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Ministry of Health, Welfare and Sport

Reducing Impacts of Air Pollution on Maternal and Child Health:

A Rapid Assessment of Intervention Strategies in Bayankhongor, Mongolia

Colophon

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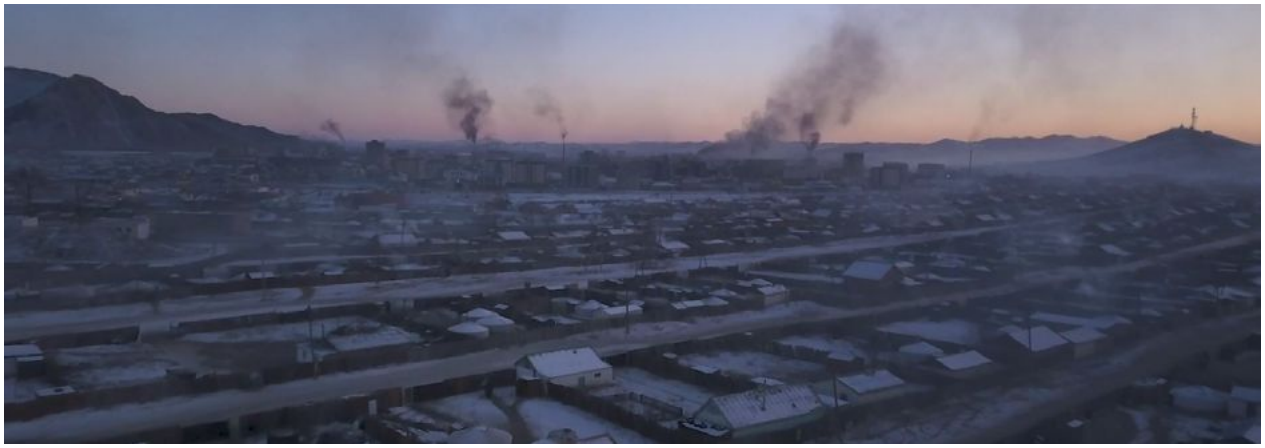
Acknowledgement
The rapid assessment of intervention strategies by UNICEF in Bayankhongor aimag was carried out in 2019. The financial and technical support was provided by UNICEF and the Government of the Netherlands.

Synopsis

Mongolia has long and very cold winters. People return to the urban area during the winter and remain there during the entire winter.

A large number of people live in gers, the tent-like traditional form of dwelling, or in single houses. The gers and houses in ger areas are heated by coal-fired stoves. The apartments are connected to central heating system, also fired with coal.



The air pollution caused by the emission of coal fired stoves provoke serious health effects in children and pregnant women in urban areas in Mongolia. UNICEF, with the support of Swiss Agency for Development and Cooperation and in collaboration with the Government of Mongolia has been implementing the project "Impacts of air pollution on maternal and child health" and launched pilot interventions to reduce the impact of air pollution exposure to maternal and child health. The interventions are supported by a numberof bilateral and multilateral organisations including the Netherlands Government.

In Bayankhongor, currently one of the most polluted urban areas outside Ulaanbaatar in Mongolia, the Cooking, Heating and Insulation Products and Service (CHIPS) concept has been piloted; gers were modified to improve the insulation against heat loss and the coal fired stoves were replaced with electric heaters.

For the winter of 2019-2020 CHIPS package was introduced to the first 200 ger households and these households have the first experiences with electric heaters and better insulated walls and roofs. As part of the evaluation of the setup and of the impact the RIVM has conducted a rapid assessment to assist in the follow-up of the intervention and extend the transition from coal to electric heating further to arrive at a Smog Free Bayankhongor by 2022.

The assessment provides the observations made during the visit to Bayankhongor and meetings with the various organisations in Bayankhongor and Ulaanbaatar. Based on these observations and discussions with the UNICEF staff a number of recommendations for UNICEF are formulated.

Keywords: UNICEF, health risk, children and pregnant women, Bayankhongor, Mongolia, air pollution, domestic heating, coal, electric heating

Executive Summary

On the request of UNICEF the RIVM made a rapid assessment of the interventions in Bayankhongor, Mongolia, launched by UNICEF to address the serious health effects on children and pregnant women caused by the extreme air pollution situation. The high levels of air pollutants are caused by the emissions of domestic stoves fired with coal, more specifically raw coal, and by Heat-Only-Boilers (HOBs) that use coal to heat apartments and other buildings through a central heating system.

The interventions fit in the framework of the "Bayankhongor Smog Free Action Plan" approved in June 2019 by the local parliament, and incorporate the concept of Cooking, Heating and Insulation Produce and Service (CHIPS) for improved insulation of gers and installation of electric heaters and energy advisory services.

During the winter of 2019-2020, 200 households living in 'gers' experience the improved thermal comfort, social comfort and financial consequences of using electric heating for their homes.
For the rapid assessment of the project, Bayankhongor province was visited as well as a number of meetings were held with staff of local governmental organisations. The observations during the visit, the information obtained during the meetings and the review of existing project documents and reports have resulted in a number of recommendations. These recommendations are to assist the future planning of the activities of the intervention and to bring project benefits to more local people.

Scaling up the project by involving a greater number of local people is necessary to arrive at the objective of the project and achieving the goal of the Smog Free Bayankhongor by 2022. The recommendations also envision scaling up of the project successes and achievements to other urban areas in other aimags in Mongolia.

Introduction

Background

Mongolia has long and very cold winters during which most of the poor households rely on the heat generated by burning coal in inefficient stoves to keep warm. Urbanization in which Mongolians move to urbanized areas in the winter or stay there the entire year has resulted in ever increasing air pollution levels in these areas due to emissions of the coal fired stoves

and the unfavourable meteorological conditions and geographic locations. The unprecedented air pollution levels, belonging to the worst in the world, have become a serious health crisis for vulnerable people, especially young children and pregnant women but also for elderly and people with a compromised health status. The effects, including stillbirth, preterm birth, lower birth weight, pneumonia, bronchitis, asthma, and lower lung function amongst children have prompted the United Nations Children's Fund (UNICEF) to address this health crisis consisting of both acute adverse effects as well as long-term irreversible health effects, such as permanent brain damage among children.

In June 2019, the Bayankhongor Smog Free Action Plan was approved by the local parliament. In close collaboration with the local government, international organisations and international and national universities UNICEF has designed and rolled out a pilot project based on the CHIPS concept (CHIPS = Cooking, Heating, Insulation, Products and Services) in Bayankhongor (BKH) that addresses both the cause of the air pollution and create alternatives. It explores various remedial actions, feasible for an economically weak population, raising awareness of health problems and potential solutions among the public and various stakeholders, both private and government. A main objective of the project is to act as the showcase illustrating feasible solutions for the health crisis by guiding households with the technical provisions of the project, assisting changing one's perception of the problem and consequently one's behaviour.

After the start of the project in 2019 UNICEF identified the need for a rapid assessment of the project to explore the current practice for further improvement of the project strategies and interventions and and recommendations helpful for the project to be extended to a larger number of households in Bayankhongor.

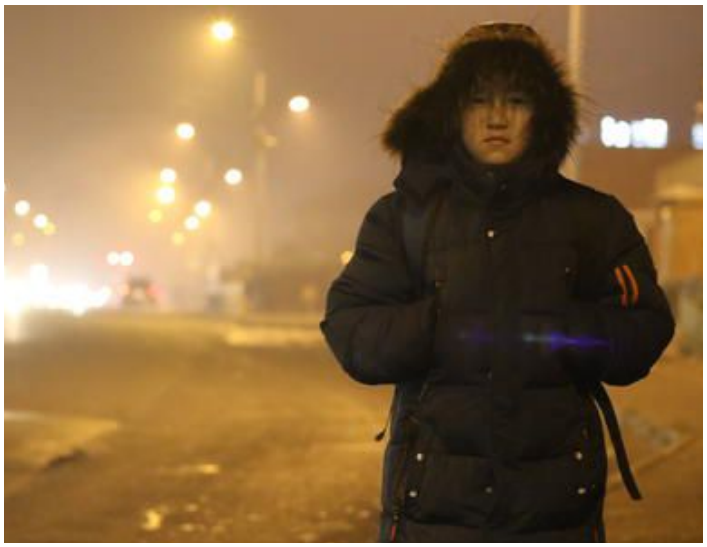
In 2019, UNICEF entered into an institutional contract with the Rijksinstituut voor Volksgezondheid en Milieu (RIVM, National Institute for Public Health and Environment), Bilthoven, the Netherlands for the 'rapid assessment of intervention strategies by UNICEF in Bayankhongor aimag to reduce the impacts of air pollution on maternal and child health' (contract no 43285301).

The mission

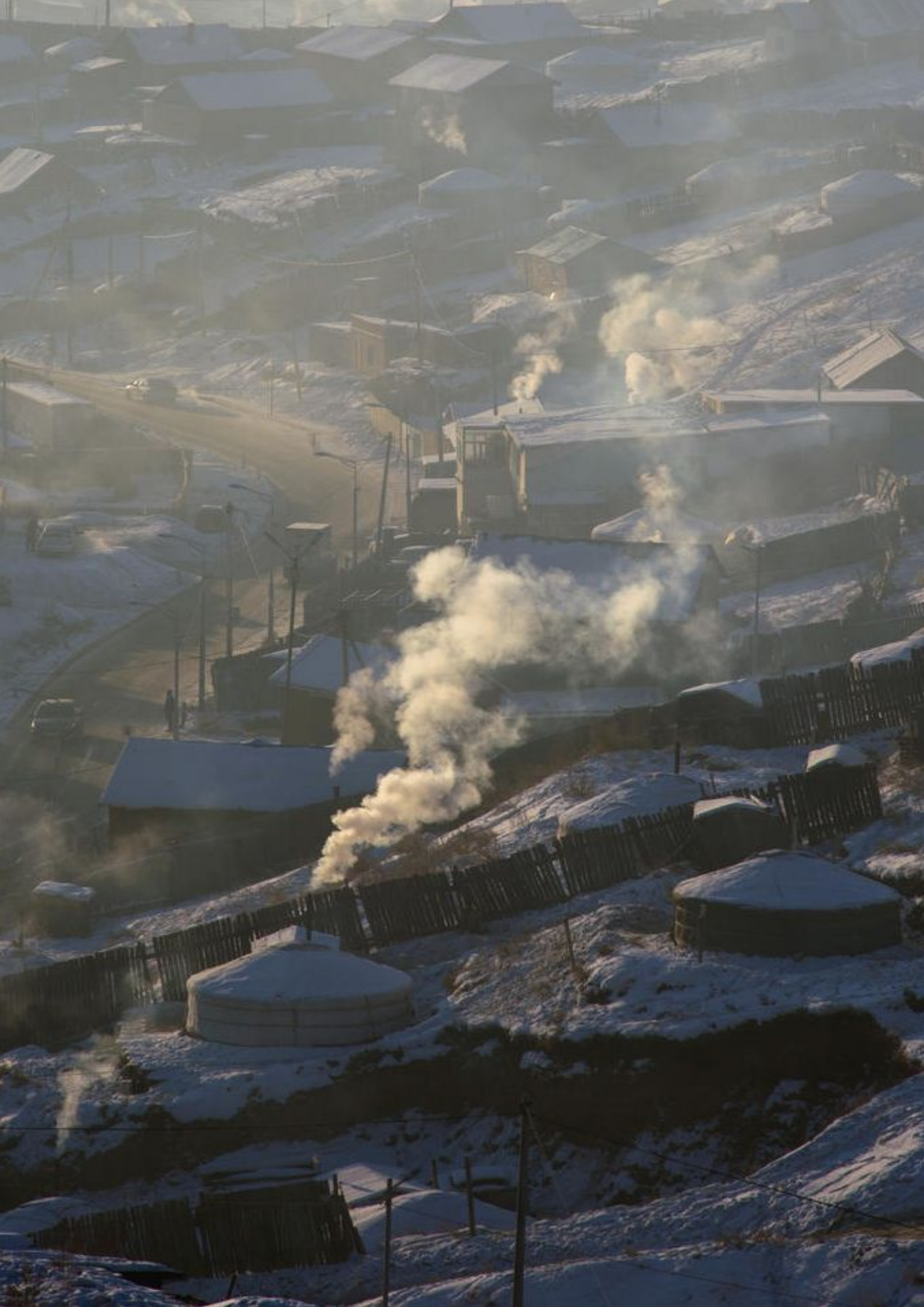
The purpose of the assignment is to carry out a rapid assessment of the comprehensive approach being developed and rolled out by UNICEF and partners in Bayankhongor (BKH). The assessment should provide conclusions and practical recommendations to adjust and strengthen the approach.

