Japan International Cooperation Agency
Ulaanbaatar City Government
Ministry of Environment and Tourism

Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 3

News Letter Vol. 4 (June, 2024)

Project Outputs of Phase 1 to 3

Summary of Phases

Phase 1	➢ From March 2010 to March 2013 (For 3 years) ➢ Capacity development for 19 organizations, including AQDCC (currently DAAEP) ➢ For stationary sources monitoring, boiler registration & management, measures on thermal power plants exhaust and energy efficiency improvement, development and usage of air quality simulation model, and etc. ➢ With provision of necessary equipment (702 million MNT)
Phase 2	➢ From December 2013 to June 2017 (For 3 years and 6 months) ➢ Capacity development for 22 organizations, including AQDCC (currently DAAEP) ➢ For stationary & mobile sources monitoring, air quality monitoring, boiler registration & management, PM speciation analysis & PM apportionment study, and etc. ➢ With provision of necessary equipment (2,754 million MNT)
Phase 3 (This Project)	➢ From September 2018 to July 2024 (For 5 years and 9 months) ➢ Capacity development for 14 organizations, including DAAEP ➢ For maintaining capacities developed in the previous two phases, improving planning through understanding air pollution of UB and pilot projects ➢ With provision of necessary equipment (680 million MNT)

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Outline

Ulaanbaatar (UB) city, the capital of Mongolia, has been covered by serious air pollution, especially by dust from combustion of low quality coal. It has been especially severe in winters because of heating demand. The major emission sources causing the severe air pollution in winter seasons in UB city are coal combustions at (1) 3 old coal fired plants for heat and electricity supply (Power Plant No. 4, No. 3 and No. 2), (2) approximately 200 Heat Only Boilers (hereinafter HOBs) for heating major buildings in Ger areas, (3) Coal Fired Water Heaters (hereinafter CFWHs) for smaller buildings in Ger areas, and (4) 200,000 to 300,000 Ger stoves utilized at households in Ger areas. In addition, other emission sources such as increasing vehicle traffics and resuspension of road dust, etc. have been in concern.

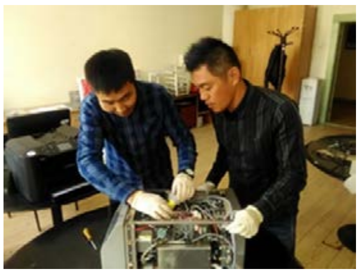
Under the circumstances above, the Government of Mongolia requested supports from the Government of Japan. JICA, with Department of Against Air and Environmental Pollution of the Capital City (DAAEP, formerly AQDCC) and Mongolian organizations related, has implemented a series of projects; 'Capacity Development Project for Air Pollution Control in UB City' (Phase 1) from March 2010 to March 2013, 'Capacity Development Project for Air Pollution Control in UB City Phase 2' from December 2013 to June 2017 and 'Capacity Development Project for Air Pollution Control in UB City Phase 3' from September 2018 to July 2024.

This newsletter reports key outputs of these projects.

Key Outputs of the Projects

(1) Flue Gas Measurement of Stationary Sources (Phase 1~3)

Before the Projects, most of the stationary sources had not been controlled because public sectors had no way to compare them with emission standards. From Phase 1, JICA provided necessary equipment, and JICA experts prepared necessary manuals and trained DAAEP on measurement and evaluation of stationary source emission.



As the resutls, in Phase 3, DAAEP has been able to continue it. DAAEP performed flue gas measurement 7 times at thermal power plants and 233 times at boilers. This number represents more than 50% of all the registered HOBs. As the side effects, DAAEP received laboratory accreditation for ISO 17025:2017 on April 28, 2022. Since DAAEP's capabilities are recognized throughout Mongolia, DAAEP was requested to measure boiler flue gas not only from UB City but also from Selenge Province, Dundgovi Province, Erdenet City, and Darkhan City. Since DAAEP prepared a combustion laboratory, DAAEP tested 66 improved fuels and fire starters in 2023 at the requests of ministries and companies such as Ministry of Energy, National Committee for Environment Pollution Reduction, Tavan Tolgoi Tulsh LLC (TTT). Results of these measurements are included in the annual activity reports of DAAEP every year, and available on the website of DAAEP (https://www.aprd.ub.gov.mn/gazriin-tailan).

(2) Improvement of Air Quality Monitoring (Phase 2~3)

Although GIZ provided 4 sets of air quality monitoring stations and trainings to DAAEP in 2009, analyzers were not well maintained in 2012, and no data was archvied officially.

