CDM PoA 8142

MicroEnergy Credits - Microfinance for Clean Energy Product Lines - Mongolia

CPA No. 001 - Issuance 1

ANNEX 5 - Household Energy Survey: Fuel Consumption and Usage Report

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Version No. 2

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Table of Contents

I. Executive Summary

The Household Energy Survey (HES) was conducted in the winter of 2014-2015 and supports the verification of Issuance 1 of *CDM PoA 8142: MicroEnergy Credits – Microfinance for Clean Energy Product Lines - Mongolia* for CPA No. 001. The small-scale CPA in this program involves the installation and maintenance of clean energy products (CEPs) including (1) efficient cooking and heating stoves and (2) 'ger blanket' insulation products, energy efficient felt coverings that improve insulation and minimize heat loss in ger homes. In Issuance 1, only efficient cooking and heating stoves are credited and monitored through the HES.

The purpose of the HES was to collect information required for emissions reductions calculations, including usage rates of CEPs (Product Operation Fraction or POF) and household coal consumption in the project and baseline scenarios ($C_{y,new,CEP-i}$ and $C_{y,old,CEP-i}$). The HES also collected data on household fuel use beyond coal and the status of each household's previous stove.

Users of CEPs in the target population live in one of two dwelling types, (a) poorly insulated houses or (b) "gers," traditional felt tents. Per the baseline study, the dwelling type as well as the district in which the household is located affects coal consumption. Thus, six sampling frames were used:

- Frame 1: Stove in house dwelling type, located in Songinokhairkhan district ("House - Song.")
- Frame 2: Stove in house dwelling type, located in Bayangol district ("House - Bayan.")
- Frame 3: Stove in house dwelling type, located in other district ("House-Other")
- Frame 4: Stove in ger dwelling type, located in Songinokhairkhan district ("Ger - Song.")
- Frame 5: Stove in ger dwelling type, located in Bayangol district ("Ger - Bayan.")
- Frame 6: Stove in ger dwelling type, located in other district ("Ger - Other")

The monitoring period for Issuance 1 is 1 August 2013 through 30 April 2014, the 2013-2014 heating season in Mongolia. The survey was conducted by partner organization, XacBank, in the ger districts of Ulaanbaatar, Mongolia from September 2014 to January 2015, with additional surveys conducted in June-July 2015. Over half the surveys were completed in person and the remaining were conducted by phone, all using Open Data Kit (ODK). Survey results were linked to unique CEP records in the MEC Tracker Platform (**ANNEX 3** – MicroEnergy Credits Tracker Platform Summary) maintained by MicroEnergy Credits (MEC), the coordinating and managing entity (CME) of the PoA.

Through random selection of households from the MEC Tracker Platform, 273 household surveys were completed with full data from the MEC Tracker Database and included in the

analysis. A summary of the monitored parameters determined through the HES for Issuance 1 are shown in Table ES 1.

Table ES 1: Summary of Monitored Parameters determined by HES for Issuance 1

Parameter	Definition	House-Song.	House-Bayan.	House-Other	Ger-Song.	Ger-Bayan.	Ger-Other
POF (%)	Fraction of CEPs that were operational during the 2013-2014 heating season	0.96	0.92	0.95	0.90	0.93	0.93
$C_{y,new,CEP-I}$ (tons)	Quantity of coal used by households in the heating season after installation of a Clean Energy Product (CEP), i.e. in the project scenario.	3.54	3.35	3.43	3.64	2.76	3.40
$C_{y,old,CEP-I}$ (tons)	Quantity of coal that would have been used by households in the 2013-2014 heating season without a CEP, i.e. in the baseline scenario	5.67	4.23	5.31	5.23	3.79	4.87

II. Introduction

The objective of the Household Energy Survey (HES) was to support the verification of Issuance 1 of *CDM PoA 8142: MicroEnergy Credits –Microfinance for Clean Energy Product Lines - Mongolia* for CPA No. 001 for the monitoring period of 1 August 2013 through 30 April 2014 (2013-2014 heating season). This report is prepared as an Annex to the Monitoring Report.

This small-scale CPA under CDM PoA 8142 involves the installation of clean energy products (CEPs) by XacBank in Mongolia. CEPs include (1) efficient cooking and heating stoves and (2) 'ger blanket' insulation products, energy efficient felt coverings that improve insulation and minimize heat loss in ger homes. The current practice in Mongolia is to use inefficient stoves for cooking and heating and inefficient home insulation at the household level, resulting in necessary combustion of large amounts of coal, the primary fuel used for heating. The use of this fuel generates several greenhouse gases (GHG), including Carbon dioxide (CO_2). The replacement of these traditional products with CEPs reduces the amount of fuel required for heating and reduces the amount of GHGs emitted into the atmosphere during combustion.

The HES was conducted to collect information on parameters used for emissions reductions calculations, household fuel use beyond coal, and the status of the households' previous stove. As only cooking and heating stoves are credited in this monitoring period, only households using this product type were included in the survey.

III. Monitoring Sampling Plan Description

A. Objectives and Reliability Requirements

The survey and sampling procedures were designed and conducted in accordance with CDM Guidance: Guidelines for Sampling and Surveys for CDM Project Activities and Programmes of Activities, EB 75, Annex 81.

The primary objective of the HES was to determine values for the following monitored parameters:

1. Product Operation Fraction (POF) – the fraction of CEPs that were operational during the 2013-2014 heating season, directly reported.
2. $C_{y,new,CEP\text{-}i}$ - the quantity of coal used by households in the 2013-2014 heating season after installation of a CEP, i.e. in the project scenario, directly reported.

[1] CDM Executive Board. 2013. Guidelines for Sampling and Surveys for CDM Project Activities and Programme of Activities, v.3.0. EB75. Annex 5. UNFCCC/CCNUCC. Available at: http://cdmrulebook.org/458. Accessed September 2013.

3. $C_{y,old,CEP-i}$ - the quantity of coal that would have been used by households in the 2013-2014 heating season without a CEP, i.e. in the baseline scenario, calculated.

