DRAFT GENERAL GUIDELINES[1] FOR SAMPLING AND SURVEYS FOR SMALL-SCALE CDM PROJECT ACTIVITIES

(Version 01)

I. BACKGROUND AND SUMMARY

1. Several approved CDM methodologies require estimates of parameter values using sampling methods. The purpose of this document is to specify the reliability requirements and provide guidance on appropriate sampling methods and what is expected to be provided in a sampling plan. This document only addresses random errors associated with sampling and does not address systematic (non-random) errors associated with topics such as measurement error.

2. CDM Project Design Documents (PDDs) utilising sampling for the determination of parameter values for calculating emission reductions shall include a *sampling plan* with a description of the sampling approach, important assumptions, and justification for the selection of the chosen approach.

3. The purpose of sampling is to obtain (a) *unbiased* and (b) *reliable estimates* of the mean value of parameters used in the calculations of greenhouse gas emission reductions. Unbiased indicates that the sampling will not systematically underestimate or overestimate the mean value determined. Reliability of a parameter value estimate, determined via sampling, is typically expressed in terms of the probability that the sample-based parameter value estimate falls within a specified interval around the population's true parameter value. All sampling methods should provide formulas for calculating and reporting the reliability of parameter estimates.

4. Requirements for reliability, expressed typically in terms of precision and confidence, are defined in either in the applicable CDM methodology or in paragraph 8 below, with the applicable methodology having precedence. *Precision* is an assessment of the error margin of the final estimate. *Confidence* is the likelihood that the sampling has resulted in the true value within a certain range of values (i.e., precision). For example, one might describe a sample-based estimate as having a 90% probability of falling in a range of ± 10% of the true population value (often denoted as 90/10 confidence/precision).

5. The reliability of a sample-based estimate directly increases with the numerical size of the sample and inversely with the variability of the parameter in the population to be sampled. Thus, prior to drawing a sample, project participants should calculate the size required to achieve a required level of reliability based on a forecast or expectation of the variability of the parameter in the population. In the PDD, the sample size chosen shall be justified. In particular it shall be explained how the target level of reliability specified in the applicable methodology (or in paragraph 8 below) will be achieved. Appropriate references shall be made to previous studies or sound engineering judgments where necessary to explain expected variability.

6. It is good practice to employ oversampling not only to compensate for any attrition, outliers or non response associated with the sample but also for the reason that in the event the required reliability is not achieved additional sampling efforts would be required to determine the parameter value.

7. Subject to the two requirements of unbiased estimates and achieving reliability levels for the specific parameter determination, project participants have broad discretion in the sampling approach they propose to use to obtain the estimates. The choice of which sampling approach to

[1] See EB 49 Annex 31 for the definition of guidance, guidelines and procedures.

use depends on several considerations, including the types of information to be collected through sampling, the known characteristics of the population, the cost of information gathering, and other conditions surrounding the project in question. Some of the most commonly used sampling methods are summarized in this document, along with typical circumstances where each may be most appropriate to apply.

II. PROCEDURES

8. Where there is no specific guidance in the applicable methodology, project proponents shall use 90/10 confidence/precision as the criteria for reliability of sampling efforts. This reliability specification shall be applied to determine the sampling requirements for each individual parameter value determined through a sampling effort[2].

For example, consider a project activity that has installed household biogas digesters in numerous distributed locations to displace fossil fuel use for cooking. The number of annually operating biogas digesters directly impacts the emissions reductions of the project activity; therefore the number of households for the sample should be chosen so as to achieve a 90% confidence with 10% precision for the data collected on the number of households with operating biogas digesters. However, a 90/10 specification of the parameter value for the number of households does not necessarily imply that the emission reduction calculation is also at the 90/10 confidence/precision reliability.

9. A sampling plan shall be included in any PDD for CDM projects that utilize sampling for determining one or more parameters. This document provides an annotated outline for what should be included in a sampling plan.

10. Some CDM methodologies specify minimum required levels of precision and confidence for various categories of variables collected by way of sampling. The samples should be chosen so as to meet or exceed these minimum levels. Project proponents may request a revision of these requirements in the methodology or request a deviation from the approved methodology in accordance with the procedures (see http://cdm.unfccc.int/Reference/Procedures/methSSC_proc02_v01.pdf and http://cdm.unfccc.int/Reference/Procedures/reg_proc03_v02.pdf) providing sufficient justifications as to why a lower level is suitable for the planned application.

