A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

AIR POLLUTION ISSUES AND AIR QUALITY MANAGEMENT PRACTICE IN ULAANBAATAR CITY, MONGOLIA

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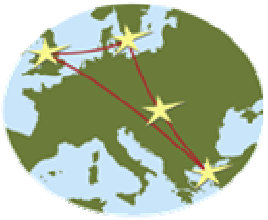
May, 2008

Budapest

Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management

MESPOM



This thesis is submitted in fulfillment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University (Hungary), Lund University (Sweden) and the University of Manchester (United Kingdom).

Supported by the European Commission's Erasmus Mundus Programme

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by: Munkhjargal BAYARLKHAGVA for the degree of Master of Science and entitled: Air Pollution Issues and Air Quality Management practice in Ulaanbaatar, Mongolia

Month and Year of submission: May, 2008.

Air pollution is becoming main issue in Ulaanbaatar city. Increasing population and a growing urbanization and industrialization have resulted in a demand for energy in several sectors including transport, heating; industrial production and construction which led to consecutive problems like decreased ambient air quality.

Air Quality Management (AQM) is essential tool to address air pollution problem. It consists of key elements which form parts of AQM system such as policies, standards and regulations, air quality monitoring and health impact monitoring and air quality management programs. Also, factors like public awareness, capacity building and financing resource are crucial for effective AQM.

This thesis outlines the current ambient air quality status, sources of pollution and health effects to the population. Also it provides an overview of the AQM framework in the Ulaanbaatar including policy initiatives and supporting programs. The purpose of this thesis was to review current practice of AQM discussing implementation of the each elements of it. Data from questionnaire surveys are used to indicate the involvement of various stakeholders in the air quality management process.

The existing data reveals that Ulaaanbaatar population exposure to pollution reached high levels. The Government of Mongolia has taken initiative to ratify legislative framework and designed air pollution reduction programs. However, implementation of successful AQM is weak due to various human, technical and financial resource problems. Identifying and strengthening the weakness in each step of current AQM system in Mongolia would help to achieve the goal of air pollution reduction.

Keywords: air pollution, air quality management

Acknowledgements

First, I would like to thank my supervisor Dr. Ruben Mnatsakanian. My work would worth nothing without inputs from Mongolian government officials, experts, and academic professors. My greatest gratitude goes to MESPOM consortium for providing excellent education environment and financial supports during my studies.
Moreover, I am thankful for my family and friends who always support me for inspiration and happiness. My especial thanks go to my friends, Sugandha Shanker and Erdenesaikhan Nyamjav and my brother Munkhnaran Bayarlkhagva for their true friendship and encouragement throughout my studies.

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List of Abbreviations

AAQS - Ambient Air Quality Standards
ADB - Asian Development Bank
ALAGaC - Administration of Land Affairs, Geodesy and Cartography
AOTA - Advisory and Operational Technical Assistance
ARD - Acute Respiratory Disease
AQD - Air Quality Division
AQM - Air Quality Management
AQMB - Air Quality Management Bureau
AQMS - Air Quality Management Service
CAI-Asia – Clean Air Initiative for Asian Cities
CEA - Country Environmental Analysis
CHP Combined Heat and Power Plants
CLEM - Central Laboratory of Environmental Monitoring
CSO - Civil Society Organization
DANIDA - Danish International Development Agency
DH - District Heating
DHW - Domestic Hot Water
DPSIR - Driving force - Pressure - State -Impact - Response
EANET - Acid Deposition Monitoring Network in East Asia
EC - European Commission
EIA - Environmental Impact Assessment
EMP - Environmental Management Plan
ESMAP - Energy Sector Management Assistance Program
ESP - Electrostatic precipitator
EU - European Union
GEF - Global Environmental Facility
GoM - Government of Mongolia
GTZ - Deutsche Gesellschaft fьr Technische Zusammenarbeit (German Technical Cooperation Agency)
HOB - Heat Only Boilers
JICA - Japanese Cooperation Agency
LPG - Liquefied Petroleum Gas
MASM - Mongolian Agency for Standardization and Meteorology
MCUD - Ministry of Construction and Urban Development
MDGs - Millennium Development Goals
MECS - Ministry of Education, Culture and Science
MFA - Ministry of Food and Agriculture
MFE - Ministry of Fuel and Energy
MNE - Ministry of Nature and Environment
MNU - Mongolian National University
MOH - Ministry of Health
MOI - Ministry of Infrastructure
NAMHEM - National Agency for Meteorology, Hydrology and Environmental Monitoring
NAMHEM - National Agency of Meteorology, Hydrology and Environment Monitoring
NAQO - National Air Quality Office
NCSD - National Council for Sustainable Development
NEAP - National Environmental Action Plan
NGO - Nongovernmental Organization

NSO - National Statistical Office
SIA - State Inspection Agency
SOER - State of Environment Report
SPIA - State Professional Inspection Agency
TA - Technical Assistance
UN - United Nations
UNDP - United Nations Development Program
UNEP – United Nations Environment Program
UNFCCC - United Nations Framework Convention on Climate Change
USAID - United States Agency for International Development
WHO - World Heath Organization

List of Technical Terms

CO - Carbon monoxide
CO2 - Carbon dioxide
m^3 - Cubic Meter
NO_2 - Nitrogen Dioxide
NO_x - Nitrogen Oxide
O3 - Ozone
Pb - Lead
PM - Particulate Matter
PM10 - Particulate matter with a diameter not more than 10 microns
PM2.5 - Particulate matter with a diameter not more than 2.5 microns
Ppm – parts per million
SO2 - Sulfur dioxide
SO_2 - Sulfur dioxide
SOx – Sulfur oxides
µg/m3 - Micrograms per cubic meter

INTRODUCTION

The thesis is about the Air Quality Management system in practice today in Mongolia and about the poor quality of ambient and indoor air that Ulaanbaatar city, Capital of Mongolia is experiencing. In this thesis, we discuss the initial achievements done so far in the AQM and drawback of the system. The topic of the thesis is worth investigating because identifying the AQM development level in Mongolia will help to improve the situation of air quality by pointing out the exact reasons and factors for AQM malfunction. This extra earned information would help to better policy formulation and well aimed action plans etc. The development and effective implementation of solutions to the air pollution problems in the Ulaanbaatar city is essential to guarantee the health and welfare of its inhabitants. To achieve this, it is essential to have the active and well designed AQM system which consists of effective well aimed policy and regulations, supporting action plans and programs, feedback monitoring system and enforcement strategies and human, financial and technical resources. As a matter of fact current AQM system is rudimentary in Mongolia so comparing situation in Mongolia with the conceptual framework of AQM system and identifying achievements and limitations of the existing practice will lead to improved strengthened air pollution abatement strategy.

Aim and Objectives

The aim of the thesis is to investigate performance of Air Quality Management (AQM) practice in Mongolia. This research explores major challenges of managing air pollution in each of AQM implementation steps. Objectives of the research were:

- To review current state of the ambient air quality in Ulaanbaatar city, Mongolia
- To describe major sources of air pollutants and potential effect on human health
- To examine existing air pollution control strategies in Mongolia

- To examine existing air pollution legislation, regulation and their implementation
- To examine air pollution abatement policy compliance and enforcement
- To identify AQM system key players in AQM in Mongolia describe their roles
- To identify achievements and limitations of the existing practice

Methodology of the Survey

It was carried out through literature research and structured interviews taken from various stakeholders of the AQM system representing different views and sectors. The "what" question of the study, a framework of the current AQM system in Mongolia is examined through qualitative research method of literature review. Each crucial elements of AQM system was examined if it exists in Mongolia and if they do, the question was until what extent. Once these existing elements were identified, the "How" question comes. Implementation of the air quality legislation and air pollution management program and monitoring activities were analyzed. These were analyzed using in dept interviewing and document analysis methods. "Why" question was raised to analyze the challenges in successful implementation of AQM in Mongolia. Collected interview data and existing literature were interpreted for the investigation. Interview data were collected from small focused samples which were main stakeholders/key players in AQM system Mongolia. Qualitative research collected data were categorized into patterns which are outlined in the report structure. In dept interview questions were "strategically" prepared to get the answer from the stakeholders of AQM system. Each section of questions was assigned to each stakeholder in charge of the elements of AQM. Interviews are conducted through direct phone calls and e-mail correspondences.

Structure of the Thesis

In Chapter 1, the nature of an existing air quality problem in Ulaanbaatar city is described. Current status of air quality, sources of major air pollutants and their potential health effects are outlined in the chapter. The AQM conceptual framework was examined through literature analysis and it is documented in Chapter 2. The key elements of AQM system including policies, standards and regulations; air quality monitoring and health impact monitoring and air quality management programs are reviewed in this chapter. Public awareness, a crucial factor for an effective AQM is described as well. The Chapter 3 provides an overview of air quality management strategies in Ulaanbaatar, including policy initiatives and supporting programs. AQM stakeholders and their responsibilities are described. Existing practice of air pollution abatement activities are examined. In Chapter 4, findings of the research are summarized. The chapter outlines the policy framework within which the Mongolia operates and reviews the air quality management process revealing currently existing major challenges of air pollution management. Then the thesis is followed by conclusion.

CHAPTER 1: UNDERSTANDING OF THE URBAN AIR POLLUTION PROBLEMS IN ULAANBAATAR

1.1 Population and Urbanization

The capital city of Mongolia, Ulaanbaatar, was established on the bank of Tuul River in the valley called Khun-Chuluu between 4 mountains 224 years ago. The city is located between Branches of Khentii Mountain Range in 1850m above sea level. The city consists of 9 districts of which 3 satellite districts are located in 100-200km far from the city. Since 1924, the city has served as the official capital and it is the country's most important economic, social and cultural centre. The official city covers total area of 470,000 ha. The total built-up area covers approximately 16,000 ha. It comprises two distinct zones of approximately 6,000 ha of formally serviced urban core and 10,000 ha or less formal periphery areas (which are traditional tented accommodation). Growing population of Ulaanbaatar is now reside in periphery areas which are predominantly poor, and this is an increasing social, economic, environmental and political concern to the government and residents (UNDP, 2003).

Ulaanbaatar is the largest and densely populated city in Mongolia. Although country's population density per square kilometer is one of the lowest in the world; urban population density is constantly increasing. It has been stated in the constitution that human can reside wherever they want in territory of Mongolia (GoM, 1992). By the year of 2006, Ulaanbaatar city had 994.3 thousand residents which led to the electricity demand, transportation, energy and industrial sectors, and energy for domestic cooking and heating. The city population makes 38 percent of total population of the country. Its population density has reached 194 per 1 sq.km., which is 120 times more than the average. There are estimated number of 215.7 thousand households and 41.2 percent 89.2 thousand of them live in apartments. In last decade, the city population has grown by 281.3 thousand . According to S.Guttikunda, the growth rate of urban population is 3.8 percent and number of residents expected to reach 1.75 million by the year of 2020 (Guttikunda, 2007). Main reason for this growth is in-migration

from neighboring provinces which is triggered by major factors like relatively higher income and more employment opportunities. The city is not well planned and constructed for such fast growing population. The lack of appropriate residence and transport infrastructure is bringing problems like poor waste management, poor clean water supply and high levels of air pollution (World Bank, 2005). During the difficult period, in which the country is transferring to market economics, the number of people, who are making from local areas to the capital city, is dramatically increasing year by year. Population and industry concentration in Ulaanbaatar causes difficulties to infrastructure, telecommunication, medicine, schools and domestic services of Capital city and also influences negatively environment and residents' health (Bat, 2008).

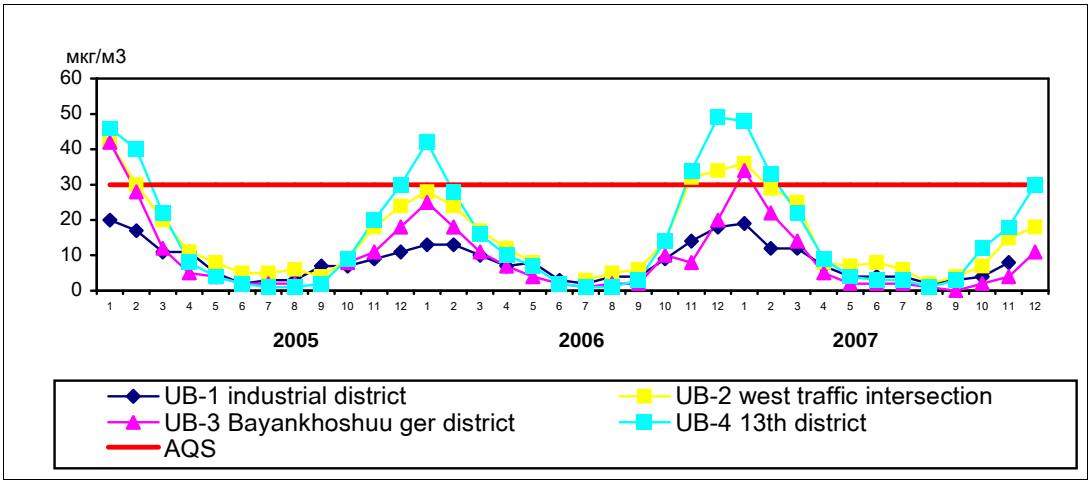
1.2 Status of Air Quality

Atmospheric sulfur dioxide (SO_2) increase is mainly caused by emissions from coal combusting combined heat and power plants, heat only boilers; and smelting, petroleum refining, sulfuric acid manufacturing industries. Ulaanbaatar electricity generation and heating demand increase during period of October to March which result in increased concentrations of SO_2 in the atmosphere.

Ulaanbaatar daily average concentration of sulfur dioxide SO_2 and nitorgen dioxide NO_2 were 12.2 and 34.5 percent above the allowed standard concentration in 2005. In year of 2006, concentrations of these gases were 13.8 and 30.6 percent above the allowed standard. By the first ten months of the 2007, daily average concentration of sulfur dioxide SO_2 and nitorgen dioxide NO_2 were 12.9 and 42.9 percent above the limit. Sulfur dioxide concentration exceedance above the standard limit in the atmosphere occur from december to april which is related to the combustion of raw coal. Monitoring station near the central traffic road has measured nitorgen dioxide NO_2 level increasing above the standard limit all around year which indicates pollution from motor vehicles. Since 1995, number of motor vehicles in

the city has grown by 3.3 times and number of households which use simple cook stoves has grown by 2.26 times (MNE, 2008).

