CT Loading Assessment

Final Report – November 15, 2010

TERMS OF REFERENCE

PURPOSE

The IESO Revenue Metering Standing Committee agreed to the final report recommendations issued in October 8, 2009 by the High Accuracy Instrument Transformer Working Group. Planned for Phase 2 implementation was a recommendation to develop a new energy approach versus the existing time/current method to assess compliant CT operation. Specifically, a "CT Loading Assessment" document will form the basis for CT compliant operation moving forward to meet:

1. Performance requirements of IESO 'Wholesale Revenue Metering Standard – Hardware' Sec 6.9.1 and 6.12.1 for Instrument Transformer Ratios – New and Existing Instrument Transformers, "Current transformer ratios shall be selected according to the following factors:
    a. the maximum sustained primary current in a current transformer shall not exceed the primary tap multiplied by the continuous current Rating Factor (RF) of the current transformer; and
    b. the minimum sustained primary current during normal operation shall not be less than 10% of the primary tap, for ANSI 0.3 accuracy class; or
    c. the minimum sustained primary current during normal operation shall not be less than 5% of the primary tap, for the defined standard of ANSI 0.15 accuracy class; and
    d. the minimum sustained primary current during normal operation shall not be less than 1% of the primary tap, for the defined standard of ANSI 0.15S accuracy class."
    e. "Approval of the *IESO* shall be required for continued use of existing *instrument transformers* in the wholesale market."
2. IESO 'Wholesale Revenue Metering Standard – Sec 9.2.2 for Parallel Connected Current Transformer Secondaries.
3. Accuracy requirements for 0.3, 0.15 and 0.15S class in the IEEE ANSI C57.13 and CAN/CSA C60044 standards.

SCOPE OF WORK

To include for CT loading assessment and remedial action aspects:

- Current loading/time duration analysis - This existing analysis tool applies IESO MV90 channel data (e.g. I^2h) selected over a 12 month time period to generate a Load Duration profile – (assessment related)
- An IESO in-house developed tool (CT Assessment Calculator) utilizes IESO MV90 meter data (e.g. kWh Del/Rec and I^2h) to parse kWh energy data into its respective CT accuracy class. kWh energy analysis will be based on the most recent 12 months of MV90 data – (assessment related)
- CT class operation review based on: (1) Current loading/Time analysis (meter data); (2) In-class kWh energy analysis with market stakeholdered energy threshold – (assessment related)
- Energy thresholds: Establish ratio of In-class kWh energy to Out-of-class kWh energy for all ANSI 0.3, 0.15 and 0.15S accuracy class – (assessment related)
- Current transformer sizing: Apply % Peak/Rated Nominal X Rating Factor as an indicator of metering design practices – (remedial action related)

- Market impact assessment of non-conformance may use ‘Out-of-class kWh’ and ‘At Risk Dollars’ – (remedial action related)
- Included in the report are Load Assessment examples grouped by Load/Generation categories as follows:
  I. Wind Turbine Generation Station – WGS
  II. Hydraulic Generation Station
  III. Generator Station Service
  IV. LDC Transformer Station
  V. Large Industrial Customer Tranformer Station
  VI. LDC Feeder/PME

CONSIDERATIONS

- Standards of the day will be adopted – Registered metering installations must implement 0.3 ANSI per Market Rules, and Measurement Canada formalized 0.15 high accuracy standard where required, effective Jan 1, 2010. Installations in-service prior to Jan 1, 2010 may warrant assessment based on meeting metering regulations of the day.
- Normal operating conditions definition to be applied – As stakeholdered and accepted at IESO Revenue Metering Sub-Committee meeting of Aug 26, 2005. See Glossary.
- Non-normal operating conditions may warrant consideration within applicable timelines. To establish accepted guidelines for what constitutes non-normal operating conditions. See Glossary.
- For embedded generator metering installation installed in LDC (Local Distribution Company) distribution system. The same Market Rules Chapter 6 metering standard for maximum error will apply for the embedded MI as for the upstream host MI.
- Identifying 'Out-of-class active energy' and 'At Risk Dollars' will serve only as an indicator of financial risk impactive on the market in support of remedial actions.

