GHG QUANTIFICATION PROTOCOL FOR ENERGY EFFICIENCY IN COMMERCIAL AND INSTITUTIONAL BUILDINGS

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1. Project and Methodology Scope and Definition

This document establishes a protocol for the quantification of greenhouse gas (GHG) emission reductions, or carbon offsets, from eligible energy efficiency measures implemented in commercial and institutional buildings. This GHG quantification protocol can be used by project developers to quantify GHG emission reduction resulting from the implementation of energy conservation measures (ECM) in eligible facilities. This quantification protocol is written for those familiar with energy efficiency projects and implementation and monitoring of energy conservation measures. Some familiarity with, or general understanding of, the terminology, processes, standards and operation associated with these measures is expected.

1.1. Protocol Scope and Description

This quantification protocol is applicable to the quantification of direct and indirect GHG emission reductions resulting from the implementation of energy conservation measures (ECMs) in new commercial and institutional (CI) buildings or for the retrofit of existing buildings. More specifically, this protocol is applicable and designed to accommodate ECM related to heating, ventilating, air conditioning and lighting systems. Other types of ECMs (i.e. building envelope, tap water heating, elevators, occupant small electrical equipment, outdoor lighting, swimming pool pumping or heating) may also be quantified with this protocol. Examples of eligible buildings include but are not limited to:

- hotel/motel/resort
- retail malls and stores
- office buildings
- arenas
- hospitals and clinics
- schools and universities
- campus residences
- community centres
- library,
- fire/ambulance service.

The document also includes requirements on measurement and monitoring approaches and defines the minimum quality control and quality assurance procedures. FIGURE 1.1 offers a typical process flow diagram for a typical project.

Protocol Approach:

The GHG quantification protocol provides guidance on determining the energy baseline, comparing it to reporting period energy use and making appropriate adjustments for changing conditions affecting the baseline. FIGURE 1.2 offers a process flow diagram for a typical baseline. The guidance for determining energy savings follows methods published by the

Efficiency Valuation Organization in its International Performance Measurement and Verification Protocol (IPMVP) (the protocol can be obtained from www.evo-world.org). IPMVP is a recognized international standard for measuring, monitoring, and verifying energy savings. It provides guidance adhering to widely accepted fundamental principles of measurement & verification and should produce verifiable savings reports. Other sources of accepted good practice guidance referred to in this protocol are listed further below in this protocol.

The document offers two levels of rigour allowing users to select a simple or advanced approach. This flexibility allows users to maximize the GHG emission reductions quantified based on availability of data and budget. The simple approach requires less accurate data monitoring but in return utilizes more conservative quantification approaches therefore yielding les GHG emission reductions, while the advanced approach requires a more accurate and detailed monitoring approach but allows users to maximize the GHG emission reductions quantified and claimed.

The development of this quantification protocol included review of the following existing energy efficiency and GHG guidance documents:

1. ISO 14064-2:2006 Specification With Guidance at the Project Level for Quantification, Monitoring and Reporting of GHG Emission Reductions or Removal Enhancements
2. International Performance Measurement and Verification Protocol, Volume I, II and III (IPMVP)
3. ASHRAE Guideline 14-2002 Measurement Of Energy And Demand Savings
4. Model Energy Efficiency Program Impact Evaluation Guide under the US National Action Plan for Energy Efficiency, November 2007
5. GE-AES Greenhouse Gas Services (GHGS) Draft Energy Efficiency Methodology
6. Various energy efficiency related Approved Methodologies, Small Scale CDM Methodologies, and New Methodologies from UNFCCC CDM Executive Board's website as of January 2008.
7. The Alberta Protocol Development Process (Carbon Offsets Solutions website)
8. Environment Canada's Draft Guide to Quantification Methodologies and Protocols (March 2006)
9. Canada's Offset System for Greenhouse Gases- Guide for Protocol Developers-August 2008 (Draft)
10. Alberta Environment's Approved Quantification Protocol for Energy Efficiency Projects (September 2007, Version 1)
11. Alberta Environment's Draft Quantification Protocol for Commercial and Institutional Green Building Projects (January 2008)
12. Alberta Environment's Offset Credit Project Guidance Document-February 2008
13. Alberta Environment's Offset Credit Verification Guidance Document-September 2007
14. ANSI/ASHRAE Standard 90.1 - Energy Efficient Design of New Buildings Except Low- Rise Residential Buildings. (1999 & 2007 versions)

These documents may be reviewed to provide further information and additional detail pertaining to this protocol. The documents should be reviewed prior to quantification using this protocol to ensure that they are up to date and no major revisions have taken place.

FIGURE 1.1: Process Flow Diagram for Project Condition

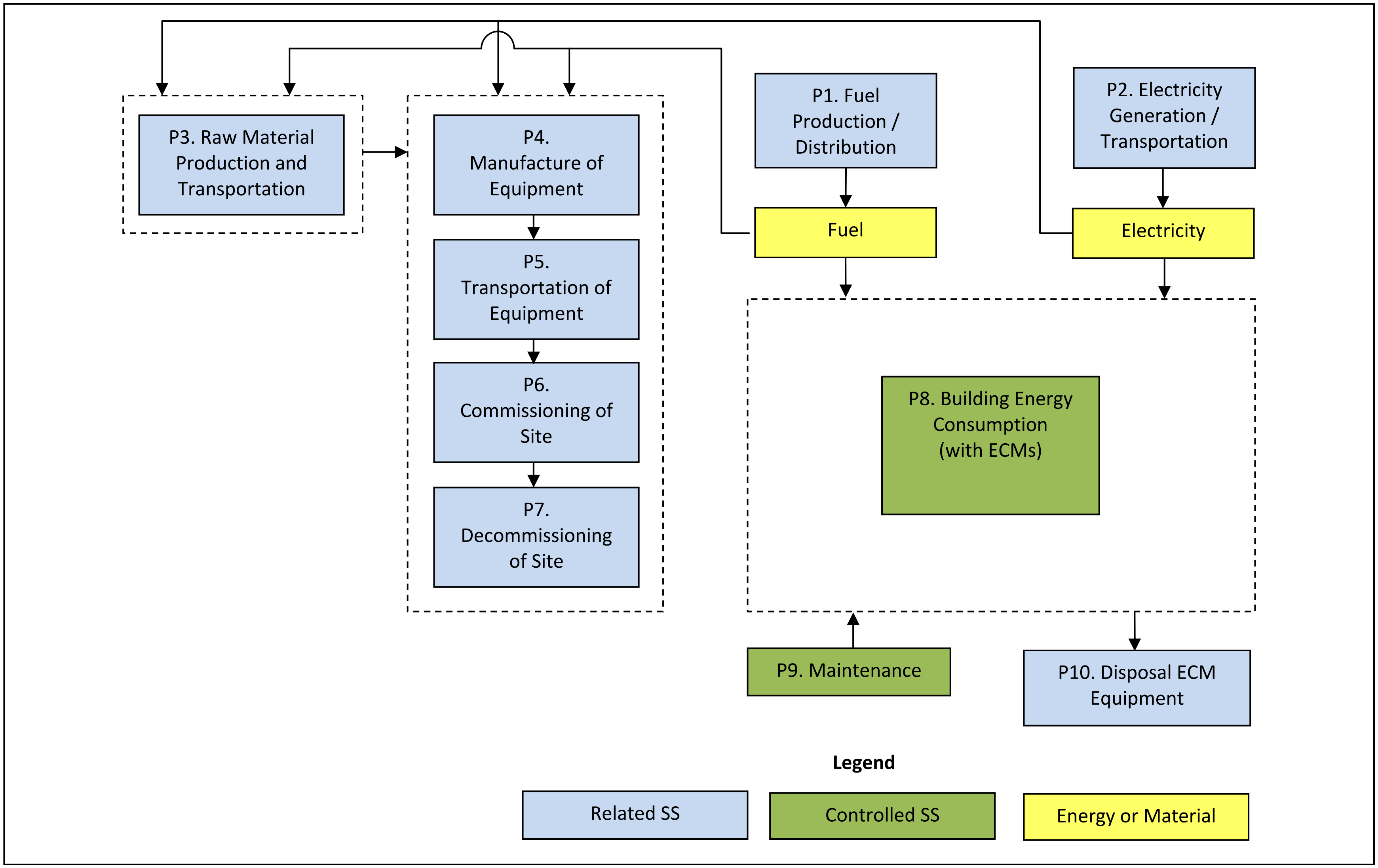
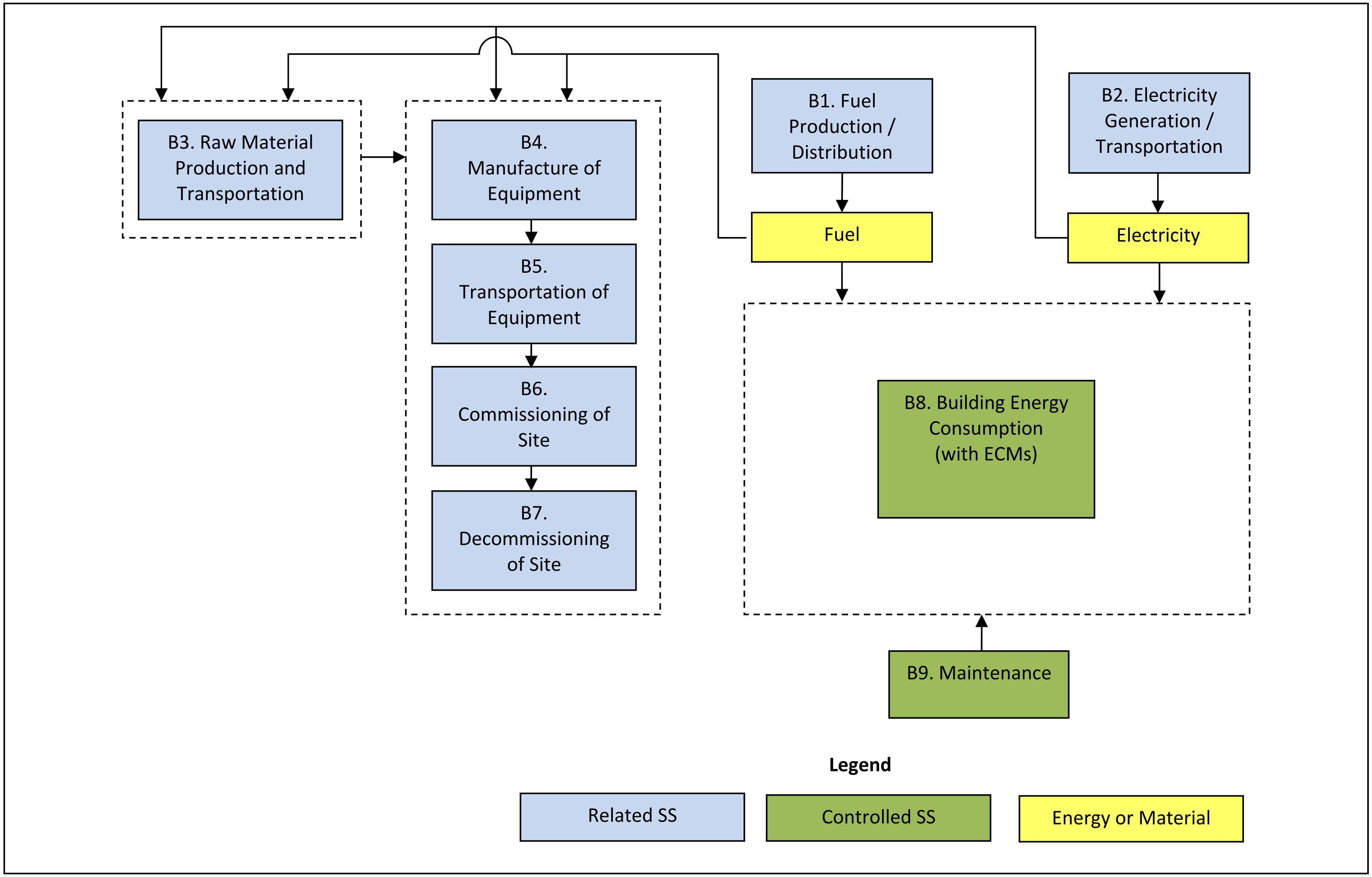