Figure1. Monthly average concentration of SO_2 (μ/m^3) in Ulaanbaatar (2005- 2007)

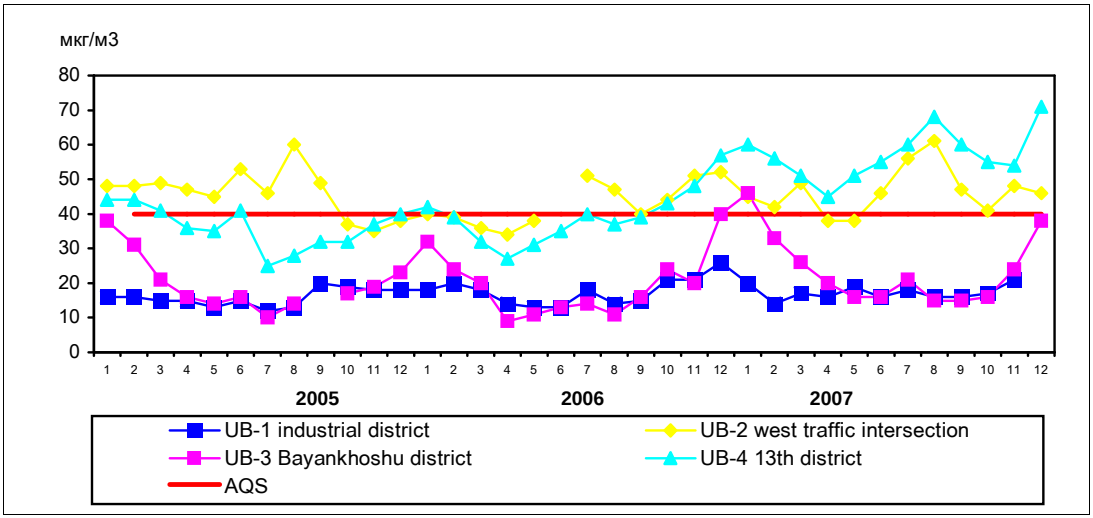


Source: Ministry of Nature and Environment (SOER, 2008)

The figure indicates that the concentrations of pollutants exceed national standards during winter. According to air quality monitoring data, annual average concentration of sulfur dioxide was 12 μ/m^3 in 2007. In January 2007, maximum concentration of sulfur dioxide, 83μ/m^3 was recorded in UB-4 monitoring station. Sulfur dioxide standard limit (30 μ/m^3) exceeded in UB-4 monitoring station area (38 μ/m^3) (SOER, 2008).

Nitrogen dioxide (NO_2) and nitrogen oxide (NO_x) are rapidly emerging problem in Ulaanbaatar. Atmospheric NO_2 is mainly formed by exhaust gases from vehicles due to a high temperature combustion process with the major oxide in combustion emission being NO and then oxidized to NO_2 in the atmosphere.

Figure2. Monthly average concentration of NO_2 (μ/m^3) in Ulaanbaatar (2005- 2007)



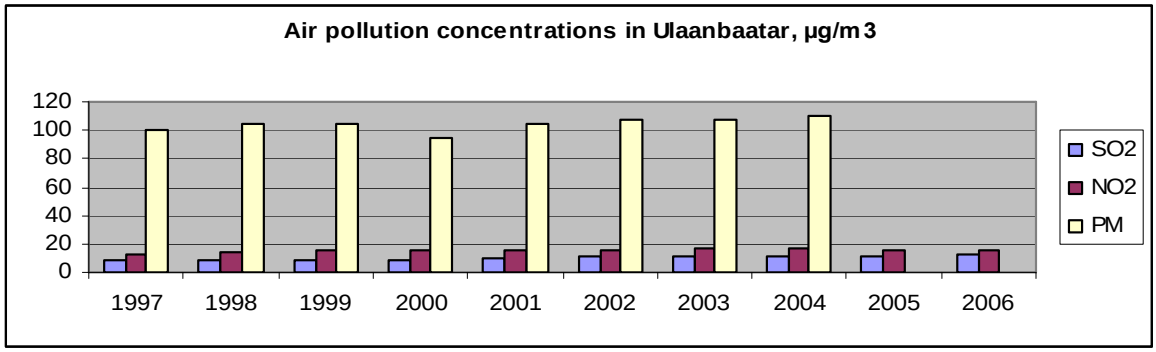
Source: Ministry of Nature and Environment (SOER, 2008)

Annual average concentration of nitrogen dioxide is 36 μ/m^3 and daily maximum level of nitrogen dioxide has reached 98 μ/m^3 in July near busy city center traffic crossroad. Nitrogen dioxide levels in the area near the air quality monitoring stations of UB-2 and UB-4 exceed Air Quality Standard limit throughout the year which indicates high level of motor vehicle emissions exist in the East and West crossroads. According to the city air quality report, in January 2008, in areas near UB-4 monitoring stations which is in the east side of the city and along the major traffic road, nitrogen dioxide level exceeded standard limit (40 μ/m^3) by 2 times (83 μ/m^3). Near the industrial area of the city, nitrogen dioxide level was 31 μ/m^3 and in the West crossroads the level was 46 μ/m^3. It can be concluded that there are high levels of nitrogen dioxide pollution in East and West traffic crossroads where constant motor vehicle congestions occur (SOER, 2008).

Particulate matter (PM) is the major air quality problem in Ulaanbaatar. During colder months PM concentrations increase just like as SO_2 and NO_2 concentration. Due to the lack of technical equipments, concentration of PM is only measured in UB-1(industrial area) monitoring station. Results of sulfur dioxide, nitrogen dioxide and particulate matter

measurements by monitoring stations and trends of their levels are revealed in graph below.

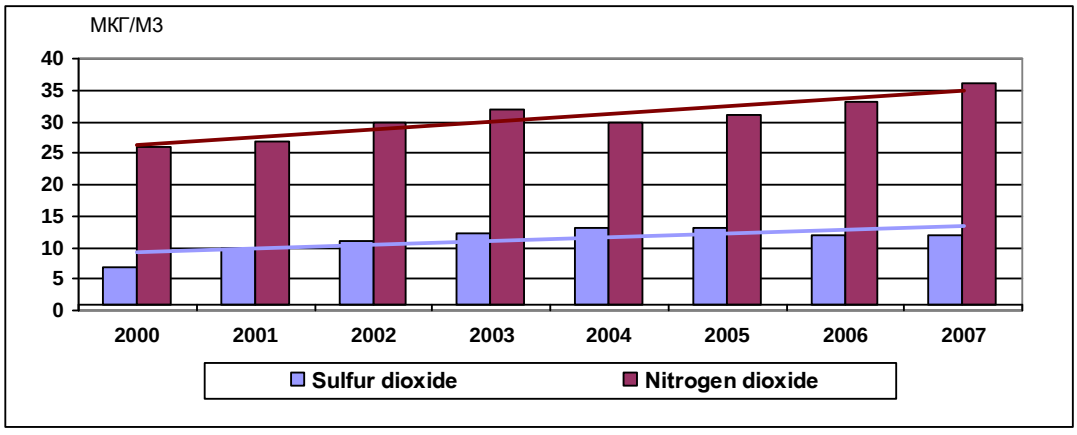
Figure3. Annual average concentrations of SO_2 , NO_2 and PM in Ulaanbaatar city atmoshphere



Source: Ministry of Nature and Environment (SOER, 2008)

Particulate matter, sulfur dioxide and nitrogen dioxide concentrations can reach excessive levels than Mongolian and World Heath Organization (WHO) guideline standards during cold months which can result in adverse health impact. The growing trend of SO_2 and PM_{10} pollution is directly linked to the increasing coal use. Monitoring data shows also growing vehicular population is one of the causes for increased NO_2 levels. Motor vehicle is precursor for ground-level ozone pollution and contributor to PM 2.5 pollution.

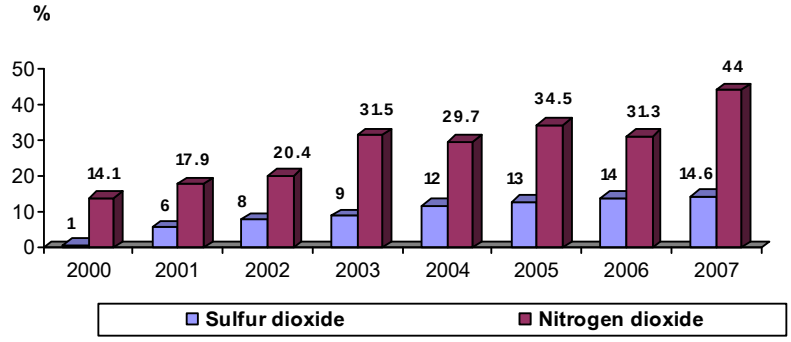
Figure4. Growth trend in concentrations of major air pollutants in Ulaanbaatar, µg /м^3



Source: Ministry of Nature and Environment (SOER, 2008)

Sulfur dioxide and nitrogen dioxide concentrations have been gradually increasing.

Figure5. Percentage of polluted days which exceed the Air Quality Standard limit



Source: Ministry of Nature and Environment (SOER, 2008)

In 2007, percentage of sulfur dioxide polluted days that exceeds Air Quality Standard has reached 14.6 percent which is 0.6 percent more than that of the 2006. Percentage of days polluted by nitrogen dioxide has reached 44 percent indicating sharp increase of pollution level by 12.7 percent from 2006.

1.3 Sources of Urban Air Pollution

The main sources of air pollution contributing to urban ambient air pollution include emissions form combined heat and power plants, heat only boilers, industry, motor vehicle, household stoves. Although coal consumption in Mongolia is relatively low compared to most of the countries, energy sector is contributing to greenhouse gas emission and harmful air pollution. Reduction of these emissions is top priority of the Government of Mongolia (ADB, 2006).

1.3.1 Emissions from the Coal Combusting Power Plants and Heat Only Boilers

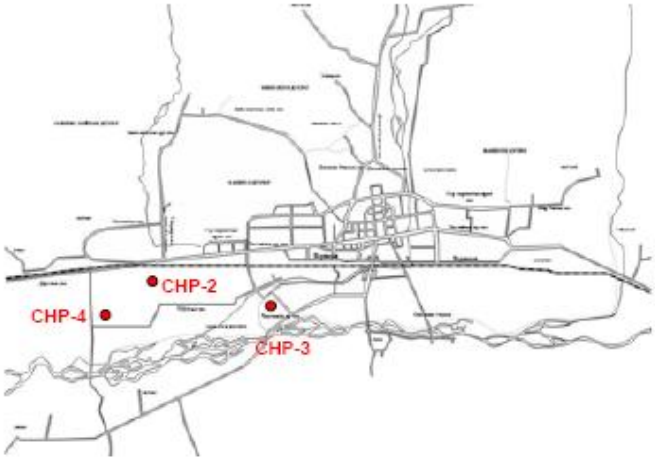
Three largest coal-fired Combined Heat and Power (CHP) Plants are one of the major energy (raw coal) consumers that comprise nearly all of the installed power capacity in the city, supplying space heating, domestic hot water and electricity to the city. District heating (DH) services cover 60% of the central Ulaanbaatar households and supply 80% of the energy

demand. The power plant operates at high work load and fuel combustion in the winter months compared to the spring and summer months which is the same trend in household fuel consumption. The pollution control technology in the power plants is operated at lower efficiencies in terms of catchments of fly ash and other stack pollutants. When fly ahs is removed by wet scrubbers and Electrostatic precipitator (ESP) in power plants, it is regimented in settling tanks and dust is collected and kept in ash ponds. The fly ash from the ponds is the unaccounted important source for particulate matter emission because it is open to wind erosion. In spring and summer season dust storms are common in Ulaanbaatar and ash particles are lifted in air. In the winter months, Due to higher moisture content and snow cover, it doesn't account much to the pollution sources. These ash ponds are located very close to CHP-2 and CHP-3 and for CHP-4 it is 3 km to the west. Fine sized ash particulate matters are re-suspended in the city and contribute to the city air quality problems (Guttikunda, 2007). Thermal Power Stations steam boilers are type of BKZ-75-39, BKZ-220-100 and BKZ-420-140 with an Efficiency of 93-95%.

The main source of heat, the three combined heat and power (CHP) plants combust 5.6 tons of coal and produce 6 percent of the air pollution emission. Two years ago, there were about 370 low pressure boilers and they made 1 percent of the air pollution emission, now number of small and medium scale low pressure boiler has increased by 3.7 times and reached 1378 (Guttikunda, 2007). These low pressure boilers burn 1.1 tons of coal and make 3 percent of the air pollution emission. Out of these, 54 medium scale low pressure boilers were counted as unqualified. There are 25 schools and 18 kindergardens which opearate low pressure boilers and estimated 89500 tons of coal is burned per year (SOER 2008). Residents who live in apartments require central heating system which is operated since mid September until mid may. Central heating and hot water is supplied from three combined heat and power plants (CHP). The three CHP in Ulaanbaatar, which consume about 5 million t of coal per

year, and release emissions, including Sulfur dioxide (SO_2), PM, and Nitrogen dioxide (NO_2) in the air (World Bank 2004). The existing technologies in coal combustion in power plants and industries are low level. The Baganuur, Shivee Ovoo, and Sharyn Gol mines provide three CHP, boilers and household with low quality lignite coal to produce energy. Lignite is the most common coal type found in Mongolia. Lignite has a heating value of 2,700 to 4,000 kcal/kg, 18-35% moisture and 12-25% ash. Coals produced in Mongolia have sulfur content less than one percent.

Figure6. Power plant locations in the city



Source: ADB, 2005

Households which are not supplied by district heating use traditional heating stoves for cooking and heating. In isolated built-up areas where district heating system not reachable, heat-only boiler (HOB) supply energy. HOB is growing emission source because due to urban growth and increasing demand of energy network installation and expansion to residential and commercial growth. HOB is major source of low lying ground level winter air pollution source in Ulaanbaatar. About 40% of sub-urban area households use stoves. According to City Chief Engineer's office survey, there are about 800 boilers with size of 100 kW or less and 150 boilers with size of 0.17 to 3.5 MW. Nearly 80% of those of larger size150 boilers

use older Russian technologies which operate with efficiency of 40-50% (Guttikunda, 2007). These are scattered in and around the city of Ulaanbaatar.