The assessment is to characterize the initial conditions, intervention strategies, and obtained results in both indoor and outdoor air quality and in child and maternal health.

Besides considering the project's conceptual approach, including objectives, interventions, indicators, and timeline, the report will assess technical and financial considerations and any risks to the project's progress and success. The Terms of Reference are provided (see annex 3). The scope of the assessment includes:



- Development of a work plan with questions to be answered by stakeholders, partners, and others;



- Undertake desk review of existing documentation of UNICEF and of the BKH programmes and projects;

- Undertake desk review of existing literature on the status of air pollution and children's health in BKH and Mongolia more broadly, efficacy and costs of measures for emission reduction, and public awareness of air pollution impacts and reduction measures;

- Review BKH budget including socio-economic directive and investment in order to provide recommendations on co-funding potential;

- Conduct mission to Mongolia;
- Organise stakeholders' meetings and consultations in Ulaanbaatar;
- Organise stakeholders' meetings, consultations and observations in BKH;
- Conduct online interviews with international partners; and
- Prepare a final report with recommendations.

More specifically, the following issues were addressed:
Air pollution conditions in BKH with a focus on PM2.5, but also including NO2, PM10, and other pollutants:

- Pollution sources (type, nature, number and amount of emission, locations);
- Dispersion in the ambient environment and temporal variation;
- Infiltration in the indoor environment / lack of exfiltration / ventilation; and
- Meteorology (temperature and source strength). Health conditions in BKH, focusing on child and maternal health:
- Pollution exposure, with attention to daily variation and the locations and activities associated with exposure;

- Health complaints and records, linking these with air quality over time; and
- Awareness of pollution and the health risks and any associated avoidance behaviour.

Measures for emissions reduction and financial considerations:

- Alternatives for domestic heating and energy use reduction, and the impact of these measures on emissions;
- Feasibility and reliability of alternatives measures;
- Proof of concept for these emission reduction measures and of the success of convincing potential users; and
- Impacts on the domestic heating sector and other comparisons of group and individual benefits and costs.

Awareness of air pollution's health effects and of program interventions:

- Government authorities;
- Public and media; and
- Special groups (parents/children, schools, medical doctors, etc.).

The mission plan was prepared and the stakeholder meetings were organized by Air pollution and environment programme team, in particular by Ms. Sunder Erdenekhuyag, the sustainable energy consultant of UNICEF Mongolia. The translation was provided by Ms. Erdenekhuyag in Bayankhongor and a professional translator hired by UNICEF in Ulaanbaatar. Ms Erdenekhuyag and occasionally, Ms Munkhtuvshin Oyunbolor, a public health officer of UNICEF Mongolia accompanied Mr. Bloemen to all meetings and often participated in the discussions when special knowledge on activities of UNICEF was required. In a number of instances when dealing with technical aspects Mr. Bat-Amgalan Gantumur, a civil engineer of UNICEF Mongolia provided explanation and translation.

Transport through the busy traffic of Ulaanbaatar and Bayankhongor and between the capital and Bayankhongor was professionally provided by the skilled drivers of UNICEF, Mr. Batmandakh Buriad and Mr. Bayartuvshin Choijiljav.

The meetings were mostly planned for 60 – 90 minutes and focused on the subjects informed during the planning stage. The exchange of information and elaboration on specific subjects was very efficient and to the point. The information and insights gathered during the meetings and in the evaluation afterwards brought forward a clear overview of the activities of UNICEF and the strategy it follows to improve the health conditions of the Mongolian people and in particular that of children.

Table 1. Itinerary of the mission

11 December 2019	Arrival at Ulaanbaatar
12-14	Stakeholder consultations Ulaanbaatar
16	Travel to Bayankhongor
17-18	Stakeholder consultations Bayankhongor
19	Travel to Ulaanbaatar
20	Stakeholder consultations Ulaanbaatar
21	Departure from Ulaanbaatar

Stakeholders' consultations in Ulaanbaatar

- UNICEF / Health
- National Centre for Public Health (NHCP)
- Bayanzurkh District Health Centre
- Ministry of Health
- National Agency for Meteorology and Environmental Monitoring
- National Committee on Reducing Environmental Pollution
- UNICEF / Local Governance

- UNICEF / Representative
- Bayanzurkh District/ Local government
- Bayanzurkh District/ social projects
- Asian Development Bank (ADB)
- UNICEF/ SPMC

Stakeholders' consultations in Bayankhongor

- Local Government Bayankhongor soum
- Local Government Bayankhongor Province
- Department of Meteorology Bayankhongor aimag
- Energy Eepartment
- Ger owners, Smog Free Bayankhongor
- Bayankhongor Health Department
- Authority for Family, Child and Youth Development (AFCYD)
- Manufacturers of CHIPS
- State Bank, Bayankhongor division

In annex 1 more details on the consultations are given.

The project in brief

In Bayankhongor, the capital of the aimag (province) Bayankhongor, a fast growing population of now 40,000 people live in an urban area surrounded by moderately high mountainous fields. A large part of the population (about 7,000 households) live in gers. Apartments and single houses form the housing for the other people. The gers and many houses are traditionally heated with a stove fuelled with raw coal, wood or dung. Apartments and other buildings are traditionally heated by Heat-Only-Boilers (HOB) also fuelled with raw coal. Raw coal is the form of coal not treated in any way to modify shape or size.

The emission of the stoves in gers and houses form a low field of smoke over the town that does not rise much vertically due to the low heat content of the plumes. The emission from the HOB are fed through chimney up to 20 – 40 meters high, also have little plume rise or stays below the inversion layer and is mostly thick and black. After travelling some time the smoke of the HOB blends with the light grey smoke of the stoves in the gers and the houses. A typical day shows a peak in the pollution concentration in the morning between 8:00 hr and 9:00 hr and in the evening from 18:00 hr on until mid-night (observations voiced during the stakeholder meetings in BKH and confirmed with the first evaluation (November-December 2019) of Washington University in St Louis). These periods coincide with the peaks in the demand for space heating. The levels of air pollution, expressed as PM2.5 concentrations, are among the highest in urban areas in the world.

Health effects, especially on vulnerable groups, including children, pregnant women, elderly and people with already compromised health conditions, are a well-established scientific finding even at substantially lower levels of air pollution than those encountered in BKH. Observations by local health institutions and preliminary health data evaluation support the cause-effect relation of (winter) air pollution and seriously adverse health effects. This situation is considered as a deep health crisis.
To counter this crisis UNICEF, in close collaboration with local government, local organisations and academic institutions inside and outside Mongolia,

has developed the CHIPS concept as part of the Bayankhongor Smog Free Action Plan 2019-2022. This concept is centred around the clean energy demand for heating and cooking as well as minimizing this demand by proper insulation and applying other products and services.

The adoption of the CHIPS concept requires substantial change of the perception about the impact of the traditional use of solid fuels, the impacts on the health of the own family as well as of the population of the town. It is expected that with a clear perception behaviour will change, the CHIPS concept is adopted and the additional financial burden is accepted.

Several activities are solely or in combination focused on raising awareness of the health problem for people in BKH and the possibilities to improve the situation. Children and organisations for children are actively involved in this outreach.

UNICEF started the project in BKH by the installation of CHIPS in 200 gers, and together with the local government selected the households based on the financial position of the household, the physical condition of one or more of the family member(s) and the composition of the family. These families could apply for a full or partial subsidy. The winter of 2019-2020 is the first winter during which the impact of CHIPS will be experienced.

In the preparation phase of the rapid assessment documents were provided describing the air pollution and health condition in Mongolia and especially in Ulaanbaatar(UB) and Bayankhongor (BKH). The study of this information raised a number of relevant issues. During the stakeholder meetings much information was shared that broadens the understanding of the activities of the project or related to the project. Also, this information enlightened the project impact and raised issues worth further contemplating. The observation that are listed here follows the division used in the ToR.

Air pollution conditions in BKH

Sources and fate

The sources of air pollution in BKH are quite clear: domestic heating, both from the stoves in the individual houses and gers as well as from the HOBs providing heat for buildings and apartments. These sources are spread over the urban area. Traffic also contributes to the air pollution levels but is of minor importance. Air pollution is mainly considered to be PM2.5. Given the present air quality conditions in BKH during the winter, the other regulated pollutants, such as NOx and SO2, although present in the mix, are of minor importance. Sources at long distances have hardly any impact. The desert-like fields around BKH might contribute to the particulate matter concentrations during dry conditions (occurring also during the winter) and substantial wind speeds but these conditions are unfavourable for the simultaneous build-up of air pollutant concentration originated from heating.

Air pollution - composition

The level of air pollution in BKH is expressed as the concentration of PM2.5 as the monitoring technique is based on the size exclusion for particles larger than 2.5 micrometre expressed as the mass of the fraction collected on a filter. Health effects related to PM2.5 are based on studies, predominantly epidemiological studies, where the composition of the PM2.5 fraction differs substantially from the composition of the found PM2.5 in BKH. The average composition measured in those studies is based on the contribution of many source types and includes secondary inorganic and organic aerosol, crustal material, sea salt and particle bound water. Carbon-containing aerosol and trace elements (such as mercury, lead, arsenic and cadmium) only make up 9.5% of the PM2.5 mass. These latter components will form an more than proportional fraction of the emitted air pollutants in BKH and further exemplifies the toxicity of emissions from incineration of coal.

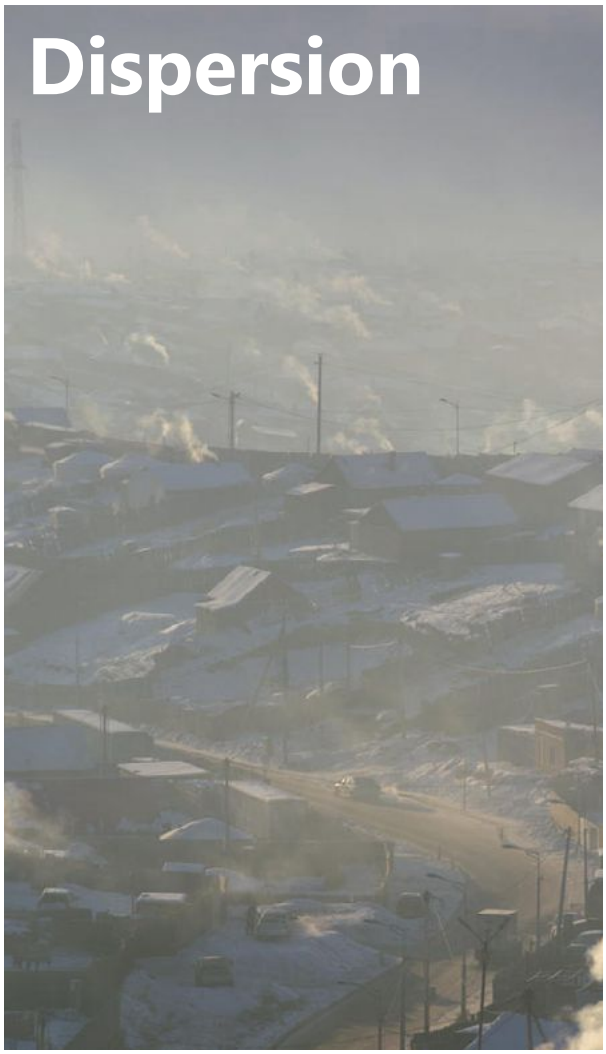
Given the indication that combustion processes produce more than average bioactive particles the health risks related to the monitored levels of PM2.5 in BKH are likely substantially underestimated.

