Load Settlement System

Procedures and Methods

Effective January 2023

ATCO Electric

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1. INTRODUCTION

ATCO Electric's Load Settlement System is designed to meet the requirements of Alberta Utilities Commission (AUC) Rule 021 Settlement System Code Rules (SSC). The SSC is a set of rules established by the AUC under the authority of section 24.1(1) of the Electric Utilities Act. All Market Participants as defined in the Electric Utilities Act are required to comply with the SSC.

ATCO Electric has been allowed discretion in implementing some aspects of the SSC. Under section 2.8 of the SSC, ATCO Electric, as Load Settlement Agent (LSA), is responsible for making public on its website the procedures and methods used to conduct settlement. The discretionary procedures and methods implemented by ATCO Electric that impact load settlement calculations are described in this document.

Two appendices are also included as part of this document. In Appendix A, a method is provided for determining hourly customer site energy consumption, loss and unaccounted for energy (UFE) from the SSC transaction set. Appendix B provides background information with respect to the calculation of the system loss equation parameters.

Questions with respect to ATCO Electric load settlement may be emailed to settlement@atcoelectric.com.

2. SITE TO SETTLEMENT ZONE MAPPING

Section 4.5 (2) of the SSC requires ATCO Electric as LSA to disclose individual site to settlement zone mapping rules. ATCO Electric assigns every site for which it is the LSA and all its service territory to a single settlement zone.

3. LOAD PROFILING

Section 3.1 (1) of the SSC defines the acceptable methods for calculating load profiles.

The ATCO Electric load settlement system uses only load research-based profiles or deemed profiles. All customer sites which are not interval-metered are assigned a specific class load profile based on their distribution tariff rate class.

Each site is assigned a profile class code. Specific codes have been assigned to interval metered sites to indicate such. All other codes are assigned according to rate class. The table below lists the rate classes with their associated profile class codes.

Table 1: Non-Interval Metered Profile Classes

Non-Interval Metered Profile Classes	
Rate Class	**Profile Class Code**
Residential	RES
Farm	FRM
Small General Service	COM
Irrigation	IRR
Street and Private Lighting	LITE
Oilfield	OIL
Large General Service / Industrial	IND

Table 2: Interval Metered Profile Classes

Interval Metered Profile Classes	
Customer Site Size	**Profile Class Code**
Sites ≥ 2 MW	INPD
Sites ≥ 500 kW and < 2 MW	INTV
Customer requested	INTV

Section 3.2 (1) of the SSC requires ATCO Electric, as LSA, to state publicly the existing rate classes for which separate load research-based profiles are used in load settlement. The profiles for the residential, farm, small general service and large general service/industrial rate classes are load research-based profiles. Deemed profiles are used for the oilfield, lighting and irrigation classes.

The use of class specific load profiles for calculating monthly pool payments ensures that the energy costs are allocated to each class as fairly as possible. However, the cost of such an implementation needs to be balanced against the degree for fairness achieved. The cost/benefit was maximized by combining other load research needs with that of load settlement so as to provide the same degree of fairness to the customer as they previously had.

Load Research Samples

Section 8 of the SSC defines the standards for load profiles based on load research samples. For details on the requirements for estimation accuracy, frame adequacy, and sample design and implementation please refer to Section 8 of the SSC.

The class load profiles used by ATCO Electric for load settlement are based on historic load surveys. ATCO Electric uses the method of stratified random sampling for the selection of samples to represent each class. This method is commonly used to ensure the most accurate results for a given sample size. An annual load profile, for each class, is developed from the metered data collected from the selected sample sites using the combined ratio estimation technique. The value of the load profile, for each hour of the year, is the energy (kW.h) used in that hour by the average customer site in the class.

