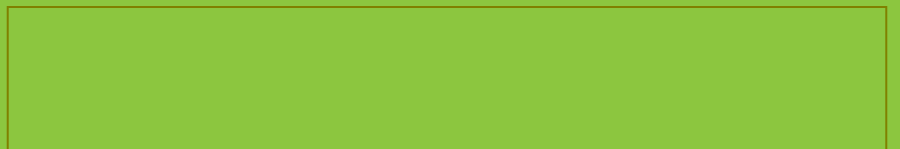


QUANTIFICATION PROTOCOL FOR DISTRIBUTED RENEWABLE ENERGY GENERATION

Draft Version 1.4

January 2012



Disclaimer:

The information provided in this document is intended as guidance only and is subject to periodic revisions. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and applicable legislation for all purposes of interpreting and applying the law. In the event that there is a discrepancy between this document and the *Specified Gas Emitters Regulation* or other legislation, the *Specified Gas Emitters Regulation* and other legislation prevail.

All Quantification Protocols approved under the *Specified Gas Emitters Regulation* are subject to periodic review as deemed necessary by the Department, and will be re-examined at a minimum of every 5 years from the original publication date to ensure methodologies and science continue to reflect best-available knowledge and best practices. Any updates to protocols occurring as a result of the 5-year and/or other reviews that are not due to legal requirements will apply at the end of the first credit duration period for applicable project extensions and for all new projects coming forward.

Where a project condition differs from approved government methodologies, or the project developer is unclear on protocol interpretation relative to their specific project, the project developer must contact Alberta Environment to discuss an appropriate interpretation and receive approval for any methodology changes prior to undertaking the project.

Any comments, questions, or suggestions regarding the content of this document may be directed to:

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Alberta Environment Related Publications

Climate Change and Emissions Management Act
Specified Gas Emitters Regulation
Specified Gas Reporting Regulation

Alberta's 2008 Climate Change Strategy

Technical Guidance for Completing Annual Compliance Reports
Technical Guidance for Completing Baseline Emissions Intensity Applications
Additional Guidance for Cogeneration Facilities
Technical Guidance for Landfill Operators

Technical Guidance on Third Party Verification¹
Supplemental Bulletin on Validation and Verification

Technical Guidance for Offset Project Developers
Technical Guidance for Offset Protocol Developers
Quantification Protocols (<http://environment.alberta.ca/1238.html>)

¹ Alberta Environment is developing guidance for third party verification.

1.0 Offset Project Description

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This quantification protocol is written for aggregators of grid-connected solar or wind electricity generators where the generating unit has a rated electrical power generating capacity of less than 1 MW, and where the generating unit is connected to the consumer end of a utility electric distribution system. A generating unit meeting these requirements is cited as a “renewable energy system” for the purpose of this protocol. Some familiarity with, or general understanding of, the operation of distribution-connected renewable energy systems is expected.

This protocol can be used to quantify avoided greenhouse gas emissions due to the project activities which involve switching the electricity source at the grid-connected facilities to renewable energy systems that have lower GHG intensity. The GHG emissions are avoided when all or part of electricity at the grid-connected project sites is substituted by a lower-emitting generation source. In addition, because distribution-connected sources of electricity are in the vicinity to the load, the project’s generated energy does not have the same amount of line losses inherent to long-distance transmission and distribution of electrical energy. Below 1 MW the line losses from renewable energy systems are anticipated to be negligible.

1.1 Protocol Scope

This protocol sets up general guidance for project proponents in order to meet the measurement, monitoring, and GHG quantification, verification/validation for avoided GHG emissions resulting from the installation of renewable energy systems. Figure 2 explains the process flow diagram of a typical project.

GHG credits that this protocol generates occur when renewable energy systems installed on grid-connected facilities start generating electricity on-site and thereby displace higher GHG intensity electricity from fossil-fired generating facilities. Conventional generation such as coal-fired facilities, are generators that are connected to the electric transmission system (cited as a “transmission-connected generating plant”, or “transmission generator” for the purpose of this protocol). By contrast, decentralized electricity generators such as solar photo-voltaic systems and small wind generation systems are typically connected to the downstream portion of electricity distribution infrastructure (cited as a “distribution-connected generation system” for the purpose of this protocol). The quantification is based on the difference between the GHG intensities of the two electricity sources. GHG reductions are achieved due to substitution of lower intensity electricity sources and avoiding electricity with high GHG intensity and the line losses associated with transporting such power to consumers.

The project sites must receive their electricity from the Alberta grid for the duration of the project, and must comply all applicable laws and regulations, including the Climate

Change Emissions Management Act (CCEMA)², the Specified Gas Emitters Regulation (SGER)³ and conform to the guidelines set out in the Technical Guidance for Offset Protocol Developers⁴ and Technical Guidance for Offset Project Developers⁵.

Alberta Environment & Water prescribes the baseline intensity of grid electricity for the purpose of calculating offsets, which is published in the Technical Guidance Document for Protocol Developers. The value at time of publishing of this protocol is 0.65 tonnes CO₂e/MWh.

This protocol quantifies avoided GHG emissions as a result of the substitution of Alberta grid-electricity with that of renewable energy systems with lower or almost negligible GHG emissions. This protocol is specifically limited to solar PV collectors and wind energy collectors that have no on-site GHG emissions.

Mathematically this can be represented as follows:

$$ER_y = BE_y - PE_y - L_y$$

Where, ER_y is the emissions reduction in year y . BE_y and PE_y are the baseline and project emissions respectively. L_y is the leakage in year y . Leakage occurs when the implementation of an activity or project shifts emissions upstream or downstream of the project boundary. Since the electricity generated from renewable energy systems is either consumed on-site or within the immediate vicinity, there is generally little to no leakage anticipated from project conditions related to this protocol. The embodied energy in renewable energy system equipment is typically small, and is typically similar to, or lower than the embodied energy of conventional energy production systems, and therefore not material for the purpose of calculating offsets. Therefore, there is no leakage anticipated from distributed solar PV and small wind turbines in Alberta.

Since the project is to displace grid electricity by renewable energy systems, the primary GHG affected by the project activities is CO₂. However, the Alberta grid represents a variety of electricity generating sources including coal, natural gas, and diesel; therefore NO_x, SO_x, VOCs, unburned hydrocarbons (HC), particulate matter and mercury emissions are affected.

Due to the losses of electricity inherent in transmission and distribution in Alberta of an average of 7.7%, for every kilowatt hour (1 kWh) of energy consumed at a household, 1.077 kWh must be produced by a transmission-connected generator. Therefore for every kWh that a distribution-connected generator supplies, a factor of 1.077 should be multiplied to calculate the total system offsets. See Appendix A for a detailed explanation of line losses in Alberta's electricity system.

² http://www.qp.alberta.ca/574.cfm?page=C16P7.cfm&leg_type=Acts&isbncln=9780779740956

³ <http://environment.gov.ab.ca/info/library/7811.pdf>

⁴ <http://environment.gov.ab.ca/info/library/8331.pdf>

⁵ <http://environment.gov.ab.ca/info/library/7915.pdf>

1.2 Protocol Applicability

To demonstrate that the project meets the requirements under this protocol, the project proponent must supply sufficient evidence to demonstrate that:

1. the sites are connected to the Alberta grid for their electricity requirements
2. the sites are located in Alberta
3. the renewable energy systems may connect to the grid under Alberta Regulation 27/2008 (i.e. the Micro-Generation Regulation and AUC Rule 024) and/or AUC Rule 007 Part 4 (Small Power Plants under 1 MW)
4. the activities are not mandated by law or regulation and are not business as usual

Greenhouse gas emission reductions are one of many environmental benefits associated with renewable energy systems. Other ancillary benefits include expanding Alberta's generation capacity, can reduce infrastructure demands on specific feeders in certain circumstances; and placing the value of electricity generation and consumption in the consumer's hands thus improving awareness and encouraging energy efficient practices.

1.3 Protocol Flexibility

There is limited flexibility in applying the quantification protocol due to the prescribed baseline and zero or near zero project emissions. However, project developers may choose among three methods for quantifying project activities (see Section 3.1). Where fewer than all of the sites are tracked for quantification, justification must be provided explaining how the sample adequately reflects the performance of the total population of distributed generation installations.

If flexibility provisions are applied, the proponent must describe the provisions used, and justify their application through detailed method, calculations, and all supporting documentation.

1.4 Glossary of New Terms

Electricity Grid: Infrastructure that transports electrical energy from generating plants to end users through long-distance high-voltage transmission systems between the generators and distribution systems, and lower-voltage distribution systems between the transmission systems and the individual customers.

Micro-Generation: To be eligible under this protocol, a generating unit must employ "Renewable or alternative energy" meeting the definition of electric energy generated from solar and wind energy collection for grid-tied electricity generation systems:

- a) Solar photovoltaic (PV) technologies generate direct-current electricity directly from the energy in solar radiation using a semi-conductor electronic material. A

solar PV system consists of an array of solar photovoltaic modules plus a grid-dependent inverter. Each solar PV module consists of multiple solar cells in which the cell converts solar energy into DC electricity via the photovoltaic effect.

- b) Micro-wind generation is a rotary device on a vertical or horizontal axis that extracts energy from the wind. When the mechanical energy absorbed from the wind is converted to electricity, the machine is called a wind turbine generator or turbine.

Micro-Generation Generating Unit:

The characteristics that define eligibility of a grid-connected renewable energy system for the purpose of this protocol are that it:

- exclusively uses sources of renewable or alternative energy (limited to solar and wind sources) for electricity generation;
- has a total nominal capacity not exceeding 1 MW, and;
- is located on an electricity customer's site and is owned or leased by the electricity customer

Alberta Electricity Grid:

The Alberta Electricity grid is a system of conductors through which electrical energy is transmitted and distributed throughout the province. This electricity grid is an interconnected network of high voltage transmission and lower voltage distribution for delivering electricity from suppliers (generators) to consumers across the province.

Line losses:

Line loss represents the electric energy converted to heat and dissipated into the local environment in the process of transporting it over wires. Line losses can be separated into two categories: transmission system losses and distribution system losses.