Three thermal Power Plants in Ulaanbaatar release to atmosphere 4.5 Mm3 of smog, 4.14 t of ash and exhaust 6.762 kg of sulfur oxide per hour at wintertime and waste 64 t of ash slag. Although the power production and consumption in Mongolia are low in comparison with the developed nations, the greenhouse gas sources are still important.

1.3.2 Emissions from the residence area in periphery areas of Ulaanbaatar

Coal combustion in cook stoves in felt and wooden household area are the largest source of air pollutants at the ground level. Ulaanbaatar city residents, who live in outskirt area o of the city, generally live in so called "Gers" which is circle wooden framed structure under layers of felt. In these dwelling, cook stoves are used for heating and cooking purpose since these are not connected to central heating system. Effectiveness of these stoves and insulation levels of felt can vary dwelling to dwelling. Annually each household is estimated to use about 5 tons of raw coal and 30 m^3 of fuel wood for their cooking and heating purposes. Usually, available fuel is coal with poor quality and high ash content. During winter, coal is dominant fuel while in summer wood is main source of energy. Rural deforestation contributes to the increasing severity of seasonal dust storms. Due to ever increasing in-migration trends from neighboring provinces, exact numbers of households are not clearly estimated (Guttikunda, 2007). Some household burn even unconventional fuels like rubber tubs and bricks dipped in coal tar for intermittent cooking and heating needs. This is creating uncertainty of total pollutant levels from cook stoves usage since there is no clear estimate of the extent of usage of these materials. Pressed coal, crushed briquette shaped coal is available in cheaper price and in variety. It has higher ash content compared to raw coal. It is often confused with the real briquettes which have higher calorific value and produces less ash. Few numbers of private manufacturers are making charcoal briquettes and supplying

limited amount of these to customers. The consumption of briquettes and Liquefied Petroleum Gas (LPG) is limited mainly due to higher price than raw coal (Bulgan, 2002). An unaccounted source of pollution, kiosks and food shops are definitely contributors of emission as long as they use same type of cook stoves for cooking and heating. In parallel with increased in-migration from neighboring districts, the numbers of food shops have more than doubled in the last five years – from 1,100 in 2000 to 2,500 in year 2005. World Bank has done survey which concluded that annual fuel consumption is 8 tons which is higher than that of households' consumption of coal per year. This source not accounted in the emissions inventory (Guttikunda, 2007).

Information about hospital waste handling is very limited. Infectious medical waste is not accepted in city landfills and hospitals are required to incinerate hospital wastes. Obviously hospital waste burning is small source of emission compared to the others but worth to take in account. Thirty five hospital lack appropriate incinerators and instead use common cook stove at high temperatures for bio-hazardous waste burning contributing to the air pollution sources (Enkhbold, 2005). An unaccounted source in the emission inventory which emits substantial amount of pollutants and toxins into the air is burning of household garbage in illegal dumps. Although garbage burning is not allowed by many local governments due to its smoke and odour problem, the practice is still being continued. Garbage burning emits air pollutants which are dispersed and contaminating the environment and accumulating in the food chain. Backyard garbage burning contributes to indoor air pollution which is hazardous to health. Burning at the landfill sites is source to emission. Japanese International Cooperation Agency (JICA) conducted a survey regarding municipal waste of Ulaanbaatar in 2005 and estimated that 555 tons of garbage produced per day in the winter and 248 tons in the summer season is produced (ADB*b*, 2005). Households produce most of the waste in the winter season, primarily due to the climatic conditions. More than

thousand small scale illegal dump sites exist in sub-urban felt and wooden household areas Ulaanbaatar and they are put on fire at time to time (World Bank, 2004).

There is a territory of 336.5 thousand hectares, so called agricultural area of the city where no construction should take place. However, 80 percent of them have been damaged by people. This contributes to air pollution by the dirt substances of loose soil caused by improper utilization. There are field sources of particulate matter which include power stations coal ash reservoir, dust from the degraded and eroded lands and waste dumps. There is 65 hectares coal ash reservoir in the power plants (Guttikunda, 2007).

1.3.3 Emission from the urban public transport

Nitrogen oxide pollution is mainly due to vehicular emissions. Transportation means are increasing at a faster rate in Ulaanbaatar and the improved technology is insufficient to counteract growth. Emissions from motor vehicles are major source of air pollution in the city. The main means of transportation in city of Ulaanbaatar is road transportation. The first road transport organization was founded in Mongolian in 1925. In 1929, the urban public transport service started with 2 buses, since then the city is experiencing constant increase in numbers of transport means. The total length of the road network in the city is 361.1 km, out of which 300.4 is km is asphalt, 47 km is concrete and 13.7 km is ground (Bat-Ochir, 2006).

Due to increased numbers of transport means, emissions form vehicle have grown as well. During the period of 1991 to 2007, the number is transport means in the city has increased more than double. Majority of these vehicles are old, second hand and often don't meet fuel consumption and emission standard of Mongolia (Bat-Ochir, 2006). In year of 2006, estimated number of 80000 motor vehicles was in Ulaanbaatar. The number of vehicles has rapidly grown in last decade and private owned passenger vehicles make majority of these number. This rapidly increasing number of motor vehicles are imposing heavy load on city transport infrastructure. The city has limited road network system of highway and secondary

street capacity to support these vehicles. This is creating traffic congestion and related pollution problem for municipality. Urban planning didn't consider this traffic load so conversion of open space in order to accommodate auto movement, parking and storage has resulted in degradation of the urban quality of life. Majority of vehicles running in the city have age of more that 10 years. Persuading people to use public transport or non-motor vehicle is difficult because owning private car is considered social status. Small size public transport mini van numbers have rapidly grown in last decade but phenomenon is creating negative effects of longer travel times for surface public transport poor traffic safety, the economic inefficiency of increased fuel use (Bat-Ochir, 2006). These mini vans are reason for traffic congestion and reduced speeds and they make regular large busses difficult to operate at normal speeds and a steady decline in their numbers. Gasoline makes major fuel for the vehicles but recently process of converting engines in to duel modes with the LPG has started. Russia is number one gasoline exporter to Mongolia and China exports small amount of gasoline as well. Even though leaded gasoline is banned internationally, Mongolia keeps importing leaded gasoline form Russia. The laboratories operating in the city lack facilities to test lead presence in gasoline and instead the level of gasoline is tested at gasoline pumping stations in Russia and China (Guttikunda, 2007). A study conducted in 2006 measured lead in child blood at 16.5mkg/dl. It is estimated that 80% of the vehicles do not meet fuel consumption or emission standards (World Bank, 2004). Railway stations and airports also contribute to fuel consumption and emissions. Estimated amount of 2000 tons of raw coal is burned during the winter in railway station. Airport is also source of emissions of VOCs, CO, NOx but is located in the west, relatively far from the city (Guttikunda, 2007). Numbers of motor vehicle especially private vehicle numbers are constantly growing with an estimated percentage of 15 per year. Diesel consuming vehicles are old and tend to produce higher emissions than permitted level (Guttikunda, 2007).

Ulaanbaatar is a linear city along the river so its major transport tracks are along east to west axis. Over the past 10 years, cars' smoke and coal's carbon monoxide in Ulaanbaatar has been deteriorating. According to the Ulaanbaatar Air Quality Office, 92,000 cars, 436 motorbikes, 779 tractors, 1626 trailers, and 95 public transportation vehicles counted, 45.1 percent were aged four to six years and 37.9 percent were aged between seven to 10 years. Plumbic fuel and diesel petrol is used for vehicles so it's also influencing the air pollution. Of these vehicles only 40 percent have satisfied vehicle exhaust requirements by the National Air Quality Office. Since 1990, total number of cars doubled and higher concentrations of NO_2 have recently been observed along the main roads and traffic intersections. According to Ph.D P.Batiimaa, director of the National Air Quality Office, - Ministry of Environment, current average concentrations of NO_2 are still below the national standard (SOER, 2008).

The lead, so called mental poison is a part of air pollution which threatens to health of citizens and children. This lead is considered to have negative effects on the growth of children. Many countries in the world have banned use of plumbic oil due to the content of lead but it is still used in Mongolia.

1.4 Impacts of Air Pollution on Health of Population

Air pollution direct effects on human health include increased risk of death (mortality) or increased risk of experiencing an adverse health effect (morbidity). Adverse health effects can be divided into acute effects such as headaches or eye irritation which generally last only a few days, and chronic effects such as emphysema or asthma which are generally associated with long-term illness (Bruce et al, 2000).A large number of studies were conducted and are being conducted around the world to document a consistent association between elevated ambient PM10 and PM2.5 levels to an increase in mortality rates, respiratory infections, number and severity of asthma attacks and the number of hospital admissions. Actual health impacts of air pollution are determined by two factors, i.e., by sufficiently high concentrations

of pollutants in the atmosphere and the presence of people in the region affected by these pollution levels (Krzyzanowski and Schwela, 1999). In Ulaanbaatar, both are true, especially in the winter season, with high ambient PM concentrations and people in high density areas of periphery being constantly exposed to them (Bulganchimeg, 2003).

Extensive coal usage for indoor heating acts as primary source of pollution and affecting health of the population. Particles with a size of mm 9.2 to 30 creates visible pollution, 5.5 to 9.2 lodges in nose/throat, 3.3 to 5.5 in main breathing passages, 2.0 to 3.3 in small breathing passages, 1.0 to 2.0 in bronchi and 0.1 to 1.0 in air sacs. Particulate matters from various sources are considered to be responsible for health impacts such as decreased lung function, acute respiratory illness, asthma, chronic bronchitis, and minor respiratory irritations in population. PM_{10} and $PM_{2.5}$ cause negative health effects when inhaled by people when they are exposed to them indoors where the cooking and heating takes place using coal, and on the roads where there is a constant exposure to fumes from vehicles and re-suspended dust in the city. World Health Organization (WHO) standards regarding PM concentrations both indoors and outdoors are exceeded in felt and wooden house city outskirt area, especially during winter time due to higher population density and coal combustion. Especially in April, strong winds pick up soil surface and cause dust storms (WHO, 2002). This is mainly due to anthropogenic and natural land degradation. There are four times as many dust storm days in Ulaanbaatar, compared to days in 1960 (SOER, 2008). Division of Policy Planning and Implementation, Ministry of Health, have conducted studies and concluded that there is a significant correlation between increased air pollution and acute respiratory infections among children every year. In Mongolia, respiratory diseases are the primary cause of morbidity and mortality among children and the fifth leading cause of death for the overall population (World Bank, 2005).

In domestic environment, people are exposed to higher levels of pollutants and exposure to indoor air pollutants and the level of respiratory symptoms are influenced by the type of dwelling the people live in. Felt dwellings and small houses are usually single room semi-permanent construction which are located in the outskirt area of the city. These constructions are not subjected to uniform building code (Saijaa et al. 2000). Felt dwellings and houses are poorly designed in terms of ventilation and other factors such as burning of coal for heating and cooking can lead to levels of indoor air pollution which may be detrimental to human health. Levels of carbon monoxide can be increased from incomplete combustion in poorly designed stoves and from passive smoking. Other products of combustion, such as SO2, and particulates from smoke and ash, are of concern (Spickett et al. 2002).

According to the survey result done by WHO with collaboration with MOH, children living in felt dwellings and houses were exposed to higher levels of respiratory symptoms than those living in apartments. Results also showed that levels of carbon monoxide and particulate matter were significantly higher in felt dwellings and houses than in apartments. The assessment of indoor air quality by monitoring sulfur dioxide, carbon monoxide and PM10 has showed that of the children involved in the study 19% had bronchitis, 1.4% had asthma and a total of 78% reported respiratory symptoms (Spickett et al. 2002). The average content of carbon monoxide complied with US EPA standard of 9ppm. However, 32.2 % of the households involved in the survey were exposed to higher content of carbon monoxide than the US EPA standard (9 ppm) and a maximum level was seen at 22.47 ppm which was 2.3 times higher than the standard. The average content of particulate matter of the current study, for all dwellings, was 4.1 times higher than the US EPA standard of 0.15mg/m3 and the maximum level was 7mg/m3, which was 46.7 times higher than the same standard (Spickett et al. 2002). Of those periphery area households involved in the survey, 53 % were

exposed to higher content of particulate matter than the US EPA standard (0.15mg/m3) and 20.1% of apartment households experienced higher particulate matter content than the standard (Spickett et al. 2002). Also, the frequency of respiratory symptoms was higher in children who lived in felt dwellings and houses than that of those lived in apartments (Table 1).

Table1. Respiratory symptoms by type of dwelling

Symptoms	Apartment (%)	Felt dwellings and houses (%)	Total (%)
Chest tightness	1.4	5.8	7.2
Morning cough	14.4	25.6	40.0
Shortness of breath	1.0	4.4	5.4
Morning phlegm	9.0	16.2	25.2

Source: Spickett et al. 2002

According to another pilot study conducted by S. C. Cowlin, the average levels of indoor PM and CO contents in stove using households were higher than Mongolian national standards for 24-hour concentrations, air quality guidelines set by the WHO and standards set by the U.S. EPA. The average of 24-hour CO concentrations over all households was 9.5 ppm which exceeded the Mongolian national 24-hour CO standard of 2.6 (ppm) and the average 24-hour observed PM concentration was 730 μg/m3) which exceeded the Mongolian national 24-hour average total suspended particles standard of 150–200 (μg/m3) (Cowlin, 2005). The average rate of diseases of respiratory system in 2002-2004 was 2.4 times more than that in 2000-2002.

