 2016	Newspapers and TV stations collected information at Conference on Air Pollution Reduction Proposals, and reported via mass media.	ETV TV, TM TV, UBS TV, Star TV, etc.
3rd to 5th August 2016	Newspapers and TV stations collected information at Northeast Asian Mayor's Forum and related equipment demonstration at Sukhbaatar Square, and reported via mass medias.	
4th May 2017	JICA Expert Team with C/P-WG presented the DPF selected and tested by the Project on the Open Day of Transportation Department of the Capital City, reported by newspapers and TV stations	TM TV

Source: JICA Expert Team

Table 2.5-10 Project Dissemination by Other Methods

Date	Content
17th November 2014	This Project was introduced in a lecture by Deputy Head of APRD and Mr. Tabata Expert in an ADB training seminar for city planning experts of Ulaanbaatar Municipality and ADB.
December 2014	Project activity photographs were supplied to an editor of a tourist guidebook “Chikyu no arukikata, Mongolia Edition”.
3rd March 2015	Activities for emission measurement and air quality monitoring station maintenance were introduced to a joint PhD course of NUM and Nagoya University.
From 3rd March to 3rd April, 2015	Project activity photographs were displayed in “Mongolia” exhibition at JICA Global Plaza in Ichigaya, Tokyo.
21st to 22nd September 2015	Northeast Asian Mayor’s Forum was held in UB. The project supported the presentation of the chief representative of JICA Mongolian Office, and carried out a poster session in environmental technology exhibition.
1st October 2015	Presentations in Northeast Asian Mayor’s Forum was introduced by News Letter of JICA Mongolia Office, September 2015
1st November 2015	Progress on HOB registration and inspection was reported by News Letter of JICA Mongolia Office, October 2015
25th December 2015	Mid-term review of the project was reported by News Letter of JICA Mongolia Office, December 2015
1st February 2016	”Air pollution of UB compared to Tokyo and Beijing” was posted by JICA Expert to News Letter of JICA Mongolia Office, January 2016
1st March 2016	”Air pollution of UB – How to read website information” was posted by JICA Expert to News Letter of JICA Mongolia Office, February 2016
1st April 2016	”Air pollution of UB – Characteristics of UB’s Air Pollution” was posted by JICA Expert to News Letter of JICA Mongolia Office, March 2016
22nd April 2016	Baterdene Deputy Mayor posted 4 minutes movie introducing APRD to Facebook. It mentioned JICA Project also. https://m.facebook.com/story.php?story_fbid=620983201390039&id=496858783802482
5th May 2016	News Movie on Ceremony on new Air Quality Monitoring Station Donation compiled by C1 TV was posted to Facebook timeline in Baterdene Deputy Mayor. https://www.facebook.com/496858783802482/videos/vb.496858783802482/627234387431587/
5th August 2016	Northeast Asian Mayor’s Forum posted an introduction of JICA Expert Mr. Nitta and his presentation to its official website. Photo on DPF presentation was also posted in

	the photo gallery of the Forum official website.
1st September 2016	Presentation of JICA Expert, Mr. Nitta in Northeast Asian Mayor's Forum was introduced by News Letter of JICA Mongolia Office, August 2016

Source: JICA Expert Team

2.5.5.2 Presentations in Northeast Asian Mayor's Forum 2015

Northeast Asian Mayor's Forum was held in UB on 21-22 September 2015 by World Bank. The project supported the presentation of the chief representative of JICA Mongolian Office, and carried out a poster session in environmental technology exhibition. The main contents of poster session are as follows;

1) Presentation on emission measurement of new coal fuels, emission measurement of vehicles by on-board analyzers and systems to distribute air quality information
2) Presentation of emission measurement equipment and on-board vehicle emission analyzers
3) Real time display of air quality information by LCD
4) Newsletter Vol. 1 to 3 of English and Mongolian versions

Source: JICA Expert Team

Figure 2.5-5 Presentations in Northeast Asian Mayor's Forum

2.5.5.3 Opening Ceremony of Air Quality Information LCD

On 22nd March 2016, Mr. Baterdene, Deputy Mayer, and Mr. Sato, Chief Representative of JICA Mongolia Office addressed in the opening ceremony for air quality information LCD, at School #39. It was reported by UBS-1 TV and TM TV on the same day, and then by Mongolian Medee Newspaper and Zasgiin Gazrin Mede Newspaper on the next day.

Source: JICA Expert Team

Figure 2.5-6 Opening ceremony for air quality information LCD

2.5.5.4 Presentations in Northeast Asian Mayor's Forum 2016

Northeast Asian Mayor's Forum was held in UB city on 3rd-5th August 2016. According to the request from Strategic Policy and Planning Department of the Mayor's Office via JICA Mongolia Office, this project prepared 2 activities. Since the request was not only for this project but for activities on JICA Mongolian Office, the following activities were prepared and carried out as joint activities with another JICA project, titled as "Survey on Reduction of Black Smoke in Exhaust Gas of Diesel Route Bus in UB City".

1. The DPF, which was proposed as air pollution reduction plan in this JICA project, was presented in Sukhbaatar Square, and its smoke reduction demonstration was carried out by Gauze Test. Not only the citizens but also the city council Chairman and 18 bus companies showed their interest. Its photo was uploaded as the 10^{th} photo of 15 official photos in the official website. http://neamf.ulaanbaatar.mn/north-east-asian-mayors-forum-2016/

Source JICA Expert Team

Figure 2.5-7 Demonstration in Northeast Asian Mayor's Forum 2016

2. A presentation in the project was held regarding on the air pollution reduction plans. The presented softcopy is being uploaded ono the official website.
    a. Date: 5th August 2016, Friday, 13:30-16:00
    b. Venue: Tuushin Hotel
    c. Attendants: APRD, JICA, JICA Expert, etc.
    d. In the session on vehicle air pollution, after presentation of JICA Experts and 3 other presenters, the discussion was held. Regarding to the presentation by JICA Expert, there was a series of questions on "Eco Drive" such as "when is it trained?" The JICA Expert replied as:
        i. In Japan, training is not done as a part of driver license education course, but as an independent training. Especially, track transportation industry requests their drivers to study and execute Eco Drive.
        ii. In some other countries, Eco-Drive is a part of driver license education course.

2.5.6 Numbers of Access to Homepages of APRD and NAMEM

Access count to the websites of APRD and NAMEM related to the project was 211,914 in 2014, and increased to 393,752 in 2016, increased by 86%. Table 2.5-11 shows the access count and increase ratio of each month and counting methods.

Table 2.5-11 Website Access Counts

Month	2014	2016	Increase Ratio
1	11,790	40,522	244%
2	10,650	28,684	169%
3	15,377	37,937	147%
4	12,453	34,471	177%
5	9,811	32,063	227%
6	6,757	24,192	258%
7	5,207	21,313	309%
8	6,728	27,454	308%
9	22,206	24,386	10%
10	36,601	31,510	-14%
11	38,161	41,874	10%
12	36,173	49,871	38%
Total	211,914	393,752	86%

Source: Website access log and related data of APRD and NAMEM, summarized by JICA Expert
Remarks: This is the total of access counts of the project related websites, which consists of (1) APRD website, (2) air quality information website operated by APRD, (3) Contents of air quality information in NAMEM website, and (4) web site of Air Quality Smart Control System. In order to exclude internal maintenance access counts, external website access is counted for (1), (2), and (3). However, maintenance internal access counts are included for (4) because there is no data available for (4).

2.6 Improvement of Evaluation and Review: Output 6

2.6.1 Review Status of CAF

The distribution of CAF budget in 2016 is shown in Table 2.6-1. Comparing to before 2015, afforestation, which do not to relate to air pollution control measures do not have budget allocation because the allocation of CAF budget only limits to air pollution control measures.

The CAF budget is mainly tax corresponding to coal production amount. However, since coal export amount from Mongolia to China decreased, the CAF budget in 2016 became to be 5 billion MNT (approximately 222 million Yen), and decrease from 15.1 billion MNT (approximately 671 million Yen) in 2015. The budget for air pollution control measures in UB city is kept as 2.15 billion MNT (approximately 96 million Yen) maximum.

The administrative structure and person in charge of Mongolian side on CAF budget was changed, and operation structure of CAF budget was decided. Approval of CAF budget in 2017 will be decided by parliament in Mongolia.

Table 2.6-1 Detailed Air Pollution Reduction Cost in 2016

№	Contents	Number	Cost /Millionth/	Remark	Administrative Agencies
1	New coal fuel supply to Ger Area	10,000 ton	650.0	from 10,000 to 12,000 household in Bayangol district	MET、Bayangol Distract
2	Test of raw improved coal	15,000 to 20,000 ton	200.0	10,000 households in Khan-Uul district	MET
3	Construction to load decrease	4 Stations	1.350.0	110KW substation	UB City
4	Replacement of HOB in kindergarten	Five kinder-garten	500.0	No. 154 and No. 173 kindergarten in Chingeltei, No. 166 kindergarten in Sukhbaatar, No. 38 and No. 125 kindergarten in Songinokhairkhan	MET UB City
5	Awareness seminar to citizen, promotion of activities for clean technology support to project and control measures	-	300.0	Central and capital city	MET
6	measurement equipment and other equipment supply for air particles	2 items	260.0	Central area of Khubsgul province, Bayankhongor province	MET, NAMEM
7	company to connect central heating system and construction of pipes	-	100.0	Uburkhangai Province	Uburkhangai Province
8	Construction of Large scale heat only boiler in local central area	16 boilers	100.0	Uburkhangai province	Uburkhangai Province
9	Other control measures for air pollution reduction		500	Capital city	MET
10	Control measures in air quality improvement are of local central area	-	740.0	Darkhan-Uul Province, Orkhon Province, Khobd Province, Bayankhongor Province, Umnugobi Province	Provinces
11	Expense of secretariat office operation	-	250.0	-	MET
12	Other cost	-	50.0	-	MET
Total Cost			5,000.0		

2.6.2 Appraisal Process of CAF Budget

CAF budget imposed by the Law of Air Payment became to be MET budget, and CAF budget became to be treated as a special budget for air pollution control measures. The secretariat office of CAF was dismissed, and all authorities of the secretariat office were relocated to MET. Due to the dismissal of isolated CAF secretariat office, the secretariat office was relocated to Environment Department of NCAPR. NCAPR members are consisted of 7 province governors, representative of Ministries, and Prime Minister. MET distributed 5 billion MNT of 2016 CAF budget to the Ministries, UB city, and province governors, based on their proposals. Then, the budget was adopted as Ministry Order in 10 February 2016. While selecting the proposed control measures, the Environment Department of MET judged that the budget distribution of CAF by technical advices of JICA Expert. For example, new coal fuel combustion implemented by APRD as air pollution control measures with high effects, and HOB replacement with high effects, and afforestation with no effect on air pollution reduction.

The technical appraisal guideline will be established by establishing indexes which will show the effect level of the air pollution control measures, in order to screen the proposals suggested from the related agencies by MET officers in charge of CAF budget. Especially, MET focuses on conversion of Ger stoves into electric stoves as the air pollution control measures until 2020. Therefore, the necessary amount of electric power for converting Ger stove into electric stove, electric power amount par a Ger, the important notice for electric stove introduction, and evaluation method of air pollutants emission reduction caused by the decrease in number of Ger stoves, the related persons such as APRD, NAMEM, and scholars and professionals will discuss them, and agreeable items will be add to the technical appraisal guideline.

As a result of reorganized MET to MET, the Director of MET and person in charge of Mongolian side on CAF was relocated. Currently, we are waiting for the decision being made regarding the roles of administrative agencies and budget allocation of CAF.

2.6.3 Preparation and Approval of Technical Guideline

Establishment of working group on preparation of technical guideline issued in January 2017. The technical guideline will be prepared to decided allocation of CAF budget from technical point of view. Therefore, first working group will be held in May 2017, and technical guideline will be approved by related agencies in June 2017. Technical guideline described indicators for screening proposals by related agencies, the indicators will be established effect and no-effect of air pollution control. In particular, MET policy has countermeasures conversion ger stove into electric stove. Therefore, necessary electric amount for conversion into electric stove, electric fare, remarks on introduction of electric stove and evaluation method on ger stove reduction, related persons such as APRD, NAMEM, professors, JICA Expert team will discussed, they are added into the guideline.

Establishment Order of working group in January 2017 decided that CAF was changed into Air Pollution Against Fund.

2.7 Regulation and Control for Emission Reduction: Output 7

2.7.1 Full Implementation of Boiler Management and Registration

Based on "Certified regulation of HOB facilities" (the City Council Resolution No.147) in September 2014 and "Administrative Instruction of Boiler Inspection and Certification" in September 2014, the flue gas measurement by smoke tester and TESTO-350 and the boiler inspection were implemented. The improvement orders to HOB faculties were issued sequentially based on the result of the Boiler Inspection and Certification.

The challenge of the Boiler Inspection and Certification of the year 2014 was that to issue the implementation order to HOB facility because currently, it cannot issue orders because measurement data and the emission standard of MNS cannot be compared. This appears to be caused by the flue gas concentration not meeting the emission standard of MNS, led by measurement result of dust concentration not being compared with the emission standard of MNS. The result of the comparison between the simplified dust measurement and the emission measurement results by JIS method from the year 2014 to the year 2015, the Mongolian side judged that they cannot accept the Boiler Inspection and Certification by dust simplified measurement because result of the simplified dust measurement was not compared with the emission standard of MNS for the Boiler Inspection and Certification, and requested a policy which inspects all HOBs within 2 years. Therefore, the measurement was changed to the precise measurement using JIS method which is able to compare measurement data with the emission standard of MNS from October 2015.

Based on "Certified Regulation of HOB Facilities" (the City Council Resolution No.147) in September 2014 and "Administrative Instruction of Boiler Inspection and Certification" in September 2015, the Boiler Inspection and Certification of the year 2015 was implemented. The improvement orders to HOB faculties were provided based on the result of the Boiler Inspection and Certification.

Detail of improvement orders to HOB faculty is shown in "2.8.4 Improvement Orders to HOBs and Steam Boiler". The achievement of the Boiler Inspection and Certification of 2015 was the establishment of full implementation of boiler management and registration. The details of achievements were 1) The Boiler inspection without the flue gas measurement, 2) Registration of boiler, 3) The flue gas measurement, 4) Notification of emission measurement results and improvement orders and 5) Confirmation of performance of improvement orders. As a result of coordination between APRD, IACC, UECC, EFDUC, infrastructure and Urban Improvement Division of each district, Inspector of each district and JICA Expert Team, the related activities were implemented. Task of each organization is shown in Figure 2.7-1. Improvement order to the rejected HOB facility based on the result of the Boiler Inspection and Certification is described in "2.8.4.1 Admonishment and an Improvement Order to HOBs and Steam Boilers".

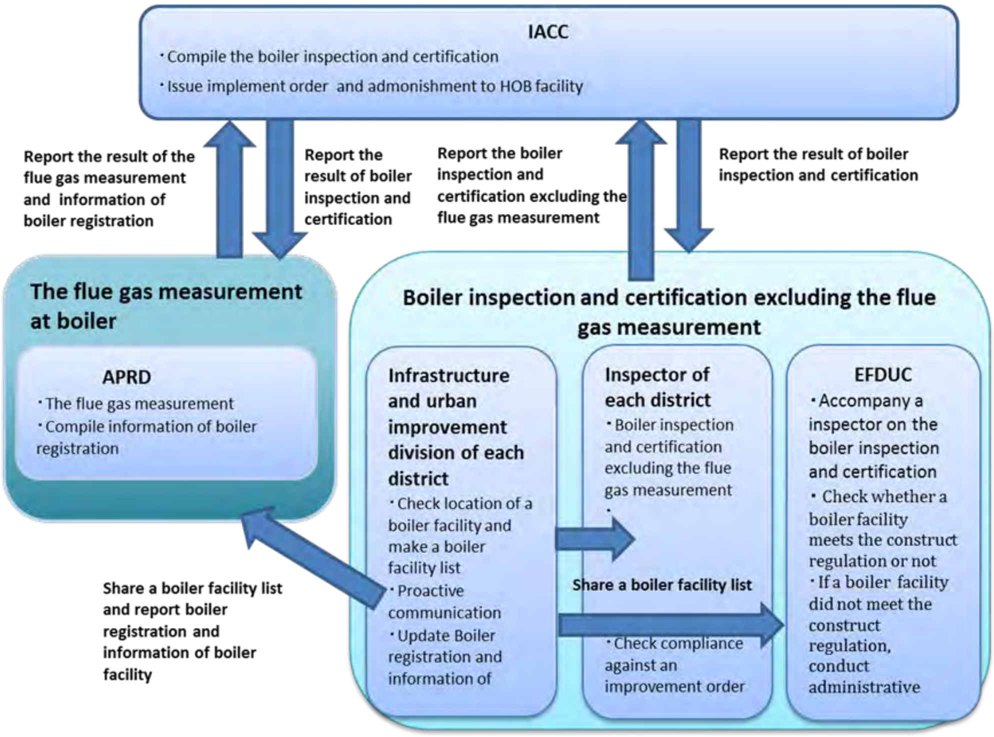


Figure 2.7-1 Task of Each Organization

Source: JICA Expert Team

"Administrative Instruction of Boiler Inspection and Certification of the Year 2016" was approved by the Mayor in November 2016. The Boiler Inspection and Certification has been implemented from December 2016. Based on the Administrative Instruction of Boiler Inspection and Certification, the boiler inspection and certification was expected to be implemented continuously after the termination of this project.

2.7.1.1 Registration Status of HOB and Steam Boiler

The boiler registration of the year 2014 was carried out as a part of the project, "Air Quality Smart Control System", within the budget of NCAPR. By bidding, the private research company "SICA Corporation" accepted an order of boiler registration project. In winter season of 2015, HOB facility for heat capacity more than or equal 100 kW was registered and inspected similar to the boiler registration and inspection of the year 2014, and all HOBs facilities were registered. The registration status of the boiler in the year 2014 and 2015 is shown in Table 2.7-1. As of April 2017, "Air Quality Smart Control System" is controlled under the jurisdiction of MET, and the "Air Quality Smart Control System" is being utilized.

From Phase 1 of the project, which began in 2010, to the year 2014, not few numbers of non-registered boilers existed, and the improvement of registration rate was becoming an every year issue for the boiler registration. The boiler registration team visited all HOBs and steam boilers in the year 2015. However, while visiting HOBs, stacks were searched by the district officers in charge of boiler registration. If non-registered stacks were found, the inspection agency has authority to enter the facilities and confirm the existence of the facilities. As a result, 11 non-registered boilers and new HOBs were found.

Table 2.7-1 Number of Boiler Facility and Boiler Registration by District

	2014		2015	
District	Number of boiler facilities	Number of boiler	Number of boiler facilities	Number of boiler
Bayangol	10	14	13	14
Songinokhairkhan	28	59	28	58
Khan-Uul	28	69	33	54
Chingeltei	23	43	22	30
Sukhbaatar	14	25	15	26
Bayanzurkh	54	120	57	105
Total	**157**	**330**	**168**	**287**

Source: JICA Expert Team

In the year 2016, the "Certified Regulation of HOB Facilities" became invalid. However, UB City understands the importance of the Boiler Inspection and Certification. Thus, the Mayor approved the "Administrative Instruction of Boiler Inspection and Certification of the Year 2016" in November 2016. APRD, IACC, UBECC, EFDUC, Infrastructure and Urban Improvement Division of each district and Inspector of each district coordinated, and the related activities have been implemented. The boiler inspection was performed in Bayanzurkh district, Bayangol district, and Sukhbaatar was performed, and the boiler inspection of Chingeltei district. The inspection team patrols thoroughly each district just as same as the boiler inspection of the year 2015. As a result, 3 new HOBs were found.

2.7.1.2 Progress of Capacity Development

A large number of submitted registration data from SICA Corporation, lacked information or had typographical errors, thus, screening was necessary before using the data. JICA Expert registered the boiler data to the database, linking them to the past data, and confirmed the data with C/P-WG members. The C/P-WG members who are the working group members of the "Administrative Instruction of Boiler Inspection and Certification" confirmed the data using the knowledge regarding the boilers, and as a result, many errors were corrected.

JICA Expert Team, C/P, and C/P-WG discussed on the problems of "Administrative Instruction of Boiler Inspection and Certification" and all target pollutants of the emission measurement for the boiler inspection from August to September 2015. The improvement plan of "Administrative Instruction of Boiler Inspection and Certification" was proposed and approved by Vice Mayor. The result showed that APRD, IACC, UECC, EFDUC, Infrastructure and Urban Improvement Division of each district and Inspector of each district, and JICA team coordinated on the related activities, and the boiler inspection progressed well from October 2015 to March 2016.

“Administrative Instruction of Boiler Inspection and Certification of the Year 2016" was approved by the Mayor in November 2016. Only C/P-WG is performing the Boiler Inspection and Certification from December 2016, excluding the flue gas measurement. Based on the administrative instruction of boiler inspection and certification, the Boiler Inspection and Certification is expected to be implemented continuously after the termination of this project.

Regarding the flue gas measurement using JIS method, as of October 2015, PP4 members were to be added to the measurement team according to the measurement plan. PP4 did not participate as the measurement team due to the restriction of acquisition of the necessary budget for the measurement. Therefore, HOB was measured only by 1 team of APRD. The technology transfer had excellent progress, and 1 team of APRD became to be able to perform emission measurement by themselves. In order to measure all HOBs within 2 years, 2 teams are necessary, and the technology transfer and OJT to the second team were applied for their development of measurement ability. However, the capability of the flue gas measurement decreased because the persons in charge of the flue gas measurement had to leave APRD due to the restructure of APRD in November 2016. APRD appealed every day to the upper administrative of the UB city for the new employment and re-employment of the discharged persons in charge. The upper administrative of the UB city did not approve the employment of staff in the end of March 2017. Currently, the C/Ps, including the head of monitoring division, are conducting the flue gas measurement, thus the flue gas measurement is able to be performed on their own.

To develop person in charge of the flue gas measurement, from 1 to 7 years are necessary, since each person in charge has different amount of capacity. The challenges need to be cleared for the continuous boiler management and registration after September 2017 are 1) re-employment of discharged person in November 2016, 2) comeback of the personnel after studying abroad in August 2017, and 3) training of successors by remaining person in charge, persons of 1) and 2) and additional person from APRD. In case the staff returns to work in August 2017 after studying abroad, C/Ps will be able to train the additional person by their selves, and expected to conduct the flue gas measurement in 2 team structures, starting from 2018. In case of structure with 1 flue gas measurement team continues, the flue gas measurement will be able to be performed on 55 boilers facilities in 1 year, and 3 years will be necessary to complete the flue gas measurement on all boilers facilities.

2.7.1.3 Certified Regulation of HOB Facilities

For the promotion of boiler registration management system, the related agencies such as IACC, APRD, and EFDUC implemented the related activities for the boiler registration management system. The “Certified Regulation of HOB Facilities” was suggested by NCAPR, and Resolution No.147 was approved by the highest officials of the city council meeting on September 8th, 2014. The boiler inspection and certification began to perform from October 2014. “Certified Regulation of HOB Facilities” regulates the necessary evaluating score, mandate of boiler owner and the working group of the boiler inspection and punitive clause to certify the boiler with heat capacity of 11kW to 3.15MW. “Certified Regulation of HOB Facilities” is shown in appendix 2.7-1. “Certified Regulation of HOB Facilities” did not mention the MNS emission standard for the steam boiler less than and equal to 3.15 MW. The calculation formula for the compliance status for the emission standard is not correct, and currently the formula calculates higher point with higher concentration.

IACC, HOB and steam boiler inspective, needs to inspect HOBs and steam boiler for all pollutants of MNS emission standard such as Dust, SO_2, NOx, and CO. All of the target air pollutants, specified in the regulation of MNS, are to be included in the evaluation items. If the original evaluation method is adopted, strengthening of the boiler inspection does not mean that the air pollution control will lead to decrease of PM concentration because the evaluation weight of other non-controlled pollutants will become very high. Therefore, JICA Expert discussed with C/P on revision of “Certified Regulation of HOB” as a review of evaluation method by setting additional evaluation items on a dust collector and other dust relating matters and less evaluation items for non-dust pollutants. Thus, the boiler inspection focuses on Dust which has most urgent priority as air pollution control measures. However, after the national election in June 2016, a controlling political party was changed, and “Certified Regulation of HOB Facilities” which was approved in past administration, became deemed invalid. According to article 7.1.2 of Air Law, MET ratifies bylaw, regulation, method and procedure regarding environmental protection and ensure a smooth implementation. MET will ratify “Certified Regulation of HOB Facilities”, and will be enforced in 2017.

2.7.1.4 Administrative instruction of Boiler Inspection and Certification

Standard of boiler certification is described in “Certified Regulation of HOB Facilities”. However, the inspection method for HOB certification was not regulated in “Certified Regulation of HOB Facilities”. Therefore, administrative instruction with summarized basic policy was necessary to operate “Certified Regulation of HOB Facilities”.

The working group made a draft of the Administrative Instruction of the Boiler Inspection and Certification in order to conduct the Boiler Inspection and Certification including the flue gas measurement on HOBs from October 2015 to March 2016. “Administrative Instruction of Boiler Inspection and Certification” was approved by the Vice Mayor on September 28th 2015. In the Administrative Instruction of Boiler Inspection and Certification, the necessary budget for inspection is specified to conduct the roles and activities of the related agencies such as APRD, IACC, and members of the working group. The boiler inspection was smoothly implemented by the cooperation of the working group with the administrative instruction of approved Boiler Inspection and Certification as the base. The Administrative Instruction of Boiler Inspection and Certification is attached as Appendix 2.7-2. The Administrative Instruction of Boiler Inspection and Certification is noted in 2.1.1.2 “Protocol for HOB Inspection”.

The approved “Certified Regulation of HOB Facilities” was deemed invalid in 2016. However, UB city understands the importance of the Boiler Inspection and Certification, and “Administrative Instruction of Boiler Inspection and Certification of the Year 2016” was approved by the Mayor in November 18th 2016. The Administrative Instruction of Boiler Inspection and Certification of the year 2016 is attached as Appendix 2.7-3

One of the biggest challenges on the Boiler Inspection and Certification in previous years was that even if the boiler facility with the dust concentration is not meeting the MNS emission standard, the boiler facility could be certified as an operational boiler. JICA Expert proposed to C/P the revision of the evaluation point on Boiler Inspection and Certification based on the preliminary point allocation in September 2016. JICA Expert discussed continuously to C/P about the revision of elaboration point, and finally, new point allocation was completed in the end of October 2016. In enforced administrative instruction of Boiler Inspection and Certification, most of the proposed point allocation was adopted, and the certified qualifying standard became to be 71 points or more out of 100 points. If the dust concentration is not able to meet the emission standard of MNS, this boiler facility will be unqualified. Therefore, it is expected that decommission or improvement of HOB will be implemented in accordance with an Improvement Order by IACC. Regarding the boiler certification, the major differences between "Certified Regulation for HOB Facilities in 2014" and "Administrative Instruction of Boiler Inspection and Certification of the year 2016" are shown in Table 2.7-2.

Table 2.7-2 Major Differences between Certified Regulation for HOB Facilities and Administrative Instruction of HOB Inspection and Certification

	Certified Regulation of HOB Facilities Resolution No.147 September 8th 2014	Administrative Instruction of Boiler Inspection and Certification A805 November 18th 2016
Qualification and Un-qualification of Boiler Certification	In case point is from 0 point to 59.9 points out of 100 points: Insufficient level (unqualified) In case point is from 60.0 points to 69.9 points out of 100 points: Middle level (qualified) In case point is from 70.0 points to 79.9 points out of 100 points: Upper middle level (qualified) In case point is from 80.0 points to 89.9 points out of 100 points: Lower high level (qualified) In case point is from 90.0 points to 100 points out of 100 points: Excellent level (qualified)	Qualification point is 71 points or more out of 100 points.
Point allocation of each pollutant in flue gas	Point allocation is 40 points or more out of 100 points. If pollutant concentration exceeds MNS emission standard, boiler is able to be certified operational possible boiler.	Point allocation is 60 points or more out of 100 points.
Dust	If dust concentration exceeds MNS emission standard, boiler is able to be certified operational possible boiler.	If dust concentration is not able to meet the emission standard of MNS,

		this boiler facility is rejected at this point.
Fixed point of each pollutant in flue gas	Fixed point of each pollutant is calculated according to the following calculating formula. Fixed point becomes high point as high concentration. $ШО = \left(\frac{ХД * БО}{ХДХ}\right) - 20$ “ШО”/ Fixed point “ХДХ” / Concentration of MNS emission standard “БО”/ Point of each pollutant “ХД” / Measured concentration “20” / Coefficient (constant number)	In case of concentration of pollutant meets MNS emission stand, point of the pollutant is added. In case of concentration of pollutant does not meet MNS emission stand, point of the pollutant is not added (0 point).
Point of each pollutant in flue gas	Dust :10 SO_2 :10 CO :10 NOx :10	Dust :30 SO_2 :20 CO :8 NOx :2

2.7.1.5 Compliance Condition of MNS Standard

C/P implemented the emission measurement from October 2015 to February 2017 by using JIS method. Comparing the MNS emission standard and measurement results in October 2015 to March 2017, measured result of 23 boilers (36.5%) satisfied the emission standard out of 63 boilers. However, comparing to the PDM indicator which is 80% compliance rates for the MNS emission standard, had still a large difference with the measurement results.

2.7.2 Proposal for Revision of MNS

2.7.2.1 Power Plant: MNS 5919 (2008)：Proposal of MNS Revision for Power Plants

(1). **Basic Idea**

Concentrations of emission gas from PP2 and PP3 are high, because MNS for PP2 and PP3 was settled according to the actual emission status of power plants as they were constructed. The emission occupies large part of PM emission in UB. MNS emission standard for most of boilers in PP2 and PP3 is mitigated; it is reason for high emission amount in UB. High value for coal consumption and gas volume, air pollution control facility should be large size; it is easy to be high value of dust collection efficiency. Therefore, strengthening MNS emission standard for existing boilers are necessary within capability of air pollution control measures.

(2). **Proposal and Reason**

Change of the MNS standard for existing power plants are proposed as described in Table 2.7-3.

Table 2.7-3 Proposed MNS Emission Standard for Existing Power Plants

Boiler Size	Dust Emission Standard	
	New	Present
Less than 100 ton/h and equal	600mg/m3$_N$	21,000 mg/m3$_N$
Less than 220 ton/h and equal	300 mg/m3$_N$	10,800 mg/m3$_N$ 1200 mg/m3$_N$（CFB）
More than 220ton/h boiler	200 mg/m3$_N$	200 mg/m3$_N$

PM emission standard for power plants in main countries are shown in Table 2.7-4. Coal consumption and gas volume is high, but MNS emission standard in UB is not severe than global level, emission from power plants against PM emission in UB occupy high ratio. However most of boilers for power plants in each country utilize larger than Mongolian boilers, dust collection facilities for less than 100 ton/h and equal boilers have limitation of collection efficiency, Less than 100 ton/h and equal boilers as emission standard are proposed 600 mg/m3N which is Japanese double emission standard

Table 2.7-4 Dust Emission Standard in Main Countries

	Dust Emission Standard
Japan	200,000m^3_N more than or equal：100mg/m^3_N 40,000～200,000m^3_N：200mg/m^3_N 40,00 m^3_N less than：300mg/m^3_N
US	35mg/m^3_N
EU	300MW more than or equal：20mg/m^3_N 100～300MW：25mg/m^3_N 50～100MW：30mg/m^3_N
China	30mg/m^3_N 20mg/m^3_N：Special Area
Thailand	New facilities：120mg/m^3_N Existing facilities：320mg/m^3_N

2.7.2.2 MNS 5457 (2005)：Proposal of MNS revision for HOB

(1). **Basic Idea**

The larger boilers become, the collection efficiency becomes higher. However, if severe emission standard such as PP4 MNS emission standard is applied to HOB, the heat capacity size of HOB to be adopted by air pollution control facilities have limitation, and even the most of the high efficiency HOB with automatic coal feeder and cyclone cannot satisfy the emission standard. Therefore, according to the efficiency of HOB which can be additionally installed, the efficiency of dust collection, and comparison of emission standard between power plants, decision for suitable revision of MNS emission standard for HOB is necessary.

(2). Proposal and the Reason

Mitigated MNS emission standard is proposed in Table 2.7-5.

Table 2.7-5 Proposal of MNS Emission Standard for HOB

	Dust Emission Standard	
	New	**Present**
HOB	Approximately 1000mg/m3$_N$	300mg/m3$_N$（0.8MW less than） 400mg/m3$_N$（0.8MW～3.15MW）

Dust concentration by emission measurement from Phase 1 in 2011 to February 2016 is shown in Figure 2.7-2. However, 2014 emission measurement data is excluded because the precision of measurement data was not able to be confirmed. DZL, which has high heat efficiency and large scale boiler, MNS emission standard is satisfied in most of the cases, and Carborobot, which has automatic coal feeder and cyclone, dust concentration had wide range of values based on HOB facilities combustion management. Revision of MNS emission standard is necessary so that Carborobot has possibility to satisfy the standard.

If emission standard of 1,000 mg/m^3_N is adopted, the achievement will be approximately 50% and emission standard of 1,200 mg/m^3_N is adopted, the achievement will be approximately 60%.

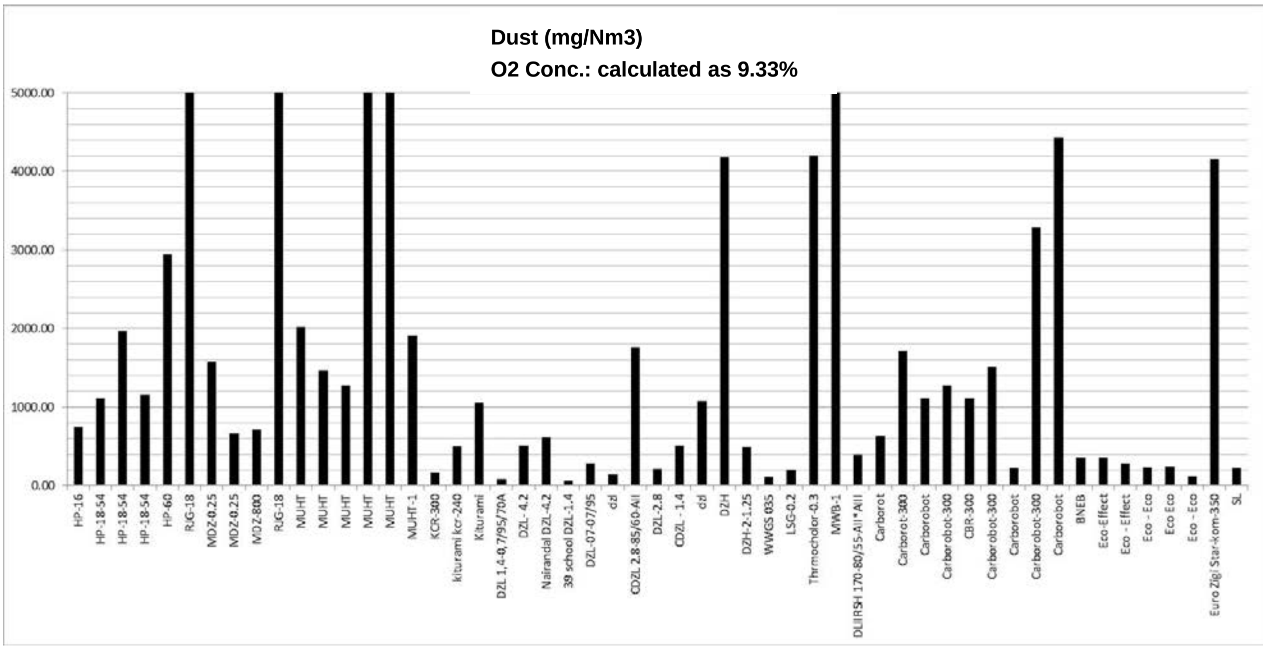


Figure 2.7-2 Result of Dust Emission Measurement of HOB

(3). <u>Future Activities</u>

For revision of MNS emission standard for power plants and HOB, compare between present and proposed MNS emission standard, related persons such as APRD, IACC and MET, ME, scholars and professionals will discuss validity of MNS emission standard based on exhaust gas volume of facilities, necessary proposal letter to MNS revision list of agency for metrology from 2017 will be discussed.

Revision of MNS emission standard regulation was approved, MNS emission standard was enforced from April 2017. Revised MNS is technically evaluated.

2.7.2.3 Proposal for MNS 4585:2007 Revision on SO2 24 Hours Average Standard

24 hours average air quality standard for SO2 of MNS 4585:2007 is as same as that of WHO Guideline 2005[11]. Because Japan, USA and EU have not yet followed this SO2 24 hours air quality standard, Mongolia can be said as a good follower to WHO. As the result, air quality in UB is generally concluded as "SO2 is worst" although it is generally "PM10 or PM2.5 is worst" if Japan, USA or EU air quality standard is applied to UB's air quality. In addition, there is no health statistics study that concluded Mongolian is much sensitive than the citizens of Japan, US and EU. NAMEM and JICA Expert Team proposed to revise SO2 24-hours average standard.

[11] WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update 2005, WHO

In June 2014, JICA Expert raised an issues caused by SO2 24 hours average standard, to the members of C/P-WG and the stakeholders of Air Quality Smart Control System.

On 1st July 2015, when Ministry of Health and Sports of Mongolia requested comments for revising MNS 4585:2007, the comments seemed not submitted by the members of C/P-WG. Since it was still revising process in November 2015, the JICA Expert submitted the following proposal with C/P-WG members on 6th November 2015.

Proposal was approved as No. 37 of Mongolian Agency for Standardization and Metrology (MASM) on 23rd June 2016, activated as MNS 4585:2016 on 8th July 2016.

(1). **Summary**

According to Article 12.3 Air Law (amended on 12th December 2013) "Public notification and safety advice must be issued to related organization and citizens whenever pollutant is over than air quality standard", and to justification of "health advice to citizens" for Article 1.3 of Appendix 1, Order of Minister of MEGDT No. A327 on 17th September 2014, MNS 4585:2007 is proposed to be revised.

(2). **Proposal**

It is proposed to change 24 hours average SO2 air quality standard of MNS4585:2007 to larger values, as similar to other countries. It is suggested to be revised quickly because health advices based on Mongolian AQI is already started.

(3). **Discussion**

Table 2.7-6 shows SO2 and PM10 air quality standards of selected countries. SO2 air quality standard of WHO Guideline and Mongolia is 0.020 mg/m3, which is 6 times lower than other countries ranged between 0.123 ~ 0.150 mg/m3.

This misleads advisory service of air quality information as follows;

If SO2 is 0.120 mg/m3, it is concluded as less than air quality standard in Japan, EU, Korea and China, and as 6 times higher than air quality standard. AQI calculated by Order of Minister of MEGDT No. A327 is "600, Mash Ikh Bokhirdoltoi (Extremely Polluted), which will be announced to citizens.

Assumed air pollution of AQI 500, Ikh Bokhirdoltoi (Largely Polluted) in Mongolian regulation is examined here by Japanese air Quality Standard. If AQI 500 is because of SO2, SO2 concentration should be 0.100mg/m3, which is concluded as "no problem" because it is less than air quality standard in Japan. If AQI 500 is because of PM10, PM10 concentration should be 0.500mg/m3, which is concluded as "serious problem" because of 5 times higher than Japanese air quality standard. Air quality of Mongolia cannot be evaluated by AQI, and concentration value of each pollutant is necessary.

AQI of this sample air pollution is calculated by AQI definitions of other countries, as shown in Table 2.7-7. If AQI 500, Ikh Bokhirdoltoi (Largely Polluted), is because of SO2, AQI calculated by USA regulation is 52, and concluded as "Moderate", and 75, "Good" by Chinese regulation. In contrast, if it is because of PM10, 400, Hazardous by USA regulation, and 500, Extremely Polluted by Chinese regulation.

As exampled above, AQI calculated by Mongolian standard tends to be Ikh Bokhirdoltoi (Largely Polluted) even though SO2 concentration is less than air quality standard of other countries. SO2 24 Hours Average Standard is proposed to be changed in order to announce suitable advices to citizens.

Table 2.7-6 Daily Average SO2 and PM10 Air Quality Standard of Selected Countries

		SO2	PM10
Country	**Legal Framework**	**mg/m3**	**mg/m3**
Mongolia	MNS 4585:2007	0.020	0.100
Japan	Notification No. 35 (1973.5.8) of Environment Agency, etc.	0.123	0.100
EU	Directive 2008/50/EC	0.125	0.050
Korea	Unknown (http://eng.me.go.kr/)	0.153	0.100
China	GB3095-2012	0.150	0.150
Iran	Unknown (http://air.tehran.ir/)	0.442	0.154
WHO	Air quality guidelines - global update 2005	0.020	0.050

Remarks: Air quality standard of Japan and Korea, which is defined in ppm, is converted into mg/m3 value in 20 degree Celsius and 1 atm. condition. SPM, which is most similar pollutants to PM10 in Japan, is assumed as PM10 in this table. USA is not shown in this table because USA does not define 24 hours average air quality standard for SO2.

Table 2.7-7 AQI of 24 Hours Average Air Quality Calculated by Selected Countries

		SO2	PM10
Country	**Legal Framework**	**0.100mg/m3**	**0.500mg/m3**
Mongolia	Order of Minister of MEGDT No. A327 on 17th September 2014	500	500
USA	40 CFR Part 58	52	400
China	HJ 633-2012	75	500

Remarks: Air pollution for AQI 500 in Mongolia is compared.

2.7.2.4 Proposal for MNS 4585:2007 Revision on CO_2 24 Hours Average Standard

JICA Expert proposes to revise CO_2 24 hour average indoor standard, activated as MNS 4585:2016 on 8th July 2016.

(1). Summary

MNS 4585:2007 is proposed to be revised to realize Article 1 of MNS 4585:2007, “To keep the healthy and safely environment for life, work and study of Mongolian Citizens and for balance of ecology system.”

(2). Proposal

Unit of CO2 indoor standard for 24 hours average is proposed to be changed from ug/m^3 to mg/m^3.

(3). Discussion

World average of outdoor CO_2 concentration is ranged between 344.3ppm in 1984 and 397.7ppm in 2014[12]. It equals to 630069ug/m^3 to 727791ug/m^3 by conversion condition 20 degree Celsius and 1 atm. defined in ISO 4225:1994 that is reference of MNS4585:2007. It is 350 to 404 times higher than 1800ug/m^3 that is CO_2 24 hours average indoor air quality standard of MNS4585:2007. Because CO2 of indoor air is tends to be higher than outdoor air by human breathing, it is almost impossible to change indoor air CO2 less than the standard.

[12] World Data Center for Greenhouse Gases, 2016, http://ds.data.jma.go.jp/gmd/wdcgg/pub/global/globalmean.html

In "Order for Act on Maintenance of Sanitation in Buildings"[13] of Japan, CO2 indoor air quality standard is 1000 ppm, which equals to 1830mg/m^3. Because it is 1000 times higher than the standard defined in MNS4585:2007, CO2 indoor air quality standard may had been intended to be 1800mg/m^3 instead of 1800ug/m^3.

2.7.2.5 Procedure of MNS revision

Necessary procedure for MNS revision in 2017 on HOB emission standard and ambient air quality monitoring is as following.

1. Request letter on standard revision is issued to nature environment technical committee in Agency for standard and metrology. Request letter can be prepared and proposed by any organization such as APRD and JICA Expert Team.
2. Nature environment technical committee describes in revision plan table list from next year. Revision working of MNS to be listed will be started.
3. Nature environment technical committee will request submission of proposal of draft MNS revision to the organization to issue request letter
4. Proposed revision standard will be sent to related agency to request comments it.
5. Based on comments to be provided by related agencies, nature environment technical committee will prepare final draft MNS.
6. Final draft is sent to related agencies, if related agencies agree it, Agency for standard and metrology will approve the MNS revision.

2.7.3 Mobile emission Source Measures and Other Emission Source Measures

2.7.3.1 Measures for Mobile Emission Source

JICA Experts conducted the awareness seminar for Experts in May 2014, October 2014, and May 2015 (the details are shown in in Appendix 2.7-3, 2.7-4, and 2.7-5). Through the activities, JICA Experts achieved the participants to understand the basic approach to apply the mobile emission control measures using the measurement result of on-board emission measurement system (Activity 7-6) in Mongolia.

Also as one of the mobile (vehicles) emission control measures, workshop concerning installation of DPF were held 2 times in October 2015 and the future plan was discussed. In December 2015, discussion was conducted regarding other measures, such as introduction of EURO IV buses, transition into low emission vehicle, limitation of high emission vehicle, introduction of low sulfur fuel, recommendation of

[13] Order for Act on Maintenance of Sanitation in Buildings (amended on 24th December 2014)
http://law.e-gov.go.jp/htmldata/S45/S45SE304.html

Eco-drive, and advancement of signal control. In addition, the estimation of the control measures effect was conducted in January 2017.

As a result, the capacity of C/P for the control measures regarding the mobile emission source dramatically improved compared to prior to this activity.

