



HOURLY SIMULATION GUIDELINES

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1. Introduction

This document has been developed by the Massachusetts energy efficiency program administrators (PAs) to create a common set of expectations for technical assistance (TA) consultants providing hourly energy simulation services. This is intended to be a living resource that is regularly updated as energy codes, modeling methodologies, and analysis tools evolve. These guidelines pull together technical direction from a variety of sources to improve modeling accuracy. This is not intended to be a comprehensive manual for how to perform energy modeling and assumes a moderate degree of experience.

The main body of these guidelines is fairly brief and intended to define the general degree of rigor required for PA study submissions. These are requirements for hourly simulation studies.

Attachments to the guidelines include technical notes for the use of modelers and a technical review guide for the use of PA reviewers.

- The technical notes are recommended practices that are likely to improve the reliability and accuracy of simulation models. There may be cases where simulation requirements reference these technical notes. The technical notes are organized by general design discipline (e.g. architectural, HVAC, plumbing, electrical, process).
- The technical review guide is developed from the simulation requirements and provides step by step guidance.

These guidelines focus on simulation and are not specific to new construction, retrofit, stand-alone, or campus projects. Please see other Mass Save documents for current incentive program requirements such as baseline definitions for new construction projects.

2. Approved Modeling Software

The approved list of hourly simulation packages is based on current computational capabilities and current familiarity of the PA technical review staff and TA vendor community. There is a strong preference for open-source software capable of 8,760-hour analysis. Other software could potentially be used but this must receive pre-approval from the PA technical reviewer.

1. eQuest v3.65 operating with DOE2.3 is currently the favored simulation package due to its widespread use in southeastern New England and fast run times. DOE2.3 has effectively addressed some of the drawbacks of DOE2.2, though DOE2 continues to use rudimentary models for radiant heat transfer, natural convection, and infiltration and cannot model complex heat pump systems. Spreadsheet models of central plants with heat recovery heat pumps and/or air-source heat pumps are acceptable as work-arounds provided that the spreadsheet models are free of errors, logically laid out, and well documented.
2. EnergyPlus is capable of modeling the next generation of HVAC systems and it can be used for Mass Save studies. The use of OpenStudio is strongly preferred since it is open source and accessible to all TA vendors and technical reviewers.
3. Other software programs such as IES, Trane TRACE, and Carrier HAP models are not accepted at this time. Non-hourly simulation programs such as WUFI or REM/Rate are not accepted.

3. Documentation Requirements

All simulation studies are required to provide the following documentation. Updated versions are required to be provided upon project completion. These guidelines introduce few changes to the work flow most TA vendors have used in the past and are likely to facilitate the documentation process.

- A. Study proposals shall follow the current proposal template available from the PAs and should provide a road map for how the study will be completed. Baseline assumptions, expected deviations from these guidelines, and anticipated work-arounds shall be described. The planned approach to developing model inputs and cost estimates shall be described for each measure.
- B. Modeling reports shall conform to documentation formats described in the current sample report available from the PAs.
 - 1. The report must state whether these guidelines have been followed in their entirety or describe what deviations have been required for the particular project.
 - 2. Graphical representations of energy use impacts by end use and month facilitate TA internal quality control and PA technical reviews. TAs may need to modify their post-processing spreadsheet templates to support automatic generation of these plots. Discussions of energy impacts for each measure should focus on these plots and explain the results.
 - 3. Use of work-arounds other than those described in the technical notes must be thoroughly and clearly explained.
- C. Modeling results for each considered ECM shall be provided to allow the relative impact of each upgrade to be assessed.
- D. Provide all simulation files necessary to open and run all models supporting the applications for incentives. For eQuest projects, this includes the .inp, .pd2, .prd, and weather files. Energy Plus projects should submit the .osm and .epw files plus the final .idf file, particularly if the model requires leaving Open Studio and using the IDF editor.
- E. Provide spreadsheet files used to generate unique model inputs supporting complex work-arounds.
- F. Should specific information from manufacturers or vendors be used to develop input assumptions, copies of supporting information should be attached in a report appendix.
- G. Cost estimation remains a program requirement for each ECM. The method of developing costs is at the discretion of the TA but the listed cost should be reasonably accurate.
- H. Screening tool input values (and results) shall be presented in a dedicated report appendix.
- I. For projects with air-to-water heat pumps, provide an equipment selection sheet at ANSI/AHRI Standard 550/590-2023 Table 4 conditions for low ambient temperature (17°F db), medium condition (120°F HW supply), with a hot water flow rate equal to the cooling mode rating condition. Place this selection sheet in the Appendix containing the screening input information.
- J. The simulation report shall not include incentive offer amounts. These are to be provided in a separate letter from the PA to the customer.

4. Baselines

Energy savings are highly impacted by baseline assumptions, and the general approach toward baseline development for a specific project needs to be clearly defined in the study proposal submitted to the PAs.

- A. The current state energy code with associated amendments (780 CMR Chapter 13) serves as the general baseline reference regardless of whether the community where the project is located has adopted the Massachusetts Stretch Energy Code or the Municipal Opt-in Specialized Code 2023. The PAs have developed a baseline document that summarizes code requirements, presents policy decisions, and covers non-regulated end use baseline assumptions. Several deviations between the PA baseline and current code are clearly listed in the baseline document. All studies are to comply with the most recent baseline document.
- B. The energy code allows compliance with IECC or ASHRAE 90.1 but does not allow switching between the two. Design teams need to select a code basis for their projects and the PA study shall, generally, use whichever basis is selected by the design team. The compliance track needs to be clearly described in study proposals.
- C. Although federal buildings are not required to meet the Massachusetts state energy code, baselines for these buildings must meet the requirements of the most recent Mass Save baseline document.
- D. ASHRAE 90.1 Appendix G is not an accepted baseline.
- E. Energy models developed to document a project's Thermal Energy Demand Intensity (TEDI) standing when pursuing the Stretch Energy Code's Targeted Performance Path are not acceptable baselines since TEDI simulation guidelines do not reflect likely future use of the building or the appropriate baseline/proposed case HVAC systems.
- F. Pursuit of building design certification (e.g. LEED, Energy Star) does not impact choice of baseline assumptions used in incentive models. In cases where a design assistance model originally developed to support the certification process is used to support an incentive study, some attributes of the baseline may need to be changed to align with the requirements in these guidelines.
- G. The following design case attributes are to be the same in the baseline model:
 1. Weather file
 2. Building orientation
 3. Shading from adjacent objects
 4. Floor plan layouts and space use assignments
 5. Presence of plenums, voids, shafts, and other spaces that are not actively conditioned
 6. Distribution and width of windows (height is to be varied to change overall WWR if necessary)
 7. Category of envelope assemblies relative to IECC 2021 Table C402.1.4 and ASHRAE 90.1-2019 Table 5.5-5
 8. Load diversity schedules and HVAC system occupied period run time schedules
 9. Process loads (changes permitted to model unique control sequences)

10. Design ventilation rates at zone level¹
11. Space temperature schedules (changes permitted to model unique control sequences)
12. Gas-fired equipment type and performance²
13. DHW fuel type (*except in the case of heat pump water heaters*)
14. Average annual utility rates. For new construction projects, the rates are defined by PAs in the custom screening tool. For retrofit projects, the rates should be based on historical averages for the most recent year. Use of a customer's likely future electricity rate structure can be used provided that the energy model accounts for every end use consuming electrical power to ensure accurate predictions of demand costs.
15. Infiltration modeling strategy, peak flow basis, and schedules are to be the same in the base and proposed cases unless there are proven reductions in infiltration rates and the source of the infiltration loads are known through on-site testing. Translation of blower door test results to modeling inputs is a complex process that must be described to PAs in the study proposal and agreed upon by the PA.

¹ Savings cannot be claimed for implementing DCV in a system with ventilation rates exceeding code minimum requirements.

² Savings cannot be claimed in Massachusetts for the installation of any new gas-fired equipment per General Law Chapter 6C.179 Item 26 (2022). Savings can be claimed for building attributes that reduce loads on gas-fired equipment.

5. Required Modeling Methodology

These guidelines assume TAs are well-versed in standard modeling protocol necessary to generate a reasonably accurate prediction of future facility energy use. The following methodology descriptions define minimum acceptable standards for models developed for the Mass Save programs.

- A. Models shall use TMYx data per direction included in Technical Note A.1
- B. Models are to be configured based upon designed or likely HVAC zoning layouts and shall adhere to Technical Note A.2.
- C. Include the effect of shading from adjacent objects that are likely to cast shadows on fenestration.
- D. Spaces located above ceilings (a.k.a plenums) are to be modeled as plenum zones if these spaces have exterior surfaces.
- E. Envelope assemblies are to be entered using layers and constructions rather than simplified methods.
- F. Envelope assemblies are to include the impact of bridging, see Technical Note B.1 for recommended options.
- G. Adequate mass is to be included in the building to more realistically dampen zone temperature swings.
- H. Zones with partial roofs, exposed floors, or subgrade walls are to include reasonably accurate representations of the actual surface areas.
- I. Spandrel assemblies shall be modeled as a separate wall or window type having thermal characteristics accounting for thermal bridging.
- J. For models that are to include daylighting controls in the baseline and/or proposed case, include adequate internal partitions to support accurate predictions of daylighting impact.
- K. Walls that do not have windows in the design shall not have windows in the model.
- L. Multiple windows on a single wall for a particular zone can be collapsed to one equivalent window having fixed width and variable height. The preferred approach is to model individual windows.
- M. Models shall account for the effects of infiltration but shall not claim savings for improved air barrier performance unless specifically accepted as an ECM by the PAs. The crack method shall be used for buildings taller than 4 stories since this approach accounts for stack effect. See Technical Note B.2 for recommended options.
- N. Models shall account for heat transfer to the ground, see Technical Note B.3 for recommended options.
- O. Separate occupancy, lighting, and equipment load schedules are to be defined for different use areas in the building. See Technical Note A.3.
- P. Schedules for a given space (e.g. occupancy, lighting, equipment) are to be consistent with one another. See Technical Note A.3.
- Q. Schedules in facilities with predictable significant changes in use patterns (e.g. schools, universities) must account for periods of limited use. See Technical Note A.3.
- R. Peak space load assumptions are to be consistent with the diversity schedules.

- S. Autosizing of HVAC systems is permitted in early and mid-design modeling and should generally not be used for final modeling unless required to capture the impact of load reductions or system type changes as part of a specific ECM. See Technical Note C.1.
- T. All end use equipment likely to consume energy on a regular basis is to be represented in the energy model regardless of whether its operation impacts systems considered by an ECM. This ensures that building-wide % energy and cost impacts are accurately captured. See the technical notes pertaining to process equipment for further information and recommendations.
- U. Baseline and design case lighting power can be modeled on a whole-building or a space-by-space basis. The space-by-space approach is preferred.
- V. Lighting diversity schedules assume the use of manually operated wall switches and code-required occupancy sensors. The impact of optional occupancy sensor control in the proposed case shall be captured by applying a 10% reduction in LPD.
- W. Savings shall not be claimed for items required by the baseline document.
- X. Simulation of equipment that recovers waste heat needs to be performed on the same time step as the overall model to accurately capture simultaneous conditions (e.g. heat recovery heat pumps).
- Y. Individual energy conservation measures shall be evaluated incrementally in the following order:
 - 1. Electrification measures including the following as applicable:
 - a. HVAC ECMs – Baseline is an equivalent gas-fired system defined in the current Baseline Document. Proposed is ISP per Baseline Document as applicable. Savings for improved heat pump performance can be claimed as a separate ECM.
 - b. Non-HVAC ECMs - Heat pump-based service water heating systems (excludes resistance heating), see the current Baseline Document. Assume proposed case equipment.
 - 2. Load Reductions, including:
 - a. Envelope improvements
 - b. Peak load factor reduction (e.g. efficient lighting design)
 - c. Space load control improvements (e.g. additional lighting controls)
 - d. HVAC zone control improvements (e.g. DCV)
 - 3. HVAC central equipment air-side improvements (e.g. improved energy recovery)
 - 4. HVAC central plant component improvements (e.g. efficient chillers, heat pumps)
 - 5. ECMs with little interactivity with other measures (e.g. condensing DW heaters)
 - 6. Notes:
 - a. Combined Heat and Power (CHP)/Co-gen is no longer supported by the incentive programs.
 - b. On-site renewables are not included in the Mass Save analysis.

- Z. Buildings receiving cooling and/or heating from a central campus plant shall comply with Technical Note C.3. Buildings receiving heat from utility steam shall comply with Technical Note C.4.