2.0 Baseline Condition

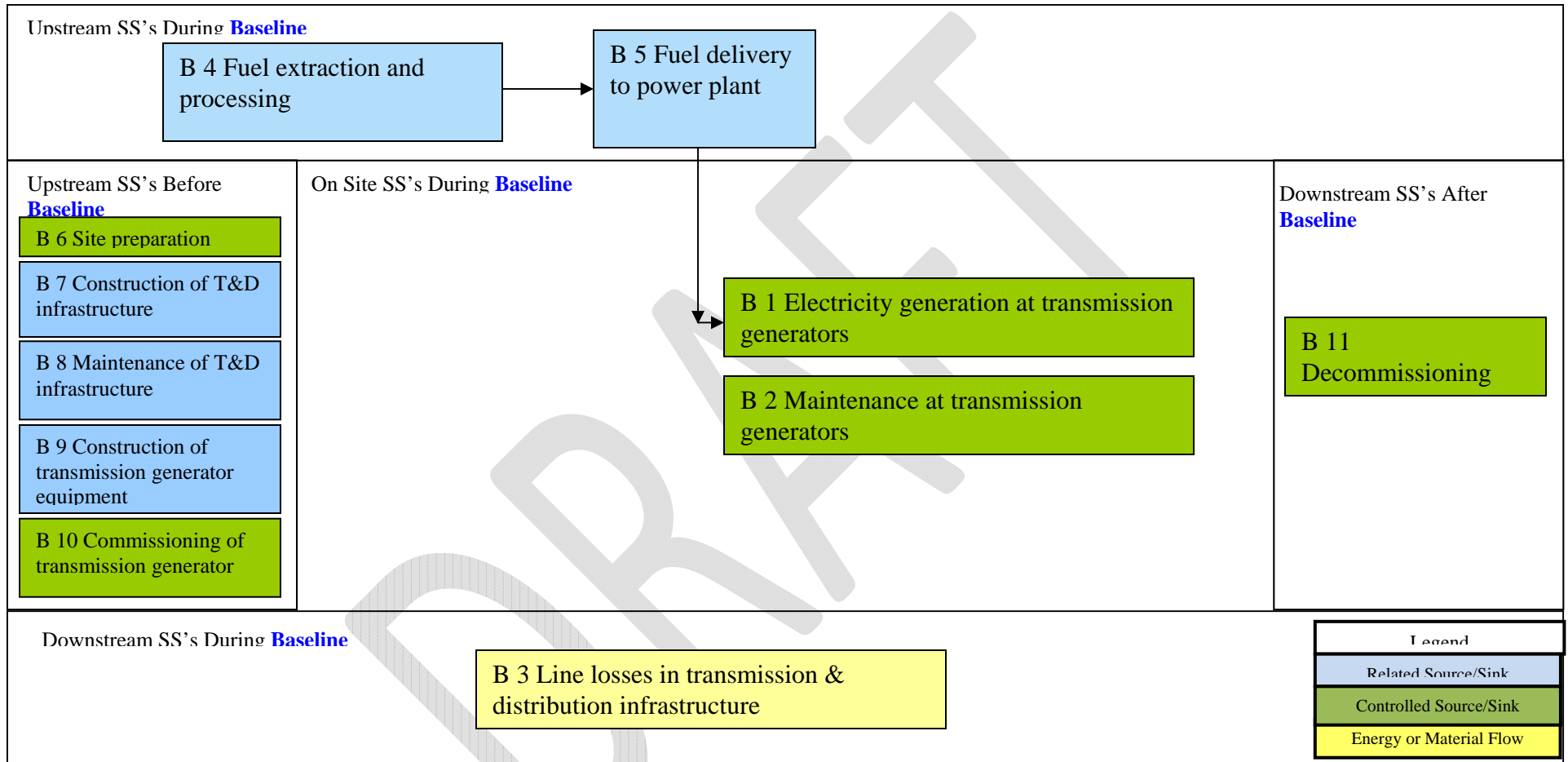
The baseline condition reflects consumption of Alberta grid electricity, which is characterized predominantly by fossil-fuel-fired generation with natural gas used for some base load plus most of the peaking capacity, smaller amounts of wind, hydro and negligible amounts of solar electricity.

For the purposes of energy efficiency offset protocols in Alberta, a conservative figure is used as the baseline for calculating offsets. This conservative value reflects the lower GHG intensity of the generating units used at peak times, which is characterized largely by natural gas. The baseline value is set by Alberta Environment for all renewable energy based GHG reduction projects and is published in the Technical Guidance Document for Protocol Developers.

It is anticipated that Alberta's electric system will continue to operate in much the same manner for a foreseeable future; although there will be the addition of low-emitting or non-emitting generation, the bulk of electricity generation will still be fossil-fuel based. Therefore the grid intensity for offset protocols will be updated from time to time to reflect material changes in baseline conditions.

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Figure 1: Process Flow Diagram for the Project Baseline



2.1 Identification of Baseline Sources and Sinks

Sources and sinks for an activity are assessed based on Guidance provided by Environment Canada and are classified as follows:

- Controlled:** The behavior or operation of a controlled source and/or sink is under the direction and influence of a Project Developer through financial, policy, management, or other instruments.
- Related:** A related source and/or sink has material and/or energy flows into, out of, or within a project but is not under the reasonable control of the project developer.
- Affected:** An affected source and/or sink is influenced by the project activity through changes in market demand or supply for projects or services associated with the project.

Projects under this protocol involve generating electricity on-site with technologies that harness energy from solar and wind resources that by their nature do not cause the release of greenhouse gases from fossil sources into the atmosphere within project conditions. By contrast, baseline conditions involve producing electricity via a range of pathways, predominantly represented by the combustion of coal or natural gas (from fossil, or subterranean carbon sources), which are released as process gases (exhaust) made up in large part by carbon dioxide into the atmosphere (or biosphere; the region in which humans and other life exists on Earth). In addition to the carbon in fuel, the baseline condition reflects emissions from fuel exploration, extraction, processing and transportation.

Some energy, and therefore greenhouse gases, are embodied in the equipment used to generate electricity from fossil or renewable energy systems,. This embodied energy is similar or lower in the project condition than the baseline, and is therefore not included in project GHG calculations. Such embodied energy is upstream and before the project condition. Site preparation, transportation, commissioning emissions and site maintenance are similarly deemed lower in the project condition (even on a normalized basis) and are therefore not material and also upstream of the project condition. Decommissioning of facilities is downstream and after the project condition and therefore not included in project conditions.