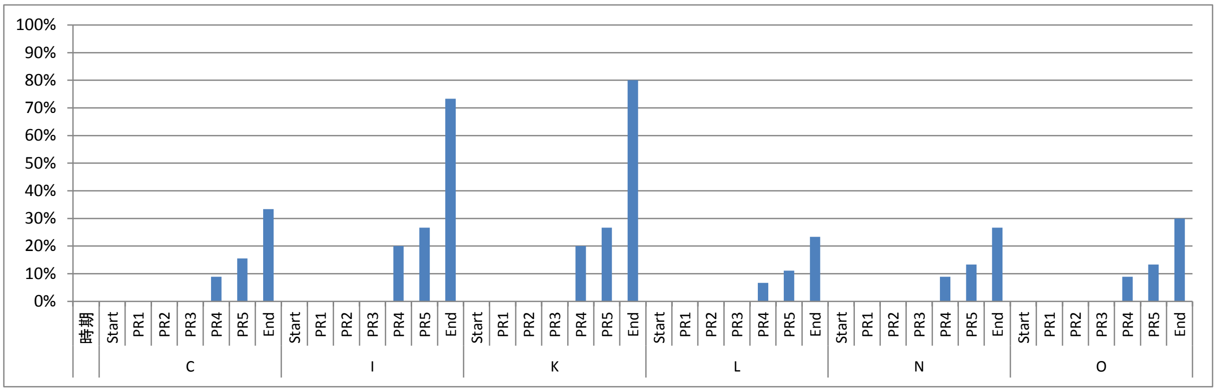


Figure 2.7-3 Progress of Technical Level on Mobile Emission Control Measures (such as APRD, NAMEM)

2.7.3.2 Improved Coal Fuel for Ger Area

(1). <u>Combustion examination protocol for fuel evaluations</u>

The protocol of combustion examination suggested to the Mongolian side shows in Figure 2.7-4.The reason why the protocol is proposed is as followings,

i. Current MNS 5216 determines the effluent standard of a stove, but there is no description of a standard fuel for test, and the property of the exhaust varies according to a kind of the fuel by the same combustion method with the same stove. For example, when semi-cokes briquettes are burned in a conventional Ger stove, the stove may be cleared by the MNS.

ii. As evaluation of the fuel needs the combustion examination under the same condition, a combustion protocol is necessary. In addition, MNS for the combustion test for the evaluation of fuel should be set.

Additional combustion called a refuel in this protocol is proposed, but the case without refuel is also thought for shortening the combustion examination measurement time. On the other hand, it should be noticed that some fuel produce much dust at the time of the refuel.

The protocol of combustion examination starts the measurement after an ignition material fires fuel. This reason as follows.

i. The protocol of combustion examination is aimed for an evaluation of the fuel at the combustion. On the other hand, it is revealed that the change of the value of the exhaust of firing materials is big by the same firing materials (cf. 2.7.3.2(4)). When emission measurement is started after firing materials fired it, distinction of the effluent gas from firing materials and the effluent gas from fuel becomes difficult. Therefore, it is important to get rid of the influence of firing materials for a fuel evaluation.

ii. The firing method to fuel is a future examination problem.

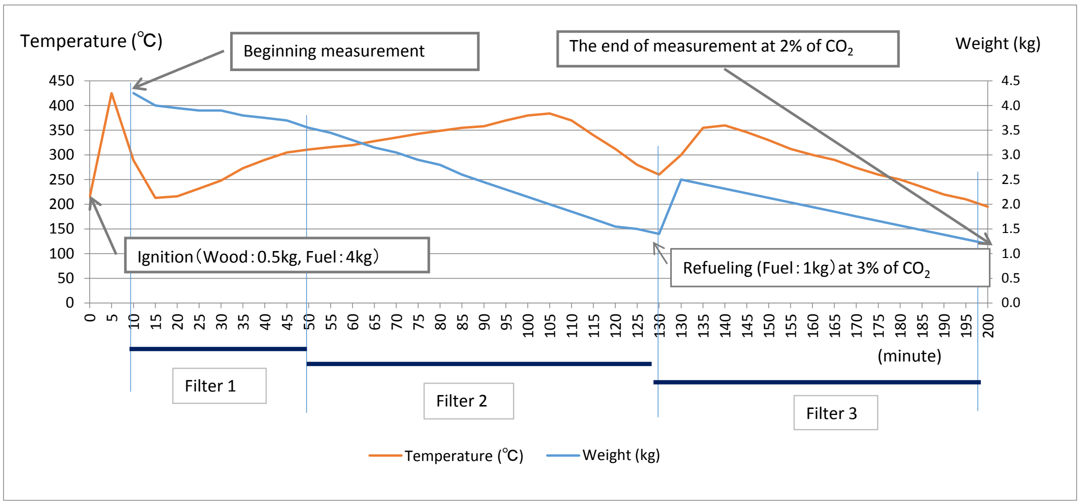


Figure 2.7-4 The combustion examination protocol

In addition, the follows are notice matters when the protocol is carried out.

i. Same type of stove like DULL stove made in turkey will be used.

ii. Combustion test will be conducted three times for one fuel and the test will be conducted once a day.

iii. Four kilograms of fuel will be input at the beginning in the case of the small type of DULL stove and one kilogram of fuel should be refueled. 0.5 kilograms of ignition material such as a chip of wood is used.

iv. In order to avoid any influence on effluent gas of firing materials, the start of measurement starts after firing to fuel.

v. Ignition will be checked by viewing when total amount of fuel and ignition material falls down from 4.5 kilograms at the beginning to around 4.0 kilograms. Flue gas temperature after the time will be carefully checked and if ignition is not verified, re-ignition will be conducted.

vi. Coal will be refueled when CO_2 concentration falls down to 3 %, and combustion test will finish when CO_2 concentration falls down to 2 %.

vii. The timing for replacement of a filter should be decided considering against clogging a filter. Normally, first time will be 30 to 40 minutes.

viii. Fuels will be weighed every 10 minutes from the beginning of the test.

PM weights measured and flue gas measurement values will be inputted in Excel file.

In the above-mentioned, the issues are in a firing method to a fuel and start of measurement time. Because the purpose of the examination is a fuel evaluation, more consideration will be required about the measurement method which is not affected by firing materials.

(2). A Kind and Contents of the Improved Fuel

Table 2.7-8 shows the classification and manufacturers of the improved fuel. Each company has own production facility, but most companies have already stopped the operation or gone bankrupt.

Table 2.7-8 The classification and manufacturers of the improved fuel

Classification	Content	Manufacturer
Coal briquette	Settling pond coal at a coal preparation plant	Khur Tug LLC
	Anthracite and bituminous coal	Derst Tokhoi LLC
Semi-cokes briquette	Making briquette after cursing semi-cokes distillated coal	Sharingol Energy LLC
		Baylag Erdene tsom” LLC
		Khokh Chono group LLC
		MSCE” LLC
		NACO
Semi-cokes	Coarse semi-cokes distillated coal	MAK
Bio-coal briquette	Making briquette by mixing coal and biomass	(Under trial producing)
Compressed fuel	Compressed biomass	（There are plural companies）

(3). The Evaluation of New Fuel

Table 2.7-9 shows the examination result of an emission factor for environmental pollution simulation development. In addition, Figure 2.7-5 shows the decrease in emission factor with the improved fuel. In Figure 2.7-5, the dust was reduced by 91%, in comparison Baganuur coal by a traditional stove with semi-coke of the Baganuur coal by a new stove. Moreover, the dust was reduced by 80% in comparison Baganuur coal by a new stove with semi-coke of the Baganuur coal by a new stove. As a result, the best result will be provided when the semi-cocks is burned with an improved stove.

Table 2.7-9 Examination Result of an Emission Factor

A kind of stove	A kind of fuel	Emission factor (kg/t)	Calorific Value (kcal/kg) at As Received base	Weight ratio based on CV
Conventional ger stove	Coal	3.02	4,072	100%
New stove	Coal	1.36	4,072	100%
	Coal briquette mixed anthracite and bituminous coal	0.90	4,815	85%
	Semi-cokes briquette	0.27	4,989	82%

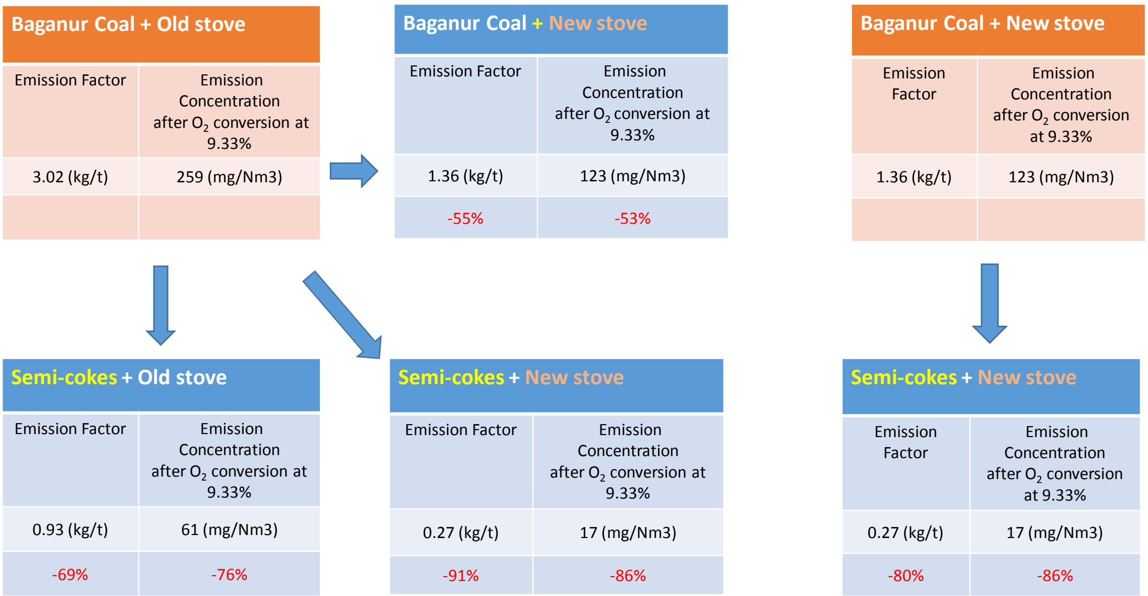


Figure 2.7-5 Decrease in Emission Factor with the Improved Fuel and Stove

(4). Ignition Material

a. Brief summary

Firing materials used in a gel stove and wall stove were generally paper and chip of woods, and it was said that the ratio of dust from the firing materials was big comparing with the total dust by ignition material and fuel. The combustion examination was carried out to measure the ratio and the result of a comparison with the improved fuel.

As a result, the quantity of dust outbreak by firing materials could not be ignored. Especially, in the case of improved fuel such as semi-cokes with a little quantity of dust outbreak, a ratio of quantity of dust outbreak by firing materials grew very big. For example, the ratio of firing materials among the quantity of dust outbreak including fuel was 30-50% in the case of the middle class of an improved fuel and 85% in the case of semi-cokes with a little quantity of dust outbreak.

The improvement of ignition material is necessary, too, but should add it to an evaluation factor of a fuel because the consumption of an ignition material fluctuates by firing characteristics of the improved fuel.

b. Combustion examination of firing materials of wood (1)

1) Test Result

Table 2.7-10 shows the result of a combustion test by only wood, 500g, as an ignition material using improved stove of DULL. Refer to Figure 2.7-6. It was found that the change of data of each result of a measurement was very large. Figure 2.7-7 shows Emission Factor of Dust in the data by a graph. When the combustion test starts from so-called Cold Start, it is difficult to distinguish the result data between an ignition material and testing fuel for evaluation of the fuel due to the large change. Therefore, the emission measurement is carried out after firing the fuel.

Figure 2.7-6 The Combustion Examination Situation of Chip of Wood Firing Materials

Table 2.7-10 Combustion Result of Wood

			No.1	No.2	No.3	No.4	No.5	No.6
Measured concentration (Raw data)	Dust concentration	g/Nm3	0.3540	0.1546	0.3992	0.1527	0.2552	0.0731
	Average dust concentration	g/Nm3	0.3539	0.1546	0.3992	0.1527	0.2552	0.073
	SO2(ppm)	ppm	11	9	40	9	15	21
	NOX(ppm)	ppm	34	45	45	30	58	42
Emission Factor	Dust	kg/t	8.84	3.85	5.39	3.95	7.57	2.89
	SO2	kg/t	0.75	0.65	1.56	0.68	1.27	2.42
	NOX *3	kg/t	1.15	1.50	0.81	1.05	2.29	2.23
	CO	kg/t	21.25	21.32	30.23	18.56	31.57	43.31
Emission Concentration after O2 conversion at 9.33%	Dust	g/Nm3	1.054	0.337	0.706	0.447	0.610	0.188
	SO2	ppm	38	39	65	35	45	63
	NOX	ppm	103	97	57	70	126	103
	CO	ppm	2,192	1,869	1,963	1,562	2,354	2,593

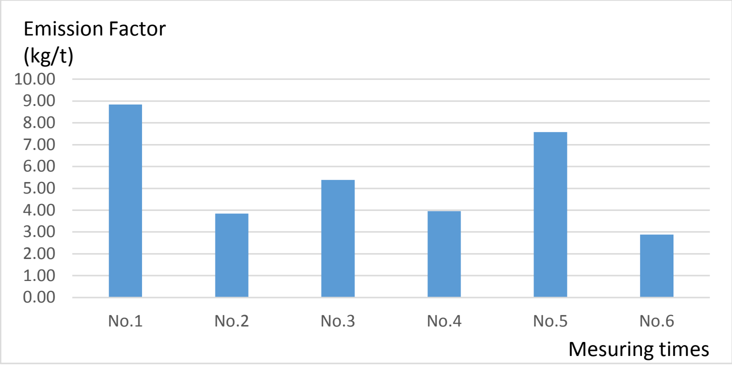


Figure 2.7-7　　Change of Emission Factor of Dust

2) Comparison between Quantity of the Dust Caused by an Ignition Material and Quantity of the Dust Caused by a Fuel

Figure 2.7-8 shows a comparison between quantity of the dust caused by an ignition material shown with a bar graph of the blue and quantity of the dust caused by a fuel shown with a bar graph of the orange and gray color. The ratio (%) of the quantity of dust caused by ignition material shows in the upper part of each bar graph. Three times of examinations were carried out by same sample of Coal Briquette (1) and (2) and two times for Coal Briquette(3) and one time for Semi-cokes. In addition, the meaning of 1st and 2 and in the figure is that 1st shows the data after firing 4 kg of fuel first and 2nd shows the data after refueling 1kg.

In the figure, the quantity of dust caused by an ignition material uses the mean of dust of Emission factor in Table 2.7-10. In other words, as the average is 5.42 kg/t, the quantity becomes 2.71 g because the ignition material consumption is 500 g per once.

This figure shows that the quantity of dust caused by fuel fluctuates, and the ratio of the quantity of dust caused by an ignition material fluctuates with it. Apart from the last semi-coke, the dust ratio of an ignition material is an average of 49% in the first combustion (1st), and 2nd becomes an average of 34%. On the other hand, in the case of semi-coke, 1st, 2nd become 87%, 86% of high rates together because there is little quantity of dust caused by the semi-coke.

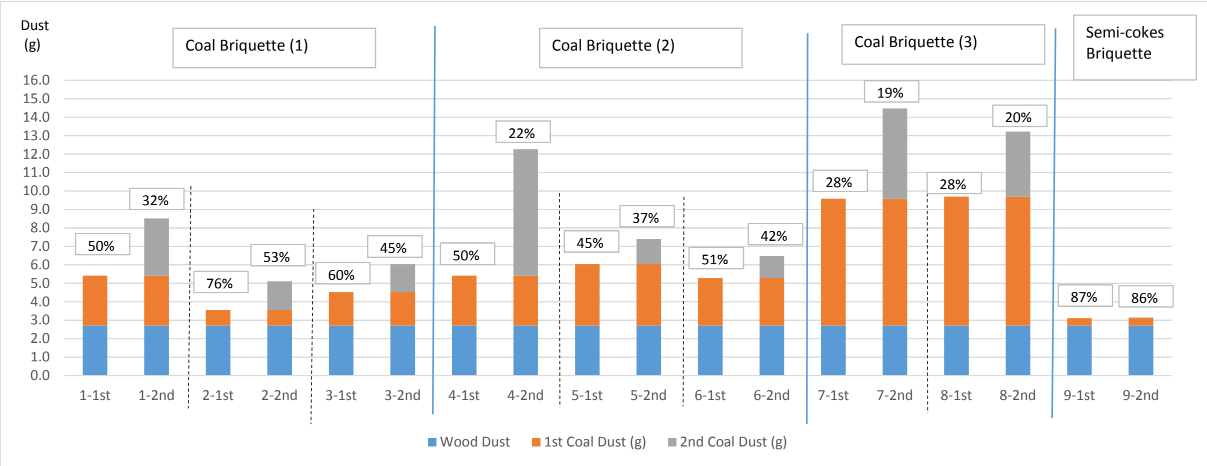


Figure 2.7-8 The Comparison between Quantity of Dust form an Ignition Material and Quantity of Dust from a Fuel

c. **Combustion examination of processed firing materials (2)**

As in late years, processed firing materials come out in a market, the combustion examination carried out. The firing agent of TARA used for the examination shows a photograph packed for sale by three pieces by a plastic bag to Figure 2.7-9 and the combustion test result is shown in Table 2.7-11. Average emission factor of 500g of the firing material of the chip of wood shows 5.4 kg/t in Table 2.7-11, but, in the case of a firing agent of TARA, it was 0.399 kg/t at 300g and 5.3 kg/t at 600g. The evaluation comparing with the chip of wood was difficult. It may be said that TARA has the characteristic that they are easy to fire rather than dust decreases.

Figure 2.7-9 The firing material of TARA (300g/pack)

Table 2.7-11 The result of the firing material of TARA

TARA : 300g			TARA : 600g		
Elapsed time	Flow rate (m/sec)	Stack gas temperature (℃)	Elapsed time	Flow rate (m/sec)	Stack gas temperature (℃)
0			0		
5	0.00	76.7	5	2.43	146.3
10	1.73	100.9	10	3.03	243.9
15	2.02	109.7	15	3.26	276.8
20	1.15	105.9	20	3.01	241.6
25	0.00	93.3	25	2.63	200.1
30	0.00	78.9	30	2.29	152.9
			35	0.00	104.5
			37		
Emission Factor.(kg/t):		0.399	Emission Factor.(kg/t):		5.343

2.7.3.3 Management of Ash Ponds of PPs

For the administration of UB city, the preferred management is to have PPs to inform annual report including the actual utilization of incinerated ash and the future forecast of the ash ponds. The contents of this report should consist of ash ponds condition such as filling operation, drying process, the control measures for the fugitive dust, surface covered by soil, and the preparation of near future filling operation. Since the influence of air pollution by strong wind in the spring season is a concern, the reporting schedule is desired every January, which is also the beginning of the accounting year.

2.8 Enhancement for Emission Control Measures at Major Polluters: Output 8

2.8.1 Power Plant: Emission Reduction of PP2 and PP3

2.8.1.1 Improvement of Dust Collection System

The multi cyclone and the water cyclone are installed in PP2, and the water cyclones with scrubber are installed in PP3 to collect the dust from the boiler flue gas before emitted from the stack. However even though such devices are installed, the dust concentration emitted from the stack is high level as 200-500mg/m3N and sometimes exceeds 1000 mg/m3N.

Recently the bag filters are installed in #1 & #2 boilers of PP2 by retrofit and in Amgalan Heat Plant in new construction. Their dust emission planned is 50mg/m3N. It is considered that this value is reasonable. (30mg/m3N in the guide line of World Bank seems too severe)

In order to achieve dust emission density of 50mg/m3N, the existing dust collector such as multi-cyclone or water cyclone is not enough. It is necessary to adopt the bag filter or the electrostatic precipitator.

In addition, dust collected by the bag filter or the electrostatic precipitator is in dry state, it has an advantage than the current wet ash in the transportation. It will enable to utilize the ash in cement industry, and to transport the ash by the railway to the coal mine for backfilling the mine. Table 2.8-1 shows the improvement plan of the dust collection system.

Table 2.8-1 Improvement Plan of Dust Collection System

	Dust Collecting Method		Expected Effect	Remarks
	Existing	Improvement		
PP2				
#1 Boiler	Multi Cyclone	Bag Filter	Efficiency 67% →99.8%	Replaced in the end of 2014
#3 Boiler	Multi Cyclone	Bag Filter	Efficiency 67% →99.8%	Will be replaced after 2015 (Plan)
#2 Boiler	Bag Filter	—	Efficiency =99.8%	Replaced in the end of 2014
#4, #5 Boiler		a) Add the Venturi Scrubber	a) Efficiency 81% →95%	a) Same system as No.3 Power Plant b) Should be installed depending on strengthening of emission regulation
		b) Bag Filter	b) Efficiency 81% →99.8%	
No.3 Power Plant				
#1～#6 Boiler	Scrubber & Water Cyclone	Bag Filter	Efficiency 95% →99.8%	By changing the ash transportation process from the wet to the dry, reuse (sale) of the ash will be expected.
#7～#13 Boiler	Scrubber & Water Cyclone	Bag Filter	Efficiency 95% →99.8%	

Note: Dust Collecting efficiency of existing system is based on the measurement result at phase 1of this project

2.8.1.2 Improvement of Boiler Combustion System

As for NOx reduction of the pulverized coal firing boiler, it can be achieved by the remodeling the combustion system such as two stage combustion, recirculation gas mixing to a combustion air, low NOx burner, and retrofit to the fluidized bed combustion boiler.

For a method to largely reduce NOx, SOx to cope with very severe environmental regulation, the setting of a denitrification system such as SCR (Selective Catalytic Reduction) and the desulfurization system such as FGD (Flue Gas Desulfurization) shall be considered, but to introduce such a system is excluded in this study because it is thought that there is no need from the Mongolian regulation level and the guidelines of World Bank for NOx, SOx emission.

It is considered that applying the retrofit to "Two stage combustion methods" to the existing coal fired boiler is simple way to reduce NOx, and “Recirculation gas mixing method” will be expected little NOx reduction because a part of the recirculation gas is already used for drying the coal in the pulverizer. The replacement to low NOx burner is effective from the view point of not only the NOx reduction but also the combustion improvement (unburned carbon reduction will be expected under the low excess air operation).

The fluidized bed boiler (FBC) and the circulating fluidized bed boiler (CFB) have a characteristic of low NOx generation and it is possible to remove SOx by introducing the limestone to the furnace. In the furnace, limestone becomes CaO, and the gypsum ($CaSO_4$) will be produced by the reaction of CaO and SO_2. For this reaction, the furnace temperature shall be kept suitable for a reaction (around 850 degree C).
It is necessary to increase the ratios of Ca/S to get the higher desulfurization efficiency, but there is a limit in desulfurization efficiency even if a lot of limestone is injected. The maximum achievable desulfurization efficiency is around 90% in CFB, and is around 30% in FBC.
The maximum achievable desulfurization efficiency depends on whether the gas temperature in the furnace which can be kept suitable for a reaction. As the gas temperature can be controlled in CFB, the high desulfurization efficiency can be achieved. However as the gas temperature in the furnace of FBC cannot keep suitable for a reaction, the high desulfurization efficiency cannot be achieved.
If a lot of limestone is injected to the furnace, the amount of the dust increases by the produced gypsum and remaining CaO. So it is necessary to consider the quantity increase of dust if in furnace desulfurization system is adopted.
The relation between the desulfurization efficiency and the quantity of the injected limestone shall be examined and it is necessary to reflect the design of the dust collecting system, and also necessary to consider about the quality of the ash as the gypsum and remaining CaO are mixed in the ash.
As #1, #3 boiler of PP2 are the stoker firing, the combustion control and NOx reduction is difficult. They have been run for a long time and the overall aged deterioration is proceeding, so it is desirable to replace them with the CFB.
#4 Boiler in PP2 and the boilers (except for #3 & #4 boiler) in PP4 are pulverized coal firing. It is thought to change the pulverizing system to the direct firing system like PP4, but it is not feasible because of the following reason.
The moisture content in the coal which is burnt in the power plant now is high, and it is concerned that it will increase in the future. As it needs the hot air more than 400 degrees C for the high moisture coal drying in the pulverizer, a frequent trouble may occur in the operation.
It is possible to retrofit the small boiler from the pulverized coal firing to the fluidized bed combustion (FBC), and it is already done in #5 Boiler in PP2 and #3, #4 Boilers in No.3 Power Plant.
It is desirable to retrofit into the fluid bed boiler (FBC), if this small capacity pulverized coal firing boilers continue to use from now. However it is recommended to replace them with the circulation fluid bed boiler (CFB), as these boilers passes 40-60 years after the construction.
In making the plan of replacement of the boiler, it is necessary to consider many items such as the boiler efficiency, the reliability, the safety, the environmental adaptability, the easiness of operation/maintenance, etc. Considering the used coal in Mongolia which contains high moisture and high ash, the circulating fluid bed boiler (CFB) is suitable.
The CFB has a good characteristics for firing the low grade coal, but it is necessary to pay enough attention whether consideration to the problem peculiar to a FBC in the boiler design such as the furnace wall erosion, the plugging of the cyclone recirculation line, and the furnace gas temperature control, etc.

About the capacity of the power generation facilities, in the replacement of the facilities, there is a choice to replace with a same capacity of old ones or larger capacity ones. If the larger capacity facility is adopted, by reduction of the number of facilities, the total cost of the equipment and the operation/maintenance can be reduced. But in the replacement plan, it is necessary to pay attention about the effect on the electricity and hot water supply during the annual inspection of the new unit, the effect on the operating unit which is running during the replacement work, etc.

Table 2.8-2 and Table 2.8-3 show the plan for the boiler replacement.

Table 2.8-2 Plan of Boiler Replacement of PP2

PP2	Existing	Improvement Plan
#1Boiler	35t/h Stoker Firing	Abolish two 35t/h Stoker firing boilers and install one n 75t/h circulation fluid bed boiler (CFB)
#3 Boiler	35t/h Stoker Firing	
#2 Boiler	35t/h CFB	Already replaced with 35t/h CFB
#4 Boiler	75t/h PC Firing	To be replaced with 75t/h CFB
#5 Boiler	75t/h FBC	To be replaced with 75t/h CFB

Emission inventory has been updated according to boiler replacement.

Table 2.8-3 Plan of Boiler Replacement of PP3

No.3 Power Plant		Existing	Improvement Plan
Medium Press. Boiler	#1 Boiler	75t/h PC Firing	The medium pressure boiler will be abolished in the future but necessary to continue to operate until the hot water supply will be covered by other boilers because the hot water for heating in the center of the city are depend on these boilers. The retrofitting of boiler is not necessary, but replacement of dust collecting system (bag filter) is required to cope with the regulation for dust emission.
	#2 Boiler	75t/h PC Firing	
	#3 Boiler	75t/h FBC	
	#4 Boiler	75t/h FBC	
	#5 Boiler	75t/h PC Firing	
	#6 Boiler	75t/h PC Firing	
High Press. Boiler	#7 Boiler	220t/h PC Firing	To be replaced with four 500t/h class CFB taking into account the abolishment of medium pressure boilers. There are two cases for the pressure of newly introduced boilers. One is the high-high pressure same as 525t/h boiler of 250MW plant, the other is the same pressure of existing high pressure boiler if utilizing the existing steam turbine which are replaced or introduced recently.
	#8 Boiler	220t/h PC Firing	
	#9 Boiler	220t/h PC Firing	
	#10 Boiler	220t/h PC Firing	
	#11 Boiler	220t/h PC Firing	
	#12 Boiler	220t/h PC Firing	
	#13 Boiler	220t/h PC Firing	

PC Firing; Pulverized Coal Firing, FBC; fluidized Bed Combustion,
CFB; Circulating Fluidized Bed Combustion

Details of the proposals for improvement above were explained to ME, PP2 and PP3. Explanation meeting mainly on effective utilization of existing equipment and key points for introduction of new equipment etc. to ME, all power plants and energy facility bureau was held in March, 2015. ME, PP2 and PP3 expressed positive reaction about above improvement. However, due to recently economic depression in Mongolia, budget for extension and replacement of PP2 and PP3 has been suspended. Therefore, proposed dust collector and combustion facilities have not been implemented.

Through strengthening MNS emission standard for power plants, above proposals to be adopted is appealed.

2.8.2 Power Plant 4

Counter measures for air pollution in power plants include controls both by hardware and by software. The controls by hardware include installation or reformation of control equipment, and control by software includes monitoring of air pollutant concentration of emission gas to decrease emission of high-concentration pollutants, including excess of emission standard.

PP4 installed a display for CEMS data in control center, and is utilizing it for operation since January 2017. In the future, it is expected for PP4 to share the experiences of utilization of CEMS data with PP2 and PP3.

2.8.3 Lecture on Boiler and Air Pollution Control Technology

ICAA and APRD held a workshop regarding the boiler and air pollution control technology. The Document of the operation management of HOBs, the implementation of a control measure for HOBs, and the environmental effects was held in 22nd April, 2015 is attached as Appendix 2.8-1. Workshop of the boiler and air pollution control technology was held 3 times in the year 2016. The next workshop will be held in May 2017.

2.8.4 HOBs and Steam Boilers

2.8.4.1 Admonishment and an Improvement Order to HOBs and Steam Boilers

APRD has submitted result of the flue gas measurement to IACC, and IACC has issued an improvement order to boiler facility based on the result of the Boiler Inspection and Certification. Flow of admonishment and improvement order to HOBs and steam boiler is shown as follows.

Flow of Admonishment and Improvement Order to HOBs and Steam Boiler

1. The Boiler Inspection and Certification (From October to March)
2. An improvement order is issued to the boiler facility based on the result of the Boiler Inspection and Certification as needed.
3. Business owner of boiler facility files an improved result report before the deadline which is described in issued improvement order.
4. If boiler facility is not conformed in the improved result report or the boiler facility is not able to be improved before the deadline, the penalty and second improvement order are issued based on the laws such as the Air Law and other laws.
5. If business owner of boiler facility does not follow an improvement order from ICAA, indefinite suspension

ICAA issued admonishment for suspension to 6 boilers facilities, ordered penalties to 11 boilers facilities and 73 improvement orders based on the result of the boiler inspection of the year 2015. The improvement results on the basis of admonishment and improvement orders are shown in Table 2.8-4. Reduced PM emission by decommissioning of boiler associated with connecting to hot water supply system and installed dust collector Emission is 23.32 ton which corresponds to 2.6 % of PM emission from all HOBs.

Table 2.8-4 Improvement Results on the Basis of Admonishment and Improvement Order based on Boiler Inspection and Certification of the Year 2015

	Item of Improvement Result	The Name of Installed Boiler
1	Decommissioning of boiler (connecting to hot water supply system)：6 facilities	・Enkhjin Town ・Khan Tushee ・Mogul Town、 ・Khan Burgedei LLC ・Saruul Tenger-2 ・Nomuun Town
2	Boiler replacement：5 facilities	・Gazarchin School ・Gobi Tushee LLC ・KhTs-0151 ・Songino Spa・ ・MGL Aqua LLC
3	Installation of dust corrector: 4 facilities	・Bitsamo LLC ・Munkhjin LLC ・Elbeg Dulaan LLC ・MNMB LLC
4	Stack replacement or modification of high of stack:4 facilities	・Vankhuu LLC ・Elbeg Dulaan LLC ・SEMUT ・KhTs-0303

Source: Based on report of ICAA and modified by JICA Expert Team

Regarding the effect on the environment through the use of HOBs and steam boilers, the list of object business owners with penalty based on the boiler inspection of the year 2015 is shown in Table 2.8-5. The object business owners with penalty paid 100 percent penalty.

Table 2.8-5 List of Object Business Owner of Penalty

No.	Business owner	Amount of penalty (unit: MNT)	Contents of infringement
1	Dalai Ombo	1,728,000	Air Law: Use of facility did not meet the standard to preserve the air quality.
2	Sipoko	1,152,000	Air law: Concentration of the flue gas did not meet MNS emission standard.
3	ANU Service	384,000	Waste Management Law: Surrounding environment was polluted by ash of coal.
4	BekhBat	250,000	Health Law: Waste was dumped on the periphery.
5	Asgat Service	384,000	National Inspection Law: Improved boiler facility is insufficient against improvement order.
6	Voltam	384,000	National Inspection Law: Improved boiler facility is insufficient against improvement order.
7	Erdene Suvarga	576,000	National Inspection Law: Improved boiler facility is insufficient against improvement order.
9	Terbileg 32 Auto	576,000	National Inspection Law: Improved boiler facility is insufficient against improvement order.
10	Elbeg Dulaan	576,000	National Inspection Law: Improved boiler facility is insufficient against improvement order.
11	Khan Burgedei	1,986,000	Air Law: Concentration of the flue gas did not meet MNS emission standard.
Total		**7,996,000**	

Source: ICAA

ICAA issued an admonishment of decommissioning of boiler to the boiler owners in the year 2016. However, the boiler owners disobeyed the admonishment, thus APRD performed the flue gas measurement at the instance of ICAA on January 21st 2017. The dust concentration exceeded the MNS emission standard, and this boiler facility did not meet the regulation of Boiler Inspection and Certification. ICAA will issue an admonishment to boiler owner again, and the HOB will be changed to an electric heater or gas heater before the winter season of 2017.

ICAA and Khan-Uul district intend to decommission HOB facility in the area where hot water system is in the neighborhood, and the heat supply will be changed to the hot water system. APRD performed the flue gas measurement at the above facility by instance of ICAA and Khan-Uul district in 2017. If the result of the flue gas measurement does not meet the MNS emission standard, the HOB will be decommissioned, and the heat supply will be changed to the hot water system before the end of year 2017.

2.8.4.2 Cooperation with Co-benefits Project of Ministry of the Environment Japan

Ministry of the Environment, Japan, has been improving HOB with Mongolian HOB manufactures from 2014 until 2017, throughout “Study on Co-benefits type pollution control for Heat Only Boiler”. The project improved multi-cyclone, air-fuel ratio adjustment by inverter control, and fuel supply system conversion from block coal manual supply to milled coal automated supply. Dust emission was reduced by 90% mainly by multi-cyclone improvement. JICA and Ministry of the Environment Japan cooperated throughout emission measurement and air pollution emission reduction evaluation.

2.8.5 Air Pollution Control Measures for Mobile Sources and Other Sources

2.8.5.1 Support to automobile drivers

For the mobile (vehicles) emission control measures, the introduction of a retrofitted DPF and Eco-drive were considered.

(1). Retrofitted DPF

For common vehicle control measures in Japan, Europe, and U.S.A, the low sulfur fuel supply is indispensable. As shown in 2.7.3.1, regarding diesel vehicle, the installation of a retrofitted DPF that correspond to high sulfur fuel is effective for short period PM control measures, until the low sulfur diesel becomes stably supplied in Mongolia.

Since there are many retrofitted DPF models in terms of technology and performances, such as selection of equipment and method of operation, the matching of the vehicle utilization situation in Mongolia is necessary. In addition, JICA Experts summarized the pros and cons, and supported the introduction of DPF and the operation method.

(2). Eco-drive

Regarding eco-drive which has been well widespread in Japan, JICA Experts supported and considered the possibility of introduction (operation) in Mongolia (here, as public transport system, buses assumed as the target of air polluters to take initiative introduction), and issues such as quantitative evaluation methods. To accomplish these, the traveling survey with eco-drive was conducted in September 2016. In addition, the actual survey and the analysis were conducted using eco-drive support system on 10 buses from

December 2016. By analyzing the result, JICA Experts will support the air pollution measures by making a concrete introduction plan.

2.8.5.2 Support to fuel consumer for Ger Area

(1) Unevenness of coal quality sold in a market

Because a difference of the quality of the sample used for a combustion examination was very big, the contents are explained here for the reference of the fuel user. The variation of Low Heating Value [14](LHV), Volatile Matter (VM) and Sulphur at the arrival base[15] about three kind of coal of Baganuur, Nalaikh, and Alag Tolgoi as a major coal sold in U/B market are summarized here.

a. Unevenness of heating value and volatile matter

Figure 2.8-1 shows variation of LHV and VM of three kind of coal and characteristics of each coal will be found from the figure. The LHV shows energy of the fuel, and VM influences firing characteristics and temperature rise speed.

As the moisture of Baganuur coal is higher than other coal, the coal has low calorific value at the arrival base, but the value increases after drying naturally. In addition, the variation of the calorific value is caused by mined coal seam. In that respect, Nalaikh coal will be liked by inhabitants because VM and calorific value are stable together. Alag Tolgoi coal is cared in particular because it has higher calorific value than other coal and is easy to burn by high VM and the temperature rises quickly. However, it is a problem that quality is more unstable due to raw coal contained laminated coal seam and rock band at mining site. As other problem, in the case of the coal having high VM, outbreak quantity of dust is very huge at combustion.

[14] LHV means calorific value excepting the evaporation heat capacity of the water in the coal and this value shows actual heating value when consumer use.

[15]The arrival base means analysis data in the state of sample purchased including surface moisture.

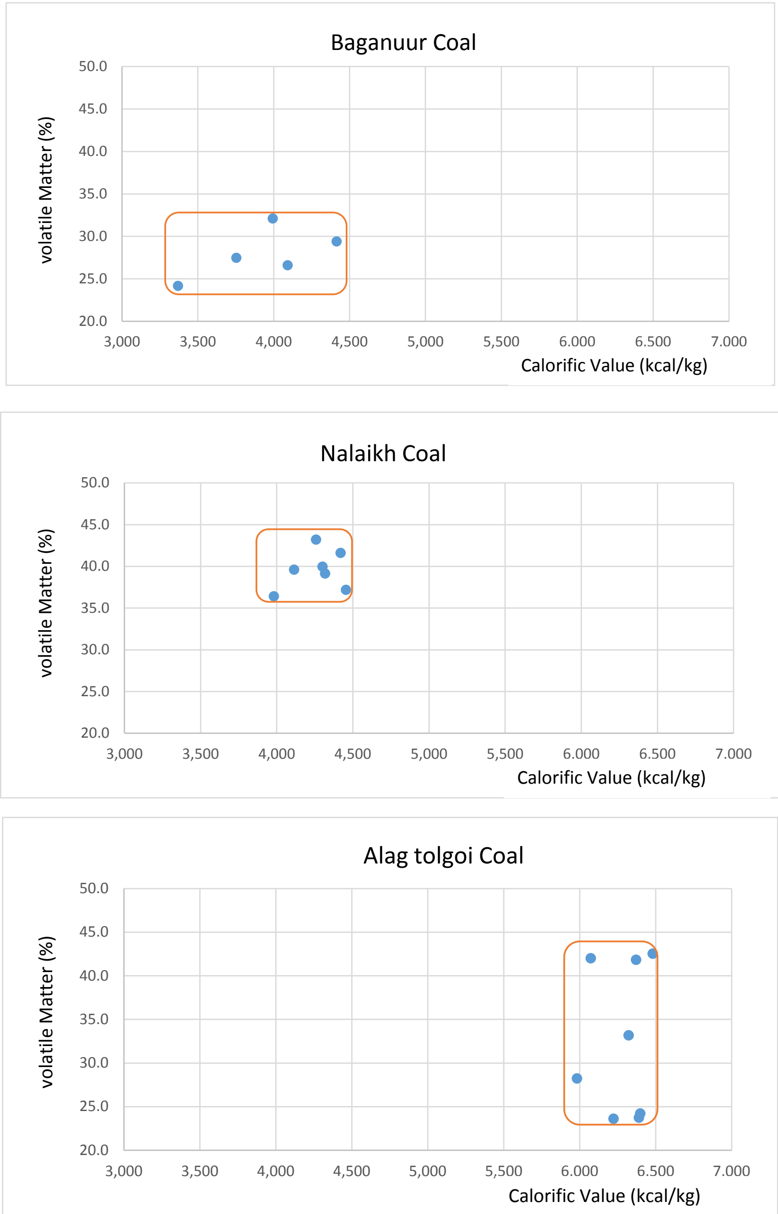


Figure 2.8-1 Variation in calorific value and the VM of the Baganuur, Nalaikh, Alag Tolgoi coal

b. Unevenness of sulfur and the calorific value

Figure 2.8-2 shows LHV and sulfur of each coal. Baganuur coal is the coal that there is the least sulfur in three coals and there are few changes. On the other hand, there is some coal in Nalaikh and Alag Tolgoi coal having sulfur content may be more than 1% and it becomes the current big problem toward SO_2 reduction.

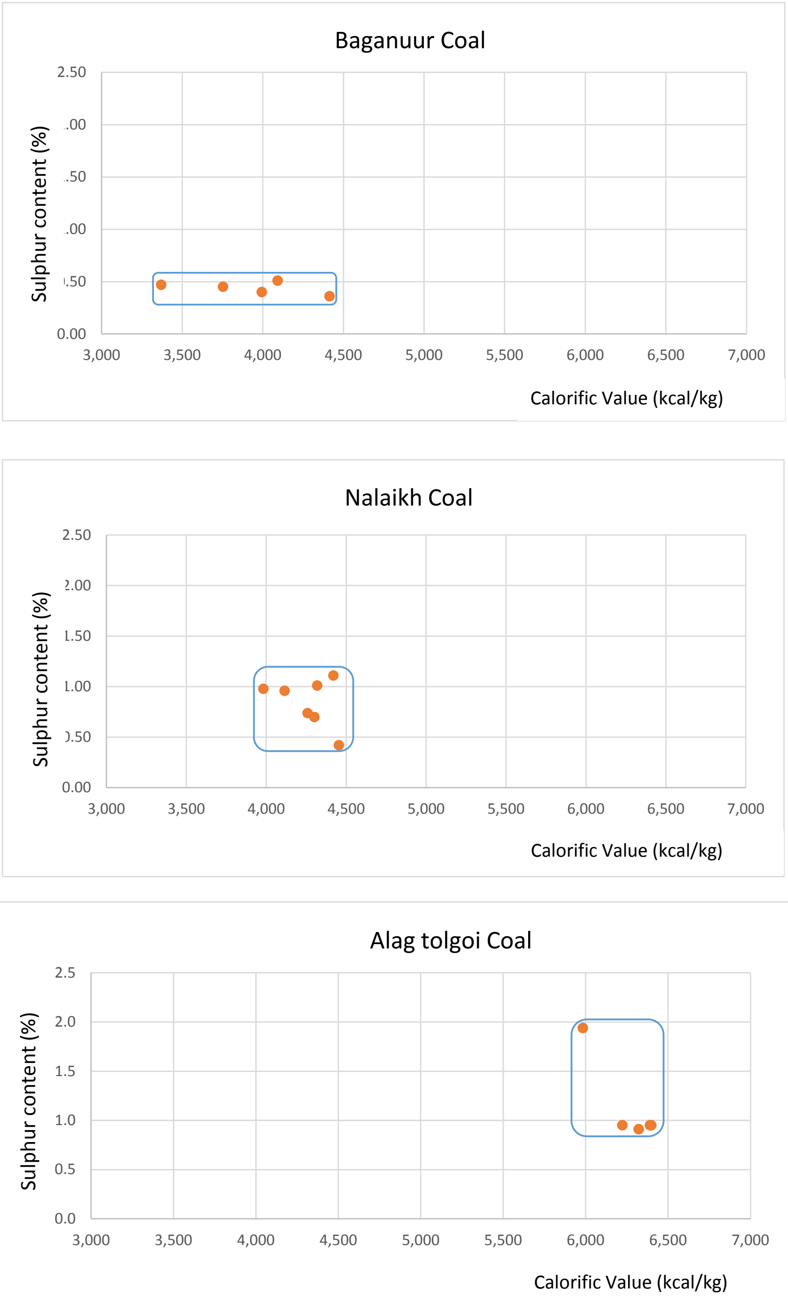


Figure 2.8-2 Variation in calorific value and the Sulphur content of the Baganuur, Nalaikh, Alag Tolgoi coal

2.8.5.3 Other

Regarding the ash pond of coal-fired power plant, after landfill of ash is completed and the surface begins to dry, the dust may be scattered from the surface of the ash pond. Before 2020, the dust may be scattered from the ash ponds of PP3 and PP4. In addition, since the PP2 has only 2 small ash ponds and uses them alternatively, the fugitive dust always has potential to be scattered. The cover soil or afforestation is considered as the control measures for this fugitive dust.

On the other hand, since the ash in ash ponds is used and some ash ponds are used continuously, these ash ponds cannot be covered with soil, it is difficult to install the windbreak hedge.

Therefore, for the purpose of reducing the scattered dust from ash pond to the center of UB city and the reduction of wind speed in ash ponds, the one of the control measure for the fugitive dust from the ash ponds is afforestation of the bank of ash ponds.

2.9 Development of Air Quality Measurement Cycle: Output 9

2.9.1 Agreement on Responsibilities of Professional Agencies (APRD and NAMEM) related to Emission Inventory and Simulation is Concluded (Activity 9-1)

In the 2nd Expert Seminar held on 16 April, 2014, the person in charge of "Emission source for updating emission inventory" was selected from NAMEM and APRD (AQDCC). List of the person in charge is shown in Table 2.9-1.