Technical Notes

The following technical notes are organized by design discipline per the following headings. Within each discipline, each note has been number incrementally as they have been added to the simulation guidelines document. This approach facilitates stable references over time.

- A. General
- B. Architectural
- C. HVAC
- D. Plumbing
- E. Electrical
- F. Process

A.1 General: Weather Files

This is a required item for all hourly simulation projects.

- A. Models shall use specific TMYx data files available from Mass Save that are developed from observations gathered between 2007 and 2021. Directions for accessing the required TMYx files are provided in Appendix D.
- B. Weather files for a particular municipality are to be selected per the map included in Appendix D. While TA vendors can choose a different weather file, an explanation must be included in the study proposal and in the final report explaining the rationale.

A.2 General: Model Zoning

This is a required item for all hourly simulation projects.

- A. Models are to be configured based upon designed or likely HVAC zoning layouts to facilitate accurate entry of ventilation and air circulation rates, lighting and equipment power demand, and scheduling.
- B. Thermodynamically similar zones (similar exposure, space use, and schedules) can be combined.
- C. Core & shell projects shall model core spaces separately from tenant spaces. For tenant spaces, tenant designs are to be used, if available. If there are no tenant designs, adhere to the requirements described in Appendix C.
- D. Voids, shafts, and other areas without lighting, active conditioning, or exterior walls are to be modeled separately as unconditioned zones or omitted from the model. These spaces can be bundled together into a single equivalent zone on a per-floor basis.
- E. Tall spaces spanning more than 1 floor shall be modeled either as one space or as multiple spaces (1 per floor) separated by air walls.

A.3 General: Diversity Schedules

This is a required item for all hourly simulation projects.

- A. Each modeled zone is to be assigned schedules consistent with the activity in the space that will have the greatest impact on annual energy use. Generally, the space-by-space lighting definitions are helpful guidelines for assigning schedule types.
- B. Some HVAC zones may include more than one activity type and the modeler will need to use discretion when assigning schedules. For example, janitorial closets and small electric rooms could potentially be grouped into adjacent corridor spaces. Schedules appropriate for a corridor would be assigned to the zone even though they may over-estimate lighting use in the support spaces.
- C. Schedules for a particular space type are to be consistent with one another. Lighting and plug loads should track reasonably well with occupancy. Unoccupied period phantom equipment loads and night lighting should be reasonably represented.
- D. Schedules for facilities with predictable variations in use (e.g. school and university buildings) are to include the impact of breaks and other unique sessions (e.g. summer school). Refer to the institutions' most recent annual calendar.
- E. Appendix B provides guidance on the use of activity codes and BDL functions in eQuest. While not required, the use of these BDL functions greatly facilitates model development and the consistency of schedules and load factors.
- F. Conservation of People - The peak number of occupants associated with each type of occupancy schedule should be determined and a calculation performed to ensure that the total facility occupancy counts for each hour make sense.
 - a. For example, occupants cannot be simultaneously in offices and in conference rooms. The occupancy diversity schedules can be adjusted to maintain a total population that is consistent with other assumptions (such as DHW use).
 - b. It is recommended that equipment and lighting schedules be developed in a manner that responds appropriately to the occupancy schedules.
- G. Appendix A provides sample diversity schedules for offices, schools, and laboratories. While these specific schedules do not need to be followed, they provide a starting point and guidance regarding the granularity of scheduling that is desired. ASHRAE 90.1 User's Guide default schedules do not provide adequate granularity.

A.4 General: Peak Period Reporting

This is a required item for all hourly simulation projects.

- A. The current peak reporting definitions are listed below. The seven ISO-NE holidays are New Years, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving, and Christmas.
 - Energy Peak Summer: June through September, non-holiday weekdays, 7 AM to 11 PM
 - Energy Peak Winter: October through May, non-holiday weekdays, 7 AM to 11 PM
 - Demand Peak Summer: June through August, non-holiday weekdays, 1 PM to 5 PM

- Demand Peak Winter: December & January, non-holiday weekdays, 5 PM to 7 PM
- B. Electricity use can be post-processed in a spreadsheet or, in eQuest, the outputs can be calculated directly using flag schedules and utility rate blocks.

B.1 Architectural: Thermal Bridging

This is a required methodology for hourly building simulation projects.

- A. Historically, thermal bridging has not been properly accounted for in whole building simulation studies or in code reference materials. The U-Factor method limits appearing in IECC 2021 Table C402.1.4 and ASHRAE 90.1-2019 Table 5.5-5 account for likely bridging in the middle of walls based on 1-Dimension (1D) heat transfer. Similarly, the tables in ASHRAE 90.1 Appendix A also only cover center of wall bridging.
- B. ASHRAE Research Project 1365-RP investigated 3-Dimension (3D) heat transfer for a range of assembly types and found significant differences in overall heat flow that were not being captured by the 1D approach. Some assembly types could potentially be compromised by as much as 50% relative to 1D apparent conductance. This can potentially have a significant impact on facility energy use regardless of whether an ECM dealing with improved insulation is being considered.
- C. BC Hydro expanded the scope of the ASHRAE study and released their Building Envelope Thermal Bridging Guide (BETBG) in 2014 with ongoing updates³. The guide can be found via an internet search. The BETBG does not need to be used but, if it is not, then the TA needs to cite what other method is employed to properly account for bridging.
- D. eQuest and other simulation tool interfaces assume 1D entry of assembly layers. The impact of bridging can be modeled by either reducing the thickness of insulation or by creating a unique material having the same density and specific heat as original but with reduced thermal resistance.
- E. Supporting documentation should show calculation details for how assembly U-values impacted by bridging have been developed. If the BETBG is used, it is recommended that the study report list which details from the guide have been incorporated into the analysis.
- F. Current Massachusetts energy code assumes the listed baseline assembly U-values include thermal bridging effects. Mass Save makes the same assumption.

B.2 Architectural: Infiltration

- A. Savings shall not be claimed for improved air sealing for new construction projects (regardless of IECC 2018 C406).
- B. Savings for reducing infiltration in existing buildings as part of a retrofit can potentially be claimed, but the TA vendor will need to provide pre- and post-retrofit blower door test results, historical trends of general building pressurization relative to ambient, and a clearly explained description for how these test results are used to develop appropriate energy modeling inputs.

³ <https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/builders-developers/building-envelope-thermal-bridging-guide-v1-6.pdf> See original website for additional appendices.

- a. The amount of infiltration air in a neutrally pressurized building cannot be greater than 50% of the total airflow quantified in a blower door test (half of the air is infiltrating while the other half is exfiltrating.)
 - b. It is unlikely that there are significant infiltration loads in a building or zone that is positively pressure relative to ambient.
 - c. Negatively pressurized buildings or zones can potentially claim infiltration reduction but only during those conditions and in those locations when negative pressurization exists.
- C. The amount of infiltration that flows into or out of perimeter thermal zones is difficult to accurately capture in any simulation program due to variations in construction quality, hour-to-hour wind force and direction, operation of doors, windows, and elevators, and the relative difference in temperature between indoors and outdoors. That having been said, there are some modeling methodologies that are likely to be more accurate than others.
- a. Energy Plus is likely to do a better job than DOE2 at capturing infiltration effects due to its airflow network calculations. While this is a potentially powerful tool, it needs to be used wisely since improper entries for boundary conditions and air entry points can significantly overstate infiltration. Complex airflow network calculations in a large commercial building can slow model processing time.
 - b. eQuest offers six different infiltration calculation methodologies, and the wizard uses the air change method. The following two options are appropriate for commercial buildings:
 - The air change method combines arbitrary assumptions of air change per hour (ACH) and airflow per floor area (AC/ft²) to arrive at the peak infiltration rate. This rate is then varied by an optional schedule (assumed to be 1.0 if not entered) and the ACH component of the flow is varied by ambient wind speed. Modelers need to activate the infiltration load for those zones with above grade perimeter exposure.
 - The crack method uses infiltration coefficients applied to windows, doors, and exterior walls, roofs, and overhangs to calculate infiltration rates. The calculation takes into account stack effect, an optional user defined schedule, and wind speed. Modelers can activate infiltration for all zones since there would only be infiltration if there is an exterior type of surface.
- D. The crack method is the preferred approach for DOE2.3 models, particularly in taller buildings since it is possible to derive infiltration coefficients from the air barrier requirements included in IECC 2021 C402.5 and ASHRAE 90.1-2019 5.4.3. Both standards have the same requirements for opaque surfaces and fenestration.

1. Infiltration Schedules

Infiltration schedules are to be used to model the impact of building pressurization on infiltration. Ideally, a building that is balanced to be slightly positive will have less infiltration when the ventilation system is operating. The associated infiltration schedule will therefore reduce infiltration during those hours of continuous ventilation system activity. The degree of reduction is dependent upon how well balanced the ventilation system actually is. Using a value 1.0 for hours when the ventilation system is off and a value of 0.5 when the system is on may be a good starting point. A value of 1.0 during all hours is likely to be more conservative and can be achieved by not assigning a schedule (the default is 1.0 during all hours).

2. Infiltration Coefficients: Opaque Surface

Peak infiltration rates for opaque surfaces (excluding spandrel) are calculated as follows:

$$\text{Opaque Surface Infiltration, cfm} = \text{INF-COEFF} * dP^{0.8} * \text{Area, ft}^2$$

Where dP is the pressure difference between outside and inside air (“w.g.”). Using code’s maximum allowable inflow rates for assemblies (0.04 cfm/ft²) and the rating condition (0.3”w.g.), the coefficient to use for opaque surfaces (walls and roofs) is:

$$\text{INF-COEFF}_{\text{opaque}} = 0.04 \div (0.3^{0.8}) = 0.1048$$

3. Infiltration Coefficients: Windows, Curtainwall, & Storefront

Fenestration infiltration coefficients can be modeled in a similar manner, though the DOE2.3 calculation is based on perimeter length rather than surface area:

$$\text{Fenestration Infiltration, cfm} = \text{INF-COEFF} * dP^{0.66} * \text{Length, ft}$$

Perimeter length is already in the model based on the window geometries (and is therefore an argument for modeling individual window assemblies). Code specifies infiltration for windows and curtainwall on an area basis, and converting these requirements to equivalent perimeter area requires knowledge of the National Fenestration Rating Council (NFRC) rating conditions. Figure B.2.1 presents recommended infiltration coefficients. Code specifies leakage rates for curtainwall and storefront systems at 75 Pa (0.30”w.g.) while window assemblies are rated at 300 Pa (1.20” w.g.).

4. Infiltration Coefficients: Doors

Loads at vestibules and other spaces with exterior doors are to be calculated using the infiltration coefficients in Figure B.2.2 (adapted from DOE2.2 Volume 2: Dictionary > Envelope Components > Door). Each exterior door in the building needs to be modeled in a manner that preserves the perimeter of the door opening. For glazed doors, separate window and door entries are required.

The energy modeler can use different infiltration coefficients provided that they are based on a specific study and developed in a manner consistent with DOE2.2’s use of the infiltration coefficients.

Figure B.2.1

Window & Curtainwall Infiltration Coefficients

	Windows Fixed	Windows Operable	Curtainwall & Storefront
Max Infiltration, cfm/ft ²	0.20	0.20	0.06
Rating Diff Pressure, “w.g.	1.20	1.20	0.30
NFRC Perimeter, ft	13.8	17.7	26.3
NFRC Area, ft ²	9.8	19.3	43.3
INF-COEFF	0.1261	0.1933	0.2186

Figure B.2.2
Door Infiltration Coefficients

	INF-COEF
Residential Normally Closed with Weather Stripping	0.24
Residential Average Use with Weather Stripping	9.8
Residential Average Use without Weather Stripping	12.0
Overhead Door, No Use	6.0
Overhead Door, Average Use	60.0
Commercial Door Closed	3.1
Commercial Door Open 10% of Time	9.3
Commercial Door Open 25% of Time	55.0
Commercial Door Open 50% of Time	153.0
Commercial Revolving Door, Average Use	12.0

5. Crack Neutral Zone Height

The Crack Method requires each space with infiltration to have an entry for the space’s vertical deviation from the overall building neutral plane. This can most easily be entered by changing the default for the NEUTRAL-ZONE-HT to use the following expression:

$$((\text{Parent}("Z") - 0) + \text{Local}("HEIGHT")/2) * -1 + (A/2 + B)$$

Where A is the height in feet between the lowest grade elevation and the highest point in the building’s air envelope. B is an adjustment that is required if the lowest FLOOR of the building has an elevation other than Z = 0. For example, if a model’s first floor had Z = -14, the value of B would be -14.