11. In addition to the parameters specifically indicated in CDM methodologies that are to be determined though sampling, project implementers may propose to obtain estimates of other variables using sampling techniques if that is the only practical or cost effective means to obtain them. In those instances project proponents shall request a revision of methodology or request deviation from the methodology or request a clarification using the approved procedures before undertaking a sampling effort.

12. As noted in paragraph 6, if the estimates from the actual samples fail to achieve the target minimum levels of precision, project participants shall perform additional data collection that is a supplemental or new sample.

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[2] As a clarification it is noted that the 90/10 confidence/precision is not required to be applied to the annual emission reduction (CER) values, only to the parameter(s) used in the calculation of CERs that are determined through a sampling effort.

III. SAMPLING APPLICATION GUIDANCE

13. In broad terms, determining emission reductions achieved by a project activity requires sampling in the following types of applications:

(a) Obtaining a point estimate for a parameter to be used in a formula. For example, the average annual hours of operation of lighting is used to estimate savings, where savings equal the change in wattage (determined at installation) multiplied by the average hours of operation (based on a sample estimate);

(b) Estimating the characteristics of equipment or a technology or an output/input parameter value. For example, several methodologies require mean values for the efficiency of replaced equipment, such as heating or lighting systems whereas methane avoidance methodologies may require a mean value for the methane content in biogas;

(c) Estimating whether the operating characteristics of an efficient technology or process have changed over time. For example, a refrigerator replacement program requires an annual survey to estimate the percent of units still in operation.

(d) Estimating whether a field value is significantly different from a value based on laboratory tests or previous studies. For example, some methodologies use the rated efficiency of equipment in estimating savings and these may need to be compared with in-situ performance of the equipment.

14. The following subsections provide a summary of some of the most common types of sampling approaches and typical situations where each is recommended. Formulas for calculating standard errors of estimates from each sampling technique and associated sample sizes are provided in the reference texts cited at the end of this report. The provided sampling information primarily relates to determining point estimates of average (mean) values of a parameter. Other potentially useful statistical modeling approaches, such as regression analysis are not covered.

Simple Random Sample

15. A simple random sample is a subset of observation (e.g., pieces of equipment, homes, individuals) chosen from a larger set (a population). Each observation is chosen randomly and entirely by chance, such that each observation has the same probability of being chosen. As each element in the population has an equal probability of being selected into the sample, the mean value of the measurement from a random sample is an unbiased estimate of the true population mean.

16. Simple random sampling has the advantages that it is the most conceptually straightforward way of obtaining a representative estimate based on a random subset of the population. Using random sampling methods is recommended when potentially more efficient sampling techniques are infeasible or impractical. Simple random sampling is best suited for relatively homogeneous population.

17. Simple random sampling requires minimum advance knowledge of the population. Its simplicity also makes it relatively easy to interpret the collected data. For these reasons, simple random sampling best suits situations where there is limited information available about the population and data collection can be efficiently conducted.

18. However, simple random sampling may not be recommended in situations where the population is very large and is geographically dispersed. In those cases, the costs of data collection associated with the distance between sampled elements (travel) may make other methods more cost effective.

Systematic Sampling

19. Systematic sampling is a statistical method involving the selection of elements from an ordered sampling frame. The most common form of systematic sampling is an equal-probability method, in which every k^{th} element in the frame is selected, where k, the sampling interval (sometimes known as the 'skip'), is calculated as:

k = population size (N) / sample size (n)

20. Using this procedure each element in the population has a known and equal probability of selection. The project participant shall ensure that the chosen sampling interval does not hide a pattern. Any pattern would threaten randomness. A random starting point must also be selected. Systematic sampling is to be applied only if the given population is logically homogeneous, because systematic sample units are uniformly distributed over the population.

21. Systematic sampling is applicable in a number of situations. If there is a natural ordering or flow of subjects in the population, such as output of bricks in a manufacturing process, then it is typically easier to sample every k^{th} unit to test for quality as they are produced. In all cases, it is important that the list of subjects or the process is naturally random, in the sense that there is no pattern to its order.