CT ASSESSMENT BASIS

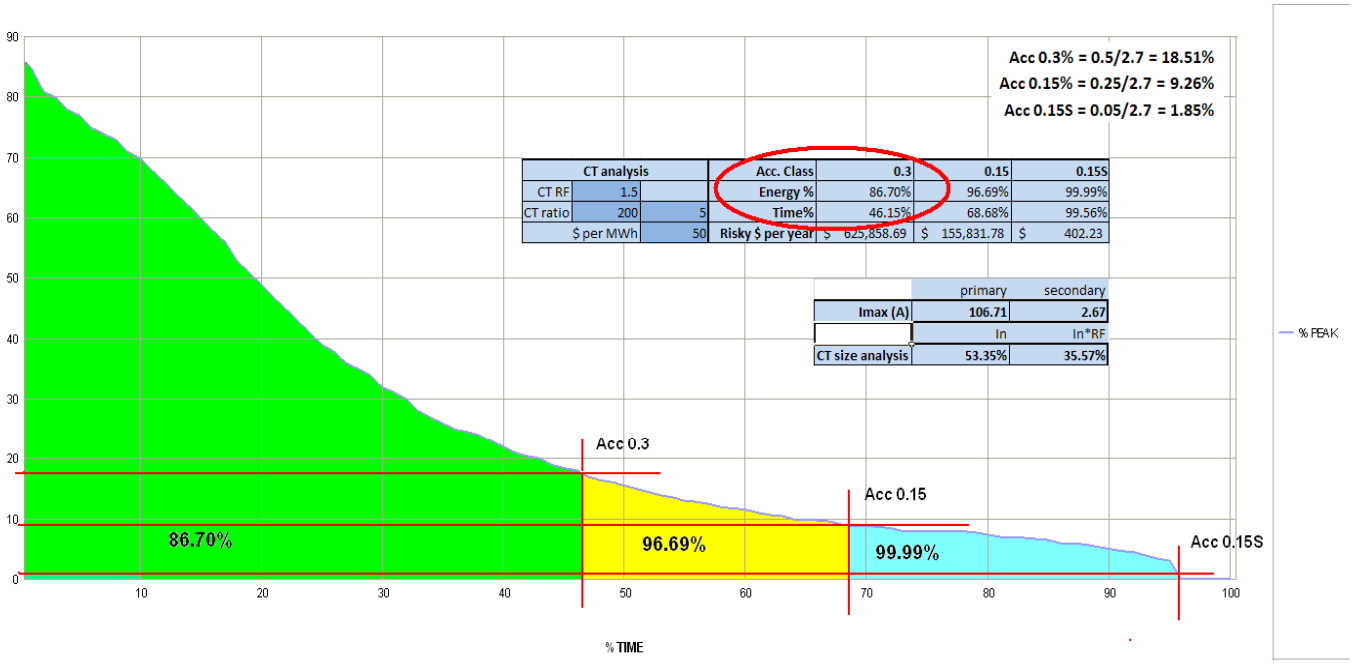
NEW METHOD PROPOSED

In the ideal situation and during normal operation, 100% of the current is >10% rated nominal for 0.3 class, >5% for 0.15 high accuracy class and >1% for 0.15S high accuracy class. A current/time based review of CT loading is readily available in the MV-90 Load Duration analysis tool. The IESO practice was to judiciously apply a 80/20 rule of thumb to assess for the CT class operation (e.g. CT operating within its accuracy class 80% of the time). This analysis served strictly as a technical and operational compliance to the Wholesale Revenue Metering Standard-Hardware 'minimum sustained primary current' requirement.

A new method being proposed today is to consider:

% in-class Energy (kWh) / % out-of-class Energy (kWh)

Such an assessment introduces the notion of compliant energy being metered as a better representation of risk. A model example is presented below:



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The time based assessment method resulting in 46.15%/53.85% non-compliance ratio, becomes 86.70% /13.3% compliance ratio, when based on the new in-class kWh energy assessment method.

In the case examples presented, the CT assessment calculator was used to process the prior 12 months of interval meter data, and MV90 was used to obtain the current/time load profile. The key approaches being adopted for the new CT assessment review process will be to utilize:

1. **% Time**: Current/time load profile will continue to be used for a pre-assessment. When the % Current/Time test meets the threshold, no further assessment will be performed. A passing 80/20 time based result will meet or better the 80/20 energy based method proposed.
2. **% Energy**: Annual in-class kWh energy will be recommended as the new CT assessment method. The % peak current will also be reviewed as a current sizing parameter to substantiate the % energy observation. When the % Energy threshold is met, no further assessment will be required.

CT LOADING ASSESSMENT

New metering installations are expected to be designed to operate during normal operations, within 0.3 class or higher accuracy class where required, and to integrate within modern day demand/energy program initiatives. In particular, external variables such as the characteristics of wind energy, need to be taken into metering design assumptions.

Existing metering installations may have been designed with protection and control applications in mind, or designed to be constrained for contingent loading conditions (e.g. Bermondsey station configuration).

- Compliant CT operation for both new and existing metering installations will be assessed based on a 80/20 threshold of in-class kWh energy for all ANSI accuracy classes. Meeting the 80% threshold will substantiate CT operation at above the 10% rated nominal for 0.3 class, 5% rated nominal for 0.15 class and 1% rated nominal for 0.15S class. Failing to meet the 80% threshold will identify such metering installations as nonconforming to the 'minimum sustained primary current' requirements. (e.g. the minimum sustained primary current during normal operation shall not be less than 10% of the primary tap for ANSI 0.3 accuracy class, not be less than 5% of the primary tap for ANSI 0.15 accuracy class and not be less than 1% of the primary tap for ANSI 0.15S accuracy class)
- Existing metering installations installed before Jan 1, 2010, comprising factory ERT (Extended range tested) CTs may be considered for percentage energy assessment at the next higher accuracy class. (e.g. 0.3 class will be considered at 0.15 class)
- In the non-conformance scenario, the Market Participant will be required to submit its conformance plan to demonstrate CT operating compliance. This remedial plan must consider impact to the market. (e.g. time duration and dollar impact when non-compliant CT operation had existed). The Market Participant may propose to implement measures such as making CT ratio change, applying a CT error correction factor, or providing a projection for return back to normal business activity levels. The IESO will use this information to accept or reject the remedial action plan.

Moving forward, current transformer pass or fail determinations are being proposed based on these two assessment review methods.

1. Current/Time assessment continues: Current/time assessment based on 80/20 passing threshold at 0.3, 0.15 and 0.15S ANSI accuracy class will continue to be used as the first level review for acceptance, and remains unchanged for all new and existing metering installations. In order to pass, the minimum sustained primary current (Amps) shall be greater than or equal to the compliance threshold set at 80% of the time. When the 80/20 time threshold is met, no further assessment will be required. When the 80/20 time threshold is not met, the kWh Energy Assessment method will be applied.
2. kWh Energy assessment: New kWh Energy assessment based on 80/20 passing threshold at 0.3, 0.15 and 0.15S ANSI accuracy class for all new and existing metering installations will be adopted. In order to pass, the percentage in-class energy (kWh)/out-of-class energy (kWh) shall be greater than or equal to 80% compliance threshold at rated class accuracy. When the 80/20 kWh energy threshold is met, no further action required. When the 80/20 kWh energy threshold is not met, non-compliance action will result. A conformance plan to demonstrate CT operating compliance will be required.