Figure 2: Baseline Sources and Sinks

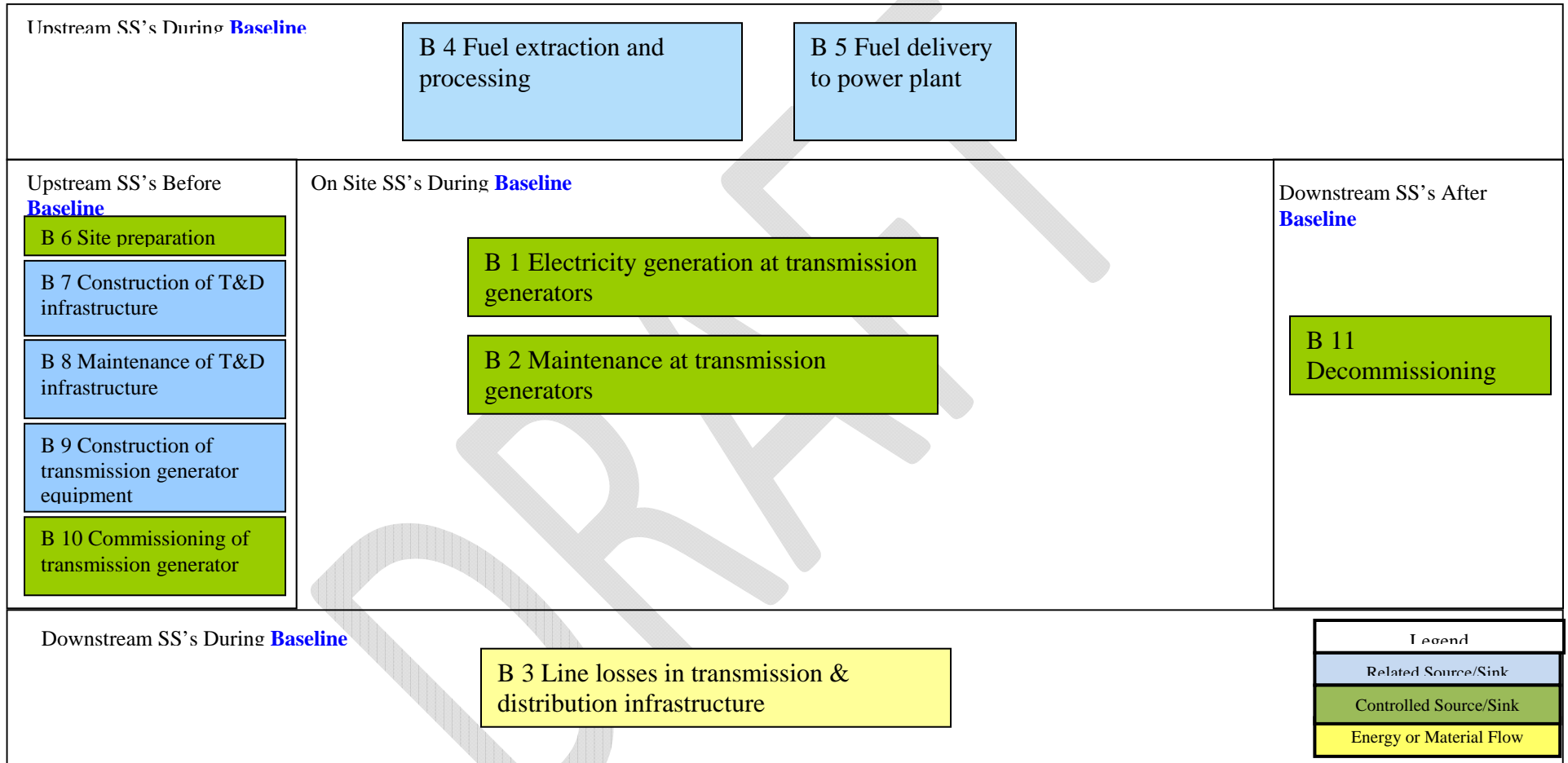


Figure 3: **Alternate diagram demonstrating sources and sinks:**

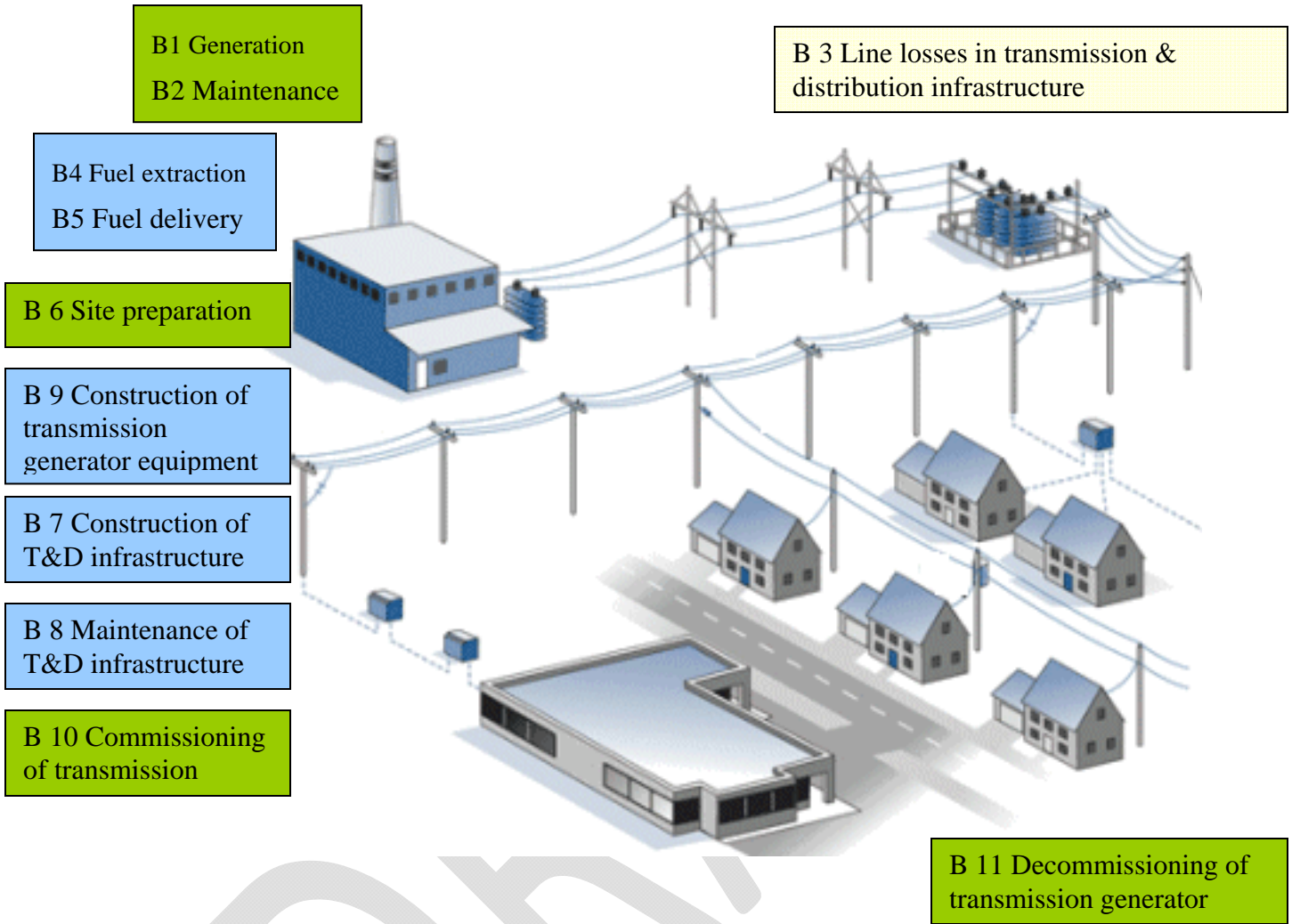


Table 1: Baseline Sources and Sinks

Sources/Sinks	Description	Controlled, Affected, Related
<i>Upstream Sources and Sinks Before Baseline</i>		
B6 Site preparation	Land clearing and ancillary utility service construction on the site of the transmission generator.	Controlled
B7 Construction of T&D infrastructure	Construction of high tension transmission lines, transformer stations and distribution wires.	Related
B8 Maintenance of T&D infrastructure	Ongoing maintenance of T&D infrastructure, including HF6 and travel of crews to sites.	Related
B9 Construction of equipment for the transmission generator	Construction and manufacturing of boilers, steam turbines, piping, pumps, controls, housing, mines, energy processing and storage facilities.	Related
B10 Commissioning of transmission generator	Transportation of equipment to site. Equipment installation and commissioning.	Controlled
<i>Upstream Sources and Sinks During Baseline</i>		
B4 Fuel extraction and processing	Upstream mining and upgrading of coal and natural gas for use in electricity generation equipment.	Related
B5 Fuel delivery to transmission generator	Shipping of process fuel to transmission generator	Related
<i>Onsite Sources and Sinks During Baseline</i>		
B 1 Electricity Generation at remotely-located transmission generator	Electricity generated at the transmission generator and transported through transmission and distribution lines to distant residential, commercial and industrial customers.	Controlled
B2 Maintenance at remotely-located transmission generators	Ongoing maintenance and periodic retrofits of transmission generator equipment.	Controlled
<i>Downstream Sources and Sinks During Baseline</i>		
B 3 Line losses in electricity transmission and distribution	T&D losses are an indirect but significant source of GHGs. Since the large-scale coal plants are located at a distance from electrical loads, a significant amount of energy is lost in transferring and distributing the energy to customers. This energy is lost as heat due to resistance in wires. These losses are classified as Transmissions line losses and Distribution line losses. These losses must be included in calculating baseline generation.	Related
<i>Downstream Sources and Sinks After Baseline</i>		
B11 Decommissioning	Eventual dismantling and disposal of transmission generator.	Controlled

3.0 Project Condition

The project condition consists of installing and operating renewable energy systems on a number of grid-connected facilities primarily for local electricity consumption. Any excess generation is transported to the other nearby grid-connected facilities (located on the downstream electrical distribution grid). The project reduces greenhouse gas emissions generated in Alberta through the following processes:

- Displacing electricity on the grid with lower GHG intensity electricity generating sources; and
- Reducing line losses through the nearby connection between electricity generation source and consumption site;

The eligible project sites under this protocol must be connected to the Alberta electricity grid. The projects substitute all or part of the electricity demand at grid-connected facilities by installing renewable energy systems. GHG emissions reduction will occur when the low GHG intensity renewable energy systems displace the grid-supplied electricity.

The eligible emission reductions are based on:

- the difference in greenhouse gas emissions between the grid and renewable energy systems for the net electricity generated; and
- the difference in greenhouse gas emissions between the grid and renewable energy system for the net electricity saved due to avoidance in line losses

The protocol accounts for the avoided line losses in calculating GHG savings due to the proximity of generation to the consumption site. Electricity generation by renewable energy systems eliminates the need for sourcing the electricity from remotely-located transmission generators. Most of the energy from distribution generators is consumed at or within relatively short distances of the project site with negligible amounts of energy lost in the electrical lines downstream. For this protocol, the line losses are assumed to be 7.7%. To quantify the avoided emissions, the total energy produced in the project condition can be multiplied by a factor of 1.077 to establish the total amount of conventional energy displaced. Justification is provided in Appendix A.

Figure 3: Process Flow Diagram for the Project Condition (Solar PV)

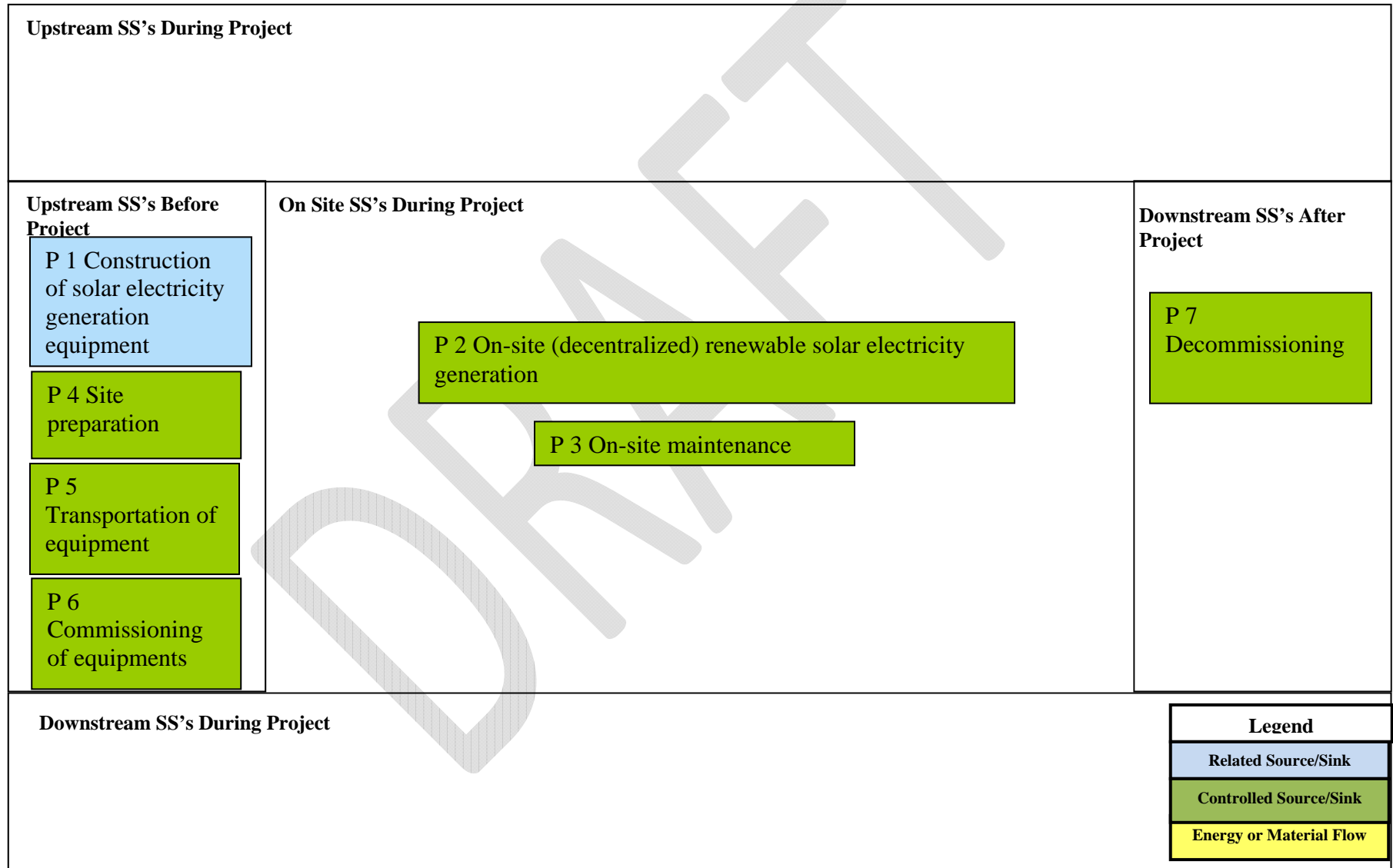


Figure 4: Process Flow Diagram for the Project Condition (Solar PV)

