

# Alberta Offset System Guidance for Protocol Development

## Technical Seed Document

### IDENTIFICATION OF THE PROTOCOL DEVELOPER

Proposed Title of Protocol: **Quantification Protocol for distributed Micro Generation**

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## ***Introduction and summary of project***

The purpose of this offset protocol is to facilitate the aggregation of carbon offsets from a large number of grid-connected solar photo-voltaic or wind energy generation systems up to 1 MW in scale.

### **1. Scope and applicability of protocol**

#### **i. Review of technology/practices**

The micro-generation systems covered in this protocol comprise grid-connected installations of photo-voltaic (PV) solar energy collectors and small micro-wind turbines. All eligible systems must be grid-tied through the use of an inverter to transform the DC voltage from generation systems into grid-following 60 Hz AC electricity.

#### **ii. Greenhouse gases identified/targeted**

The primary greenhouse gas targeted by this offset protocol is carbon dioxide. Given that that baseline carbon intensity of grid power is prescribed by Alberta Environment, no calculation is required of the baseline; it is set at 0.650 tonnes CO<sub>2</sub> equivalent per megawatt hour.

#### **iii. Additionality**

The emissions reduction from the forms of renewable electricity generation described in this protocol are additional because grid-electricity and the related losses of electricity between conventional generation sites and homes, where it is consumed are displaced by electricity generated on-site from technologies that have no direct emissions (i.e. solar and wind).

#### **iv. Review of existing projects/common practice**

The current adoption rate for renewable energy systems in Alberta is very low, and the solar and wind industries are still in their early stages of growth, with 273 sites recorded as of August 2011 out of approximately 1.5 million residential dwellings and hundreds of thousands of commercial buildings in Alberta. As such, the incorporation of renewable energy systems into buildings and sites are not yet considered as a business as usual activity at this time.

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<sup>1</sup> AUC micro-Generation Reporting – Total Alberta as found at: [http://www.auc.ab.ca/rule-development/micro-generation/Documents/Micro\\_Generation/Micro-Generation\\_Reporting\\_2011\\_Aug.pdf](http://www.auc.ab.ca/rule-development/micro-generation/Documents/Micro_Generation/Micro-Generation_Reporting_2011_Aug.pdf)

Solar Collectors:

ENMAX's typical residential PV installations consist of multiples of 1.2-1.3 kW PV systems comprising a number of PV modules (typically multiples of 5 or 6 modules of 180-240W), each of which is made up of a collection of silicon wafers with thin lines of conductor. The DC voltage from the modules is transformed in an inverter to AC voltage and synchronized to the phase of grid power. Such systems must incorporate anti-islanding failsafe features such that if grid power is lost, the system cannot energize the local distribution grid.

**Figure 1: Typical residential-scale PV installations**



**Table 1: Features of typical PV systems**

<b>Rated Capacity</b>	<b>1.0 to 1.5 kW</b>
<b>Weight</b>	<b>200-300 lbs (2 lb/sq ft)</b>
<b>Height</b>	<b>Less than 12" (30 cm)</b>
<b>Surface area</b>	<b>10 m<sup>2</sup> (6m x 1.5m)</b>
<b>Grid feeding</b>	<b>120/240VAC 50-60 Hz</b>
<b>Auto disconnect</b>	<b>No power to grid when power fails (for safety) CSA 22.2</b>

Larger PV systems use string inverters (one inverter per set of modules). String inverters collect the DC voltage from a larger number of modules and transform the higher DC voltage to AC voltage centrally. By contrast, micro-inverters take the relatively smaller DC voltages from individual modules and transform them to AC, typically at the site of the module, thereby facilitating normal AC power from the roof to the inside of the building.

Wind energy collectors:

Typical micro-scale wind turbines consist of a rotor that spins about a central hub (or nacelle) that contains an electrical generator (or dynamo). Electricity from the generator may be AC or DC, and may run through an inverter to rectify the voltage and phase, resulting in grid-following AC electricity. Like PV installations, wind turbines must have anti-islanding safeguards and comply with the Alberta Micro-Generation Regulation.

**Figure 2: Typical micro-wind installations**



**Table 2: Features of typical micro-wind systems**

<b>Rated Capacity</b>	<b>2-4 kW</b>
<b>Weight</b>	<b>~200 lbs</b>
<b>Height</b>	<b>33-66 ft (10-20 m) hub height</b>
<b>Blade radius</b>	<b>Approximately 6 ft</b>
<b>Grid feeding</b>	<b>120/240VAC 50-60 Hz</b>

- 1 Applicability to all Alberta offset system criteria
  - i. Barriers

#### Financial Barriers

High capital cost and longer payback periods are still the biggest hurdles in mass scale acceptance of micro-generation systems. For centralized generation, the cost per unit of energy is spread over the life of the asset, whereas for decentralized energy production, consumers typically face the full up-front cost, which is perceived as a significant financial barrier. Similar barriers come in the form of having to navigate permitting requirements and fees at municipal and other levels of government.