FIGURE 1.2: Process Flow Diagram for Baseline Condition



Protocol Applicability:

To demonstrate that a project meets the requirements under this protocol, the project developer must provide evidence that:

1. The new build or facility retrofits must rely on functionally equivalent inputs and outputs from the modified process as indicated by an affirmation from the project developer and project schematics;
2. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and
3. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset system.

Protocol Flexibility:

Flexibility in applying the quantification protocol is provided to project developers in the following ways:

1. Four (4) quantification options[1] are available to the project developers
    a. Option A – *Retrofit Isolation: Key Parameter Measurement*; Savings are determined by measurements of the key parameters which affect the energy use of the ECM-affected systems
    b. Option B – *Retrofit Isolation: All Parameter Measurement*; Savings are determined by measuring the energy use of the ECM-affected systems
    c. Option C – *Whole Facility*; Energy use for the entire facility is measured and any savings are calculated accordingly
    d. Option D – *Calibrated Simulation*; Energy use and savings are determined using an accurate and calibrated simulation of the facility

2. The protocol offers two levels of rigour:
    a. Simple Approach - prescribes conservative monitoring methods, computations and assumptions.
    b. Advanced Approach - requires a higher level of monitoring (and usually associated cost), and less conservative assumptions, which may allow eligible projects to deliver greater GHG credits to the market than the simple approach.

These two approaches are allowed in order to provide flexibility. They balance the level of detail in monitoring requirements with the degree of conservativeness in various calculations to ensure that GHG emission reduction quantified under each approach are comparable from the standpoint of quality and verifiability. If applicable, the proponent must indicate and justify why flexibility provisions have been used.

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[1] These options are described in more details further in the document

1.2. Glossary of New Terms

Adjusted-baseline energy	The energy use of the baseline period, adjusted to a different set of operating conditions (IPMVP Volume I, 2007)
Baseline Adjustments	The non-routine adjustments arising during the reporting period from changes in any energy governing characteristic of the facility within the measurement boundary, except the named independent variables used for routine adjustments. (IPMVP Volume I, 2007)
Baseline Energy	The energy use occurring during the baseline period without adjustments. (IPMVP Volume I, 2007)
Baseline Period	The period of time chosen to represent operation of the facility or system before implementation of an ECM. This period may be as short as the time required for an instantaneous measurement of a constant quantity, or long enough to reflect one full operating cycle of a system or facility with variable operations. (IPMVP Volume I, 2007)
Confidence Level	The probability that any measured value will fall within a stated range of precision. (IPMVP Volume I, 2007)
Constant	A term used to describe a physical parameter which does not change during a period of interest. Minor variations may be observed in the parameter while still describing it as constant. The magnitude of variations that are deemed to be 'minor' must be reported in the M&V Plan. (IPMVP Volume I, 2007)
Cycle	The period of time between the start of successive similar operating modes of a facility or piece of equipment whose energy use varies in response to operating procedures or independent variables. For example the cycle of most buildings is 12 months, since their energy use responds to outdoor weather which varies on an annual basis. Another example is the weekly cycle of an industrial process which operates differently on Sundays than during the rest of the week. (IPMVP Volume I, 2007)
ekWh (Equivalent kilowatt hours)	A non-electric energy use (e.g.fuel) is converted to the equivalent electrical energy quantity in kWh, using standard conversion factors.
Energy Conservation Measure (ECM)*	An activity or set of activities designed to increase the energy efficiency of a facility, system or piece of equipment. ECMs may also conserve energy without changing efficiency. Several ECM's may be carried out in a facility at one time, each with a different thrust. An ECM may involve one or more of: physical changes to facility equipment, revisions to operating and maintenance procedures, software changes, or new means of training or managing users of the space or operations and

	maintenance staff. An ECM may be applied as a retrofit to an existing system or facility, or as a modification to a design before construction of a new system or facility.
Estimate	A process of determining a parameter used in a savings calculation through methods other than measuring it in the baseline and reporting periods. These methods may range from arbitrary assumptions to engineering estimates derived from manufacturer's rating of equipment performance. Equipment performance tests that are not made in the place where they are used during the reporting period are estimates, for purposes of adherence with IPMVP. (IPMVP Volume I, 2007)
Functional Equivalence	The Project and the Baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement (such as the mass of beef produced, land area cropped, energy use/per unit of product) for comparison between the Project and Baseline activity (refer to the Project Guidance Document for the Alberta Offset System for more information).
Independent Variable	A parameter that is expected to change regularly and have a measurable impact on the energy use of a system or facility(IPMVP Volume I, 2007)
M&V Plan	Measurement and Verification Plan – Plan that focuses on the determination of energy savings following IPMVP guidance.
Measurement Boundary	A notional boundary drawn around equipment and/or systems to segregate those which are relevant to savings determination from those which are not (IPMVP Volume I, 2007)
Named Sites	Sites within a project which are listed within the project documents. They do not need to be near each other.
Non-Routine Adjustments	The individually engineered calculations to account for changes in static factors within the measurement boundary since the baseline period. When non-routine adjustments are applied to the baseline energy they are sometimes called just "baseline adjustments" (IPMVP Volume I, 2007). For this quantification protocol non-routine adjustments also account for changes in the "surplus" characteristics of the project.
Precision	The amount by which a measured value is expected to deviate from the true value. Precision is expressed as a "±" tolerance. Any precision statement about a measured value should include a confidence statement. For example a meter's precision may be rated by the meter manufacturer as ±10% with a 95% confidence level. (IPMVP Volume I, 2007)

Reporting Period	The period of time following implementation of an ECM when savings reports adhere to IPMVP... For this protocol the reporting period is also the crediting period.
Routine Adjustments	The calculations…made by a formula shown in the M&V Plan to account for changes in selected independent variables within the measurement boundary since the baseline period. (IPMVP Volume I, 2007)
Savings	The reduction in energy use… Physical savings (are) expressed as avoided energy use… Savings…are not the simple difference between baseline and reporting period utility bills or metered quantities. Site Energy: The energy quantity measured at an end user's site, without consideration of upstream energy delivery system's energy use. (IPMVP Volume I, 2007)
Static Factors	Those characteristics of a facility which affect energy use, within the chosen measurement boundary, but which are not used as the basis for any routine adjustments. These characteristics include fixed, environmental, operational and maintenance characteristics. They may be constant or varying. (IPMVP Volume I, 2007)

2. Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1. Identification of Sources and Sinks (SS's) for the Project

All SS's relevant to the project must be identified. In addition to on-site SS's, SS's upstream and downstream of the facility must also be identified.

Common SS's found in energy efficiency projects related to buildings include, but are not limited to:

- On Site fuel burning
- Materials manufacturing
- Transportation of equipment
- Electricity production (on-site or purchased from grid), fossil fuel production and delivery to the site
- Maintenance, construction and decommission (energy consumed during these activities)

Based on the good practice guidance documents identified earlier in this protocol and the following seven step procedure a list of relevant SS's, for typical projects eligible under this protocol, was identified and illustrated in a process flow diagram (FIGURE 1.1: Process Flow Diagram for Project Condition).

