$$ENERGY_{base} = \sum_{j=1}^{m}\left(FULL\ LOAD_{j,base} \times LF_{j,base} \times HOURS_{j,base}\right)$$

where

$ENERGY_{base}$ ≡ Annual Baseline Energy Use - Annual Energy Use for baseline equipment calculated separately for each measure and each *energy source* (electric, gas).

$FULL\ LOAD_{j,base}$ ≡ Baseline Full Load - the maximum operating load of each baseline system and subsystem with operating condition *j* (as defined below).

$LF_{j,base}$ ≡ Load Factor - fraction of Full Load for each baseline system and subsystem with operating condition *j* (as defined below). Typically less than 1.00 unless the equipment was sized to run at 100% of rated capacity.

$HOURS_{j,base}$ ≡ Total Annual Operating Hours – Total Annual Operating Hours for each system and subsystem with operating condition *j* (as defined below).

j ≡ System Condition - refers to each distinct combination of system mode, number of hours, Full Load demand, and Load Factor for each system or subsystem.

m ≡ Number of Terms – total Number of Terms needed to cover all conditions of affected systems and subsystems.

Document the inputs and outputs to the building model as described in the LEED Reference Guide for Green Building Design and Construction, Energy and Atmosphere Credit One, Option 1, Whole Building Simulation and as described in Section 4.

Baseline Case Coincident Electric Demand (kW)

Document the baseline case coincident electric demand for each measure according to one of the following equations:

For variable loads:
$C\ LOAD_{base} = AVG\ PH\ LOAD_{base}$

Where

$AVG\ PH\ LOAD_{base}$ ≡ Average Baseline Load of all affected equipment during the *Performance Hours* of 3-6 pm, weekday, non-holidays from June 1 – August 31 for a total of 195 hours. Includes non-operating time during the *Performance Hours* and is equal to total energy use during the *Performance Hours* divided by the total *Performance Hours*.

For constant loads:

$$C\ LOAD_{base} = \sum_{h=1}^{m}\left(FULL\ LOAD_{h,base} \times LF_{h,base} \times CF_{h,base}\right)$$

where

$C\ LOAD_{base}$ ≡ Average Coincident Baseline Load – average coincident load of all affected baseline equipment during the *Performance Hours* of 3-6 pm, weekday, non-holidays from June 1 – August 31 for a total of 195 hours. Includes non-operating time during the *Performance Hours*.

$FULL\ LOAD_{k,base} \equiv$ Baseline Full Load - the maximum nameplate load of each baseline system and subsystem in operation during the *Performance Hours* with operating condition *k* (as defined below), exclusive of non operating time.

$LF_{k,base} \equiv$ Load Factor - fraction of Full Load for each baseline system and subsystem with operating condition *k* (as defined below). Typically less than 1.00 unless the equipment was sized to run at 100% of rated capacity.

$CF_{k,base} \equiv$ *Coincidence Factor* - the Coincidence Factor is the fraction of time that each baseline system and subsystem is operating during the *Performance Hours* for operating condition *k* (as defined below). The three typical conditions for CF are as follows: CF is unity if the equipment is continuously on during the *Performance Hours;* CF is zero for each system or subsystem that is not operating during the *Performance Hours*; otherwise, CF is the ratio of the 'on' time to the total number of performance hours.

$k \equiv$ System Condition - refers to each distinct combination of the system mode (e.g. high speed, low speed), Full Load demand, and Load Factor for each system or subsystem operating during *Performance Hours*.

$n \equiv$ Number of Terms – total Number of Terms needed to cover all operating modes of affected systems and subsystems during *Performance Hours*.

The analysis shall take into account that not all system components are expected to operate during all of the *Performance Hours*. For example on a cooling tower some of the cooling tower fans could periodically be staged in the "off" position while the compressors could be operating at 100% load. In these cases the system load during *Performance Hours* will not equal the sum of the loads for all system components.

Document the modeled measure inputs and outputs specifically for the *Performance Hours*.

The analysis shall include documentation of how the load varies during the *Performance Hours*. For constant load equipment, the analysis shall be based on the equipment load and operating schedule during the *Performance Hours*. For variable load equipment, the analysis shall address variations in equipment load and operating schedule during the *Performance Hours*.