Sampling Accuracy Requirements

Section 8.2.3 (2) of the SSC requires the design sampling variance V_{cs} to meet the following criterion:

$$RSE_{cs} = \sqrt{V_{cs}} \Big/ U_c < 0.008$$

Historic Class Load Profiles

The historical profiles used in load settlement are posted on ATCO Electric's web site and can be accessed at

https://www.atco.com/en-ca/retailer-resources.html.

Load Profiling Method

For load research-based profiles, ATCO Electric uses a profiling method known as “proxy day” for estimating class load profiles. The proxy day method compares the available characteristics of the settlement day to the characteristics of historic days. The historic day that best matches the settlement day is used as the proxy day. The historical class profile for that day is then used as the class profile for the settlement day. This process is repeated every day to produce a class load profile for the settlement period.

The proxy day method requires a library of class load profiles for historic days as well as associated characteristics for selecting the proxy day. These profiles are developed from the historic load studies described above. The system load profile is a commonly used associated characteristic. The system load profile (DSLS) is defined as the energy delivered to the settlement zone less the energy delivered to all transmission-connected sites. Other characteristics that may be used include day type, season, temperature and time of the system peak.

The proxy day selection process used by ATCO Electric is provided by ORACLE. ORACLE Utilities Load Profiling and Settlement (LPS) uses a two-step process to find a proxy day. The first step uses information about settlement day to select a list of matching “eligible days”. The information used to select the eligible days may include a combination of the following characteristics:

- Day type
- Holiday
- Season
- System Peak Time
- Ambient Temperature

These parameters may be varied for each profile class to ensure the eligible days selected best represent the characteristics of the class.

Once a list of matching eligible days has been selected, the list is ranked by comparing the system load profile for the settlement day to that of each eligible day. Ranking may be done using a “magnitude” comparison or a “shape” comparison. The two methods may also be combined by selecting a weighting factor for each comparison and summing the weighted values. The eligible day with the highest rank is then selected as the proxy day.

Once the proxy day is selected, the date of the proxy day is used to select the load profile for the class from the library of historic class load profiles.

Modelling Accuracy Requirement

Section 8.2.3 (3) of the SSC requires the modeling variance V_{cm} to satisfy the following criterion

$$RSE_{cm} = \sqrt{V_{cm}} / U_c < 0.008$$

For details regarding this criterion see the section 8 of the SSC.

To select the parameters that meet the above criterion for each profile class, ATCO Electric has analyzed load profile data for the historical period indicated in the table below. Using the methods described in section 8 of the SSC, ATCO Electric has determined that the SSC requirements can be met using the following parameters.

Table 3: Proxy Day Parameters

	Residential	**Farm**	**Small General Service**	**Oilfield**	**Industrial**
Historical Period	2017-2019	2017-2019	2017-2019	2017-2019	2017-2019
System Load Profile	scaled DSLS	scaled DSLS	DSLS	scaled DSLS	scaled DSLS
Day Type	Day of Week	Day of Week	None	Week Day/ Weekend	None
Holiday	No	No	Yes	Yes	Yes
Season	2 Seasons	4 Seasons	Monthly	4 Seasons	4 Seasons
Peak Separation	All Peaks	All Peaks	All peaks	All Peaks	All Peaks
Magnitude Weight	0.1	0.1	0.3	0.2	0.1
Shape Weight	0.9	0.9	0.7	0.8	0.9
Achieved RSE_{cm}	0.0073	0.0018	0.0062	0.0078	0.0071

Deemed Load Profiles

Section 3.1 (3) of the SSC requires oilfield, irrigation, lights and unmetered loads to be profiled using a “deemed” shape. ATCO Electric deems the oilfield load shape to be the one determined from load research samples. The irrigation load profile is deemed to be flat in the months of April through October. The value of the profile for each hour is the average hourly energy (kW.h) used by an irrigation customer site in the period April through October. The value of the lighting load profile for each hour is a number between 0 and 1 that represents the proportion of the hour that the lights are on. The deemed load shape for all other unmetered loads is the load shape of the profile class to which the customer site belongs.