Procedure used for the identification of relevant SS's

The following procedure was used to identify relevant SS's for the project.

1. Identification of all SS's controlled or *owned* by the project proponent relevant to the primary project activities. Energy conservation measures (ECMs) may affect the following systems which impact the identified SSs:
    a. Heating,
    b. Ventilating,
    c. Air conditioning, and;
    d. Lighting systems

2. Identification of all SS's physically *related* to the primary project activities, by tracing products, materials and energy inputs/outputs upstream to origins in natural resources and downstream along their life-cycles. For example electricity production, fossil fuel production, etc...

3. Identification of all SS's affected by the project through consideration of the economic and social consequences of the project. This was achieved by looking for activities, market effects, and social changes that result from or are associated with the project activity, and documenting the associated GHG emissions.

4. For each identified SS's the parameters required to estimate or measure the greenhouse gases are determined including materials and energy inputs/outputs, and information on activities, products and services.

5. Determination of the function[2] provided by the system of SS's in order to assist in assessing equivalence of service between the project and the baseline scenario.

6. Aggregation or disaggregation of identified SS's. The number of SS's defined and the degree of detail presented is determined in large part by data availability and required level of accuracy.

7. Review system of SS's identified for the project by confirming that:
    a. all relevant SS's are identified;
    b. each SS is classified appropriately as controlled & owned, related or affected;
    c. all GHG inputs and outputs for each element are identified; and
    d. that the sequence of SS's for the system is correct.
    e. Repeat previous steps as necessary.

[2] The function is the products, goods and/or services provided by the SS's identified for the project scenario.

Justification for Procedure to Identify SS's for the Project

The seven step procedure identified above is a generic "streamlined life cycle assessment" used to identify types of activities (e.g. production, transportation, installation, operation, maintenance, utilization, decommissioning, etc.) and associated inputs and outputs that may be attributable to the project. This approach follows good practice guidance (ISO 14040 LCA series) and, therefore satisfies the principle of completeness, transparency and relevance ensuring all SSs relevant to the project are identified.

All SSs have been arranged by their relation to the project site and the time at which GHG emissions occur, as seen in FIGURE 2.1.

FIGURE 2.1: Project Element Life Cycle Chart

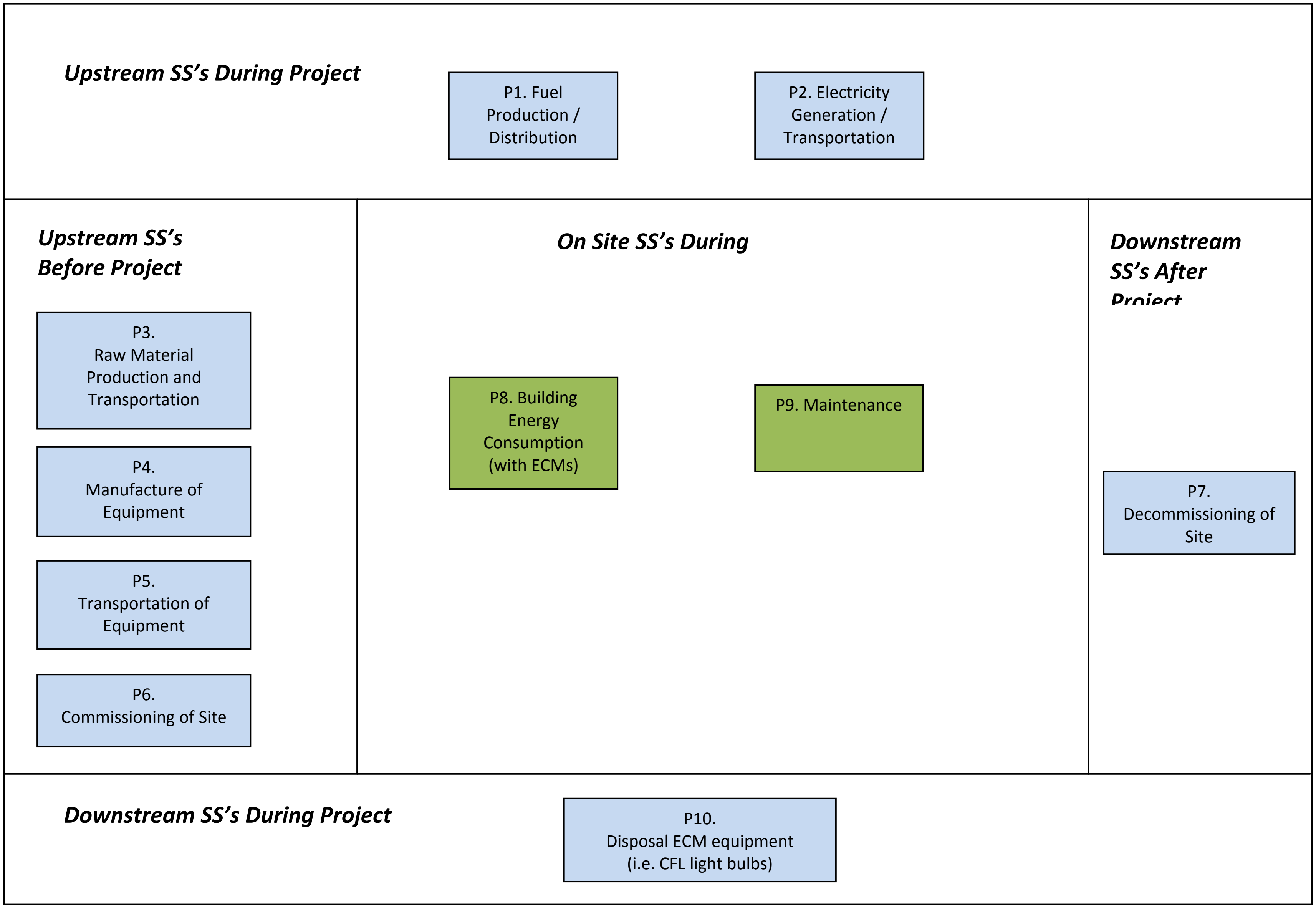


Figure 2.1 identifies and describes all relevant SS's for projects.

TABLE 2.1: Project SS's

Sources, Sinks and Reservoirs (SS's)	Description	Controlled, Related or Affected
Upstream Before Project Operation		
P3. Raw Material Production and Transportation	Raw materials, used in the manufacture of equipment for in the implementation of ECM and conventional building operation. Usually produced offsite and transported to the manufacturing facility. Emissions will arise from the use of fossil fuels and electricity during these processes. These raw materials may include but are not limited to cement, plastic, aluminum, steel, rubber, etc...	Related
P4. Manufacture of Equipment	GHG emissions will arise from the manufacturing process of the equipment to implement the ECMs and conventional building operation in the project. Such emissions will likely be associated with the fossil fuels and electricity consumed during the manufacturing process.	Related
P5. Transportation of Equipment	Equipment used in the implementation of the ECMs and conventional building operation must be transported to the project site. GHG emissions will primarily be attributed to the combustion of fossil fuels during the transportation process.	Related
P6. Commissioning of Site	The development of the site (technically on-site before project) and installation of equipment will result in GHG emissions, primarily from the use of fossil fuels and electricity during this process.	Related
Upstream During Project		
P1. Fuel Production/Distribution	The production and distribution of fuel used during building operations will result in GHG emissions. The volume and type of fuel will be required for GHG emission calculations, as will be the distribution distance.	Related
P2. Electricity Generation/Distribution	Building operations will require significant amount of electricity. The generation and distribution of electricity will result in GHG emissions. The quantity of electricity generated.	Related

On Site During Project Operation		
P8. Building Energy Consumption (with ECMs)	Energy (including fossil fuel and electricity) is required on-site to operate the building. Equipment utilizing this energy includes boilers, lighting systems, HVAC Systems, ventilation systems, etc...	Controlled
P9. Maintenance	The facility and systems within the facility will require maintenance (both routine and non-routine). GHG emissions will arise from the use of fuels and electricity in maintenance procedures.	Controlled
Downstream During Project Operation		
P10. Disposal of ECM Equipment	The disposal of some materials/equipment which compose all or a component of the ECM(s) may result in GHG emissions. E.g. the disposal of CFL light bulbs to appropriately remove mercury, disposal of transformer containing SF_6	Related
Downstream After Project Operations		
P7. Decommissioning of ECM equipment	Once the ECM equipment comes to the end of its life GHG emissions may arise from the incremental use of fossil fuels and electricity during equipment disassembly, disposal, and other required activities during the process, compared to the baseline.	Related

2.2. Identification of Baseline

The baseline is the most appropriate and best estimate of GHG emissions and removals that would have occurred in the absence of the project. In this protocol, Identification of the baseline scenario is presented for two distinct project types; retrofits to existing facilities and new buildings.

Baseline Scenario Identification for Existing Facilities

According to the IMPVP guidance, the baseline scenario for existing facilities is typically determined based on the historical data collected over the baseline period. IPMVP describes the baseline period as:

- "Representing all operating modes of the facility. This period should span a full operating cycle from maximum energy use to minimum. For example, building energy use is normally significantly affected by weather conditions, so a whole year's baseline data is needed to define a full operating cycle. Likewise the energy use of a …system (fan) may only be governed by a fixed occupancy pattern…, which varies on a weekly cycle. So one week's data would be all that is needed to define baseline performance. ECM planning may require study of a longer time period than is chosen for the baseline period. Longer study periods assist the planner in understanding facility performance and determining what the normal cycle length actually is."

