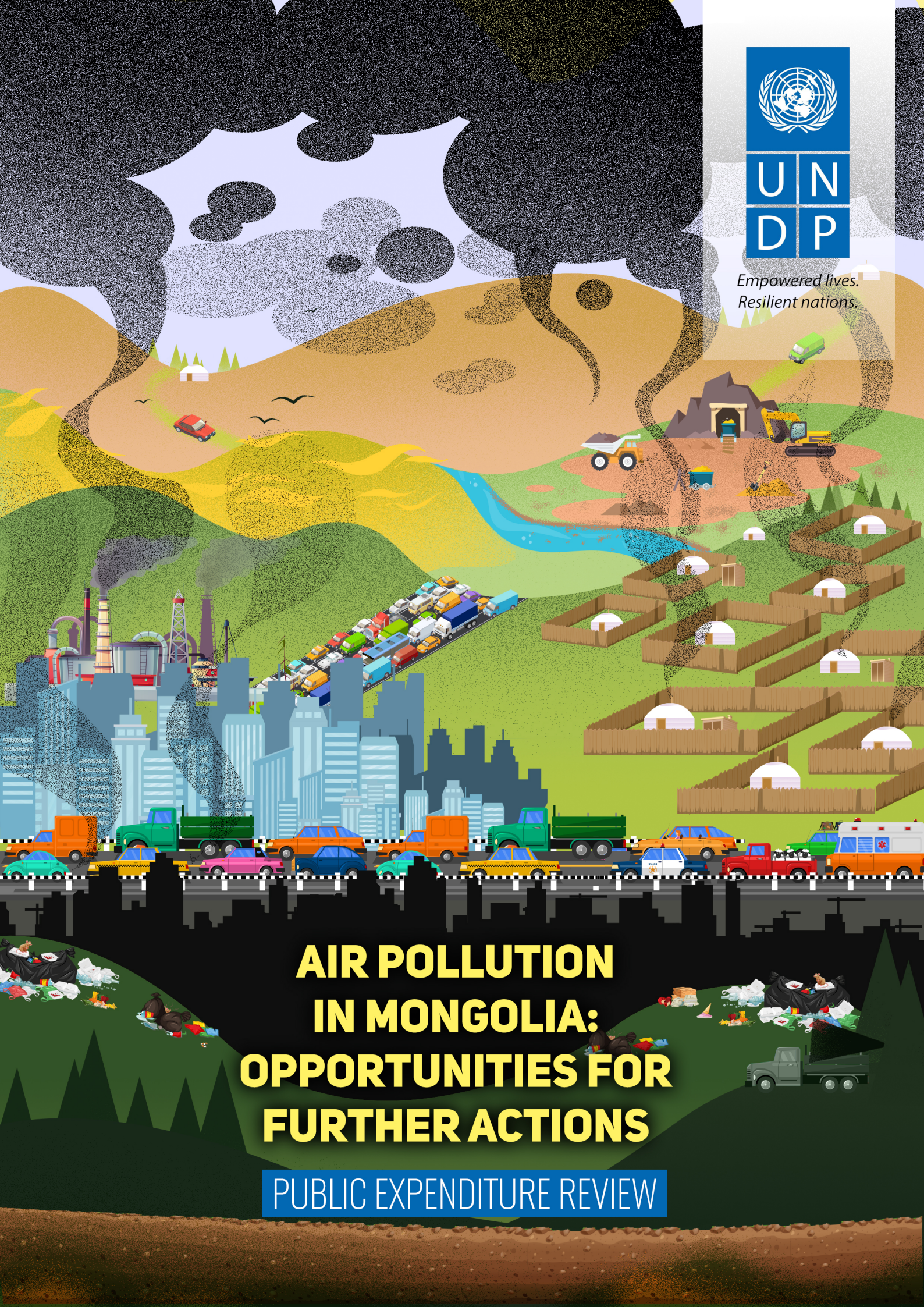


UNDP

Empowered lives.
Resilient nations.

AIR POLLUTION IN MONGOLIA: OPPORTUNITIES FOR FURTHER ACTIONS

PUBLIC EXPENDITURE REVIEW


AARC

ACKNOWLEDGEMENTS

This document is the outcome of a study undertaken by a team of Mongolian and international consultants between October 2017 and May 2019. The international team consisted of Wayne Bartlett, Omon Narzikulov, Philip Schubert, Hendrik Wolff, Nick Bain and Patrick Corrigan. The Mongolian team was led by Nergui Dorj, MCDS and included Uranbileg Jamba, Batbayasgalan Myagmardorj and Tummenast Budsuren.

The study summarizes and analyses the various steps that have been undertaken since 2010 to solve the serious problem of air pollution in Mongolia. The review includes an analysis of the health impacts and economic costs of air pollution and provides policy recommendations for future strategic actions that the Government of Mongolia can take in the short, medium and longer term to address air pollution. The review focuses particularly on an assessment of existing government policies and their potential to generate the desired impact, and whether they are affordable and appropriately prioritized. The Government's National Program for Reducing Air and Environmental Pollution (NPRAEP) and its Action Plan constitute the key framework documents for this exercise.

The study assesses the likely efficiency and effectiveness of those that are planned for the future. It is hoped that this study will stimulate debate on the measures required for the reduction of air pollution in the country and encourage determined attempts to improve them and make them more effective. As the study demonstrates, the effects of air pollution are serious and have a wide-ranging impact on the lives and well-being of Mongolian citizens. At the time of writing, these effects are being actively recognized by the government and stimulating vigorous debate. This issue currently has a high profile at both presidential and parliamentary levels as well as within the local government of Ulaanbaatar.

The study team is grateful to many people who have contributed openly and actively in discussions and in providing data and ideas. Without their help, this study report would not have been possible. We also appreciate numerous authors of studies and analyses in the past in areas connected to air pollution; their indirect inputs to our analysis have been invaluable.

Finally, we are grateful to the UNDP for the opportunity to undertake our work in this important area and in particular to the staff in the office at Ulaanbaatar who have given unstinting support to the work of the study team. It should be noted that the opinions expressed herein are those of the authors but, in the process, we have attempted to reflect the knowledge of as wide a range of stakeholders as possible in the time available.

AARC Consultancy
Dublin, Ireland
www.aarcconsultancy.com
aarc@aarcconsultancy.com
+353.1.634.9706

CONTENTS

GRAPHS

FIGURES

TABLES

BOXES

ABBREVIATIONS

AAQS	Ambient Air Quality Standards
ADB	Asian Development Bank
AQMS	Air Quality Monitoring Station
ARI	Acute respiratory infection
CBA	Cost-Benefit Analysis
CHP	Combined heat and power (thermal power plant)
CPI	Consumer Price Index
DALY	Disability Adjusted Life Years
EFF	Extended Fund Facility
ESMP	Energy Sector Master Plan
FDI	Foreign Direct Investment
GBD	Global Burden of Diseases
GCF	Green Climate Fund (UNFCCC)
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOM	Government of Mongolia
HH	Household
HOB	Heat-only Boiler
IARC	International Agency for Research on Cancer
IHME	Institute for Health Metrics and Evaluation
ILO	International Labour Organization
INDC	Intended Nationally Determined Contribution
JICA	Japan International Cooperation Agency
LPG	Liquefied Petroleum Gas
MCC	Millennium Challenge Corporation
MET	Ministry of Environment and Tourism
MNT	Mongolian Tugriks
MOF	Ministry of Finance
MOH	Ministry of Health
NAMEM	National Agency for Meteorology and Environmental Monitoring
NCREP	National Committee on Reducing Environmental Pollution
NPRAEP	National Program for Reducing Air and Environment Pollution
NSO	National Statistical Office
OECD	Organisation for Economic Co-operation and Development
PETS	Public Expenditure Tracking Survey
PM	Particulate Matter
PPP	Public-Private Partnership
ppp	Purchasing Power Parity
SDG	Sustainable Development Goal
SVL	Statistical Value of Life
SDR	Special Drawing Rights
UB	Ulaanbaatar
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USD	United States Dollar
VSL	Value of Statistical Life
WB	World Bank

WHO	World Health Organisation
WTP	Willingness to pay
YLD	Years Lost due to Disability
YLL	Years of Life Lost

EXECUTIVE SUMMARY

This study analyses public sector expenditure and the institutional framework for air pollution reduction in Mongolia for the period from 2010 to 2017 and along with an analysis of current future plans and options for dealing with this challenge. It includes an assessment of the National Programme for Reduction Air and Environmental Pollution (NPRAEP) 2017-2025 and other relevant policies, public sector spending and institutional settings and mechanisms.

Mongolia's air pollution problem, caused by an alignment of various conditions and circumstances, has risen to internationally high levels, especially in Ulaanbaatar (UB). Various efforts made in the past, especially since 2010, have aimed to address this issue but with limited success. Since 2017, the legal and policy environment on reducing air pollution has been further strengthened, but outcomes are still unsatisfactory. If sustainable progress is now to be made, the underlying reasons for those failures, which include weak design, as well as inadequacy and ineffectiveness of implementation must be addressed.

The two ministries with the main responsibility for dealing with air pollution in Mongolia are the Ministry of Energy and the Ministry of Environment and Tourism (MET). The Mayor's Office in Ulaanbaatar also plays a critical role in dealing with air pollution, specifically in the capital.

Mongolia's internal rural-to-urban migration since the 1990s and its rapid economic development, the continued burning of brown coal in gers, and to a lesser extent an increase in the number of vehicles on the road, have all contributed to poor air quality in Ulaanbaatar. However, air pollution reduction initiatives have generally not been effective, due to inconsistent fiscal allocations that fell sharply due to a tight budget, poor monitoring of implementation and an absence of post-evaluation mechanisms. The country's macroeconomic crisis in 2015-16 led to a marked slowdown in actions to reduce air pollution, which had a further negative impact on health and the economy.

Air pollution, particularly in Ulaanbaatar, remains significantly above the set targets. Levels of NOx, $PM_{2.5}$ and PM_{10}, which increase in the winter months, are significantly higher than both World Health Organization (WHO) recommended and Mongolian National Standards. Expenses for winter fuel are estimated to consume on average at least 17.5% of the household budget of the poorest Ulaanbaatar households, those living in the peri-urban ger districts. While residents in apartments receiving heat from the grid pay subsidized rates for that service, the lowest-income Ulaanbaatar residents in ger districts have no alternative to paying the market price for fuel. This drives them to choose the cheapest fuel available, which tends to be dirtier, leading to worse air pollution problems.

To deal with this problem, in March 2017 the government adopted the NPRAEP. The program is to be implemented in two phases, from 2017 to 2019 and from 2020 to 2025, with the ultimate target of reducing pollution by 80% compared with the baseline year of 2016. Mongolia's energy policy is also challenged, not just locally, but also globally by its commitments under the Paris Climate Change Agreement. Some of the recommendations for the short and long term include carbon pricing and the long-term banning of raw coal in favor of renewable energy sources. It is important to note that both short-term and long-term goals must be kept in sight with a common goal to make a long-term transition to greater dependency on renewable energy sources.

The activities of the NPRAEP and their costs and benefits are assessed in this report. The cost benefit analysis in this report is an essential part of moving the effort forward. At the same time there are other issues that must also be addressed, such as technical feasibility, affordability, governance-related issues and social acceptance. World Bank (2011) and JICA (2017) reports have been compared to produce an appropriate cost and benefit analysis of energy options for Mongolia. Various energy options available in Mongolia have been

evaluated, such as gasification of coal, geo-thermal energy and the feasibility of renewables.

aspirational guideline, it is very broad, and costly, that in its current state it is of limited value as a guide to action and a focus for resource mobilization. We recommend that the NPRAEP and its Action Plan should be updated. Appropriate prioritization and sequencing of air pollution reduction actions is essential, accompanied by robust monitoring and enforcement mechanisms. All activities should be fully costed and their benefits assessed. A number of potential sources of financing are available for such an agenda; however it must be carefully designed and realistic in scope in order to mobilize the needed funds.

The NPRAEP must also recognize that successful implementation of some of its most significant measures will not be possible over the medium- to long-term without fundamental reforms that are recommended in this report. These include:

- the need to set energy prices that recover the full costs of fuel plus the additional cost of externalities including air pollution and greenhouse gas emissions, and;
- effective governance and monitoring mechanisms to increase transparency of government processes.

Support from the private sector is vital in reducing air pollution but several serious obstacles currently mitigate against this. In many areas full cost recovery does not exist. This creates disincentives to future investment in renewable and cleaner energy. Equally, a lack of transparency and perceptions of its absence discourage such investment.

To support initiatives to reduce air pollution, the Government of Mongolia (GOM) must ensure that scarce financial resources are used effectively, that the legal framework facilitates such initiatives and that institutions are strong enough to monitor and enforce air pollution reduction actions. Public sector expenditure on combating air pollution has fluctuated over the

We find that while the NPRAEP is valuable as an

years, and fallen markedly when the economy slowed down, as in 2015-2016. However the negative impact of air pollution on the health and welfare of the Mongolian people and on prospects for sustainable development are too serious for this pattern to be allowed to continue. A firm long-term commitment to the necessary actions is required.

Air pollution is considered an environmental risk to human health (WHO), has serious economic consequences (OECD) and has a particularly serious impact on children (UNICEF). It is estimated that the welfare costs attached to air pollution are equivalent to 5.3% of the GDP in Mongolia as a whole. Added to this should be the costs associated with “willingness to pay (WTP)”. No study on economic costs has been carried out for Mongolia due to lack of data.

To address the air pollution problem in Mongolia the NPRAEP, even after the streamlining and prioritization that we recommend, will still require additional fiscal space. Options range from reprioritization of Mongolia’s budget, to concessional borrowing, external grants, private sector mobilization and public-private partnerships.

MAIN FINDINGS:

- The policies adopted by the GOM have had an impact on air pollution reduction with apparent positive impacts on PM levels from 2012 to 2015. However, air pollution levels have risen since then and remain significantly above both WHO recommended and national standards.

- Serious health problems can be linked to air pollution in Ulaanbaatar; with air pollution one of the top ten risk factors driving death and disability in Mongolia.

- The economic costs associated with air pollution are estimated to be at least

$645 million (approx. 1.6 trillion MNT) per annum.

- Currently, the prices that Mongolians pay for electricity and heat do not reflect the enormous externality costs of consuming the energy. This creates disincentives to invest in cleaner energy options and to save energy.

- Another serious fuel price issue is that at present only ger district residents pay full market prices for energy. All other groups are subsidized by the GOM, though the levels of subsidies are being reduced. Such inequalities further burden those who generally have low incomes and the government policy should address this inequity.

- This inequity is compounded by poor household's reliance on more fuel-intensive individual heating stoves in each home, making heat provision much more expensive for them than for households in homes connected to the heating network. This often leads poor households to purchase the cheapest – often the dirtiest – fuel available. Subsidies to encourage use of higher quality and cleaner fuel is needed.

- Expenditure of 147.3 billion MNT from the state budget and $60.7 million equivalent in foreign aid on air pollution measures had taken place annually from 2008 to 2018, and resulted in some reduction of air pollution during this period.

- The NPRAEP is forecast to cost about $4.1 billion (9.8 trillion MNT); 86% of these costs appear to be related to air pollution reduction measures and about 80% of the funding required for air pollution reduction measures is still unsecured. This is an unrealistically high number; The NPRAEP should be further prioritized.

- Both short-term and long-term goals must be maintained and addressed in parallel, such as short-term introduction of cleaner stoves and fuels for ger area households and insulating existing homes and the building of apartments to rehouse ger residents. In the long term, options and pilot projects for greater use of renewable energy sources must be ongoing.

- Short-term air pollution reduction measures such as the use of clean stoves in ger areas should be continued. There has been some criticism of past clean stove programs because they did not address local non-availability of the required fuel and suffered from weak governance arrangements. However this was a problem with implementation arrangements, rather than a fundamental flaw in the policy. Ongoing World Bank and JICA research demonstrates that clean stoves provide a valuable and potentially major contribution to the reduction of air pollution until they can be replaced by viable long-term alternative sources of energy.

- Mongolia is in a unique position to develop its vast renewable energy resources to meet its own demand and to become a power supplier to its neighbors.

- Institutional arrangements for reducing air pollution involve a number of different bodies on several different levels. They run the risk of being uncoordinated unless the National Committee on Reducing Environmental Pollution, which was established when the NPRAEP was approved, is sufficiently strengthened to ensure the effectiveness of NPRAEP implementation.

- The ongoing housing and ger area redevelopment programs are key solutions for reducing air pollution in Ulaanbaatar in the medium and long run. Unfortunately, low-income ger district households cannot meet the minimum requirements to obtain mortgage loans. Job creation and sub-mortgage loan programs targeting low income households in ger districts are

fundamental in ensuring that redevelopment programs are effective.

- Funding for prioritized air pollution reduction measures can be made available in a number of potential forms. Among them are better-controlled and targeted public expenditure, gradual rationalization of energy tariffs, increasing air pollution tax, introducing eco-tax, better governance and transparency measures, concessional loans, grants and private sector investment, including foreign direct investment (FDI) and public-private partnerships (PPP).

Overall recommendations:

1. Dirty energy should be taxed by adding the marginal damages to the final product price.

2. Program measures must be prioritized based on “Low cost + High Impact Actions First”, following the principles of “Sustainability” and ’Realism”’.

3. The linkage of air pollution reduction actions with their impacts must be strengthened.

4. Appropriate measures should be included to increase accountability for and coordination among respective government agencies and other stakeholders.

5. Effective governance and monitoring mechanisms must be in place to guard against corruption and help ensure value for money among respective government agencies and other stakeholders.

6. The actions of the NPRAEP should be fully costed, and then, if they are economically cost effective, divided into short, medium and long-term measures.

7. All measures must be prioritized, rightly sequenced and developed into an “Integrated Financing Framework for Air Pollution Reduction”.

8. Public awareness needs to be raised on impacts of air pollution to health and well-being, measures for protection and reduced exposure to it, as well as actions that can be taken at individual and household levels to contribute to combating air pollution.

1.1. Recommendations for the Short-term (2019/2020)

9. A comprehensive policy framework to combat air and environment pollution should be put in place to supplement the current NPRAEP.

10. A more market-based approach to the provision of energy should be initiated. Subsidies should be gradually withdrawn and air pollution tax collection increased.

11. The Law on Air Pollution Tax should be amended to ensure that all taxes collected are spent for their intended purpose only.

12. The combination of clean stoves, improved fuel option and home insulation should be an important short-to-medium term policy measure. The government should continue programs for the replacement and upgrading of stoves and testing of a variety of options.

13. Financial support for the stove and home insulation initiatives should be made available through differentiated subsidy rates depending on income. Measures should be taken to ensure that any subsidies are used only to support the cleaner stove and home insulation initiatives.

14. Staff of respective government agencies should be trained to monitor new “standards” on fuels and stove technologies to ensure the enforcement of these new standards.

15. Efforts to enhance electricity distribution network capacities to provide more power to ger area households should continue, as well as providing financial support for those who cannot finance electric heaters.

16. We recommend that the existing housing and apartment rent program be expanded. This will be a short, medium and long-term measure.

17. The GOM and the Municipality of Ulaanbaatar should continue to work very closely with interested and active external assistance partners in their efforts to improve the air pollution situation.

18. Institutional arrangements for the management of air pollution must be strengthened, with particular attention given to ensuring proper coordination of activities and cohesion at all levels of government.

19. The capacity of the National Committee on the Reduction of Environmental Pollution

and the relevant offices in Ulaanbaatar Municipality should be strengthened.

20. An effective monitoring mechanism should be put in place to measure NPRAEP progress against objectives.

21. The draft Law on Human Settlements should be finalized and then approved by the Parliament.

22. The existing pricing arrangements for electricity and heating should be reviewed and an implementable plan for full cost recovery in all relevant areas should be developed.

23. A specific study is recommended to arrive at a detailed timetable over which it is possible to move to full cost recovery.

24. Environmentally-friendly standards for stoves, fuel, the building industry and other relevant sectors should be introduced. They should continue to be further improved, adopted and enforced.

1.2. Medium term (2020- 2025)

25. Measures to increase the efficiency of thermal power plants (CHPs) and technology renovation should be adopted.

26. Measures of ash management for CHPs, including disposal and re-use, should be put in place.

27. The implementation of housing and rental apartment programs, including of a sub-program for low- income households in ger districts should be continued.

28. The job creation program targeting ger area low-income households should be an integral part of the NPRAEP.

29. The Energy Sector Master Plan (ESMP) should be regularly updated. Strategies for energy transformation to reduce coal as a source of energy to satisfy Mongolia's energy demand in the mid-to-long term are the only way to address the root cause of air pollution.

30. The GOM should continue to take measures to reduce air pollution caused by the transport sector through enhanced law enforcement and renewal of regulations regarding vehicle fuel and fuel quality.

31. Fiscal space (unsecured funding needs) for prioritized and rightly sequenced actions of the NPREAP should be created by the GOM and the Municipality of Ulaanbaatar.

32. Financing mechanisms for air pollution reduction through the "Integrated Financing Framework for Air Pollution Reduction" should be strengthened.

33. Public Expenditure Tracking Surveys should be regularly undertaken.

34. The GOM should arrange for the future calculation of the country's Value of Statistical Life (VSL).

35. The GOM should initiate a study on the total damage costs of air pollution.

1.3 Long-term (2025 and beyond)

36. Full cost recovery of fuel supplied to consumers should be ensured in all cases through a variable tariff system that will be appropriate for all income groups by means of carefully chosen cross-subsidies.

37. Alternative renewable energy sources should be made available to Mongolia. Strategies for an energy transformation to increase the share in renewable energy sources must be designed, going beyond the exploration of options. This should also include the creation of a private sector environment that is conducive to investment in renewables.

38. We recommend several options for increasing the use of renewable energy: hydroelectric reservoirs, development of pumped storage, compressed air energy storage and using batteries. The potential of wind and solar power generation must also be investigated.

39. The GOM and the Municipality of Ulaanbaatar should ensure greater transparency and address any misconduct.

40. The housing program should continue in an incremental fashion.

41. For greater energy efficiency, existing (precast panel) buildings should be retrofitted and users should pay in accordance with their level of heating energy usage (through installation of thermo-meters).

1. INTRODUCTION

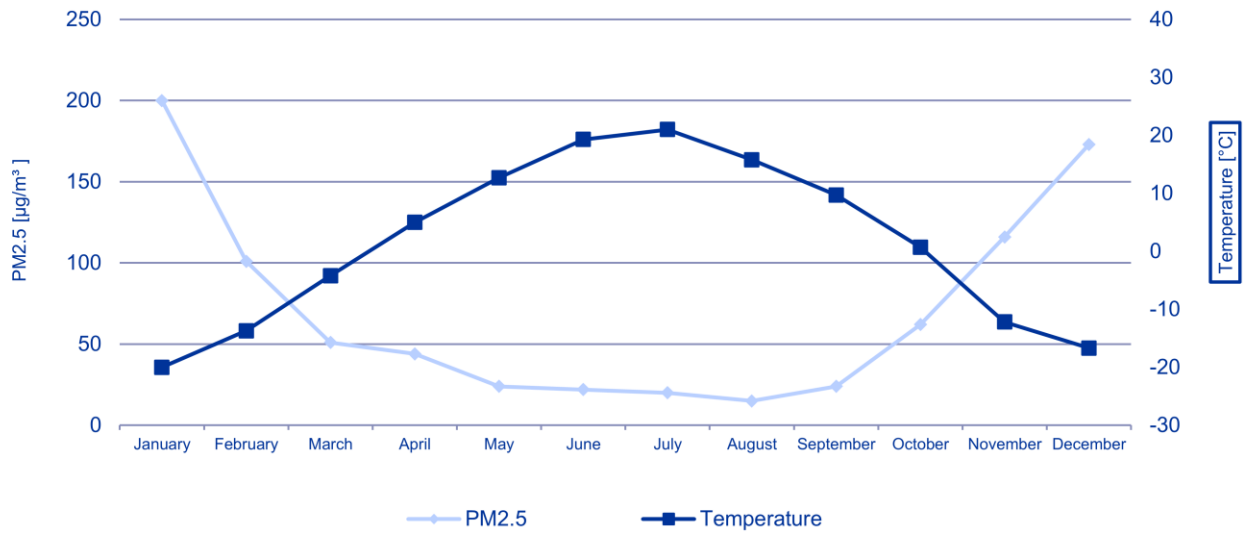
The objective of this study is to provide an analysis of public expenditure and an institutional review with regard to the air pollution reduction efforts of the Government of Mongolia (GOM), as well as review of current future plans and options for dealing with this challenge It includes the assessment of the National Program for Reducing Air and Environment Pollution (NPRAEP) and the relevant policies, public expenditures and institutional settings and mechanisms that relate to the reduction of air pollution.

Air pollution is a major problem for Mongolia. An unfortunate alignment of a number of conditions, including economic, social, geographic and climatic factors have created a toxic cocktail that has led to internationally high levels of air pollution, especially in the capital city Ulaanbaatar (UB). The main contributing factors to this high level of air pollution include the acceleration of economic growth, rapid urbanization (and as a result increased energy demand) and the use of fossil fuel for energy generation, district heating, and heating in thousands of gers (yurts or portable circular dwellings similar to what is called a “yurt” in Central Asia) and individual houses mainly simple brick or block houses, which are located on the periphery of Mongolia’s major cities.

Because Mongolia‘s increased levels of air pollution are particularly marked in Ulaanbaatar, the capital city is the focus of this study. However, air pollution and its causes are also an emerging and serious problem for many other parts of Mongolia; for example, in other urban areas such as Dalanzadgad and Bayankhongor. Air quality monitoring reports reveal that as of January 2019, the 24-hour mean level of $PM_{2.5}$ is 3.9 times higher, and the PM_{10} is 2.5 times higher, SO_2 is 34% higher and NO_2 is 14% higher than the target Air Quality Standards in Ulaanbaatar.[1] Climatic conditions play a key role and air pollution is extreme in the winter months. January is the coldest month in Ulaanbaatar when heating demand reaches its maximum level. Temperature variations and the level of $PM_{2.5}$ in the city are shown in Graph 1.1; they are highly relevant given the link between air temperature, the need for heating and air pollution.

The economic backdrop to Mongolia’s recent development must be addressed when considering air pollution. Mongolia’s Gross Domestic Product (GDP) has increased ten-fold in the past 20 years, mainly due to the exploration and development of mining of Mongolia’s extensive mineral reserves. The

Graph 1.1. *PM2.5 Levels and Average Temperature In UB by Month, 2017*



Source: National Statistics Office (NSO), 2017

[1] National Standards, MNS 4585: 2016.

country experienced high economic growth from 2012 to 2015, reaching 17.5% in 2012.[2] However, in 2015/16[3] Mongolia was hit by a sharp decline in world commodity prices, particularly for coal and copper. The economy slowed down to an annual growth rate of 2.4% in 2015 and 1.0% in 2016.[4] From the second half of 2017 it started to recover, with 5.3% GDP growth in 2017. This followed a successful negotiation with the International Monetary Fund (IMF) and the resulting Extended Fund Facility (EFF). The GDP growth further increased reaching 6.9% in 2018; the IMF has projected that Mongolia's GDP growth is expected to be 5.3% to 8.5% during 2019-2022.[5]

Linked to this general economic backdrop, the government's finances have deteriorated in the past few years. The budget deficit increased to 17% of GDP in 2016, more than double the level of 2015: this appears to be linked to fiscal consolidation measures resulting from government negotiations with the IMF in 2016 in response to fiscal deterioration. As a result, the government has started implementing measures aimed at reducing the deficit through expenditure rationalization, increasing taxation, improving fiscal discipline and implementing cost-saving initiatives. This should have an impact on the 'fiscal space' available to tackle air pollution (and it is important that the situation is proactively monitored to ensure that it does). However, one fundamental cause of the absence of fiscal space is the fact that current tariffs in the provision of electricity and heat do not include the associated costs. These cannot be recovered with the exception of the provision of raw and brown coal to the ger districts.

After Mongolia opened up its economy to the rest of world in the early 1990s, major socio-economic and governance reforms followed. This led to an easing of the control of movement of citizens within the country. The migration of the rural population to the capital city increased substantially; Ulaanbaatar's population increased from 586,228 in 1990 to 1.4 million in 2016. This is approximately 44% of the country's population.[6]

This increased population in Ulaanbaatar combined with insufficient urban planning and inadequate urban management to factor in this increasing urban population (a 245% increase in around 25 years) led to a corresponding increase in the numbers of those living in the "ger districts", a part of Ulaanbaatar where currently around 220,000 households live in traditional gers and individual houses. The major heating source for ger area is coal in cold season, which led to a substantial increase in the city's air pollution. The GOM has reported that, as of 2015, about 80% of air pollution in the capital is caused by the coal-burning stoves used by households in the ger districts and 3,200 heat-only boilers operated by various entities; 10% by vehicles; 5-6% by combined heat and power (CHP) and 4% by ash ponds and dusty ground base.[7]

In order to assess past, present and future expenditure patterns, institutional arrangements, and their effectiveness, the UNDP commissioned this study, which was undertaken between October 2017 and March 2019. The approach has been to consult (Engel, 2015) a wide range of stakeholders involved in the management and targeted reduction of air pollution in Mongolia. These included staff from government agencies as well as representatives of the Ulaanbaatar municipality who have the potential to play a critical role in driving forward air pollution reduction efforts in the capital. The study team also spoke to representatives of external organizations to obtain their inputs and perceptions. The study team accessed and analyzed studies on air pollution and related topics, relating to both Mongolia and the wider international sphere, which were reviewed and which informed this study report.

The Constitution of Mongolia adopted in 1992 states that every citizen has the right to live in a healthy and safe living environment, as well as

[2] NSO, 2017, Statistics Information Database
[3] World Bank, 2018, http://www.worldbank.org/en/country/mongolia/overview
[4] NSO, 2017, Statistics Information Database
[5] IMF 2017b

[6] NSO, 2017, Statistics Information database
[7] GOM, 2017, "National Program on Reducing Air and Environment Pollution

the right to be protected from environmental pollution and ecological imbalance (Article 6.2). The GOM has made efforts to reduce air pollution, particularly since 2010, when air pollution in the capital city had reached levels that could significantly affect human health and well-being. The legislative framework has also been developed with the Law on Air Pollution Reduction in the Capital City and the Law on Air of Mongolia, adopted by Parliament in 2011 and 2012 respectively.

The aim of this legal framework was to improve existing legislation and adopt new laws to create a foundation for government policies and define the roles and mandates of government agencies involved in the reduction of air pollution. Various other laws and policy initiatives followed: the Law on Air, the Law on Air Pollution Tax, the Sustainable Development Vision of Mongolia – 2030 (adopted in 2016), the Green Development Policy of Mongolia adopted in 2014, the Government Action Plan 2016-2020 and the NPRAEP adopted in March 2017. The NPRAEP aims to reduce air pollution through the optimization of urban planning, decentralization, improving infrastructure and encouraging environmentally positive lifestyles. The total budget for implementing this program in the next seven years is over 9.8 trillion MNT (US$4 billion).[8] This equates to expenditure on air and environmental pollution reduction measures of approximately 1.1 trillion MNT ($450 million). This is about 4.1% of GDP (2017 nominal), a significant commitment.

The NPRAEP is particularly important in the context of air pollution reduction as its stated purpose is to lay out the strategy for the next decade and beyond. Therefore, an assessment of its viability and the costs and benefits of the various measures to be implemented forms an important part of this study.

Data from the Ministry of Finance (MOF) shown in Tables 3.2, 3.3 and 3.4 reveal the levels of expenditure that have been committed to the reduction of air pollution in Mongolia: this includes 9.7 billion MNT (around $67.3 million)[9] from state current budget expenditures (2011-2016) and around 49.6 billion MNT ($34.4 million) through the public investment program (2008-2016). In addition, seven projects with a value of around $60 million for reducing air pollution were implemented between 2008 and 2016. The public expenditure for this purpose was 4.6 billion MNT ($2 million) in 2017 and 10.9 billion MNT ($4.4 million) in 2018 respectively according to the National Committee on Reduction of Air and Environment Pollution.

Given the high level of fluctuation in the Consumer Price Index (CPI) and currency exchange rates during this period, the CPI-adjusted total budget expenditure for air pollution reduction amounted to around 122.3 billion MNT ($86.5 million) during 2008-2016, including recurrent budget expenditures of 84.4 billion MNT ($59.2 million) and investment expenditures of around 37.9 billion MNT ($27.3 million). Total budget spending for air pollution reduction ranged from 0.05-1.2% of total annual state budget expenditure during the period 2010 to 2016. The budget allocated specifically to air pollution reduction was lower in the years 2015 to 2018 than the average over the previous four years, despite the political prominence of the issue. The 2019 Budget Bill, approved in November 2018, included several targets such as a 25% reduction of air polluting substances and creation of an enabling environment for 41 200 households in ger areas to use electric heaters relating to air pollution reduction and their corresponding budgets of 75.7 billion MNT for implementation.

Despite these government efforts over the last nine years, the level of air pollution has not decreased, and the situation remains a major concern. When air quality was measured in January 2017 (NAMEM, 2017), the level of $PM_{2.5}$ was six times the national air quality standard, PM_{10} four times, SO_2 2.7 times and NO_2 was 2.4 times higher. The government's target is to reduce these air pollutants by 2025 ($PM_{2.5}$ to 3.7 times the national standard, PM_{10} to 2.8 times

[8] 2017 annual average exchange rate was used for conversion of MNT to USD

[9] Annual average exchange rate at the time was used for converting MNT to USD for all calculations

and SO_2 by 76%)[10] compared with the base year of 2016. This is intended to be achieved by implementing a wide range of air pollution reduction measures that will be discussed in the sections below.

1.1. Recent Developments in Air Pollution Reduction Measures in Mongolia

Past concerns about the slow pace of improvement and on-going worries about the apparent ineffectiveness of air pollution reduction measures led the President to send an official letter of recommendation to Parliament. In January 2018 Parliament adopted a resolution setting out immediate measures for reducing air pollution. These included improvement of legislation related to air quality and air pollution and increasing accountability for air pollution reduction actions. Nevertheless, the root causes for the air pollution problem must be identified and addressed. There have been serious problems in implementing effective measures in the past; but it is critical that measures which can have a meaningful short-term impact (such as the use of “clean stove technology”) are not abandoned without investigating and evaluating why they were not successful. The problem is more one of implementation than any deficiencies in the technology. If lessons are not learnt from this, a similar situation is likely to occur with the introduction of new air pollution reduction or approaches. In parallel, longer-term developments such as the transition to renewable energy need to be further developed, as well as exploiting the country’s significant coal reserves in a way that minimizes damage to the environment. It is understood that a gradual transition to renewable energy will reduce the use of coal over time.

Air pollution presents a high-profile and important current challenge for Mongolia. As well as stimulating the interest of government, civil society in Mongolia, including “Mothers and Fathers against air pollution”, has been proactively pushing the government to take urgent action to reduce air pollution in Ulaanbaatar.

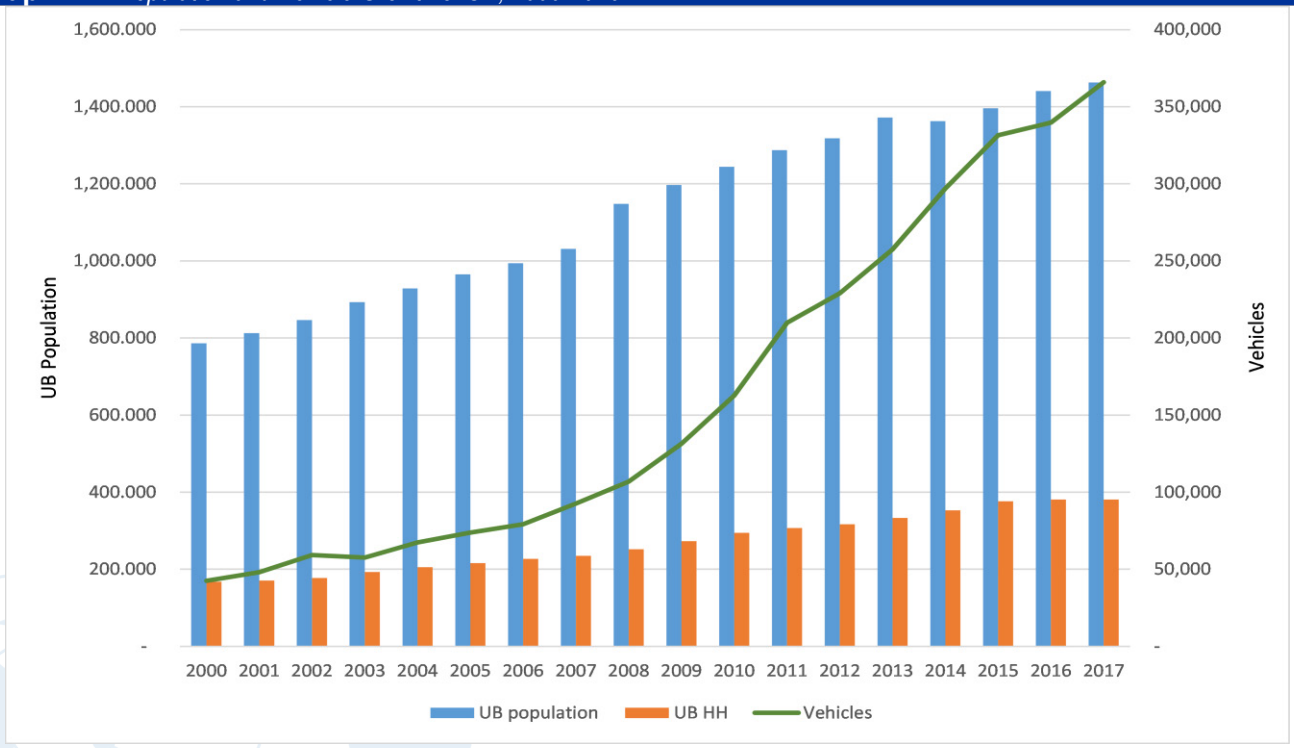
[10] Targets are specified in the NPRAEP, GOM, 2017

2. ENVIRONMENTAL BACKGROUND

Air pollution has been a challenging issue in Mongolia over the past two decades – a result of the intensification of the transition of the political system during the 1990s. This difficult transition which saw high inflation and food shortages, led to uncontrolled urbanization with a mass flow of the population into central settlements (Ulaanbaatar, Darkhan, Erdenet cities and provincial centers), creating densely populated areas around the cities[11] with the widespread burning of raw coal[12] in regular stoves[13] for heating during the cold winters. The city was built during the Soviet era for a population of 400,000;[14] it now holds more than three times[15] that number. The use of raw coal in ordinary stoves generates ash, sludge, toxic chemicals (CO and SO_2) and leads to a series of environmental and health problems.

In addition, due to rapid economic development and improved living standards, the number of vehicles on the roads has dramatically increased since the 1990s, although the population of Ulaanbaatar and the number of its households has stabilized in recent years (see Graph 2.1). Vehicles more than 10 years old form the majority of those on the road,[16] creating persistent traffic jams in Ulaanbaatar and contributing to the poor quality of air. This overload of traffic further contributes to air pollution with a high concentration of nitrogen

Graph 2.1. *Population and Vehicle Growth of UB, 2000-2016*



Source: NSO, Statistical Yearbook, 2000-2016; Statistics Information Database, 2017

[11] As of 2016, the ger district of UB has an estimated area of 19,990 ha, covering 74.3% of the UB city area: *UB Municipal Governor's Report*. October 18, 2017.
[12] In UB approximately 2.43 tonnes of coal and 3.966 m3 wood is burned annually in one stove. *UB Clean Air Initiative project report*. MNE/Mott MacDonald. 2012.
[13] According to the "Unified registration of Air Pollution sources in 2016", a total of 195,090 stoves with a capacity of up to 10 kWh were counted in UB, where 45% or 88,330 households used simple stoves and 54% or 106,760 households used what were declared to be "improved" stoves. Also, a total of 2,829 water heating boilers with a capacity of 11-100 kWh were registered in six districts. *Report on state of Environment of Mongolia 2015-2016.*
[14] Pre-survey report for public transport project in Ulaanbaatar, 2012
[15] According to the *Capital Statistics Office*, the population of UB reached 1.38 million in 2016.
[16] In UB, a total of 458,204 vehicles were counted in 2016, an increase of 19,000 vehicles over the previous year. Similar to previous years, 75% of cars were ten or more years old, 13% 6-9 years, 9% 4-6 years, and 3% were 0-3 years old. *Report on state of Environment of Mongolia 2015-2016.*

dioxide and particulate matter (PM), particularly PM_{10} all year round.