The deemed load profiles used in load settlement are posted on ATCO Electric’s web site.

Profiling Cap

Section 3.3 (1) of the SSC requires a profiling cap of 2 MW or the WSP's current policy, whichever is lower. ATCO Electric's profiling cap is 500 kW consistent with currently approved rate schedules. Interval metered customer sites that are below the profiling cap and are not a part of a profile class load research sample will be settled according to their own interval data.

4. DISTRIBUTION LOSSES AND UFE

Section 4.1 (2) of the SSC requires ATCO Electric, as a Wires Service Provider (WSP), to provide 90-day notice prior to implementing changes to load settlement loss calculations. This document describes the procedures ATCO Electric will use to perform load settlement loss calculations on and after the effective date of this document. Background information as to how the parameters used in these procedures were derived is also provided.

Historic Loss Studies

Section 4.1 (1) of the SSC requires the WSPs that have been doing loss calculations as part of cost-of-service studies to continue to use similar methods to those they have been using.

The parameters used in the loss calculation procedures described below come from two sources: previous load settlement calculations and distribution loss studies of randomly selected distribution feeders.

Annual distribution losses were determined from total annual energy delivered to the settlement zone less the total annual site energy consumption. The source of this information is 2013 through 2017 load settlement results adjusted for PFAMs applicable to the same period. The average annual distribution system losses (4.23% of total annual site energy consumption) calculated from these results form the basis for determining the required loss calculation parameters.

The separation of total distribution losses into primary and secondary distribution losses for each loss group is based on the results of studies ATCO Electric conducted on randomly selected distribution feeder systems. Information on feeder loading, configuration, physical characteristics, and the customer mix served from the feeders are used to determine the distribution system losses for each loss group.

Service Level

For the purpose of performing loss calculations the ATCO Electric distribution system has been separated into primary and secondary distribution systems. Primary distribution consists of all 3-phase 25 kV lines. There are no transformers in the primary distribution system. Secondary distribution includes all elements of the distribution system that are not part of the primary distribution system.

A service level attribute is assigned to each site based on whether the site takes service directly from the transmission system, from the primary distribution system or from the secondary distribution system. Sites connected to the secondary distribution system have a *secondary* service level. Sites connected to the primary distribution system have a *primary* service level. Sites that are connected to the transmission system have a *transmission* service level.

Calculation of Total System Losses

Section 2.7 (1) of the SSC assigns to ATCO Electric as LSA the responsibility for calculating distribution losses for each settlement interval.

Section 6.4.2 (2) of the SSC requires the zone losses to be the sum of the separately determined retailer losses or to be calculated first and then allocated to the retailers.

For each settlement interval, ATCO Electric calculates the total distribution losses for each service level and allocates these losses to retailers. The losses are calculated by applying a loss equation to the hourly load for the distribution system.

The primary distribution energy loss for each hour is calculated as follows:

$$PL_i = A_{P0} + A_{P2} D_i^2$$

Where PL_i is the loss (kW.h) within the primary distribution system in hour i
D_i is the total energy delivered (kW.h) to the distribution system in hour i (does not include transmission-connected sites)
A_{P0} and A_{P2} are loss equation parameters of the primary distribution system

As there are no transformers in the primary distribution system, the constant loss coefficient A_{P0} is zero. The value of the A_{P2} coefficient for the 2019 settlement year is determined as follows (see Appendix B):

$$A_{P2} = \frac{p_P I}{kE} = \frac{(0.015197)(8760)}{(1.012464025)(9691161246)} = 0.00000001356727$$

where p_p is the ratio of the total annual primary energy loss to the total annual energy delivered to the distribution system from historical studies
I is the number of hours in the year
k is the constant determined from the distribution system load shapes for 2013 to 2017
E is the forecast energy delivered to the distribution system for 2019 (kW.h)

Thus for each hour the total energy loss for ATCO Electric's primary distribution system is calculated by multiplying the A_{P2} coefficient by the square of the hourly energy delivered to the distribution system.