Additional analysis will typically be prepared to address the impact of the baseline equipment on customer peak demand. Such analysis is critical to calculating customer cost savings but should not be confused with the required calculation of the coincident demand during the *Performance Hours*.

Savings

Savings shall be calculated from the efficient case and baseline case energy and demand calculations from above via whole building modeling. Ensure that the model addresses project variables as described in Section 3. Whole building models are designed to address interactive effects; the analyst shall ensure that the model accurately addresses such effects.

Annual Energy Savings (kWh for electrical, therms for gas)

$$ENERGY_{saved} = ENERGY_{base} - ENERGY_{eff}$$

where

$ENERGY_{base}$ and $ENERGY_{eff}$ are defined above.

Coincident Electrical Demand Reduction (kW) =

$$C\,LOAD_{saved} = C\,LOAD_{base} - C\,LOAD_{eff}$$

where

$C\,LOAD_{base}$ and $C\,LOAD_{eff}$ are defined above.

Section 3: Project Variables

Accurately capturing and documenting the variables that affect annual energy use and savings as well as those affecting peak period demand coincidence are critical elements in developing meaningful and reliable energy savings estimates. The savings analysis shall consider and address the variables over the life of the measure for both the baseline and efficient case. Uncertainty in variables shall be quantified and the savings analysis shall clearly demonstrate transparency and reasonableness in definition and application of variables affecting energy savings[770].

The variables below are common to many custom energy analyses. Document the variables that affect the energy use of the project for both the baseline and efficient scenarios. Describe the modeling methods used and any uncertainty associated with the values used in the model. ALL savings calculations must be *normalized* to reflect consistent application of the assumed variables for the project under both baseline and post-installation conditions over the full range of operating conditions for the affected systems. Modeling for new construction projects is the expected method for accounting for these variables as described in Section 4.

Load Characterization
Accurate characterization of the baseline and efficient energy use involves a comprehensive analysis of all variables that affect the loads over the analysis period. Concepts that are commonly used in performing energy analysis are discussed below. In all cases it is the intent of this document to require that the variations in load due to all factors (weather, production, schedule, etc) are accounted for in the analysis.

Load Shape
The load shape reflects variations in load over the course of a year, with specific attention paid to the peak periods defined by the affected utility and/or regional transmission organization. The model shall generate an 8760 load shape[771] that captures the expected period at which the load will operate at full load (full load hours) as well as all part load and non-operating or standby-modes..

Load Factor
Load Factor is the ratio of maximum energy demand to the average electric demand for the affected end use. Analysis of loads across a representative sample of operating conditions can generate a single load factor for constant load applications. For variable load applications, a series of load factors must be developed to accurately represent the variations in energy use under the variety of loading conditions that occur over the range of operating cycles in a typical calendar year. Variable load analysis shall address the variations in load factor over a one year period for all dependent variables.

Peak Load Factor
Peak Load Factor describes the variation between the maximum connected load of the equipment and the highest actual load of the equipment. In some cases the Peak Load Factor is unity. For oversized

[770] Anne Arquit Niederberger, PhD, A+B International (2005), Baseline Methodologies for Industrial End-Use Efficiency Presentation. Presented at World Bank; Anne_Arquit_Niederberger_Industry_EE_CDM_Dec_05.xls
[771] Patil, Yogesh, et. al. (Aug. 2009) "Taking Engineering Savings to the Next Level, presented at IEPEC 2009 http://www.ers-inc.com/images/articles/Papers/takingsavingstonextlevel.pdf

equipment it is frequently less than one. In some rare instances where equipment is operated above its rated load, the Peak Load Factor may be greater than one.

Coincidence Factor
Coincidence Factor is the coincidence of the demand savings during the *Peak Performance Hours*. For modeled measures, the average coincident demand, including non-operational hours, is generated through the hourly simulation of building demand for the baseline and efficient conditions during *Peak Performance Hours*.

Operating Conditions
Characterize all variable operating conditions that affect the load over the analysis period. Typical operating variables are outlined below. Additional factors may be required to accurately characterize variability in equipment operations and the energy savings resulting from energy efficiency measures over the full range of operating conditions.