#### Technological Barriers

There are two technological barriers; supply chain and operations and maintenance (O&M).

Supply chain: Micro-generation faces a fractured supply chain, lack of manufacturers and lack of qualified independent contractors for installation, which impedes homeowners from implementing micro-generation.

Operation and maintenance: There is a lack of experienced personnel in servicing distributed micro-generation, which tends to prevent the long term operation of this type of generation.

#### Social Barriers

##### Lack of Information: -

Availability of limited information is a big hurdle in mass penetration of distributed micro-generation systems. Consumers in Alberta are either unaware or poorly informed of the various choices they have to source their electricity, and how their choices contribute towards addressing climate change. The lack of awareness about the technological and operational know-how is a critical barrier in making decisions to install these systems.

Institutional: Residential customers are aware about the benefits but skeptical of the expected performance and high cost. The technologies are in the initial phase of mass implementation in Alberta.

Others: Regulatory- Beyond the Micro Generation Regulation there are no regulations to support the implementation of such technologies.

#### ii. Permanence

This protocol addresses instantaneous energy displacement and thus permanence is not a concern. Neither wind nor solar PV technologies release GHGs during or subsequent to their use in generating electricity.

#### iii. Risks to implementation/leakage

Based on the definition of leakage in the Technical Guidance for Offset Protocol Developers Version 1.0, Leakage cannot occur in this type of project.

#### iv. Impacts/co-benefits

Micro-generation may create ancillary environmental and social benefits such as:

- Reduction in other air pollutants like SO<sub>2</sub>, NO<sub>x</sub>, PM, Hg etc
- Encourage market penetration of distributed generation
- Saves infrastructure development cost by providing demand side energy management or energy efficiency
- Create additional green jobs and entrepreneurship opportunities for the green industry/business opportunities

#### v. Ownership

To be eligible for offsets, the proponent must be able to prove ownership of the environmental attribute (GHG reduction) through a clear record of custody such as a contract.

vi. Verification

The reduction of GHG emissions must be verified by a qualified third party to the satisfaction of Alberta Environment & Water.

## 2. Protocol Technical Scientific Foundation

The micro-generation protocol is based on sound technical science. Displacement of grid power by electricity of lower carbon intensity by homeowners (or other end users of electricity) amounts to a form of demand side management. The greenhouse gas reduction associated with micro-generation is predicated on the lower carbon intensity of power on-site and the avoided line losses from producing power at the site of consumption. Line losses are accounted for by multiplying the amount of avoided energy consumption by a factor equivalent to the average physical loss of electrons on the transmission and distribution systems (for the purpose of this offset protocol, the factor in Alberta is 1.077, representing avoided line loss of 7.7%).

The carbon intensity of solar PV-generated electricity is very low. There are no direct emissions from operation of PV solar collectors. There is, however, embodied energy (and thus greenhouse gas emissions) in the materials of the modules and support structures to support them. According to the journal *Environmental Science & Technology*, Volume 42, No. 6, 2008 in an article entitled *Emissions from Photovoltaic Life Cycles* by Fthenakis, Kim and Aselma, the embodied emissions in solar PV modules, averaged over 30 years, amounts to 22-55gCO<sub>2</sub>e/kWh (about 5-10% of which is from the racking/support structure). When compared to values for coal-fired power in Alberta in the range of 1000gCO<sub>2</sub>e/kWh (1.0 t/MWh), the embodied emissions in PV panels are similar to those of the equipment used in the baseline condition and small enough to be negligible. They are excluded from offset calculations.

The carbon intensity of wind-generated electricity is similarly very low. As with PV solar collectors, there are no direct emissions from operation of wind turbines. There is, however, embodied energy (and thus greenhouse gas emissions) in the materials of the rotor, nacelle and support structure to support them. A study by R.H. Crawford in *Renewable and Sustainable Energy Reviews*, Vol. 13 (2009) shows that the embodied energy of small wind turbines amounts to less than two tones of greenhouse gas emission per kWh (rated capacity), and that their energy payback is near one year of operation (depending on the size), a quarter of which is represented by metal in the pole that supports the nacelle. The embodied emissions in small wind turbines are small and similar to those of the equipment used in the baseline condition and are therefore excluded from offset calculations.

This protocol follows the ‘streamlined lifecycle assessment’ approach, which means that certain parts of the complete lifecycle of in the project condition may be explained as being similar to or less than the equivalent activity in the baseline condition, and therefore excluded from both. For example, the embodied energy of solar modules is presented as being similar to the embodied energy of coal-fired power plants, and therefore neither is included as explicit calculations in the project or baseline conditions (they are shown as outside of the project boundary conditions).