Table 2.9-1 List of Person in Charge for Updating Emission Inventory (in April 2014)

	NAMEM, IMHE	APRD
Power Plant	Mr. Buyantogtokh, Mr. Munkhsaikhan, Mr. Gansukh, Ms. Nyamdavaa, Mr. Davaanyam	Ms. Narmandakh, Ms. Bayarmaa
HOB		Mr. Batsaya
CFWH		Ms. Urantsetseg
Industrial factory	Mr. Buyantogtokh, Ms. Tsatsral	Mr. Erdenebaatar
Small stove (Ger stove etc.)		Ms. Bayasgalan
Exhaust gas by vehicle	Mr. Buyantogtokh, Ms. Enkhmaa	Mr. Altangerel
Fugitive dust by vehicle	Ms. Enkhmaa, Mr. Gansukh	Ms. Nasanjargal, Mr. Altangerel
Fugitive ash from ash pond		Ms. Sanchirbayar

Based on the above decision, JICA Expert provided the homework in the lecture held in April 2014, but almost of person in charge did not do this homework. Therefore as of December 2014, only few persons in charge in Mongolian side were keeping the skill from the lecture in April 2014.

Regarding the above situation, JICA Expert Team reported to APRD and NAMEM in December 2014 and January 2015. APRD staffs were changed during organization re-structure in beginning of 2015, and recovery was implemented. JICA Experts made lecture to 4 members including 2 new staffs, and provided review and homework.

Based on the condition of achievement of homework for officers of APRD, C/P and C/P-WG selected the progress manager of updating emission inventory and dispersion simulation, and the total coordinator for all of these activities from APRD and NAMEM. The current organization chart and the current the persons in charge list are shown in Figure 2.3-1 and Table 2.3-2. The persons in charge of each source were arranged so that the attribute of both agencies might be utilized according to the kind of possessing data.

2.9.2 Coordinating Mechanism of APRD and NAMEM for Integrated Air Quality Monitoring Network at UB City Area (Activity 9-2)

As reported in PR4, coordinating mechanism of APRD (AQDCC) and NAMEM for Integrated Air Quality Monitoring Network at UB city area was realized by the end of 2014, and it was documented and signed on 30th December 2015.

The agreement is shown in Appendix 2.9-1.

2.9.3 Coordinating Mechanism of Professional Agencies and NCAPR is Established (Activity 9-3)

To promote boiler registration management system, NCAPR implemented explanation meeting of boiler registration management system for HOB maker and owner in April 2014. APRD implemented technical support to meeting.

Explanation meeting and discussion regarding new coal fuel and measurement results were implemented by working group of NCAPR, through providing technology documents regarding new coal fuel from professional agencies, establishment of coordinating mechanism of professional agencies and NCAPR is progressed. However, secretariat office of NCAPR was moved to MET, system of NCAPR is not clear, Mongolian People’s Party had ruling party of Mongolian government by national election in June 2016. Therefore, Mongolian organization structure was changed in October 2016, when NCAPR members were decided and NCAPR held in November 2016. Information will be provided to NCAPR on emission measurement data by APRD and trail results of air pollution control effect through JCC to select projects for air pollution control measures, coordinating mechanism with NCAPR will be strengthened.

2.9.4 Coordinating Mechanism of Professional Agencies and CAF is Established (Activity 9-4)

Some of tax to be imposed by law of air payment in 2016 treats as CAF budget. Administration of CAF budget was moved to MET for special budget for air pollution control measures, and environment department of MET was assigned as secretariat office. CAF budget for 2016 was approved in February 2016. When projects for air pollution control measures were adopted for CAF budget, APRD and JICA Experts gave technical advises. Air pollution control measures which are requested by related agencies, MET person in charge of CAF budget can prioritize effective control measures based on technical documents to be prepared by APRD and JICA Experts, and can select target control measures to be requested by related agencies.

2.9.5 Coordinating Mechanisms of Professional Agencies and Relevant Authorities for Inspection of Emission Sources are Established (Activity 9-5)

APRD, IACC, UB energy coordinating committee, JICA Experts and related organizations discussed boiler inspection and certification, and "the administrative instruction of boiler inspection and certification", which describe roles and activities of related agencies for boiler inspection and certification was drafted. The administrative instruction of boiler inspection and certification was approved by Vice Mayor in September 2015. The flue gas measurement was conducted from October to March 2016. Summary on boiler inspection and certification from September to March 2016 was submitted to Vice Mayor in May 2016. Boiler audit results from November 2016 to March 2017 were submitted to Vice Mayor in May 2017.

2.9.6 Coordinating Mechanism of UB City, MET, Ministry of Energy and Power Plant (Activity 9-6)

CEMS of JICA equipment are scheduled to be installed at PP4 around Oct. 2016. For emission management, system to transfer and show CEMS data in related public administration will be necessary to be designed and installed, and workflow to check CEMS data and to share its report will be necessary to be started.

Trainees on training in Japan in December, 2016 examined cooperation mechanism between UB City and Power plants. Ministry order of MET officially announced as revised MNS, actual proposal was prepared. As of end of March 2017, revised Ministry order was finished, comments on revised Order collected from related agencies.

2.10 Air Pollution Control Measures

Air pollution control measures including Introduction of improved coal fuel, Ger stoves and wall stoves, automobile emission control, and HOB emission control were discussed. Also, representative 15 air pollution control measures were evaluated.

2.10.1 Control Measures

2.10.1.1 Introduction of improved coal fuel

Issues on introduction of improved coal fuel to Ger area was summarized as below.

(1). **Pollution-Abatement Measures caused by the Coal Combustion of the Ger Area**

What causes it?

Fuel in accord with a combustion appliance is not being used. Traditional stove used by nomads is a stove for the dry feces of domestic animals, but coals are burned in UB City. As a result, the major air pollution from coal dust is being emitted in the winter season where much coal is used due to the incomplete combustion.

What measures did the country and private enterprises take

[Update of the apparatus] — The present conditions

	The present conditions
1. Improved stove	An improved stove has some limit against pollution-abatement measures by quality of coal and usage of the improved stove.
2. Other apparatus	Second burner apparatus to burn coal dust appears in the market, but it is not popular.

[Fuel shift]

	The present conditions
3. Fuel shift to improved fuel	• Many kinds of improved fuel have been made, but they could not sell without a subsidy due to the competition with existing coal price. • Because all the subsidies become the ash, it is difficult for the government to pay a large amount of subsidy to improved fuel.
4. Fuel shift to gas	A plan to use SNG produced from the coal gasification as city gas for houses and vehicle fuels are being realized. (SNG: Substitute Natural Gas)
5. Fuel shift to liquid fuel	A plan to use DME produced by GTL of coal for houses and vehicle fuels are existing. (DME: dimethyl ether, GTL: Gas To Liquid)

How should be the future?

As for the heating in ger area, coal plays a key role in both the short and middle term and the cooking will shift to use gas and liquid fuel in future.
The fuel shift to LPG & CNG in Ger area will depend on the income of the households.
(LPG: Liquefied Petroleum Gas, CNG: Compressed Natural Gas)

➢The dissemination of improved fuel is indispensable to the pollution-abatement measures in Ger area, and the firm national strategy is absolutely necessary to lower the fuel price to the same level as coal for continuation of stably supply of the improved fuel.

(2). Issues on the Dissemination of Improved Fuel

Figure 2.10-1 shows the high target area that an air pollution degree divided into four groups, such as Target area1 to Target area4 in pollution-abatement measures area, after examination of the data of an air pollution monitoring in areas using coal in UB City.
Table 2.10-1 shows a necessary % of the improved fuel supply as an example and shows the required amount of the improved fuel from the number of the households every each local khoroo. As a result, 200,000 households need improved fuel and the total required amount becomes 570,000 tons in the case of a semi-coke.
Table 2.10-2 shows classified the total sum of the subsidy in three cases according to the supply ratio from the required amount of the improved fuel. The price difference between of a semi-cocks price (180,000MTN/t) and of market price of coal (130,000MTN/t) is 50,000MTN/t. It becomes a key for the spread of an improved fuel how this price difference is made up. Figure 2.10-2 shows an example of the production cost of the semi-coke for reference.

The following is considered as a method to fill the price gap.

i. Government provides subsidies to the producers.
ii. Government compensates for the coal costs within the production cost and/or railroad transportation costs.
iii. Government imposes taxation for the subsidy to a citizen as user fees.

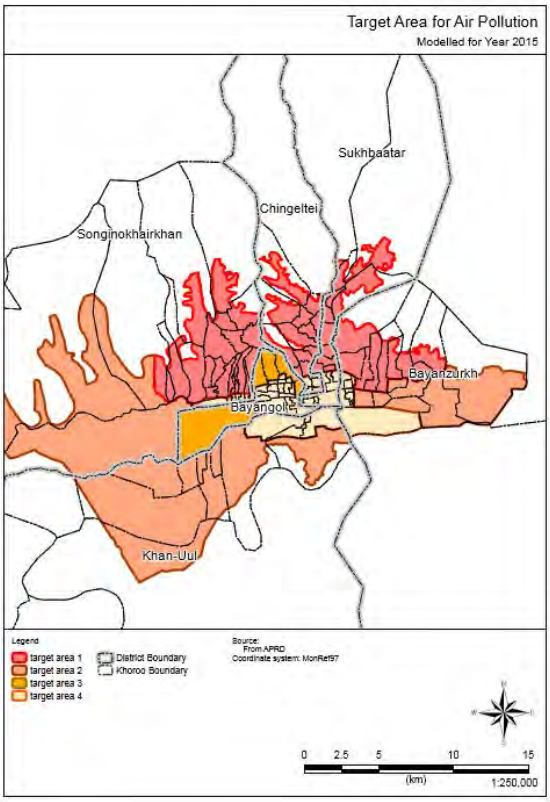


Figure 2.10-1 Area of Ulaanbaatar City required pollution-abatement measures

Table 2.10-1 Total Number of Households and Total Quantity of Improved Fuel Considering Required Ratio of Improved Fuel for Each Region in the Ulaanbaatar City

Name of duureg	Required ratio of improved fuel				Total
	Target area 1	Target area 2	Target area 3	Target area 4	
	100%	75%	50%	25%	
Bayangol	0	0	10,489	2,229	
Bayanzurkh	0	41,361	0	12,355	
Songinokhairkhan	62,000	0	0	1,044	
Sukhbaatar	0	18,942	0	974	
Khan-Uul	0	19,460	0	124	
Chingeltei	32,118	0	0	4	
Total No. of household at each khoroo	94,118	79,763	10,489	16,730	201,100
Total quantity of improved fuel (t/a)	329,413	209,378	18,356	14,639	571,785

Table 2.10-2 Total Amount of Required Subsidy

Annual consumption of semi-coke	Required subsidy (MTN/t)	The number of Ger households		Ratio	Reference	Quantity of semi-coke (t/y)	Total amount of subsidy (MTN/t)y
3.5t/ household	50,000	Case 1	201,100	100%	Target: all households using coal as a fuel in UB City	571,785	28.6billion
		Case 2	100,550	50%	Target: half of households using coal as a fuel in UB City	285,892	14.3billion
		Case 3	43,000	21%	Target: households under action plan in national program (3.5t/y)	150,500	7.5billion

	MNT/t	%
Raw Coal	41,963	26%
Binder	38,383	24%
Utility	19,424	12%
Personnel Cost	8,388	5%
Maintenance Cost	6,560	4%
Rail Freight	1,476	1%
Sales fee	25,500	16%
Profit(15%)	21,261	13%
OPEX	162,955	100%
Depreciation cost	17,045	
Total Price (MNT)	180,000	

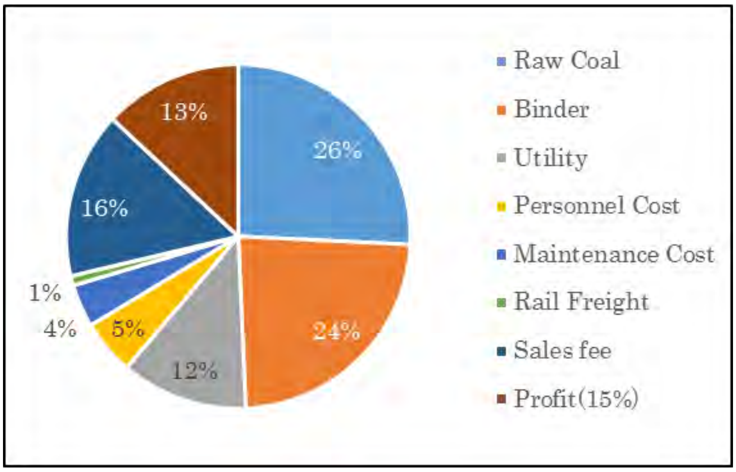


Figure 2.10-2 An Example of the Semi-Coke Plant Production Cost

(3). Issue of Fuel

a. Dust

As explained in 2.7.3.2(3), the emission factor of semi-cokes was the smallest, then anthracite coal briquette, coal briquette, and coal in order regarding the improved fuels sold in UB City. In addition, the coal briquette mixed with biomass called bio-coal briquette, which is disseminating abroad, also have small emission factor similar to semi-cokes. This bio-coal is currently undergoing tests in Mongolia.

Figure 2.10-3 shows the emission factor of each fuel and the upper limit of the emission factor specified in MNS5216. Some coals are lower than the upper limit as shown in Figure 2.10-3, thus it is thought that the emission factor should be lowered further more from the view point of current conditions of the air pollution in UB City. The shift to semi-cokes and/or trial manufacture of bio-coal briquette is strongly expected.

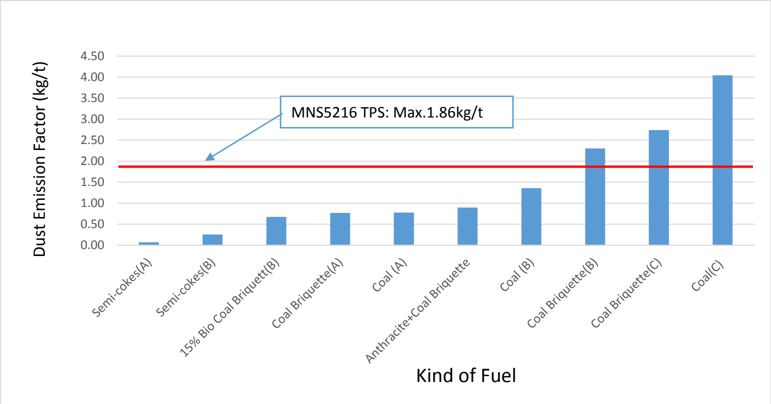


Figure 2.10-3 The Emission Factor of Dust of Each Fuel

b. SO_2

The emission factor of the SO_2 of each fuel and upper limit level 17.4 kg/t as specified in MNS216 are shown in Figure 2.10-4. The quantity of SO_2 emission is related to quantity of sulfur contained in coal as a raw material used in each improved fuel. SO_2 can be reduced by the desulfurization in a stove by adding limestone ($CaCO_3$) or calcium hydroxide (Ca (OH_2)) to an improved fuel. When the coal contains 1% of sulfur, approximately 80% of SO_2 is reduced with 5% addition rates of the limestone. Since limestone or calcium hydroxide is added easily at molding stage, the improved fuel briquette with mixed limestone or calcium hydroxide has a large effect for SO_2 reduction.

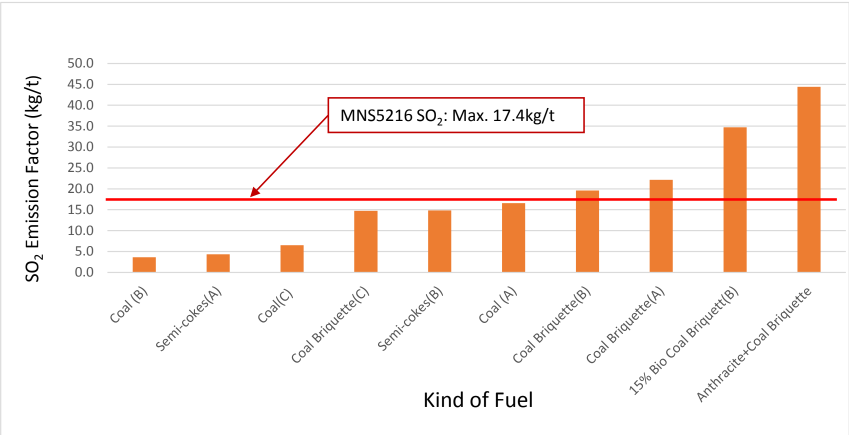


Figure 2.10-4 The Emission Factor of Sulphur of Each Fuel

c. Semi-Cokes and Bio-Coal Briquette

There are Semi-cokes and bio-coal briquette are the good improved fuel which reduces the emission remarkably. The comparisons are shown in Table 2.10-3.

Table 2.10-3 Comparisons of a Semi-Coke with a Bio-Coal Briquette

	Semi-cokes Semi-cokes Briquette	Bio-coal Briquette
1.Manufacturing method	・Coal is carbonized at low-temperature and decreases the volatile matter of the coal. ・Semi-coke is a carbonized coal in the state of the rough grain. ・Semi-coke briquette is a molded powder of the semi-coke.	・Coal is crushed finely and about 20w% biomass is mixed and molded.
2.Characteristic	・As volatile matter is decreased, quantity of dust emission decreases at combustion.	・As biomass burns first, then volatile matter of coal is burned , thus quantity of dust emission decreases.
3.Production cost	・The costs of equipment such as distillation furnaces are expensive.	・Much cheaper than semi-cokes plant
4.Issues	・Adjustment for the residual volatile matter is important. Ignitionability will become worse when volatilization decreases too much and more ignition agents will be required. ・Disposal of tar, which is the by-product, is an issue depending on a distillation furnace.	・Securing of biomass ・Molding becomes difficult when biomass is added, thus molding machine at low pressure which requires a binder and molding machine with high pressure which use no binder are used.
5. Factory in Mongolia	・There are four factories, however, they are currently all closed.	・It is possible to convert existing molding facilities to produce the bio-mass briquette.
6. SO_2 measures	・SO_2 is reduced by mixing limestone or calcium hydroxide at molding.	(Same as left)

2.10.1.2 Ger Stove and Wall Stove

The emission standard of the exhaust at stove combustion was revised in MNS5216 for a Ger stove and wall stove. However, it was an issue that the quality of the fuel at the combustion examination is not prescribed.

Though the combustion examinations of each fuel were conducted many times under the same condition with the same stove at testing laboratory of APRD (old AQDCC), it is the fact that the result of the measurement changed remarkably by each fuel. For the example, the result shown in Figure 2.10-3 and Figure 2.10-4 will prove their diversity. The evaluation of a stove will be difficult because the performance of each stove changes depending on fuel. Thus, the standard fuel should be fixed when conducting combustion test for the evaluation of a stove.

2.10.1.3 Automobile Emission Control

(1). <u>Diesel Smoke Control Measures (Retrofitted DPF)</u>

In UB city, the measured result of PM10 monitoring stations exceeded 1000μg/m3 per hour, and the severe condition is still continuing.

Although there are several factors for the high PM10 concentration, PM emitted from tailpipe of diesel vehicle is one of the main factor of the mobile emission source. Therefore, the coping strategies such as regulation were considered in this project.

In April 2015, the traveling survey of the retrofitted DPF that correspond to high sulfur fuel was conducted based on the proposal of APRD, which was to grasp emission reduction effect using on-board emission measurement system (vehicle number 0011 of Appendix 2.10-1). Also, the traveling survey without the retrofitted DPF was conducted (vehicle number 0003 of Appendix 2.10-1). In this project, as Activity1-13, the effect of the control measure to reduce air pollution was evaluated by comparison of the survey that was conducted before and after control measures (with DPF or without DPF). By virtue of using the reduction effect of PM, the draft of the effective measure for preventing air pollution was made as Activity3-9.

At the first meeting, opinions regarding the characteristics of the retrofitted DPF (such as usable for high sulfur contained fuel) and operation issues (such as equipment cost, operational cost, and decrease of fuel consumption) were exchanged. At the second meeting, the legal basis of installment of retrofitted DPF, the necessity to develop legal systems for the installment, and the proposal to NCAPR were discussed.

As a result of the first and second meetings, the document that was made by Mongolian side indicated not only the comparison of PM emission before and after measures, but also, indicated the reduction ratio of PM automobile concentration on Peace Avenue by using simulation model. In addition, based on the emission reduction effect of the retrofitted DPF, the cost-efficiency of PM emission reduction by installing retrofitted DPF to the regular route bus in UB city was estimated (Table 2.10-4).

Table 2.10-4 Estimated Result of Installment of Retrofitted DPF

Item1	Item2	Amount million(Tg)	Quantity	Sub Total million(Tg)	Notes(The budget was set from a hearing, such as relevant organizations.)
1.The budget for DPF	Manufacturer's suggested retail price(unit)	11.25	100	1,125	DPF:750,000 yen(Filter:3units, spare parts:3units)→exchange rate:15.0 Tg/yen
	Import expenses(unit)	0.75	100	75	Procedural costs from Japan to Mongolia
2.DPF regeneration device	Manufacturer's suggested retail price(unit)	6.00	50	300	Regeneration device:400,000 yen→exchange rate:15.0 Tg/yen. Assume one of two.
	Import expenses(unit)	0	75	0	Include an apparatus main body.
3.Charge for attaching DPF	Charge for attaching(unit)	0.47	100	47	Track records as of 2015.
	Guarantee for bus service(2 days)	5.0	100	500	Security expense by stopping a bus service on an installation day of the DPF.
4.During regeneration of DPF	Electricity bill(year)	0.22	100	22	2kW/units, 3units, each of twice a day, 77.1Tg/kWh, 237 days a year operation
	Expenses for buildings and land(year)		50	0	Under confirmation.
	Labor cost(year)	34.37	10	344	Such as DPF regeneration and the DPF exchange (manage 10 units in one person).
5.During operation of bus	Loss compensation against worsening fuel consumption(year)	3.33	100	333	The result of DPF attaching for 237 days is 8% fuel aggravation against the vehicle that is 2.2km/L.
	Interest regarding initial introduction cost	0.00	100	0	Set no interest.
Total expenses(the first year)				2,746	Total expenses(1.～5.)
Total expenses(the second year)				699	Total expenses(4.～5.)
Total expenses(the first to fifth year)				5,542	It is assumed for 2016～2020 year.

Item	Unit	PM emission reduction	Notes
PM emission reduction of automobile(t/year)	100	12.0	Install to non-regulation vehicle. The emission reduction per 1unit for DPF is 78%.
PM emission reduction rate of automobile		6.4%	
PM emission reduction of automobile for the first to fifth year(t/5year)		60.0	It is assumed for 2016～2020 year.

Therefore, as Activity3-10, the introduction of the retrofitted DPF was evaluated as an effective measure for preventing air pollution, through comparison of estimation result before and after measures, the estimation of measure cost, and consideration of techniques and implementation suitability.

The members of the meeting are APRD, NAMEM, PTDCC, and MRT. Through the activities, management ability of the member for emission regulation was reinforced. As a result, one of the air pollutant measures was proposed as Output 7 of Indicator 2.

Also, as an outcome of the discussions with the DPF Project Group and the trainings regarding the improvement of selecting process of mobile environment control measures for the future, which was held in Japan (December 2015), the emission measurement of the regular route bus with installed retrofitted DPF was requested to APRD from PTDCC (Appendix 2.1-4).

(2). <u>Regulation of Exhaust Gas of Motor Vehicles other than MNS 5013:2009 or MNS 5014:2009</u>

The matters relating to retrofitted DPF were considered in October 2015. Thus, for other vehicle control measures, estimation method of emission reduction and cost efficiency were considered (the method of thinking, utilizing data, image of the outcome, and brief utilization method have been discussed) for cases of introducing newest exhaust gas regulation conformity vehicle and introducing low sulfur fuel (including introduction of exhaust gas regulation conformity vehicle adapted to low sulfur diesel).

APRD and NAMEM conducted the noted emission reduction effect and cost effectiveness of introducing vehicle emission control measures, with guidance of JICA Experts. However, JICA Experts also estimated to compare both outputs. More specific estimation work is conducted in September 2016.

(3). Sulfur Content Measurement of Vehicle Fuel

Low sulfur supply is indispensable for the technical control measure that is currently the mainstream in Japan for preventing automobile air pollution. Regarding the sulfur content of fuel, the measurement was conducted in 2014, however, some gas station has begun to sell EURO-V fuel (sulfur content is under 10 ppm) from 2016. For this reason, the sulfur content of fuel was measured again.

After confirming the fuel sold at gas stations are EURO-V fuel to the gas station staffs, diesel fuel was purchased at 5 gas stations and analyzation was conducted. As a result, diesel of 3 stations was about 2000 ppm, and even the lowest was about 70 ppm. These fuels do not conform to EURO-V nor EURO-IV.

Although the proposal of introduction regarding low sulfur supply is indispensable, the introduction was predicted to take a long period. Therefore, most effective measures that are possible with high sulfur supply are needed, such as DPF made by COMOTEC Corporation that was tested in feasibility study of JICA ("Survey on Reduction of Black Smoke in Exhaust Gas of Diesel Route Bus in Ulaanbaatar City", referred to as feasibility study of JICA).

(4). Introduction Measures of Eco-Drive

One of the vehicle emission control measures, Eco-drive, is a reduction method using driving techniques with refrained acceleration, deceleration, and speed. The traveling survey was conducted using data logger (drive recorder) that records speed, acceleration, longitude, and latitude. Judging from the result, the method of Eco-drive, the control effect, and the future diffusion strategy were considered

(5). Revising Measures of Traffic Signal Control

One of the vehicle emission control measures, smoothing traffic flow, was confirmed and organized the current traffic signal control including revising the control plan in order to consider the signal control measure.

From the result, the necessity to promote the measure and emission reduction effect regarding the signal control was confirmed.

(6). Operation Restriction Measures for High Emission Vehicle

Regarding one of the vehicle measures, "emission factor reduction measure", RSD (Remote Sensing Device) is one of the restriction methods used for high emission vehicles in UB city. UB city has a severe air pollution condition, which is a reason to consider conducting the survey using RSD.

RSD enables measurement of exhaust gas instantly (within 1 second) against vehicles while driving, which is different from units generally used by inspection agencies. In addition, RSD is a device that enables measurement for a large number of vehicles at a short time. If the measured value is over a certain threshold value (it will be set in the future survey), the possible control measures will be to impose penalty and stop the operations. As a result, the operation of high emission vehicle will become restricted, contributing to improve air pollution.

To consider the possibility of introduction for vehicle restriction measures against high emission vehicle, RSD will be set at the tollgate of the boundary of UB city, and the exhaust gas concentration (NO, CO, HC, and PM) will be measured on April 2017. In this survey, all of the vehicles passing through the tollgate will be the target.

The exhaust gas concentration distribution of vehicles driving into UB city will be compiled and the threshold value will be considered for high emission vehicle by using the measured result. Also, operation method for RSD, such as measurement locations, frequencies, fines, and stopping of the operation will be considered.

2.10.1.4 HOB Emission Control

(1). **Seminar on Boiler**

A seminar on electrostatic precipitators was held for the related personnel invited by APRD. This seminar intended to foster and diffuse technical knowledge and introduce procedures of electrostatic precipitators. The content of the seminar is as follows.

Date: 23rd November, 2016 Venue: APRD, 14FL Meeting room

Participants: 13 (excluding APRD Staffs)

Content (1) Applicability of electrostatic precipitators (based on the electric resistivity measurement results)

(2) Guidance for introduction of electrostatic precipitators

(3) Issues at introduction stage

(2). **Policy for the Development of Measures**

The following two approaches may reduce dust emissions from HOBs.

(1) Reducing the amount of coal use by improving boiler efficiency

(2) Reducing the discharge of dust from the stack by installing dust collection equipment, and etc.

JICA Experts have decided to pursue the following goal with regard to the two approaches above.

(1) Improvement of technology to increase boiler efficiency

Most HOBs do not control the excess air ratio according to the combustion load. Therefore, JICA Experts have decided to study methods to increase boiler efficiency by optimizing the excess air ratio.

(2) Installation of dust collection equipment

In Mongolia, dust collection equipment such as cyclone dust collectors and scrubbers has been installed. However, many HOBs are still used without dust collection equipment. Mr. Batsaya, who is an official of APRD in charge of HOBs, examined dust collection equipment installed for HOBs through exhaust gas measurement, boiler inspections and other means, and the results indicate that some of the installed dust collectors are not fully used due to incomplete daily maintenance. To address this issue, JICA Experts have decided to study the collection efficiency of dust collection equipment and technologies needed for the effective use of dust collection equipment.

(3). Increasing Boiler Efficiency by Optimizing the Excess Air Ratio

Since HOBs equipped with manual coal feeding are unstable in terms of combustion, DZL, which is a type of HOB with continuous coal feeding, was used for the test. Test results are shown in Appendix 2.10-3. The results indicate that reducing the excess air ratio did not improve boiler efficiency clearly. This is presumably because in DZL-type HOBs, the opening in the furnace body is so large as to make it impossible to prevent ingress of air even if the draft in the furnace is increased by reducing combustion air. We examined these results with Prof. Oidov, who teaches boiler classes at the Mongolian University of Science and Technology, and his views on the results were the same as ours. By contrast, commonly used HOBs, which have large openings for coal feeding and ash removal, the boiler body is not airtight and therefore the boiler is heavily affected by the air entering from the openings even if combustion air can be reduced. For this reason, we determined that it would be infeasible to increase boiler efficiency based on the excess air ratio.

However, regarding Carborobot (a type of HOB equipped only with the exhaust fan), we paid attention to a wide variation in the concentration of O2 in the exhaust gas between sites, checked with ANU Service, which operates a site with a low oxygen concentration in the exhaust gas, and found that securing the airtightness of the furnace body was crucial. Appendix 2.10-4 shows what we have found.

(4). Study on Dust Collection Equipment

a. Cyclone Dust Collector

The collection efficiency of cyclone dust collectors was measured in Phase 1, and the result indicated their collection efficiency is about 60%. The operating principles of the cyclone dust collector, its operational precautions, cost of installation, and other relevant information are shown in Appendix 2.10-5.

An ongoing project by Japanese Ministry of the Environment aims to develop a hot water boiler that excels in energy and environmental conservation by using Japanese technology to modify MUHT, a type of HOB developed in Mongolia. The project also seeks to enhance the performance of cyclone dust collectors manufactured in Mongolia. This has successfully led to the commercialization of an advanced cyclone dust collector with collection efficiency at around 90-95% in Mongolia.

Source: Overseas Environmental Cooperation Center, Japan, "Report on the Study on Commissioned Project for Assistance to the 2015 Research Project on Co-benefits Type Environmental Pollution Control in Mongolia," 2016, Ministry of the Environment

The overview is shown in Appendix 2.10-6. The project has identified issues with the design of conventional cyclone dust collectors and indicated that the high efficiency cyclone dust collectors can be procured from domestic sources in Mongolia.

b. **Scrubber**

JICA Experts studied the collection efficiency of scrubbers in cooperation with exhaust gas measurement team of APRD. The measurement results, operational precautions, cost of installation and other relevant information are shown in Appendix 2.10-7. The study indicated that collection efficiency of scrubbers ranged from 60% to 80%.

Unlike cyclone dust collectors, scrubbers are expected to provide desulphurization effects. Therefore, installing a scrubber can be an effective measure for HOBs that generate exhaust gas with a high SOx content.

However, both cyclone dust collectors and scrubbers will become inoperable if dust deposits build up inside the unit. In UB City, some of the installed dust collection systems are inoperable for this reason. Since this is improvement information, JICA Experts explained the details to APRD and the Inspection Agency of the Capital City.

c. **Electrostatic Precipitators**

Diffusion of electrostatic precipitators requires not only study of applicability such as HOB fly ash resistivity, etc. but also fabrication technology of manufacturers in Mongolia. APRD introduced Khasu Megawabatt khkhk (KM), Germany Mongolian Training Center (GMTC), and Bento Co. for the surveys of technology about design, structure manufacturing, electric instrumentation, and etc. The actual conditions of these 3 companies are confirmed and described in Table 2.10-5.

Table 2.10-5　Actual Conditions to Manufacture Electrostatic Precipitators for HOB

Company name	Facility for manufacturing	Electric instrumentation	Business interest
KM	・ Manufacturing of towers and vessels (welding plate thicker than 3mm) ・ Expeiriences of manufacturing dust collector for coal firing plants based on Japanese drawings ・ No capacity for structural design	・ No capaciry for design ・ Experience of wire distribution work ・ Subcotnracting work from South Korea, China, Japan, etc ・	Very positive
GMTC	・ Possession of technical training center for welding and processing ・ Posession of welding facility ・ Capacity of drawings for manufacturing	・ Under training of electric instruments engineer ・ No training of engineer for design	Subcontractor of KM etc.
Bento	・ Experience of maufacturing Japanese dust collector as a subcontructor ・ No experienc of maufacturing electrostatic precipitators	・ No experience for dust collector ・ No capacity of design	No intention

Boiler market in UB City is not developed yet. There is no designer for original drawings, and technology level of steel processing and fabrications is low. The experiences of manufacturing equipment for the thermal power plant are based on the design and drawings from abroad, and no track record of electrostatic precipitators for industrial boilers exist. Furthermore, there is no experience for necessary technologies for manufacturing electrostatic precipitators, such as high voltage DC power supply, DC power charge control, designing and manufacturing technology for complicated hammering system etc., designing for draft pressure loss, and etc.

In order to improve situation mentioned previously, APRD proposed domestic production of test equipment for the HOB at the #41 school with the assistance of JICA. However, this HOB is an old type boiler for hot water heating with wet type dust collector, with only one induced draft fan, manual coal feeding, and manual raking of ash. In addition, the coal storage is located outside and opened to the air. Furthermore, there are complaints such as dust fall from neighbors. Therefore, Japanese side judged that this HOB is inappropriate for a model facility. Japanese side has now advised APRD to choose another HOB.

(5). Diffusion of Measures, and Utilization of Measures

Air pollution abatement measures cannot be achieved only by tightening emission standards. Japan has achieved present situation by voluntarily efforts of private companies, support of public fund for technology development, support of financial mechanism, introduction of foreign technology, etc. It is a big issue that measures for HOBs necessitates engineering improvements for dust collector, funds, manufacturing technology, and refurbishment of existing boiler and its system.

The dissemination of introduction of high performance dust collector does not especially refer to the technology of electrostatic precipitators as a concrete output, because backgrounds for air pollution abatement technology is still not developed enough, and furthermore APRD had institutional reorganization.

(6). Future Issues to be Solved

Dust collection measures deeply depend on fuels, combustion type, operation, control, and etc. and various measures are required. At the same time, overall measures including acceptance inspection capacity, operational management capacity, and etc. are required. Diffusion of air pollution abatement measures requires development of electrostatic precipitators. Since Mongolian market too small, the Japanese companies are not expected to join the market in Mongolia. It is advisable to transfer technology that Mongolian companies import rectifier, etc. and install them to the electrostatic precipitator from abroad such as China and South Korea which are low entry barrier to Mongolia.

(7). Proposal of measures for the HOB

Based on the results of study described in Section 2.10.1.4(1)～(6) , JICA Experts proposed the following 4 measures for the HOB.

(1) Proposal 1: Installing high efficiency cyclone dust collectors

Cyclone dust collectors with optimal design are expected to provide 90% or higher collection efficiency. Also, the maintenance of cyclone dust collectors, which use water, is easier than scrubbers, and the installment is less expensive.

(2) Proposal 2: Installing scrubbers

Although scrubbers are more expensive than cyclone dust collector, they are capable of reducing SOx in exhaust gas.

(3) Proposal 3: Strategically using existing dust collection equipment

In some HOBs, built-in dust collection equipment, such as cyclone dust collectors and scrubbers, does not perform at its full potential. These HOBs need improvement of equipment maintenance to enable their dust collection function to exert a good performance. The necessary maintenance that should be conducted is summarized in Appendices 2.10-5 and 2.10-7. The key to the maintenance is discharging dust collected from exhaust gas before accumulating inside the equipment.

(8). Activities for Implementation and Penetration of the Measures

a. Awareness Activities for Boiler Operators

APRD conducts a workshop on boiler operation for boiler operators annually.

The workshop held in April 2016 included a seminar on Proposals 1 to 3 in section 2.10.1.4 (7). The materials used in the seminar are shown in Appendix 2.10-8. These awareness activities through the workshop are conducted by an independent effort of APRD.

b. Application for Boiler Inspections

The Inspection Agency of the Capital City conducts inspections of HOBs in cooperation with APRD and the Regional Engineering Supply Administration Bureau, and issues the correction orders to HOBs exceeding the regulatory limits for air pollution, and etc. Since winter inspections of FY 2015, the Inspection Agency of the Capital City has begun to include control measures 1 to 3 in inspection reports for HOBs whose exhaust gas measurement results have exceeded the regulatory limits on dust concentration.

c. On-the-job Training for HOB Control Measures

At the time of inspection, the Inspection Agency of the Capital City responds to consultations from companies on control measures that should be conducted. As part of our activities in February 2017, JICA Experts visited boiler sites that had sought consultation and those that were expected to become priority inspection sites in the next fiscal year, together with Ms. Narangerel, an inspector in charge of HOBs from the Inspection Agency of the Capital City and an inspector in charge of the environment. JICA Experts and others discussed on the specific measures that these sites should take. From these activities, JICA Experts received a response from officers at the Inspection Agency of the Capital City and their understanding of HOB control measures deepened. The discussions with the Inspection Agency of the Capital City through these activities enabled JICA Experts to realize that the Inspection Agency of the Capital City is giving guidance on corrective action not in a standardized manner but in consideration of each business operator (e.g., financial and human resources).

A report on these activities is shown in Appendix 2.10-9.

d. Report to the Council on Draft Measures for Air Pollution Control

JICA Experts discussed Proposals 1 to 3 with APRD and established draft measures. Mr. Batsaya of APRD reported these measures to the Council on Draft Measures for Air Pollution Control during the meeting on May 20, 2016. As a result, it was decided that these proposals will be active as part of air pollution reduction plan for 2017 in UB City.

The materials that APRD reported to the Council are shown in Appendix 2.4-2. At the time of reporting, information on high efficiency cyclone dust collectors described in Section 2.10.1.6 was not obtained, and therefore the collection efficiency shown in the report is 60%, which is the previously known figure.

Note: A summary of information on high efficiency cyclone dust collectors was completed in January 2017.

(9). Future Tasks

a. HOB Inspections

Organizations related to HOB inspections and their roles are summarized in Table 2.10-6.

Table 2.10-6 Inspection Organizations and Roles

Organization	Role
Inspection Agency of the Capital City	Give guidance on corrective action, based on measurement results and technical studies by APRD and the Regional Engineering Supply Administration Bureau
APRD	- Measure exhaust gas - Study air pollution control technologies
Regional Engineering Supply Administration Bureau	- Study stable supply of heat - Study methods to improve HOBs (boiler efficiency, improvement of the boiler room environment, and etc.)
Each district and the Infrastructure and Urban Development Division	- Confirm the locations of the installed HOBs - Accompany inspection teams because HOB operation permits are issued by the district (this is presumably for the purpose of confirming the compliance with permission criteria)

Source: JICA Expert team

Among these, the functions of APRD and the Regional Engineering Supply Administration Bureau are important because they develop specific measures.

To improve the thermal efficiency and similar aspects of HOBs, the Regional Engineering Supply Administration Bureau must be able to propose improvements suitable for the HOB model being considered. In this regard, JICA Experts have not been able to confirm that the Regional Engineering Supply Administration Bureau has a technical capacity to meet this need. The reason for this is a lack of communication in the project, because the Regional Engineering Supply Administration Bureau did not participate in the inspections in FY 2015.

APRD should also be able to propose not just environmental measures for dust collection equipment in general but also environmental measures suitable for each model in use. For example, dust concentration varies even among HOBs of the same model, and it is essential for APRD to examine the factors of such variation through exhaust gas measurement and other activities.

2.10.2 Evaluation of Air Pollution Control Measures

JICA Experts prepared and verified 15 plans of air pollution control measures and reduction effect of emission and concentration using the settings shown in Table 2.10-7.

Table 2.10-7 Setting of Air Pollution Control Measure

No	Control measure	Target source	Setting of reduction of pollutant	Setting of considering condensed dust
1-1	Introduction of improved fuel to whole UB city (Semi-coke briquette)	Small stove for household	The result of combustion test is applied; Fuel consumption: 82% when using coal SO2 emission factor: 25% when using coal PM emission factor (kg/ton): 0.93(traditional stove),0.27(improved stove)	Condensed dust reduces 63.75% of emission before control measure
1-2	Introduction of improved fuel to partial area in UB city (Semi-coke briquette)	Small stove for household	Target area is khoroo where calculation concentration from small stove was high. Fuel consumption in this area is corresponding to about 160 thousand ton. Others are the same as 1-1.	Same as 1-1
2	Installment of DPF to large size bus	Vehicle exhaust gas	Based on the result of vehicle exhaust gas measurement with/without DPF, PM emission from large size bus reduces by 80%.	Condensed dust is proportional to reduction of emission
3	Introduction of EURO-IV emission standard bus	Vehicle exhaust gas	Emission factor of EURO-IV emission standard bus measured in UB city by on-board equipment is applied.	Condensed dust is proportional to reduction of emission
4	Abolishing HOBs around Amgalan Heat Supply Facility	HOB	HOBs in area described master plan in 2013 are abolished and these emission change to 0ton.	Emission from abolishing HOB is 0. Condensed dust from others is proportional to reduction of emission
5	Installation of Appropriately-Designed Multi-Cyclone	HOB	Dust collection efficiency is 60%.	Condensed dust do not reduce
6	Installation of Appropriately-Designed Scrubber	HOB	Dust collection efficiency is 70%.	Condensed dust is proportional to reduction of emission

7	Introduction of low sulfur fuel	Vehicle exhaust gas	Sulfur content in gasoline and diesel change to respectively 1/20 and 1/100[16]. By this setting, SO2 emission reduces to 1/20 and 1/100 and catalysts will not be damaged by high-sulfur fuel	Condensed dust is proportional to reduction of emission
8	Recommendation of eco-driving	Vehicle exhaust gas	Based on the result in Japan, fuel consumption and SO2 of gasoline vehicle reduces by 12% and fuel consumption and SO2 of diesel reduces by 21%, NOx by 35%, and PM by 45%.	Condensed dust is proportional to reduction of emission
9	Fuel Conversion from Coal to Coal Gas	HOB	Gas amount is set as same calorie as the case of using coal. Emission factor is set from the result of flue gas measurement of HOB using coal gas.	Condensed dust is proportional to reduction of emission
10	Improvement of Dust Collection System for PP2 and PP3	Power plant	Dust collection efficiency by power plant is based on Table 2.8-1 of improving proposal of dust collection system.	Condensed dust does not reduce
11	Introduction of low emission gas vehicle	Vehicle exhaust gas	Vehicles manufactured before 2005 are changed to the ones that cleared exhaust gas regulation in 2005 (New Long Term).	Condensed dust is proportional to reduction of emission
12	Ignition Material for a Ger and Wall Stove	Small stove for household	With implementing No1 (Introduction of improved fuel), the result of combustion test is applied as emission factor.	Condensed dust is proportional to reduction of emission
13	Construction of apartments in ger area	Small stove for household	Number of Ger and building in target area for air pollution control measure is set as 0.	Condensed dust is proportional to reduction of emission
14	Improvement of signal control system	Vehicle exhaust gas	Travel speed at the road which was less than 30km/h, will increase 5km/h.	Condensed dust is proportional to reduction of emission
15	Introduction of RSD	Vehicle exhaust gas	Vehicles exceeding exhaust gas standard will be found by RSD and the regular inspection and maintenance are promoted,	Condensed dust is proportional to reduction of emission

[16] Sulfur content of gasoline: Settings to improve to 10ppm from 200ppm that is considerable substantial sulfur contents of EURO4 fuel
Sulfur content of diesel: Settings to improve to 10ppm from 1000ppm that is considerable substantial sulfur contents of EURO4 fuel

			and degradation of vehicle sill be suppressed.	

To evaluate the control measure effectively, the evaluation sheet of air pollution control measure was developed. The evaluation of 15 plans is shown in Table 2.10-8.

Table 2.10-8 Evaluation Sheet of Air Pollution Control Measure (draft)

Evaluation Sheet of Air Pollution Control Measure

Name of Control Measure: (1-1) Introduction of improved fuel to whole UB city (Semi-coke briquette)

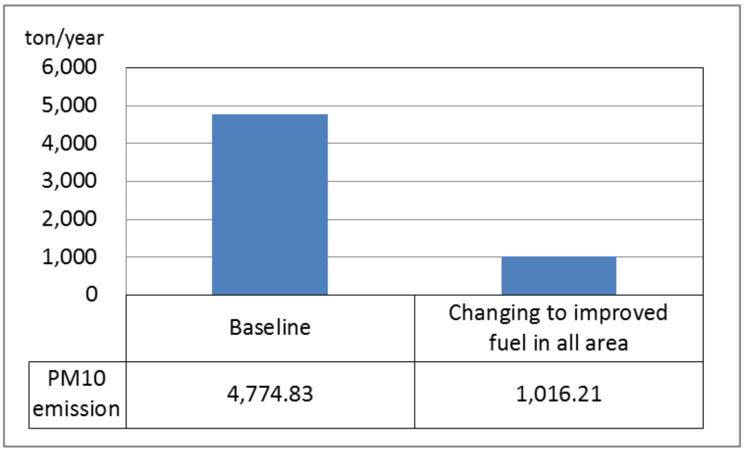
Target Source: Small stove for household

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

The assumed case is that all coal used by small stove for household will be converted to improved fuel (semi-coke briquette).