In addition to parameters listed above, the HES collected information on the use of fuels other than coal in the project scenario and the status of previous stoves.

B. Target population

All energy efficient stoves (CEPs) included in CPA No. 001 were installed in the ger area districts of Ulaanbaatar, in one of six districts[2]: Chingeltei, Songinokhairkhan, Bayanzurkh, Bayangol, Sukhbaatar, and Khan-Uul. Users of CEPs in the target population live in one of two dwelling types, poorly insulated houses or "gers," traditional felt tents.[3]

All CEPs included in CPA No. 001 for Issuance 1 were installed from May 2013 through December 2014. All CEPs are included in the MEC Tracker Platform, a web-based platform that contains a unique entry for each CEP included in the project, as well as corresponding household identifying information such as passport number, telephone number, and GPS coordinates (See **ANNEX 3** – MicroEnergy Credits Tracker Platform Summary). The MEC Tracker Platform enables the CME and PO to export relevant databases for crediting of specific assets. The MEC Tracker Database for Issuance 1 of CPA No. 001 is presented in **ANNEX 4** – MicroEnergy Credits Tracker Database.

The current monitoring status of each CEP, as listed in the MEC Tracker Platform reflects XacBank's practice of monitoring the usage of each CEP at least biennially. This is a key component of XacBank's quality control and customer service procedures and ensures that if follow up is needed, it can be provided. Products that were found to be permanently out of use were not included in the sampling or in the project activities.

The purpose of the HES was to determine each participating household's fuel consumption during the full 2013-2014 heating season, 1 August 2013 - 30 April 2014. As such, while CEPs credited in CPA No. 001 were installed from May - December 2013, only stoves installed prior to August 2013 were included in the population for sampling to ensure that all HES respondents could comment on use of their purchased CEP for the full 2013-2014 heating season. This is a more accurate as well as more conservative approach, as older stoves are

[2] The Ger Area in Ulaanbaatar is comprised of 6 districts. The baseline regression model is derived from data drawn from these 6 districts and the project activity credited in this monitoring period credits stoves distributed only to these 6 districts.

[3] World Bank – Asia Sustainable and Alternative Energy Program. 2009. Mongolia: Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar. Washington DC: October 2009. http://siteresources.worldbank.org/INTMONGOLIA/Resources/Mongolia_heating_poor_peri_urban_ger_areas_of_UB_ASTAE_ENG.pdf

more heavily represented in the survey, which are more likely to have a lower usage rate. Relevant dates for the project crediting and HES sampling frames are shown in Table 1.

Table 1. Tracker CEP installation dates used for crediting and household sampling for HES

Subset of CPA No. 001	Installation Date Range
CEPs included in Issuance 1 crediting	5/1/2013 - 12/30/2013
CEPs included in HES sampling frames	5/1/2013 - 7/30/2013

C. Sampling Frames

Users of CEPs in the target population live in one of two dwelling types, poorly insulated houses or gers. Per analysis of the results of the baseline study, the dwelling type has a statistically significant impact on the baseline coal consumption of individual households (see **ANNEX 8** – Baseline Fuel Consumption Analysis). The baseline study also indicated that specific districts also have a statistically significant impact on baseline coal consumption - specifically households in Bayangol district use less coal than other districts and households in Songinokhaikhan district use more coal than other districts. As such, the annual coal consumption of gers and houses in specific districts was expected to be different in the survey population. Therefore, the target population was divided into six sampling frames:

- Frame 1: Stove in house dwelling type, located in Songinokhairkhan district ("House - Song.")
- Frame 2: Stove in house dwelling type, located in Bayangol district ("House - Bayan.")
- Frame 3: Stove in house dwelling type, located in other district ("House-Other")
- Frame 4: Stove in ger dwelling type, located in Songinokhairkhan district ("Ger - Song.")
- Frame 5: Stove in ger dwelling type, located in Bayangol district ("Ger - Bayan.")
- Frame 6: Stove in ger dwelling type, located in other district ("Ger - Other")

In accordance with the emissions reductions calculation approach defined in the PDD, mean project and baseline emissions were calculated separately for each frame. Therefore, unique annual coal consumption values in the project scenario were determined and applied for monitored parameter $C_{y,new,CEP\text{-}i}$.

D. Sampling Method and Size

Sample sizes were calculated and sampling was conducted for each sampling frame in accordance with CDM Guidance[4] using simple random sampling within each frame. Sample sizes were calculated for the two parameters required for emissions reductions calculations, $C_{y,new,CEPi}$ (mean value) and POF (proportional value), to meet required 90/10 confidence/precision for each of the frames. The calculated sample size for $C_{y,new,CEPi}$ was larger and was applied for sampling both parameters in each frame.

The estimated sample size for each frame included an additional 50% of samples ensuring that there were sufficient households available to account for instances of non-response or refusal to participate in the survey. To draw the sample, CEP installations in Tracker were classified as being located in one of the two frames. The database was exported to Excel, a random number generator was used to randomly select the required number of stoves in each frame.

The survey was conducted with non-replacement, meaning if a household was called or visited and no one was available to respond, the enumerator did not return to the household. During execution of the survey, additional samples were randomly selected using the same method in place of households that could not be reached.

Initially, sample sizes were calculated for only two sampling frames: (1) stoves in house dwelling types and (2) stoves in ger dwelling types. Due to the expectation that the district type may also have an effect, the samples were divided into six sampling frames, as noted above. Additional sampling was conducted in June-July 2015 to ensure all six sampling frames met required 90/10 confidence/precision levels.

Overall, enumerators called or visited a total of 403 households of the samples from CPA No. 001 which agreed to take the survey. A total of 130 surveys were dropped from the HES analysis due to incomplete survey responses, enumerator error, or inconsistencies within survey and Tracker responses, resulting in analysis of 273 surveys.