TIMELINES

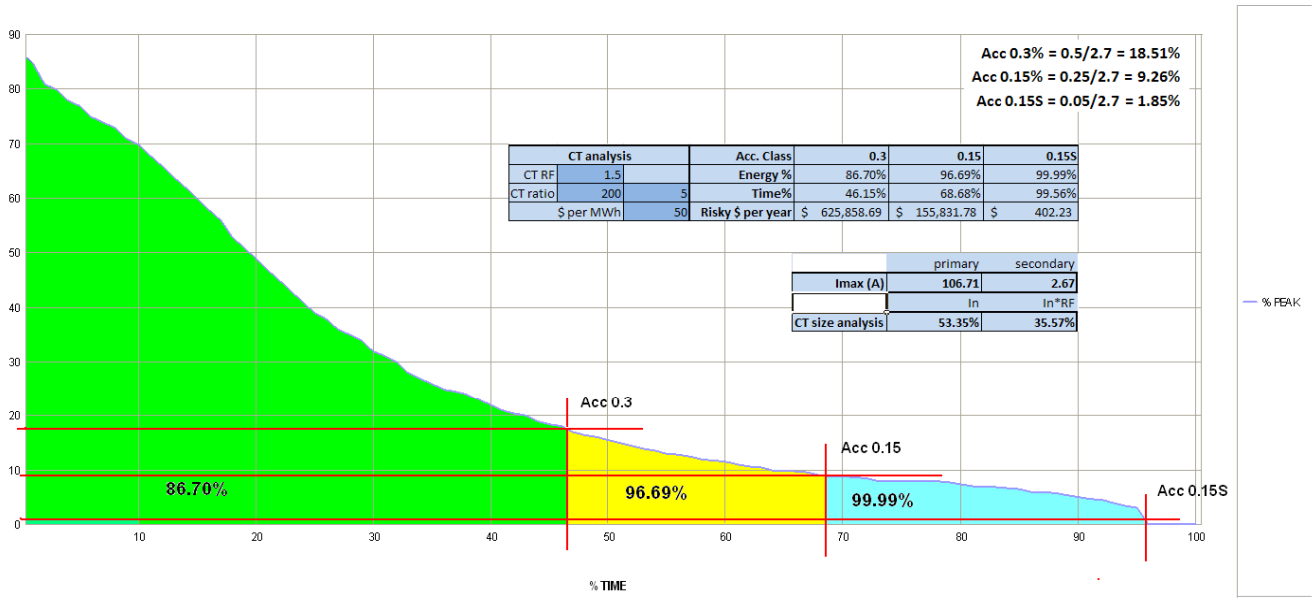
- To review and finalize with Revenue Metering Standing Committee meeting of October 28, 2010.
- Immediate implementation of new in-class kWh energy assessment in the determination of metering installations meeting the passing 80/20 threshold.
- To present to Metering Service Provider User Group meeting of November 25, 2010 as an information item.

EXAMPLES

The following are examples of the operating characterics of select wholesale revenue metering installations and the resulting assessment parameters based on the the MV90 Load Duration Plot and the CT assessment calculator.

I. WIND TURBINE GENERATION STATION

Example # 1



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In this example, the assessment parameters are presented as:

0.3 class: 46.15% @ Current/Time criteria
86.70% @ Class kWh Energy criteria
$625,858 @ At Risk Dollars criteria

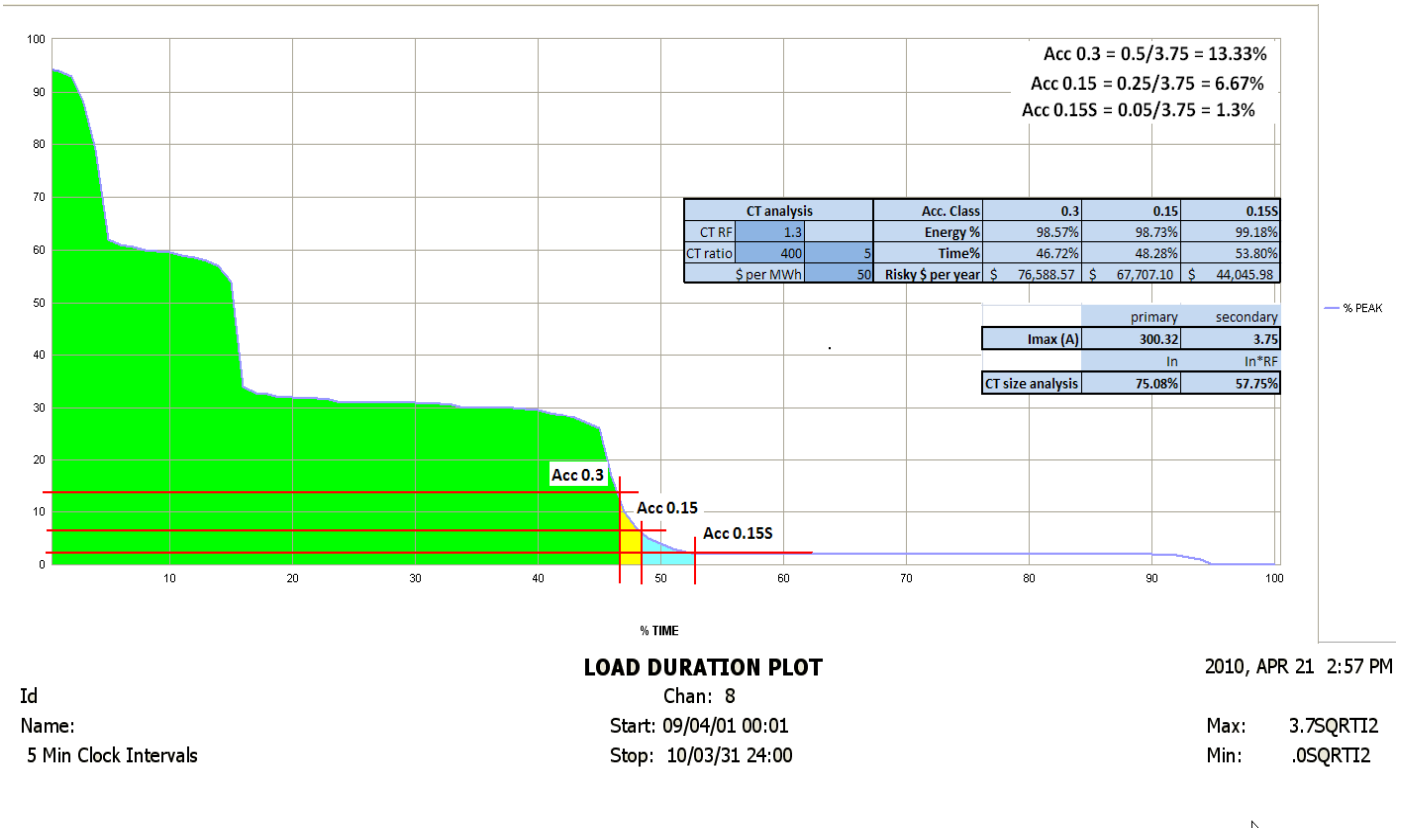
0.15 class: 68.68% @ Current/Time criteria
96.69% @ Class kWh Energy criteria
$155,831 @ At Risk Dollars criteria