Fuel consumption is reduced to 82% of when using coal. SO2 emission factor is reduced to 25% of when using coal. PM emission factors from traditional and improved stove using improved fuel are respectively changed to 0.93kg/ton (traditional stove) and 0.27kg/ton (improved stove).

Emission Reduction Effect



Reduction amount was 3,758.62ton and reduction ratio was 78.72%.

Settings of Considering Condensed Dust

Condensed dust reduces 63.75% of emission before control measure.

Cost for Control Measure: 17,044,900,000 Tg (811,660,000 Yen)

Coal consumption is 968,540ton for small stove and when these coals are all converted to improved fuel, the improved fuel will reduce to 794,300ton. Cost of improved fuel and coal is respectively set as 180,000Tg/ton and 130,000Tg/ton. Therefore, when the fuel for small stove is converted to improved fuel, the cost burden of user is as follows.

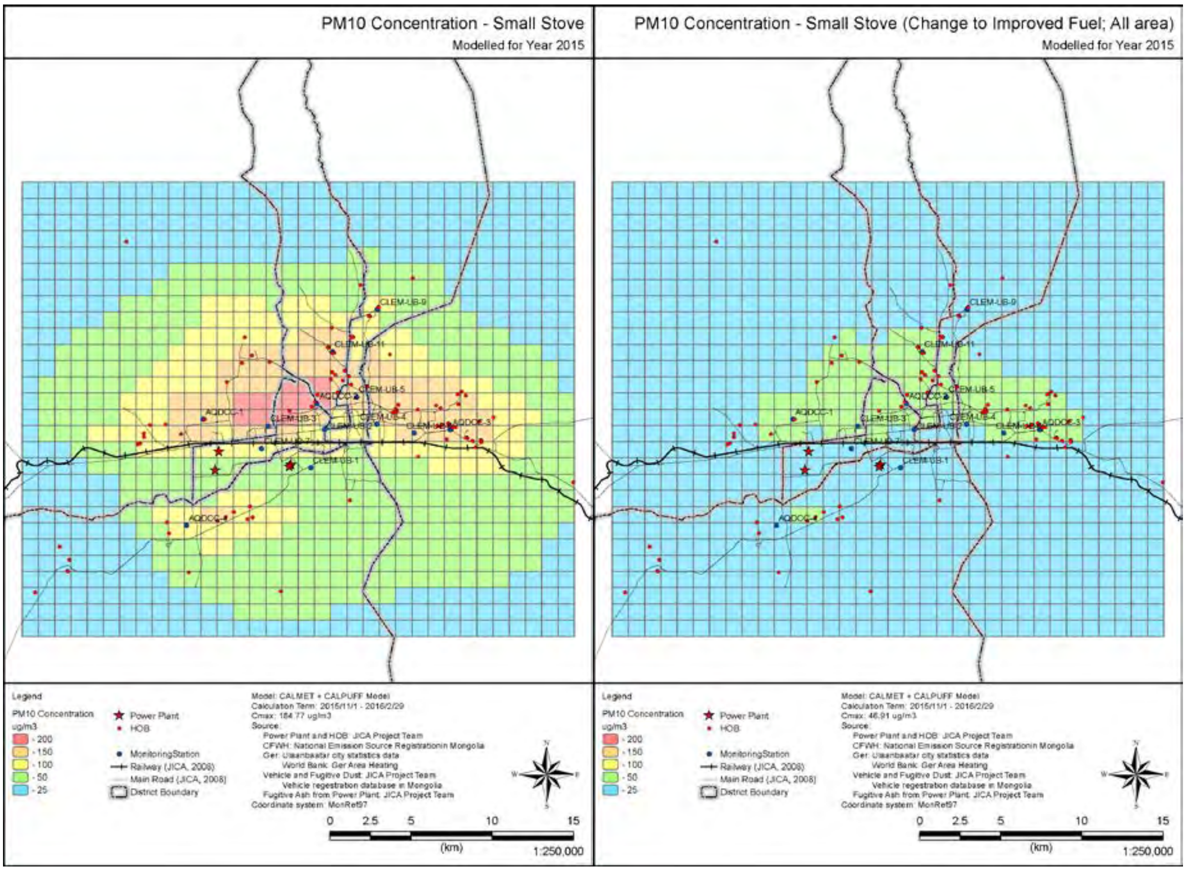
180,000 x 794,130-130,000 x 968,450 = 17,044,900,000Tg

Cost-Effectiveness: 4,535,000 Tg/ton (216,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

The reduction effect of emission and concentration is very high and this effect is a key to the promotion of fuel conversion, the securement of production, and the high quality fuel production. To promote the conversion of improved fuel, the support by the grant from government is necessary for manufacturer and consumer. The more production is, the less unit price will be and the more cost-effectiveness will improve. Also, for the reduction effect of emission and concentration by improved fuel, control measure such as the revision of MNS on the production of improved fuel, the addition of standard items is necessary to prevent from the production and distribution of larger emission factor than coal.

Dispersion Simulation Result and Concentration Reduction Effect



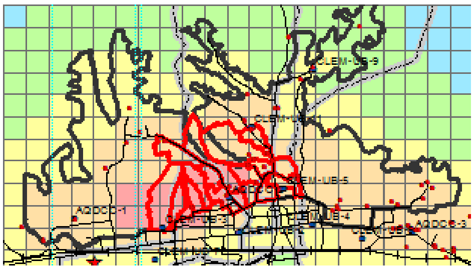
	Before	After	Reduction amount
Maximum ground concentration	184.77	46.91	137.86
PWE	99.17	25.70	73.47

Evaluation Sheet of Air Pollution Control Measure

Name of Control Measure: (1-2) Introduction of improved fuel to partial area in UB city (Semi-coke briquette)

Target Source: Small stove for household

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

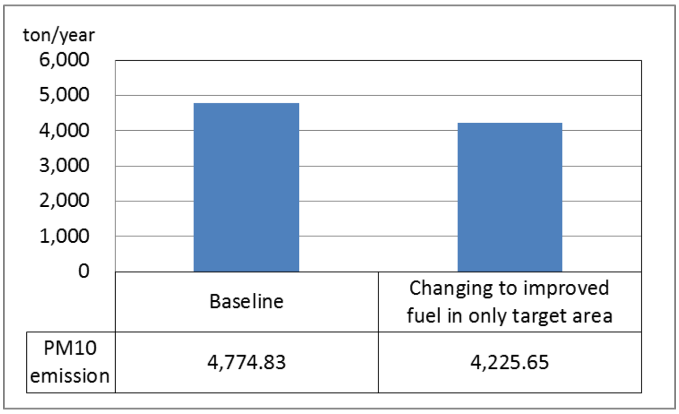


The assumed case is that all coal used by small stove for household will be converted to improved fuel (semi-coke briquette) in a partial area.

Fuel consumption is reduced to 82% of when using coal. SO_2 emission factor is reduced to 25% of when using coal. PM emission factors from traditional and improved stove using improved fuel are respectively changed to 0.93kg/ton (traditional stove) and 0.27kg/ton (improved stove).

Selected area is the high concentration area (red area) by dispersion simulation in 1st priority area of year 2015 (black area)

Emission Reduction Effect



Reduction amount was 549.18ton and reduction ratio was 11.50%.

Settings of Considering Condensed Dust

Condensed dust reduces 63.75% of emission before control measure.

Cost for Control Measure: 2,901,380,000 Tg (128,160,000 Yen)

Coal consumption is 164,854ton for small stove and when these coals are all converted to improved fuel, the improved fuel will reduce to 135,180ton. Therefore, when the fuel for small stove is converted to improved fuel, the cost burden of user is as follows.

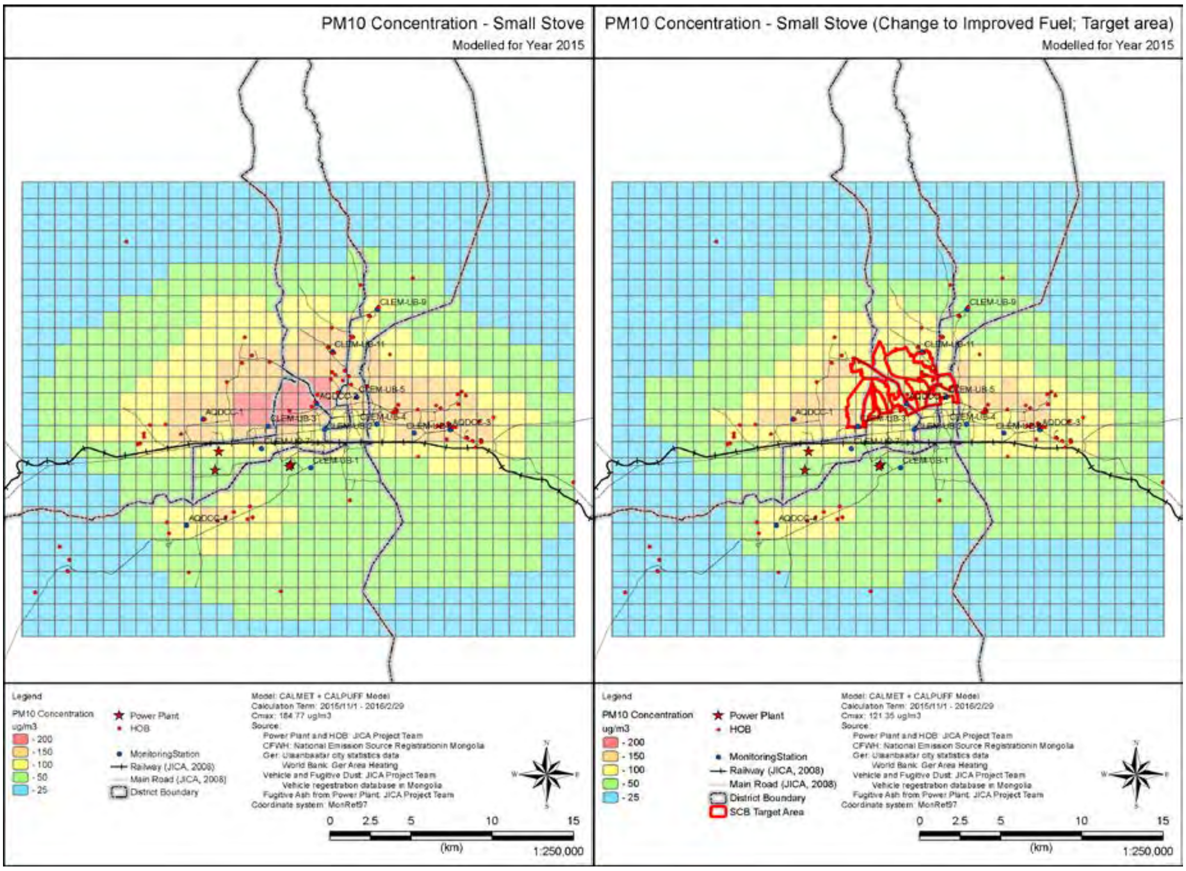
180,000 x 135,180-130,000 x 164,854 = 2,901,380,000Tg

Cost-Effectiveness: 5,283,000 Tg/ton (251,000 Yen/ton)

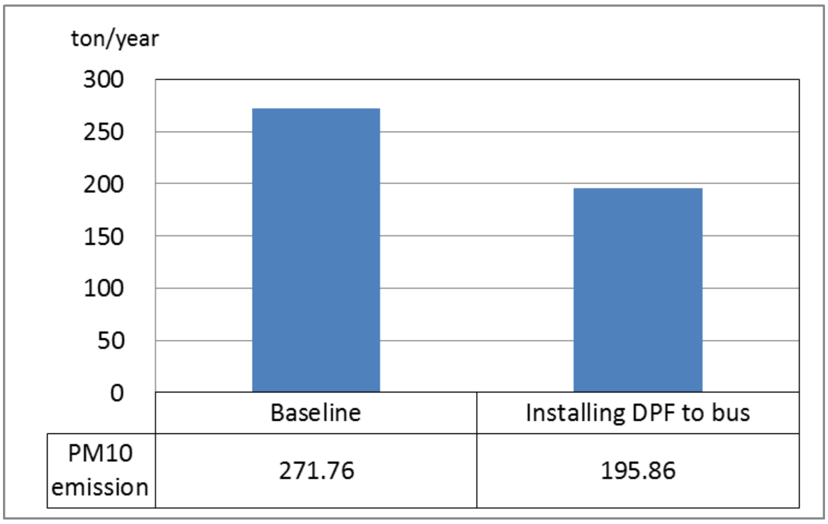
Comprehensive Evaluation (economical and technical feasibility)

Although the effect of reducing emissions only within the target area is large, the concentration reduction is suppressed by the inflow of pollutants from outside the target area. Nevertheless, a certain level of concentration reduction effect is expected. Since there is no significant difference in cost-effectiveness compared to the cases introduced in all regions, it is realistic to verify the reduction effect in the pilot area before introducing improved fuel to the entire of UB city.

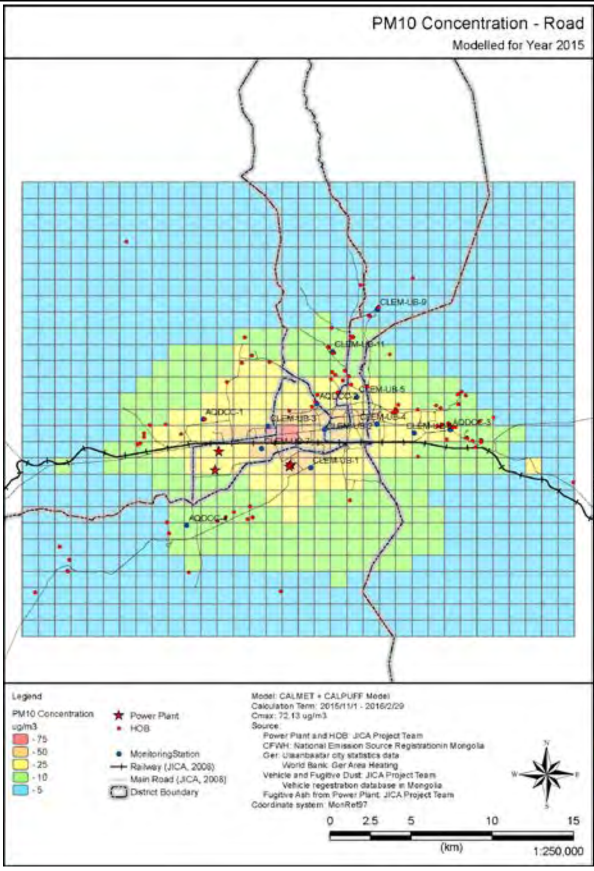
Dispersion Simulation Result and Concentration Reduction Effect

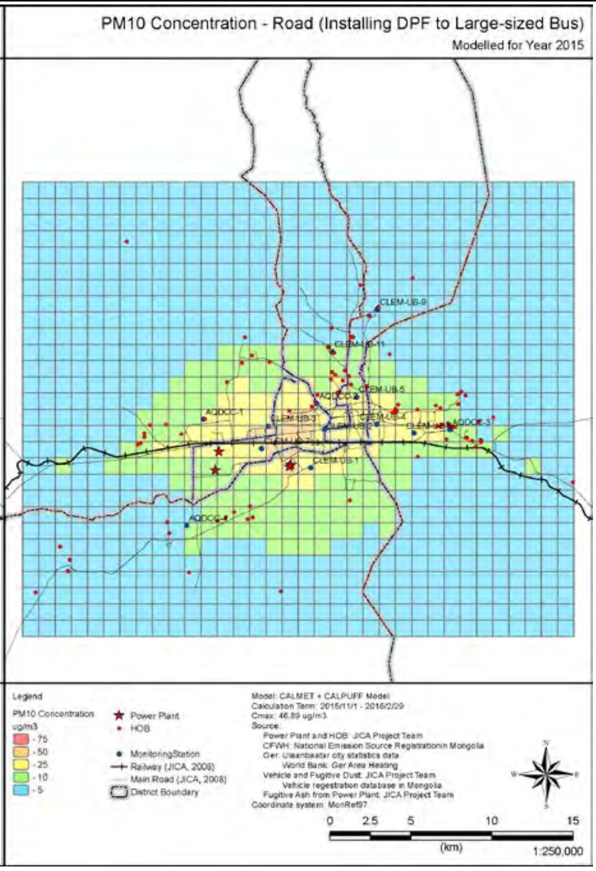


	Before	After	Reduction amount
Maximum ground concentration	184.77	121.35	63.42
PWE	99.17	68.98	30.19

Evaluation Sheet of Air Pollution Control Measure
Name of Control Measure: (2) Installment of DPF to large size bus
Target Source: Vehicle exhaust gas
Settings to Update Emission Inventory (such as target area, activity data, and emission factor)
According to the installment of DPF to large size bus (1,729 units), the PM emission factor of large size bus is set to reduce 80%. However, similar to the DPF that measured its effect in this project, the condition of target DPF was confined to the one which utilizes high sulfur diesel oil and may be used continuously under the extreme low temperature in winter seasons of UB city, and achieved the high reduction effect.
Emission Reduction Effect
 Reduction amount was 75.90ton and reduction ratio was 27.93%.
Settings of Considering Condensed Dust
Condensed dust reduction is proportional to PM10 emission reduction.
Cost for Control Measure: 30,245,400,000 Tg (1,440,260,000 Yen)
Referring to the project formulation survey by JICA, DPF installation cost per unit: 830,000 Yen (17,493,000Tg) 17,493,000Tg/unit x 1,729unit = 30,245,397,000Tg
Cost-Effectiveness: 398,490,000 Tg/ton (18,980,000 Yen/ton)
Comprehensive Evaluation (economical and technical feasibility)
Installation of DPF is costly and its output of the emission and concentration reduction for the entire UB city is not large. On the other hand, this control measure is necessary to improve the air pollution of nearby road, such as bus stop, and the method to examine the concentration distribution nearby road need to be established.

Dispersion Simulation Result and Concentration Reduction Effect





	Before	**After**	**Reduction amount**
Maximum ground concentration	72.13	46.89	25.24
PWE	17.09	12.40	4.69

Evaluation Sheet of Air Pollution Control Measure

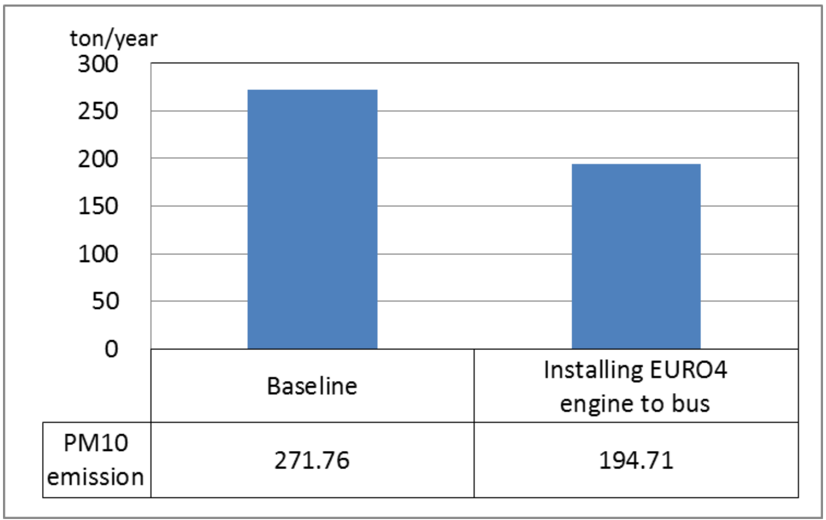
Name of Control Measure: (3) Introduction of EURO-IV emission standard bus

Target Source: Vehicle exhaust gas

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

With the introduction of the EURO 4 engine to large size bus (1,729 units), PM and NOx emission factors will be the output of EURO-IV emission standard by on-board equipment installed

Emission Reduction Effect



Reduction amount was 77.05ton and reduction ratio was 28.35%.

Settings of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 465,403,575,000 Tg (22,162,075,000 Yen)

Purchase fee of EURO4 engine bus (Assuming Ecobus): 269,175,000Tg (12,820,000Yen)

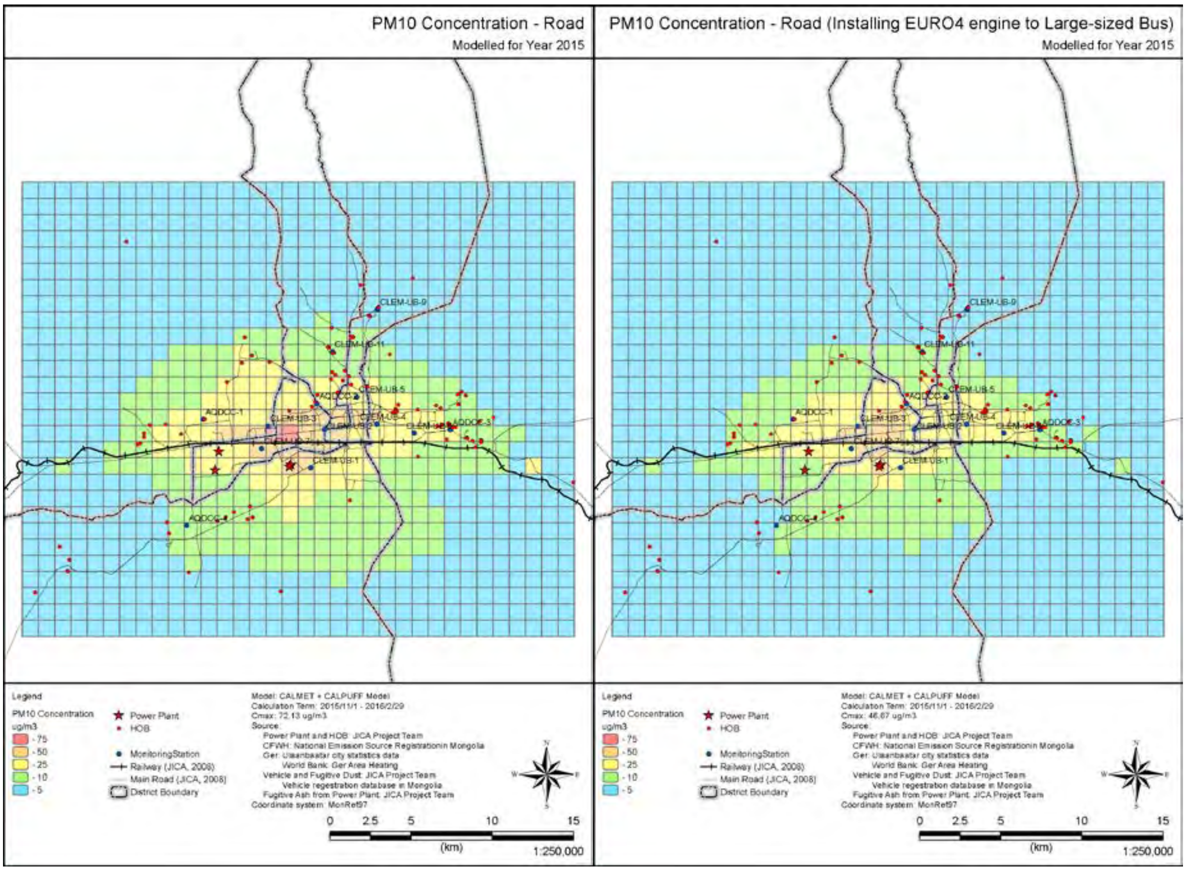
269,175,000Tg*1,729unit = 465,403,575,000Tg

Cost-Effectiveness: 6,040,280,000 Tg/ton, (287,632,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

Introduction of bus with EURO4 engine is costly and its output of the emission and concentration reduction for the entire UB city is not large. On the other hand, this control measure is necessary to improve the air pollution of nearby road, such as bus stop, and the method to examine the concentration distribution nearby road need to be established.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	72.13	46.67	25.46
PWE	17.09	12.28	4.81

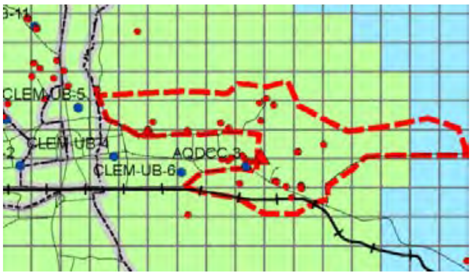
Evaluation Sheet of Air Pollution Control Measure
Name of Control Measure: (4) Abolishing HOBs around Amgalan Heat Supply Facility
Target Source: HOB

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

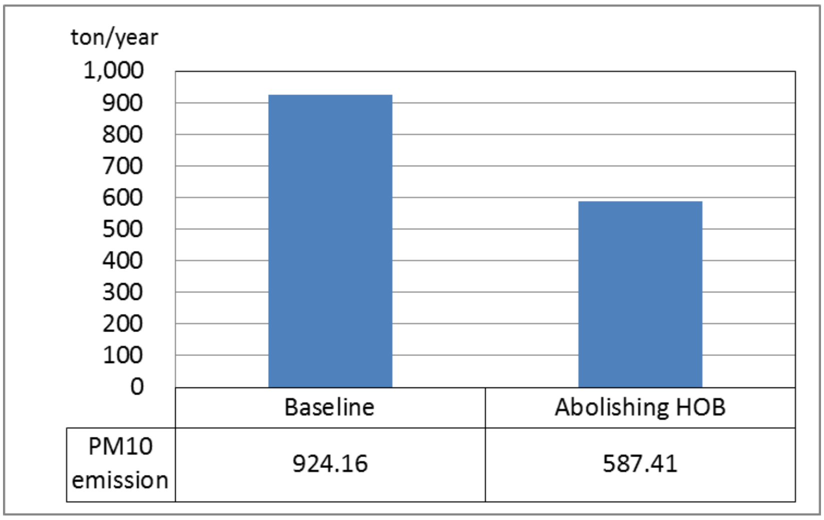
Heat will be supplied in area described in master plan of 2013 (in red dashed line) and HOBs are abolished instead, meaning the emission in the range will be 0 ton.

Target boilers are 77 out of the total 276 boilers.

Red triangle indicated the location of Amgalan Heat Supply Facility and red circles indicates of HOBs.



Emission Reduction Effect



Reduction amount was 336.75ton and reduction ratio was 36.44%.

Settings of Considering Condensed Dust

Emission from abolishing 77 HOBs is 0. Condensed dust from the target area will be reduced proportionally to the emission.

Cost for Control Measure: 7,885,800,000 Tg (375,510,000 Yen)

The cost of coal used by HOB is saved from the cost of coal used by the Amgalan Heat Supply Facility.

(Coal consumption in Amgalan Heat Supply Facility – Coal consumption in HOB)*130,000

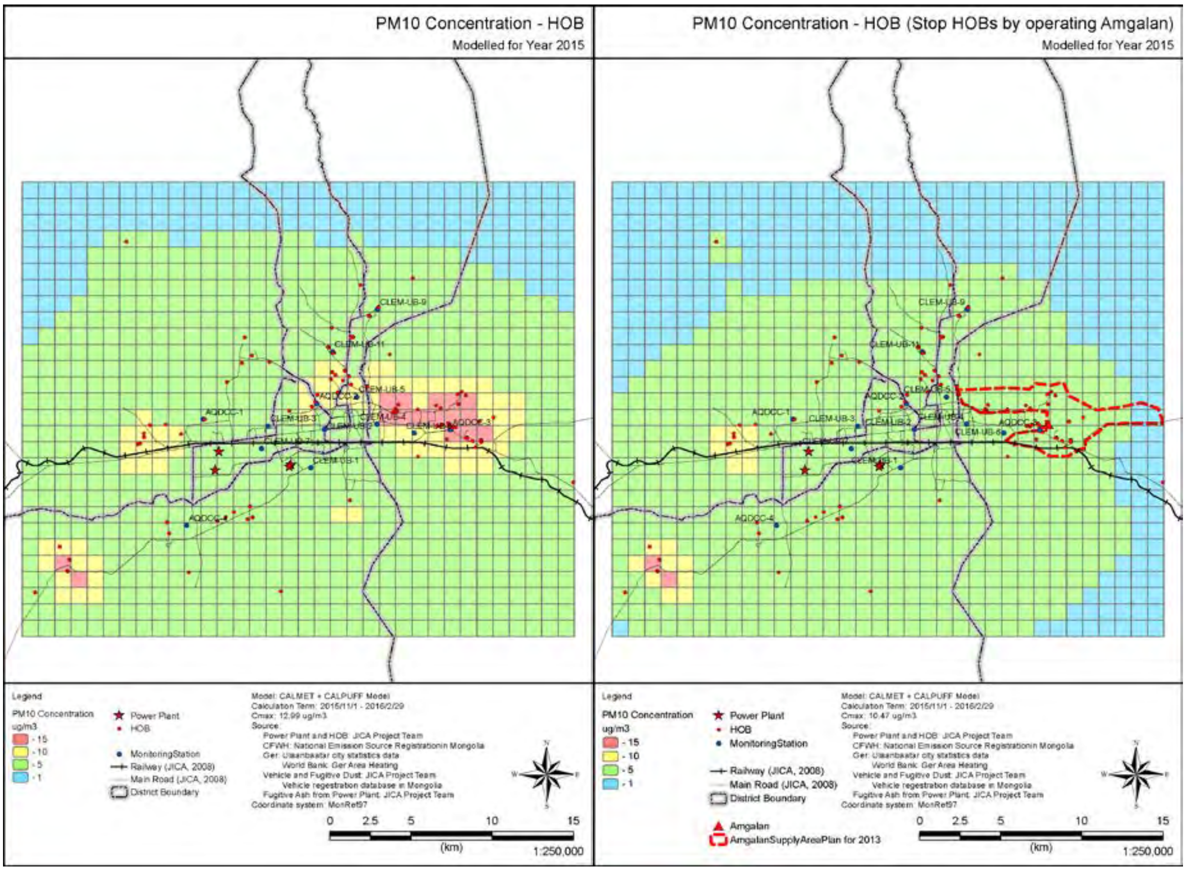
= (109,733ton – 49,073ton) x 130,000Tg/ton = 7,885,800,000Tg

Cost-Effectiveness: 23,417,000 Tg/ton (1,115,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

The reduction effect for the concentration due to using heat supply facility instead of HOB is expected to some extent however, the cost to reduce 1 ton of emissions is somewhat high. This is caused by the flue gas from Amgalan Heat Supply Facility diffuses widely due to the installation of a high stack and the concentration decreases by the diffusion. On the other hand, it can be assumed that heat loss due to supply to distant is also considered, thus more coal will be used compared to the use of HOB.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	12.99	10.47	2.52
PWE	4.85	2.72	2.13

Evaluation Sheet of Air Pollution Control Measure

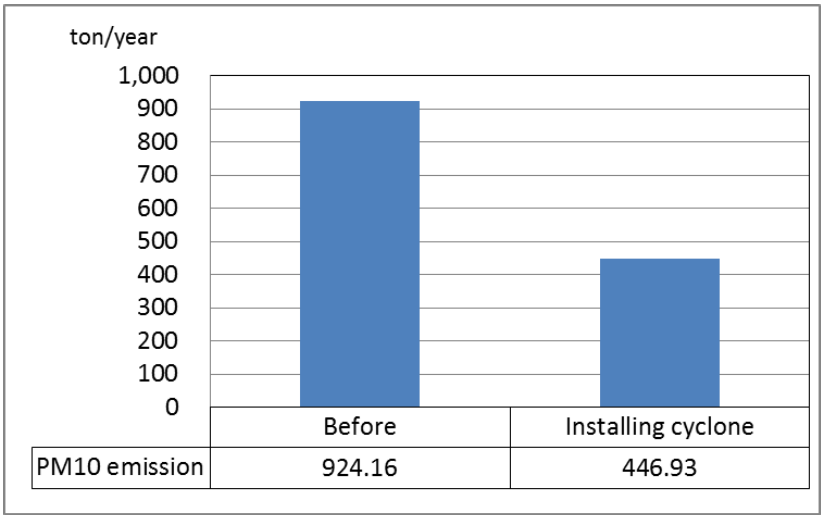
Name of Control Measure: (5) Installation of Appropriately-Designed Multi-Cyclone

Target Source: HOB

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

Cyclone is installed to all boilers without stack gas treatment equipment (164 units). Dust collection efficiency of cyclone is set to 60%.

Emission Reduction Effect



Reduction amount was 477.23 ton and reduction ratio was 51.64%.

Settings of Considering Condensed Dust

Since only particulate matter can be collected by cyclone, amount of condensed dust is set to be the same as before the control measure.

Cost for Control Measure: 974,160,000Tg (46,390,000 Yen)

Since many boilers without cyclone have relatively small capacity, the installment cost of a cyclone is set as the average of 0.4 MW and 0.7 MW (5,940,000Tg).

5,940,000Tg x 164units = 974,160,000Tg

Cost-Effectiveness: 2,041,000 Tg/ton (97,000 Yen/ton)

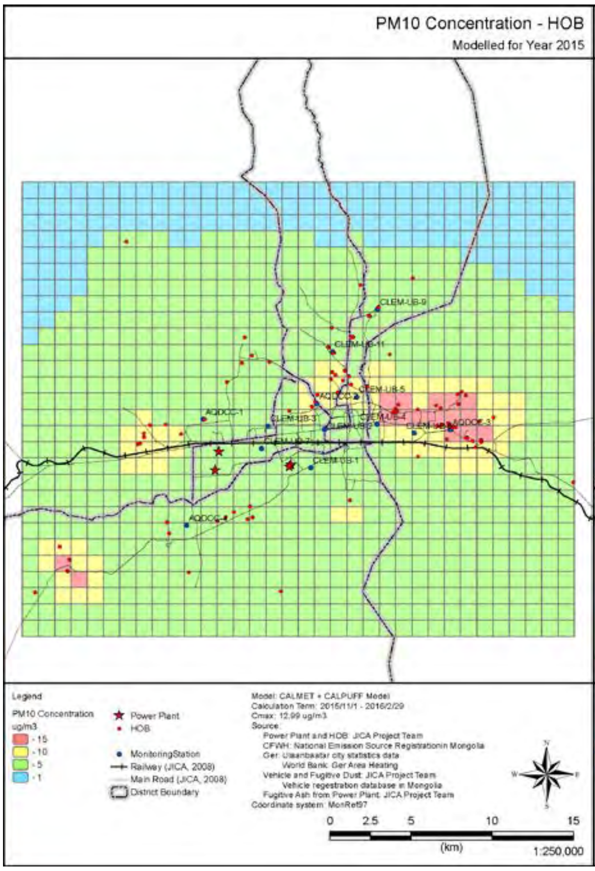
Comprehensive Evaluation (economical and technical feasibility)

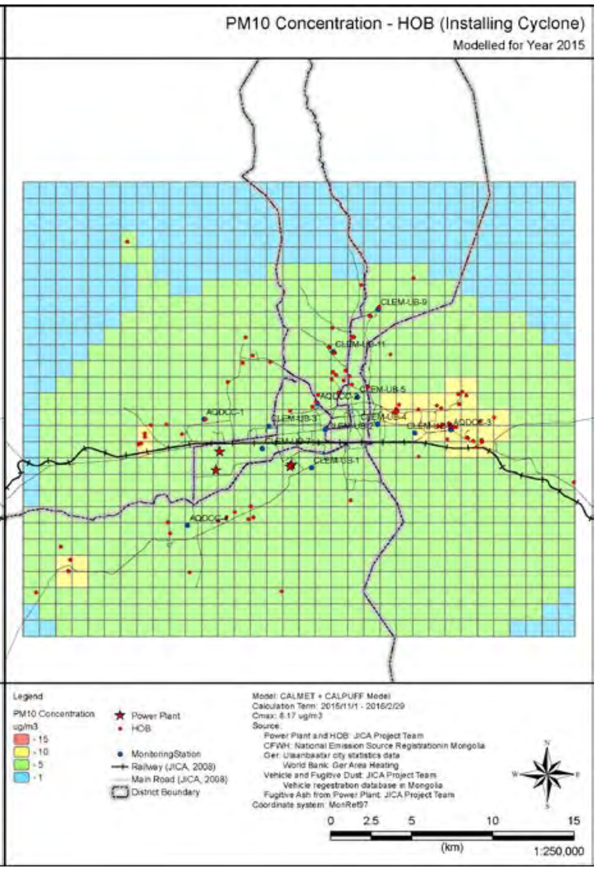
If cyclone is installed to all HOBs, the cost-effectiveness is large.

Also, the grant is necessary to install HOB to each facility.

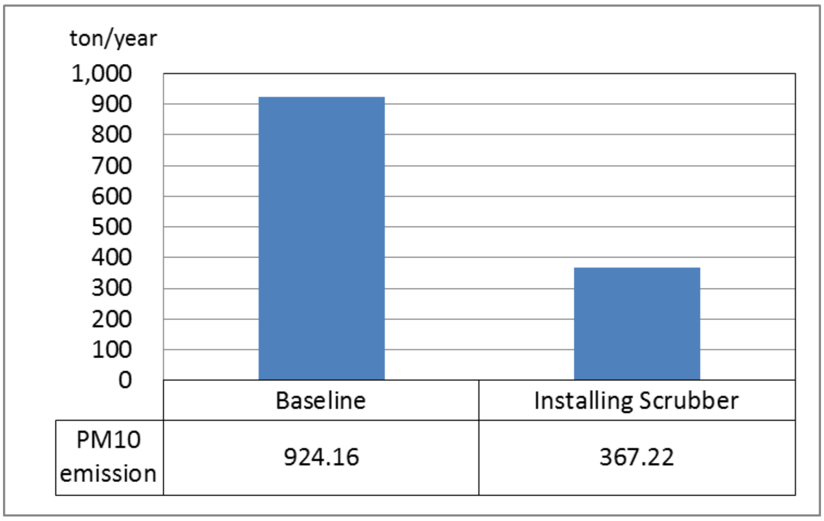
On the other hand, if installation is focused to be conducted to the area which will have high effect on air pollution from HOB, the concentration reduction effect around the facility area is expected to some extent.

Dispersion Simulation Result and Concentration Reduction Effect

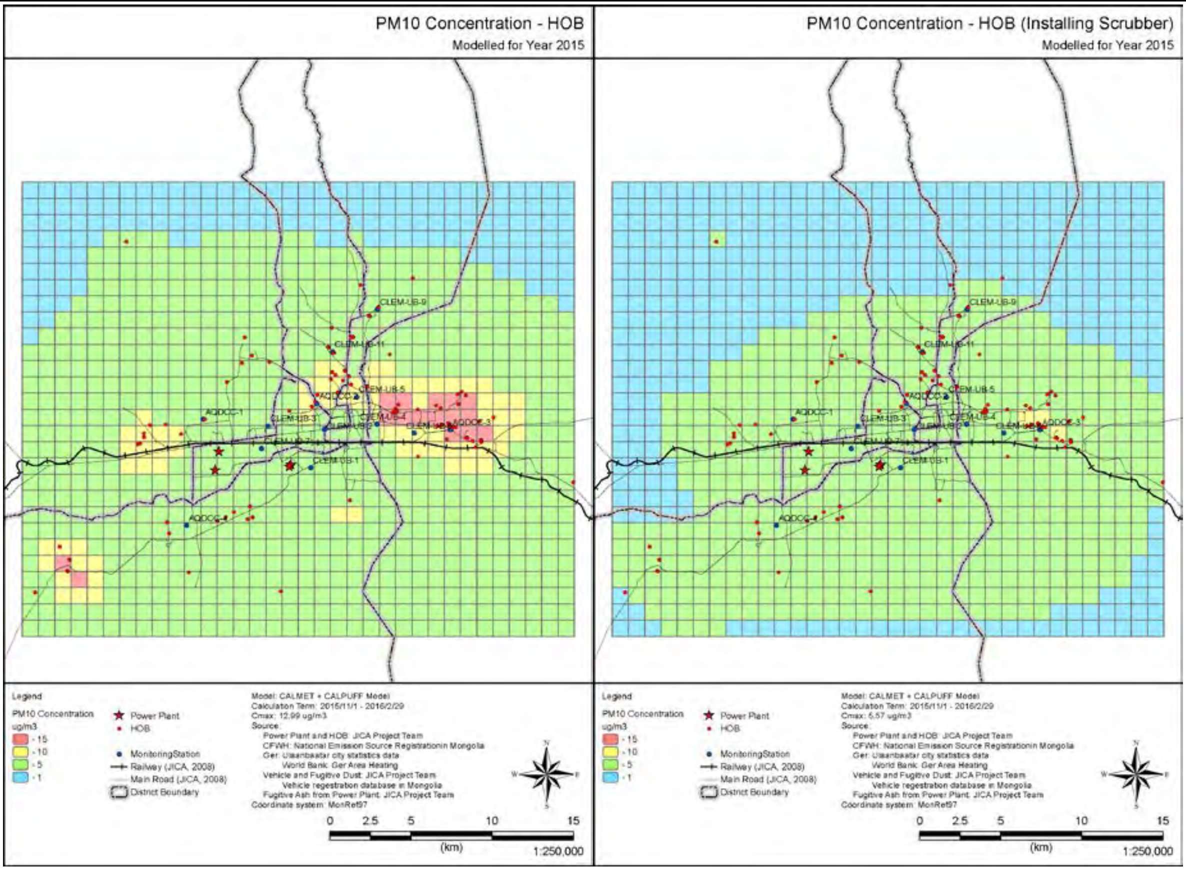




	Before	After	Reduction amount
Maximum ground concentration	12.99	8.17	4.72
PWE	4.85	3.10	1.76

Evaluation Sheet of Air Pollution Control Measure
Name of Control Measure: (6) Installation of Appropriately-Designed Scrubber
Target Source: HOB
Settings to Update Emission Inventory (such as target area, activity data, and emission factor)
Wet scrubber is installed to all boilers without stack gas treatment equipment (164 units). Dust collection efficiency of the scrubber is set to 70%.
Emission Reduction Effect
 Reduction amount was 556.94ton and reduction ratio was 60.26%.
Settings of Considering Condensed Dust
It is assumed that the wet scrubber is able to collect PM as well as other gaseous substances and condensed dust reduction is set as proportional to PM10 emission reduction.
Cost for Control Measure: 6,015,030,000 Tg (286,430,000 Yen)
Since many boilers without cyclone are relatively small capacity boilers, the installment cost of a cyclone is set as the costs for 0.7 MW (36,677,000Tg). 36,677,000Tg x 164units=6,015,028,000Tg
Cost-Effectiveness: 10,800,000 Tg/ton (514,000 Yen/ton)
Comprehensive Evaluation (economical and technical feasibility)
The cost for reducing the PM10 emissions by 1 ton is about 5 times the cost when cyclone is installed, thus the cost effectiveness is small. In addition, conditions for installation are the stable securement of water for flue gas treatment and the ability of the adequate wastewater treatment. On the other hand, similar to the cyclone, if the installation is focused to be conducted to the area which will have high effect on air pollution from HOBs, the concentration reduction effect around the facility area is expected to some extent.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	12.99	5.57	7.42
PWE	4.85	2.15	2.70

Evaluation Sheet of Air Pollution Control Measure

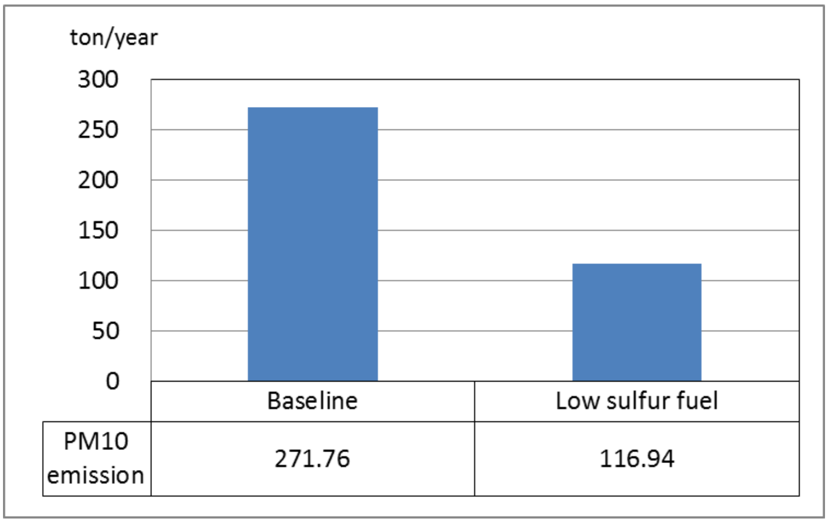
Name of Control Measure: (7) Introduction of low sulfur fuel

Target Source: Vehicle exhaust gas

Settings to Update Emission Inventory (such as target area, activity data, and emission factor,)

As fuel equivalent to EURO4 is assumed to be introduced, the limits of sulfur content in gasoline and diesel oil are both 10ppm. Therefore, sulfur content in gasoline and diesel oil will reduce to respectively 1/20 and 1/100 and it is set that the function of catalysts will recover since there will no longer a damage by high-sulfur fuel.