Air pollution – fine fraction

The sizes of particles formed during the incineration of coal range from a few nanometres to beyond 10 micrometre. The very small particles, although their summed mass is small, have a large total surface-area. Besides the mass of PM2.5 also the surface area is considered a relevant parameter to explain the health effects.

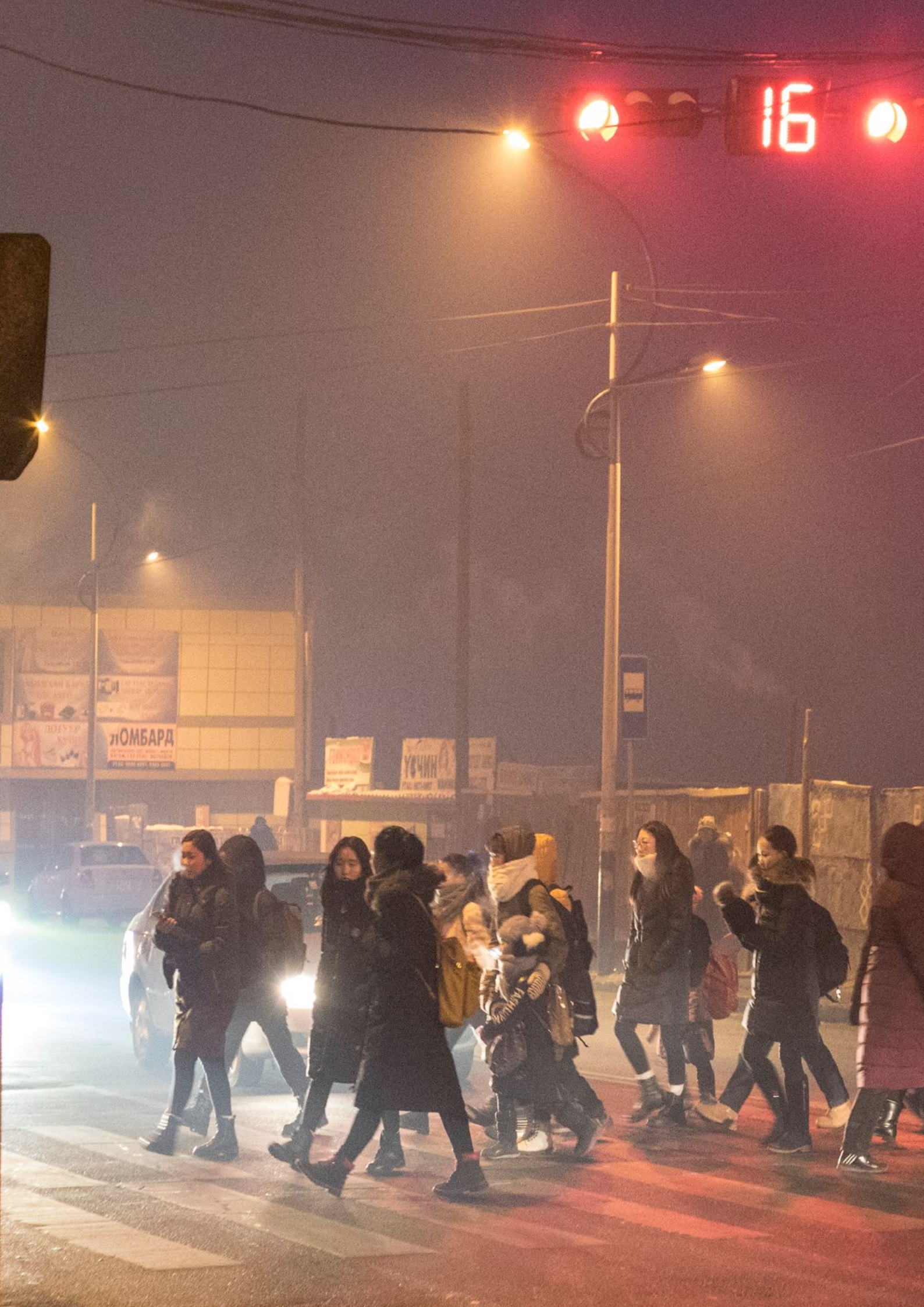
For the evaluation of filters the fraction below 0.3 um (300 nm), often identified as Ultrafine, is relevant as it will not be retained by HEPA filter, considered the most effective filter material. Nevertheless, the fraction above 300 nm will more effectively be filtered by this type of filters, and will also remove the particles that cause the smell sensation of burned coal or wood.

It is shown that also incineration of coal with minimum (expressed as mass per energy) and maximum energy content form substantial number of small particles, much of which with particle sizes smaller than 300 nanometre.



Dispersion of the emitted pollutant is predominantly determined by the low energy content of the plumes, the low emission heights and the atmospheric conditions during winterdays with low mixing layer heights in the morning, a newly formed mixing layer in the late afternoon accompanied with low or medium wind speeds. Given the diurnal pattern of the heating emissions, peaks in the morning (7-9 hr) and afternoon (after 17:00 / 18:00 hr), and the diurnal pattern of the mixing layer, the concentrations are (extremely) high during the morning and the (late) afternoon, and (somewhat) lower during mid-day. The first evaluation of the winter period until mid-December confirms this and during the stakeholders' meetings in BKH this pattern was referred to several times.

Ironically, as also stated by the Head of Bayankhongor Health Department, the morning peak (07:30 – 09:30 hr) of ambient air pollution coincides with the time children go to school and other dwellers start their activities outdoor and the late-afternoon peak (17:30 – 20:30 hr) with their return home.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Infiltration

Ambient air forms the reservoir of “clean” air for the indoor environment. This implies that the indoor air quality is the sum of infiltrated ambient air pollution and the pollutants emitted indoor by material or due to activities of the dwellers. One of the important sources of indoor air pollution are the pollutants leaked from the heating / cooking devices using (solid) fuels.
Given a low to moderate ventilation rate of 0.1 – 0.5 the indoor air pollutant concentration will follow the levels in the ambient environment, although (slightly) delayed. The notion that the indoor environment provides shelter for outdoor air pollution is mostly incorrect. Only if the development of the air pollution concentration over time is a (sharp) peak (lasting one to three hours) the average indoor environment concentration will remain substantially lower. In case ventilation is excessive during the morning hours, often common practice, the average indoor concentration might even be higher than the average ambient concentration! On the other hand, orchestrated forced ventilation and knowledge on the variability of the outdoor air pollution levels might enable optimal refreshment of the indoor environment during low concentration periods of the day.

Meteorology

Domestic heating is controlled by the perceived thermal comfort as dwellers start using their heating devices. The energy demand is defined by the temperature (substantial heating is started when the minimum temperature is 15oC or lower) and wind speed, the efficiency of the stove or HOB and the insulation quality of the heated space.
The total energy demand is defined by the number of houses and gers. A quick-and-dirty method to assess air quality levels and exposure rates might be based on the relation of temperature and wind speed (the independent variables) and the number of houses and gers (only moderately changing over time). The relation can be developed using meteorological data and air quality monitoring data, becoming available further with time. This relation gives the possibility to assess the exposure levels of the public in retrospect even if no air quality monitoring data was available.

Resuspension

The fraction of air pollutants emitted by stoves or HBO, that consists of particles with sufficiently large diameters (the heavier fraction of PM2.5/ PM10), will deposit within the urban area. Resuspension by either wind or mechanical agitation (tyres of cars and particularly trucks and busses on road) will contribute to the exposure through inhalation. Furthermore, hand-to-mouth exposure of especially children will contribute to the health treats although the exposure pathway is oral.

Health condition in BKH, focusing on child and maternal health

Exposure of children and vulnerable people

Children are exposed in most if not all environments in which they move; at home, en route to school or kindergarten and back and at the school/ kindergarten, in particular when they have a higher activity level (inhalation of more than average volume). Environments, for which filters are installed to purify the infiltration air, will have an improved air quality for as much as other infiltration routes are minimized. As corroborated above the exposure to the finest fraction of PM will also happen with filtered air.
That children are extremely vulnerable to air pollution follows from their physical disposition and has often been elaborated extensively.

Vulnerable groups, such as pregnant women and the elderly that stay mainly indoor will be exposed to the average indoor environment concentrations not much different from the ambient concentrations.

The notion that also in the indoor environment exposure to ambient air pollution continues is well understood by the stakeholders in the health departments (National Centre for Public Health (NCPH) and Bayankhongor Health Department and Bayankhongor General Hospital) and they will not consider indoor environment as an active shelter.

At present acute and mid-term health effects are focussed on. However, coal incineration causes the emission of many compounds, such as mercury, cadmium and arsenic, at much lower concentrations but with nonetheless harmful effects at the long term. This aspect needs to be kept in mind.

Health complaints and records

Health complaints and records, such as admissions to hospitals, visits to family doctor or general practitioner, use of medicines or absenteeism from school were one of the initial signals that environmental conditions formed a serious health threat. The relation of air pollution and the health effects is accepted by all stakeholders and consequently the ultimate measure for success of the interventions is considered the decrease and finally vanishing of the related symptoms.

In the discussion with the Head of Bayankhongor Health Department and the Director of the General Hospital as well as the discussion partners at the National Centre for Public Health (NHCP), they illustrated their argumentation with much detailed knowledge on the health effects.

In both discussions they brought forward the need for training health workers on understanding air pollution and health effects, self-protection and what to advice to the public with regard to stay at home, use masks and which masks, how to improve health condition and immune system (vaccination) and provide adequate nutrition advice. Budgets for this training are not allocated by the government.

Forced by the lack of sufficient hospital beds for the care of children in the Bayanzurkh district in UB the Health Centre, represented by Ms Enkhzul Jargal, developed with the support of UNICEF an efficient practice for screening and treating a large number of children and pregnant women on health and general condition (including nutrition status) in the framework of Community-Based Integrated Management of Childhood Illnesses (CIMCI) . These data form an important basis for monitoring the impact of interventions on the health of children.

Both health institutes signal an increase in CO- intoxication, often fatal, that seems to be related with the use of 'refined fuel' and improved insulation. The precautions to be taken by dwellers should be a part of the training and information campaign for the public.

The health institutes acknowledge the importance of scientific sound evaluation of the health and air pollution data. The registration of the related health complains according to the international adopted methodology (ICD10) together with air pollution concentrations, or even better exposure levels, will provide the basis for sound scientifically evidence of the existence of the causative relation between air pollution and health effects. This approach might indicate other than the commonly identified effects because of the extreme air quality conditions and underpins further the necessity to improve the quality of air in BKH. The discussion partners mentioned the need for training on sophisticated software and programmes for the research and analysis on health effects and air pollution as well as for the licences or software packages (like R). Both organisations have built datasets on the various health effects using ICD10 for many years. Partners in the foreseen health effect assessment include the Centre for Health Development, National Agency for Meteorology and Environmental Monitoring (NAMEM) and the General Authority for Specialised Inspection (GASI). The current situation would then allow the study to be carried out in all 21 aimags. Some of the studies supported or mediated by UNICEF with foreign academic groups might form the seeding point for a broad health effect assessment study.

The outcome of these studies among other applications will further guide the search for approaches and treatment for chronic effects and permanent loss of health due to exposure to air pollutants.

Measures for emission reduction

Measures are ultimately directed at the reduction and even complete removal of exposure to harmful substances. All the proposed measures need to be evaluated with this objective in mind.

The severe condition in Bayankhongor and many other urbanized areas are the result of the combination of emission very close to people's living area, under very unfavourable conditions (low emission height, stable atmosphere and so minimum dispersion), caused by a very inefficient combustion process using poor quality of coal and high heating demand due to very cold conditions.