The secondary distribution energy loss for each hour is calculated as follows:

$$SL_i = A_{S0} + A_{S2} D_i^2$$

Where SL_i is the loss (kW.h) within the secondary distribution system in hour i
D_i is the total energy delivered (kW.h) to the distribution system in hour i (does not include transmission-connected sites)
A_{S0} and A_{S2} are loss equation parameters of the secondary distribution system

The values of the A_{S0} and A_{S2} coefficients for the 2019 settlement year are determined as follows (see Appendix B):

$$A_{S0} = \frac{c_s p_S E}{I} = \frac{(0.40)(0.025387)(9691161246)}{8760} = 11{,}234.1417872$$

$$A_{S2} = \frac{p_S I (1 - c_S)}{kE} = \frac{(0.025387)(8760)(1 - 0.40)}{(1.012464025)(9691161246)} = 0.00000001359904$$

where p_s is the ratio of the total annual secondary energy loss to the total annual energy delivered to the distribution system from historical studies
I is the number of hours in the year
c_s is the ratio of the annual constant loss to the total annual loss in the secondary distribution system
k is the constant determined from the distribution system load shape for 2013 to 2017
E is the forecast energy delivered to the distribution system for 2019 (kW.h)

For each hour the total energy loss for ATCO Electric's secondary distribution system is calculated by multiplying A_{S2} by the square of the hourly energy delivered to the distribution system and adding A_{S0}.

Allocation of Total System Losses

Section 2.7 (1) of the SSC assigns to ATCO Electric as LSA the responsibility for establishing the formulas for allocating distribution losses for each interval to the customer sites.

ATCO Electric allocates distribution system losses by loss group which is comprised of service level and loss class. The secondary distribution loss allocated to each site by hour is calculated using the following equations:

$$SL_{si} = SF_i \cdot SA_s \cdot E_{si} \qquad SF_i = \frac{SL_i}{\sum_{s \in S_i} SA_s E_{si}}$$

Where SL_{si} is the secondary loss (kW.h) allocated to site s in hour i
SF_i is the factor that ensures all secondary loss for hour i is allocated
SA_s is the secondary loss allocation factor (see table below) for the loss group to which site s belongs
E_{si} is the energy consumption (kW.h) for site s in hour i
SL_i is the total secondary loss (kW.h) in hour i
S_i is the set of all energized sites s in hour i

The primary distribution loss allocated to each site by hour is calculated using the following equations:

$$PL_{si} = PF_i \cdot PA_s \cdot (E_{si} + SL_{si}) \qquad PF_i = \frac{PL_i}{\sum_{s \in S_i} PA_s \cdot (E_{si} + SL_{si})}$$

Where PL_{si} is the primary loss (kW.h) allocated to site s in hour i
PF_i is the factor that ensures all primary loss for hour i is allocated
PA_s is the primary loss allocation factor (see table below) for the loss group to which site s belongs
E_{si} is the energy consumption (kW.h) allocated to site s in hour i
PL_i is the total primary loss (kW.h) in hour i
S_i is the set of all energized sites s in hour i

The loss allocation factors used were developed from an analysis of historic load profile data and distribution loss studies. For the years 2015 through 2017 the distribution system losses were modeled using the load profile of the energy delivered to the distribution system as well as load profiles, annual energy consumption, and annual energy losses for each loss group. The loss group load profiles were developed from the hourly loads of sample sites. The annual energy consumption was calculated from site metering. The annual energy losses are calculated from historic loss studies.

