IMPACT EVALUATION DESIGN REPORT

MCA MONGOLIA - ENVIRONMENT AND ENERGY PROJECT

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Updated for 2012 – 2013 Heating Season
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November 27, 2012

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ACRONYM LIST

CI	Confidence Interval
CO	Carbon Monoxide
EEP	Energy and Environment Project
ERR	Economic Rate of Return
GHG	Greenhouse Gases
HOB	Heat Only Boiler
IE	Impact Evaluation
MCA	Millennium Challenge Account
MCC	Millennium Challenge Corporation
MCEEIF	Millennium Challenge Energy Efficient Innovation Facility
MI	The Mining Institute
PIC	Incomplete Combustion
PIU	Project Implementing Unit
PM	Particulate Matter
SI	Social Impact
SUM	Stove Use Monitor
QA	Quality Assurance
QC	Quality Control
IPSL	Institute of Philosophy, Sociology, and Law

1 INTRODUCTION

1.1 Background

In October 2007, a $285 million Compact was signed between the Government of Mongolia and the Millennium Challenge Corporation (MCC). The Compact provides grant funding to support a five-year Program to reduce poverty in Mongolia through economic growth with projects in Property Rights, Technical and Vocational Education, and Health. In December 2009, the MCC Board of Directors approved an amendment to the Compact to include expansions to the other existing projects, a Road Project, and the Energy and Environment Project.

The Energy & Environment Project (EEP) is focused on a critical issue for many Ulaanbaatar City residents: air quality. There is severe winter air pollution in Ulaanbaatar, at levels from two to ten times the international standards, which is a major cause of serious respiratory illness among urban residents. Those especially at risk include the poor, undernourished, very young and the elderly, as well as people with preexisting respiratory disease and generally poor health. In addition to other contributing factors, such as heat-only boilers, vehicles, dust, and combined heat and power plants, a significant factor in the deterioration of air quality is the heavy use of raw coal in stoves with poor combustion efficiency for heating and cooking by residents of ger[7] districts. An estimated 90 percent of Ulaanbaatar air pollution comes from ger areas, which are predominantly lower income households. An average ger[8] consumes approximately five tons of coal and 4.3 cubic meters of wood for heating and cooking.

Air quality around Ulaanbaatar is a classic common pool resource issue and is subject to typical problems with pollution control externalities: underinvestment in emission reduction methods, further complicated by the incomplete technical information about how to reduce emissions cost effectively. In response, as part of a coordinated effort among donors including the World Bank, ADB, GTZ, and JICA, and led by the national and UB city governments (the National Committee on Coordination, Management, and Oversight of Activities of Government Agencies with regard to the Implementation of the Government Policy on Air Pollution Reduction), MCC created a program to fund financial incentives and provide technical assistance for adoption of cleaner, more efficient technologies and to support the introduction of wind energy into the national electric grid. The Energy & Environment Project constitutes approximately $47 million and consists of three activities: (i) the Millennium Challenge Energy Efficiency Innovation Facility (MCEEIF), which will provide consumer subsidies for the purchase of energy efficient and lower emissions products and homes, technical assistance in assessing the viability of such technologies, and funds to replace existing heat only boilers (HOBs); (ii) the wind power electricity generation activity, which will provide an operational subsidy to the state-owned transmission company, critical infrastructure upgrades for the introduction of renewable energy

[7] Gers are traditional houses typically used by nomadic Mongolian herders, but also found in suburban areas of cities in Mongolia.

[8] Ger households spend approximately MNT 1000-2000 (US$1.0-US$2.0) daily to purchase fuel. The office of the Mayor of Ulaanbaatar reports that 154,500 families (664,391 people) were living in the ger areas in 2008. Of these, 66,538 families are living in gers and 85,016 families are living in small houses.

into the national grid, and technical assistance for the establishment of the renewable energy fund; and (iii) a public awareness campaign, which will increase consumer awareness of renewable energy, energy efficiency, benefits, timeliness and availability of subsidies, and the identity of participating partners. This task order is designed to evaluate MCEEIF.

The primary goal for MCEEIF is a reduction in air pollution, which would result in improved health outcomes and financial savings associated with reduction in health costs and fuel costs. The MCEEIF is expected to reduce air pollution by helping the residents of Ulaanbaatar to adopt more energy efficient and lower emissions technologies. The total benefits of the EEP will ultimately depend on which technologies are implemented and adopted, the validity of technical data that underlie product selection, and to what extent reductions occur as expected.

The MCEEIF is designed to be relatively market-based and provides temporary consumer subsidies for energy efficient products and homes that demonstrate lower emissions than traditional models, and which reduce emissions in a cost effective manner. The subsidies are fixed per product based on market and economic analysis from a set of laboratory and field tests[9]. The MCEEIF includes a product review process for the identification and evaluation of emissions and efficiency performance of energy efficient technologies in the form of testing and modeling, cost benefit analysis, market analysis, and subsidy setting, after which products will be considered for consumer subsidy.

Interventions include:

- Ger wood/coal stoves to be used for heating and cooking.
- Energy efficient homes: small houses built with advanced technology to save thermal energy, consequently to reduce fuel consumption and particulate matter (PM). The project implementation unit (PIU) is working with UNDP BEEP project on this product.
- Extra layers of ger insulation: gers are covered by additional insulation - blankets made from wool (hereafter referred to as “insulation”).
- Vestibules at ger entrances: a small box at the entrance of a ger, which is meant to separate inside and outside air to prevent heat loss, as with storm doors.
- Greening: grants for supporting the reduction of particulate matter from dust through planting and maintaining trees and shrubs in strategic locations of ger districts surrounding Ulaanbaatar city.
- Heat Only Boiler (HOB) replacement: 50 HOBs that have more than 250 Kwt capacities will be replaced.

[9] However, the Mongolian government has added additional subsidies for some products.

1.2 Evaluation Objectives

EEP Objective: Increased productivity and wealth through greater fuel use efficiency and decreased health costs associated with air pollution in Ulaanbaatar.

The impact evaluation (IE) is designed to allow the SI team to quantify both the direct and indirect impacts of the improved-efficiency stove component of the MCEEIF project.[10] The IE will directly measure household emissions, fuel use, and fueling behavior to measure the changes in fuel efficiency, emissions, and associated direct and indirect costs. Reductions in emissions will then be modeled to evaluate the impact of the compact on ambient air quality in Ulaanbaatar. Where possible, SI will attempt to relate these impacts on ambient air quality to health outcomes by combining ambient air quality measurements with established dose response functions from other areas.[11] The SI team has designed the evaluation to minimize selection bias and other confounding issues.

As with all impact evaluations funded by MCC, the EEP IE is designed to meet the dual goals of learning and accountability. The research questions, evaluation methodology and outcomes of interest are selected to maximize the utility of evaluation findings. In addition to answering programmatic questions about the efficacy of the intervention and how benefits accrued to population sub-groups, the evaluation seeks to inform future MCC programming, to inform more effective and more efficient investment decisions. By documenting and substantiating lessons learned with rigorous research methodology, the evaluation will provide useful and actionable information to MCC and MCA senior management, project managers, beneficiaries, implementing partners, evaluators and other evaluation stakeholders. Lastly, with MCC's emphasis on evaluation transparency, the findings and data will be shared with the broader donor and development community, supplementing the global knowledge pool and amplifying the utility of the EEP IE.

The impact evaluation is being implemented in two stages. In the first stage, the SI team worked with MCC M&E and Economics (DPE) staff, the MCA-Mongolia M&E staff, the PIU and other evaluation stakeholders to develop a proposed evaluation design and an implementation plan. In the second stage, which started with pilot data collection in the winter of 2011-2012, the SI team is monitoring and advising MCA, the PIU, and the relevant local agencies to ensure evaluation requirements with regard to project implementation and data collection are met.

The impact evaluation addresses the following issues:

- Effectiveness of program activities in meeting compact goals: the most recent economic rate of return (ERR) for stoves, which were funded at about $7 million, are estimated to be between 55% and 246%. The ERR for ger insulation, funded at about $10 million, is estimated to be 17%.

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[10] The evaluation team will strive to include other components of the MCEEIP project to the extent possible, given the evaluation resources, timing, as well as practical and methodological considerations.

[11] As there are currently no site-specific dose response functions, the evaluation team will have to rely on data from the US and other locations.

- Estimating which fraction of measurable outcomes can be attributed to MCC/MCA-M interventions.
- Evaluation of the reasons behind the initiative's ability to achieve goals, objectives, and targets.
- Description of possible unintended results of the program, both positive and negative.
- Long-term sustainability of results.
- Re-estimation of the economic rates of return, comparison to the original estimates, and assessment of differences.
- Lessons learned applicable to similar projects.

1.3 Potential Contribution to Economic Development and Poverty Reduction Literature

This evaluation has the potential to contribute in meaningful ways to the existing literature on economic development and poverty reduction. Given the scale and anticipated impact of the MCEEIF Program, MCC and the broader donor community have much to learn about which intervention or combination of interventions, can be most effective and efficient in decreasing air pollution. This study will provide an unprecedented set of data of winter-time household stove use, as well as emissions at different points in the season. This data will allow analysis of stove use and emissions relative to ambient temperatures.

Following endline data collection, the team will synthesize the data into a report that will be submitted for publication in a peer-reviewed journal. As with all evaluations conducted by MCC, de-identified data will be made available for public use. This transparency will further facilitate the MCC goal of promoting learning.

2 EVALUATION QUESTIONS AND HYPOTHESES

The following section outlines the main questions the evaluation is designed to investigate.

Evaluation Question 1: How do energy-efficient products impact ambient air pollution levels, and health and income of residents in Ulaanbaatar?

1. How does the use of project stoves affect Ulaanbaatar's ambient air pollution, and health and income of its residents?
2. How does the use of other energy-efficient products impact Ulaanbaatar's ambient air pollution, and health and income of its residents?

In order to answer these questions, it is important to first map out the program logic model. Mapping the theory of change will facilitate the evaluation by making causal pathways explicit and amenable to investigation. Specifically, several sub-questions will be addressed in the following categories:

a. Ambient air pollution:

   (1) What is the impact of project stoves on stove emissions of carbon monoxide (CO) and particulate matter (PM)?

   (2) How do emissions vary with the use of project stoves? Do deviations from prescribed usage affect CO and PM emissions?

   (3) How does the number of lightings (cold starts, warm starts, and refueling) affect emissions from project stoves?

b. Health:

   (1) What would be the estimated change in health for Ulaanbaatar residents, as calculated from emissions measurements and international dose-response functions?

c. Income:

   (1) How does the use of project stoves affect the frequency of fuel purchases?

   (2) How does the use of project stoves affect fuel expenditures?

d. What are the impact pathways? (Figure 1 presents a schematic.)

Evaluation Question 2: Which stove models are most likely to impact Ulaanbaatar's ambient air pollution, and the health and income of the residents?

These primary evaluation questions focus on assessing the economic effects of the EEP project and on measuring the extent to which the intervention contributed to MCC's overriding goals of economic growth and poverty alleviation. However, to provide a more nuanced and complete picture of the sustainability of the EEP, we will also explore the following secondary questions:

1. To what extent are the beneficiary households following the usage prescriptions associated with the project stoves?
    a. Are they using the project stove models appropriate for their dwelling?
    b. Have households altered their chimney connection?
    c. Are they using the proper fuel and the proper fueling procedure for their stoves?
2. For what purposes do households use the project stoves?
3. Did the EEP result in differential impacts on men versus women?

Key outcomes in the evaluation include:

a) fuel consumption and costs
b) stove usage
c) emissions from houses and gers in ger areas
d) indoor air pollution levels
e) ambient air pollution levels
f) air pollution related health effects
g) household income

Hypotheses for each objective (stated as the null):

a. Fuel consumption and costs:

H_o: Stoves promoted by the EEP do not result in reduced fuel consumption and costs.

b. Emissions from houses and gers in ger areas:

H_o: Stoves promoted by the EEP do not reduce emissions from gers and houses in ger areas.

c. Indoor air pollution levels:

H_o: Stoves promoted by the EEP do not reduce indoor air pollution levels.

d. Ambient air pollution:

H_o: Modeled contributions from stoves promoted by the EEP significantly reduce household contributions to ambient air pollution in Ulaanbaatar.

f. Household income:

H_o: Usage of stoves promoted by the EEP is not associated with increase in household income.