The micro-generation protocol is based on sound technical science. Displacement of grid power by electricity of lower carbon intensity by homeowners (or other end users of electricity) amounts to a form of demand side management which reduces emissions instantaneously and permanently. The greenhouse gas reduction associated with micro-generation is predicated on the lower carbon intensity of power on-site and the avoided line losses from producing power at the site of consumption. Line losses are accounted for by multiplying the amount of avoided energy consumption by a factor equivalent to the average physical loss of electrons on the transmission and distribution systems (for the purpose of this offset protocol, the factor in Alberta is 1.077, representing avoided line loss of 7.7%).

### **3. Protocol Operational Framework**

#### **i. Baseline Condition**

The baseline condition reflects the current carbon intensity of emissions from grid power. For the purpose of offsets, the intensity of grid power is prescribed by Alberta Environment & Water in the Technical Guidance Document for Offset Developers (currently set AENV at 0.65t/MWh at time of print). By contrast, the average Alberta electricity grid factor was published by Environment Canada in its National Inventory Report 1990-2008<sup>2</sup> in 2010 to be 0.88 tonnes/MWh.

#### **ii. Assessment of Baseline Scenarios**

There is only one baseline condition for this protocol, reflecting the prescribed baseline carbon intensity of grid power.

#### **iii. Selection and Justification of Baseline Scenario**

ThereBecause there is only one baseline scenario for carbon intensity of grid power when applied to offset projects, prescribed by Alberta Environment & Water (currently set at, the default baseline reflects 0.65 t/MWh).

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<sup>2</sup> Canada’s National Inventory Report can be found at <http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1> or [http://unfccc.int/national\\_reports/annex\\_i\\_ghg\\_inventories/national\\_inventories\\_submissions/items/5888.php](http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php).

iv. Additionality

Additionality is preserved, as the offset emissions are counted only once, may only be counted from installations within the province of Alberta, and are voluntary emission reductions by parties other than obligated parties (under SGER).

v. Identification of Baseline Conditions

Because there is only one baseline scenario, the default baseline reflects the grid intensity prescribed by Alberta Environment & Water in the Technical Guidance for Offset Project Developers, set at time of publishing at 0.65 t/MWh.

vi. Baseline Determination/Quantification

The baseline emission quantification is calculated by multiplying the amount of electricity displaced at the end user's site by 0.65t/MWh by the grid loss factor (1.077).

vii. Risk Assurance Factors, if appropriate

Risk is reduced by monitoring all sites. For cases where a sample is used to extrapolate to the production of a larger population of sites, assurance factors should be provided to demonstrate how various types of improper calculations can be mitigated.

viii. Project Condition

The project condition reflects the total produced electricity of a qualifying micro-generation system over a period of time. The equipment manufacture, transport, commissioning, decommissioning and recycling are considered similar to conditions in the baseline, and therefore not included within the project boundaries.

ix. Project Scope

The project sites must receive their power from the Alberta grid prior to the installation of distributed micro-generation system and comply with the Climate Change Emissions Management Act (CCEMA)<sup>3</sup>, the Specified Gas Emitters Regulation (SGER)<sup>4</sup> and conform to the guidelines set out in the Technical Guidance for Offset Protocol Developers<sup>5</sup> and Technical Guidance for Offset Project Developers<sup>6</sup>. The installations must be within the province of Alberta and be commissioned after January 1, 2001.

x. Definitions of Practices

Operation means installing a micro-generation system in accordance with specifications in areas and for conditions where normal operation is unimpeded and expected to be favourable.

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<sup>3</sup> [http://www.qp.alberta.ca/574.cfm?page=C16P7.cfm&leg\\_type=Acts&isbncln=9780779740956](http://www.qp.alberta.ca/574.cfm?page=C16P7.cfm&leg_type=Acts&isbncln=9780779740956)

<sup>4</sup> <http://environment.gov.ab.ca/info/library/7811.pdf>

<sup>5</sup> <http://environment.gov.ab.ca/info/library/8331.pdf>

<sup>6</sup> <http://environment.gov.ab.ca/info/library/7915.pdf>

Owning means having legal title to physical equipment and the contractual clarity for owning the environmental attributes of operating physical equipment.

xi. Identification of Project 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 movement of greenhouse gases from source to sink 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 (which are 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). By definition, the baseline condition takes carbon from subterranean fossil sources (the source) and releases it as greenhouse gases into the sink which is the biosphere (the sink, which is affected). In addition to the carbon in fuel, the baseline condition reflects emissions from fuel extraction, processing and transportation but these are considered upstream of the project condition and are therefore excluded.

Some energy, and therefore greenhouse gases, are embodied in the equipment used to harness solar and wind energy, as are likewise embodied in the equipment used to produce electricity from fossil sources. 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 also 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.