The following procedure was used to develop the loss allocation factors for the primary and secondary distribution systems separately. Total loss profiles for each year were estimated using a load/loss relationship of the form described above. Next, initial loss allocation factors for each loss group were calculated by dividing the annual energy losses by the annual energy consumption for each loss group. An iterative process was then used to

refine the loss allocation factors. The first step consisted of scaling the load profile for each loss group to the group annual energy loss using the estimated loss allocation factors. In the second step the resulting group loss profile was adjusted for each hour so that the sum of losses for all the loss groups was equal to the total loss profile. Because this hourly adjustment changed the shape of the group loss profiles the loss allocation factors were readjusted. This iterative process was repeated, and the loss allocation factors refined until the difference between the total loss profile energy and the annual energy loss for each loss group was less than 0.3%.

The loss allocation factors for each loss group determined for each year were averaged to arrive at the loss allocation factors reported below.

Table 4: Loss Allocation Factors

Loss Group		Loss Group Code	Secondary Loss Allocation Factor (SA_s)	Primary Loss Allocation Factor (PA_s)
Loss Class	**Service Level**			
Residential	Secondary	RESSECN	0.0372	0.0115
Residential	Primary	RESPRIM	0	0.0115
Residential	Transmission	RESTRAN	0	0
REA and Co Farm	Secondary	FRMSECN	0.0346	0.017
REA and Co Farm	Primary	FRMPRIM	0	0.017
REA and Co Farm	Transmission	FRMTRAN	0	0
Small General Service	Secondary	COMSECN	0.0375	0.0113
Small General Service	Primary	COMPRIM	0	0.0113
Small General Service	Transmission	COMTRAN	0	0
Irrigation	Secondary	IRRSECN	0.0277	0.0166
Irrigation	Primary	IRRPRIM	0	0.0166
Irrigation	Transmission	IRRTRAN	0	0
Street Lighting	Secondary	STLSSECN	0.0392	0.0112
Street Lighting	Primary	STLSPRIM	0	0.0112
Street Lighting	Transmission	STLSTRAN	0	0
Private Lighting	Secondary	SENTSECN	0.04	0.0096
Private Lighting	Primary	SENTPRIM	0	0.0096
Private Lighting	Transmission	SENTTRAN	0	0
Oilfield	Secondary	OILSECN	0.0306	0.0256
Oilfield	Primary	OILPRIM	0	0.0256
Oilfield	Transmission	OILTRAN	0	0
Industrial < 2 MW	Secondary	INDSECN	0.03	0.0187
Industrial < 2 MW	Primary	INDPRIM	0	0.0191
Industrial < 2 MW	Transmission	INDTRAN	0	0
Industrial > 2 MW	Secondary	INPDSECN	0.0138	0.013
Industrial > 2 MW	Primary	INPDPRIM	0	0.0054
Industrial > 2 MW	Transmission	INPDTRAN	0	0

The target annual energy loss expressed as a percentage of annual energy consumption for the loss group to which customer site s belongs can be calculated as follows:

$$P_s = 100 \cdot \left[PA_s + SA_s + (PA_s \cdot SA_s) \right]$$

Where P_s is the percentage annual energy loss for the loss group to which site s belongs
PA_s is the primary loss allocation factor for the loss group to which site s belongs
SA_s is the secondary loss allocation factor for the loss group to which site s belongs

Unaccounted For Energy

Section 4.2.1 of the SSC requires that the UFE calculated for each hour be allocated to the customer sites of all retailers in proportion to their settled load and allocated losses. Transmission-connected customer sites billed using the same interval metered data as is used in the calculation of POD load are exempt from this calculation.

ATCO Electric allocates UFE for each hour in proportion to the energy consumption and associated losses for that hour. The following formula is used for this purpose:

$$U_{si} = UF_i \cdot W_{si} \cdot (E_{si} + PL_{si} + SL_{si}) \qquad UF_i = \frac{U_i}{\sum_{s \in S_i} W_{si} \cdot (E_{si} + PL_{si} + SL_{si})}$$