B.3 Architectural: Ground Contact Modeling

- A. The importance of ground heat exchange is highly variable and depends on building geometry, space temperature setpoints, and activity in the spaces with ground contact. Few energy simulation programs are currently able to accurately model ground contact heat loss or accept an F-factor entry for slab-on-grade edge loss performance. The approach described below is likely to be warranted for projects that include optional insulation below slabs and projects that increase perimeter insulation above code minimum requirements. TAs can use other methodologies provided that they are explained in enough detail to support technical review and are agreed to be reasonable by the PA.

1. Average Floor Resistance & Ground Temperature Path

This method involves two steps: 1) the development of unique floor layers for each space based on the exposed perimeter and floor area and 2) the development of typical ground temperatures beneath the building. The eQuest Wizard does step 1 but does not appear to do step 2.

1. Create global parameters for slab insulation conduction (SLABU) and slab perimeter insulation conduction (SLABF).
2. Define SLABU based on the actual construction.

3. Define SLABF based on tables included in DOE2.2 Volume 3: Topics (July 2006) pages 166 to 168.
4. In a spreadsheet, determine the ratio of exposed perimeter length to floor area (R%) for each space.
5. For each space, define layers consisting of light soil, damp (0.5 ft thick), Polystyrene 4in, R-5/in, and Conc HW 140lb 4in (CC03). The thickness of the polystyrene layer should be defined as follows using a user defined expression:
6. $1/(R\% * \#PA("SLABF") + \#PA("SLABU")) / 5 / 12$
7. Create constructions associated with each layer, apply to the appropriate spaces.

Soil located remotely from the edge of the building is more likely to be impacted by the constant far-field ground temperature than seasonal variations in ambient air temperature. The temperature of soil beneath these core areas is likely to be 2°F colder than the average monthly interior temperature. Given that each model can only have one ground temperature schedule and that each building has a unique aspect ratio, the following method is suggested for calculating monthly ground temperature values:

8. Create an hourly report of ground temperatures from the weather file, convert to °F, and determine average monthly values.
9. Use hourly reports to determine the average space temperatures of conditioned ground-contact zones and determine the average overall monthly value (weighted by floor area).
10. Determine a perimeter area that is 6 ft wide, divide this by the overall ground contact area of conditioned spaces (floor and any subgrade walls). The result is %P. For buildings with subgrade walls and basements, the 6 ft perimeter area could potentially include all or a portion of the vertical walls and no floor area. Consider two examples:
 - a. A 1st floor space has 3 ft of subgrade wall and 6 ft above grade. The perimeter area would include 3 ft of the below grade wall and 3 ft of the floor. The overall ground contact area would include all of the floor area and 3 ft of the perimeter wall.
 - b. A basement space has 9 ft high walls located entirely below grade. The perimeter area would be the top 6 ft of the wall and the total ground contact area would be the whole floor area plus the area of the subgrade walls.
11. Calculate monthly temperature using the following expression:

$$\text{Avg Ground Temp, } ^\circ\text{F} = \%P * \text{Weather File Ground Temp} + (100\% - \%P) * (\text{Avg Space Temp} - 2^\circ\text{F})$$

This approach is intended to support savings from improved perimeter and under-slab insulation as well as provide a realistic calculation of heat loss to the ground. It is admittedly not perfect but it is likely to be more accurate than 1) not accounting for heat loss to the ground or 2) assuming the temperature differential apparent from the model file would apply to the entire underside of a building.

2. Average Ground Temperature Path

Calculate monthly temperature using the following expression:

$$\text{Avg Ground Temp, } ^\circ\text{F} = (\text{Avg Space Temp} - 2^\circ\text{F})$$

This more simplified approach is appropriate for buildings with large core areas where perimeter losses are negligible.

3. Energy Plus Models

Models developed in Energy Plus can take advantage of improved ground contact heat loss modeling algorithms. Kiva is now part of the standard Energy Plus release (version 8.7 and after).

B.4 Architectural: Window-to-Wall Ratio (WWR)

- A. Baseline maximum allowable WWR is 40% for buildings pursuing code compliance via ASHRAE 90.1-2019. The baseline for buildings following IECC 2021 is either 30% or 40% depending on the provisions of C402.4.1.1.
- B. When calculating WWR, the area of party walls is not to be included in the gross wall area. A party wall is a wall that is common to two adjoining buildings and is most common in building additions and urban spaces.
- C. If a building design has more than the maximum allowable WWR, window area is to be varied by changing the height of all windows uniformly around the building. Changing window height is less likely to impact daylighting calculations. When using eQuest, changing window height is most easily accomplished using a global parameter.
 - a. The reduction in window height in the baseline of a heavily glazed building will impact the fraction of lighting impacted by daylighting. The control fraction entries for daylit zones need to be changed when changing window heights.
 - b. Baseline windows in heavily glazed buildings shall be assumed to have lower sills located 2.5 ft above floor level.
- D. For eQuest projects, the actual WWR for the proposed and baseline cases needs to be calculated based on LV-D report details. This can be complex for buildings with sloped roofs since the roof surfaces can potentially be counted along with vertical exterior walls.

B.5 Architectural: Fenestration Performance

- A. Window and curtainwall performance is defined by code on the basis of assembly, not on the basis of center-of-glass ratings.
- B. The PAs prefer that fenestration performance be defined using glass library data rather than simplified U-value and SHGC (or SC) entries. This requires frame area and U-value to be separately defined. Assembly SHGC is based on the average of glazing and frame areas, where the frame SHGC is 0.0. Window inset fields can be used to capture hyperlocal shading impacts of frame projections.
- C. The simplified U-value approach is acceptable for non-transparent glazing since incidence angle does not impact solar heat gain.
- D. When using eQuest, window frame width can be defined based upon the vision fraction (%V) and the following expression entered as the default expression for FRAME-WIDTH. %V needs to be calculated for each general window type at the discretion of the energy modeler. Generally, %V is higher for curtainwall than it is for operable punched windows.

$$(\#L("HEIGHT")+ \#L("WIDTH")) / -4 + (\text{SQRT}(\%V) / (4 * \%V)) *$$

$$\text{SQRT}(\%V * (\#L(\text{"HEIGHT"}) * \#L(\text{"HEIGHT"}) - 2 * \#L(\text{"HEIGHT"}) * \#L(\text{"WIDTH"}) + \#L(\text{"WIDTH"}) * \#L(\text{"WIDTH"})) + 4 * \#L(\text{"HEIGHT"}) * \#L(\text{"WIDTH"}))$$

- E. When using eQuest, it is recommended that frame U-value be entered as a user-defined default or via a global parameter to facilitate changing the assumptions. The actual window performance for the proposed and baseline cases needs to be calculated based on LV-H report details to ensure that the target performance values are entered into the program.

C.1 HVAC: Autosizing

This is a required item for all hourly simulation projects.

- A. Autosizing can be used in early to mid-design work when specific design information is unknown or likely to change.
- B. Autosizing shall not be used to assign zone-level ventilation rates if design information is available. Baseline zone ventilation rates shall match design case. If there is no design case ventilation rate information, it is recommended that BDL inputs be used to automatically calculate zone airflow rates based on ASHRAE 62.1 ventilation rate procedure. Sample BDL language is provided in Appendix B.
- C. Autosizing shall not be used to assign zone-level air circulation rates for centralized air systems (e.g. VAV) if design information is available. If there is no design information, the baseline autosized zone airflow rates shall be used in proposed case modeling runs.
- D. Autosizing can be used for zone circulation rates for FCUs and other systems utilizing cycling zone fans. The assumption is that run times are linearly related to space loads.
- E. Pump autosizing shall only be used in the absence of an analogous proposed case pump.
- Baseline autosized water flow rates shall be hard coded in ECM modeling runs to prevent ghost savings from being calculated due to changing pump sizing.
 - Pump head resulting in Appendix G power demand can be calculated using the following user-defined expression:
$$\text{Pump Head, ft} = \text{Desired Pump W/gpm} * 1,000 \div (0.746 \text{ kW/hp} * 3960 * 77\% \text{ Pump Eff} * 93.0\% \text{ Motor Eff})$$
 - The number of baseline building circulation pumps shall be a reasonable estimate of what would be used in a typical installation (e.g. 2 pumps for lead/lag systems, 1 pump for lead/standby systems).

C.2 HVAC: Work-Arounds

This is a required item for all hourly simulation projects that use work-arounds.

- A. Not all simulation programs can directly model every type of HVAC system and it may be necessary to utilize 'work-arounds'. Generally, it is the TA's responsibility to 1) select a work-around they feel accurately models the HVAC system, and 2) defend their work-around during technical review. Extended review discussions can be avoided by including plots in the study report that illustrate important correlations. It is particularly important that work-arounds take into account all significant impacts on the primary system being modeled as well as on zones.

C.3 HVAC: Campus Energy

- A. For projects focusing on individual buildings receiving heating and/or cooling from campus central plants, the preferred method of analysis is to include a central plant in the model based on ASHRAE 90.1-2019 Appendix G. District hot water systems shall assume a boiler efficiency of 75% while district steam systems shall use 70%. If the site can provide field tested system performance results, these values can be used instead.
- B. It is assumed that part-load effects experienced by the modeled building will be similar to the general loading on central chilled water plants.

C.4 HVAC: Utility Steam

- A. Utility steam is different than district/campus steam in that there is no information about the central plant or other buildings on the system. Mass Save projects will report all steam savings and penalties for a given project on the basis of therms with no adjustments for generation efficiency or for distribution losses. It is important that savings be identified on a per-measure basis. The Mass Save PAs cannot claim savings for large steam conserving measures (e.g. airside heat recovery in a lab that lacks adequate heat pump capacity) but they can claim savings for the following:
 - a. Fuel switching (e.g. steam baseline, air-to-water heat pump proposed case)
 - b. Incidental steam savings/penalties arising from measures loads that primarily save electricity (e.g. envelope improvements in a building with central heat pumps)
- B. The useful heat from utility steam shall be developed from steam tables per the site's delivery pressure (assume saturated if there is no guaranteed superheat) minus the heat content of liquid water at 212°F and atmospheric pressure. Final reporting needs to describe this calculation.
- C. Monetizing utility steam can be challenging and a default rate typical for Metro Boston as of this release is \$35 per thousand pounds of 200 psig saturated steam as of 2023. This corresponds to \$3.431/therm.

C.5 HVAC: Disaggregation of Unitary Performance Ratings

- A. Most simulation software requires separate inputs for evaporator fan power (e.g. supply fans) and condensing section performance. EER, SEER, COP, and HSPF ratings for unitary and split systems include the power demand of evaporator fans, and this needs to be disaggregated. In the absence of specific manufacturer data, the methodology presented in ASHRAE 90.1-2016 G3.1.2.1 shall be used.
- B. IEER appears to be similar to SEER and the two are assumed to be interchangeable.

C.6 HVAC: Equipment Performance Curves

- A. Default performance curves are included with all hourly simulation packages. The defaults may be appropriate for use in some studies, but their ability to accurately capture the performance of baseline and proposed case equipment should be checked. TA vendors are encouraged to calculate IPLV and IEER values predicted by the default curves and make adjustments as needed to bring the curves into agreement with the target performance values.
- B. Air source heat pump models need to account for the impact of defrost cycles on heating average performance via derating curves that account for heating load and ambient dewpoint.

C.7 HVAC: Energy Recovery Performance

- A. The effectiveness of energy recovery shall be calculated on the basis of how much load is avoided on the supply side. Performance needs to be explicitly calculated for design conditions and should take into account supply:exhaust flow imbalances. Simulation programs assume the entered recovery performance is on the supply side while manufacturers sometimes report exhaust side recovery.

C.8 HVAC: Combined Heat & Power

- A. New construction projects that include new CHP equipment are to be studied without the impact of CHP on building energy use or energy supply.
- B. New construction projects on campuses with a central CHP plant and single point of interconnection to the grid are to be considered as if they were stand-alone buildings.