The main sources of PM in the air of Ulaanbaatar are not only coal-fired thermal power plants, coal-burning stoves and vehicles, but also wind-blown dust from open surfaces, including dust from coal and burnt waste ash. During the cold season, air pollution, PM in particular, is caused by the burning of raw coal, while during the warm season PM_{10} is generated mainly by vehicles and construction activities.[17]

The landscape of central Mongolia is made up of hills and mountains and has a climate typified by long, dry and very cold winters. In the past, local populations chose deep valleys for shelter from the wind and for the protection of their livestock. The particular geographical location of Ulaanbaatar encourages the accumulation of air pollutants which blanket the city for long periods, especially in winter.

This is exacerbated because the ger area is located sub-optimally in the path of the prevailing wind direction (NW to E-SE), generating stable atmospheric inversions during the winter season. Thus the PM released into the environment in Ulaanbaatar cannot easily disperse. As a result, the level of air pollution often exceeds Mongolian and international ambient air quality standards for days, or even weeks at a time.

Before 2009, air quality was measured at four locations using two indicators. In 2009 the monitoring network was improved by adding two air quality monitoring stations (AQMSs); and in 2010 a further five stationary AQMSs and one mobile station were added (enabled by a soft loan from the French Government) and four stations were created within the jurisdiction of the capital city. As of December 2018 there were 12 AQMSs.

By 2016, under the responsibility of the Environmental Monitoring Laboratory, data on air quality were collected at 37 points within the large urban areas of Mongolia. Fourteen of these provided continuous monitoring in the capital (shown in red dots in Figure 2.1[18]).

By 2016 there were ten AQMSs in Ulaanbaatar related to the Meteorological and Environmental Monitoring Agency and four stations of the Municipal Air Quality department, including automated and mobile AQMSs (shown by dots in Figure 2.1).

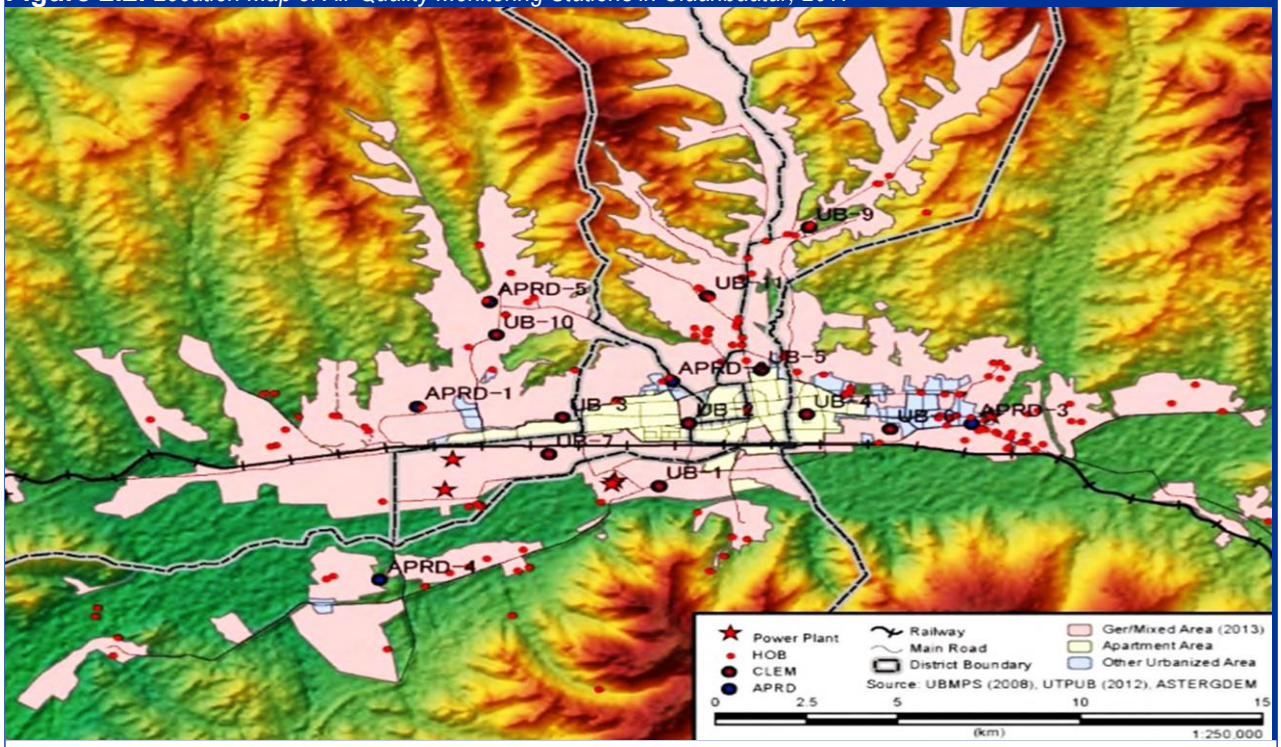
Figure 2.1. *Map of Stationary Stations for Air Quality Monitoring in Mongolia*

Source: National Agency for Meteorology and Environmental Monitoring (NAMEM), 2014, by Jadamba Batbayar

[17] PM10 particulate levels for 2015 and 2016 exceed the permissible level specified in the air quality standard (MNS4585: 2016). www.agaar.mn

[18] NAMEM, Jan 2017

Figure 2.2. *Location Map of Air Quality Monitoring Stations in Ulaanbaatar, 2017*



Source: JICA, SUURI-KEIKAKU CO. LTD, Capacity Development Project for Air Pollution Control in UB City Phase 2 in Mongolia, Final report, 2017

Automated stations monitor six types of contaminants (sulphuric gas, nitrogen oxides, carbon monoxide, ozone and large and fine particles) while mobile stations monitor only two (sulphuric gas and nitrogen dioxide) by 24-hour average volume (see Table 2.1 for more detail).

Table 2.1. *Air Polluting Substances Measured by Air Quality Monitoring Stations*

Pollutants	Air quality stations
Sulphuric gas (SOx)	All stations
Nitrogen dioxide (NO2)	All stations
Carbon monoxide (CO)	UB-2, UB-4, UB-5, UB-7, UB-8, Sukhbaatar, Moron, Erdenet, Arvaikheer, Darkhan, Ulaangom, Khovd
Particle matter (PM10)	UB-2, UB-4, UB-5, UB-7, UB-8, Moron, Darkhan, Khovd, Uliastai, Olgii, Bayankhongor, Sukhbaatar
Particle matter (PM2.5)	UB-2, Arvaikheer, Erdenet
Ozone (O3)	UB-4, UB-5, UB-8
Mercury (Hg)	Central Environmental Monitoring Laboratory, Arvaikheer, Tsetserleg, Bayankhongor, Moron, Sukhbaatar
Heavy metals (Pb, Cu, Co...)	Central Environmental Monitoring Laboratory,

Source: Ministry of Environment and Tourism, 2018

The information provided by the AQMSs is used by relevant government agencies both to initiate and take corrective action and to inform the public about the daily ambient air quality. The National Agency of Meteorology and Environmental Monitoring (NAMEM) publishes information on air quality on a weekly basis on its website and advises the public on how to protect themselves from exposure to polluted air and how to reduce the negative health impacts of air pollution. It also offers an application called "Agaar" which can be installed on mobile phones with interactive maps showing air quality indicators, air quality news, advice and explanations of air pollutants. As 99.6% of Mongolians aged 15 to 60 use a mobile phone (according to the *UB Post*[19]) Ulaanbaatar residents are monitoring their air quality by receiving up-to-date information on air pollution and prevention.

[19] UB Post, 14 March 2018, by B. Chintushig

Table 2.2. *Permissible Levels of Physical Impact and Permissible Exposure Limits for Common Dispersed Substances in Air*

	Mean time of measurement	Measuring unit	Permissible exposure limit		
			MNS 4585:2007	WHO AQ Guideline 2005	MNS 4585:2016
Chemical impact					
Sulphur dioxide (SO_2)	20-minute mean 24-hour mean Annual mean	µg/m³	450 20 10	500 – 10-minute 20 – 24-hour	450 ↑50 ↑20
Carbon monoxide (CO)	20-minute mean 24-hour mean Annual mean	µg/m³	60000 -30-min 30000-1-hour 10000-8-hour		60000 30000 10000
Nitrogen dioxide (NO_2)	20-minute mean 24-hour mean Annual mean	µg/m³	85 40 30	 200 – 1-hour 40 – annual mean	↑200 ↑50 ↑40
Ozone (O_3)	8-hours mean	µg/m³	100	100	100
Total particles	20-minute mean 24-hour mean Annual mean	µg/m³	500 -30min 150 100		500 150 100
PM_{10}	24-hour mean Annual mean	µg/m³	100 50	50 20	100 50
$PM_{2.5}$	24-hour mean Annual mean	µg /m³	50 25	25 10	50 25
Lead (Pb)	24-hour mean Annual mean	µg /m³	1 0.5		1 ↓0,25
Benzo(a) pyrene ($C_{20}H_{12}$)	24-hour mean	µg/m³	0.001		0,001
Physical impact					
Noise Day time (07-22) Night time (22-07)	16-hour mean 8-hour mean	dBA	 60 45		60 45

Source: MNS 4585:2007; MNS 4585:2016; WHO Air Quality Guidelines, 2005

However, there is a lack of AQMSs in ger areas where inhabitants experience the most severe air pollution in winter. It is still sometimes impossible to identify their air pollution status, except for the Bayankhoshuu area in Bayangol district where the Japanese International Cooperation Agency (JICA) project installed a new AQMS in 2016.

Ambient air quality standards (AAQS) were legislated in 1998 through the adoption of standard MNS[20]4585-98, updated in 2007 (MNS 4585:2007) and in 2016 (MNS 4585:2016) (see Table 2.2 for more details). National standards for sulphur dioxide and nitrogen dioxide were lowered between 2007 and 2016, suggesting some easing of the benchmarks set.

To combat air pollution, in the 1990s the GOM adopted a multi-directional approach. Special efforts focused on Ulaanbaatar; institutional and management principles were defined to support activities such as the introduction of new technology for effective fuel combustion, improvements in traffic infrastructure and other initiatives to limit environmental pollution.

[20] Mongolian National Standard (MNS)

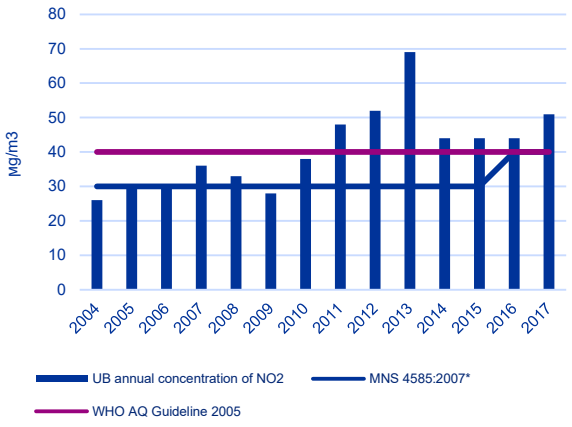
Since then, numerous surveys have been conducted and research and monitoring on the effects of air pollution has been carried out. Plans and action programs against air pollution have been adopted, including the replacement of traditional home heating stoves with improved versions (which unfortunately required a special fuel which the marketplace could not fully provide), encouraging the substitution of coal in the ger districts by electricity for heating, replacing low pressure coal-fueled stoves (heat-only boilers) by connecting residences to centralized heating stations, establishing large thermal power stations in the eastern part of the city, upgrading roads and road intersections and implementing housing programs. However, with the exception of the Millennium Challenge Account (MCA) project on improved stoves, there is no independent evaluation of these plans and programs.

Despite these initiatives and evidence of some progress, air pollution reduction activities in Ulaanbaatar have not been effective. This is likely due to poor monitoring of program implementation, the absence of a post-evaluation of the program or any detailed study and a slowdown of air pollution reduction actions during 2015-2016. As a result, air pollution remains significantly above the set targets. Below we describe in more detail the four main categories of air pollutants – nitrogen oxides, sulphur oxides, particulates and carbon monoxide.

Nitrogen oxides (NOx)

The national standard for NOx (MNS 4585:2007) has been changed from 30 μg/m^3 annual mean to 40 μg/m^3 annual mean in 2016 which is equivalent to WHO safe levels for nitrogen dioxide in the ambient air. Analyzing data from 2009 to 2017, the amount of nitrogen oxide in 2004 and 2009 was at its lowest point, not exceeding both the recent national and WHO standards but still not achieving the required standard. Graph 2.2 below demonstrates that the amount of NO_2 in the air increased in 2011-2013, decreased in 2014-2015, and moved up again slightly in 2016, likely because of the slowdown of air pollution reduction efforts and a further increase in the number of ger area households.

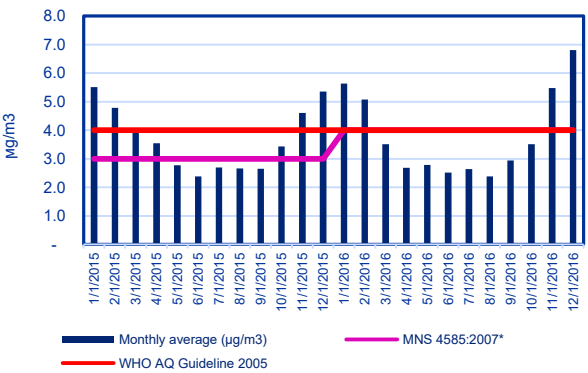
Graph 2.2. *Monthly Average Concentration of NO2 in Air, UB, 2015-2017*



Source: NAMEM, 2018

As shown in Graph 2.3, the level of NO_2 increases during the cold season as a result of the increased use of coal for heating and decreases in the warm season.

Graph 2.3. *Monthly Average Concentration of NO2 in Air, UB, 2015-2016*[21]



Source: NAMEM, 2017

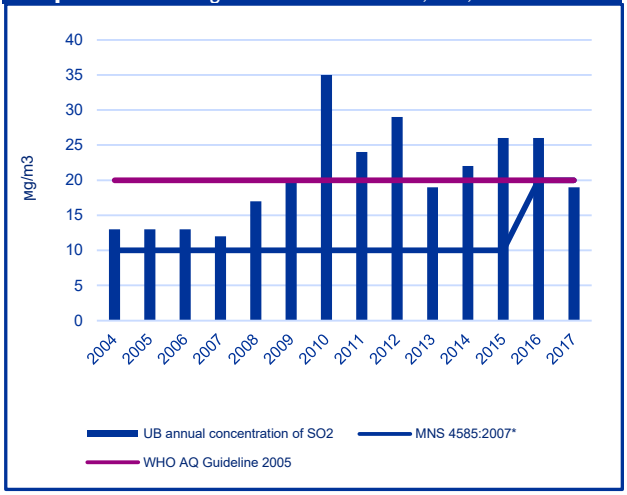
Sulphurous gas (SOx)

The annual average permissible level of SO_2 is 20 μg/m^3 by MNS 4585:2016.

Since 2004, the concentration of SO_2 in the ambient air of Ulaanbaatar has increased substantially with the highest levels observed in 2010; again, maximum impacts are observed during the winter months.

[21] *MNS 4585:2016 was used for NO2 concentration from 2016-2017 which is equal to WHO standard

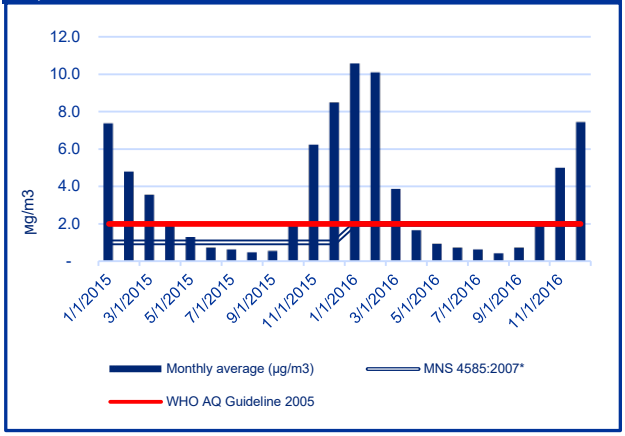
Graph 2.4. *Average Annual SO2 in Air, UB, 2011-2017*[22]



Source: NAMEM, 2018

Despite a drop in SO_2 concentrations in 2013 and 2014, concentrations in 2015 and 2016 climbed to record highs (Graphs 2.4 and 2.5) in the last five years. The likely reasons for increased SO_2 levels during the period 2015 to 2016 are a significant reduction of funding for air pollution reduction (from average annual funding of 32 billion MNT to 5 billion MNT) and low levels of absolute wind speed during 2015-2016 compared with 2013-2014 winters (from 14-17 m/sec to 11-12 m/sec wind) which affects the speed at which smoke is dispersed in the air.

Graph 2.5. *Monthly Average Concentration of SO2 in Air, UB, 2015-2016*[23]



Source: NAMEM, 2017

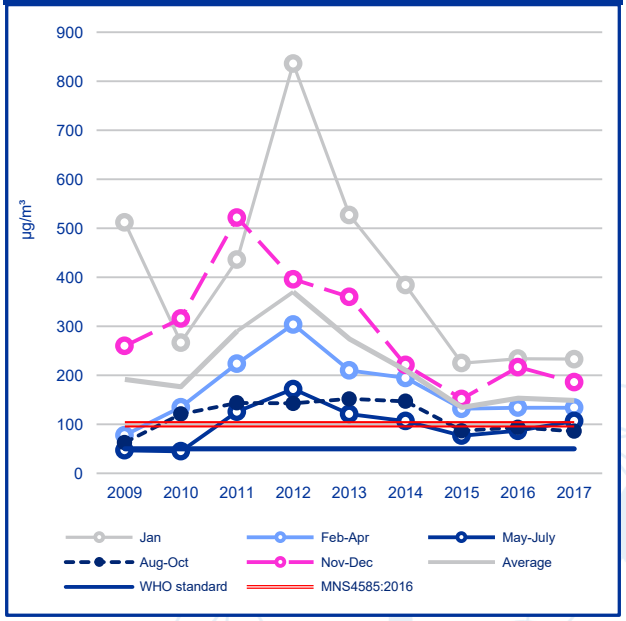
[22] *MNS 4585:2016 was used for NO2 concentration from 2016-2017 which is equal to WHO standard

[23] *MNS 4585:2016 was used for NO2 concentration from 2016-2017 which is equal to WHO standard

Particulates (PM_{10} and $PM_{2.5}$)

As shown in Graph 2.6, the 24-hour mean level of concentration of PM_{10} reached its maximum in January 2012 at 836 µg/m3 and the annual average level of PM_{10} also reached its maximum level in 2012 at 370.2 µg/m3. This was probably due to the lowest level of average absolute wind speed in 2012 (15.3m/sec), and in January 2012 (10 m/sec) in particular, compared with the past 8 years (15.8-18.7 m/sec): concentrations reached particularly alarming levels in the winter months. In subsequent years, allied to the GOM's direct interventions, concentrations have gradually declined. However, the situation in recent years has plateaued and remains persistently high and well above both the WHO and the National Standards of Mongolia (the 24-hour average shall not exceed 100 µg/m³ and the annual average shall not exceed 50 µg/m³ by MNS 4585:2016).

Graph 2.6. *Yearly Concentration of PM10 in Air, UB, 2009-2017*[24]



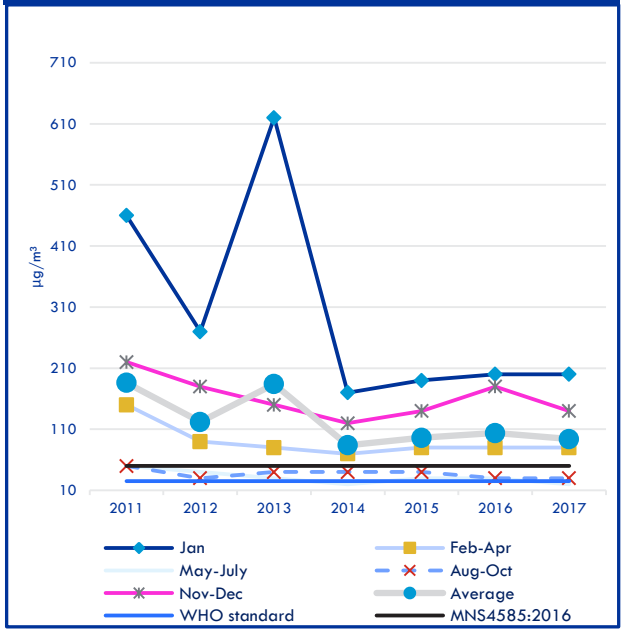
Source: NSO, Statistical Yearbook, 2008-2016; NAMEM, 2018

As Graph 2.7 shows, the 24-hour mean concentration of $PM_{2.5}$ in Ulaanbaatar reached its maximum level in January 2013 at 620 µg/m³; the annual average concentration in 2013 was also highest at 184 µg/m³. Possible explanations for this could be increased sources of pollution

[24] *MNS 4585:2016 was used for NO2 concentration from 2016-2017 which is equal to WHO standard

and/or changes in meteorological conditions (World Bank, 2011).

Graph 2.7. *Yearly Concentration of PM2.5 in Air, UB, 2009-2017*[25]



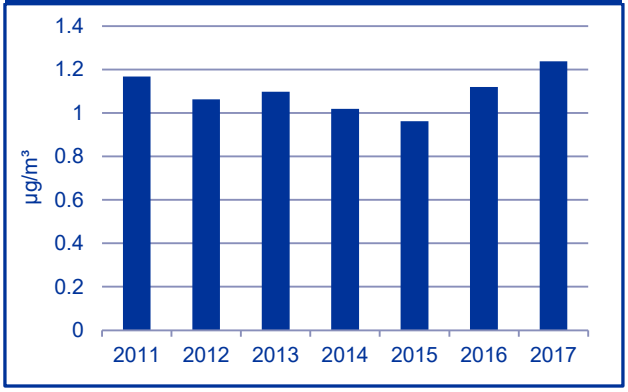
Source: NSO, Statistical Yearbook, 2008-2016; NAMEM, 2018

Following the implementation of the GOM's direct measures to reduce air pollution in Ulaanbaatar and possibly because the average absolute wind speed increased to 17.8 m/sec in 2014 from 15.8 in 2013, the level of $PM_{2.5}$ declined sharply from 184 µg/m3 in 2013 to 84 µg/m³in 2014. However, since then the level has not decreased further; in fact, it increased slightly to 104 µg/m³ in 2016, possibly due to a slowdown in air pollution reduction efforts and the decline of absolute wind speed between 2015 and 2017 (15.5-16.5 m/sec). The level of $PM_{2.5}$ is still four times above permissible WHO levels and twice the permissible level prescribed by the National Standards of Mongolia.

Carbon oxides (CO and CO_2)

The largest source of CO emission in Ulaanbaatar is coal stoves (51%) used for heating and cooking in ger districts. This is followed by thermal power plants (CHPs) and heat-only boilers (HOB) run by different entities (JICA, 2017). The level of CO declined at a very slow rate from 2011 to 2015, with the exception of 2013 as shown in Graph 2.8. It then increased two years in a row in 2016 and 2017, likely due to the slowdown of government air pollution reduction efforts before NPRAEP implementation started. The level of CO reaches its maximum in the winter season in Mongolia, especially in Ulaanbaatar, though the level of CO did not exceed MNS 4585:2016, even in cold seasons.

Graph 2.8. *Average Annual CO Emissions in Ulaanbaatar 2011-2017*



Source: Meteorology and Environment Monitoring Agency, 2018;

Mongolia's international climate commitments

Mongolia is fully committed to the United Nations Framework Convention on Climate Change (UNFCCC) negotiation process. This process leads to the adoption of a legal instrument or an agreed outcome with legal force under the Convention that is applicable to all parties. In line with the aim of confining global warming increases to less than 2°C, Mongolia has communicated its intention to support the multilateral negotiation process and international community efforts to fulfil the objectives of the UNFCCC.

Climate change assessments undertaken in Mongolia in 2009 and 2014 demonstrated that fragile ecosystems, a reliance on pastoral animal husbandry and rain-fed agriculture, allied to the growing population with a tendency towards urbanization, have all combined to make Mongolia's socio-economic development vulnerable to climate change. Mongolia is committed to pursuing mitigation actions within the framework of its Intended Nationally Determined Contributions (INDC) among others, by reducing fuel use in individual households through the improvement of stove efficiency (with

[25] *MNS 4585:2016 was used for NO2 concentration from 2016-2017 which is equal to WHO standard

an added benefit of air pollution reduction). By its INDC submitted to UNFCCC, Mongolia made a commitment to achieving a 14% reduction in total national GHG emissions by 2030.[26]

Main air pollution sources in Ulaanbaatar

Urbanization is an important part of Mongolia's socio-economic development. In recent years, the Mayor of Ulaanbaatar has attempted to limit migration to the capital city. The latest instruction to this effect was issued on 27 December 2017 and extended the pre-existing limitations to January 2020. There are concerns that this impinges on the right to freedom of movement as enshrined in the Constitution. Migration from rural areas to Ulaanbaatar dropped by about 11,000 in 2017 compared to 2016 and net migration for the year was negative.[27] The average annual net migration to Ulaanbaatar has been 18,000 over the seven years from 2010 to 2016.

The NPRAEP, has made recommendations to limit migration through improved regional, urban and rural development programs.[28]

In accordance with Order # A-181 of 2014 of the Minister of Environment and Green Development – the "Regulation on Conducting State Integrated Registry of Air Pollution" – in 2016 a third annual state survey of air pollution sources was conducted by the Government Meteorology and Environmental Monitoring Agency at the aimag[29] and at Ulaanbaatar city level.

The results of the 2016 survey were as follows:[30]

- There were 435,990 stoves with a capacity of up to 10 kWh, of which 44.7% are in Ulaanbaatar.
- There were 5,668 boilers for water heating with a capacity of up to 11-100 kWh, of which 49.9% are in Ulaanbaatar.
- There were 846 boilers for water heating with a capacity of more than 101kWh, of which 37.7% are in Ulaanbaatar.

According to the final report of the "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia" (JICA and SUURI-KEIKAKU Ltd, 2017), the main sources of air pollutants such as PM_{10}, SO_4 and NOx are CHPs (67.4%), followed by small stoves for household use (including both traditional and improved) (15.3%), dust from roads (6.5%), vehicle exhaust gas (6%), HOBs (3.2%) and fugitive ash from ash ponds in CHPs (0.9%) and coal-fired water heaters (0.7%). However, the small stoves in ger districts are the largest and most important contributor of $PM_{2.5}$ (60%[31]) and CO (51%) emissions (JICA, 2017).

Air pollution is also caused by vehicle tyres. Tyre dust contains two main classes of chemicals, organic and inorganic. Small particles generated by friction contribute to particulate matter that creates significant health problems such as lung disease. This is discussed in more detail in Chapter 4 of this report.

The World Bank report "Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts" (2011) highlighted the fact that dust (PM_{10}) resulting from car tyres and roads is the third largest contributor to PM_{10} in Ulaanbaatar, following the burning of coal in ger households and CHP heating.

Indoor pollution is also a concern. Especially during the cold season, people spend up to 90% of their time indoors, breathing the air in offices and homes. Many factors can degrade indoor air quality such as outdoor air pollution, the use of solid-fuel fired stoves, poor sanitation and hygiene practices, smoking and air ventilation.

Expenses for winter fuel are estimated to consume at least 17.5% of the average annual

[26] GOM, Intended Nationally Determined Contribution (INDC) to UNFCCC, 2016

[27] NSO, 2018, www.1212.mn

[28] These are positive rather than negative measures. Negative measures are defined as those which seek to prevent internal migration to Ulaanbaatar without addressing the underlying causal factors for such movements and are supported in this report.

[29] An aimag is the first-level administrative sub-division in Mongolia. There are 21 of them across the country. UB is administered as a separate municipality.

[30] Ministry of Environment and Tourism, "State of the Environment 2015-2016, http://www.mne.mn/wp-content/uploads/2017/09/Tailan-pdf-last-1-ilovepdf-compressed-ilovepdf-compressed.pdf, 2017b; http://unuudur.mn/article/93792

[31] World Bank, Air Quality Analysis of Ulaanbaatar, 2011

income of a Ulaanbaatar ger household, with poorer families[32] spending a higher proportion of income on fuel (World Bank, 2002). However, the ger households are the only consumers who pay the market price for fuel and its cost is fully recovered by the government. This report recommends reforms that, if implemented, would oblige all Mongolians to pay tariffs reflecting the cost of the different forms of actual energy they consume. Energy tariffs must also price in externalities caused by burning fossil fuels. It would then be possible to implement a system of cross-subsidization alleviating a portion of the financial burden on those households least able to pay – the large proportion of which, but not exclusively, live in ger districts.

In the case of biomass fuels, elevated levels of indoor particulate concentrations have been linked to an increased incidence of acute respiratory infections (ARIs), chronic bronchitis and a range of other health problems (Bruce et al., 2000). The link between respiratory diseases, including lung cancer, and exposure to smoke from dirty cooking stoves and fuels has been well established by the WHO[33] and, given similarly high pollution levels, it can be anticipated that indoor coal combustion produces similar risks for other diseases. Those most affected by exposure to emissions from indoor cooking stoves are often elderly people, the unemployed and pre-school-age children because they spend much of their time at home. Also, pre-school-age children have less developed immune systems which makes them more vulnerable. Without efforts to moderate indoor concentrations, the full benefits of pollution reduction efforts will not be realized.

A health assessment of $PM_{2.5}$ exposures from indoor and outdoor sources in Ulaanbaatar, conducted in 2017 by a group of scientists from the US and the School of Public Health, Mongolian National University of Medical Sciences, concluded that average annual exposures in the city (estimated at 59 $\mu g/m^3$ in 2014) remained high, despite a wide range of pollution reduction measures recently carried out by the Mongolian government. These measures include ambient air quality standards, energy efficiency programs, anti-smoking law and improved stove subsidies. As pointed out elsewhere in this report, the pollution reduction measures adopted have not been effective due to poor monitoring of project implementation, limited availability of improved fuel and discontinuity of measures to further reducing air pollution.

2.1. Initial Environmental Assessment

The problem of air pollution has been addressed to some extent at the policy level, and has been acknowledged by the GOM. Levels of major air pollutants, including $PM_{2.5}$, PM_{10}, So_2 and NOx in Ulaanbaatar did decrease somewhat during the years when the GOM took direct measures to reduce air pollution.

However, although significant efforts have been made, supported by financial contributions from multilateral and bilateral institutions, to supplement the constrained budget of the GOM, the full range of measures necessary to resolve the problem have not been carried out, i.e. implementing the policy reforms recommended by this report. The further growth of ger areas has also not been limited nor have efforts towards well-planned urban development been made. Changes of government have also hampered the continuity of air pollution reduction initiatives.

The air pollution strategy must be based on a sound, long-term sustainable energy policy vision, taking into account the energy resources available to Mongolia. It must address how to meet Mongolia's energy needs in a way that does not result in such a high level of ambient air pollution, and include well planned and sustained air pollution reduction measures beyond any one government tenure. While it is recognized that Mongolia's existing natural resources must be exploited, at least in the foreseeable future, to meet its energy needs, the GOM should also pursue multiple strategies to reduce its levels of air pollution and the proportion of raw coal in its overall energy mix.

[32] 38% of HHs living in ger districts are poor of which 57.5% live in gers, World Bank report "Urban Poverty in Ulaanbaatar" published in 2017
[33] https://www.who.int/airpollution/en/

3. PUBLIC EXPENDITURE AND LEGAL AND INSTITUTIONAL ARRANGEMENTS FOR THE CONTROL OF AIR POLLUTION

Part of the wider context for reducing air pollution is to ensure that scarce financial resources are used effectively and deliver value for money, i.e. that funds are utilized efficiently to deliver the desired outcomes. The legal framework and specific GOM policy initiatives also play a key part in addressing the challenges of air pollution. Institutional arrangements are critical in delivering results efficiently and play a key role in ensuring effective communication and continuous monitoring of progress towards achieving objectives.

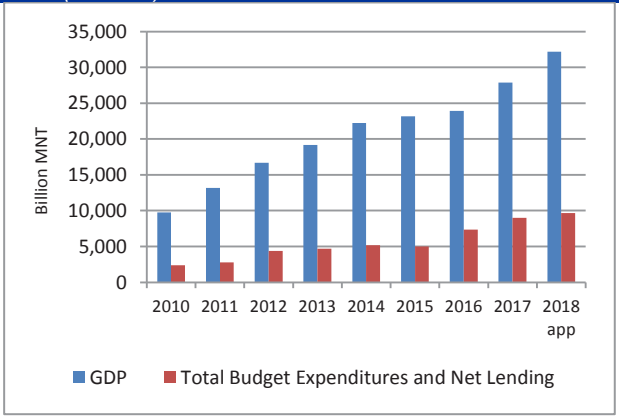
3.1. Public Expenditure Background

Total Budget Expenditure

The budget expenditure has gradually increased in Mongolia as a proportion of total GDP (nominal) over the past nine years (2010-2018), with the exception of 2015. State budget expenditures increased sharply by 30% in 2012 compared with the previous year and then by 25% in 2016 compared to 2015 (IMF, 2015).

The share of total budget expenditure as a proportion of GDP (nominal) ranged from 30.0 to 40.5% (IMF, 2015 and 2017) between 2010 and 2018. Graph 3.1 shows the general trend of the increase of state budget expenditure as well as GDP in nominal terms, whereas Graph 3.2 shows changes in the share of total state budget expenditure as a percentage of total GDP.

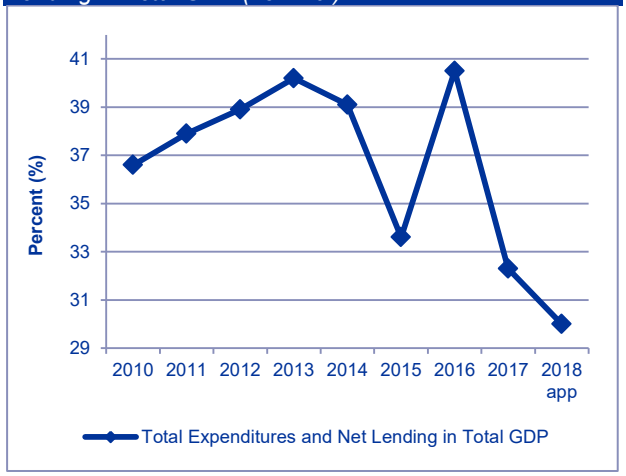
Graph 3.1. *Total Expenditures and Net Lending and GDP (nominal)*



Source: IMF, 2015 and 2017b, MOF, 2019c

Both graphs show the increasing levels of public expenditure over the period; such increases bring with them an increased responsibility to spend funds wisely and effectively.

Graph 3.2. *Share of Total Expenditures and Net Lending in Total GDP (nominal)*

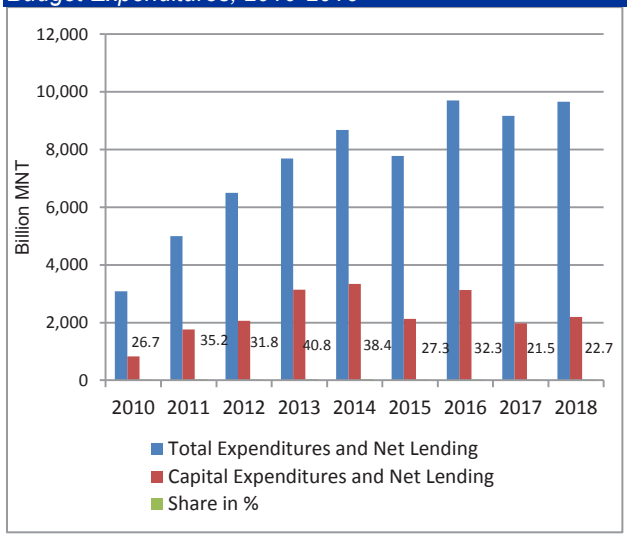


Source: IMF, 2015 and 2017b, MOF, 2019c

The declining trend of this share from 2014-2015 can be explained by the economic slowdown in Mongolia, mainly due to an unfavorable external economic environment, including falls in world commodity prices for items such as coal and copper. The main reason for a sharp increase in this share for 2016 is the change in fiscal reporting through fiscal consolidation by bringing off-budget expenditures into the budget. Fiscal consolidation is one of the critical pillars of the Extended Fund Facility (EFF) program of the IMF.

Recurrent expenditures are the largest proportion of total state budget expenditures. Capital expenditures funded by the state budget have ranged from 22.7% to 40.8% of total state budget expenditures, with the largest share expended in 2013 and the smallest in 2018 (IMF, 2015 and 2017) (see Graph 3.3).

Graph 3.3. *Share of Capital Expenditures in Total State Budget Expenditures, 2010-2016*

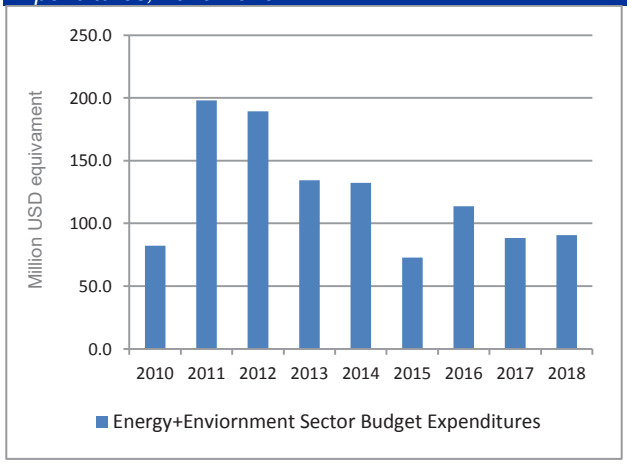


Source: IMF, 2015 and 2017b, MOF, 2019c

The allocation of funds through the inclusion of particular sectors and areas in national development strategies and plans conveys a strong message about government and public spending priorities.[34] Two sectors that are of critical significance to air pollution reduction initiatives are energy and the environment.

Public sector expenditure related to energy and the environment has fluctuated between 2.8% of total state budget expenditure in 2015 to 9.0% in 2011. The main reasons for budget expenditures of these two sectors in 2011 included an increase in investment expenditures, including expansion of electricity and heat transmission lines, renovation of CHPs in Ulaanbaatar and other urban areas, establishment of a factory for semi-coke fuel production based in CHP 2 and improved stoves with air pollution reduction capacities.[35] Table 3.1 (in MNT) and Graph 3.4 (in $US equivalent) present the total public recurrent and investment expenditures for the energy and environment sectors. A significant increase in expenditure is shown in Graph 3.4, from $82.3 million in 2010 to $198 million in 2011 and then steadily decreasing, reaching the lowest point of $72.7 million in 2015. During the following three years, the budget expenditure of these two sectors increased steadily. The last column of Table 3.1 shows the percentage of expenditure of the two sectors relative to the overall state budget. The data provided in Tables 3.2, 3.3, 3.4 and Graph 3.8 suggest that 2.0%-17.4% of these expenditures with a high in 2013 and a low in 2015-2017 were spent on air pollution reduction measures.

Graph 3.4. *Energy and Environment Sector Budget Expenditures, 2010-2018*



Source: MOF, 2017 and 2019b and c

There is a significant difference in expenditure levels for the energy sector when comparing 2015 to 2014 and 2016. The major economic slowdown occurred in 2015, which in turn led to a reduction in energy sector budgets and resultant expenditures. This variation was targeted almost entirely at investment expenditure (recurrent expenditure was changed very little). It increased again in 2016, as the GOM decided to finance infrastructure projects through the Development Bank of Mongolia and also issued a promissory note to finance those infrastructure projects which had not been funded in the previous fiscal year.

In addition to these direct public sector investments in energy and environment, the government is also investing other funds indirectly by supporting a policy of energy pricing which in many cases is below full cost recovery. This is discussed in more detail below. This policy, in effect covering the deficit incurred in the provision of electricity and heat at less than their recovery cost (except for the raw and brown coal consumed in the ger districts) is not sustainable. This report recommends the implementation of a full cost-recovery policy in the longer term.