Stratified Random Sample

22. Another method is called stratified random sampling. When sub-populations vary considerably, it is advantageous to group elements into relatively homogeneous subpopulations and sample each subpopulation, called a stratum, independently. The strata should be mutually exclusive: every element in the population must be assigned to only one stratum. The strata should also be collectively exhaustive: no population element can be excluded. For example, the population of participants in a commercial lighting program might be grouped according to building type (e.g., restaurant, food stores, and offices).

23. Stratification can increase the efficiency, i.e., produce a gain in accuracy for a given sample size, if the cases within each stratum are more homogeneous than across strata. For example, if lighting usage within building types (office buildings, retail stores, etc.) varies less than across building categories, then estimates of hours of operation using a stratified sample will produce an estimate with lower variance for a given sample size.

24. If population density varies greatly within a region, stratified sampling can also ensure that estimates will be made with equal accuracy in different parts of the region allowing better comparisons of sub-regions. For example, a survey taken throughout a particular province might use a larger sampling fraction in the less populated north, since the disparity in population between north and south is so great that a sampling fraction based on the provincial sample as a whole might result in the collection of only a handful of data from the north.

25. Stratified random sampling is most applicable to situations where there are natural groupings of subjects whose characteristics are more similar within group than across groups. It requires that the grouping variable be known for all subjects in the sample frame. For example, the sampling frame would require information on the building type for each case in the population to allow stratification by that characteristic.

Cluster Sampling

26. Clustered sampling refers to a technique where the population is divided into sub-groups (clusters), and the sub-groups are sampled, rather than the individual elements to be studied. Cluster sampling is used when "natural" groupings are evident in a population. In this technique,

the total population is divided into sub-groups (clusters), and a sample of the groups is selected. For example, suppose a project installs high efficiency motors in buildings, with several motors typically in each building. If one is interested in estimating the operating hours of the motors, one might take a sample of the buildings instead of the motors, and then meter all of the motors in the selected buildings. In contrast to stratified sampling, where the equipment of interest is grouped into a relatively small number of homogeneous segments, there are many clusters of motors (i.e., buildings), and there is no expectation that the motors in each building are more homogeneous than the overall population of efficient motors.

27. One version of cluster sampling is area sampling or geographical cluster sampling. Clusters consist of geographical areas. Because a geographically dispersed population can be expensive to survey, greater economy than simple random sampling can be achieved by treating several respondents within a local area as a cluster.

28. A clustered sampling approach to collect data may offer cost advantages in certain instances. If a significant component of the cost of data collection is travel time between sites, then it may make sense to monitor all of the equipment at individual locations to reduce that cost component. Under that approach, it will typically be necessary to meter more pieces of equipment than under random sampling to achieve a given level of precision. But the reduction in cost may more than offset any negative effects on sample precision, allowing one to take a larger sample for a given budget, with an increase in accuracy.

29. In most applications of cluster sampling to monitor efficient equipment, the sub-groupings of units occur naturally, with a different number of elements per cluster. For example, a building or plant location might constitute a natural cluster, with varying numbers of motors per location.

Multi-Stage Sampling

30. Multistage sampling is a complex form of cluster sampling. Measuring all the sample elements in all the selected clusters may be prohibitively expensive or not necessary. Under those circumstances, multistage cluster sampling becomes useful. In multi-stage sampling, the units (referred to as primary units) in the population are divided into smaller sub-units (referred to as secondary units), similar to cluster sampling. In contrast to cluster sampling where all of the secondary units (elements) are measured, data are collected for only a sample of the sub-units. For example, a study of efficient lighting might first draw a sample of buildings, and then take a sample of lighting fixtures in each selected building. If the characteristics of the fixtures in a given building are very similar and the costs of measuring them is relatively high, then taking a sample of fixtures may be sufficient to achieve a target level of precision at lower cost. On the other hand, if the measurements are inexpensive once a technician is on-site, then it may make sense to monitor all of the fixtures.

Multi-stage sampling can be extended further to three or more stages. For example, one might group the population into building complexes, then buildings, and finally fixtures.