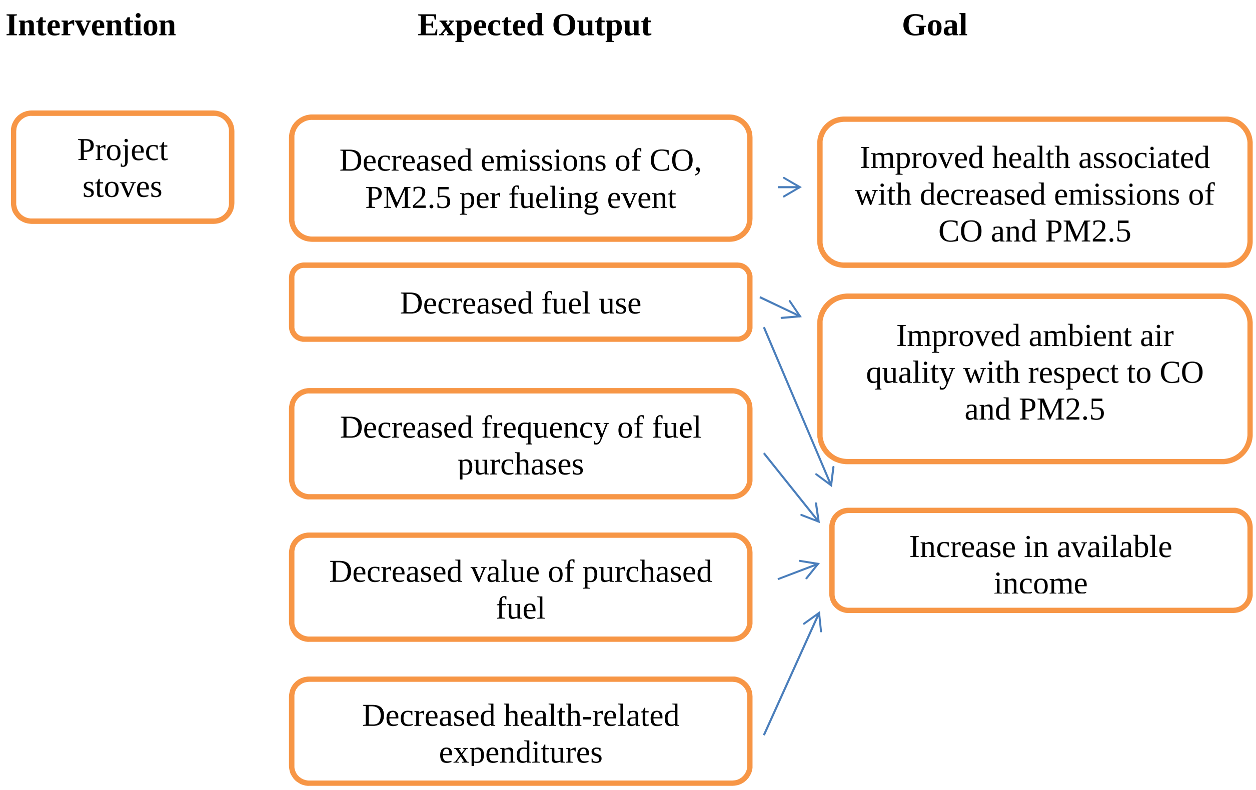

Figure 1: Causal pathways

3 METHODOLOGY

3.1 Methodology Overview

To measure changes in fuel consumption and expenditures at the household level, we compare a sample of households using project stoves to a sample of households using traditional stoves. Since households can choose whether to obtain a project stove at the subsidized price, the households that decide to purchase the project stove may systematically differ from those that do not. Households that choose to obtain the project stoves (hereafter called “participating” households) may be wealthier, for example, or more fuel-conscious than non-participating households. If so, differences in outcomes between participating and non-participating households might be explained by this selection bias, rather than attributed to the use of the project stove. In order to control for these differences, we utilize a statistical technique called propensity score matching (PSM). This matching technique allows the estimation of the differences in outcomes between participating and non-participating households while accounting for differences in characteristics that predict the probability that a household adopts the project stove. The PSM approach is described in more detail in Section 3.2.

To measure the effect of project stoves on emissions, we employ a similar household-based approach. Simple comparisons of total emissions levels from households with project versus traditional stoves may be biased, since households that adopt project stoves may be more conservative in terms of fuel consumption, and by extension emit lower emissions, even if they were still using traditional stoves. This type of bias could distort the estimates of outcomes and the differences in stoves use by households with different behaviors and characteristics. To account for this potential bias, we will measure emissions on a per-unit-of-fuel basis, which allows us to estimate the relative emissions of different stove types under real-world conditions. To estimate the overall reduction in emissions from project stoves in Ulaanbaatar in response to Evaluation Question 1, we will combine measured emissions rates with differences in fuel consumption for houses matched by propensity score. The emissions measurement approach is described in Section 3.3.

Ultimately, if project stoves are found to effectively reduce emissions, we would expect, all else being equal, to see improved ambient air quality and resultant health benefits. Unfortunately, we cannot assume that all else remains equal. Changes in weather, other emissions sources, economic conditions, and behavior, among others, are likely to exert significant influence over ambient air quality, such that changes from one year to the next would be difficult to attribute to any one intervention, such as EEP. Moreover, reliable, source-apportioned[12] data over time does not currently exist. To facilitate this analysis, our IE will take a modeling approach that will estimate air pollution levels under two scenarios: (1) the existing scenario, in which the project stoves have been distributed, and (2) a hypothetical counterfactual in which all households would still be using traditional stoves as if the project stoves had never been distributed. In each case, we will estimate

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[12] Source apportionment examines the ‘fingerprint’ of ambient air pollutants to characterize the relative contributions of different sources, such as cars, stoves, factories, etc., to ambient air quality.

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and compare air pollution levels based on our emissions measurements and fuel consumption data. We will then use global dose-response functions to calculate health outcomes for Ulaanbaatar residents resulting from the estimated decrease in local ambient pollution levels. Although we lacked sufficient data during the 2011–2012 season to construct these models, the additional data collected in 2012-2013 will provide sufficient data to perform this modeling. The modeling approach is detailed in Section 3.4.

In the remainder of this section, we elaborate upon our methodological approach with regard to each of the following components: 1) household fueling behavior: assessed through household surveys, stove-use monitor temperature readings and PSM; 2) changes in emissions, indoor air quality, and related health outcomes: assessed through emissions measurements; and 3) changes in city-wide air pollution and macro-level health outcomes: assessed through ambient air modeling and indoor air measurements.

3.2 Household Fueling Behavior

To evaluate the impacts of the project stove, we must compare the outcomes between the households using project stoves, and the outcomes that would have occurred if these households did not adopt project stoves. It is tempting to assign participating households that installed project stoves to the treatment group and hose households that did not participate to the control group. However, this comparison would only be statistically valid under stringent conditions: that the control group can be deemed an accurate representation of the treatment households had they not purchased the project stoves. This could be a reasonable assumption if the households had been randomized into the treatment, in which case the statistical comparison between the two groups would be rather straightforward, because it would be easier to identify the causal impacts of the treatment (the project stove adoption). In this case, the variation in outcomes between participating and non-participating groups could be attributed to the adoption of the project stove and the effect of confounding factors (factors that affect the outcome through non treatment channels) would be limited. Unfortunately, in this case randomization was not possible. The targeted rollout of the stove subsidy program began prior to the impact evaluation and a randomized design was not feasible. Because households could choose whether to participate in the program, there was self-selection into the treatment group instead of random assignment. This means that there are likely systematic differences between the control group households that did not participate, so simply using non-participating households as the control group would not be appropriate since this fails to account for the selection bias.

To alleviate this bias, we construct an appropriate counterfactual using a matching technique that is frequently used to assess the effect of treatment in observational studies in the absence of randomization: propensity score matching (PSM). This technique approximates randomization and reduces the selection bias by making treatment and non-treatment groups more comparable. Confounding is reduced by using household characteristics to predict the receipt of the treatment and by matching the participating and non-participating households on a range of observable characteristics. Since baseline data was not collected prior to project roll-out, households will be matched on a variety of characteristics collected through the household survey that are unlikely to have been unaffected by adoption of a project stove. These characteristics could include the type of dwelling, size of the ger or house, household size, location, and household head characteristics (e.g., gender). The PSM approach was chosen to efficiently match observations on multiple variables.[13]

PSM utilizes the household characteristics as predictors to calculate the probability that a particular household receiving the treatment intervention, in this case, obtaining a project stove. Using this methodology, the expected probability of treatment, called propensity score, can be calculated for each household, which mitigates the selection bias.

To select which household characteristics would best predict project stove use, a bivariate correlation table can be constructed through iterative specification of probit regressions until the pseudo R-squared peaks. The considered characteristics include those correlated with project stove adoption (e.g., dwelling type, use of non-stove cooking devices, and number of times ash is removed per day), or exhibiting logical causal relationships with project stove adoption (e.g., household income and age of household head). The final probit regression identifies how each predictive characteristic is associated with project stove adoption. Using this relationship between predictive household characteristics and project stove adoption, each household will be assigned a propensity score, which represents the likelihood of project stove adoption based on the household's characteristics.

After the propensity scores are generated, we can test for balance to ensure that households with similar scores are indeed similar to each other. In addition to testing for balance, we can also examine the overlap, called common support, of propensity scores assigned to adopting versus non adopting households. Since the propensity score estimates the likelihood that a household would adopt a project stove based on their observable characteristics, we would expect the treatment group (households adopting project stoves) to generally have higher propensity scores. If there are no comparison households with traditional stoves that have a similar propensity score, then we are unable to identify a match with similar characteristics and the observation must be dropped.

Once balance and common support are verified, we can use the propensity scores to match adopting households with a group of comparison, non-adopting households with similar propensity scores. By matching on propensity scores, we are able to construct treatment and comparison groups that are balanced along the observed characteristics, even in the absence of randomization.[14] However, PSM, as any regression approach, is only able account for observable characteristics. The omission of any potentially predictive unobserved characteristics that may influence a household's adoption could thus still contribute to potential bias. By using the current 2012 pilot data to address any issues present in the survey data and to identify new variables for measurement in the upcoming winter, the propensity scores used in the final analysis during winter 2012-2013 will offer improved estimates.

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[13] Rosenbaum, PR, and DB Rubin. "The central role of the propensity score in observational studies for causal effects." *Biometrika* 70, no. 1 (1983): 41-55.; and Rubin, Donald B. "Matching to Remove Bias in Observational Studies", Biometrics, 29, no. 1 (1973): 159-183.

[14] Heckman, James J., Hidehiko Ichimura, and Petra E. Todd, "Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme," *The Review of Economic Studies* 64, no, 4 (1997): 605-654.; and Hirano, Keisuke, Guido W. Imbens, and Geert Ridder. "Efficient Estimation of Average Treatment Effects Using the Estimated Propensity Score," *Econometrica* 71, no. 4(2003): 1161-1189.

To match the participant and non-participant households with similar propensity scores, we will utilize nearest-neighbors matching with replacement and caliper width, augmented by robustness checks using alternative matching algorithms. Nearest-neighbors matching implies that pairs of households in the treatment and comparison group will be selected for comparison so that their propensity scores are closest to each other. The number of neighbors may vary, depending on the distribution of propensity scores. The use of replacement means that each household can be used more than once in the matching process; that is, even if a given comparison household has already been matched to a treatment household, it can still be used again if it is the nearest neighbor for another treatment household. The caliper width is the maximum difference in propensity scores.

After propensity score matching is completed, the effects of project stove adoption on household-level outcomes such as fueling behavior can be estimated using non-parametric methods. In other words, the impact on outcomes of interest can be directly estimated using a simple difference between the treatment and control groups matched through PSM, without a priori definition of specific functional relationships between the treatment and the outcomes of interest. The non-parametric method is in contrast with parametric regression methods that impose a functional form on the relationship between the treatment and the outcomes of interest, and attempt to control for observable characteristics by entering covariates into a specific regression model (e.g., linear, probit, or logistic regression). This evaluation utilizes standard propensity score matching packages designed for Stata including *pscore*[15], *psmatch2* and *pstest*[16].

3.3 Household Indoor Air Quality, and CO and PM Emissions

This evaluation will measure the indoor air concentrations in surveyed households and emissions directly from the flue. Indoor air concentrations will be measured to assess the effect of the household's stove type on the health of household members. Figure 2 presents a basic stove configuration and the flue location. Flue emissions will be combined with behavioral data and ambient modeling to evaluate the impact of project stoves on ambient air quality in Ulaanbaatar during the 2012–2013 heating season. In addition to measurement of indoor air concentrations and emissions, the assessment will include an evaluation of carbon, moisture, and ash content of the utilized fuels.

[15] Becker, Sascha O., and Andrea Ichino. "Estimation of average treatment effects based on propensity scores," The Stata Journal, 2, no. 4 (2002): 358–377.
[16] Leuven, Edwin, and Barbara Sianesi. "PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing," Boston College Department of Economics, 2003, revised 19 Jul 2012, available online: http://ideas.repec.org/c/boc/bocode/s432001.html.

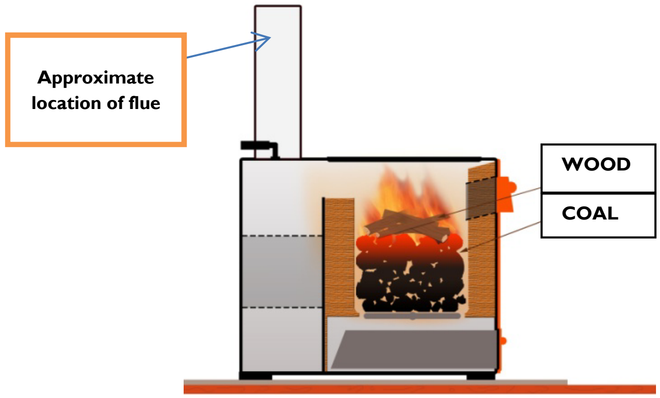

Figure 2: Basic Stove Configuration
(Source: “Royal Stove Firing Instructions”, User Manual)

Some assumptions have been made based on the most updated information available, will be refined through further analysis and testing as part of the IE. These assumptions include: (1) the moisture, carbon and ash content of the coal, obtained from stove performance testing in a stove laboratory in Mongolia (which will aid in comparison of values) and from communication with the Mining Institute; (2) the carbon content of the particulate matter, obtained from historical measurements from coal burning stoves, which we hope to refine though analysis of quartz filters; and (3) the moisture and carbon content of the fuel wood used to light the stove, obtained from historical measurements of fuel wood.