[34] https://ec.europa.eu/europeaid/sites/devco/files/erd5-background-paper-public-expenditure-trends-2015_en.pdf
[35] MOF, Budget expenditure breakdown, 2017 and 2019c

Table 3.1. *Public Spending in the Energy and Environment Sectors, Recurrent and Investment (million MNT)*

Year	State Budget	Energy	Share in Total	Environment	Share in Total	Energy+Env (E+E)	Share of E+E in Total
2010	2,367,200.0	84,563.0	3.6%	26,264.2	1.1%	110,827.2	4.7%
2011	2,782,700.0	164,383.7	5.9%	86,091.4	3.1%	250,475.1	9.0%
2012	4,379,400.0	175,809.1	4.0%	81,475.5	1.9%	257,284.6	5.9%
2013	4,683,000.0	136,912.1	2.9%	67,597.5	1.4%	204,509.6	4.4%
2014	5,176,400.0	180,873.1	3.5%	59,615.7	1.2%	240,488.8	4.6%
2015	4,998,300.0	86,847.0	0.7%	50,958.8	1.0%	137,805.8	2.8%
2016	7,367,300.0	195,782.3	1.8%	49,077.4	0.7%	244,859.7	3.3%
201	7,139,637.5	149,337.8	2.1%	66,438.1	0.9%	215,775.9	3.0%
2018 approved budget	7,710,777.6	141,507.1	1.8%	82,776.5	1.1%	224,283.6	2.9%

Source: MOF, 2017 and 2019b and c

Expenditures of the Ministry of Energy

Total recurrent expenditure of the Ministry of Energy decreased as a share of total government recurrent expenditures from 0.3% to 1.2% over the past seven years. If the effects of changes in the structure of the GOM are excluded, the share of total recurrent expenditures in total expenditures of the Ministry on average over the past seven years except for 2015[36] was 22%. Total annual investment expenditures fluctuated between 46.7 billion MNT and 148.3 billion MNT over the same period.[37]

Annual investment expenditures of the energy sector have averaged 12.1% of total public investment expenditure, revealing it as a capital-intensive sector. The majority of this investment covered the expansion of existing CHPs, energy transmission and distribution networks, the construction of new CHPs and renewable energy production facilities such as hydropower plants, the installation of energy sub-stations and electricity distribution lines. Technology investment was meant to mitigate climate impacts such as the renovation of electrostatic filters to reduce the emission of PM and air pollution in general. The design, location and operation of these power infrastructure projects should take into consideration their potential environmental impacts to ensure that they help to reduce air pollution in the future rather than contributing to it.

Graph 3.5 shows a sharp decline in total public expenditures and public investment expenditures for the energy sector in 2015. It then rises again since 2016.

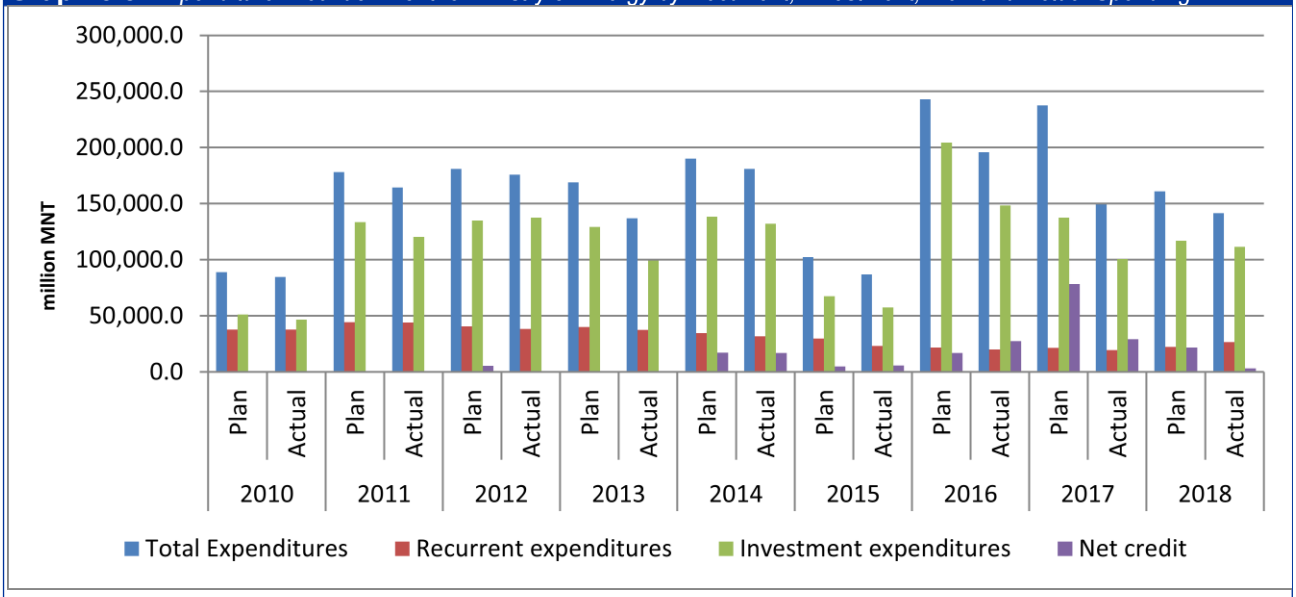
The share of public investment expenditure in total expenditure for the energy sector is much higher than recurrent expenditures because of the capital-intensive features of this sector as well as the fact that all major energy companies, including CHPs, energy transmission and distribution systems (which require huge investment) are owned by the government. Expenditures of the Ministry of Energy, excluding subsidies to energy production, transmission and distribution entities, can be considered as positive expenditures relating to air pollution reduction given their limited negative impact on human health and the overall benefits of energy sector production and services for the country's socio-economic development. However, this depends on the technologies applied, and the way the resulting installations are operated and maintained. Given the continuing improvements in energy sector technology to take into account the environment and human health, overall positive benefits should be possible.

Energy Sector Negative Expenditures

Payments to the energy sector that disguise the fact that costs are not fully recovered are considered as negative expenditures. Between 2010 and 2018 these ranged from

[36] The share of MOE recurrent expenditures increased sharply (69.4%) due to sharp decline of investment expenditures as a result of economic slowdown.
[37] Ministry of Finance, 2017c

Graph 3.5. *Expenditure Breakdown of the Ministry of Energy by Recurrent, Investment, Plan and Actual Spending*

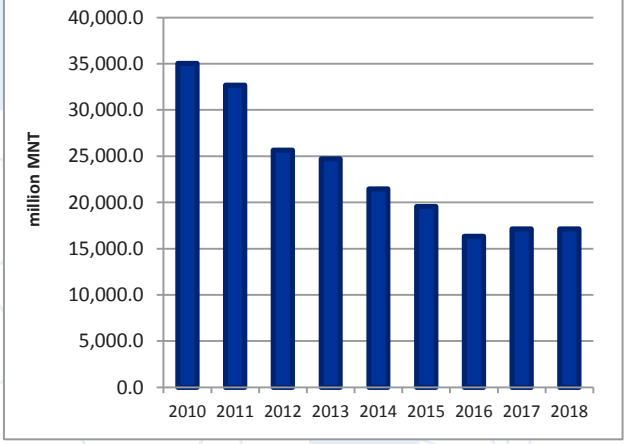


Source: MOF, 2017 and 2019c

16.3 billion MNT to 35.0 billion annually as shown in Graph 3.6.[38]

The total of these payments was higher when state-owned energy sector companies, including major energy production and distribution entities (CHP2, CHP3, CHP4, CHP in Erdenet, CHP in Darkhan, CHP in Nalaikh and the National Electricity Distribution Network), received such subsidies in the period before 2014. A positive trend of declining subsidies from the state budget have taken place since the 2012 peak; but full cost recovery is still not taking place in most cases, and this must be urgently addressed.

Graph 3.6. *Energy Sector Subsidies 2010-2018*



Source: MOF, 2019c

[38] MOF, 2019c

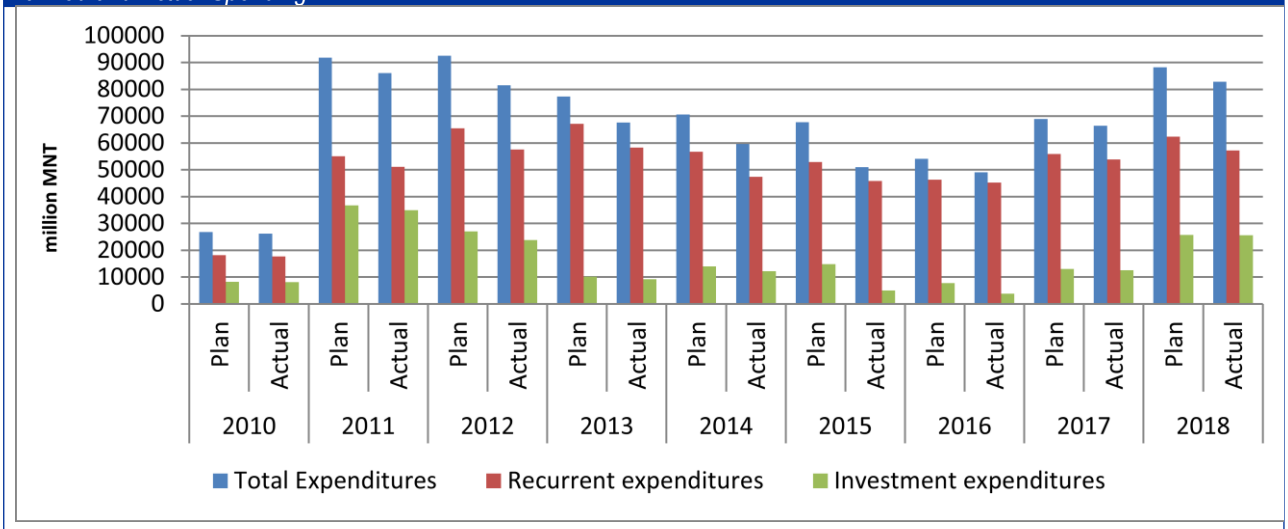
Expenditures of the Ministry of Environment and Tourism[39]

The total recurrent and investment expenditures of the MET (MET) increased substantially from 2011. This was the result of the inclusion in the budget of interventions directly related to air pollution reduction. Among these was energy-efficient stove distribution, renovation of low-pressure heat-only boilers, connecting entities that had previously used heat-only boilers to the central heating system and installation of the air pollution measurement equipment included in the portfolio of the MET.

The total expenditure level of the sector reached its maximum in 2011-2012 when the government allocated a total of $68.1 million equivalent ($40.4 million recurrent, $27.6 million investment) in 2011 and $60.0 million equivalent ($42.4 million recurrent, $17.6 million investment) in 2012 (see Graph 3.7) to the environment sector. Since 2013, public expenditure in this sector has gradually declined till 2017 and then it has increased in 2018 almost to the level of 2011. In both 2015 and 2016, the majority (over 90%) of environment sector expenditures were recurrent, with less than 10% for investment purposes.

[39] The portfolio of the Minister did not include the tourism sector during 2012-2016 due to an amendment made to the Law on Government in 2012.

Graph 3.7. *Expenditure Breakdown of the Ministry of Environment and Tourism by Recurrent and Investment and by Planned and Actual Spending*



Source: MOF, 2017 and 2019b

Again, the budget approved for this sector has always been underspent for all the years from 2010 to 2018 with an average under expenditure of 12% per annum. This can be considered a lost opportunity.

Direct Expenditures for Air Pollution Reduction

Table 3.2 shows state budget funding for air pollution activities between 2008 and 2016. The Clean Air Fund was given a mandate to deal with air pollution issues but struggled to fulfil it. Monitoring mechanisms were perceived to be weak and the fund was finally closed in November 2015. The closure was based on changes made to the Law on Government Special Funds and widespread concerns over the misuse of funds.

Recurrent expenditures for reduction of air pollution – Direct Intervention

Total recurrent expenditures for air pollution reduction amounted to 97.7 billion MNT from 2011-2016, the majority of which (93.5 billion MNT) were spent through the Clean Air Fund and the rest by the Ministry of Environment and Tourism. The measures funded through the Clean Air Fund include energy-efficient stove distribution to ger area households, the supplying of improved fuel, activities relating to the connection of ger area households to the central heating system and the expansion of district heating systems.

Table 3.2. *Air Pollution Reduction Measures Funded by GOM Financing Sources, 2008-2016 (million MNT)*

#	Implementing agency	Recurrent expenditures	Investment expenditures	Total
1	Ministry of Environment and Tourism	4,263.70	16,644.70	20,908.40
2	Ministry of Construction and Urban Development		989.60	989.60
3	Ministry of Energy		31,959.20	31,959.20
4	Clean Air Fund	93,454.20		93,454.20
Total		97,717.90	49,593.50	147,311.40

Source: Ministry of Finance, 2017a

These measures resulted in a reduction of air pollution in Ulaanbaatar, including NOx, $PM_{2.5}$ and PM_{10}, as shown in Graphs 3.3, 3.7 and 3.8. The approved budget and actual spending of the Clean Air Fund by year are shown in Table 3.2.

Table 3.3. *Clean Air Fund Budget and Expenditures 2011-2015 (million MNT)*

No.	Year	Approved Budget	Actual Spending	Performance rate (%)
1	2011	31,500.0	31,445.0	99.8
2	2012	30,000.0	24,641.0	82.1
3	2013	29,755.5	22,924.4	77.0
4	2014	15,260.8	9,185.9	60.1
5	2015	5,259.2	5,257.9	99.9
Total		111,775.5	93,454.2	83.6

Source: Ministry of Finance, 2017a

The Clean Air Fund-approved budget was underspent across its lifetime of five years and this can be considered as a lost opportunity. The underspending in 2012 was 17.9%, in 2013 it was 23% and in 2014 it was 39.9% of the approved budget, respectively. Since the slowdown of spending and the abolition of the Clean Air Fund in late 2015, the funding allocated for the reduction of air pollution has declined substantially. Only 4.5 to 5.9 billion MNT in funding was allocated for this purpose in the budgets of the Ministry of Environment and Tourism in 2016-2018. The majority of this was spent on price subsidies for the night-time use of electricity for heating in ger areas. This should be considered a negative recurrent expenditure for this Ministry.

Investment Expenditures for Air Pollution Reduction – Direct Intervention

The GOM first budgeted investment expenditure for air pollution reduction in 2008. However, no budget was approved for such an investment in 2015-2016. During the three peak years of investment for air pollution reduction (2011 to 2013), investment expenditures ranged from 8.6 billion MNT to 20.1 billion MNT per annum.

Table 3.4. *Investment Expenditures for Air Pollution Reduction 2008-2018 (billion MNT)*

No.	Years	Actual Spending
1	2008	1.7
2	2009	0.3
3	2010	5.2
4	2011	10.6
5	2012	20.1
6	2013	8.6
7	2014	2.6
8	2015	0.0
9	2016	0.0
10	2017	0.0
11	2018	0.0
Total		49.1

Source: Ministry of Finance, 2019a

A total of 49.1 billion MNT of state funding was spent on 21 relevant projects, eight of which were funded in 2012 alone (Table 3.4). The largest investment projects include the establishment of 210,000 tons of improved fuel production complexes based on CHP2 (actual spending – 15.3 billion MNT); expansion of the heating network of Ulaanbaatar (11.7 billion MNT), an energy-efficient stoves project (13.5 billion) and the introduction of new technology for reducing ash and smoke from CHP4 (4.8 billion). In addition to central government, local government also has a role to play, especially in Ulaanbaatar. The Ulaanbaatar Mayor's Office has also been managing and co-managing projects on air pollution reduction and allocating local budgets for this purpose.

Since 2011 Ulaanbaatar has allocated just over 2.5 billion MNT (just over $1.5 million) for three purposes which likely made a marginal contribution to reducing air pollution in Ulaanbaatar:

- Use of renewable energy for heating
- Strengthening the capacity of the Air Quality Department of Ulaanbaatar
- Introduction of advanced technology for public transport

Ulaanbaatar is planning to spend approximately 61.8billion MNT in 2019 on direct measures that aim to reduce air pollution, including an initial budget for what will be recurrent expenditures by the Air Pollution Reduction Department, funding for a "Ger area Re-development" program, as well as for the cost of implementing the "Ulaanbaatar with no smoke" program. This amounts to approximately 0.3% of the GDP of Ulaanbaatar.

Table 3.5. *Projects and Programs on Air Pollution Reduction, Funded by Foreign Financing Sources*

No	Funding partner	Types of funding sources	Project title	Timeframe	Total funding approved	Actual expenditure
Completed projects						
1	France	Concessional loan	Setting-up an Ulaanbaatar air pollution monitoring network	2008-2010	1.6 million euro	1.6 million euro
2	ADB	Grant assistance	Air pollution reduction in poor households in ger districts	2009-2011	2.0 million USD	2.0 million USD
3	ADB	Technical assistance	Ulaanbaatar clean air – Policy advisory TA project	2010-2011	0.55 million USD	0.55 million USD
4	MCC, USA	Grant assistance	Clean air project (mainly clean stove distribution)	2010-2013	47.2 million USD	40.4 million USD
5	ADB	Technical assistance	Clean fuel from coal to supply heat and energy to ger districts TA	2016-2017	0.35 million USD	0.35 million USD
6	World Bank	Concessional loan	Ulaanbaatar clean air project	2012-2017	9.7 million SDR	7.4 million Special Drawing Rights (SDR)
7	JICA	Technical assistance	Strengthening the capacity of UB air pollution monitoring, projects 1and 2	2010-2017	850.0 million yen (8 million USD	480.0 million yen* (4.5 million USD
Major ngoing projects						
8	ADB	Policy-based Concessional loan	Ulaanbaatar air quality improvement program	2018 -	130 million USD	
9	Green Climate Fund (GCF), Project owner is ADB	Loan, grant and equity combined	Ulaanbaatar Green Affordable Housing and Resilient Urban Renewable Project	2018-2027	544 million USD	

**This amount could have increased as the figure was provided by the MOF in November 2017.*
Source: MOF, 2018, ADB, 2018 and GCF, 2018

External Assistance for Air Pollution Reduction

Over the same period (2008 to 2016) the GOM received around $60 million[40] in external assistance for air pollution reduction from various donors. The resulting programs and projects mainly focused on the distribution of over 140,000 improved stoves to households in the ger districts (an MCC-funded initiative), the production and supply of improved fuels, improvement of the energy distribution system, insulation of gers, air quality monitoring, and capacity strengthening (see Table 3.5 for more detail). The independent evaluation of the MCC-funded improved stove initiative suggested that MCC stoves significantly lowered emissions (65% reduction in $PM_{2.5}$ and 16% reduction in CO) compared to traditional stoves. However, this initiative did not achieve a significant reduction in daily coal consumption or fuel expenditures under typical usage conditions.[41]

The German Corporation for International Cooperation (GIZ), KfW, Germany and the European Bank for Reconstruction and Development (EBRD) also contributed to the GOM's efforts in reducing air pollution by providing and implementing funding to increase energy efficiency and expand the use of renewable energy in Mongolia.

In addition to the above, between 2013 and May 2017, the Capital City Administration

[40] Ministry of Finance, 2017b

[41] Social Impact, 2014, https://socialimpact.com/portfolio-items/impact-evaluation-mcc-mongolia-energy-environment-project/

implemented a project aimed at strengthening its capacity in air pollution control with approximately 569 million MNT ($235,000) of funding provided by JICA.[42]

Looking at Table 3.5, the most significant project in funding terms was the Clean Air Project funded by the MCC. This involved the distribution of stoves to the ger districts in particular. Stakeholders have suggested that the effectiveness of the project was limited due to the type of fuel required for these stoves to burn cleanly, which was not available in the marketplace. It has also been suggested that there was no commitment on the part of householders because the stoves had been received almost free of charge with many subsequently being sold on. Value for money on this project was therefore limited.

Air Pollution Tax

The greatest source of funding available to the GOM from domestic sources for air pollution reduction purposes is the Air Pollution Tax. This is the main source of funds specifically targeting air pollution reduction on the part of the GOM, even if it is insufficient to resolve the atmospheric pollution problem on its own. It is paid mainly by coal mining companies, but also by vehicle owners and dealers and importers of organic solvents. The air pollution tax collected and the total expenditure for air pollution reduction from this fund is shown in Graph 3.8.

Graph 3.8 demonstrates that the majority of air pollution tax collected was not spent on air pollution reduction during 2014-2018; the Law on Air Pollution Tax does not specify that the tax collected must be spent on air pollution reduction/prevention only. The amendment made in the Law on Government Special Funds in January 2018 states that the primary funding source for the Anti-Air Pollution Fund should come from the air pollution tax (100%). However, the Law on Air Pollution Tax should be amended to ensure that the funds collected are spent for their intended purpose only.

Air pollution taxes collected annually between 2011 and 2018 ranged from 13 billion MNT to 41 billion MNT – see Graph 3.8).[43] The annual average amount of tax collected from 2011-2018 is equal to 0.1% of GDP and 0.3% of total revenue and net credit. The taxes thereby collected were fully utilized for their intended purpose in the period 2011-2013. However, only 12.6%-38% of taxes were utilized for their intended purpose during 2014-2018. This may have been due to the termination of the Clean Air Fund which was mandated to manage the funds, as well as weak management and lack of coordination of air pollution-reduction efforts generally. The total funds collected in 2015 and 2016 declined sharply in both nominal and real terms due to deteriorating general economic conditions though there has been some bounce-back in 2017. The air pollution tax collected reached 36.4 billion MNT in 2017 and 41.8 billion MNT in 2018 respectively.

As highlighted in the section above, levels of both $PM_{2.5}$ and PM_{10} have declined substantially starting in 2013-2014 allied to direct interventions in reducing air pollution in Ulaanbaatar. In terms of value for money, the public expenditures for air pollution reduction during 2011-2016 can therefore be considered justified. However, the levels of these two major pollutants are still much higher than the levels permitted by WHO and National Standards.

2018 Expenditures and Approved Budget for 2019

Appendix 4 shows a combination of measures for air pollution reduction and associated actions for the 2018 budget. They cover both the Ministry of Energy and the MET. A combination of measures is envisaged. The MET (with a budget of 26.9 billion MNT – around $10.25 million) was responsible for the creation of better conditions in the ger districts. The Ministry of Energy (with a budget of around 36 billion –$14.8 million) had the responsibility to engage in several infrastructure schemes (e.g. expanding the heat distribution network, connection of HOBs to the central heating system and expansion of local level electricity transmission and distribution

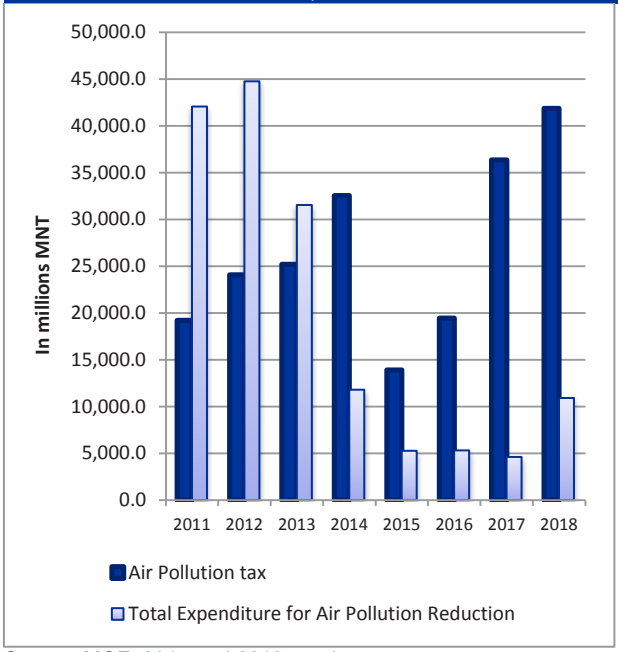
[42] UB City Mayors Office, 2017

[43] Annual average exchange rates used for conversion of MNT to USD

networks). Actual expenditure was 10.936 billion MNT. Major under spending occurred in heating renovation in 10 selected buildings, procurement and instalment of air quality monitoring equipment and the production of improved briquette fuel.

For 2019, a total of 75.7 billion MNT has been approved for MET and 57.1 billion MNT for MOE respectively for air pollution reduction purpose. The major expenditure is earmarked for continuing subsidy for zero night-time tariff for the ger area, a filtering system for boilers, improved fuel production, storage and distribution, expansion of electricity transmission and its distribution system, demolishing HOBs and enforcement of a ban for the use of raw coal.

Graph 3.8. *Air Pollution Tax and Total Expenditure on Air Pollution Reduction Measures, 2011-2016*



Source: MOF, 2017 and 2019a and c

3.2. Expenditure on Energy and Environment

State budget expenditure has been gradually increased as a proportion of total GDP (nominal) over the past seven years from 2010 to 2018. The share of total state budget expenditures in GDP (nominal) ranged from 21.1% to 30.8%[44] over those years.

Public sector expenditure relating to energy and environment (see Graph 3.7) fluctuated between 2.8% in 2015 and 9.0% in 2011 (a sharp increase in investment expenditures on air pollution reduction in 2011).[45]

The most significant proportion of public expenditures for the energy sector relates to investment expenditures whereas the majority of environment sector expenditures are recurrent in nature.

Negative expenditure in 2010-2018 relates to subsidies for energy sector entities, including CHPs and energy transmission and distribution systems. It is a positive trend that the level of subsidy has been declining in more recent years; but that should not obscure the reality that under-recovery of costs remains a significant problem.

The government has spent a total of approximately 147.3 billion MNT (~$101.7 million)[46] from the state budget for direct air pollution reduction measures from 2008 to 2016. Of this amount approximately 97.7 billion MNT (~$67.3 million) is recurrent expenditure and 49.6 billion (~ $34.4 million) is investment expenditure. In addition, $60 million has been spent on donor-funded projects and programs aimed at reducing air pollution, including energy efficient stove distribution to ger area households. These projects were implemented from 2008 to 2017 and were primarily funded by the MCC and the World Bank. An additional 15.5 billion MNT was spent for 2017-2018.[47]

However, because of the high level of fluctuations in the CPI and currency exchange rates during this period, the CPI adjusted total budget expenditures for air pollution reduction amounted to 122.3 billion MNT (~ $86.5 million),[48] including recurrent budget expenditures of around 84.4 billion MNT (~ $59.2 million) and investment expenditures of around 37.9 billion MNT (~$27.3 million). Total budget spending for air pollution reduction ranged from

[44] MOF, 2017 and 2019b and c

[45] MOF, Budget Expenditure breakdown, 2017 and 2019b and c
[46] Annual average exchange rate at the times was used for converting MNT to USD
[47] National Committee on Environmental Pollution Reduction, 2019
[48] CPIs for 2010-2016 were used for defining the real value of MNT where CPI=100 for 2010.

0.05% to 1.2% of total state budget expenditures annually between 2010 and 2018.

The major domestic source of funding for air pollution reduction is the air pollution tax, mainly collected from coal mining companies and vehicle owners. The annual average tax collected amounted to over 26 billion MNT. In recent years, a lower proportion of funds collected from this tax have been directed at air pollution reduction measures.

The collective expenditures on air pollution reduction can be considered an investment with positive net social benefits/returns based on considerable reductions of $PM_{2.5}$ and PM_{10} since 2013-2014. However, the levels of $PM_{2.5}$ and PM_{10} are still high compared with WHO and the National Standards of Mongolia. Future measures to eliminate the still-existing gap must be realistic, practical and affordable. This is considered further in Section 5 below.

To make the GOM's efforts on reducing air pollution more effective and cost-efficient, the Ministry of Finance should develop an "Integrated Financing Framework for Air Pollution Reduction" which could also incorporate any related Sustainable Development Goals (SDG) for Mongolia.[49] Such a document would bring together the prioritization, sequencing and costing of measures, the resources required and those that are already available. The gap between required and available funds must be addressed if air pollution reduction targets are to be met.

By gradually reforming its planning, budgeting and budget execution through results-based budgeting and by establishing links between policy targets and budget allocations, Mongolia can exercise better management of the resources dedicated to combating air pollution and achieve the targets of the NPRAEP.

Public Expenditure Tracking Surveys (PETS) could be undertaken by the GOM in collaboration with national universities and think tanks in order to better understand if the programs are performing well or not and use survey results to improve planning and budgeting. International experience suggests that the PETS is one of the most powerful tools to systematically access more detailed data and ultimately help strengthen actual public expenditure processes for provision of cleaner air to the population(World Bank, 2009).

3.3. Macro-Level Inputs to Energy Efficiency and Connected Initiatives

The GOM is acutely aware of the issues facing the population because of air pollution as well as wider issues of energy efficiency. The air pollution challenge is a complex one, which is linked to a range of issues: economic, social, environmental and technological. Some of the more significant of these are discussed below.

Energy efficiency

The Law on Energy Conservation was adopted by Parliament in 2015 and is the main legal act regulating energy conservation and efficiency. In addition to this law, the legislation that is related to energy efficiency consists of the Energy Law, the Law on Renewable Energy and other relevant acts including the Law on Air, the Law on Air Pollution Reduction and the Law on Environmental Protection.

To implement the Law on Energy Conservation, the Parliament adopted the National Program on Energy Efficiency (2018-2022) in September 2017. With this program, the government aims to reduce CO_2 emissions and decelerate climate change impacts through the integrated management of energy conservation and energy efficiency measures. The program will also ensure consistency between policy measures and introduce innovation-based energy-efficient advanced technologies. For it to be successfully implemented, the introduction of a mandatory energy auditing system for large energy consumers is necessary; voluntary energy auditing and associated incentive schemes for

[49] : Mongolia Sustainable Development Vision 2030: http://sdg.1212.mn/EN/Home/SDV_Indicator

"beyond-standard" energy savings are also important.[50]

The National Program has 13 separate objectives and 53 different actions, including improvement of the legal environment. This is intended to ensure energy efficiency, fulfil Mongolia's obligations under the Paris Agreement to reduce CO_2 emissions by increasing energy efficiency of production and consumption of energy sources, provide tariff support for energy efficiency measures, increase efficiency in electricity transmission and distribution, decrease electricity and heat distribution losses and introduce a management system that supports the efficient use of energy and the introduction of green building principles and criteria.

To support government initiatives on energy conservation and increased energy efficiency, several multilateral and bilateral external partners have provided assistance to Mongolia. Examples include GIZ grant assistance of €3 million to assist the government in developing regulations and procedures for implementation of the Law on Energy Conservation, the development of a methodology for estimating energy tariffs and the unit price/cost of production and establishing rules for electricity markets. A UNDP project, "Nationally Appropriate Mitigation Actions (NAMA) in the Construction Sector in Mongolia" (with funding of $1.26 million) aims to facilitate market transformation for energy efficiency through the development and implementation of a NAMA initiative in Mongolia. The Ministry of Energy declared 2018 to be a "Year of Energy Conservation and Efficiency" and made efforts to remove identified barriers and exploit opportunities to accelerate the adoption of cost-effective energy efficiency.

Apartment rental program

To work towards its energy-efficiency goals, the government is implementing an Apartment Rental Program (2015-2021) to enable those households that cannot buy an apartment to rent one at below the market rental price. The State Housing Corporation, a government-run company, reports that 16,000 households in the capital city and 4,000 households in other areas can benefit from this program.[51]

The target group for these subsidized households includes young families (with parents up to 35 years of age), public servants, households with four or more children, households with single parents, pensioners, citizens with a disability or that are caring for disabled people, as well as households left homeless following natural disasters. According to data provided by the State Housing Corporation, a total of 600 households have been included in the program since its inception.

Considering the fact that an estimated 30,000 new unsold apartment units are available in the market[52], this initiative could clearly assist the air pollution reduction program by reducing the number of households in the ger districts, provided their new housing is provided with electricity and heat from sources other than those that add to the air pollution problem and where the costs are recovered.

Ger area redevelopment program

The essence of this program is to free up land occupied by ger areas and build apartments. Twenty-one different locations in the capital city have been selected for redevelopment. The program covers 15% of ger territory and 10% of the ger population. The heating and electricity supply, waste water treatment facilities, mortgage lending schemes and apartment rentals are issues addressed within the framework of this program. Since the start of the ger area redevelopment program in late 2013, a total of 5,200 apartments have been built and occupied by ger area households. According to the Ulaanbaatar Development Master Plan about 78,000 new apartments were planned for ger area households during 2014-2018. However, implementation of this project has been much slower than anticipated due to the constraints on

[50] https://www.researchgate.net/publication/325803868_Obligatory_versus_voluntary_energy_audits_are_there_differences_in_quality

[51] State Housing Corporation, 2015, Apartment rental program of the Government

[52] Interview with Kh. Badelkhaan, Minister of Construction and Urban Development, 2017, https://news.mn/r/741372/

funding. The government plans to have 20,000 HHs in rental apartments by 2021.

3.4. Legal and Institutional Arrangements for Air Pollution Reduction

Sections 3.4 and 3.5 describe the current legal, policy and institutional frameworks for reducing air pollution in Mongolia with particular focus on Ulaanbaatar. They propose several measures to improve the institutional and regulatory frameworks.

Several laws relate directly to air pollution reduction:

The Law on Air (2012) regulates the protection of the atmosphere to provide environmental balance for the sake of present and future generations, allows government to set standard limits on emissions from all sources and provides for the regular monitoring of ambient air pollution, hazardous impacts and changes in small air components such as ozone and hydrogen. The Law on Air was revised in January 2018. As a result the aimag and capital city governors will establish offices responsible for organizing and implementing air pollution mitigation measures within their territories. The Anti-Air Pollution Fund has also been re-established and will start operating from 2019.

The Law on Air Pollution Tax (2010) regulates relations concerning the imposition and payment of air pollution fees on air pollutants and sets four types of fees – from coal burning, automobiles, organic substances and other sources –to be collected by the state budget. The law was revised in January 2018; accordingly, air pollution fees must be collected by the Anti-Air Pollution Fund from January 2019.

The Law on Energy (2001) regulates energy use, generation, transmission and distribution activities and supports the construction of efficient, reliable and sustainable energy resources. The law supports the creation of subsidized energy tariffs for households in ger districts to encourage the use of affordable electric energy sources for heating and cooking rather than the traditional burning of raw coal and woody biomass.

The Law on Renewable Energy (2007) regulates the generation and distribution of electricity created by renewable energy sources and gives special priority to wind and solar energy. The law sets the government guaranteed feed-in tariffs for renewable energy power sources and sets up a renewable energy fund.

Policy Framework: The National Program on Reduction of Air and Environment Pollution (NPRAEP)

The NPRAEP was adopted by the GOM on 20 March 2017 by Resolution No.98 following the recommendations of the National Security Council of 10 January 2017. The Action Plan on Program Implementation was approved by Order of the Minister of Environment and Tourism No. A/107 on 27 April 2017. The National Program consists of two stages: covering the periods 2017 to 2019 and 2020 to 2025. The Action Plan (MET, 2017a) on Program Implementation specifies accountable institutions, timeframes and costs. The NPRAEP is discussed in much more detail in Section 5.1 and Appendices 2 and 2a.

The NPRAEP explicitly states as its objective improving air quality nationwide and in key areas. It provides five measures (specified in Table 5.1 of this report) and 58 specific actions to help achieve these objectives. To evaluate progress in the implementation of the various measures and the relevant environmental, social and economic benefits which serve as the basis for future policy adjustment, the National Program has established 25 performance indicators with baselines and targets. Funding for this Program is planned to come from state and local budgets, air pollution charges, water pollution charges, loans and grants from international organizations and development partners, private companies and organizations and other sources.

Policies to reduce air pollution: In 2011, the government established the Clean Air Fund which had similar functions as Anti-air Pollution Fund and supplied funding assistance to improve the efficiency of household stoves and small low-pressure steam boilers. In parallel, the Ulaanbaatar Clean Air Project, funded by the World Bank, is being implemented since 2012,

also to support energy efficiency of household stoves and small low-pressure steam boilers (Heat only boilers), monitor air quality and conduct a public awareness campaign.

In January 2017, the government issued a zero night-time electricity payment policy for selected ger districts to encourage a switch from coal to electricity for heating in the winter season. In March 2017, the government also issued the National Program on Reduction of Air and Environment Pollution Air Pollution Action Plan (2017–2025) which includes (i) rolling out the zero night-time electricity policy to encourage the population in ger districts to use electric heating stoves, (ii) diffusing clean coal technologies such as semi-coke briquettes – or lower carbon emitting fuel –for household heating use to significantly reduce emissions, and (iii) expanding district heating networks while decommissioning small inner city steam boilers.

To support the GOM policies on reducing air pollution, ADB approved a $130 million policy-based loan in March 2018. Details of this loan are provided in Box 3. 1 below.

Box 3.1. *ADB policy loan*

A $130 million policy-based loan between ADB and Mongolia, to assist Ulaanbaatar in fighting air pollution, was approved in March 2018. This program is composed of three recommended reform areas 1) measures to reduce air pollution and increase health protection, 2) improving the air pollution control regulatory framework and 3) better environmental planning for the infrastructure, energy and transport sector. The key policy actions include expanding district heating in order to remove HOBs, providing cleaner fuel in ger areas, vaccinating children against pneumonia and promoting higher quality fuels in Mongolia. The policy loan will be disbursed in two tranches of $100 million and $30 million respectively.

Institutional Framework: The main institutions established to address air pollution reduction, with their roles and responsibilities, are set out in the above-mentioned laws and include: the Parliament of Mongolia, the Government of Mongolia, the Anti Air-Pollution Fund, the National Committee on the Reduction of Air and Environmental Pollution, the MET, the Capital City Citizens' Representatives Khural, City and aimag governors, the Energy Regulatory Commission, the State Administrative Body in Charge of Professional Inspection and business entities and organizations. At the local level there are two agencies under the Capital City Mayor's Office in charge of air pollution reduction: the Air Pollution Reduction Department and the Environment Agency.

The Great State Khural (Parliament): The parliament is responsible for overseeing the implementation of legislation related to the protection of air quality; it approves the budget required for implementing this law and monitors subsequent expenditure against it; it approves a national programs and ensures its implementation.

The Government: The Government approves the program implementation plans and ensures its implementation; it establishes a National Committee with responsibility for regulating the implementation of policies to reduce air pollution and ensures their coordination; as well it develops and seeks approval for budget proposals for the mitigation of pollution; develops and approves a plan of action to reduce pollution and reports annually to the State Great Khural; organizes the expansion of electric transmission and distribution networks in ger district areas that require air quality improvement and improves the capacity of existing networks; establishing the type and percentage of premium-price incentives for ger district households that meet the conditions and criteria set forth in Article 14 of this law; finances tariff incentives from the state budget; implements a set of measures aimed at ensuring the safety and reliability of electric power generation and the transmission and distribution infrastructure required for the heating of households in the district; and provides financial incentives to individuals, business entities and organizations to facilitate the reduction of air pollution, reducing heat loss and saving electricity.

Anti-Air Pollution Fund: The decision on the establishment of the Fund was made by the Parliament of Mongolia by the amendment to the Law on Air on January 12, 2018 and started to operate from January 1, 2019. The Fund will be managed by a member of the Government in

charge of nature and environment, who at the same time is a Chair of the National Committee on Reduction of Air and Environment Pollution. Its operations are governed in accordance with the Law on Air, Law on Air Pollution Charge and Law on Government Special Fund, which stipulate that the Fund shall have a Governing Board to direct its activities and its members shall be appointed by the Prime Minister on a non-permanent basis.

The Fund will finance the activities directed to air protection and air pollution reduction and provision of soft loans to introduce new advanced techniques and technology; it will support the production of clean fuels and stoves and provision of discounts for their purchase, support the introduction and utilization of the complete combustion stove technology, strengthen the air quality control and analysis capability, purchase measurement instruments, study the evolution of air quality and develop standards, norms, rules, methods and methodologies for air protection, conducting and implementing research work and projects, support the development of new energy sources, increase buildings energy efficiency, promote and build environmentally friendly, safe and reliable new energy sources, connect consumers to the central heating grid, support citizens and public activities, projects and activities aimed at reducing air pollution; support activities, projects and activities aimed at developing renewable energy and clean technology, organize training and awareness-raising activities to educate the public on reduction of air pollution, to finance and support activities to eliminate pollution of the mining and to prevent its negative impacts on the population.

National Committee on Reduction of Air and Environment Pollution: The Committee was established by Prime Ministerial Decree No.51 on 20 March 2017. The Committee is headed by the Prime Minister as Chair, with the Minister of Environment and Tourism as Deputy Chair. There are two Secretaries: the director of the Department of Environment and Natural Resources Management and the Vice-Mayor of Ulaanbaatar in charge of green development and air pollution issues. However, as of 14 September 2018 under the Prime Minister Order the National Committee on Reduction of Air and Environment Pollution is headed by the Minister of Environment and Tourism as Chair. There are 23 Committee members composed of representatives of ministries and selected agencies and other representative bodies. The overall structure for overseeing air pollution reduction measures is shown in Figure 3.1. Government policy on setting up the National Committee calls for multi-level coordination between responsible government agencies, Ulaanbaatar Municipality and NGOs to ensure sectorial and cross-cutting planning, programming and implementation of air and environmental pollution reduction.

Regular meetings are to be held quarterly. The National Committee plans its activities quarterly, semi-annually and annually, and provides an end-of-year report. Its main functions include determining the role of relevant central state administrative and local administrative organizations as well as other state organizations in the reduction of environmental pollution and monitoring the implementation of activities.

To ensure the effective functioning of this Committee, focal points have been established in each member Ministry and agency. They are responsible for providing day-to-day information and inputs to the Committee.