CHAPTER 2: URBAN AIR QUALITY MANAGEMENT

2.1 Urban Air Quality Management

The Air Quality Management process is the number of activities undertaken by the responsible authorities to control the source of pollution and reduce the air pollutant until certain agreed level. The priority of the Air Quality Management (AQM) is for the maintenance of air quality which is important for human health, wildlife, ecosystems and aesthetics. Each air quality management activity is related to the others. An air quality management system is an integrated system that assesses emission to the atmosphere; determines resultant concentrations in the ambient environment and assesses the impact against legislation (Korea Environment Institute, 2002). Continuous review and assessment of standards and strategies based on their effectiveness and new research on health and environmental effects is important for the successful AQM implementation. Although AQM is undertaken by the Government, informed participation of the civil society, the academic community and the private sector has important role to play.

2.1.1 A Logical Framework for Urban Air Quality Management

There is a logical framework for urban air quality management. A useful framework for management of urban air pollution is the classic *Driving force - Pressure - State -Impact - Response* (DPSIR) framework (Korea Environment Institute. 2002). The driving forces of air pollution in cities are the rapid growth of population accompanied by the expansion of the transport and industry sectors. The pressures of air pollution in cities include emissions of acidifying substances, ozone precursors and particulate matter etc. The state of air quality is reflected in the database of an air quality monitoring system. The state of air quality includes information regarding air pollution exposure of the population and the degree of compliance to WHO Air Quality Guidelines or National Standards (WHO, 2000). Impact of the air pollution is reflected on the health of the population and on the surrounding ecosystems as

well. Also, negative impacts of the air pollution include infrastructure damage and economic loss. The response is the measures undertake by the national and local government to manage an air quality. The responses targeting the air pollution problem, take the form of policies and regulations for control and amelioration through enforcement. The effectiveness of these responses is determined through the monitoring of air quality and human health (Korea Environment Institute, 2002). Specific air pollution response may include measures like air quality monitoring, cleaner production, and public transport reorganization, regulation of mobile and point sources of pollution, applying taxation and increasing public information on air quality.

There are several key steps in the development of an AQM system. First there is an assessment process of the problem which includes identifying emission sources, quantifying emission sources, monitoring air pollution, assessing the exposure conditions, identifying-source exposure relationships, estimating relative importance of pollution sources and assessing environmental damage. Then, process of analyzing the options to solve the problem, including, investigating short and long-term control options and performing cost-benefit analysis. Another important step is air pollution control process which covers developing institutions, regulations and enforcement mechanisms, raising awareness and environmental education and implementing an action plan (Korea Environment Institute. 2002). The surveillance or establishing an air quality information system is an important step as well.

2.1.2 Stages of Urban Air Pollution in cities

With regard to the stage of air pollution problem in the city, strategic framework for response actions on urban air quality should address those elements of AQM which are of most importance. The condition of an air quality in a city is divided into five general stages according to the severity of their air pollution problem:

1. Stage 0 Pre-problem stage

2. Stage I Moderate and increasing levels of air pollution
3. Stage II High but stabilizing levels of air pollution
4. Stage III Moderate and decreasing levels of air pollution
5. Stage IV Low and decreasing levels of air pollution

Depending on stages, AQM key elements give priority to solution measures. Developing solutions of urban air pollution problem is subject to the overall level of economic development of a certain city (Korea Environment Institute, 2002).

Stage 0 – Pre-problem stage

At this stage air pollution is very light where main source of air pollution is not from heavy industrial development but from the domestic sector and light industry. Ulaanbaatar city is clearly not at this stage in this case.

Stage I – Moderate and increasing levels of air pollution

At this stage air quality begins to worsen with increased industrialization, urbanization and demand for transport. Combustion of high-sulfur fuels like coal and leaded gasoline in the transport sector is the norm. At this stage management of air quality is rudimentary with little or no systematic air quality monitoring. The pollution emission control is minimal which causes rising levels of pollutants such as SO2, SPM and Pb. Usually major pollutants frequently exceed WHO guidelines. Impact on the health and the environment are becomes apparent.

Stage II – At this stage there is a high but stabilizing level of air pollution. High emission level of air pollution is due to emissions from heating facilities, electrical generators, vehicles and small, medium and large-scale industrial boilers. Concentrations of many pollutants (SO_2, CO, NOx and O_3) regularly exceed WHO guideline values (WHO, 2000) and impacts of them are widespread and severe. There are increased efforts to manage air quality by monitoring air quality and controlling air pollutant emission sources due to relatively raised concerns.

Stage III – There is a high to moderate and decreasing levels of air pollution at this stage. Here, concentrations of many air pollutants are decreased as a result of efficient air quality management systems. Reduced emissions are achieved through the implementation of various control measures. However, adverse impacts are still evident due to photochemical smog and due to exceeded concentrations of pollutants above the standards.

Stage IV –Low and decreasing levels of air pollutants are achieved at this stage. Air quality is generally acceptable and acute adverse health episodes are seldom experience. A comprehensive and efficient air quality management systems and vigorous implementation policies stimulate this achievement (Korea Environment Institute, 2002).

It is difficult to accurately assess air quality trends for cities in the early stages (0 – II) of their developing air pollution problems because of the lack of adequate monitoring data or because monitoring systems have been installed only recently. The impacts of air pollution are not always well characterized especially for cities in the early stages of their developing air pollution problems. Lead levels in blood are often found to be higher than maximum tolerable limit for cities at stage II because of the continued use, or only recent banning, of leaded petrol. Also, the urban population has significantly more respiratory symptoms compared with those living in the rural areas (Korea Environment Institute, 2002).

2.2 Key Measures in Air Quality Management

2.2.1 Policy Measures to Control Air Pollution

For Air Quality Management systems legislation and regulations are crucial for providing legal foundation. Air quality legislations are established by the Government and contain set goals and targets and responsibilities and roles of stakeholders to achieve better air quality. Also, it includes pollutants of concerns, emission sources to be controlled and desired public health outcomes. Laws provide general guidelines which is not enough to implement

immediately so regulations are developed to give detailed instructions on how much pollution can be legally emitted into the air, and what the penalty will be if emission is exceeded. The purpose of the regulation is to provide more specific information for how the broad legislative objectives will be met. In order to ensure legislative and regulatory requirements to be achieved development of detailed plans, procedures and mechanisms are needed. AQM should be dynamic and cyclical constantly reflecting feedbacks from monitoring, modeling, health assessments and economic analysis. These inputs will inform legislators on the need to modify goals or enforcement mechanisms on a legislative level.

2.2.2 Air pollution reduction action plan

Well defined pollution reduction action plans which are based on existing institutional frameworks and activities are priority task for the AQM authority. For the pollution reduction action plans, information about current status of air pollution, well defined sources of air pollution are important. For development of such plan, the AQM authority should consider factor such as practicability of the action plans depending on short and long term benefits. Action plan developing process should involve stakeholders from public, private, political, and academic backgrounds (Guttikunda, 2007). Actions for reducing pollution emissions should be based on assessments of pollution emission contributions from relative emission sources. The effectiveness of a pollution reduction action plan will depend on these assessments. Existing actions to reduce emissions and institutional framework for implementation are crucial factors for the process of air quality management. Awareness of public, non-governmental organizations, industry, the municipality, government and donor agencies are inevitably important. Activities for pollution reduction should cover all technical, institutional, and policy fields (Guttikunda, 2007). Practicability and cost effectiveness of air quality improvement action plans are integral parts of air quality management.

2.2.3 Air pollution inventory

An emission inventory is quantified information on the status of air quality and the main sources of pollutants and their locations. This documented information is required for the formulation of emission control strategies (Korea Environment Institute, 2002). The emissions inventory is essentially a planning tool for air pollution abatement measures. Emission estimates are a requirement to track changes in response to new developments and policy measures for air pollution abatement. While being able to monitor compliance levels of industries, vehicles, and other pollution sources to the standards, it is also important to keep track of the pollution source input to ambient pollutant levels. An accurate inventory can be used for evaluating and comparing the impacts of various policy options on future emission levels, thus facilitating selection of the most effective control option (Guttikunda, 2007).

As with any action planning process, it is important to have a well-defined data baseline upon which to base the "Action Plan" and against which its success can be measured. In this context, the most important information will be obviously related to air quality, and should include the following:

- Current air quality status, identified by pollutant;
- Likely future trends, and known developments, over the next five to ten years, under a business as usual scenario;
- The sources of air pollution and their relative contribution to air quality (source apportionment);
- Annual, weekly and diurnal variations for both emissions and air quality;
- The specific locations affected by poor and impoverished air quality; and
- The extent to which the public are exposed.

Most of this information should arise from the air quality review and assessment process (Guttikunda, 2007).

2.2.4 Ambient Air Quality Standards

The starting point for any air quality management program is air quality goal setting which can be represented by an acceptable level of major pollutants or a desired level of control for a facility that emits pollutants. One of the essential steps in AQM is the implementation of Air Quality Standards. This serves as a mark which indicates necessity of response measures that should be taken to reduce air pollution levels when air quality standards are exceeded. Air quality standards such as the WHO Guidelines for Air Quality (GAQ) and the National Air Quality Standard are applied for the reference. The purpose of the guideline is to give recommendation to Governments with respect to standard setting, developing and implementing air quality plans to protect from the adverse effects of ambient and indoor air pollution on health (WHO, 2000).

Table1. WHO Air Quality Guidelines

Pollutant	Annual ambient air concentration (µg/m3)	Guideline value (µg/m3)	Concentration at which effects on health start to be observed (µg/m3)	Exposure time
Carbon Monoxide	500-7000	100,000 60,000 30,000 10,000		15 min 30 min 1 hour 8 hours
Lead	0.01-2.0	0.5		1 year
Nitrogen Dioxide	10-150	200 40	365-565	1 hour 1 year
Ozone	10-100	120		8 hour
Sulfur Dioxide	5-400	500 125 50	1000 250 100	10 min 24 hour 1 year

Source: WHO, 2000

2.2.5 Air Quality Monitoring

Another important aspect in the development of an AQM is Air Quality Monitoring. Its purpose is to provide information on pollutant concentrations and to improve decision making and formulation of the appropriate response measures for pollution emissions reduction in a

city. Ambient Monitoring is the activity that measures concentrations of certain pollutants in surrounding atmosphere over the long term. The measurement of both type and quantity of these contaminants is obtained for implementing a meaningful control program. Emission monitoring measures certain pollutant emissions from a specific source. The purpose of air quality monitoring is to ensure compliance with national legislation, evaluate control options, and provide data for air quality modelling. Strategically placed monitoring stations provide data depending on purpose of the monitoring. For example if the purpose of monitoring is for human health; monitoring stations are located in population centres or near busy roads etc. Also, "control" monitoring station should be placed other place than those to compare the data later. These collected data are stored in database then be retrieved and analyzed. Results of these interpretations should reveal about the effectiveness of regulatory standards and impacts on health of the population. It is clear that an efficient, well coordinated, properly funded monitoring capability is an important pre-requisite for improving air quality in cities. Without such a capability, the magnitude and sources of the air pollution can not be reduced and cost-effective and targeted responses are impossible. In the city like Ulaanbaatar, air quality monitoring is still rudimentary and requires further expansion. Once a well-developed monitoring system is achieved, investment in air quality information systems and monitoring of health impacts are required (Korea Environment Institute, 2002).

2.2.6 Environmental Impact Assessment

Environmental Impact Assessment (EIA) is used for AQM process as a tool to quantify the impact of the current state of air quality and the incremental impact of a specific policy or program to reduce emissions and improve the current state of air quality. Impacts of air pollution can include contamination of the physical environment such as problems of odour, noise, and poor visibility and negative acute and chronic health impacts.

2.2.7 Compliance and Enforcement

Compliance and enforcement of the designed legislation and programs are crucial part of successful AQM. Compliance and enforcement activities can encompass a range of actions and activities such as compliance monitoring, administrative, civil, and criminal enforcement, compliance assistance, compliance incentives and auditing, creating data system and implementing environmental justice. In Mongolia, State Inspection Agency (SIA) is responsible for enforcing and assuring compliance with environmental regulations. SIA conducts compliance inspection process which a key element of a compliance program.

2.3 Air Pollution Control Strategies

Control strategy development is the process of assessing specific abatement measures, management practices and control technologies to determine the best combination of approaches to provide the emission reductions necessary to achieve the air quality standard or goal (USEPA, 2008). There are four main steps in developing a control strategy including determining priority pollutants, identifying control measures and incorporating the control measures into an action plan. Every country develops their own air quality prevention and control strategies which is best suitable for them. For effective response measures to the air quality problem, city and other stakeholder co-operation has the greatest role to play. For such strategy the implementation of economic measures and of policies, laws and regulations, accompanied by monitoring and enforcement should be applied. In order to achieve success in such strategy technical and management capacity and financial implications are substantial at every stage of the strategy implementation process (Korea Environment Institute, 2002).

The strategy includes air quality standards for pollutants and emission standards for the main sources of pollutants such as power plants, certain industries and motor vehicles etc. In cities, at their early stages of air pollution problems, a coherent legislative or policy

framework is often lacking. There may be no ambient air quality standards and no systematic air quality monitoring. More advanced AQM, with ambient air quality standards and comprehensive air quality monitoring systems is crucial. There should be legislation to control emissions from stationary and mobile sources including stringent vehicle emission standards (equivalent to EU standards in some cases), stringent fuel standards and efficient inspection and enforcement systems. There should also be schemes to inform the public about air quality and raise awareness, as well as strategies to develop and encourage the use of public transport.

A control strategy is a set of specific measures identified and implemented to achieve reductions in air pollution until the acceptable air quality standard or goal. There is a range of options to reduce emissions by addressing fuel quality including switching to cleaner fuels and rationalizing fuel prices to provide incentives for efficient fuel use, adopting technologies that reduce emissions at source, and applying energy efficient measures which reduce emissions through reduction in the quantities of fuel used. Emission control technologies in practice are usually focused on the modification of fuel or the combustion technique or removal of flue gases (Korea Environment Institute, 2002). Measures for emission reduction from motor vehicles include, improving road infrastructure and restricting downtown traffic in order to take the pollution pressure away form the heavy pollution concentrated areas. Another option is converting vehicles to cleaner fuels like LPG and improving vehicle well maintenance. Also, using more fuel efficient vehicles, installing catalytic control devices, and increasing use of environment friendly less polluting traffic modes such as walking and cycling are part of the strategy (Korea Environment Institute, 2002). The goal for all control strategies is to achieve real and measurable emission reductions. The control strategies should have implementation deadlines and mechanisms for enforcement.