IV. Survey Development and Implementation

A. Survey Development

The HES was developed by consultant Megan O'Neil, MEC, and XacBank. The survey form was developed on Open Data Kit (ODK) open source software, to create a form for use on an

[4] CDM Executive Board. 2013. Guidelines for Sampling and Surveys for CDM Project Activities and Programme of Activities, v.3.0. EB75. Annex 5. UNFCCC/CCNUCC. Available at: http://cdmrulebook.org/458. Accessed September 2013.

Android phone for in-person surveys and a webform for phone surveys. Total sample size achieved after dropping incomplete household survey responses and the survey methods used for each of the four HES sampling frames is shown in Table 2.

There were a total of 273 completed surveys for the parameter 'POF' or usage rate, of which 50% were conducted in person (137), 50% by phone (136). Of households that were using their CEP, a total of 224 surveys included complete responses for coal consumption, or the parameter '$C_{y,new,CEPi}$'.

Table 2: Sample size achieved and survey method by household sampling frame and total

	House-Song.	House-Bayan.	House-Other	Ger-Song.	Ger-Bayan.	Ger-Other	Total HH	%
In person	18	11	47	11	17	33	137	50%
By Phone	6	41	18	20	24	27	136	50%
Total POF Completed	24	52	65	31	41	60	273	100%
Total $C_{y,new,CEPi}$ Completed	22	39	51	26	37	49	224	

The HES survey design and question format was based on the survey used in the baseline study, MCA-Mongolia Household Survey Report (**ANNEX 9**), which was prepared for the Millennium Challenge Account (MCA) in 2011 (See also **ANNEX 10** – MCA-Mongolia Household Survey Questionnaire). This baseline survey was conducted on 1,047 households throughout the six ger districts of Ulaanbaatar, the same target population of the project activity and HES.

As the most comprehensive source of recent data on fuel consumption among households in the ger districts of Ulaanbaatar, regression analysis was conducted on the 2011 MCA - Mongolia Household Survey data to develop models to calculate baseline coal and wood consumption in a manner that normalizes for annual climate variability. The model and analysis are described in **ANNEX 8** – Baseline Fuel Consumption Analysis. The analysis determined which independent variables had a significant impact on coal consumption and wood consumption separately in the baseline population. These variables included in the regression model equations are then monitored each monitoring period to calculate what each household would have consumed in the monitored heating season.

In order to ensure comparability between the calculated baseline fuel consumption and the monitored project fuel consumption, specific consideration was taken to ensure questions regarding coal consumption were asked as similarly as possible to the 2011 MCA - Mongolia Household Survey.

Further, a lack of larger-scale government or policy related impacts on coal consumption between 2011 and 2014 provide sufficient justification for employing an interrupted time-series design to compare coal consumption using the Nexant Baseline Survey and Household Energy Survey. Supporting data is described below:

1. This project uses a regression model to calculate baseline coal consumption. Development of the model is described in **ANNEX 8** – Baseline Fuel Consumption Analysis and is based on baseline survey data described in **ANNEX 9** – MCA – Mongolia Household Survey Report. The regression model includes the independent variables that were found to most significantly affect household coal consumption. These factors are: dwelling type, temperature, wind speed, and select districts. Demographic metrics such as education level, income level, or HH size were not found to be an important predictor of a household's coal consumption. Use of the regression equation inherently corrects for the variables that influence coal consumption.

2. Based on 2009 data from the UB Statistical Office[5], over one-third of all households in the six ger districts had purchased and installed a CEP prior to participation in the HES in Autumn 2013 and were contained in MEC's Tracker database, lessening the potential for sampling bias in the HES population.

3. Review of national data and consultation with local partners revealed that there have been no significant policy changes or disruptions in the country since 2011 that would dramatically alter fuel availability and usage patterns relative to conditions during the baseline study.

B. Fuel Consumption Units

Baseline study and HES questions regarding fuel consumption were asked by the unit in which the fuel was purchased to ensure the households could respond in a consistent manner. In Ulaanbaatar, households purchase coal and wood in either trucks (Zils or Porters) or bags.

In November 2014, a Fuel Vendor Survey was conducted to verify the size of coal and wood units of consumption in the ger districts (see **ANNEX 11** - Fuel Vendor Survey Report). The

[5] According to the Nexant Household Survey Report, in 2009 there were 256.6 thousand households in the 6 main Ger districts in Ulaanbaatar, Mongolia. While the number of households in these districts was not available in 2013, drawing on previous rates of population growth (2006-2011) one can estimate this number did not greatly exceeded 300 thousand households. See also: 2013. Bayanchimeg, Ch. and Batbayar, B. "The Population and Economic Activity of Ulaanbaatar." Erina Report, No. 109 January. Accessed 12/6/2013: https://www.erina.or.jp/jp/Research/db/pdf24/122041-7.pdf

survey was conducted in response to numerous comments from households in the ger districts and local partners that the size of units was getting smaller each year, while the price was increasing. The survey resulted in values for the size of porters of coal and non-government subsidized or "other" bags of coal which met 90/10 confidence precision levels. The remaining unit sizes were unable to be surveyed and conservatively remain at the level used by enumerators in the MCA-Mongolia Household Survey Report and confirmed by local survey team. Units included and values applied in HES survey for coal were:

- **Porter**: A porter is a medium sized-truck. Fuel Vendor Survey confirmed that the size of a porter in the 2013-2014 heating season is 1.72 tons of coal.

- **Zil-130:** A Zil-130 is a Russian-made truck, which has larger capacity than a porter. At the start of the 2014-2015 heating season, vendors were no longer selling coal in this size truck, thus it was unable to be surveyed. An informal review of buyers and sellers of coal in December 2013 confirmed that the maximum carrying capacity of the Zil-130 truck is 5 tons, but that it typically supplies 3.5 to 4.3 tons. The MCA - Mongolia Household Survey Report assumes that a Zil-130 consists of 5 tons of coal; this value is conservatively applied in the HES survey.