Operating Hours
Establish the projected operating hours for all affected equipment in the building – scheduled operating hours are the same for base and efficient case models except where necessary to model nonstandard efficiency measures[772]. Address all variations in operating schedule over an annual operating cycle including, but not limited to weekends, holidays, and shift or occupancy changes that are a result in cyclical changes in operations over the course of a year. (For example retail applications may have longer operating hours in November and December). Project analysis shall clearly identify all operating, non-operating, and standby hours, the related loads, the periods for which those conditions apply and the basis for the assumptions in the analysis. Special attention should be paid that the hours of *Coincident Peak* (3:00 – 6:00 weekdays from June 1 through August 31) are detailed.

Weather
The analysis shall address the impact of annual weather, including temperature, humidity, and solar incidence (where applicable) on energy consumption. All savings (energy and demand) should be normalized to the TMY3 (Typical Meteorological Year) that corresponds to the nearest TMY3 weather site using modeling and/or regression analysis. TMY3 data should be obtained from National Renewable Energy Laboratory (NREL[773]) and used as the 8760 weather file to model and/or normalize annual energy use for weather dependent measures. Modeling tools, such as eQuest[774], currently use TMY2 data. TMY3 data is based on more-recent and more accurate data and is available for many more locations; TMY3 data is available for over 1,000 locations, where TMY2 data is available for fewer than 300 locations.

Production
This applies only to industrial new construction projects that include production measures. Project analysis shall reflect variations in production over the cycles within the analysis period. Variations can include such things as the number of shifts or changes in quantity or type of product manufactured.

For industrial process measures, production documentation shall normalize energy use based on the energy intensity of the process (i.e. energy use per unit of output) over the lifetime of the measure for both the baseline and efficient cases. Measurement of output should be based on physical measures of output (i.e. ton of steel or paper) and capture variations in both production levels and manufactured product types over the analysis period for both the baseline and efficient case[775].

Assumptions regarding economic climate, changes in production levels, and shifts all affect calculated energy savings over the life of the measures. Develop reasonable assumptions regarding these variables

[772] ASHRAE Standard 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings, Appendix G, Table G3.1, Section 4.
[773] Typical Meteorological Data (TMY3) - http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/
[774] DOE2 eQuest simulation software - http://www.doe2.com/equest/
[9] Ruth, Michael, Lawrence Berkeley National Laboratory, et. al. (2001) A Process-Step Benchmarking Approach to Energy Use at Industrial Facilities: Examples from the Iron and Steel and Cement Industries; Process_Step_Benchmarking_ACEEE_LBNL-50444.doc

and ensure the application of these variables is clearly identified in both the analysis and project documentation. Identify the uncertainty introduced into the energy savings estimates as a result of these assumptions.

Controls
Control settings and level of control shall be accounted for in the analysis in accordance with ASHRAE Standard 90.1 2007, Appendix G. Clearly document the control points that affect energy use, the control setpoints, sequence of operation and accuracy of controls that are required for the baseline case in Appendix G. Clearly document the changes in these conditions for the efficient case and how they are modeled. Include relevant information such as commissioning of control points, potential manual overrides of control sequences and anticipated control point calibration over the life of the measure.

Occupancy
Where occupancy affects energy use and varies over time, capture the variations in occupancy and their effects over the analysis period. At a minimum there is typically an 'occupied' and an 'unoccupied' mode for most facilities.

Assumptions regarding economic climate and shifts in hours of occupancy affect calculated energy savings over the life of the measures. Develop reasonable assumptions regarding these variables and ensure the application of these variables is clearly identified in both the analysis and project documentation. Identify the uncertainty introduced into the energy savings estimates as a result of these assumptions.

Interactive Effects
Analysis shall explicitly account for interactive effects between measures. For projects that include both prescriptive and custom measures, account for the energy use reduction from the prescriptive measure in the custom measure analysis. As prescriptive measures include interactive effects themselves, document the methodology that is used to ensure that savings from the interactive effects are only accounted for once in the claimed savings.

One common set of interactive effects is the impact of electrical energy efficiency measures within a facility on that facility's heating and/or cooling load. These shall be addressed as follows:

Waste Heat
For efficiency upgrades that reduce the rejection of waste heat into air conditioned spaces (i.e. evaporator fans in a refrigerated enclosure), quantify the reduction in heat rejection[776] and the associated cooling reduction.