In Phase 2 and Phase 3, human resources of DAAEP were trained for operation and maintenance of air quality monitoring, such as calibration of measurement equipment, analysis of malfunctioning analyzers to identify how to solve it, and confirmation of measurement results. Additionally, the Project also assisted to develop a new website (http://agaar.mn/index?lang=en) that continuously shares air quality information to public, provided equipment for new AQMS at Bayankhoshuu, and supported repair and replacement of malfunctioning analyzers of other AQMSs.

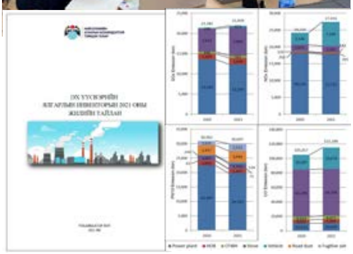
In addition, DAAEP followed recommendations by JICA Projects, such as installing new AQMS recommended by Phase 2 Project, renewing data loggers and securing maintenance budget.

Through these supports, operation and maintenance capacity of DAAEP on AQMS has been improved, and valid data availability rate of 5 AQMSs of DAAEP has been high at 84.3% as average of 6 years from 2018. Air quality information is used by National Agency for Meteorology and Environment Monitoring Meteorological and Environmental Monitoring (NAMEM) to analyze air pollution, and to prepare and submit weekly, monthly, winter and annual reports to the National Statistics Office, National Committee for Environment Pollution Reduction and Ministry of Environment and Tourism.

(3) Developing Emission Inventories (Phase 1~3)

In order to identify efficient way to solve air pollution, air pollutant emissions should be calculated, and air pollution countermeasure proposals should be evaluated and selected quantitatively.

Human resource were trained to develop and update emission inventories annually from Phase 1 to 3. In order to realize it, data collection and surveys on traffic volume, travel speed, and actual usage of household stoves were mainly carried out by Mongolia side. This methodology was fully referred by Clean Air Asia to develop an emission inventory manual, which was authorized by NAMEM as the official manual for Mongolia and is used to calculate emissions of provinces other than UB City.



Before the start of Phase 1, Mongolia was unable to develop emission inventories for air pollutants. Through the Project, Mongolia has improved its capacity to identify emissions quantitatively.

Since 2014, DAAEP has calculated air pollutant emissions almost every year and published annual emission inventory reports on its website (https://www.aprd.ub.gov.mn/jica-tusul).

Additionally, the emission inventory enabled Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE) to develop and operate 72-hours air quality forecast.

(4) Chemical Speciation and Source Apportionment of Ambient PM (Phase 2~3)

Major sources of ambient PM can be identified by chemical speciation and source apportionment, which enables to identify efficient and effective way to solve air pollution.

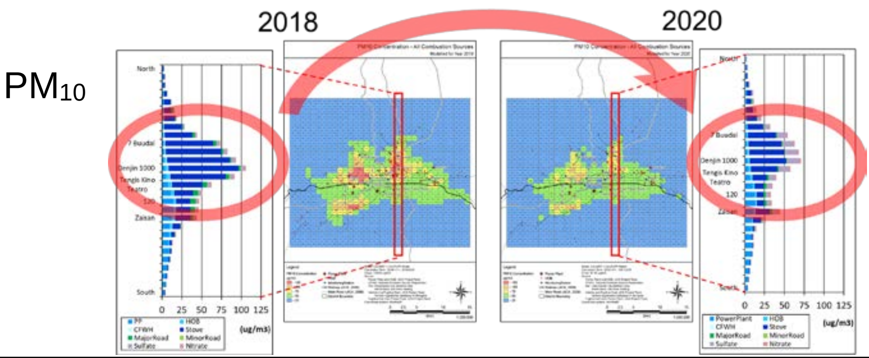
Sampling, chemical speciation analysis and source apportionment of Ambient PM was studied mainly for winter in Phase 2, and throughout a year in Phase 3. Positive Matrix Factorization (PMF) method was selected for source apportionment.

Chemical speciation laboratory practices were mainly trained in Japan from Nov. 9 to 23, 2022, for 6 researchers of Central Laboratory of Environment and Metrology (CLEM) and 2 NAMEM experts. Additionally, the Project improved air quality simulation model bases on the outputs of chemical speciation data of ambient PM.