31. There are many variations in methods in applying multi-stage sampling. If the number of secondary units in each primary unit is not known in the sampling frame, then one approach is to draw a sample of primary units at random, count the number of secondary units in each selected primary unit, and then take detailed measurements for a sample of secondary units. If the number of secondary units is known in the sampling frame and varies only moderately across units, then one can stratify the primary unit population by size and draw successive random samples of primary and secondary units. The standard formulas for random sampling apply to the secondary unit means, and the formulas for stratified sampling apply to the grand mean. Another option is to sample the primary units with probability proportional to size, and to draw a random sample of the secondary units in the selected primary units. The relative performance of these alternatives

depends on the population characteristics, the costs of data collection, and the availability of information on the primary and secondary units in the sample frame.

Sampling Practices

32. In all of the approaches, care must be taken to ensure that the samples are drawn in a manner that avoids any bias and that the data collection minimizes non-sampling (non-random, systematic) errors. In order to achieve those goals, practitioners are expected to observe sound practices in designing samples and administering surveys and field measurements[3]. Those practices include:

- **Defining precisely the sampling objectives and target population and the measurements to be taken and/or data collected.** The target population from which the sample will be drawn, the information that will be collected, and the methods of measurements should be clearly specified, see Section V.
- **Developing the sampling frame.** Sampling frame is a list of all members of a population used as a basis for sampling i.e. a set defining which individuals, households, institutions qualify a sample or in the case of clusters, the sub-sections of the study area/population used to allocate clusters or select households to be sampled[4]. Without such a frame, or its equivalent, methods of sampling with assured properties such unbiasedness are not available. Implementer of the survey effort shall compile a clear description of the target population, including those characteristics of the population which define membership. From the description and characteristic the implementer then selects a sampling frame.
- **Randomizing cases and drawing sample.** The implementer should ensure that the sample is drawn at random from the sampling frame. If, for example, a systematic sampling is chosen, then the ordering of subjects on the sample should be random and free of any trend or cyclical pattern.
- **Selecting the most effective information gathering method.** The implementer should decide on what would be the most reliable and cost effective method for collecting the data, depending on the variables of interest. Alternative methods include visual inspections, physical measurements, respondent self-reports, and operational logs. For example, equipment retention rates may be determined by inspections or self-reports. Estimates of electric consumption could be based on different metering technologies depending on the characteristics of the equipment. Vehicle travel miles or equipment operating schedules could be drawn from odometers or operation logs.
- **Conducting surveys/measurements.** The project implementer is expected to establish and implement procedures to ensure that the field data collection is performed properly and that any potential intentional errors or unintentional errors are minimized and documented. Such procedures include developing field measurement protocols, training personnel, establishing contact procedures, documenting coverage problems, missing cases, and non-response, minimizing non-sampling measurement errors, and quality control for data coding errors.
- **Minimizing non-response and adjusting for its effects**. The project implementer is expected to make all reasonable efforts to minimize non-response, to analyze potential bias arising from non-response, and to correct for any detected biases or losses in

[3] For a very comprehensive treatment of issues surrounding sample/survey design, see Household Sample Surveys in Developing and Transition Countries, United Nations, 2005, ISBN 92-1-161481-3.

[4] A suitable map with the sampling units marked on it and properly delineated may also be regarded as a sampling frame and be used in drawing samples.

precision due to non-response. Field data collection protocols should specify procedures for multiple contacts to minimize non-response, require documentation of reasons for non-response, and prescribe corrective measures to compensate for its occurrence. Corrective measures may include over-sampling, replacing non-respondents with similar subjects, applying “correction factors,” and imputing responses.

IV. SAMPLING PLAN DOCUMENTATION

Requirements for Sampling Plan in PDD

33. PDDs for projects that rely on sampling for parameter value determination should include complete sampling plans. These plans should include:

- **Sampling Objective.** The plan should include the objective of the sampling effort, the time frame of the estimated parameter value(s), and confidence/precision criteria to be met. For example, the objective is determining the mean monthly value of parameter “X” during the crediting period, and with a 90/10 confidence/precision.
- **Field Measurement Objectives and Data to be collected.** The plan should clearly describe the variables and data to be collected, the scope and method of the survey or field measurements, their frequency, and how the data will be used.
- **Target Population and Sampling Frame.** The plan should describe the target population and the sampling frame summarizing their known characteristics.
- **Sample Method.** The sampling method should be presented.
- **Desired Precision/Expected Variance and Sample Size.** The plan should present and justify the target number of completed surveys or field measurements (the sample size). That justification should include a prediction of the variance of the parameters of interest and basis for that prediction. The plan must include formulas for calculating confidence and precision of determined parameter value.
- **Procedures for Administering Data Collection and Minimizing Non-Sampling Errors.** The plan should describe the procedures for conducting the data collection and/or field measurements including training of field personnel, provisions for maximizing response rates, documenting out-of-population cases, refusals and other sources of non-response, and related issues. An overall quality control and assurance strategy should be documented in the plan. This should include a procedure for defining outliers and under what circumstances outlier data/measurements may be excluded and/or replaced.
- **Implementation.** The schedule for implementing the sampling effort should be defined as well as indication of who will conduct the actual data collection and the analyses; include qualifications, experience and any potential conflicts of interest of those involved in the data collection and analyses.

Sampling Plan Evaluation Criteria

34. The proposed sampling plans will be evaluated based on whether they adequately address all of the issues and topics outlined in paragraph 33 and can provide parameter value estimates in an unbiased and reliable manner. Evaluation includes whether the proposed approach to sample is practical and likely to provide usable results given the available information about the population and the feasibility of developing the sample frame. The sampling approach will be evaluated for its adequacy in dealing with the range of sampling and non-sampling errors that may arise. The basis

for the forecasts of parameter value's variance will be assessed, along with the sufficiency of the proposed sample size given the minimum precision/confidence levels.

The sampling plan submitted by project proponents will be reviewed using to access a range of issues and questions, such as:

- Does the sampling plan present a reasonable approach for obtaining unbiased, reliable estimates of the variables?
- Is the data collection/measurement method likely to provide reliable data given the nature of the parameters of interest and project, or is it subject to measurement errors?
- Is the population clearly defined and how well does the proposed approach to developing the sampling frame represent that population? Does the frame contain the information necessary to implement the sampling approach?
- Is the sampling approach suitable, given the nature of the parameters, the data collection method, and the information in the sampling frame?
- Is the proposed sample size adequate to achieve the minimum confidence/precision requirements? Is the ex ante estimate of the population variance needed for the calculation of the sample size adequately justified?
- Are the procedures for the data measurements well defined and do they adequately provide for minimizing non-sampling errors? Is the quality control and assurance strategy adequate? Are there mechanisms for avoiding bias in the answer, including possible fraud?
- Are the persons conducting the sampling activities qualified?

References

The following are references to textbooks on survey sampling that are generally regarded as authoritative treatments of that subject:

Cochran, W.G. 1977, Sampling Techniques, 3d edn, Wiley, New York.

Dillman, D.A. 2007, Mail and internet surveys: the tailored design method, 2., 2007 update wi new internet, visual, a mix-mode guide edn, J. Wiley, Hoboken, N.J.

Groves, R.M. 2004, Survey methodology, J. Wiley, Hoboken, NJ.

Groves, R.M. 1989, Survey errors and survey costs, Wiley, New York.

Hansen, M.H. 1953, Sample survey methods and theory, Wiley, New York.

Harkness, J., de Vijver, F.J.R.v. & Mohler, P.P. 2003, Cross-cultural survey methods, J.Wiley-Interscience, Hoboken, N.J.

O'Sullivan, K., and Barnes, D. 2007, Energy Policies and Multi-topic Household Surveys Guidelines, World Bank.

Kish, L. 1995, Survey sampling, Wiley classics library edn, Wiley, New York.

Levy, P. & Lemeshow, S. 1999, Sampling of populations: methods and applications,New York ; Wiley, c1999.

Household Sample Surveys in Developing and Transition Countries, United Nations, 2005, ISBN 92-1-161481-3

Sampling Software Packages

Most statistical software packages have procedures for drawing samples. Widely used commercial packages include SAS, Stata, and SPSS. The UN report cited above reviews these packages and others. Other resources are summarized at the following websites, along with links to free software.

http://www.hcp.med.harvard.edu/statistics/survey-soft/#Online

http://www.freestatistics.info/stat.php

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History of the document

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