C.9 HVAC: Integrated Zone Controls

- A. Use of lighting occupancy sensors to also control zone ventilation rates and space temperatures is becoming more common and is a good energy conservation measure. Proper modeling of integrated zone control (IZC) is likely to require more complicated schedule development than has been used in the past.
 - a. Occupancy Schedules – There needs to be a very good accounting of where people are likely to be in the building to ensure that occupancy-responsive controls are modeled correctly.
 - b. Diversity Factors - Diversity factors can potentially reflect both the probability that a particular space is occupied (e.g. private office) and/or the degree of occupancy (e.g. large conference room). The IZC HVAC sequence needs to capture those hours when the space is ventilated and at occupied space temperature setpoints rather than in setback. This precludes the use of a single set of schedules for one particular type of space, such as conference rooms or private offices, where most savings are likely to accrue. One option is to divide the population of a particular space type into high-use and low-use.
 - c. For example, consider a university building that has central HVAC occupied period scheduling from 7 AM to 10 PM throughout the week. During a typical class week, there may be 30% of private offices in use during evening and weekend hours while 70% are otherwise vacant. Savings can more accurately be claimed by directly modeling the spaces in setback mode rather than relaxing space temperatures and ventilation rates for the entire population of spaces.

C.10 HVAC: Non-Lab Space Energy Recovery

- A. For lab-type buildings where supply and exhaust is blended from lab and non-lab spaces, the baseline needs to account for the equivalent energy recovery that would be required by an energy recovery system complying with ISP minimum performance (see current Baseline Document). One approach to calculating the baseline performance is to use the ISP energy recovery guidance and assume it is equivalent to the heat recovery capability. This is then scaled by the ratio of non-lab design fresh air volume to the total design fresh air volume.

D.1 Plumbing: Service Water Temperatures

This is a required item for all hourly simulation projects involving domestic water heating.

- A. Street water temperature data from the Massachusetts Water Resources Authority (MWRA) is presented in Figure D.1 below. This data is consistent with other studies of water main temperatures in central Connecticut.

Figure D.1

Municipal Water Supply Temperatures in Southern New England

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
46.2°F	43.6°F	45.0°F	49.9°F	56.6°F	63.6°F	68.9°F	71.6°F	70.7°F	66.5°F	59.7°F	52.0°F

D.2 Plumbing: DHW Loads

This is a required item for all hourly simulation projects involving domestic water heating.

- A. DHW flow rates entered into the energy model should be the flow rate of primary hot water (140°F), not the flow rate from the end use points. Assume 105°F average water temperatures for faucets (all types) and showers.
- B. Multifamily projects shall use the most recent version of the Energy Star MFHR Performance Path Calculator with the “medium” use type of occupancy and relevant appliances and fixture flow rates to determine peak loads.
- C. DHW diversity schedules in commercial projects shall track the dominant occupancy schedule. Residential DHW shall use the Energy Star MFHR diversity schedule presented in the Performance Path Calculator.

E.1 Electrical: Lighting Design

This is a required item for all hourly simulation projects.

- A. Lighting analyses can be performed using the space-by-space method or the whole-building method. The space-by-space method is preferred since it is better able to predict future HVAC and electrical loads in buildings with many different uses.
- B. The basis of proposed case lighting power densities or whole-building connected loads needs to be based on a COM Check analysis provided by the design team or a lighting takeoff performed by the TA vendor. Lighting takeoffs are to be performed on the basis of modeled spaces with the understanding that a particular HVAC zone could include multiple space use types defined in IECC 2018 Table C405.4.2(2). In these cases, an average power demand weighted by floor area should be used.
- C. The current Baseline Document allows the baseline to be defined by either the Whole-Building Method or the Space-by-Space Method. If the baseline is defined using the Whole-Building Method, then the % reduction in overall lighting demand shall be applied equally across all end use groups when setting the baseline LPD inputs. The final report needs to clearly describe how the baseline LPDs are developed.

$$\text{Baseline Space LPD} = \text{Proposed Space LPD via takeoff} \times (\text{Whole-Building Baseline Watts} \div \text{Whole-Building Proposed Watts})$$

E.2 Electrical: Lighting Occupancy Sensor Controls

This is a required item for all hourly simulation projects.

- A. Lighting diversity factors provided by various sources are assumed to capture the impact of manually operated lighting controls as well as code-required occupancy controls.
- B. Non-code required occupancy-based lighting controls reduce lighting power density by 10% uniformly during all facility operating hours. Schedule modifications are not required to model occupant-controlled lighting in most spaces.
- C. Stairways and warehouses are required by ASHRAE 90.1-2019 9.4.1.1(g) to set back lighting by 50% during unoccupied periods. Lighting schedules shall be used to model 90% diversity during facility occupied periods and 50% during unoccupied periods.

E.3 Electrical: Daylighting Controls

- A. Daylighting shall be modeled with sensors located at 2/3 the depth into the daylit zone as defined by ASHRAE and IECC.
- B. Adequate interior surfaces are to be included in daylit spaces to support daylight modeling algorithms.
- C. Daylighting control factors (e.g. the fraction of installed lighting wattage impacted by automatic daylighting controls) shall be based on actual controlled wattage for each zone. These factors can be developed by determining the daylit portion of each zone from window data obtained from the LV-H report. Hourly daylighting response is to be calculated by the simulation program.
 - a. Different daylighting control factors need to be developed for baseline designs where fenestration area is limited to 40% of gross vertical wall area.
- D. Glare control direction indicators and glare factors shall be set in the model.
- E. Light level control values shall be 50 fc as measured 2.5 ft above the floor unless design requirements call for other specific values.

E.4 Electrical: Networked Lighting Controls

- A. Networked lighting controls provide code-required occupancy sensing, dual level, and daylighting controls and can also support these strategies in spaces where not required by code. The method of modeling savings for occupancy sensor and daylighting control are the same regardless of the use of networked lighting controls, stand-alone controls, or fixtures with integral controls.
- B. Networked lighting controls support task tuning and this can potentially lead to reliable energy savings. However, there is no guarantee that savings will actually result unless the system is designed, installed, and commissioned to achieve task tuning. To claim credit, the following must be true:
 - 1. The lighting designer must provide the anticipated degree of turndown that is to be installed in each space with task tuning. This is the basis of savings to be claimed in the energy model. The modeling report needs to clearly list what tuning factors are applied to the space LPD. The tuning factor is to be considered in addition to control factors for occupancy sensors and lighting schedules.

2. The project construction documents must clearly list the intended light level that the systems are to be tuned to (foot candles as measured below the light at a specific height above the floor).
3. The project construction documents must clearly describe lighting controls commissioning requirements and methods for implementing task tuning.

For initial screening of potential savings arising from task tuning, the following methodology can be followed.

4. Determine the LPD reduction relative to the max allowed by code for each space.
5. Generate a task tuning control factor for each space that varies linearly between 10% for LPDs at 100% of code down to a value of 0% for LPDs at $\leq 50\%$ of code.
6. Apply these task tuning control factors in addition to any control factors for occupancy sensors.

F.1 Process: General Equipment Loads & Diversities

This is a required item for all hourly simulation projects.

- A. It is important that adequate process loads are included in a model in order to ensure the following:
 1. Support accurate estimates of percent impacts of design upgrades on overall energy use and
 2. Ensure that HVAC system loads are realistic.
 3. Ensure that HVAC autosizing, where used, is likely to be realistic.

Models with low equipment loads will have exaggerated % energy reductions, the impact of envelope characteristics will be skewed, and improvements to cooling system performance will be understated. Some loads, such as exterior lighting and water pressurization systems, may not impact HVAC but it does impact overall energy use.

- B. Separate equipment schedules and peak load factors are to be used for different space types. Appendix A provides suggested load factors and diversity schedules for common office and school space types. This default information is intended to serve as a starting point where specific information is not yet known for a project or where tenant activities are undefined. eQuest schedule library inputs can also be used provided that they are a realistic projection of future space use. All schedules should be correlated to occupancy and the peak occupancy for the facility verified to not be excessive for any particular hour.
- C. Modeling reports should include a description of the basis of loads used in the model.
- D. Baseline equipment loads and diversities are to be identical to the proposed case unless savings are being claimed for a specific measure.
- E. The ratio of sensible to latent loads should be taken into account and based on information such as ASHRAE Fundamentals Chapter 18, Nonresidential Cooling and Heating Load Calculations.
- F. HVAC autosizing generally assumes a diversity of 1.0 and the peak load factor for a particular space. It is not uncommon for spaces to be designed to support more equipment than would typically be operating during full occupancy on a typical day. Peak load factors should reflect the intent of the design team, and the diversity factors should be adjusted downward. For example, a tenant space in a spec office building may be designed to support 2.0 W/ft² of equipment (excluding lighting) but the likely load is probably around 1.2 W/ft² on a fully

occupied hour. The maximum diversity factor should therefore be $1.2 \text{ W/ft}^2 \div 2.0 \text{ W/ft}^2 = 0.65$ (not 1.00) for a fully occupied hour. Variability in occupancy would further reduce the diversity assuming use-responsive controls typical of most office equipment.

F.2 Process: Elevators

- A. The number of elevators shall match the actual design.
- B. Peak power demand for each elevator is ideally based on the designed motor size with a peak loading factor of 70%. If motor size is not known, interpolation between 15 hp for 3 stories and 40-hp for 8 stories can be assumed. The % sensible fraction shall be 42% for hydraulic elevators and 36% for other technologies. Baseline elevator technology shall match design case unless the TA can provide a sound basis for claiming savings.
- C. Power demand shall be assigned to an elevator machine room if EMRs are included in the design. Otherwise, elevator power demand and schedules can be direct loads on electricity meters.
- D. Schedules are provided for different facility types in Appendix A. The diversity schedules account for the fact that elevator drive systems are typically only loaded for half of each trip and most systems generate electricity during non-drive travel.

F.3 Process: Food Service

- A. Kitchens, coffee shops, break room, and servery energy use is highly variable but can have a noticeable impact on energy use. The design case and baseline electricity and natural gas consumption should be the same unless savings are being claimed through an ECM. The energy modeling report should include a description of how peak load factors were developed and provide a narrative of the anticipated hours of operation for cooking and servery equipment.
- B. If a single schedule is used to model all food service electricity use, the base load is likely to be dominated by refrigeration. Peak hourly power demand values need to account for the brevity of some high-demand appliances such as dishwasher booster heaters or cappuccino makers that may not be in continuous service.
- C. Refrigeration annual energy use is to be developed from ASHRAE 90.1-2019 Table 6.8.1-11 (Commercial Refrigerator and Freezers) and Tables 6.8.1-18, 19, and 20 (Commercial Refrigeration). Similar tables are included in IECC 2021 C403.11. For systems with remote condensers that reject heat to ambient, the energy use of the system shall impart 0% sensible and 0% latent loads to the space.
- D. Equipment located under exhaust hoods can be assumed to exert space conditioning loads that are 25% sensible and 0% latent. Most of the heat is lost into the exhaust air stream while the loads in the space are due to radiant heat transfer from hot surfaces and the cooling of cooked food.
- E. Refrigeration in supermarkets requires specialized analyses and assumptions that are beyond the scope of these guidelines at this time.
- F. The Energy Star Commercial Kitchen Equipment Savings Calculator can be used to generate annual energy use of covered equipment. Care is required to ensure that the calculator assumptions match the anticipated operation of the kitchen being modeled.
- G. Servery equipment is not included in the Energy Star calculator and will need to be estimated by the modeler. One approach is to assume that heated and cooled basins will be active beginning 1 hour before food is served

and extending through the serving period. Peak power demand can be estimated based on nameplate power and an average peak diversity factor of 25%. The sensible space load fraction can be assumed to be 80% and the latent 20%. Modelers are free to use different assumptions but the rationale needs to be documented.

- H. The purchase and installation of Energy Star rated commercial kitchen equipment shall be handled outside of the model via a prescriptive application or upstream. The modeled energy use shall assume the use of the proposed case equipment in the baseline model

F.4 Process: Servers & Telecom

- A. Server rooms can potentially dominate base load electricity consumption in a building. Projects can be described as follows:
 1. Customer plans to do a full or partial build-out of server capacity but IT load is not known. The design team will need to have some estimate of load to size HVAC equipment. The future IT power demand is likely to be approximately 75% of cooling capacity, converted from tons or Btu to kW. The value can be scaled down as needed if a partial server build-out is anticipated for the near to mid future.
 2. Customer knows what server equipment is to be installed. Review the nameplate wattage (or calculate from rated voltage and amperage) and assume the average operating peak demand is 50% of nameplate.
 3. An existing server room is in operation. Power metering is ideal if the IT load represents a large portion of the facility energy use. UPS units typically will provide a measure of output amperage or kW. Absent this information, a rough approximation of IT power demand can be developed from nameplate information or the room's installed cooling capacity and discussions with facility operators regarding how much excess cooling capacity they feel is installed. Convert the cooling load to input power demand.