- "Fairly represent all operating conditions of a normal operating cycle. For example, though a year may be chosen as the baseline period, if data is missing during the selected year for one month, comparable data for the same month in a different year should be used to ensure the baseline record does not under represent operating conditions of the missing month."
- "Include only time periods for which all fixed and variable energy-governing facts are known about the facility. Extension of baseline periods backwards in time to include multiple cycles of operation requires equal knowledge of all energy-governing factors throughout the longer baseline period in order to properly derive routine and non-routine adjustments…after ECM installation."
- "Coincide with the period immediately before commitment to undertake the retrofit. Periods further back in time would not reflect the conditions existing before retrofit and may therefore not provide a proper baseline for measuring the effect of just the ECM."

This type of baseline scenario is referred to in this protocol as an historical benchmark.

When parts of the projects involve change in operating procedures or replacement of failed equipment, the baseline energy use shall reflect the lowest energy usage level contained in the then prevalent laws, regulations, and legal obligations.

Baseline for New Facilities

For energy efficiency projects added to the design and construction of a new system or facility, the baseline is the lowest energy usage level reflected by the then prevalent laws, regulations and legal obligations. Local building codes may provide minimum requirements for the energy-efficient design of buildings which can be used as the baseline scenario[3]. ASHRAE Standard 90 and Canada's MNECB are examples of relevant building code referenced standards that can be used to determine the minimum requirement for building energy efficiency. The code or standard selected must be the version current at the time of building design. If the time of design is unclear (may be difficult to clearly identify), it will be deemed to be no more than 3 years before the commissioning of the building. The code/standard selected for the purpose of determining the baseline of new facilities must be identified and justified. Publication date and version number must also be clearly identified.

Procedure for the Baseline Scenario Selection

The procedure used to identify the baseline scenario for each type of project (retrofit and new facilities) is presented in Table 2.2 below. Various potential baseline scenarios were considered and assessed in order to determine the best available option.

[3] Refer to IPMVP Volume III, Part 1 (2006) Chapter 2, and Volume I (2007), section 4.10.4 for additional information on baselines for new facilities

A comparison of each potential baseline scenario is presented below. Potential types of baseline scenarios approaches evaluated include:

1. Historical benchmark: Typically site-specific and can be constructed to reflect reductions in a base period (such as the average emissions of the previous three years). This approach assumes that past trends in emissions and/or carbon stock changes will continue into the future.
2. Performance standard: Assumes the typical emissions profile for the industry or sector is a reasonable representation of the baseline. An assessment of comparable activities within a given industry or sector is necessary.
3. Comparison-based: Actual measurements of parameters from a control group (such as a plot of forested land, space heating natural gas consumption per square meter, etc.) to compare with the project. Emissions or removals from the control group are monitored throughout the project and compared with the emissions from the project site to determine the incremental reductions from the project. Such a control group can be used with more than one project.
4. Projection-based: Projections of reductions in the future can use a variety of techniques, from simple straight-line growth assumptions to complex models. Forward-looking projections can be specified in terms of a set of constant parameters or can vary over time according to pre-defined procedures.

The baseline scenario approach most appropriate for this protocol was determined based on expected project types in the building sector, typical data availability and good practice guidance for the energy efficiency sector, more specifically the International Performance Measurement and Verification Protocol, Volume I, II and III (IPMVP). The possible baseline approaches are presented in Table 2.2, below, in hierarchal order (i.e. “historic benchmark” is the preferred approach, while “performance standard” may be used if “historic benchmark” is not feasible, etc.). Any departure from the hierarchal order must be justified appropriately.

Table 2.2: Assessment of Potential Baseline Scenario Approaches

Possible Baseline	Rational For	Rational Against
Historic Benchmark	• Accurate, historical data is available for an appropriate operating periods • Historical data in conjunction with baseline adjustments best represents the conditions that would have taken place had the project not been implemented • According to the IMPVP guidance, the baseline scenario for existing facilities is typically determined based	• Accurate, historic information may not be available because the facility is new or historical data has not been recorded accurately • A historic benchmark assumes that past predominant energy use patterns will continue into the future and, under current circumstances, this is unlikely

	on the historical data collected over the baseline period.	
Performance Standard	• Historical data for the facility is not available • Available performance standard are used throughout the industry and accurately represents common industry practice • Good practice guidance (i.e. MNECB, ASHRAE) can provide minimum requirements for the energy-efficient design and can be used as a conservative baseline scenario	• Does not necessarily represent the conditions that would have taken place at the facility had the project not been implemented, but rather the conditions that would typically take place in the industry • In some cases, a performance standard for the relevant project type may not be readily available
Comparison-Based	• For a new facility, in the absence of a performance standard, a comparison-based baseline from a comparable building built by the same owner for the same purpose, with the same level of occupancy may provide an accurate representation of energy use had the project not been implemented	• No accurate comparison exists for this type of facility/project • More accurate baseline approaches can be available for this project
Projection-Based	• In the absence of both a performance standard and accurate comparison, a project-based methodology provides the more accurate baseline scenario	• In most cases, projections are not as accurate as other readily available baseline conditions • Often, more accurate baseline approaches for this type of project are available

Justification of Baseline Scenario Selected for Retrofit Projects
The evaluation of the potential baseline approaches performed and the guidance provided in IPMVP strongly support selecting an historical baseline scenario approach. Therefore the default baseline scenario approach selected for this protocol related to retrofit projects is the historical baseline approach.

Justification for Baseline Scenario Selected for New Building

The evaluation of the potential baseline approaches performed strongly support the use of a performance standard (or the lowest energy usage level contained in the then prevalent laws, regulations and legal obligations-i.e. MNECB, ASHRAE) for projects related to new buildings/facilities. Since historical data is not available, the best option left to project proponents to determine GHG emissions from the baseline scenarios is a conservative approach following the lowest energy usage level contained in regulations. In these cases good practice guidance or standards (including, but not limited to MNECB, ASHRAE) provide minimum requirements for the energy-efficient design of buildings can be used as the performance standard. The selection of the appropriate edition of the standard or building is left to the protocol user but require justification to ensure that the relevant version is used based on the project/building characteristics and year of design and/or commissioning.

Baseline Scenario Adjustments[4]

The baseline scenario identified for the projects eligible under this quantification protocol may require adjustments to ensure functional equivalence with the project. These adjustments are usually performed when the energy savings are quantified. In many cases, the quantification and claims of GHG emission reductions will occur on a yearly basis, therefore these adjustments will need to be performed according to that same schedule.

Typical adjustment includes routine adjustments and non-routine adjustments as defined below.

Routine Adjustments of the Baseline

IPMVP provides the following guidance on performing routine adjustments. "for any energy-governing factors, expected to change routinely during the reporting period, such as weather… A variety of techniques can be used to perform the adjustments. Techniques may be as simple as a constant value (no adjustment) or as complex as a several multiple parameter non-linear equations each correlating energy with one or more independent variables. Valid mathematical techniques must be used to derive the adjustment method." Users of the protocol are strongly encouraged to review IPMVP volume for examples of routine adjustments.

Non-Routine Adjustments of the Baseline

IMPVP provides the following guidance on performing non-routine adjustments "for those energy-governing factors which are not usually expected to change, such as: the facility size, the design and operation of installed equipment, or the type of occupants. These static factors must be monitored for change throughout the reporting period."

Non-Surplus Adjustments of the Baseline

[4] Appendix A of IMPVP Volume 1 contains examples of routine and non-routine adjustments that may be useful for users of this protocol to review.

Non-routine adjustments are defined to also include any necessary adjustments to the baseline arising from changes in the 'surplus' status of the project or parts thereof. During the reporting period, baseline data must be adjusted for any parts of the project which become non-surplus.

Surplus projects are defined has ECMs that were not required by law, regulation or legal obligation. However, if any change occurs to such requirements after the project was installed, project eligibility (or surplus) may change. Therefore any necessary non-surplus adjustment must be made to the baseline.

A common situation warranting a non-surplus baseline adjustment arises when a project replaces equipment with more efficient equipment, but ahead of its normal end of life date. Up to its normal end of life date, the savings would be surplus and therefore determined relative to the historical baseline. However after this date, the baseline becomes the efficiency standard prevailing at the time of the retrofit.

To enable non-surplus baseline adjustments, the project design document must report the:

- original installation date and normal lifetime of all equipment that is replaced under the project. Normal lifetime data should come from referenced independent sources.
- energy standards inherent in any relevant laws, regulations, legal obligations and common products or practices used in the industry, as of the date of the retrofit.

Ongoing reporting of savings must make non-surplus adjustment beginning with the date of change in surplus status, such as the date of a relevant new regulation or the notional end of life dates of relevant sections of the retrofit. These adjustments must bring the baseline level to that of the standard that was in place at the time of project design. (If the project only installed equipment meeting those standards, the baseline equals the project energy use, and there are no further eligible savings.)

2.3. Identification of SS's for the Baseline

Historical Benchmark and Performance Standard

All SS's relevant to the baseline scenario selected must be identified. In addition to on-site SS's, SS's upstream and downstream of the facility must also be identified.

Common SS's found in energy efficiency projects related to buildings include, but are not limited to:

- On Site fuel burning
- Materials manufacturing
- Transportation of equipment
- Electricity production (on-site or purchased from grid), fossil fuel production and delivery to the site
- Maintenance, construction and decommission (energy consumed during these activities)

All SS's have been arranged by their relation to the project site and the time at which GHG emissions occur, as seen in FIGURE 2.1 .