- **Large Government Bag of Baganuur Coal:** In the 2013-2014 season, the government began subsidizing 40kg bags of Baganuur coal to incentivize buyers and sellers to stop using Nalaikh coal, which is from a closed mine. These bags were not available in previous seasons, so there is no comparable quantity in the MCA 2011 report. This bag size was also no longer available in the 2014-2015 heating season, thus it was not surveyed. Therefore, the value of 40kg is applied for this unit.

- **Other Bag**: Many households that cannot afford to buy coal in bulk purchase coal in bags. The Fuel Vendor Survey Report resulted in a value of 22.1kg per bag which met 90/10 confidence/precision level. The MCA - Mongolia Household Survey assumed that an average bag of coal weighed 14.3kg, with 70 bags weighing 1 ton. The higher value found in the Fuel Vendor Survey is applied, despite assumptions in the ger district that the amount of coal has decreased. The surveyed value is conservative as well because the surveyed vendors in November 2014 had stopped selling larger government subsidized Baganuur bags, but had continued to sell larger bags of non-subsidized Baganuur coal, which brought the overall mean higher. Nonetheless, the surveyed value of 22.1 kg per bag is applied to ensure conservativeness in calculation of coal consumption in the 2013-2014 heating season.

In the HES, enumerators asked households about the quantity of each unit of coal used during the heating season. Responses were multiplied by the relevant conversion factors (shown in Table 3 below) to calculate seasonal coal consumption according to the following equation:

> ***Household Coal consumption per season (ton)*** *= Zil-130 used * (5 ton/Zil) + porter used * (1.72 ton/porter) + government bags used * (.04 ton/government bags) + other bags used * (0.022 ton/other bag)*

Table 3. Conversion of coal purchasing units to consumption units: kilograms and metric tons

Purchasing Unit	kg	ton
Zil-130	5000	5
Porter	1720	1.72
Government Bag	40	0.04
Other Bag	22.1	0.0221

For wood, households either purchase in porters or in bags. As households use wood as a starter fuel and coal as the primary cooking and heating fuel, fewer households buy wood in bulk. Wood is measured in cubic meters (m^3), with the following unit sizes used.

- **Porter:** MCA - Mongolia Household Survey applied a value of 2-3 m^3 of wood. This unit was not available during the Fuel Vendor Survey. To be conservative, the HES applied a value of 3 cubic meters.

- **Bag:** MCA - Mongolia Household Survey applied a value of 0.05 m^3 per bag, or 20 bags to 1 m^3. The Fuel Vendor Survey did not reach required confidence/precision for the size of this unit. Though households report a decrease in the size of bags of wood, to be conservative the MCA-Mongolia Household Survey value was applied in the HES project scenario.

A similar process was followed to determine seasonal wood consumption for each household surveyed. Wood consumption is reported in cubic meters (m^3) and conversion factors between wood purchasing units and m^3 are shown in Table 4. Seasonal wood consumption was calculated according to the following equation:

> ***Household Wood consumption per season (m^3)*** *= porter purchased *(3 m^3/porter) + bags purchased*(0.05 m^3/bag)*

Table 4. Conversion of wood purchasing units to consumption unit: m^3

Purchasing Unit	m^3
Porter	3
Bag	0.05

C. Seasonal Fuel Consumption

Both the MCA - Mongolia Household Survey and the HES asked respondents to estimate their fuel usage by season, specifically for Autumn, Winter, Spring, and Summer. As in the baseline report, Autumn, Winter, and Spring fuel consumption were summed to determine heating season fuel consumption. As explained in the PDD and the MR, the reduction in fuel consumption is only credited during the heating season. Equations used to determine coal and wood heating season consumption in the HES analysis are:

- **Household Heating season coal consumption (ton)** = Winter coal consumption (ton) + Spring coal consumption (ton) + Autumn coal consumption (ton)

- **Heating season wood consumption (m^3)** = Winter wood consumption (m^3) + Spring wood consumption (m^3) + Autumn wood consumption (m^3)

D. Enumerator Training

Training was conducted by the XacBank Survey Manager and Operations Manager with remote support from consultant Megan O'Neil in September 2014 and again in January 2015. 13 enumerators were trained to conduct the survey, 2 call center staff and 11 in-person monitoring staff. All members of the survey team were employed conducting ongoing phone monitoring and in-person monitoring of products sold through Xacbank programs.

Training consisted of a 2-day group training for enumerators led by the Survey Manager and the Operations Manager, which was based on the HES Survey Guide, **ANNEX 7** - Introduction to the HES. Training included an introduction to the survey and objectives; in-depth survey review; role playing exercises; specific training on conducting survey in ODK and Survey Monkey.

V. Data Collection, Analysis, & QAQC

A. Field Measurement Schedule and Data Collection

The first round of HES in-person and phone surveys were conducted in September 2014, with a follow-up round conducted in December 2014 - January 2015.

The use of electronic data collection simplified and shortened the data collection process. Each enumerator conducting in-person surveys used an Android HTC Wildfire.

Each HES question was programmed with specific constraints such as "Numerals Only", or Relevance Requirements (e.g. Only ask this question if the previous question was "Yes"), and Choice Sets (e.g. Select one or select multiple as appropriate).

Following the collection of surveys each day, the enumerator connected to a wireless internet connection and submitted the completed form to the server through the smart phone. All completed surveys were available on the web-based ODK Aggregate server in .csv format. In the aggregated survey responses from ODK, each question corresponded directly with a column and each row corresponds to one household survey completed.

B. Procedures for Minimizing Non-Sampling Errors & QAQC Measures

All questions were constructed and tested to avoid recall bias, confirmation bias, and leading questions. For example, coal and wood consumption was calculated blind to the respondent. The household reports a set of quantities and units and the consumption is calculated, meaning households have less opportunity to overstate their coal savings. In addition, rather than asking "How much coal did you save?"; the questions "How did your consumption of coal change after purchasing the clean energy product? More, Less, Same" followed by the question "How much coal did you save" if the respondent selected "Less".