Ministry of Environment and Tourism: The MET organizes the implementation of state policy on air quality protection and associated national programs; approves the rules, procedures, methodology and instructions pertaining to air quality protection and ensures their implementation; develops standards and is responsible for their approval from the relevant authorities; provides professional management for conducting the monitoring of quality control and monitoring methodology; issues permits, grants extensions, and carries out termination, cancellation and determination of allowable air emissions from settlement sources.

The National Agency for Meteorology and Environmental Monitoring (NAMEM)

NAMEM reports to the Minister of Environment and Tourism and is the air quality control agency on the national level. The responsibility of NAMEM is to exercise regular monitoring of the environmental quality, including air pollution and to provide the most up-to-date information on air pollution along with other environmental and meteorological issues for action and prevention purposes.

Capital City Citizens' Representatives (Churls)
One of the main responsibilities of the Khurals is approving local budgets for air quality improvement zones in the relevant year and supervising the work of the Mayor's Office on reducing air pollution in the capital city.

Business entities and organizations
The Law on Air requires business entities and organizations to exercise internal control on air pollution and to avoid burning raw coal or causing other forms of air pollution by using new technologies and liquefied petroleum gas (LPG) and other sources of energy to reduce the generation of pollution through their activities.

State Administrative Body in Charge of Professional Inspection
This body at both central and local level is responsible for the implementation of the Law on Air and the integrated standards in air pollution reduction.

Energy Regulatory Commission: The Commission was established after the passing of the Law on Energy in 2001 with the main purpose of creating an independent energy regulator. The Commission grants special licenses to energy sector entities, reviews and approves tariffs for special license holders and consumers, ensures that the rights and interests of both energy license holders and energy consumers are protected in a balanced manner and creates an environment for fair competition among license holders. It plays an important role in the implementation of air pollution reduction measures overall. It is therefore vital that it be seen by all stakeholders to be independent in the decisions it takes (AKAF, 2003).

There are two relevant bodies at the municipal level under the Ulaanbaatar Vice-Mayor in charge of green development and air pollution issues: the Air Pollution Reduction Department and the Environment Agency.

Air Pollution Reduction Department: This department was established in August 2016, is fully funded by the budget of the capital city and has three divisions and 20 full-time staff. The department is responsible for planning, implementing and reporting on air pollution reduction measures in the capital city.

Environment Department: This department has as its main function the responsibility for ensuring the implementation of environmental legislation, including limiting harmful and adverse environmental impacts and preventing environmental degradation: this includes atmospheric air pollution. It shall also implement the ‘green policy’ of the capital city, promoting ecological education, green activities and introducing eco-technologies and standards.

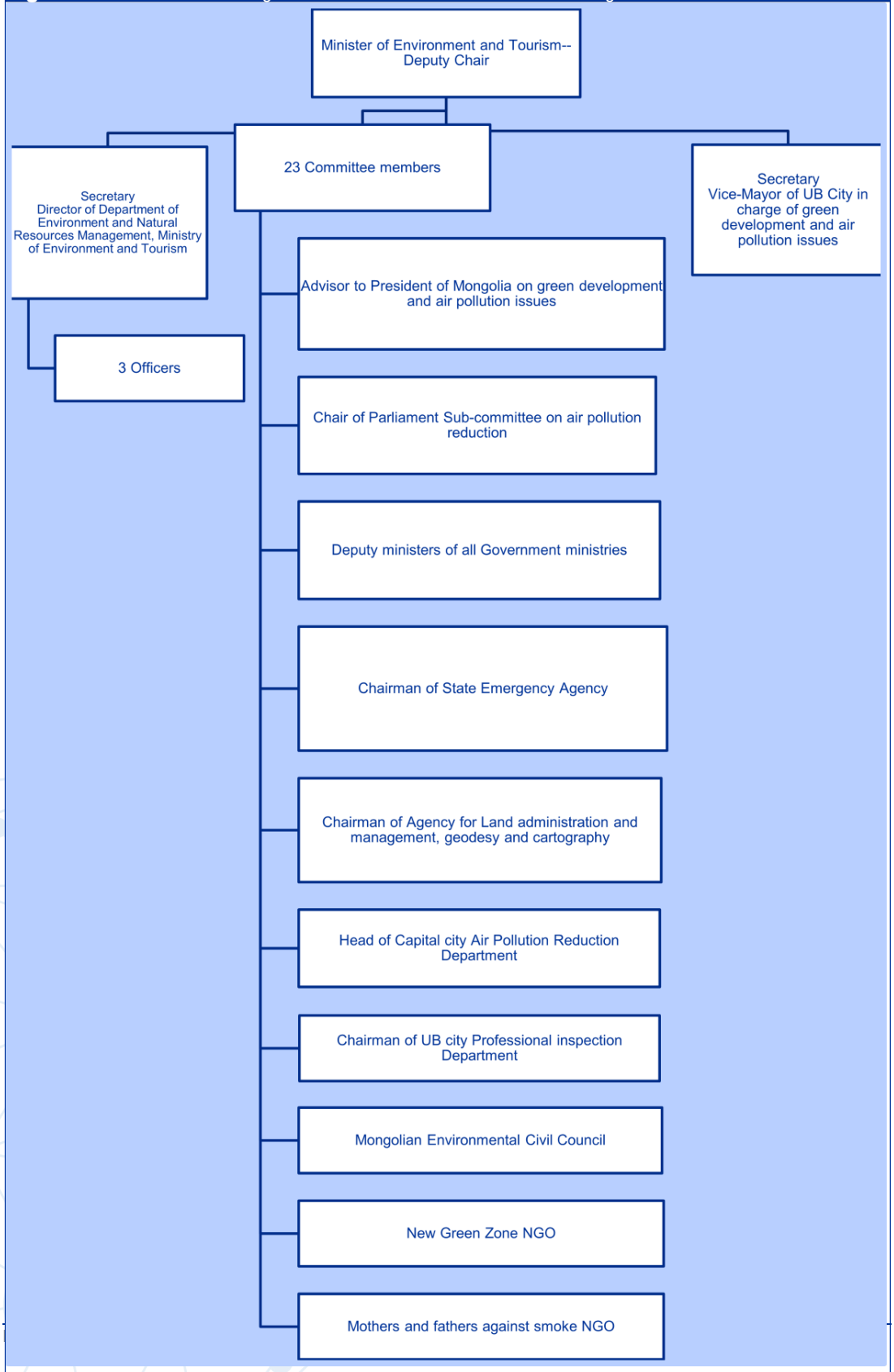
In order to reduce air pollution in the capital city, in 2017 the MET and the Ulaanbaatar City Governor approved the decree on “Re-establishment of the Air Quality Improvement Zones and the Regulation to be pursued in Those Zones". Under this regulation, Ulaanbaatar was divided into four zones. Citizens and legal entities in the Air Quality Improvement Zones have the obligation to perform specific duties and functions to improve air quality. The decree prescribes measures for urban development within the zones which must be complied with and limits new settlement areas in Ulaanbaatar. The four zones are selected according to data provided by the AQM stations in Ulaanbaatar. The specific measures to be taken vary from zone to zone.

The Decree sets standards for air quality improvement, such as the permitted maximum level of polluting substances permitted, technical requirements for stoves and the use of improved fuels, standards on renewable sources of energy, biofuels, electricity and the use of electric and different types of heaters using LPG. The decree states that the MET, the Ulaanbaatar City Governor and Governors of the districts and khoroos must coordinate implementation of this regulation and the Environment Inspector will

supervise its implementation. The implementation status of this decree will be reported to the National Committee.

In October 2017 the Prime Minister of Mongolia stated at the National Forum that “in 2008-2016,

Figure 3.1. *Institutional Arrangements for Air Pollution Reduction in Mongolia*



Source: GOM, 2017

the country spent over 147 billion MNT for projects and programs to reduce air pollution in Ulaanbaatar city. They showed certain results, but did not achieve the expected outcome."[53] He also pointed out that the liquidation of the Clean Air Fund drastically reduced the financing of air pollution reduction and admitted that the revenues from the air pollution fees were not spent appropriately. At the same time the Prime Minister recognized that a restriction on the consumption of unprocessed coal would be a main direction of further actions. To do this, public-private partnerships (PPP) would be required.

Review of Institutional Arrangements for Air Pollution Reduction: The annual monitoring and evaluation of the program is to be conducted by the National Committee on the Reduction of Air and Environmental Pollution in collaboration with representatives of professional associations and NGOs. At the local level, in the rural areas, monitoring and evaluation of the program shall be performed by Governors of soums and aimags and by governors of khoroos and districts in the capital city. Program implementation reports will be presented to the GOM by the National Committee on Reduction of Air and Environmental Pollution during the first half of every year. The NPRAEP Action Plan and performance appraisal indicators may be amended in accordance with relevant laws and regulations on the basis of the program's monitoring and evaluation findings and recommendations. In addition, an independent evaluation of NPREAP and other related government projects and programs shall be carried out to assess results and impacts and ensure accountability as no budgets for NPREAP evaluations have been allocated for either 2018 or 2019.

Air pollution reduction efforts have been coordinated and monitored through the National Committee on Air Pollution Reduction, and more recently through the National Committee on Reduction of Air and Environmental Pollution.

Representatives from both central government (deputy ministers of all government ministries) and Ulaanbaatar municipality (the Vice-mayor in charge of green development and Head of City Air Pollution Reduction Department) are present as shown in Figure 3.1. This mechanism aims to ensure that air pollution reduction measures and expenditures are consistent at both national and local levels and are well coordinated. However, a lack of full-time staff employed by the National Committee needs to be addressed to ensure that highly professional and timely support can be provided to the committee led by the Prime Minister. There are other important issues such as a shortage of the required expertise which are addressed as part of the recommendations in this report.

Examining the performance indicators as stated by the NPRAEP, permissible limits for $PM_{2.5}$, PM_{10} and SO_2 are targeted to drop significantly between 2019 and 2025, but even by the end of this period they will still be significantly higher than the Mongolian Standard MNS 4585:2016 (25 мg/m3 for $PM_{2.5}$, 50 мg/m3 for PM_{10} and 20 мg/m3 for SO_2). It is important that these performance indicators should be further assessed, refined and clearly quantified. A program performance framework including air quality improvement and program performance indicators with clear annual targets should be established as well as a cost-effectiveness analysis for decision-making should be carried out.

The National Committee for the Reduction of Air and Environmental Pollution oversees and monitors the implementation of the NPRAEP. However, appropriate full-time staffing of the National Committee is necessary if it is to be effective. It is also important to develop the capacity of the National Committee to undertake options analysis and develop policies, incorporating lessons learnt from the current implementation of the programs and plans. The National Committee has no system for overseeing overall spending and progress of the activities of the NPRAEP. This means that there is no body within government that has an informed view as to whether the initiatives undertaken form a coherent portfolio that delivers

[53] Prime Minister U. Khurelsukh speech at the National Forum on Air Pollution, October 23, 2017, Montsame news
Mongolia scored 38 out of 100 in the 2016 Corruption Perceptions Index; see https://www.transparency.org/country/MNG

value for money or whether air pollution reduction is being achieved as targeted.

Monitoring and accountability mechanisms regarding the NPRAEP must be significantly strengthened. The NPRAEP was approved by Government Resolution No.98 but there are no enforcement mechanisms currently in place to ensure involvement of authorities for implementing the program.

The legal, policy and institutional review of air pollution reduction shows that in Mongolia this issue is clearly a cross-government responsibility. It is also a devolved matter with organizations responsible for air pollution reduction at both the national and local levels. Therefore, cross-governmental collaboration and clear accountability lines are essential for success.

However, the environmental regulations and instruments for enforcing air pollution control are incomplete and the authorities of the organizations to impose air pollution control are unclear. Because of the need to attract investment in significant amounts for these initiatives to be implemented, the perceived lack of transparency could be a serious obstacle.[54] The Corruption Perception Index 2017 published by Transparency International also suggests that the perception of corruption in Mongolia has been worsening in the past two years compared with previous years.

Generic problems relating to public administration in Mongolia such as weak law enforcement are important as they have an impact on the efficacy of air pollution reduction measures as much as any other initiative involving public expenditure. Stricter controls and the imposition of penalties on local governments for non-compliance with air pollution regulations and standards and even withholding of budget funds must be introduced. The significant capacity constraints of public administration coupled with recent budget pressures are likely to exacerbate this issue.

The lessons learned from past experience, including poor management of projects and programs, weak governance and poor participation[55] which have affected the results of air pollution reduction measures need to be addressed in managing the implementation of NPRAEP.

[54] For further references to corruption, see http://www.business-anti-corruption.com/country-profiles/mongolia

[55] Sensory Researchers' Association of Mongolia, 2018

4. HEALTH AND ECONOMIC ASSESSMENT OF THE NEGATIVE EXTERNALITIES OF AIR POLLUTION

4.1. The Health Impact of Air Pollution

The WHO considers air pollution to be a major environmental risk to human health. It increases the burden of disease from stroke, heart disease, lung cancer, both chronic and acute respiratory diseases and creates distress due to illness. As assessed by the WHO, in 2018, 91% of the global population was living in areas where the WHO air quality guideline levels were not being met (WHO, 2018); 7 million people die every year from exposure to fine particles ($PM_{2.5}$) in polluted air. As discussed further below, in Mongolia such issues have both a major health impact, with attendant human and societal consequences, and a substantial economic cost.

The WHO reports that in 2012 some 72% of outdoor air pollution-related premature deaths were due to ischemic heart disease and strokes, while 14% of deaths were due to chronic obstructive pulmonary disease or acute lower respiratory infections, and 14% of deaths were due to lung cancer. The WHO Air Quality Guidelines indicate that reducing PM_{10} from 70 to 20 micrograms per cubic meter (mg/m^3) can reduce air pollution-related deaths by about 15% (WHO 2017).

The GOM goal is to reduce 24 hour December mean of $PM_{2.5}$ to 70 mg/m^3 and PM_{10} to 100 mg/m^3 in December by 2025. The WHO guidelines specify the following targets for particulate matter: (i) $PM_{2.5}$: 10 mg/m^3 annual mean; 25mg/m^3 24-hour mean; (ii) PM_{10}: 20 mg/m^3 annual mean, 50 mg/m^3 24-hour mean. Meteorological Office data confirms that problematic levels of $PM_{2.5}$ pollution occur only in the winter months as in summer there is no need for those living in gers to burn coal to the same extent. However, the level of PM_{10} mainly caused by vehicles and dust still remains higher than the WHO recommended levels during the summer.

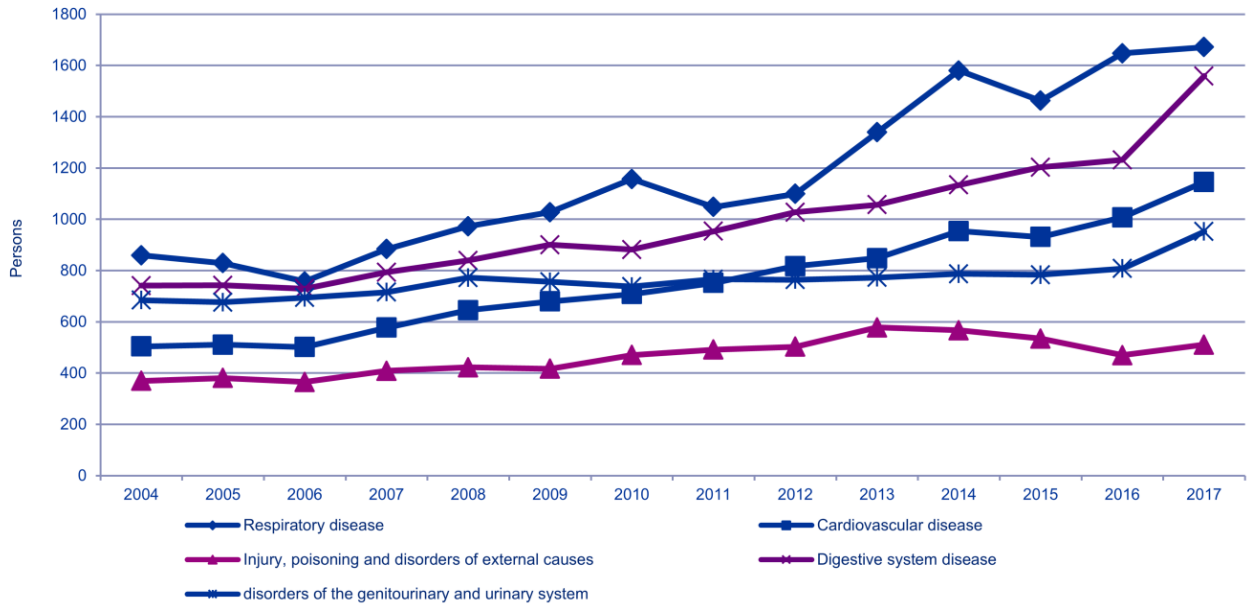
According to the Ministry of Health (MOH), air pollution levels – especially in the capital city – have reached dangerous levels that have a negative impact on human health. The World Bank study "Air Quality Analysis in Ulaanbaatar" concluded that 19.5% of respiratory diseases and 23.5% of cardiovascular disease are caused by air pollution (2011).

Graph 4.2 shows the levels for the five major diseases in Mongolia between 2004 and 2017. They are likely to be principal contributors to the burden of Disability-Adjusted Life Years (DALYs) as discussed in the next section. Two out of the five diseases that are most prevalent in Mongolia, namely respiratory and cardiovascular diseases, are closely linked to air pollution.

Institute for Health Metrics and Evaluation (IHME)[56] data suggest that as of 2016 air pollution is among the 10 major risk factors driving the highest number of deaths and disability combined in Mongolia (IHME, 2017) (see Figure 4.1). Indeed, the National Statistical Office (NSO) confirms that cardiovascular disease is the leading cause of death in the country (NSO, 2017a).[57]

[56] An Independent Global Health Research Center at the University of Washington in Seattle, USA
[57] NSO, Statistical Information Database, 2017

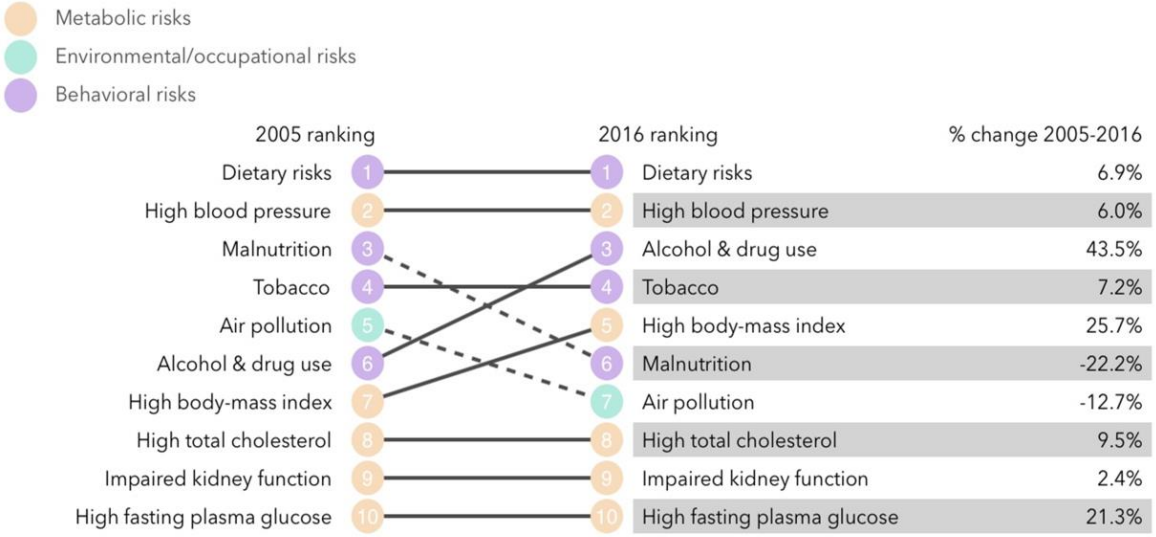
Graph 4.1. *Major Diseases per 10,000 Population, Mongolia, 2004-2017*



Source: Ministry of Health, 2016; Health Development Center, 2018

There are other indications of the dangers of air pollution to health. Cardiovascular disease has the highest mortality rate amongst the top five diseases causing the most deaths in Mongolia (MOH, 2016). Based on hospital admissions data, there are strong correlations between $PM_{2.5}$ and PM_{10} levels and cardiovascular disease. Exposure to $PM_{2.5}$ and PM_{10} could increase daily hospital admissions for cardiovascular disease by approximately 9% over the normal level of hospitalization (World Bank, 2011).

Figure 4.1. *Risk Factors Driving the Highest Number of Deaths and Disability Combined*

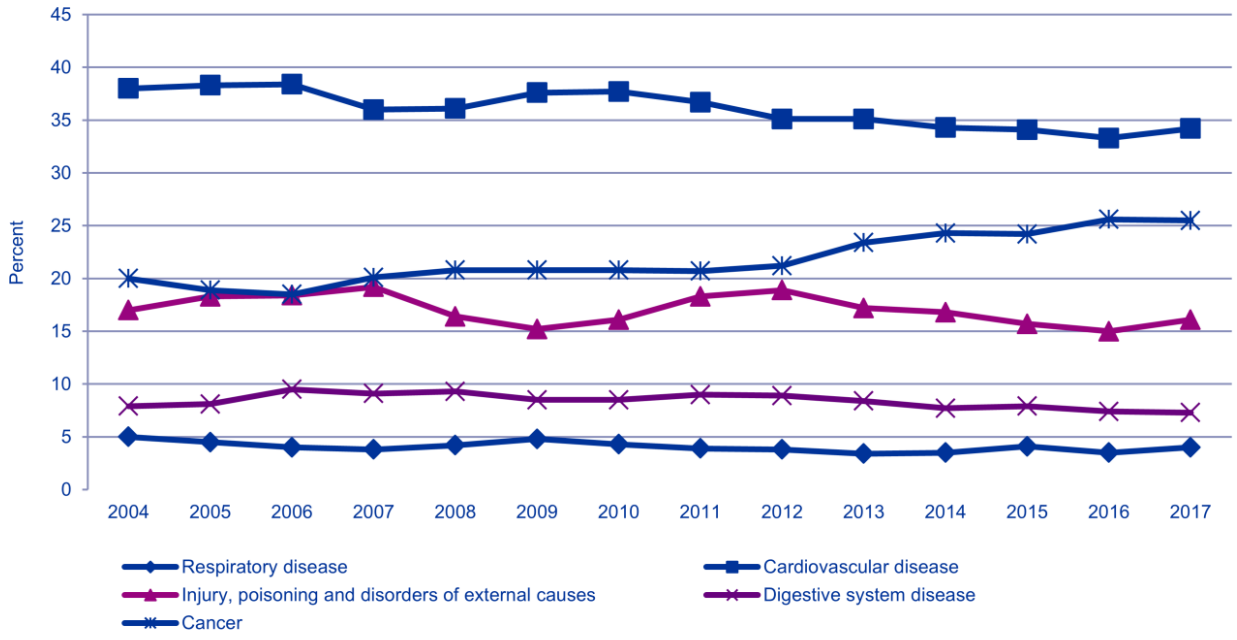


Source: Institute of Health Metrics and Evaluation, Mongolia Health Data, 2017

Graph 4.1 shows the major causes of death in the country; again, the diseases that are linked to air pollution should be noted.

Compared with the comparison group (for death and DALY) chosen by a recent Global Burden of

Graph 4.2. *Top 5 Diseases Causing the Most Deaths in Mongol, 2004-2017*



Source: MOH, 2016 ; Health Development Center, 2018

Diseases (GBD) Study, Mongolia has the second highest and highest numbers of deaths per 100,000 people from ischemic and cerebrovascular diseases respectively. These are also diseases that have a high correlation with air pollution.

Several studies have been carried out to examine the health and other implications of outdoor and indoor air pollution in Mongolia since mid-2000, including "Air Quality Analysis of Ulaanbaatar" (World Bank, 2011); "A Study on Air Pollution in Ulaanbaatar City of Mongolia" (Amarsaikhan et al, 2014); and "Mongolia's Air Pollution Crisis: Urgent Interventions to Reduce the Impact on Children's Health" (UNICEF, 2016).

UNICEF's Report on Children's Health

The UNICEF report titled "Mongolia's Air Pollution Crisis: Urgent Interventions to Reduce the Impact on Children's Health" (UNICEF, 2018) identified the significant impact of air pollution on children's health specifically. For example, in Mongolia there is a 3.5-fold increase in foetal deaths from summer to winter. In the last 10 years, the incidence of respiratory diseases in Mongolia has increased alarmingly, including a 2.7-fold increase in respiratory infections per 100,000 population. Pneumonia is now the second leading cause of under-five child mortality in the country. Children living in a highly polluted district of central Ulaanbaatar were found to have 40% lower lung function than children living in a rural area (UNICEF, 2018).

The UNICEF study provided several recommendations on conducting additional assessments, including a feasibility study to identify, cost and promote a package of interventions to reduce the exposure to air pollution of pregnant women and neonates living in the ger districts; analysis and further piloting of the provision of affordable and good quality medicine to treat acute respiratory infections and chronic lung diseases among children of poor families and recommendations on mobilizing funds for measures to protect children from air pollution health impacts.

The UNICEF report recommendations are concentrated both on mitigation and prevention measures and will be very important in addressing the negative impacts of air pollution on these vulnerable groups.

As can be seen, the health impact caused by air pollution is significant in Mongolia and in the capital city in particular. The effects of this should be monetized and the estimated effects of health

damage taken into account to assess the net benefits of any air pollution reduction measures.

4.2. The Economic Impact of Air Pollution

The total costs of inaction in addressing outdoor air pollution include both "market" and "non-market" (also known as "welfare") costs (OECD, 2016). Market costs are measured in lost GDP in the form of lost labor productivity and health expenditures linked to air pollution. Non-market costs include the estimated cost of premature deaths and distress due to air pollution-related illness based on people's 'willingness to pay' to reduce health risks and to avoid pain and suffering from illness.

Several studies, including the OECD publication "Economic Consequences of Outdoor Air Pollution" (2016), state that the welfare costs of lost lives and illness resulting from outdoor air pollution could reach alarming levels by 2060 worldwide, with significant economic costs. This is a problem for many countries but has already reached acute levels in Mongolia.

Quantification of welfare costs is not easy, although estimates can be carried out. The World Bank and the WHO use the concept of DALY to measure the welfare cost of air pollution. Appendix 4 summarizes the terminology used for some of the key elements of economic cost.

The study developed with World Bank support in 2011 ("Air Quality Analysis of Ulaanbaatar") confirms that there is a strong correlation between air pollution and cardiovascular diseases. This study concluded that an increase of $PM2_{.5}$ by 10 mg/m³ led to an increase in the hospitalization of patients with cardiovascular diseases by 0.8%. The study also suggested that an 80% emission reduction from coal combustion in ger areas yields an estimated 48% reduction in outdoor $PM_{2.5}$, equating to approximately $66 million in annual avoided health costs.

The UNICEF report also included vital data on the health impacts on children specifically and included cost estimations. This stated unambiguously that "if no immediate action is taken to reduce the levels of air pollution, the direct financial cost of treating air pollution-attributable diseases in children is expected to increase considerably". It included estimates that the cost of treating air pollution-induced diseases in children would, given inaction on the part of the GOM, likely lead to direct expenditure of 24.8 billion MNT (about $9.8 million) in the 2017 to 2025 period in Ulaanbaatar alone. When indirect costs are included this figure escalates significantly to approximately 46.6 billion MNT (approximately $18.4 million) (UNICEF, 2018).This is just the tip of a rather large iceberg as the wider economic impacts of air pollution must also be considered.

According to the World Bank study on "Air Pollution in Ulaanbaatar: Initial Assessment of the Current Situation and Effects of Abatement Measures", annual health costs associated with exposure to air pollution amounted to $147 million in 2007. Cases of cardiovascular and respiratory diseases and hypertension tend to increase in winter time (Burmaajav et al., 2016) when the 220,000 households in the ger district of Ulaanbaatar and entities that are not connected to the central heating system use raw and brown coal for heating. Similar results are found in other studies carried out in recent years. Two of these studies found that the correlation between air and environmental pollution and miscarriage and full carriage with low-weight birth is high (Enkhmaa, 2014; G. Dorj et al., 2014).

Another World Bank study published in 2011 stated that the health damage of air pollution in Ulaanbaatar ranged from 18.8% to 27.9% of Ulaanbaatar GDP and 8.8% to 13.1% of the GDP of Mongolia as of 2008. This big difference in estimated health damage indicates substantial uncertainty in estimating the consequences of exposure to air pollution. Damage to health by air pollution is still substantial however it is measured (World Bank, 2011).

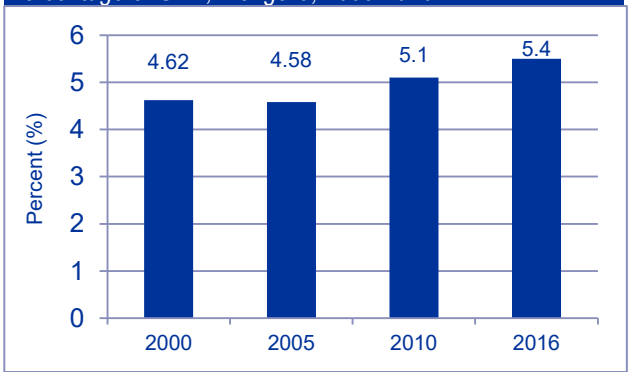
The World Bank report "Cost of Air Pollution" (2016) postulated that the ambient and household air pollution cost to the world economy was about $5.11 trillion in welfare costs. The study estimated that such welfare costs in Mongolia were equivalent to 6.9% of annual GDP (purchasing power parity – ppp adjusted) which suggests welfare costs of about $1.2 billion

(about 2.8 trillion MNT) annually due to exposure to poor air.

The Mongolia data extracted from a database maintained by the Organisation for Economic Co-operation and Development (OECD) show that the welfare cost from exposure to $PM_{2.5}$ in Mongolia is equivalent to 5.3% of its GDP (ppp) in 2015.[58] However, the welfare cost of premature deaths from exposure to air pollution of $1.1 billion ppp-adjusted (2.6 trillion MNT) per year is still too high. These two estimates of the cost of air pollution where the ppp-adjusted GDP is used are useful for international comparison purposes.

Specific estimates of the actual welfare cost from exposure to air pollution will follow below in this section. Before considering this, it would be interesting to see a time-series of Mongolia's welfare costs arising from exposure to air pollution in terms of the percentage of GDP and compare this to other countries. Graph 4.3 shows the changes in welfare costs of premature deaths due to air pollution in Mongolia between 2000 and 2016. Premature deaths increased by 0.88 percentage points comparing 2016 to the 2000 level.

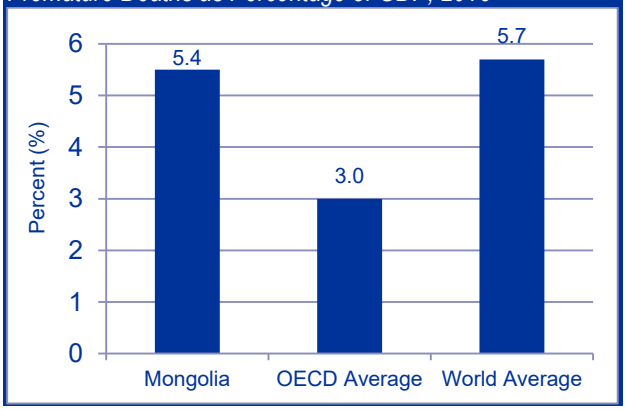
Graph 4.3.[59] *Welfare Cost of Premature Deaths as Percentage of GDP, Mongolia, 2000-2016*



Source: OECD, 2018
https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

The welfare costs of premature deaths from exposure to air pollution in terms of the percentage of GDP (ppp) in Mongolia are 2.4 percentage points higher than the OECD average: this is highly significant. But comparing the same indicator with the world average gives an outcome that is 0.3 percentage points % lower for Mongolia as of 2016 (see Graph 4.4).

Graph 4.4. *Country Comparison of Welfare Cost of Premature Deaths as Percentage of GDP, 2016*



Source: OECD, 2018
https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

DALY, VSL and Calculation of Welfare Costs of Air Pollution

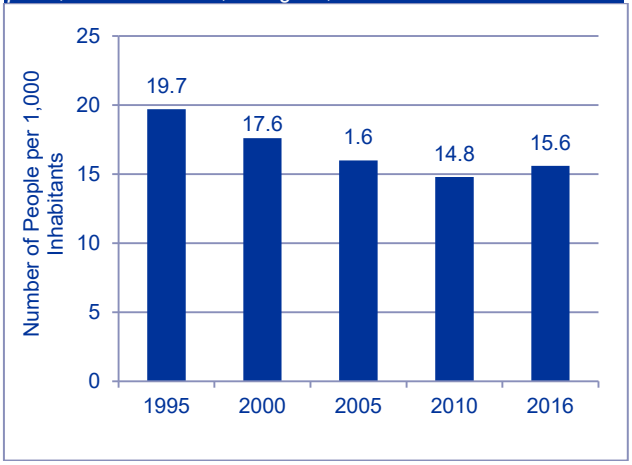
The DALY is one lost year of "healthy" life as defined by the WHO. It is calculated as the sum of Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with health conditions or their consequences.[60] DALYs from exposure to $PM_{2.5}$ per 1,000 inhabitants in Mongolia have been declining with apparent progress being made between 1995 and 2010, until it increased slightly in 2016 (Graph 4.5 below). Unfortunately, the

[58] GDP (ppp Adjusted) of Mongolia in 2015 was 20.876 billion USD. IMF Estimation

[59] The OECD data was used for Graphs 4.3 to 4.8 as no such comprehensive and detailed data cannot be found in national statistical database and at respective government agencies in Mongolia.

[60] WHO, http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/

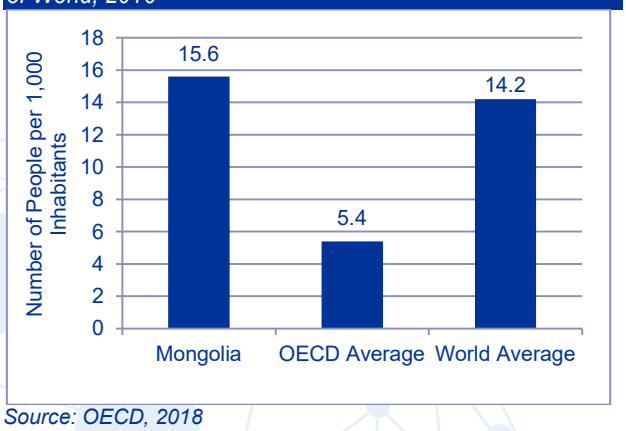
Graph 4.5. *Number of DALYs from Exposure to PM2.5 per 1,000 Inhabitants, Mongolia, 1995-2016*



Source: OECD, 2018
https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

reasons for this slight increase cannot be found in any documents that are available publicly. However, it may relate to the health impacts of long-term exposure to $PM_{2.5}$. The level of DALYs in 2016 was 15.6 per 1,000 inhabitants. When compared to the OECD average, DALYs of Mongolia are significantly higher, but only slightly higher when compared to the global average (see Graph 4.6).

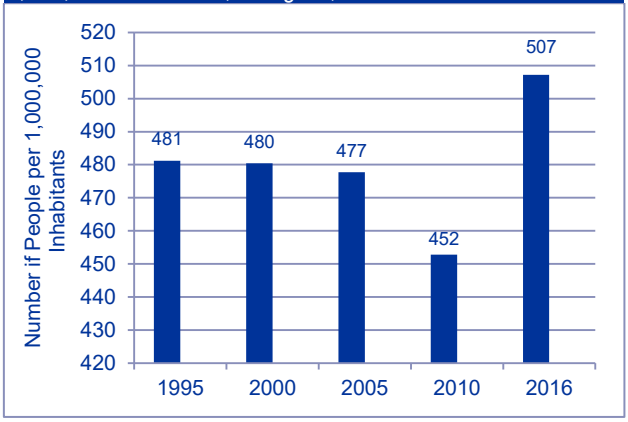
Graph 4.6. *Number of DALYs from Exposure to PM2.5 per 1,000 inhabitants for Mongolia compared with the Rest of World, 2016*



Source: OECD, 2018
https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

Mortality (premature deaths) is one of the major components of the DALY. Mortality per 1,000,000 inhabitants in Mongolia from 1995-2016 data as shown in Graph 4.7 suggests a decline from 481 in 1995 to 452 in 2010 showing a net benefit, but as of 2016, levels of

Graph 4.7. *Mortality from Exposure to PM2.5 per 1,000,000 inhabitants, Mongolia, 1995-2016*



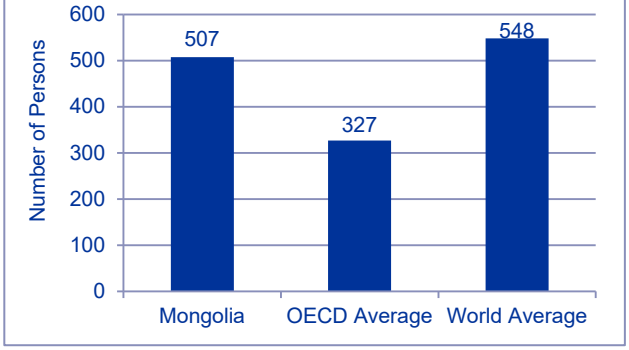
Source: OECD, 2018
https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

mortality has increased, reaching the highest level (507 persons) since 1995.[61] This could be a result of long-term exposure to $PM_{2.5}$ as Graphs 4.6 and 4.8 show a similar trend for an increased level of DALYs and mortality from exposure to $PM_{2.5}$. Mortality from exposure to $PM_{2.5}$ per 1,000,000 population is higher in Mongolia (507) than the OECD average (327), but slightly lower than the global average (548) as shown in Graph 4.8.

The use of the concept of the DALY for environmental policymaking enables us to estimate the burden of disease, including that caused by air pollution. In order to monetize a DALY, the concept of the "Value of Statistical Life (VSL)" has been used for Mongolia – for instance in the "Air Pollution on Health in Ulaanbaatar" report prepared for the Ministry of Environment and Green Development in 2014 and in the Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts" study undertaken by The World Bank in 2011.

[61] OECD; https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

Graph 4.8. *Country Comparison of Mortality from Exposure to PM2.5 per 1,000,000 Inhabitants, 2016*



Source: OECD
https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

According to the aforementioned World Bank study where the "willingness to pay" (WTP) concept was used to calculate the economic value of reducing mortality risks, the VSL in Mongolia is $221,000 (319 million MNT) (World Bank, 2011).

The suggested formula for defining the value of DALY is that the VSL should be divided by 22 – the average population is assumed to experience an average loss of 22 DALYs per premature death according to the age distribution of DALYs (World Bank, 2017c). This gives a value for the DALY in Mongolia of $10,045. Statistical data of the OECD suggest that the annual DALY for Mongolia due to air pollution is a little over 47,680 (14.9 DALY per 1,000 inhabitants). This gives a total welfare cost of $478.9 million (1.15 billion MNT) per annum due to air pollution exposure.

The Resources for the Future publication, "How Should the World Bank Estimate Air Pollution Damages" (Cropper and Khanna, 2014) suggested the same formula, but a different approach for estimating the "willingness to pay". The US figure was multiplied by the ratio of the country's per capita gross national income (GNI) to GNI per capita for the United States, measured at market exchange rates.

The estimation of the "willingness to pay" provides us with the value of a DALY in Mongolia equaling $10,340.70. Using this approach, the total welfare cost from air pollution is therefore estimated to be $493.0 million (1.18 trillion MNT) per year.

There is only a marginal difference between the estimated figures of the welfare costs of air pollution in Mongolia using the two different approaches discussed. An appropriate approximation would be to use the mean value of the two as a welfare cost of air pollution for Mongolia, namely $485.9 million per annum.

Wider socio-economic impacts

Air pollution presents not only health risks, it also impacts negatively on socio-economic development. Quality of life is reduced due to air pollution-related diseases and premature deaths; labor productivity also declines which in turn impacts negatively on economic activities. Air pollution can have a lasting effect on productivity in other ways as well – for example, by stunting plant growth and reducing the productivity of agriculture, and by making cities less attractive to talented workers, thereby reducing cities' competitiveness (World Bank Group, 2016).

The total market costs in the case of Ulaanbaatar consist of labor productivity losses and health expenditures incurred due to exposure to air pollution.