3.4 Ambient Air Quality and Citywide Health Outcomes

In addition to the direct household level impacts anticipated from project stove use, the program is expected to lead to improvements in ambient air quality in Ulaanbaatar, holding all else equal. These ambient air quality improvements are in turn expected to yield indirect health and income benefits for the city’s entire population. For this level of analysis, a suitable comparison group for the city of Ulaanbaatar is not available, so these indirect impacts will be estimated through modeling based on emission factors measured during this IE, combined with established dose-response functions from other contexts.

Household CO and PM emissions measurements will be utilized to model citywide effects of project stoves on ambient air quality. This model will use the levels of CO and PM emitted from households with project stoves and households with traditional stoves, combined with air pollution gradients and climatic considerations, to estimate citywide levels of CO and PM concentrations. Using these measurements, we can compare current levels of air pollution in Ulaanbaatar given the adoption of project stoves to a counterfactual estimate of the levels of air pollution that would have been observed if all households had traditional stoves. The difference between current pollution levels with the program and modeled levels without the program represent the impact of project stoves on the ambient air pollution in Ulaanbaatar.

Emissions analysis methodologies can be broadly classified into two approaches: top-down and bottom-up. Top-down methods use ambient air quality monitoring data to estimate changes over time. These changes are aligned with data for the timing of program implementation to estimate air quality changes from the intervention.

A top-down data collection effort was contracted by MCA-Mongolia, and will measure ambient levels of PM2.5 and apportion them to local sources. This effort will take into account the contribution to ambient PM2.5 of power plants, HOBs, automobile traffic, and residential stoves. It will use wind direction, proximity to power plants, and other potential confounding factors to isolate the contribution of project and traditional stoves to ambient levels of PM2.5.

Several factors complicate the use of the top-down approach in this case. First, there are numerous emission source categories contributing to ambient PM burdens in Ulaanbaatar. For example, in addition to residential heating stoves and HOBs, there are also large power plants and motor vehicles. The top-down approach requires a method to apportion observed ambient air pollutant concentrations to each of these emission source categories. To estimate PM burdens, top-down analysis requires the knowledge of the composition of particulate matter, and while these data have been collected at a few sites in special studies, these are not routinely collected and detailed data for PM composition is not available. In addition, the variation in weather would need to be carefully modeled. Other factors complicating the use of the top-down approach are the short history and relatively sparse spatial coverage of the Ulaanbaatar ambient air quality monitoring networks. Even with a long data record, the attribution of air quality changes to the intervention program would be challenging, if not intractable, because the emissions from other source categories also change over time. Collectively, these limitations place significant constraints on the applicability of top-down methods alone to assess the changes in air quality resulting from program implementation.

The second approach to estimating air quality changes consists of bottom-up methods, which use emissions estimates and meteorology data to drive an air quality dispersion model. This is the approach we chose to take, because we are generating emission factor and activity data that can be used to estimate emissions from both traditional and project residential heating stoves. A base case will be modeled using emission factors and activity estimates developed for the traditional stoves and for the original HOBs (hereafter collectively called “heating devices”). Emissions will be allocated to hourly levels over the winter season using activity estimates (e.g., fuel usage) and spatially-resolved data for the number and locations of replaced heating devices. Air quality modeling will be used to estimate ambient PM concentration contributions across Ulaanbaatar resulting from these emission sources in the absence of program implementation. Holding the meteorology constant, the modeling will be repeated for the intervention scenario by using emission factors and activity estimates developed for the project stoves and for the replaced HOBs. Modeled concentration differences between the intervention scenario and the base case will be used to evaluate the impact of the heating device replacement program on ambient PM air quality.

As the 2011–2012 heating season served as a pilot for emissions measurements and the sample was small (21 households) and highly variable, no modeling had been conducted during that heating season. The full modeling estimation will take place for the 2012–2013 heating season.

3.5 Data Collection

Approach to Evaluating Household Level Interventions

To assess the impact of project stove use on health and income effects of household level improvements, a cross-sectional design will be used to compare outcomes of a sample of households using project stoves against a matched comparison group using traditional stoves. The sample of treatment and comparison units will be drawn from the household level behavioral study allowing us to identify of participating and non-participating households with similar characteristics. Comparison units will be selected from within areas in which the subsidy was offered as these households are most likely to match the fuel use and demographic profile of the treatment group. To attenuate the selection bias inherent in the comparison between participating and non-participating, the PSM approach was used (see section 3.2). Households will be matched on observable characteristics such as income levels, households size, age of residents, fuels used, and geographic district, but these variables are not sufficient to fully control for all differences between treatment and comparison groups. Those households that adopted the project stove technology made a choice to do so which may reflect an underlying, unobservable difference between them and the 'average' household so even after accounting for observed factors, there remains the possibility of an unobservable, self-selection bias.

To evaluate the impact of the EEP. SI will use a nested design approach consisting of the following components:

1) Household level survey in at least 1095 homes.

2) Emissions and indoor air pollution monitoring in a subsample of 150 homes.

3) Modeling of changes in ambient urban PM in Ulaanbaatar using emissions and fuel consumption data measured above.

Household survey

Household surveys will be conducted in at least 1095 households (including houses and gers) with both project and traditional stoves to assess demographic or control characteristics, fuel consumption, fuel expenditure, health outcomes, and stove use behavior. This data will be used to estimate direct income effects of the adoption of project stoves. Fuel and stove use varies considerably throughout the winter (heating season), based on changes in outdoor air temperature. To quantify this seasonal variation, each sampled household will be visited multiple times, and stove use sensors will be installed to track stove use and refueling events in between survey visits. A stove use monitor (SUM) will be installed directly underneath the main stove in each household sampled for stove use measurements. In a subsample of these households, the team will install an additional SUM on the inside of the wall. This second SUM will be used to measure indoor air temperature and will to assess the effect of insulation on thermal efficiency. This round of household data collection will take place in the winter of 2012 – 2013.

The pilot household survey took place during winter 2011 – 2012 in 447 households. It served as a pilot of instruments and measurement approaches, yielding preliminary outcome data, but also, perhaps more importantly, point estimates of important outcome variables and their variance, which facilitate more refined power calculations for future survey rounds and emission measurements. Due to the timing of the contract award, the pilot could only be implemented in the second half of the heating season. This pilot only covered the second half of the heating season with initial measurements in January-February and follow-ups in March and assessed seasonal variation in stove and fuel use between the peak and shoulder winter seasons. Between October and April 2012-2013, the first full heating season measurements will be conducted in three phases. The first phase will take place in October; the second, in January; and the third, in March and early April.

Emissions and indoor air pollution monitoring

The household survey data will be integrated with emission measurements from a subsample of households including both houses and gers with project and traditional stoves. In this subsample, emissions and indoor air quality will be assessed over a 5-day period. Emission factors will be combined with seasonal fuel use from the household survey leading to overall emissions estimates. We will use the emissions data to model ambient air pollution changes and exposure for Ulaanbaatar more generally. Where possible we will estimate health impacts using established dose response functions from other contexts and modeled changes in ambient air quality.

The first round of pilot emissions measurements took place during January and February of 2011-2012. These measurements served as a pilot of the measurement approach and equipment, as well as an opportunity to train local counterparts in emissions measurement, so that they may more fully participate in, and eventually lead, measurements in subsequent years. The pilot measures provided an initial estimate of stove performance, and formed the basis of statistical power calculations of sample size for the comparison groups. The first full round of data collection during the 2012-2013 heating season will take place in October 2012 and will continue through March 2013.

Cross-seasonal evaluation of indoor air pollution

A small sample of around 150 homes spread across comparison groups will have passive particle monitors installed in the winter of 2012-2013 to monitor longer term variation in indoor air pollution. This pilot evaluation will be undertaken as part of a household air pollution study. Although not part of the current impact evaluation, nesting this component in the homes already being monitored will result in a database with much broader applicability, and will reference the impact evaluation to a robust assessment of health outcomes. Of course, not all health outcomes of interest will be covered by this study, and the team will therefore attempt to estimate the other health endpoints (as mentioned above).

Geo-referenced modeling of ambient urban PM

The rollout of the project stove subsidy program will likely not be completed until the end of the impact evaluation. Further, ambient air pollution concentrations are variable from season to season and dependent on a range of meteorological factors, in addition to the emissions from a variety of sources. As a result, direct measurement of the program's impact on ambient air pollution concentrations may be confounded by a number of uncontrollable factors (e.g., year-to-year differences in meteorology may mask the impact of the program, other stove programs may also influence air pollution, emissions from other sources such as motor vehicles may change), affecting accurate representation of program impact. The impact of the stove subsidy program will thus be assessed through modeling approaches that will give estimates of program impact for the residential sector under a standardized set of environmental conditions (i.e. a single year that has been deemed representative of the prevailing meteorology in Ulaanbaatar) and a "hold all else equal" scenario.

In this approach, the emissions measurements will be used to develop hourly ambient temperature-dependent emission rates that will be used to model residential sector contributions to ambient air pollution in Ulaanbaatar. An hourly approach is undertaken since wind patterns and mixing height have diurnal patterns that impact the accumulation and ventilation of ambient air pollutants in the urban area.

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3.6 Precision of Measurements

The pilot phase of measurements allowed the estimation of values and variability for key outcomes, which in turn informed the power analysis calculations and the estimation of the levels of precision of current data collection and measurement activities.

Household Survey

To determine the household survey sample size, we first considered the number of stoves to be compared. As Table 1 illustrates, our pilot household survey sample included households with traditional stoves and three EEP subsidized stoves: 1) Selenge Khas, 2) Selenge Ulzii, and 3) Royal Ocean Dul. It did not include any households with the Royal Ocean Golomt stove.

Therefore, we have calculated the sample size based on comparisons of the three project stoves we observed against traditional stoves. As outcomes among the three types of MCA stoves in the 2011-2012 sample were similar, we expect similar power across project stove types in comparison to traditional stoves. Furthermore, because the pilot results varied little among project stoves, it is unlikely that we will be able to reliably demonstrate differences among the project stove types, relative to one another.

Table 1: Prevalence of EEP Stoves in Pilot Sample

	Traditional	Ulzii	Khas	Dul	Golomt	TOTAL
Gers	87	118	4	13	0	222
Houses	125	57	36	7	0	225
	212	175	40	20	0	447

We do not power the sample for dwelling type since our analysis will be focused on measuring differences by stove type, irrespective of the type of dwelling, although our sample will be stratified by dwelling type to ensure representativeness on this critical variable. Therefore, the sample is powered based on the number of households with each type of stove, irrespective of dwelling. Based on matched differences in outcomes from the pilot between project stoves and traditional stoves, we conducted power calculations for multiple outcomes. As reported coal use over a 24-hour period required the highest sample, we use it to power the sample size estimates. The estimated difference during the pilot between households with project and traditional stoves was 3.6kg.

As a result of these calculations, we require a sample size of 225 stoves per stove type for 85% power. If we assume 15% attrition, we require a total sample of 260 per stove type (Table 2). We originally requested that the data collection firm interview 1050 households in the first phase of data collection, to allow for non-response. Discussions between the household data collection partner, the Joint Venture between Robust, LLC and the Institute of Philosophy, Sociology, and Law (JVRIPSL) and SI, led to an increase of the intended sample to 1095 households (Table 3, Panel A), divided equally among eight strata, representing the four types of project stoves and traditional stoves represented equally in gers and houses.

However, given that the “Khas” stove is intended for medium size houses, gers do not typically choose to purchase the Khas stoves. Even if they do, pilot data suggests that these households are not actually using it, in 75% of the cases. Not only is it extremely difficult to identify gers with Khas stoves, which means the effort to acquire the requisite sample ger-Khas stratum would be substantial, but also pilots suggest that only 25% of gers listed in the bank records as having purchased Khas stoves were confirmed to actually have a Khas stove at present.

For these reasons, the Ger-Khas stratum was drastically reduced to only 15 observations, to provide suggestive data for households in this group. This allowed a reallocation of the survey sample to the other groups, increasing the size of the other sub-samples to at least 150 and improving the power. The final sample stratification for the intended household sample size is presented in Table 3, Panel B.

Table 2: Household Survey Sample Size Calculations

	Daily Coal Use (kg)	Number of Reported Fueling Events	Number of Reported Cold Starts	Number of Reported Refuels	Average Amount of Coal (kg) per Fueling Event
Project Stove Average	21.37	3.00	2.11	0.77	7.61
Project Stove Standard Deviation	11.92	1.62	1.11	1.74	2.81
Traditional Stove Average	24.98	4.31	0.95	3.36	5.91
Traditional Stove Standard Deviation	13.59	1.85	0.97	1.74	2.78
Minimum Sample Size	225	32	15	11	49
Statistical Power of Minimum Sample	85%	85%	85%	85%	85%
Attrition Buffer (15%)	34	5	2	2	7
Calculated Sample (Minimum + Buffer)	260	38	18	14	57
Intended 2012-2013 Sample	274	274	274	274	274
2012-2013 Statistical Power	91%	100%	100%	100%	100%

Table 3: Intended Household Sample Size

Panel A: Sample stratification proposed initially

Dwelling/stove	Traditional	Ulzii	Khas	Dul	Total
Ger	137	137	137	137	548
House	137	137	137	137	548
Total	274	274	274	274	1096

Panel B: Final target sample stratification

	Traditional	Ulzii	Khas	Dul
Ger	150	150	15	150
House	180	150	150	150
Total		1096		

Emissions and Indoor Air Quality Measurements

With the emissions data collected during winter 2012-2013, we intend to make three major comparisons, as illustrated in

Table 4. First, in gers, we will compare Selenge Ulzii stoves to traditional stoves. In houses with and without heating walls, we will also compare each of the two Selenge stoves (Khas and Ulzii) and traditional stoves. As Table 5 shows, the prevalence of heating walls was higher in the pilot sample among households with traditional stoves than in households with project stoves. While 89% of houses with heating walls in our pilot sample use traditional stoves, 72% of houses without heating walls use project stoves. This difference may be due to selection bias toward project stoves in households with heating walls or a tendency among households who purchase project stoves to remove part or all of their heating walls. Accordingly, the traditional stove stratum in houses includes more households with heating walls than without them. Likewise, the Khas and Ulzii strata include more houses without heating walls than houses with them. The stratum of Dul houses is evenly divided between houses with and without heating walls because the subsample of Dul stoves in the pilot was small—only 7 houses—and it was almost evenly divided between houses with heating walls (3) and houses without heating walls (4). Overall, the sample size will allow us to compare emissions and indoor concentrations of the project stove types to traditional stoves.