Heating Increase
For efficiency upgrades that reduce the rejection of waste heat into heated spaces, quantify the additional heating fuel required to offset the change and maintain temperature within the space[14]. The analysis shall address heating system efficiency and include basis for assumptions regarding fossil fuel increases.

For projects with multiple measures, the procedure for interactive effects is to calculate savings for the longest lived measure first, then consider that measure's impact on the next longest-lived measure, and so on. This is because a short-lived measure can affect savings from a long-lived measure, but only for part of its life. Since tracking system limitations require that annual measure savings remain constant for all years, this is the only way to ensure proper lifetime savings and total resource benefits are captured.

Measure Life
Document both the life of the baseline and efficient case equipment. The efficient case analysis is typically performed over the lifetime of the efficiency measures. Where the analysis period and the efficiency measure life are not the same, describe the rationale for the analysis period and assumptions regarding replacement equipment for measures with lives that are shorter than the analysis period.

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[776] 2009 ASHRAE Handbook, Fundamentals, Chapter 18, page 18.3.

Persistence
Persistence factors may be used to reduce lifetime measure savings in recognition that initial engineering estimates of annual savings may not persist long term[777]. The persistence factor accounts for uncertainties and for normal operations over the life of the measure. For instance if energy efficient motors are installed as part of a process and the customer's standard procedure is to have motors rewound upon failure, the energy efficiency associated with the efficient motor would only persist until the expected time when the motor is rewound. Persistence is also affected by measures being removed or failing prior to the end of its normal engineering lifetime, improper maintained over the life of the measure, control overrides or loss of calibration (controls only), etc.

Related Variables:
Related variables are those which are not included in the energy and demand calculations, but may be required for project cost-effectiveness screening by the utility(ies). Document the following variables for the project:

Operation &Maintenance (O&M) Impacts
Where O&M practices would have resulted in changes to the baseline during the analysis period, account for such practices in the establishment of baseline and efficiency case energy use.

Water Consumption Impacts
Quantify any changes in water consumption attributable to the project.

Cost
Document the cost of each measure. Include invoices, bids and other documentation to substantiate project cost data. Identify portions of the cost which are for equipment being purchased for redundancy or backup and will not generate savings in the project. Related costs such as the costs for audits, design, engineering, permits, fees or M&V should be reported separately from the costs associated with the design and installation of energy efficiency improvements.

Other Variables
As needed - clearly document all variables affecting the energy use of the project that have not been covered in this document.

Section 4: Documentation and Modeling

Documentation and modeling of custom new construction projects are essential to developing reliable energy savings and peak demand reductions claims.[778] The following guidelines support the accurate estimation of energy and demand savings.

Modeling
Computer modeling is an acceptable method of analysis using an 8760 model which meets the requirements of ASHRAE 90.1 Appendix G and the requirements of the LEED Reference Guide for Green Building Design and Construction, Energy and Atmosphere Credit One, Option 1, Whole Building Simulation.

Process measures, such as industrial process or data center efficiency that are additional to the building design modeled under ASHRAE 90.1 Appendix G shall be either included in the simulation using customized algorithms, or modeled separately using measure specific analysis tools. The results of measure specific analysis shall be accounted for in the building model and any custom simulations should be documented in accordance with the TRM and the Custom Analysis Template (Appendix B).

Calculations
Computer simulation of energy efficiency measures using 8760 hourly simulation models such as eQuest, or customized spreadsheet analysis or other energy analysis tools shall be employed to calculate energy savings. The

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[777] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February 19, 2010
[778] Parlin, Kathryn, et. al. (August, 2009 IEPEC) "Demand Reduction in the Forward Capacity Market, Verifying the Efficiency Power Plant"

algorithms of the modeling software must be designed to address the modeled measures. Minimum documentation requirements include model output reports stating unmet load hours for the baseline and efficient case, hourly energy use and demand, and electronic copies of the model or spreadsheet analysis files.

Annual kWh and therms for baseline and efficient cases shall be the *annualized* and *normalized* per the equations in Section 2 using the methods described above. Document the assumptions and calculations for baseline and efficient Coincident Electric Demand (kW) as the average kW over the *Performance Hours* as indicated in Section 2. Calculation documentation shall include definitions and reference sources for all variables and assumed factors in Section 3.