Several studies carried out on the relationship between labor productivity and air pollution suggest that labor productivity declines by 6% on high-level pollution days (*The Economist*, 2016). For an estimate of lost labor productivity, and consequently the loss of GDP overall, the existing method of using wages as a proxy value for marginal productivity can be used. According to a Labor Survey undertaken by the NSO in 2017, the working population of Ulaanbaatar is 518,683 of which approximately 300,000 live in the ger districts.

In order to estimate the annual loss of productivity due to air pollution in Ulaanbaatar, the following facts and assumptions are taken into consideration:

- The entire working population of Ulaanbaatar is exposed to air pollution; therefore, labor productivity decreases by 6% as an estimation based on research undertaken for

other countries (Economist, 2016; Chang et al., 2016). The number of households in Ulaanbaatar at the end of 2016 was 380,828.

- The number of households in ger districts at the end of 2016 was approximately 220,000, including those living in gers and individual houses.
- The total working population of UB is 518,683.
- The approximate number of the working population in ger districts is 300,000.
- The approximate number of the working population in non-ger districts is 218,700.
- The average monthly wage in Mongolia is 966,600 MNT (as per the NSO) which is $367.70.
- The average monthly wage for the working population in ger districts in 2017 was 600,000 MNT ($228) as mainly low income and poor households live in these districts.[62]
- Air pollution is worse in the winter months from October to the end of March, especially in the coldest month of January.

The estimation of annual lost productivity using the above facts and assumptions provides a figure of 141 billion MNT ($58 million) annually which is 0.6% of total GDP as of 2016. The World Bank study on “Cost of Air Pollution” suggests that the loss of productivity/total foregone labor output in Mongolia is 0.47% (World Bank, 2016) of GDP (ppp adjusted equivalent) as of 2013 which is equal to $145.7 million per annum.

4.3. Overall Assessment of Health and Economic Impact

The data discussed above reinforce the hugely negative impact that air pollution has on health in Mongolia. The recent UNICEF study “Mongolia’s Air Pollution Crisis: A Call to action to protect children’s health” brings out very clearly how devastating the effects are on one particularly vulnerable and exposed section of the community – children and their quality of life in the future. There is substantial evidence that it will have an impact on many if not all sections of society to a significant extent without effective remedial action being taken.

The health effects and associated societal impacts are unacceptable in their own right; but there is also a corresponding and very high economic cost, not just in terms of the treatment of these diseases but also regarding the impact on economic activity as measured by GDP over the longer term. Based on the above data, the total economic costs of air pollution, including market and non-market costs in Mongolia are likely to be $645.1 million[63] per annum (around 1.6 trillion MNT – approximately 2.5% of 2017 GDP) (ppp); these would be higher if other costs associated with the ”willingness to pay” (to avoid pain and suffering from illness) were added to the total cost of air pollution. In addition, the total damage costs of air pollution such as those to agriculture, the environment, material and property are also not included in the total costs of air pollution due to non-availability of data for Mongolia; no such study has been undertaken in Mongolia, but it could usefully be considered in the future.

Air pollution reduction measures can be well justified and effective only if they are fact-based, results-oriented and well-managed with full transparency and strong governance. They must form part of a comprehensive package of measures – given the seriousness of the air pollution problem in the country and the magnitude of the total welfare and economic costs arising from exposure to air pollution. Although the costs involved may be substantial, in the longer term they will be more than offset by the economic, social and health benefits. To be fully effective, it is essential that the necessary fundamental reforms required for strengthening governance mechanisms, the improvement of living standards for the low-income population through job creation, small business support and targeted housing programs and recovering full cost of energy generated through fossil fuel are properly implemented on a timely basis.

[62] NSO, 2017 (http://www.1212.mn/BookLibraryDownload.ashx?url=HSES_2017_2q.pdf&ln=Mn)

[63] Welfare cost + Productivity Loss + Direct Health Cost

5. AIR POLLUTION REDUCTION STRATEGIES AND THE ENERGY SECTOR IN MONGOLIA

5.1. Introduction

The GOM recognizes Mongolia's serious problems in controlling air pollution and is moving forward to create policy and fiscal space to address them. Mongolia's strategy will need to be sustained and systematically pursued over an extended period of time. However, the actions that drive it should begin immediately and will be short, medium and long-term, according to realistic evaluation of Mongolia's capacity and fiscal space.

Mongolia must address its immediate air quality problems through clear agenda and policy guidelines. Its short-term goals should include a transition to clean stoves and cleaner fuel, while taking account of Appendix 7, and the expansion of energy distribution network capacities. This is particularly important within the ger districts.

At the same time, and in parallel, it must work towards longer-term transformation of the energy economy, moving into greater reliance on renewable energy sources. Mongolia's commitment to the transformation from coal energy to renewables must be demonstrated, over time, by the phasing out of coal in favor of renewables. This must be done in consideration of the fiscal space available for the government and for the Mongolian population. [64]

Mongolia's immediate air quality problems and its longer-term transition to renewables are two issues that cannot be treated in isolation. In the short term, a clear sequence of actions is required, starting with policy measures that provide more efficient stoves and better-quality fuel. At the same time, in the longer term, it must consider the options for investment in renewable energy sources and how to pay for them, whether through a feed-in tariff system or an auction mechanism that allows investors to bid for renewables. Efforts must come from all of society – government, the private sector, civil society organizations, producers and consumers alike. Changing behavior among the population plays an important part – whether it is through better regulation of motor vehicles and fuel, encouraging homes in apartments outside the gers, or the imposition of tariffs at a variable rate on the basis of cross-subsidies. In all these actions, a significant study of baseload capacity is required.

5.2. Energy Sector Background

Mongolia's Energy Policy: Challenged by Local and Global Pollution

Energy policy in Mongolia faces two major challenges: reducing **local** air pollution in UB and honoring its commitment to reducing **global** greenhouse gas emissions (GHG). The Paris Agreement asks Mongolia to explicitly provide aggressive greenhouse gas targets. Mongolia has committed to a 14% reduction in total national GHG emissions excluding land use, land use change and forestry (LULUCF) by 2030, compared to the projected emissions under a business as usual scenario. These and other potentially more ambitious commitments depend on access to new technologies and sources of finance through internationally agreed mechanisms and instruments under the auspices of the UNFCCC.[65]

Treated separately, these two challenges have resulted in time-inconsistent policy recommendations. A more long-term vision is needed, including an integrated renewable energy policy.

Currently, Mongolia's renewable power sources are still insufficiently used. Hence, most of the short-term expansion in electricity is likely to come first from increasing generation by coal. Mongolia's current renewable energy strategy includes targets of 20% renewables by 2020, 25% by 2025 and 30% by 2030 (of the installed capacity). Today, renewables account for around only 3% in terms of actual electricity generation due to a lack of investment, although as of 2017 renewable energy accounts for 11.8% of installed capacity in Mongolia's total energy production. Potential opportunities for exploiting these renewables are explored below in Section 5.3.

[64] The situation of the government is complicated by the position adopted by some donor countries which will not get involved in the use of any form of hydrocarbons in Mongolia. This was confirmed to be the position of Germany, in the meeting the team held with GIZ in preparing this report in Ulaanbaatar on 18 November 2017.

65 Intended Nationally Determined Contribution (INDC) Submission by Mongolia to the Ad-Hoc Working Group on the Durban Platform for Enhanced Action (ADP), 2015.

Banning (Raw) Coal: an immediate realistic option for Mongolia

While a complete phase out of coal may not be realistic in the short term, it is essential to embark on energy transformation and gradually shift reliance on coal for energy generation to cleaner and sustainable energy sources.

The GOM made a decision to ban raw coal for heating in ger districts (at the household level) from May 2019. However, there is no ban on raw coal for CHPs. While it is recognized that coal burning is the main contributor in Mongolia to both local air pollution and global GHG emissions, within the short/medium/long-term framework of this report, it still seems unrealistic to ban raw coal entirely in Mongolia. The coal sector has been growing and today is a major part of Mongolia's foreign trade and exports. To provide context, even highly developed nations struggle to ban coal. Canada's announcement to ban coal by 2030 has resulted in about 10% of electricity in Canada now coming from burning coal, half of what it was 15 years ago, largely because Ontario has shut down its coal fired power stations.[66] A carbon tax is now being implemented in each Canadian province by the Federal Government, unless the province has implemented a similar mechanism. Germany is still subsidizing coal, in part having no choice due to shutting down of its nuclear power stations. While Germany is currently discussing banning coal by 2038, studies indicate the very high costs of approximately $90 billion of this policy.[67]

If gers are gradually shifted to the electricity for heating (currently heated mainly by coal) local air pollution will be reduced. However, the problem is shifted to global air pollution, namely the GHG emissions of coal-fired power plants. Increasing the CO_2 emissions anywhere is in direct conflict with the goals of the Paris Agreement and this would be a short-term solution while establishing the longer-term energy sources available through renewable energy sources.

Unfortunately, at present the electricity distribution system at its maximum capacity and use of electricity for heating in ger areas is only possible for 20% of ger households without its collapse.

The "Strategy for a Northeast Asia Power System Interconnection" was first put forward at the concept level in a regional conference on the power system interconnection held in November 2012. It is now the subject of Technical Assistance TA 9001-MON and Project Number 48030-001 funded by the Asian Development Bank.[68] In the medium term, it may make it possible to greatly increase the electricity available within Mongolia. At present there is no such interconnected power market in Northeast Asia, even though it is home to some of the world's largest and most prosperous economies.

Mongolia is in a unique position to spur economic growth by developing its vast renewable energy resources to meet the power demands of its more prosperous neighbors as a power supplier, while improving power security and driving sustainable development within Mongolia. The proposed regional power system interconnection would be an ideal and comprehensive solution to reduce power system carbon emissions in the PRC, Japan, the Republic of Korea and Russia. The power system interconnection would allow the existing decrepit transmission line infrastructure in Mongolia to be upgraded, which Mongolia cannot afford on its own.

The ADB is undertaking a comprehensive analysis and will chart out a clear strategy for Mongolia for power system interconnections in Northeast Asia. Mongolia has tremendous renewable energy potential, especially wind and solar. Its wind and solar power potential are estimated to be equivalent to 2,600 gigawatts of installed capacity, or 5,457 terawatt-hours of annual power generation (equivalent to 27% of global electricity consumption in 2014). If one-third of this wind and solar potential was exploited, Mongolia could supply about 25% of the combined annual electricity demand of the

[66] https://globalnews.ca/news/3865485/canada-uk-phase-out-coal-provinces-want-out/
[67] https://www.thelocal.de/20190126/germany-should-phase-out-coal-mining-by-2038-commission

[68] https://www.adb.org/projects/48030-001/main#project-pds

PRC, Japan, and the Republic of Korea. Using abundant and diversified resources, Mongolia could serve as a power supplier to neighboring countries, while improving power security and driving sustainable prosperity domestically. The Northeast Asia Power System Interconnection would be an ideal and comprehensive solution to reduce power system carbon emissions in Northeast Asia. An interconnection by low-loss, high-voltage direct current transmission lines would allow transmission of electricity from Mongolia to demand centers in neighboring countries, as well as allowing these countries to exchange power with each other.

Mongolia's Energy Geography

To understand Mongolia's energy needs, it is important to look at its energy geography. Mongolia is divided into five regions, (i) central, where the capital city (Ulaanbaatar) is located, which dominates in terms of population and nominal GDP, and had a poverty rate of 24.8% in 2016,[69] (ii) northern, with the second largest economy after Ulaanbaatar, (iii) southern, with the smallest population with significant mining development activities, (iv) western, where the poverty ratio is the second highest in the country (36% in 2016), and (v) eastern, where the poverty ratio is highest (43.9% in 2016).

Similar to its geographic division, the power network is made up of four systems: (i) the Central Energy System, the largest system covering northern, central, and southern Mongolia (with a peak demand of 975 megawatts (MW), (ii) the Western Energy System (with peak demand of 32 MW), which covers Bayan Ulgii, Uvs, and Khovd aimags, (iii) the Altai-Uliastai Energy System (with peak demand of 15 MW), which covers the middle-western aimags such as Govi-Altai, Zavhan, Bayankhongor, Arkhangai, and Huvsgul, and (iv) the Eastern Energy System (with a peak demand of 36 MW), which covers Dornod, Sukhbaatar, and Khenti aimags.

Mongolia's Energy Economics

Mongolia's dependence on certain forms of energy is a result of its geography, but also of the natural resources at its disposal and its economic development.

A major study carried out in 2013 by the ADB stated the following, which still remains true today:[70]

"Coal is a dominant source both in primary energy (70% for Mongolia, 66% for the PRC and 22% for Japan) and secondary energy - electricity and heat generation (over 95% for Mongolia). There is no natural gas available in Mongolia and all refined oil is imported, mainly from Russia with some minor imports from the People's Republic of China (PRC), and South Korea."

In the economic chain which provides Mongolia's coal at the power sector level, the industrial and factory level, the commercial level and the residential level, surprisingly, it is only the coal being consumed in stoves in the "ger districts" for heating and cooking where the costs are fully recovered. The end-user charge for raw and brown coal delivered to gers is equivalent to $40 per ton,[71] based on total sales of 700,000 tons per year, or total revenue of $48 million in the case of Ulaanbaatar only. This corresponds to 106,000 small, detached houses, 88,000 gers and 1,800 high-end detached houses or a total of 195,800 households.[72] There are approximately 215,150 ger households (2018) in the ger districts and 3,200 HOBs in Ulaanbaatar with air pollution problems. The total consumption of coal to cater to the electricity and heating needs of all households in Ulaanbaatar is between 3.5 and 5 tons of coal per ger household. Revenue at a price of on average 100,000 MNT (US$40) per ton would be approximately 120 billion MNT ($48 million) per annum.[73]

[69] Data on poverty: http://www.worldbank.org/en/news/press-release/2017/10/17/2016-poverty-rate-in-mongolia-estimated-at-296-percent

[70] Executive summary, "1. _TA 7619_MON_Executive Summary_Final.pdf", page 26 of 35

[71] $40 per ton is the approximate world price per ton of coal (https://www.eia.gov/energyexplained/index.cfm?page=coal_prices).

[72] First quarter report formatted 2017 4 14.pdf drafted by the World Bank, page 7/47 that according to statistics for 2016, approximately 88,000 gers, 106,000 small detached houses and 1,800 high-end detached houses were registered within the ger area of Ulaanbaatar and that over 700,000 tons of coal was being used for heating on an annual basis.

[73] There are 435,990 stoves in Mongolia, including wall-stoves built using bricks and ceramics etc according to the Mongolian State of Environment Report 2015-2016. The households in other urban centers use less coal than households in UB. The total coal consumption by households was estimated to be 1.2 million tons per year based on this report.

The ger area market for coal is the exception in terms of cost recovery in Mongolia. The prices paid for coal by other consumers, according to the "Coal Prices & Consumption of Heat Generation by LHs (License Holders) and RBoACC (Regulatory Boards of Aimags and Capital City/Municipalities)"[74] vary from a low of 8,800 MNT ($3.63) per ton to a high of 72,900 MNT ($30) per ton.[75] The total amount paid by this latter market, according to "Receivables & Payables of Energy Companies",[76] totaled approximately 6.9 billion MNT ($2.85 million). This equates to an average cost of $5.58 per ton vs. the $40 per ton paid by the ger districts. In fact, it is over seven times higher. Households with the lowest incomes pay an even higher price ($50-60 per ton) by buying coal by the bag.

In contrast, subsidies paid to the energy companies by the GOM[77]in 2016 amounted to 16.3 billion MNT ($6.84 million).

The economic chain providing coal within Mongolia is made up of a few large enterprises, a number of small enterprises and a very large number of micro-enterprises. Their estimated annual business volume is approximately $48 million per year in the market made up of the ger districts and a market of $2.88 million for the remaining coal consumers. If the reforms recommended in this report are implemented and prices for coal are charged in a more equitable way, this latter market could grow to approximately $20.65 million, or a total market size of approximately $68.65 million per year.

The active population of Mongolia was employed as follows in 2016: 4.1% in mining sector, 15.9% in trade and 4.1% in transportation and communications.[78] As of December 2017, the working age population in Mongolia was 1.67 million,[79] thus approximately 56,000 Mongolians are employed in mining of which it is reasonable to assume that about 50% work in coal mining, thus about 28,000.

Assuming a third of the working population earns its living transporting coal, including at the micro-enterprise level, this would be a further 18,000. The trade sector totals 265,000 and assuming that 5% were intermediaries in the coal business; this comes to a further 13,000.

Thus, it is reasonable to assume that, together with the rest of the coal market, approximately 59,000 people earn their livelihoods in the coal sector in Mongolia, together with their families, totaling about 295,000 people or 10% of the population. Considering the ban on raw coal, the government should be mindful of those who depend on the sector. As a short-term goal, we recommend that the government considers alternative employment and retraining programs for those affected. Retraining could include learning how to install, fire and start-up and to repair new efficient stoves; recycling or upgrading older stoves and learning about regulations, including new standards and be engaged in support of the raw coal ban enforcement. Training in trading of new energy sources, such as natural gas, improved fuels such as briquettes, and semi-coking coal would have the added benefit of increasing awareness of the transition to cleaner fuels.

Space is very limited in the ger districts and to spread out the financial burden faced by a household, there is an average of four deliveries per year to each household, a total load of about 0.69 tons in each shipment. Total deliveries are about 1.7 million per year.

Full cost recovery in the ger district is the exception in Mongolia; all other consumption of electricity and heat results in deficits which the Mongolian government is obliged to cover. These deficits currently amount approximately US$7 million in 2017, approximately 0.06% of GDP.

[74] See "2016 Statistics on Energy Performance", published by the Energy Regulatory Commission of Mongolia, page 12
[75] This booklet is available from the Energy Regulatory Commission of Mongolia and a copy was given to those carrying out this mandate at a meeting with them on November 30, 2017. This is on total sales of 516,200 tons per annum according to the booklet.
[76] Ibid page 38
[77] Per "State and Subsidies to Energy Companies", as documented on page 42 of the above booklet.

[79] https://www.ceicdata.com/en/mongolia/labour-force-survey-population-by-economic-status/population-labour-force-economically-active-employed

At the international level, while Mongolia is a net energy and coal exporter, the current tariff structure is “tariff insufficient” (see Appendix 5). In addition, in the long run, energy tariffs also need to price in externalities caused by the extraction and burning of fossil fuels. This will alter current investment decisions, overall favoring the comparative advantages of renewables relative to the current and future exploration and burning of domestic coal.

Importantly, tariff inequality must be addressed through the Government policy. The poorer ger areas, where the costs of fuel are recovered in full must be supported. With the implementation of the reforms recommended in this report, cost recovery can be achieved elsewhere in the country, providing more fiscal space for support of ger residents, whether in the form of housing subsidies, heating subsidies if switching to alternative or less harmful sources of energy, creating a balancing out of payment for energy throughout the country. The Mongolian government covers the current deficit in other areas from its budget and it can do so for ger residents if appropriate energy tariffs are applied throughout the country.

5.3. Future Policy Steps for Reducing Air Pollution: the NPRAEP

In March of 2017 the GOM adopted the new program relating to reduction of air pollution, the "National Program for Reducing Air and Environmental Pollution" (NPRAEP). The potential importance of the NPRAEP cannot be understated.

The NPRAEP aims to address the challenges of increasing levels of air and environmental pollution in Mongolia and of ensuring a healthy and safe living environment for its citizens. Its actions must anticipate a cleaner environment for future generations. Anticipating such a shift, rather than backward-looking policy design will make the implementation of new policies smoother, less costly and easier to implement.

The program is to be implemented in two phases; the first covers the period 2017-2019 and the second 2020-2025.

The most significant target is the reduction of air and environmental pollution by 80% by 2025 compared with the baseline year of 2016. The activities included in this plan are estimated to require expenditure of 9.8 trillion MNT (roughly $3.7 billion).[80]

This figure is higher by several magnitudes as compared to previous efforts and is most likely unrealistic. Between 2008 and 2016 total public spending amounted to around 147 billion MNT from the state budget plus $60 million equivalent in foreign aid. During those same years, average annual spending was over $12 million – see Section 3.1 above). The forecast NPRAEP cost of 9.8 trillion MNT (roughly $3.7 billion) assumes vastly larger expenditures.[81] If this new program were to be fully implemented the annual average cost could reach 1.1 trillion MNT (over $450 million).[82] Currently, confirmed funding falls substantially short of what is required. The GOM hopes to acquire the remaining funds from the following sources:

- Loan and grant assistance from international financial institutions and other development partners
- Private sector funding
- Other sources such as Public Private Partnerships when conditions allow

The NPRAEP has five main objectives (see Table 5.1 above) along with their projected costs. The most significant of these objectives is (2):

Table 5.1. *NPRAEP Cost Breakdown by Program Objective*

#	NPRAEP Objectives	Estimated costs (billion MNT)	Share in total (%)
1	Improvement of air and environment quality in cities and urban centers by implementing effective policies in urban planning and development, infrastructure development and decentralization through local development	1,810.8	18.5%
2	Reduction of pollution sources through introduction of environmentally-friendly and advanced technologies, step-by-step banning the use of raw coal and restricting the use of polluting substances	7,764.6	79.1%
3	Undertaking comprehensive measures towards reducing vehicle emissions	107.0	1.1%
4	Clearly defining the management, coordination and financing of the air and environment pollution activities and setting up an incentive system for air and environment pollution reduction activities	98.1	1.0%
5	Increasing citizen's participation and accountability in reduction of environmental pollution, cultivating healthy living habits and attitudes and strengthening the capacity of environmental quality monitoring and analysis	30.6	0.3%
	TOTAL	9,811.1	100%

Source: Ministry of Environment and Tourism, 2018

[80] Current exchange rate of MNT2640= $1 was used for conversion

[81] Note that the study team has not validated the workings behind the NPRAEP costs provided to us by the GOM and has taken them at face value. We recommend that the NPRAEP needs to be reworked and fully re-costed as part of the next steps in the air pollution reduction program as part of the work of an independent planning group which also forms a key recommendation of this study.

[82] Average exchange rate of MNT to USD of the Bank of Mongolia from Jan-Aug 2018 was used for conversion

"Reduction of pollution sources through introduction of environmentally-friendly and advanced technologies, step-by-step banning of the use of raw coal and restricting the use of polluting substances".

This alone absorbs 79% of the NPRAEP's $4 billion budget.

Linked to the NPRAEP's 5 goals are 25 evaluation criteria which are shown in Appendix 1 with short comments on their impact on environmental outcomes. Each target is separated into a short-term target for 2019 as well as a medium term target up to 2025. Th e most significant target is to reduce particulate matter (PM) 2.5 to 70 мg/m3 by 2025, to be implemented by MET and Ulaanbaatar Municipality. Appendix 1 provides the definition for each evaluation criterion, the 2016 baseline, the 2019 and 2025 targets and the responsible institutions. Breaking down the targets of the NPRAEP further, over 200 specific actions are included. The targets range from high-impact measures to reduce air pollution, (e.g. within the ger area housing development program, connecting ger area energy consumers to central heating systems, planning, designing and construction green buildings for energy efficiency and measures to reduce air pollution from vehicles) to actions with low impact, or those which are unaffordable or unrealistic or not directly related to air pollution reduction actions (such as a highway to the new airport and a 500-km cement road).

For the purpose of this report, the effectiveness and efficiency of the NPRAEP has been assessed based on data available from respective government agencies.

To provide an overview and to start to build a first cost-benefit analysis (CBA) of the NPRAEP, this report separates the over 200 actions into 27 groups (groups of actions) which are shown in detail in Table 5.3. A few remarks are required to interpret this table: first, while the goal of Table 5.3 is to evaluate each group of actions based on its cost and impact for air pollution reduction, many of the actions have other goals (i.e. to reduce other pollutants or restructure the economy, make transportation more efficient, etc. even though they have indirect link to reducing air pollution).[83] Because of these other goals within the NPRAEP, detailed remarks on conditionalities and the importance of actions relative to air pollution reduction have been included in the last two columns of (see Appendix 2). Within this analysis, each action-group has two main indicators: (i) impact and (ii) affordability. The "ranking" for each group of actions was done by using the "sum of both scores", and the total score and the rank of each "Group of Action" further condensed in Table 5.2.

For further analysis, an additional more detailed description and impact analysis of specific measures is included as Appendix 1. This appendix compares the costs of various parts of NPRAEP actions with their potential benefits, summarizing their potential impact on air pollution in greater depth. The affordability of such measures is an altogether different issue: the cost of the NPRAEP schemes proposed is often prohibitive in the light of the current economic landscape in Mongolia. However, it is essential to finance these measures so that they can be implemented at some point. This is considered further in Section 5.5 on Fiscal Space. Because of the issue of affordability, prioritization is essential to consider those actions that are both cost-effective and have significant direct impacts on air pollution reduction as the top priority for health and environment.

Appendix 1 discusses each element in the NPRAEP from the narrower perspective of air pollution reduction only.

As shown in Appendix 1, one of the important initiatives is the provision of apartment housing to replace ger area in the long-run. Affordability ranges widely, from low-cost to high-cost actions. Planned measures, such as the prohibition of the burning of raw coal and the use of alternative fuel

[83] The NPRAEP looks at environmental pollution in its wider sense as opposed to air pollution in isolation. However, there are often integral links between the two. Given the large amount of detail included and the importance of the NPRAEP in a strategic sense to air pollution reduction, detailed comments on the various activities and their likely effect on air pollution are included in the last two columns of Table 5.3.

sources are costly to enforce and unless properly monitored will have a very limited impact on air pollution. Capacity building for appropriate monitoring and enforcement is thus key to their success.

There are no close links between various actions regarding the reduction of air pollution. It is not clear how different energy alternatives (coal, improved fuels, electricity, renewables and gas) to ger households are interrelated and integrated. This deficiency may be because there

Table 5.2. *NPRAEP Cost Breakdown by Program Objective*

Groups of Actions	Reference in Appendix 1	Impact	Affordability	Total score	Ranking
Highly ranked actions					
Housing developments in ger district (assuming that additional funding to that of the NPRAEP will be provided by the private sector for construction of residential buildings and houses)	3	5	4	9	1=
Improved building/ger insulation and greening buildings	13	4	5	9	1=
Coal gasification	16	5	3	8	2=
Connect consumers to central heating supplies (assuming that the infrastructure needed is possible and more ger area HHs use electric heaters, instead of coal)	5	4	4	8	3=
Gas supply master plan (assuming that this will lead to a change in energy mix and significantly increase the gas supply)	26	3	5	8	4=
Environmentally friendly buildings	12	3	5	8	4=
Revise and enforce environmental measures and standards	18	3	5	8	4=
Reduce pollutants from vehicles	22	3	5	8	4=
Environmental monitoring and awareness building	27	3	5	8	4=
Mid-ranked actions					
Expanding heating supply and extension of grid of 10 aimags	14	5	2	7	10=
Use of alternative energy/fuels for trains	17	2	5	7	10=
Development of standards for home appliances and gas heaters and establishment of 'Green Fund'	21	2	5	7	10=
Establish environmentally friendly technology and exhibition center	20	3	4	7	10=
Green urban planning initiatives	8	2	5	7	10=
Protect river systems and surrounding areas	9	2	5	7	10=
Reduction in tariffs etc.	11	2	5	7	10=
Establish Anti-Air Pollution Fund	24	3	4	7	10=
Improved institutional and methodological arrangements	25	2	5	7	10=
Prohibition of raw coal and use of alternative fuel sources (if we exclude the 500-km cement road from this group, the ranking of this action will be moved up to "1" (high ranking actions)	10	4	2	6	19=
Roads, production and mining	7	3	3	6	19=
Improvements to sanitation and other facilities	6	2	4	6	19=
Environmental protection research and development	19	3	3	6	19=
Improved road fuels and network	23	2	4	6	19=
Low-ranked actions					
New forms of heating for the ger district	4	3	2	5	22=
Extension of power transmission/distribution network (to connect over 200,000 households to be able to use electric heaters)	2	3	1	4	23=
Improved environmental actions: water supply, garbage collection, waste disposal, recycling	15	2	2	4	23=
Human settlement development	1	2	1	3	27=

Source: GOM, Action Plan of the NPRAEP

is no updated and relevant Energy Master Plan, last updated in 2013. Importantly, a new and independent[84] Energy Master Planning mechanism should be put in place to provide this information in the near future. The Energy Master Plan must be regularly updated and monitored.

There are also no independent reports evaluating the effectiveness of air pollution reduction efforts in the past. The exception is the independent evaluation reports for an MCC-funded energy efficient stove project. This lack of documentation, too, must be addressed in the future in light of the development of the NPRAEP.

Overall, the NPRAEP sets ambitious targets and high expectations of performance. As an aspirational document it is extremely important. However, the lack of rigorous costing, of detailed cost benefit analysis to justify each activity and the almost certain impossibility of funding so large a program reduces its practical usefulness. For example, the total funding used for measures including energy efficient stoves, supply of improved fuels, expansion of the heating network and investment in CHP4 to reduce ash and smoke was over 143 billion MNT plus $60 million (144.5 billion MNT at the exchange rate of 23 May 2018)[85] with an annual average expenditure of 32 billion MNT. In comparison, the air pollution reduction target for 2017-2025 is 80% and the annual average funding required for NPRAEP implementation is 1 trillion MNT.[86]

This air pollution reduction target is thus lower compared with the baseline year than the previous program of action. However, the funding required for implementing the NPRAEP (funding only air pollution reduction-related actions) is 30 times higher than the funding expended on previous efforts from 2008 to 2016. This seems to suggest that the NPRAEP is not cost efficient compared to 2006-2016 air pollution reduction measures.

To assess cost efficiency and chart a concrete path forward, we recommend that the government undertakes a cost benefit analysis of future programs and projects for reducing air pollution. This will ensure that actions are prioritized and rightly sequenced. Such an analysis must also take into consideration main factors such as impacts and affordability which are fundamental to successful implementation of programs and achieving set targets.

While this program can be used to mobilize additional resources, it should also be designed based on a realistic expectation of available resources, given likely macroeconomic trends and the full range of government spending priorities.

Detailed analysis of linkages between air pollution and poverty in Ulaanbaatar would provide a clearer picture about how much support is needed for ger district residents.[87]

[84] Independent of the Government
[85] Will become lower if an exchange rate of the days in which the expenditures were incurred is used
[86] Majority of funding of NPRAEP (About 90%) is planned to be spent for air pollution reduction purposes

[87] Participants in the National Forum on "Air Pollution Reduction" (October 2017) recommended measures that are linked to the housing program and housing mortgage schemes.

Box 5.1. *High Level Recommendations on NPRAEP*

The program as a whole and each action/measure within it would be improved if designed as follows:

- Program goals and targets
- Regulatory aspects (laws, other legislation, including standards); does an appropriate current legal basis exist or should one be created?
- Appropriate and most cost-efficient air pollution (environment) reduction measures/actions prioritized, properly sequenced and costed to achieve their goals and targets
- Supportive actions (research and studies, monitoring and evaluation of policy measures, public awareness and knowledge-building activities) need to be a part of the program
- A results and monitoring framework to assess the progress and expected results/impacts of the program where actions and targets are linked
- Financing mechanisms (sources of funding) are available or can be mobilized in the form of an Integrated Financing Framework"

The urgent need for prioritization and the correct sequencing of actions to achieve the set targets means that the following questions must be answered when defining the prioritization of policy measures:

- Does this measure have an impact on reducing air pollution? If yes, how much will it contribute to achieving the desired results?
- Is this action realistic? Are funding sources available or can they be mobilized?
- How can this action be cost effective?
- Is this policy action linked to long term policies of the state, including Mongolia's sustainable development?

The prioritization of air pollution reduction measures outlined in NPRAEP can be guided by the following:

- Actions that have a high impact on air pollution reduction in general through achieving energy efficiency;
- Actions that are most likely to succeed and fit Mongolia's long-term energy sustainability goals;
- Actions that are cost effective;
- Actions with readily available funding sources or committed funding sources

Actions in the NPRAEP could also be divided into:

- Short-term measures
- Medium-term measures
- Long-term measures

These actions need to be integrated into one overall framework of financing; an "Integrated Financing Framework for Air Pollution Reduction" to ensure that all actions are funded in a timely manner by appropriate funding sources. In addition to fiscal measures, non-fiscal measures should also be considered to increase the efficiency of use of public funds/funding sources in general. This can be done by improving respective legislation and law enforcement. A fundamental issue here is the existence of strong institutions with optimal levels of capacity that are accountable and free of corruption.

The NPRAEP measures are ranked in Table 5.3 and are analysed in Appendix 1.

The NPRAEP contains appropriate actions that could contribute to reducing air pollution in Mongolia, in the capital city in particular. However, the overall plan could include other measures that are fundamental to addressing the air pollution reduction problem. The program is incomplete with no prioritization or "right sequencing" of measures and actions and no close links between actions and targets. Without addressing these shortcomings, the goal of reducing air pollution by 80% over 8 to 9 years is not realistic. All air pollution reduction actions must be closely linked with the targets to be achieved in the short-to-medium term as well as by the end of program implementation. An updated and revised NPRAEP should then be adopted by Parliament. In the meantime, the GOM should prioritize lower cost/high performance actions in the ger districts such as cleaner stoves and improved fuel initiatives. This is one of the few short-term options available within the limited fiscal space against the funding required in the upcoming 6 to 7 years without

jeopardizing the country's long-term sustainable development.

The Recommendations in Chapter 7 below highlight the most "appropriate" and fundamental concrete actions in order of priority that could help Mongolia achieve its ambitious air pollution reduction targets by 2025.

5.4. Energy Options for Mongolia

In addition to the NPRAEP analysis, this section discusses additional specific policy and technical suggestions for Mongolia and presents their associated costs and benefits. Three main studies carried out in this area have been reviewed: the World Bank (2011) study, the JICA (2017) report and the cost and benefit analysis (CBA) by Enkhtsolmon, Matsumoto and Tseveen (2016). The key results of these studies were summarized and the results of JICA (2017) vs. World Bank (2011) were compared. After summarizing the CBA by Enkhtsolmon et al. (2016) the report provides a CBA of preferable cost-efficient energy policy options for Mongolia with number of additional energy options.

Cost and Benefit Analysis of Energy Options

The following sections summarize policy options that were studied by the World Bank (2011 and 2017) and by JICA (2017). Comparing these different scenarios is important in order to understand the cost effectiveness of these policy options, to prioritize them and to appropriately sequence these actions over time.

The World Bank project explored the cost effectiveness of reducing particulate emissions. As this section may attract considerable attention among policy-makers in Mongolia, it is necessary to reinforce the point that there are still considerable data limitations. Details of these can be studied in the JICA (2017) and World Bank (2011 and 2017) reports where a number of key assumptions[88] had to be made in these reports.

The World Bank report performed a cost analysis using eight scenarios against the baseline. The following four scenarios were found to be important for this report:

- Using cleaner/energy efficient stoves without changing the fuel/raw coal
- Using cleaner/energy efficient stoves with improved fuel/semi-coking coal
- Using electricity for heating by installing electric heaters in gers
- Relocation of ger area households into apartments

Costs have been estimated for each of the above intervention scenarios, as well as the incremental benefits relative to the baseline situation. The goal of this analysis was to determine which of the intervention scenarios is most cost-effective.

The main findings of the World Bank report on the specified scenarios are described in Table 5.3.

Table 5.3. *Comparison of Cost and Benefit Analysis for 4 Selected Scenarios, (million $US)*[89]

Select scenarios	$ per ton PM reduction	Investment costs (million USD)	NPV of costs of implementing the option	NPV health benefits (NPV costs)	Cost/Benefit
Clean stove	-4.6	8.1	-0.36	1846.8	1846.4
Clean stove+semi-coking coal	632.7	57.5	42.2	1140.9	1183.2
Electric heating	8,654.5	1,337.9	1622.1	452.0	2074.1
Relocation into apartments	51,682.2	4,776.5	4709.8	-4022.9	686.7

Source: World Bank, 2011

[88] Two assumptions are exemplified as follows, for details please refer to the WB and JICA reports:

a) The analysis that follows does *not* study the benefits, only the costs needed to realize each of the scenarios for reducing emissions. Benefits are simply assumed to be approximately equal in terms of health benefits of the PM_{10} reduction from the literature, but do not incorporate many of the co-benefits of the consumer surplus from more expensive/cheaper and more efficient heating, the market that it creates or destroys and the various transaction cost/benefits.

b) As a second example, we take the WB scenario (5) of relocating a household from a ger to an apartment. It was modeled on a reduction of PM emissions by almost 100%. However, as the WB itself self-critically describes in footnote 16, this is unrealistic as the current electric grid and load capacity is unable to support the move without massively increasing coal fired power plants, which will necessarily increase pollution. For other assumptions, we need to refer the reader to the details of the previous reports. Besides these limitations the JICA and the WB reports provide steps for a cost analysis available for UB. Here we intend to summarize the key findings.

[89] The CPI calculator was used to convert 2010 $US to 2018 $US

For this table, figures in $US in the 2010 World Bank report were converted into August 2018 $US using an inflation calculator. The descriptions of these selected scenarios are presented in Appendix 6.

These findings suggested that "Clean stove only" and "Clean stove + semi-coking coal/improved fuel" options are less costly and have higher net benefits compared with the other two options. However, the estimated cost/benefit ratio indicates that the use of electricity for heating in gers has the highest health benefits through PM emissions reduction; the relocation of ger area households into apartments has the lowest net benefits. The costs of implementing the latter option are extremely high due to the huge investment required and can only be realized in the long term.

Cost and benefit considerations are one of the main and essential factors for selection of air pollution reduction measures. However, there are other factors, including technical feasibility in Mongolia, affordability from the perspective of both the GOM and consumers, program implementation capacity, governance-related issues and social acceptance.

Table 5.4. *Main Results of Cost Effectiveness Analysis of PM Reduction Measures*[90]

Control Measure	Reduction of PM10 (ton/year)	Initial cost of control measure (in USD)	Control measure cost per ton (in USD)	Durable year	Control measure annual cost per ton (in USD)
Introduction of improved fuel	3,758.6	7,233,699.1	1922.5	1	1922.5
Relocation project	2,762.5	847,423,588.1	306,749.7	30	10,227.8

Source: JICA, 2017

Similarly, to the World Bank report, JICA also conducted different scenarios to reduce PM. The introduction of improved fuel to ger area households and the promotion of apartment construction in ger areas were the options that we found most relevant to this report. The report reveals that the use of improved fuel/semi-coke briquettes can reduce condensed dust/PM by 63.75%. It is recommended that improved fuel is a necessary measure in reducing air pollution in Ulaanbaatar (see Table 5.4).

The World Bank and JICA reports present highly valuable efforts towards understanding the sources of air pollution and prioritizing different policy options. The reports also encourage the GOM to further support similar studies to test various policy and technical options for ger areas of Ulaanbaatar, where 60% of PM and 51% of CO emissions take place.

They conclude that cleaner stoves and improved fuel actions should be continued as a short-to-medium-term solution. In parallel, testing and piloting of cleaner and more efficient stove and fuel technologies should continue in Ulaanbaatar. To create fiscal space for these actions, subsidies for the energy sector should be gradually reduced and air pollution taxes increased. Eliminating subsidies will not only create fiscal space (to be used for helping bridge the cost difference for affected households) but also directly reduces this problem, which is the price difference in favor of coal. The resulting financial resources should be invested in piloting different technologies and implementing the actions mentioned above.

Another CBA of policy options was undertaken in 2016 (Enkhtsolmon, Matsumoto and Tseveen) which covers the following three scenarios:

- Relocation of ger area households into apartments
- Using electricity/electric heaters for heating
- Connecting ger area households to the central heating system

The CBA considers period of 2014 to 2020 and it divides the city into its distinct regions for the analysis:

Option 1 applies to 59,084 households living in the city center. The proposed option is relocation into apartments.

Option 2 applies to 124,769 households living in mid-tier and fringe areas in gers. The proposed option is the use of electric heaters instead of coal stoves.

[90] The costs in this table expressed in $US by converting figures in MNT of 2017 to 2018 MNT using Mongolia CPI and then converting it to $US using 2018 average exchange rate of MNT to $US.

Option 3 applies to 17,500 households living in small detached houses in the mid-tier ger area. The proposed option is the connection of those households to the central heating system.

The main findings of this analysis are presented in Table 5.5 below.

Table 5.5. *Main Results of Cost and Benefit Analysis*

Options	Average emission reduction (%)	Investment costs (in million $US)	Number of HHs to be involved	Health benefits (in million $US)	NPV (in million $US)
Relocation	13	2103	59084		
E Heating	22	498	124769		
Central Heating System	5	24	17500		
Combined	41	2625	201353	301.6	-1499.7

Source: Enkhtsolmon, et al. 2016

The study findings stipulate that all three options can be seen as possible air pollution reduction options with 41% of combined pollution reduction impacts, but with different timelines over seven years. Option 1 is a long-term measure as the construction of new apartments will take time to accommodate about 60,000 households and requires a large investment. Also, there is an affordability problem as most households in gers are low-income earners.