Table 4: Intended Emissions and Indoor Air Quality Sample

	Traditional	Ulzii	Khas	Dul	TOTAL
Gers	25	25	0	15	65
Houses with heating walls	15	10	10	5	40
Houses without heating walls	10	15	15	5	45
	50	50	25	25	150

Table 5: Prevalence of Heating Walls within 2011-2012 Pilot Sample

	Traditional	Ulzii	Khas	Dul	TOTAL
Houses with heating walls	89%	28%	26%	43%	139
Houses without heating walls	11%	72%	74%	57%	85
	125	57	35	7	224

The sample of households where emissions and indoor air quality measurements will take place is a subsample of the household survey sample. It is highly dependent on whether households live in houses or gers for two reasons. First, pilot measurements from 2011-2012 demonstrated high variability between houses and gers. Second, the prevalence of each stove type varied in the pilot sample between houses and gers, as shown in Table 1.

Within houses, the sample must account for the presence of heating walls, so houses are stratified by this criterion as well. Heating walls are structures that some households build around chimneys to disperse heat throughout the home. As the limited pilot data showed considerable variability in emissions of PM2.5 and concentrations of CO and PM2.5 between houses with and without heating walls, the sample must be stratified by the presence of a heating wall.

Sample size estimates are based on the prevalence of the stove types purchased in Ulaanbaatar, and the sample sizes required to show statistical differences between groups. First, the sample must represent the stoves that are actually present in dwellings in Ulaanbaatar to produce robust estimates for the most prevalent groups, while obtaining estimates for other smaller categories for modeling purposes. Second, the sample must be adequate for statistical comparisons between major groups. We acknowledge that we will not have the sample sizes to compare between all groups. Instead, the sample was designed to be sufficiently large for comparisons among major groups and for producing the estimates necessary to model ambient levels of PM2.5. Project stove prevalence, according to bank distribution lists, is presented in the Table 6 below.

Table 6: Prevalence of Subsidized EEP Stoves

	Ulzii	Khas	Dul	Golomt
Gers	78%	0%	22%	0%
Houses	42%	44%	13%	0%
Undetermined	56%	11%	33%	0%
Total number of Stoves	44110	11384	13205	147
Overall Prevalence	64%	17%	19%	0%

3.7 Beneficiary Disaggregation

All analysis will follow the guiding principles of the MCC Gender Policy. All behavioral data will be collected for both male and female household members. Collecting sex-disaggregated data will allow the team to assess whether there are gender differences in participation (e.g., households headed by males may adopt the technologies more or less often than those headed by females) and/or impact (e.g., perhaps the health effects will disproportionately accrue to women if they are found to engage in most of the stove use). Analysis will disaggregate, to the extent possible, data by gender, age, and poverty level, where applicable, when measuring impacts on beneficiaries. Reasonable cost-effective efforts will be made to estimate the benefits and costs borne by gender and age of household members.

4 DATA

4.1 Variables (detailed definitions)

Variable	Variable definition	Description
% Difference in PM2.5 Emissions, Homes	% Difference in Total PM2.5 Emissions from Project vs. Traditional stoves in Gers and Houses	Based on collection by MCC IE contractor in 2012 - 2013. The impact of project stoves on average ambient PM2.5 contributions from the residential sector in ger districts will be modeled for the 2012-2013 winter heating season. Key model inputs will be hourly meteorology (wind speed, wind direction, mixing height and ambient temperature), ambient temperature dependent hourly emission rates by type of subsidy, and the geo-referenced location of all subsidies. These parameters will be used to drive an air pollution dispersion model to estimate the change in the contributions of the residential sector to ambient PM2.5 as a result of the adoption of project stoves compared to the base case of traditional stoves.
Absolute Difference in PM2.5 Emissions, Homes	Absolute Difference in Total PM2.5 Emissions from Project vs. Traditional stoves in Gers and Houses	Based on collection by MCC IE contractor in 2012 - 2013. The impact of project stoves on average ambient PM contributions from the household sector in ger districts will be modeled for the 2012-2013 winter heating season. Key model inputs will be hourly meteorology (wind speed, wind direction, mixing height and ambient temperature), ambient temperature dependent hourly emission rates by type of subsidy, and the geo-referenced location of all subsidies. These parameters will be used to drive an air pollution dispersion model to estimate the change in contributions of the residential sector to ambient PM2.5 as a result of the adoption of project stoves compared to the base case of traditional stoves.
% Difference in median fuel costs	Difference in median annual heating and cooking fuel costs for participating homes versus nonparticipating homes.	Median annual heating and cooking fuel costs from MCA-M&E ger stove behavioral survey of household selected from product sales information from PIU. The fuel-related costs of participating households are estimated across project districts during the heating season (October - April). Nonparticipating households have traditional stoves and no subsidized products with two layers of insulation.
% Difference Daily Household PM Emissions	Average Daily Household PM2.5 Emissions for participating versus non-participating households	Calculated from PM2.5 emissions sample from in field sample of monitored homes. For 2012 - 2013 heating season, based on an assessment of approximately 150 households from October 2012 to April 2013. Estimates calculated as microgram/kg fuel/day x estimated fuel use.

CO Concentration in Participating Homes	Average Short-term Indoor CO Concentration in Homes with Project Stoves	For the 2012 - 2013 heating season, based on in-field assessment by MCC IE contractor of approximately 150 households.
PM Concentration in Participating Homes	Average Short-term Indoor PM Concentration in Homes with Project Stoves	For the 2012 - 2013 heating season, based on in-field assessment by MCC IE contractor of approximately 150 households.
% Difference in Raw Coal Consumption	Average Raw Coal Consumption, Households with Project Stoves versus Households with Traditional Stoves and Two layers of Insulation	Actual consumption data calculated from behavioral survey. Estimated across heating season (October - April). Disaggregated values are measured in tons of coal (as received, metric).

4.2 Data Sources

Household survey

To identify the households to be sampled in both the treatment and comparison groups, the evaluation team used data provided by the household behavioral study data collection firm, which was generated from a proxy means test survey conducted by the Ministry of Population Development and Social Welfare (formerly the Ministry of Social Welfare and Labor; for the full sample frame of all eligible households) as well as through the two distributing banks: Xacbank and Khaan Bank (for the sample frame of households that have adopted project products). This dataset included a full list of both eligible and participating households in the eligible districts from which the evaluation team drew a sample frame.[17] From this sample frame, the EEP-IE team will select a stratified random sample as described in Table 3 Panel B, yielding the following sample sizes, including replacements.

This sample size was estimated using expected differences in coal consumption between project stoves and traditional stoves. Assuming an effect size of -3.6kg[18], the required size of each stove stratum is 197 households, yielding a required sample size is 788 households. The intended sample of 1095 includes an extra 39 percent of households, in case of attrition.

Data for the household survey is being collected by JVRIPSL under the supervision of SI. The baseline household data collection instrument (Attached as Annex A) includes modules on:

[17] This initial sample frame contained numerous data quality issues, which are being documented in a separate report. This report will be used to improve the sample frame over the coming summer to ensure a more comprehensive and accurate sample frame for measurements in the next winter.
[18] This implies that households with project stoves use 3.6kg less coal daily, on average. This figure is calculated from differences in coal consumption between matched households with project and traditional stoves measured in the 2011-2012 pilot

1. Housing CharacteristicsStove and Other Heating and Cooking Device Characteristics
2. Stove Use
3. Fuel Type, Use, and Cost
4. Comparison of Traditional and Project Stoves
5. Household Demographics and Socio-economic Status
6. Health Symptoms
7. Housing Measurements

Under SI supervision, Robust & IPSL will field 15 teams of two enumerators each (supported by three supervisors/quality control monitors and an overall field coordinator) to conduct a panel survey of at least 1095 households with three visits per household. If the person who tends the stove is not present at the time of the first visit, enumerators will attempt to make an appointment and return again to interview the appropriate person, provided that this return visit is possible within the time that the survey team will be in the area.

The survey has detailed sections for each of the outcomes to be evaluated, including both intermediate and final outcomes. In addition, to be able to monitor stove use, approximately 275 gers and 275 houses will be equipped with stove use monitors (SUMs) at the time of the first phase of the survey.

Emissions and indoor air pollution monitoring

Data will be sourced from direct measurements of emissions in participating homes compared to non-participating homes. Time permitting, the team will conduct limited measurements of other combinations (e.g., traditional and project stoves, low pressure boilers, and DME stoves), as these are particularly important for determining the long-term impact of the compact. An ultimate goal of most ger residents is to move into houses, thus many of ger residents have low pressure boilers installed. Since houses consume considerably more coal than gers, a potential outcome is that without additional measures air pollution either stays the same or could even worsen. In addition, there are a number of other initiatives to promote cleaner fuels, such as promotion of DME stoves. Since the current compact may impact the adoption of cleaner technologies either through increasing awareness or through creating social value based on affordability, the assessment of the emissions impacts of programs as part of this study could provide useful data for these programs as well. Lastly, the study will place particular importance on training Mongolian personnel for further measurements after the 2012-13 heating season, for continued assessment of program impact.

i. Methods for household measurements

Stove emission samples will be collected directly from the stove's flue with a sampling probe inserted approximately 70cm above the stovetop. Emission factors will be determined using the carbon balance approach, which accounts for the fate of the fuel carbon in the emitted species[19] and has been used extensively in previous stove emission studies to derive cook stove emission factors[20]. A more comprehensive description of this approach can be found in Zhang et al.[21]. Emission factors will be reported as grams per kilogram fuel burned ($g\ kg^{-1}$) on a dry basis.

Emission samples will be drawn through a metal probe inserted to the center of flue. PM2.5 will be collected for gravimetric analysis and gas concentrations monitored for CO and CO_2 concentrations with flue gas analyzers. A subsample will have additional quartz filters for EC/OC and gas bags for analysis of CO_2, CO, CH_4 and Nonmethane hydrocarbons using a GC FID. For gravimetric assessment of $PM_{2.5}$ samples will be collected on a 37 mm Teflon filter. For gas analysis and quartz filters, samples will be drawn by an SKC low flow sampling pump through Teflon tubing to a 47 mm pre-fired quartz filter (SKC Inc, USA) before going to a 200 liter Kynar bag, a small sample of which will be transferred to metal lined bags for shipping and subsequent analysis. All flow rates will be set using Dry cal flow meter primary standard. Background concentrations in *gers* will be sampled simultaneously at flow rates similar to the emissions samples. The background concentrations will be then subtracted from the emission sample concentrations to account for background contributions to emissions samples. $PM_{2.5}$ and CO indoor air concentrations will be monitored using real time instruments TSI Q-Trak and DustTrak with simultaneous $PM_{2.5}$ filter collection, respectively.

ii. Sample collection and analysis In field sampling of emissions

Flue gas analyzers for real-time assessment of $CO_2/(CO_2+CO)$ ratios will be factory calibrated prior to study. Gas sampling bags will be purchased for the study and purged 3 times with zero air prior to transport to the field. Air check primary flow meters to set pump flow rates will be factory calibrated. 5% of the total sample number of filters will be collected as field blanks. Spiked control samples of gas bags with NIST traceable gas standard mixture of CO_2, CO, and CH_4 in a helium balance (Scott Specialty Gases, USA) will be used to determine sample loses in metal lined multilayer bags. The MMT bags have been demonstrated to maintain stability of CO_2, CO, CH_4, and total hydrocarbons for 3 months. Filter samples of particulate matter will be weighed in an environmentally controlled microbalance room based on the EPA IP-10A method of the USEPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air (EPA/600/4-90/010). Standard operating procedures will be written and followed for all procedures. OC/EC analyses will be performed using a Sunset analyzer. Blanks are performed daily, and the analysis automates a calibration with methane gas after each sample. A three-point calibration using sucrose is performed weekly.

iii. Handling and custody of samples

Samples will be given unique identification numbers recorded on data sampling sheets for each home, which will be identified through the parcel number of each house. Household information will be collected by field workers during sample collection and recorded with sampling information

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19 Smith et al. 1993
20 Roden et al., 2006; Zhang et al., 2000; Pennise et al., 2001; Smith et al., 2000
21 Zhang et al 2000

on data sheets. Electronic and hard copies of the data sheets will be made and will return with the field teams to UCI.

iv. Analytical methods used and calibration analysis of GHG in emissions samples

Certified standards will be used in all analysis of greenhouse gases (GHG). 7-point calibration curves will be used for quantification ($r^2 > 0.998$). 5% of the CO2, CO, CH4, and THC samples will be randomly selected for duplicate analysis. All repeated samples will be within 10% of the initial samples with a coefficient of variation of <5% for CO_2, CO, CH_4 and THC respectively. Standard operating procedures have been written and will be followed for all procedures.

v. Data reduction, analysis and reporting

10% of all manual data entry will be rechecked independently to ensure accuracy in transcription. If errors in transcription are detected the data will be reentered a second time and the two data sets subtracted from one another to identify where data entry discrepancies occurred, so they can be corrected.