The HES was also conducted in September-October 2013 on 690 households for monitoring of GS2434 for Issuance 1 of VPAs 001-006, and had been piloted prior to the full deployment.[6] The results of the 2013 HES survey informed minor revisions to the questionnaire to improve the efficacy in gaining complete, accurate surveys with low bias risk and to include a new fuel unit type in 2013-2014, the government subsidized bag of Baganuur coal.

Use of carefully coded, constrained, and piloted electronic surveys further ensured low-error data collection. Pre-programmed constraints ensured that enumerators would not enter alphabetical characters where there should be a number and ensured that there could be no "free text" responses that are difficult to interpret.

Extensive training for enumerators further served as a QAQC measure to ensure that enumerators asked questions as intended. Enumerators were trained to take notes on observation forms to note any issues in survey that were not captured in electronic survey responses.

[6] GS2434 PoA is identical in the technologies deployed, target population, and program scope to CDM PoA 8142, and both are managed by the same CME. The GS PoA was developed to credit CEPs installed prior to the CDM PoA. All CEPs in GS2434 and CDM PoA 8142 are included in MEC Tracker, in which each CEP is clearly assigned to a specific asset and project activity, ensuring no double counting (See **ANNEX 3** - MicroEnergy Credits Tracker Platform Summary).

After completing the surveys, the Survey Manager spot checked responses by enumerators, reviewing notes collected by each enumerator and confirming responses. Consultant Megan O'Neil conducted review of survey responses while the survey was ongoing and an in-depth review following completion of the survey, as described in the following section.

A further measure for QAQC for in-person surveys was the use of visual confirmation by enumerators for three questions about the purchase and location of CEPs. Enumerators were able to visually confirm 100% of survey respondent answers for the following questions:

- During previous heating season, were you living in a house or a ger?
- What type of stove did you purchase through XacBank?
- Where are you using the stove?

C. Data Checks for Completeness, Errors, and HES Analysis QAQC

Consultant Megan O'Neil reviewed the aggregated data for completeness, inconsistencies, and errors. In case of incomplete or inconsistent surveys, responses were removed from analysis. Errors were corrected when possible or removed entirely from analysis.

- **Problem enumerator:** In review of initial surveys in September 2014, it was found that one enumerator entered identical responses for multiple surveys. The Survey Manager spot-checked responses from this enumerator and concluded that he had not correctly conducted the survey, thus all surveys from this enumerator (40) were removed and an additional round of surveying was conducted.
- **Sysnum repeat:** 16 completed surveys were removed due to the same sysnum entered for multiple surveys. In cases where it was not possible to determine which survey was correct; both were removed.
- **Consistency checks:** Further review was conducted to ensure that household responses were consistent with corresponding MEC Tracker information. Inconsistencies were found between the dwelling type reported in the survey and that reported in MEC Tracker. Spot-checks confirmed that in the majority of cases, the MEC Tracker dwelling type was correct. As dwelling is key to crediting, the surveys with dwelling type mismatch with MEC Tracker were considered errors and removed from analysis (52). Inconsistencies were also found regarding the recorded stove type in the survey compared to MEC Tracker. Spot-checks confirmed the accuracy of Tracker over the survey, and confirmed that the errors were due to the enumerators limited recognition of the various stove models. As stove model does not affect crediting, the surveys with inconsistent stove types were not removed from analysis in order to broaden the sample size and ensure a more robust value.
- **Incomplete surveys:** Several phone surveys were removed from analysis because the survey responses ended midway through.

- **Entry errors:** There were 3 cases of entry errors which were corrected for LPG and Electricity consumption, which were either corrected or removed from analysis. Further explanation provided in **ANNEX 6** - Household Energy Survey Data Analysis.

After all data quality checks and cleaning above, the final dataset contained 273 households with complete entries in both HES and Tracker.

- **Outliers for fuel consumption:** As described in the PDD, data points for heating season fuel consumption greater than quartile 3 (Q3) plus 1.5 times the interquartile range (IQR) or less than quartile 1 (Q1) minus 1.5 times the IQR were deemed outliers and excluded from the fuel consumption analyses. This process was repeated separately for coal and wood. Only households reporting use of their CEP(s) during the 2013-2014 heating season were included in fuel consumption calculations.

VI. Results

A. Usage - Product Operation Fraction

The parameter POF is the portion of products that are in use. The parameter is determined through the HES for each CEP in each household sampling frame. Enumerators asked households if they were using their product during the previous heating season (August 2013 - April 2014), the monitoring period in question. The portion of respondents who responded that their products were in use was applied for the parameter POF in project emission reduction calculations. This value with confirmation that required confidence/precision level met is demonstrated in Table 5 below.

Table 5: Product Operation Fraction by Product and Dwelling Category

	N	Usage rate	Std Err	90% Confidence Interval	Lower 90% CI	Upper 90% CI	Precision	Meets 90/10 Rqmnt?
House-Song.	24	96%	0.04	0.13	0.89	1.03	7.00%	Yes
House-Bayan.	52	92%	0.04	0.12	0.86	0.98	6.59%	Yes
House-Other	65	95%	0.03	0.09	0.91	1.00	4.49%	Yes
Ger-Song.	31	90%	0.05	0.17	0.82	0.99	9.67%	Yes
Ger-Bayan.	41	93%	0.04	0.13	0.86	0.99	7.22%	Yes
Ger-Other	60	93%	0.03	0.11	0.88	0.99	5.68%	Yes

B. Project Coal Consumption in Heating Season

The parameter $C_{y,new,CEPi}$ is mean household coal consumption during the heating season. The parameter is determined for each sampling frame, calculated according to equation below:

Household Heating season coal consumption *(ton) = Winter coal consumption (ton) + Spring coal consumption (ton) + Autumn coal consumption (ton)*

Average household coal consumption per heating season (project scenario) is shown for sampling frames 1-6 in Table 6.