0.15S class: 99.56% @ Current/Time criteria
99.99% @ Class kWh Energy criteria
$402 @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 35.57%

II. HYDRAULIC GENERATION STATION

Example # 2



In this example, the assessment parameters are presented as:

0.3 class: 46.72% @ Current/Time criteria
98.57% @ Class kWh Energy criteria
$76,588 @ At Risk Dollars criteria

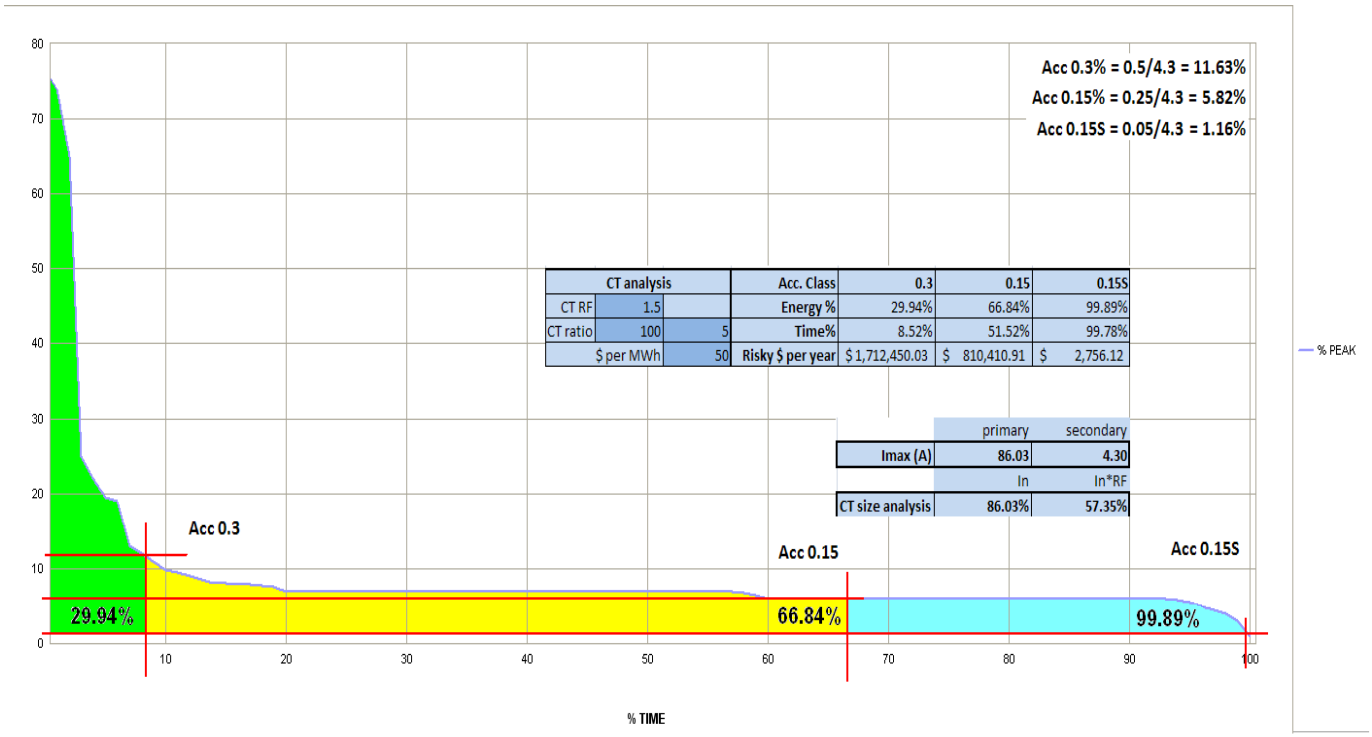
0.15 class: 48.28% @ Current/Time criteria
98.73% @ Class kWh Energy criteria
$67,707 @ At Risk Dollars criteria

0.15S class: 53.80% @ Current/Time criteria
99.18% @ Class kWh Energy criteria
$44,045 @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 57.75%

III. GENERATOR STATION SERVICE

Example # 3



In this example, the assessment parameters are presented as:

0.3 class: 8.52% @ Current/Time criteria
29.94% @ Class kWh Energy criteria
$1,712,450 @ At Risk Dollars criteria

0.15 class: 51.52% @ Current/Time criteria
66.84% @ Class kWh Energy criteria
$810,410 @ At Risk Dollars criteria