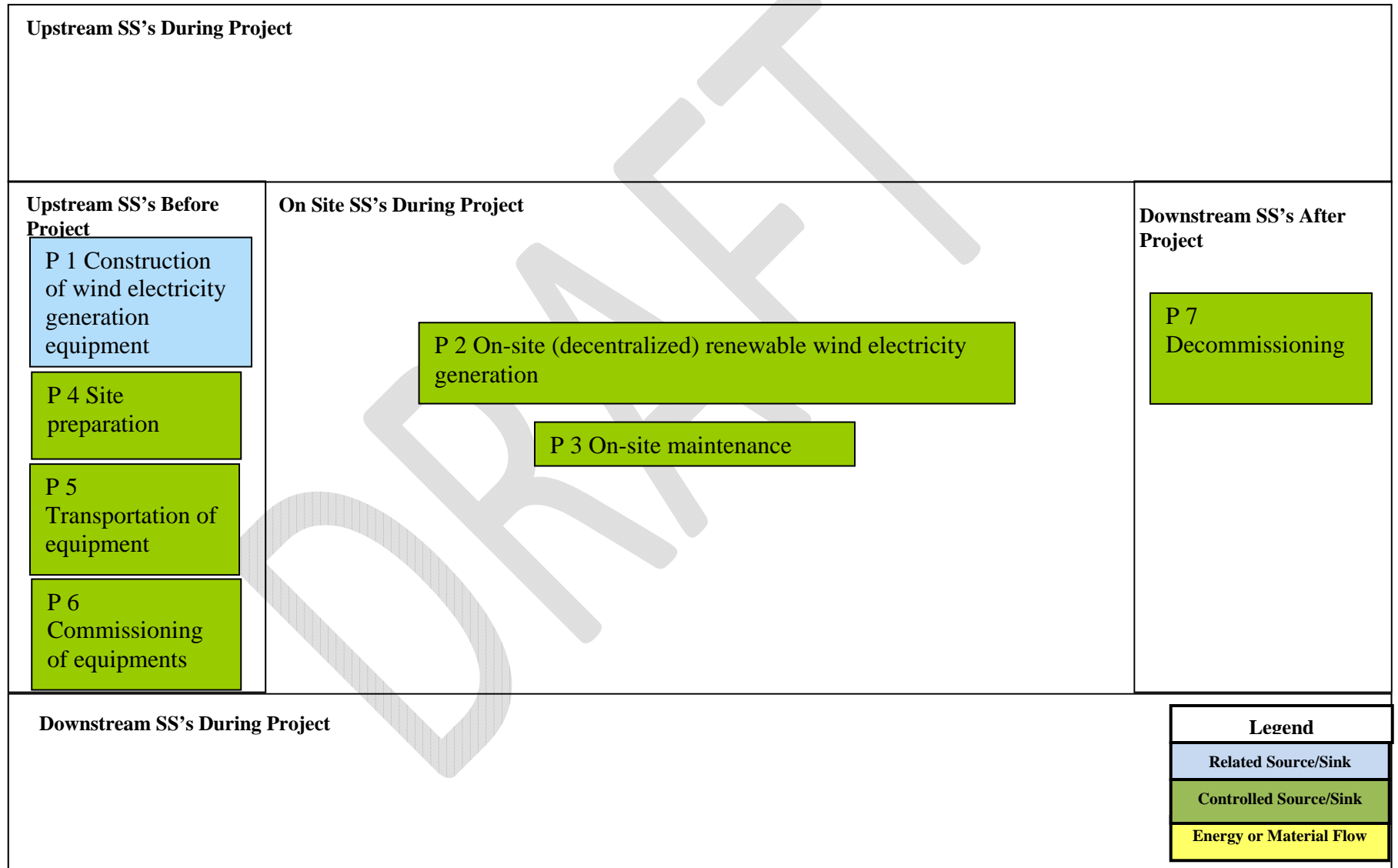
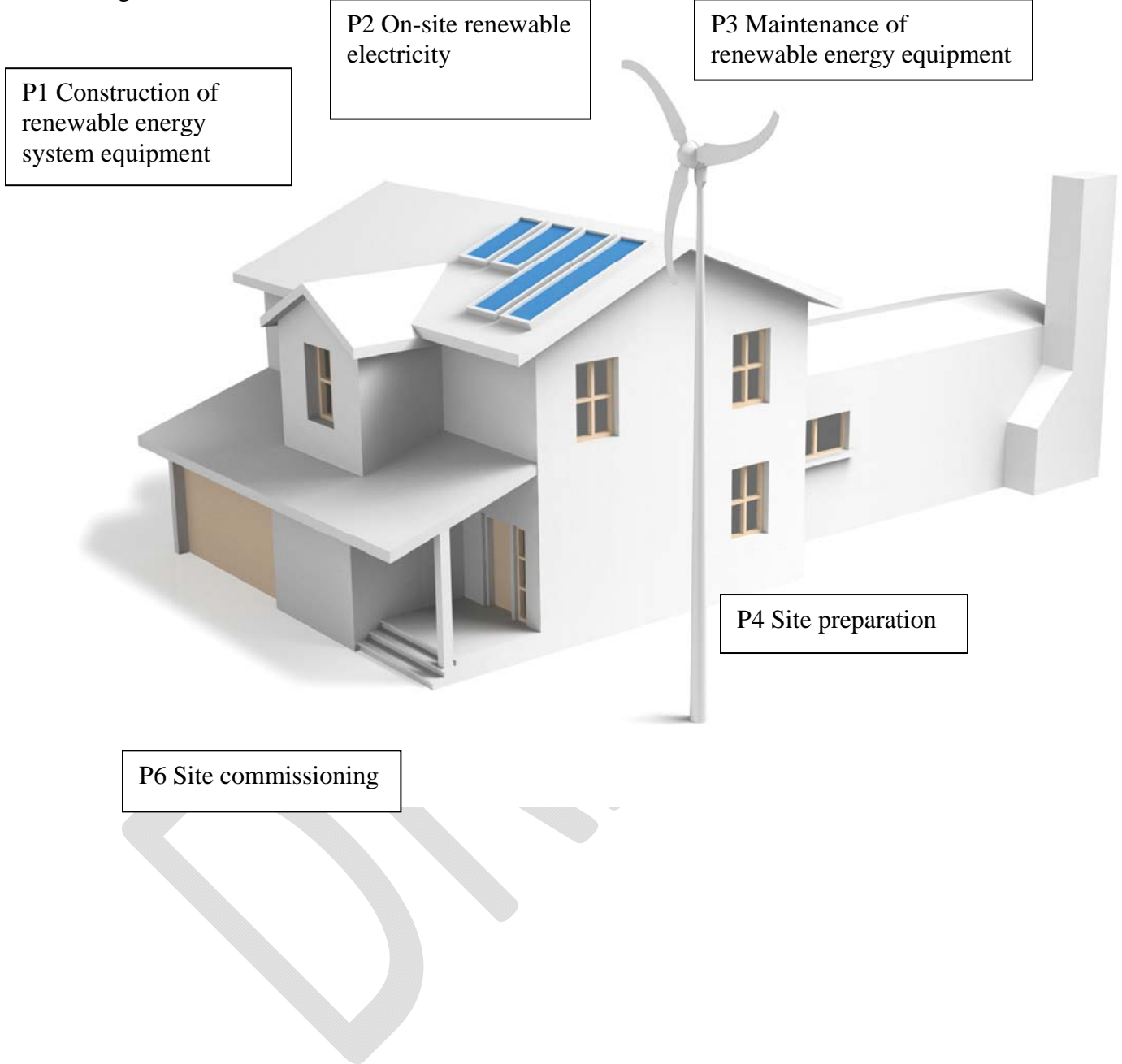


Figure 4: **Alternate diagram demonstrating sources and sinks:**



3.1 Identification of Project Sources and Sinks

Sources and sinks for the micro-generation project were identified based on scientific peer review. The Technical Working Group confirmed that source and sinks in the process flow diagram (Figure 3) covered the full scope of eligible project activities under this protocol.

These sources and sinks have been further refined according to the life cycle categories identified in Figure 4. These sources and sinks were further classified as controlled, related, or affected as described in Table 3 below.

There are no material direct sources of emissions during the project activities. In the baseline condition, the electricity consumption at the grid-connected project sites results in indirect emissions. In the project condition, on-site electricity generation from renewable energy systems (with lower or zero project emissions) displaces these indirect emissions. There are no sinks under the baseline scenario.

No direct GHG sink is present during the project activity. The reductions achieved are due to displacement of high GHG intensity grid electricity by low or negligible GHG intensity electricity from renewable energy systems. There are no changes to the baseline assumptions.

Figure 4 below shows all the emission sources during the project activity. Maintenance on an as-required basis is the only operational source of GHG emission but is typically so low that it is not material (measurable in grams as opposed to tonnes) and are therefore excluded.

Example calculation of maintenance and commissioning emissions:

Conditions: 100 km round trip, 10 litres per 100 km. According to GHGenius using default values for Alberta, light-duty gasoline vehicles emit approximately 330 gCO_{2e} per km. For a 100 km round trip, total transport emissions would amount to 33.2 kg CO_{2e}. This value is two orders of magnitude smaller than the emissions reductions represented by the project each year, and can therefore be excluded.

The other sources of emissions are: transportation of equipments, installation of the systems, and decommissioning at the end of their operational life. These sources are similarly small, and also exist within the baseline and likely to be similar or lower than that of the baseline condition. Maintenance-related emissions are therefore excluded.

Figure 4: Project Conditions Sources and Sinks for Renewable Energy System Activity