Modeling of ambient PM concentrations

Data sources will be emission rates determined from the direct measurement in homes with project stoves and in homes with traditional stoves (e.g., ambient temperature adjusted grams PM per day per dwelling), geo-referenced data for the participating homes including the type of stove, changes in emission rates for the HOB units that are replaced (e.g., ambient temperature adjusted grams PM per day per HOB), spatially resolved population data, and ambient air quality monitoring data.

4.3 Data Quality

Dr. Olga Rostapshova, as the program manager, will be responsible for the overall quality of the EEP IE and all project deliverables produced under the contract. Dr. Rufus Edwards will be the individual responsible for the overall quality assurance (QA) and quality control (QC) aspects of household measurements. Dr. Edwards will also be responsible for the QA and QC of analysis of air pollutants and greenhouse gases conducted at the University of California Irvine. Dr. Jay Turner will be responsible for the QA of the ambient air data and analysis.

SI has worked with the household survey data collection partner Robust & IPSL to develop a comprehensive data quality plan, which includes the following:

- 3-day classroom and field training for all enumerators and supervisors
- Daily supervisor review of all surveys for completion and abnormal responses
- Survey back-checks or audits by supervisors and the SI team
- Data entry supervisor review of all submitted surveys for completeness
- Double data entry with manual reconciliation of discrepancies
- Entry into data entry system developed in CSPro with internal consistency and range checks to identify potential errors
- Voice recording of all interviews (as approved by respondents), with a random sample reviewed for accuracy

In addition, SI has engaged a Mongolian data collection firm to conduct data quality monitoring (DQM). In each phase of data collection DQM staff will conduct re-visits to 55 households interviewed during the household survey. During these revisits, they will administer a shortened questionnaire, with questions that are not likely to change between the original interviews and revisits, including dwelling type, household composition, and ownership of cooking devices. DQM staff will also listen to audio recordings of 55 interviews conducted by Robust & IPSL enumerators. For both revisits and audio verification, the responses provided by the households will be compared to the responses written on the original questionnaire by Robust & IPSL enumerators. All differences between DQM-verified responses and original responses will be recorded and an error rate established.

Following the completion of data entry by Robust & IPSL, the DQM firm will also conduct data entry monitoring (DEM). During DEM they will manually compare the values entered by Robust & IPSL data entry staff to responses in the original questionnaire. As with revisits and audio verification, all differences between DQM-verified responses and original responses will be recorded and an error rate established.

Through these activities, the team expects to minimize survey and transcription errors.

4.4 Data Analysis

Household Data

Household data sets will be imported into STATA for cleaning and management. Outliers will be identified and analyzed, with select outlier values verified. Descriptive statistics (central tendency and variance) will be calculated for all outcomes and demographic or control variables. Values of demographic and control variables will be compared across households with traditional and project stoves testing for significant differences across groups (symptomatic of selection bias). We will also make an initial, 'naïve' comparison of outcomes of interest (such as health symptoms, stove use, fuel use, and fuel costs) across all traditional and all households with project stoves. However, we expect these estimates to be biased as a result of the selection bias since the treatment was not randomized. Accordingly, we will use PSM methods to match households with project stoves with traditional stove households, testing a variety of propensity score matching algorithms for robustness. We will also perform regression analysis to identify predictors of purchase of project stoves, as these variables may be useful to the MCA in future program rollout. Finally, analysis will test for differences in outcomes for critical sub-groups, including low-income households, women, children and the elderly.

Emissions Data

Emissions data sets will be imported into PSPP, STATA or similar statistical processing package for cleaning and management. Outliers will be identified and reasons for outlier values determined to the extent feasible. We will calculate descriptive statistics (central tendency and variance) for all emissions and indoor air parameters. Both parametric and non-parametric testing for significant differences between groups (traditional stoves vs. project stoves for both houses and gers) will be performed. Analysis will test for differences in outcomes for stove sub-groups, including income and household size.

Modeled Ambient Air Concentrations

The impact of the program on average ambient PM concentrations in the winter season (defined as the "heating season" in this project) will be modeled. Key model inputs will be hourly meteorology data (i.e. wind speed, wind direction, mixing height and ambient temperature), ambient temperature dependent hourly emission rates by type of stove, and the geo-referenced location of participating households. These parameters will be used to drive an air pollution dispersion model to estimate on an hourly basis the change in ambient PM from project stove adoptions compared to the base case of no adoption. Modeling will be conducted at hourly resolution to account for the dependence of emissions on ambient temperature and diurnal patterns in the winds and mixing height. Winter season averages, and possibly other metrics, will be constructed from the hourly concentrations. The modeled concentrations will be spatially resolved so the location-dependent change in ambient PM can be overlaid on the geographic distribution of population to estimate the population-weighted changes in PM exposures.

Given the large number of participating households, a GIS database will be constructed to include the location and other attributes of participating dwellings. Emissions from dwellings will be modeled as area sources that each covers a certain land area (e.g., 1x1 km) and includes numerous participating dwellings. The geo-referenced data on participating stoves will be used to determine the total emissions assigned to each area source. HOB units will be modeled as point sources.

Modeling will likely be conducted using hourly meteorology from the first year of the program. The representativeness of the model year will be evaluated by comparing the distributions of hourly meteorology parameters for the modeled year to at least five years of data. If the model year is deemed to not be representative, then another year will be chosen that meets the criteria for representative meteorology.

An appropriate dispersion model will be chosen for this analysis using selection criteria including, but not limited to, consistency with the input data that are available (some dispersion models require meteorological parameters that might be unavailable). Preference will be given to models that have been previously used for Ulaanbaatar. Candidate models are currently being evaluated with one option being ATMoS 4.0 that was used in a World Bank-funded study of air pollution in Ulaanbaatar.

Given the number of emission sources and other factors that can influence observed ambient PM concentrations, there will likely be significant confounding in relating the impact of subsidies on monitored ambient air pollution data. As a result modeling will focus on the impact on household sector contributions to ambient concentrations. Nonetheless, we will obtain and analyze the ambient PM data to look for evidence of the subsidies on ambient PM measured at the Ulaanbaatar air quality monitoring stations.

4.5 IRB Approvals

SI is in the process of acquiring approval for its own internal IRB, which will be used for the study.

4.6 Management, Communication and Data Sharing

Dr. Edwards will be responsible for coordinating measurements at field sites. Dr. Edwards' laboratory manager will be responsible for preparation of supplies and equipment, and his group will conduct the initial home measurements. Digital storage media will be used to make copies of data collected in the field and kept separate from the field laptop. A central database of all project data will be kept and backed up at SI as the master copy, and copies sent to Dr. Edwards and Dr. Turner. Data obtained as part of this study will be available to outside investigators as part of global emissions inventories. We will also make final data sets from this study available to outside investigators in response to data requests after publication of the main findings. Data to be shared will be final analysis datasets, and documentation explaining the variables in the datasets. Allowing broad access will enable identification of associations not discovered through our methods, and to validate preliminary associations that do not meet the standards of significance set out in this study. To maintain privacy and confidentiality personal identifiers will be removed in the shared datasets.

4.7 Timing of Results and Timeline

In accordance with the EEP IE contract, within 21 days of MCC acceptance of this design report, the SI team will submit a detailed Evaluation Execution work plan. Commencing with the acceptance of the Design Report, the SI team will be submitting quarterly reports. The first of these reports will be sent three months after acceptance of this report. Additional deliverables include: (1) a Draft Midline Impact Evaluation Report – 60 days prior to completion of Option Year 1, (2) Draft Final Impact Evaluation Report - 90 calendar days prior to completion of Option Period 3, and (3) trip reports detailing the activities and outcomes of trips to the field.

The data collection timeline for the Winter 2012 - 2013[22] heating season is as follows:

- Phase I Household Data Collection: October 22 – November 8
- Full Phase I dataset from the Mining Institute: December 20
- Phase II Household Data Collection: January 14 – February 2
- Full Phase II dataset from the Mining Institute: March 14
- Phase III Household Data Collection: March 18 – April 6
- Full Phase III dataset from the Mining Institute: May 18
- Emissions Measurements: October 29 – April 6
- Baseline Data Analysis: June 20
- Baseline Report: July 31

5 KEY CHALLENGES AND RISKS

As with any multi-year, multi-pronged study, the EEP IE will face a number of challenges. For all challenges that can be identified at this early stage of the evaluation, the SI team has created mitigation and contingency plans. Inevitably, over the course of the evaluation, the team will face unforeseen challenges, as well. All such issues will be identified and communicated to the primary evaluation stakeholders as soon as possible. Through discussions with MCC, MCA-Mongolia and MI, the SI team will identify the best possible solution and ensure full transparency in its implementation.

Over the course of document review and the scoping trips, the evaluation team has been able to identify the following challenges and prepared the corresponding mitigation plans:

1. Households that have received MCA-subsidized stoves may not have installed or started to use them by the time of data collection. On the other hand, they may have stopped using their subsidized stoves by the time of data collection. In these cases, Robust & IPSL will note the unexpected stove use. Moreover, because the sample frame includes data from many different sources, some of which are more recent than others, households' addresses and even dwelling types may different from those recorded in the existing datasets. Furthermore, some households that

[22] The first contract option period concludes on September 29, 2013. Subsequent data collection will only occur if MCC choses to exercise subsequent option years (total of one base year and three option years).

purchased subsidized stoves may have provided inaccurate addresses. As previously described, Robust & IPSL will record incorrect addresses or dwelling types and SI will provide replacement households within the same stratum.

2. It is possible that households will be absent during the second round of visits, during which the SUMs are to be read, or during the third round of visits when the SUMs are to be collected. To reach households that have been surveyed in the baseline, Robust & IPSL have requested mobile telephone numbers from households so the survey team can schedule appointments for the second round of visits. In addition, they have compiled contact information for kheseg leaders and khoroo governors, who may be able to provide information on households' whereabouts.

3. Lastly, due to their small size, it is possible for SUMs to become lost or misplaced between household visits. To prevent the loss of the monitors, the Robust & IPSL team, with guidance from SI, has placed them out of sight and away from the floor, where small children and pets are unlikely to have access to them.

ANNEX A

HOUSEHOLD ID NUMBER:_____ _____ _____ _____ _____ _____ **(**Replaced household ID: _____ _____ _____ _____ _____ _____**)**

ENUMERATOR TEAM INFORMATION

TEAM LEADER		
1.1.	**Code**	
1.2.	**Name**	
1.3.	**Signature of the team leader**	
ASSISTANT		
1.4.	**Code**	
1.5.	**Name**	
1.6.	**Signature of the assistant**	

VISITS TO THE HOUSEHOLD (to be filled by the enumerator)

	1 visit (YY/MM/DD)	**2 visit(YY/MM/DD)**	**3 visit(YY/MM/DD)**	**Code of RESULT:**
DATE:	_ _ / _ _ / _ _	_ _ / _ _ / _ _	_ _ / _ _ / _ _	1. Complete 2. Complete but Mismatch dwelling type 3. Complete but Mismatch stove type 4. Respondent was not at home **(re-visit)** **5.** Temporarily not present **(re-visit)** **6.** Household permanently moved **(use replacement Household)** **7.** Household not found **(use replacement Household)** 8. Refused**(use replacement Household)** 9. Other improved stove/ low-pressure boiler **(use replacement Household)**
RESULT:	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	

NOTES:

STOVE FUELING BEHAVIOR STUDY SURVEY

HOUSEHOLD COORDINATE	LATITUDE(N/S)	LONGITUDE(E/W)
	___ ___ . ___ ___ . ___ ___ ___	___ ___ ___ . ___ ___ . ___ ___ ___

HOUSEHOLD ADDRESS:	
DISTRICT:	
KHOROO:	
KHESEG:	
STREET:	
DOOR NUMBER:	

Starting time:

Hour	Minute

Introduction

The members of research team will strictly follow the law on "Statistics" and "Personal Secrets" relevant laws and regulations of Mongolia. The personal identifiers you provide will only be used for project planning purposes and will be kept confidential and the fueling data will be analyzed by researchers.

The survey respondent should be person who fuels the stove most often and has knowledge about fuel purchases. Questionnaire sections 1, 2, 6 can be asked from other members of household.

"Hello", my name is ______ and I am here on behalf of the "The Joint Venture between Robust LLC and Institute of Philosophy, Sociology and Law". We are conducting a survey on stove use and pollution. MCA-Mongolia is the main subscriber of the survey. I would like to ask you information about your stove, how you fuel it; as well as some demographic, economic and respiratory health questions about your household. I expect that the discussion will continue for about 40 minutes.

With your permission, I would like to record your responses in this questionnaire. The personal information you provide will only be used for project planning and evaluation purposes and will be kept confidential. To collect data about your fuel use over the next two months, including the frequency of fuelling and the temperature of your stove, I will place one stove use monitor (SUM) beneath your stove and another one on the wall. Also we'll measure your house/ger size and weight of coal and wood. I or one of my colleagues will return in January to replace the SUMs and in March to collect them and may ask more questions. To compensate you for your time in completing this interview we would like to offer you 2,000 tugrik for your mobile phone at this interview and 2,000 more at the consequent two visits, totaling 6000 tugriks for your mobile phone. You may also be visited another time. We appreciate your participation in this interview. Please let us know if you would like to stop the interview at any point. If you are willing to be interviewed please indicate this by giving your verbal consent now.