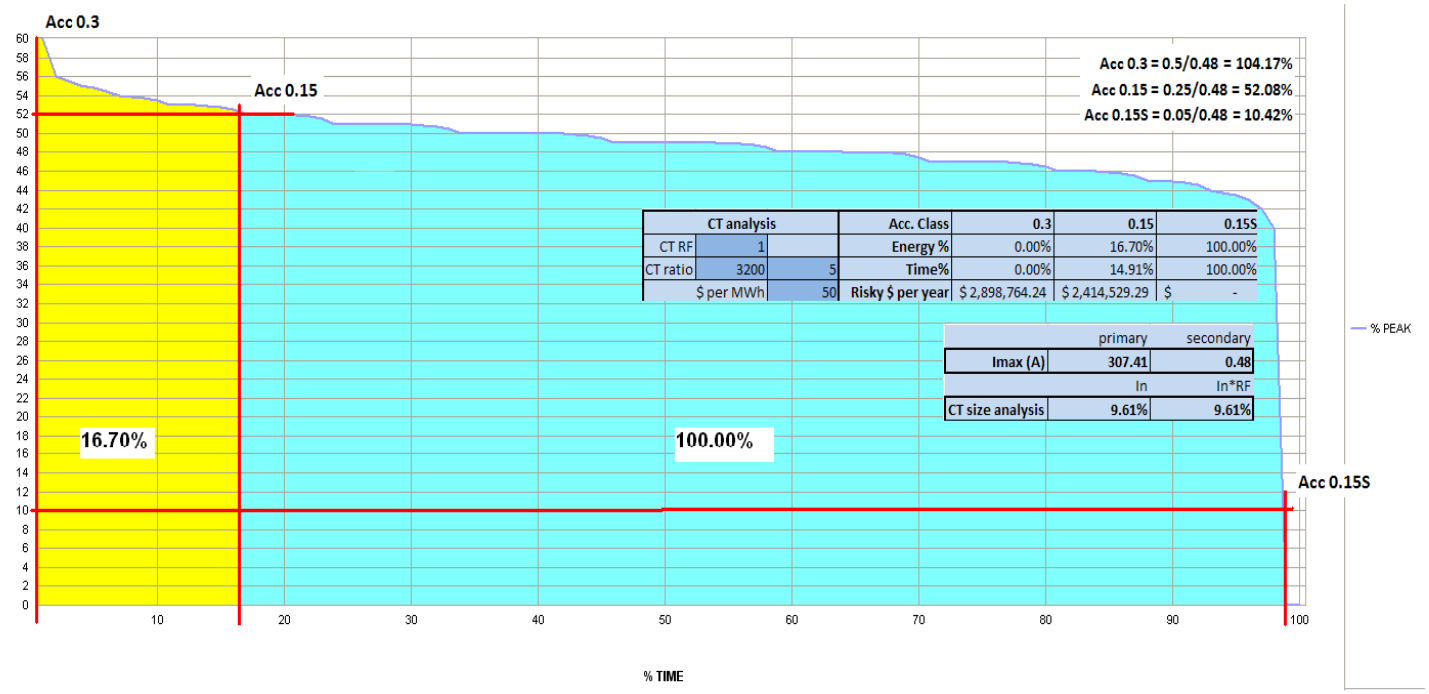
0.15S class: 99.78% @ Current/Time criteria
99.89% @ Class kWh Energy criteria
$2,756 @ At Risk Dollars criteria

% Peak/Rated Nominal X RF: 57.35%

IV. LDC TRANSFORMER STATION

Example # 4

In this example,



CT analysis			Acc. Class	0.3	0.15	0.15S
CT RF	1		Energy %	0.00%	16.70%	100.00%
CT ratio	3200	5	Time%	0.00%	14.91%	100.00%
$ per MWh		50	Risky $ per year	$ 2,898,764.24	$ 2,414,529.29	$ -

	primary	secondary
Imax (A)	307.41	0.48
	In	In*RF
CT size analysis	9.61%	9.61%

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In this example, the assessment parameters are presented as:

0.3 class: 0.0% @ Current/Time criteria
0.0% @ Class kWh Energy criteria
$2,898,764 @ At Risk Dollars criteria