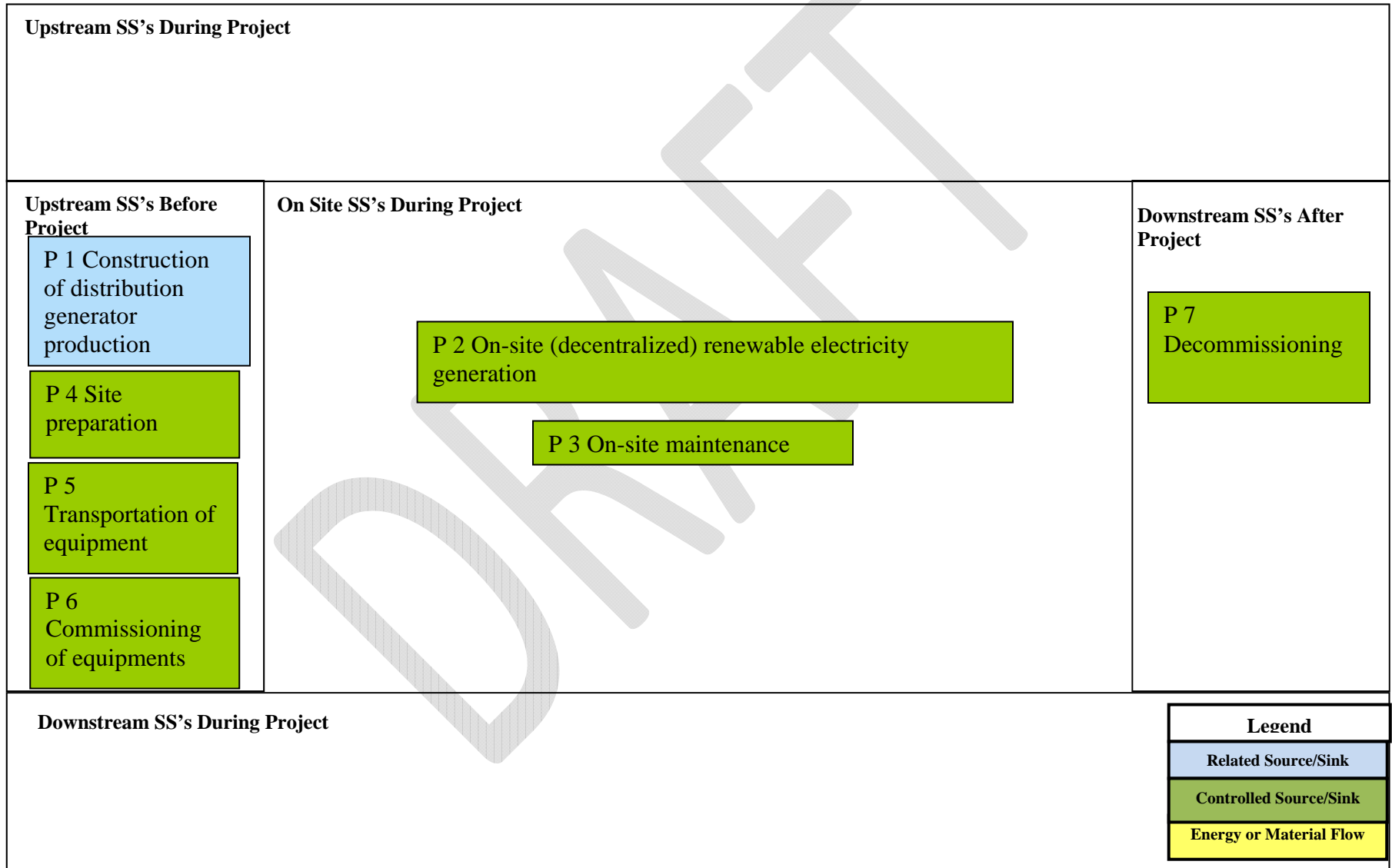


Table 2: Project Condition Sources and Sinks

Sources/Sinks	Description	Controlled, Affected, Related
<i>Upstream Sources and Sinks Before Project</i>		
P1 Construction of distributed generator equipment	Manufacturing of distribution generator equipment and ancillary materials, including supportive racking, supports, wiring, inverters and foundation materials.	Related
P4 Site preparation	Installation of distribution generator systems, which may involve driving to the site, roof preparation, equipment erection, connecting to the home or building, etc.	Controlled
P5 Transportation of equipment	Moving material and equipments from ware houses to the project sites.	Controlled
P6 Commissioning of distributed generator	Testing and commissioning of systems to ensure proper performance of components. Linking the system to the building and make the system operational.	Controlled
<i>Upstream Sources and Sinks During Project</i>		
<i>Onsite Sources and Sinks During Project</i>		
P2 On-site Electricity Generation	Renewable electricity generation from the systems	Controlled
P3 Project Maintenance	Includes visual inspection, performance testing, and cleaning. This may require a site visit.	Controlled
<i>Downstream Sources and Sinks During Project</i>		
<i>Downstream Sources and Sinks After Project</i>		
P5 Decommissioning of the units	At the end of operational life or project life these systems will be removed from the site, which may involve removing the equipments and support structure, driving to the site and transportation of equipments from project site to a warehouse.	Controlled

4.0 Quantification

All sources and sinks identified in Tables 1 and 2 above are listed in Table 3 below, where each source and sink is listed, compared between baseline and project condition, and listed as include or excluded. Justification for these categorizations is provided.

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Table 3: Comparison of Sources/Sinks

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion/Exclusion
Upstream Sources/Sinks				
B4 Fuel extraction and processing	Related	N/A	Exclude	Fuel extraction and processing are key to availability of primary energy source to fire electricity generation, and a large source of emissions.
B5 Fuel delivery to transmission generator	Related	N/A	Exclude	Fuel delivery is needed to bring primary energy source to conventional electricity generation site, but is small enough to be considered insignificant and therefore excluded.
B6 Site preparation	Controlled	N/A	Exclude	Site preparation may require earthworks but is small enough in comparison to facility operation to be considered insignificant and therefore excluded.
B7 Construction of T&D infrastructure	Related	N/A	Exclude	Construction of transmission and distribution infrastructure is upstream of project condition and excluded.
B8 Maintenance of T&D infrastructure	Related	N/A	Exclude	Maintenance of transmission and distribution infrastructure is upstream of project condition and excluded.
B9 Construction of transmission generation equipment	Controlled	N/A	Exclude	Emissions from production of centralized electricity generation equipment including turbines, coal combustion equipment, etc are excluded as they are relatively small in comparison to GHG emissions from operation.
B10 Commissioning of transmission generation	Controlled	N/A	Exclude	
P1 Construction of distributed generation equipment	N/A	Related	Exclude	Emissions from production of modules, inverters, wire and racking, nacelles and poles. Similar emissions are embodied in equipment for centralized electricity production, and are small enough to be negligible; they are excluded.
P2 Development of Site	N/A	Controlled	Exclude	Emissions from site development & transportation are not material given the long project life, and the minimal site development typically required, thus they are excluded.
P3 Transportation of equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not material when compared to the long project life and are excluded.
P4 Commissioning	N/A	Controlled	Exclude	Emissions from testing and commissioning of equipments are not material given the long project life, and are excluded.
Onsite Sources/Sinks				
B1 Electricity Generation	Controlled	N/A	Include	The baseline reflects electricity generation from centralized, primarily fossil fuel-fired generation systems. The carbon intensity of grid power in Alberta for calculating offsets is prescribed by Alberta Environment & Water in the Technical Guidance Document for Offset Project Developers at 0.65 t/MWh. These emissions are included.

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion/Exclusion
B2 Maintenance	Controlled	N/A	Exclude	Emissions from maintenance are not material and therefore excluded.
P2 Electricity Generation	N/A	Controlled	Include	The project activity involves substitution of the source of current electricity consumption by renewable energy that have zero emissions from the project site. The reductions are included.
P3 Maintenance	N/A	Controlled	Exclude	Emissions from maintenance are not material and therefore excluded.
Downstream Sources/Sinks				
B3 Line losses from electricity transmission and distribution (T&D)	Related	N/A	Include	A percentage of energy is lost as heat during transportation. This is captured in two parts: transmission and distribution. Since the proposed renewable systems will replace the grid electricity, they will also eliminate these losses, also called as line losses. An average loss factor can be used to adjust the electricity production to account for the losses.
B11 Decommissioning	Related	N/A	Exclude	The emissions from decommissioning are not anticipated to be different from the baseline condition on a normalized basis and are therefore excluded.
P5 Decommissioning	N/A	Related	Exclude	The emissions from decommissioning are not anticipated to be different from the baseline condition on a normalized basis and are therefore excluded.
Other				

**Where C is Controlled, R is Related, and A is Affected.

4.1 Quantification Methodology

The project activity avoids GHG emissions through substitution of fossil fuel-based grid electricity by renewable energy systems.

Baseline and project conditions will be assessed against each other to determine the scope for reductions quantified under this protocol. Sources and sinks will either be included or excluded depending on how they are impacted by the project condition. Sources that are not expected to change between baseline and project condition are excluded from the project condition. It is assumed that excluded activities will not be affected by the project, as they occur at the same magnitude, or emission rate, in both the baseline and project conditions. A conceptual equation is provided below.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{B1 Alberta grid electricity consumed (in MWh)} \times \text{AENV approved intensity factor (0.65 tonnes/MWh)} \times \text{Adjustment factor to account for line losses (1.077)}$$

$$\text{Emissions}_{\text{Project}} = 0^*$$

Therefore...

$$\text{Project Emission Reductions} = \text{P2 Electricity Production}_{\text{Project}} \times \text{Emission Factor}_{\text{Baseline}} \times \text{Line Loss Adjustment Factor}$$

* Project emissions include installation, commissioning/decommissioning, and maintenance related emissions, which in this case are measurable in kg as opposed to tonnes, and therefore not material in comparison to overall reductions achieved from the systems and thus assumed as '0'. However, to qualify for the line loss adjustment factor, the project proponent must demonstrate that any excess electricity generated and exported from the project site does not require long-distance transmission to reach its consumer.

This protocol provides three approaches for quantifying generated electrical energy from a multi-site distribution generator project with known or predictable generation duty cycles, for aggregation purposes.

As a general principle, wherever actual data exists it must be used rather than modeled data. Meters and tracking systems must be accurate within +/-3%. Where tracking

systems have accuracies outside of this range, a discount must be applied to bring the total into the +/-3% range (e.g. if a tracking system has an accuracy of +/-3.5% a 0.5% discount should be applied to the measured total energy production from all systems using this tracking mechanism).

Method 1: Data for All Sites

This method can be used when generation data is available for all sites. This method would be more suitable for larger renewable electricity sites that in aggregate do not make up a statistically significant sample, but are accessible and separately metered at all times.

Example: One hundred similar 10 kW solar PV systems are monitored remotely (separately) using inverters with integrated energy production tracking capability. The total production from all systems may be tallied at the end of the year from software reports to quantify the total electricity produced during the course of the year.

Method 2: Partial Data for All Sites

Small renewable energy generators may be metered separately but spread over a wide geographic area with limited capability for remote monitoring. Generation data should be collected from multiple sites to develop a model reflective of the geographical area and based on the similar properties of each installed renewable energy system. Variables that affect production at each site can be integrated into the model to better predict the performance of specific units. Missing data can be calculated using a model and the performance data of other units in the fleet.

To extrapolate actual production from a number of similar nearby systems, the production should be modeled on the basis of kilowatt hours (kWh) per installed kilowatt of generation capacity, and then discounted as necessary to avoid overestimation. Discounting may be done to reflect lower measured production of nearby systems in comparison to resource maps. In all cases, each system must be confirmed to be working and producing power as designed at least once per year (whether by remote monitoring or in person).

Example calculation:

One 1.3 kW system installed in Edmonton near other similar systems is missing electricity production data for six months but the error was confined to the tracking system (due to internet connection failure).

According to Figure 5, the estimated solar resource in Edmonton is 1200-1300 kWh per kW of solar modules. Twenty nearby similar solar systems (with equivalent ages and technologies) generated on average 1150 kWh per installed kW of modules during the year in question. Therefore, as long as there is no identified risk of production gaps or other reasons for reduced production, the annual electricity production of the 1.3 kW system should be approximately 1.3 kW x 1150 kWh/kW, or 1495 kWh.

Method 3: Data from a Sample of Sites

In some cases, limited capabilities for onsite data collection or remote monitoring may be encountered where a large number of renewable electricity generators is spread over a common geographic region.

Sampling the sites with remote monitoring can provide representative production data depending on the type of generation. Sites that do not have the infrastructure for remote monitoring such as high-speed internet or access to a cellular network would typically be located in more remote rural areas. For solar and wind applications, rural locations typically provide sites with less obstruction of the sun and wind, which result in higher performing of solar PV and micro-wind systems.

Full 12 month tracking data from a sufficient number of sites may allow for statistical methods to be used in calculating total production. This method must utilize a statistically significant sample to determine the mean output per site. For a given reporting period, generation data should be collected from a sample of the renewable energy systems that represent a statistically valid number of units. The data available will be sampled annually with a sample size that provides a margin of error +/- 2.5 95% of the time. Separate populations should be established corresponding to the categories (colour codes) of incident solar energy resource as reflected in Natural Resources Canada's Solar Potential Map (see Figure 5).