The use of electricity has the highest air pollution reduction benefits, and consequently the highest health benefits. However, the cost of electric heating is significantly higher than the cost of heating with coal which leads to increased pressure on the budget to increase energy sector subsidies to cover the price difference. In addition, a large investment is required to expand electricity generation and its transmission and distribution system, although the initiative to create a Northeast Asia Power System Interconnection may greatly help in achieving this. Connecting a small proportion of ger area households to the central heating system is a possible option if the expansion of central heating systems can be achieved in the short-to-medium term.

In the following section we briefly examine other policy options that were discussed by the study team, but only provide general remarks without a formal CBA or cost-effectiveness analysis.

Use of Electricity for Heating

The above CBA analysis of the NPRAEP, the World Bank Reports (2011 and 2017) and the CBA by Enkhtsolmon et al. (2016) indicate that the use of electricity for purpose of heating in Ulaanbaatar is not a feasible option in terms of reducing air pollution. No nation with an Arctic climate[91] has ever attempted to do so. Nevertheless, electrification has many other co-benefits to boost the economy. We therefore recommend that electrification be continued in the short term, also within the ger districts, especially those closest to the urban center of Ulaanbaatar. While the investment costs and benefits of the various studies are wide-ranging, i.e. a cost of $88 million to expand the transmission lines in the NPRAEP, $1.2 billion in the World Bank (2010) scenario and $498 million in the Enkhtsolmon et al. (2016) scenario, we recommend putting aside a significant state budget in the short term for this development. For example: the attempt to use electricity for heating through the use of 4 kW electric heaters in 220,000 households in ger districts can be difficult to sustain in a country with such a long and cold winter. It would require approximately 1,750 MW in additional generation, costing approximately $8 billion[92] and approximately $5 billion to strengthen transmission and distribution systems.

In terms of renewable energy, wind and solar energy are variable, wind often falling to zero on the coldest days and solar electricity generation unavailable at night. They need to be backed up by a firm source of electricity, i.e. a thermal power plant controlled exclusively by human inputs and not depending on wider environmental factors. In Mongolia's case this is likely to be coal fired; either pulverized coal or methane produced by the gasification of coal if there is a technology that is feasible for Mongolia.

The findings of the Ulaanbaatar Clean Air project point out that the recent GOM-approved

[91] https://www.wecc.biz/Reliability/1210_BV_WECC_TransCostReport_Final.pdf for relevant unit cost information

[92] https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capcost_assumption.pdf (per page 6, for a "Pulverized Coal Greenfield" power station, the estimated capital cost in 2016 is $US4,620 per kilowatt)

electricity night tariffs adjustment for 'ger district' residents, reduced to zero during the winter months to promote non-coal heating solutions in the city would consume 80% of the state budget for air pollution reduction in 2017 (World Bank, 2017a). And this is only when providing electricity for heating to a small percentage of the total number of gers. The World Bank comments in the same section that "it is not certain that the electricity distribution system in ger areas can support a large shift to electric heating". This approach is one of multiple solutions and should only be used for those households that use electric heaters.

Renewable energy could meet some of the load, but about 80% of the generation would need to be from firm sources, meaning the use of coal through one technology or another. All types of power stations cannot suddenly increase their output when generation is suddenly lost elsewhere in the system. In the case of Mongolia, only thermal power stations can keep the country from blacking out when generation is lost elsewhere.

The thermodynamic cycle in thermal generation means that approximately 40% of the heat is lost before the electricity leaves the power station. Some of these losses could be avoided if combined power/steam producing units are included.

A decentralized approach to providing electricity for load growth can lower the need for redundancy. In a country such as Mongolia failure in the supply of electricity would result in the freezing up of central heating systems, making it impossible to return them to service when electricity was restored. This would possibly result in deaths and economic damage. Decentralized heating options could include distributed generation of electricity (for, example, using renewables or hybrid systems), or distributed heating (for example, using geothermal heat pumps or CHPs burning biomass or biogas). Pre-feasibility or feasibility studies should be undertaken to determine which technologies are the most viable in technical, financial and economic terms. A number of studies funded by the multilateral lending banks and other donors already offer some direction on which technologies are most promising.

Today, no developed country is adopting a decentralized approach to its power system. On the contrary, the Americas and Europe are adopting a continent-wide approach to increase the reach of the interconnectedness of their power systems, in order to reduce costs and increase the reliability of their power systems. The more advanced coverage of energy networks in developed countries does not provide any compelling reason to decentralize. However, for many developing nations this is a valuable approach to provide energy to isolated communities spread over vast territories.

Geothermal Energy and a Decentralized Approach to Heating Gers

The application of geothermal energy and a decentralized approach to heating the ger districts could conceivably play a role but would first need to be thoroughly examined.

Previous initiatives with geothermal energy developed a bad reputation after unsuccessful attempts to implement this technology in communities within the Ulaanbaatar area. Discussions with stakeholders suggest that there may have been deficiencies in both the efforts made and the governance arrangements around them with the required water wells not being drilled to the appropriate depth. However, the most obvious and promising geothermal heat sources are not located in the close proximity of larger cities; otherwise, these potential resources would be attractive for combined heat and power operations.

Government should make use of the studies already completed by multilateral lending banks in this area and undertake additional pre-feasibility or feasibility studies as needed to assess the technical, economic, and financial viability of such technologies.

JICA is nevertheless interested in the application of small-scale geothermal energy for schools and greenhouses and could provide further information on the viability of this approach through the on-going research and testing. However, while the geo-thermal energy

generation is potentially viable in the long-run, in our view, there could be other immediately beneficial approaches as discussed in this report.

Gasification of Coal

Mongolian Coalbed Methane gas reserves are estimated to be 3.2 trillion cubic meters (m^3) in size (Otgochuluu and Bold-Erdene, n.d.) compared to natural gas reserves in the USA totaling 10 trillion m^3,[93] thus the reserve is hugely significant.

The gasification of coal is a well proven technology; but it is not competitive when the same methane is available in the form of natural gas at a low cost. The gasification of coal is a potential long-term solution if the technology and economics of this approach improves substantially.

There are more than 272 operating gasification plants worldwide with 686 gasifiers. There are currently 74 plants under construction worldwide that will have a total of 238 gasifiers and produce 83 MWth. Currently, China has the largest number of gasification plants. Coal is now the dominant feedstock and will continue to be so for the foreseeable future.[94]

Coal gasification can be part of an Integrated Gasification-Combined Cycle (IGCC) technology. In IGCC, coal is gasified and the gasification products are purified to remove acidic compounds and particulates before entering gas turbines generating electricity. Heat recovered from the gas turbine exhaust gas can then be used to generate steam to drive additional steam turbines generating electricity. The efficiency of an IGCC-based electricity generating plant is significantly higher than a conventional thermo power plant, which results in significantly less carbon dioxide being emitted per ton of coal consumed. This makes IGCC the preferred technology for reducing greenhouse gas emissions where it is not possible to switch to other energy sources with still lower carbon dioxide emissions.[95]

In the medium-to long-term, coal gasification could be a way to significantly reduce air pollution as well as GHG emissions. In the short-term, the Government should investigate the feasibility, cost, and impact on air pollution and GHG emissions of widespread adoption of coal gasification technologies, as a way to transition to cleaner-burning feedstock for electricity and heat generation.

This recommendation is consistent with both the NPRAEP analysis as well as the JICA recommendation on gasification of coal (JICA report 2011, p. 305). Not all experts agree on the viability. First, notably, Minchener (2013) has serious concerns on how to finance gasification in Mongolia (Minchener, 2013). Second, and more importantly, gasification is in direct conflict with the goals of the international climate treaties and the Paris Agreement. This means that the costs of coal gasification will be even higher if Mongolia pays the externality costs in terms of GHG from the gasification process.

Clearly, countries with access to reliable sources of low-cost natural gas would never proceed with the gasification of coal. Mongolia does not have reserves of natural gas and the Mongolian Government is justifiably hesitant to put itself in the strategically vulnerable situation of depending on its neighbors for gas imports. At the same time, it is important to continue to develop sustainable long-term relationships with neighboring countries, as ultimately the import of natural gas, at current prices, would be the more economical and much cleaner short-to-medium term option.

Status of Renewable Energy in Mongolia

Table 5.6 summarizes the different sources of energy in Mongolia.

Table 5.6. *Power for Heat and Electricity Only in Mongolia as of 2016*

Source	Total Annual Generation (GWh)	Percentage of Total Generation*
Combined Heat and Electricity Plants	5802.4	77.7%
Imports (Electricity Only)	1419.1	19. 00%
Diesel (Electricity Only)	3.8	0.05%

[93] https://en.wikipedia.org/wiki/List_of_countries_by_natural_gas_proven_reserves
[94] https://www.globalsyngas.org/resources/the-gasification-industry/
[95] https://www.thecanadianencyclopedia.ca/en/article/coal-gasification

Solar Photovoltaic (Electricity Only)	0.3	0.00%
Hydro Power (Electricity Only)	84.7	1.13%
Wind Power (Electricity Only)	157.5	2.10%
Total	7467.8	100

**Heat and Electricity, or Electricity Only*
Source: 2016 Statistics on Energy Performance drafted by the Energy Regulatory Commission of Mongolia

The GOM is committed to exploiting the country's renewable energy resources.[96] Mongolia's parliament set out energy production and supply goals for 2015-2030 with a target to increase the renewable energy share to 20% by 2020, 25% by 2025 and 30% by 2030.

The opportunities for exploiting these in practice are explored below.

Wind Energy

The Renewable Energy Law (adopted in 2007) introduced a feed-in tariff for wind power, currently set at 8-9.5 cents/kWh. This is currently not sustainable as the tariff for the sale of electricity is only 5.3 and 4.9 cents/kWh for, respectively, industry, commercial, institutional and residential customers.

The government has signed seven Power Purchase Agreements for wind projects, among them Mongolia's first wind project, the 50 MW Salkhit wind farm, which came on line in the summer of 2013 with the GOM covering the deficit.

Clean Energy Asia, a joint venture between Japanese developer SB Energy and Mongolian infrastructure investor Newcom are developing Tsetsii, a 50 MW wind farm. The Tsetsii wind farm is operational since late 2017[97] and is being supported with funding from the EBRD and JICA.

A financing agreement has been reached on the Sainshand project in the Gobi Desert – the third wind farm in the country. Sainshand, which will produce 54 MW of power, will receive a $120 million project financing package from a group of international investors and financiers and has a range of international and Mongolian contributors. The lenders have agreed to provide total project financing of $78.5 million.

Construction was completed in September 2018 and Sainshand's yearly output is expected to be 190,000 MWh, a capacity factor of 40%, very high for a wind farm.

Hydroelectric Energy

Mongolia's attempts to develop hydroelectric energy are dependent on its effective cross-border cooperation with Russia and China. Several rivers cross the border into either Russia or China. Mongolia badly needs to develop this hydroelectric potential which is both renewable and which has a much higher potential to provide baseload capacity (so called "firm energy") than either wind or solar. It is trying to resolve this problem satisfactorily with energy production approaches that are more beneficial to the air pollution reduction agenda.

The feed-in tariff for electricity generated and supplied by a hydropower station is between 0.045 and 0.06 cents/kWh.

In 2016 China's National Development and Reform Commission, the China EXIM Bank and the GOM placed a temporary hold on constructing the proposed 315 MW Egiin Gol hydroelectric project on the Eg River near Khatgal, Mongolia, citing concerns over transboundary issues and "due diligence" related to downstream environmental concerns. The hold remains in place. The project, which includes a dam, is estimated to cost $1 billion. Although Mongolia and China had agreed to build the hydropower station in Mongolia and the GOM approved feasibility studies for the project in 2013, according to several local and international reports in 2015, building the project could adversely affect Lake Baikal, which is downstream.

The hydropower project is located on the Eg River near its confluence with the Selenge River, the main source of Lake Baikal, the oldest (25 million years) and deepest (1700 m) lake in the world. It has a capacity of 25.6 million acre-feet

[96] For feed-in tariffs, see page 12 of http://www.carecprogram.org/uploads/events/2013/ESCC-Meeting-KAZ/005_104_209_Renewable-Energy-Development-in-Mongolia.pdf
[97] https://www.windpowerengineering.com/business-news-projects/mongolias-50-mw-tsetsii-wind-farm-begins-commercial-operations/

and contains 20% of the world's total unfrozen freshwater reserve.

The Egiin Gol project, if completed, could help Mongolia reduce annual payments of about $24 million to Russia for exported energy to Mongolia.

The second hydroelectric project proposed by Mongolia, Shuren, with an installed capacity of 300 MW (which would also provide water for Mongolia's mining industry) is also blocked due to concerns about its impact on Lake Baikal. The project is to be built on the Selenge River in northern Mongolia, its largest river. The project would also include building one of the world's largest pipelines to transport water from the Orkhon River. It would remove water from the affluence leading to Lake Baikal, unlike in the case of the Egiin Gol hydroelectric project, suggesting that Russia's concern in this case may be environmental and not just economic.

Solar Energy

In 2016, a 10-MW solar farm, built by the Japanese company Sharp Corp and partners, started power generation in Darkhan, northern Mongolia, one of the biggest cities in the country. The solar farm is expected to produce 15.2 million kWh, amounting to a capacity factor of only 17%, much less attractive than the Sainshand wind farm. Sharp is a supplier of solar modules and has announced plans to install 20 MW of photovoltaic capacity in Ulaanbaatar.

The feed-in tariff for solar power is between 0.15 and 0.18 cents/kWh.

In late 2017, the EBRD announced that it is to provide financing to Desert Solar Power One LLC for a 30-MW solar project in Mongolia. The plan includes a loan of up to $30.7 million which is pending final review. Construction of the solar photovoltaic farm near Sainshand city in Dornogobi Province is expected to start in 2019 at a total cost of $47.5 million.

Energy Storage

For successful implementation of the 20% and 30% renewables targets by GOM, it is of upmost importance to be aware of the "intermittency" problem. Renewables such as wind and solar power typically generate energy only during certain time windows of daylight or weather conditions. These may not coincide with times of high energy demand. Hence, renewables will be more cost-efficient if they are combined with an energy storage system.

One example is a pumped storage system where water is pumped into a reservoir in mountainous areas when the wind is blowing and the sun is shining, and then runs back down when the energy is needed, generating electricity as it runs back down from the reservoir in the mountain. Pumped storage is used widely in the world, including in Canada where the winter climate resembles with that of Mongolia.[98] An example in Canada is in Hinton, Alberta.[99] The climate in Hinton, Alberta[100] is similar to that of Mongolia.[101]

Compressed air storage has the potential to provide similar benefits to pumped storage, however it has the added benefit of being flexible in terms of location and topography, such as utilizing a cavern already created at a disused mine site.[102]

[98] https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2016/10-03pmpdstrghdr-eng.html
[99] https://www.hydroworld.com/articles/2019/01/first-pumped-storage-project-in-alberta-canada-approved-by-legislature.html
[100] https://www.bing.com/search?q=average+temperature+in+hinton+alberta&form=EDNTHT&mkt=en-ca&httpsmsn=1&plvar=0&refig=438227ffb47a455091fcfd8afa84b4a6&PC=LCTS&sp=1&qs=AS&pq=average+temperature+in+hinton&sc=8-29&cvid=438227ffb47a455091fcfd8afa84b4a6&cc=CA&setlang=en-US
[101] https://www.bing.com/search?q=Average+temperature+in+Ulaan+Bataar&form=EDNTHT&mkt=en-ca&httpsmsn=1&plvar=0&refig=d0edeb8676af4319ecb685b36bb062ea&PC=LCTS&sp=-1&ghc=1&pq=average+temperature+in+ulaa&sc=0-27&qs=n&sk=&cvid=d0edeb8676af4319ecb685b36bb062ea
[102] https://www.energy-storage.news/news/funding-boost-for-australias-first-compressed-air-energy-storage-system

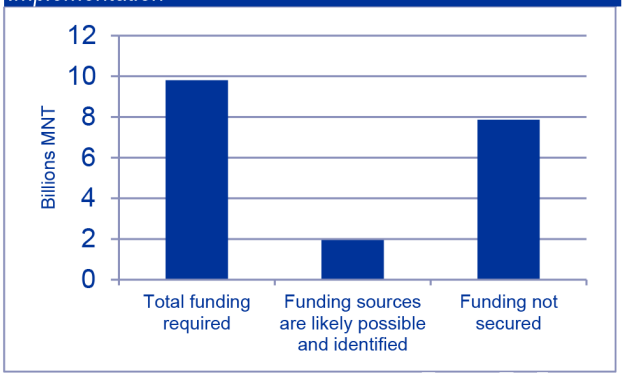
The use of batteries for energy storage is being increasingly considered. Over the last 10 years the price of batteries has been falling dramatically, by approximately 15% each year, from over USD 1000/KWh to today's price of approximately 150/KWh. As many companies are on the verge of investing in factories for lithium ion batteries, a further decrease in the price can be expected. Whilst battery performance declines in cold weather conditions by up to 50%, newer battery technologies are addressing this issue. In fact, Finland recently developed battery storage based on an energy system sized at 2 MW and is testing how well these systems work in cold winter conditions.[103] While this 2 MW plant is still very small in comparison with the well-known 100 MW battery storage system that Tesla recently built in Australia,[104] these developments should be closely observed by GOM and considered for inclusion in their renewable energy strategy.

5.5. Generating fiscal space for reducing air pollution in Mongolia:

The Gap of Financing Sources

The NPRAEP Action Plan as presently drafted requires 9.8 trillion MNT (roughly US$3.7 billion at the current exchange rate as of February, 2019) in financing to fully implement. Our view is that this is not a realistic option, and that it is necessary to review the sequencing and costing of key plan components, Recent developments in securing funding e.g. from China, South Korea, the ADB, Singapore FDI and other multilateral and bilateral institutions, are helpful in financing the anti-pollution effort, but represent only roughly 20% of the current NPRAEP Action Plan budget, a clear sign of the impossibility of raising the designated volume of funding (Graph 5.1).

Graph 5.1. *Gap of financing sources for NPRAEP Implementation*



Source: Ministry of Environment and Tourism, 2017

The missing 80% of the total funding required includes funding for several large investment-intensive programs such as improved fuel transportation, production and supply; construction of a new paved road to a new international airport which could support the GOM's development of sub-urban centers' program; coal gasification; renovation of heating systems in 11 urban areas and establishment of industrial parks outside Ulaanbaatar. At this point the best option for the GOM is to focus on prioritization, costing and resource mobilization for the most high-impact air pollution reduction measures based on suggestions specified in the Analysis of the NPRAEP section above, rather than trying to find funding for all measures from the National Program.

Possible and potential financing sources

Theoretically there are several main possibilities for generating fiscal space:

- Domestic revenue generation/mobilization
- Expenditure switching and raising efficiency of expenditures
- Local private sector financing and PPPs
- External financing (concessional loans, grant assistance, commercial borrowing and FDI)

The GOM should explore the possibility of reallocating its own resources from low priority projects and programs to projects and programs of high importance such as the reduction of air pollution.

Because of the high economic cost of addressing the problem of air pollution estimated in the report, the GOM must commit to this expenditure

[103] https://www.energy-storage.news/news/largest-battery-developed-within-nordic-countries-commissioned-in-jaervenpa

[104] https://www.gizmodo.com.au/2017/07/all-the-details-on-teslas-giant-australian-batteryt/

and the required actions and identify ways of paying for it.

The required level of fiscal expansion through implementation of the NPRAEP, including any revisions that are made in line with the recommendations of this report, should be assessed from the perspective of long-term benefits, including reduced levels of DALYs and reduced GDP losses due to air pollution.

Possible options for generating fiscal space for air pollution reduction can be looked at from several dimensions; domestic versus external; public versus private; grants versus borrowing and fiscal versus non-fiscal.

The following are potential financing sources to fund prioritized air pollution reduction measures:

Domestic funding sources: Dirty Energy Tax and Elimination of Subsidies

Increasing the air pollution tax and improving law enforcement and collection rates are important areas to address. The specific ramp up for the tax rate can be designed to avoid economic hardship. For example, an option would be doubling the tax rate every year from 2019-2025 up to the point where the tax collected is roughly equal to the total damage caused.

Currently, the energy prices paid by Mongolians do not reflect the enormous externality costs of consuming the energy, even in the case of the ger districts, who unlike other Mongolians, pay the market cost of the coal they consume. Instead of subsidizing dirty fossil energy, dirty energy should be taxed, by adding the marginal damages to the price of the energy. This will

- Provide an incentive to the consumers to reduce the consumption of dirty goods and make cleaner forms of energy more competitive;
- Generate state budget savings by reducing the subsidies in the energy market and generating additional air pollution tax revenues;

Explicit subsidies to the energy sector are currently only $7 million per annum. While it would be helpful to eliminate these subsidies at once, the impact on the budget would be small.

The major budget improvement will need to come from the increased air pollution tax, to help reduce the estimated US$645 million per annum in economic costs created by air pollution. This tax should be designed in such a way that it avoids penalizing the poorest households, for whom fuel costs are already often a large part of their total expenditures. A good example how tax revenues are redistributed is the British Columbia Carbon tax. Since the enforcement of the Law on Air Pollution Tax started in 2011, an average of $15 million[105] in air pollution tax is collected annually.

The Canadian Federal Government is now imposing a carbon tax on all Canadian provinces that do not have a similar system such as cap-and-trade. The amount collected remitted to Canadians through their income tax. It is anticipated that Canadians, rather than wasting this amount, will change their energy consumption patterns.[106] It is only with proper redistribution measures that the tax on dirty goods will obtain sufficient public support.

External financing sources

External sources for reducing air pollution can include grants from international agencies, concessional borrowing and FDIs.[107] Those projects and programs that have purely development objectives (social, environmental) should ideally be funded by grants.
Projects which in addition have income-generating possibilities should be funded by concessional borrowing which may include large-scale construction and infrastructure projects and especially energy sector projects that directly and indirectly contribute to reducing air pollution.

Projects that require substantial investments such as large renewable energy projects could attract foreign investors. However, again the GOM should ensure that a full cost recovery strategy in the energy sector is implemented. Alongside this there must be determined efforts to improve transparency and accountability on

[105] The annual average exchange rates of MNT to $US and the CPI inflation calculator were used for this estimation

[106] https://www.theglobeandmail.com/canada/article-canadas-carbon-tax-a-guide/

[107] The report does not recommend considering commercial borrowing for this purpose

the part of the government. In order to attract FDIs, the GOM should also take appropriate actions to reduce economic and exchange rate risks, ensure policy sustainability and diminish political uncertainty.

Concessional borrowing

Based on Mongolia's previous experience with international partners, including the ADB, it would be possible to use concessional loans as a significant source of funding of air pollution reduction measures. The feasibility of such a partnership would be increased if the reforms recommended in this report are carried out.

External grants

Grant assistance can provide fiscal space for air pollution reduction by releasing funds for projects. The fact that Mongolia has joined the Paris Agreement and has made an international commitment to implement effective climate change actions will work in its favor. Such grant programs must contribute to reducing air pollution. Therefore, the grant policy of the government needs to focus on the efficiency and effectiveness of grant programs. External partners can be major sources of grant assistance to Mongolia carrying out its air pollution reduction measures.

One major external funding source that is readily available for Mongolia is the Green Climate Fund (GCF), established in 2010 as part of the financing mechanism of the United Nations Framework Convention on Climate Change (UNFCCC). GCF funding in the form of grants, loans, equity and guarantees are all potentially available and can be used to prepare projects, though only GCF accredited agencies can develop and submit requests for the Project Preparation Facility (PPFD) funding. To date, the XAC Bank is the only national agency accredited by GCF, in addition to multilateral development agencies currently present in Mongolia, including the UNDP. Any project that meets GCF criteria can be submitted for funding, but only through these accredited agencies.

Equity financing and guarantees also provide opportunities for air pollution reduction projects and programs, including renewable energy and energy efficiency projects. Mongolia is one of the most successful countries globally in attracting funding from the GCF to date, however energy sector transformation and changes in the related policy environment will need to follow in order for it to sustain its success rate and further improve its access to the GCF. The GCF grants targeting the ger-area re-development program will be one of the most important funding sources for reducing air pollution in Ulaanbaatar.

The GOM may also consider negotiating with the Government of the Republic of Korea (ROK) on $500 million of new loans for construction of apartments through the ger area re-development program and/or renewable energy projects. This potential source of opportunity is currently under consideration. However, the GOM must ensure debt sustainability.

The Clean Development Mechanism (CDM) under which emission reduction projects can earn certified emission reduction credits[108] each equivalent to one ton of CO_2 is funding another opportunity for Mongolia.

Private sector resource mobilization

Mobilization of local and foreign private sector investment in the energy, construction and environment sectors could play a significant funding role, especially in the area of clean energy production and distribution systems. However, the first step to enabling this is to address current perceptions of lack of transparency and other fundamental reforms required. The more private sector involvement in implementation of the NPRAEP there is, the larger the value of public funds that can be freed up to spend on other pressing air pollution reduction measures that lack funding. Opportunities include privatization, PPPs (see below) and investment by local businesses. Tax incentives such as a green credit fund could also be useful. The coal gasification project using about $1.3 billion of FDI, if this project is implemented as planned, would be an excellent example of successful resource mobilization regarding the NPRAEP. Another example of private sector involvement would be through the

[108] https://cdm.unfccc.int/

XAC Bank partnership with the GCF by which the Bank can lend with lower interest rates and issue loan guarantees.[109] As a further example, the GCF approved funding of $8.65 million in October 2017 for a solar project in Mongolia to enable the development, construction, commissioning and operation of a 10MW solar plant. There is a link between public and private financing mobilization particularly into renewable energy initiatives that have cost implications (in the form of subsidies) and these costs/ expenditures should be factored in when planning to benefit from such investments.

Public-Private Partnerships

PPPs can enlarge the fiscal space for the investment needed to reduce air pollution by allowing the government to transfer the risks associated with the required investment to the private sector. The use of PPPs in the form of long-term contracts between government and private entities for providing a public service or building and/or operating an asset are a useful instrument for generating fiscal space. PPPs are potentially important given the lack of funding for the large investments required by the NPRAEP, although it is recognized internationally that a PPP's return on investment is likely to be higher than traditional wholly private or government-funded methods.[110] The use of PPPs in Mongolia has not been successful, including a CHP-5 concession agreement signed in 2014. The reasons include the weak legal framework for PPPs, a lack of coordination among government authorities, insufficient contract enforcement power, unstable government policies, an under-developed procurement system, a lack of competition in bidding, financial risks relating to interest rates and foreign exchange rate fluctuations and weak government capacity to manage complex PPP deals.[111] These problems must be fully addressed before PPPs are a viable way of building fiscal space. According to the National Development Agency (NDA), there is one concession project in the energy sector (Baganuur CHP with 700 MW installed capacity) that is in the Investment Program of Mongolia for 2018-2021, approved in 2018[112].

The balancing of the public interest with income-earning opportunities for the private partner/ company is key to the success of PPP projects. Tariffs should be transparent and sufficient to cover the costs of attracting private investment; on the other hand, there should be clear indicators and benchmarks to ensure sufficient quality and quantity of the output, as well as targets to support the poor; including differentiated tariffs making cross subsidization possible.

Carbon Pricing

In order to shift electricity production from coal to renewables, a sound policy framework must include carbon pricing. "Carbon taxes"[113] and "cap and trade"[114] are the two most common policy systems, currently planned and/or implemented in many countries. Both aim to provide financial incentives to the GHG-producing and the GHG-consuming sector, while encouraging renewables. Although, in theory, both systems are equivalent, we note here that from a purely business point of view a carbon tax has one important advantage (relative to the cap and trade system) for a small country like Mongolia: there is no "pollution certificate" price uncertainty. Carbon taxes provide a certain price signal to the industry and a longer planning horizon for investment into renewables and disinvestment from non-renewables. Furthermore, carbon taxes can be scheduled to ramp up over time, providing entrepreneurs with certainty in costs over time, while investors can incorporate these costs into their planning decisions (for both, investments into renewables and accounting for these costs when considering expanding or disinvesting from non-renewables). In addition, the government revenues resulting from the carbon tax can be used to alleviate distributional inequalities, facilitate the diffusion

[109] https://www.xacbank.mn/mn/552/about-xacbank/social-responsibility/eco-bank/gcf-news

[110] The Balance, https://www.thebalance.com/public-private-partnership-pros-and-cons-844713

[111] Global Green Growth Institute, http://gggi.org/site/assets/uploads/2017/02/2016-Green-Public-Private-Partnerships-for-Public-Infrastructure-in-Mongolia-1.pdf

[112] http://nda.gov.mn/1344.html

113 a tax levied on the carbon content of fuels.

114 a market-based approach to controlling pollution by providing economic incentives for achieving reductions in the emissions of pollutants.

of technologies related to renewables and partially compensate those who initially lose (in particular those employed formally or informally in the coal sector). To prevent economic hardship they can also finance appropriate retraining and alternative employment programs.

On the other hand, the advantage of a cap and trade system is that it guarantees that a certain limit of CO_2 is not exceeded per year. However, this comes at the disadvantage of "price uncertainty" as the price of the pollution certificate can fluctuate, in some cases quite drastically, especially if the market is relatively thin (a small number of trading partners as in the case of Mongolia). As a result, this makes long-term investments in renewables more uncertain. To overcome these price fluctuations, many regions with cap and trade systems (i.e. the Emission Trading System – ETS – in Europe, California, and Ontario[115]) have implemented price floors and price ceilings, making the cap and trade system essentially more similar to a carbon tax.

In the context of electricity generation, it is important to point out that the rules for carbon pricing must apply equally to all emitters, whether they are private, state-owned enterprises (SOE) or municipal emitters, in transport, construction or district heating sectors. If a country establishes one uniform carbon price, it achieves the most efficient outcome in terms of reducing GHG at a minimum social cost, known as the equi-marginal principle.

[115] A new provincial government in Ontario has ended the cap and trade system and, as a result, the Federal Canadian Government is imposing a carbon tax on the province (https://www.cbc.ca/news/canada/toronto/doug-ford-ending-cap-and-trade-1.4731954).

6. FINDINGS AND CONCLUSIONS

6.1. Policy and State of the Environment

The GOM has undertaken a number of measures to reduce Ulaanbaatar air pollution from 2008 onwards, including the creation of a legal environment and the implementation of programs and projects with direct air pollution reduction interventions. As a result of these policies and actions, the main air pollutants, including $PM_{2.5}$ and PM_{10} declined between 2012 and 2015. However, particularly due to the on-going expansion of ger area households over the past five years, an economic slowdown and inconsistent air pollution reduction efforts in 2015-2016, allied to much lower levels of expenditure in air pollution reduction measures in the same period (only 22.7% of the annual average air pollution reduction expenditures compared to 2011-2014), air pollution has not declined further. Consequently, the level of air pollution is still several times that stipulated by the WHO and the National Standards of Mongolia.

Even though the main air pollution source in Ulaanbaatar remains CHPs for all polluting substances except CO and $PM_{2.5}$, the main impact of polluted air on human health is caused by the use of raw coal for heating in ger districts which currently has about 220,000 households.

Although air quality monitoring capacity has increased in recent years, more capacity needs to be created including more air quality monitoring stations in ger areas of the capital city.

Past projects and initiatives to reduce air pollution have suffered from poorly-implemented measures and weaknesses in governance and management. Planning has also not always been coordinated and cohesive. To attain any level of success, these issues must be addressed in any future plans that are developed.

6.2. Public expenditure

Public spending of 147.3 billion MNT ($56 million) from the state budget and $60.7 million equivalent external assistance for reducing air pollution in the nine years from 2008-2016 (about 32 billion per annum – around $13.3 million) should be considered as an investment with positive net social benefits/returns based on sharp reductions in $PM_{2.5}$ and PM_{10} levels from those of 2013-2014. However, these are still high compared with WHO's Air Quality Index and the National Standards of Mongolia. There have been criticisms of expenditure (around $40 million) from funds received from the MCC that were spent on the purchase of new stoves. However, there is strong evidence that the low impact of this initiative was due to the local non-availability of the fuel required and weak governance arrangements rather than any flaw in the idea itself.

Existing subsidies to the energy sector should be considered as a negative expenditure though it should be noted that the level of subsidy has been declining over the years. Inequality is an issue at present, as full cost recovery is only from coal purchased in the ger districts where ironically households are least able to afford it.

According to the approved budget for 2019 a budget of 75.7 billion MNT was approved for the MET for air and environmental pollution reduction. In addition, a 36 billion MNT budget was approved for the Ministry of Energy for several infrastructure schemes that are directly linked to air pollution reduction.

6.3. Institutional Arrangements

The main government authority responsible for air pollution reduction is the MET. Nevertheless, the National Committee on Air and Environment Pollution led by the Prime Minister plays an important role in coordinating government actions on reducing air pollution. Due to a limited number of full-time staff working at the National Committee on Air and Environment Pollution, there is a risk that the Committee will fail to respond in a timely and effective manner to the challenges that arise.

In addition, all Ministries and the Capital City Mayor's Office, governors of Ulaanbaatar districts and other relevant government agencies have responsibility for air pollution measures within the

framework of their respective areas and mandates.

6.4. Health Impacts

Air pollution levels –especially in the capital city – are at dangerous levels with a negative impact on human health. Two out of the five diseases that are most prevalent in Mongolia, namely respiratory and cardiovascular diseases, are closely linked to air pollution. No less than 19.5% of respiratory diseases and 23.5% of cardiovascular diseases in Ulaanbaatar may be caused by air pollution. Air pollution is amongst the ten major risk factors driving the most deaths and disabilities combined in Mongolia. Children, especially those living in highly polluted areas of Ulaanbaatar are much more vulnerable to air pollution with 40% lower lung function than children living in rural areas.

6.5. Economic Cost – Economic Impact

The total economic costs linked to air pollution in Mongolia are likely to be at least $645.1 million (around 1.6 trillion MNT) per annum. This figure could be higher if other costs associated with "willingness to pay" to avoid pain and suffering from illness and eco-system health problems are estimated and added to the total cost of air pollution.

Air pollution reduction measures can be justified only if they are fact-based, results-oriented and well-managed without misconduct or other forms of weak governance. Because of the seriousness of the air pollution problem in the country and the magnitude of total welfare and economic costs arising from exposure to air pollution, they must form part of a cohesive package of measures. Although the costs involved may be substantial, in the longer term they will be more than offset by economic, social and health benefits.

It would be useful, given the importance of the measure, if the GOM would ensure that the country derives its own Value of Statistical Life (VSL) in the future.

6.6. Future Policy – NPRAEP and the Energy Sector

The major policy document of the GOM, the NPRAEP, aims to ensure a healthy and safe living environment for its citizens through the reduction of air and environmental pollution. The total funding for this program is around 9.8 trillion MNT (around $4.1 billion) for the nine years from 2017 to 2025, of which 86% directly relates to reducing air pollution. This averages out at direct public expenditure for air pollution reduction of 1.09 trillion MNT ($455.8 million) per annum. This very large sum appears to be unrealistic based on past expenditure and in the face of the many economic pressures and competing priorities in Mongolia at present.

The NPRAEP and its Action Plan covers some important direct measures to address air pollution. However, it must have sharper and more realistic priorities and sequencing. Most importantly it must include a full cost recovery-strategy in the energy sector. The creation of an independent Energy Master Planning mechanism is also important. The NPRAEP should be periodically reviewed, amended and adopted by Parliament to ensure that the measures that are included have a high priority in Mongolia's policy. The main focus should be given to those actions with the greatest air pollution reduction impacts that could contribute most to a sustainable and affordable energy system especially given the short period of time available to achieve the targets specified in the NPRAEP.

As Mongolia cannot resolve the air pollution reduction challenge overnight, some short-to-medium term measures such as the use of stoves in the ger areas that meet the National Standard on small stoves and the use of clean fuel including semi-coke for heating are appropriate, provided that improved fuel, including semi-coke are made available in the market place.

The majority of households in the ger districts are low-income with a considerable share (38% of which 57.5% HHs live in gers) (World Bank, 2017d) below the national poverty line. This prevents them from buying an apartment or using alternative heating solutions during winter rather than burning raw coal. It is important that this should be considered in any air pollution reduction efforts. Job creation and family-based business support programs and sub-

mortgage/housing schemes targeting low-income ger district households are crucial in reducing air pollution in Ulaanbaatar.

The governance and institutional arrangements needed for the management of air pollution are in place to some extent. They presently lack the Energy Master Planning mechanism recommended in this report, which together with the Energy Regulatory Commission of Mongolia already in place and fully operational, would be able to develop and oversee the implementation of the needed strategies. The planning mechanism can be established with an independent planning group, especially if it is initially helped through the recommended aid program. It must have the skill sets necessary to understand and make appropriate recommendations on issues such as the design and implementation of reforms to ensure cost recovery in the provision of energy, on feasible energy sources in the Mongolian context and it must consider how to combine the use of renewable energy with the needed sources of firm energy, etc. This group must be supported by comprehensive and timely reporting of progress against NPRAEP objectives so that the any corrective action can be addressed as problems arise.

Mongolia has several realistic energy options to replace the “clean stove + improved fuel” short-to-medium term solutions in the longer term. The use of electricity for heating is possible though it is limited at present, given the current capacity of CHPs. This capacity must be increased and the initiative to create a Northeast Asia Power System Interconnection may greatly help in achieving this. The option of geothermal energy will need to be further tested before establishing large-scale geothermal facilities. The decentralized approach for the use of geothermal energy might be more realistic in the short term. Coal gasification is an important part of the solution; given available resources, Mongolia can benefit from this option if existing cost recovery problems are resolved and if it finds a suitable technology option for Mongolia. Financing sources will be required after testing and piloting. As far as renewable energy is concerned, many types are possible for Mongolia, including the use of wind, hydropower and solar energy with adequate storage capacity in place which can help Mongolia to move forward in achieving a gradual phasing out of coal and ensuring that the country is less dependent on it.

6.7. Fiscal Space

A total of about 80% of the funding required for NPRAEP implementation has not been secured yet and no financing sources were identified for a number of important air pollution reduction initiatives as of the end of 2017. The GOM has a number of possibilities to explore to generate more fiscal space to fund the prioritized air pollution reduction measures specified in the NPRAEP. Among them are public expenditure re-prioritization by eliminating unnecessary and unproductive expenditures, including the gradual removal of subsidies in the energy sector through the rationalization of tariffs; increasing revenue by increasing the air pollution tax; increasing efficiency through improved governance and elimination of misconduct; obtaining concessional loans and grants from external multilateral and bilateral sources, including the Green Climate Fund (GCF); CDM/JCM mechanism, mobilization of local and foreign private sector entities, including FDI; using PPPs; and successful implementation of the IMF program.

However, the lack of an Integrated Financing Framework for air pollution reduction may lead to ad hoc, unintegrated financial planning, budgeting and management of funds for air pollution reduction.

7. RECOMMENDATIONS

Based on the conclusions outlined, we present the following general recommendations

7.1 Overall recommendations:

The most serious air pollution, with an important impact on health and the economy, occurs in Ulaanbaatar. For that reason, our recommendations focus on addressing the situation in Ulaanbaatar (UB).

1. Dirty energy should be taxed by adding the marginal damages to the final product price.

Currently, the prices paid by Mongolians do not reflect the enormous externality costs of consuming energy. Instead of subsidizing dirty fossil energy, it should be taxed. This will:

- provide an incentive to the consumers to reduce the consumption of dirty goods and make cleaner forms of energy more competitive;
- allow the use of savings made in the state budget (by reducing the subsidies in the energy market and the additional government revenues by increased air pollution tax) to support the poorest residents of Ulaanbaatar to upgrade their stoves and help in the transition to less polluting forms of energy;
- provide the GOM with the unique possibility of performing randomized treatment-control type pilot studies in the short-term. This is important because of the considerable uncertainty around some of the policy options (see also the uncertainty linked to “short-term” policy recommendations in the next section).

Note that subsidies are currently only $ 7 million in the energy sector. However the cost of air pollution is estimated to be over $645 million per annum. Hence the major shift in the state budget will need to come from the increased air pollution tax. Clearly, for the poorest households, the increased level of air pollution tax will imply financial burdens. Hence it will be important for GOM to redistribute the revenues to the poorest households through subsidies or other form of financial support.

The specific tax rate can be ramped up annually, doubled every year from 2019 to 2025 until the tax collected is roughly equal to the total damages.

3. Program measures must be prioritized based on “Low cost + High Impact Actions First”, following principles of “Sustainability” and ’Realism”’.

5. The linkage of air pollution reduction actions with their impacts must be strengthened.

Excluded from the program should be those measures which appear unrealistic within its timeframe.