Where U_{si} is the UFE (kW.h) allocated to site s in hour i
UF_i is the factor that ensures all UFE for hour i is allocated
E_{si} is the energy consumption (kW.h) for site s in hour i
PL_{si} is the primary loss (kW.h) allocated to site s in hour i
SL_{si} is the secondary loss (kW.h) allocated to site s in hour i
U_i is the total UFE (kW.h) in hour i
W_{si} is 0 for UFE exempt sites in hour i and 1 for all other sites in hour i
S_i is the set of all energized sites s in hour i

5. OTHER DISCRETIONARY MATTERS

Estimation of Consumption Amounts

Section 2.6 (3) of the SSC assigns to ATCO Electric, as LSA, the responsibility of estimating cumulative consumption amounts where consumption calculated from meter readings is not yet available. For daily, monthly, interim and final settlement these estimates are based on customer rate class profiles and energy consumption from the most recent period for which energy consumption between actual reads is available as follows:

$$E_{si} = \frac{E_{DCM} \cdot P_{ci}}{\sum_{i \in m} P_{ci}}$$

Where E_{si} is the energy consumption (kW.h) estimated for site s in hour i
P_{ci} is the average site energy (kW.h) for profile class c in hour i
E_{DCM} is the energy consumption (kW.h) for site s from the most recent DCM covering reading period m that ends prior to the profile freeze date.

Deemed Times

Section 2.14 of the SSC allows ATCO Electric, as WSP, to define an assumed time of day for the reading of cumulative meters as well as for energize and de-energize events. For the purpose of performing load settlement, ATCO Electric deems these events to have taken place at the end of the day during which they were actually performed.

Implementation Assumptions

Section 6.2 (1) of the SSC specifies assumptions under which the calculation formulas of section 6.4 have been developed. These assumptions are that energization, de-energization and profile class changes for a customer site will always be accompanied with a meter read on the same day and that switch of retailer will not necessarily be accompanied by a meter read. ATCO Electric has implemented the settlement calculations consistent with these assumptions.

Post Final Adjustment Mechanism (PFAM) Processing

Section 5.3.3 (1) (c) of the SSC requires LSAs to identify their PFAM processes and timelines. These are described in the following paragraphs.

Following the final settlement run each month, an automated process identifies changes to cumulative consumption site data since the previous final settlement run. If the affected periods are already final settled, the process produces the required RSA transactions. These transactions are reviewed and submitted by the end of the 7th business day of the following month (see SSC Section 5.3.7 (1)). All other changes to data between the same two final settlement runs affecting periods already final settled are identified manually. The required RSA and/or TAA transactions are manually prepared and submitted at the same time as the RSA transactions produced by the automated process.

Daily profiles are used in producing the RSA transaction set only in the case where final profiles are not available. The use of daily profiles in such cases allows RSA transactions to be issued one month earlier with little impact on the result.

Section 5.3.3 (1) (c) of the SSC requires parties to withhold submitting a PFAM Application Form after identifying an error until the LSA is able to process the RSA transaction set as per the LSA's processes and timelines. For ATCO Electric this withholding period is 45 calendar days. This allows for the maximum number of days between final settlement runs and the maximum number of days between the last final settlement run and date the RSA and/or TAA transactions must be submitted.

The following procedures are used in the production of RSA transactions:

- The final settled hourly energy consumption, loss and UFE for a site is determined using the SSC transaction set as described in Appendix A.
- Corrected hourly energy consumption for sites settled using cumulative consumption is determined as described in SSC Section 6.4.2 (12).
- Corrected hourly loss and UFE are determined as follows:

$$L'_{si} = \left(\frac{L_{rcgi}}{E_{rcgi}} \right) E'_{si}$$

$$U'_{si} = \left(\frac{U_{rcgi}}{E_{rcgi}} \right) E'_{si}$$

Where L'_{si} is the corrected energy loss (kW.h) for site s in hour i
L_{rcgi} is the energy loss (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
U'_{si} is the corrected UFE (kW.h) for site s in hour i

U_{rcgi}	is the UFE (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
E'_{si}	is the corrected energy consumption (kW.h) for site s in hour i
E_{rcgi}	is the energy consumption (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)

Cumulative Metering Validation Test Parameters

Section 10.3.2.1 of the SSC requires MDMs to make available to the market the high and low limits for usage and demand in their cumulative metering validation tests. For this information please refer to the AUC Rule 004 Alberta Tariff Billing Code Rules, section A1.2.