Emission Reduction Effect



Reduction amount was 154.82ton and reduction ratio was 56.97%.

Setting of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 16,195,200,000Tg (771,200,000 Yen)

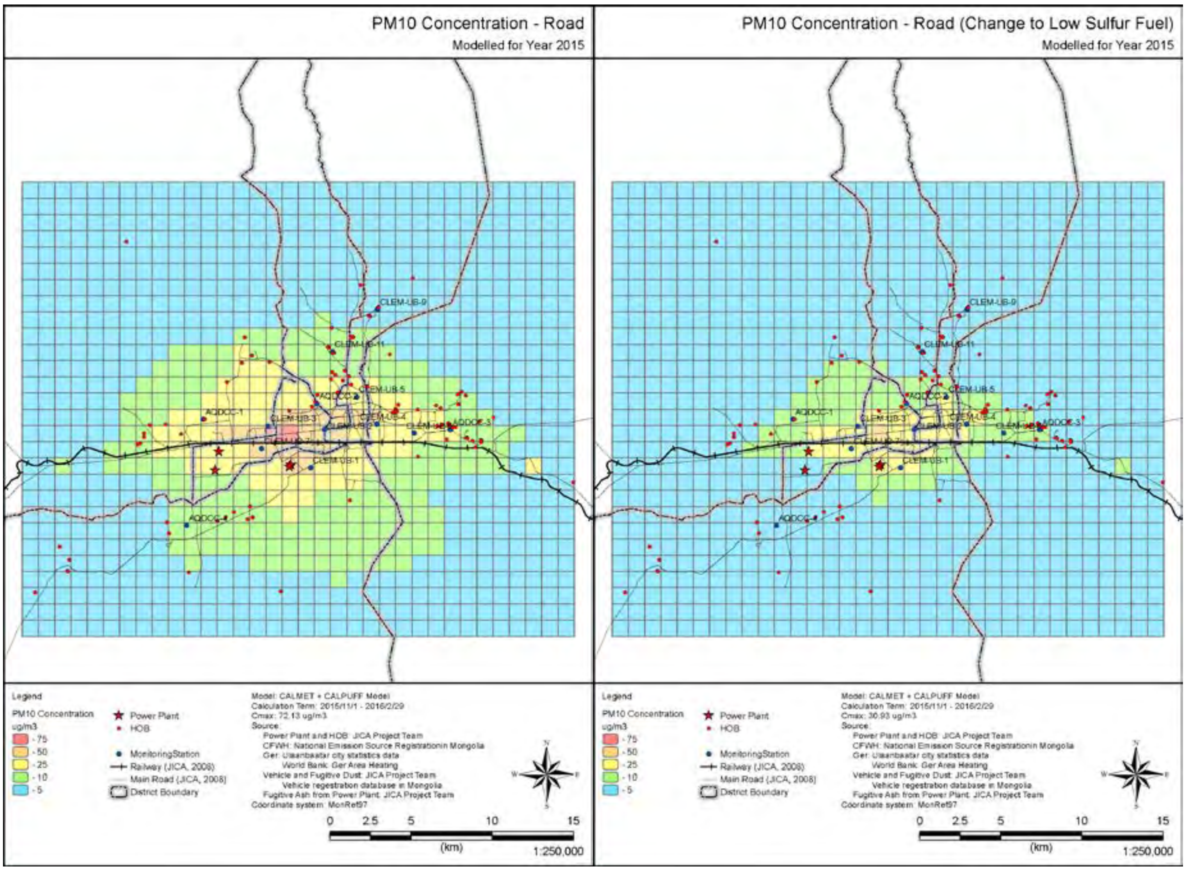
The cost of fuel satisfying EURO4 standards is set up 42Tg/L (2Yen) higher than the fuel sold in UB city. The annual consumption of gasoline and diesel oil is respectively 205,398.52ton and 92,201.65ton and the density is set as 0.7519 and 0.8201 respectively by the fuel analysis result of JICA project; (205,398.52*10^3kg/0.7519kg/L + 92,201.65*10^3kg/0.8201kg/L) *42Tg/L = 16,195,199,239Tg

Cost-Effectiveness: 104,607,000 Tg/ton (4,981,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

Among the control measure of vehicle exhaust gas, this measure had a relatively high effect of reducing emissions and concentrations. In order to introduce this control measure, it is necessary to revise MNS concerning liquid fuel and manage the quality of fuel in order to properly import fuel satisfying EURO 4 standards. Depending on the transportation management method, the fuel price rise may fluctuate.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	72.13	30.93	41.20
PWE	17.09	7.69	9.41

Evaluation Sheet of Air Pollution Control Measure

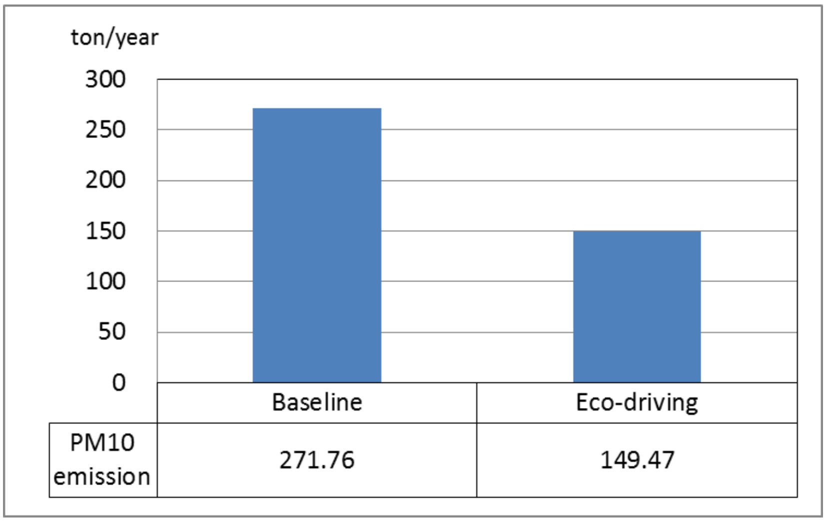
Name of Control Measure: (8) Recommendation of eco-driving

Target Source: Vehicle exhaust gas

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

Based on the result in Japan, fuel consumption and SO_2 of gasoline vehicle reduces by 12% and fuel consumption and SO_2 of diesel reduces by 21%, NOx by 35%, and PM by 45%.

Emission Reduction Effect



Reduction amount was 122.29ton and reduction ratio was 45.00%.

Settings of Considering Condensed Dust

Amount of condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 52,965,000 Tg (2,522,000 Yen)

50 lectures for promoting eco-driving x the 1 hour lecture fee (150,000Tg/time)

(The number of attendees assumed to be 50 people.)

Purchase fee of 50 sets of the drive recorders for eco-driving test: 909,300Tg/unit (43,300Yen/unit)

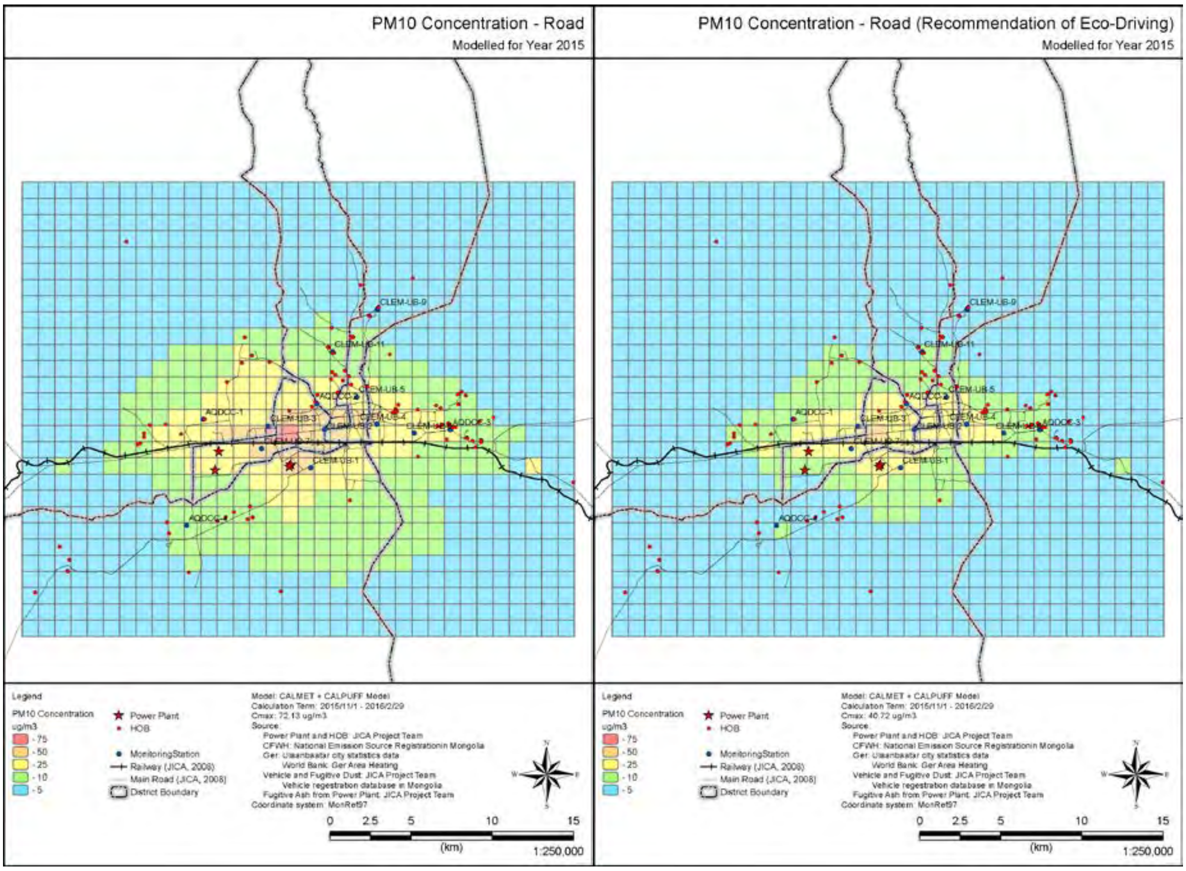
150,000Tg x 50+909,300Tg x 50 = 52,965,000Tg

Cost-Effectiveness: 433,000 Tg/ton, (21,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

The effect of eco-driving on emission and concentration reductions is large. The cost-effectiveness is also large, however, due to the characteristics of this measure, the visualization maybe done only by using the drive recorder. In addition, since promotion of eco-driving is depended on the consciousness of driver, it is assumed that the reduction effect of emission and concentration has a large range.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	72.13	40.72	31.41
PWE	17.09	9.83	7.27

Evaluation Sheet of Air Pollution Control Measure

Name of Control Measure: (9) Fuel Conversion from Coal to Coal Gas

Target Source: HOB

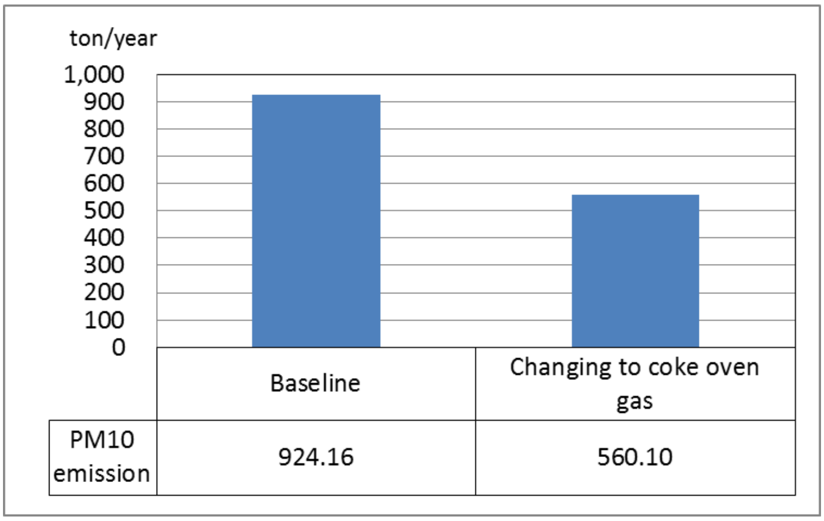
Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

Used gas amount is set same as the calorie of coal used.

Emission factor from the result of flue gas measurement of HOB using coal gas is applied.

Supply range of coal gas is set to within a 10km radius from coal gas generating plant (within the blue dotted line of distribution map).

Emission Reduction Effect



Reduction amount was 364.05ton and reduction ratio was 39.39%.

Setting of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 3,791,123,000 Tg (180,530,000 Yen)

According to the brochure of Grand Power, the cost for gas supply was 65Tg/m^3. Therefore, the difference between the value multiplying the amount of gas supply by this cost and the coal purchase cost was calculated.

Gas: 167,144,963m^3 x 65Tg/m^3 = 10,864,422,600Tg

Coal: 54,410ton x 130,000Tg/ton = 7,073,300,000Tg

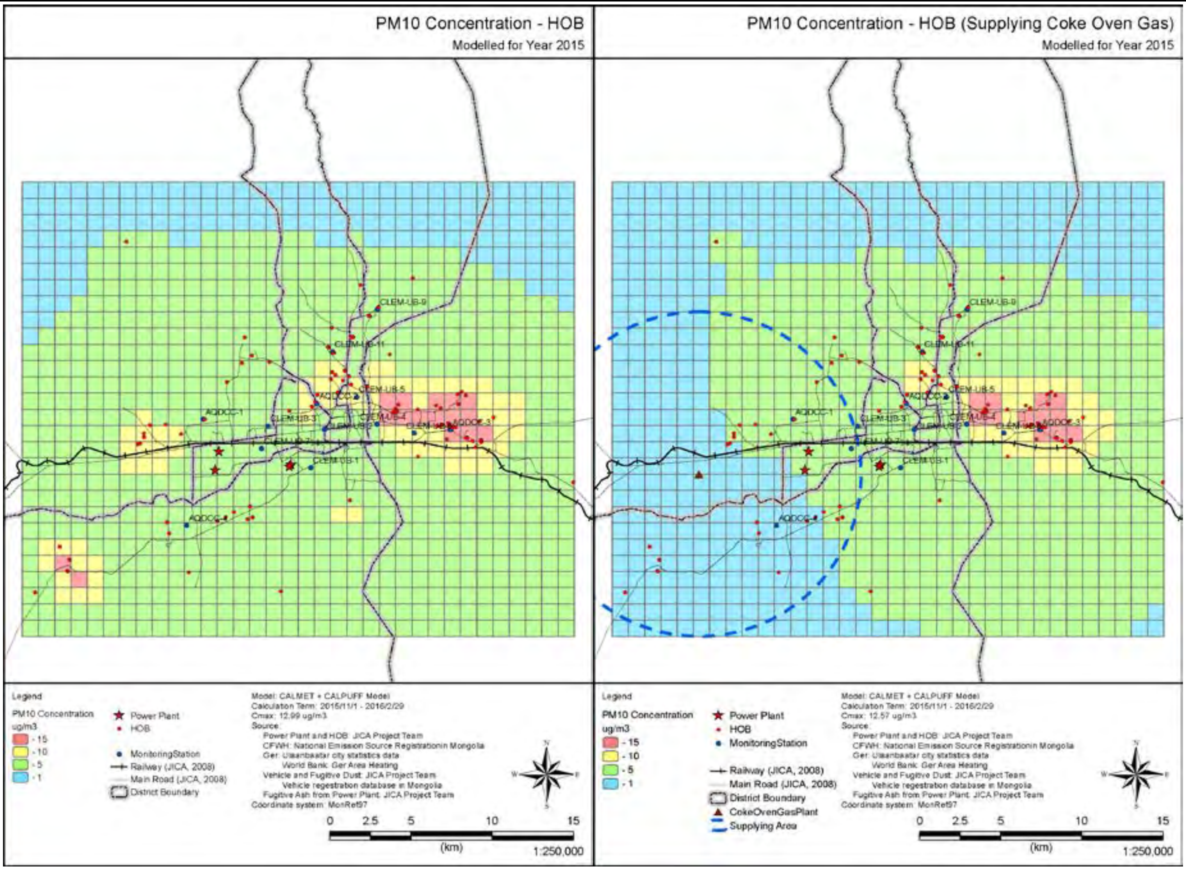
The difference was 3,791,122,600Tg.

Cost-Effectiveness: 10,414,000 Tg/ton, (496,000 yen/ton)

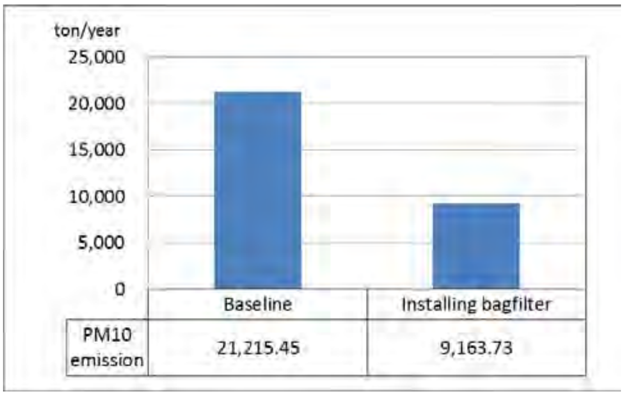
Comprehensive Evaluation (economical and technical feasibility)

The reduction effect of emission and concentration is estimated to be large. Since gas supply is expensive, the cost-effectiveness is smaller than the case of installing cyclone. On the other hand, the cost-effectiveness is larger than the other control measures for HOB. In the case of implementing the gas supply over a wide range, there seem to be a difference in the unit price, depending on the supply method. In addition, since the gas has higher risk of explosion than other fuels, a safe system to supply gas is necessary.

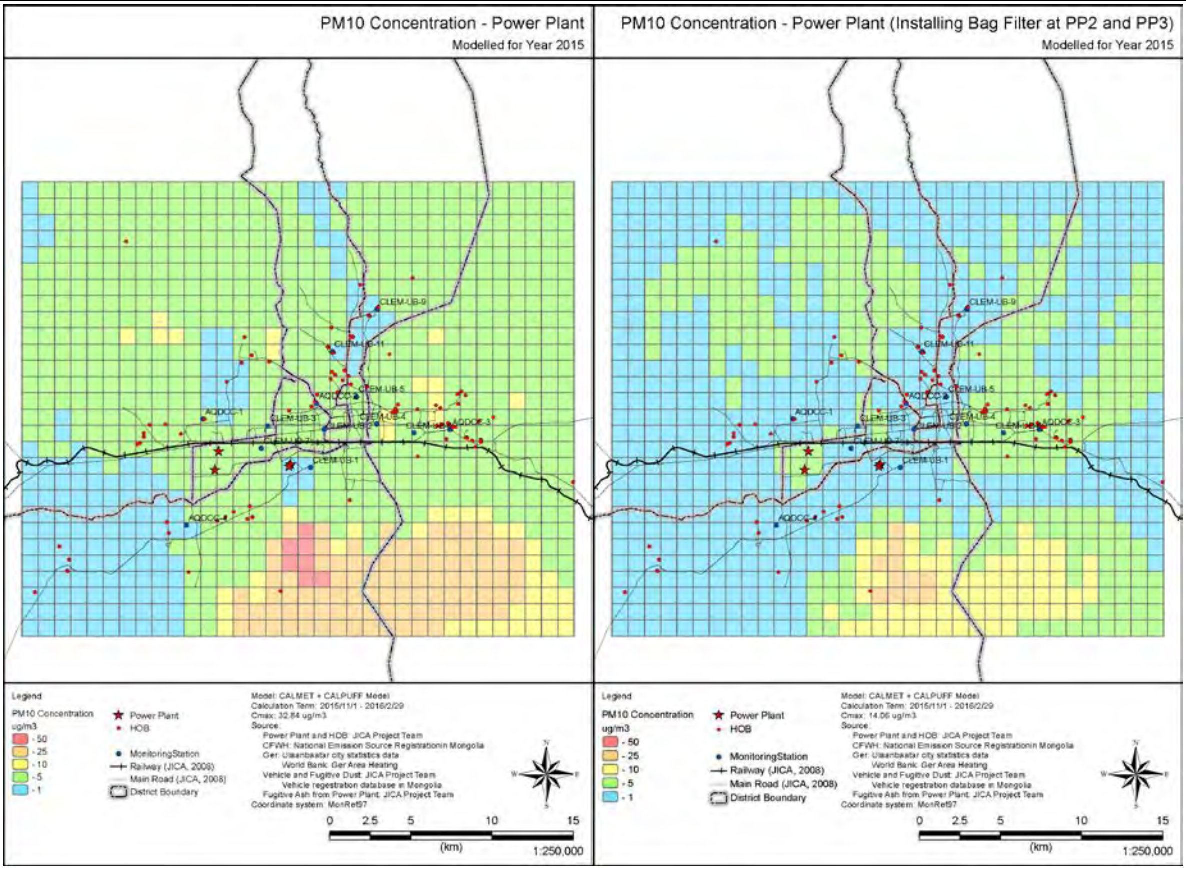
Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	12.99	12.57	0.42
PWE	4.85	3.79	1.06

Evaluation Sheet of Air Pollution Control Measure
Name of Control Measure: (10) Installation of bag filter to PP2 and PP3
Target Source: Power plant
Settings to Update Emission Inventory (such as target area, activity data, and emission factor)
PP2: Since bag filters have already been installed to Boiler 1 and 2, new bag filters will be installed to Boiler 3 to 5. PP3: It is set that all bag filters are installed for each 13 boilers. Dust collection efficiency of bag filter is set as 99.8%.
Emission Reduction Effect
 Reduction amount was 12,051.72ton and reduction ratio was 56.81%.
Settings of Considering Condensed Dust
Since only particulate matters can be collected by bag filter, amount of condensed dust is set as same as before the control measure.
Cost for Control Measure: 25,620,000,000 Tg (1,220,000,000 Yen)
PP2: 5,775,000,000Tg (275,000,000 Yen)、PP3: 19,845,000,000Tg (945,000,000 Yen) This cost is the reference price of the main unit of bag filter when manufactured in Japan, and does not include the installation costs, export expenses, reserve funds, and trial operation costs. Also, the setting condition of gas velocity for the bag filter is different by manufacturers and many different material of the filter cloth exist as well. In addition, it is necessary to note that the combustion condition of boiler and constraint condition such as load of boiler.
Cost-Effectiveness: 2,126,000 Tg/ton (101,000 Yen)
Comprehensive Evaluation (economical and technical feasibility)
The reduction effect of emission from power plant seems to be grate by installation of bag filter to power plant. Also, since the stack height of the power plant is high, the pollutant will be diffused to large area, thus the reduction effect of the concentration is expected to a wide area. On the other hand, since electricity and hot water are supplied, batch installation is impossible, and installation is necessary to conduct step by step by suspending the operation of a few boilers. Also, since the power plants cannot bear the cost of these facilities by themselves, funds and technical assistance from overseas donors are necessary.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	32.84	14.06	18.78
PWE	2.36	0.82	1.54

Evaluation Sheet of Air Pollution Control Measure

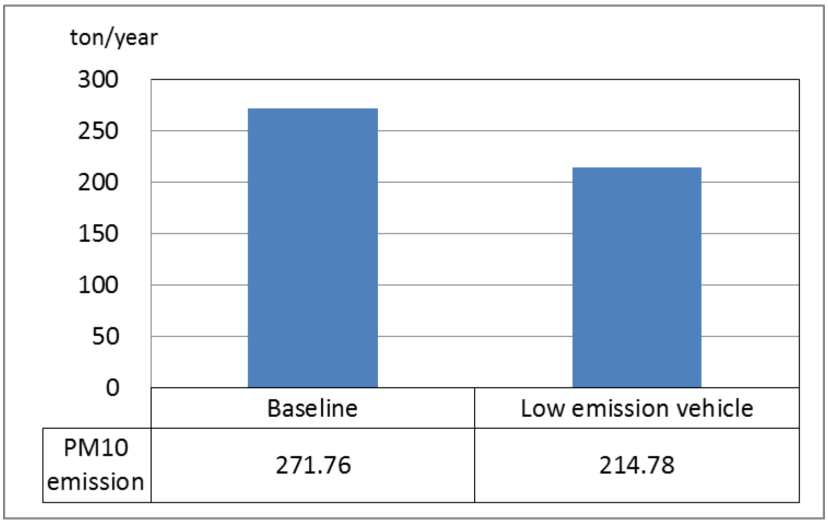
Name of Control Measure: (11) Introduction of low emission gas vehicle

Target Source: Vehicle exhaust gas

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

Vehicles that were manufactured before 2005 (116,533 vehicles) is changed to the vehicles that cleared the vehicle exhaust gas regulation in Japan of 2005 (New Long Term).

Emission Reduction Effect



Reduction amount was 56.98ton and reduction ratio was 20.97%.

Settings of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 932,264,000,000 Tg (77,688,670,000 Yen)

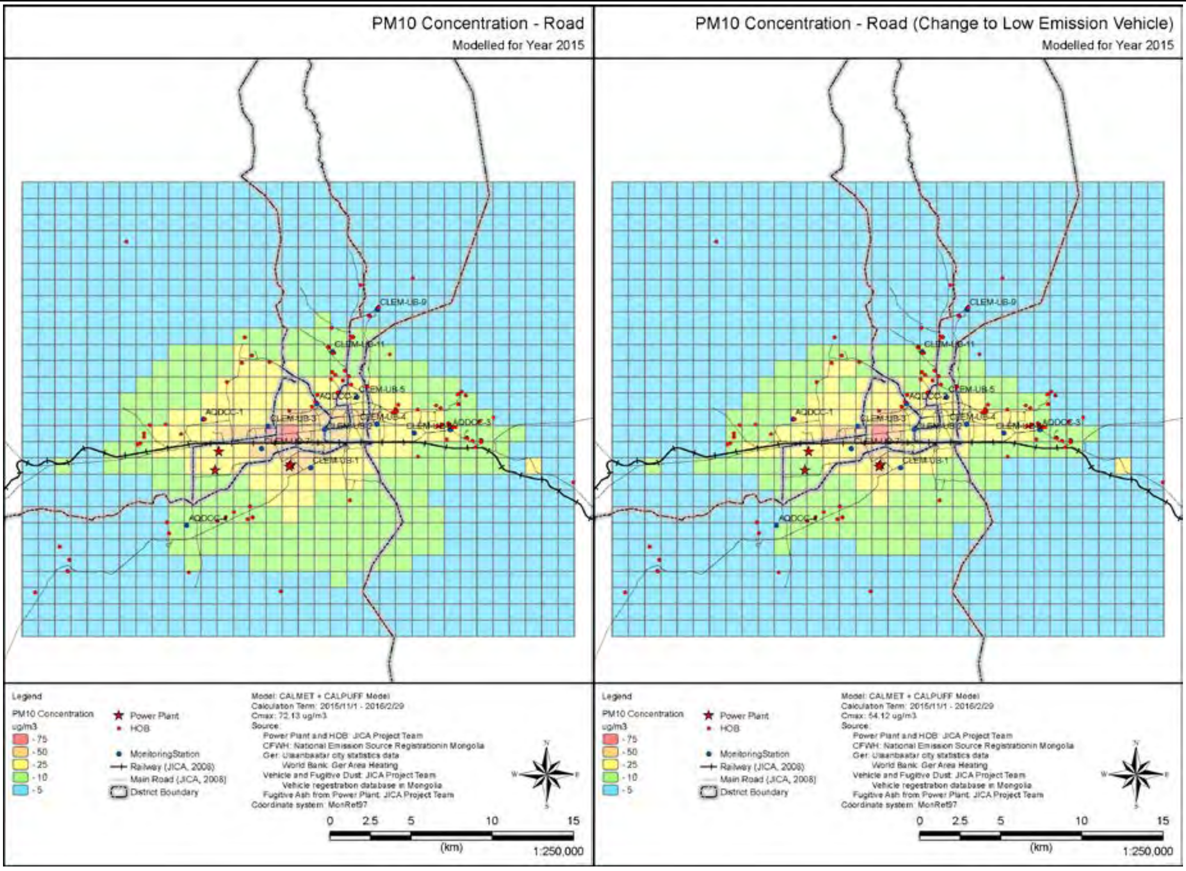
Low emission vehicle manufactured in around 2008 costs about 8 million Tg in Mongolia.
8,000,000Tg x 116,533units = 932,264,000,000Tg

Cost-Effectiveness: 16,361,250,000 Tg/ton (1,363,440,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

In UB city, old passenger cars are still being used, which is the cause of air pollution.
However, the cost effectiveness is smaller than other vehicle control measures, and it is a heavy burden to replace expensive cars individually. On the other hand, since this control measure is necessary to improve the air pollution of nearby road such as bus stop, the method to examine the concentration distribution nearby road must be established and the promotion to introduce low emission vehicle is necessary by the grant from government or municipal administration.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	72.13	54.12	18.01
PWE	17.09	13.02	4.08

Evaluation Sheet of Air Pollution Control Measure

Name of Control Measure: (12) Ignition material that dust emission is lower

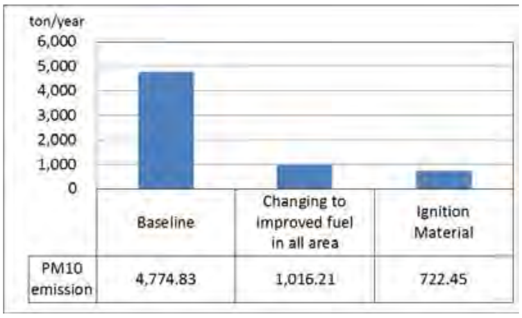
Target Source: Small stove for household

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

All of the coals used by small stoves for household are assumed to be converted to improved fuel (semi-coke briquette) and the more reduction of PM emission is expected by introduction of the ignition material which has lower dust emission. The improved fuel and ignition material is set as follows;

Fuel consumption is reduced to 82% of when using coal. SO2 emission factor is reduced to 25% of when using coal. PM emission factors from traditional and improved stove using improved fuel are respectively changed to 0.93kg/ton (traditional stove) and 0.27kg/ton (improved stove). Also, PM emission factor from stove using ignition material is set to 2.87kg/ton.

Emission Reduction Effect



Reduction amount was 293.76ton and reduction ratio was 28.91%.

Settings of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 80,844,020,000 Tg (3,849,715,000 Yen)

The cost of 1 bag of improved ignition material, which weighs 500g, is set as 500Tg and the cost of 1 bag of conventional wood, which weighs 15kg, is set as 5000Tg.

Purchase cost of improved ignition material: 121,266.03ton/0.0005 x 500=121,266,030,000Tg

Purchase cost of conventional wood: 121,266.03ton x 5000Tg/0.015ton=40,422,010,000Tg

Therefore, when converting the wood to the ignition material, the cost burden of the user is as follows.

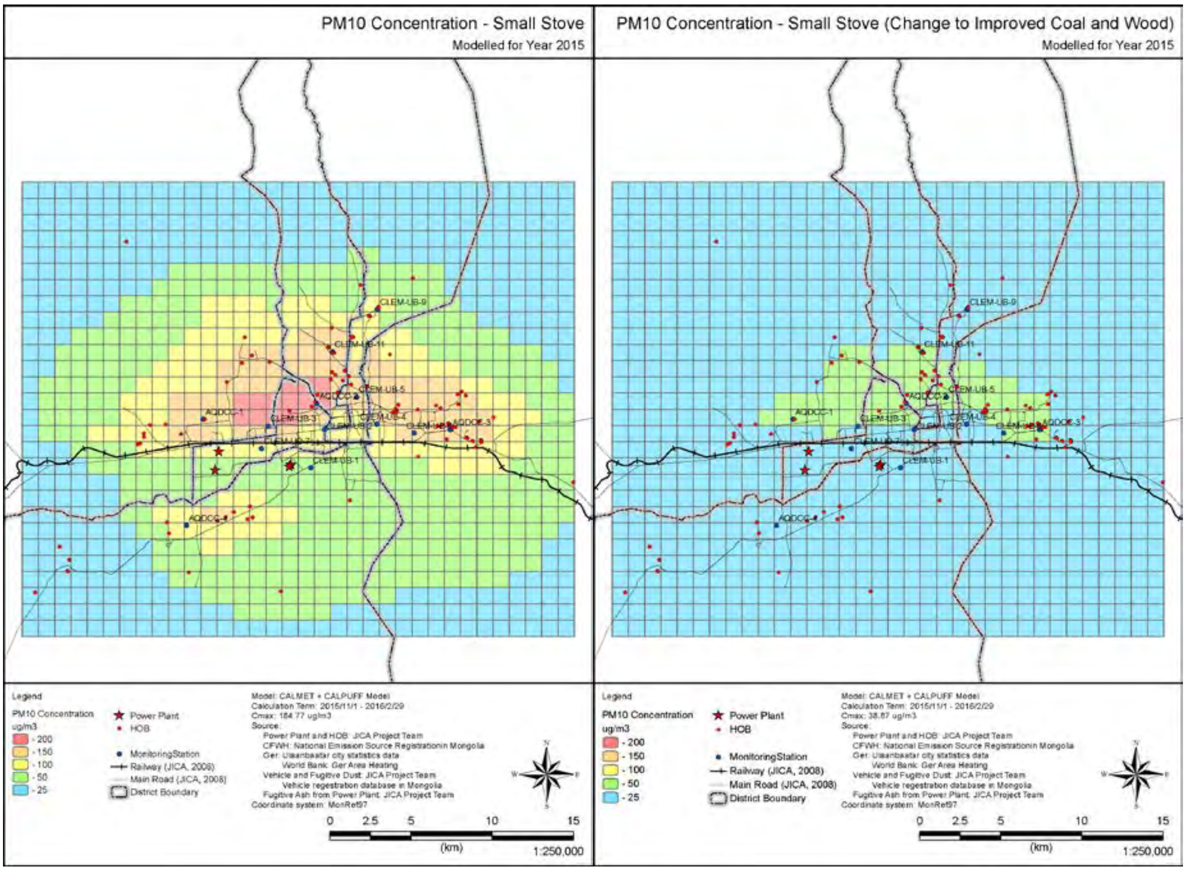
121,266,030,000Tg - 40,422,010,000 = 80,844,020,000Tg

Cost-Effectiveness: 275,204,000 Tg/ton, (13,105,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

Through the conversion to the ignition material which has difficulty to discharge soot, further PM10 emission is reduced. However, ignition material is more expensive than conventional wood, thus this conversion is not very cost effective. It is necessary to consider the introduction of the ignition material to the entire UB city based on the evaluation of experimental introduction in a high concentration area. Also, there was a large difference in PM concentration of individual ignition material in the flue gas measurement of the project. In order to obtain the reduction effect of emission and concentration by the improved ignition material, it is necessary to take measures to prevent the manufacture and distribution of the improved ignition material having a larger PM emission factor than the conventional wood material.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	184.77	38.87	145.90
PWE	99.17	21.25	77.92

Evaluation Sheet of Air Pollution Control Measure

Name of Control Measure: (13) relocation from ger and house to apartments constructed in ger area, and connecting central heating system

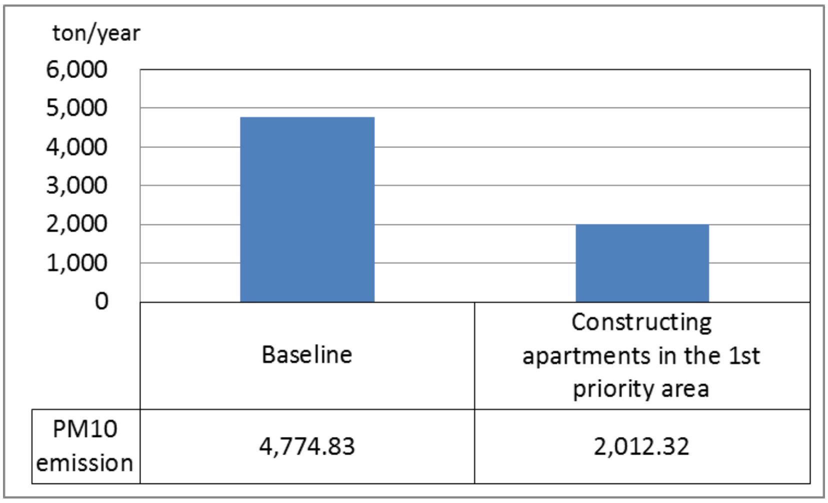
Target Source: Small stove for household

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

All of Ger and buildings in the 1st priority area for air pollution control measure are changed to apartment buildings and all heat will be supplied from the central heating system.

Thus, number of Ger and buildings in the 1st priority area for air pollution control measure is 0.

Emission Reduction Effect



Reduction amount was 2,762.52ton and reduction ratio was 57.86%.

Settings of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 1,996,800,000,000 Tg (95,085,714,000 Yen)

2,496 apartments (50 households / buildings) are necessary for transferring Gers and buildings in the 1st priority area (124,797 households) to the apartment connected to the central heating system.

When the necessary space for developing an apartment is set as 800m^2, the price required to develop 1m^2 is set as 1 million Tg/m^2, and the cost of developing an apartment will be as follows.

2,496 apartments x 800m^2 x 1,000,000Tg/m^2 = 1,996,800,000,000Tg

Cost-Effectiveness: 722,818,000 Tg/ton, (34,420,000 Yen/ton)

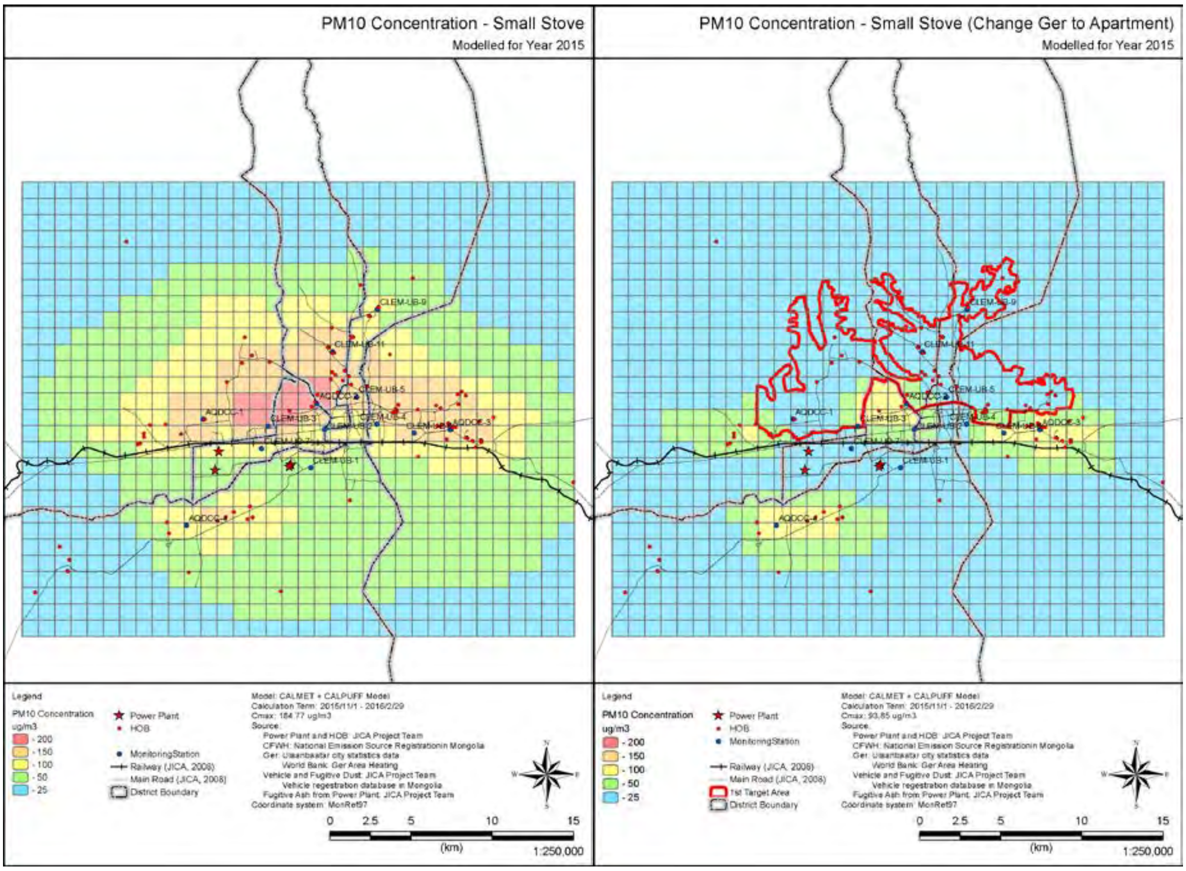
Comprehensive Evaluation (economical and technical feasibility)

Since apartment construction is a large-scale development, the cost to reduce emissions is very high.

Dust generated during the construction of the apartment is also likely to be a problem, thus environmental assessment is implemented and it is also necessary to improve the work environment for construction and consider the environment of the surrounding area.

In addition, it is necessary to select the development area based on the measurement result by the ambient monitoring stations and the concentration distribution by dispersion simulation.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	184.77	93.85	90.92
PWE	99.17	29.09	70.08

Evaluation Sheet of Air Pollution Control Measure

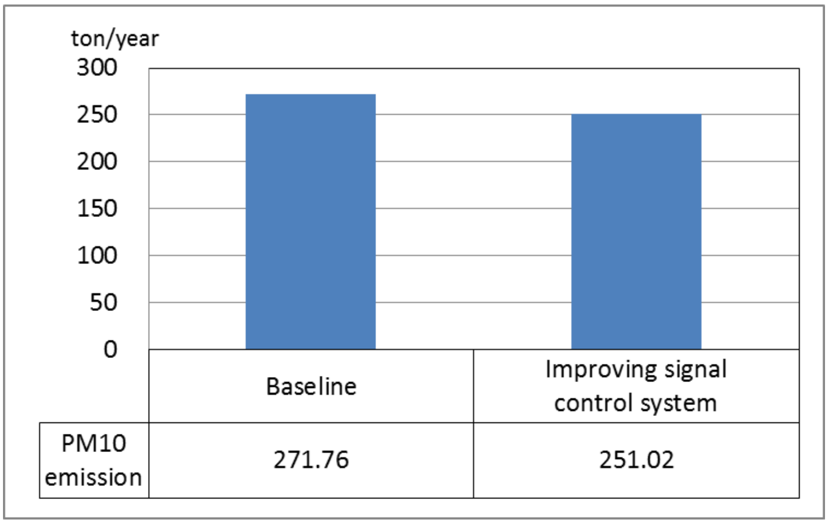
Name of Control Measure: (14) Rising travelling speed by improvement of signal control system

Target Source: Vehicle exhaust gas

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

Travelling speed is set to increase 5km/h in the major road where link travelling speed was less than 30km/h in the travelling speed survey. The main target is near the center of UB city and large market where traffic congestion is becoming chronic.

Emission Reduction Effect



Reduction amount was 20.74ton and reduction ratio was 7.63%.

Settings of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 737,000,000 Tg (3,510,000 Yen)

It is necessary to train human resources for about one month thus the person will be able to use the traffic flow simulation system on their own. Also, traffic count survey is necessary as input data for carrying out traffic flow simulation. Therefore, the following expenses are estimated.

Mongolian staff cost x 2 people + instructor fee for training (0.5 months of Japanese expert) + Traffic count survey

700,000Tg x 2 + 26,000,000Tg + 47,000,000Tg = 1,400,000Tg

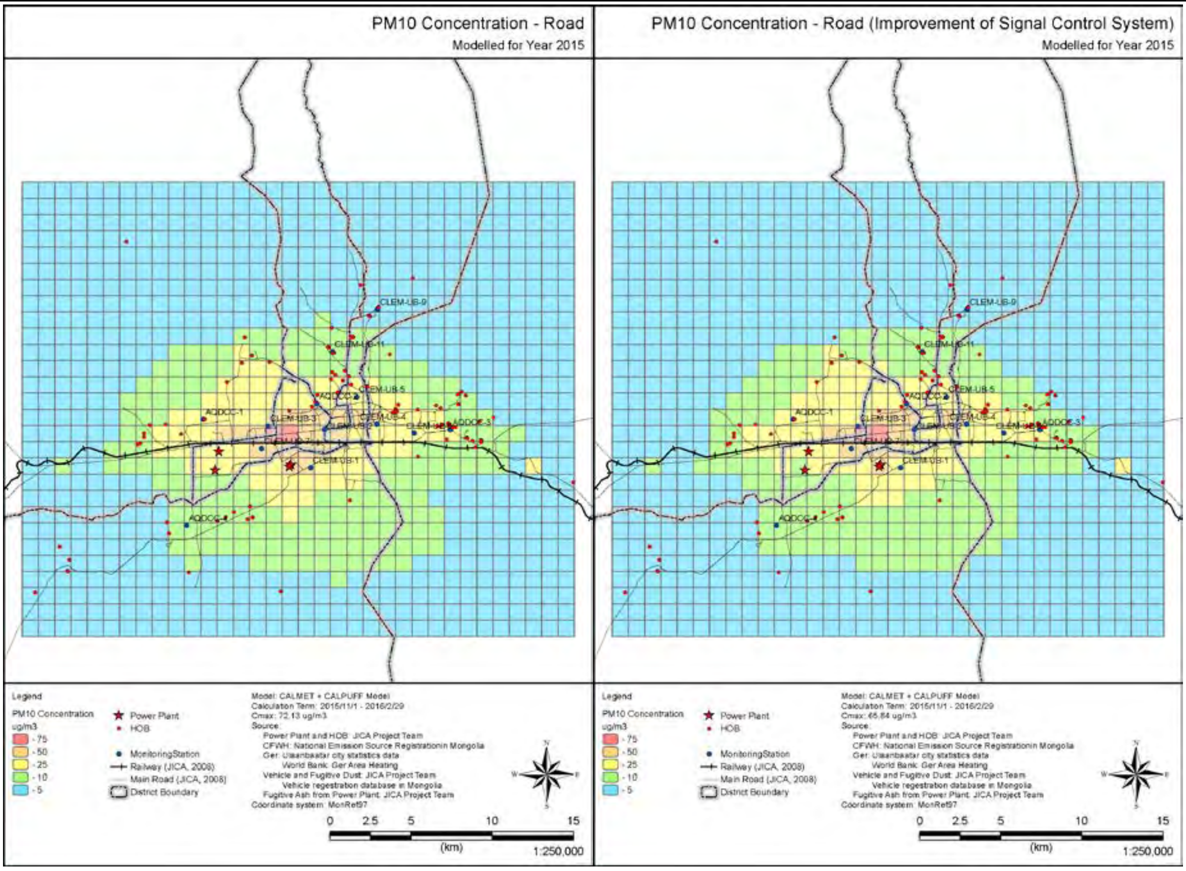
Cost-Effectiveness: 3,554,000 Tg/ton (169,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

The reduction of emission and concentration is small however, since UB city already has the latest traffic flow system, no additional investment for equipment is necessary.