All these aspects create the conditions that lead to the current health crisis. Only measures or combinations thereof that addresses all these aspects sufficiently might bring forward the sought for improvements.

Several measures have been developed or are being contemplated by national and local government and other stakeholders. These measures are evaluated hereafter:

Measure: Insulation of ger and house

This measure has several advantages: first of all the energy demand will be reduced and consequently, the associated emission of harmful substances and greenhouse gasses. For the dweller insulation of the house and ger results in lower costs and more thermal comfort (no draft or thermal gradients).

When improving insulation this has the consequence that natural ventilation (one of the reason for energy loss) is minimized and this needs to be replaced by forced ventilation. To use optimally this feature the dweller needs to be trained on indoor quality management, including moisture and odour control and adequate timing (optimal ambient air quality).

When improved insulation is not accompanied by removal of the stove for heating and cooking and the reduced natural ventilation is not replaced by proper forced ventilation conditions favourable for CO-intoxication might be formed. Especially in this case training on how and when to ventilate is crucial.
Insulation of the ger and house is core of the CHIPS concept.

Measure: replacing raw coal for refined coal (briquettes) in stoves

It has been acknowledged that raw coal is a poor fuel resulting in huge emissions of dust and smoke and produce less energy per mass than what is coined 'refined fuel'. Full enrolment of the ban of raw coal and use "Clean fuel" is expected to reduce air pollution to 50%. First results in Ulaanbaatar might support this expectation.

However, the level after 50% reduction of an extreme high level is still extreme, maybe not the highest in the world anymore, but still causing severe health effects among many of the public, especially children and other vulnerable groups.

Furthermore, the reduction is as large as 50% expressed as the mass concentration. As elaborated here above, for the reactive particles the surface area is relevant and these small particles are formed also when 'clean fuel' is used especially because the stove temperature is higher. More investigation might give a better estimate of the improvement of this measure in terms of potential health effects.

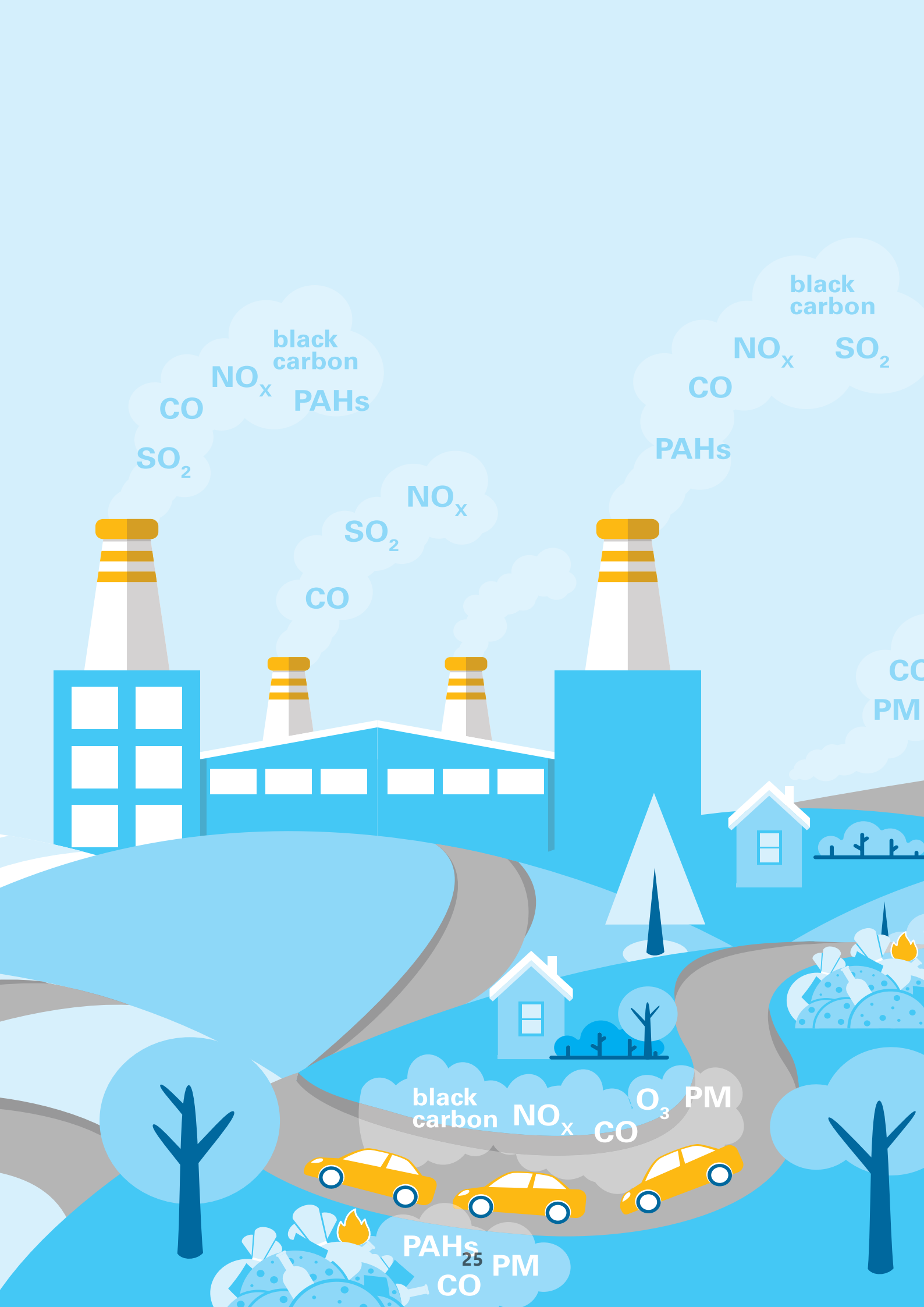
Replacing raw coal with briquettes will also reduce or eliminate the typical odour of burning or burned coal and so the notion that ventilation is needed for replenishing with 'fresh' air will be insufficient. Therefore, "Clean fuel'" for domestic heating in stoves in the houses or gers is recommended only as a temporal measure.

Measure: replacing raw coal for "refined fuel" (briquettes) in HOBs

The same applies as given here above as the emission from HOB in the town is still near the area where people live. Using "Clean fuel" in HOBs might enable better control of the incineration process resulting in higher temperatures in the oven and more constant performance. This will reduce the emission for a large part but still results in pollution levels in the town at a harmful level near people. Therefore, "Clean fuel" for HOB is recommended only as a temporal measure. This temporary nature is best acknowledged in the planning of the investments and the future function of the HOB as a distribution point of the heat generated by the HOP (see hereafter).

Measure: replacing HOBs for a Heat-Only-Plant (HOP)

This measure will move the emission source from the urban area and consequently the exposure of people if the location is far enough (emission is sufficiently diluted before it can reach the town) and the stack high enough (enabling strong dilution/dispersion and during stable weather conditions high enough to stay above the mixing layer (in the morning!). Replacing HOBs for a Heat-Only-Plant will contribute to better the air quality in BKH.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Measure: replacing stoves in houses and gers by electric heaters

This measure consists of the replacement of the stove for electrical heaters and install an electric cooking device. This totally removes the need for any fuel to be burned in the ger or house and reduces the emission from the ger or house completely.
This measure optimally contributes to the reduction of hazardous exposure to the ambient environment air pollution and leakages in the house. The infiltration of pollution in ambient air into the house or ger is reduced by filters in the forced ventilation system. What remains is the natural infiltration by opening the door.

The positive effect is proportionally experienced with the number of other houses and gers that also have CHIPS installed.
This measure, installation of electric heaters and cooking devices, and installing filters for ventilation, is a core of the CHIPS concept.

When increasing the number of gers equipped with electric heaters the capacity of the local electricity network needs to be upgraded. During the stakeholders' meeting with Energy LLC, a company fully owned by the local government buying power from the national grid and responsible for the distribution in BKH, it was mentioned that recently 2 MW capacity was installed and in the near future this would be replaced with 2 transformers each with a capacity of 10 MW. This is to be financed by the local government (owner of Energy LCC). At current, demand levels 20 MW would be enough for all the gers. Though the demand would be more than 75% of maximum capacity. This might result in non-constant voltage in the grid. Furthermore, the industrial activities in the areas around BKH (additional mines, HOP), and the increase in use of electrical appliances in the households will lead to shortages not far in time. Aiming at 40 to 50 MW installed power might prove to be a more realistic goal.

The price of electricity and heating is set by Energy Regulatory Commission and consequently is a politically driven price rather than a market price. As per government regulation the electricity tariff for heating in ger areas during the night is subsidized by 50% in BKH. In UB the subsidy is 100% according to the same rule. The disadvantage to fully subsidize the night tariff is the loss of value of the good or service and the absence of an incentive to save using the good or service. In BKH the subsidy is still 50% and it might be recommended to find a subsidizing vehicle that motivates saving on the service if the percentage is increased.

When electricity is the basis for heat services during the winter a black-out or brown-out (still some power but far from enough (lower voltage)) will create an emergency for the CHIPS ger dwellers especially when this condition last for more than a few hours.
To inquire the failure rate the discussion partners of Energy LLC replied that many factors determine this, such as the level of maintenance and the dependency on the national grid. For the last two years once each year the network went down for 3 respectively 5 days all during summer.

No emergency plan exists to enrol when the failure occurs during winter. One does not expect that a failure will happen in winter!

Heat capacitors, devices that can store heat for some time, will help to overcome such a limited shut down. These devices might also favour the use of subsidized night-tariff energy. At present such devices are very expensive and not an optimal option for the gers and houses in Mongolia. The development of an innovative approach or inexpensive device might be recommended.

The trade and distribution of coal in BKH has established an economy on its own; a steady demand for coal justified investments and created jobs, although seasonal. Inquired into the effects of complete transition of the households from coal (raw coal or eventually briquettes) to electricity with respect to the coal sector, several arguments were put forward.

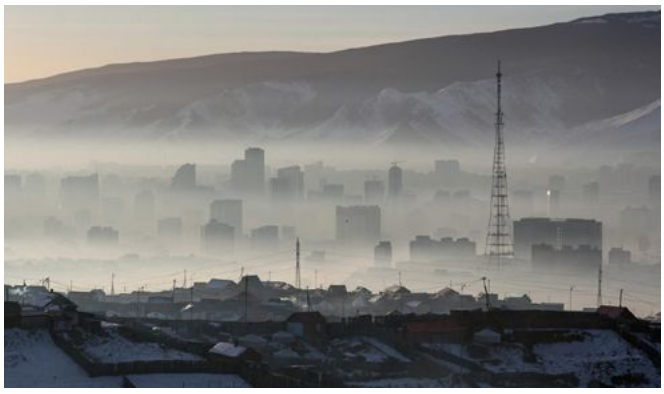
All arguments were to illustrate the very modest or zero effect, such as the seasonal nature of these jobs or the new distribution centres needed for all goods as a new rule stipulates that large trucks will not be allowed to enter the town centre anymore. No information could be gathered to assess the economic impact of the transition.

Measures for exposure reduction

Measures to reduce exposure to the harmful substances are designed to avoid inhalation of polluted air or reduce the concentration before the air is inhaled. Several ways are possible. The following are practised in BKH.

Measure: Staying inside the house or the ger

As most of the polluted air is coming from outside it is assumed that staying inside will provide a shelter against the air pollution. As elaborated here above (see infiltration) the shelter is only functional for short bursts of air pollution. When the levels are high for a longer period infiltration of air will render the air quality inside at least as bad as outside. A side effect of staying in is the lower activity level and consequently the lower inhalation of air pollutants.



Measure:Orchestrated ventilation

The air pollution is not the same during the day; concentrations will decrease during the morning and will rise again at the end of the afternoon. When air is purged through the house or the ger (at the expense of loss of heat) during midday the air quality in the house is optimally improved and this better level might last somewhat longer than outside. The effect of this way of ventilation is the reduction of exposure for those inside the house or ger.