Please sign your signature if you agree to participate in the 3-phase survey (will revisit in January and March) and agree to install temperature sensor in your house/ger:

Mobile credit card number: ________________________________ Mobile Unit: __ __ __ __
Name of Recipient Signature of

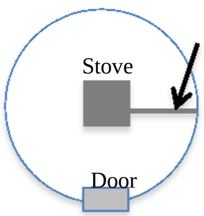
WHAT KIND OF STOVE DO YOU USE?	
Selenge ULZII	1
Selenge XAC	2
Royal Ocean DUL	3
Royal Ocean GOLOMT	4
TRADITIONAL	5

	FULL NAME:	Registration Number	Mobile Number	Respondent? 1. Yes 2. No	Does this person tend to the stove? 1. Yes 2. No
Head of household:				1 2	1 2
Other adult member of the household:				1 2	1 2

Digital Thermometer Information

Enumerator: be careful not to burn yourself on the stove.

********If unsure where to place sensor, please call supervisor.********

Place at stove:		
Serial #: ____ ____ ____ ____ ____ ____	**Location:** 1. Right back stove leg 2. Wall behind stove, 15cm from ground 3. Other (specify): ________________________	**Instructions:** Write down the serial number. Place sensor with serial number touching duct tape. **If stove has legs:** Face the door of stove. Place the sensor on back right leg of stove. **If stove is on floor:** Face the door of stove. Place the sensor directly behind stove, 15 cm above ground.
Place on beam or wall:		
Serial #: ____ ____ ____ ____ ____ ____	**Location:** 1. House: corner farthest away from stove 2. Ger: right top beam, 50cm from wall 3. Other (specify): __________________________	**Instructions:** If the house has more than ONE room, DO NOT PLACE second sensor. Write down the serial number. Place sensor with serial number touching duct tape. **In house with ONE room:** In the room with the stove, identify the corner that is furthest away from the stove. Place the sensor in that corner. **In ger:** Stand with your back to door. Walk towards stove. When you reach stove look right for the closest beam. Place the sensor on rightmost beam at the level of the stove. The sensor should be placed on top of the beam, between beam and roof, 50cm from where the beam meets wall. 

Section 1. Housing and its heating (CAN BE ANSWERED BY ANY ADULT IN THE HOUSEHOLD)

1.1	Does your ger or house have a vestibule? ONLY FOR OBSERVATION	1 2	1. Yes 2. No [⇒1.3]
1.2	Did you receive a vestibule from MCA?	1 2 -98	1 Yes 2 No -98 N/A
1.3	What type of housing do you live in? ONLY FOR OBSERVATION	1 2	1. Ger 2. House [⇒1.15]

ONLY ASK FOR GERS

Question #	Layer	a) Type of roof material 1. Felt cover 2. Cotton cover 3. Brizent (waterproof denim 4. Zulhai (cotton wool blend 5. Karton paper 6. Canvas 7. Plastic 8. Other materials (Specify -98. N/A -99. Don't know/Refuse.	b) Is this roof layer part of the ger insulation package from MCA? 1. Yes 2. No -98 N/A -99 Don't know/Refuse.	c) Type of wall material 1. Felt cover 2. Cotton cover 3. Brizent (waterproof denim) 4. Zulhai (cotton wool blend) 5. Karton paper 6. Canvas 7. Plastic 8. Other materials (Specify) -98 N/A -99 Don't know/Refuse.	d) Is this wall layer part of the ger insulation package from MCA? 1. Yes 2. No -98 N/A -99 Don't know/Refuse.
1.4	1st layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99
1.5	2nd layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99
1.6	3rd layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99
1.7	4th layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99
1.8	5th layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99
1.9	6th layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99
1.10	7th layer	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99	1 2 3 4 5 6 7 8 -98 -99	1 2 -98 -99

1.11	What type of ger floor do you have?	1 2 3 4 5 -98 -99	1. No floor 2. Concrete floor 3. Elevated wooden floor (With a space between the floor and the ground) 4. Wooden floor (Touching the ground) 5. Other____________________________ -98 N/A -99 Don't know/refuse
1.12	Does the ger have a floor covering? ONLY FOR OBSERVATION	1 2 -98	1. Yes 2. No >>> [SECTION 2] -98 N/A >>> [SECTION 2]
1.13	Type of the floor covering? ONLY FOR OBSERVATION (Circle all that apply)	1 2 3 4 -98	1. Wool Carpet 2. Synthetic Carpet 3. Linoleum 4. Karton paper -98 N/A
1.14	Floor covered area? ONLY FOR OBSERVATION	1 2 -98	1. <50% >>> [SECTION 2] 2. >50% >>> [SECTION 2] -98 N/A >>> [SECTION 2]
1.15	What type of house do you live in? ONLY FOR OBSERVATION	1 2 3 4 -98	1. One-story house 2. Two-story house 3. Studio apartment 4. Other (Specify) ____________________________ 5. N/A
1.16	How many rooms does your house have?	__ __ -98	Number of rooms -98 N/A

1.17	Which basic materials constitute the walls in your house? *(Circle all that apply)*	1 2 3 4 5 6 7 8 9 -98 -99	1. Shingle 2. Wooden boards 3. Mud 4. Bricks 5. Wood 6. Cement blocks 7. Log 8. Straw and wooden frame 9. Other (Specify) ________________ -98 N/A -99 Don't know/Refuse
1.18	What are the insulation materials of the walls? *(Circle all that apply)*	0 1 2 3 4 5 6 7 -98 -99	0. None 1. Fiber glass 2. Rock wool 3. Foam 4. Straw 5. Mud 6. Sawdust 7. Other (Specify) ________________ -98 N/A -99 Don't know/Refuse
1.19	What basic material is the floor of your house made of?	1 2 3 -98 -99	1. Wooden boards 2. Cement 3. Other (Please specify)________________ -98 N/A -99 Don't know/Refuse

1.20	Does the house have a ceiling? ONLY FOR OBSERVATION	1 2 -98	1. Yes 2. No [⇒1.23] -98 N/A [⇒1.23]
1.21	What material is the ceiling made of? *(Highest floor ceiling)*	1 2 3 4 5 6 -98 -99	1. Wooden boards 2. Concrete 3. Shingle 4. Clay board 5. Argelit 6. Others (Specify) ______________ -98 N/A -99 Don't know/Refuse
1.22	Do you have additional insulation materials on the ceiling? (Circle all that apply)	1 2 3 4 5 6 7 -98 -99	1. No insulation 2. Keramzit 3. Fiber glass 4. Rock wool 5. Foam 6. Ash 7. Other(Specify) ______________ -98 N/A -99 Don't know/Refuse
1.23	What material is the roof of your house made of? (Circle all that apply)	1 2 3 4 5 -98 -99	1. Asphalt roof shingles 2. Metal 3. Tile 4. Cement 5. Others (Specify) ______________ -98 N/A -99 Don't know/Refuse
1.24	*(Ask ONLY if improved stove)* Did your house have a heating wall before the installation of the MCA approved stove?	1 2 -98	1. Yes 2. No -98 N/A

Section 2. Stove, fireplace/oven, heater, and their types in your winter house/gers (MUST BE ANSWERED BY PERSON WHO TENDS THE STOVE)

Note: the 1st stove should be the one used most often.			1st stove	2nd stove	3rd stove
		Define chosen stove			
2.0	Do you use this stove now?	1. Yes 2. No -98. N/A	1 2	1 2 -98	1 2 -98
2.1	What kind of stove do you have?	1. Traditional stove [⇒2.7] 2. Stove from MCA -98 N/A	1 2	1 2 -98	1 2 -98
2.2	Type of MCA-approved stove ONLY FOR OBSERVATION	1. Ulzii 2. Khas 3. Dul 4. Golomt -98 N/A	1 2 3 4 -98	1 2 3 4 -98	1 2 3 4 -98
2.3	Did you receive subsidy?	1. Yes 2. No -98 N/A	1 2 -98	1 2 -98	1 2 -98
2.4	When did you get your MCA-approved stove?	Year Month -98 N/A -99 Don't know/Refuse	_ _ _ _ _ _ -98 -99	_ _ _ _ _ _ -98 -99	_ _ _ _ _ _ -98 -99
2.5	Have you made any changes to your MCA-approved stove?	1. Yes 2. No [⇒2.8] -98 N/A [⇒2.7] -99 Don't know/Refuse [⇒2.8]	1 2 -98 -99	1 2 -98 -99	1 2 -98 -99

Note: the 1st stove should be the one used most often.			1st stove	2nd stove	3rd stove
2.6	What changes have you made to your MCA-approved stove? *(circle all that apply)*	1. Chimney upside down 2. Connected to No channel wall new chimney 3. Connected to no channel wall chimney, breaking old wall chimney with channels 4. Half of stove inserted in the ground 5. Chimney insulated 6. Other(Specify)____________ -98 N/A -99 Don't know/Refuse	1 2 3 4 5 6 -98 -99	1 2 3 4 5 6 -98 -99	1 2 3 4 5 6 -98 -99
2.7	Type of traditional stove used	1. Metal stove without insulation 2. Metal stove with bricks insulation 3. Mud stove 4. Saw dust stove 5. Stove for wood 6. Other(Specify) ____________ -98 Not applicable -99 Don't know/Refuse	1 2 3 4 5 6 -98 -99	1 2 3 4 5 6 -98 -99	1 2 3 4 5 6 -98 -99
2.8	Do you have wall chimneys? ONLY FOR OBSERVATION	1. Yes 2. No -98 N/A -99 Don't know/Refuse	1 2 -98 -99	1 2 -98 -99	1 2 -98 -99
2.9	What do you use your stove and fireplace for?	1. For heating only 2. For cooking only 3. For both heating and cooking -98 N/A -99 Don't know/Refuse	1 2 3 -98 -99	1 2 3 -98 -99	1 2 3 -98 -99

Answer for the last 7 days:

2.10	**Do you have work day and non-working day?**	1 2 3 -99	1. I don't have a work day [skip 2,3,4 and 5] 2. I don't have a non working day [skip 6,7,8 and 9] 3. I have a work and non working day -99. Don't know/ Refuse

	Additional heating and cooking devices	**Do you have the device?** 1. Yes 2. No >> [next] -99 Don't know/Refuse >> [next]	**Did you use it last workday?** 1. Yes 2. No -98 N/A -99 Don't know/Refuse	**When did you use it?** 1. Used 2. No -98 N/A			**Did you use it last non working day** 1. Yes 2. No >> [next] -98 N/A -99 Don't know/Refuse >> [next]	**When did you use it?** 1. Used 2. No -98 N/A		
				Morning ***4H- 12H***	**Afternoon** ***12H-18H***	**Evening** **18H-4H**		**Morning** ***4H- 12H***	**Afternoon** ***12H-18H***	**Evening** **18H-4H**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2.11	Low pressure boilers	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.12	Floor heaters	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.13	Curtain heaters	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.14	Electric heater 1	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.15	Electric heater 2	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.16	Electric heater 3	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.17	Other heating device (Specify): __________________	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.18	Induction cooking	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.19	Hot pot	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.20	Electric cooking stove	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.21	Gas stove cooking	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.22	Rice cooker	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.23	Water boiler/heater	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.24	Microwave oven	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98
2.25	Other(Specify): __________________	1 2 -99	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98	1 2 -98 -99	1 2 -98	1 2 -98	1 2 -98

Section 3. Fuel use and fueling behavior, frequency (MUST BE ANSWERED BY THE HOUSEHOLD MEMBER WHO LIGHTS THE STOVE)

Do you use any of these materials for fuel and lighting?

	Fuel materials ***(Read all options)***	**Code:** 1. Yes 2. No [⇒ Next Item] -99 Don't know/Refuse [⇒ Next]	**Use for:** 1. Fuel 2. Light 3. Both -98 N/A	**How often?** 1. Daily 2. Few times per week 3. Few times per month 4. Few times per year -98 N/A -99 Don't know/Refuse	**Reason why?** ***(Circle all that apply)*** 1. Easy to get 2. Cheap 3. Free 4. Reduce waste 5. Easy to use 6. Less dust 7. Other(Specify)__________ -98 N/A	**Do you buy it?** 1. Yes 2. No -98 N/A
		3.1	**3.2**	**3.3**	**3.4**	**3.5**
1	Paper	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99		
2	Dry firewood	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99		
3	Cow and horse dung	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
4	Plastic	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
5	Asphalt roof shingles	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
6	Plastic bag	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
7	Particle board	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
8	Different types of garbage	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
9	Worn out car and bicycle tires	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
10	Worn out clothes, cloth	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
11	Cloth, cotton	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
12	Flammable liquid, petroleum	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
13	Candle	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
14	Wet firewood	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99		
15	Gas	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
16	Sawdust	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
17	Coal	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99		
18	Bag of coal and firewood	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
19	Coal with its bag	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
20	Firewood with its bag	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98
21	Others (Specify..............................)	1 2 -99	1 2 3 -98	1 2 3 4 -98 -99	1 2 3 4 5 6 7 -98	1 2 -98