On the other hand, since the training of personnel for using traffic flow system and the implementation of the traffic count survey is necessary, additional expenses are expected.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	After	Reduction amount
Maximum ground concentration	72.13	65.84	6.29
PWE	17.09	15.73	1.36

Evaluation Sheet of Air Pollution Control Measure

Name of Control Measure: (15) The reduction effect of un-passed inspection vehicle or poor maintenance vehicle by introduction of RSD (Remote Sensing Device)

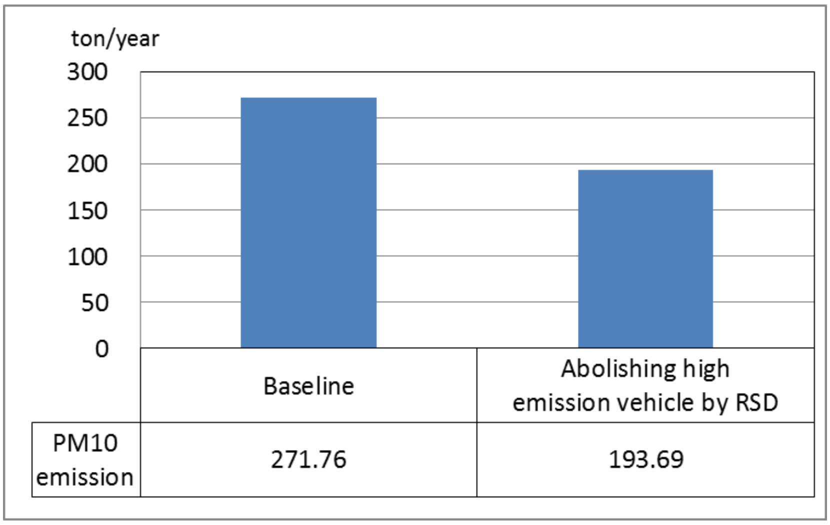
Target Source: Vehicle exhaust gas

Settings to Update Emission Inventory (such as target area, activity data, and emission factor)

By conducting RSD survey, the vehicle exhaust gas concentration during actual driving can be measured efficiently.

It is assumed that by improving the regulation effect of vehicle exhaust gas concentration using RSD, there will no longer be vehicles with defective maintenance and all vehicles will satisfy the vehicle exhaust gas regulation standards for vehicle inspection.

Emission Reduction Effect



Reduction amount was 78.07ton and reduction ratio was 28.73%.

Settings of Considering Condensed Dust

Condensed dust reduction is proportional to PM10 emission reduction.

Cost for Control Measure: 630,000,000 Tg (30,000,000 Yen)

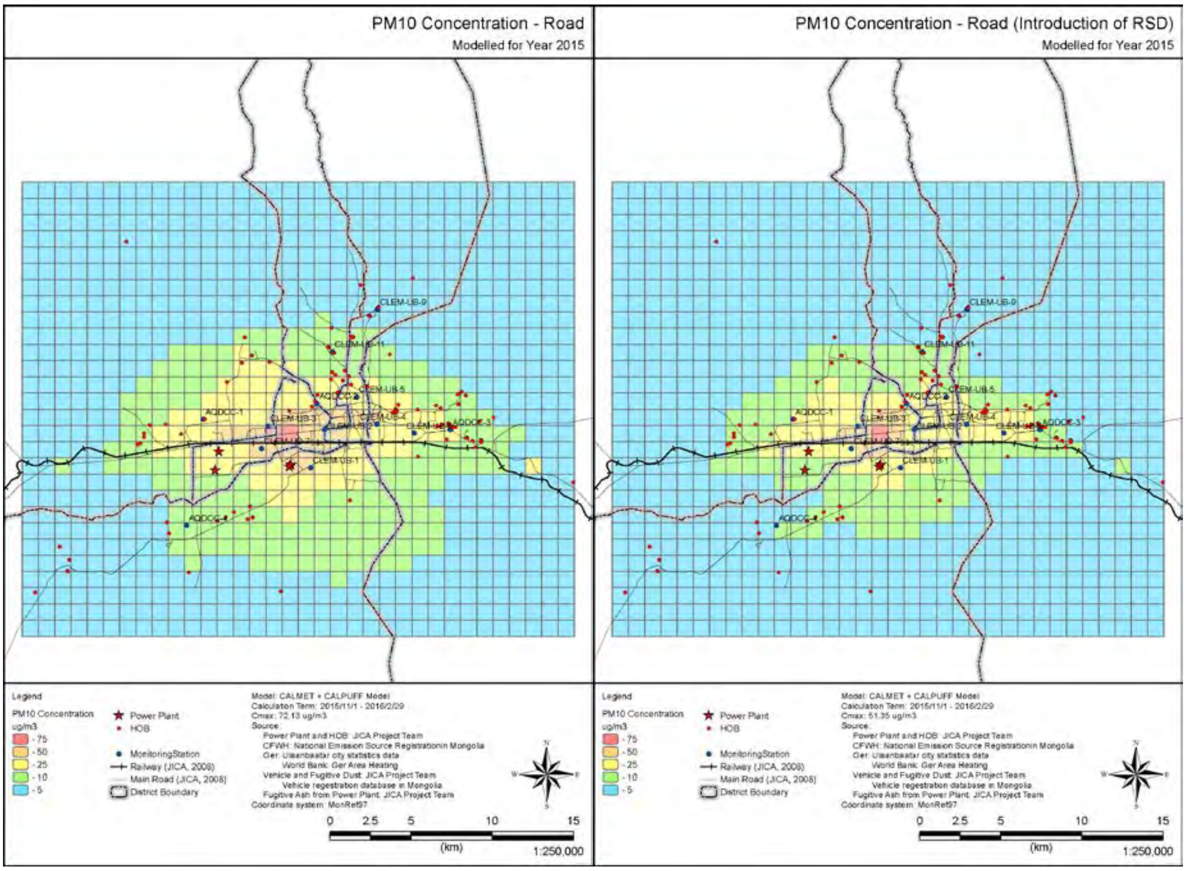
It costs 30,000,000 Yen (630,000,000Tg) for RSD, its peripheral equipment, and survey cost.

Cost-Effectiveness: 8,070,000 Tg/ton (384,000 Yen/ton)

Comprehensive Evaluation (economical and technical feasibility)

With the introduction of RSD, it becomes possible to measure vehicle exhaust gas concentration in the state where the vehicle is actually running. As a result, it is possible to grasp the exhaust gas concentration of the vehicle that is driving and at the same time, promote the vehicle to transfer to the low emission vehicle. In addition, although the price of the equipment is expensive, it is more cost effectiveness compared to other control measures for vehicle exhaust gas.

Dispersion Simulation Result and Concentration Reduction Effect



	Before	**After**	**Reduction amount**
Maximum ground concentration	72.13	51.35	20.78
PWE	17.09	12.05	5.04

3 Issues, Improvements and Lessons on Project Implementation and Management

3.1 Improvement of Project Implementation and Management

3.1.1 HOB Inspection

Emission inspection of HOB including the flue gas measurement during the winter season of the year 2014 did not follow MNS emission standard because the flue gas measurement by smoke tester and TESTO-350 was implemented. In the winter season of the year 2015, C/Ps of APRD, as one emission gas measurement team equipped with JICA donated equipment, implemented emission inspection for 41 HOBs, and checked the measured output is under the MNS emission standard, with guidance of JICA Experts.

In order to follow the rule of "Certified Regulation of HOB Facilities", all HOBs need to be inspected every two years. In the winter season of year 2016, 127 HOBs had to be inspected, which is 3 times of inspections conducted in 2015. In order to prepare APRD for the inspections, JICA Experts Team trained C/Ps for implementation of measurement technicians, and all of the followings are necessary to be completed by the end of summer. JICA Experts Team advised that for the successful completion, the support of UB Municipality and Governor is necessary.

A. Three (3) emission measurement teams as recommendation, or 2 teams in minimum, are necessary to be prepared.
   (a) Three (3) emission measurement technicians for each team, or 6 in total, are necessary to be allocated and educated.
   (b) Two (2) technicians of them are necessary to be well experienced for team leader.
B. In order not to stop the measurement in winter, all of the followings are necessary to be ordered before the election in June 2016.
   (a) Inside of emission gas measurement vehicle is furnished suitable for emission gas measurement in order to minimize possible equipment damage.
   (b) Budget for expenses such as drivers and fuels are allocated.
   (c) All of the important equipment is overhauled in order to minimize possible equipment failure in winter season.
   (d) Consumables such as dust filters and standard gases are procured by APRD

According to the boiler inspection conducted in 2014 and 2015, issues of rules such as regulation for HOB registration became clear. These issues are necessary to be amended. However, after the national election in June 2016, a controlling political party was changed, and "Certified Regulation of HOB Facilities" which was approved in the past administration, became deemed invalid. MET will ratify "Certified Regulation of HOB Facilities", and will be enforced in 2017.

Objectively Verifiable Indicator 7-1 is "Compliance rate of MNS emission standards (dust concentration) for Boiler with 100kW or more become more than 80% at the Project completion". However, according to the measurement from October 2015 to February 2016, count of HOBs that complies with MNS emission standards (dust concentration) was only 21 among 56, which was 37.5%. It revealed also that 12 of 14 HOBs of "Carborobot 300 model", which is expected as environmentally friendly HOB model equipped with cyclone, exceeded the MNS emission standards. Even replacement to so-called environmentally friendly HOB models may not be enough to increase the compliance rate. UBCAP made a draft MNS emission standard, and revised the MNS emission standard, which was implemented in 1st of April, 2017. The comparison between MNS5457:2005 and MNS5043:2016 is shown in Table 3.1-1. Although standard of dust concentration was relaxed, "Carborobot 300 model" do not have enough level to meet the MNS emission standard. JICA Experts suggested to the working group to discuss the amendment of MNS emission standard or intermediate target dust concentration.

Table 3.1-1 Comparison between MNS5457:2005 and MNS5043:2016

Standard	Target	Emission Standard (mg/Nm^3)					Standardized Oxygen Concentration
		SO_2	NOx	CO	Dust	PM2.5	
Previous Stasndard	HOB :0.8MW＜Boiler Capacity ≦3.15MW（MNS 5457:2005）	600	400	2,000	300	-	9.33%
	HOB :Boiler Capacity ≦0.8MW（MNS 5457:2005）	800	450	2,500	400	-	
Present Standard	HOB: 0.8MW≦Boiler Capacity ＜4.2MW（MNS 5043:2016）	600	400	4,000	400	300	10.0%
	HOB: 0.1MW≦Boiler Capacity＜0.8MW（MNS 5043:2016）	800	450	5,000	600	400	
	HOB: Boiler Capacity ＜0.1MW（MNS 5043:2016）	1,000	500	9,700	225	170	

Source: JICA Experts

3.1.2 Project Implementation Improvement Regarding CEMS

Although CEMS installation possibility was started to be discussed from the beginning of the project in 2013, R/D amendment was agreed in May, 2015 to supply CEMS. Since procurement, production and delivery procedures of CEMS require some period, and CEMS was expected to be delivered to UB in the last part of the project period, coordinating mechanism of related organizations and CEMS data transmission system were started to be discussed in advance.

As the result, a system to show CEMS data in the central control room of PP4, and another system to share the CEMS data to related organizations were ready in January 2017 when the CEMS became ready. Coordination mechanism was also proposed by the representatives of related organizations throughout training course in Japan in December 2016.

3.1.3 Utilization of On-Board Emission Measurement System for Vehicle

Members of C/P and C/P-WG for on-board emission measurement system for vehicle have been trained well throughout this project. However, the emission measurement output may be biased data because the sample count is very low. It is suggested to measure many vehicles by equipment and human resources of APRD and NAMEM.

First measurement was conducted in March 2017 without JICA Experts. Measurements after the Project termination will be continued, measurement results will be utilized for improvement of emission factors and examination of countermeasures. Therefore, the provision of measurement expenses, continuation of measurement staff employment and providing technology transfer from Mongolian to Mongolian is necessary.

3.1.4 Air Quality Monitoring by Automated Stations

Three (3) new maintenance experts of APRD are improving their capability throughout this project. However, the new experts have not conducted the calibration without JICA Experts. The schedule was made and tried to be followed by APRD, however even with additional re-scheduling, it is not yet successful because of issues on work load, schedule management, and budget. It is suggested for APRD to improve allocation on transportation budget and securing of work hours.

NAMEM/CLEM stations are managed by higher level experts. However, monitoring is going to be difficult because there is a procurement difficulty on repair parts and scheduled replacement parts. It is suggested to allocate necessary budget by MET and prepare an exception on governmental budget usage.

3.1.5 Updates of Emission Inventory

Emission inventory is important data to identify air pollution sources quantitatively. For example, although Mongolian government and municipality have carried out air pollution control measures for last 5 years, SO2 emission has been increasing in the last years due to sulfur contents in the fuel have not yet decreased and the fuel consumption have increased. Emission inventory are recommended to be used to develop upper programs, such as national mid-term program, amendment of city master plan, and CAF budget allocation planning.

JICA Expert has been updating emission inventory from 2010, and trying to develop Mongolian counterpart. However, C/P-WG is not trained enough because the staffs have been reallocated frequently and not enough training was experienced. It is advised to allocate enough time to the members of C/P-WG to practice and exercise in this last year of this project.

In April 2015, JICA Expert Team proposed change of technology transfer to APRD, APRD allocated new member for emission inventory as last change. APRD new member understood those situations and tried to acquire technology, and then she can conduct collection of related documents, update of emission factors, and calculation of emission. From December 2016 to March, for examining air and environmental pollution reduction national program, various documents for examining the national program were prepared by using emission inventory technology.

Technology transfer for APRD needs at least two years, some of APRD members could not acquire technology over five years. For preparing promotion and/or internal transfer of APRD members, technology transfer by inside of APRD needs several years.

3.1.6 Countermeasures for High PM Episodes in Winter

The maximum daily average of PM10 in 2015 was 1.009 mg/m3. Although it is decreased by 1/3 from 3.000mg/m3 recorded in 2012, it is still 10 times higher than 0.100mg/m3 defined as air quality standard in MNS 4585:2007. For the future, more and most efficient air pollution reduction must be selected and realized. The advices are to establish a working group to find best PM reduction programs using the wide range, scientific and latest data of this project. The working group will evaluate and summarize the emission gas measurement data.

Current air pollution reduction activities are selected basically according to the existing laws and master plans. The basics were discussed and executed before 2010, when there was no automated air quality monitoring station, no automated PM10 and PM2.5 analyzers, and no emission analyzer which was donated by JICA Technical Cooperation Project. As the results, not small share of the budget and human resources are allocated to the activities which have been concluded as “not efficient for air pollution reduction” by emission measurement and/or air quality simulation. The working group, proposed here, is recommended to study the air pollution reduction proposals based on measured data only, and to propose amendment of any laws, rules, regulations or standards that contradict with the measured data.

The followings are the process of preliminary draft proposal.

1. To classify the emission source types by contribution to air pollution exceeding air quality, by air quality simulation model. In addition, spontaneous local high pollutions, which cannot be simulated by the current air quality model, are also advised to be monitored and/or studied. It will lead limited budgets and resources to the most effective pollution sources.
2. To classify the emission reduction methods based on their emission measurement data, the classification will be made by emission source types, emission reduction effectiveness, and costs. Even in the same technology names, such as coals, multi cyclones, improved fuels, and hybrids vehicles, their emission reduction effects depends on their brands or designs. Thus, the emission reduction data will also be classified and differentiated.
3. To encourage the reporting of the study outputs to decision makers and scientific authorities before the information will be commonly known. Recommendations by inspection authorities are also encouraged.

In the last 2 technical cooperation projects, capacity development of each field was necessary. In this working group, studies and reporting by experts cooperation developed for several fields are proposed.

3.1.7 Elaborating Manuals

JICA Experts will not be available in future when any of C/P-WG needs to educate its new staff. Thus, JICA Experts elaborated the manuals for successor training by the person in charge of Mongolian side.

3.1.7.1 Stack Gas Measurement Protocol (for Power Plant, HOB, Ger Stove)

According to the previous agreement in April 2016, JICA Expert Team made necessary technical manuals for stationary source monitoring and JICA Expert Team consulted with C/Ps. C/Ps and JICA Expert Team agreed on the contents of those manuals. Finally, all necessary technical manuals for the stationary source monitoring (technical deliverables) which are produced by JICA project were completed.

3.1.7.2 On-board Exhaust Gas Measurement Protocol (for Vehicle)

Manuals were prepared in the beginning of this project. The manuals were used for education of the experts of APRD and NAMEM, and confirmed to contain enough information.

3.1.7.3 Air Quality Monitoring Manual for Rehabilitation, Operation and Maintenance

Manuals attached to the analyzers are full and detailed, however, not suitable for the beginners.
According to the discussion with JICA Expert and APRD, the 4 members of APRD wrote the manual based on understandings throughout the OJT education, and updated the contents based on the advice from JICA Expert.

3.1.7.4 Air Quality Monitoring Manual for Integrated Network and Public Dissemination

Manuals attached to the equipment are full and detailed, however not enough for combination of equipment.
According to the discussion with JICA Expert and APRD, manual were compiled for any processes that APRD needed in this project, and combined into one manual.

3.1.7.5 Manual for PM10 and PM2.5 Measurement and their Components Analysis

Manuals of the sampler “FRM-2000i” model and slit jet sampler are translated into Mongolian language.
Manuals for chambers and weighing will be developed.
Manuals to be developed were discussed with CLEM, and C/P agreed with contents of results. Each manual will be combined into one manual.

3.1.7.6 Manual for Making and Updating Emission Source Inventory

“Guideline on Preparing and Revision of Emission Inventory” was elaborated in the Project. Some portions of the manual were not easy to be understood by the new counterparts of the Project. These portions have been updated.

3.1.7.7 Manual for Implementing and Revision Simulation Model

"Guideline on Implementing and Revision of Simulation" was elaborated in Phase 1 of this project. Some portions of the manual were not easy to be understood by the new counterparts of Phase 2. These portions have been updated.

3.1.7.8 Boiler Registration System Guidelines

This guideline was developed as "Regulation for HOB Registration" and "Implementation Plan Approved for HOB Registration", and updated.

3.2 Improvement of Project Implementation Management

Air pollution control measures to be evaluated by the decision makers are discussed and agreed by JCC. Then, the control measures are to be submitted to decision makers by Vice Mayor, and to be approved by decision makers. This is the improved method by which air pollution control measures were evaluated.

According to the regulation on APRD, APRD had allocated one person for each task position. Due to this reason, no one had a chance to study other task position. leading to no one being able to support other task position nor teach new person whenever someone resign from his or her task position. Based on Phase I terminal evaluation results, APRD changed this system to allocate multiple persons to each task position. As a result, all the members of group understood the task, and now able to help each other. Sustainability of each task position has improved.

Recently, APRD often allocates necessary budget for repairing equipment for ambient air monitoring stations and emission measurements, overhaul and consumes. Sustainability is improved in terms of budget allocation.

APRD has developed coordination between professional agencies and decision making agencies, such as providing technical advices for NCAPR in November 2016.

3.3 Cooperation with Ministry of Environment of Japan

Ministry of Environment Japan (MoEJ) and MET agreed to promote capacity development program for developing air pollutant emission inventory in Mongolia, in "8th Japan-Mongolia Environment Policy Dialogue" which was held in 29th, July 2013. JICA Experts of this project and C/P-WG cooperatedly made air pollutant emission inventory guideline in MoEJ project, utilizing knowledge about emission gas measurement and inventory manual which were issued in this project. This guideline and related human resources are succeeded to the cooperation with Clean Air Asia, as described later.

MoEJ conducted Cobenefit-appoach pollution control study project since 2014 until 2016. In the MoEJ project, emission gas measurement equipment which was provided in this project was utilized. APRD proposed to visit the measurement site as a kind of training, but it was rejected. The measured emission data was supposed to be reported to APRD as one of the HOB inspection, but the data hadn't been provided for a half year or more, so it wasn't able to report the result of the measurement in the annual report of IACC. Used equipment became lost temporarily after the measurement, due to lack of communication when returning the equipment. Although there were some small troubles like these, the result of the measurement was utilized for considering control measures.

3.4 Cooperation with UBCAP

3.4.1 Cooperation between the Project and UBCAP

Mr. Todd Johnson was allocated for the position of Mr. Gailius, the World Bank controller for UBCAP. JICA Headquarter had an online TV meeting with the new person in January 2016, to discuss on the cooperation between JICA and UBCAP. The main topics were emission measurement differences between SEET laboratory and APRD, and training course on emission measurement method of APRD for SEET laboratory by OECC.

Budgets for spare parts and periodic replacement parts for NAMEM/CLEM stations were allocated by Mongolian Government in 2014 and 2015. However, the budgets were not implemented in both years. As the results, troubles of some analyzers were not able to be fixed for the last years. In addition, NAMEM began the process to purchase a set of analyzers for new automated air quality monitoring station. However, the purchase was cancelled due to the budget cancel.

In order to solve these problems, NAMEM proposed these plans to UBCAP in the end of 2015. UBCAP requested comments from JICA, and JICA Experts explained the importance. To realize these plans, JICA Expert supported NAMEM to develop detailed plans, as activities for Integrated Ambient Air Quality Monitoring Information System (Activity 2-4), Establishing Unit for Maintenance and Calibration (Activity 2-5) and Supporting New Air Quality Monitoring Station (Activity 2-8). In April 2016, the plan consists of 4 packages as follows; (1) Spare parts for periodical replacement and repair, (2) Additional analyzers for the existing stations (4 sets of PM2.5 analyzer), (3) A full set of analyzers for a new automated station, and (4) A full set of data transfer and management system to replace the existing ones. JICA Experts have supported for planning, such as developing specification.

UBCAP held seminars on FS results of power plants in November 2014. JICA Expert team reviewed on emission measurement method and countermeasures facility of draft final report which had several technical mistakes and reported to UBCAP. Final report in March 2015 which was not considered by JICA Expert, thus the Final report of UBCAP has technical mistakes.

Based on the comparison of vehicle emission measurement data between original and DPF equipped vehicle (Activities 1-10 and 1-13) and control measure development for diesel dust emission (Activity 7-6), UB proposed a project to UBCAP installing DPF suitable for high sulfur diesel oils to city public buses. UBCAP requested comments from JICA, and JICA Experts explained that DPF suitable for high sulfur diesel oils have a large effect on reducing PM emission. Vehicle is out of the scope of UBCAP.

Although UBCAP approached World Bank to allocate the project budget to the DPF project proposed by the deputy mayor, however, the budget was not approved by World Bank.

Based on the budget of UBCAP and examination of Mongolian University of Science and Technology MNS 5041:2001, MNS 5043:2001 and MNS5457:2005 were summarized, and then MNS 5043:2016 was proposed. Through the approval procedure of Mongolia, the proposed MNS was enforced from April 2017.

3.4.2 Discussion on Emission Measurement with UBCAP

The measurement methods on emission gas of new coal fuels between the SEET laboratory of UBCAP and the project do not coincide. JICA Experts proposed that the measurement methods shall be used in combination depending on the measurement target and purpose. However, the Mongolian side was using different measurement methods than proposed by JICA Experts. The measurement method used at SEET laboratory is not approved by international measurement method, thus treatment of measured data in the past might become a problem. JICA Expert Team prepared questionnaire related to the measurement method at SEET laboratory and action will be implemented in correspondence. Since the measurement method should be selected depending on the project purpose, both measurement methods were coexisting in the project.

UBCAP has being measured by using emission gas monitoring other than JIS method in SEET laboratory. UBCAP sounded out the participation in JICA training course on emission gas measurement through the Vice Mayor, in order to obtain deeper understandings of emission measurement by using JIS method. JICA trainings are not conducted to agencies which are not C/P-WG. Therefore, Oversea Environmental Cooperation Center (OECC) is to examine the possibilities of conducting the trainings for UBCAP. A video conference was held with the World Bank, UBCAP, and JICA headquarter in January 2016, and discussed on the provision of equipment for new monitoring station in NAMEM and the connection method to the monitoring network. As of September 2016, the roles of administrative agencies of Mongolian side was not clear due to the change of government party, thus the cooperation with UBCAP and the JICA Expert Team was not able to be conducted.

3.5 Cooperation with TSL (Two Step Loan)

“Two-Step-Loan Project for Small- and Medium-scaled Enterprises Development and Environmental Protection Phase II” has started from July 2011 and implemented for 4 years. In the project, Environmental Protection Loan (EPL) has also started from July 2011 and will continue for 3 years. Mr. Tabata who is in charge of stationary source inventory and simulation participate in this project as environmental advisor has close cooperation with local advisor.

EPL aims to protect air pollution and the targets of the loan include new installation, replacement and production of HOBs, and production of improved fuels from coal, and etc. Environmental guideline was made for eligibility criteria of loan and environmental evaluation, before and after loan disbursement. Loan criteria for HOB include 20 % reduction of coal consumption compared with those before the loan disbursement and more than 75 % combustion efficiency, and they were defined after considering the investigation results from the project.

As cooperation between the projects, the person in charge of TSL accompanied during boiler visit survey of the project at areas where many private HOBs exist. These areas were chosen because private HOBs were the targets of TSL.

Number of EPL in UB City is low and in whole Mongolia is high, and number of renewal and replacement of HOB in UB City is low. Therefore, environmental improving effected was limited. However, EPL loan application for heating system with geothermal heat pump in central prefecture was approved, and the applications of cases with large amount of coal reduction were approved. Air pollution control should be promoted by more introduction of HOB with low pollutant emission and new technology with TSL.

JICA has been preparing for project of Phase III (TSL3), however, Mongolian and IMF are discussing on agreement of loan, and thus the start of the TSL3 is being delayed. TSL3 will be starting from 2018. TSL3 as well as TSL2 will focus on EPL loan.

3.6 Cooperation with Clean Air Asia

Clean Air Asia (CAA) has begun the project of air pollution control measure in Mongolia in November 2016. This project involved the elaboration of air pollutant emission inventory guideline. JICA Expert was supposed to join this project by request from ACAP.

In the interview survey, MET and NAMEM requested to develop the manual for emission inventory for the entire Mongolia. According to the request, ACAP and JICA Expert indicated the list of necessary data to elaborate the manual and agreed to elaborate the manual using the collected data by NAMEM.

Also, regarding the emission inventory guideline elaborated by MoEJ in Japan-Mongolia Environment Policy Dialogue, MET and NAMEM commented the following.

1. Since emission inventory in UB city is used as the base, it is difficult to apply the inventory to other prefecture (aimag)/city.
2. The content of guideline is too high in level to develop emission inventory by only using this guideline.
3. The translation from Japanese to Mongolia is very poor.

In regard to developing emission inventory by CAA, it was agreed with NAMEM that emission amount in the entire Mongolia will be estimated first. Using the country emission as the base, select the region which needs to be estimated in detail, and conduct the method in order to grasp the detailed emission. For emission of the UB city, the estimating method of the emission in this JICA project will be used.

3.7 Cooperation with USA Embassy Mongolia

As reported in PR4, APRD refers PM2.5 air quality data measured by USA Embassy, and presents it in APRD website, with the permission of USA Embassy Mongolia. Since PM2.5 reporting in USA Embassy website is based on US regulation, and against Mongolian regulation, PM2.5 index shown in USA Embassy website is much different from the index shown in Air Quality Smart Control System and APRD websites. . As a result, some Mongolian citizens were confused. The PM2.5 index at USA Embassy shown in APRD website is recalculated by Mongolian regulation.

3.8 Lessons Learned by the Project

(1). Approach to the Decision Making Higher Authorities

NCAPR and CAF were involved for implementing air pollution control measures. Release of SMART and introduction of CEMS were conducted by through NCAPR. On the other hand, CAF was stagnated by administrative revolution.
Even if potential risk existed, the approach to the decision makers is necessary for conducting control measures of air pollution. The close communication among the related agencies for minimum risk is important. It is desirable to allow leeway for cooperation period.

(2). Formulation of C/P-WG

Related agencies such as Ministries, UB City, National Institutes, and power plants, and etc., participated in the Project and formulated C/P-WG. Since approach and control measures for environmental field diverges, it is useful to formulate C/P-WG. Mongolia, which has government agencies in small scale, the network among the related agencies through C/P-WG supplied the limited human resources.

(3). Importance through Standardized Technology

The Project cooperated well with other projects by implementation of Japanese government and JICA. The factors of successful cooperation adopted standardized technology such as emission gas measurement method. Since the methodology was orthodox and universal, other projects were able to utilize the methodology as well.

(4). Importance of Technical Assessment in Setting Indicators

Indicator 7.1 of the Project on MNS emission standard was decided considering political decision without technical examination. Actually, the indicator was impossible to be achieved. When setting the indicators, feedbacks from the Expert judgment are important.

(5). Good Utilization of Training in Japan

Specific issues such as CEMS, emission gas measurement and DPF were set, and the training courses in Japan were designed for solving through preparation of action plan. As the results, the trainees were able to work with concrete issues. The training compared experiences in Japan and situation in Mongolia, considering promotion of the applicability on specific issues in Mongolia.

3.9 Difficulty of Corresponding Special Language

Around 3 interpreters for 14 experts were involved in the project. Practically, the occasions on which direct communications with Mongolian sides in English were limited and the experts had to work with many C/P and C/P-WG members. The number of the interpreter sometimes became limitations for activities of the project.

It was difficult for the JICA Experts to increase the number of interpreters, since the concepts of air pollution control, stack gas measurement, emission inventory and simulation and others were new in Mongolia and the corresponding technical terms in Mongolian did not exist in many cases.

As a result, 3 excellent interpreters such as Mr. Batsukh, Mr. Khishigjargal and Ms. Baasankhuu fully supported us for smooth implementation of the project. Mr. Batsukh was related to the project from the detailed planning survey stage and established close and smooth relationships with many Mongolian members of the organizations. Mr. Khishigjargal was particularly in charge of stack gas measurement and accompanied with the experts on actual stack gas measurement sites. Also, he had to understand principle of stack gas measurement with certain extent and fully helped the experts. Ms. Baasankhuu had finished master course of literature in Japanese university and contributed accurate interpretation and translation.

It was very fortunate for this project to secure 3 excellent interpreters with a series of short-term contracts during long period of 3 years. On the other hand, the 3 interpreters had deeply understood the air pollution control in UB city as well as the technical terms.

Education and securing of capable interpreters in the country of specific language is one of key factors for a success of the project.

4 Future Assignment

4.1 Summary Seminar

A program of summary seminar held on 25th April 2017 is shown in Table 4.1-2. In this seminar, each session was summarized through discussion, and in the last session, project activities and their output, future assignments and prospects for air pollution control measures were discussed and wrapped up as described below.

a. Air Quality Monitoring and Citizen's Awareness Activities

The improvement of the air quality monitoring network has been a big achievement and the stable measurement has contributed to stable publication system for air quality information to citizens. This achievement has raised the interest of the citizens, and led the whole country to work toward improving air pollution problems actively. Sustaining and maintaining stable data supply is a large responsibility of municipality, and securing the necessary budget is important. Mayor and decision makers understand this condition, which makes the daily maintenance possible. However, equipment in air quality station including data transfer system has become old, and are necessary to be renewed.

b. Identification of Emission Sources

Both introduction of technology and professional training of Mongolian experts have strengthened a capacity to identify emission sources. Trained experts are now able to process and arrange data as information. By providing this information to the decision makers, a large cycle of data to the control measures is connected. Until now, control measures have not been prioritized which corresponded to the ineffectiveness. However by organizing the capacities in the field of PM source apportionment, source contribution became clear, and control measures has become possible to be prioritized.

PM source apportionment of this project was carried out as sampling and weighing in UB, and then component analysis in Japan. In order to analyze components, laboratory equipment for PM2.5 component analysis, experts and consumable budgets will be necessary. Since National Program for Air and Environment Pollution Reduction clearly declares the necessity of analysis equipment, component analysis would become viable in future.

c. Capacity Development of HOB Inspection

Full implementation of the boiler registration system became realized by cooperation of APRD, IACC, UB Energy Coordinating Committee (UECC), Engineering Facilities Department of the UB City (EFDUC), and Infrastructure and Urban Improvement Division of districts and Inspectors of districts under "the administrative instruction of boiler inspection and certification". Throughout HOB site survey, the Project Team found some problems in air pollutants emission reduction. For examples, there are dust reduction equipment models of which not only cost but also effect was minimized. It is not rare that HOB user does not maintain dust reduction equipment by which dust emission increased. This information became to be used in IACC's recommendations to HOB operators. However, regarding to emission measurement, count of emission measurement in 2016 winter became half of plan because UB dismissed the last 3 emission measurement experts of APRD, without developing alternative experts. It is necessary to allocate and educate emission measurement experts. Since it may not be easy to change the employment rule for APRD, alternative plan was proposed educating and training emission measurement on any other organization (i.e. IACC) than APRD.

d. Air Pollution by Vehicles

Agendas for evaluation and implementation of effective and viable measures for mobile emission sources were discussed. It is known that suitable DPF reduces 80 to 90% of PM emission and RSD also has the same level of effect. However, for example, introduction of RSD has the feature to require standard such as MNS standard in order to compare measured results. Air pollution from vehicle is a large emission source and further control measures are to be studied. Since technical cooperation in the vehicle pollutant emission has been carried out only by JICA project, further JICA's advice and support were requested.

e. Air Pollution by Ger Stoves

The roadmap for Ger Stoves is shown below. Although gas fuel by coal gasification or DME by coal liquefaction is recommended as long-term air pollution control measures, improved fuel is necessary as the mid-term control measures. For promotion, subsidy is necessary, and emission standards is also required to ban some types of improved fuel which is less effective for air pollution reduction. JICA's cooperation was concluded as necessary to setup effective and feasible emission standard for improved fuel.

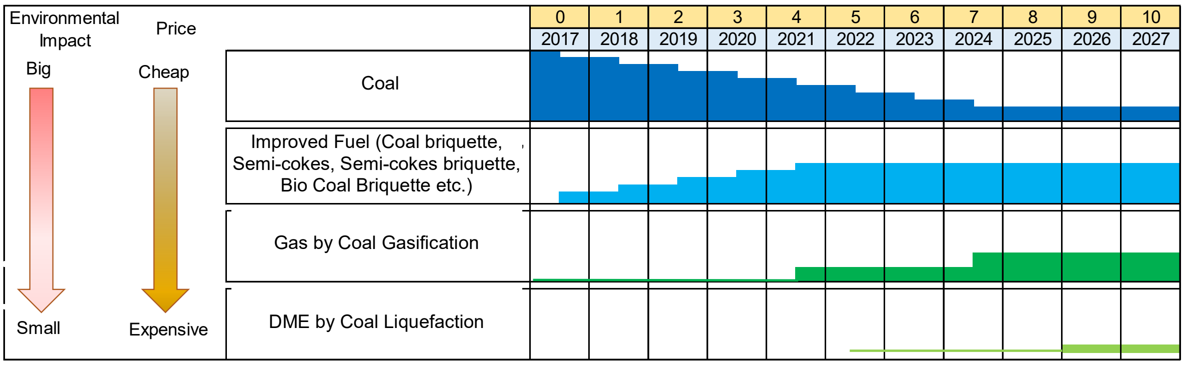


Figure 4.1-1 Roadmap for Ger Stove

f. Air Pollution from HOBs and Power Plants

In the seminar, it was presented that the methodologies to measure and evaluate emissions for stationary sources, especially for HOBs and thermal power plants, were established and effective control measures for emissions were evaluated. For NAMEM, PP4, and APRD, it is important to ensure the necessary budget and to keep their own experts for new staff training. For PP4, the necessity of technical training for maintaining CEMS is also emphasized. Since power plants are the main source of PM10 in UB, it is necessary to monitor and control their emission by CEMS data, and to prepare for the emission reduction planning.

g. Air Pollution Control Measures Evaluated by PM Emission Reduction Cost

Air pollution control measures evaluated by this project are listed in Table 2.10 7. For each proposals, PM emission reduction, air quality improvement and costs are calculated as summarized below.

Table 4.1-1 Cost-Effectiveness for PM Reduction Amount of Air Pollution Control Measures

No	Control Measures		PM10 reduction amount (ton/year)	Maximum ground concentration(μg/m3)			Initial cost of control measures		Control measures cost per ton (Million MNT)	Durable year	Control measures annual cost per ton (Million MNT)	
				Before control measures	After control measures	Capacity of variation	Million MNT	Million Yen			Million MNT	Million Yen
1-1	Introduction of improved fuel (Whole Area)	Household small stove	3,758.62	184.77	137.86	46.91	17,044.9	811.7	4.53	1	4.53	0.21
1-2	Introduction of improved fuel (a part of UB)	Household small stove	549.18	184.77	121.35	63.42	2,913.8	138.8	5.31	1	5.31	0.24
2	Introduction of DPF to Buses	Vehicle exhaust gas	75.90	72.13	46.89	25.24	30,245.4	1,440.3	398.49	10	39.85	1.81
3	Introduction of EURO-IV Buses	Vehicle exhaust gas	77.05	72.13	46.67	25.46	465,403.6	22,162.1	6,040.28	10	604.03	27.43
4	Abolishment of HOB by operating of Amgalan heating facility	HOB	336.75	12.99	10.47	2.52	7,885.8	375.5	23.42	30	0.78	0.04
5	Introduction of cyclone to HOB	HOB	477.23	12.99	8.17	4.82	974.2	46.4	2.04	10	0.20	0.01
6	Introduction of wet scrubber to HOB	HOB	556.94	12.99	5.57	7.42	6,015.0	286.4	10.80	10	1.08	0.05
7	Introduction of low sulfur fuel	Vehicle exhaust gas	154.82	72.13	30.93	41.2	16,195.2	771.2	104.61	1	104.61	4.75
8	Recommendation of eco-drive	Vehicle exhaust gas	122.29	72.13	40.72	31.41	53.0	2.5	0.43	10	0.04	0.00
9	Fuel conversion of coal gas	HOB	364.06	12.99	12.57	0.42	3,791.1	180.5	10.41	30	0.35	0.02
10	Dust collector improvement of PP2 and PP3	Power Plant	12,051.72	32.84	14.06	18.78	25,620.0	1,220.0	2.13	30	0.07	0.00
11	Introduction of low emission vehicle	Vehicle exhaust gas	56.98	72.13	54.12	18.01	932,264.0	44,393.5	16,361.25	10	1,636.12	74.30
12	fire materials of low dust emission	Household small stove	4,052.38	184.77	38.87	145.9	80,844.0	3,849.7	19.95	1	19.95	0.91
13	promotion of apartment construction in Ger Area	Household small stove	2,762.51	184.77	93.85	90.92	1,996,800.0	95,085.7	722.82	30	24.09	1.09
14	Improvement of traffic signal system	Vehicle exhaust gas	20.74	72.13	65.84	6.29	73.7	3.5	3.55	10	0.36	0.02
15	Introduction of RSD	Vehicle exhaust gas	78.07	72.13	51.35	20.78	630.0	30.0	8.07	10	0.81	0.04

PM reduction potential of control measures on coal fuel and vehicle is shown in Figure 4.1-2 and Figure 4.1-3. These are cumulative charts of PM emission reduction and costs, ordered by PM emission reduction ascending.

Control measures for heat source using coal fuel, such as cyclone, coal gas, wet scrubber, switching heat source from HOBs to Amgalan Heat Facility, improved fuel, and duct collector of PP2 and PP3, could be implemented by 61,331 million MNT (2,785 million Yen) as initial cost, and PM10 of 17,545 ton would be reduced.

Control measures of vehicle emission, such as traveling speed by traffic signal control improvement, substituting high emission vehicle with low emission one, installation of suitable DPF to buses, introduction of EURO-IV Buses, banning high emission vehicle by RSD, recommendation of eco-driving and introduction of low sulfur fuel, could be implemented by 1,444,865 million MNT (65,611 million Yen) as initial cost, and PM10 of 585.85 ton would be reduced.

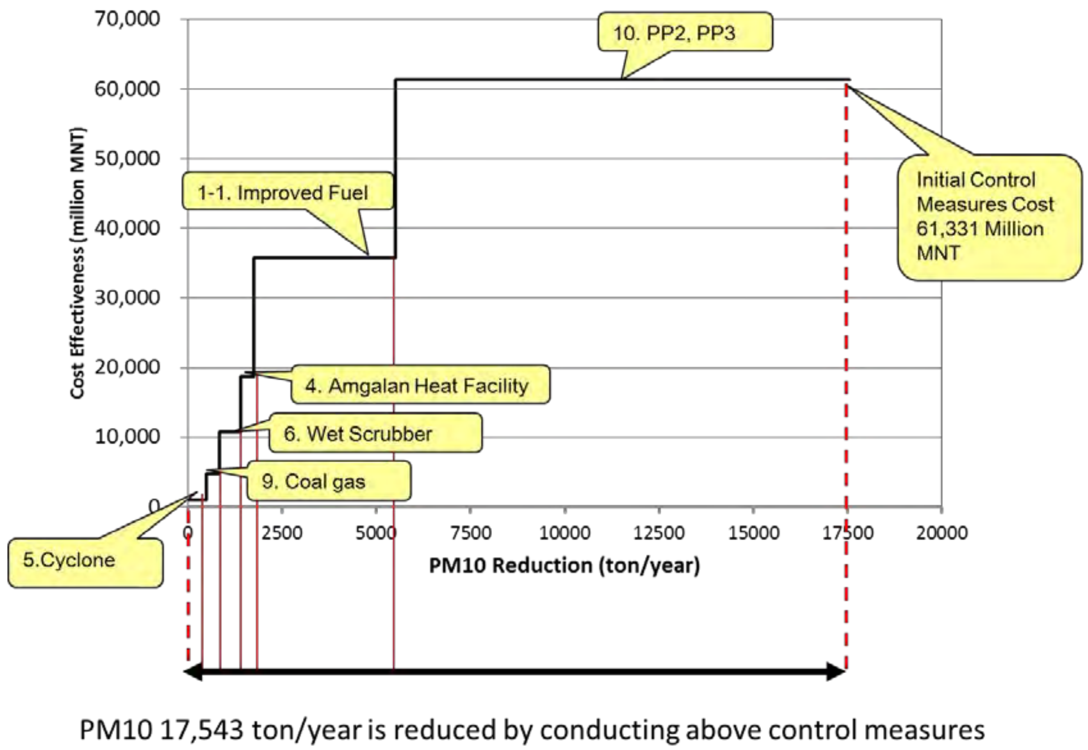


Figure 4.1-2 PM Reduction Potential by Control Measures for Coal Combustion Sources

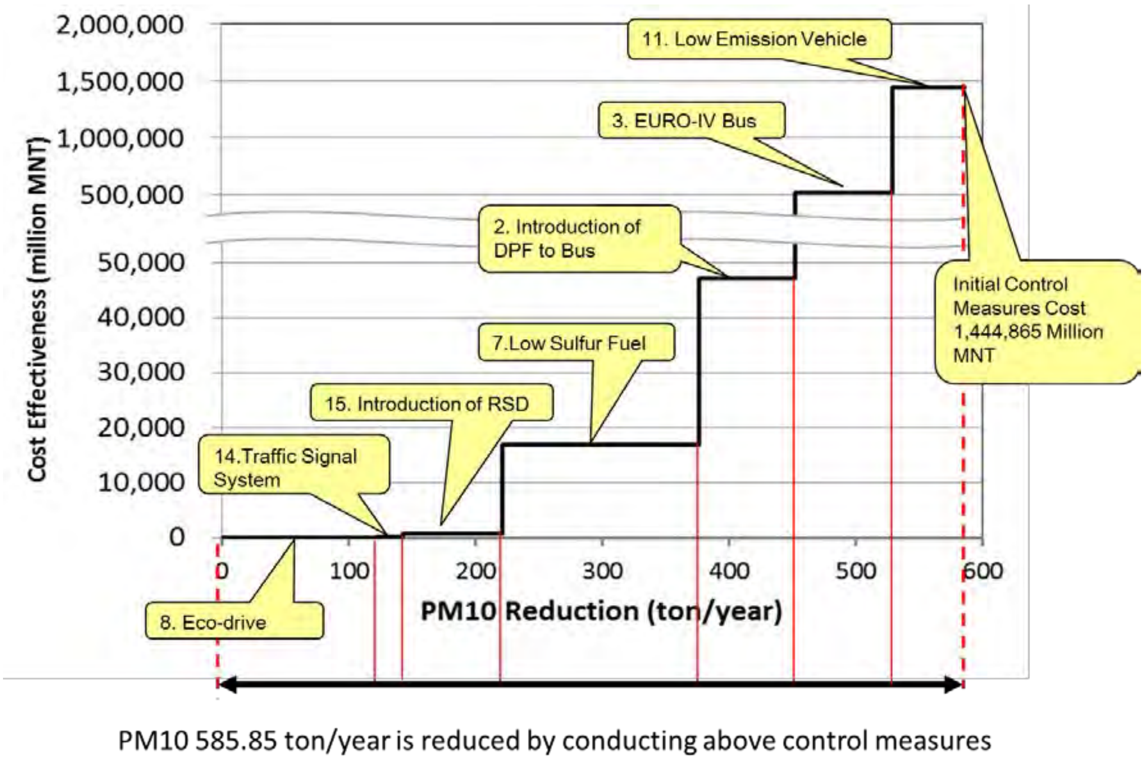


Figure 4.1-3 PM Reduction Potential by Control Measures for Vehicle Exhaust Gas

h. **Arrangement of Assignments for Implementation of Future Air Pollution Control Measures**

Replacement and increment of air quality monitoring stations: NAMEM air quality monitoring stations would be difficult to keep stable continuous measurement. It seemed to become important to adopt the same technical system as the one of APRD from cooperation points of view for maintenance.