Example calculation:

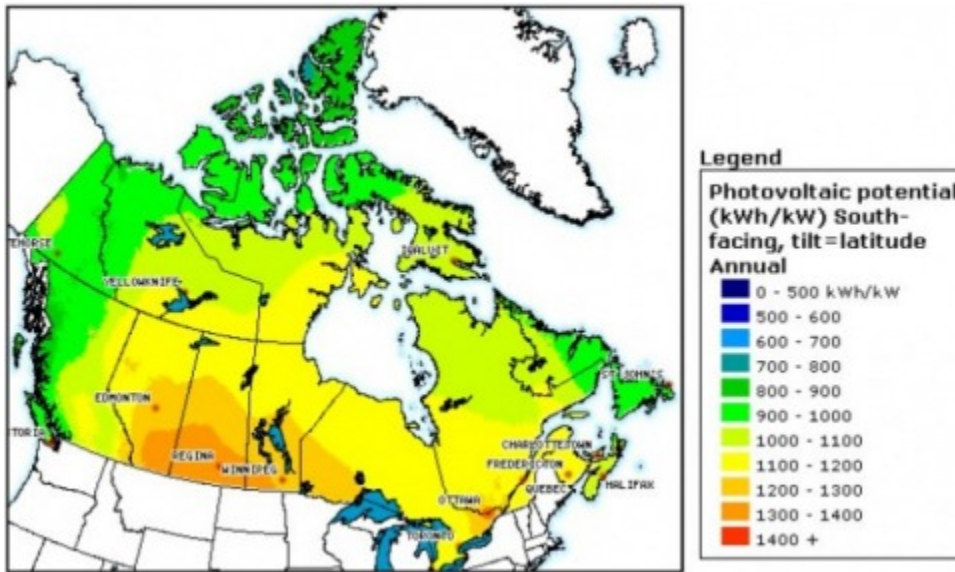
A project developer installs a total of 1,000 residential solar PV systems in southern Alberta spanning two zones of the Canadian Solar Resource Map (600 systems in the zone containing Edmonton with a solar resource of 1200-1300 kWh/kW and 400 systems in the area containing Calgary with a solar resource of 1300-1400 kWh/kW).

To produce an acceptable electricity production tally, annual production data for a sufficient number of sites would be required to ascertain a +/- 2.5% margin of error to estimate the mean production value for all sites in the fleet (total of 5% margin of error) in each category. The production from each system should be normalized on a kWh/year per installed kW basis (in other words, annual production divided by system size for each renewable energy system).

In this example, to reach a margin of error of +/- 2.5% and a confidence interval of 95%, 235 sites would need to be monitored in the Edmonton area (out of 600) and 197 from the Calgary area (out of 400)⁶. To be conservative, this value would then be discounted by half the margin of error (2.5%; the amount which could be over-estimated). The populations for Calgary and Edmonton should be calculated separately because they sit in different colour categories shown in Figure 5.

⁶ Description of how to calculate minimum population required to achieve statistical significance targets is outside the scope of this protocol but is a standard statistical technique

Figure 5: Solar Potential (kWh/kW installed capacity) in Canada



Source: https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php

The normalized mean production for each category (annual kWh per installed kW) should be multiplied by the total installed kW of renewable energy systems in that category to yield the gross production for that category (or region). The sum of production from all regions would then be discounted by half the margin of error to maintain a conservative estimate of total production.

Example figures:

Edmonton

Total number of Edmonton solar PV systems	600
Total kW capacity installed (systems typically 1.2 or 1.3 kW each)	750
Sample size (monitored installations)	235
Mean production from metered sites (annual kWh/kW) at 95% confidence with 5% margin of error	1250
Gross production (1250 kWh/kW x 750 kW)	937,500 kWh

Calgary

Total number of Calgary solar PV systems	400
Total kW capacity installed	500
Sample size (monitored installations)	197
Mean production (annual kWh/kW)	1350
Gross production (1350 kWh/kW x 500 kW)	675,000 kWh

The total renewable energy production would be shown by ($\text{Production}_{\text{Edmonton}} + \text{Production}_{\text{Calgary}}$) less 2.5% of the total. Therefore the total renewable energy production for calculating offsets before line loss factor is $(937,500 \text{ kWh} + 675,000 \text{ kWh}) - 2.5\%$.

The total renewable energy production for calculating offsets would be $1,612,500 - 40,312.5 \text{ kWh}$, or $1,572,187.5 \text{ kWh}$.

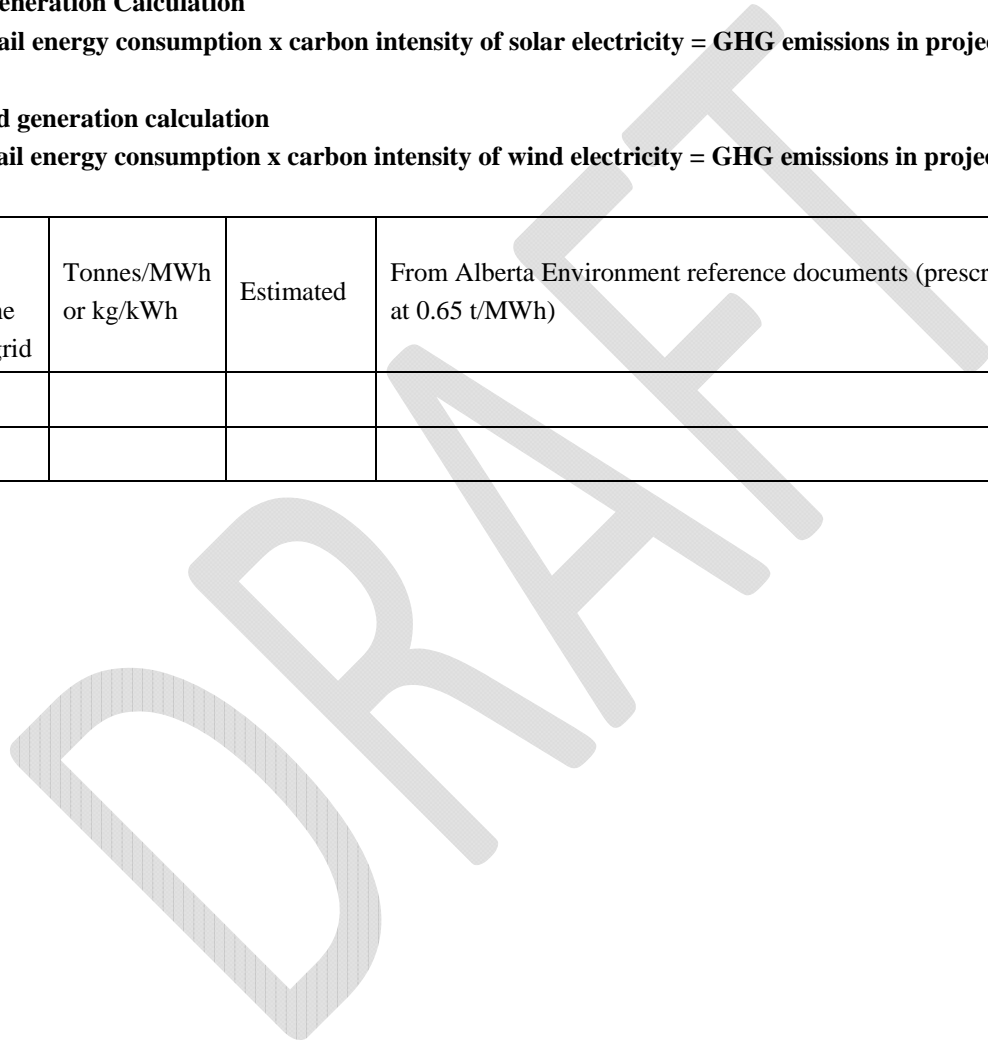
Including the line loss factor of 7.7%, the total renewable energy production for calculating offsets would be $1,572,187.5 \times 1.077 = 1,693,245.94 \text{ kWh}$, or $1,693.25 \text{ MWh}$.

To calculate the number of tonnes of offsets, this value ($1,693.25 \text{ MWh}$) would be multiplied by the grid intensity factor for offsets as prescribed by AENV in the Technical Guidance Document for Project Developers (currently 0.65 t/MWh). Thus the total eligible for offsets would be $1,100.6 \text{ tonnes}$.

Table 4: Quantification Methodology

Source/Sink	Parameter / Variable	Unit	Measured/ Estimated	Method	Frequency	Justify measurement or estimation and frequency
Baseline Condition						
	Equation X kWh retail energy consumption x carbon intensity of grid electricity x 1.077 (line loss factor) = GHG emissions in baseline condition					
Source/Sink 1B2 Electricity Transmission and Distribution	Line Losses	%	Estimated	Context drawn from AESO documents. Weighted average of average provincial transmission and distribution losses from CASA, 2004 (Jem Energy consulting report).	AESO calculates annually	AESO publishes transmission and distribution losses for each distribution area. Should not change materially enough from year to year to justify updating annually; updated when protocol is reviewed (i.e. every 5 years).
Project Condition						

Source/Sink 1 P1 Onsite Electricity Generation	<p>Equation</p> <p>Solar PV generation Calculation</p> <p>Y kWh retail energy consumption x carbon intensity of solar electricity = GHG emissions in project condition</p> <p>Micro-wind generation calculation</p> <p>Z kWh retail energy consumption x carbon intensity of wind electricity = GHG emissions in project condition</p>					
	GHG emissions factor for the electricity grid	Tonnes/MWh or kg/kWh	Estimated	From Alberta Environment reference documents (prescribed at 0.65 t/MWh)	Annual	AENV approves the grid intensity factor and updates from time to time



5.0 Data Management

Data quality management must be of sufficient quality to fulfill the quantification requirements and be substantiated by actual records for the purpose of verification.

A project developer shall establish and apply quality management procedures to manage data and information. Written procedures must be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigor of the management system for the data, the more easily verification will be to conduct for the project.

The data management plan should produce complete, reliable and accurate data for processing and analysis purposes. Aggregators should develop a QA/QC plan for ensuring a successful data management process.

Similarly, an easy to understand and easily replicable quantification methodology must be employed to estimate GHG reductions. In the absence of complete and accurate information, conservative estimates should be used to minimize the risk of overestimation.

5.1 Project Documentation

5.1.1 Project Eligibility Documentation

To be eligible a project must be located in Alberta and be operating in accordance with the Alberta Electric Utilities Act as enforced by the Alberta Utilities Commission's Rule 007 Part 4 and use solar or wind as its renewable energy source for electricity production.

5.1.2 Baseline Condition Documentation

The baseline condition for all eligible products assumes a grid connected customer within the Province of Alberta. The default carbon intensity is set by Alberta Environment in the Guidance Document for Offset Protocol Developers.