Measure: Wearing masks

Masks will filter a large part of the particles from the air before it is inhaled. As discussed here before the finest particles will not be removed with filters and these particles will penetrate deeply in the lungs. Filters might frustrate easy breathing causing bursts of air entering the mouth and likely the lung at a higher speed changing the penetration. Good filters are costly (10 -15 $) and maybe too expensive for families.

Measure: Using filters for the infiltration air

Filters through which infiltration air is cleaned will remove a large part of the particles from the air before it fills the indoor environment. Filters are best used for forced infiltration (ventilation) to compensate for the natural ventilation of the ger or house. The limitations of the filters result in only partially removal of the finest particles as discussed in 3.2.3 (air pollution – fine fraction)

Evaluation of CHIPS

The core of the CHIPS concept, as already indicate here above, is removing coal-burning from the direct living environment of the people, minimizing the energy-demand for heating by better insulation, and (a beginning of) indoor environment quality management.

Visit to gers

A short visit to some of the gers with or without the CHIPS installed revealed that CHIPS improved dramatically the living comfort, reduced smells from burning coal and the temperature was easier to control at a certain value.

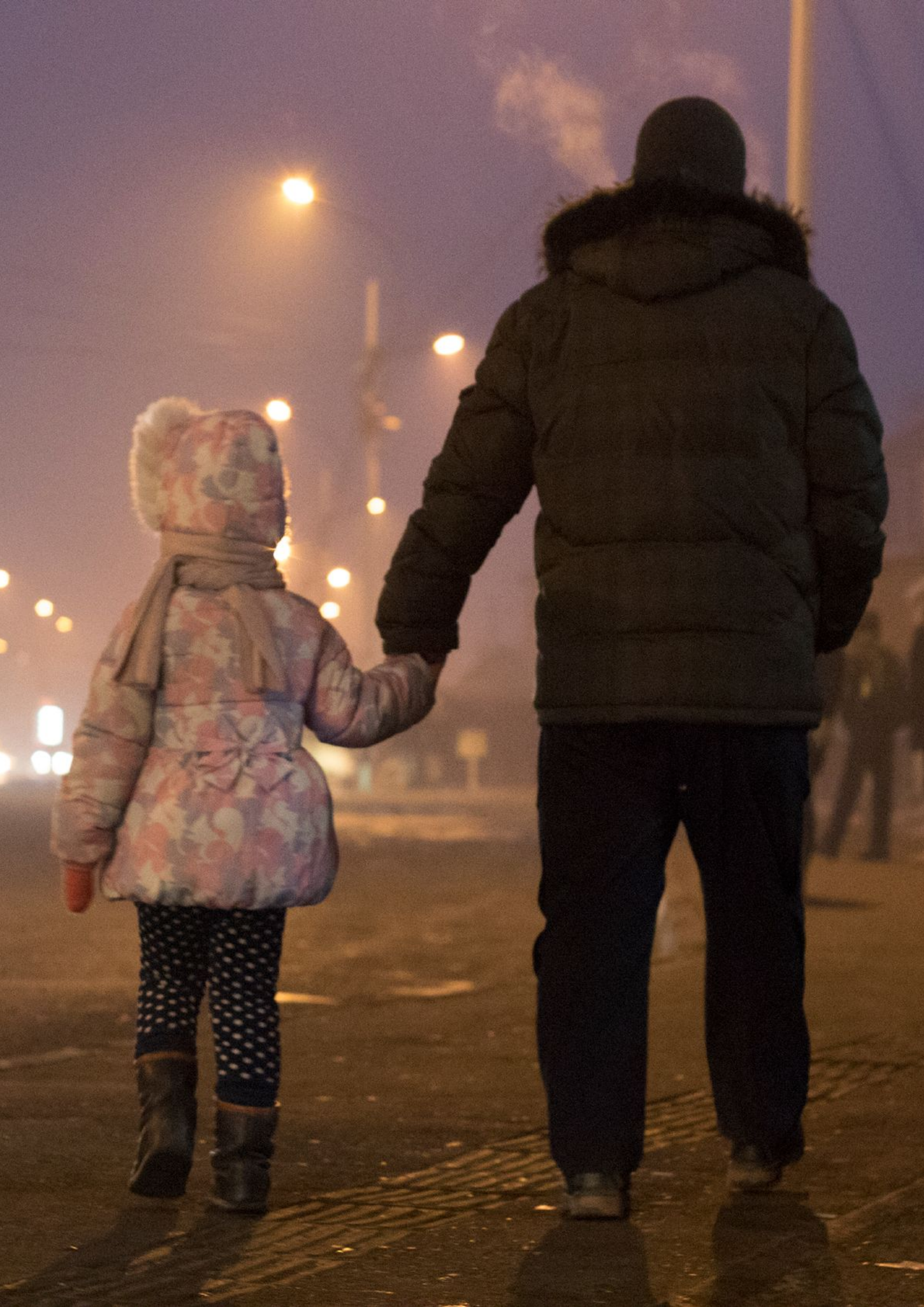
CHIPS further saved much time as no coal needed to be brought to the ger anymore and the household was easier to keep clean. The notion was voiced that a cleaner indoor environment was good for health but the full impact seems not (yet) completely appreciated. Some examples were shared of advocating the benefits of CHIPS among the neighbours. Dwellers of the ger without CHIPS showed interest based on the visits to nearby CHIPS gers but they expected the investment to be too large a hurdle.

A first economic evaluation

Based on the information provided by the dwellers of the gers the following overview could be made.

	Non-CHIPS Ger	CHIPS ger (before)	CHIPS ger
General electricity costs	No information	MNT 20.000	MNT 20.000
Heating device	Old stove	Stove	CHIPS heaters
Fuel	Raw coal, wood, dung	Raw coal, dung	Electricity only
Consumption heating/ month	1 truck coal (130 kMNT) 40 bags wood(180 kMNT)	1/3 truck coal 43 kMNT 2/3 trucks dung 60 kMNT	91 kMNT (first month)
Costs total / month	310 kMNT	103 kMNT	91 kMNT 116 kMNT
Costs / winter (*6)	1860 kMNT	618 kMNT	546 kMNT 696 kMNT

The costs without CHIPS vary drastically (620 – 1860 kMNT) per winter. The one ger with CHIPS already had relatively low costs when using coal and had now a first month electricity bill of 91 kMNT (excluding the 25 kMNT subsidy) and extrapolating this arrives at 10-15% higher costs for heating and cooking.



This information can only be seen as a rough indication that insulation and proper use of the facility might compensate greatly for the higher cost of electricity. A more conclusive result needs a much more extensive assessment including the 200 CHIPS gers and 200-300 gers without CHIPS. This assessment will be essential to support decisions of dwellers to make the transition from coal to electricity as well as financial institutions for individual loans (banks) or for investing in specific infrastructure (national and local government).

Important issues need to be taken into account:

- Prices of electricity and coal, at least for briquettes, are controlled by the national government and the economic value might differ.

- Energy demand is highly determined by meteorology (temperature, wind) and when assessing average costs, the winter of the assessment needs to be compared with a number of winters in the past (e.g. 10 winters).

- During discussion with the manufacturers of the various CHIPS hardware they indicated that some improvements might better the efficiency of the insulation and the heaters.

Financial aspects of CHIPS

The minimum CHIPS set costs 1.800 kMNT and includes the addition of material to insulate wall and roof of the ger, the furniture for mounting the heaters, the heaters including a thermostat, and the cooking device. It further includes filters for cleaning infiltration air and an electrical fan for forced ventilation. For the first 100 gers the subsidy of the CHIPS was 100%, for the second 100 gers the subsidy was 85%.

As the number of gers in BKH is about 7000 ideally, many more need to be equipped with the CHIPS hardware than the current 200 and the 300-500 planned for 2020. If individuals cannot finance it themselves a GREEN-LOAN might be helpful.

The State bank, together with other banks, had developed this GREEN-LOAN, reduced interest rates of 9% (instead of 17%), a loan term of 30 months and 3% provision for the bank, for electrical cars and electric motorcycles. On the initiative of the Ministry of Environment and Tourism the GREEN-LOAN has broadened for environmental friendly products, including heating and insulation. Although the broadening of the GREEN-LOAN is active since August 2018, no application has been received.
The Director of the State bank. Mr Batbayar Baasan, identified several factors for this lack of response:

- Monthly payments (loan repayment, interest) might be too high for a number of households
- The need to replace coal from the direct environment is not fully appreciated by heads of some households
- Unclear or uncertain information about the cost/benefit analysis outcome
- Customers already have used the full loan capacity and need to wait the remaining part of the usual 60 months loan term before a new loan is to be applied for. This is supported by the outcome of a rapid assessment carried out early 2019 indicating 80% of the 200 gers now installed with CHIPS had already a loan.
- 1.800 kMNT (the costs of the minimum CHIPS set) is not a very large amount for many people.

The Director and the Deputy Governor of Bayankhongor soum, Mr Naranbayar Batmunkh, stated that based on all these factors, together with the pressing necessity to improve air quality, a special loan for CHIPS (1.8 MMNT) is considered possible and desirable. They summed the following conditions that have to be met to arrive at a successful launching of this new green-loan ("CHIPS-loan"):

- An explicit commitment of the partners: UNICEF - local government - Bank- consortium
- Staff of local government and staff of the banks in the consortium are

aware of the need to improve air quality and how this can be done.
- Cost/benefit analysis of CHIPS both for financial as well as social aspects
- Estimate of health gains when coal is banned from the direct environment
- Broad understanding of public why CHIPS is needed and shows willingness and readiness to install CHIPS in their homes
- Specific permission of the Mongol Bank.

The Director and the Deputy Governor expressed their willingness to support the development and implementation of this specific loan type. To prepare this a rapid assessment could be started as early as spring 2020.

Production of CHIPS

In the summer of 2019 200 CHIPS were prepared and installed by local manufacturers aided by experts from Mongolian University of Science and Technology in Ulaanbaatar (MUST). When asked for three of them gave the following production specifics:

- 100 sets of insulation, 20 days, 36 employees, price 1200 kMNT
- 100 sets of insulation, 40 days, 40 employees, price 1200 kMNT
- 100 sets of furniture, 2 weeks, 4 employees, price 100 kMNT

The manufacturers stated that the costs were higher than anticipated but a moderate profit was still possible.

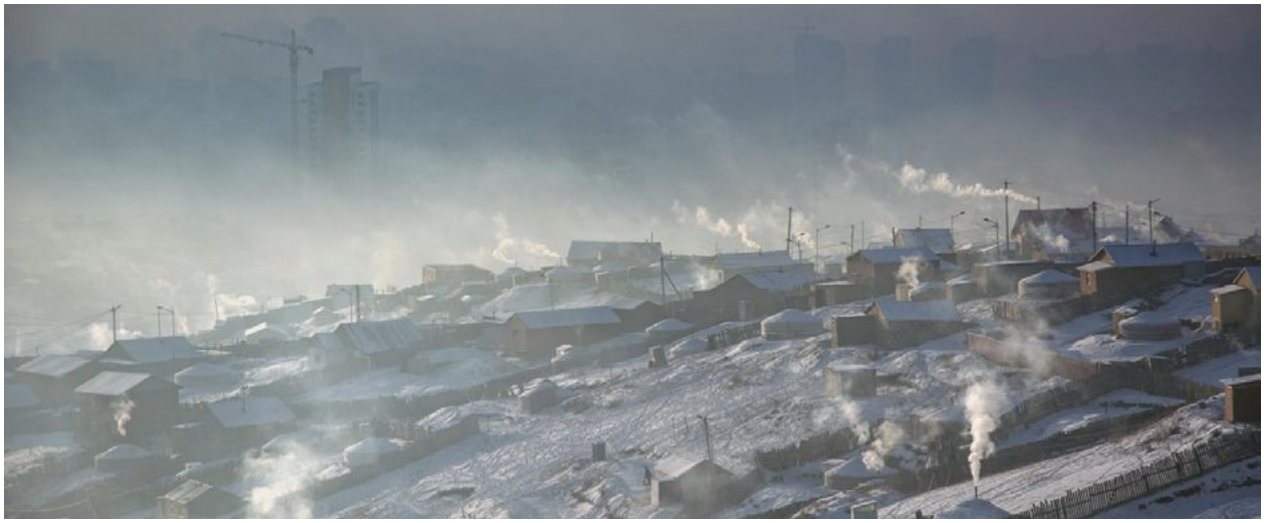
Improvements were identified during the installation of the CHIPS and in some case were mounted already against little costs.