Publication method of air quality information: It is desirable that AQI was also published abroad according to the international standards based on the health data. At this moment annual report on air quality was supplied to decision makers and NGO. However NGO and stakeholders including the national congress were shocked by this information and therefore publication method of air quality information should be considered.

Componential analysis of PM: Since JICA Experts analyzed PM components and source apportionment and only the results were supplied in this project, technology transfer is necessary hereinafter. Although component analysis of PM is also expected to check the usage of raw coal which is planned to be banned, it may not be applicable because emission component of raw coal and improved fuels are expected to be similar.

Development of a MNS standard regarding to discharge amount from fuel combustion: Improved fuel is necessary as the mid-term control measures. For its promotion, subsidy is necessary, and emission standards is also required to ban some types of improved fuel which is less effective for air pollution reduction.

Experts for studying possibility of new pollution resulting from implemented measures: There was a comment that DPF may emit dust and dangerous exhaust gas when it will be cleaned, and this requires another study by JICA experts whether one measure for pollution leads to another new pollution. In case of DPF plan proposed, risk in operational failure situation had been evaluated and countermeasure have been already proposed.

Pollution control measures for PP4: Since PP4 has large emission, the reduction of emission must be undertaken, and have enough leeway to conduct the control measure. Electrostatic precipitators have been worked for 35 years, and need to be renewed. Furthermore, since SO2 exceeds its emission standard, desulfurization equipment or desulfurization-denitrification equipment must be installed. Reclaimed land for ash after drying must be also reused in order to reduce reclaimed land. JICA is expected to provide possible cooperation for the control measures which thermal power plants shall cope.

Request of support for technology innovation: Support for technology innovation was strongly requested in order for Mongolian side to achieve their best efforts, and continue their best efforts in the future. However, alternative DPF, which was highly evaluated by Innovation Department of the Capital City, was made of combustible material, and was burnt in its evaluation test. It is necessary to discuss on and identify the field and contents of “technology innovation”.

Table 4.1-2 Summary Seminar Program

Date: April 25th, 2017 (Tue.) 9:00 ~ 17:00 Venue: Meeting room at 1st floor at Fresh water resources, natural maintenance center 1. Opening Remarks (9:00 - 9:10) Deputy Mayor, Mongolian Office of JICA 2. Outline of the project (9:10 - 9:30) Secretary of APRD, Sub project manager (Mr. Tabata) Photographing (9:30 - 9:40) 3. Air quality monitoring and citizen’s awareness activities (9:40 - 10:40) 3.1 Operational condition of APRD air quality monitoring stations (Including revitalization, new installation, and maintenance) Mr. Otgonbayar (APRD) / Mr. Maeda (JICA Expert) 3.2 Operational condition of CLEM air quality monitoring stations (Including maintenance) Mr. Barkhasragchaa (CLEM) / Mr. Maeda (JICA Expert) 3.3 State of the air quality (Including modification of monthly and annual report) Mr. Bayarmagnai (NAMEM) / Mr. Maeda (JICA Expert) 3.4 Publication for air quality state to citizens Mr. Bolor (APRD)/ Mr. Maeda (JICA Expert)

3.5 Discussion regarding to future air quality monitoring system: Mr. Galimbyek (APRD)

4. Identification of emission sources (10:40 - 11:20)
4.1 Analysis of contribution from PM emission sources: JICA team
Mr. Edo (JICA Expert)
4.2 Emission inventories and diffusion simulation
Ms. Narmandakh (APRD) / Mr.Nakata (JICA Expert)
4.3 Discussion regarding to future analysis of contribution from PM emission sources and diffusion simulation:
Dr. Batbayar

Coffee break (11:20 - 11:30)

5. Air pollution by vehicles(11:30 - 12:30)
5.1 Measurement results of onboard emission measurement system for vehicles, and utilization of these measurement data
Mr. Altangerel (APRD) / Mr.Okabe (JICA Expert)
5.2 Description of vehicle emission abatement measures proposed from the Project
Introduction of DEF for public bus, EURO IV bus, low Sulphur fuel and low emission vehicle, Adoption of eco-friendly driving, Introduction of RDS, Improved traffic signal system permitting faster driving, etc.
Mr. Altangerel (APRD) / Mr.Okabe (JICA Expert)
5.3 Discussion regarding to future vehicle emission abatement measures : Mr. Galimbyek (APRD)
5.4 Demonstration of DPF (12:20 - 12:30)

Lunch time (12:30 - 13:20)

6. Air pollution from Ger Stoves (13:20 - 14:00)
6.1 Exhaust gas measurement results using an improved fuel, and measures for Ger Stoves
Ms. Mart / Mr. Endo (JICA Expert)
6.2 Discussion regarding to future Ger Stoves: Ms. Davaasuren (ME)

7. Air pollution from HOB and thermal power plants (14:00 - 15:00)
7.1 Exhaust gas measurement results of HOB
Ms., Urantsetseg / Mr.Tabata (Sub project manager)
7.2 Condition of boiler registration system
Ms. Narangerel (Inspection Agency of the city) / Mr.Tabata (Sub project manager)
7.3 Dust abatement measures by introduction of cyclone and scrubber
Ms. Bat-Oyun (APRD) / Mr.Tabata (Sub project manager)
7.4 The introduction of CEMS at PP4, and information sharing of CEMS data by relevant organizations
Mr. Battuvshin (CHP4) / Mr. Maeda (JICA Expert)
7.5 Abolition of HOB by commissioning of Amgalan district heating facility
Ms. Narmandakh / Mr. Nakata (JICA Expert)
7.6 Discussion regarding to future HOB abatement measures and thermal power plant abatement measures:
Mr. Galimbyek (APRD)

Coffee Break (15:00 - 15:10)

8. Arrangement of assignments for implementation of future air pollution abatement measures (15:10 - 16:50)
Mr. Galimbyek (APRD), Dr. Batbayar (NAMEM) / JICA Experts
- Discussion results and arrangement of assignments
- Assignments for funds on national program for air pollution abatement measures
- Future prospects for air pollution abatement measures and priorities to be implemented

9. Closing remarks (16:50 - 17:00)
Mr. Delgerekh: Secretary of APRD, Mr. Fukayama: Project manager, Mr. Yamada (Senior advisor of JICA)

4.2 Future assignments and prospects for air pollution control measures

At the 10th JCC meeting, the following future assignments and prospects for air pollution control measures presented in the summary seminar were discussed, and discussion result was wrapped up as M/M.

- Air quality monitoring and awareness of the citizens
- Component analysis of PM samples
- Identification of emission sources
- Air pollution control measures for vehicles
- Air pollution control measures for Ger stoves
- Air pollution control measures for HOB and thermal power plants
- Assignments for future implementation measures and their solutions

It is important to enhance the capacity of Mongolian stakeholders in developing and executing air pollution reduction plans. In order to realize this capacity development, it is proposed to execute a pilot project of priority and feasible air pollution reduction plan, validate its effect, and then expand the project utilizing any budget source including post CAF or ADB. For this kind of plan, capacity developed through Phase 1 and Phase 2 of this project are also necessary to be kept and upgraded.

5 Project Inputs

5.1 Activity Schedule

Activity schedule is shown in Table 5.1-1 to Table 5.1-3.

Table 5.1-1 Activity Schedule (1)

Duration	1st year																			2nd year																							
		2014												2015												2016												2017					
Activities	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
For All Outputs																																											
Preparation and Discussion of Work-plan																					=																						
Implementation of Training in Japan												=														=		=															
Implementation of Capacity Assessment																																											
Making of project report																					=																					-	
Explanation of project report	△						△							△					△		△							△						△							△		
Support of supplying equipments			=																			=		=						=													
《Strengthening capabilities for analysis of air quality and emission sources, and for evaluation of air pollution control measures》																																											
Activity 1: Emission source monitoring																																											
【Stationary emission sources monitoring】																																											
1-1 Self-sustained emission measurement is reinforced.																																											
1-2 Capacity for emission measurement required for boiler registration system is developed.																																											
1-3 Capabilities for emission measurement at power plants are strengthened.																																											
1-4 Emission measurement protocol for boiler inspection is developed.																																											
1-5 QA/QC (Quality Assurance/ Quality Control) capabilities on CEMS data are developed at PP4.																																											
1-6 Dedicated unit for maintenance and calibration of CEMS is established by PP4																																											
1-7 Transmission system of CEMS data from PP4 to related organizations (Ulaanbaatar City, Ministry of Environment, Green Development and Tourism, Ministry of Energy) is developed																																											
1-8 Related organizations evaluate CEMS data from PP4.																																											
【Mobile emission sources monitoring】																																											
1-9 In-vehicle equipment for automobile emission measurement is introduced, and appropriate methodology at Ulaanbaatar City and its manual are elaborated.							=																									=											
1-10 Related training for automobile emission measurement is implemented.																																											
1-11 Self-sustained emission measurement operation using in-vehicle equipment is initiated.																																											
【Other emission sources monitoring】																																											
1-12 Monitoring system for ash ponds and road fugitive dust etc. is established.																																											
【Application to technical evaluation for air pollution control measures】																																											
1-13 Effectiveness of air pollution control measures are verified by emission measurement.																																											
Activity 2: Ambient air quality monitoring																																											
【Development of integrated ambient air quality monitoring network for Ulaanbaatar City Area】																																											
2-1 Operational status of existing ambient air quality monitoring stations is reviewed.																																											
2-2 Rehabilitation of existing monitoring stations is implemented.																																											
2-3 QA/QC (Quality Assurance/ Quality Control) capabilities are developed at NAMEM.																																											
2-4 Integrated ambient air quality monitoring information system for AQDCC and NAMEM is developed.																																											
2-5 Dedicated unit for maintenance and calibration of equipment is established by AQDCC and NAMEM.																																											
2-6 Necessary technical manuals for monitoring network are elaborated.																																											
2-7 Ambient air quality monitoring network design is developed and the network design manual is elaborated.																																											
2-8 At least one monitoring station is newly established abased on the network design manual.																																											
【PM10 and PM2.5 measurement and composition analysis】																																											
2-9 Capability for PM10 and PM2.5 measurement is developed at AQDCC and NAMEM.																																											
2-10 Capability for PM10 and PM2.5 composition analysis is developed at NAMEM, related training for AQDCC is implemented.																																											
2-11 Necessary technical manuals and SOPs for PM10 and PM2.5 measurement and composition analysis are elaborated.																																											

Table 5.1-2 Activity Schedule (2)

	Duration	1st year																			2nd year																							
			2014												2015												2016												2017					
	Activities	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Activity 3: Evaluation of pollution structure by integrating emission inventory, simulation model and ambient air quality monitoring																																											
	【Self-reliant and sustained update of emission source inventory/ simulation by Mongolian side】																																											
3-1	Plan for emission inventory continuous update is elaborated.																																											
3-2	Emission inventory is updated using related information such as emission measurement data, boiler registration, automobile registration and relevant statistics.																																											
3-3	Emission estimation of PP4 is refined with CEMS data.																																											
3-4	Reliabilities for ambient air quality monitoring data and emission inventory is reviewed. Preliminary analysis of pollution structure is implemented. Guidelines for these processes are developed.																																											
3-5	Reliabilities of the simulation model are examined by elaborating simulation model for SO2, CO and NOx based on the related data such as updated emission inventory and ambient air quality monitoring data.																																											
	【Analysis on discrepancy between PM10 air quality monitoring result and simulation model】																																											
3-6	PM10 simulation model is restructured by taking into account of secondary particles originated from SO2, NOx based on updated emission inventory.																																											
3-7	Mechanism for PM10 formation at Ulaanbaatar City is studied.																																											
3-8	PM10 pollution sources are identified by taking into account of dust emission and precursors such as SO2, NOx and others.																																											
	【Application for technical evaluation of air pollution control measures】																																											
3-9	Air pollution control measures are reviewed and developed for PM10 and other pollutants which are not achieving ambient air quality standards, based on discussion with the Mongolian side and Japanese experts.																																												
3-10	Those pollution control measures are technically evaluated based on updated emission inventory, simulation model, and ambient air quality monitoring.																																											
	《Air pollution control strategy, policy and decision making》																																											
	Activity 4: Decision making process improvement for air pollution control																																											
4-1	Decision making process in air pollution control utilizes improved information and technical capabilities of AQDCC, NAMEM and the relevant agencies.																																											
4-2	Communication between decision makers, AQDCC and NAMEM is strengthened by establishing periodical air quality reports.																																											
4-3	Members of C/P and C/P-WG study legal and administrative framework for air pollution control by comparing Japan and Mongolia in training program in Japan and seminar in Ulaanbaatar City.																																												
4-4	AQDCC and NAMEM provide technical advices on air pollution control measures for decision makers.																																											
	Activity 5: Public awareness program and advisory system for citizen in Ulaanbaatar city on air pollution																																											
5-1	Dissemination of air quality information and advisory services are provided through operation of integrated air quality monitoring network.																																											
5-2	AQDCC and C/P-WG implement public awareness program for citizens.																																											
5-3	Communication between citizens and AQDCC on air pollution is strengthened.																																											
5-4	AQDCC and C/P-WG implement seminars and symposium for professionals on status of air pollution and project activities.																																											
5-5	Newsletters, publication, and media are utilized for disseminating project activities.																																											
	《Evaluation of air pollution control measures》																																											
	Activity 6: Technical evaluation of air pollution control measures.																																											
6-1	On-going process for appraising air pollution control measures at CAF and the relevant agencies is reviewed.																																											
6-2	Technical guideline to appraise air pollution control projects is developed.																																											
6-3	Technical abilities of AQDCC, NAMEM, scholars and professionals are utilized in the appraisal process of air pollution control projects.																																											

Table 5.1-3 Activity Schedule (3)

No.	Activities \ Duration	1st year																			2nd year																							
			2014												2015												2016												2017					
		12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	《Implementation of air pollution control measures》																																											
	Activity 7: Regulation and control for emission reduction																																											
	[Full implementation of the boiler registration system]																																											
7-1	Obligatory emissions measurement at HOB and other boilers is phased in.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																								
7-2	MNS emission standards compliance at HOBs and other boilers is reviewed through boiler inspection based on the developed protocol (see Activity1-4).																					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7-3	"Permissions to operate" (or "good boiler certifications") are issued to the boilers which satisfy conditions.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	[Proposal for MNS revision]																																											
7-4	Appropriateness and relevance of MNS including parameters and values for regulation, and measurement methods are examined. If necessary, revision of MNS is proposed.																										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7-5	Draft MNS revision for improved fuel is elaborated.																						■	■	■	■	■	■	■	■	■	■												
	[Mobile sources and other sources]																																											
7-6	Control measures including regulation for mobile emission sources and other sources are elaborated.																						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
	[Utilization of CEMS data]																																											
7-7	Related organizations compile and utilize CEMS data from PP4 and enhance air pollution control measures by power plants.																														■	■	■	■	■	■	■	■	■	■	■	■		
	Activity 8: Enhancement for emission control measures at major polluters																																											
8-1	JICA experts assist entities (power plants, HOB, industries, and others) of pollution sources to elaborate air pollution control measures.			■		■		=				■	■	■	=	■		■					■	■	■		■	■	=						■		■	=						
8-2	Emission source monitoring for power plants (boilers and ash ponds) No.4, No.3 and No.2 are strengthened. Air pollution control measures are discussed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■									
8-3	PP4 investigate operation improvement and draft air pollution control measures, and share the information among power plants.																															■	■	■	■	■	■	■	■					
8-4	Air pollution control measures for mobile sources and other sources are enhanced.Air pollution control measures for mobile sources and other sources are enhanced.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
	《Development of air quality management cycle》																																											
	Activity 9: Development of air quality management cycle																																											
9-1	Agreement on responsibilities of professional agencies (AQDCC and NAMEM) related to emission inventory and simulation is concluded.	■	■	■	■	■	■	■	■	■	■	■	■															■	■	■	■	■	■											
9-2	Coordinating mechanism of AQDCC and NAMEM for integrated air quality monitoring network at Ulaanbaatar City Area is established.	■	■	■	■	■	■	■	■	■	■	■	■										■	■	■																			
9-3	Coordinating mechanism of professional agencies and NCAPR is established.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9-4	Coordinating mechanism of professional agencies and CAF is established.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9-5	Coordinating mechanisms of professional agencies and relevant authorities for inspection of emission sources are established					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
9-6	Coordinating mechanism of Ulaanbaatar City, Ministry of Environment, Green Development and Tourism, Ministry of Energy and power plants is developed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									

Legend ——preparatory work ■ activites in Mongolia = activities in Japan △Explanation of project report -- Other work

5.2 Project Participants of Mongolian Side

Project participants of Mongolian side are shown in Table 5.2-1.

Table 5.2-1 Project Participants of Mongolian Side

Activity	Name	Organization
All Outputs		
Project Director	Mr. Mandakh DELGEREKH	APRD
Project Manager	Mr. A. AMARSAIKHAN	APRD
Output 1: Capability of emission source monitoring is strengthened.		
Stationary Source Monitoring	Mr. S. BATSAYA	APRD
	Ms. G. URANTSETSEG	APRD
	Mr. M. OTGONBAYAR	APRD
	Mr. A. BATTUVSHIN	PP4
	Mr. Ts. NATSAGDORJ	PP4
	Mr. S. BOLDSAIKHAN	PP3
Mobile Source Monitoring	Mr. O. ALTANGEREL	APRD
	Mr. A. TSATSRAL	APRD
	Ms. S. ENKHMAA	CLEM
	Mr. S. MUNKHSAIKHAN	NAMEM
	Mr. D. TUMENDELGER	CLEM
Other Area Sources	Mr. B. BOLOR	APRD
	Ms. S. ENKHMAA	CLEM
Verification of Effectiveness of Air Pollution Control Measures	Ms. L. NARMANDAKH	APRD
	Ms. U. ODONBILEG	APRD
	Ms. S. ENKHMAA	CLEM
	Mr. S. MUNKHSAIKHAN	NAMEM
	Mr. B. BUYANTOGTOKH	IMHE
Output 2: Capability of ambient air quality monitoring is strengthened.		
Development of Air Quality Monitoring Network / PM10/PM2.5 measurement and Analysis	Mr. M. OTGONBAYAR	APRD
	Ms. L. NARMANDAKH	APRD
	Ms. D. SANCHIRBAYAR	APRD
	Ms. N. ORKHON	APRD
	Ms. S. MART	APRD
	Ms. S. ENKHMAA	CLEM
	Mr. B. BARKHASRAGCHAA	CLEM
	Ms. Sh. NYAMDAVAA	NAMEM
	Mr. J. BAYARMAGNAI	NAMEM

Output 3: Capability to evaluate pollution structure is strengthened by integrating emission inventory, simulation model and ambient air quality monitoring.		
Emission Inventory / Simulation Model / Analysis on PM10	Ms. L. NARMANDAKH	APRD
	Ms. U. ODONBILEG	APRD
	Ms. S. ENKHMAA	CLEM
	Ms. Sh. NYAMDAVAA	NAMEM
	Mr. B. BUYANTOGTOKH	IMHE
Application for technical evaluation of air pollution control measures	Ms. L. NARMANDAKH	APRD
	Ms. S. ENKHMAA	CLEM
	Ms. Sh. NYAMDAVAA	NAMEM
	Mr. S. MUNKHSAIKHAN	NAMEM
	Mr. B. BUYANTOGTOKH	IMHE
Output 4: Decision making process for air pollution control is improved, by utilizing technical abilities of AQDCC and the relevant agencies.		
	Mr. Kh. GALIMBYEK	APRD
	Ms. L. NARMANDAKH	APRD
	Mr. J. BATBAYAR	NAMEM
	Ms. S. ENKHMAA	CLEM
	Ms. Sh. NYAMDAVAA	NAMEM
Output 5: AQDCC and the relevant agencies promote public awareness program and implement advisory system for citizen in Ulaanbaatar city on air pollution.		
	Ms. L. NARMANDAKH	APRD
	Ms. B. BAYARMAA	APRD
	Ms. N. NAASANJARGAL	APRD
	Ms. S. ENKHMAA	CLEM
	Ms. Sh. NYAMDAVAA	NAMEM
	Mr. J. BAYARMAGNAI	NAMEM
Output 6: Capability of technical evaluation of air pollution control measures is strengthened.		
	Ms. S. ENKHMAA	CLEM
	Mr. G. OYUNBILEG	CAF
Output 7: Capability of AQDCC and the related agencies to regulate and to control emission sources is strengthened.		
Boiler registration system	Mr. S. BATSAYA	APRD
	Ms. G. BAT-OYUN	APRD
	Ms. N. NARANGEREL	IACC

	Mr. G. MARGAD	APES
Proposal for MNS revision	Mr. Kh. GALIMBEK	APRD
	Mr. J. BATBAYAR	NAMEM
	Ms. S. ENKHMAA	CLEM
Mobile sources and other sources	Mr. O. ALTANGEREL	APRD
	Mr. P. MUNKHBAT	MRT
	Mr. D. ERDENEBAT	PTDCC
	Mr. D. TUMENDELGER	CLEM
	Ms. S. ENKHMAA	CLEM
Output 8: Emission control measures at major polluters are enhanced by AQDCC and the related agencies.		
	Mr. Kh. GALIMBEK	APRD
	Mr. J. BATBAYAR	NAMEM
	Ms. S. ENKHMAA	NAMEM
	Mr. G. MUNKHBOLD	PP2
	Mr. S. BODLSAIKHAN	PP3
	Mr. G. GALBADRAKH	PP4
	Mr. Ts. NATSAGDORJ	PP4
	Mr. B. BATTSEREN	PP4
	Mr. G. BATSAIKHAN	PP4
	Ms. S. UUGANTSETSEG	PP4
Output 9: Coordinating mechanism by AQDCC and the related agencies for output 1 to 8 are developed		
	Mr. Kh. GALIMBEK	APRD
	Mr. J. BATBAYAR	NAMEM
	Ms. S. ENKHMAA	CLEM
	Mr. G. MUNKHBOLD	PP2
	Mr. S. BODLSAIKHAN	PP3
	Mr. G. GALBADRAKH	PP4
	Mr. Ts. NATSAGDOR	PP4
	Mr. B. BATTSEREN	PP4
	Mr. G. BATSAIKHAN	PP4
	Ms. S. UUGANTSETSEG	PP4

5.3 Expert Dispatch Records

Japanese expert dispatch schedules table are shown in Table 5.3-1. Experts' assign plan and result table is shown in Table 5.3-2 and Table 5.3-3.

Table 5.3-1 Expert Dispatch Schedule Table

Name of Expert	Specialty	Period	Total M/M
Akeo FUKAYAMA	Chief Adviser	2013/12/15 – 2013/12/21: 7 Days 2014/1/15 – 2014/1/25: 11 Days 2014/2/25 – 2014/3/1: 5 Days 2014/4/17 – 2014/4/26: 10 Days 2014/5/29 – 2014/6/3: 6 Days 2014/6/26 – 2014/7/9: 14 Days 2014/8/6 – 2014/8/10: 4 Days 2014/10/15 – 2014/10/24: 10 Days 2014/12/4 – 2014/12/10: 7 Days 2014/12/16 – 2014/12/19: 4 Days 2015/2/8 – 2015/2/14: 7 Days 2015/2/21 – 2015/2/28: 8 Days 2015/4/15 – 2015/4/23: 9 Days 2015/5/26 – 2015/5/30: 5 Days 2015/6/7 – 2015/6/13: 7 Days 2015/9/18 – 2015/10/1: 14 Days 2015/11/1 – 2015/11/14: 14 Days 2015/12/6 – 2015/12/12: 7 Days 2016/1/6 – 2016/1/10: 5 Days 2016/1/31 – 2016/2/4: 5 Days 2016/4/29 – 2016/5/5: 7 Days 2016/5/19 – 2016/5/24: 6 Days 2016/9/11 – 2016/9/17: 7 Days 2016/10/4 – 2016/10/6: 3 Days 2016/10/9 – 2016/10/16: 7 Days 2016/12/11 – 2016/12/22: 12 Days 2017/1/19 – 2017/1/28: 10 Days 2017/3/19 – 2017/3/23: 5 Days 2017/4/24 – 2017/5/1: 8 Days 2017/5/22 – 2017/5/29: 8 Days	7.76

Toru TABATA	Sub-chief Adviser / Air Pollution Control Measures 1	2014/1/11 – 2014/1/25: 15 Days 2014/4/9 – 2014/4/24: 16 Days 2014/5/25 – 2014/5/31: 7 Days 2014/6/19 – 2014/7/4: 16 Days 2014/8/10 – 2014/8/24: 15 Days 2014/9/23 – 2014/10/3: 11 Days 2014/11/9 – 2014/11/20: 12 Days 2014/12/7 – 2014/12/20: 14 Days 2015/2/21 – 2015/3/7: 15 Days 2015/4/4 – 2015/4/23: 20 Days 2015/5/29 – 2015/6/14: 17 Days 2015/8/29 – 2015/9/8 and 2015/9/24 – 2015/10/15 : 33 Days 2015/11/1 – 2015/11/14: 14 Days 2015/12/3 – 2015/12/15: 13 Days 2016/1/9 – 2016/1/16: 8 Days 2016/2/26 – 2016/3/6: 10 Days 2016/3/26 – 2016/4/7: 13 Days 2016/4/21 – 2016/5/6: 16 Days 2016/5/14 – 2016/5/27: 14 Days 2016/6/8 – 2016/6/19: 12 Days 2016/9/10 – 2016/9/18: 9 Days 2016/10/1 – 2016/10/6: 6 Days 2016/10/9 – 2016/10/15: 7 Days 2016/12/25 – 2016/12/29: 5 Days 2017/1/11 – 2017/1/29: 19 Days 2017/3/11 – 2017/3/23: 13 Days 2017/4/8 – 2017/4/28: 21 Days 2017/5/22 – 2017/5/31: 10 Days	12.70
Hajime ENDO	Air Pollution Control Measures 2	2014/8/16 – 2014/8/22: 7 Days 2014/9/22 – 2014/10/21: 30 Days 2014/12/13 – 2014/12/18: 6 Days 2015/1/18 – 2015/1/24: 7 Days 2015/5/6 – 2015/6/2: 28 Days 2015/6/7 – 2015/6/13: 7 Days 2015/8/22 – 2015/8/29: 8 Days 2015/9/13 – 2015/9/25: 13 Days 2015/11/11 – 2015/11/20: 10 Days 2016/4/13 – 2016/4/20: 8 Days	6.53

		2016/5/19 – 2016/5/25: 7 Days 2016/9/4 – 2016/9/28: 25 Days 2016/12/16 – 2016/12/26: 11 Days 2017/3/20 – 2017/3/31: 12 Days 2017/4/17 – 2017/5/3: 17 Days	
Toshiharu OCHI	Emission Measurement for Stationary Sources 1 /Ambient Air Quality Monitoring 1 / PM10 and PM2.5 measurement and composition analysis 2	2013/12/29 – 2014/1/26: 29 Days 2014/3/23 – 2014/4/5: 14 Days 2014/8/6 – 2014/10/4:60 Days 2014/11/23 – 2014/12/20: 28 Days 2015/3/11 – 2015/4/9: 30 Days 2015/4/24 – 2015/6/11: 43 Days 2015/8/22 – 2015/9/10: 20 Days 2015/11/29 – 2015/12/16 and 2015/12/25 – 2015/12/28: 22 Days 2016/2/13 – 2016/2/19: 7 Days 2016/2/25 – 2016/3/25: 30 Days 2016/4/3 – 2016/4/30: 28 Days 2016/5/29 – 2016/6/18: 21 Days 2016/8/27 – 2016/9/11: 16 Days 2016/11/9 – 2016/12/8: 30 Days 2017/1/14 – 2017/2/12: 30 Days 2017/3/19 – 2017/4/8: 21 Days	14.30
Natsuji SAWAKI	Emission Measurement for Stationary Sources 2	2014/12/7 – 2014/12/20: 14 Days 2015/3/4 – 2015/4/2: 30 Days 2015/8/23 – 2015/9/2: 11 Days 2015/9/16 – 2015/10/2: 17 Days 2015/10/12 – 2015/10/31: 20 Days 2015/11/9 – 2015/11/17 and 2015/11/29 – 2015/12/11: 22 Days 2016/1/11 – 2016/2/5: 26 Days 2016/6/6 – 2016/6/19: 14 Days 2016/9/14 – 2016/9/28: 15 Days 2016/10/20 – 2016/10/29: 10 Days 2016/11/21 – 2016/12/16: 26 Days 2017/1/8 – 2017/1/27: 20 Days 2017/2/8 – 2017/2/24: 17 Days 2017/3/13 – 2017/3/29: 17 Days	8.64
Tadayoshi USUI	Emission Measurement for Stationary Sources 3	2014/2/23 – 2014/3/15: 21 Days 2014/11/1 – 2014/11/15: 15 Days	6.53

		2015/1/25 – 2015/2/14: 21 Days 2015/3/1 – 2015/3/15: 15 Days 2015/11/29 – 2015/12/12: 14 Days 2016/1/10 – 2016/2/6: 28 Days 2016/2/15 – 2016/2/24: 10 Days 2016/12/4 – 2016/12/24: 21 Days 2017/1/8 – 2017/2/3: 27 Days 2017/2/12 – 2017/2/24: 13 Days 2017/3/7 – 2017/3/17: 11 Days	
Atsushi SATO	Automobile Emission Measurement 1 / Mobile Source Control	2013/12/19 – 2013/12/24: 6 Days 2014/5/25 – 2014/5/31: 7 Days 2014/10/1 – 2014/10/18: 18 Days 2015/4/12 – 2015/5/7: 26 Days 2015/8/30 – 2015/9/12: 14 Days 2015/10/11 – 2015/10/24: 14Days 2015/12/13 – 2015/12/23: 11 Days 2016/9/18 – 2016/10/1: 14 Days 2016/12/28 – 2016/1/11: 15 Days 2017/4/10 – 2017/4/14: 5 Days 2017/5/1 – 2017/5/8: 8 Days	4.60
Jun OKABE	Automobile Emission Measurement 2	2013/12/19 – 2013/12/24: 6 Days 2014/5/25 – 2014/5/31: 7 Days 2014/8/10 – 2014/8/30: 21 Days 2014/10/1 – 2014/10/18: 18 Days 2015/4/12 – 2015/5/2: 21 Days 2015/8/23 – 2015/9/12: 21 Days 2016/4/10 – 2016/4/30: 21 Days 2017/1/11 – 2017/1/27: 17 Days 2017/4/10 – 2017/4/26: 17 Days	4.96
Ryuta NITTA	Automobile Emission Measurement 3	2014/5/25 – 2014/5/31: 7 Days 2014/8/10 – 2014/8/30: 21 Days 2014/10/1 – 2014/10/18: 18 Days 2015/4/12 – 2015/5/2: 21 Days 2016/8/4 – 2016/8/9: 6 Days	2.43
Fumihiko KUWAHARA	Other Emission Source Monitoring	2014/4/13 – 2014/4/26: 14 Days 2014/10/19 – 2014/11/1:14 Days 2015/4/11 – 2015/4/25: 15 Days 2015/8/23 – 2015/9/6: 15 Days 2016/3/26 – 2016/4/9:15 Days	3.03

		2016/8/23 – 2016/9/9: 18 Days	
Hitoshi YURA	Ambient Air Quality Monitoring 2	2014/1/8 – 2014/1/25: 18 Days 2014/6/17 – 2014/7/8: 22 Days 2014/12/11 – 2015/1/9: 30 Days 2015/4/15 – 2015/5/4: 20 Days 2015/9/12 – 2015/10/11: 30 Days 2016/1/6 – 2016/2/4: 30 Days	5.00
Ei EDO	Data Analysis for Ambient Air Quality Monitoring	2014/4/13 – 2014/4/26: 14 Days 2015/3/28 – 2015/4/18: 22 Days 2015/5/6 – 2015/5/21: 16 Days 2015/9/14 – 2015/10/3: 20 Days 2015/10/15 – 2015/10/28: 14 Days 2016/1/24 – 2016/2/7: 15 Days 2016/5/15 – 2016/6/4: 21 Days 2016/9/4 – 2016/9/17: 14 Days 2016/11/6 – 2016/11/19: 14 Days 2017/4/17 – 2017/4/28: 12 Days 2017/5/24 – 2017/5/31: 8 Days	5.66
Akira MIZOHATA	PM10 and PM2.5 measurement and composition analysis 1	2014/1/12 – 2014/1/25: 14 Days 2014/4/17 – 2014/4/26: 10 Days 2014/12/7 – 2014/12/20: 14 Days 2015/4/12 – 2015/4/26: 15 Days 2015/10/25 – 2015/11/5: 12 Days 2016/1/24 – 2016/2/6: 14 Days 2016/9/6 – 2016/9/17: 12 Days 2017/5/22 – 2017/5/31: 10 Days	3.37
Hiroyuki MAEDA	Emission Source Inventory / Ambient Air Quality Monitoring 3 / Evaluation of Air Pollution Control Measures 2 / Public awareness and advisory system	2014/1/19 - 2014/1/25: 7 Days 2014/2/25 – 2014/3/1: 5 Days 2014/6/26 – 2014/7/10: 15 Days 2014/11/24 – 2014/12/27: 34 Days 2015/4/4 – 2015/5/3: 30 Days 2015/8/23 - 2015/9/1: 10 Days 2015/10/25 – 2015/11/21: 28 Days 2015/12/17 – 2015/12/26: 10 Days 2016/1/15 – 2016/2/7: 24 Days 2016/2/22 – 2016/2/28: 7 Days 2016/5/10 – 2016/5/13: 4 Days 2016/6/5 – 2016/6/19: 15 Days	8.03

		2016/9/22 – 2016/10/3: 12 Days 2017/1/18 – 2017/1/28: 11 Days 2017/4/21 – 2017/5/8: 18 Days 2017/5/14 – 2017/5/24: 11 Days	
Shinya NAKATA	Air Pollution Simulation Modeling	2014/4/13 – 2014/5/1: 19 Days 2014/12/3 – 2014/12/18: 16 Days 2015/1/11 – 2015/1/24: 14 Days 2015/4/18 – 2015/5/2: 15 Days 2015/5/25 – 2015/6/6: 13 Days 2015/10/15 – 2015/10/28: 14 Days 2016/1/24 – 2016/2/7: 15 Days 2016/5/15 – 2016/6/11: 28 Days 2016/9/4 – 2016/10/1: 28 Days 2016/12/7 – 2016/12/22: 16 Days 2017/2/1 – 2017/2/18: 18 Days 2017/3/8 – 2017/4/1: 25 Days 2017/4/17 – 2017/4/28: 12 Days	7.77
Yasufumi NAKAJIMA	Power Plant Control Measures 1	2014/5/25 – 2014/6/8: 15 Days 2015/3/1 – 2015/3/15: 15 Days	1.00
Nobuchika KOIZUMI	Power Plant Control Measures 2	2014/5/25 – 2014/6/8: 15 Days 2015/5/11 – 2015/5/16: 6 Days 2016/3/17 – 2016/3/26: 10 Days 2016/10/3 – 2016/10/19: 17 Days 2016/10/25 – 2016/10/29: 5 Days 2017/1/16 – 2017/1/28: 13 Days	2.20
Masanori EBIHARA	Industry and HOB Control Measures	2014/3/2 – 2014/3/15: 14 Days 2015/1/18 – 2015/1/31: 14 Days 2015/3/8 – 2015/3/21: 14 Days 2016/3/20 – 2016/4/2: 14 Days 2016/5/15 – 2016/5/21: 7 Days 2017/1/8 – 2017/1/14: 7 Days 2017/2/11 – 2017/2/24: 14 Days	2.80
Nobuhiro KOYANAGI	Coal Combustion Technology 1	2015/5/6 – 2015/5/24: 19 Days 2016/9/4 – 2016/9/16: 13 Days 2016/12/16 – 2016/12/26: 11 Days 2017/3/20 – 2017/3/31: 12 Days 2017/4/18 – 2017/4/25: 8 Days	2.10
Shinji TOMITA	Coal Combustion Technology 2	2014/10/9 – 2014/10/23: 15 Days 2015/9/22 – 2015/10/3: 12 Days	1.23

		2016/9/21 – 2016/9/30: 10 Days 2017/3/xx – 2017/3/xx: xx Days	
Tatsuhito NAKANO	Coal Combustion Technology 3	2014/10/9 – 2014/10/29: 21 Days	0.70
Shigeo FUJII	Evaluation of Air Pollution Control Measures 1	2015/2/21 – 2015/3/7: 15 Days 2015/4/11 – 2015/4/25: 15 Days 2016/2/22 – 2016/3/5: 13 Days 2016/11/19 – 2016/12/4: 16 Days 2017/1/14 – 2017/1/29: 16 Days	2.50
Katsutoshi NISHIURA	Supporting Air Pollution Control Measures 1	2017/3/20 – 2017/3/24: 5 Days	0.17
Kiyoshi UMEZAWA	Supporting Air Pollution Control Measures 2	2017/3/20 – 2017/3/24: 5 Days	0.17
Atsushi MURAI	Boiler Registration System	2014/4/13 – 2014/5/3: 21 Days 2014/6/24 – 2014/7/6: 13 Days 2014/8/4 – 2014/8/24: 21 Days 2014/10/27 – 2014/11/16: 21 Days 2015/2/8 – 2015/2/15: 8 Days 2015/3/28 – 2015/4/11: 15 Days 2015/5/24 – 2015/6/13: 21 Days	4.00

Table 5.3-2 The Assignment Plan and Result of the Experts (1st Fiscal Year)

Name of Expert (Specialty)	Rank		Trip Count	Days Total	MM Total
Akeo FUKAYAMA (Chief Adviser)	2	Plan	14	112	3.73
		Result	15	115	3.83
Toru TABATA (Sub-chief Adviser / Air Pollution Control Measures 1)	2	Plan	9	149	4.97
		Result	11	158	5.27
Hajime ENDO (Air Pollution Control Measures 2)	2	Plan	4	95	3.17
		Result	6	85	2.83
[illegible] (Emission Measurement for Stationary Sources 1 / Ambient Air Quality Monitoring 1 / PM10 and PM2.5 measurement and composition analysis 2)	3	Plan	6	210	7.00
		Result	6	204	6.80
Natsuji SAWAKI (Emission Measurement for Stationary Sources 2)	4	Plan	2	44	1.47
		Result	2	44	1.47
Tadayoshi USUI (Emission Measurement for Stationary Sources 3)	4	Plan	4	72	2.40
		Result	4	72	2.40
Atsushi SATO (Automobile Emission Measurement 1 / Mobile Source Control)	3	Plan	4	45	1.50
		Result	4	57	1.90
Jun OKABE (Automobile Emission Measurement 2)	4	Plan	5	81	2.70
		Result	5	73	2.43
Ryuta NITTA (Automobile Emission Measurement 3)	4	Plan	3	66	2.20
		Result	4	67	2.23
Fumihiko KUWAHARA (Other Emission Source Monitoring)	4	Plan	4	60	2.00
		Result	3	43	1.43
Hitoshi YURA (Ambient Air Quality Monitoring 2)	4	Plan	4	90	3.00
		Result	4	90	3.00
Ei EDO (Data Analysis for Ambient Air Quality Monitoring)	4	Plan	2	45	1.50
		Result	3	52	1.73
Akira MIZOHATA (PM10 and PM2.5 measurement and composition analysis 1)	2	Plan	4	60	2.00
		Result	4	53	1.77
Hiroshi MAEDA (Emission Source Inventory / Ambient Air Quality Monitoring 3 / Evaluation of Air Pollution Control Measures 2 / Public awareness and advisory system)	3	Plan	4	120	4.00
		Result	5	91	3.03
Shinya NAKATA (Air Pollution Simulation Modeling)	4	Plan	3	60	2.00
		Result	5	77	2.57
Yasufumi NAKAJIMA (Power Plant Control Measures 1)	3	Plan	2	30	1.00
		Result	2	30	1.00
Nobuchika KOIZUMI (Power Plant Control Measures 2)	3	Plan	3	45	1.50
		Result	2	21	0.70
Masanori EBIHARA (Industry and HOB Control Measures)	3	Plan	3	42	1.40
		Result	3	42	1.40
Nobuhiro KOYANAGI (Coal Combustion Technology 1)	3	Plan	1	19	0.63
		Result	1	19	0.63
Shinji TOMITA (Coal Combustion Technology 2)	4	Plan	1	15	0.50
		Result	1	15	0.50
Tatsuhito NAKANO (Coal Combustion Technology 3)	5	Plan	1	21	0.70
		Result	1	21	0.70
Shigeo FUJII (Evaluation of Air Pollution Control Measures 1)	3	Plan	2	30	1.00
		Result	2	30	1.00
Atsushi MURAI (Boiler Registration System)	3	Plan	5	120	4.00
		Result	7	120	4.00
Total		Plan		1631	54.37
		Result		1579	52.62

Legend: Result (black bar), Plan (blue bar)

Table 5.3-3 The Assignment Plan and Result of the Experts (2nd Fiscal Year)

Name of Expert (Specialty)	Rank		Trip Count	Days Total	MM Total
Akeo FUKAYAMA (Chief Adviser)	2	Plan	16	126	4.20
		Result	15	118	3.93
Toru TABATA (Sub-chief Adviser / Air Pollution Control Measures 1)	2	Plan	14	203	6.77
		Result	17	223	7.43
Hajime ENDO (Air Pollution Control Measures 2)	2	Plan	9	135	4.50
		Result	9	111	3.70
Toshiharu OCHI (Emission Measurement for Stationary Sources 1 /Ambient Air Quality Monitoring 1 / PM10 and PM2.5 measurement and composition analysis 2)	3	Plan	9	225	7.50
		Result	10	225	7.50
Natsuji SAWAKI (Emission Measurement for Stationary Sources 2)	4	Plan	6	124	4.13
		Result	12	215	7.17
Tadayoshi USUI (Emission Measurement for Stationary Sources 3)	4	Plan	6	124	4.13
		Result	7	124	4.13
Atsushi SATO (Automobile Emission Measurement 1 / Mobile Source Control)	3	Plan	7	84	2.80
		Result	7	81	2.70
Jun OKABE (Automobile Emission Measurement 2)	4	Plan	3	56	1.87
		Result	4	76	2.53
Ryuta NITTA (Automobile Emission Measurement 3)	4	Plan	1	4	0.13
		Result	1	6	0.20
Fumihiko KUWAHARA (Other Emission Source Monitoring)	4	Plan	3	45	1.50
		Result	3	48	1.60
Hitoshi YURA (Ambient Air Quality Monitoring 2)	4	Plan	2	60	2.00
		Result	2	60	2.00
Ei EDO (Data Analysis for Ambient Air Quality Monitoring)	4	Plan	6	97	3.23
		Result	8	118	3.93
Akira MIZOHATA (PM10 and PM2.5 measurement and composition analysis 1)	2	Plan	5	75	2.50
		Result	4	48	1.60
Hiroyuki MAEDA (Emission Source Inventory / Ambient Air Quality Monitoring 3 / Evaluation of Air Pollution Control Measures 2 / Public awareness and advisory system)	3	Plan	12	180	6.00
		Result	10	150	5.00
Shinya NAKATA (Air Pollution Simulation Modeling)	4	Plan	9	225	7.50
		Result	8	156	5.20
Yasufumi NAKAJIMA (Power Plant Control Measures 1)	3	Plan	1	15	0.50
		Result	0	0	0.00
Nobuchika KOIZUMI (Power Plant Control Measures 2)	3	Plan	4	45	1.50
		Result	4	45	1.50
Masanori EBIHARA (Industry and HOB Control Measures)	3	Plan	3	42	1.40
		Result	4	42	1.40
Nobuhiro KOYANAGI (Coal Combustion Technology 1)	3	Plan	4	50	1.67
		Result	4	44	1.47
Shinji TOMITA (Coal Combustion Technology 2)	4	Plan	3	30	1.00
		Result	2	22	0.73
Tatsuhito NAKANO (Coal Combustion Technology 3)	5	Plan	0	0	0.00
		Result	0	0	0.00
Shigeo FUJII (Evaluation of Air Pollution Control Measures 1)	3	Plan	3	45	1.50
		Result	3	45	1.50
Katsutoshi Nishiura (Supporting Air Pollution Control Measures 1)	3	Plan	0	0	0.00
		Result	1	5	0.17
Kiyoshi Umezawa (Supporting Air Pollution Control Measures 2)	3	Plan	0	0	0.00
		Result	1	5	0.17
Atsushi MURAI (Boiler Registration System)	3	Plan	1	21	0.70
		Result	0	0	0.00
Total		Plan		2011	67.03
		Result		1967	65.56

Legend: Plan; Result; Result; Company's own cost; Other job

5.4 Trainings in Japan

Training in japan was implemented in November 2014 in the 1st year, and December 2015, September 2016 and December 2016 in the 2nd year. Their results are shown in Table 5.4-1 to Table 5.4-8.