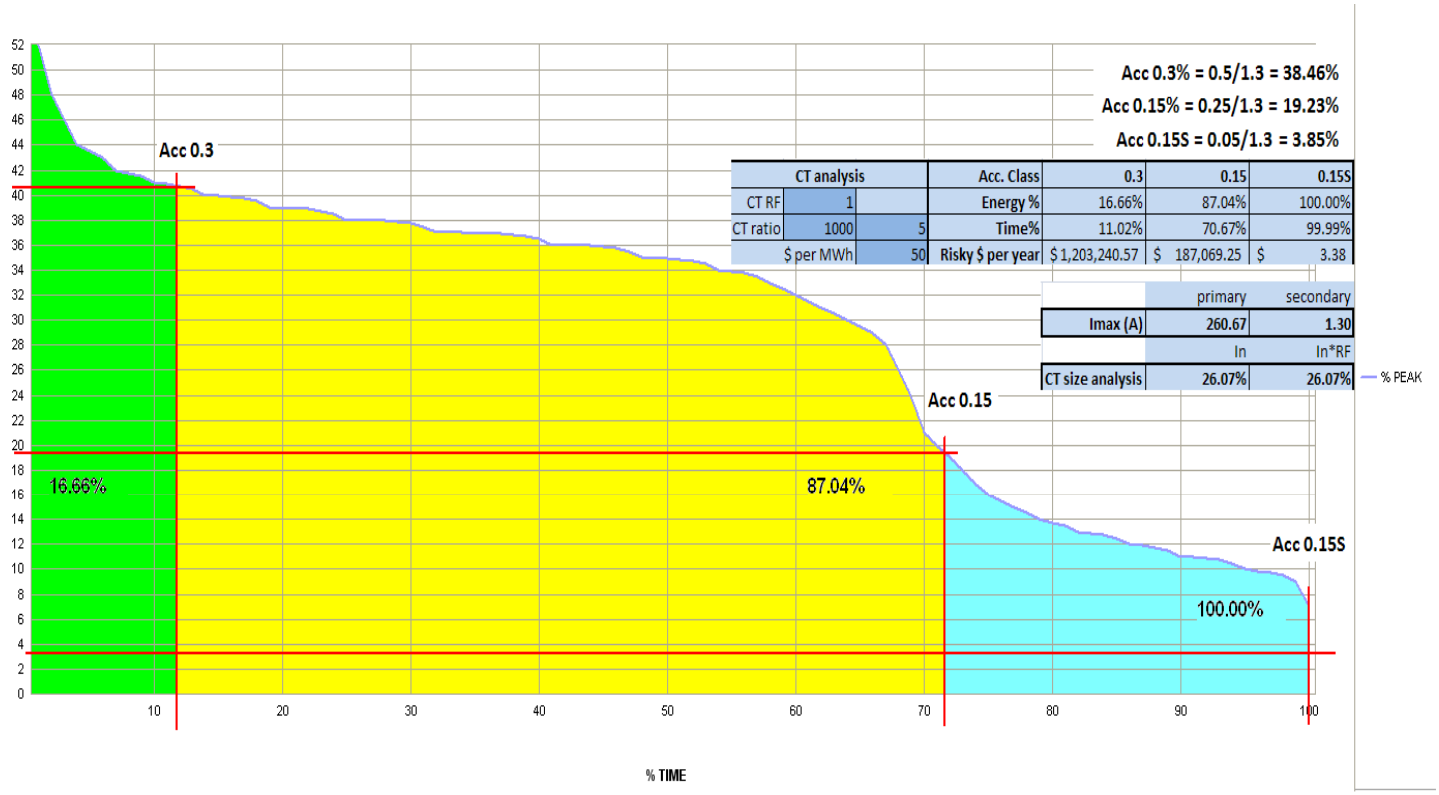
0.15 class: 14.91% @ Current/Time criteria
16.70% @ Class kWh Energy criteria
$2,414,529 @ At Risk Dollars criteria

0.15S class: 100% @ Current/Time criteria
100% @ Class kWh Energy criteria
Nil @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 9.61%

V. LARGE INDUSTRIAL CUSTOMER TRANSFORMER STATION

Example # 5a



CT analysis			Acc. Class	0.3	0.15	0.15S
CT RF	1		Energy %	16.66%	87.04%	100.00%
CT ratio	1000	5	Time%	11.02%	70.67%	99.99%
$ per MWh		50	Risky $ per year	$ 1,203,240.57	$ 187,069.25	$ 3.38

	primary	secondary
Imax (A)	260.67	1.30
	In	In*RF
CT size analysis	26.07%	26.07%

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Min: .0SQRTI2

In this example, the assessment parameters are presented as:

0.3 class: 11.02% @ Current/Time criteria
16.66% @ Class kWh Energy criteria
$1,203,240 @ At Risk Dollars criteria

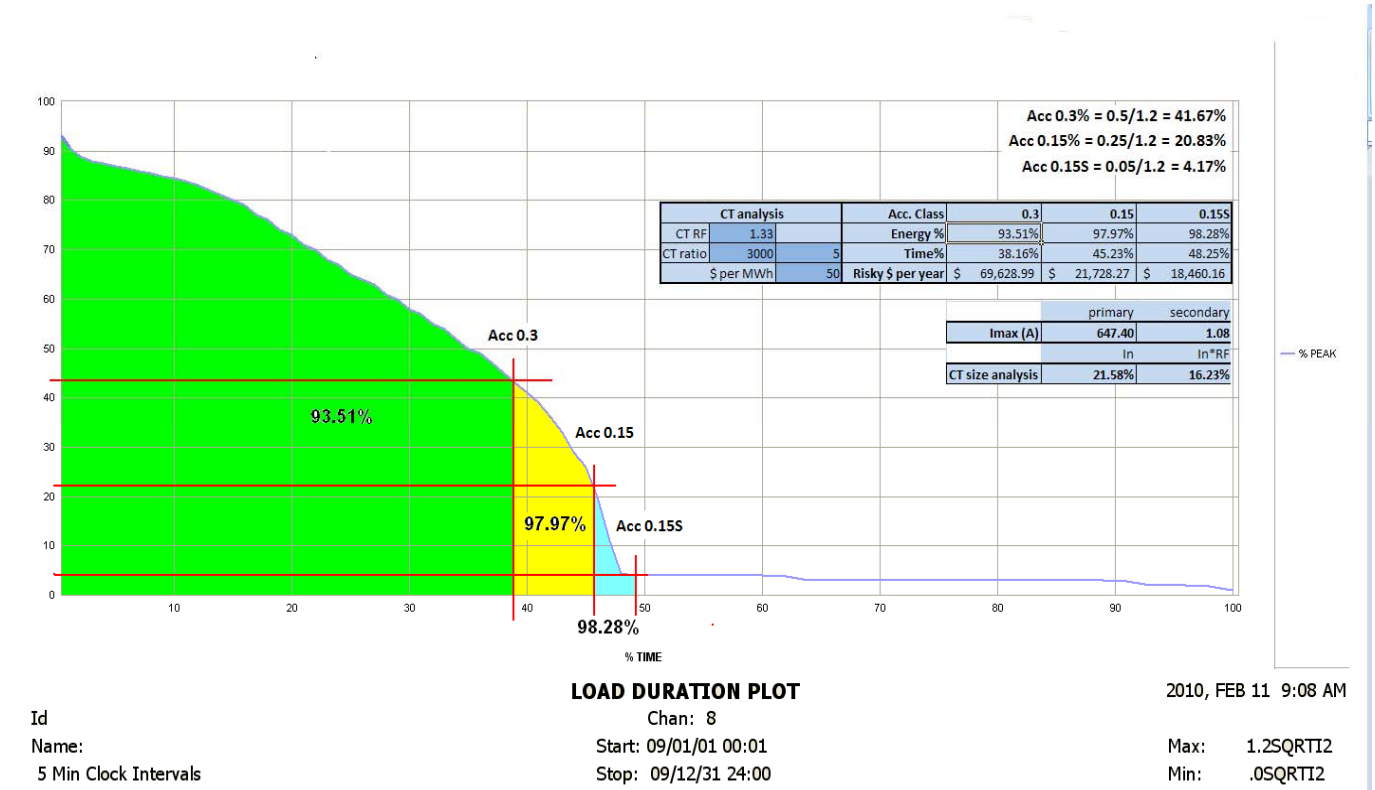
0.15 class: 70.67% @ Current/Time criteria
87.04% @ Class kWh Energy criteria
$187,069 @ At Risk Dollars criteria