Only a little number of users of CHIPS were asked for feedback and the manufacturers acknowledged that more users should have been approached.

The production capacity, if given 6 months notice would be, 2-3000 pieces with the same employees that are expected to be available. The manufacturers mentioned that other aimag and nearby towns are inquiring about CHIPS and a market seems to be developing.

With respect to improvement and innovations the manufacturers expressed:

- Close collaboration with MUST is seen as a prerequisite as the necessary knowledge and experience is still lacking. Some tests were done but the interpretation of the results remains difficult.
- A procedure is requested for that is to guide the development of new ideas, developing and performing tests, evaluation, adoption of the improvement in the CHIPS concept to close the cycle with explicit involvement of MUST or others.
- The users/dwellers of the ger should be trained in how to use the thermostat, the force ventilation, and the exhaust through the centre roof of the ger for moisture and temperature control.



Awareness of air pollution's health effects

All the stakeholders met during this mission were well aware of the harmful effects of exposure to air pollution caused by incineration of coal, or more in general, solid fuel. They also acknowledged that employees within their

respective organisations and the general public have insufficient or at least incomplete information on the gravity of the air pollution situation in BKH and the possibilities to counter the effects.
Many stakeholders emphasized the need for training and behaviour change of employees and above all the general public inspired by a change of perception.

Health care workers and health officials are probably one of the best equipped group of professionals to inform and motivate the public on health issues. And so repeatedly they are mentioned as the group to provide trainings and support activities for, to give them confidence and knowledge when they actively approach the public.

The Authority for Family, Child and Youth Development has organized a group of volunteers (The Volunteers - children 14-16 years of age) within the framework of the Bayankhongor Smog Free Action Plan supported by UNICEF and implemented by the local government and Child and Family Development Committee. 300 out of 1050 applicants were selected to actively approach the civil society, in particular their peers and own families, to explain air pollution, the health effects and the possible solutions. Communication paths include personal contacts, social media, TV and radio and street activities. The message they bring includes: 'Health effects are only during the winter. During summer everything is OK' and the theme they use: 'Child educating parents: protecting the family'.

During a gathering of the volunteers and other youth of similar age they met older volunteers being role-models for them and sharing their experiences. This energetic group is expected to have a serious impact on the perception of the people in BKH and possibly the behaviour change.

UNICEF emphasises the Gender and Social inclusion in this project and the National Consultant for Social Protection Measures for Health, Mr Munkhzorig Bulgankhuu, explores the various ways this can be implemented effectively. The outcomes of this initiative is to be included in the strategy for raising awareness and outreach.

Further project development

The phase-out of the HOB as the source of heat for the apartment and other buildings is to start in 2020 or as soon as the HOP is operational. The current HOB will then be reconstructed to function as a distribution point for the heat produced in the HOP. The current number of gers with CHIPS installed is 200 and using local government budget in 2020 will maximally increase to 700. This is only 10% of the total number of households in gers (7000). Expanding this number to contribute to the ambitious goal having a Smog Free Bayankhongor by 2022 annually 2000-3000 gers need to be equipped with CHIPS. Confronted with this ambitious planning the Governor of Bayankhongor would consider 70% in 2022 already a success, although during severe winter episodes the concentration will still be beyond WHO standards.

With regard to the expansion of the project the following can be stated:

- The production capacity seems to be sufficient although with a delivery time of 6 months.
- Improvement and innovation need to be guided and supported by experts (MUST and others).
- Power supply from the network is critical if not from the investments' financial perspective than from the rate of increasing the maximum power supply.
- Financing the CHIPS installation depends on the special Green-Loan the bank consortium is offering to develop, which also depends on the permission of the State Bank.
- Above all the perception and the behaviour change of the public is a critical factor. People need to perceive the benefits (even if the subsidy on CHIPS is expected to decrease) for themselves and their next of kin even when then know that others need to act in the same way to have a real benefit. This will need strong motivation and coordination.

- At a farther horizon the generation of renewable energy is a logic development. In Mongolia several projects on sustainable and renewable energy are being developed or are currently underway. The Asian Development Bank (ADB) is one of the major players in this. During the consultation with the ADB (Ms Ongonsar Purev, Senior Environment Officer) potential ways to develop projects or tap-in into current projects were explored. She recommended further consultation with the Senior Urban Development Specialist for ADB.
- Other highly polluted aimags (as indicated by Ms Gantuya of the National Committee on Reducing on Reducing Air Pollution) have showed interest to adopt the CHIPS concept.
- During the meeting with the Governor of the Bayanzurkh District, Mr. Bayasakh, he expressed the interest in the CHIPS approach. The recent ban of raw coal to be used in private houses and gers and replacing it with "Clean Fuel" (briquettes) did not bring the expected improvement of the air quality to an acceptable level.
- The increased number of towns following the CHIPS concept might strengthen the priority it needs in the coming years at several layers in the government and with financing organisations. The trained people of BKH with the experience and knowledge might act as trainers and consultants for the aimags.
- For the further development of the CHIPS concept; to start the expansion needed to archive the objectives of Bayankhongor Smog Free; to convince the various groups needed to support and adopt the goals of UNICEF; and to get priority over other competing interests to be weighed by the local and national government sound (scientific) evidence is required on the relation between air pollution and the serious health effects.
- Further development requires information on the performance of CHIPS in terms of energy efficiency, thermal and social comfort; clear and understandable cost/benefit analysis including the facilities for financing the investment of CHIPS.

RECOMMENDATIONS

The many activities of the project are taken care of by many organisations either as part of their organisational responsibilities by themselves or in close collaboration and consultation with other organisations, or from their specific role in the project Smoke Free Bayankhongor.
The initiating and coordinating role of UNICEF focusses on optimizing the impact of the various actors to achieve the ultimate objective: a better environment in particular for children and pregnant women.
The recommendations are formulated and directed at the organisation responsible for the issue the recommendation deals with:

General recommendations

RECOMMENDATION 1: Complete the transition in bkh from coal fired domestic heating to electric heating services as soon as possible and make financially feasible

Responsibility: Local Government of BKH
Rationale: Given the characteristics of the main source of air pollution in BKH, the meteorological and geographical situation, the only real solution of the current health crisis is complete removal of the sources of air pollution from the direct environment of people, not only children and other vulnerable groups; the current levels will affect all human beings.

The CHIPS concept enables the total removal.
Other measures, such as replacing raw coal by briquettes (“Clean fuel”), installing filter for the indoor environment or wearing masks will only reduce the impact partially, but still leaves very hazardous conditions for certainly the vulnerable groups.

Replacing raw coal for briquettes might be useful only to bridge from the current situation to a real Smog Free Bayankhongor.

Risks: Convincing organisations and decision makers of the hazardous conditions when using coal for domestic heating, a common practice for long, will require clear, sound and robust information as well as persuasion skills.

Mitigation: Clear and robust information is found in the scientific literature and should be communicated broadly and understandably for all stakeholders by the leading health authorities in Mongolia.

RECOMMENDATION 2: Coordinate support for local and national government with adequate and sound information on the health effects of coal of any quality when burned in the proximity of people and the effective remedial actions

Responsibility: UNICEF in close collaboration with national health authorities
Rationale: Emissions to air from incineration of coal or other solid fuels consist of many substances, many of them are harmful to human health, particularly when inhaled. Clean fuel, if it is solid fuel, does not exist and the emissions should be kept from the living environment of people, in particular people who are reactive to the exposure with these substances. Have lessons-learned in the pilot areas (eg. BKH) be appreciated by the staff of organisations at the national and aimag level.

Risks: Misunderstanding, uncertainties and doubts overshadow the clear statement of serious health effects. The consequences are far-reaching and promotes denial.
Mitigation: Clear message repeatedly shared.

Air quality monitoring

RECOMMENDATION 3: Validate and process the data from the air quality monitoring network and build capacity

Responsibility: Department of Meteorology of Bayankhongor aimag in close collaboration with UNICEF and their contacts, i.c. The Washington University (St Louis)
Rationale: The newly installed monitoring station and the installation of simple and inexpensive monitors (soon to be completed) will provide a means to describe the air pollution conditions and the meteorological parameters in terms applicable for other municipalities and aimags. It further provides insight in the impact of abatement measures and provide exposure information for health impact studies.
Risks: Discussion on data quality, availability and applicability.
Mitigation: Provide the data to the experts even when quality and completeness are not fully guaranteed

RECOMMENDATION 4: Complete the emission inventory for BKH and build capacity

Responsibility: Department of Meteorology, Bayankhongor aimag
Rationale: The project financed by Japan International Cooperation Agency (JICA) has provided training on various aspects of building emission inventory databases to staff members of the Government.
Combining emission inventory with air pollutant concentrations data (even without modelling) provides a solid bases for validation of the data and further developing policy measures and evaluating their impact
Risks: Insufficient expertise at the local level.
Mitigation: At the national level the staff member of the National Agency for Meteorology and Environmental Monitoring has indicated to have developed the skills for building emission inventories. The expertise and skills should be shared with the local staff.

Health system

RECOMMENDATION 5: Extend the trainings or organize dedicated training on air pollution to the health officers and workers in BKH

Responsibility: Ministry of Health in consultation with UNICEF
Rationale: The health system, in this mission represented by the institutions and organisations visited, is managed by motivated and well-informed officials. They are fully aware of the disastrous impact of the air pollution in the main urban areas, in particular BKH. They acknowledge the need for training of the health officers and health workers in their organisation, including the advice they can give to the public.
However, currently no budget is allocated for such training.
Risks: Insufficient budget allocation and no clear training curriculum
Mitigation: Budget allocation might be helped by a clear training set up and communication of the necessity. UNICEF is to develop or assist to develop the training curriculum. Recent experiences in the Bayanzurkh District Health Centre form an important input.

RECOMMENDATION 6: Prepare for winter smog episodes

Responsibility: Local government
Rationale: Until Smog Free Bayankhongor has been established prepare the civil society on the prospective winter smoke episodes with high air pollution and the health impacts on vulnerable groups but also health persons will suffer. Remind the population on the possible actions they can take to prepare for it and to prevent exposure to high levels.
Risks: Attention deficiency because no direct crisis experienced
Mitigation: Concentrate on the action perspective

RECOMMENDATION 7: Support, facilitate, organise, and promote the nationwide health impact analysis

Responsibility: UNICEF
Rationale: Robust evidence for the relation between air pollution and the various health effects in the general population and the different vulnerable groups, including children and pregnant women, forms strong arguments in political prioritizing processes. Training on the statistical approaches and software, assessing exposures of long and short periods and to tap in the international accepted approaches are the means for this.
The health data to be used in scientific sound health impact analysis is stored in various data bases. This data together with the air quality form the important ingredients of these studies. At the moment several ideas, plans or initiatives are formed or executed. To ensure adequate approaches the Mongolian scientists might need facilities, assistance, feedback or just peers. The result and its robustness is to attract attention and to gain support for measures and budget in priority setting processes.
Risks: Insufficient ambition or possibilities at the local academic institutes.
Mitigation: UNICEF has a wide network for this type of investigations and will likely be able to bring scientists together on the topic.