Table 6: $C_{y,new,\ CEP\text{-}i}$ – Project Scenario Coal Consumption (tons) in Heating Season 2013-2014, calculated by coal purchasing unit

Household Frame	N	Mean	Outliers Removed	STD	90% Confidence Interval*	Lower 90% CI	Upper 90% CI	Precision	Meets 90/10 Rqmnt?
House-Song.	22	3.54	5	0.74	0.16	2.42	4.75	7.31%	Yes
House-Bayan.	39	3.35	1	1.20	0.19	3.94	5.32	9.43%	Yes
House-Other	51	3.43	2	1.16	0.16	3.80	5.33	7.77%	Yes
Ger-Song.	26	3.64	5	1.00	0.20	3.27	5.28	8.81%	Yes
Ger-Bayan.	37	2.76	10	0.64	0.11	2.11	3.82	6.29%	Yes
Ger-Other	49	3.40	1	1.40	0.20	4.61	5.70	9.69%	Yes

In CPA No. 001, a total of four stove models were distributed: Royal Single, Royal Double, Silver Mini, and Silver Turbo. As the heating efficiency of each stove is within +/-5%, sampling was not conducted separately for each stove type in the HES (See **ANNEX 15** - Stove Testing Report). ANOVA analysis confirmed that the coal consumption did not differ significantly between surveyed stove types at $\alpha = 0.05$.

In addition to asking respondents the numbers of units in which they purchased their coal, the survey also asked households to simply estimate the amount of tons of coal they used each season. This question served as an internal confirmation of their responses. As fewer households responded to this question, the values met 90/10 confidence/precision for one frame, though most frames are close to meeting the requirement, as demonstrated in Table 7 below.

Table 7: Project Scenario Coal Consumption (tons) in Heating Season 2013-2014, determined by simple reporting of tons used

Household Frame	N	Mean	Outliers Removed	STD	90% Confidence Interval*	Lower 90% CI	Upper 90% CI	Precision	Meets 90/10 Rqmnt?
House-Song.	11	3.45	0	0.82	0.25	2.70	4.80	11.78%	No
House-Bayan.	4	2.25	0	0.87	0.43	2.85	3.67	31.66%	No
House-Other	21	3.26	1	0.97	0.21	3.20	4.86	10.74%	No
Ger-Song.	9	2.61	0	0.70	0.23	2.29	3.76	14.64%	No
Ger-Bayan.	4	1.83	1	0.29	0.14	0.95	2.31	12.95%	No
Ger-Other	17	2.66	1	0.51	0.12	1.67	3.49	7.62%	Yes

The mean values for each frame are similar to those calculated based on fuel unit size, though the simple reporting by tons are lower for both frames. While these values are not used to calculate emissions reductions, they do lend confidence to the efficacy and conservativeness of the chosen calculation method.

Outlier analysis was conducted as described in Section V. c. above. Outliers are values that lay outside 1.5 times the IQR. The number of outliers removed is reported in each table.

C. Baseline Coal Consumption in Heating Season

The parameter $C_{y,old,CEPi}$ was determined by applying the baseline regression model (see **ANNEX 8** – Baseline Fuel Consumption Analysis) to each surveyed household. The regression model developed for baseline coal consumption is:

$$C_{y\_old,CEPi} = 4.57681 - \left(0.67248 \sum WS_{y,s}\right) - \left(0.01124 \sum T_{y,s}\right) + 0.14638DW_{y,house} + 0.11988D_{y,Songinokhairkhan} - 0.36234D_{y,Bayangol}$$

Independent variables required for the regression model are shown in Table 8.

Table 8. Parameters required for Calculation of Baseline Coal Consumption

Parameter Required	Description	Value Applied		Source
$T_{y,s}$	Mean temperature in Celsius for year y and season s (Autumn, Winter, Spring)	Autumn:	7.5	NOAA National Climatic Data Center
		Winter:	-18.2	
		Spring:	-7.2	
$WS_{y,s}$	Mean wind speed in Knots for year y and season s (Autumn, Winter, Spring,)	Autumn:	5.5	NOAA National Climatic Data Center
		Winter:	3.0	
		Spring:	5.0	
$D_{y,Songinokhairkhan}$	District location is Songinokhairkhan district	binary variable by household, 1=yes in distict, 0=not in district		Tracker sales database (District_ENG variable)
$D_{y,Bayangol}$	District location is Bayangol district	binary variable by household, 1=yes in district, 0=not in district		Tracker sales database (District_ENG variable)
$DW_{y,house}$	Dwelling is a house	binary variable by household, 1=house, 0=ger		HES dwelling variable, Tracker direct_restype variable

Baseline coal consumption was calculated for the monitoring period for each survey household reporting use of their CEP by using temperature and wind speed data for the 2013-2014 heating season from NOAA and household information collected from the HES and the MEC Tracker database. Baseline consumption was calculated by season, and results for Autumn, Winter, and Spring were summed to generate baseline heating season consumption. The individual households which were excluded as outliers based on project coal consumption were also excluded from baseline coal consumption calculation, ensuring the baseline and project populations are identical. Calculated baseline coal consumption is demonstrated in Table 9 below.

Table 9. $C_{y,old,\,CEP\text{-}i}$ – Baseline Scenario Coal Consumption (tons) in Heating Season 2013-2014

Household Frame	N	Mean	Outliers Removed*	STD	90% Confidence Interval*	Lower 90% CI	Upper 90% CI	Precision	Meets 90/10 Rqmnt?
House-Song.	22	5.67	5	0.00	0.00	0.00	5.67	0.00%	Yes
House-Bayan.	39	4.23	1	0.00	0.00	0.00	4.23	0.00%	Yes
House-Other	51	5.31	2	0.00	0.00	0.00	5.31	0.00%	Yes
Ger-Song.	26	5.23	5	0.00	0.00	0.00	5.23	0.00%	Yes
Ger-Bayan.	37	3.79	10	0.00	0.00	0.00	3.79	0.00%	Yes
Ger-Other	49	4.87	1	0.00	0.00	0.00	4.87	0.00%	Yes

D. Coal Savings in Heating Season – Calculated

Calculations shown in Table 10 demonstrate that households in all sampling frames consumed less coal during the project scenario heating season as compared to the baseline.