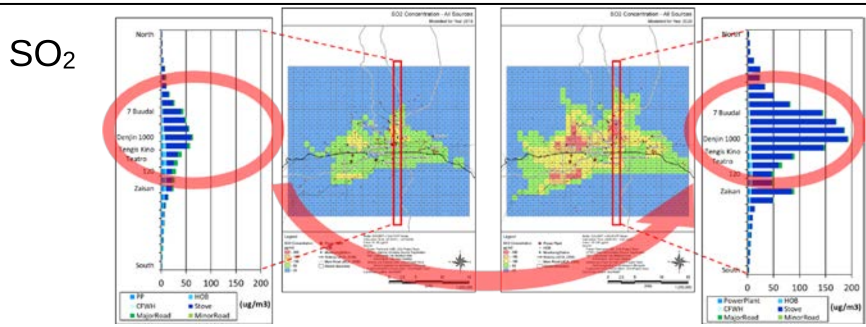
In this letter, as a sample output of capacity development activities in the field of source apportionment of ambient PM, we present an evaluation and suggestion on the current improved fuel.

A) <u>Changes in Concentration and Distribution of PM</u>

By simulations on ambient PM_{10} and SO_2, it was found that **<u>household stoves have the greatest impact on the air quality</u>** in winter. Comparing the simulation outputs of before and after the raw coal ban, PM_{10} concentration decreased significantly especially in the northern part of UB city where household stoves is the main source of air pollution. On the other hand, SO_2 concentration increased significantly. These suggests that switching from the raw coal to the current improved fuels was very effective in decreasing PM_{10} concentration, and further measures are necessary for PM and SO_2 concentration.



PM_{10} concentration decreased and SO_2 increased after switching to the current improves fuel.



Ambient PM_{10} and SO_2 concentration simulated for winter

(Simulated by combustion-derived sources only)

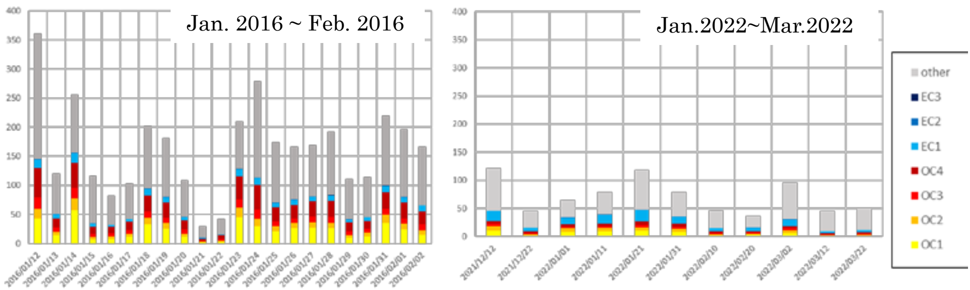
B) <u>Changes in Chemical Composition of PM</u>

In Phase 3, PM was sampled at three locations in UB city throughout a year from Nov. 2021. Composition of carbon, ions, and other elements of PM samples were analyzed in order to identify the major emission sources of ambient PM.

PM sampling locations and seasonal variation of major PM components (Nov. 2021 ~ Nov. 2022)

As shown in the charts above, ambient $PM_{2.5}$ concentration was generally very high in winter, and its major component is Particulate Organic Matter, particularly near the Ger area shown by orange color.

As shown in the charts below, high concentration of PM was significantly mitigated after the raw coal ban (2016). Among the components, total of organic carbons (OC1 ~ OC4), which was the main component in the 2016 samples, has significantly decreased in the 2022 samples. In particular, volatile organic carbon (VOC, OC1 in the charts) was significantly decreases, which also should be the major factor that decreased PM_{10} concentrations.



Share Change of Elemental and Organic Carbon of Samples at NAMEM

Followings are the summary of the activities:

- **PM_{10} concentration has decreased and SO_2 concentration has increased by switching to improves fuel.**
- **One of the main factors of PM_{10} concentrations mitigation was decreased OCs such as VOCs. This should be kept in mind in further improvement of fuel.**
- **In order to decrease SO_2 emissions, further improvements on fuel are necessary, such as controlling the sulfur content in fuel and/or adding desulfurizer.**

(5) Implementation of Pilot Projects (Phase 3)