Note: the first stove is the one used most often by the household.			**Define chosen stove (Use same sequence defined in section 2)**		
			1st stove	2nd stove	3rd stove
3.6	Please describe your cold start procedure *(Don't read the answers)* ***(T) – Traditional stove*** ***(Im) – Improved stove*** ***Identify stove type first than circle appropriate answer.***	If the respondent names **paper**: 1. (T) Put wood and paper to door side of stove and put coal on the wood and start 2. (T) Put wood and paper ignite them first and put coal after wood start charcoaling 3. (T) Put wood and paper to the chimney side, put coal to the door side and start 4. (Im) First put coal and put wood and paper on the coal and start 5. (Im) First put wood and paper ignite them and put coal after wood start 6. Other(Specify) ____________________ If the respondent DOES NOT name **paper**: 7. (T) Put wood to door side of stove and put coal on the wood and start 8. (T) Put wood ignite them first and put coal after wood start charcoaling 9. (T) Put wood to the chimney side, put coal to the door side and start 10. (Im) First put coal and put wood on the coal and start 11. (Im) First put wood ignite them and put coal after wood start 12. Other(Specify) ____________________	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12
3.7	How do you control air intake for your stove? (Circle all that apply)	1. Open ash tray 2. Use flue control on the chimney 3. Use air intake control (MCA stoves only) -98 N/A -99 Don't know/refuse	1 2 3 -98 -99	1 2 3 -98 -99	1 2 3 -98 -99
3.8	***(Ask of MCA stoves only)*** Did you get firing instructions for MCA-approved stoves?	1. Yes 2. No -98 N/A -99 Don't know/Refuse	1 2 -98 -99	1 2 -98 -99	1 2 -98 -99
3.9	How many times did you remove ash from your stove yesterday?	Number of times(Put 0 if didn't remove ash): -98 N/A -99 Don't know/Refuse	______ -99	______ -98 -99	______ -98 -99

3.10 Please provide information on firing stoves between yesterday morning and today morning

Yesterday was :	1. A work day 2. Non work day

3.11 First stove (1. Ulzii, 2. Khas, 3. Dul, 4. Golomt, 5. Traditional, 6. Other)

	Fueling Event	**a) Time (Hour: Minute)** No fire ……-96	**Purpose** For heating …..1 For cooking …2 Both purpose…..3	**Was the stove warm or cold?** Hot(flams)………..1 Warm ….2 Cold………………3 N/A….-98 Don't know/refuse . -99	**Was there coal or** embers **already in the stove?** Coal….1 Embers ….2 None..3 N/A….-98 Don't know/refuse…. -99	**Type of fuel** *(Circle all that apply)* Firewood …………..1 Coal …………………2 Briquette …………...3 Semi-Coked Coal ….4 Other (Specify) ……._______________									
							kg		**kg**		**kg**		**kg**		**kg**
3.12	First	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.13	Second	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.14	Third	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.15	Fourth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.16	Fifth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.17	Sixth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.18	Seventh	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.19	Eighth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.20	Ninth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.21	Tenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.22	Eleventh	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.23	Twelfth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.24	Thirteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.25	Fourteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.26	Fifteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.27	Sixteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.28	Seventeenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.29	Eighteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.30	Nineteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.31	Twentieth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.32	Twenty-first	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.33	Twenty-second	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.34	Twenty-third	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.35	Twenty-fourth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.36	Twenty-fifth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	

*- To be weighed in special sacks

3.37 Second stove (1. Ulzii, 2. Khas, 3. Dul, 4. Golomt, 5. Traditional, 6. Other, -98 N/A)

	Fueling Event	**b) Time (Hour: Minute)** No fire ……-96	**Purpose** For heating …..1 For cooking …2 Both purpose…..3	**Was the stove warm or cold?** Hot(flams)………..1 Warm ….2 Cold………………3 N/A….-98 Don't know/refuse . -99	**Was there coal or** embers **already in the stove?** Coal….1 Embers ….2 None..3 N/A….-98 Don't know/refuse…. -99	**Type of fuel** Firewood ……………1 Coal …………………2 Briquette …………….3 Semi-Coked Coal ….4 Other (Specify) …….5 *(Circle all that apply)*									
							kg		**kg**		**kg**		**kg**		**kg**
3.38	First	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.39	Second	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.40	Third	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.41	Fourth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.42	Fifth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.43	Sixth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.44	Seventh	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.45	Eighth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.46	Ninth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.47	Tenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.48	Eleventh	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.49	Twelfth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.50	Thirteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.51	Fourteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.52	Fifteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.53	Sixteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.54	Seventeenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.55	Eighteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.56	Nineteenth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.57	Twentieth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.58	Twenty-first	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.59	Twenty-second	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.60	Twenty-third	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.61	Twenty-fourth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	
3.62	Twenty-fifth	____:____	**1 2 3**	**1 2 3 -98 -99**	**1 2 3 -98 -99**	**1**		**2**		**3**		**4**		**5**	

*- To be weighed in special sacks

3.63 Third stove (1. Ulzii, 2. Khas, 3. Dul, 4. Golomt, 5. Traditional, 6. Other, -98 N/A)

	Fueling Event	c) Time (Hour: Minute) No fire ……-96	Purpose For heating …..1 For cooking …2 Both purpose…..3	Was the stove warm or cold? Hot(flams)………..1 Warm ….2 Cold………………3 N/A….-98 Don't know/refuse . -99	Was there coal or embers already in the stove? Coal….1 Embers ….2 None..3 N/A….-98 Don't know/refuse…. -99	Type of fuel Firewood ……………1 Coal …………………2 Briquette …………….3 Semi-Coked Coal ….4 Other (Specify) …….5 *(Circle all that apply)*									
							kg		kg		kg		kg		kg
3.64	First	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.65	Second	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.66	Third	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.67	Fourth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.68	Fifth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.69	Sixth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.70	Seventh	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.71	Eighth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.72	Ninth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.73	Tenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.74	Eleventh	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.75	Twelfth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.76	Thirteenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.77	Fourteenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.78	Fifteenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.79	Sixteenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.80	Seventeenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.81	Eighteenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.82	Nineteenth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.83	Twentieth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.84	Twenty-first	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.85	Twenty-second	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.86	Twenty-third	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.87	Twenty-fourth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	
3.88	Twenty-fifth	____:____	1 2 3	1 2 3 -98 -99	1 2 3 -98 -99	1		2		3		4		5	

*- To be weighed in special sacks

Section 4. Purchasing of fuel and their price

(CAN BE ANSWERED BY ANY HOUSEHOLD MEMBER FAMILIAR WITH FUEL PURCHASES)

4.1	Have you obtained **COAL** by **TRUCKS** since last June?	1 2 -99	1. Yes 2. No [⇒ 4.8] -99 Don't know/Refuse [⇒ 4.8]

COAL purchases by TRUCKs, since beginning of June:

Fuel code 1. Nalaikh 2. Alag tolgoi 3. Baganuur 4. Shariin gol 5. Shivee ovoo 6. Korean (yontan) 7. Briquette (Egg shape) 8. Briquette (Stick shape) 9. Sawdust briquette 10. Semi coking coal 11. Saw dust 12. Other 13. Did not purchase yet -98 N/A		**Date obtained** (month)	**Where did you get coal?** 1. From a street retail vendor 2. From a coal market 3. Khoroo assistance 4. From a mine 5. Others(Specify) -98 N/A	**Did you share?** 1. Yes 2. No -98 N/A	**Amount of coal for your HH** (tons)	**Amount of money spent by your HH (in thousand tugrugs)** ***(fill out 4.7.1 + 4.7.2 OR 4.7.3)*** 4.7		
						For coal only	For transpo-rtation only	For coal with transp-ortation
		-99 Don't know/Refuse						
	4.2	4.3	4.4	4.5	4.6	4.7.1	4.7.2	4.7.3
First time	1 2 3 4 5 6 7 8 9 10 11 12 13 -98	__ __	1 2 3 4 5 -98 -99	1 2 -98 -99				
Second time	1 2 3 4 5 6 7 8 9 10 11 12 13 -98	__ __	1 2 3 4 5 -98 -99	1 2 -98 -99				
Third time	1 2 3 4 5 6 7 8 9 10 11 12 13 -98	__ __	1 2 3 4 5 -98 -99	1 2 -98 -99				
Fourth time	1 2 3 4 5 6 7 8 9 10 11 12 13 -98	__ __	1 2 3 4 5 -98 -99	1 2 -98 -99				
Fifth time	1 2 3 4 5 6 7 8 9 10 11 12 13 -98	__ __	1 2 3 4 5 -98 -99	1 2 -98 -99				

4.8	Have you obtained **COAL** by **SACKS** in the last 30 days?	1 2 -99	1. Yes 2. No [⇒ 4.13] -99 Don't know/Refuse [⇒ 4.13]
4.9	How many **SACKS** of **COAL** have you bought in the last 14 days?	__ __ -99	Number of sacks -99 Don't know/Refuse
4.10	How many **SACKS** of **COAL** have you bought in the last 7 days?	__ __ -99	Number of sacks -99 Don't know/Refuse
4.11	Where do you usually get your **COAL**?	1 2 3 4 -98 -99	1. From a street retail vendor 2. From a coal market 3. Khoroo assistance 4. Other(Specify) -98 N/A -99 Don't know/Refuse
4.12	When was your last purchase of **COAL** by **SACKS**?	____ ____ -99	Date(month-day) -99 Don't know/Refuse

What is the price and amount for the LAST PURCHASE of coal BY SACKS?

	Fuel type	**Number of SACKs**	**Price per SACK** (thousand tugrugs) -99 Don't know/Refuse	**Where did you get your coal on your last purchase?** 1. From a street retail vendor 2. From a coal market 3. Khoroo assistance 4. Other(Specify) -98 N/A -99 Don't know/Refuse
		4.13	4.14	4.15
1	Nalaikh			1 2 3 4 -98 -99
2	Alag tolgoi			1 2 3 4 -98 -99
3	Baganuur			1 2 3 4 -98 -99
4	Shariin gol			1 2 3 4 -98 -99
5	Shivee ovoo			1 2 3 4 -98 -99
6	Korean (yontan)			1 2 3 4 -98 -99
7	Briquette (Egg shape)			1 2 3 4 -98 -99
8	Briquette (Stick shape)			1 2 3 4 -98 -99
9	Sawdust briquette			1 2 3 4 -98 -99
10	Semi coking coal			1 2 3 4 -98 -99
11	Saw dust			1 2 3 4 -98 -99
12	Other			1 2 3 4 -98 -99

4.16	Have you purchased **WOOD** by **TRUCKS** since last June?	1 2 -99	1. Yes 2. No [⇒ 4.20] -99 Don't know/Refuse [⇒ 4.20]

How much WOOD have you purchased by TRUCKS, since beginning of June?

	Wood code 1. Pine 2. Larch 3. Burch 4. Rim timber board 5. Waste wood 6. Mixed 7. Other (Specify)_______ 8. Did not purchase yet -98 N/A -99 Don't know	**Date purchased** (month)	**Where did you get wood?** 1. From a street retail vendor 2. From a wood market 3. Khoroo assistance 4. Mountain 5. Others(Specify) -98 N/A	**Did you share?** 1. Yes 2. No -98 N/A	**Amount of wood (m^3)**	**Amount of money spent (in thousand tugrugs)** ***(fill out 4.22.1 + 4.22.2 OR 4.22.3)*** 4.19		
						For wood only	For transp-ortation only	For wood with transp-ortation
		Don't know/Refuse .-99						
	4.17	4.18	4.19	4.20	4.21	4.22.1	4.22.2	4.22.3
First time	1 2 3 4 5 6 7 8 -98 -99	_ _	1 2 3 4 5 -98 -99	1 2 -98 -99				
Second time	1 2 3 4 5 6 7 8 -98 -99	_ _	1 2 3 4 5 -98 -99	1 2 -98 -99				
Third time	1 2 3 4 5 6 7 8 -98 -99	_ _	1 2 3 4 5 -98 -99	1 2 -98 -99				
Fourth time	1 2 3 4 5 6 7 8 -98 -99	_ _	1 2 3 4 5 -98 -99	1 2 -98 -99				
Fifth time	1 2 3 4 5 6 7 8 -98 -99	_ _	1 2 3 4 5 -98 -99	1 2 -98 -99				

4.23	Have you purchase d**WOOD** by **SACKS** in last 30 days?	1 2 -99	1. Yes 2. No [⇒ Section 5] -99 Don't know/Refuse [⇒ Section 5]
4.24	How many **SACKS** of **WOOD** have you bought in the last 14 days?	________	Number of sacks
4.25	How many **SACKS** of **WOOD** have you bought in the last 7 days?	________	Number of sacks
4.26	Where do you usually get your **WOOD** by **SACKS**?	1 2 3 4 -98 -99	1. From a street retail vendor 2. From a coal market 3. Khoroo assistance 4. Other(Specify) ____________ -98 N/A -99 Don't know/Refuse
4.27	When was your last purchase of **WOOD** by **SACKS**?	___ ___ -99	Date(month-day) -99 Don't know

What is the price and amount for the last purchasing firewood?