FIGURE 2.2: Baseline Element Life Cycle Chart

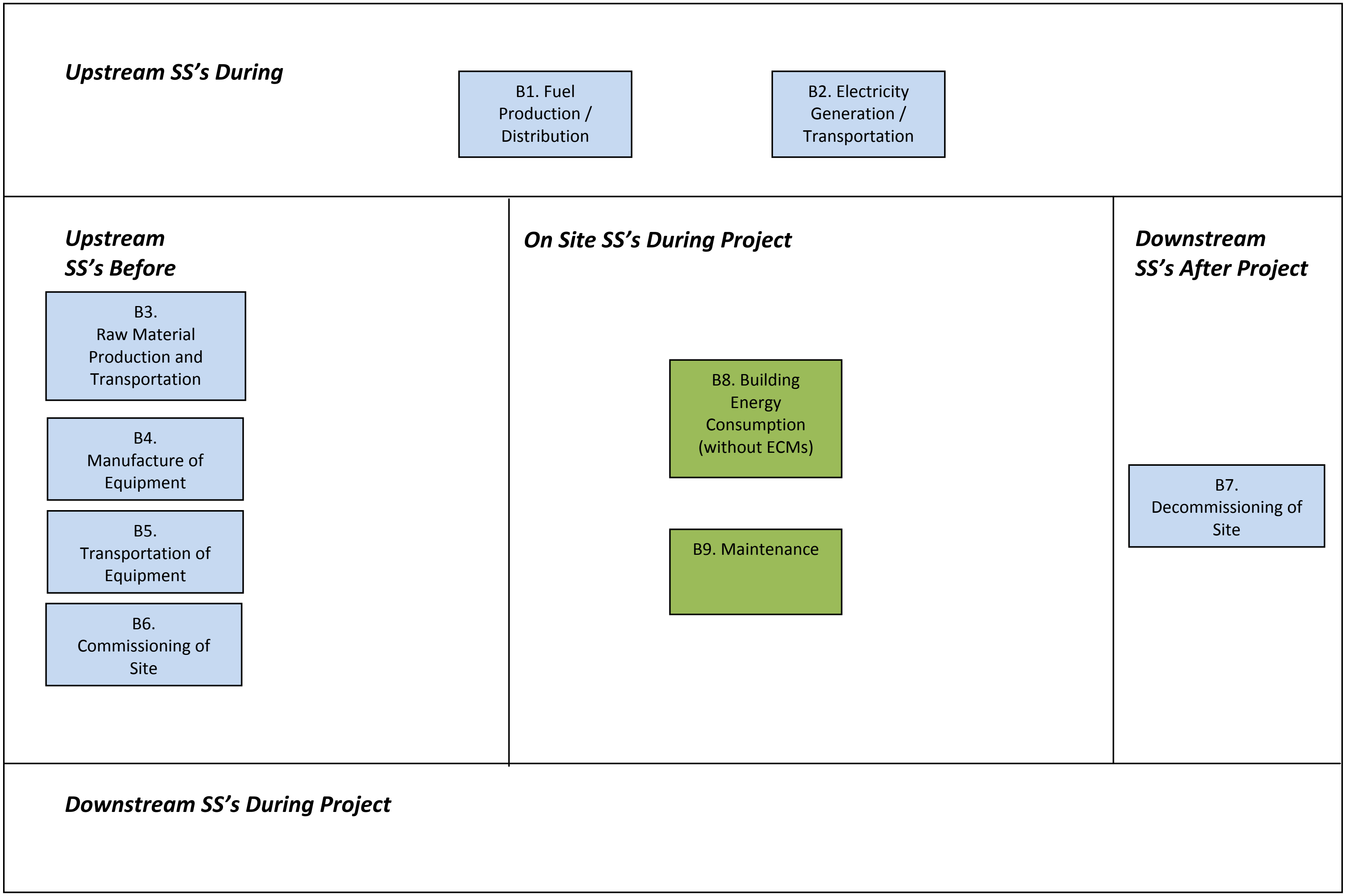


Table 2.3 Identifies and describes all relevant SS's for the baseline scenario.

TABLE 2.3: Baseline SS's

Sources, Sinks and Reservoirs (SS's)	Description	Controlled, Related or Affected
Upstream SS's Before Project Operation		
B3. Raw Material Production and Transportation	Raw materials, used in the manufacture of equipment for in the implementation of ECM and conventional building operation. Usually produced offsite and transported to the manufacturing facility. Emissions will arise from the use of fossil fuels and electricity during these processes. These raw materials may include but are not limited to cement, plastic, aluminum, steel, rubber, etc...	Related
B4. Manufacture of Equipment	GHG emissions will arise from the manufacturing process of the equipment to implement the ECMs and conventional building operation in the project. Such emissions will likely be associated with the fossil fuels and electricity consumed during the manufacturing process.	Related
B5. Transportation of Equipment	Equipment used in the implementation of the ECMs and conventional building operation must be transported to the project site. GHG emissions will primarily be attributed to the combustion of fossil fuels during the transportation process.	Related
B6. Commissioning of Site	The development of the site (technically on-site before project) and installation of equipment will result in GHG emissions, primarily from the use of fossil fuels and electricity during this process.	Related
Upstream SS's During Project Operation		
B1. Fuel Production/Distribution	The production and distribution of fuel used during building operations will result in GHG emissions. The volume and type of fuel will be required for GHG emission calculations, as will be the distribution distance.	Related
B2. Electricity Generation/Distribution	Building operations will require significant amount of electricity. The generation and distribution of electricity will result in GHG emissions. The quantity of electricity generated as well as the location and source (if available)	Related

	of the electricity generation will be required.	
On Site SS's During Project Operation		
B8. Building Energy Consumption (without ECMs)	Energy (including fossil fuel and electricity) is required on-site to operate the building. Equipment utilizing this energy includes boilers, lighting systems, HVAC Systems, ventilation systems, etc...	Controlled
B9. Maintenance	The facility and systems within the facility will require will require maintenance (both routine and non-routine). GHG emissions will arise from the use of fuels and electricity in maintenance procedures.	Controlled
Downstream SS's During Project Operation		
None		
Downstream SS's After Project Operations		
B7. Decommissioning of Site	Once the site is no longer in operation, the site will most likely need to be decommissioned. GHG emissions will arise from the use of fossil fuels and electricity during equipment disassembly, disposal, and other required activities during the process.	Related

2.4. Selection of Relevant Project and Baseline SS's

The following procedure illustrated in FIGURE 2.3 was applied to determine if each identified SS for the baseline and the project was relevant and to determine if it is necessary to quantify the GHG emissions by direct monitoring or estimation. This procedure was adapted from Canada's Offset System for Greenhouse Gases – Guide for Protocol Developers (August 2008-Draft version).