Six pilot projects were carried out in Phase 3 in order to support evaluations and accelerations of Mongolian government on policies such as Mongolia Cabinet Decision No. 98 on Mar. 20th, 2017 (National Air Pollution Reduction Program). Further improvement of improved fuel for home use was selected as one of the pilot projects because the previous phases proved that the main reason of the serious air pollution in winter is home emissions in Ger areas, and further improvement of fuels is one of the highest potential method to solve the air pollution efficiently. Other five projects are improving traffic signal control, promoting low-sulfur fuel, Eco-driving, promoting Diesel Particulate Filters (DPF, PM reduction devices for diesel engine), and evaluating exhaust gas of in-use automobiles more efficiently by Remote Sensing Devices (RSD). Air pollution by automobiles can be solved through longer time span such as 10 years or more by controlling importing and production, and then waiting for automobile replacement. These five projects are selected because these have a high potential to reduce emissions as soon as possible. In this letter, we present 3 projects as samples.

A) Further improvement of Improved fuel for home use

According to the prior Phases, it was found that less volatile coals has high potential to mitigate air pollution, but is not easy to start fire in small stoves commonly used in families in Ger area. As one of the highest potential solution, biomass-mixed coal briquettes (BCB) were produced using the same less-volatile coals used for the current improved fuel (middling briquettes). Environmental performance and manufacturing costs of BCB was compared with those of the current improved fuel manufactured by TTT.

The table below shows that BCB satisfies all the parameters of the emission standard MNS 5216:2016 at combustion tests by the improved stoves. In addition, BCB showed lower concentrations of Dust, SO_2, NOx and CO compared to TTT's improved fuel. The difference in CO concentration was particularly large, which is estimated to be the result of quick temperature rise in the stove furnace because fire starting of BCB is quicker than that of TTT's improved fuel.

Feasibility of BCB was studied in view point of biomass supply. It is concluded that Töv Province, next to UB city, has the capacity to supply 115,000 tons of biomass per year, which is more than 71,500 tons of biomass needed to manufacture 650,000 tons of BCB to meet UB city's winter demand. Manufacturing cost of BCB is calculated to be 22% higher than the planned manufacturing cost of TTT's improved fuel in 2023. In addition, new investment will be required before full scale production because the existing improved fuel manufacturing equipment cannot be used to manufacture BCB, and biomass supply chain is necessary to be established.

Combustion tests results of TTT improved fuels and BCB with improved stoves

MNS 5216:2016	2020 year TTT					2021 year TTT				2023 year TTT			2023 year BCB (Saudust10%.$CaCO_3$3%)			
	1	2	3	4	Average	1	2	3	Average	1	2	Average	1	2	3	Average
Dust 130 mg/Nm3	137	124	120	139	130	204	149	105	153	151	125	138	98	86	47	77
SO2 1,200 mg/Nm3	919	776	1,042	1,027	941	637	748	464	616	747	778	762	518	371	724	538
NOx 700 mg/Nm3	187	178	277	220	215	231	225	269	241	177	178	178	152	163	140	152
CO 9,800 mg/Nm3	7,570	10,694	11,119	8,313	9,424	9,064	9,286	8,116	8,822	10,698	11,581	11,139	3,513	1,492	2,988	2,664

*Red numbers indicate exceedance of emission standards.

Changes in traffic conditions before/after signal adjustment

Parameters	**Signal adjustment**	
	before	**after**
Traffic volume (10 intersection)	574,270	593,767
Congestion length	8,260 m	7921 m
Travel speed (Nighttime Vertical)	9.5 km/h	11.2 km/h
Number of interventions (14 intersection total)	340 times	315 times
Average inter-vention time	3′14″	2′13″

B) Improving traffic signal control

This pilot project aimed to reduce air pollutant emission by proper control of traffic. Traffic Control Center of the Capital City (TCC) engineers were trained in Japan, and as the first step, TCC adjusted traffic signal light durations at 10 intersections in the center of UB city based on the result of traffic count survey.

Positive impacts were observed by comparing traffic parameters such as volume, congestion length, travel time, and traffic signal intervention before and after adjustment. However, in order to improve the traffic congestion in UB city well, not only improving traffic signal controls, but also other measures such as rearranging traffic lanes, increasing roads, improving public transportation systems, controlling traffic demand, and improving traffic manners are required.

This pilot project was also introduced in News-Letter Vol. 2 (Sep. 2023).