5.1.3 Project Quantification Documentation

Project proponents must, at a minimum, have specific site information for each location to be included in the project. This includes:

1. Legal land description
2. Unique site ID (utility customer ID number)
3. Type of renewable energy system
4. Rated generating capacity of the generator portion of the renewable energy system
5. Activation date of the renewable energy system
6. Date of decommissioning for the renewable energy system (if applicable)
7. Data measurement system (e.g. electricity production in kWh) in place for all project sites

To avoid any duplication of GHG reduction claims, the GHG offsets will be tied to the unique site ID, which will eliminate the possibility of any undesirable leakage due to relocation of the systems from one project site to another.

Contract documents that establish ownership of credits for the consumer and the aggregator's right to aggregate the credits.

5.2 Record Keeping

Alberta Environment requires that Project Developers maintain appropriate supporting information for the project, including all raw data for the project for a period of 7 years after the end of the project crediting period. Where the Project Developer is different from the person implementing the activity, as in the case of an aggregated project, the individual projects and the aggregator, must both maintain sufficient records to support the Offset Project. The Project Developer (project implementer and aggregator) must keep the information listed below (in addition to others that will support the project) and disclose all information to the verifier and/or government auditor upon request.

Record Keeping Requirements:

- Site location, unique identifier, renewable energy type, system generator capacity, commissioning date, decommissioning date (if applicable).
- Electricity production for project period
- Energy measurement equipment specifications (model number and manufacturer's calibration procedures)
- All calculations of greenhouse gas emissions/reductions and emission factors
- Energy measurement equipment maintenance activity logs
- Initial and annual verification records and audit results

In order to support the third party verification and the potential supplemental government audit, the project developer must put in place a system that meets the following criteria:

- All records must be kept in areas that are easily located;
- All records must be legible, dated and revised as needed;
- All records must be maintained in an orderly manner;
- All documents must be retained for 7 years after the project crediting period;
- Electronic and paper documentation are both satisfactory; and
- Copies of records should be stored in two locations to reduce the likelihood of data loss.

Table 5: Data and Record Keeping Requirements

Data Requirement	Examples of Acceptable Records	Why it is Required
<i>Proof of renewable energy system location</i>	<i>Copies of AESO registration or contractor site assessment form (used for municipal permitting application).</i>	<i>This is needed to establish the legal address and utility customer site ID number, installation date and renewable energy system type.</i>
<i>Proof of ownership of environmental attributes of renewable energy system</i>	<i>Copies of paid invoices for equipment and records of installation in the case of direct ownership of renewable energy systems. For lease arrangements, copy of signed Lease Agreement between lessor of renewable energy equipment and lessee clearly defining ownership or assignment of environmental attributes of renewable energy system.</i>	<i>This is needed to confirm ownership and rights to transact on offset credits.</i>
<i>Proof of system operation and summary of energy generation</i>	<i>Detailed summary from automated tracking system or periodic meter readings</i>	<i>This is needed to confirm that the system is producing electricity, and to quantify the amount of electricity produced.</i>
<i>Greenhouse gas reduction calculations</i>	<i>Copies of calculations, methodologies and results</i>	<i>This is needed to be able to verify mathematical procedures, emissions factors used and other issues affecting validity of quantification claims.</i>

<i>Tracking system accuracy and calibration information</i>	<i>Equipment manufacturer's operating guidelines or product literature describing tracking accuracy and frequency and process for calibration (if required).</i>	<i>This is needed to verify that tracking equipment is appropriate and in good operating order throughout the crediting period.</i>
<i>Maintenance records</i>	<i>Log of maintenance activity, driving distance and physical or operational changes made</i>	<i>This is needed to ascertain the materiality of maintenance-related emissions.</i>
<i>Initial and annual verification records and audit results</i>	<i>Copies of audit reports and annual data summaries</i>	<i>These are required to confirm that calculation and accounting methods remain consistent over time (or are properly noted for auditors).</i>

Note: Attestations will not be considered sufficient proof that an activity took place and will not to meet verification requirements.

5.3 Quality Assurance/Quality Control Considerations

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

- Protecting measuring and monitoring equipment (sealed meters and data loggers);
- Protecting records of measured 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 measurement devices;
- Establish minimum experience and requirements for operators in charge of project and monitoring; and
- Performing re-calculations to make sure no mathematical errors have been made.

5.4 Liability

Offset projects must be implemented according to the approved protocol and in accordance with government regulations. Alberta Environment reserves the right to audit Offset Credits and associated projects submitted to Alberta Environment for compliance

under the *Specified Gas Emitters Regulation* and may request corrections based on audit findings.

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6.0 References

Alberta Micro-Generation Regulation

http://www.auc.ab.ca/rule-development/micro-generation/Documents/Micro_Generation/Microgen_Regulation.pdf

Alberta Utilities Commission Micro-Generation Reporting

http://www.auc.ab.ca/rule-development/micro-generation/Documents/Micro_Generation/Micro-Generation_Reporting_2011_May.pdf

Alberta Utilities Commission Micro-Generator Application Guidelines

http://www.auc.ab.ca/rule-development/micro-generation/Documents/Micro_Generation/Micro-Generator_Application_Guidelines.pdf

Alberta Utilities Commission Rule 007. URL: <http://www.auc.ab.ca/acts-regulations-and-auc-rules/rules/Documents/Rule007.pdf>

Alberta Utilities Commission Rule 024. URL: <http://www.auc.ab.ca/acts-regulations-and-auc-rules/rules/Documents/Rule024.pdf>

Alberta Quantification Protocol for Solar Electricity Generation

<http://environment.gov.ab.ca/info/library/7960.pdf>

Alberta Quantification Protocol for Low-Retention Water-Powered Electricity Generation as Run-of-River or on an Existing Reservoir

<http://environment.gov.ab.ca/info/library/7957.pdf>

Alberta Quantification Protocol for Wind-Powered Electricity Generation

<http://environment.gov.ab.ca/info/library/7933.pdf>

Clean Air Strategic Alliance, 2004. A Study on the Efficiency of Alberta's Electrical Supply System. Linked via:

<http://www.assembly.ab.ca/lao/library/egovdocs/ca6/casa/2004/146660.pdf>

Climate Change Emissions Management Act

http://www.qp.alberta.ca/574.cfm?page=C16P7.cfm&leg_type=Acts&isbncln=9780779740956

Technical Guidance for Offset Project Developers

<http://environment.gov.ab.ca/info/library/7915.pdf>

Technical Guidance for Offset Protocol Developers

<http://environment.gov.ab.ca/info/library/8331.pdf>

Specified Gas Emitters Regulation

<http://environment.gov.ab.ca/info/library/7811.pdf>

7.0 Appendix A: Line Loss in Alberta Electricity System

Line losses

With the 2009 introduction of the Alberta Micro Generation Regulation, distributed generation at the customer level became more likely. Distribution generators cause a direct reduction on the line losses incurred by those customers that choose to use a distributed generation technology. The basic principle is that customers that utilize distributed generation do not incur the line loss, as they do not use the transmission system and only use a very small portion of the distribution system in the consumption and export of the electricity generated on-site. The avoidance of these losses means less transmission-connected electricity is generated and less GHG produced in the delivery of that energy to the household.

Under the current Alberta Electric System Operator (AESO) terms and conditions the line loss charges for System Access Service (SAS) are divided between the generator and the consumer. Generators pay for losses on the Alberta Interconnected Electrical System (AIES) at the transmission level (STS charges), while the consumer pays for lines loss at the distribution level (DTS charges). Alberta generators, load centers, and major transmission enhancements affect losses on both the distribution and transmission wires systems. A more detailed description on line loss can be found in the Electric Utilities Act chapter E-5.1 or at http://www.aeso.ca/downloads/Electric_Uilities_Act.pdf.

Transmission losses

The *Transmission Regulation*, 2004 (updated in 2007) requires transmission connected generators, Industrial Systems Designations, Demand Opportunity Service, Import and Export Service to pay for losses. Since the transmission lines are made of metallic conductors, *loss* of electrical energy occurs in the *line*. These Transmission *losses* can be significant and are determined by the AESO based on the following principles.

Loss Factor Principles (source: http://www.aeso.ca/downloads/Loss_Factors_-_High_Level_Process_Review.pdf)

1. The loss factor methodology shall produce results that are accurate, repeatable, and predictable,
2. The loss factor methodology should provide a long-term generation siting signal,
3. Assigned loss factors must be a single number at each location,
4. Loss factors can be changed in less than one year if the AESO determines that a system change or upgrade materially changes the line losses,
5. Loss factors must apply for a period of not less than one year and not more than five years (to increase accuracy, the AESO is utilizing an annual calculation of loss factors),
6. Loss factors must be representative of the impact on system losses by each generator, group of generators,
7. Normalized loss factors shall not exceed 12% system average losses for charges and 12% system average losses for credits,
8. A calibration factor under the ISO tariff will ensure that the actual cost of losses is reasonably recovered on an annual basis,
9. The methodology for determining loss factors shall incorporate the best technical solution to meet the requirements of the regulation,
10. Loss factors will be made publicly available,

11. The new loss factor methodology was effective January 1, 2006 (subject to further Regulation), and
12. Access to the Loss Factor Methodology was provided in 2006.

Based on the line loss methodology, AESO determines the STS line loss factors for each transmission-connected generator in the province. Generators who locate near major load centers receive an incentive whereas generators that are more remote from the load centers are charged for line loss. The table below shows the transmission line loss for each transmission-connected generator in the province.