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1. Customer plans to do a full or partial build-out of server capacity but IT load is not known. The design team will need to have some estimate of load to size HVAC equipment. The future IT power demand is likely to be approximately 75% of cooling capacity, converted from tons or Btu to kW. The value can be scaled down as needed if a partial server build-out is anticipated for the near to mid future.
 2. Customer knows what server equipment is to be installed. Review the nameplate wattage (or calculate from rated voltage and amperage) and assume the average operating peak demand is 50% of nameplate.
 3. An existing server room is in operation. Power metering is ideal if the IT load represents a large portion of the facility energy use. UPS units typically will provide a measure of output amperage or kW. Absent this information, a rough approximation of IT power demand can be developed from nameplate information or the room's installed cooling capacity and discussions with facility operators regarding how much excess cooling capacity they feel is installed. Convert the cooling load to input power demand.

Appendix A: Schedules and Load Factors

Assumptions about building and system use schedules, diversity factors, and load factors drive the energy use of an hourly simulation model yet the degree of certainty surrounding these inputs is generally moderate at best. Ideally these inputs are developed from details provided by the project owner and/or design team since it is likely that custom schedules will better predict future energy use. This is important since future evaluation efforts may choose to modify schedule and load factor assumptions based on what is found on site. If no other sources of information are available, the information contained in this appendix is intended to provide a starting point.

If information in this appendix is used to fill in gaps where project-specific information is not known, it is important that the default and custom schedules are consistent with one another. For example, if the schedule for office building HVAC assumes that there is no occupied Sunday operation. If other custom schedules indicate significant Sunday occupancy (e.g. to support an active call center), then the HVAC schedule needs to be updated as well.

Consistency among schedule assumptions is a common problem in energy models and is something that is focused on during PA technical reviews.

The current version of this guide includes schedules and load values for offices, elementary schools, high schools, and laboratories. Additional schedules and information is likely to be included in future revisions of this document. Feedback from TA vendors is encouraged.

Table L.1
LAB SPACES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	3%	3%	3%	20%	20%	20%
2	0%	0%	0%	3%	3%	3%	20%	20%	20%
3	0%	0%	0%	3%	3%	3%	20%	20%	20%
4	0%	0%	0%	3%	3%	3%	20%	20%	20%
5	0%	0%	0%	3%	3%	3%	20%	20%	20%
6	0%	0%	0%	3%	3%	3%	20%	20%	20%
7	5%	5%	0%	100%	100%	3%	23%	23%	20%
8	10%	10%	0%	100%	100%	3%	25%	25%	20%
9	20%	10%	0%	100%	100%	3%	30%	25%	20%
10	40%	30%	0%	100%	100%	3%	40%	35%	20%
11	40%	30%	0%	100%	100%	3%	40%	35%	20%
12	30%	30%	0%	100%	100%	3%	35%	35%	20%
13	40%	30%	0%	100%	100%	3%	40%	35%	20%
14	40%	10%	0%	100%	100%	3%	40%	25%	20%
15	40%	10%	0%	100%	100%	3%	40%	25%	20%
16	40%	10%	0%	100%	100%	3%	40%	25%	20%
17	40%	10%	0%	100%	100%	3%	40%	25%	20%
18	40%	10%	0%	100%	100%	3%	40%	25%	20%
19	30%	5%	0%	100%	100%	3%	35%	23%	20%
20	10%	5%	0%	100%	100%	3%	25%	23%	20%
21	10%	5%	0%	100%	100%	3%	25%	23%	20%
22	5%	5%	0%	100%	100%	3%	23%	23%	20%
23	0%	0%	0%	3%	3%	3%	20%	20%	20%
24	0%	0%	0%	3%	3%	3%	20%	20%	20%

Source: TNZ

Table L.2
OPEN OFFICES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	3%	3%	3%	20%	20%	20%
2	0%	0%	0%	3%	3%	3%	20%	20%	20%
3	0%	0%	0%	3%	3%	3%	20%	20%	20%
4	0%	0%	0%	3%	3%	3%	20%	20%	20%
5	0%	0%	0%	3%	3%	3%	20%	20%	20%
6	0%	0%	0%	3%	3%	3%	20%	20%	20%
7	5%	0%	0%	100%	3%	3%	24%	20%	20%
8	10%	5%	0%	100%	100%	3%	28%	24%	20%
9	30%	10%	0%	100%	100%	3%	44%	28%	20%
10	30%	10%	0%	100%	100%	3%	44%	28%	20%
11	30%	10%	0%	100%	100%	3%	44%	28%	20%
12	30%	10%	0%	100%	100%	3%	44%	28%	20%
13	20%	5%	0%	100%	100%	3%	36%	24%	20%
14	30%	5%	0%	100%	100%	3%	44%	24%	20%
15	30%	5%	0%	100%	100%	3%	44%	24%	20%
16	30%	5%	0%	100%	100%	3%	44%	24%	20%
17	30%	5%	0%	100%	100%	3%	44%	24%	20%
18	30%	5%	0%	100%	100%	3%	44%	24%	20%
19	10%	5%	0%	100%	100%	3%	28%	24%	20%
20	10%	0%	0%	100%	3%	3%	28%	20%	20%
21	10%	0%	0%	100%	3%	3%	28%	20%	20%
22	10%	0%	0%	100%	3%	3%	28%	20%	20%
23	5%	0%	0%	100%	3%	3%	24%	20%	20%
24	5%	0%	0%	100%	3%	3%	24%	20%	20%

Source: TNZ

Table L.3
PRIVATE OFFICES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	0%	20%	20%	20%
2	0%	0%	0%	0%	0%	0%	20%	20%	20%
3	0%	0%	0%	0%	0%	0%	20%	20%	20%
4	0%	0%	0%	0%	0%	0%	20%	20%	20%
5	0%	0%	0%	0%	0%	0%	20%	20%	20%
6	0%	0%	0%	0%	0%	0%	20%	20%	20%
7	5%	0%	0%	30%	0%	0%	24%	20%	20%
8	10%	0%	0%	35%	0%	0%	28%	20%	20%
9	30%	10%	0%	55%	35%	0%	44%	28%	20%
10	30%	10%	0%	55%	35%	0%	44%	28%	20%
11	30%	10%	0%	55%	35%	0%	44%	28%	20%
12	30%	10%	0%	55%	35%	0%	44%	28%	20%
13	20%	0%	0%	45%	0%	0%	36%	20%	20%
14	30%	0%	0%	55%	0%	0%	44%	20%	20%
15	30%	0%	0%	55%	0%	0%	44%	20%	20%
16	30%	0%	0%	55%	0%	0%	44%	20%	20%
17	30%	0%	0%	55%	0%	0%	44%	20%	20%
18	30%	0%	0%	55%	0%	0%	44%	20%	20%
19	10%	0%	0%	35%	0%	0%	28%	20%	20%
20	5%	0%	0%	30%	0%	0%	24%	20%	20%
21	0%	0%	0%	0%	0%	0%	20%	20%	20%
22	0%	0%	0%	0%	0%	0%	20%	20%	20%
23	0%	0%	0%	0%	0%	0%	20%	20%	20%
24	0%	0%	0%	0%	0%	0%	20%	20%	20%

Source: TNZ

Table L.4
CONFERENCE & MEETING ROOMS

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	50%	0%	0%	55%	0%	0%	50%	0%	0%
10	100%	0%	0%	100%	0%	0%	100%	0%	0%
11	50%	0%	0%	55%	0%	0%	50%	0%	0%
12	25%	0%	0%	30%	0%	0%	25%	0%	0%
13	25%	0%	0%	30%	0%	0%	25%	0%	0%
14	100%	0%	0%	100%	0%	0%	100%	0%	0%
15	50%	0%	0%	55%	0%	0%	50%	0%	0%
16	25%	0%	0%	30%	0%	0%	25%	0%	0%
17	0%	0%	0%	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: TNZ

Table L.5
KITCHENETTE / BREAK ROOM SPACES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	0%	35%	35%	35%
2	0%	0%	0%	0%	0%	0%	35%	35%	35%
3	0%	0%	0%	0%	0%	0%	35%	35%	35%
4	0%	0%	0%	0%	0%	0%	35%	35%	35%
5	0%	0%	0%	0%	0%	0%	35%	35%	35%
6	0%	0%	0%	0%	0%	0%	35%	35%	35%
7	5%	0%	0%	100%	100%	0%	37%	35%	35%
8	25%	0%	0%	100%	100%	0%	45%	35%	35%
9	20%	5%	0%	100%	100%	0%	43%	37%	35%
10	15%	5%	0%	100%	100%	0%	41%	37%	35%
11	15%	5%	0%	100%	100%	0%	41%	37%	35%
12	50%	5%	0%	100%	100%	0%	55%	37%	35%
13	75%	5%	0%	100%	100%	0%	65%	37%	35%
14	50%	5%	0%	100%	100%	0%	55%	37%	35%
15	15%	5%	0%	100%	100%	0%	41%	37%	35%
16	25%	5%	0%	100%	100%	0%	45%	37%	35%
17	30%	5%	0%	100%	100%	0%	47%	37%	35%
18	5%	0%	0%	100%	100%	0%	37%	35%	35%
19	5%	0%	0%	100%	0%	0%	37%	35%	35%
20	5%	0%	0%	100%	0%	0%	37%	35%	35%
21	5%	0%	0%	100%	0%	0%	37%	35%	35%
22	5%	0%	0%	100%	0%	0%	37%	35%	35%
23	0%	0%	0%	0%	0%	0%	35%	35%	35%
24	0%	0%	0%	0%	0%	0%	35%	35%	35%

Source: TNZ

Table L.6
COMMON SPACE LIGHTING

Hour End	Corridors			Stairs	Stairways w OS*			Restrooms			Support	
	M-F	Sat	Sun	All	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Other
1	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
2	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
3	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
4	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
5	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
6	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
7	100%	100%	15%	100%	55%	55%	50%	30%	0%	0%	5%	0%
8	100%	100%	15%	100%	60%	60%	50%	35%	0%	0%	5%	0%
9	100%	100%	15%	100%	70%	60%	50%	55%	35%	0%	5%	0%
10	100%	100%	15%	100%	90%	80%	50%	55%	35%	0%	5%	0%
11	100%	100%	15%	100%	90%	80%	50%	55%	35%	0%	5%	0%
12	100%	100%	15%	100%	80%	80%	50%	55%	35%	0%	5%	0%
13	100%	100%	15%	100%	90%	80%	50%	45%	0%	0%	5%	0%
14	100%	100%	15%	100%	90%	60%	50%	55%	0%	0%	5%	0%
15	100%	100%	15%	100%	90%	60%	50%	55%	0%	0%	5%	0%
16	100%	100%	15%	100%	90%	60%	50%	55%	0%	0%	5%	0%
17	100%	100%	15%	100%	90%	60%	50%	55%	0%	0%	0%	0%
18	100%	100%	15%	100%	90%	60%	50%	55%	0%	0%	0%	0%
19	100%	15%	15%	100%	80%	55%	50%	35%	0%	0%	0%	0%
20	100%	15%	15%	100%	60%	55%	50%	30%	0%	0%	0%	0%
21	100%	15%	15%	100%	60%	55%	50%	0%	0%	0%	0%	0%
22	100%	15%	15%	100%	55%	55%	50%	0%	0%	0%	0%	0%
23	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
24	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%

*Assumes 50% Turndown, lighting power assumption should not account for any control factors.

Source: TNZ

Table L.7
OTHER COMMON SCHEDULES

Hour End	HVAC "Occupied"*			Elevator			DHW		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0	0	0	0%	0%	0%	5%	5%	5%
2	0	0	0	0%	0%	0%	5%	5%	5%
3	0	0	0	0%	0%	0%	5%	5%	5%
4	0	0	0	0%	0%	0%	5%	5%	5%
5	0	0	0	0%	0%	0%	5%	5%	5%
6	0	0	0	0%	0%	0%	5%	5%	5%
7	1	1	0	0%	0%	0%	7%	5%	5%
8	1	1	0	14%	0%	0%	19%	5%	5%
9	1	1	0	28%	6%	0%	35%	11%	5%
10	1	1	0	17%	8%	0%	38%	15%	5%
11	1	1	0	15%	7%	0%	39%	21%	5%
12	1	1	0	17%	10%	0%	47%	19%	5%
13	1	1	0	23%	8%	0%	57%	23%	5%
14	1	1	0	19%	5%	0%	54%	20%	5%
15	1	1	0	15%	3%	0%	34%	19%	5%
16	1	1	0	15%	2%	0%	33%	15%	5%
17	1	1	0	18%	2%	0%	44%	12%	5%
18	1	1	0	25%	2%	0%	26%	14%	5%
19	1	0	0	5%	0%	0%	21%	7%	5%
20	1	0	0	2%	0%	0%	15%	5%	5%
21	1	0	0	2%	0%	0%	17%	5%	5%
22	1	0	0	2%	0%	0%	8%	5%	5%
23	0	0	0	0%	0%	0%	5%	5%	5%
24	0	0	0	0%	0%	0%	5%	5%	5%

*Hours when ventilation for occupancy is active; morning startup begins ahead of these hours.