6. Appropriate measures should be included to increase accountability for and coordination among respective government agencies and other stakeholders.

7. The actions of the NPRAEP should be fully costed, and then, if they are economically cost effective, divided into short, medium and long-term measures and .

8. All costed measures must be prioritized, rightly sequenced and developed into an “Integrated Financing Framework for Air Pollution Reduction”.

This should help ensure that each “prioritized” action of the program is funded in a timely manner by the most appropriate funding sources specified in the framework.

The report recommends prioritizing measures towards achieving the air pollution reduction targets by 2025. Impact was the main criterion used to divide actions into short, medium and long-term actions. While concrete technical actions are summarized in Table 7.1 below, the following bullet points provide key economic elements of the reforms that need to be considered during each phase of its implementation.

7.2 Recommendations for the Short-term (2019/2020)

9. A comprehensive policy framework to combat air and environment pollution should be put in place.

It should consist of:

(1) pollution prevention and control policies;

(2) policy implementation timetables;

(3) scientific and economic evaluation of emission reduction policies;

(4) emergency programs for serious episodes of atmospheric pollution; and

(5) strengthening of implementation and enforcement mechanisms.

10. A more market-based approach to the provision of energy in Mongolia should be initiated. Subsidies should be gradually withdrawn and air pollution tax collection increased.

Reducing subsidies in the energy and electricity sector means that all consumers will pay world market prices plus the marginal damages. The subsidies thus saved and additional fiscal revenues from the increased air pollution tax can then be used to help ger dwellers to adopt cleaner technologies.

11. The Law on Air Pollution Tax should be amended to ensure that all taxes collected are spent for their intended purpose only.

12. The combination of clean stoves, improved fuel options and home insulation and use of electric heater where feasible, should be an important short-medium term policy measure.

Research indicates that this is technically viable and would have a significant short-term impact on air pollution levels in Ulaanbaatar and in other cities in Mongolia.

13. Financial support for the improved stoves and fuels and home insulation should be made available but only to those households that are unable to meet the cost without hardship; governance measures should be taken to ensure that they are used only to support the improved stoves and fuels and home insulation measures.

In other cases, the possibility of other forms of funding such as leasing should be explored. For the improved fuel initiative, the GOM policy on subsidy to fuel producers can be applied in the initial stage.

Staff of respective government agencies should be trained to monitor new “standards” on fuels and stove technologies to ensure the enforcement of these new standards. Training in new cleaner energy technologies should be part of this activity.

St Staff can be employed in various pilot programs as well as instructing on clean fire start up in cleaner stoves and home insulation. They should study the regulations and market for alternative cleaner-burning fuels, such as briquettes and semi-coking coal.

14. The government should continue to carry out pilot programs for the replacement and upgrade of stoves and improving home insulation, as well as testing a variety of options with proper monitoring and evaluation.

Based on our review, it is not yet 100% clear whether the future energy source in gers should be in the form of wood stoves, briquettes, electricity, natural gas, renewable energy (wind, solar) or other investments. While the JICA and World Bank reports discussed in Section 5 show promising cost-benefit ratios for these (around $50 to $80 million of investment), the numbers on the benefits side comparing the two reports are somewhat contradictory and still surrounded by institutional uncertainty (behavioral adoption issues in traditional households, price development of alternative fuels etc.).

Because of this current uncertainty, it is important to find out which technologies are financially feasible, given the market price development of fuels, and behavioral adoptions in ger areas. Due to these unknowns, several smaller pilots will be the better option, rather than one big new technology adoption.

15. We recommend the continuation of the efforts to expand capacities of electricity distribution network in Ulaanbaatar[116] by providing more power to ger households and providing financial support for those residents who are not able to finance electric heaters, as well as home insulation.

Increasing the capacity of the electricity sector to provide power to more ger households, especially those closest to the urban center of Ulaanbaatar will be a main part of this effort. Financial mechanisms such as leasing can be used for households to buy electric heaters, but the GOM should consider providing financial support to those households that are unable to purchase electric heaters and home insulation on their own. The initiative to create a Northeast Asia Power System Interconnection may greatly help in achieving this.

16. We recommend that the existing housing and rental program be expanded. This will be a short, medium and long-term measure.

As the population of Ulaanbaatar is increasing, especially in ger areas, it is essential to expand the existing housing program, including zoning regulations, housing standards and energy planning that ensures that Ulaanbaatar can adopt the influx in an environmentally sound manner.

17. The GOM and the Municipality of Ulaanbaatar should continue to work alongside interested and active external assistance partners in their efforts to improve the air pollution situation.

Such support should take the form of not only funding but also political support in efforts to address fraud, resolving conflicts of interest in the coal market and raising awareness of alternative energy options. These steps are critical in building credibility and encouraging investment, and also in addressing wider international difficulties such as border issues which potentially have a significant impact on accessibility to hydroelectricity and natural gas.

18. Institutional arrangements for the management of air pollution must be strengthened, with particular attention to ensuring that there is proper coordination of activities and cohesion at all levels of government.

As part of this, a system of ex-ante and post evaluation, including post independent evaluation of government projects and programs to assess results and impacts should be established.

19. The capacity of the National Committee on Reducing Air and Environment Pollution and Ulaanbaatar Municipality should be strengthened.

This will ensure the sustainability of NPRAEP implementation.

20. An effective monitoring mechanism to measure NPRAEP progress against objectives should be put in place.

Ideally, such a mechanism should be reviewed by an objective and independent body.

21. The draft Law on Human Settlements should be finalized and then approved by Parliament.

This will ensure that actions relating to human settlements, inclusive of ger area households in the NPRAEP will have a solid legal basis.

22. The existing pricing arrangements for electricity and heating should be reviewed and an implementable plan to move to full cost recovery in all relevant areas should be developed.

23. A specific study is recommended to arrive at a detailed timetable over which it is possible to move to full cost recovery.

This will prevent ‘financial shocks’ to the consumers affected and will show the detailed steps required.

[116] While in the CBA analysis of NPRAEP as well as in WB and Enkhtsolmon et al. electrification is not always the most preferred option in terms of reducing air pollution (see Section 5), for any developing nation electrification has many co-benefits to boost the economy. We recommend that electrification be continued in the short-term, also within the ger districts, especially those closest to the urban center.

7.3 Recommendations for the Medium term (2020-2022)

24. Measures to increase efficiencies of CHPs and technology renovation should be adopted.

These include flue gas treatment aimed to reduce air pollution.

25. Measures of ash management for CHPs, including disposal and re-use, should be put in place.

This should also be applied at the household level.

26. The implementation of housing programs, including of a sub-program for low- income households in ger districts should be continued.

27. The job creation program targeting ger area low-income households should be an integral part of the NPRAEP.

28. The Energy Sector Master Plan (ESMP) should be regularly updated and its implementation monitored by an independent and adequately funded team of qualified experts. The ESMP should include strategies to gradually reduce the reliance on coal-powered energy in Mongolia's energy mix.

29. The GOM should continue to take measures to reduce air pollution caused by the transport sector through law enforcement and renewal of regulations regarding vehicle fuel and fuel quality.

30. Fiscal space (unsecured funding needs) for prioritized and rightly sequenced actions of the NPREAP should be created by the GOM and the Municipality of Ulaanbaatar.

It should take into account the range of measures discussed in this study, as well as any others that subsequently arise which appear suitable.

31. Financing mechanisms for air pollution reduction through the "Integrated Financing Framework for Air Pollution Reduction" should be strengthened.

This includes proper management of the Anti-Air Pollution Fund.

32. Public Expenditure Tracking Surveys should be undertaken.

The results of the survey should be used for improving the planning and budgeting of air pollution reduction measures.

33. The GOM should arrange for the future calculation of the country's VSL.

The VSL can be used in macro level analysis and planning.

34. The GOM should initiate a study on the total damage costs of air pollution.

This could include air pollution costs to health, agriculture, the environment, materials and property in the future.

7.4 Recommendations for the Long-term (-2025)

35. The full cost recovery of fuel supplies should be ensured in all cases through a variable tariff system.

This is fundamental to achieving sustainability as well as attracting private sector engagement.

36. The use of alternative renewable energy sources available to Mongolia should be further explored, including the creation of a conducive private sector investment environment.

This is essential in order to achieve the renewables targets set by the GOM. Simultaneously with the implementation and experimentation of renewables, the GOM must address the intermittency problem in energy supply.

37. We recommend four concrete options for firming up renewable energy – development of pumped storage, compressed air energy storage, storing water in hydroelectric reservoirs and using batteries.

As the price of batteries is expected to further decrease, we recommend that the GOM consider this energy option in the medium term.

38. The GOM and the Municipality of Ulaanbaatar should ensure that maximum

attention is paid to increasing transparency and addressing misconduct.

This should be achieved by strengthening institutional mechanisms and the institutions that are responsible for auditing, increasing the accountability of the public service and combatting dishonest dealings.

Only greater transparency can encourage future investment and ensure that public expenditure is properly directed and used effectively.

39. The housing program should continue in an incremental fashion.

The implementation of the ger area re-development program based on Energy Integrated Smart Urban Planning should be continued.

40. For greater energy efficiency, existing buildings, especially the pre-cast panel buildings with significant heat loss, should be retrofitted.

This retrofit should be based on thorough expert analysis and implementation of a greener building sector strategy.

41. Environmentally-friendly standards for stoves, fuel, the building industry and other relevant sectors should be introduced, adopted and enforced.

Table 7.1. *Recommended concrete direct actions for reduction of air pollution*

Measures	Potential impacts	Likely costs (in million $US) if available and likely funding source		Likely air pollution reduction in percentage	Remarks and key conditions for success
Short-term measures (For the best effect, the two measures combined)					
Testing and piloting of newly developed (locally) clean stoves	NA	Low - $100,000 (approximate estimation for developing, testing and piloting of 5 types of new stoves)		NA	There are several local companies that develop clean stove technologies. Key to success: -field testing and piloting under the strict monitoring of respective government agencies -win-win cooperation between the GOM and producers -Continued support of the WB.
Clean Stove	High	Low – $20-30 million (max) – partial government funding		53% (compared with traditional and wall stove)	Research carried out within the framework of WB and as well as JICA projects identified that the stove technology that burns coal cleanly is possible and available. According to JICA, at least 34% of ger area HHs do not use clean stoves as of 2017. They use traditional iron stove or wall stoves). Key condition for success: - -standard for clean stoves strictly enforced; GOM to provide support to those households with low incomes - not only traditional stoves, but also wall stoves to be replaced by clean stoves. According to JICA (2017), about 80,000 wall stoves are used by HHs in ger areas.
Switch to clean fuels	Medium	Low - Private sector producers' fund +Subsidy of $2.5 million		33% (compared with traditional fuel)	According to JICA, most companies that had been producing improved fuels stopped the operation or had gone bankrupt by 2017. However, the working group of the GOM at the beginning of 2018 officially informs that it is possible to produce and supply 500,000 tons of improved fuel annually through 11 companies and a production facility based in CHP2. Key conditions for success: -gradual phase-out and ban of inefficient stoves from use and sales and its enforcement - gradual phase-out and ban of raw coal from use and sale and its enforcement - tax air pollution, so cleaner fuels will become more competitive - initial phase-in subsidies available, before the full cost-recovery from source introduced - independent, objective verification of the effectiveness and efficiency of introduced strategies and transparency
Clean Stove and improved fuel option combined	High	$22.5-32.5 million partial government funding, private sector		Over 80% (compared with traditional stove + raw coal)	See above mentioned key conditions for success. This measure might be also continued in the medium term. The duration will dependent on how long it could take until other clean energy options are available.
Electricity for heating/Electric heaters	High	High (About $500 investment expenditure per HH (this estimation was based on NPRAEP actions, this does not		About 100% compared with using stove and raw coal	The NPRAEP specifies number of actions for this purpose, including expansion of electricity generation and transmission network. This measure should be continued in the medium-term as well. Key to success: - existing capacity of CHPs to be able to supply required electricity in near term - the expansion of electricity transmission and distribution

Measures	Potential impacts	Likely costs (in million $US) if available and likely funding source		Likely air pollution reduction in percentage	Remarks and key conditions for success
		include the expenditure for increasing electricity generation capacity and price for electric heater. The market price for electric heater varies from $58-1040) - State Budget			network (planned) to be funded in a timely manner - appropriate financing mechanism, including leasing or funding secured from other possible sources. - closely follow the initiative to create a Northeast Asia Power System Interconnection which may be able to greatly help in achieving this.
Medium-term measures					
For CHPs: Increase efficiency, flue gas treatment, selective catalytic reduction and electrostatic filters	High	High ($200-600/ton removal of SO_2. The cost includes capital, operations and maintenance costs) – State budget and concessional loan		Over 90% removal of SO2	According to the JICA study, the CHPs a are major contributor of PM_{10}, NOx and SO_4 in Ulaanbaatar. The increased efficiency and the flue as treatment would help to decrease air pollution, mainly over 90% reduction of SO_2 emissions Key to success: -administrative and financial reforms to increase efficiency of CHPs -mandatory flue gas treatment policy for CHPs in place -flue gas treatment and other relevant technology transfer -capacity building
CHP and HH level ash management, disposal and re-use	Moderate	Moderate (+Private sector funding for the re-use)		Marginal, but positive impact on creation of economic and social value	Research carried out in the past 10 years (Khurelbaatar, 2017) suggested that there are about 17 m tons of ash accumulated in a 110-hectare area near CHPs and 700 thousand tons of new ash added to the ash pond. The ash is harmful to human health and the environment as it contains PM_{10}, heavy metals and radioactive substances. It also contains important substances such as iron ore, chalk, aluminum and sand. All these can be re-used to produce construction materials instead of negatively affecting human health and the environment. Key to success: -appropriate procedure for COP ash management -supply of ash to companies that produce construction materials with no bureaucracy -strict enforcement of MNS3927:2015 standard for production of construction materials using CHP ash
Strengthening financial mechanism of air pollution reduction efforts	Moderate	Low ($36.8 billion from the budget) – State Budget (air pollution tax)		N/A	The newly established Anti-Air Pollution Fund (AAPF) is expected to mobilize and manage funds allocated for air pollution reduction purpose while the MOF plays a lead role in planning and budgeting. Key to success: -Integrated Financing Framework for Air Pollution Reduction developed -AAPF management procedures need to be in place -the Fund needs to have a strong capacity for resource mobilization and financial management -Introduction of good governance principles

Measures	Potential impacts	Likely costs (in million $US) if available and likely funding source		Likely air pollution reduction in percentage	Remarks and key conditions for success
					-The Public agencies engaged should be free of misconduct
Job creation	Moderate	Low - Combination of State Budget and external assistance		Marginal, but it depends on the coverage of results of the program)	The GOM agrees that the poverty and low-income levels of ger area households is one of the major reasons for expansion of the ger districts and thereby increasing sources of Ulaanbaatar air pollution. Creation of employment opportunities targeting ger area household members will play a crucial role in both air pollution reduction and increased livelihoods of low-income population. Key to success: -full-fledged new program on job creation targeting ger area low-income households - resource mobilization -capacity building
Extended housing program with specific target for ger area low-income households	High	Moderate – State Budget and funding from international financial institutions such as ADB and GCF		10%	The government housing program which had been successfully implemented in the past should continue with an extension targeting ger area low income households. Key to success: - housing program updated -resources allocated -encourage private sector participation -good governance in place and free of dishonest program management
Long-term measures					
Full cost recovery in the energy sector	Low	Low			Cost recovery in the energy sector is one of the fundamental policy measures which should be an integral part of the air pollution reduction program Key to success: -ensure that costs are minimized and are "just and reasonable" in the context of appropriate efficiency benchmarks -ensure that excessive financial shocks are not caused to consumers as a result of the adjustments required -collection efficiency needs to be ensured through appropriate billing and collection procedures
Ger area re-development program	High	High – PPPs and private sector funding		Up to 100% depending on how many HHs involved in this program	The ger area re-development program with improved de-centralized infrastructure would play an important role in reducing air pollution. Key to success: -energy-integrated smart urban planning -update of the Energy Master Plan -resources mobilized -good governance principles in place and free of dishonest program management
Retro-fitting buildings and greener building sector development	Moderate	High – State Budget and private funding		5%	Retrofitting of existing buildings and establishing greener building rating system for new buildings can ensure sustainability of the building sector and energy performance. This is an integral part of the Green Development Policy of Mongolia. Key to success: -Retrofitting: Engineering assessment carried out to determine the building condition and assess the net benefits of retrofitting -cost sharing of the retrofitting strategy is used - greener building rating system created and used initially for

Measures	Potential impacts	Likely costs (in million $US) if available and likely funding source		Likely air pollution reduction in percentage	Remarks and key conditions for success
					all new public buildings
Renewable energy	Moderate	High – Private sector funding		10%	As Mongolia has extensive renewable energy sources which can become an important component of Mongolia's diversified energy mix in the future. Key to success: -cost recovery policy implementation -incentives for production and consumption of renewable energy
Transport sector	Moderate	Moderate – Private sector		Up to 10% (PM_{10} SO_4)	The transport sector contributes over 10% of PM_{10} and SO_4 emission (JICA). Measures to decrease emission form vehicles and roads are important. Key to success: -law enforcement on vehicles which create more pollution -renewal of regulations on vehicle fuels (more upgraded fuel supply) -strict control of fuel quality supplied and sold in the market
Environmentally friendly standards	Moderate from long-term perspective	Low		N/A (Only indirect impacts, but will have long-term policy and health implications	Standards are crucial for setting a minimum requirement for both environmental protection and human health and well-being. Key to success: -enforcement mechanisms need to work -good governance principles in place and the civil service free of dishonesty
Coal gasification	High	High – $2.4 billion – private sector funding such as FDI		Nearly 80%	The GOM plan on production and supply of gas is an extremely important initiative as gas burning heating emits 60-100 times less pollution than coal burning heating. Key to success: -cost recovery policy implemented -gas supply-purchase agreement -Funding sources available -necessary infrastructure for gas supply developed

SELECT BIBLIOGRAPHY

AKF (2003). Regulatory Independence in Theory and Practice – a Survey of Independent Energy Regulators in Eight European Countries (http://regulationbodyofknowledge.org/wp-content/uploads/2013/03/Johannsen_Regulatory_Independence_in.pdf)

Amarsaikhan.D et al. (2014). "A Study of Air Pollution in Ulaanbaatar City, Mongolia". Journal of Geo-science and Environment Protection, 2, pp. 123-128. Scientific Research Publishing

Asian Development Bank (ADB) (2013) "Updating Energy Sector Development Plan" (TA No 7619-MON" Final Report. Ulaanbaatar

ADB (2014) "Affordable Housing Strategy for Ulaanbaatar", ADB, Manila.

ADB (2017) "Country Partnership Strategy for Mongolia, 2017-2020", ADB, Manila.

ADB (2019) "TA 9001-MON: Strategy for Northeast Asia Power System Interconnection", ADB, Manila. Bank of Mongolia, Monthly Foreign Exchange Rates, 2010-2018

Brett Forrest, "James Passin, the American Who Bought Mongolia", Business Week, 2013-05-16.

Bruce, N., R. Perez-Padilla, and R. Albalak (2000). "Indoor Air Pollution in Developing Countries: A Major Environmental and Public Health Challenge." Bulletin of the World Health Organization 78: 1078–92. Bulgan.T. (2019) PPT on Introduction of the draft law on Eco-tax, Ulaanbaatar

Bulganmurun, T. (2012/2013). "Assessment of Urban Air Pollution Abatement Policy Implementation vis-à-vis the Role of Household Energy Use in Ger Areas of Mongolia". University of Twente, Enschede.

Burmaajav.B. et al. (2016). "Impact of Air Pollution on Population Health", Mongolian Academy of Medical Sciences and Public Health Institute, Mongolian Observer, No 3. 2016. pp. 26-28. Ulaanbaatar,

Capital City Mayor's Office (2014). "Ulaanbaatar 2020 Development Master Plan and Development Approaches for 2030. Ulaanbaatar.

Capital City Mayor's Office (2017) "Capital City Budget and Expenditure Data for 2010-2017 and 2018 Approved Budget". Ulaanbaatar.

CEE Bankwatch. 2017. "Mongolia's Energy Sector Time for a Rethink". CEE Bankwatch Network.
Chang, Tom Y.et al. (2016). "Air Pollution is Making Office Workers Less Productive", Harvard Business Review, September 2016, at: (https://hbr.org/2016/09/air-pollution-is-making-office-workers-less-productive).
Civil Service Commission (2016). "Statistics of civil servants". Ulaanbaatar.

Cropper, M and S. Khanna, (2014)."How Should the World Bank Estimate Air Pollution Damages", Resources for the Future, World Bank. Washington, DC.
Engel, D (2015). "Ulaanbaatar's Ger District Issues: Changes and Attitudes", Independent Study Project, SIT Graduate Institute/SIT Study Abroad, Brattleboro.
Enkhmaa. D. et al. (2014). "Seasonal Ambient Air Pollution Correlates Strongly with Spontaneous Abortion in Mongolia", BMC Pregnancy and Childbirth, 14:146.

Enkhtsolmon. et al. (2016). "Cost Benefit Analysis of Air Pollution Abatement Options in the Ger Area, Ulaanbaatar, and Health Benefits Using Contingent Valuation", International Journal of Environmental Science and Development, Vol 7, No 5.

Global Green Growth Institute (2014). "Strategies for Development of Green Energy Systems in Mongolia" Final Report, Seoul.

Global Green Growth Institute (2016). "Green Public-Private Partnerships for Public Infrastructure in Mongolia", Seoul.

Government of Mongolia and United Nations in Mongolia (2016). "United Nations Development Assistance Framework 2017-2021", Ulaanbaatar.

Government of Mongolia, (2015). "Scaling-up Renewable Energy Programme: Investment Plan for Mongolia", Ulaanbaatar.

Government of Mongolia (2016). "Action Plan for Implementation of the Green Development Policy", Ulaanbaatar.

Government of Mongolia (2017). "National Program for Reducing Air and Environment Pollution", Ulaanbaatar.
He, Jiaxiu et al. (2016). "Severe Air Pollution and Labour Productivity: Evidence from Industrial Towns in China", International Economic Association, Discussion paper series, No 8916, Bonn.

Heller, Peter (2005). "Understanding Fiscal Space" International Monetary Fund Discussion Paper, IMF, Washington, DC.

IMF (2017a). World Economic Outlook data, IMF, Washington, DC.

IMF (2017b). "Mongolia: 2017 Article IV Consultation and Request for an Extended Arrangement Under the Extended Fund Facility-Press Release: Staff Report;

and Statement by the Executive Director for Mongolia", IMF Country Report No 17/140, Washington, DC.
Institute for Health Metrics and Evaluation (2017). "Mongolia Health Data", Seattle.

Japan International Cooperation Agency (JICA) (2013). "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Mongolia", Final Report, Ulaanbaatar.

JICA (2017). "Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia" Final report, Ulaanbaatar.

Lopez-Claros, Augusto (2014) Six Strategies to Fight Corruption

MAD Investment Solutions (2015) "Affordable Housing and Ger Area Redevelopment in Ulaanbaatar", Ulaanbaatar.

Miller, Ted R. (2000). "Variations between Countries in Values of Statistical Life", Journal of Transport Economics and Policy, Vol 34. No 2, May 2000, University of Bath, Claverton Down, available at JSTOR.

Minchener, Andrew (2013). Challenges and Opportunities for Coal Gasification in Developing Countries, International Energy Agency, Clean Coal Centre, London.

Ministry of Environment and Green Development. Municipal office of Ulaanbaatar (2012). Ulaanbaatar Clean Air Initiative project report, MNE/Mott MacDonald.

Ministry of Environment and Green Development (2014). "Mongolia's Transition to a Green Economy: a Stocktaking Report". Partnership for Action on Green Economy, Ulaanbaatar.

Ministry of Environment and Tourism (MET) (2002). "State of the Environment of Mongolia", Ulaanbaatar.
MET (2010). "State of the Environment of Mongolia", ",Ulaanbaatar.

MET (2012). "State of the Environment of Mongolia", Ulaanbaatar

MET (2014). "State of the Environment of Mongolia", Ulaanbaatar.

MET (2017a). "State of the Environment of Mongolia 2015-2016", Ulaanbaatar.

MET (2017b). Action Plan for Implementation of the National Program on Reducing Air and Environment Pollution, Ulaanbaatar.

Ministry of Finance (MOF) (2017 and 2019a). "Air Pollution Tax Collection Data", Ulaanbaatar.

MOF (2017 and 2019b). "Recurrent and Investment Expenditures for Minister of Environment and Tourism for 2010-2018", Ulaanbaatar.

MOF (2017 and 2019c). "Recurrent and Investment Expenditures for Minister of Energy for 2010-2018, Ulaanbaatar.

MOF (2017 and 2019d). "Recurrent and Investment Expenditures for Minister of Construction and Urban Development for 2010-2018", Ulaanbaatar.

MOF (2017a). "2019-2020 Fiscal projection", Ulaanbaatar.

MOF (2017b). "Introductory Note on Air Pollution Finance, Ulaanbaatar.

MOF (2017 and 2019c). "Mongolia State Budget Data for 2010-2018, Ulaanbaatar.

Mongolian Agency for Standard and Metrology (2007). "MNS 4585:2007, Ulaanbaatar.

Mongolian Agency for Standard and Metrology (2016). "MNS 4585:2016, Ulaanbaatar.

Municipal office of Ulaanbaatar (2017). Governor's report,18 October 2017.

Municipal office of Ulaanbaatar (2014a). Ulaanbaatar Air quality department annual report.

Municipal office of Ulaanbaatar (2014b). Ulaanbaatar Clean Air Program, Monitoring of results of improved boiler registration, Ulaanbaatar.

Municipal office of Ulaanbaatar (2013). Ulaanbaatar Clean Air Program, Annual report, Ulaanbaatar.

Municipality of Ulaanbaatar (2016). "Mongolia: Ulaanbaatar Urban Services and Ger Areas Development Investment Program", Environmental Monitoring Report, Ulaanbaatar.

National Agency of Meteorology and Environmental Monitoring (NAMEM), Mongolia, Air Pollution Data, 2004-2018.

National Committee on Reducing Environmental Pollution (2018). Implementation Plan of the National Program for Reducing Air and Environmental Pollution, Ulaanbaatar.

National Committee on Reducing Environmental Pollution (2019). Decree # 19/01, National Committee on Reducing Environmental Pollution, Ulaanbaatar.
National Secretariat for the Second Compact Agree-

ment between the Government of Mongolia and Millennium Challenge Corporation (MCC), (2016). "Second Compact Agreement, Washington, DC.

National Statistics Office (2008-2017). Statistical Year Book", Ulaanbaatar.

National Statistics Office (2016). "Poverty Profile-2016", Ulaanbaatar.

National Statistics Office (NSO) (2017a). "Health Statistics", Ulaanbaatar,

NSO (2017b). "Mongolia Consolidated Budget Data", Ulaanbaatar.

NSO (2017c). "National income statistics", Ulaanbaatar.

NSO (2017d). "Population statistics", Ulaanbaatar.

NSO (2017e). "Statistical Information Database", Ulaanbaatar.

NSO (2017). "Sustainable Development Indicators". Ulaanbaatar
NSO (2017). "Ulaanbaatar Weather Statistics", Ulaanbaatar.

Nomun-Erdene, D. (2013). "Migration of Ulaanbaatar and its social statement", Proceedings of the Mongolian Academy of Sciences, vol.53, no 02(206), Department of Sociology, Institute of Phi¬losophy, Sociology and Law.

Organisation for Economic Co-operation and Development (OECD) (2016). The economic consequences of outdoor air pollution, OECD, Paris.

OECD (2017). Mortality and Welfare Cost from Exposure to Air Pollution, OECD.Stat ,Geneva.

Otgochuluu, C. and Bold-Erdene (n.d.), available at: https://www.erina.or.jp/en/wp-content/uploads/2015/02/se12716_tssc.pdf

Parliament of Mongolia (1995). "Law on Environmental Protection", Ulaanbaatar.

Parliament of Mongolia, (2010). "Law on Air Pollution Tax", Ulaanbaatar.

Parliament of Mongolia (2011a). "Budget Law of Mongolia", Ulaanbaatar.

Parliament of Mongolia (2011b). "Law on Energy", Ulaanbaatar.

Parliament of Mongolia (2012). "Law on Air", Ulaanbaatar.

Parliament of Mongolia (2014). "Green Development Policy", Ulaanbaatar.

Parliament of Mongolia (2015). "Law on Energy Conservation", Ulaanbaatar.

Parliament of Mongolia (2016a). "Action Plan of the Government of Mongolia 2016-2020", Ulaanbaatar.
Parliament of Mongolia (2016b). "Law on Hygiene", Ulaanbaatar.

Parliament of Mongolia (2016c). "Sustainable Development Vision 2030", Ulaanbaatar.

Public Health Institute of Mongolia and University of California Berkeley (2014). "Air pollution and Health in Ulaanbaatar", Ulaanbaatar.

Regulatory Independence in Theory and Practice – a Survey of Independent Energy Regulators in Eight European Countries at: (http://regulationbodyofknowledge.org/wp-content/uploads/2013/03/Johannsen_Regulatory_Independence_in.pdf)

Sensory Researchers' Association of Mongolia (2018). Studies, projects and programs on reducing air pollution implemented since 2011, Ulaanbaatar.

Shah PS and T Balkhair (2011) . "Air pollution and birth outcomes: a systematic review", available at: https://www.ncbi.nlm.nih.gov/pubmed/21112090

State Housing Corporation (2015). "Apartment Rental Program", Ulaanbaatar

Statistical Institute for Consulting and Analysis (2017). "Current Status, Possibilities and Solutions for Air Pollution Reduction", Ulaanbaatar.

The Economist (2016). "How air pollution affects office workers – and the economy", available at: (https://www.economist.com/blogs/economist-explains/2016/10/economist-explains-2)

Transparency International, 2018, Corruption Perceptions Index 2017, available at: https://www.transparency.org/news/feature/corruption_perceptions_index_2017

Ulaanbaatar City Mayor's Office and Asian Development Bank. (2016) "TA-6293 REG: Managing the Cities in Asia-Mongolia National Urban Assessment", Final Report, Cities Development Initiative in Asia, April 14, 2016.

Ulaanbaatar City Mayor's Office (2017). "Note on Expenditures for Reducing Air Pollution in Ulaanbaatar", Ulaanbaatar

Ulaanbaatar City Mayor's Office (2018). "Ulaanbaatar

City Budget for 2019", Ulaanbaatar
Ulaanbaatar City Mayor's Office, British Embassy Ulaanbaatar and Asia Foundation (2016). "Green Development Strategic Action Plan for Ulaanbaatar 2020", Ulaanbaatar.

United Nations Children's Fund (UNICEF) (2016a). "Understanding and Addressing the Impact of Air Pollution in Children's Health in Mongolia", Ulaanbaatar.
UNICEF (2016b). "Understanding and Addressing the Impact of Air Pollution on Children's Health in Mongolia", Ulaanbaatar.

UNICEF (2018). "Mongolia's Air Pollution Crisis: Urgent Interventions to Reduce the Impact in Child Health", Ulaanbaatar.

United Nations Development Programme (UNDP) (2007). "Fiscal Space for What? Analytical Issues from Human Development Perspective", UNDP, New York.
UNDP (2009). "The MDGs and relation of short and long policy planning. Ensuring environmental sustainability of the MDGs", MON 05/201, Assessment report, Ulaanbaatar.

UNDP (2016). "Country Programme Document 2017-2021 for Mongolia", UNDP, New York.

World Bank and Institute for Health Metrics and Evaluation (2016). "The Cost of Air Pollution: Strengthening the Economic Case for Action", University of Washington, Seattle.

World Bank and Kingdom of the Netherlands 2011. "Mongolia: Air Quality Analysis of Ulaanbaatar Improving Air Quality to Reduce Health Impacts", NORAD.
World Bank (2002), Annual report, Energy Sector Management Assistance Programme (ESMAP).

World Bank (2009). "Air pollution in Ulaanbaatar: Initial Assessment of Current Situation and Effects of Abatement Measures", Discussion paper, World Bank, Washington, DC.

World Bank ((2009). Implementing Public Expenditure Surveys for Results: Lessons of a Decade of Global Experience, World Bank, Washington, DC.

World Bank (2011). "Air Quality in Ulaanbaatar: Improving air quality to reduce health impacts of air pollution", World Bank, Washington, DC.

World Bank (2016). Death in the Air. Air Pollution Costs Money and Lives, World Bank, Washington, DC.

World Bank. 2017a. Briefing Note: "Ulaanbaatar Clean Air Project Mongolia".

World Bank. 2017b. First Quarter Report 2017 – "Ulaanbaatar Clean Air Project".

World Bank. 2017c. "Valuation of Health Impacts: Value of a DALY", World Bank, Washington, DC.

World Bank (2017d). "Urban Poverty in Ulaanbaatar: Understanding the Dimensions and Addressing the Challenges (Mongolian), World Bank, Washington, DC, at: http://documents.worldbank.org/curated/en/233371543335178520/Urban-Poverty-in-Ulaanbaatar-Understanding-the-Dimensions-and-Addressing-the-Challenges

World Health Organization (2017). "Disability-Adjusted Life Year (DALY)", WHO, Geneva.

WEB-BASED/ONLINE SOURCES

www.agaar.mn

www.eic.mn

www.1212.mn

www.nationalgeographic.com/environment/global-warming/pollution/

www.ncbi.nlm.nih.gov/pmc/articles/PMC4154221

www.scientificamerican.com/article/the-worst-climate-pollution-is-carbon-dioxide/

www.ubstat.mnhttps://en.wikipedia.org/wiki/List_of_countries_by_GNI_(nominal,_Atlas_method)_per_capita

https://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?sy=2011&ey=2017&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=46&pr1.y=2&c=948&s=NGDP%2CNGDPD%2CNGDP_D%2CPPPGDP&grp=0&a=

http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/

https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC#

https://en.wikipedia.org/wiki/Mongolia

https://www.xacbank.mn/mn/552/about-xacbank/social-responsibility/eco-bank/gcf-news

https://en.wikipedia.org/wiki/List_of_countries_by_public_sector

http://www.1212.mn/tables.aspx?TBL_ID=DT_NSO_0500_003V1

http://www.pcsp.gov.mn/en

https://www.transparency.org/news/feature/corruption_perceptions_index_2017

https://www.thebalance.com/public-private-partnership-pros-and-cons-844713

https://economics.mit.edu/files/7589

https://www.transparency.org/research/cpi/overview

http://www.worldbank.org/en/country/mongolia/overview

http://www.parliament.mn/files/11383

https://voxeu.org/article/impact-pollution-worker-productivity

http://www.worldbank.org/en/topic/publicprivatepartnerships/overview

https://www.energy-storage.news/news/funding-boost-for-australias-first-compressed-air-energy-storage-system

APPENDIX 1. NPRAEP CRITERIA AND TARGETS

№	Criteria		Measuring unit	Baseline level	Target level		Implementing organization	Comments
				2016	2019	2025		
1	Decrease of pollutants (average characteristics of December of 2016 will be the baseline)	PM2.5 particles	мg/m3	256	190	70	MET, UB Municipality	According to MNS 4585:2016 the yearly permissible limit for PM2.5 is 25, for PM10 is 50, for SO2 is 20 мg/m3, which are much lower figures than the target levels. Inhalation of such particles may cause or worsen respiratory diseases, such as emphysema or bronchitis, or may also aggravate existing heart disease. The date of the baseline is not justified The main source of SO2 is the burning of raw coal. But the target level stated to reduce it by only 19 mkg/m3 in 2019 (21.3%) and 39mkg/m3 in 2025 (43.8%), which is too small given the nine-year period
		PM10 particles	мg/m3	279	210	100	MET, UB Municipality	
		Sulfuric dioxide (SO2)	мg/m3	89	70	50	MET, UB Municipality	
2	Number of consumers of ger district that met conditions for the night-time electricity tariff		number	110 895	135 000	150 000	MOE, ERC	This is not considered to be a viable or effective option. Could become feasible if and only if enough generation, transmission and distribution capacity created.
3	Number of households with a technical capacity to use electric heaters of 2.5 kW		number	20 000	110 000	-	MOE	As pointed out in the report, this measure is unlikely to be feasible due to limited electricity production capacity and the non-availability of required funding. Could become feasible if and only if enough generation, transmission and distribution capacity created.
4	Number of households with a technical capacity to use electric heaters of 4 kW		number	3 000	20 000	80 000	MOE	As pointed out in the report, this measure is unlikely to be feasible due to limited electricity production capacity and the non-availability of required funding. Could become feasible if and only if enough generation, transmission and distribution capacity created.
5	Newly connected households with electricity		number	-	5 800	-	MOE	As pointed out in the report, this measure is unlikely to be feasible due to limited electricity production capacity and the non-availability of required funding. Could become feasible if and only if enough generation, transmission and distribution capacity created. .
6	Number of households displaced raw coal use with refined fuel		number	150	23 000	43 000	UB Municipality, MOE	
7	The volume of refined fuel production		Tons/year	500	90 000	150 000	MOE, MMHI	
8	Discharged heating boilers where consumers are transferred to centralized		number	-	123	228	MOE, UB Municipality	According to the environmental statement report of Mongolia (2015-2016) 259,987 boilers were

№	Criteria		Measuring unit	Baseline level	Target level		Implementing organization	Comments
				2016	2019	2025		
	engineering supplies							counted. 228 boilers are just 0.087% of the total, which is too small a target.
9	Number of persons who moved to a remote district or countryside		number	-	2 000	9 600	UB Municipality, NSO	No baseline is set. According to responsible parties, the criteria is for only UB, not for country level. The criteria are also unmeasurable
10	Workspace created in the remote district or countryside		number	-	1 000	10 000	MFALI, MLSP, NSO, AUB Municipality	The criteria have too broad a character, and the target set to too low.
11	Supported target group households		number	-	13 300	13 000	UB Municipality, MET, MLSP	In the document there is no definition on target group households. It is also not clear who will take what support. The criteria are not accurate. 13,000 household is only 3.4% of the 380,828[117] households of UB.
12	Sub-centers with engineering Infrastructure		number	-	20	100	MCUD, UB Municipality	According to the ADB GADIP[118] project in UB the plan is to support the establishment 4-6 sub-centers for 10 years. The target stated as 100 is too abstract.
13	Number of ger district households that provide technical support to the engineering network		number	20 000	40 000	70 000	MCUD, MOE, UB Municipality	
14	Housing supply for ger area households and number of households moved to new apartment		number	-	20 000	70 000	MCUD, UB Municipality	Good target. However, the GOM needs to have an extended or sub-mortgage loan program specifically targeting ger area households for this target to be achievable.
15	Population covered by improved sanitation		percent	38	43	50	MCUD, AUB Municipality	Target is too low Definition is not precise
16	Urban population covered by improved sanitation		percent	40	60	80	MCUD, AUB Municipality	Definition is not precise
17	Gas fueled vehicles	Taxi	number	312	1 000	3 000	MRTD, UB Municipality	In 2016 in UB, 458,204 vehicles were counted. The target is aimed at only 0.65% of taxi and 5.45% of other vehicles, which is not a challenging target in the light of current air pollution levels
		Cars	number	14 500	17 000	25 000		
18	Percentage of fuel that meets the Euro-5 standard	Gasoline	percent	-	50	80	MRTD, MMHI, АМГТГ	
		Diesel fuel	percent	-	50	80		
19	Total seat train that possible to equip with electric heating		number	16	72	159	MRTD, MOE, UB Municipality	From the environmental pollution point of view, the train has an impact on air quality, but is not significant with regard to UB air quality, which means the criteria is not such an important issue in terms of reducing air pollution

[117] *As of 2016, NSO*
[118] *Ger Area Development and Investment Program*

№	Criteria		Measuring unit	Baseline level	Target level		Implementing organization	Comments
				2016	2019	2025		
20	Waste processing and power generation plant		number	-	-	1	MOE, UB Municipality	
21	Decrease of the respiratory system illness (hospitalized per 10000 population)		Per mille	456	448	433	MOH	Target level is almost the same as the baseline. No substantial change is expected.
22	Reduction of cardiovascular disease (hospitalization per 10000 population)		Per mille	399	393	384	MOH	Target level is almost the same as the baseline. No substantial change is expected.
23	Pneumonia (hospitalized per 10000 population)		Per mille	239	206	146	MOH	-
24	Additional areas planted with grasses in ger area and public property		Ha	110	1 450	3 000	UB Municipality	Exact locations need to be defined in a way that will have a direct impact on the reduction of air pollution. Greening areas far away from pollution source is not important.
25	Percentage of green areas in urban areas	Ulaanbaatar	percent	1	7	25	UB Municipality	
		Province	percent	1	5	25	Provincial government	