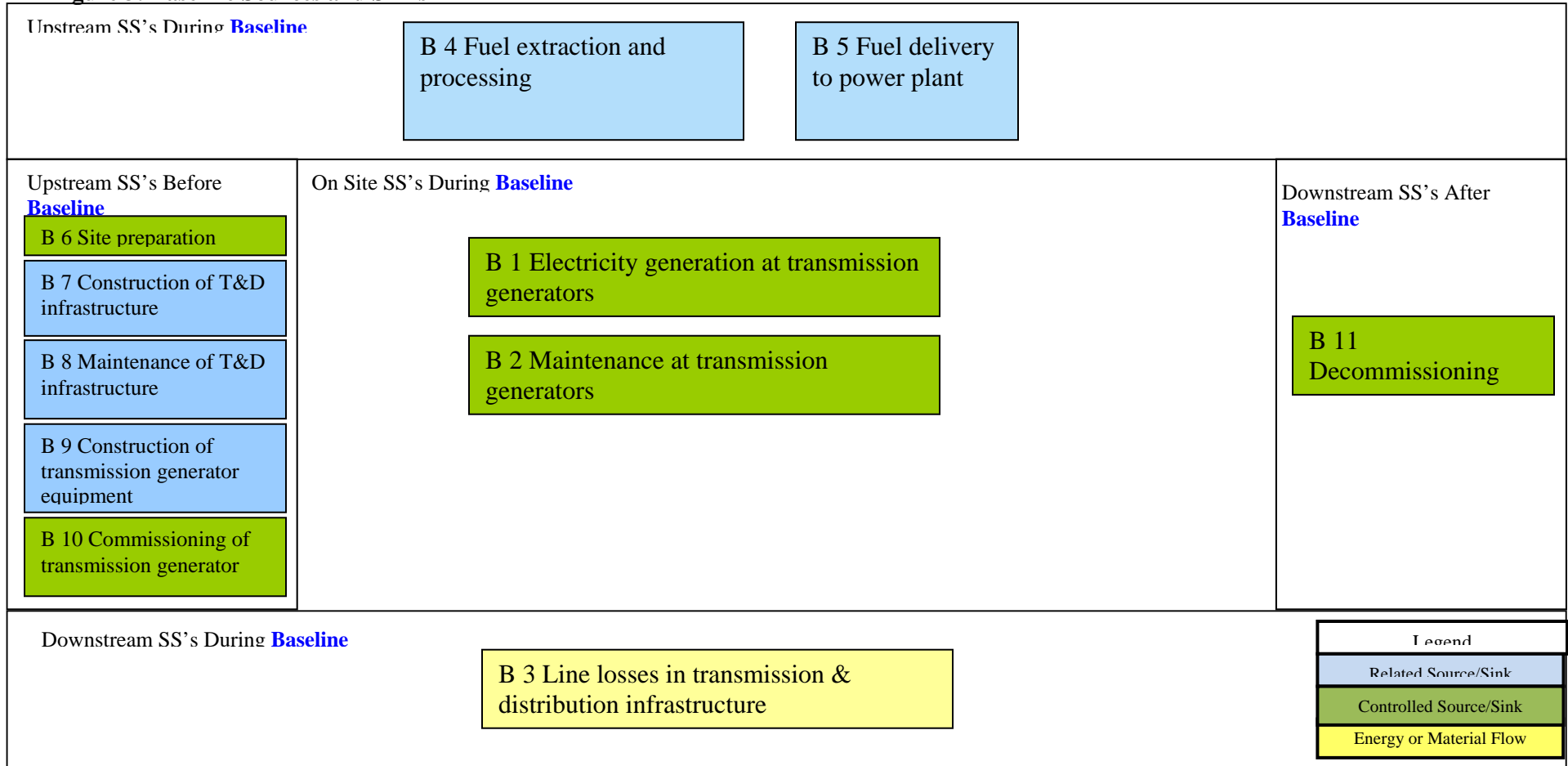
xii. Identification of Relevant Sources and Sinks

See Figures 3 and 4 below.