Source: TNZ

Table L.8
LAB BUILDING LOAD FACTORS

Occupancy

Ideally, the occupant counts are based on furniture counts in offices. Occupancy in offices is the same as labs if all office workers also work in labs. Otherwise, use the ASHRAE 62.1 default densities

Occupant Heat Loads

250 Btu/h/person sensible, 200 Btu/h/person latent

Lighting → Per design and IECC 2018 Table C405.4.2(2).

Office Equipment

Ideally, equipment loads are tied to occupant counts (rather than W/ft²) with peak power demand developed from ASHRAE Fundamentals 2013 Tables 18.8, 18.9, and 18.10.

If equipment is not known, reference ASHRAE Fundamentals 2013 Table 18.11:

% Laptop	% Desktop	No. Monitors	Workspace	Occs/Printer	Diversity?	W/ft ²
100%	0%	0	167 ft ²	10	Yes	0.25
100%	0%	0	125 ft ²	10	Yes	0.33
50%	50%	1	167 ft ²	10	Yes	0.40
50%	50%	1	125 ft ²	10	Yes	0.50
0%	100%	1	167 ft ²	10	Yes	0.60
0%	100%	1	125 ft ²	10	Yes	0.80
0%	100%	2	125 ft ²	10	Yes	1.00
0%	100%	2	85 ft ²	8	Yes	1.50
0%	100%	2	85 ft ²	8	No	2.00

Non-Office Equipment

Background miscellaneous loads: 0.2 W/ft² on 24/7 for corridors, stairs, and most support spaces

Labs: 4.5 W/ft²

IDF/MDF rooms: 4.0 W/ft² on 24/7

Electrical closets: 0.5 W/ft² on 24/7

Break Rooms:

Peak Watts Assumptions

Typical Refrigerator	191	constant operation
1,100 W Microwave Oven	80	1,100 W model, 1.0 hr/day, 251 days/yr
1,000 W Coffee Maker	110	1,000 W model, 1.5 hr/day, 251 days/yr
1,051 W Toaster Oven	19	1,051 W model, 0.25 hr/day, 251 days/yr

Peak Wattage is based on 3,431 EFLH for Table L.5 plug loads

Table O.1
OPEN OFFICES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	3%	3%	3%	20%	20%	20%
2	0%	0%	0%	3%	3%	3%	20%	20%	20%
3	0%	0%	0%	3%	3%	3%	20%	20%	20%
4	0%	0%	0%	3%	3%	3%	20%	20%	20%
5	0%	0%	0%	3%	3%	3%	20%	20%	20%
6	0%	0%	0%	3%	3%	3%	20%	20%	20%
7	10%	0%	0%	100%	3%	3%	28%	20%	20%
8	20%	0%	0%	100%	3%	3%	36%	20%	20%
9	85%	5%	0%	100%	100%	3%	88%	24%	20%
10	90%	5%	0%	100%	100%	3%	92%	24%	20%
11	95%	5%	0%	100%	100%	3%	96%	24%	20%
12	90%	5%	0%	100%	100%	3%	92%	24%	20%
13	75%	5%	0%	100%	100%	3%	80%	24%	20%
14	85%	5%	0%	100%	100%	3%	88%	24%	20%
15	90%	5%	0%	100%	100%	3%	92%	24%	20%
16	95%	5%	0%	100%	100%	3%	96%	24%	20%
17	85%	5%	0%	100%	100%	3%	88%	24%	20%
18	30%	0%	0%	100%	3%	3%	44%	20%	20%
19	10%	0%	0%	100%	3%	3%	28%	20%	20%
20	5%	0%	0%	100%	3%	3%	24%	20%	20%
21	5%	0%	0%	100%	3%	3%	24%	20%	20%
22	5%	0%	0%	100%	3%	3%	24%	20%	20%
23	0%	0%	0%	3%	3%	3%	20%	20%	20%
24	0%	0%	0%	3%	3%	3%	20%	20%	20%

Source: TNZ

Table O.2
PRIVATE OFFICES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	0%	20%	20%	20%
2	0%	0%	0%	0%	0%	0%	20%	20%	20%
3	0%	0%	0%	0%	0%	0%	20%	20%	20%
4	0%	0%	0%	0%	0%	0%	20%	20%	20%
5	0%	0%	0%	0%	0%	0%	20%	20%	20%
6	0%	0%	0%	0%	0%	0%	20%	20%	20%
7	10%	0%	0%	15%	0%	0%	28%	20%	20%
8	20%	0%	0%	25%	0%	0%	36%	20%	20%
9	85%	10%	0%	90%	15%	0%	88%	28%	20%
10	90%	15%	0%	95%	20%	0%	92%	32%	20%
11	90%	15%	0%	95%	20%	0%	92%	32%	20%
12	90%	10%	0%	95%	15%	0%	92%	28%	20%
13	75%	5%	0%	80%	10%	0%	80%	24%	20%
14	85%	5%	0%	90%	10%	0%	88%	24%	20%
15	90%	5%	0%	95%	10%	0%	92%	24%	20%
16	90%	5%	0%	95%	10%	0%	92%	24%	20%
17	90%	5%	0%	95%	10%	0%	92%	24%	20%
18	40%	0%	0%	45%	0%	0%	52%	20%	20%
19	10%	0%	0%	15%	0%	0%	28%	20%	20%
20	10%	0%	0%	15%	0%	0%	28%	20%	20%
21	5%	0%	0%	10%	0%	0%	24%	20%	20%
22	5%	0%	0%	10%	0%	0%	24%	20%	20%
23	5%	0%	0%	10%	0%	0%	24%	20%	20%
24	5%	0%	0%	10%	0%	0%	24%	20%	20%

Source: TNZ

Table O.3
CONFERENCE & MEETING ROOMS

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	50%	0%	0%	55%	0%	0%	50%	0%	0%
10	100%	0%	0%	100%	0%	0%	100%	0%	0%
11	50%	0%	0%	55%	0%	0%	50%	0%	0%
12	25%	0%	0%	30%	0%	0%	25%	0%	0%
13	25%	0%	0%	30%	0%	0%	25%	0%	0%
14	100%	0%	0%	100%	0%	0%	100%	0%	0%
15	50%	0%	0%	55%	0%	0%	50%	0%	0%
16	25%	0%	0%	30%	0%	0%	25%	0%	0%
17	0%	0%	0%	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: TNZ

Table O.4
KITCHENETTE / BREAK ROOM SPACES

Hour End	Occupancy			Lighting			Plug Loads		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	0%	35%	35%	35%
2	0%	0%	0%	0%	0%	0%	35%	35%	35%
3	0%	0%	0%	0%	0%	0%	35%	35%	35%
4	0%	0%	0%	0%	0%	0%	35%	35%	35%
5	0%	0%	0%	0%	0%	0%	35%	35%	35%
6	0%	0%	0%	0%	0%	0%	35%	35%	35%
7	5%	0%	0%	100%	100%	0%	37%	35%	35%
8	25%	0%	0%	100%	100%	0%	45%	35%	35%
9	20%	5%	0%	100%	100%	0%	43%	37%	35%
10	15%	5%	0%	100%	100%	0%	41%	37%	35%
11	15%	5%	0%	100%	100%	0%	41%	37%	35%
12	50%	5%	0%	100%	100%	0%	55%	37%	35%
13	75%	5%	0%	100%	100%	0%	65%	37%	35%
14	50%	5%	0%	100%	100%	0%	55%	37%	35%
15	15%	5%	0%	100%	100%	0%	41%	37%	35%
16	25%	5%	0%	100%	100%	0%	45%	37%	35%
17	30%	5%	0%	100%	100%	0%	47%	37%	35%
18	5%	0%	0%	100%	100%	0%	37%	35%	35%
19	5%	0%	0%	100%	0%	0%	37%	35%	35%
20	5%	0%	0%	100%	0%	0%	37%	35%	35%
21	5%	0%	0%	100%	0%	0%	37%	35%	35%
22	5%	0%	0%	100%	0%	0%	37%	35%	35%
23	0%	0%	0%	0%	0%	0%	35%	35%	35%
24	0%	0%	0%	0%	0%	0%	35%	35%	35%

Source: TNZ

Table O.5
COMMON SPACE LIGHTING

Hour End	Corridors			Stairs	Stairways w OS*			Restrooms			Support	
	M-F	Sat	Sun	All	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Other
1	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
2	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
3	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
4	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
5	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
6	15%	15%	15%	100%	50%	50%	50%	0%	0%	0%	0%	0%
7	100%	100%	15%	100%	60%	50%	50%	35%	0%	0%	5%	0%
8	100%	100%	15%	100%	70%	50%	50%	45%	0%	0%	5%	0%
9	100%	100%	15%	100%	100%	55%	50%	100%	35%	0%	5%	0%
10	100%	100%	15%	100%	100%	55%	50%	100%	40%	0%	5%	0%
11	100%	100%	15%	100%	100%	55%	50%	100%	40%	0%	5%	0%
12	100%	100%	15%	100%	100%	55%	50%	100%	35%	0%	5%	0%
13	100%	100%	15%	100%	100%	55%	50%	100%	30%	0%	5%	0%
14	100%	100%	15%	100%	100%	55%	50%	100%	30%	0%	5%	0%
15	100%	100%	15%	100%	100%	55%	50%	100%	30%	0%	5%	0%
16	100%	100%	15%	100%	100%	55%	50%	100%	30%	0%	5%	0%
17	100%	100%	15%	100%	100%	55%	50%	100%	30%	0%	0%	0%
18	100%	100%	15%	100%	80%	50%	50%	65%	0%	0%	0%	0%
19	100%	15%	15%	100%	60%	50%	50%	35%	0%	0%	0%	0%
20	100%	15%	15%	100%	55%	50%	50%	35%	0%	0%	0%	0%
21	100%	15%	15%	100%	55%	50%	50%	30%	0%	0%	0%	0%
22	100%	15%	15%	100%	55%	50%	50%	30%	0%	0%	0%	0%
23	15%	15%	15%	100%	50%	50%	50%	30%	0%	0%	0%	0%
24	15%	15%	15%	100%	50%	50%	50%	30%	0%	0%	0%	0%

*Assumes 50% Turndown, lighting power assumption should not account for any control factors.

Source: TNZ

Table O.6
OTHER COMMON SCHEDULES

Hour End	HVAC "Occupied"*			Elevator			DHW		
	M-F	Sat	Sun	M-F	Sat	Sun	M-F	Sat	Sun
1	0	0	0	0%	0%	0%	5%	5%	5%
2	0	0	0	0%	0%	0%	5%	5%	5%
3	0	0	0	0%	0%	0%	5%	5%	5%
4	0	0	0	0%	0%	0%	5%	5%	5%
5	0	0	0	0%	0%	0%	5%	5%	5%
6	0	0	0	0%	0%	0%	5%	5%	5%
7	1	1	0	0%	0%	0%	7%	5%	5%
8	1	1	0	35%	0%	0%	19%	5%	5%
9	1	1	0	69%	14%	0%	35%	11%	5%
10	1	1	0	43%	21%	0%	38%	15%	5%
11	1	1	0	37%	18%	0%	39%	21%	5%
12	1	1	0	43%	25%	0%	47%	19%	5%
13	1	1	0	58%	21%	0%	57%	23%	5%
14	1	1	0	48%	13%	0%	54%	20%	5%
15	1	1	0	37%	8%	0%	34%	19%	5%
16	1	1	0	37%	4%	0%	33%	15%	5%
17	1	1	0	46%	5%	0%	44%	12%	5%
18	1	1	0	62%	6%	0%	26%	14%	5%
19	1	0	0	12%	0%	0%	21%	7%	5%
20	1	0	0	4%	0%	0%	15%	5%	5%
21	1	0	0	4%	0%	0%	17%	5%	5%
22	1	0	0	4%	0%	0%	8%	5%	5%
23	0	0	0	0%	0%	0%	5%	5%	5%
24	0	0	0	0%	0%	0%	5%	5%	5%

*Hours when ventilation for occupancy is active; morning startup begins ahead of these hours.