Source: GOM, NPRAEP, 2017

APPENDIX 2. ANALYSIS OF DETAILED ACTIVITIES IN NPRAEP

1. Most activities 1.1.1 to 1.5.3 ($71,918,943) are intended to stop the rural exodus and thus are important. Two of the activities involve implementing construction of a road to a new international airport near UB and a railway extension. This project is to be financed through foreign loans. Given the likelihood of these two latter initiatives operating on a cost recovery basis, they would be feasible but without an obvious connection to atmospheric pollution. No law on resettlement is approved yet, and resettlement requires a huge investment. No funding is reflected for most of major resettlement actions specified. Full implementation of resettlement will require longer than nine years;

2. Activities 1.6.1 to 1.6.5, heating the gers in UB with electricity ($87,661,581). The sharp reduction of air pollution in UB is highly desirable. However, given the uncertainly of funding required, the maximum level of electricity production in UB (until Baganuur CHP is operational) and low levels of living standards of the population in ger districts, it might be not fully achievable. Heating gers in UB with electricity is not feasible as a large-scale solution; this would be the case in any country with a winter climate, even the most developed. The issue of the current conditions of ger insulation must also be resolved. With electric heating, electricity consumption in poorly-insulated gers will be unnecessarily high. However, the initiative to create a Northeast Asia Power System Interconnection may greatly help this;

3. Activities 1.7.1 to 1.7.4 are all intended to improve the quality of housing available to ger area residents and would be good initiatives ($3,428,090); they will also have a high impact on reducing air pollution. The total funding identified above would be seed funding at best and much bigger amounts would clearly be needed. 1.7.4 seems intended to bring methane from the gasification of coal to new housing developments, which is a far more rational strategy than the one involving electric heating as it would bring the source of the energy to where it would be consumed in heating;

4. Activities 1.8.1 to 1.8.5 appears to be an unfocused attempt to connect the ger districts to new forms of heating (centralized and de-centralized), including new and renewable energy ($347,617.338). Renewable energy in Mongolia would take the form of wind and solar, neither of which will be able to provide electricity on a continuous basis; both require huge investments in transmission and distribution. The large-scale hydroelectricity project is currently blocked by Russia. It also is not firm and would require huge investments in transmission and distribution. This option is even less viable than attempting to provide electricity to electric heaters using thermal power, which at least is firm though it comes with an enormous cost. In addition to state sources, funds have recently been received in the form of loans and grants from various directions e.g. the Republic of China, South Korea and the Asian Development Bank but the ultimate use of these is not yet fully defined. However, the initiative to create a Northeast Asia Power System Interconnection may greatly help in achieving this;

5. Activity 1.9.1 involves shutting down the localized district heating plants and HOBs which are inefficient and are a factor in atmospheric pollution. Extending the piping systems to draw hot water from the more efficient coal-fired thermal power stations, currently running on coal, is a move in the right direction. Later, if the coal-fired power stations can be converted to methane from the gasification of coal, this will virtually eliminate about 10% of the present atmospheric pollution. The problem facing Mongolia in attempting to cover this work through foreign loans ($37,958,553), is a failure to recover costs in the district heating systems. This is one of the many problems in cost recovery which need to be addressed through the recommended reforms;

6. Improvements in sanitation and other facilities (1.10.1 to 1.10.3) improving the lives of those living in the ger districts and other less well-off areas of UB is a positive move. It should attract outside funding ($11,695, 223), although perceived transparency issues will cause concerns that the funds

provided could be siphoned off due to fraud. This emphasizes the need for appropriate and effective anti-corruption reforms;

7. Industrial reforms,(1.11.1 to 1.11.4) helping decentralize employment in Mongolia will assist in slowing down the rural exodus and thereby help to limit further increases in atmospheric air pollution ($191,345,869). The fact that at least one of the sources of financing is the EXIM Bank of South Korea suggests that Korean investors are involved;

8. Improvements in the urban areas (1.12.1 and 1.13.1 through to 1.13.5) will improve the quality of life of the inhabitants and thus is very desirable. The present failure to recover costs, coupled with the lack of transparency and perceived dishonesty on the part of the state puts into doubt the likelihood of obtaining the needed local funds ($4,090,406), pending completion of the needed overall reforms;

9. Activities 1.14.1 and 1.14.2 are further desirable actions ($41,738) to stop the rural exodus and will help to prevent further air and environment pollution. Law enforcement is again crucial;

10. Activities 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.3.1, 2.3.2 and 2.3.3 ($279,211,971) are further attempts to proceed with the previous partially failed strategy to switch to a higher-quality coal (semi-coke briquettes, coal briquettes and other types of improved fuels) for heating, which is supported by the World Bank. The required funding as specified in the Action Plan of the NPRAEP is huge relative to its impact on air and environmental pollution reduction; 97% of the total funding required is for the construction of a 500-km cement road. This is unlikely to be effective in terms of air pollution reduction from a longer-term perspective. However, if the improved fuel is used in combination with the energy efficient stove, it will be one of the cost-efficient air pollution reduction measures in the short-to-medium term;

11. Activity 2.4.1 is a further initiative ($17,739,007) linked to attempting to heat the gers with electricity. Reduction of air pollution can be achieved through this measure. The night tariff policy shall be only used for those households that use electric heaters. Activity 2.4.2 is to provide support to a few thousand ger area households to use improved stove and fuels. This is a desirable action providing support to vulnerable and low-income households. The target group that will get support in using clean stoves is too small. In addition, the government may consider providing support to new technology stove producers to commercialize the production and selling of stoves;

12. Activities 2.5.1 and 2.5.2 (implementing legal regulations to support domestic production of environmentally friendly building materials – $4,061,189) are desirable actions. Preventing heat loss in gers and buildings coupled with other system losses can contribute to reducing energy use and consequently air pollution reduction;

13. Activities 2.6.1 to 2.6.6 will reduce the heat loss in buildings ($1,343,990) and thus will play a role in reducing atmospheric air pollution;

14. Activity 2.7.1 involves expansion of the aimags heating supply, extension of the grid, and technological renovation to reduce coal consumption and waste. However, given the absence of cost recovery in the district heating sector and without implementing the needed reforms, it is unlikely that it will be possible to secure all the foreign loans and planned private investment ($135,651,230);

15. Activities 2.8.1 to 2.11.4 deal with waste and health problems ($457,161,341) and are important initiatives. They include 2.9.2 which is an initiative to recycle the waste and build a power plant to produce 32 MW from the waste, costing $144,276,156, supposedly financed from external sources and private investment. No direct link to reducing air pollution;

16. Activities 2.12.1 to 2.12.2 require $2,324,143,832 of funding. These measures deal with a very important initiative (intensify research of coal seam methane resources, support the development of coal enrichment, deep processing plant and coal synthetic gas), which if collectively successful would essentially resolve the problem of atmospheric air pollution in Mongolia. A substantial amount of the funding for this (according to the MOE at least $1.5 billion) has already been secured via FDI.

17. Activity 2.13.1 is a good approach to using electricity and improved fuel for passenger trains. However, the previous partially failed attempt to use improved fuel for ger stoves shall be taken into consideration;

18. Activities 2.14.1 to 2.14.3 are initiatives for setting environmental standards for energy sold to Mongolians and should be supported, although only indirectly linked to the issue of atmospheric pollution ($20,869) which will have long-term policy and health implications;

19. Activities 2.15.1 to 2.15.5 are a series of unfocused, general innovation and technology development-related actions ($13,573,053).Some specific measures may have long-term positive impacts if targets are achieved and if all associated innovation and technology development, including testing, takes place in properly regulated conditions;

20. Activity 2.16.1 is the establishment of an "Environmentally friendly technology and exhibition center" to reduce air and environment pollution ($17,530). This is a good initiative that could have a positive impact on consumer preferences and attitudes.

21. Activities 2.17.1 and 2.17.2, require funding ($4,182,231). The green credit fund can be considered one of the foundations for creating financing mechanisms which are missing in today's financial system. However, there is a need for reforms to increase transparency and for good governance practices to be in place. No obvious connection to air pollution. However, if successful may have long-term positive impacts on environmentally friendly business development, and consequently an indirect marginal impact on air pollution reduction;

22. Activities 3.1.1 and 3.1.2 constitute a comprehensive approach to reduce the amount of pollutants emitted by vehicles ($292,171) and will gradually help reduce the atmospheric pollution associated with vehicles;

23. Activities 3.2.1 to 3.7.2 are a series of actions regarding the motor vehicle/transport sector ($44,381,743) which are very desirable;

24. Activities 4.1.1 and 4.1.2 require funding of $40,486,674. This relates to the establishment of a system of coordination and management of air pollution reduction efforts through the Anti-Air Pollution Fund. This could be useful in filling the existing gap in managing the overall initiative and/or filling the existing gap in financing mechanisms. However, the new fund should implement good governance practices and its activities should be transparent and free of wrongdoing. Will have an indirect impact on reducing air pollution;

25. Activities 4.2.1 to 4.7.1 deal with amendments to existing legislation and the development of new programs related to increased accountability of all those concerned with air, water and soil pollution and remediation, policies regarding environmental sustainability, regional development, urban planning, energy conservation and support for domestic production of environmentally friendly and efficient energy ($20,869) and are very desirable;

26. Activities 4.8.1 to 4.8.3 develop and enforce the "Gas Supply Master Plan" ($436,170) which is an extremely important initiative and should be an integral part of the Energy Master Plan. Again, it

should be noted that the gasification of coal has the potential to resolve the problem of atmospheric air pollution in Mongolia;

27. Activities 4.9.1 to 5.11.1 are a series of initiatives covering environmental monitoring, awareness building on the part of Mongolians and concerning negative impacts such as noise and electromagnetic waves ($12,780,432). No direct link to reducing air pollution. However, will have positive outcomes regarding air pollution monitoring.

APPENDIX 3. COSTS AND POTENTIAL AIR POLLUTION REDUCTION BENEFITS OF NPRAEP

*Key to Impact and Affordability

1 None/seemingly impossible
2 Little/not likely
3 Some/unclear
4 Significant/possible
5 Very significant/highly feasible

Action	NPRAEP Article no. (Action Plan no.)	Description	Cost ($US)	Impact*	Affordability*	Conditionality and Remarks	Relative Importance for Air Pollution Control with Remarks
1	4.1.1-4.1.5 (1.1.1-1.5.3)	Human Settlement Development	71,918,943	2	1	Most actions entail changes to laws, except for financing a new international airport town project and a railway extension. No clear budget for moving entities out of UB and resettlement. No law on human settlement approved yet. Resettlement requires a huge investment. No funding reflected for most of major resettlement actions specified. Full implementation of resettlement will require more than 9 years.	The changes in laws are intended to slow the rural exodus and thus are important for air pollution reduction. The new international airport town project and railway extension have no obvious relation to air pollution reduction.
2	4.1.6 (1.6.1-1.6.5)	Extension of power/electricity transmission and distribution network	87,661,581	3	1	The intention of a sharp reduction of air pollution in UB is highly desirable. However, given the uncertainly in funding required, the maximum level of electricity production in UB (until Baganuur CHP is operational) and low level of living standards of population in ger districts it might be not fully achievable. Heating gers in UB with electricity is not feasible as a large-scale solution; this would be the case in any country with a winter climate, even the most developed. The issue of the current conditions of the insulation of the gers must also be resolved. With electric heating, the electricity consumption in poorly insulated gers would be high. However, the initiative to create a Northeast Asia Power System Interconnection may greatly help in achieving this.	Decreasing the use of coal for heating in ger districts will have an impact on reducing air pollution. It should be noted that less use of coal in power generation through more energy efficient technologies that have lower heat rates will reduce greenhouse gas (GHG) emissions and air pollution.
3	4.1.7 (1.7.1-1.7.4)	Housing developments in ger district	3,472,254	5	4	Seed funding only foreseen. However an initiative to improve the quality of housing available to households currently living in gers is likely to attract funding from the private sector as well as donors. Ger householders have incomes in the majority of cases.	If the measures outlined are implemented with the caveat that the number of ger households does not increase, then actions will have a high impact on air pollution.
4	4.1.8 (1.8.1-1.8.5)	New forms of heating for the ger district	347,617,338	3	2	These is a series of initiatives to connect the ger districts to new forms of heating, including renewable energy. There are serious practical obstacles to the implementation of these in Mongolia. Significant amounts of financing in the form of foreign loans and grants in addition to state funds have already been secured from the ADB, Republic of China and South Korea; however, details are not yet clear on how these will specifically be used.	Renewables can play a part in reducing air pollution. However, there are serious practical difficulties involved in their implementation in Mongolia.
5	4.1.9 (1.9.1)	Connect consumers to central heating supplies	37,958,553	4	4	Involves shutting down the localized district heating plants and HOBs which are inefficient and are a factor in atmospheric pollution. Extending piping systems to draw hot water from the more efficient coal-fired thermal power stations, currently running on coal, is a move in the right direction.	Can eliminate up to 10% of the pollution.
6	4.1.10 (1.10.1-1.10.3)	Improvements to sanitation and	11,695,223	2	4	Improvements in sanitation and other facilities, improving the lives of those in ger districts and other less well-off areas	Very little connection to air pollution; rather it may have a good impact on overall environmental

Action	NPRAEP Article no. (Action Plan no.)	Description	Cost ($US)	Impact*	Affordability*	Conditionality and Remarks	Relative Importance for Air Pollution Control with Remarks
		other facilities				of UB is a good idea. It should attract $outside funding but transparency issues will cause concerns that the funds could be siphoned off due to fraud, underscoring the need for this issue to be addressed in the needed reforms.	pollution, including soil and groundwater pollution but only if the budget is spent for its intended purposes.
7	4.1.11-4.1.12 (1.11.1-1.12.1)	Roads, production and mining issues – protecting urban areas	191,345,869	3	3	Involvement of the EXIM bank of South Korea should help offset the danger of the funds being siphoned off due to fraud at a state level.	Will have only marginal impact on air pollution reduction, but limiting the rural exodus will help prevent further air and environmental pollution.
8	4.1.13 (1.13.1-1.13.5)	Green urban planning initiatives	4,090,406	2	5	Improvements in the urban areas through greening will improve the quality of life of the inhabitants and thus is very desirable.	May have only marginal impact on improving air quality.
9	4.1.14 (1.14.1-1.14.2)	Protect river systems and surrounding areas	41,738	2	5	Law enforcement is crucial.	Limiting the rural exodus will help prevent further air and environmental pollution.
10	4.2.1-4.2.3 (2.1.1-2.3.3)	Prohibition of raw coal and use of alternative fuel sources	279,211,971	4	2	The required funding is huge relative to its impact on air and environmental pollution reduction; 97% of total funding required is for the construction of a 500-km cement road. Unlikely to be effective in terms of air pollution reduction from a longer-term perspective. If the improved fuel can be produced and supplied without constructing a 500-km cement road, this measure will be a far more cost-efficient measure for reducing air pollution.	Will have a reasonably high impact on reducing air pollution if it is used in combination with energy efficient stoves in the short-to-medium term. The impact on air pollution reduction will be limited from a long-term perspective.
11	4.2.4 (2.4.1-2.4.2)	Reduction in electricity consumption and tariffs. Provision of alternative fuels and stoves.	17,739,007	2	5	The use of a night-tariff decreases the effectiveness of public spending compared with other possible effective measures. However, the use of alternative stoves will have a positive impact but only if poorer households are supported in obtaining them on a sufficiently wide scale.	Reduction of air pollution can be achieved through some of these measures but the number of households in the target group that will get support in using clean stoves is too low. In addition, the government may consider providing support to new technology stove producers to commercialize the production and selling of stoves. The night tariff should only be used for those HHs using electric heaters.
12	4.2.5 (2.5.1-2.5.2)	Environmentally friendly building materials	4,061,189	3	5	Implementing legal regulations to support domestic production of environmentally friendly building materials are desirable actions although the link to the existing atmospheric air pollution problem is not evident in Mongolia.	Decreasing heat loss will decrease the quantity of coal used.
13	4.2.6 (2.6.1-2.6.6)	Improved building insulation	1,343,990	2	5	Will reduce the heat loss in buildings and thus will play a role in reducing atmospheric air pollution. The introduction of a green building requirement is a desirable action.	Reduction in heat losses in buildings will reduce the level of air pollution.
14	4.2.7 (2.7.1)	Expanding heating supply and extension of grid of 10 aimags	135,651,230	5	2	The expansion of the city's heating supply, extensions of the grid and technological renovation to reduce coal consumption and waste are important. However, given the absence of cost recovery in the district heating sector and without implementing the needed reforms, it is very unlikely that it will be possible to secure the foreign loans and private investment planned.	Can eliminate up to 10% of air pollution.
15	4.2.8-4.2.11 (2.8.1-2.11.4)	Improved environmental actions: water supply, garbage collection, waste disposal, recycling	457,161,341	2	2	These actions deal with waste and health problems and are important initiatives. It includes 2.9.2 which is an initiative to recycle waste and build a power plant to produce 32 MW from the waste, costing $144,276,156 and supposedly financed from external sources and private investment.	No obvious connection to air pollution. However it will have an impact on reduction of and prevention of future air and environmental pollution if an energy-integrated development approach for the waste (solid and liquid) management sector is used. If properly designed, constructed and operated, a waste-to-energy facility will contribute to reducing

Action	NPRAEP Article no. (Action Plan no.)	Description	Cost ($US)	Impact*	Affordability*	Conditionality and Remarks	Relative Importance for Air Pollution Control with Remarks
							GHG emissions and other air pollutants from reduced coal consumption.
16	4.2.12 (2.12.1-2.12.2)	Coal gasification	2,324,143,832	5	3	These measures deal with a very important initiative (intensify research of coal seam methane resources, support the development of coal enrichment, deep processing plant and coal synthetic gas), which if collectively successful would essentially resolve the problem of atmospheric air pollution in Mongolia. A substantial amount of the funding for this (according to the MOE at least $1.5 billion) has already been secured via FDI.	Gasification of coal could significantly reduce the problem of atmospheric air pollution in Mongolia. The GOM needs to address potential environmental issues from coal gasification such as migration of volatile organic compounds into potable groundwater, and migration of contaminated ground water to potable water aquifers. This action should be closely linked with the Energy Master Plan and the Gas Supply Master Plan.
17	4.2.13 (2.13.1)	Use of alternative energy/fuel sources for passenger trains	3,728,947	2	5	Good approach to use electricity and improved fuel for passenger trains. However, the previous partially failed attempt to use improved-fuel ger stoves shall be taken into consideration.	Almost no visible impact on air pollution reduction. Note severe practical difficulties in obtaining correct fuel given past experience.
18	4.2.14 (2.14.1-2.14.3)	Revise and enforce environmental protection measures and standards	20,869	3	5	These are initiatives for setting environmental standards for energy sold to Mongolians and is an initiative which should be supported, although only indirectly linked to the issue of atmospheric pollution.	Only indirect marginal link to air pollution. However, will have long-term policy and health implications.
19	4.2.15 (2.15.1-2.15.5)	Environmental protection research and development	13,573,053	3	3	These are a multitude of unfocused actions on R&D.	Some specific measures may have long-term positive impacts if targets are achieved and if all associated innovation and technology development, including testing, takes place in properly-regulated conditions.
20	4.2.16 (2.16.1)	Establish environmentally friendly technology and exhibition center	17,530	3	4	This is a good initiative that could positively affect consumer preferences and attitudes.	Only a marginal link to air pollution.
21	4.2.17 (2.17.1-2.17.2	Development of standards for home appliances and gas heaters and establishment of 'Green Fund'	4,182,231	2	5	The green credit fund can be considered one of the foundations for creating financing mechanisms which are missing in today's financial system. However, there is a need for reforms to increase transparency and good governance practices.	No obvious connection to air pollution. However, if successful may have long-term positive impacts on environmentally-friendly business development.
22	4.3.1 (3.1.1-3.1.2)	Reduce pollutants emitted from vehicles	292,171	3	5	A comprehensive approach to reducing the amount of pollutants emitted from vehicles will help reduce the atmospheric pollution associated with vehicles.	Some marginal link to air pollution.
23	4.3.2-4.3.7 (3.2.1-3.7.2)	Promote improved fuels for vehicles and less atmospheric pollution. Improve road network's environmental friendliness.	44,381,743	2	4	This is a series of actions regarding motor vehicles which are very desirable from an atmospheric pollution viewpoint.	Only a marginal link to air pollution.
24	4.4.1 (4.1.1-4.1.2)	Establish an 'Anti-Air Pollution' Fund	40,486,674	3	4	Establishment of the system of coordination and management of financing of air pollution reduction efforts through an Anti-Air Pollution Fund could be useful to fill the existing gap in managing the overall initiative. However, the new fund should implement good governance practices and its activities should be transparent and free of dishonest dealings.	Only a marginal link to air pollution.
25	4.4.2 (4.2.1-4.7.1)	Improved institutional and methodological arrangements for environmental areas including air pollution. Better regional	20,869	2	5	Dealing with environmental regulations is very desirable but not feasible without carrying out the needed reforms to ensure cost recovery in the electricity and heat sectors and ensuring transparency and a lack of fraud at government level.	Only a marginal link to air pollution. The results would be positive if the updated Energy Master Plan which could be an integral part of the Energy integrated urban development planning approach is used for those measures.

Action	NPRAEP Article no. (Action Plan no.)	Description	Cost ($US)	Impact*	Affordability*	Conditionality and Remarks	Relative Importance for Air Pollution Control with Remarks
		and urban development measures.					
26	4.4.8 (4.8.1-4.8.3)	Gas supply master plan	436,170	3	5	This is an extremely important initiative but cannot go forward without being preceded by fundamental reforms ensuring transparency on the part of the government and an end to fraud through international pressure and monitoring.	Gasification of coal could significantly reduce the problem of atmospheric air pollution in Mongolia.
27	4.4.9-4.5.11 (4.9.1-5.11.1)	Environmental monitoring and awareness building	12,780,432	3	5	A series of initiatives covering environmental monitoring, awareness building on the part of Mongolians and ending with the negative impacts of noise and electromagnetic waves.	No direct link to reducing air pollution. However, will have positive outcomes regarding air pollution monitoring and awareness building.
	TOTAL FUNDING REQUIRED		4,095,035,154				

Exchange rate: $1US=2395.85 MNT (MongolBank rate of 18 Feb 2018)

*Key to Impact and Affordability

1 None/seemingly impossible
2 Little/not likely
3 Some/unclear
4 Significant/possible
5 Very significant/highly feasible

APPENDIX 4: AIR POLLUTION-RELATED TARGETS, INDICATORS AND BUDGET ALLOCATED FOR 2018

Targets	Indicators	Budget – 2018 (million MNT)	Has budget for the purpose	Remarks
Ministry of Environment and Tourism				
Reduction of pollutants (compared with baseline year 2016)	5-10%	17,900.0	MNET, MOE	(i) Air pollution-related recurrent expenditures planned for 2018 (ii) In addition, below specified investment expenditures are also added value to reducing air pollution
Creation of a technical condition for households in ger areas to use night-tariff discount (number of households)	130,000	9,000.0	MNET, MCUD MOE,	Nationwide, includes UB. Investment expenditures
Creation of a technical condition for ger area households to use electric heater (number of households)	20,000		MOE	MOE budget
Ministry of Energy				
Expansion of the heat distribution network (km)	36.2	5,208.9	MCUD	Nationwide
Connect entities using heat-only boilers to the central heating system	41	11,979.5	MOE	UB, Investment expenditures
Expansion of the Ulaanbaatar electricity transmission and distribution network (number of households)	20,000	4,800.0	MOE	UB, Investment expenditures
Expansion and renovation of the local level electricity transmission and distribution network (number of soums)	10	14,230.7	MOE, MCUD	Nationwide, but mainly rural areas, Investment expenditures
Total for 2018		62,219.1		Recurrent = 17,900.0 Investment = 45,219.1

Note: The 2018 Budget was used as the basis of these estimates. It was planned to collect 30 billion MNT air pollution tax in 2018.

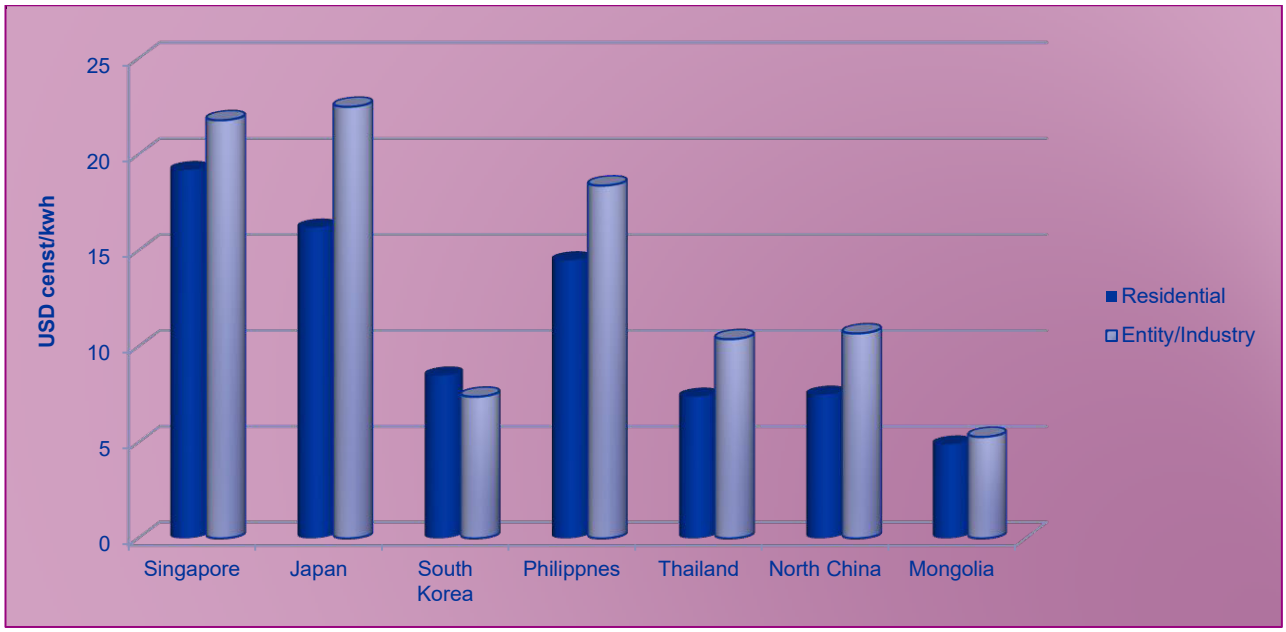
APPENDIX 5. DATA ON TARIFF INSUFFICIENCY FROM "2016 STATISTICS ON ENERGY PERFORMANCE"

Data published by the Energy Regulatory Commission of Mongolia used for the following Table on Energy Sector Deficit Financing and two Graphs on Electricity Price Comparison. .

The deficit covered by the Mongolian Government in 2016 was $6.7 million:

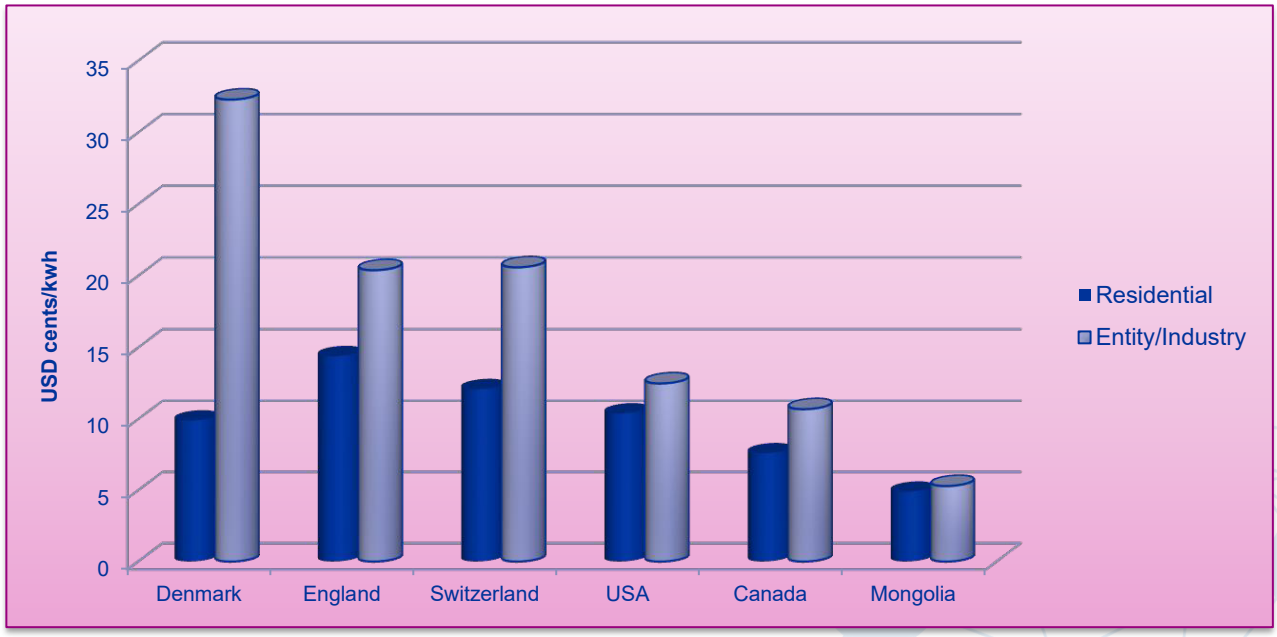
Name of LHs	2011	2012	2013	2014	2015	2016
CHPP-2 SOJSC	1,080.0	490.0	500.0	-	-	-
CHPP-3 SOJSC	2,980.1	-	1,400.0	-	-	-
CHPP-4 SOJSC	3,738.0	-	2,100.0	-	-	-
DCHPP SOJSC	2,280.0	1,419.9	700.0	-	-	-
ECHPP SOJSC	2,280.0	490.0	900.0	-	-	-
NPTG SOJSC	1,800.0	980.0	1,400.0	-	-	-
BSEDERN SOJSC	-	295.0	400.0	-	-	-
DHP SOJSC	500.0	490.0	-	-	-	-
WRES SOJSC	4,499.9	6,480.6	5,870.6	7,000.0	8,600.0	8,600.0
DRES SOJSC	1,550.0	2,790.0	2,000.0	2,200.0	2,200.0	-
DrCHPP SOJSC	1,800.0	2,205.0	1,700.0	1,600.0	1,600.0	1,600.0
AUES SOJSC	7,979.0	6,771.3	4,632.0	7,650.0	4,150.0	3.150.0
BNTP SOJSC	900.0	1,445.1	1,455.1	1,100.0	1,100.0	1,100.0
TPSND SOJSC	1,302.0	1,795.7	1,645.8	1,400.0	1,400.0	1,400.0
DShGOL SOJSC	-	-	-	500.0	500.0	500.0
TOTAL	32,689.0	25,652.6	24,703.5	21,450.0	19,550.0	16,350.0

COMPARISON OF ELECTRICITY END USER PRICES OF SOME ASIAN COUNTRIES (Exchange of USD to MNT 1: 2489.53)



COMPARISON OF ELECTRICITY END USER PRICES OF DEVELOPED COUNTRIES AND MONGOLIA (Exchange of USD to MNT 1: 2489.53)

Electricity Tariffs are lower in Mongolia than in other countries surveyed



APPENDIX 6. TERMINOLOGY USED FOR ECONOMIC COST ESTIMATION

Disability Adjusted Life Years (DALY): One DALY is calculated as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, is a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with a health condition or its consequences.[119]

Value of Statistical Life (VSL): How much people are willing to pay for small reductions in their risks of dying from adverse health conditions that may be caused by environmental pollution. These estimates of 'willingness to pay' for small reductions in mortality risks are often referred to as the Value of Statistical Life (VSL).[120]

Welfare cost of air pollution: The cost of the health impact of air pollution is evaluated in terms of what the population at large would be 'willing to pay' to avoid premature death, and the mortalities due to exposure to air pollution. The welfare costs are calculated using estimates of the VSL.[121]

Total economic cost of air pollution: Total cost of air pollution includes both market and non-market costs. The market impacts comprise additional health expenditures due to illness and labor productivity losses due to absences from work for illness. Non-market impacts are evaluated using estimates of 'willingness to pay' to reduce health risks (OECD, 2016).

[119] World Health Organization, http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/

[120] https://en.wikipedia.org/wiki/Value_of_life

[121] OECD, https://stats.oecd.org/Index.aspx?DataSetCode=EXP_MORSC

APPENDIX 7. DESCRIPTION OF SELECT SCENARIOS FROM WORLD BANK STUDY, 2011 AND 2017[122]

Baseline; business as usual. This describes the status quo as observed today with several trends expected to continue: (a) growth of the city through natural population increase and a large influx of migrant workers from the country side; (b) conversion of moveable ger dwellings into fixed wooden and brick homes; and (c) relatively fast growth of low pressure boilers and decreased use of simple stoves (with or without heating wall), which increases coal consumption.

■ **Scenario 1 (short-term).** Reduce start-up emissions. This is a promising option that was first described in the World Bank's Mongolia: Heating in Poor, Peri-Urban Ger Areas of UB. It has become apparent that most of the emissions come from the cold start-up phase of the stove and to a lesser extent from the refueling. Measurements confirmed that PM emission reductions of 60 to 80 percent can be obtained when the fire is started differently and when the fire is not allowed to die down but continues to burn throughout the day and night. This scenario thus reflects mainly behavioral changes and not necessarily large capital investments for the beneficiary.

■ **Scenario 2 (short-term).** Replace existing stoves with new coal stoves ("cleaner stoves") without changing the fuel. Although several models of emission reducing stoves exist, not all combinations have been tested. Of those tested, measurements indicate that the right type of stove with a traditional fuel (nalaikh coal) can achieve relative reductions in excess of 95 percent. In addition, fuel savings of up to 50 percent have been observed and the stove may remain hot for much longer periods (one model stays warm for over 10 hours). This scenario refers to an effort to make cleaner stoves available to users on a large scale. Successful implementation would require (a) an awareness campaign to convince households of the advantages of changing their stove; (b) a financing mechanism with a possible subsidy component to enable households to purchase the stove as well as to promote a wide variety of eligible stoves to address customer preferences and increase chances of rapid market penetration; and (c) an eligibility program to select the appropriate stoves for support and dissemination, and to create a sustainable production capacity of such stoves. The main issue with adoption of this scenario will be the perceived benefits from the stove to the user. The likely questions include: "Does it save fuel? How quickly does it give off heat, and is cooking within accustomed times and methods possible? How often is refueling needed? Does it smoke when opening the door for refueling? How much does it cost?" The costs of realizing this scenario will include the investment in new stoves, the replacement of these stoves after their useful service life, removal of old stoves, a publicity/promotional program, a quality control mechanism to maintain a sustainable production capacity of these stoves, and a possible subsidy that might be required for quick adoption. The new stoves will reduce fuel consumption and thus provide a benefit to end-users. Another economic benefit for this scenario is a reduction in implementation costs.

■ **Scenario 3 (medium-term).** Replace existing stoves and fuels. Semi-coked coal (SCC) receives much attention, and while SCC can burn cleanly in an appropriate stove, there are two challenges associated with this scenario. SCC is difficult to light and its production costs are higher than raw coal. Raw coal burns very cleanly after the start-up phase and actually transforms into coked coal with associated low emissions. The bulk of emissions occur during the start-up phase. Since semi-coked coal is difficult to ignite due to the absence of volatiles, wood and other start-up fuels are needed, which promote high emissions. Moreover, because the cost of producing semi-coked coal is high, the heating costs associated with the converted fuel are much higher than with raw coal, and equalization payments (subsidies) are necessary to avoid poor households paying more for heating. Since start-up emissions constitute most of the total emissions, the overall impact remains unclear if more wood is needed to get the fire started compared to raw coal. Tests so far have been inconclusive as to whether SCC will reduce emissions. Furthermore, it is necessary to use new stoves to burn SCC cleanly. Because SCC is more expensive than raw coal, the European Bank for Reconstruction and Development (EBRD)'s Clean Air Initiative has proposed a continuation of equalization payments until scale economies can be obtained and SCC could be sold without subsidies. This scenario still requires additional basic research to develop the emission details, and therefore the study team needed to assume certain benefits that could be verified later. The scenario therefore includes setting up the production capacity of SCC and SCC stoves, an awareness campaign to convince people to start using it in new stoves, and recurrent annual subsidies to enable the use of SCC at equal costs to raw coal. The industrial production of semi-coked coal from raw coal requires a commitment by the government to recurrent fuel consumption subsidies until the economies of scale are achieved and/or incomes rise to afford the more expensive fuel. Therefore, the benefits need to be confirmed conclusively before a program is started.

■ **Scenario 4 (medium-term)**. Install electric heating in existing ger homes. This approach is discussed in more detail in the *Ger Heating Report* (World Bank/ASTAE 2009). This requires a large investment program to create the capacity to generate the power needed to supply ger households with electricity for heating (estimated at 1.7 GW by MMRE in 2011). In addition, an equalization charge is needed because the cost of electric heating is significantly higher than the cost of heating with coal. In this option, people do not move into new homes but continue to live at their current residence and start using electric stoves for heating and cooking. The cost of electric stoves and heaters, the cost of electricity minus the savings of coal fuel, and the cost of infrastructure for incremental generation and distribution capacity will need to be incorporated into the cost analysis. The emission reduction can be large (close to 100 percent; see also remarks on apartment buildings21), assuming that people will actually refrain from using coal once they obtained an electric heater. A limiting factor will be the infrastructure investments to supply the additional electricity and the willingness of households to pay for the electricity, because although electric heating is more convenient than coal heating it will also be more expensive (or, a subsidy may be needed to equalize heating costs, but this has not been incorporated for now). The scenario assumes that most people in ger districts will actually switch to electricity once the government announces the availability of this option.

■ **Scenario 5 (long-term)**. Relocation of ger households into apartments. This is the preferred long-term option, indicated in the Smokeless UB program. New apartment buildings are established in newly developed areas, in existing ger areas, and in other cities. The impact is relatively simple, as coal consumption can be avoided almost completely (from heating in coal stoves). There will be an increased contribution from the district heating system, but this is estimated to be small compared to the consumption of coal used for heating in ger stoves. The costs of construction, as well as the incremental capacity needed for district heating, will need to be incorporated in the cost analysis, and these costs are very high.

APPENDIX 8. DESCRIPTION OF HARMFUL AIR POLLUTANTS

Nitrogen oxides (NOx).

Nitrogen oxides, particularly nitrogen dioxide, are expelled from high temperature combustion, and are one of the most significant air pollutants. They can be seen as a brown haze dome above or downwind of affected cities. For the general public, the most prominent sources of NO_2 are internal combustion engines burning fossil fuels such as those found in vehicles. Indoors, exposure arises from cigarette smoke and butane and kerosene heaters and stoves.

Sulphurous gas (SOx)

Coal and petroleum often contains sulphur compounds and their combustion generates sulphur dioxide. This is a major cause for concern in the use of coal and petroleum fuels as power sources and their concomitant environmental impact. Unfortunately, no evidence has been found on the process or plans to reduce the SO_2 content of flue gases, for example through flue gas desulfurization at CHP plants which are the largest consumers of coal.

Particulates (PM_{10} and $PM_{2.5}$)

Particulates, alternatively referred to as particulate matter (PM), atmospheric particulate matter, or fine particles, are tiny particles of solid or liquid suspended in a gas. In the main, human activities such as the burning of fossil fuels in vehicles, power plants and various industrial processes generate significant amounts of aerosols. Sub-types of atmospheric particles include suspended particulate matter (SPM), thoracic and respirable particles, inhalable coarse particles which are particles with a diameter between 2.5 and 10 micrometres (μm) (PM_{10}), fine particles with a diameter of 2.5 μm or less ($PM_{2.5}$), ultrafine particles and soot. The International Agency for Research on Cancer (IARC) and the WHO designate airborne particulates as a Group 1 carcinogen. Particulates are the deadliest form of air pollution due to their ability to penetrate deep into the lungs and blood stream unfiltered, causing permanent DNA mutations, heart attacks and premature death.

Carbon oxides (CO and CO_2)

Carbon dioxide is a natural component of the atmosphere, essential for plant life and generated by the human respiratory system. CO_2 currently forms about 405 parts per million (ppm) of the earth's atmosphere, compared to about 280 ppm in pre-industrial times, and billions of metric tons of CO_2 are emitted annually by the burning of fossil fuels. CO_2 increases in the earth's atmosphere have been accelerating. CO_2's role as a greenhouse gas has been described as "the leading pollutant"[123] and "the worst climate pollution".[124]

[123] https://www.nationalgeographic.com/environment/global-warming/pollution/
[124] https://www.scientificamerican.com/article/the-worst-climate-pollution-is-carbon-dioxide/