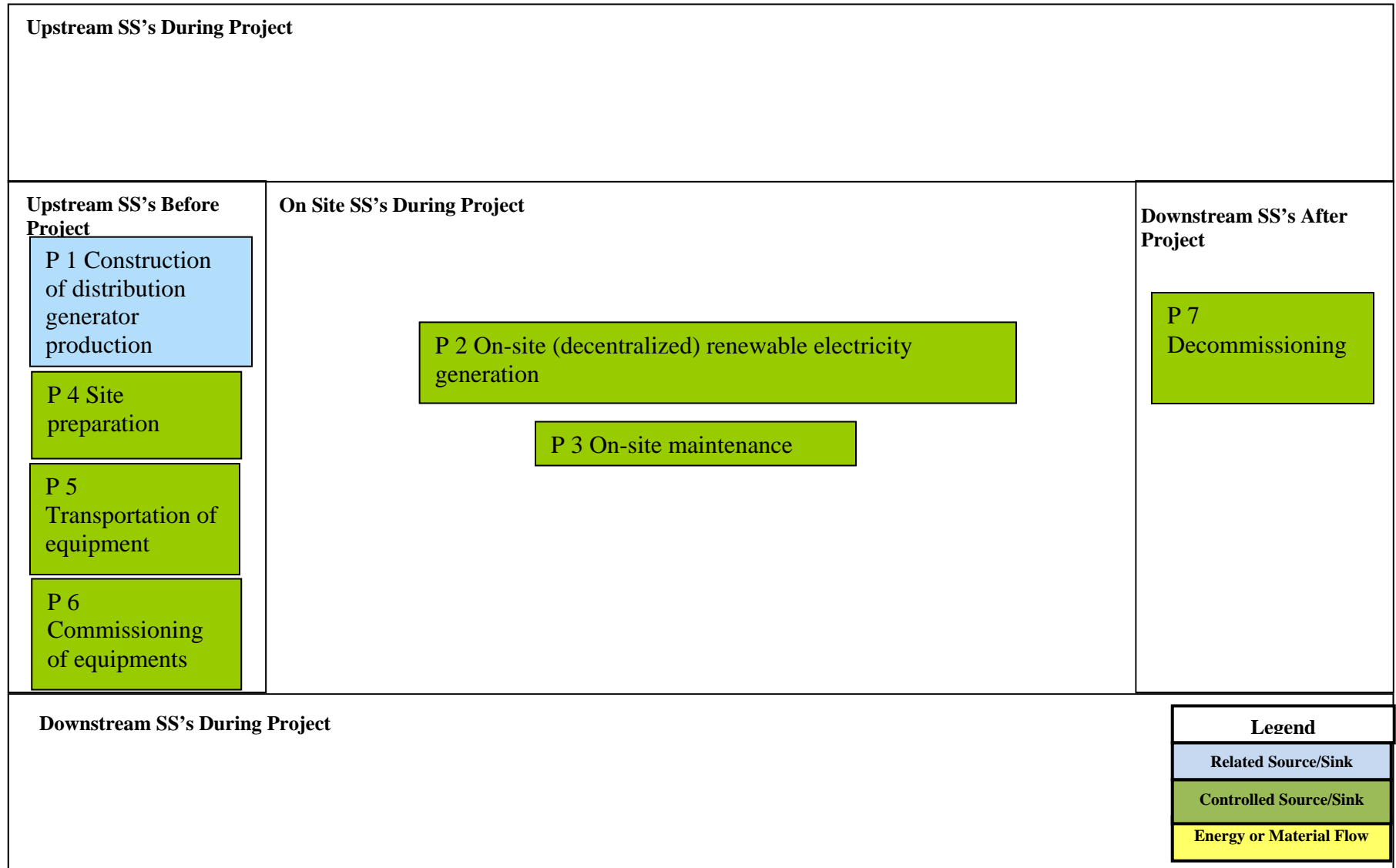
xiii. Permanence and Reversibility

Emission reductions from micro-generation are instantaneous and cannot be reversed.

**Figure 3: Baseline Sources and Sinks**



**Figure 4: Project Sources and Sinks**



xiv. Comparison of Project and Baseline Sources and Sinks

**Table 3: Comparison of Project and Baseline Sources and Sinks**

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion/Exclusion
<b>Upstream Sources/Sinks</b>				
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.

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion/Exclusion
B10 Commissioning of transmission generation	Controlled	N/A	Exclude	Commissioning emissions are small in relation to plant operation and therefore excluded.
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.
<b>Onsite Sources/Sinks</b>				
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.
B2 Maintenance	Controlled	N/A	Exclude	Emissions from maintenance are not material and therefore excluded.

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification for Inclusion/Exclusion
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.
<b>Downstream Sources/Sinks</b>				
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.
<b>Other</b>				

#### **4. State of Science**

The science of lifecycle assessment for renewable energy systems has matured significantly over the last five to ten years, with more commonality as to the boundary conditions and improvement in data availability for models that is based on higher-volume production of equipment. As the technologies mature, most renewable energy technologies are likely to exhibit considerable improvements in per-unit embodied energy due to economies of scale and process efficiencies, limited by the physical requirements to extract and upgrade primary resources and the carbon intensity of energy sources used in extraction and upgrading of these resources.

Overall, the technologies presently available in the Alberta market are unlikely to represent material deviation in embodied energy from those technologies examined in recent studies.

#### **5. Consultation Workshop results**

##### **ISSUES DISCUSSION AND RESOLUTION:**

###### **Introduction:**

On April, 30<sup>th</sup>, 2011, ENMAX Corporation resubmitted its INTENT OF PROTOCOL DEVELOPMENT to both the Climate Change Central (C3) and AENV. This submission was substantially modified and updated to meet the Specified Gas Emitters Regulation's (SGER) offset system requirements and address Alberta Environment concerns around quantification and verification approaches.

In its recent submission, ENMAX expanded the scope of the protocol to cover a wide range of micro-generation projects based on proven technologies. The earlier protocol proposal was targeted for only renewable micro-generation projects as defined in the mini-micro category of Micro-generation Regulation i.e. renewable projects. The current version covers all grid-tied micro-generation systems that are 1 MW and under from solar PV and micro-wind. Micro-generation projects that use biomass or cogeneration are not part of this protocol and should use other approved protocols available at [www.carbonoffsetsolutions.ca](http://www.carbonoffsetsolutions.ca).