Local air quality management does need to consider an effective way to address urban air pollution problems. City authorities should be better positioned to develop local air quality strategies in cooperation with all stakeholders and to improve poor air quality hotspots and report the state of local air quality to the public. Local action and cooperation is the most effective way of addressing urban air quality problems. This involves cooperation between city authorities, industry, commerce, public transport providers and the public.

Specifically targeted economic instruments have strong direct (e.g. environmental taxes and subsidies) and indirect (e.g. prices and costs of raw materials and products) effects on the pollution level, and its abatement. If the city was with the highest level of economic development, it appears to control air pollution most successfully through regulation and defensive expenditures (Korea Environment Institute, 2002).

According to specialists, there are number of common reasons that are preventing development and implementation of an effective air quality management strategy.

- Ineffective policy formulation due to the insufficient capacity of expertise;
- Lack of attention given to the air pollution problem due to priorities given to other social and environmental issues;
- Insufficient financial resources to support implementation of pollution control policies;
- Lack of government commitment for the solution of the problem and insufficient cooperation between administrative framework

2.3.1 Learning from the experience of Europe and North America

The experience of AQM in Europe and North America revealed that improvements in air quality will be achieved through a well co-coordinated strategy to address different aspects of the air pollution problem. In Europe and North America, the general approach in improvement of urban air quality is to control the emissions from the main polluting sectors.

For example in the transport sector strategy has included measures to reduce motor vehicles emissions, improve fuel quality, transport and traffic management to control travel demand and reduce the need to travel. In case of the industrial sector, integrated pollution control approach was applied. It has required that all emissions from the industrial plants to air, water and land must be considered together. The overall environmental performance must be taken into account including issues such as the generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, risk management, etc (Korea Environment Institute, 2002).

From the experience of European and North American countries, several main factors could be highlighted which have influenced the improvement of urban air quality:

1. Enactment and enforcement of international, regional, national and local emission and air quality regulations such as EU Air Quality Framework Directives, UN/ECE Long-range Transport of Air Pollution Convention and the North American Ozone Annex etc.
2. Applications of technological advances which have increased energy efficiency and reduced pollutant emissions. This lead to the decoupling of energy use and economic growth. Such technologies include catalytic converters, flue gas desulphurization units.
3. Structural changes in the economy which lead to less pollution. For example in some countries of Europe and North America, share of heavy industry declined and share of service sector increased which is less polluting.
4. Increased environmental expenditure to protect society from the impacts of pollution. In countries, as the economic growth has increased so have the levels of investment in air pollution control and abatement (Korea Environment Institute, 2002).

Based on the past experience the European Commission has identified a number of key issues which should be addressed in order to improve urban air quality. These key issues address action to be taken at both the national and local level to solve the problem of deteriorating urban air quality (Korea Environment Institute, 2002). According European Commission, these actions are applicable to other countries outside Europe and country like Mongolia could reflect some good practices on its own strategy. These are:

1. A comprehensive air quality management strategy should be drawn up to improve and maintain air quality, addressing all issues of concern and focusing on issues of immediate concern in terms of complying with air quality criteria
2. Air quality management and regulation should be effectively integrated with that of other environmental sectors like water, noise and waste management
3. A good quality of ambient air quality assessment should be undertaken which is crucial for formulating a strategy for air quality improvements. Also, compiling an inventory of emissions and mapping emissions should be undertaken
4. There should be more involvement of interest groups which have a significant role or function to perform in relation to air quality management. Measures should take place for effective public participation
5. Provisions should be made for monitoring, regulation and enforcement of legislation, regulations, permits and licenses. Also, sufficient human and technical resources need to be allocated to enable above functions to be properly performed
6. Regular records and reports should be put in place to inform the public about the situation regarding air quality standards and guidelines being obeyed
7. Air quality management plans should be regularly reviewed and updated to ensure that they remain relevant to the key issues of concern (Korea Environment Institute, 2002).

2.4 Public Participation

In every other AQM process activities, community and other affected parties should be consulted as part of the strategy development process. The main purpose is to reflect different views and ideas in strategy development so that it reduces later challenges and streamlines implementation.Since individuals, communities, industries, businesses, organizations and institutions, governments are all responsible for AQM; their inputs into decision making are gaining more recognition. Taking part of decision making process in which affect them, especially in case of AQM is duty for educated citizen. In some countries public has information access system where they can take information and give feedback. For such effective public participation, community should be well aware of air quality status and how they are affected, so that they influence decision makers for the benefit of all society (U.S.EPA, 2008).

CHAPTER 3: URBAN AIR QUALITY MANAGEMENT PRACTICE IN ULAANBAATAR

A successful AQM strategy is dependent on number of factors including, emission inventories; air quality monitoring networks; dispersion and air quality prediction models; exposure and damage assessments; health and environmental based standards; pollution control measures; the legislation and a range of resources to implement and enforce them (Elsom, 1996). Effective air pollution management is a challenge for Ulaanbaatar city. Knowledge of critical pollutants in the Ulaanbaatar and their sources are crucial for accurate air quality management. Analyzing possible pollution control options, conducting of more detailed studies about critical pollutants are prerequisite steps for stakeholders to combat with air pollution in Ulaanbaatar. The management of these air pollution problems also posing huge financial, technical and logistical problems for urban and national authorities in Mongolia. Furthermore, current trends in urbanization do not suggest that there will be any rapid abatement in the problems posed.

3.1 Air Pollution Response, Policy Enforcement and Control Strategies

3.1.1 Emissions Inventory

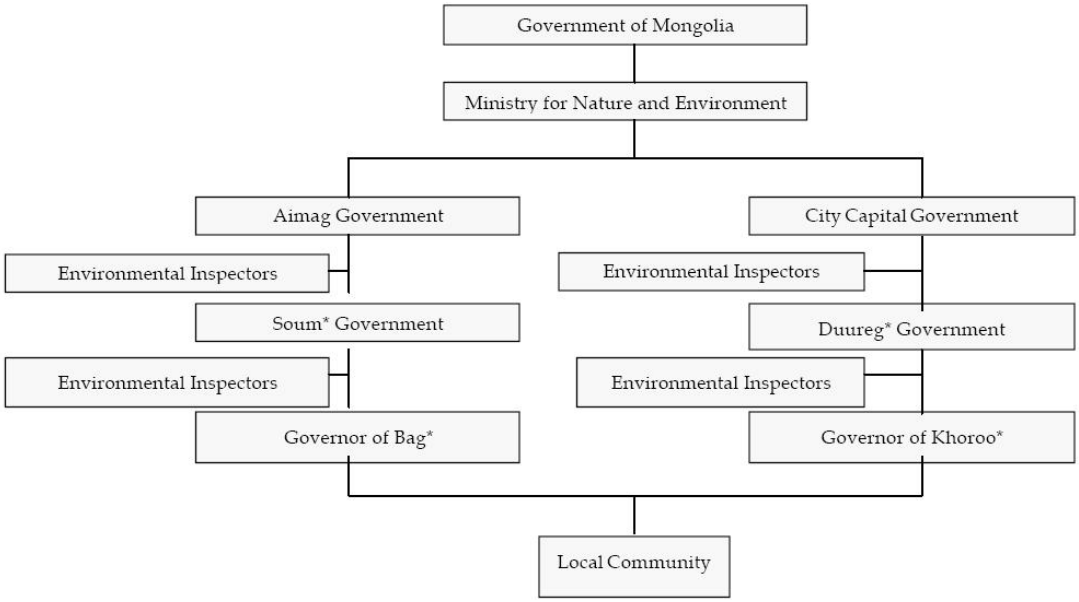
Keeping an account of the amount of air pollutants emitted into the atmosphere, chemical and physical identity, geographic area coverage, and time period of emission, sources and cause of the pollution are crucial. Such emission inventory is important for policy makers for developing air quality management strategies and regulations, monitor the process of compliance with the strategies. In emission inventory, apart from well documented sources, some sources such as garbage burning and fugitive dust are not at all accounted.

3.1.2 Legislative and Regulatory Development

The environmental legislation of Mongolia is divided into five layers of hierarchy. These include the Constitution, international treaties, general environmental laws, Law on

Environmental Impact Assessment 1998 and laws relating to natural resources and fee-related laws. Examples of laws relating to natural resources include law on water, forest, air, land, fauna, hunting, strictly protected areas, natural plants, buffer zones, underground resources, petroleum, and mining laws while fee-related laws encompass water fees, hunting fees, forest use fees, natural plants fees, and a law on the reinvestment of natural resource use fees for conservation and restoration of natural resources. Relative detailed orders, regulations, requirements and standards are applied to support environmental laws. There are about 30 environmental management associated laws and about 150 related regulatory documents (ADB, 2005). Strengthening the legal basis of natural resources management and in particular land legislation has been the priority direction of recent legislative activities in Mongolia since 2001.

Figure7. Institutional Structure of the Environment Sector



Source: ADB, 2005

*Soum = district in rural areas;
*Bag = sub-district in rural areas;
*Duureg = district in urban areas;
*Khoroo = sub-district in urban areas;

The implementation of environmental legislation; development of guidelines for the use of natural resources; monitoring of environmental standards and enforcement of environmental regulations fall under responsibility of local governors at the aimag[1], capital soum[2], duureg[3], khoroo[4] and bag[5] levels. These administrative levels are also responsible for the provision of information and data to the central administration about local environmental conditions (World Bank, 2002). Actual implementation of environmental laws and regulations takes place at the local district levels.

3.1.3 Air Quality Legislation

In 1995, a set of 14 environmental laws was adopted to update and enhance the existing legislation. These laws were to reflect the new structure of environmental institutions in the country, and recent international environmental legislation. The 1995 laws extended protection of natural resources, and provided increased environmental regulations. They also introduced monitoring, record -keeping, information sharing, and user-fees regulations as a starting point to address the needs of a market economy. Numbers of Environmental Laws were ratified such as Law on Environmental Protection (1995), Law on Air (1995), Law on Hydro meteorological Information and Service (1997) and Law on Environmental Impact Assessment (1998). There are several laws and regulations relating to Air Quality Management in Mongolia. The 1992 Constitution of Mongolia (Article 16) recognizes the basic human right of Mongolians to live in a clean and healthy environment. The 'Mongolia National Security Policy Orientation', the 'National Development Strategy', and the 'Ecological Policy Orientation of the Mongolian State' reinforce Article 16 of the Constitution and establish the basic principles for protecting the environment and natural resources (MFE, 2007).

The Parliament of Mongolia ratified the Law on Air In 1995, as an Air Quality Policy Responses and in 1996; Government of Mongolia developed the Action Program to Protect

Air in 1999. This shows Mongolia's commitment for air pollution monitoring and management. Also environmental standards like Air Quality Standard (1999) and procedure on ambient air quality monitoring in urban area including sampling, analytical methods were produced. Since 1997, Government of Mongolia (GoM) has been working to develop an integrated air pollution management program for Ulaanbaatar. Following are some of the main priorities of this program: switching to cleaner fuels, market-based measures, regulatory incentives to energy producers, incentives to the private sector and to consumers for energy efficient investments, enhanced monitoring and enforcing capacity; and improved traffic management. The Government is working on to produce clearer policy implementation guidelines through amendments in current existing laws rather than sole focus on new legislations.

3.1.4 Ambient Air Quality Standard

There are about 150 environmental standards in Mongolia. Only eight standards are ambient or discharge standards. Ambient standards exist for air, drinking water, surface water, and soil. Discharge standards exist for selected air pollutants and wastewater entering centralized treatment plants (ADB, 2005). Ambient air quality standards (AAQS): MNS4585-98 was adopted in 1999 (Table 3). The World Health Organization (WHO) standard for annual average concentration of SO_2 is 50 μg/ m3. The WHO 24 hour ambient air quality standard for SO_2 is 20 μg/ m3 while that of the Mongolian standard is 30 μg/ m3. The AAQS for annual average concentration of NO_2 is 40 μg/ m3. The World Health Organization (WHO) standard for annual average concentration of PM is 10 μg/ m3. The Mongolian standard for 24 hour suspended particle concentration is 150- 200 μg/m3. This standard is very high considering the standard set by US-EPA for PM2.5 is 65μg/m3 (US.EPA, 1997).

Table3. Ambient Air Quality Standards in Mongolia

Parameter	At Maximum (µg/m3)	Daily Mean (µg/m3)
Carbon Monoxide	3,000	1,000
Sulfur Dioxide	500	50
Nitrogen Oxide	600	60
Nitrogen Dioxide	85	40
Particulate Matter	500	150

Source: Mongolian Agency of Standardization and Metrology (MASM), 2008

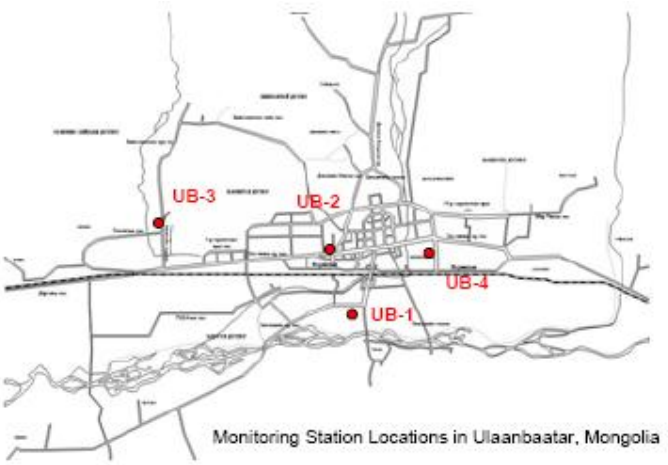
3.1.5 Air Quality Monitoring

Air quality monitoring measures the exceedance of air quality limits. Daily data are collected and transferred to the centre from local laboratories/stations. Monthly data collected and verified at Central Laboratory of Environmental Monitoring (CLEM). Then data is saved in Air quality database. Interpreted data is reported on State of the Environmental Report and on Air quality bulletin of Ulaanbaatar. Environmental compliance monitoring is the exclusive domain of the State Inspection Agency (SIA) under Prime Minister. SIA combines all inspection functions in Mongolia. Environmental impact assessment documentation remains the responsibility of MNE.