RECOMMENDATION 8: Be aware and stay alert for other health effects than currently in the sight

Responsibility: UNICEF
Rationale: Exposure to hazardous air pollution in duration and intensity under Mongolian condition is rather exceptional and might potentially has more health effects than usually associated with the type of exposure. Emissions from incineration of coal will include many different organic and inorganic compounds, among which heavy metals and oxidized organics are prominent substances. The exposures might result in more systemic health effects.

Furthermore, the soil in and around the urban areas might be loaded with the compounds from the emissions and cause exposure to these substances along oral or skin contact pathways, in particular for children.
Risks: Insufficient information to assess the relation between exposure and effect.
Mitigation: Awareness among health care workers.

Performance of CHIPS

RECOMMENDATION 9: Evaluate the performance of CHIPS

Responsibility: UNICEF
Rationale: The CHIPS concept is well received by the users and by the top of the aimag government. For further expansion, improvement and innovation the actual performance is to be established to enable quantitative cost/benefit analysis relevant for convincing people to invest in CHIPS and financial institutions to provide loans.
The 200 gers in which CHIPS is already installed form a substantial test group to assess thermal performance, thermal comfort and social comfort and financial burden. This group can form their own control group (conditions before CHIPS installed) as well as being compared to the group with non-CHIPS gers.

The evaluation might also indicate the promotion strength of CHIPS and the perception on CHIPS of the non-CHIPS group.

Risks: A large group needs to be interviewed during a rather limited period and both technical and non-technical aspects are to be included: a substantially labour-intensive effort.

Mitigation: Well-designed inquiry and application of computer-aided-interview methodology. The University of Pennsylvania might play an important role with respect to the technical aspects.

RECOMMENDATION 10: Organise, facilitate and promote a guided process for improvement and innovation

Responsibility: Innovation Centre
Rationale: The current version of CHIPS is the one installed in 200 gers. For a limited number of gers some improvements have been implemented. During the meeting with the manufacturers a number of improvements and ideas for innovation have been briefly touched. They also indicated that they are in need for more technical and scientific support from MUST and maybe others and possibly also guidance in the process of innovation and implementation.

The Innovation Centre might be the dedicated organisation to setup and manage the process of improvement/innovation, consultation with technicians and scientists as well as financial experts. The seasonal nature of CHIPS requires a cycle that allows improvements and innovation being implemented in the production version during the summer.

The indication the manufacturers have of a growing market (they got requests from other aimags) justifies a structural setup of improvements and innovation.

Risks: Availability of expertise from MUST and others requested by the manufacturers. Intellectual property (IP) of innovation delays the implementation

Mitigation: UNICEF with its network and oversight is best equipped to support the setup of the guided process.
During the meeting with manufacturers the issue of IP was raised but not considered important.

RECOMMENDATION 11: Develop the special 'CHIPS Loan'

Responsibility: Bank consortium BKH and local government
Rationale: The investment for CHIPS (1.8M MNT) might be too much to consider without a loan. As many households already have a loan they will consider a new one or are granted a new loan when the existing one is fully paid. As 1.8 MMNT is not extreme a 'Green Loan' for CHIPS could be developed and possibly granted even when a loan already is taken.

Risks: Clean cost/benefit analysis of CHIPS is required both for the bank and the consumer. Lack of interest due to insufficient awareness with consumer and bank staff.

Mitigation: Information campaign to inform the public on financial consequences, thermal and social comfort, health aspects both individual and societal. Align this campaign with the outreach activities.

Education of the bank staff (as indicated by the director of the Mongol Bank in BKH) and the staff of the local government.

RECOMMENDATION 12: Assess the potential number of households prepared to shift to electrical heating, the relation with income and possible subsidies on the decision.

Responsibility: Bank consortium BKH and local government
Rationale: Preparedness of the dwellers in BKH to shift from coal to electricity is relevant in relation to the target for complete transition in 2022. If subsidies are needed the availability of budget will indicate the feasibility of the 2022 target.
Risks: Expertise for such an assessment not present in BKH
Mitigation: Assistance from the national level.

Outreach and perception/behaviour change

RECOMMENDATION 13: Start developing and testing the outreach and promotion campaign not later than May 2020 to find 2000-3000 new gers for the transition

Responsibility: Local Government
Rationale: Outreach and perception modification followed by behaviour change is a prerequisite for success. Given the early stage of the pilot at the beginning of 2020 it is expected that informing the public will grow in scope and intensity further during the year. To attain the 2020 quota of approximately 2000-3000 new gers informing the public and promoting the transition shouldn't start later than spring or begin summer

Prepare for the 2021 campaign and promotion
Risks: Lack of urgency with organisations
Lack of capacity in the various organisations

Mitigation: Intensify campaign and increase commitment among organisations, even in summer!

RECOMMENDATION 14: Teach dwellers how to optimize indoor air quality management

Responsibility: Local Government in collaboration with health care workers
Rationale: Air quality management, including applying orchestrated ventilation, humidity control and proper use of the thermostat when using electrical heaters will improve the indoor air quality and optimize the use of energy. It also will improve the thermal and social comfort for the dwellers.

Risks: Concept and instruction still too complicated
Lack of training capacity
Mitigation: Use the power of repeating and involve health care workers. Produce simple flyers.

RECOMMENDATION 15: Address the future energy demand when BKH has completed the transition from coal to electricity.

Responsibility: Local Government, Energy LCC
Rationale: Transition to electrical domestic heating cause strain on the electric grid and reduce the supply security, essential for households to join the transition.
Risks: Lack of funds and urgency
Mitigation: Highlight the need for an adequate power supply to support the transition on a national level and find supporting organisations.

Further development of the project

RECOMMENDATION 16: Further develop the long-term strategy aiming at improvement of the health perspectives for the children and pregnant women in Mongolia.

Responsibility: UNICEF
Rationale: Provided that the assessment of the performance of CHIPS is positive, without or with further improvements the project is to expand in different ways. In BKH the annual quota needs to be attained to arrive at a BKH Smog Free by 2022; other aimags might want to start their implementation of the CHIPS concept and other means of power and heat generation in a more sustainable manner are further steps of the project.

An increasing number of organisations both government as well as NGOs are active in the various fields the project of UNICEF is dealing with and indeed the transition includes a wide variety of aspects, skills and networks. At present UNICEF catalyse various developments with respect to protecting children and pregnant women and provides guidance to several initiatives. Currently no risk exists for duplication. Worth to note that during the mission the long term strategy was neither discussed nor was it lacking.

Risks: Sub-optimal use of UNICEF capacity and funds
Mitigation: Maintain a clear oversight of all actors and their perspectives.

RECOMMENDATION 17: Investigate possibilities to connect the CHIPS concept to current or new initiatives for renewable energy sources.

Responsibility: UNICEF
Rationale: A step on the sustainability ladder would be using renewable energy for the CHIPS energy demand. As mentioned here above the Asian Development Bank has oversight. The Ministry of Finance, the Ministry of Environment and Tourism or Ministry of Energy, are to develop renewable energy projects. Several forms and sizes are possible and developing needs substantial effort and time.

Risks: Unclear which Ministry would be responsible and able to put in resources for developing the project.

Mitigation: Evaluate feasibility with Senior Urban Development Specialist for ADB.

Appendices

Annex 1: Itinerary Meetings in Ulaanbaatar and Bayankhongor

Meeting 1	
Date, Place	12 December 2019, Ulaanbaatar
Organisation	UNICEF
Name	Mr. Ch. Bataa / bchuluunbaatar@unicef.org
Function	Health Specialist UNICEF

Meeting 2	
Date, Place	12 December 2019, Ulaanbaatar
Organisation	National Centre for Public Health (NCPH)
Name	Dr. Suvd Batbaatar / suvd552001@gmail.com
Function	Advisor (policy development, research and training)
Name 2	Ms. Enkhtuya Palam /p_enkhee2001@yahoo.com
Function	Advisor
Name 3	Ms. Tsegmid Sambuu /stsegmed@yahoo.com
Function	Environmental surveillance officer

Meeting 3	
Date, Place	12 December 2019, Ulaanbaatar
Organisation	BZD Health Centre
Name	Ms. Enkhzul Jargal
Function	Head of Bayanzurkh district health Centre

Annex 2: List of project related documents

Meeting 4	
Date, Place	12 December 2019, Ulaanbaatar
Organisation	Ministry of Health
Name	Dr. Enkhmaa Ulziikhutag
Function	Officer in charge of Pediatric health care services

Meeting 5	
Date, Place	13 December 2019, Ulaanbaatar
Organisation	National Agency for meteorology and environmental monitoring
Name	Mr. Barkhasragchaa B.
Function	Chief engineer of National Agency for Meteorology and Environmental Monitoring

Meeting 6	
Date, Place	13 December 2019, Ulaanbaatar
Organisation	National Committee on Reducing Environmental Pollution
Name	Ms. Gantuya Ganbat
Function	Head, Unit of Research, Innovation and Environmental Quality

Meeting 7	
Date, Place	13 December 2019, Ulaanbaatar
Organisation	UNICEF / Local Governance
Name	Ms. Tungalag Battsengel / tbattsengel@unicef.org
Function	Community development specialist

Meeting 8	
Date, Place	14 December 2019, Ulaanbaatar
Organisation	UNICEF
Name	Mr. Alex Heikens
Function	Representative UNICEF Mongolia

Meeting 9	
Date, Place	17 December 2019, Bayankhongor
Organisation	Local Government Bayankhongor soum
Name 1	Mr. Munkhsoyol Jadamba
Function	Governor of Bayankhongor soum
Name 2	Mr. Naranbayar Batmunkh
Function	Deputy Governor of Bayankhongor soum
Name 3	Mr. Dorjnamjil Enkhtaivan
Function	Officer of Innovation Center

Meeting 10	
Date, Place	17 December 2019, Bayankhongor
Organisation	Local Government Bayankhongor Province
Name 1	Mr. Batjargal Gonchigdorj
Function	Governor of Bayankhongor Province
Name 2	Mr. Munkhbat Magvan
Function	Deputy Governor of Bayankhongor Province
Name 3	Mr. Dashtseren Tsevelmaa
Function	Head of Governor's office

Meeting 11	
Date, Place	17 December 2019, Bayankhongor
Organisation	Department of Meteorology Bayankhongor aimag
Name	Ms. Oyunchimeg Chimed
Function	Director of Department of Meteorology Bayankhongor aimag

Meeting 12	
Date, Place	17 December 2019, Bayankhongor
Organisation	Department
Name 1	Mr. Otgonbaatar Tumenkhuu
Function	Director of Energy LCC
Name 2	Ms. Badamtsetseg Badarch
Function	General Engineer of Energy LCC

Meeting 13	
Date, Place	17 December 2019, Bayankhongor
Organisation	SF Bayankhongor
Name 1	Ms. Tserendejid Ravjaa
Function	Ger owner without CHIPS
Name 2	Ms. Enkhamgalan Urchger
Function	Ger owner with CHIPS

Meeting 14	
Date, Place	18 December 2019, Bayankhongor
Organisation	Bayankhongor Health Department
Name 1	Ms. Baljmaa Dorjgotov
Function	Head of Public Health Unit
Name 2	Ms. Dechmaa Ayush
Function	Specialist Health Department
Name 3	Ms. Javzan Chultem
Function	Deputy Director of General Hospital

Meeting 15	
Date, Place	18 December 2019, Bayankhongor
Organisation	Authority for Family, Child and Youth Development
Name 1	Ms. Mendbayar Nyamdagva
Function	Head of Authority for Family, Child and Youth Department
Name 2	Ms. Baljmaa Khurelbat
Function	Volunteer officer for Authority for Family, Child and Youth Depart-ment

Meeting 16	
Date, Place	18 December 2019, Bayankhongor
Organisation	Manufacturers of CHIPS
Name 1	Mr. Gansukh Lkhagvajav
Function	CHIPS insulation producer
Name 2	Ms. Tsermaa Galsanvaanchig
Function	CHIPS Heater (furniture) producer
Name 3	Ms. Uuganbayar Tsedendorj (substitute for head of company)
Function	CHIPS insulation producer

Meeting 17	
Date, Place	18 December 2019, Bayankhongor
Organisation	State bank
Name 1	Mr. Batbayar Baasan
Function	Director of State Bank
Name 2	Mr. Naranbayar Batmunkh
Function	Deputy Governor of Bayankhongor soum

Meeting 18	
Date, Place	20 December 2019, Ulaanbaatar
Organisation	Bayanzurkh District
Name 1	Mr. Bayasakh Tumurbaatar
Function	Governor of Bayanzurkh district

Meeting 19	
Date, Place	20 December 2019, Ulaanbaatar
Organisation	Bayanzurkh District
Name 1	Ms. Sainbileg SUVD-ERDENE
Function	Head of Social development department (not initially planned)

Meeting 20	
Date, Place	20 December 2019, Ulaanbaatar
Organisation	Asian Development Bank
Name 1	Ms. Ongonsar Purev
Function	Senior Environment Officer

Meeting 21	
Date, Place	20 December 2019, Ulaanbaatar
Organisation	UNICEF
Name 1	Mr. Munkhzorig Bulgankhuu
Function	National Consultant for Social Protection Measures for Health

Prior to the mission UNICEF offices Mongolia provided information on the project and the issues on air pollution and health in Mongolia. These are listed hereafter accompanied with short comments.