Transmission line loss factors by generator

(source: www.aeso.ca/downloads/Final_Alberta_Loss_Factors_for_2011.pdf)

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2011 Alberta Loss Factors - 2010-11-01, Final

MP-ID*	Facility Name	PSS/E Bus	Normalized and Compressed Loss Factor (%)	Loss Factor Asset	Difference % in Loss Factor to System Average
0000034911	ALTAGAS PARKLAND	4235	-1.06	Gen	-5.19
NX01	BALZAC	290	-0.21	Gen	-4.34
BAR	BARRIER	216	-1.65	Gen	-5.78
BR3	BATTLE RIVER #3	1491	4.92	Gen	0.80
BR4	BATTLE RIVER #4	1491	4.92	Gen	0.80
BR5	BATTLE RIVER #5	1469	4.15	Gen	0.02
BCRK	BEAR CREEK G1	10142	-1.76	Gen	-5.88
BCR2	BEAR CREEK G2	10142	-1.76	Gen	-5.88
BPW	BEARSPAW	183	-1.13	Gen	-5.25
BLYR	BELLY RIVER IPP	447	0.46	Gen	-3.67
BIG	BIGHORN	103	1.60	Gen	-2.53
BTR1	BLUE TRAIL WIND FARM	328	1.06	Gen	-3.06
BRA	BRAZEAU	56153	1.57	Gen	-2.55
GOC1	BRIDGE CREEK	19145	0.00	Gen	-4.13
0000045411	BUCK LAKE	80	3.16	Gen	-0.96
TC01	CARSELAND	5251	-0.19	Gen	-4.32
CAS	CASCADE	175	-2.08	Gen	-6.21
CR1	CASTLE RIVER	234	0.59	Gen	-3.54
EC01	CAVALIER	247	0.09	Gen	-4.04
CHIN	CHIN CHUTE	406	0.00	Gen	-4.13
CMH1	CITY OF MEDICINE HAT	680	-0.66	Gen	-4.79
ENC1	CLOVER BAR 1	516	4.09	Gen	-0.04
ENC2	CLOVER BAR 2	516	4.09	Gen	-0.04
ENC3	CLOVER BAR 3	516	4.09	Gen	-0.04
CNR5	CNRL HORIZON	1263	4.86	Gen	0.73
CRE1	COWLEY EXPANSION 1	264	2.42	Gen	-1.71
CRE2	COWLEY EXPANSION 2	264	2.42	Gen	-1.71
CRE3	COWLEY NORTH	264	2.42	Gen	-1.71
PKNE	COWLEY RIDGE WIND POWER PHASE1	264	2.42	Gen	-1.71
CRWD	COWLEY RIDGE WIND POWER PHASE2	264	2.42	Gen	-1.71
DAH1	DIASHOWA	1088	-0.54	Gen	-4.67
DKSN	DICKSON DAM 1	4006	3.91	Gen	-0.22
DOWGEN15M	DOW GTG	61	4.06	Gen	-0.06
DV1	DRAYTON VALLEY PL IPP	4332	0.00	Gen	-4.13
DRW1	DRYWOOD 1	4226	0.40	Gen	-3.73
Project462_1_SUP	ENEL ALBERTA CASTLE ROCK WIND FARM	221	0.82	Gen	-3.31
CES1	ENMAX CALGARY ENERGY CENTRE CTG	187	-0.07	Gen	-4.20
CES2	ENMAX CALGARY ENERGY CENTRE STG	187	-0.07	Gen	-4.20
FNG1	FORT NELSON	1016	4.15	Gen	0.02
Project837_1_GEN	FORTISALBERTA AL-PAC PULP MILL	2392	-3.48	Gen	-7.61
EC04	FOSTER CREEK G1	1301	4.98	Gen	0.85
0000001511	FT MACLEOD	4237	0.30	Gen	-3.83
GN1	GENESEE 1	525	5.80	Gen	1.67
GN2	GENESEE 2	525	5.80	Gen	1.67
GN3	GENESEE 3	525	5.80	Gen	1.67
GHO	GHOST	180	-1.69	Gen	-5.82
Project518_1_SUP	GHOST PINE WIND FARM	603	2.42	Gen	-1.71
0000022911	GLENWOOD	4245	0.23	Gen	-3.90
GPEC	GRANDE PRAIRIE ECOPOWER CENTRE	1101	-2.09	Gen	-6.21
Project723_1_SUP	GREENGATE HALKIRK WIND PROJECT	1435	4.92	Gen	0.79
HSH	HORSESHOE	171	-1.67	Gen	-5.80
HRM	HR MILNER	1147	1.92	Gen	-2.21
INT	INTERLAKES	376	-0.34	Gen	-4.46
KAN	KANANASKIS	193	-1.63	Gen	-5.76
KH1	KEEPHILLS #1	420	6.39	Gen	2.26
KH2	KEEPHILLS #2	420	6.39	Gen	2.26
Project 500_1	KEEPHILLS #3	610	5.73	Gen	1.61
KHW1	KETTLES HILL WIND ENERGY PHASE 2	402	0.84	Gen	-3.29
IOR1	MAHKESES COLD LAKE	56789	6.08	Gen	1.95
AKE1	MCBRIDE	901	0.61	Gen	-3.51
MKRC	MCKAY RIVER	1274	5.05	Gen	0.92
MEG1	MEG ENERGY	405	5.12	Gen	0.99
MKR1	MUSKEG	1236	5.14	Gen	1.01

MP-ID*	Facility Name	PSS/E Bus	Normalized and Compressed Loss Factor (%)	Loss Factor Asset	Difference % in Loss Factor to System Average
NX02	NEXEN OPTI	1241	5.96	Gen	1.83
NPP1	NORTHERN PRAIRIE POWER PROJECT	1120	-4.57	Gen	-8.70
NPC1	NORTHSTONE ELMWORTH	19134	-4.38	Gen	-8.51
NOVAGEN15M	NOVA JOFFRE	383	1.47	Gen	-2.66
OMRH	OLDMAN	230	0.83	Gen	-3.29
WEY1	P&G WEYERHAUSER	1141	-1.91	Gen	-6.04
0000039611	PINCHER CREEK	4224	0.72	Gen	-3.41
POC	POCATERRA	214	-1.03	Gen	-5.16
PH1	POPLAR HILL	1118	-4.51	Gen	-8.83
PR1	PRIMROSE	1302	3.81	Gen	-0.32
RB1	RAINBOW 1	1031	0.85	Gen	-3.28
RB2	RAINBOW 2	1032	0.26	Gen	-3.87
RB3	RAINBOW 3	1033	1.05	Gen	-3.07
RL1	RAINBOW 4	1035	1.43	Gen	-2.70
RB5	RAINBOW 5	1037	1.04	Gen	-3.09
RYMD	RAYMOND RESERVOIR	413	0.00	Gen	-4.13
TC02	REDWATER	50	3.80	Gen	-0.33
RUN	RUNDLE	56197	-1.72	Gen	-5.85
SH1	SHEERNESS #1	1484	3.07	Gen	-1.06
SH2	SHEERNESS #2	1484	3.07	Gen	-1.06
SHCG	SHELL CAROLINE	3370	-0.91	Gen	-5.04
SCTG	SHELL SCOTFORD	43	3.69	Gen	-0.44
GWV1	SODERGLEN	358	1.27	Gen	-2.86
SPR	SPRAY	310	-1.76	Gen	-5.89
0000038511	SPRING COULEE	4246	-1.45	Gen	-5.58
STMY	ST MARY IPP	3448	0.00	Gen	-4.13
0000006711	STIRLING	4280	-0.31	Gen	-4.43
ST1	STURGEON 1	1166	-0.26	Gen	-4.38
ST2	STURGEON 2	1166	-0.26	Gen	-4.38
IEW1	SUMMERVIEW 1	336	1.20	Gen	-2.92
IEW2	SUMMERVIEW 2	336	1.20	Gen	-2.92
CRS1	SUMMIT CROSSFIELD ENERGY CENTRE	503	0.08	Gen	-4.04
CRS2	SUMMIT CROSSFIELD ENERGY CENTRE	503	0.08	Gen	-4.04
CRS3	SUMMIT CROSSFIELD ENERGY CENTRE	503	0.08	Gen	-4.04
SCR3	SUNCOR HILLRIDGE WIND FARM	389	-0.21	Gen	-4.34
SCR2	SUNCOR MAGRATH	251	0.53	Gen	-3.59
SCR1	SUNCOR MILLENIUM	1208	5.25	Gen	1.12
SD1	SUNDANCE #1	135	5.22	Gen	1.10
SD2	SUNDANCE #2	135	5.22	Gen	1.10
SD3	SUNDANCE #3	135	5.22	Gen	1.10
SD4	SUNDANCE #4	135	5.22	Gen	1.10
SD5	SUNDANCE #5	135	5.22	Gen	1.10
SD6	SUNDANCE #6	135	5.22	Gen	1.10
SCL1	SYNCRUDE	1205	5.03	Gen	0.90
TAB1	TABER WIND	343	-0.81	Gen	-4.93
TAY1	TAYLOR HYDRO	670	0.82	Gen	-3.31
TAY2	TAYLOR WIND PLANT	670	0.82	Gen	-3.31
THS	THREE SISTERS	379	-1.76	Gen	-5.88
ARD1	TRANSALTA ARDENVILLE WIND FARM	739	1.29	Gen	-2.84
VVW1	VALLEYVIEW 1	1171	0.60	Gen	-3.53
VVW2	VALLEYVIEW 2	1172	0.45	Gen	-3.68
WTRN	WATER IPP	3449	0.00	Gen	-4.13
0000040511	WAUPISOO	2417	-1.72	Gen	-5.85
WST1	WESGEN	14	0.00	Gen	-4.13
EAGL	WHITE COURT	410	0.00	Gen	-4.13
0000016301	Amoco Empress (163S)	262	0.75	DOS	-3.37
0000079301	ANG Cochrane (793S)	191	3.67	DOS	-0.46
341S025	Syncrude Standby (848S)	1200	-4.40	DOS	-8.53

Notes:

* MP-ID - point where loss factors assessed

For loss factors, "-" means credit, "+" means charge

Loss factors effective from January 01, 2011 to December 31 2011.

System Average Losses, %: **4.13**For more information, please visit www.aeso.ca

For 2011 Line loss factors have been determined based on their location to load. The large transmission generators such as Keephills or Genesee are subject to a line loss cost of about 6% where as the generators such as the Northern Prairie Power project are located near load and receive a line loss payment of - 4.5% from the AESO for reducing line loss (see MP ID NPP1 in table above). Distributed generation is not eligible for a line loss payment because of the energy-generating scale of these sites. Regardless of this line loss payment tariff the use of distributed generation achieves the same reduction in actual delivered energy as does the Northern Prairie Power Plant.

Utilizing this logic for renewable energy systems implies those customer sites would receive a credit for avoided line loss just like the Northern Prairie Power Plant. In absolute terms the average transmission system loss as determined by the AESO for 2011 is 4.13 %.

Distribution losses

Distribution generator sites provide the best system support with respect to line loss since they are located at or near the end of the distribution system. For distribution line loss the calculation of the additional associated factors is done by the franchise wires companies like ATCO, Fortis, ENMAX, EPCOR or the REA's. Each wires company calculates the line loss for their service territory and applies it in their tariff. Those line losses factors are avoided by distributed generation as they remove some need for additional energy for system support. Service territories like ENMAX Power Corp. or the Southern Alberta REA are examples of the significant range in line losses as a factor of population density and total length of wires. In the ENMAX service territory the 2010 line loss calculation was determined to be 3.3% as part of the 2010 ENMAX Power Corp. tariff application (Source: EPC, FBR compliance filing, Appendix 5). Conversely the Southern Alberta REA has calculated their distribution losses at 13% and applied it in their 2010 tariff.

Total Line Loss

With those examples in mind the total avoided line loss for both transmission and distribution wires can be shown to have a wide range. A study by Jem Energy for the Clean Air Strategic Alliance in 2004 provides a weighted average line loss calculation for transmission and distribution in Alberta at approximately 7.7%⁷. Given that this number represents only physical losses (and disregards the financial settlement factors used by AESO for load settlement).

Since these grid line losses are avoided by the use of distributed generation, approximately 1.077 units of electricity from transmission-connected generators are offset by each unit of electricity generated at distributed generation sites.

⁷ CASA, 2004. URL: <http://www.assembly.ab.ca/lao/library/egovdocs/ca6/casa/2004/146660.pdf>