There are four fixed air quality monitoring stations and 15 mobile stations operated by the city Air Quality Division (AQD) for regulatory purposes. These four stations measure ambient air pollutant concentrations. The four ambient air quality monitoring stations are located in selected sites of Ulaanbaatar: UB-1 monitoring station is located at about 6 km east of TES4, on the south side of the city, in factory area. UB-2 monitoring station is located at about 7 km east-northeast of TES4, in the center of the city in areas with much traffic density on a main road, near a crossing. UB-3 monitoring station is located at about 3 km north-northeast of TES4 on the west side, in cook stove using household residential area. UB-4 station is located at about 10 km east-northeast ofTES4, on the east side of city center, in residential area (ADB 2005). Only sulfur dioxide (SO_2) and Nitrogen Oxides (NO_2) concentrations are measured due to lack of appropriate technical equipment. Particulate

matters (PM) are not measured in all four stations although PM is considered as the main health deterrent (Guttikunda, 2007). Japanese automatic measurement equipment and a high volume air sampler are installed in UB-1 station while Russian measurement devices for SO_2, NO_2 are installed in the other stations.

Figure8. Locations of the air quality monitoring stations in Ulaanbaatar



Source: Guttikunda, 2007

Stations UB-2 and UB-4 are closer to central Ulaanbaatar, which are indicative of urban environment.

3.1.6 Environmental Impact Assessment process

Environmental Impact Assessment (EIA) Law was adopted in 1998 to regulate environmental impact assessment and decision-making on the implementation of development projects. The Law requires environmental screening for each proposed development project before it is implemented, to determine the appropriate type of EIA. The general assessment is completed by EIA officers at the national within the MNE and The EIA reports are prepared by private companies, certified by MNE to conduct EIA (World Bank, 2002).

3.1.7 The Master Plan for the reduction of air pollution

Currently group of specialist on respected fields are working on preparation of the Master Plan for the reduction of air pollution. Members of Parliaments and members of ministries including Nature and Environment, Fuel and Energy, Construction and Urban Development, Transport are taking part in the Master Plan preparation. Also, academia representatives take part in working group. The Master Plan aims to achieve the following:

- Improved urban planning and constructing multi-storey residence apartments. By 2020, the city municipality is planning to convert 80% of existing city outskirt wooden and felt dwelling areas into housing complexes.
- Production of smokeless coal briquettes. The Government is planning of establishing manufacture of smokeless coal in CHP-2 and near the Baganuur coal mine for supplying better quality coal for fuel.
- Construction of a new power plant to support increasing demand for hot water and heat.
- Strengthening inspection of motor vehicles, supporting LPG (Liquid Petroleum Gas) consumption for vehicles, fazing out old vehicles, strengthening legislation and regulation on fuel imports, in particular, importing lead free gasoline.
- Preparation of policy regulations applying “Polluter Pays” principle for industries and individual polluters.
- Promotion of air quality monitoring and improving laboratories for assessments.
- Promoting short term action plans with ecological and economical assessments for supporting long term master plan.

Technical working groups are working on preparation of air pollution reduction action plan strategies. This group is consisting of two teams which are headed by Prof. Gonchigsumlaa,

with the department of Geo-ecology and Land Use Management at National University of Mongolia and by Dr. Oyun Ravsal, General Director, JEMR Consulting Co. Ltd. Responsibility of this working group is conducting an integrated analysis consolidating technical, economic, physical and ecological aspects of air pollution. In particular, main responsibilities of the working groups include coordinating among departments to establish baseline and action plan, conducting analysis for better air quality, developing a Master Plan of action incorporating measures to secure political commitment and ensuring the participation of community, NGOs and private sectors to mobilize nongovernmental resources (Guttikunda, 2007).

3.2 Air Quality Management Stakeholders

Government Organizations

- Ministry of Nature and Environment (MNE)
- Air Quality Management Bureau (AQMB)
- Ministry of Health (MH)
- Ministry of Education, Culture and Science (MECS)
- Ministry of Finance (MF)
- Ministry of Fuel and Energy (MFE)
- Ministry of Construction and Urban Development (MCUD)
- State Professional Inspection Agency: Centre of Standardization and Measurement
- National Agency of Meteorology, Hydrology and Environment Monitoring (NAMHEM)

Local Governance Office

- City Environmental Agency

- City Inspection Office
- City Air Quality Division

Scientific Research and Universities

- Scientific Research Academy (SRA) and Institute
    - Social Health Institute
    - Central Laboratory of Environmental Monitoring (CLEM)
- Scientific Research Universities and Institutes
    - School of Geology, Energy and Construction
    - Ecological Research Center for Technical University

Public and School Communications

- General Public
- Non Governmental Organizations (NGO)

International Organizations

- International Conventions and Agreements (Kyoto Protocol)
- United Nations Branches (UNDP, UNEP)
- World Health Organization (WHO)
- International Monetary Organizations (World Bank, Asian Development Bank)
- Asian and East Asian Regional Networks (NEASPEC, DSS, NEAN)
- Japanese Cooperation Agency (JICA)

3.2.1 Environmental Institutions

The main environmental institution responsible for the development and implementation of environmental policy and laws is The Ministry for Nature and Environment. The ministry is also responsible for the environmental issue like air pollution and environmental monitoring thus designing programs for environmental restoration (MNE, 2008). The Ministry of Nature

and Environment (MNE) and the Ministry of Health (MOH) share overlapping responsibility of setting emissions standards for air pollutants and measuring air pollution and its impacts on health. Just like the MNE, the Ministry of Education, Culture and Science (MECS) is responsible for drafting and implementing environmental education and public awareness programs (World Bank, 2002). According to ADB technical assistance report, environmental institutions of Mongolia is divided into following administrative layers (ADB, 2005):

First Layer (Ministry of Nature and Environment)

1. Minister
2. Deputy Minister
3. State Secretary

Second Layer (Ministry of Nature and Environment)

1. State Administration and Monitoring Department
2. Strategic Planning Department
3. Policy Implementation and Coordination Department
4. Sustainable Development and Environment Department
5. Finance and Budget Division
6. International Cooperation Division
7. Protected Area Division

Third Layer (Ministry's own agencies)

1. Water, Forest and Natural Resource Agency
2. NAMHEM

Other Ministries and Agencies with Environment-related Activities

1. ALAGaC Administration of Land Affairs, Geodesy and Cartography
2. State Inspection Agency (Environment Protection Agency's functions are taken over by the State Inspection Agency)

3. Ministry of Finance and Economy, Ministry of Food and Agriculture, Ministry of Industry and Trade, Ministry of Infrastructure, Ministry of Justice and Internal Affairs, and Ministry of Health.

3.2.2 Air Quality Management Bureau, Mongolia

The Air Quality Management Bureau (AQMB) was established and operates under the National Agency for Meteorology Hydrology and Environmental Agency (NAMHEM) and under a national air quality council with the Ministry of Nature and Environment (MNE) (MNE, 2008). AQMB is a focal point for air quality related activities at national and international level. The priority of AQMB is the management of air quality at various spatial scales, from national, district to local scale.

Responsibilities of AQMB include:

- Preparation of proposals for standards, regulations and procedures for the improvement of air quality and establishment of decision making authorities for implementation of these.
- Preparation of short and long term air quality protection programs
- Establishment methodology for national air quality monitoring network unit
- Data collection from air quality monitoring network, including local centres and emission sources, for the purpose of creating database for analysis and information sharing for government and public
- Organizing activities for setting emission standards for stationary and mobile sources
- Conducting assessment for air pollution emission based on measurements and analysis by the air quality divisions and centres for meteorology, hydrology, and environmental monitoring
- Preparation of inventory regarding greenhouse gases and CFCs (Chlorofluorocarbons) for submission to MNE

- Registration of air pollution emission sources with MNE annually
- Renewing inventory of emission sources every 5 years for submission to MNE

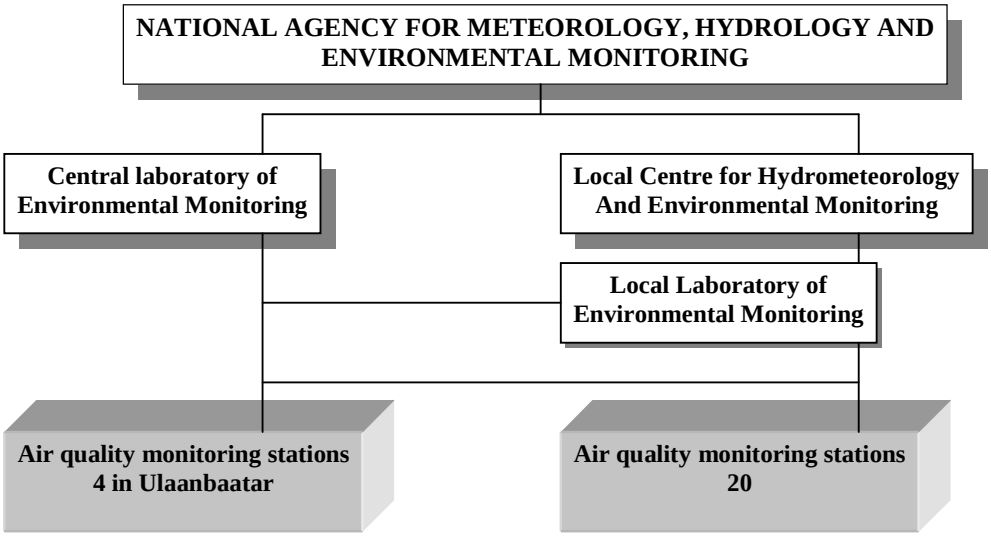
Rights of AQMB are:

- To control national air quality monitoring network
- To control air pollution emission sources and collect information
- To control implementation of the emissions and air quality standards
- To control and assess emissions from mobile and stationary sources
- To control and check all equipment at emission reduction facilities (Guttikunda, 2007).

3.2.3 National Agency for Meteorology, Hydrology and Environmental Monitoring

National Agency for Meteorology, Hydrology and Environment Monitoring of Mongolia (NAMHEM) is a semiautonomous agency which works in association with Ministry of Nature and Environment (MNE). Its responsibility includes observing, forecasting, and warning of hydro meteorological risks, such as droughts, dust storms, and weather conditions conducive to wildfires etc. The agency is also responsible for monitoring air pollution, developing pollution inventories, and implementing national air quality action plans (Enkhmaa, 2006). The agency operates about 400 observation points and field stations throughout Mongolia to collect data about weather for the purpose of observing, forecasting and warning against potential hazardous weather conditions. Air pollutant emission data are collected annually and reported to MNE by the NAMHEM. Data of complied air pollutant covers PM10, PM2.5, nitrogen dioxide and sulfur dioxide emission (ADB 2005).

Figure9. Structure of National Agency for Meteorology, Hydrology and Environment Monitoring (NAMHEM)



Source: World Bank 2002

3.2.4 State Professional Inspection Agency, Mongolia

Environmental regulation compliance monitoring, used to be a responsibility of Ministry of Nature and Environment (MNE). Since 2002, environmental compliance monitoring is performed by State Professional Inspection Agency (SPIA). Environmental inspectors, employees of SPIA are distributed throughout local area district levels and inspect implementation of environmental laws and regulations.

3.2.5 The Role of International Organizations in AQM

The Government of Mongolia actively cooperates with Development Partners or international organizations such as Asian Development Bank (ADB) and United Nations Development Program (UNDP) for addressing air pollution. The government is also implementing acid rain monitoring program through the Acid Deposition Monitoring Network in East Asia (EANET) (ADB 2006). External funding agencies such as ADB and World Bank (WB) have contributed to the improvement of air quality management by providing technical assistance

and loans. Major bilateral programs are in place in Mongolia. Among those with important environment-related components are those of Deutsche Gesellschaft fьr Technische Zusammenarbeit, European Union, Japan International Cooperation Agency, Netherlands, and United States Agency for International Development. Deutsche Gesellschaft fьr Technische Zusammenarbeit (GTZ) one of largest source financial support to projects related to resource conservation with improved livelihoods, as well as projects in the renewable energy and forestry sectors (ADB, 2005). Netherlands provides financial support to current environmental awareness building activities. The Environmental Public Awareness Program is funded by the Netherlands and UNDP. The public awareness activities include offering curricula on environment, sustainable development, and public health via Mongolian television and under the auspices of the Ministry of Science, Technology, Education and Culture (ADB, 2005). JICA is funding projects addressing wastewater and solid waste management. It also provided pollution abatement equipment for the coal-fired power stations in Ulaanbaatar.

Financial Support from International Partners in Environmental Sectors is increased over the years and it plays major role in air quality management in Mongolia. International Projects with the financial and technical assistance have become important part in environmental sector (Batbayar, 2006).

The following international projects are started or ready for implementation:

- Integrated Water Resource Management, Government of the Netherlands;
- National Geographical Information Centre for Natural Resource Management in Mongolia, The Government of the Netherlands;
- Project to Building Capacity for Effective Participation in the Biosafety Clearing House, UNEP-GEF; Strengthening Monitoring Assessment and Reporting (MAR) on Sustainable Forest Management in Asia, The Government of Japan;

- Capacity Building and Institutional Development for Participatory Natural Resources Management and Conservation in Forest Areas of Mongolia, The Government of the Netherlands The Government of the Netherlands;
- Capacity Building for Desertification Combating, Swiss Government; Desertification Prevention and Green Belt Program Support, ROK; and NEMO-2 Project, World Bank and The Government of the Netherlands.

Yellow Dust and Sand Storm are main cause for increased particulate matter pollution in Ulaanbaatar, especially in dry spring season. Japanese International Cooperation Agency (JICA) within its Technical Cooperation project has installed Measurement Equipments (TSP and PM10) of the Dust and Sand Storm Monitoring station in Ulaanbaatar. Measurement data would be reported to the Ministry of Nature and Environment (MNE) and National Agency of Meteorology, Hydrology and Environment Monitoring (NAMHEM).