FIGURE 2.3: Decision Tree for the Selection of Relevant SS's

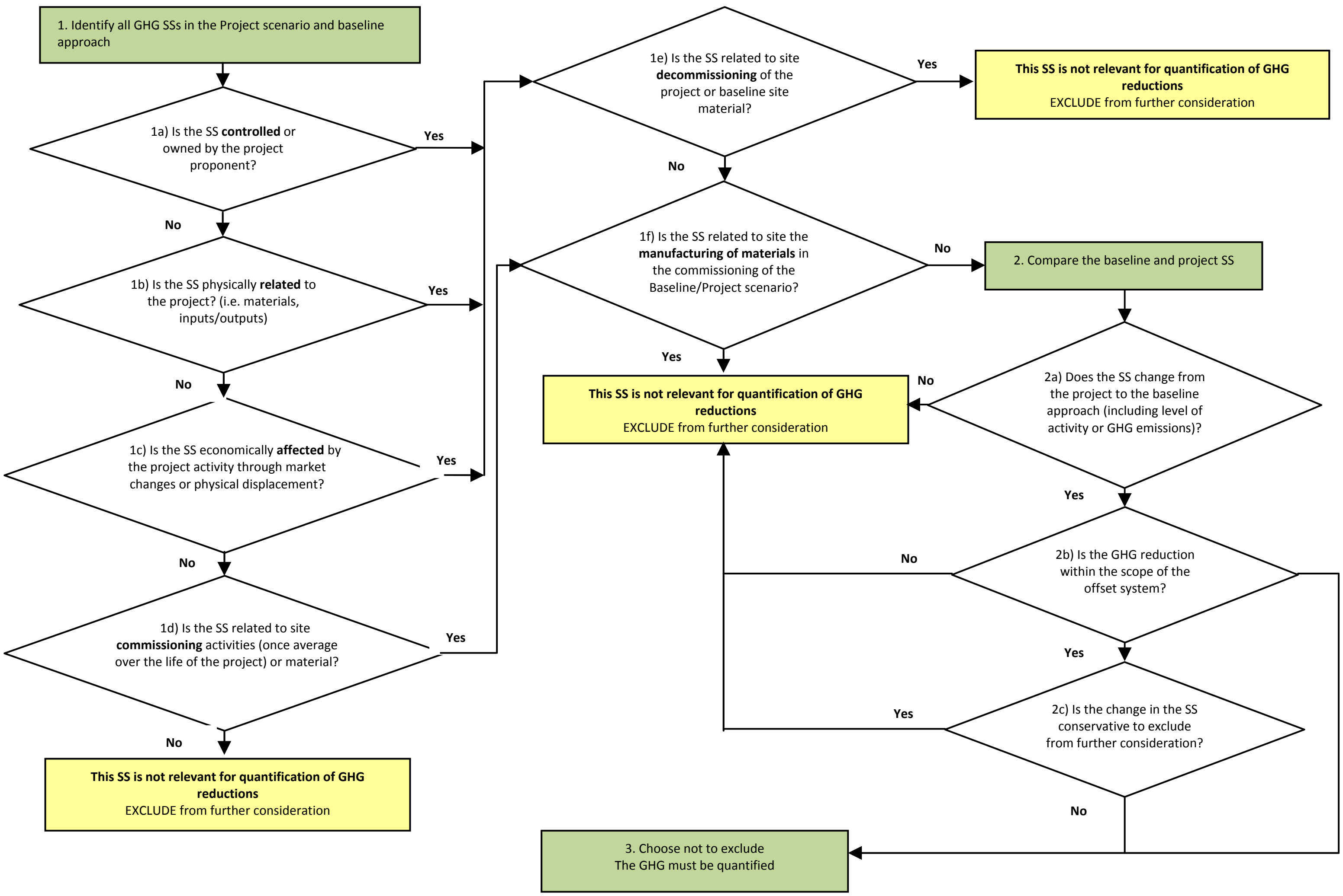


TABLE 2.4: Comparison of SS's

Identified SS's	Baseline (C, R, A)	Project (C, R, A)	Included or Excluded	Justification for Exclusion
Upstream SS's				
P1/B1 Fuel Production/Distribution	Related	Related	Excluded	Excluded since emissions from fuel production/distribution are expected to be greater under the baseline condition†
P2/B2 Electricity Generation/Distribution	Related	Related	Excluded	Excluded since emissions from electricity generation/distribution are expected to be greater under the baseline condition†
P3/B3 Raw Material Production and Transportation	Related	Related	Excluded	Excluded as per good practice guidance from Environment Canada; FIGURE 2.3–Box 1d, in addition these GHG emission are expected to be insignificant over the course of the project.
P4/B4 Manufacture of Equipment	Related	Related	Excluded	Excluded as per good practice guidance from Environment Canada; FIGURE 2.3–Box 1d, in addition these GHG emissions are expected to be insignificant over the course of the project.
P5/B5 Transportation of Equipment	Related	Related	Excluded	Emissions from transportation of equipment are not expected to be material given the long project life and the minimal transportation of equipment typically required.
P6/B6 Commissioning of Site	Related	Related	Excluded	Emissions from the commissioning of the site are not material given the long project life and minimal construction

				typically required for ECM implementation.
On Site SS's				
P8/B8 Building Energy Consumption (with ECMs/without ECMs)	Controlled	Controlled	Included	N/A
P9/B9 Maintenance	Controlled	Controlled	Included	N/A
Downstream SS's				
P7/B7 Decommissioning of Site	Related	Related	Excluded	Excluded as per good practice guidance from Environment Canada; FIGURE 2.3–Box 1e, in addition these GHG emissions are expected to be insignificant over the course of the project.
P10 Disposal of Equipment for ECM	N/A	Related	Excluded	Excluded as emissions from equipment disposal are expected to be minimal‡

†In the case that the project results in increased fuel consumption or increased electricity consumption, GHG emissions from this SS will be higher for the project scenario than baseline and must be quantified and subtracted from gross GHG reductions.
‡Sources of GHG emissions from ECM equipment/material must be reviewed as inclusion should be determined on a case-by-case basis. Any GHG emissions from this SS should be noted and quantified or excluded with justification while other environmental impacts should be noted.

2.5. Quantification of Reductions, Removals and Reversals of Relevant SS's

2.5.1. Quantification Approaches

The project may generate GHG emission reductions through the introduction of eligible energy savings which affect the GHG emission output of the project SS's. Eligible energy savings are comprised of energy reductions achieved through the implementation of a project, and not through a decrease in operating capacity.

The project's GHG emission reductions are quantified for each energy type (i) saved as:

$$\textbf{GHG Emission Reduction}_i = \sum (\textbf{Eligible Energy Savings}_i \times \textbf{Emission Factor}_i)$$

Where:

Eligible Energy Savings$_i$ come from the procedures defined below, for each energy type i

Emission Factor$_i$ comes from the procedures defined in this section of the protocol and Section 3, for each energy type i.

GHG emission reductions shall be expressed in metric tonnes of CO_2 equivalent.

Determination of Energy Savings

Quantification of GHG emission reduction is performed based on the energy savings created by the project (difference between the baseline scenario and the project). The IPMVP suggests four (4) energy savings quantification options, defined in section 0 of this protocol. Should IPMVP Option A or Option B be applied, secondary effects (described in Section 0) must be taken into consideration.

According to the IPMVP "energy savings cannot be directly measured, since savings represent the absence of energy use. Instead, savings are determined by comparing measured use…before and after implementation of a program, making suitable adjustments for changes in conditions." For this Quantification protocol the energy savings are calculated according to the following formula taken from IPMVP:

Energy Savings = "Adjusted Baseline" Energy – "Reporting Period" Energy +/- "Non Routine Adjustments" of baseline energy to reporting period conditions

Where,

"Adjusted Baseline Energy" is defined as the baseline energy plus any routine adjustments needed to adjust it to the conditions of the reporting period."

“Baseline energy”, “Routine Adjustments”, and “Non routine Adjustments” are discussed and defined below in this section of the protocol.

Typical baseline information required includes the following:

- energy consumption values with meter reading intervals at various locations depending on quantification option selected (A, B, C or D);
- static factors: “energy governing characteristics of the facility which do not normally change. For example: building size shape, type of usage, fixed schedules, indoor temperatures , light levels, ventilation rates, equipment nameplate data”[5]; and
- independent variables: “energy governing characteristics of the facility and its use or environment which are expected to routinely change.” For example: weather, occupancy, etc...

Options for Determining Energy Savings

The energy savings equation presented in above can be applied following 4 different options as defined by IPMVP and summarized in Table 2.5: Site Savings Determination Options, presented below.

[5] From IPMVP Volume I, 2007

Table 2.5: Site Savings Determination Options[6]

IPMVP Option	How Savings Are Calculated	Typical Applications
A. Retrofit Isolation: Key Parameter Measurement Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the ECM's affected system(s) and/or the success of the project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated (need to evaluate the savings uncertainty associated with the estimation versus the savings uncertainty associated with actual measurements)	Engineering calculation of baseline and reporting period energy from: • Short-term or continuous measurements of key operating parameter(s); and • Estimated values. Routine and non-routine adjustments as required. Interactive effects must be examined to accurately determine net energy savings.	A lighting retrofit where power draw is the key performance parameter that is measured periodically. Estimate operating hours of the lights based on building schedules and occupant behaviour.
B. Retrofit Isolation: All Parameter Measurement Savings are determined by field measurement of the energy use of the ECM-affected	Short-term or continuous measurements of baseline and reporting-period energy,	Application of a variable-speed drive and controls to a motor to adjust pump flow.

[6] From IPMVP Volume 1, April 2007, page 19

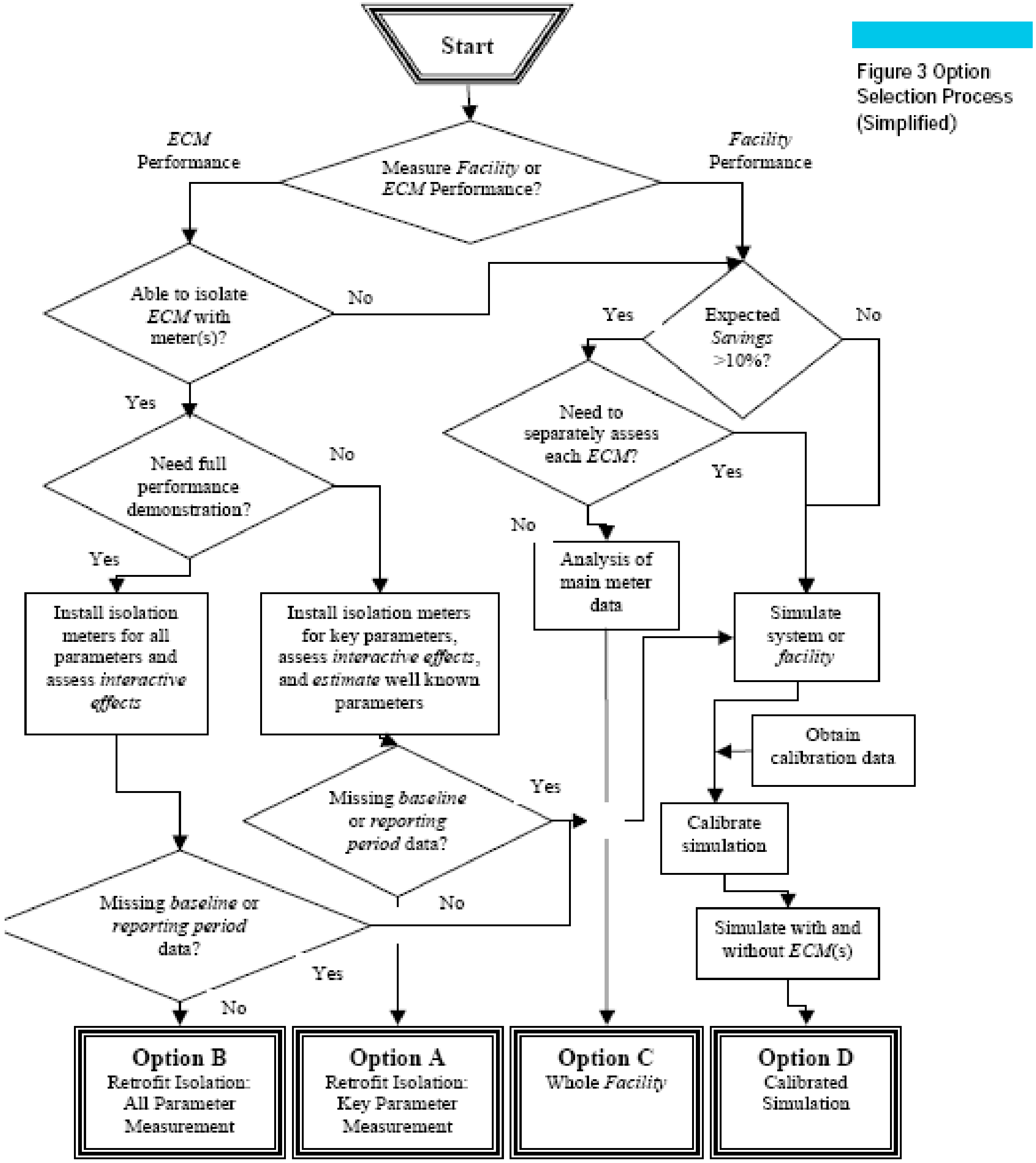
system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period.	and/or engineering computations using measurements of proxies of energy use. Routine and non-routine adjustments as required. Interactive effects must be examined to accurately determine net energy savings.	Measure electric power with a kW meter installed on the electrical supply to the motor, which reads the power every minute. In the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.
C. Whole Facility Savings are determined by measuring energy use at the whole facility or sub-facility level. Continuous measurements of the entire facility's energy use are taken throughout the reporting period.	Analysis of whole facility baseline and reporting period (utility) meter data. Routine adjustments as required, using techniques such as simple comparison or regression analysis. Non-routine adjustments as required.	Multifaceted energy management program affecting many systems in a facility. Measure energy use with the gas and electric utility meters for a twelve month baseline period and throughout the reporting period.
D. Calibrated Simulation Savings are determined through simulation of the energy use of the whole facility, or of a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the facility. This Option usually requires considerable skill in calibrated simulation. (see IPMVP volume 1- Section 4.10.1 titled "Option D: Types of Building Simulation Programs" for examples of simulation software)	Energy use simulation, calibrated with hourly or monthly utility billing data. (Energy end use metering may be used to help refine input data.)	Multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period. Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation. Baseline energy use, determined using the calibrated simulation, is compared to a simulation of reporting period energy use.