Table 10. Project Coal Savings (tons) for Heating Season 2013-2014

	House-Song.	House-Bayan.	House-Other	Ger-Song.	Ger-Bayan.	Ger-Other
	Mean (tons)	Mean (tons)	Mean (tons)	Mean (tons)	Mean (tons)	Mean (tons)
$C_{y,old,CEP\text{-}i}$: Baseline Coal Consumption	5.67	4.23	5.31	5.23	3.79	4.87
$C_{y,newCEP\text{-}i}$: Project Coal Consumption	3.54	3.35	3.43	3.64	2.76	3.40
Project Coal Savings	2.13	0.88	1.89	1.59	1.02	1.48
% Change in Consumption	-38%	-21%	-35%	-30%	-27%	-30%

E. Project & Baseline Wood Consumption in Heating Season

The HES and baseline study also collected information on consumption of wood. Wood is used as a starter fuel for heating stoves amongst households. Although some wood savings are

expected due to the need to light the efficient stove fewer times in the project scenario, the project conservatively does not credit wood savings.

After converting reported wood consumption by purchasing units into cubic meters (m^3) of wood consumption by season, heating season wood consumption for each household was calculated by summing household wood consumption for autumn, winter, and spring as shown below:

> ***Household Wood consumption per season (m3)*** = *porter purchased *(3 m3/porter) + bags purchased*(0.05 m3/bag)*

Project scenario wood consumption for all stoves during the monitoring period is displayed in Table 11. As wood consumption is not expected to be affected by dweling type or the same districts as coal, per analysis of the baseline study, consumption was not divided by frame. No outliers were removed in the analysis. As demonstrated below, the estimated mean project wood consumption met 90/10 confidence/precision levels.

Table 11. Project Scenario Wood Consumption (m^3) for Heating Season 2013-2014

Household Frame	N	Mean	Outliers Removed	STD	90% Confidence Interval*	Lower 90% CI	Upper 90% CI	Precision	Meets 90/10 Rule?
All Stoves	229	3.99	0	2.05	6.73	0.62	7.36	5.58%	Yes

Baseline wood consumption was determined by applying the baseline regression model for wood (see **ANNEX 8** – Baseline Fuel Consumption Analysis) to each surveyed household. The regression model developed for baseline coal consumption is:

$$B_{y\_old,CEPi} = 3.42434 - (0.46183 \sum WS_{y,s}) - (0.00748 \sum T_{y,s}) + 0.57023 D_{y,Songinokhairkhan} - 0.36234 D_{y,Bayangol} - 0.14078 D_{y,Chingeltei}$$

Independent variables needed for the regression model are shown in Table 12.

Table 12. Parameters required for Calculation of Baseline Wood Consumption

Parameter Required	Description	Value Applied		Source
$T_{y,s}$	Mean temperature in Celsius for year y and season s (Autumn, Winter, Spring)	Autumn:	7.5	NOAA National Climatic Data Center
		Winter:	-18.2	
		Spring:	-7.2	
$WS_{y,s}$	Mean wind speed in Knots for year y and season s (Autumn, Winter, Spring,)	Autumn:	5.5	NOAA National Climatic Data Center
		Winter:	3.0	
		Spring:	5.0	
$D_{y,Songinokhairkhan}$	District location is Songinokhairkhan district	binary variable by household, 1=yes in distict, 0=not in district		Tracker sales database (District_ENG variable)

$D_{y,Bayangol}$	District location is Bayangol district	binary variable by household, 1=yes in district, 0=not in district	Tracker sales database (District_ENG variable)
$D_{y,Chingeltei}$	District location is Chingeltei district	binary variable by household, 1=yes in district, 0=not in district	Tracker sales database (District_ENG variable)

As for baseline coal consumption, baseline wood consumption was calculated using data from NOAA listed above and information collected from the HES and the MEC Tracker database.

Table 13. Baseline Scenario Wood Consumption (m^3) in Heating Season 2013-2014

Household Frame	N	Mean	Outliers Removed	STD	90% Confidence Interval*	Lower 90% CI	Upper 90% CI	Precision	Meets 90/10 Rqmnt?
All Stoves	229	4.11	**0**	1.00	3.30	2.46	5.76	2.65%	Yes

The change in wood consumption from project to baseline is summarized below, based on comparison of calculated baseline wood consumption to the surveyed project consumption. As demonstrated in Table 14 below, wood consumption decreased slightly in the project scenario.

Table 14. Change in Project Wood Consumption (m^3) for Heating Season 2013-2014

	All Stoves
	Mean (m^3)
Baseline Wood Consumption	4.11
Project Wood Consumption	3.99
Project Wood Savings	0.12
% Change	-3%

F. Old Stove Status

XacBank procedures are to collect the old stove for every household that purchases a project stove. A full description of procedures and tracking is included in **ANNEX 14** - Old Stove Dismantling Procedures.

To confirm the status of the old stoves collected by XacBank, the HES asked respondents what occurred with the old stove upon installation of the new project stove. Results are displayed in Table 15. Over 98% of total households gave up their old stove. One household responded they did not give up their old stove because they did not have an old stove, as certified by their neighborhood ("Khoroo") governor's office. As explained in **ANNEX 14**, if a newly married couple or household that is otherwise purchasing their first stove wants to purchase an energy

efficient stove, they had to get a certified letter to certify they were purchasing a new house and had no other stove to give up.

The survey results confirm XacBank's procedures of taking each household's old stove when installing the new stove, or requiring a letter to confirm no stove is available.