The World Bank provides loans for environmental projects such as the Energy Project, emphasizing energy efficiency. The World Bank also provides technical assistance which includes guidelines for forest management, mining activity assessments and Environmental Impact Assessment Guidelines for Ministry of Environment of Mongolia. The World Bank implements household stove improvement project in Ulaanbaatar, in cooperation with Global Environmental Facility. World Bank assistance priorities cover sectors like transport, energy and areas of legal and judiciary reforms and distance learning etc. The World Bank's recent loans with environmental content include the Energy Project with an emphasis on energy efficiency. Moreover, with Global Environmental Facility (GEF) financing, World Bank continues to implement a household stoves project in Ulaanbaatar and several biodiversity-related projects (ADB, 2005).

United Nations Development Program's assistance policy focuses on fields like social services, economic transition, good governance, disaster management and the environment. In

particular, UNDP takes activities to assist environmental policies, program management, finance and implementation of pilot projects, capacity building for environmental governance and natural resource management. Global Environmental Facility (GEF) gives substantial amount of financial support to environmental projects (ADB, 2005).

3.2.6 Environmental Public Awareness and the Role of Nongovernmental Organizations

Many environment-related Nongovernmental Organizations have emerged over the past decade. By 2004, the number of environmental nongovernmental organizations increased further to 125 and in 1999, Union of Mongolian Environmental NGO's was formed. However, these NGOs cover various environmental issues and don't solely focus on air quality problem (ADB, 2005). Nongovernmental organizations tend to focus mainly in Ulaanbaatar bridging the information gaps only in part. There are several environment related NGOs, particularly, Mongolian Association for the Conservation of Nature and Environment, Mongolian Green Movement, Mother Earth Foundation, Parachuting Environmental Helpers Association, Development and Environment, Mongolian Society for Environment and Development, Women's Society for Environment and Development, Mongolian Nature and Environment Consortium, Mongolian Meteorological Society and Mongolian Society for Combating Desertification (Network of NGO in Mongolia, 2008).

There are some activities done by Government of Mongolia to arise environmental public awareness such as adopting the National Program for Public Environmental Education (1997) and establishing the Ecological Training Centre to develop environmental and ecological curricula. Also, the Ministry of Nature and Environment has established a Civil Society Committee to reflect public opinion into account in crucial environmental decision making, and to coordinate public participation activities between government agencies and NGOs at local and national levels (World Bank, 2002). Through the endorsement of the Millennium Development Goals (MDGs), MNE has renewed its commitment to broaden

opportunities for civil society and NGO participation in environmental management, and to strengthen local governments' capabilities to fulfil their roles in environmental management (World Bank, 2002).

3.3 Measures taken by the Government of Mongolia and other stakeholders to address Ulaanbaatar Air Pollution Issues

3.3.1 Measures taken by the Government of Mongolia regarding environmental sector

Environmental development is defined as one of the three key priorities of the Mongolian development policy. It was indicated in the Government Action Program that one of the Government Action Priorities is to "improve the living environment of the citizens by reducing air, water, and soil pollution in urban areas, and by recycling garbage and waste". The Millennium Development Goal based Comprehensive National Development Strategy (NDS) was developed and submitted to the President. Establishment of a solid legal basis for environmental protection took place in the country. Several steps have been taken in order to integrate environmental considerations into Mongolia's national development policies and plans. Parliament has passed over 20 laws on conservation, and several environmental conventions have been signed and ratified. Also The National Council on Sustainable Development was established in 1997. However, implementation has been weak, due to competing interests in the society and the economy and lack of environmental awareness.

For the Parliament and Government of Mongolia and as well as for the Ulaanbaatar City Authorities, city air pollution issue has gained serious consideration. Development process of the Environmental indicators is initiated by the Government and the Annual Budget for Environment Sector has notably increased in recent years. Legislative framework of the sector has improved according to the Ministry of Nature and Environment (Jambaldorj, pers.comm.).Several amendments on environmental laws were approved by the Parliament

including Law on Environmental Protection, Law on Toxic and Dangerous Chemicals, Law on Hunting Resource Use payment and on Hunting and Trapping Authorization Fee. Several laws are considered at the Government and submitted to the Parliament. In particular, Law on Bio-safety, revised edition of the Law on Forest and National Action program on restoration of mining sites was approved by the Government. Several regulations regarding implementation of the environmental laws are approved by the Government of Mongolia. These measures indicate that legislative framework of the environmental sector is straightened.

MNE paid more attention to the allocation of the Financial Resources to Environment Sector and efficiency of spending of approved environmental sector budget. Annual budget for MNE has increased including allocation of a certain amount of money for activities to reduce air pollution in Ulaanbaatar.

Table4. Annual Budget Allocation (in million Tg*)

Budget categories	2006	2007	2008 (proposal)
Operational	5,767.2	8,172.5	14,712.8
Investment	465.0	1,412.0	6,572.1
Total	6,232.2	9,584	21,284.9
Percentage of GDP	0.20	0.28	0.56
Percentage of Country's Total Expenditures	0.50	0.65	1.26

* Tugrug , Currency of Mongolia

3.3.2 Measures taken by the Government of Mongolia and other stakeholders to address Ulaanbaatar Air Pollution Issues

Improved air quality monitoring, assessed human health impacts from air pollution and capable policymakers and stakeholders in managing air quality in Ulaanbaatar are the aims of

the air quality management. A Working Group was established by The Parliament of Mongolia, to develop a proposal to address air pollution issues in Ulaanbaatar. Ministry of Nature and Environment organizes events like Open Day to introduce new developments of small stoves and alternative fuels and it supported testing new environmentally sound technologies in alternative fuels and heating systems in stove using household areas. Workshops, seminars and discussions on air pollution reduction among relevant stakeholders have been organized (Badarch, pers.comm.). Ulaanbaatar City Government has established working groups to develop a Master Plan on Air Pollution Reduction in Ulaanbaatar. To date, the draft Master Plan on Air Pollution Reduction is being developed and its submission was planned in early 2008. However, Action Plan preparation is still not finished yet. Activities to reduce air pollution and improve solid waste management in Ulaanbaatar, finalizing the development of environmental indicators and incorporating the indicators into MNE's operations are the next important steps to pursue. In 2006, Air Quality Management Service (AQMS) was established in structure of National Agency for Meteorology, Hydrology and Environment Monitoring (NAMHEM) for the purpose of developing, implementing and monitoring air quality management action plans. Ministry of Fuel and Energy (MFE) is implementing national program called "Coal', which intends to promote clean coal technologies, provide incentives to develop clean smokeless coal briquettes for household stoves. The ministry is enacting a program for widespread use of Liquid Petroleum Gas for household use and for vehicle fuel (Sundui 2006). The Government and its related agencies are taking activities on raising public awareness and monitoring air pollution in the atmosphere.

Resolutions intending to reduce the air pollution:

- The Parliament Resolution 46, 2007
- Resolution 218 of the Government of Mongolia, 2007

- Resolution 14 of the Government of Mongolia, 2008

Within these regulations, following activities are set to be implemented (GoM, 2007):

- Improving legal environment for air pollution
- Expanding the supply system of infrastructure of Ulaanbaatar, establishing new thermal power plant, introducing electric heater
- Constructing multistory houses the peri-urban household district
- Developing the semi coke briquette production, enhancing the number of gas fueled vehicles
- Improving the petrol quality, paving the roads linking central and peri-urban household districts
- Capacity building of air quality offices
- Coordinating the civil movement to the city
- Encouraging the insulation for felt dwellings
- Allocating more than 50 billion Tugriks to state budget between 2007 and 2010, for implementation of the above mentioned measures to reduce air pollution.

Resolution 14 of the Government of Mongolia regarding policy for semi coke briquette production (GoM, 2006):

- To intensify the experiments to produce semi coke briquette and to establish semi coke briquette plant built at "Thermal power plant-II" state owned company;
- To support high quality semi coke briquette production fulfilling the standard's requirement, to produce legal and economic environment allowing tax exemption and reduction for semi coke production
- To enhance the supply of semi coke briquette by supporting private participation and competition

- To provide residents in felt dwelling peri-urban district with semi coke briquette form August, 2009
- To establish sales network for delivering semi coke briquette to the consumers, to acknowledge and educate consumers on benefits or advantages of using semi coke briquette
- To set up National committee to coordinate, to regulate and to control the activities of government organizations involved to implement the government policy to decrease air pollution (Minister of fuel and energy).

Specific measures which have been undertaken for air quality improvement

Ulaanbaatar is the coldest capital in the world, inefficient stoves and poor quality coal is used for heating households, so The Improved Urban Stoves Project was designed for urban Mongolians. The project, funded with a 750.000 $ grant from the GEF, is aiming to reduce coal fuel consumption in the periphery areas. The project aims facilitating the creation of a market-based system that would encourage the manufacturing and marketing of efficient indoor coal stoves, and the development of small, private energy service providers. Coal burning stoves in the periphery districts account for most of Ulaanbaatar's air pollution. This GEF funded project aims to improve household stoves by slightly modifying a locally produced stove and by marketing a kit designed by project technicians which can be added to improve existing stoves. If the stoves and the kit are widely adopted, they could potentially reduce carbon dioxide emissions.

Measures taken to reduce the pollution

Decision was made by the Ministry for Nature and Environment and Ulaanbaatar city Authority to take measures to promote modern environmentally friendly stoves in periphery area of the city. For the purpose of reducing coal consumption, urban air pollutant concentrations, and greenhouse gas emissions, projects for new stove designs with improved

fuel efficiencies have been implemented (Cowlin, 2005). Result of the survey comparing unimproved and improved stoves; have showed that coal consumption has significantly decreased by an average of 5 kg per day in households with improved stoves of G2-2000 and TT-03 model. However, promotion of the improved stoves has faced challenge of population affordability. The news stoves cost MNT 60, 0000-MNT 70,000 which is almost twice expensive than the common stoves (Cowlin, 2005). These depict that there is some *ad hoc* effort in the city to encourage or compel some switching to cleaner fuels (such as LPG) especially for vehicles.

CHAPTER 4: SUMMARY AND FINDINGS

Air pollution is becoming main issue in Ulaanbaatar, due to growing population, energy consumption for the cooking and heating, and rapidly expanding motor vehicles. Increasing population and a growing urbanization and industrialization have lead to a demand for energy in several sectors including transport, construction, heating, industrial production and have resulted in consecutive problems as pollution from transport, industries and waste disposal problems etc. Industrial processes, fossil fuel combustion including diesel and petroleum for motor vehicles, coal for steam and power generation, heating, and household cooking, are main sources of major air pollutants. Suspended particulate matter (SPM), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx) and ozone (O_3) are the most common air pollutants in the city of Ulaanbaatar. Of these pollutants particulate matters (PM) are the most critical pollutant in the city and it is believed that it is the main pollutant responsible for the population health. More than half of the population in the city lives in households burning coal and wood without any pollution control.

A successful AQM strategy is dependent on number of factors including, emission inventories, air quality monitoring networks, dispersion and air quality prediction models, exposure and damage assessments, health and environmental based standards and pollution control measures and the legislation and a range of resources to implement and enforce them. One of the initial steps in AQM is establishing priorities and goals and standards to achieve. Mongolia has set target its air quality management system. This target is an acceptable level of major pollutants such as SO_2, NO2 and PM pollutant in the ambient air.

Correct identification and better understanding of air pollution sources, management options, potential technical, institutional, economic, and policy solutions are prerequisites for better air quality. Air quality review and assessment is a process which includes local

institutions, municipality and the Parliament. The city municipality is one of the stakeholders responsible for monitoring pollution levels of air pollutants and preparing short and long term action plan to reduce local air pollution levels. Well defined pollution reduction action plans which are based on existing institutional frameworks and activities are priority task for the AQM authority. Action plan developing process should involve stakeholders from public, private, political, and academic backgrounds. Existing actions to reduce emissions and institutional framework for implementation are crucial factors for the process of air quality management. Strengthened ambient air quality monitoring, well determined impact of air pollution on human health in Ulaanbaatar and applicable action plan about how air pollution in Ulaanbaatar can be reduced are the priority of the air quality management.

Government has been taking a variety of target and some actions to implement the following resolutions and directives aimed at reducing air pollution in Ulaanbaatar, such as Mongolian President's directive to the Government on 16 May, 2007, The Parliament Resolution 46 dated 28 June, 2007, its follow up Government Resolution 218, as well as Government resolution 14 dated 16 January, 2008. The Government has established the Government Steering Committee (GSC) headed by the Ministry of Fuel and Energy with representation of main ministries and relevant agencies. Law on Air, a law for air quality management was adopted in 1995 and Air Protection Program was adopted in 1999. However, at that time air pollution problem was not recognized enough so these laws and program lack appropriate supporting action plans and detailed guidance (Batnyam, L. pers.comm.). Upon the Government Resolution 14, the Minister for Fuel and Energy has been assigned to set up the National Committee aimed at ensuring interaction and prompt coordination of activities by relevant government agencies, and strengthening efforts in implementing government policy statements and goals in reducing air pollution (Batnyam, L. pers.comm.).

Main causal factors of ground level air pollution in Ulaanbaatar are normally regarded expanding periphery district households, their heating stoves in addition to pollution from vehicles. Therefore, it is noted that production, supply and application of smog-less, environmentally friendly clean fuel are urgently required to reduce these pollution sources and thus play a decisive role in solution of the problem. Countermeasures to be implemented in the near future apparently include actions aimed at developing semi-coke briquette production, increasing gas supply and utilization, and creating new power and energy sources. The issue of reducing air pollution cannot be solved within or by one ministry (Saijaa, N. pers.comm.). Therefore, activities of all institutions involved in this matter should be intertwined with other organizations. In addition to Government efforts such as clear policy statements, extensive resources are needed to solve this prevailing problem. Multifaceted and wide-ranging activities aimed at reducing air pollution of Ulaanbaatar would better produce positive implementation outputs based on increased participation and joint efforts by government, the general public and individuals (Gonchigsumlaa,Ch. pers.comm.). Under efforts and participation of donor bilateral and international organizations, proposed initiatives, recommended projects and programs would become valuable contribution to solve this extensive work which needs significant resources, efforts and experiences. Daily data are collected and transferred to the centre from local laboratories/stations. Monthly data collected and verified at Central Laboratory of Environmental Monitoring (CLEM). Then data is saved in Air quality database. Interpreted data is reported on State of the Environmental Report and on Air quality bulletin of Ulaanbaatar (Enhmaa,S. pers.comm.). Environmental compliance monitoring is the exclusive domain of the State Inspection Agency (SIA) under Prime Minister. SIA combines all inspection functions in Mongolia. Environmental impact assessment documentation remains the responsibility of MNE.