Table 2.5 is only a brief summary of the four options presented in IPMVP. Additional guidance provided in volume 1 and 3 of the IPMVP may be useful to project proponent in developing the project document associated with their projects.

Guidance on Option Selection

IPMVP states that the selection of the option is a decision based on various factors including project conditions, analysis required, budget and professional judgment. The following figure (from IMPVP volume 1) presents a diagram meant to assist project developers in determining which option is best suited for their type of project.

FIGURE 2.4: IPMVP Suggested Option Selection Process



In addition IPMVP provides the following table to further assist project developers in selecting an option. Table 2.6 presents key characteristics that suggest commonly favoured options.

Table 2.6: Suggested Option Selection Based on Project Key Characteristics

Table 3 Suggested (not the only) Options - Marked by X

ECM Project Characteristic	Suggested Option			
	A	B	C	D
Need to assess *ECMs* individually	X	X		X
Need to assess only total facility performance			X	X
Expected *savings* less than 10% of utility meter	X	X		X
Multiple *ECMs*	X		X	X
Significance of some *energy* driving variables is unclear		X	X	X
Interactive effects of ECM are signficant or unmeasurable			X	X
Many future changes expected within *measurement boundary*	X			X
Long term performance assessment needed	X		X	
Baseline data not available				X
Non-technical persons must understand reports	X	X	X	
Metering skill available	X	X		
Computer simulation skill available				X
Experience reading utility bills and performing regression analysis available			X	

Secondary Effects for Option A and B (sometimes D): Retrofit Isolation

The application of the retrofit isolation techniques requires that no significant energy effects be excluded from the measurement boundary. When the measurement boundary is selected, care should be taken to ensure that energy flows affected by the ECM but outside the measurement boundary are considered. The project document must list all potential effects of an ECM (positive or negative) on any energy stream, along with an estimate of the likely annual savings magnitude of each. The method of estimating each listed impact must be described, noting the factors affecting the accuracy of each estimate.

The largest energy effect must be measured. All other secondary energy effects must be treated as described below[7].

1. The secondary energy effects associated with the ECMs listed in Table 2.7 must be measured or estimated depending on the approach (simple or advanced) selected.

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[7] Taken from GHGS Draft Energy Efficiency Methodology

2. If all secondary effects which individually have an impact less than 10% of the primary effect, have a combined net effect of *reducing* energy savings by 5% or more, advanced approaches must be used.

3. For all secondary effects and ECMs not covered by 1) or 2) above, the following rules govern the measurement or estimation of interactive effects for simple and advanced approaches when applying Options A or B.

A) For Simple Approaches:

- Measure any single secondary effect that is estimated to be greater than:
  i. 10%, of the primary effect (positive or negative), where the net estimated energy impact of all ECM secondary effects would *increase* savings by more than 30%, or
  ii. 30% of the primary effect (positive or negative)
- Estimate all other secondary effects which *reduce* savings; and
- Ignore all other secondary effects.

B) For Advanced Approaches:

- Measure all secondary effects equal to or larger than 10% of the primary effect. Estimate all other secondary effects.

Table 2.7: Minimum Interactive Effect Treatment[8]

ECM	Simple Approach	Advanced Approach
	Estimated Secondary Effects	**Measured Interactive Effects**
Electric to fuel conversion	Fuel	Fuel
Lighting efficiency improvement or operating period reduction	Heating, Cooling	
High efficiency electric motor	Motor speed effect on system and horsepower needs	Motor speed effect on system and horsepower needs
High efficiency boiler or furnace	Less heat recovered elsewhere	Less heat recovered elsewhere
High efficiency refrigeration or chilling compressor system	Condenser fan, pump	Condenser fan
Heat recovery device	Load on associated air or water circulation systems	Load on associated air or water circulation systems

Savings Accuracy Requirements and Eligibility Multiplier Factors

[8] Table adapted from Draft GHGS Energy Efficiency Methodology

Depending on the approach chosen by the project proponent; simple or advanced, a multiplier factor must be applied to the energy savings calculated. This multiplier is applied to ensure that GHG emission reductions are not over-estimated due to uncertainty related to monitoring techniques selected. Since the advanced approach requires more accurate data to be collected the multiplier factor will be less stringent for project proponent utilizing this approach.

Eligible Energy Savings = Energy Savings * M

Where,

Energy Savings are derived from the equation at the beginning of Section 0

M is an Eligibility Multiplier factor determined as described towards the end of this section of the protocol.

Simple Approach Accuracy Requirements

Minimum requirements governing accuracy of different activities are defined below, for simple approaches.

Table 2.8: Minimum Accuracy Requirements - Simple Approach

<table>
<tr><th>Meter Type</th><th>Confidence Interval</th><th>Precision</th><th>Additional Information</th></tr>
<tr><th colspan="4">Measurement</th></tr>
<tr><td>Whole facility energy meters</td><td>N/A</td><td>N/A</td><td>Utility Quality Metering</td></tr>
<tr><td>Electrical sub-meters</td><td rowspan="10">95%</td><td>±2%</td><td rowspan="9">No more than 15% of the expected measured values will exceed the selected meter’s range, and no more than 1% of the expected measured values will exceed it by more than 20% the meter’s range maximum or minimum.</td></tr>
<tr><td>Liquid flow meters</td><td>±10%</td></tr>
<tr><td>Liquid flow meters (used to compute energy flow)</td><td>±3%</td></tr>
<tr><td>Air flow meters</td><td>±10%</td></tr>
<tr><td>Air flow meters (used to compute energy flow)</td><td>±3%</td></tr>
<tr><td>Steam flow meters</td><td>5%</td></tr>
<tr><td>Simple temperature</td><td>3%</td></tr>
<tr><td>Differential temperature readings with matched sensors</td><td>0.5%</td></tr>
<tr><td>Pressure or differential pressure</td><td>3%</td></tr>
<tr><td>Operating hours</td><td>0.1%</td><td></td></tr>
<tr><th colspan="4">Random Sampling</th></tr>
</table>

Random sampling	80%	±20%	Provide statistical analysis of all quantifiable uncertainties.
Modeling			
Regression models	R^2 static of 0.8 or higher		
	t statistic independent variable of 1.8 or higher		

If measured data comes from an independent source (e.g. government weather data, electricity grid emission factor accepted by Alberta Environment) precision is presumed ±0%.

Special circumstances for option A and C:

Option A: In addition, any parameter(s) estimated in IPMVP Option A must be selected to yield savings that are lower than would be obtained from 90% of the probable actual values of the estimated item. [9]The project design document must present the range of possible values, their likely distribution, and the statistical analysis to justify the selection.

Option C :(without the on/off test method[10]):

- there can be no gaps in the baseline record;
- there shall be a minimum of 9 valid energy meter readings during the baseline period;
- no baseline data points can be excluded;

Accuracy & the Advanced Approach

Minimum requirements are defined below, for advanced approaches.

- The project design document shall present full analysis of all quantifiable uncertainties expected in the energy savings reports. This analysis must use good statistical techniques[11].
- Average savings must have an expected ±10% precision at 90% confidence or better, assuming savings are achieved as planned.
- When using Calibrated Simulation Option D1[12], the Coefficient of Variation of the Root Mean Squared Error or CV (RMSE)[13] of deviations between actual calibration energy data and the simulation model's predicted energy data must be less than 15% if using monthly calibration data, or 30% if using hourly data[14].

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[9] 90% of all values in a normally distributed range are above a value that is 1.28 standard deviations below the mean (z = 1.28, see standard normal distribution tables). Example – Under Option A, measured chiller efficiency improvement will be multiplied by estimated annual cooling load. Suppose the plausible values of annual cooling loads ranged between 2,000,000 ton-hours and 2,500,000 ton hours and can be assumed to be normally distributed over the range. The mean is 2,250,000 ton-hours. Assuming the 500,000 ton-hours range represents 99% of all possible values (and six standard deviations), one standard deviation is 83,300 ton-hours. The mean is 2,250,000 ton-hours. So, 1.28 standard deviations below the mean is 2,250,000 – (1.28 * 83,300) = 2,140,000 ton-hours. The estimated load should be 2,140,000 ton-hours, or lower to satisfy the 90% criterion.