0.15S class: 99.99% @ Current/Time criteria
100.0% @ Class kWh Energy criteria
$3.00 @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 26.07%

V. LARGE INDUSTRIAL CUSTOMER TRANSFORMER STATION

Example # 5b



In this example, the assessment parameters are presented as:

0.3 class: 38.16% @ Current/Time criteria
93.51% @ Class kWh Energy criteria
$69,629 @ At Risk Dollars criteria

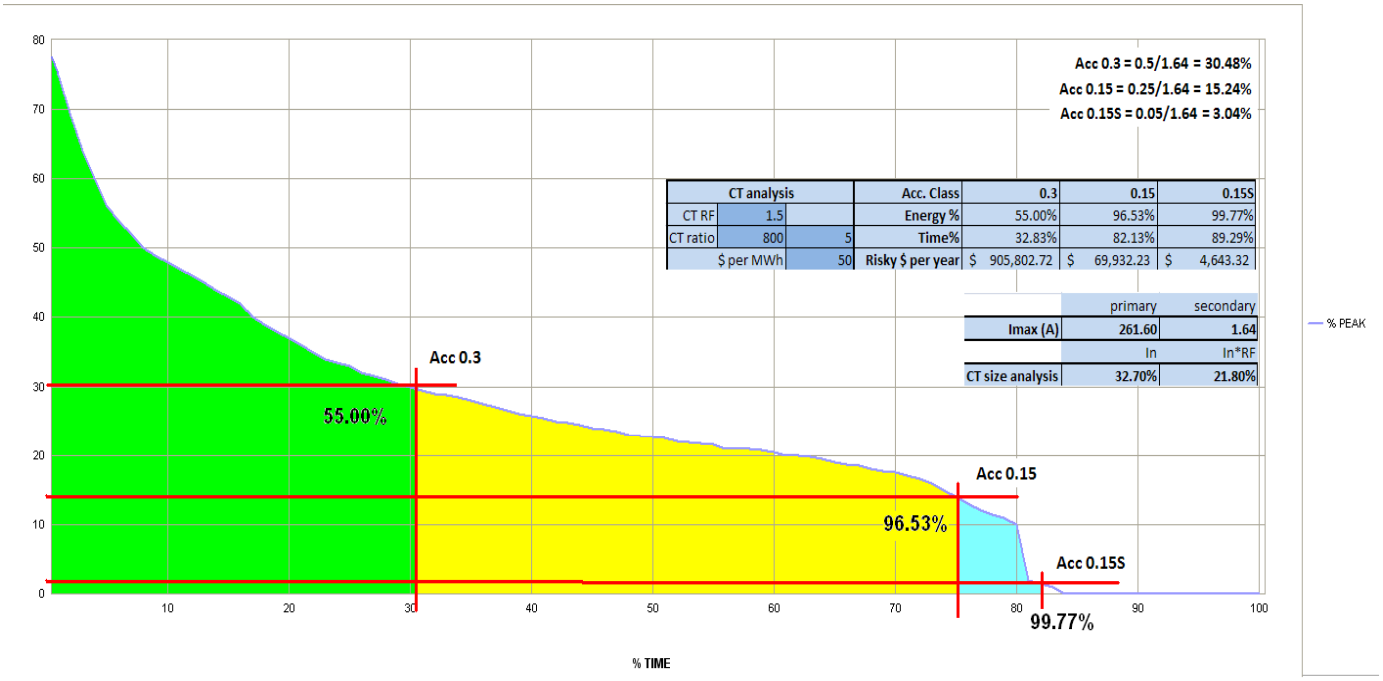
0.15 class: 45.23% @ Current/Time criteria
97.97% @ Class kWh Energy criteria
$21,728 @ At Risk Dollars criteria

0.15S class: 48.25% @ Current/Time criteria
98.28% @ Class kWh Energy criteria
$18,460 @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 16.23%

VI. LDC FEEDER/PME METER INSTALLATION

Example #6a



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In this example, the assessment parameters are presented as:

0.3 class: 32.83% @ Current/Time criteria
55.00% @ Class kWh Energy criteria
$905,802 @ At Risk Dollars criteria