Table 5.4-1 Trainee List (November 2014)
(Improvement of the selection process of air pollution control measures)

No.	Trainee	Occupation
1	Mr. Tumurbaatar KHASBAATAR	The Cabinet office, Government of Mongolia
2	Mr.Nergui BATTULGA	Ministry of Roads and Transportation
3	Mr. Natsagdorj GALTSOG	NAMEM
4	Mr. Chultemsuren BATSAIKHAN	AQDCC (APRD)
5	Mr. Munkhtuvshin GANBAT	MEGD (MET)
6	Mr. Tserendelger TERBISH	National Committee for Reducing Air Pollution
7	Ms. Bymbajav ERDENETSETSEG	Ministry of Mining

Table 5.4-2 Training Contents
(Improvement of the selection process of air pollution control measures)

Title	Improvement of the selection process of air pollution control measures
Duration	2014.11.9 – 2014.11.21
Trainees	7
Content	＜lectures＞ Air pollution condition in Ulaanbaatar, evaluation of air pollution management policy, evaluation of Japanese air pollution management policy ＜field trip＞ Air pollution control in coal-fired power station, Air pollution control by collecting boilers, improved coal fuel production

Source: JICA Expert

Table 5.4-3 Trainee List (December 2015)
(Improvement of the selection process of air pollution control measures for vehicles)

No.	Trainee	Occupation
1	Mr. P. MUNKHBAT	Ministry of Road and Transportation of Mongolia
2	Mr. D. ERDENEBAT	Public Transportation Department of Ulaanbaatar City
3	Mr. D. TUMENDELGER	NAMEM
4	Mr. O. ALTANGEREL	AQDCC (APRD)

Table 5.4-4 Training Contents
(Improvement of the selection process of air pollution control measures for vehicles)

Title	Improvement of the selection process of air pollution control measures for vehicles
Duration	2015.12.6 - 2015.12.12
Trainees	4
Content	[lectures] Vehicle emission factor and vehicle emission calculation, air pollution control for vehicles, emission monitoring planning for evaluation of air pollution control plan, comparison of vehicle emission control policy between Japan and Mongolia. [field trip] Vehicle production process at truck and bus manufacturer

Source: JICA Expert

Table 5.4-5 Trainee List (September 2016)
(Practice of calculation using emission monitoring data)

No.	Trainee	Occupation
1	Mr. S.BATSAYA	AQDCC (APRD)
2	Mr. Kh. GERELCHULUUN	AQDCC (APRD)
3	Mr. L. TUGSBAYAR	AQDCC (APRD)
4	Mr. O.TUVSHINJARGAL	AQDCC (APRD)
5	Ms. G.URANTSETSEG	AQDCC (APRD)

Table 5.4-6 Training Contents
(Practice of calculation using emission monitoring data)

Title	Practice of calculation using emission measurement data
Duration	2016.9.4 - 2016.9.10
Trainees	5
Content	[lectures] Practice of calculation of emission concentration using emission measurement data [field trip] Air pollution control in coal-fired power station

Source: JICA Expert

Table 5.4-7 Trainee List (December 2016)
(Sharing and utilization of CEMS data between administrative agencies)

No.	Trainee	Occupation
1	Ms. A. OYUN	Ministry of Environment and Tourism
2	Ms. D. DAVAASUREN	Ministry of Energy
3	Ms. T. TSOLMON	APRD
4	Mr. B. BATTSEREN	PP4
5	Mr. S. BOLDSAIKHAN	PP3

Table 5.4-8 Training Contents
(Sharing and utilization of CEMS data between administrative agencies)

Title	Sharing and utilization of CEMS data between administrative agencies
Duration	2016.12.1 - 2016.12.10
Trainees	5
Content	[lectures] Air pollution control policy in Japan, emission control using CEMS in coal-fired power station, CEMS specifications and maintenance, and data transmission system [field trip] Emission control using CEMS in coal-fired power station, utilization of CEMS at monitoring center of local government

Source: JICA Expert

5.5 Equipment Provided

The detail is shown in Attachment

5.6 Local Expenditure by Japanese Side

Local expenditures of each year are shown below.

5.6.1 Local Expenditure

Local expenditures of each year are shown Table 5.6-1.

Table 5.6-1 Local Expenditure

	1st fiscal year	2nd fiscal year	Total
Traveling	40,123,000	49,038,000	89,161,000
General operation	36,204,000	42,564,000	78,768,000
Making deliverables	2,705,000	2,015,000	4,720,000
Equipment	6,948,000	980,000	7,928,000
Local Contract	3,826,000	9,540,000	13,366,000
Training in Japan	725,000	789,000	1,514,000
Direct Labor Cost	42,401,000	54,696,000	97,097,000
Other Cost	85,958,000	111,531,000	197,489,000
Tax	17,511,200	21,692,240	39,203,440
Total	236,401,200	292,845,240	529,246,440

Note: The cost of 2nd fiscal year is assumption at 2017.3.

Source: JICA Expert

5.6.2 Output by Local Contract

Four (4) Local Contracts was implemented in the 1st fiscal year and 2 contracts in the 2nd fiscal year. Their outputs are shown below.

(1). Component Analysis of Solid Fuel

In order to evaluate the effect of improved fuel regarding output 8-1, component analysis was implemented for some types of coals and improved fuels. JICA Experts and APRD discussed and implemented designated quotation competition by 3 eligible Mongolian companies. As a result, the Mining Institute Laboratory was selected.

The analyses items are proximate analyses (Total moisture, Ash, Volatile matter, Fixed Carbon), Calorific value, and Sulfur content. JICA Experts requested analyses of 15 samples in October 2014 and received their result on 3rd November. The analyses results were utilized for discussion of air pollution control by improved fuels as same as combustion test results.

(2). Installation of measurement holes

In order to measure emission gas from stationary sources and to implement boiler inspection regarding output 1-1, 1-3, the construction of measurement hole and flange installation on HOB stacks or pipes was implemented by the contract. JICA Experts and APRD discussed and implemented the designated quotation competition by 3 eligible Mongolian companies. As a result, Dornii Elch Co., Ltd. was selected.

The company made flange according to the order of JICA Experts, measurement hole was installed at 24. Installed flanges were utilized for HOB emission gas measurement and boiler inspection in activities 1-1, 1-2, and 1-4.

(3). Component Analysis of Liquid Fuel

The component of liquid fuel for motor vehicles used in Ulaanbaatar was analyzed. Since there was no laboratory which can analyze liquid fuel component, the analysis was ordered to Tokyo Chemical Analysis Center as same as in Phase I. The content and specific weight of S and Pb were analyzed for 8 samples including Euro 5 gasoline, diesel oil and so on. The result was utilized in order to update the emission inventory by making SO2 emission factor of vehicles.

(4). Component Analysis of PM10 and PM2.5 (1^{st} and 2^{nd} fiscal year)

The component analysis of PM referred in indicator 2-3 of PDM was implemented through the 1^{st} and 2^{nd} fiscal year. Not only the component analysis but calculation of CMB model was necessary for this analysis. Thus the contractor should have had enough experience and high ability of analysis. Osaka Prefecture University was considered to have unique eligibility in experience of these analyses, special private contract was selected.

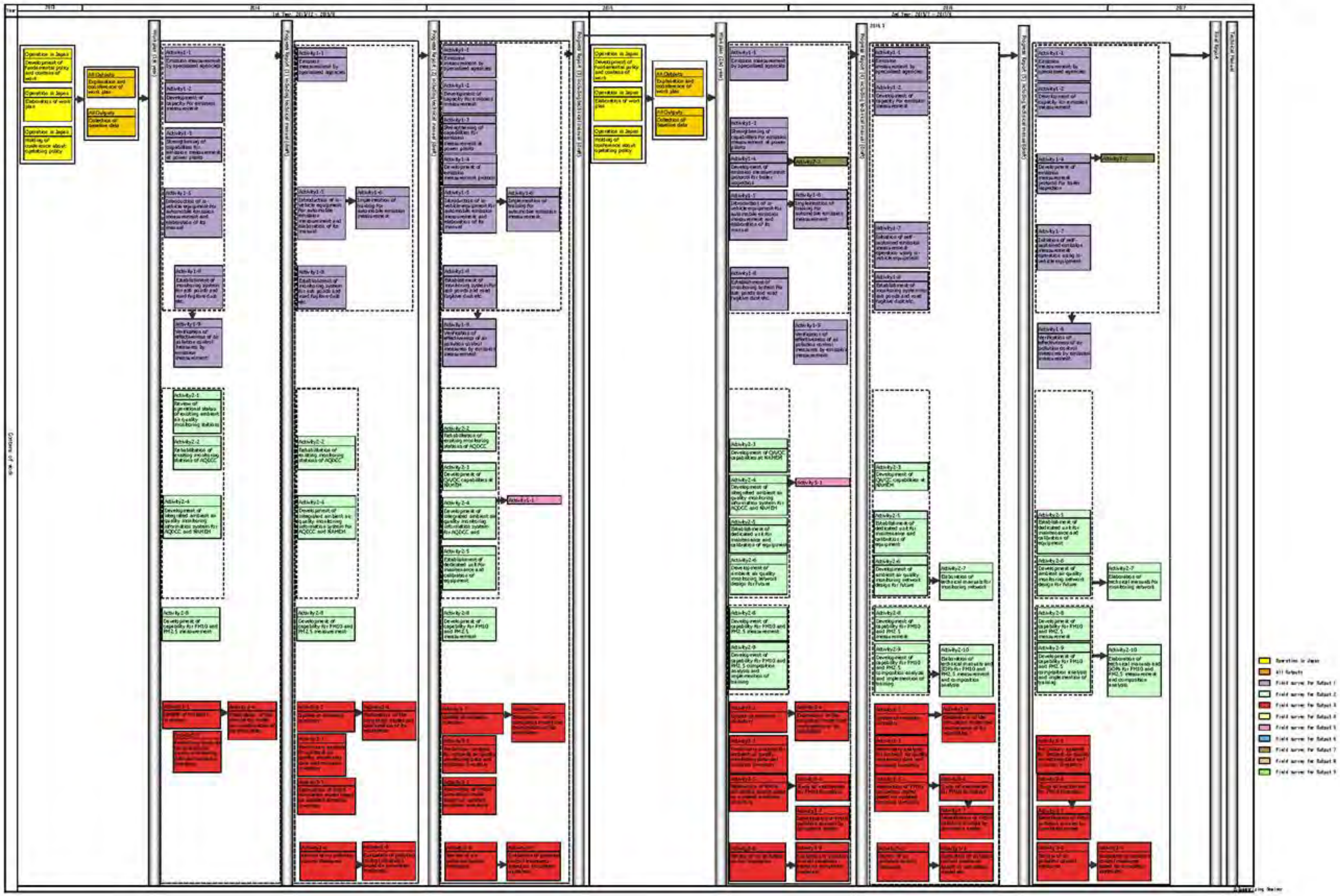
The analyzed items were carbons, ions, and some metal elements, and 240 samples were analyzed through the 1^{st} and 2^{nd} fiscal year (including PM10 and PM2.5 collected on PTFE filters only). The analyzed results were used to reveal PM formation mechanism (activity 3-7) through estimation of emission source contribution by CMB. Also, air diffusion model was updated based on the observation from CMB model.

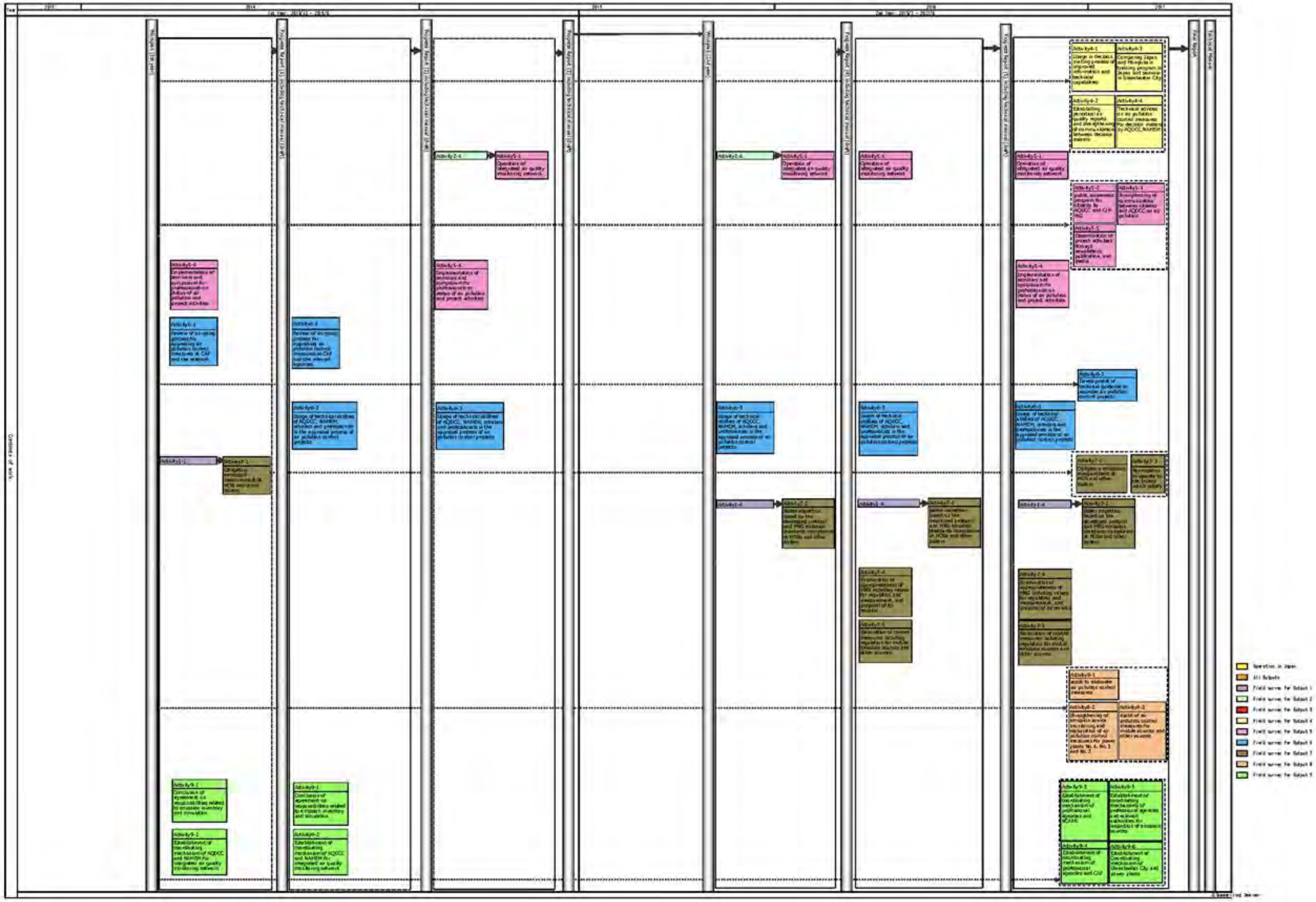
(5). Measurement of Electric Resistivity of Fly Ash

Regarding activity 8-1 of PDM, installation of electric precipitator (EP) was discussed as air pollution control for HOB. The efficiency of dust collection by EP depends on the electric resistivity of fly ash. Since the electric resistivity of fly ash was needed to design the EP, this local contract was added based on the agreement from JICA. JICA Experts implemented designated quotation competition by 3 eligible companies. As a result, Chugai Technos co., ltd. was selected. Analysis item was electric resistivity (100 to 350 degrees C) and 5 samples were analyzed. The result was utilized in consideration of emission control policy by installation of EP.

Attachment

Attachment 1 Work Flow Chart





Attachment 2 Detailed Work Plan

Duration / Activities	1st project period																			2nd project period																							
		2014												2015												2016												2017					
Activities	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
For All Outputs																																											
Preparation and Discussion of Work-plan	-■	■																		=■	■																						
Implementation of Training in Japan				■	■	■	=									■	■	■=										■	■	■	=												
Implementation of Capacity Assessment		■					■							■					■									■						■						■	■		
Making of project progress report	-■	■					■							■					■	=■	■							■						■						■	■-		
Explanation of project progress report	△						△							△					△	△								△						△						△			
Assistance in delivery of equipments			=																																								
《Strengthening capabilities for analysis of air quality and emission sources, and for evaluation of air pollution control measures》																																											
Activity 1: Emission source monitoring																																											
【Stationary emission sources monitoring】																																											
1-1 Self-sustained emission measurement is reinforced.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1-2 Capacity for emission measurement required for boiler registration system is developed.	■	■	■	■	■	■	■						■	■	■	■	■	■						■	■	■	■	■	■	■	■												
1-3 Capabilities for emission measurement at power plants are strengthened.	■	■	■	■	■	■	■						■	■	■	■	■	■						■	■	■	■	■	■	■	■												
1-4 Emission measurement protocol for boiler inspection is developed.													■	■	■	■	■	■						■	■	■	■	■	■	■	■												
【Mobile emission sources monitoring】																																											
1-5 In-vehicle equipment for automobile emission measurement is introduced, and appropriate methodology at Ulaanbaatar City and its manual are elaborated.					■	■	■=	■	■	■	■																					=											
1-6 Related training for automobile emission measurement is implemented.									■	■	■						■	■				■	■																				
1-7 Self-sustained emission measurement operation using in-vehicle equipment is initiated.																														■	■	■	■	■	■	■	■	■	■	■	■	■	■
【Other emission sources monitoring】																																											
1-8 Monitoring system for ash ponds and road fugitive dust etc. is established.					■	■				■	■	■					■	■				■	■	■	■					■													
【Application to technical evaluation for air pollution control measures】																																											
1-9 Effectiveness of air pollution control measures are verified by emission measurement.	■	■	■	■	■	■	■						■	■	■	■	■	■				■	■	■	■	■	■	■	■	■	■												
Activity 2: Ambient air quality monitoring																																											
【Development of integrated ambient air quality monitoring network for Ulaanbaatar City Area】																																											
2-1 Operational status of existing ambient air quality monitoring stations is reviewed.		■	■	■	■	■	■																																				
2-2 Rehabilitation of existing monitoring stations is implemented.					■	■	■	■	■	■	■	■	■	■	■	■																											
2-3 QA/QC (Quality Assurance/ Quality Control) capabilities are developed at NAMEM.																■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■												
2-4 Integrated ambient air quality monitoring information system for AQDCC and NAMEM is developed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																		
2-5 Dedicated unit for maintenance and calibration of equipment is established by AQDCC and NAMEM.		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■												
2-6 Ambient air quality monitoring network design for future is developed.																										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2-7 Necessary technical manuals for monitoring network are elaborated.													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
【PM10 and PM2.5 measurement and composition analysis】																																											
2-8 Capability for PM10 and PM2.5 measurement is developed at AQDCC and NAMEM.		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
2-9 Capability for PM10 and PM2.5 composition analysis is developed at NAMEM, related training for AQDCC is implemented.																						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
2-10 Necessary technical manuals and SOPs for PM10 and PM2.5 measurement and composition analysis are elaborated.																						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					

Legend ———Preliminary Work Period ■ Work Period in Mongolia ＝ Work Period in Japan

Activities	Duration	1st project period																			2nd project period																							
			2014												2015												2016												2017					
		12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Activity 3: Evaluation of pollution structure by integrating emission inventory, simulation model and ambient air quality monitoring																																											
	【Self-reliant and sustained update of emission source inventory/ simulation by Mongolian side】																																											
3-1	Plan for emission inventory continuous update is elaborated.		■	■	■	■																																						
3-2	Emission inventory is updated using related information such as emission measurement data, boiler registration, automobile registration and relevant statistics.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3-3	Reliabilities for ambient air quality monitoring data and emission inventory is reviewed. Preliminary analysis of pollution structure is implemented. Guidelines for these processes are developed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3-4	Reliabilities of the simulation model are examined by elaborating simulation model for SO_2, CO and NOx based on the related data such as updated emission inventory and ambient air quality monitoring data.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
	【Analysis on discrepancy between PM10 air quality monitoring result and simulation model】																																											
3-5	PM10 simulation model is restructured by taking into account of secondary particles originated from SO_2, NOx based on updated emission inventory.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3-6	Mechanism for PM10 formation at Ulaanbaatar City is studied.																							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3-7	PM10 pollution sources are identified by taking into account of dust emission and precursors such as SO_2, NOx and others.																							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
	【Application for technical evaluation of air pollution control measures】																																											
3-8	Air pollution control measures are reviewed and developed for PM10 and other pollutants which are not achieving ambient air quality standards, based on discussion with the Mongolian side and Japanese experts.											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3-9	Those pollution control measures are technically evaluated based on updated emission inventory, simulation model, and ambient air quality monitoring.											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
	《Air pollution control strategy, policy and decision making》																																											
	Activity 4: Decision making process improvement for air pollution control																																											
4-1	Decision making process in air pollution control utilizes improved information and technical capabilities of AQDCC, NAMEM and the relevant agencies.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4-2	Communication between decision makers, AQDCC and NAMEM is strengthened by establishing periodical air quality reports.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4-3	Members of C/P and C/P-WG study legal and administrative framework for air pollution control by comparing Japan and Mongolia in training program in Japan and seminar in Ulaanbaatar City.						■						■						■						■						■						■							
4-4	AQDCC and NAMEM provide technical advices on air pollution control measures for decision makers.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Legend ————Preliminary Work Period　　■ Work Period in Mongolia　　＝ Work Period in Japan

Duration / Activities	1st project period																		2nd project period																							
		2014												2015												2016												2017					
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Activity 5: Public awareness program and advisory system for citizen in Ulaanbaatar city on air pollution																																											
5-1 Dissemination of air quality information and advisory services are provided through operation of integrated air quality monitoring network.													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5-2 AQDCC and C/P-WG implement public awareness program for citizens.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5-3 Communication between citizens and AQDCC on air pollution is strengthened.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5-4 AQDCC and C/P-WG implement seminars and symposium for professionals on status of air pollution and project activities.	■																■																								■		
5-5 Newsletters, publication, and media are utilized for disseminating project activities.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
《Evaluation of air pollution control measures》																																											
Activity 6: Technical evaluation of air pollution control measures.																																											
6-1 On-going process for appraising air pollution control measures at CAF and the relevant agencies is reviewed.	■	■	■	■	■	■	■	■	■	■	■	■																															
6-2 Technical guideline to appraise air pollution control projects is developed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
6-3 Technical abilities of AQDCC, NAMEM, scholars and professionals are utilized in the appraisal process of air pollution control projects.											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
《Implementation of air pollution control measures》																																											
Activity 7: Regulation and control for emission reduction																																											
【Full implementation of the boiler registration system]】																																											
7-1 Obligatory emissions measurement at HOB and other boilers is phased in.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7-2 MNS emission standards compliance at HOBs and other boilers is reviewed through boiler inspection based on the developed protocol.																					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7-3 "Permissions to operate" (or "good boiler certifications") are issued to the boilers which satisfy conditions.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
【Proposal for MNS revision】																																											
7-4 Appropriateness and relevance of MNS including parameters and values for regulation, and measurement methods are examined. If necessary, revision of MNS is proposed.																										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
【Mobile sources and other sources】																																											
7-5 Control measures including regulation for mobile emission sources and other sources are elaborated.																														■	■	■	■	■	■	■	■	■	■	■	■	■	■

Legend ———Preliminary Work Period ■ Work Period in Mongolia ＝ Work Period in Japan

Activities / Duration	1st project period																				2nd project period																						
		2014												2015													2016												2017					
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Activity 8: Enhancement for emission control measures at major polluters																																											
8-1 JICA experts assist entities (power plants, HOB, industries, and others) of pollution sources to elaborate air pollution control measures.			■		■		=				■	■	■	■ =	■		■						■	■	■	■	■	=						■		■		■	=		■		
8-2 Emission source monitoring for power plants (boilers and ash ponds) No.4, No.3 and No.2 are strengthened. Air pollution control measures are discussed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
8-3 Air pollution control measures for mobile sources and other sources are enhanced.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
《Development of air quality management cycle》																																											
Activity 9: Development of air quality management cycle																																											
9-1 Agreement on responsibilities of professional agencies (AQDCC and NAMEM) related to emission inventory and simulation is concluded.	■	■	■	■	■	■	■	■	■	■	■	■																															
9-2 Coordinating mechanism of AQDCC and NAMEM for integrated air quality monitoring network at Ulaanbaatar City Area is established.	■	■	■	■	■	■	■	■	■	■	■	■																															
9-3 Coordinating mechanism of professional agencies and NCAPR is established.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9-4 Coordinating mechanism of professional agencies and CAF is established.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9-5 Coordinating mechanisms of professional agencies and relevant authorities for inspection of emission sources are established.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
9-6 Coordinating mechanism of Ulaanbaatar City and power plants is developed.					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							

Legend ————Preliminary Work Period ■ Work Period in Mongolia ＝ Work Period in Japan

Attachment 3 List of Machinery and Equipment Provided by JAPAN and its Present State

In the next table, write down the provided machinery and equipment by JAPAN and the state of its use.

1. Office Equipment

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover
1	Multifunction Printer	Sharp MX3111U	1	MNT	14,999,990	APRD	Working	2014.05.29
2	Lap top computer	Samsung	2	MNT	3,219,600	APRD	Working	2014.06.20
3	Office Software	MS Office Professional 2010	2	MNT	1,447,800	APRD	Working	2014.06.20
4	Anti-Virus Software	AVG Internet security -4 Licensees	1	MNT	304,400	APRD	Working	2014.06.20
5	Multifunction Printer	Sharp MX3111U	1	MNT	11,799,979	NAMEM	Working	2015.03.27
Sub total				MNT	31,771,769			
Sub total				JPY	-			

2. Stationary Source Monitoring Equipment

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover
1	Dust Monitor	Matsushima Measure Tech PFM-M11PN(Sensor) with PFM-KCU12(Indicator)	1	JPY	574,560	APRD	Working	2014.10.01
2	Portable Gas Analyzer	Horiba PG350 with cooling unit PS 300	1	JPY	5,830,000	APRD	Working	2014.04.02
3	Flue Gas Analyzer	Hodaka HT-3000 with sampling probe	1	JPY	2,624,800	APRD	Working	2015.04.02
4	Vane Type Flow Meter	Sentronic NT with Vane type flow sensor	1	JPY	1,235,000	APRD	Working	2015.04.02
5	Trans former	Toei Trans Formers TD-6	4	JPY	44,000	APRD	Working	2015.04.02
6	Trans former	Sugano Electric Laboratory SE-1500	2	JPY	54,000	APRD	Working	2015.04.02
7	Sampling probe	Maruni Science 4021-31 with circular filter holder	1	JPY	233,000	APRD	Working	2015.04.02
8	Dry Type Gas Meter	Shinagawa DC-2CM	1	JPY	230,000	APRD	Working	2015.04.02
9	Stack Gas Analysis System	Horiba ENDA5800	2	JPY	30,770,000	PP4	Working	2016.10.27.
10	Sampling tube	-	2	JPY	3,900,000	PP4	Working	2016.10.27
11	Mixed gas for	Taiyo Nippon Sanso	2	JPY	400,000	PP4	Working	2016.10.27

	Stack Gas Analysis System for calibration	NO+N2, 10L/Cylinder SO2+N2, 10L/Cylinder CO+N2, 10L/Cylinder CO2+N2, 10L/Cylinder						
12	Dust Density Meter	Tanaka Electric Laboratory DDM-fc	1	JPY	2,575,000	PP4	Working	2016.10.27
Sub Total				MNT	-			
Sub Total				JPY	48,470,360			

3. Mobile Source Emission Monitoring Equipment

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover
1	NOx･A/F Analyzer	Horiba Mexa720 with NOx sensor and calibration unit	1	JPY	1,171,800	APRD	Working	2014.10.06
2	NOx sensor for Horiba MEXA720	Horiba NOx sensor	3	JPY	812,800	APRD	Working	2015.04.15
3	Inverter	Cotek S1500-112	1	JPY	81,000	APRD	Working	2015.04.15
4	Inverter	Cotek S1500-124	1	JPY	81,000	APRD	Working	2015.04.15
5	Pressure regulator	Takachiho Chemical Industrial TUS2063	2	JPY	14,4000	APRD	Working	2015.04.15
6	Data Logger	Kyoto SR KSR-600A	1	JPY	2,850,000	APRD	Working	2015.04.15
7	Opacity Meter	Horiba MEXA600S	1	JPY	850,000	APRD	Working	2015.04.15
8	Proofreading Filter for Opacity Meter	Horiba Proofreading Filter 4 pcs	1	JPY	190,000	APRD	Working	2015.04.15
9	NO Standard Gas	NO: 300ppm, NO: 1000ppm NO: 2000ppm	1	JPY	207,000	APRD	Working	2015.04.15
10	Emission testing of CNG, LPG and petrol engines possible	MET 6.1	1	MNT	17,043,653	APRD	Working	2015.10.23
11	Emission tester for diesel engines	MET 6.2	1	MNT	18,259,199	APRD	Working	2015.10.23
12	Mobility Kit for	MET 6.xMAH	1	MNT	5,600,912	APRD	Working	2015.10.23
13	Oil Temperature Sensor for Cars,		1	MNT	1,165,485	APRD	Working	2015.10.23

	length 100-1500 mm, with 6m cable							
14	NOx·A/F Analyzer	Horiba Mexa720 with NOx sensor and calibration unit	1	JPY	1,171,800	CLEM	Working	2014.10.06
15	NOx sensor for Horiba MEXA720	Horiba NOx sensor	3	JPY	812,800	CLEM	Working	2015.04.15
16	Inverter	Cotek S1500-112	1	JPY	81,000	CLEM	Working	2015.04.15
17	Inverter	Cotek S1500-124	1	JPY	81,000	CLEM	Working	2015.04.15
18	Data Logger	Kyoto SR KSR-600A	1	JPY	2,850,000	CLEM	Working	2015.04.15
19	Opacity Meter	Horiba MEXA600S	1	JPY	850,000	CLEM	Working	2015.04.15
20	Proofreading Filter for Opacity Meter	Horiba Proofreading Filter 4 pcs	1	JPY	190,000	CLEM	Working	2015.04.15
21	Pressure regulator	Takachiho Chemical Industrial TUS2063	1	JPY	7,2000	CLEM	Working	2015.04.15
22	Emission testing of CNG, LPG and petrol engines possible	MET 6.1	1	MNT	17,043,653	CLEM	Working	2015.10.23
23	Emission tester for diesel engines	MET 6.2	1	MNT	18,259,199	CLEM	Working	201510.23
24	Mobility Kit for	MET 6.xMAH	1	MNT	5,600,912	CLEM	Working	2015.10.23
25	Oil Temperature Sensor for Cars, length 100-1500 mm, with 6m cable		1	MNT	1,165,485	CLEM	Working	2015.10.23
Sub Total				MNT	84,138,498			
Sub Total				JPY	12,496,200			

4. Ambient Air Quality Monitoring Equipment

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover

1	Ambient Ozone Monitor	Horiba APOA-370	4	JPY	9,081,000	APRD	Working	2015.04.02
2	Ambient Real-time Particle Monitor	Thermo Scientific 5030SHARP Monitor with shelter	2	JPY	7,800,000	APRD	Working	2015.04.02
3	Data Collecting and Communication Software	Horiba IDAZRW4.0 DCS5.4 I/O VIS2.3	1	JPY	1,085,000	APRD	Working	2015.04.02
4	Standard Gas Diluter	Ecotech GASCAL 1100 with CALIBRATOR 8301LC Zero Air Generator	1	JPY	1,778,400	CLEM	Working	2015.04.01
5	Standard Gas Diluter	Kimoto Electric SG-741	1	JPY	4,446,000	CLEM	Working	2015.04.01
6	Ozone Analyzer	Nippon Thermo 49i－PS	1	JPY	2,050,000	CLEM	Working	2015.04.01
7	Zero Gas Generator	Nippon Thermo 94－1	1	JPY	389,000	CLEM	Working	2015.04.01
8	Ambient Sulfur Dioxide Monitor	Horiba APSA-370	1	JPY	2,478,000	CLEM	Working	2015.04.01
9	Ambient Nitrogen Oxide Monitor	Horiba APNA-370	1	JPY	2,861,000	CLEM	Working	2015.04.01
10	Ambient Carbon Monoxide Monitor	Horiba APMA-370	1	JPY	3,771,000	CLEM	Working	2015.04.01
11	19 Inch Rack	Horiba 19 Inch Rack for Ambient Quality Monitor	2	JPY	545,600	CLEM	Working	2015.04.01
12	Data Display with Data Logger	Chino KR3121 - NOA	1	JPY	465,000	CLEM	Working	2015.04.01
13	Nitrogen Gas	99.99995%	2	JPY	98,000	CLEM	Working	2015.04.01
14	Gas Flow Calibrator	Mesa Laboratories ML-500-B with Measurement Cell ML-500-10 and ML-500-44	1	JPY	3,118,000	CLEM	Working	2015.04.01
15	Standard Flow Meter	Kofloc RK1400--25SS-(Rc1/4+H6)-AIR-2L/min-N	1	JPY	31,000	CLEM	Working	2015.04.01
16	Standard Flow Meter	Kofloc RK1400--25SS-(Rc1/4+H6)-AIR-20L/min-N	1	JPY	31,000	CLEM	Working	2015.04.01

17	Mass Flow Meter	Azbil CMS9500BTTN200000	1	JPY	77,600	CLEM	Working	2015.04.01
18	Mass Flow Meter	Azbil CMS0020BTTN200000	1	JPY	81,300	CLEM	Working	2015.04.01
19	Micro Gas Flow Meter	GL Science GLF-1000	1	JPY	88,000	CLEM	Working	2015.04.01
20	Standard Barometer	Vaisala Portable digital barometer PTB330TS with Indicator MI70	1	JPY	594,000	CLEM	Working	2015.04.01
21	Temperature and Humidity Calibrator	Omega RHCL-2	1	JPY	1,695,000	CLEM	Working	2015.04.01
22	Weather Station	Prede PRMET-100	4	JPY	4,108,000	CLEM	Working	2015.04.01
23	PM10/2.5 Air Sampler	Thermo Scientific FRM2000i	1	JPY	1,345,000	CLEM	Working	2015.04.01
24	PM10/2.5 Air Sampler	Murata Measuring Instruments Service MCAS-SJ-M4	1	JPY	3,866,000	CLEM	Working	2015.04.01
25	Climate Chamber	Yamato Science Flexible closed chamber FCCZ	1	JPY	3,320,000	CLEM	Working	2015.04.01
26	Microbalance	Mettler Toledo XP6U	1	JPY	2,100,000	CLEM	Working	2015.04.01
27	Standard Materials for Calibration of XRF Analysis	45 Elements	1	JPY	1,013,300	CLEM	Working	2015.04.01
28	Board for CO Analyzer	RTC BOARD	1	EUR	407.00	CLEM	Working	2015.06.05
29	UPS with AVR	APC Smart-UPS RT 3000VA RM 230 /SURTD 3000RMXLI/	1	MNT	4,445,455	CLEM	Working	2015.03.17
30	Regulator	Hongye YQF 2stage pressure regulator	3	MNT	1,400,000	APRD	Working	2016.01.14
31	Ambient Sulfur Dioxide Monitor	Horiba APSA-370	1	JPY	2,839,000	APRD	Working	2016.05.02
32	Ambient Particulate Monitor for PM10	Horiba APDA-371	1	JPY	3,166,000	APRD	Working	2016.05.02
33	Ambient Particulate Monitor for PM2.5	Horiba APDA-371	1	JPY	3,166,000	APRD	Working	2016.05.02

34	Standard gas dilutor with zero gas generator	Horiba APMC-370	1	JPY	3,166,000	APRD	Working	2016.05.02
35	Data acquisition system	Horiba IOX-370 IO-Expander	1	JPY	1,070,000	APRD	Working	2016.05.02
36	Meteorological Equipment	Ogasawara WS-BN6H TS-301C-1 NP110A P-MS-402 P-PTB210 TS-301C-1 OKSAM-4100 Expansion Pole	1	JPY	2,893,000	APRD	Working	2016.05.02
37	19 Inch Rack	Horiba 19 Inch Rack for Ambient Quality Monitor	2	JPY	1,114,000	APRD	Working	2016.05.02
38	Stand for gas cylinder	Kuki KBS15-3 stand for 1500L gas cylinder	2	JPY	33,500	APRD	Working	2016.05.02
39	Sample Air Sampling System	Breifuss PNS-GAS-fest Gas sampling system	1	JPY	384,000	APRD	Working	2016.05.02
Sub total				MNT	5,845,455			
Sub total				JPY	76,148,200			
Sub total				EUR	407.00			

5. Integrated Ambient Air Quality Monitoring Information System for APRD and NAMEM

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover
1	Remote control Software	Team Viewer 9 Business	1	JPY	66,300	APRD	Working	2014.09.09
Sub Total				MNT	-			
Sub Total				JPY	66,300			

6. Evaluation of Pollution Structure by Integrating Emission Inventory, Simulation Model and Ambient Air Quality Monitoring

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover
1	Desktop Computer	Dell Optiplex 9020	1	MNT	2,623,500	NAMEM	Working	2015.05.19

2	Laptop Computer	Dell Inspiron 7737	1	MNT	3,019,500	NAMEM	Working	2015.05.19
3	Office Software	MS Office Professional 2013	2	MNT	1,593,000	NAMEM	Working	2015.05.19
4	Fortran Compiler	Software Intel Parallel Studio XE 2015 Pro for Fortran Windows	1	JPY	272,320	NAMEM	Working	2015.05.19
5	Arc GIS	Software Arc GIS for Desktop Basic single Use License 10.2	1	USD	3,551.05	NAMEM	Working	2015.05.19
Sub total				MNT	7,236,000			
Sub total				JPY	272,320			
Sub total				EUR	-			
Sub total				USD	3,551.05			

7. Public Awareness Program and Advisory System for Citizen in Ulaanbaatar City on Air Pollution

No.	Name	Description	Q'ty.	Unit	Asset Value	Site installed	Working state	Date of Handover
1	LCD	Tosh-40L2400	2	MNT	1,709,600	APRD	Working	2014.10.01
2	PC	Fujitsu LH532	2	MNT	1,720,000	APRD	Working	2014.10.01
Sub Total				MNT	3,429,600			
Sub Total				JPY	-			
Total				MNT	132,421,322			
Total				JPY	99,808,380			
Total				EUR	407.00			
Total				USD	3,551.05			

Attachment 4 Appendix List

In the next table, write down the Appendix list. Appendices are available only in electronic version and are enclosed in the CD-ROM.

Appendix	Contents
1.3-1	Identification Matrix of Output and Investigation Matrix categorized by Outputs of PDM
1.6-1	Minutes of the Joint Coordinating Committee Meetings
2.1-1	The Various Manuals for Vehicle Emission Measurement
2.1-2	Handout of Professionals Seminar Regarding Theory and System of On-board Mobile Emission Measurement in May 2015 and October 2015
2.1-3	Request of the Retrofitted DPF Emission Measurement
2.1-4	Other Emission Source Monitoring Plan
2.2-1	Air Quality Monitoring Station Maintenance Manual, Annual Management Schedule for Air Quality Monitoring Stations, List of Expendables for Air Quality Monitoring Stations and Example of Recording Sheets for Air Quality Analyzers
2.2-2	Ambient Air Quality Monitoring Network Design for Future
2.2-3	The Results of Chemical Composition Analysis Regarding PM samples
2.3-1	Handout of Professionals Seminar Regarding Emission Inventory and Dispersion Simulation
2.3-2	The Annual Report of Emission Inventory
2.4-1	Regulation for Working Implementation of National Committee for Air Pollution Reduction
2.4-2	Outline of Air Pollution Control Measures on Conference on Air Pollution Reduction Proposals
2.5-1	The Brochure and Presentation on Public Awareness Program for Schools
2.5-2	The Attendants List of Awareness Seminar and Symposium for Professionals
2.5-3	The Newsletters (Material of Project Public Relations)
2.5-4	Introduction of Presentation Speaker on Northeast Asian Mayor's Forum
2.5-5	The Presentation Material on Northeast Asian Mayor's Forum in 2016
2.7-1	Certified Regulation of HOB Facilities
2.7-2	Administrative Instruction of Boiler Inspection and Certification of the Year 2015
2.7-3	Administrative Instruction of Boiler Inspection and Certification of the Year 2016
2.7-4	Handout of Professionals Seminar Regarding Mobile Emission Source in May 2015
2.8-1	Lecture on Heat Only Boiler and Air Pollution Control Technology
2.9-1	Consensus Document of Coordinating Mechanism regarding APRD and NAMEM for Integrated Air Quality Monitoring Network
2.9-2	Proposal on CEMS Data Sharing and Utilization
2.9-3	Deputy Mayor Order on Establishing Working Group for DPF Implementation Planning
2.10-1	Traveling Survey Result Using On-board Emission Measurement System

2.10-2	Report on Increasing Boiler Efficiency Test by Optimizing the Excess Air Ratio
2.10-3	Interview Report to Anu Service on HOB Operation
2.10-4	Material on the Operating Principles of the Cyclone, Its Operational Precautions, Cost of Installation and Other Relevant Information
2.10-5	Material on Cyclone Upgrade
2.10-6	Material for the Operating Principles of the Scrubber, Its Operational Precautions, Cost of Installation and Other Relevant Information
2.10-7	Material for the Boiler Operation Workshop
2.10-8	Material for On-the-job Training for HOB Inspection
3.1	19 times Seminars and Workshops Material of the Project 1st Seminar on Project Outline 2nd Seminar on Emission Inventory 3rd Symposium on PM10 and PM2.5 4th Seminar on Mobile Source Emission Measurement 5th Seminar on Vehicle Emissions Countermeasures 6th Seminar on Emission Test Result of New Coal Fuels' Combustion 7th Seminar on Boiler and Technology of Air Pollution Control Measures for CHP 8th Symposium on PM and Air Quality Monitoring 9th Seminar on Improvement Order and Air Pollution Control Measures for HOB 10th Seminar on Measurement and Control Measures of Vehicle Exhaust Emissions 11th Seminar on Emission Test Result of New Coal Fuels' Combustion 12th Seminar on PM10 and PM2.5 Composition sampled in UB 13th Mid-term Seminar 14th Seminar on Source Apportionment by Air Quality Simulation Model and Receptor Modelling 15th Conference on Air Pollution Reduction Proposals 16th PM Source Apportionment Analysis by Receptor Models 17th Seminar for Promoting Gas Supply 18th Summary Seminar 19th PM Source Apportionment Analysis by Receptor Models
3.2	Material of Training Course in Japan and Training Completion Report 1st Air Pollution Control (FY2014) (to improve the process how to select air pollution counter measures) 2nd Air Pollution Control (FY2015) (to develop reduction plan on vehicle air pollution in UB, and to make vehicle emission measurement plan for developing reduction plan) 3rd Air Pollution Control (FY2016) (to understand the calculation method of the air pollutant emission concentration with the use of the flue gas measurement data on small boiler and the combustion test laboratory) 4th Air Pollution Control (FY2016) (to study the coordination mechanism between company

	and government, law system and CEMS utilization in Japan, and then to elaborate action plan to use CEMS under the legal system in Mongolia)