Documentation

Analysis shall be documented with comprehensive, well labeled supporting information including, but not limited to:

Manufacturer literature documenting connected load for both the baseline and the installed equipment or manufacturer data documenting the information necessary to calculate peak demand (such as horsepower, voltage, efficiency, etc.) shall be included in the project documentation. Manufacturer data shall be clearly marked to indicate the specific equipment model number and data that is applicable to the project and used in the calculations.

Reporting

The following shall be reported:

- All information required in this protocol
- Custom Analysis Template (Appendix B) Section 1 and Documentation Worksheet (Appendix C) only
- Documentation as required by LEED Reference Guide for Green Building Design and Construction, Energy and Atmosphere Credit One, Option 1, Whole Building Simulation.
- Assessment of the level of uncertainty associated with the energy and demand calculated savings.
- Project commissioning can reduce energy use and is recommended. If the project was commissioned, submit a copy of the commissioning report.

V. Protocols for Transmission & Distribution Projects

T&D Loss Reductions – Mass Plant Replacement and Expansion Analysis Protocol

This protocol defines the requirements for analyzing and documenting loss reductions due to installation of mass utility plant with lower losses than standard equipment, when that equipment is required due to failure, need for increased capacity, or connection of new loads. Where equipment is replaced prior to the end of its rated service life in order to achieve energy savings, the project is classified as Retrofit and the "T&D Loss Reductions – Mass Plant Retrofit Analysis Protocol" should be used to guide analysis.

Examples of mass plant include line transformers, secondary lines, service drops, and meters. For these common and generally small investments, determination of loads and losses for each installation will not generally be feasible or cost-effective. This protocol is intended to address the energy impacts of operating energy efficiency improvements of installed equipment on average over many installations.

This analysis protocol does not apply to equipment installed to serve interval-metered load in excess of 500 kVA. Those projects should be analyzed with the Large Customer Connection Analysis Protocol.

The Analysis Protocol is divided into four sections:
Section 1: Program Information
Section 2: Equipment Loading
Section 3: Base and Efficient Cases and Savings
Section 4: Screening Inputs

Section 1: Program Information

Program Title
Provide a unique title for the program so that it is easily distinguishable from other programs with similar scope. Example: "50 kVA 13.8 kV transformers specified for new connections".

Sites (locations)
Provide a list of the locations at which equipment was installed under this program. Locations may be identified by the customer addresses, pole numbers, transformer identification numbers, or similar identifiers.

Class/Sector/Industry Description
For each installation, specify the customer classes (residential, small general service, etc.) served by the equipment, and for non-residential customers, the sector (Industrial, Commercial, Institutional, Multi-family) and type of use (e.g., office, restaurant, dormitory, gas station).

Technology Description
Describe the type of equipment affected (e.g., line transformer, secondary, etc.), including the range of capacities, wire sizes, span lengths, or other descriptors affecting energy losses.

Describe the base-efficiency equipment that would be installed under current standard utility practice.

Describe the high-efficiency equipment installed in the program. Provide specific details (e.g., wire sizes, transformer loss specifications) relevant to loss computations.

Program Implementation schedule
Define the implementation schedule for the program, including number of installations by month.

Analysis Contact(s)

Provide contact information for the personnel responsible for tracking installations and for estimating loss reductions, including company name, individual(s) name, address, phone and email.

Section 2: Equipment Loading

For each type of equipment included in the program, provide (1) the estimated maximum load on the typical or average installation, (2) the estimated average load on the equipment on weekdays between 3:00 p.m. and 6:00 p.m., June through August (the coincident peak period), and (3) the estimated load-duration curve on the equipment.

Include the sources of the estimates, including utility load-research data.

Include any data on the variability of loads among installations, reflecting the number of customers served by the equipment (e.g., customers on a transformer or a span of secondary), the size of customer, and the customer class(es) (e.g., residential, street lighting, small commercial) served.

The load data should reflect the conditions prevailing in the year for which savings are claimed. Particularly for expansions of the distribution system, the loads in the year of installation may be less than loads in later years.

Where possible, the annual billed sales to the customers served by the equipment should be used as a check on the total energy usage assumed. Where these data are not available, describe the system configuration (e.g., secondary network) or database limitations that prevent such comparison.