There are number of reasons that are preventing development and implementation of an effective air quality management strategy. less effective policy formulation due to the insufficient capacity of expertise , less attention given to the air pollution problem due to priority given to other social and environmental issues, less financial resources to support implementation of pollution control policies, and less government commitment for the solution of the problem and insufficient cooperation between administrative framework (the responsibility for air quality is divided between a number of government of ministries and local administrations which makes policy making complicated) (Batnyam, L. pers.comm.).

Some PM monitoring has taken place since winter 2007, but source apportionment capacity is lacking. A critical element in identifying clearly sources of air pollution and monitoring effectiveness of measures. There is diverse source of air pollution. Dust could be accumulated from coal burning, lack of green vegetation growth and unpaved roads, dust storms, construction work and garbage burning. Coordination among local agencies to share information, equipment, staff capacities is necessary to make optimal use of assistance from different sources (WB, ADB, JICA, GTZ, and Korea) and provide comprehensive information to the public. Since 2007, heightened donor interest and new programs under development. World Bank has mobilized about $1 million in technical assistance funding for various activities, of which about $350,000 spent this year. 43% executed by Government of Mongolia.

Ulaanbaatar Master Plan for Air Pollution not adopted, many resolutions on air pollution, but there is an implementation gap, but there are some promising developments. Sixty percent of households live in larger single family homes with larger energy needs. Households are willing to switch to apartments, better fuels and better stoves but cost is a major concern. Heating expenditures make 42% of total income in poorest families. Laboratory and staff capacities are inadequate to carry out full compliance testing for emissions standards.

There are several short term options which GoM is considering for air pollution reduction including housing, fuel switching, insulation, better heating appliances, road paving, increasing green area and better sector performance (solid waste and district heating). However, there are number of issues to consider such as economic cost/benefit of the new application, affordability of the population, technical and financial feasibility (Emissions performance of old appliances with new fuels, Market penetration and payback).

Best Practice Approaches for successful implementation include combination of regulation, enforcement and incentives; use of efficient end-use equipment (combined approach of applying fuels and appliances) and regulation. Regulations include standards (fuel composition, energy value, pollutants, equipment efficiency, equipment maximum fuel consumption, maximum emissions) and voluntary compliance through information campaign and compulsory compliance through enforcement (Banning raw coal, phasing out leaded gasoline and allowing only qualifying/certified equipment). Also, financial incentives such as taxation (to impose tax on polluter, tax on dirty fuels, imposing no tax on cleaner fuel in order to make clean fuel more affordable, tax on energy in-efficient equipments like car and stoves etc.) and providing subsidies for energy-efficient or clean equipment and subsidies on clean fuels (to make clean them more affordable) are part of air pollution reduction approaches (Gonchigsumlaa,Ch. pers.comm.).

World Bank experts have concluded in their Environmental Monitor report of Mongolia that there are number of drawbacks in the environmental institutions performances (World Bank, 2002). These are:

- Limited coordination between ministries and government agencies with no systematic feedback exchange on the respective sector issues. Coordination with the national authorities on overall policy direction is carried out on an ad-hoc basis.

- Environmental agencies at local authorities in urban and countryside areas have weaker administrative structures.
- Weaker implementation of environmental legislation, less clear and weak administrative and civic liability
- Inadequate human and financial capacity of the MNE which leads to low performance of the implementation, monitoring and enforcement of environmental legislation. The reason for limited human resource is continued loss of professional staff to the private sector mainly due to less salary.
- Moreover, poor implementation of existing legislation due to limited public awareness and understanding of environmental laws and regulations.
- Very limited amount of detailed information of environmental financing and environmental impact assessment results, especially the results of environmental inspection activities undertaken by SIA reach the public or not at all.
- Most government officials have no regular communication experience with the related constituents except for periodic development partner-sponsored conferences thus leading to limited amount of feedback from them.

According to ADB expert report, the key institutional problems in Mongolia's environmental management today are:

- Imbalance between the assignment of implementation responsibilities and the allocation of budget resources.
- The pattern of local environmental management continues to be unsustainable because local government budgets are low and are dependent upon the development partner funding

In order to conduct a full scale analysis of pollution sources, there are a number of problems developing countries have to overcome (ADB, 2005). These include:

- Existing methodologies usually require significant data, and are "super-specialized," expensive, and inflexible within the context of developing countries;
- Developing country environmental agencies are often young, with inadequate skills, interaction, and capacity;
- Institutional problems are very common in developing countries (For example, public, bureaucratic and political interest in environment quality is oftentimes in its infancy and with competing demands for scarce financial resources; decision-making is often ad-hoc and crisis-driven and there is often little time to develop a suite of high-end models for a bewildering array of options.) Databases are often inaccessible and not of the required quality and consistency

Air quality network presently includes 4 urban, 20 rural sites across Mongolia and gather sulfur dioxide (SO2) and nitrogen dioxide (NO2) only. There are number of major constraints such as financial limitation, different sampling period at the monitoring stations, deficiency of the monitoring equipment, lack of calibration/maintenance support and operational problem such as lack of consumables. Continuous monitoring equipment suspended particulate monitor and sampling devices are needed in air pollution monitoring stations. Emission estimates are a requirement to track changes in response to new developments and policy measures for air pollution abatement. In Ulaanbaatar, up to date and complete emission inventory is lacking for various reasons. Even though vehicle tailpipe emissions are tested, so far no comprehensive vehicle emission standards and no legislation regarding petrol quality standards have been adopted (ADB 2006). Mongolia is still consuming leaded petrol. For the successful air quality management in Mongolia, effective cooperation between related government agencies in areas of transport, energy and health is essential. The Government of Mongolia is addressing pollution emission problem from the thermal sources, but emissions from motor vehicle sources should be addressed as well. In order to reduce nitrogen dioxide

and other pollutant emission form the increasing number of motor vehicle, comprehensive action plan and regulation should be developed. There is need to promote use of unleaded petrol and use of public transport. Standards regarding fuel quality and vehicle emission standards should be developed (Enhmaa,S. pers.comm.). The Mongolian Parliament is discussing a draft resolution on measures for the reduction in air pollution in Ulaanbaatar City. Currently group of specialist on respected fields are working on preparation of Master Plan for the reduction of air pollution. Members of Parliaments and members of ministries including Nature and Environment, Fuel and Energy, Construction and Urban Development, Transport are taking part in Master Plan preparation. Technical working groups are working on preparation of air pollution reduction action plan strategies. Responsibility of this working group is conducting an integrated analysis consolidating technical, economic, physical and ecological aspects of air pollution. In particular, main responsibilities of the working groups include coordinating among departments to establish baseline and action plan, conducting analysis for better air quality, developing a Master Plan of action incorporating measures to secure political commitment and ensuring the participation of community, NGOs and private sectors to mobilize nongovernmental resources (World Bank 2007). Although political commitment at the ministerial level to tackle air pollution problems is considered to be ensured, the integration of air pollution mitigation policies with economic, transport, energy, waste management, spatial planning and other policy frameworks are another step to achieve for better air quality management. NGOs cover various environmental issues and don't solely focus on air quality problem. Details of environmental financing and environmental impact assessment results, especially the results of environmental inspection activities undertaken (since 2003) by SIA doesn't reach the public or reach unsystematically (Saijaa, N. pers.comm.). Most officials continue to have little experience in communicating regularly

with their constituents, and other than periodic development partner-sponsored conferences, few formal mechanisms and funding exist to seek feedback from them.

CONCLUSIONS

Existing evidence suggests that rapid increases in industrial, transport and household emissions have caused a decline in air quality of Ulaanbaatar over the last decade years. Quality assured reporting of the emission data of a high quality is essential for air pollution state assessment. Emissions of sulfur dioxide (SO_2) in Ulaanbaatar continued to show a clear upward trend. Emissions situation of nitrogen oxides (NO_x) is not satisfactory as well. Acute and chronic health effects of ambient and indoor air pollution is more visible on elderly, children and those with respiratory and cardiovascular disorder. High concentration of noxious pollutants has increased since 1994 which exceeds safety standards. Consumption of low-grade coal, low-efficiency heating systems, lack of proper insulation in buildings, and overall lack of incentives to conserve energy use are among significant factors contributing to air pollution in Mongolia. Leaded gasoline is still used in Mongolia. There is insufficient awareness of the health risks about lead posed on population and no strategy on the lead phase-out has been adopted yet.

From the information outlined the thesis, it can be concluded that Mongolia has taken initiatives to adopt key elements that form part of an AQM system. Government of Mongolia has taken an initiative of policies, standards and regulations to reduce air pollution. However, at that time air pollution problem was not recognized enough so these laws and program lack appropriate supporting action plans and detailed guidance. So Mongolia has to finish preparation of the Air Pollution Reduction Master Plan. In this Master Plan, all the stakeholders in AQM and especially affected parties, general public should be consulted to reduce later problems. The approach to air pollution continues to suffer from insufficient coordination that would make it possible to sequence available pollution reducing options in the most cost-efficient manner. Thus, there is urgent need to produce Air Pollution Abatement Master Plan. National or local governments are focusing on obvious sources of air pollution

and taking initiatives to undertake the quickest means of control. More sophisticated and comprehensive strategies are not applied yet but can be developed over time.

One of the initial steps of AQM, emission inventory is not fully understood or documented. In Ulaanbaatar, up to date and complete emission inventory is lacking for various reasons. It lacks some essential emission input information from certain sources and air quality monitoring lack technical capacity. Air quality health impacts on population of Ulaanbaatar is not fully studied so further research on this field is welcome. There should be new law regarding the leaded petrol and additional law amendments should be conducted. Government of Mongolia is discussing to apply "Polluter-Pays" principle in existing laws which lacked. Although there are number of environmental laws and regulations in Mongolia there are weak disposition for feedback and settling environmental issues through courts. Implementation and enforcement of air quality laws remain poor. A limited financial resource, absence of implementation guidelines for monitoring and inspection procedures, led to less effective law enforcement by local government agencies.

The strongest support for mainstreaming environmental concerns typically comes not from the environmental or environment-related ministries themselves but from outside, especially foreign funds and NGOs. AQM in Mongolia is financially dependent on foreign NGOs and in future there should be our own mechanism for AQM finance. Provisions for monitoring and evaluation of environmental impacts were consistently weak and largely excluded civil society. Civil society also played no or a minimal role in project design. Although general public are becoming aware of environmental pollution the city, limited information about detailed effects on their health do in a limited way or don't reach people. This is preventing the general public from playing a more active role in managing and protecting the air quality. AQM system in Mongolia is rudimentary and it has limitations on

almost every AQM development stage. Key factors like increased technical, financial resources and public participation are crucial in current AQM in Mongolia.

APPENDIX 1: LIST OF INTERVIEWEES

1. Mrs. Nergui Jambaldorj, Ministry of Nature and Environment, Ulaanbaatar, Mongolia
2. Dr. Enhmaa Sarangerel, Central Laboratory of Environmental Monitoring Ulaanbaatar, Mongolia
3. Dr. Saijaa, Public Health Institute , Ulaanbaatar, Mongolia
4. Prof. Gonchigsumlaa, the department of Geoecology and Land Use Management at National University of Mongolia
5. L .Batnyam, Air Quality Management Bureau, Ulaanbaatar, Mongolia
6. S. Chuluunhuyag, NGO - Ecological education center
7. M. Badarch, Environmental Consortium, Ulaanbaatar, Mongolia

APPENDIX 2: LIST OF INTERVIEW QUESTIONS

- Please tell me your opinion about human and financial capacity which Ministry of Nature and Environment and related agencies possess?
- Could you tell about the performance of the implementation, monitoring and enforcement of environmental legislation?
- Does the Air Law in Mongolia reflect "Polluter Pays" principle?
- What do you think about the situation of air quality management in Mongolia?
- Do you think we have necessary legislation and policy to support air quality management?
- What kind of legislation and policy are there? How are the enforcements?
- When air quality legislation adopted and what were the results since then?
- Who are the main stakeholders in air quality management in Mongolia? What is the structure of air quality management?
- How well the voice of stakeholders represented in air quality management decision making?
- How well do current legislation and policies support air quality management in Mongolia?
- Is there any target set by the government of Mongolia to reduce certain air pollutants?
- Does Government of Mongolia apply market-oriented policies and economic instruments to reduce air pollution?
- Are there any set goals to increase renewable energy source?
- Is any of the power plants are using new technologies?
- What is being done in each sector to reduce air pollution?
- Do you think the city is planned suitable for circlers?
- Do any regular public awareness activities take place? Is there any practice of eco-labeling of environmentally friendly products taken place in Mongolia?
- What is your opinion about current emission inventory? How well was emission inventory conducted?
- Does researchers in Mongolia conduct studies and surveys regarding air pollution or AQM? If yes, until what extent were those conducted?
- Does Mongolia have Air Quality Management Action Plan? Were representatives of the AQM stakeholders consulted?
- Why AQM Action Plan had to postpone its submission to Parliament? What challenges were faced in action plan preparation process?
- What are the weak points in current air quality management in Mongolia? If there is any?
- What are the strong points in current air quality management in Mongolia? If there is any?
- Do difficulties exist for the successful implementation of air quality management? If yes on which levels? What are the difficulties?
- Does Mongolia have emission inventory?
- Does Mongolia have air quality monitoring networks?
- Does Mongolia have dispersion and air quality prediction models?
- Does Mongolia have exposure and damage assessments?
- Are there institutions, regulations and enforcement mechanisms for air pollution abatement?
- Is there a substantial amount of financial resource for air pollution abatement?

- Is there sufficient technical and human resource available?
- Please tell me your opinion about the NGO and public participation in current environmental management activities? In particular in AQM process.
- Do you think that the public is educated and informed about current air quality situation and their negative impacts?
- How well general public is aware of the environmental laws and regulations?
- What is your opinion about air quality information accessibility?
- Do NGO's in Mongolia conduct activities related to AQM?

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