Source: TNZ

Table O.7
OFFICE BUILDING LOAD FACTORS

Occupancy

Ideally, the occupant counts are based on furniture counts
 Otherwise, use the ASHRAE 62.1 default densities

Occupant Heat Loads

250 Btu/h/person sensible, 200 Btu/h/person latent

Lighting → Per design and IECC 2018 Table C405.4.2(2).

Office Equipment

Ideally, equipment loads are tied to occupant counts (rather than W/ft²) with peak power demand developed from ASHRAE Fundamentals 2013 Tables 18.8, 18.9, and 18.10.
 If equipment is not known, reference ASHRAE Fundamentals 2013 Table 18.11:

% Laptop	% Desktop	No. Monitors	Workspace	Occs/Printer	Diversity?	W/ft ²
100%	0%	0	167 ft ²	10	Yes	0.25
100%	0%	0	125 ft ²	10	Yes	0.33
50%	50%	1	167 ft ²	10	Yes	0.40
50%	50%	1	125 ft ²	10	Yes	0.50
0%	100%	1	167 ft ²	10	Yes	0.60
0%	100%	1	125 ft ²	10	Yes	0.80
0%	100%	2	125 ft ²	10	Yes	1.00
0%	100%	2	85 ft ²	8	Yes	1.50
0%	100%	2	85 ft ²	8	No	2.00

Non-Office Equipment

Background miscellaneous loads: 0.2 W/ft² on 24/7 for corridors, stairs, and most support spaces

IDF/MDF rooms: 4.0 W/ft² on 24/7

Electrical closets: 0.5 W/ft² on 24/7

Break Rooms:

Peak Watts Assumptions

Typical Refrigerator	191	constant operation
1,100 W Microwave Oven	80	1,100 W model, 1.0 hr/day, 251 days/yr
1,000 W Coffee Maker	110	1,000 W model, 1.5 hr/day, 251 days/yr
1,051 W Toaster Oven	19	1,051 W model, 0.25 hr/day, 251 days/yr

Peak Wattage is based on 3,431 EFLH for Table O.4 plug loads

Table E.1
ADMINISTRATION OFFICES

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	10%	0%	100%	0%	28%	20%
8	50%	0%	100%	0%	60%	20%
9	100%	0%	100%	0%	100%	20%
10	100%	0%	100%	0%	100%	20%
11	100%	0%	100%	0%	100%	20%
12	90%	0%	100%	0%	92%	20%
13	100%	0%	100%	0%	100%	20%
14	100%	0%	100%	0%	100%	20%
15	50%	0%	100%	0%	60%	20%
16	50%	0%	100%	0%	60%	20%
17	0%	0%	0%	0%	20%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table E.2
ADMINISTRATION OFFICES - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	0%	0%	0%	0%	10%	10%
9	50%	0%	85%	0%	55%	10%
10	50%	0%	85%	0%	55%	10%
11	50%	0%	85%	0%	55%	10%
12	50%	0%	85%	0%	55%	10%
13	50%	0%	85%	0%	55%	10%
14	50%	0%	85%	0%	55%	10%
15	50%	0%	85%	0%	55%	10%
16	50%	0%	85%	0%	55%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table E.3
TYPICAL CLASSROOMS

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	0%	0%	0%	0%	20%	20%
8	5%	0%	100%	0%	24%	20%
9	45%	0%	100%	0%	56%	20%
10	90%	0%	100%	0%	92%	20%
11	90%	0%	100%	0%	92%	20%
12	25%	0%	100%	0%	40%	20%
13	90%	0%	100%	0%	92%	20%
14	90%	0%	100%	0%	92%	20%
15	35%	0%	100%	0%	48%	20%
16	5%	0%	100%	0%	24%	20%
17	0%	0%	0%	0%	20%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table E.4
TYPICAL CLASSROOMS - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	0%	0%	0%	0%	10%	10%
9	50%	0%	85%	0%	55%	10%
10	50%	0%	85%	0%	55%	10%
11	50%	0%	85%	0%	55%	10%
12	50%	0%	85%	0%	55%	10%
13	50%	0%	85%	0%	55%	10%
14	50%	0%	85%	0%	55%	10%
15	50%	0%	85%	0%	55%	10%
16	50%	0%	85%	0%	55%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table E.5
GYMNASIUM

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%
8	60%	0%	100%	0%	0%	0%
9	10%	0%	100%	0%	0%	0%
10	10%	0%	100%	0%	0%	0%
11	10%	0%	100%	0%	0%	0%
12	10%	0%	100%	0%	0%	0%
13	10%	0%	100%	0%	0%	0%
14	10%	0%	100%	0%	0%	0%
15	60%	0%	100%	0%	0%	0%
16	30%	0%	100%	0%	0%	0%
17	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%

Source: TNZ

Table E.6
GYMNASIUM - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%
13	0%	0%	0%	0%	0%	0%
14	0%	0%	0%	0%	0%	0%
15	0%	0%	0%	0%	0%	0%
16	0%	0%	0%	0%	0%	0%
17	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%

Source: TNZ

Table E.7
LIBRARY / MEDIA CENTER

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	0%	0%	0%	0%	20%	20%
8	0%	0%	0%	0%	20%	20%
9	30%	0%	100%	0%	100%	20%
10	30%	0%	100%	0%	100%	20%
11	30%	0%	100%	0%	100%	20%
12	15%	0%	100%	0%	100%	20%
13	15%	0%	100%	0%	100%	20%
14	30%	0%	100%	0%	100%	20%
15	50%	0%	100%	0%	100%	20%
16	50%	0%	100%	0%	100%	20%
17	0%	0%	0%	0%	20%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table E.8
LIBRARY / MEDIA CENTER - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	5%	0%	100%	0%	100%	10%
9	15%	0%	100%	0%	100%	10%
10	15%	0%	100%	0%	100%	10%
11	15%	0%	100%	0%	100%	10%
12	15%	0%	100%	0%	100%	10%
13	5%	0%	100%	0%	100%	10%
14	0%	0%	0%	0%	10%	10%
15	0%	0%	0%	0%	10%	10%
16	0%	0%	0%	0%	10%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table E.9
CAFETERIA

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	0%	0%	0%	0%	20%	20%
8	20%	0%	100%	0%	20%	20%
9	5%	0%	100%	0%	20%	20%
10	5%	0%	100%	0%	20%	20%
11	5%	0%	100%	0%	20%	20%
12	100%	0%	100%	0%	100%	20%
13	100%	0%	100%	0%	100%	20%
14	5%	0%	100%	0%	20%	20%
15	5%	0%	100%	0%	20%	20%
16	5%	0%	100%	0%	20%	20%
17	0%	0%	0%	0%	20%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table E.10
CAFETERIA - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	0%	0%	0%	0%	10%	10%
9	0%	0%	0%	0%	10%	10%
10	0%	0%	0%	0%	10%	10%
11	0%	0%	0%	0%	10%	10%
12	0%	0%	0%	0%	10%	10%
13	0%	0%	0%	0%	10%	10%
14	0%	0%	0%	0%	10%	10%
15	0%	0%	0%	0%	10%	10%
16	0%	0%	0%	0%	10%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table E.11
KITCHEN & SERVERY

Hour End	Occupancy		Lighting		Gas Cooking		Electric Cooking		Electric Servery		Refrigeration		Dishwash	
	M-F	Other	M-F	Other	M-F	Other	M-F	Other	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
8	20%	0%	100%	0%	0%	0%	25%	0%	0%	0%	85%	75%	0%	0%
9	100%	0%	100%	0%	50%	0%	50%	0%	0%	0%	90%	75%	0%	0%
10	100%	0%	100%	0%	75%	0%	100%	0%	100%	0%	95%	75%	0%	0%
11	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	75%	25%	0%
12	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	75%	50%	0%
13	100%	0%	100%	0%	0%	0%	25%	0%	100%	0%	95%	75%	75%	0%
14	100%	0%	100%	0%	0%	0%	0%	0%	0%	0%	100%	75%	100%	0%
15	75%	0%	100%	0%	0%	0%	0%	0%	0%	0%	85%	75%	50%	0%
16	5%	0%	100%	0%	0%	0%	0%	0%	0%	0%	85%	75%	0%	0%
17	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
18	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
21	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
22	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%

Source: TNZ

Table E.12
KITCHEN & SERVERY - Summer & Break Periods

Hour End	Occupancy		Lighting		Gas Cooking		Electric Cooking		Electric Servery		Refrigeration		Dishwash	
	M-F	Other	M-F	Other	M-F	Other	M-F	Other	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
13	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
14	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
15	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
16	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
17	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
18	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
21	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
22	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	0%	0%

Source: TNZ

Table E.13
COMMON SPACE LIGHTING

Hour End	Corridors		Stairs	Stairways w OS*		Restrooms		Support Spaces	
	M-F	Other	All	M-F	Other	M-F	Other	M-F	Other
1	15%	15%	100%	50%	50%	0%	0%	0%	0%
2	15%	15%	100%	50%	50%	0%	0%	0%	0%
3	15%	15%	100%	50%	50%	0%	0%	0%	0%
4	15%	15%	100%	50%	50%	0%	0%	0%	0%
5	15%	15%	100%	50%	50%	0%	0%	0%	0%
6	15%	15%	100%	50%	50%	0%	0%	0%	0%
7	50%	15%	100%	60%	50%	50%	0%	25%	0%
8	100%	15%	100%	100%	50%	100%	0%	25%	0%
9	100%	15%	100%	100%	50%	100%	0%	25%	0%
10	100%	15%	100%	100%	50%	100%	0%	25%	0%
11	100%	15%	100%	100%	50%	100%	0%	25%	0%
12	100%	15%	100%	100%	50%	100%	0%	25%	0%
13	100%	15%	100%	100%	50%	100%	0%	25%	0%
14	100%	15%	100%	100%	50%	100%	0%	25%	0%
15	100%	15%	100%	100%	50%	100%	0%	25%	0%
16	100%	15%	100%	100%	50%	100%	0%	5%	0%
17	100%	15%	100%	50%	50%	100%	0%	5%	0%
18	15%	15%	100%	50%	50%	0%	0%	5%	0%
19	15%	15%	100%	50%	50%	0%	0%	0%	0%
20	15%	15%	100%	50%	50%	0%	0%	0%	0%
21	15%	15%	100%	50%	50%	0%	0%	0%	0%
22	15%	15%	100%	50%	50%	0%	0%	0%	0%
23	15%	15%	100%	50%	50%	0%	0%	0%	0%
24	15%	15%	100%	50%	50%	0%	0%	0%	0%

*Assumes 50% Turndown, lighting power assumption should not account for any control factors.

Source: TNZ

Table E.14
OTHER COMMON SCHEDULES

Hour End	HVAC "Occupied"*		Elevator		DHW		DHW - Vacations	
	M-F	Other	M-F	Other	M-F	Other	M-F	Other
1	0	0	0%	0%	5%	5%	5%	5%
2	0	0	0%	0%	5%	5%	5%	5%
3	0	0	0%	0%	5%	5%	5%	5%
4	0	0	0%	0%	5%	5%	5%	5%
5	0	0	0%	0%	5%	5%	5%	5%
6	0	0	0%	0%	5%	5%	5%	5%
7	1	0	0%	0%	5%	5%	5%	5%
8	1	0	5%	0%	34%	5%	10%	5%
9	1	0	5%	0%	60%	5%	10%	5%
10	1	0	5%	0%	63%	5%	10%	5%
11	1	0	5%	0%	72%	5%	10%	5%
12	1	0	5%	0%	79%	5%	10%	5%
13	1	0	5%	0%	83%	5%	10%	5%
14	1	0	5%	0%	61%	5%	10%	5%
15	1	0	5%	0%	65%	5%	10%	5%
16	1	0	5%	0%	10%	5%	5%	5%
17	0	0	0%	0%	10%	5%	5%	5%
18	0	0	0%	0%	5%	5%	5%	5%
19	0	0	0%	0%	5%	5%	5%	5%
20	0	0	0%	0%	5%	5%	5%	5%
21	0	0	0%	0%	5%	5%	5%	5%
22	0	0	0%	0%	5%	5%	5%	5%
23	0	0	0%	0%	5%	5%	5%	5%
24	0	0	0%	0%	5%	5%	5%	5%

*Hours when ventilation for occupancy is active; morning startup begins ahead of these hours.