- UNICEF Prototype Report by University of Pennsylvania (UPenn)
- Terms of reference for Innovation Center
- Air pollution, Maternal and Child health study in Bayankhongor City
- Bayankhongor update.November2019
- Clean air for children in Bayankhongor workplan
- Draft report Workshop 3
- Progress report by Mongolian University of Science and Technology
- Terms of reference for CHIPS implementation
- Terms of reference on Financing mechanisms

- Training report.Bayankhongor
- UNICEF Global Content Advocacy Strategy
- UNICEF Mongolia Air Pollution Crisis 2018
- Volunteer engagement

Annex 3: Terms of reference

A rapid assessment of intervention strategies by UNICEF in Bayankhongor aimag
to reduce impacts of air pollution on maternal and child health

Location: Ulaanbaatar, Mongolia
Duration: December 2019 - January 2020
Related programme/project: SC 180841: Impact of air pollution on maternal and child health
Duty station: Ulaanbaatar (UB) and Bayankhongor (BKH), Mongolia

INTRODUCTION

The United Nations Children's Fund (UNICEF) works for the rights of children to survival, development, participation and protection as guided by the Convention on the Rights of Children (CRC). UNICEF provides long-term humanitarian and developmental assistance to children and their families in developing countries. UNICEF is active in over 190 countries and territories through country programmes and National Committees. Seven regional offices provide technical assistance to country offices as needed. UNICEF headquarter in New York oversees overall management and administration of the organization.

In Mongolia, one of UNICEF's top priorities is to address the maternal and child health crisis caused by air pollution in much of urban Mongolia. UNICEF Mongolia has developed a programme, mobilized significant funding, expertise, and partnerships with local, national and international partners. Early 2019, implementation has started both in Ulaanbaatar and in the provincial capital of Bayankhongor (BKH).

BACKGROUND INFORMATION

Mongolia's winter is long and cold. Between October and March, average night temperatures are -10° and lower, and can reach -40°C around December and January. To stay warm, most of the poor households rely on the burning of raw coal using inefficient stoves to warm their often poorly insulated homes, including the traditional home called "ger", a tent-like structure covered with felt. This results in unprecedented levels of air pollution in many urban centres across the country. During a UNICEF field visit to BKH City early December 2018, pollution levels exceeded the WHO guideline with a factor of 40. In urban Mongolia, where well over 60% of the population resides, air pollution has become an unprecedented maternal and child health crisis, contributing to stillbirth, preterm birth, lower birth weight, pneumonia, bronchitis, asthma, and lower lung function amongst children. Exposure during pregnancy and early life is also associated with damage to brain development, diminished the ability to concentrate, and disrupted behaviour thus reducing educational attainment, mental development and lifetime earnings.

It is thus essential for Mongolia to take a comprehensive approach encompassing 1) reduce pollution by adopt more sustainable energy solutions, 2) reduce exposure of the most vulnerable (especially pregnant women and young children) for example by improving indoor air quality at home and at kindergarten, 3) strengthen health services for affected people, for example by improving diagnosis and treatment of pneumonia, and 4) systematically monitor air quality and health parameters.

Together with the local government, UNICEF Mongolia aims to showcase this comprehensive approach in Bayankhongor City. On 18 April 2019, the Bayankhongor government and UNICEF held a public event formally launching their cooperation, committing to have Bayankhongor city coal free by 2022. This is the first city in the country making this commitment and it will serve as an example and learning ground for all others. In July 2019, the Bayankhongor Smog Free Action Plan was approved by the local parliament.

UNICEF Mongolia has mobilized initial funding from the Swiss Agency for Development and Cooperation (SDC), the Government of the Netherlands, Moncler (UNICEF Italy), the Manitoba Council for International Cooperation (UNICEF Canada) and UNICEF Headquarters to start addressing these barriers. UNICEF partners to implement the work include the Local Government of BKH, the Mongolian University of Science and Technology, Washington University of St Louis, University of Pennsylvania. Others such as the Mongolian National University of Medical Sciences, Children's Hospital Los Angeles, the Murdoch Children's Research Institute, and the University of California Berkeley are foreseen to engage as well.

PURPOSE AND SCOPE OF WORK

3.1. Purpose

The purpose of this assignment is to undertake a rapid assessment of the comprehensive approach being developed and rolled out by UNICEF and partners in BKH. This assessment should provide conclusions and practical recommendations to adjust and strengthen the approach. The assessment will characterize the initial conditions, intervention strategies, and obtained results in both indoor and outdoor air quality and in child and maternal health. Besides considering the project's conceptual approach, including objectives, interventions, indicators, and timeline, the report will assess technical and financial considerations and any risks to the project's success.

3.2. Scope of work

- Develop workplan with questions to be answered by stakeholders, partners, and others;
- Undertake desk review of existing documentation of UNICEF and of the BKH programmes and projects, including the Sustainable and Green Development Mid-term Strategy of Bayankhongor aimag;
- Undertake desk review of existing literature on the status of air pollution and children's health in BKH and Mongolia more broadly, efficacy and costs of measures for emission reduction, and public awareness of air pollution impacts and reduction measures;

- Review BKH budgeting including socio-economic directive and investment to make recommendations on cost-sharing approach;
- Conduct mission to Mongolia:
- Stakeholder consultations in Ulaanbaatar;
- Stakeholder consultations and observations in Bayankhongor;
- Conduct online interviews with international partners;
- Prepare final report with recommendations.

More specifically, the assessment will concentrate on the following issues:

- Air pollution conditions in BKH, focusing on PM2.5, but also including NO2, PM10, and other pollutants. The assessment should cover:
  - Pollution sources (type, nature, number and amount of emission, locations)
  - Dispersion in the ambient environment and temporal variation
  - Infiltration in the indoor environment / lack of exfiltration / ventilation
  - Meteorology (temperature and source strength)

Health conditions in BKH, focusing on child and maternal health:

- Pollution exposure, with attention to daily variation and the locations and activities associated with exposure
- Health complaints and records, linking these with air quality over time
- Awareness of pollution's health risks and any associated avoidance behaviour

Measures for emissions reduction and financial considerations:

- Alternatives for domestic heating and energy use reduction, and the impact of these measures on emissions
- Feasibility and reliability of alternatives measures
- Proof of concept for these emission reduction measures and of the success of convincing potential users
- Costs of current applications and alternatives, and possibilities for funding mechanisms

- Impacts on the domestic heating sector and other comparisons of group and individual benefits and costs

Awareness of air pollution's health effects and of program interventions:

- Government/Authorities
- Public
- Special Groups (parents/children, schools, medical doctors, etc)
- Media

DELIVERABLES AND TIMELINE

The expected deliverables will consist of an inception note completed prior to the mission to Mongolia and a final report. The final report should include recommendations on what and how to strengthen the programme's approach, actions, scaling up, and on opportunities for cost sharing between UNICEF, BKH government, private sector, the community and development partners. The following table summarizes the consultancy timeline and deliverables:

Timeline	Task	Outputs and deliverables
December 2019	Formulate a detailed workplan	Workplan including meetings List of stakeholders and partners Relevant additional documentation
	Questions to stakeholders, partners, and others	Answers to these questions
December	Undertake desk study	**Deliverable 1:** Inception report
	Interview international partners	Contact information for international partners
January	Prepare for and undertake mission to Mongolia, with total of 8 days in Mongolia	**Deliverable 2a:** Final report draft **Deliverable 2b:** Final report with recommendations

KEY SKILLS, TECHNICAL BACKGROUND AND EXPERIENCE REQUIRED

The institution should preferably be either a university or a research organization and should adequately demonstrate the availability of high calibre expert/s in the social sciences with an expressed specialization in Communication for Development. The institution should provide a senior consultant:

- Advanced University degree in a relevant field such as environment or energy.
- In-depth expertise on urban air pollution and air quality policy and programmes, including technical, financial, social and gender aspects
- At least 10-15 years of relevant professional work experience at the national and international level
- Strong research and analytical skills
- Demonstrated ability to produce high quality analytical reports
- Excellent interpersonal skills
- Excellent writing skills in English language.

TYPE OF SUPPORT TO BE PROVIDED BY UNICEF

6.1. Support to be provided

UNICEF will provide overall guidance, direction and support for this assignment. Specifically:

- Provide access to all relevant available data
- An in-depth briefing and discussion in preparation for the mission
- On arrival, introductions to the team and latest update
- Facilitate meetings with stakeholders in Ulaanbaatar and in Bayankhongor
- UNICEF will arrange airport pickup in Ulaanbaatar and will provide transport (by road) to Bayankhongor.
- Upon request, UNICEF will provide support with acquiring visa for personnel appointed by the organisation to this assignment.

- Organise transportation and interpretation during meetings where required.
- Provide timely and complete inputs and feedback on work-in-progress outputs
- Ensure timely payment on completion of key tasks and submission of deliverables.

6.2. Travel and work arrangements

Home based with one mission to Mongolia to discuss, present and validate the report. The cost of travel to Mongolia will be covered by UNICEF. Proposed duration of mission is 8 days and expected to take place in November (exact date to be mutually agreed on). Lump sum should cover economy round trip ticket cost, daily allowance not more than UN rate and inclusive of visa and all types of insurance related costs.

Abbreviation

ADB	Asian Development Bank
AFCYD	Authority for Family, Child and Youth Development
BKH	Bayankhongor
CHIPS	Cooking, Heating, Insulation, Products and Services
CIMCI	Community-Based Integrated Management of Childhood Illnesses
CO	Carbon monoxide, a inhalation toxic
GASI	General Authority for Specialised Inspection
HEPA	High-efficiency particulate air(particulate absorbing / particulate arrestance)
HOB	Heat-Only-Boiler
HOP	Heat only plant
ICD10	International Statistical Classification of Diseases and Related Health Problems (WHO), 10th revision
kMNT	1000 Mongolian Tughrik, 1000
MW	MegaWatt, unit of power, 1. 000 000 Watt
NAMEM	National Agency for Meteorology and Environmental Monitoring NAMEM
NCPH	National Centre for Public Health of Mongolia
nm	(nanometer) = 0.000 000 001 meter
NO2	nitrogen dioxide
PM	Particulate matter
PM10	Particulate matter with particles smaller than 10 micrometer (coarse and fine fraction)
PM2.5	Particulate matter with particles smaller than 2.5 micrometer (fine fraction)
RIVM	Dutch National Institute for Public Health and Environment
SO2	sulfur dioxide

SPMC	Social Protection Measures for Health
UB	Ulaanbaatar
um	(micrometer) = 0.000 001 meter
UNICEF	United Nations Children's Fund
WHO	World Health Organisation
WUSTL	Washington University in St Louis