Below is the summary of issues and discussions, and the decisions made during the protocol development process.

## **Issues and discussions:**

### **1. Term of the protocol**

In the initial draft, ENMAX proposed a 40 year crediting period to ensure certainty in government's support to the program. Micro-generation systems are costly compared to traditional types of generation and are not considered as business as usual (BAU) at this time. ENMAX proposed a 40 year period to align with the long term horizon that is required for investments micro-generation.

*AENV's response:* AENV responded by indicating that the current rules under the Alberta Offset System allow for a crediting period of 8 years with a possible extension of 5 years. The offset system doesn't allow any variation in crediting period beyond 13 years. Moreover, AENV is not contemplating modifying the rules of the offset system at this time. AENV advised that each technology based protocol must follow this standard crediting period.

*ENMAX's resolution:* In the revised submission ENMAX proposes to use 8 + 5 years as first protocol term with a provision to extend the projects beyond the first 13 years in 5-year period in subsequent years until the activity becomes BAU or mandated by the government. This provision is developed in consultation with AENV, and both parties agreed to the proposal.

### **2. Crediting time**

In the initial draft, ENMAX proposed an upfront allocation of credits that the project would generate during its economic life. This would mean that project proponents would have to submit a onetime third-party verified quantification report. The logic behind this proposal was to secure lump-sum credits upfront which then could be used to adjust the high upfront cost and resulting in a higher uptake of the micro-generation program. ENMAX offered a guarantee of production values to minimize the risk of any leakage or over crediting.

*AENV's response:* Alberta Environment responded that the system is build around reductions that have occurred and have been quantified. Upfront crediting is not allowed in the existing rules because these are not real reductions. AENV raised the concern that creating offset credits in the absence of real reductions is problematic and against the existing rules. As per the SGER, the offset credits must be quantified and verified by the third party after the reductions have occurred.

*ENMAX's resolution:* In the revised submission, ENMAX has replaced the upfront crediting approach by relying on actual production data that represents reductions after they have occurred. The proposal uses actual measurements from micro-generation facilities and if a large enough uniform fleet of micro-generation is available then a statistically valid sample would be used. This proposal also ensures that each site is auditable regardless if the site was sampled or measured.

### 3. Grid intensity factor

In the initial draft, ENMAX used the actual grid intensity published by Environment Canada for Alberta's Electricity sector. To make sure the intensity represent conservativeness approach, ENMAX used the lowest of last 5 years published intensity values. ENMAX's argument was that the projects under this protocol would be directly connected to the grid and using more accurate grid intensity instead of a generic factor is more appropriate. Moreover, it was proposed that the intensity would be updated with the changing generating mix in Alberta.

*AENV's response:* AENV rejected the EC published grid intensity factor and strongly recommended AENV published intensity factor of 0.65 tonnes/MWh, which AENV had included in its offset guidance document. AENV indicated that proponents of electricity related projects shall use AENV's published grid intensity factor. The protocol guidance document proposes to develop and use a project specific grid factor, however it doesn't apply in projects covered under this protocol.

*ENMAX's resolution:* In the revised submission, ENMAX has included the 0.65 tonnes/MWh AENV approved grid intensity factor for quantification.

### 4. Line loss

In the initial draft, ENMAX proposed an average of 14% line loss due to both transmission and distribution systems based on estimates made in-house. Transmission line loss occurs when power is transported from centralized large scale generating plants at high voltages and the distribution line losses occur at lower voltages when power is delivered to customers.

The Alberta Electric System Operator or AESO publishes the line losses for each region in Alberta. The combined total line losses in Alberta account for an average of 14 % of the total generated power. The electricity produced by distributed micro-generation is consumed on or near where it is produced, which effectively in eliminates the line losses in both the transmission and distribution systems

*AENV's response:* AENV responded that current AB grid factor for electricity based offset protocols/projects is set at 0.65 tonnes/MWh without any additional factor for line losses. However, if ENMAX can demonstrate how these line losses are avoided by the micro-generation project, AENV may approve it.

*ENMAX's resolution:* ENMAX provided detailed calculation on the line loss factor calculation and also submitted a PowerPoint presentation demonstrating how micro-generation systems are connected at the load and avoid line losses. The presentation is submitted as seed document. Provided below is basic calculation of line loss factor:

The overall line loss factor for the distributed micro-generation systems is a combination of Supply Transmissions System (STS) and Demand Transmissions System (DTS) losses. The supply side is picked up by the generators and the demand side by the wire operators.

Demand side or DTS: The line losses at the demand side include heat loss in the distribution systems including wires plus UFE (unaccounted for energy; another form of transmission & distribution systems). For the Calgary distribution region, ENMAX estimates these losses to be approx. 3%. For the Edmonton region these losses are estimated at roughly 2.5%. For Central Alberta Rural Electrification Association or REA, however, the estimated losses are over 11 %.