Section 3: Base and Efficient Cases

Calculate and document energy losses for the efficient and base cases as outlined below.

Baseline-Case Losses
For each type of equipment included in the program, compute the annual losses per unit of equipment as

$$loss_{base} = \Sigma_t [kVA_t \div FLC]^2 \times FLLL_b + 8766 \times NLL_b$$

where

t	= hour
FLC	= full-load capacity
$FLLL_b$	= load losses at full load
NLL_b	= no-load loss/hour

Compute the pre-project losses in the coincident peak period in kW as

$$peakloss_{base} = \Sigma_h \{[kVA_h \div FLC]^2 \times FLLL_b\} \div H + NLL_b$$

where

h	= hour in the coincident peak period
H	= number of hours in the coincident peak period

Provide manufacturer's specifications or standard-reference data for typical baseline equipment for FLC, FLLL, and NLL.

Provide the spreadsheet in which the base losses are computed.

Provide information demonstrating that the assumed base efficiency is in fact standard practice, including:

Current Industry Practice – Document current industry practice using articles from industry journals, manufacturers' sales data, recent distribution standards from other utilities, and/or similar sources.

Applicant Practice – Document the utility's own recent standard practices through purchase records, distribution standards, internal guidelines for linemen, and similar documents. Document the effect on equipment selection of allowances for growth, including new infill construction in expansion applications.

Efficient-Case Losses

For each type of equipment included in the program, compute the annual losses per unit of the efficient equipment as

$$loss_{efficient} = \sum_t [kVA_t \div FLC]^2 \times FLLL_e + 8766 \times NLL_e$$

where

- t = hour
- FLC = full-load capacity
- $FLLL_e$ = load losses at full load
- NLL_e = no-load loss/hour

Compute the post-project losses in the coincident peak period in kW as

$$peakloss_{efficient} = \sum_h \{[kVA_h \div FLC]^2 \times FLLL_e\} \div H + NLL_e$$

where

- h = hour in the coincident peak period
- H = number of hours in the coincident peak period

Provide manufacturer's specifications or standard-reference data for efficient equipment for FLC, FLLL, and NLL.

Provide the spreadsheet in which the efficient-case losses are computed.

Savings

$$\text{Energy Savings} = (loss_{base} - loss_{efficient}) \times (1 + ULF)$$

where

- ULF = Upstream Loss Factor, the change in losses on the primary distribution and transmission systems per kWh reduction in secondary losses

$$\text{Peak Savings} = (peakloss_{base} - peakloss_{efficient}) \times (1 + UPLF)$$

where

- ULF = Upstream Peak Loss Factor applicable to the coincident peak period

If the utility has estimates of load-related losses on the primary distribution and transmission systems, and uses those estimates in screening customer end-use efficiency measures, it may add those losses to the load reduction due to efficiency improvements in mass plant on the secondary distribution system. Provide the derivation of the estimate of primary and transmission losses, and demonstrate the consistency of the claimed losses with the loss values used for the savings behind the customer meter.

Section 4: Screening Inputs

Measure Life

Document the life of each type of added equipment, including reference to the utility's depreciation studies. The efficient case analysis is typically performed over the lifetime of the major components. Where some equipment has a useful life shorter than the analysis period, describe the rationale for the analysis period and assumptions regarding the replacement cost of equipment with lives shorter than the analysis period.

Discount savings with respect to existing equipment over time, to the extent that the utility would make this (or a similar) change in configuration in the foreseeable future to meet peak load or reliability requirements.

O&M Cost Effects
Include any foreseeable changes in O&M costs related to the changes in equipment and to any changes in operating practices.

Cost
Document the actual cost of the project, including equipment, internal and contract labor, allocated overheads, design, engineering, and permitting.

T&D Loss Reductions – Mass Plant Retrofit Analysis Protocol

This protocol defines the requirements for analyzing and documenting loss reductions due to replacement of existing mass utility plant with more efficient equipment, prior to the end of the existing equipment's useful life and in the absence of any need for increased capacity.

Examples of mass plant include line transformers, secondary lines, service drops and meters. For these common and generally small investments, determination of loads and losses for each installation will not generally be feasible or cost-effective. This protocol is intended to address the energy impacts of operating energy efficiency improvements of installed equipment on average over many installations.