Table 15: Old Stove Status

	Total Stoves	
Old Stove Status	**N**	**%**
Gave up	251	98%
Khoroo Letter	1	0%
Gave to relative/friend	2	1%
Sold	0	0%
Still using - not for heating/ cooking	0	0%
Still using - heating/cooking in same house	0	0%
Still using - heating/cooking in other dwelling	0	0%
Other	1	0%
Total	255	100%

G. Summer Coal Consumption

The project conservatively only credits coal consumption during the heating season, because this is the most intensive period of coal consumption. In summers, households use lesser amounts of coal for cooking only. To confirm the conservativeness of this approach, the HES asked households how their coal consumption has changed in the summer since adopting the CEP. As demonstrated in Table 16 below, 25% of all households reduced their coal consumption during summer; 74% maintained the same coal consumption, and less than 1% (one household) reported increased consumption in the summer.

Table 16. Summer Coal Consumption, Comparison to Before CEP Use

	Total Stoves	
Summer Coal Consumption	**N**	**%**
Less	64	25%
Same	188	74%
More	1	0%
Total	253	100%

H. LPG Usage

The HES asked if households used liquefied petroleum gas (LPG) in addition to their coal stoves for cooking or heating. The question was included in the HES to assess if the use of the clean energy cooking and heating stoves resulted in a change of usage of LPG. Table 17 presents the portion of households surveyed that use LPG for cooking and/or heating. Of those who use LPG, respondents answered if their perceived usage increased, decreased, or remained the same during the project scenario (Table 18).

Overall, only 3% of sampled households reported using an LPG stove for either cooking or heating in addition to the CEP. Of the five households that use LPG, one uses it for both cooking and heating, two used it for only cooking, and two for only heating, as demonstrated in Table 17. LPG Usage Ratesbelow. As demonstrated in Table 18, in both usage of LPG for cooking and heating, one of the three households reported decrease usage, the remaining reported the same usage. Given the responses, aggregate LPG consumption is expected to decrease or stay constant across the population using CEPs.

Table 17. LPG Usage Rates

	All Houses - Cooking		All Households - Heating		All Households - Cooking or Heating	
LPG Usage	N	%	N	%	N	%
Yes	5	2%	3	1%	7	3%
No	251	98%	250	99%	246	97%
Total	256	100%	253	100%	253	100%

Table 18. Change in LPG Stove Use in Project Scenario vs. Baseline – Perceived

	All Houses - Cooking		All Households - Heating	
Perceived LPG Use:	N	%	N	%
Less Use	1	20%	1	33%
Same Use	4	80%	2	67%
More Use	0	0%	0	0%
Total Households Reporting	5	100%	3	100%

I. Electricity Usage

The HES asked if households used electricity in addition to their coal-burning stoves for cooking or heating. The question was included to assess if the use of the clean energy cooking and heating stoves resulted in a change in the usage of electricity.

Table 19. presents the portion of households surveyed that use electric stoves or heaters. Table 20. demonstrates how users of electric stoves or heaters answered when asked if their perceived usage of electric stoves/heaters increased, decreased, or remained the same during the project scenario. Finally, Table 18Table 21 presents quantitative responses of the expenditure on electricity for electric stoves and heaters before and after CEP usage.

Overall, 73% of households reported using electric stoves or heaters; the vast majority of whom are using electric stoves (182) rather than electric heaters (15). Of those using electric stoves, 94% reported that their usage decreased or stayed the same. 6% of households reported an increase in consumption. Of those using electric heaters, 100% reported that their usage had either stayed the same or decreased.

Users of electric stoves and/or heaters also reported the amount of money spent on their electricity bill before and after purchasing their CEP. As demonstrated in Table 21, the means for both before and after CEP usage meet 90/10 confidence/precision levels, and indicate that in the aggregate households are reducing their expenditure on electricity by 16%. This clearly indicates that no leakage is occurring due to increased electricity consumption.

Table 19. Electric Stove/Heater Usage Rates

	All Houses - Cooking		All Households - Heating		All Households - Cooking or Heating	
Electricity Usage	N	%	N	%	N	%
Yes	182	71%	15	6%	187	73%
No	74	29%	241	94%	69	27%
Total	256	100%	256	100%	256	100%

Table 20. Change in Electric Stove/Heater Use in Project Scenario vs. Baseline – Perceived

	All Houses - Cooking		All Households - Heating	
Perceived Electric Stove/Heater Use Change:	N	%	N	%
Less Use	54	30%	4	27%
Same Use	116	64%	11	73%
More Use	11	6%	0	0%
Total Households Reporting	181	100%	15	100%

Table 21. Electricity Expenditure Before and After Use of CEPs (MNT)

All Users	N	Mean (MNT)	STD	90% Confidence Interval*	Lower 90% CI	Upper 90% CI	Preci-sion	Meets 90/10 Rqmt?
Before CEP	100	67,023	37,642	3,764	123,842	5,102	9.24%	Yes
After CEP	100	56,072	29,276	2,928	96,318	7,913	8.59%	Yes
Difference		10,952						

(Before - After)		

J. Perceived Air Quality

The HES asked a series of five questions to measure user perceptions of the change in air quality as a result of using their stoves. Enumerators asked respondents since using the CEP, if they perceived more, less, or the same amount of:

1. Coughing
2. Respiratory illness
3. Itchy eyes
4. Indoor air pollution
5. Outdoor air pollution

Household responses regarding the change in air pollution due to combustion of coal and associated health symptoms are summarized in **Fehler! Verweisquelle konnte nicht gefunden werden.** below. Overall, for the health indicators (1-3), over 65% of households responded that the incidence was less with the new stove, below 35% reported the same incidence, and only one household reporting increased incidence of itchy eyes.

For indoor and outdoor air pollution, the vast majority of respondents reported less – 86% for indoor air pollution and 84% for outdoor air pollution – with the remaining reporting no change, and no households reporting an increase in air pollution.

Table 22: Air Quality Indicators

	Coughing		Respiratory Illness		Itchy Eyes		Indoor Air Pollution		Outdoor Air Pollution	
All Users	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Less	164	65%	168	66%	170	67%	86%	214	84%	164
Same	90	35%	86	34%	83	33%	13%	41	16%	90
More	0	0%	0	0%	1	0%	0%	0	0%	0
Total	254	100%	254	100%	254	100%	100%	255	100%	254