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%<sup>7</sup>.

ENMAX also provided an addendum, “Line Loss supporting Document” as part of seed documents detailing discussions and justification of the line loss claim.

#### 5. Data management and monitoring plan

In the initial draft, ENMAX did not provide detailed information on the data management and monitoring plan as calculations were based on estimated values and a sampling approach was suggested to validate the claim.

*AENV's response:* AENV indicated that to ensure the integrity of the system, project proponents must develop a data management and monitoring plan to collect verifiable data. Good quality data is required to minimize the risk of reversal and leakage.

*ENMAX's resolution:* ENMAX proposed that data be measured at all sites. If a generation fleet is large enough, a statistically valid sample will be taken from sites where data can be collected feasibly (ie. remote monitoring). Sites that are in remote locations and do not have remote monitoring capabilities must have on site data storage to ensure that a sample can be taken if required for auditing purposes.

And to address data backfill issue, ENMAX proposes to use AESO's approach to backfill missing Data: The Alberta Electric System Operator (AESO) allows for the estimation of missing data. As part of seed document, attached is an excerpt from the AESO's “Measurement System Standard”, which outlines the process for estimation of missing metering data. It includes looking at operational information and using a previous period to estimate for missing metering data. AENV indicated that all backfill data must be auditable.

#### 6. Quantification approach

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

In the initial Quantification Methodology draft, ENMAX proposed to use a combination of actual and surrogate data to estimate total electricity production from micro-generation systems. ENMAX proposed to develop a model using actual generation and true up the model going forward with subsequent year's data. At the time of aggregation, actual and proxy generation will be combined to obtain total production from all the aggregated sites to quantify offset credits.

*AENV's response:* AENV requires that data needs to follow an approach that is traceable, verifiable, and auditable with all assumptions clearly laid out and in a transparent manner.

*ENMAX's resolution:* ENMAX reviewed the capabilities of typical equipment that is used for monitoring and measuring micro-generation and proposed a revised quantification methodology. The quantification methodology will either rely on an actual measurement or if the fleet size is sufficient, a statistically relevant sample of actual measurements. If the sample method is used, the data must be available for audit for both sites where data was collected remotely and for sites where remote data collection was not possible. ENMAX indicated that sampling from the group of sites that have remote monitoring enabled and extrapolating the results for the overall population is a conservative approach for micro-generation such as wind and solar. Sites that do not have access to remote monitoring channels such as high-speed internet are typically in rural areas, which typically perform better due to a lower incidence of solar shading or wind barriers (i.e. adjacent buildings).

## 7. Validation in place of verification

In the initial draft, ENMAX proposed to validate quantified emissions in place of verification of reductions. ENMAX also proposed to use a statistically relevant sample to validate the claims. ENMAX's reason for the request was due to the existing rules for micro-generation which are not conducive for the verification process. The current rules do not permit real time billing for generation from micro sites, and if the sites are expected to install meters, it means additional cost to wire service provider

*AENV's response:* AENV indicated that verification is a very important element of maintaining the offset system integrity as the offsets generated through the program are used for compliance purposes. Validation is done prior to real reductions been achieved and there is no provision in the system that allows project proponents to claim credits before the reductions have occurred.

*ENMAX's resolution:* ENMAX included verification in its final submission. For details please see next section.

## 8. Verification

In the initial draft, ENMAX proposed a limited approach to verification by using a statistically significant sample to verify generation data with the estimated values. At the time of aggregation, all the actual data as well as surrogate would be consolidated and a

sample would be selected for verification. A materiality threshold agreed upon by AENV was to be used to adjust the claimed reductions

*AENV's response:* AENV informed that the verification requirement was changed from limited to reasonable and therefore meant a higher level of data verification requirements. AENV requires data be available for review and requested ENMAX's plan to meet reasonable assurance. AENV indicated that the ideal situation would be to have metered data at each site, or hours of operation for each piece of equipment.

*ENMAX's resolution:* To address AENV's concerns around verification, ENMAX engaged PWC to assist in developing the verification section of the protocol. ENMAX would use a statistically valid sample of sites that are monitored to provide values for sites that are not remotely monitored. Larger micro-generators, such as commercial sized solar photovoltaic systems would rely on the collection of actual energy production of each unit. All the data collected for calculating the GHG reduction claims will be available for verification and can be fully auditable from collection thru to verification. The project proponents will be responsible to ensure auditor access to all data required to support the claims regardless of the source.