This analysis protocol does not apply to equipment installed to serve interval-metered load in excess of 500 kVA. Those projects should be analyzed with the Large Customer Analysis Protocol.

The Analysis Protocol is divided into four sections:
Section 1: Program Information
Section 2: Equipment Loading
Section 3: Base and Efficient Cases and Savings
Section 4: Screening Inputs

Section 1: Program Information

Program Title
Provide a unique title for the program so that it is easily distinguishable from other programs with similar scope. Example: "Replacing 25 kVA 13.8 kV transformers with amorphous-core transformers".

Sites (locations)
Provide a list of the locations at which equipment was installed under this program. Locations may be identified by the customer addresses, pole numbers, transformer identification numbers, or similar identifiers.

Class/Sector/Industry Description
For each installation, specify the customer classes (residential, small general service, etc.) served by the equipment, and for non-residential customers, the sector (Industrial, Commercial, Institutional, Multi-family) and type of use (e.g., office, restaurant, dormitory, gas station).

Technology Description
Describe the type of equipment affected (e.g., line transformer, secondary, etc.), including the range of capacities, wire sizes, span lengths, or other descriptors affecting energy losses.

Describe the existing equipment that was replaced.

Describe the high-efficiency equipment installed in the program. Provide specific details (e.g., wire sizes, transformer loss specifications) relevant to loss computations.

Program Implementation schedule
Define the implementation schedule for the program, including number of installations by month.

Analysis Contact(s)
Provide contact information for the personnel responsible for tracking installations and for estimating loss reductions, including company name, individual(s) name, address, phone and email.

Section 2: Equipment Loading

For each type of equipment included in the program, provide (1) the estimated maximum load on the typical or average installation, (2) the estimated average load on the equipment on weekdays between 3:00 p.m. and 6:00 p.m., June through August (the coincident peak period), and (3) the estimated load-duration curve on the equipment.

Include the sources of the estimates, including utility load-research data.

Include any data on the variability of loads among installations, reflecting the number of customers served by the equipment (e.g., customers on a transformer or a span of secondary), the size of customer, and the customer class(es) (e.g., residential, street lighting, small commercial) served.

The load data should reflect the conditions prevailing in the year for which savings are claimed.

Where possible, the annual billed sales to the customers served by the equipment should be used as a check on the total energy usage assumed. Where these data are not available, describe the system configuration (e.g., secondary network) or database limitations that prevent such comparison.

Section 3: Base and Efficient Cases

Calculate and document energy losses for the efficient and base cases as outlined below.

Baseline-Case Losses

For each type of equipment included in the program, compute the annual pre-program losses per unit of equipment as

$$loss_{base} = \Sigma_t [kVA_t \div FLC]^2 \times FLLL_b + 8766 \times NLL_b$$

where

t	= hour
FLC	= full-load capacity
$FLLL_b$	= load losses at full load
NLL_b	= no-load loss/hour

Compute the pre-project losses in the coincident peak period in kW as

$$peakloss_{base} = \Sigma_h \{[kVA_h \div FLC]^2 \times FLLL_b\} \div H + NLL_b$$

where

h	= hour in the coincident peak period
H	= number of hours in the coincident peak period

Provide manufacturer's specifications, test results, or standard-reference data for typical baseline equipment for FLC, FLLL, and NLL.

Provide the spreadsheet in which the base losses are computed.

Provide information demonstrating that the existing equipment could have remained in service.

Document that the existing equipment was functioning properly.

Provide certification that the existing equipment was adequate to meet anticipated loads.

Describe the disposition of the existing equipment. If the equipment has been or may be returned to service, explain how that return to service would not offset the claimed loss reductions.

Describe the manner in which equipment was selected for replacement (e.g., vintage, design, location), and provide documentation to demonstrate that the replacements were targeted for loss reduction, rather than actual or imminent failure.