[10] Refer to IMPVP volume 1 for detailed description of on/off test method

[11] IPMVP Vol I, 2007, Appendix B, gives some basic guidance on statistical concepts relevant to energy savings reports, but does not define all aspects of statistical analysis.

[12] Refer to IMPVP volume 1 for detailed description of Calibrated Simulation Option D Method 1.

[13] See IPMVP Vol I 2007, Appendix B-2.2.2

[14] See ASHRAE Guideline 14-2002 Section 5.3.2.4.f for examples of error ranges although these are not the only acceptable values but rather examples to guide the users

Eligibility Multipliers for Simple Approaches
For simple approaches, the Eligibility Multiplier is 0.90. This ensures a conservative energy savings calculation when using the simplified approach. [15]

Eligibility Multipliers for Advanced Approaches
For advanced approaches, the Eligibility Multiplier is 1.0.

GHG Emission Factors
The GHG emission factors are taken from Environment Alberta. GHG emission factors accepted by Alberta Environment are provided in Table 3.1.

2.5.2. Contingent Data Approaches

Contingent means for calculating or estimating the required data are outlined in the simple approach.

2.6. Management of Data Quality

2.6.1. Record Keeping

For energy efficiency projects, the monitoring plan will be specific to the ECMs implemented and the energy savings quantification approach selected. The monitoring plan shall be designed based on the accuracy requirements presented in this protocol.

Measurement system design and installation shall follow best practice in the industry, as defined in relevant standards and by the manufacturer of the measurement, communication and logging equipment.

Meters shall be selected and operated to meet the accuracy requirements specified in this protocol for both the simplified and the advanced approach.

The monitoring plan shall include, at a minimum, for all parameters measured:

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[15] The 0.90 eligibility multiplier was determined based on the following: Monitoring and quantification procedures prescribed for the simple approaches (particularly selection of secondary effects), are designed to err on the conservative side in order to not over-estimate GHG emission reductions. The EE industry has found that monitoring and verification of "acceptable" quality can be done at a cost of 3% of annual savings for large projects over several years. "Acceptable" in this case can be defined in terms of buyers and sellers of ESCO services being comfortable with the amounts to be paid under a performance contract. The industry also gives guidance that monitoring &verification costs should not exceed 10% of savings. However, for the purpose of a GHG transaction due to incremental revenue and public interest, we might consider 10% of savings as a guidepost for what might be paid for an Advanced approach, recognizing the need for greater confidence when dealing with the atmosphere rather than 'acceptability' to buyer and seller of ESCO services. So, simple approaches may have monitoring & verification costs of 2-3% of the savings, and advanced approaches closer to 10%. The requirements prescribed herein for both approaches aim to achieve this balance. So project developers or protocol users may see a net savings differential of 7-8% by moving from the simple to advanced methods. The 10% discount (0.9 multiplier) on the carbon value of simple approaches aims to offset some of the extra costs of advanced approaches (plausibly 10% of the annual energy savings), encouraging serious consideration of advanced approaches. The incremental amount of GHG emission reductions that can be claimed by moving from the simple approach to the advanced approach will have to be assessed for each project, in order to determine if the additional effort and cost associated with the advanced approach is worth pursuing from a net value perspective.

- Purpose of measurement, type of meter, units or measure, physical location, frequency of measurement
- Manufacturer of sensor, model, serial number
- Frequency of regular reading or polling of the sensor
- Memory capacity of any instrument temporarily storing data,
- Contingency procedures in case of memory overflow
- Meter reading process (if reading are done manually)
- Manufacturer of data logger, model, serial number
- Sensor and logger range and precision
- The expected range of values to be measured
- Frequency of calibration, calibration method
- Maintenance procedures
- Address of data telemetry point, archive place for data and frequency of archiving
- Monitoring/measurement roles and responsibilities

Meter systems may be designed to measure an accumulated quantity, or an instantaneous quantity by regular periodic sampling. Accumulating meters can have their values read on an irregular basis without impeding the quality of the resultant data because they report cumulative energy. However when instantaneous readings are taken periodically, the frequency of meter reading is critical to the quality of the resultant data. The measurement period for instantaneous quantities must be matched to the rate of change of the quantity.

When periodically sampling the values of a quantity by instantaneous rather than cumulative measurement, the project design document must show the expected rate of rate of change of the quantity. It must also show how the selected measurement frequency allows the net measurement error to meet the accuracy requirements of the simple or advanced approach.

Measurements may also be made by statistically valid random sampling of a group of many similar devices or systems operating in similar ways. The mean of the readings from such random samples can be taken as valid readings of the entire group, providing the random sampling error meets the requirements of the simple or advanced approach.

Project proponent shall keep the information listed in Table 2.9 for the time period stated. All information must be available to the verifier upon request.

Table 2.9: Recordkeeping Requirements

Kept for Duration of Project's GHG Credit-Production
Raw baseline period energy data, independent variable data, and static factors within the measurement boundary
A record of all adjustments made to raw baseline data with justifications
All analysis of baseline data used to create mathematical model(s)
All data and analysis used to support Option A estimates

Expected end of life date of equipment removed or renovated under the project
Efficiency standards or common practices relevant to each ECM at the date of project commitment
Metering equipment specifications (model number, serial number, manufacturer's calibration procedures)
Kept for 5 Years After Generation
Raw reporting period energy data, independent variables, and static factors within the measurement boundary
A record of changes in static factors and non-surplus characteristics along with all calculations for non-routine adjustments
If Calibrated Simulation Option D1 is used: all input data, output data. Also the software name and version number, if public domain software is used. If private software is used (even if available for purchase), a copy of the software must remain available for the verifier's free use and evidence retained of why it is suited to the simulation task
All calculations of energy savings, emission factors and GHG emission reductions
Measurement equipment maintenance activity logs
Measurement equipment calibration records
Initial and annual verification records and audit results

2.6.2. Quality Assurance/Quality Control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

- Protecting monitoring equipment (sealed meters and data loggers);
- Protecting records of monitored data (hard copy and electronic storage);
- Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
- Comparing current estimates with previous estimates as a 'reality check';
- Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
- . Establish minimum experience and requirements for operators in charge of project and monitoring; and
- Performing recalculations to make sure no mathematical errors have been made.

3. Appendix A – Emission Factors for Electricity Generation and Fuel Combustion

Table 3.1 lists the most recent emission factors available for typical energy used in buildings. Project proponents using this protocol must ensure they utilize the most recent available emission factors. More specific emission factors (i.e. site specific emission factors) can be used but must be justified.

Table 3.1: GHG Emission Factors Accepted by Alberta Environment

Emission factor	Value			
Electricity				
Alberta Electricity Grid	0.650 [t CO_2e/kWh]			
Combustion				
Fuel	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
Natural gas	1891[g CO_2/m^3]	0.037[g CH_4/m^3]	0.035[g N_2O/m^3]	0.001903 [t CO_2e/m^3]
#2 Fuel Oil	2725[g CO_2/L]	0.026[g CH_4/L]	0.031[g N_2O/L]	0.002735 [t CO_2e/L]
Diesel	2663[g CO_2/L]	0.133[g CH_4/L]	0.4[g N_2O/L]	0.002790 [t CO_2e/L]

Other required emission factors, such as those for the production of raw materials, may be acquired from the Environment Canada National Inventory Report or, if not listed in the Inventory Report, a life cycle database (such as SimaPro). Should a required emission factor not be available from this source, an emission factor from another source may be used if justified appropriately.

Sources of Emission Factors Listed in Table 3.1

Electricity – Emission factor developed and approved by Alberta Environment, will be updated on a on-going basis

Natural Gas – Environment Canada National Inventory Report, Table A12-1: Emission Factors for National Gas and NGLs; Residential, Construction, Commercial/Institutional, Agriculture

#2 Fuel Oil – Environment Canada National Inventory Report, Table A12-2: Emission Factors for Refined Petroleum Products; Light Fuel Oil; Forestry, Construction, Public Administration, and Commercial/Institutional

Diesel - Environment Canada National Inventory Report, Table A12-2: Emission Factors for Refined Petroleum Products; Diesel

Note: It is the responsibility of the project developer to ensure that all emission factors used for quantification purpose are the most recent.

4. Appendix B – Key Steps for Protocol Users

Key Steps for Energy Efficiency Protocol Users

1. Determine and evaluate all ECMs for the project
2. Determine if the ECMs/project are eligible under the protocol
3. Identify all project SS's, including those upstream and downstream (i.e. material production, disposal) if relevant
4. Select baseline quantification approach
5. Identify all baseline SS's, including those upstream and downstream (i.e. material production, disposal) if relevant
6. Determine what adjustments may need to be applied to the baseline to allow for accurate comparison between project and baseline (routine and non-routine adjustments)
7. Select and justify quantification approach (IPMVP Option A, Option B, Option C, or Option D)
8. Gather required data and factors for quantification
9. Following method selected in Step 6, quantify energy consumption for project and baseline as well as eligible energy savings
10. Using the energy savings determined in Step 9 and appropriate emission factors, quantify GHG reductions resulting from project (consider if GHG emission must be netted out of GHG emission reductions quantified due to increase in energy consumption in the project compared to the baseline, or due to disposal of ECM equipment)
11. Develop monitoring and QA/QC procedures
12. Develop GHG project report