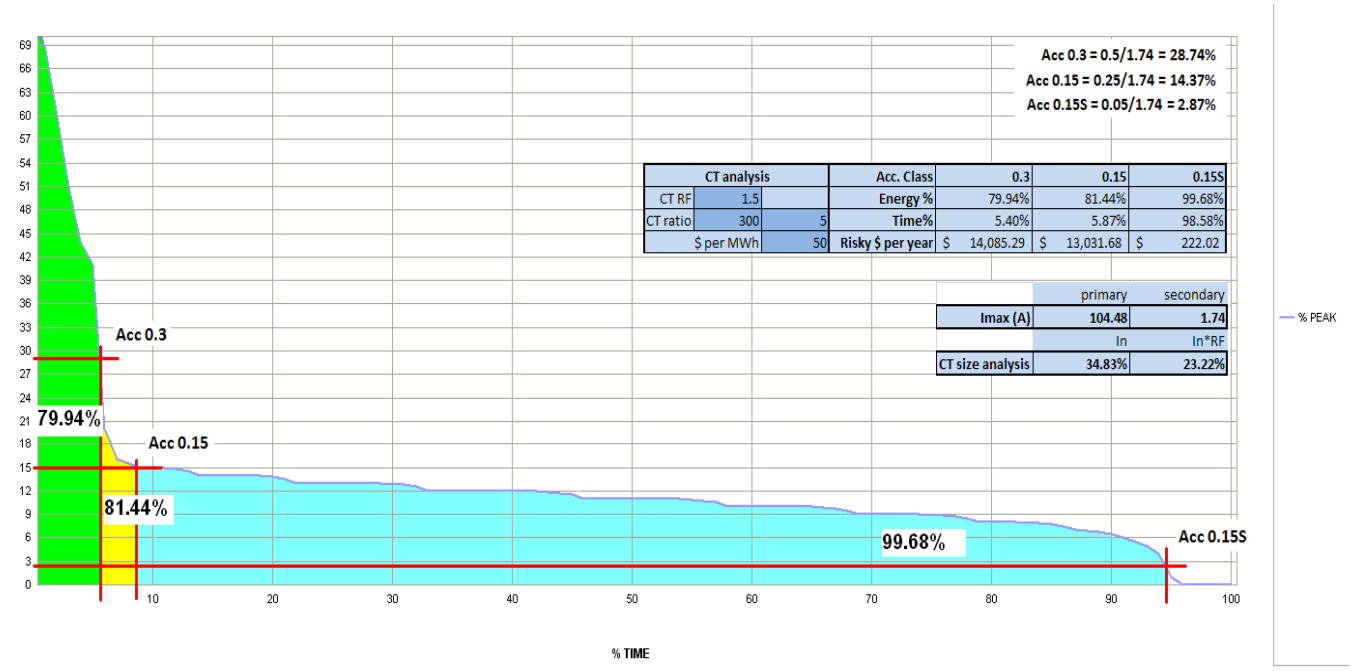
0.15 class: 82.13% @ Current/Time criteria
96.53% @ Class kWh Energy criteria
$69,932 @ At Risk Dollars criteria

0.15S class: 89.29% @ Current/Time criteria
99.77% @ Class kWh Energy criteria
$4,643 @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 21.80%

VI. LDC FEEDER/PME METER INSTALLATION

Example #6b



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Min: .0SQRTI2

In this example, the assessment parameters are presented as:

0.3 class: 5.40% @ Current/Time criteria
79.94% @ Class kWh Energy criteria
$14,085 @ At Risk Dollars criteria

0.15 class: 5.87% @ Current/Time criteria
81.44% @ Class kWh Energy criteria
$13,031 @ At Risk Dollars criteria

0.15S class: 98.58% @ Current/Time criteria
99.68% @ Class kWh Energy criteria
$222 @ At Risk Dollars criteria

% Peak/Rated Nominal x RF: 23.22%

RECOMMENDATIONS

- To continue with Current/time assessment based on 80/20 passing threshold for determining compliant Current Transformer (CT) operation at 0.3, 0.15 and 0.15S ANSI accuracy class for all new and existing metering installations registered in the IESO-administered markets. Current/time assessment will continue to be used as the first level review for acceptance.
- To adopt a new 'in-class kWh energy' assessment based on 80/20 passing threshold for determining compliant Current Transformer (CT) operation at 0.3, 0.15 and 0.15S ANSI accuracy class for all new and existing metering installations registered in the IESO-administered markets.
- To adopt a compliance threshold criteria for all new and existing installations at accuracy class. A single 80/20 passing threshold is being proposed for the new 'in-class kWh energy' method.
- To have the Market Participant submit its conformance plan to demonstrate CT operating compliance when the passing threshold is not met. IESO to assess compliance taking into consideration the 'At Risk Dollars' and the time duration.

CONCLUSIONS

On a moving forward basis, the four bulleted recommendations per the RECOMMENDATIONS section of the CT Loading Assessment Final Report – November 15, 2010 are being presented:

- These recommendations as stakeholdered and endorsed at the Revenue Metering Standing Committee of October 28, 2010 will be planned for immediate implementation.

GLOSSARY OF TERMS USED

Normal operating conditions: The facility's historical load (or generation) pattern over an extended period of time, (typically the most recent year), which the MMP deems is likely to be repeated in the future. The periods within the past year when the load (or generation) is truly zero are irrelevant and therefore are excluded from the analysis for establishing compliance with the Wholesale Revenue Metering Standard - Hardware Section 6.9. (Reference RMSC meeting Aug 26, 2005)

Non-normal operating conditions: When business operating conditions change beyond the MMP's control, non-normal CT operation may result at below the minimum sustained current for its accuracy class. For example, a plant shutdown due to labour disruption, economic market conditions or business cycles, or insolvency may all require only minimum caretaker power. Unforeseen circuit loading dynamics, for example due to embedded generation, may also result in non-normal CT operation. Any poor metering installation design cannot be justified with non-normal CT operation.

Class kWh: Metered active energy associated with CT operation at or above the rated nominal current threshold for revenue metering accuracy class. Respectively, these thresholds are: (1) 10% rated nominal or 0.5 A secondary for 0.3 class, (2) 5% rated nominal or 0.25 A secondary for 0.15 class, and (3) 1% rated nominal or 0.05 A secondary for 0.15S class. For the purposes of this report, class kWh is parsed from 5 minute interval meter data.

Embedded/Distributed Generation: Embedded or distributed generation is usually a small scale production of power connected within the distribution network and not having access to the transmission network. These generators are typically located close to the electricity consumer.