C) Promoting low-sulfur fuel

Low emission vehicles are being imported commonly in the last decades. Although they require ultra-low sulfur gasoline or diesel oil, high sulfur gasoline and diesel oil are commonly sold in UB, and damaged low emission vehicles. In order to promote low-sulfur fuels, in cooperation with Ministry of Mineral and Heavy Industries, the Project tested sulfur content of fuel sold at petrol stations, simulated SO_2 emission reduction possibility, supported legal development, and supported public relations by explaining the experiences in Japan.

Sulfur content tests revealed that high-sulfur fuels with sulfur content of over 1000 ppm were commonly sold. Based on the test data, SO_2 emissions reduction potential was calculated assuming that low-sulfur fuel is commonly sold. SO_2 emissions from automobiles in UB city was 408.6 ton/year in 2018 (when the sales ratio of low-sulfur fuel was 12.8%) and is estimated to be 97.3 ton/year in 2025 (Sales ratio is assumed to be 80.0%), meaning that the dissemination of low-sulfur fuel will result in a reduction of SO_2 emissions by 76.2%. Based on this calculation, a new Article 16.1.6 was added to Air Law on Apr. 22nd, 2022 to use Euro 5 standard (K5 in Mongolia) fuel in air pollution improvement areas in UB city. Dissemination of low-sulfur fuel has been slow due to the price difference between Euro 5 fuel and normal fuel, but it can be seen from the amount of imported low-sulfur fuel that low-sulfur fuel use is increasing year by year.

Regarding this pilot project, interviews with JICA expert by Mongolian television channel “NTV” are available online.

https://www.facebook.com/NTVNewsMN/videos/2018039411898251/
https://www.facebook.com/watch/?v=611376561080018
https://www.facebook.com/watch/?v=1548909752338264

Sulfur content survey results for Euro 2 fuels

GS No.	**Sulfur content ASTM D5453-09 (ppm)**
GT065	3546.0
GT066	2217.0
GT067	1431.0
GT068	1921.0
GT069	1424.0
GT070	1431.0
GT071	1738.0
GT072	3150.0
GT073	1848.0
GT074	1405.0
GT075	1538.0
GT076	1480.0
GT077	2795.0

*Survey in Mar.2023

Summary

The activities of the "Capacity Development Project for Air Pollution Control in UB City (Phases 1-3)", which have been implemented since April 2010, have achieved four main outputs as follows:

1. Analysis of air pollutants emission sources and evaluation of air pollution control measures

   By capacity development through the Phases, capacities of Mongolia side for measurement were developed about air quality monitoring and air pollutants emissions measurement from power plants, HOBs, Ger stoves, and automobiles. In addition, the effectiveness of air pollution control measures such as fuel additives, Euro-IV buses, and DPFs was evaluated by emission measurement in the Project activities.

   Furthermore, capacity of Mongolia side was developed to update the emission inventory, enabling Mongolia to update it regularly.

   In addition, JICA experts evaluated PM_{10} and SO_2 concentrations for each air pollution control measure by using air quality simulation model, enabling the Mongolia to compare and verify air pollution control measures based on the simulation results.

2. Air pollution control strategy, policy, and decision making

   In the Project activities, air pollution structure was evaluated in 2018, when raw coal was used commonly in home, and in 2020, after the ban on raw coal use. Based on these evaluation, the Project evaluated the air pollution control measures result from Mongolia's national policy of fuel conversion from raw coal to improved fuels and suggested to deputy mayor of UB city the need for further fuel improvements.

   In addition, in preparation for the full-scale introduction of BCB, the Project submitted technical information to decision making organizations of Mongolia regarding the results of fuel test, possibility of securing raw biomass enough for UB households, and manufacturing costs of improved fuels.

3. Evaluation of air pollution control measures

   In the Project, the effectiveness of air pollution control measures for each pilot project was evaluated and compared based on the simulation of ambient PM_{10} and SO_2 concentration.

   Through this comparison work, the Project ensured that decision makers of Mongolia could use the results of the pilot projects when planning air pollution control measures by the roll-out of the pilot project to full-scale introduction.

4. Implementation of air pollution control measures

   Starting in 2019, in order to reduce ambient PM, Mongolia banned raw coal use as house use fuel and introduced improved fuel manufactured by TTT.

   In addition, low emission automobiles (Euro V buses) and low-sulfur fuel were fully introduced to Ulaanbaatar as measures for air pollution from automobiles.

In order for Mongolia to introduce the pilot projects into a full-scale as air pollution control measures later, it will be necessary to calculate the cost and time required, and to evaluate the effectiveness of the proposed countermeasures in order to establish a system and secure necessary budget.