APPENDIX A – CALCULATION OF HOURLY ENERGY CONSUMPTION, LOSS AND UFE

In this appendix, a method is provided for determining hourly customer site energy consumption, loss and UFE from the SSC transaction set.

In the following:

- The WCI, WSD and SPI transactions used must be from the same settlement run.
- Cumulative meter reads, energization, de-energization, profile class changes and retailer switches are all deemed to occur on daily boundaries.
- Site s is a member of profile class c as well as loss group g and is enrolled to retailer r on day d which is in meter reading period m.
- Hour i is within day d.

Cumulative Metered and Unmetered Sites

Hourly energy consumption, loss and UFE for cumulative metered and unmetered sites can be calculated as follows:

$$E_{si} = \frac{E_{sd} E_{rcgi}}{\sum_{i \in d} E_{rcgi}}$$

$$L_{si} = \frac{L_{sd} L_{rcgi}}{\sum_{i \in d} L_{rcgi}}$$

$$U_{si} = \frac{U_{sd} U_{rcgi}}{\sum_{i \in d} U_{rcgi}}$$

Where
- E_{si} is the energy consumption (kW.h) for site s in hour i
- E_{sd} is the energy consumption (kW.h) for site s in day d (from the WSD transaction)
- E_{rcgi} is the energy consumption (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
- L_{si} is the energy loss (kW.h) for site s in hour i
- L_{sd} is the energy loss (kW.h) for site s in day d (from the WSD transaction)
- L_{rcgi} is the energy loss (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
- U_{si} is the UFE (kW.h) for site s in hour i
- U_{sd} is the UFE (kW.h) for site s in day d (from the WSD transaction)

U_{rcgi} is the UFE (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)

Interval Metered Sites

Hourly energy consumption, loss and UFE for interval metered sites can be calculated as follows:

$$L_{si} = \left(\frac{L_{rcgi}}{E_{rcgi}} \right) E_{si} W_{si}$$

$$U_{si} = \left(\frac{U_{rcgi}}{E_{rcgi}} \right) E_{si} W_{si}$$

Where
- E_{si} is the energy consumption (kW.h) for site s in hour i (from the DIM transactions available at the time of the settlement run)
- E_{rcgi} is the energy consumption (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
- L_{si} is the energy loss (kW.h) for site s in hour i
- L_{rcgi} is the energy loss (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
- U_{si} is the UFE (kW.h) for site s in hour i
- U_{rcgi} is the UFE (kW.h) for all sites with retailer r, profile class c and loss group g in hour i (from the WCI transaction)
- W_{si} is a weighting factor that has the value 0 if site s is transmission-connected in hour i in day d (from the WSD transactions) and a value of 1 if it is not

Note that the last formula does not work for a transmission-connected site that is not deemed to be a direct connect site according to section 5.3.5 (2) (b) of the SSC.

APPENDIX B – DEVELOPMENT OF THE SYSTEM LOSS EQUATION

In this appendix the coefficients of the following system loss equation are developed.

$$l_i = A_0 + A_2 e_i^2$$

Where l_i is the system loss for hour i
e_i is the system load for hour i
A_0 is the constant coefficient associated with transformer core losses
A_2 is the coefficient associated with resistive line losses

Assumptions

- Total distribution system transformer capacity grows at approximately the same rate as the load growth in the distribution system.
- The load growth for the secondary and primary distribution systems is approximately the same.