Efficient-Case Losses

For each type of equipment included in the program, compute the annual losses per unit of the efficient equipment as

$$loss_{efficient} = \Sigma_t [kVA_t \div FLC]^2 \times FLLL_e + 8766 \times NLL_e$$

where

t	= hour
FLC	= full-load capacity
$FLLL_e$	= load losses at full load
NLL_e	= no-load loss/hour

Compute the post-project losses in the coincident peak period in kW as

$$peakloss_{efficient} = \Sigma_h \{[kVA_h \div FLC]^2 \times FLLL_e\} \div H + NLL_e$$

where

h	= hour in the coincident peak period
H	= number of hours in the coincident peak period

Provide manufacturer's specifications or standard-reference data for efficient equipment for FLC, FLLL, and NLL.

Provide the spreadsheet in which the efficient-case losses are computed.

Savings

Energy Savings = $(loss_{base} - loss_{efficient}) \times (1 + ULF)$

where

ULF = Upstream Loss Factor, the change in losses on the primary distribution and transmission systems per kWh reduction in secondary losses

Peak Savings = $(peakloss_{base} - peakloss_{efficient}) \times (1 + UPLF)$

where

ULF = Upstream Peak Loss Factor applicable to the coincident peak period

If the utility has estimates of load-related losses on the primary distribution and transmission systems, and uses those estimates in screening customer end-use efficiency measures, it may add those losses to the load reduction due to efficiency improvements in mass plant on the secondary distribution system. Provide the derivation of the estimate of primary and transmission losses, and demonstrate the consistency of the claimed losses with the loss values used for the savings behind the customer meter.

Section 4: Screening Inputs

Measure Life

Document the life of each type of added equipment, including reference to the utility's depreciation studies. The efficient case analysis is typically performed over the lifetime of the major components. Where some equipment has a useful life shorter than the analysis period, describe the rationale for the analysis period and assumptions regarding the replacement cost of equipment with lives shorter than the analysis period.

Discount savings with respect to existing equipment over time, to the extent that the utility would make this (or a similar) change in configuration in the foreseeable future to meet peak load or reliability requirements.

O&M Cost Effects
Include any foreseeable changes in O&M costs related to the changes in equipment and to any changes in operating practices.

Cost
Document the actual cost of the project, including equipment, internal and contract labor, allocated overheads, design, engineering, and permitting.

T&D Loss Reductions – Large Customer Connection Analysis Protocol

This protocol defines the requirements for analyzing and documenting loss reductions due to installation of distribution equipment to serve interval-metered load in excess of 500 kVA, where the installed equipment has lower losses than

- standard equipment, in the case of incremental improvements over equipment required due to failure, need for increased capacity, or connection of new loads, or
- existing equipment, in the case of retrofit of equipment solely for the energy savings.

Each project may include equipment serving one or a few customers, each with interval metering, at single location. The equipment may also serve small amounts of non-interval-metered street lighting and private area lighting, so long as the load shape of the outdoor lighting can be reasonably estimated.

Examples of distribution plant covered by this protocol include line transformers, secondary lines, service drops, and meters.

The Analysis Protocol is divided into four sections:
Section 1: Project Information
Section 2: Equipment Loading
Section 3: Base and Efficient Cases and Savings
Section 4: Screening Inputs

Section 1: Project Information

Project Title
Provide a unique title for the project so that it is easily distinguishable from other projects with similar scope. Example: "Install low-loss transformers and upgrade service drops for the Midway Office Park".

Sites (locations)
Provide a list of the locations at which equipment was installed under this project. Locations may be identified by the customer number, address, pole numbers, transformer identification numbers, or similar identifiers.

Technology Description
Describe the type of equipment affected (e.g., line transformer, secondary, etc.), including the capacity, wire size, span lengths, voltages, or other descriptors affecting energy losses. Provide a one-line diagram of the interconnection.

If this project consists of the incremental increase of efficiency for a new or replacement connection, describe the equipment that would be installed under standard utility practice. Demonstrate that the assumed base efficiency is in fact standard practice, including:

> Current Industry Practice – Document current industry practice using articles from industry journals, manufacturers' sales data, recent distribution standards from other utilities, and/or similar sources.
>
> Applicant Practice – Document the utility's own recent standard practices through purchase records, distribution standards, internal guidelines for linemen, and similar documents. Document the effect on equipment selection of allowances for growth, including new infill construction in expansion applications.

If this project consists of the loss-driven retrofit of existing connection equipment, describe the existing equipment.

Describe the high-efficiency equipment installed in the project. Provide specific details (e.g., wire sizes, transformer loss specifications) relevant to loss computations.