## 6. References

Alberta Micro-Generation Regulation

[http://www.auc.ab.ca/rule-development/micro-generation/Documents/Micro\\_Generation/Microgen\\_Regulation.pdf](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](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](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>

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

Crawford, 2008. Life cycle energy and greenhouse gas emissions analysis of wind turbines and the effect of size on energy yield. Renewable and Sustainable Energy Reviews, Vol. 13 (2009). URL:

[http://www.apere.org/manager/docnum/doc/doc1248\\_090706fiche36.pdf](http://www.apere.org/manager/docnum/doc/doc1248_090706fiche36.pdf)

Fthenakis, Kim and Alsema, 2008. Emissions from Photovoltaic Life Cycles. Environmental Science & Technology, Vol. 42, No. 6. URL:

<http://pubs.acs.org/doi/abs/10.1021/es071763q>

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>

## Appendices

### **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.

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

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

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

Therefore...

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

\* 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%.

### **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 each site for a period to develop a model based on the properties of each installed unit. 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 fill in the energy production from the sites described above, the electricity production from each system may be estimated by comparing against established solar resource maps such as those published by Natural Resources Canada<sup>8</sup>. Conversely, missing data or sites without metering can be calculated using a model that accounts for system size, solar incidence, module azimuth and orientation, performance degradation and geographic region.

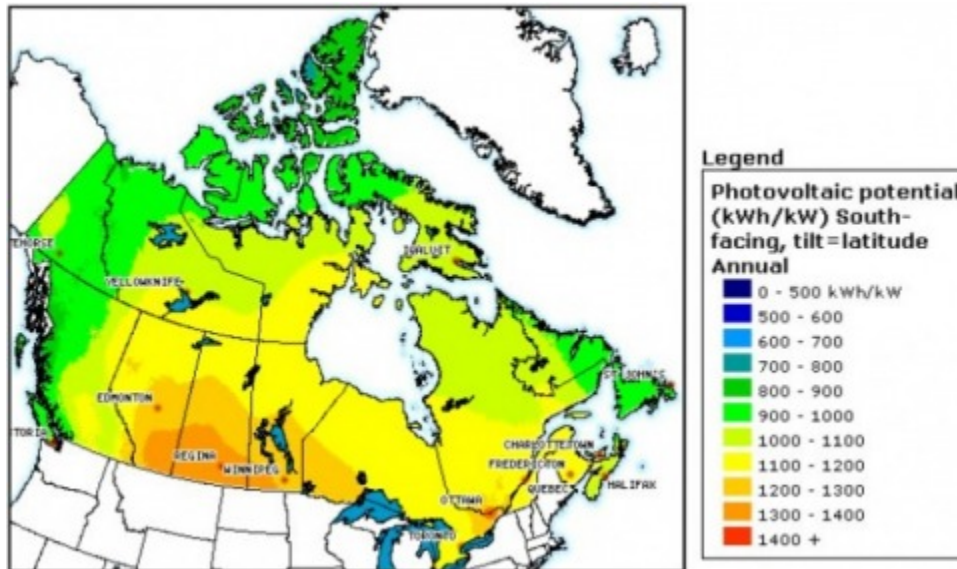
To extrapolate actual production from a number of similar nearby systems, the production should be modeled on the basis of kilowatt hours (kWh) per installed kilowatt of generation capacity, and then discounted as necessary to avoid overestimation. Discounting may be done to reflect lower measured production 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).

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<sup>8</sup> See

[https://glfc.cfsnet.nfis.org/mapserver/pv/pvmapper.phtml?LAYERS=2057,4240&SETS=1707,1708,1709,1710,1122&ViewRegion=-2508487%2C5404897%2C3080843%2C10464288&title\\_e=PV+potential+and+insolation&title\\_f=Potential+photovolta+que+et+ensoleillement&NEK=e](https://glfc.cfsnet.nfis.org/mapserver/pv/pvmapper.phtml?LAYERS=2057,4240&SETS=1707,1708,1709,1710,1122&ViewRegion=-2508487%2C5404897%2C3080843%2C10464288&title_e=PV+potential+and+insolation&title_f=Potential+photovolta+que+et+ensoleillement&NEK=e)

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



Source: [https://glfc.cfsnet.nfis.org/mapserver/pv/index\\_e.php](https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php)

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  $1.3 \text{ kW} \times 1150 \text{ kWh/kW}$ , or 1495 kWh.

### **Method 3: Data from a Sample of Sites**

A large fleet of uniform renewable electricity generators may be spread over a wide geographic area with limited capabilities for onsite data collection or remote monitoring. However, the quantity of sites allows for statistical methods to be used in calculating total production. This method utilizes 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 confidence level of 95% and a total margin of error of no more than 5%. The mean of the sample should be used for all sites in the fleet to calculate offsets.

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.

Example calculation: A fleet of 1,000 residential solar PV systems rated at 1.2 kW each (nameplate production capacity) are installed in southern Alberta spanning two zones of the Canadian Solar Resource Map (600 in the zone containing Edmonton with a solar resource of 1200-1300 kWh/kW and 400 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.

In this example, to reach a margin of error of +/- 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). 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 total production would be shown by  $(\text{Production}_{\text{Edmonton}} + \text{Production}_{\text{Calgary}}) - 2.5\%$