Definition of Variables

e_i is the energy flow in interval i into the distribution system.
c is the ratio of the annual constant energy loss to the annual total energy loss.
p is the ratio of the annual total energy loss to the annual total energy flow into the system
l_i is the total energy loss in the distribution system in interval i
I is the total number of intervals in the year.
L is the total energy loss for the year
E is the total energy entering the system during the year.

By Definition

$$E = \sum_{i=1}^{I} e_i \quad (1)$$

$$c = \frac{\text{Annual Constant Energy Loss}}{L} \quad (2)$$

$$p = \frac{L}{E} \quad (3)$$

$$L = \sum_{i=1}^{I} l_i \quad (4)$$

From the system loss equation

$$l_i = A_0 + A_2 e_i^2 \quad (5)$$

$$\text{Annual Constant Energy Loss} = \sum_{i=1}^{I} A_0 = A_0 I \quad (6)$$

Combining 4, 5 and 6

$$L = \sum_{i=1}^{I} l_i = \sum_{i=1}^{I} A_0 + \sum_{i=1}^{I} A_2 e_i^2 = A_0 I + A_2 \sum_{i=1}^{I} e_i^2 \quad (7)$$

From equation 2 and 3

$$\text{Annual Constant Energy Loss} = cpE \quad (8)$$

Combining 6 and 8

$$A_0 = \frac{cpE}{I} \quad (9)$$

Combining equation 3, 7 and 9

$$pE = cpE + A_2 \sum_{i=1}^{I} e_i^2$$

Solving for A_2

$$A_2 = \frac{pE(1-c)}{\sum_{i=1}^{I} e_i^2} \quad (10)$$

Substituting 9 and 10 into 5 the equation for the total loss for interval i becomes

$$l_i = \frac{cpE}{I} + \frac{pE(1-c)}{\sum_{i=1}^{I} e_i^2} e_i^2 \quad (11)$$

The value of c and p can be determined from historic loss studies and E is normally forecasted. The value that is not readily available is the sum of the square of the interval energy. This value can be determined from its relationship to E, the annual energy delivered to the system.

From historic load data, it has been found that over a calendar year, the average of the square of the interval energy has a linear relationship to the square of the average interval energy.

$$\frac{\sum_{i=1}^{I} e_i^2}{I} = k\left(\frac{E}{I}\right)^2$$

Simplifying the equation we have

$$\sum_{i=1}^{I} e_i^2 = k\frac{E^2}{I} \qquad (12)$$

Solving for the constant k

$$k = \frac{I\sum_{i=1}^{I} e_i^2}{E^2} \qquad (13)$$

By calculating an average k for historic interval energy, the sum of the square of the interval energy may be estimated from the forecast annual energy. The resulting energy loss equation for interval i becomes:

$$l_i = \frac{cpE}{I} + \frac{pI(1-c)}{kE} e_i^2 \qquad (14)$$

And the loss coefficients are:

$$A_0 = \frac{cpE}{I} \qquad A_2 = \frac{pI(1-c)}{kE} \qquad (15)$$

If we define the following relationships, the loss equation can be disaggregated to the primary and secondary distribution systems.

$$p = p_S + p_P \qquad cp = c_S p_S + c_P p_P$$

Where c_p is the ratio of the annual constant energy loss in the primary distribution system to the total annual energy loss in the primary distribution system

c_s is the ratio of the annual constant energy loss in the secondary distribution system to the total annual energy loss in the secondary distribution system

p_p is the ratio of the total annual energy loss in the primary distribution system to the annual energy delivered to the distribution system

p_s is the ratio of the total annual energy loss in the secondary distribution system to to the annual energy delivered to the distribution system

As there are no transformers in the primary distribution system, c_p is equal to zero and the loss coefficients for the primary distribution system becomes

$$A_{P0} = 0 \qquad A_{P2} = \frac{p_P I}{kE}$$

And the loss coefficients for the secondary distribution system are

$$A_{S0} = \frac{c_S p_S E}{I} \qquad A_{S2} = \frac{p_s I(1-c_S)}{kE}$$