	Firewood type	Number of SACKs	Price per SACK (thousand tugrugs) -99 Don't know/Refuse	Where did you get your coal on your last purchase? 1. From a street retail vendor 2. From a wood market 3. Khoroo assistance 4. Other(Specify) -98 N/A -99 Don't know/Refuse
		4.28	4.29	4.30
1	Pine			1 2 3 4 -98 -99
2	Larch			1 2 3 4 -98 -99
3	Burch			1 2 3 4 -98 -99
4	Rim timber board			1 2 3 4 -98 -99
5	Waste wood			1 2 3 4 -98 -99
6	Mixed			
7	Don't know the wood type			1 2 3 4 -98 -99
8	Other (Specify)...			1 2 3 4 -98 -99
-99	Don't know			

Section 5. Impressions

5.1	How has the smoke in Ulaanbaatar changed comparing this time to last autumn ?	Much better …………………..................... Better ………………………………………….. Same…………………………………………… Worse ………………………………………….. Much worse…………………………………….. Don't know/Refuse……………………………..	1 2 3 4 5 -99	
5.2	*(Ask only if NO improved stove)* Will you acquire the improved stove provided by MCA ?	Yes …………………………………………………………………………………………… No …………………………………………………………………………………………… N/A ,(Already purchased)…………………………………………………………………….. Don't know/Refuse……………………..	1 2 -98 -99	 [⇒5.4] [⇒5.5] [⇒5.4]
5.3	If you decided to acquire the improved stove, please describe reasons? *(Do not give respondents answers. Circle all that apply)*	Heats well. ..... …………………………………………………………………………… Keep warm in long time…………………………………………………………………….. Saves fuel expenses………………………………………………………………………… Good appearance and color………………………………………………………………… Low price after subsidies……………………….. …………………………………………. Believed to reduce air pollution…,……………..……………….. ………………………….. Gives an opportunity to receive subsidies on electricity bill……………..…………………… District and Khoroo Governors office insisted to purchase the improved stove……………….. Takes less time to fuel………………………………………………………………………….. Other (Specify)……… ……………………..………………………………………………… N/A …………………………………..…………………………………………………….. Don't know/Refuse………………..……………………………………………………………	1 2 3 4 5 6 7 8 9 10 -98 -99	
5.4	If you decided not to acquire the improved stove, please describe reasons? (*Do not give respondents answers. Circle all that apply)*	Although, the improved stove has been subsidized, don't have a cash to purchase it……… Don't want to give traditional stove………………………………..………………………….. Can't find stove top to trade for new stove…………………………………………………… Difficult for usage (takes time for lightening, can't cook on it and refill fuel during firing, etc.) . Doubt that it will perform reliably during extreme cold winter………………………….. Don't believe that stove reduce smoke………………………………………………………… Gets overheated, posing risks to small children and elderly of getting burnt………………………….. Emits more smoke …………………………………………………………………………………… Difficult/ cannot to cook…………………………………………………………………………… Other (Specify)……… ……………………..………………………………………………… N/A …………………………………..…………………………………………………….. Don't know/Refuse………………..……………………………………………………………	1 2 3 4 5 6 7 8 9 10 -98 -99	

5.5 Comparison of improved and traditional stove. ***(Ask it only household with improved stove)***

Advantages / Weaknesses Please name which one is: *(Read each option)*		Which stove: 1. Traditional 2. Improved 3. Equal -98 N/A -99 Don't know/Refuse
1	Takes more time (firing, refueling etc…)	1 2 3 -98 -99
2	Uses less fuel	1 2 3 -98 -99
3	Requires more cold starts	1 2 3 -98 -99
4	Emits less smoke and pollution	1 2 3 -98 -99
5	Maintains the heat after one firing for a long time	1 2 3 -98 -99
6	Generates less ash	1 2 3 -98 -99
7	Good appearance and color	1 2 3 -98 -99
8	Easy to remove ash	1 2 3 -98 -99
9	Adaptable for more types of fuel	1 2 3 -98 -99
10	Gets overheated, posing risks to small children and elderly of getting burnt	1 2 3 -98 -99
11	Firing takes meticulous effort	1 2 3 -98 -99
12	Easier to cook	1 2 3 -98 -99
13	Faster to cook	1 2 3 -98 -99
14	Less smoke through chimney	1 2 3 -98 -99
15	Less cleaning inside of the chimney	1 2 3 -98 -99
16	Which one disrupts your sleep in night	1 2 3 -98 -99

SECTION -6: HOUSEHOLD DEMOGRAPHIC AND SOCIAL INFORMATION (Please)

Personal number	Names of HH members *(Household is group of people which is consisted of one or more individuals, live together under the same roof with their collective budget and provide their food and other commodities together* *People who stay at different place to sleep, but eat together, and spend some time in the family, are considered as one of the household members)*	Is he/she a permanent member of HH (sleeps here at night) 1 Yes 2 No	Does this person fire stoves? 1 Usually 2 Sometimes 3 No Fires	What is his/her relationship to the head of the HH? 1. Head of household 2. Husband/wife 3. Son/daughter 4. Mother/father 5. Brother/sister 6. Parent in law 7. Son in law/daughter in law 8. Grandfather / grandmother 9. Grandson / granddaughter 10. Other relatives 11. Non relative	Sex 1 Male 2 Female	How old he/she (If <1 year old, write 0) -99 Don't know/Refuse	Marital status (N/A, if respondent is under 15) 1. Not married 2. Officially married 3. Non married partners 4. Separated 5. Divorced 6. Widowed -98 N/A	Indicate the highest education level ever obtained (Ask respondents aged 6 and above) 1. Non educated 2. Elementary not graduate 3. Elementary(~11) 4. Middle school(~15) 5. High school graduated(~18) 6. Vocational 7. Bachelor and diploma 8. Master and above -98 N/A -99 Don't know/Refused	How many hours did he/she spend at your home the last 7 days?	
									work day (hours)	Non work day (hours)
A	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.10
01		1 2	1 2 3	1	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
02		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
03		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
04		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
05		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
06		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
07		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
08		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
09		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
10		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
11		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
12		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
13		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
14		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _
15		1 2	1 2 3	1 2 3 4 5 6 7 8 9 10 11	1 2	_ _ _	1 2 3 4 5 6 -98	1 2 3 4 5 6 7 8 -98 -99	_ _	_ _

SECTION -6: CONTINUED

Personal number	Did he/she work for monetary compensation during the last 12 months? 1 Yes 2 No -98 N/A [⇒ 6.15] -99 Don't know/Refuse [⇒6.15]	If yes, please describe the employment status of his/her primary job? 1. Paid employee 2. Employer 3. Member of cooperative 4. Self-employed 5. Unpaid family worker 6. Other -98 N/A	In last month how many work/school days did you missed due to illness? (respiratory only) Didn't miss – 0	How much did you earn income from last month) -99 Don't know / Refuse -98 N/A	Please provide us with the information on the pension/allowance/income you have received during the last month? **If didn't get allowance ……….0 or cross lines** **Don't know / Refuse ………..-99** 1. Old age pension / allowance 2. Disability pension/ 3. Allowance for the loss of life of household breadwinner? 4. Military pension 5. Pregnancy and child birth allowance 6. Allowance for looking after child 7. Children fund **8.** Other type of allowance								
					1st source 6.15			2nd source 6.16			3rd source 6.17		
					Type	Amount	Month	Type	Amount	Month	Type	Amount	Month
A	6.11	6.12	6.13	6.14	6.15.1	6.15.2	6.15.3	6.16.1	6.16.2	6.16.3	6.17.1	6.17.2	6.17.3
01	1 2 -98 -99	1 2 3 4 5 6 -98											
02	1 2 -98 -99	1 2 3 4 5 6 -98											
03	1 2 -98 -99	1 2 3 4 5 6 -98											
04	1 2 -98 -99	1 2 3 4 5 6 -98											
05	1 2 -98 -99	1 2 3 4 5 6 -98											
06	1 2 -98 -99	1 2 3 4 5 6 -98											
07	1 2 -98 -99	1 2 3 4 5 6 -98											
08	1 2 -98 -99	1 2 3 4 5 6 -98											
09	1 2 -98 -99	1 2 3 4 5 6 -98											
10	1 2 -98 -99	1 2 3 4 5 6 -98											
11	1 2 -98 -99	1 2 3 4 5 6 -98											
12	1 2 -98 -99	1 2 3 4 5 6 -98											
13	1 2 -98 -99	1 2 3 4 5 6 -98											
14	1 2 -98 -99	1 2 3 4 5 6 -98											
15	1 2 -98 -99	1 2 3 4 5 6 -98											

Section 7. People's health (Ask only of stove tender)

7.1	Do you smoke? (at least 1 per day)	1 2 -99	1. Yes 2. No [⇒7.4] -99 Don't know/Refuse [⇒7.4]
7.2	When did you start smoking?	 -98 -99	Started at ________years old. In total about _______ years -98 N/A -99 Don't know/Refuse
7.3	How many cigarettes did you smoke yesterday?	__ __ -98 -99	Number of Cigarettes -98 N/A -99 Don't know/Refuse
7.4	Were you exposed to environment tobacco smoking (ETS) yesterday?	1 2 -99	1. Yes 2. No [⇒7.6] -99 Don't Know/Refuse [⇒7.6]
7.5	How many smokers were you exposed to indoors yesterday (at home and at work)?	1 2 3 4 -98 -99	1. 1~2people 2. 3~4people 3. 5~6people 4. over 6 people -98 N/A -99 Don't know/Refuse

Now consider all household members over 60 and under 5 years old. Which one experiences the most respiratory symptoms? (Answer the following questions for the person named)			Name: ____________________		Household member number from question 6.1: ______		
	Symptoms	a) Do you have it now? 1 Yes 2 No >>[next item] -99 Don't know/Refuse >>[next item]	b) How many days has it lasted?	c) Are you taking medication for it? 1 Yes 2 No >>[next item] -99 Don't know/Refuse >>[next item]	d) How many days have you been taking medication for it?	e) Did you purchase medication last 30 days 1 Yes 2 No -99 Don't know/Refuse >>[next item]	f) How much has it cost last 30 days?
7.6	Phlegm	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.7	Cough	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.8	Shortness of breath	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.9	Wheezing	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.10	Dizziness	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.11	Eczema	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.12	Dry or sore throat	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.13	Eye irritation	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.14	Cold	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.15	Chest tightness	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.16	Rapid heartbeat	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.17	Burned themselves on the stove	1 2 -99	__ __ __	1 2 -99	__ __ __		
				7.18 TOTAL (only if respondent doesn't remember for each)			

Now consider all household members under 5 years old. Which one experiences the most respiratory symptoms? (Answer the following questions for the person named)			Name: ________________		Household member number from question 6.1: _____		
	Symptoms	a) Do you have it now? 1 Yes 2 No >>[next item] -99 Don't know/Refuse >>[next item]	b) How many days has it lasted?	c) Are you taking medication for it? 1 Yes 2 No >>[next item] -99 Don't know/Refuse >>[next item]	d) How many days have you been taking medication for it?	e) Did you purchase medication last 30 days 1 Yes 2 No -99 Don't know/Refuse >>[next item]	f) How much has it cost last 30 days?
7.19	Phlegm	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.20	Cough	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.21	Shortness of breath	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.22	Wheezing	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.23	Dizziness	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.24	Eczema	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.25	Dry or sore throat	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.26	Eye irritation	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.27	Cold	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.28	Chest tightness	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.29	Rapid heartbeat	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.30	Burned themselves on the stove	1 2 -99	__ __ __	1 2 -99	__ __ __		
7.31							
				7.31 TOTAL (only if respondent doesn't remember for each)			

Section 8. Measurement

8.1	Does the household have electricity?	1 2	1. Yes 2. No [>>>8.3]
8.2	How much was the electricity bill for your household last month?	__ __ ______ -98 -99	Month Amount -98 N/A -99 Don't know/Refuse
8.3	*(Only for gers)* How big is the ger? ONLY FOR OBSERVATION	__ __ __cm __ __ __cm __ __ __cm -98	Center height Door height RADIUS (center to door) -98 N/A
8.4	*(Only for house)* *If the of the room with the main stove IS rectangular:* What are the height, width and length of the room? ONLY FOR OBSERVATION	__ __ __cm __ __ __cm __ __ __cm -98 -99	Height Width Length -98 N/A -99 Don't know/refuse
8.5	*(Only for house)* *If the of the room with the main stove IS NOT rectangular:* What are the height, and other dimensions of the room? Please draw the shape below and label the sides. ONLY FOR OBSERVATION	__ __ __cm __ __ __cm __ __ __cm __ __ __cm __ __ __cm __ __ __cm __ __ __cm __ __ __cm __ __ __cm -98 -99	Height Side 1 Side 2 Side 3 Side 4 Side 5 Side 6 Side 7 Side 8 -98 N/A -99 Don't know/refuse

8.6	Main wall thickness ONLY FOR OBSERVATION *(Only for house)*	________ -98 -99	(cm) -98 N/A -99 Not possible to measure

Question Number *(Only for house)*	WINDOWS (not covered window) Start from nearest window from door and count clockwise)	a. Present? 1. Yes 2. No -98 N/A	b. Type of Window: 1. Single Wooden 2. Double Wooden 3. Vacuum 4. Other -98 N/A	c. Direction of Window: 1. South 2. North 3. East 4. West -98 N/A	Size of window:	
					d. Width (cm)	e. Height (cm)
8.7	First Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		
8.8	Second Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		
8.9	Third Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		
8.10	Fourth Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		
8.11	Fifth Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		
8.12	Sixth Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		
8.13	Seventh Window	1 2 -98	1 2 3 4 -98	1 2 3 4 -98		

Question Number (*For both houses and gers)*	DOORS *If HH has only one door then it's outside door* *Don't count vestibule door*	a. Present? 1. Yes 2. No -98 N/A	b. Type: 1. Single wooden door 2. Insulated wooden door 3. Metal door 4. Wooden door with metal cover 5. Vacuum door 6. Others (Specify) -98 N/A -99 Don't know/Refuse
8.14	Outside door	1 2 -98	1 2 3 4 5 6 -98 -99
8.15	Inside door	1 2 -98	1 2 3 4 5 6 -98 -99

Outside Temperature:

Thank You for participating in our survey!

Time of completion:

Hour	Minute

QUALITY CONTROL SHEET:

SURVEY RECORDS (to be filled by the supervisor)

SUPERVISOR					
	Code				
	Name				
	Supervisor's verification and confirmation		**Month**		**Day**
	Signature of the supervisor				

CLARIFICATION Follow the Field Supervisor's checklist.