Source: TNZ

Table E.15
ELEMENTARY SCHOOL LOAD FACTORS

Occupancy

Ideally, the occupant counts are based on furniture counts
 Otherwise, use the ASHRAE 62.1 default densities

Occupant Heat Loads

Teacher & Admin Spaces: 245 Btu/h/person sensible, 155 Btu/h/person latent
 Student Spaces: 231 Btu/h/person sensible, 158 Btu/h/person latent
 Gymnasium: 500 Btu/h/person sensible, 375 Btu/h/person latent

Lighting → Per design and IECC 2018 Table C405.4.2(2).

Office Equipment & Teach Break Rooms

See direction for office buildings

Classroom Equipment

Develop loads based on actual equipment planned for the space; the following are example average coincident peak values:

Computers	47.5 Watts	Display	19.5 Watts
Soundfield	98.8 Watts	Projector	63.3 Watts
		iPad Cart	183.0 Watts

Cooking & Servery Equipment

Develop peak demand using ASHRAE 2013 Fundamentals Tables 18.5A through 18.5E

Non-Office Equipment

Background miscellaneous loads: 0.2 W/ft² on 24/7 for corridors, stairs, and most support spaces
 IDF/MDF rooms: 4.0 W/ft² on 24/7
 Electrical closets: 0.5 W/ft² on 24/7

Table H.1

ADMINISTRATION OFFICES

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	50%	0%	100%	0%	60%	20%
8	100%	0%	100%	0%	100%	20%
9	100%	0%	100%	0%	100%	20%
10	100%	0%	100%	0%	100%	20%
11	100%	0%	100%	0%	100%	20%
12	90%	0%	100%	0%	92%	20%
13	100%	0%	100%	0%	100%	20%
14	100%	0%	100%	0%	100%	20%
15	75%	0%	100%	0%	80%	20%
16	50%	0%	100%	0%	60%	20%
17	50%	0%	100%	0%	60%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table H.2

ADMINISTRATION OFFICES - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	0%	0%	0%	0%	10%	10%
9	50%	0%	85%	0%	55%	10%
10	50%	0%	85%	0%	55%	10%
11	50%	0%	85%	0%	55%	10%
12	50%	0%	85%	0%	55%	10%
13	50%	0%	85%	0%	55%	10%
14	50%	0%	85%	0%	55%	10%
15	50%	0%	85%	0%	55%	10%
16	50%	0%	85%	0%	55%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table H.3
TYPICAL CLASSROOMS

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	0%	0%	0%	0%	20%	20%
8	50%	0%	100%	0%	60%	20%
9	90%	0%	100%	0%	92%	20%
10	90%	0%	100%	0%	92%	20%
11	90%	0%	100%	0%	92%	20%
12	25%	0%	100%	0%	40%	20%
13	90%	0%	100%	0%	92%	20%
14	90%	0%	100%	0%	92%	20%
15	35%	0%	100%	0%	48%	20%
16	5%	0%	100%	0%	24%	20%
17	5%	0%	100%	0%	24%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table H.4
TYPICAL CLASSROOMS - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	0%	0%	0%	0%	10%	10%
9	50%	0%	85%	0%	55%	10%
10	50%	0%	85%	0%	55%	10%
11	50%	0%	85%	0%	55%	10%
12	50%	0%	85%	0%	55%	10%
13	50%	0%	85%	0%	55%	10%
14	50%	0%	85%	0%	55%	10%
15	50%	0%	85%	0%	55%	10%
16	50%	0%	85%	0%	55%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table H.5
GYMNASIUM

Hour End	Occupancy			Lighting			Plug Loads		
	M-Th	Fr	Other	M-Th	Fr	Other	M-Th	Fr	Other
1	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	30%	0%	0%	100%	0%	0%	0%	0%	0%
8	30%	0%	0%	100%	0%	0%	0%	0%	0%
9	10%	0%	0%	100%	0%	0%	0%	0%	0%
10	10%	0%	0%	100%	0%	0%	0%	0%	0%
11	10%	0%	0%	100%	0%	0%	0%	0%	0%
12	10%	0%	0%	100%	0%	0%	0%	0%	0%
13	10%	0%	0%	100%	0%	0%	0%	0%	0%
14	10%	0%	0%	100%	0%	0%	0%	0%	0%
15	30%	0%	0%	100%	0%	0%	0%	0%	0%
16	30%	0%	0%	100%	0%	0%	0%	0%	0%
17	30%	0%	0%	100%	0%	0%	0%	0%	0%
18	5%	0%	0%	100%	0%	0%	0%	0%	0%
19	5%	50%	0%	100%	100%	0%	0%	100%	0%
20	30%	100%	0%	100%	100%	0%	0%	100%	0%
21	30%	100%	0%	100%	100%	0%	0%	100%	0%
22	5%	50%	0%	100%	100%	0%	0%	100%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%

Plug loads are assumed to be score board and game lights that are typically not used.

Source: TNZ

Table H.6
GYMNASIUM - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%
9	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%
13	0%	0%	0%	0%	0%	0%
14	0%	0%	0%	0%	0%	0%
15	0%	0%	0%	0%	0%	0%
16	0%	0%	0%	0%	0%	0%
17	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%

Source: TNZ

Table H.7
LIBRARY / MEDIA CENTER

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	0%	0%	0%	0%	20%	20%
8	5%	0%	100%	0%	100%	20%
9	30%	0%	100%	0%	100%	20%
10	30%	0%	100%	0%	100%	20%
11	30%	0%	100%	0%	100%	20%
12	15%	0%	100%	0%	100%	20%
13	15%	0%	100%	0%	100%	20%
14	30%	0%	100%	0%	100%	20%
15	75%	0%	100%	0%	100%	20%
16	75%	0%	100%	0%	100%	20%
17	50%	0%	100%	0%	100%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table H.8
LIBRARY / MEDIA CENTER - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	5%	0%	100%	0%	100%	10%
9	15%	0%	100%	0%	100%	10%
10	15%	0%	100%	0%	100%	10%
11	15%	0%	100%	0%	100%	10%
12	15%	0%	100%	0%	100%	10%
13	5%	0%	100%	0%	100%	10%
14	0%	0%	0%	0%	10%	10%
15	0%	0%	0%	0%	10%	10%
16	0%	0%	0%	0%	10%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table H.9
CAFETERIA

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	20%	20%
2	0%	0%	0%	0%	20%	20%
3	0%	0%	0%	0%	20%	20%
4	0%	0%	0%	0%	20%	20%
5	0%	0%	0%	0%	20%	20%
6	0%	0%	0%	0%	20%	20%
7	0%	0%	0%	0%	20%	20%
8	20%	0%	100%	0%	20%	20%
9	5%	0%	100%	0%	20%	20%
10	5%	0%	100%	0%	20%	20%
11	5%	0%	100%	0%	20%	20%
12	100%	0%	100%	0%	100%	20%
13	100%	0%	100%	0%	100%	20%
14	5%	0%	100%	0%	20%	20%
15	10%	0%	100%	0%	20%	20%
16	5%	0%	100%	0%	20%	20%
17	0%	0%	0%	0%	20%	20%
18	0%	0%	0%	0%	20%	20%
19	0%	0%	0%	0%	20%	20%
20	0%	0%	0%	0%	20%	20%
21	0%	0%	0%	0%	20%	20%
22	0%	0%	0%	0%	20%	20%
23	0%	0%	0%	0%	20%	20%
24	0%	0%	0%	0%	20%	20%

Source: TNZ

Table H.10
CAFETERIA - Summer & Break Periods

Hour End	Occupancy		Lighting		Plug Loads	
	M-F	Other	M-F	Other	M-F	Other
1	0%	0%	0%	0%	10%	10%
2	0%	0%	0%	0%	10%	10%
3	0%	0%	0%	0%	10%	10%
4	0%	0%	0%	0%	10%	10%
5	0%	0%	0%	0%	10%	10%
6	0%	0%	0%	0%	10%	10%
7	0%	0%	0%	0%	10%	10%
8	0%	0%	0%	0%	10%	10%
9	0%	0%	0%	0%	10%	10%
10	0%	0%	0%	0%	10%	10%
11	0%	0%	0%	0%	10%	10%
12	0%	0%	0%	0%	10%	10%
13	0%	0%	0%	0%	10%	10%
14	0%	0%	0%	0%	10%	10%
15	0%	0%	0%	0%	10%	10%
16	0%	0%	0%	0%	10%	10%
17	0%	0%	0%	0%	10%	10%
18	0%	0%	0%	0%	10%	10%
19	0%	0%	0%	0%	10%	10%
20	0%	0%	0%	0%	10%	10%
21	0%	0%	0%	0%	10%	10%
22	0%	0%	0%	0%	10%	10%
23	0%	0%	0%	0%	10%	10%
24	0%	0%	0%	0%	10%	10%

Source: TNZ

Table H.11
AUDITORIUM

Hour End	Occupancy			Lighting			Plug Loads		
	M-Th	Fr	Other	M-Th	Fr	Other	M-Th	Fr	Other
1	0%	0%	0%	0%	0%	0%	5%	5%	5%
2	0%	0%	0%	0%	0%	0%	5%	5%	5%
3	0%	0%	0%	0%	0%	0%	5%	5%	5%
4	0%	0%	0%	0%	0%	0%	5%	5%	5%
5	0%	0%	0%	0%	0%	0%	5%	5%	5%
6	0%	0%	0%	0%	0%	0%	5%	5%	5%
7	0%	0%	0%	0%	0%	0%	5%	5%	5%
8	0%	0%	0%	0%	0%	0%	5%	5%	5%
9	0%	5%	0%	0%	100%	0%	5%	10%	5%
10	5%	100%	0%	100%	100%	0%	10%	100%	5%
11	5%	100%	0%	100%	100%	0%	10%	100%	5%
12	0%	5%	0%	0%	100%	0%	5%	10%	5%
13	5%	5%	0%	100%	100%	0%	10%	10%	5%
14	5%	5%	0%	100%	100%	0%	10%	10%	5%
15	5%	5%	0%	100%	100%	0%	10%	10%	5%
16	5%	5%	0%	100%	100%	0%	10%	10%	5%
17	0%	0%	0%	0%	0%	0%	5%	5%	5%
18	0%	0%	0%	0%	0%	0%	5%	5%	5%
19	0%	5%	0%	0%	100%	0%	5%	10%	5%
20	0%	100%	0%	0%	100%	0%	5%	100%	5%
21	0%	100%	0%	0%	100%	0%	5%	100%	5%
22	0%	5%	0%	0%	100%	0%	5%	10%	5%
23	0%	0%	0%	0%	0%	0%	5%	5%	5%
24	0%	0%	0%	0%	0%	0%	5%	5%	5%

Table H.12
AUDITORIUM - Summer & Break Periods

Hour End	Occupancy			Lighting			Plug Loads		
	M-Th	Fr	Other	M-Th	Fr	Other	M-Th	Fr	Other
1	0%	0%	0%	0%	0%	0%	5%	5%	5%
2	0%	0%	0%	0%	0%	0%	5%	5%	5%
3	0%	0%	0%	0%	0%	0%	5%	5%	5%
4	0%	0%	0%	0%	0%	0%	5%	5%	5%
5	0%	0%	0%	0%	0%	0%	5%	5%	5%
6	0%	0%	0%	0%	0%	0%	5%	5%	5%
7	0%	0%	0%	0%	0%	0%	5%	5%	5%
8	0%	0%	0%	0%	0%	0%	5%	5%	5%
9	0%	0%	0%	0%	0%	0%	5%	5%	5%
10	0%	0%	0%	0%	0%	0%	5%	5%	5%
11	0%	0%	0%	0%	0%	0%	5%	5%	5%
12	0%	0%	0%	0%	0%	0%	5%	5%	5%
13	0%	0%	0%	0%	0%	0%	5%	5%	5%
14	0%	0%	0%	0%	0%	0%	5%	5%	5%
15	0%	0%	0%	0%	0%	0%	5%	5%	5%
16	0%	0%	0%	0%	0%	0%	5%	5%	5%
17	0%	0%	0%	0%	0%	0%	5%	5%	5%
18	0%	0%	0%	0%	0%	0%	5%	5%	5%
19	0%	0%	0%	0%	0%	0%	5%	5%	5%
20	0%	0%	0%	0%	0%	0%	5%	5%	5%
21	0%	0%	0%	0%	0%	0%	5%	5%	5%
22	0%	0%	0%	0%	0%	0%	5%	5%	5%
23	0%	0%	0%	0%	0%	0%	5%	5%	5%
24	0%	0%	0%	0%	0%	0%	5%	5%	5%

*Plug loads are likely to be dominated by stage lighting (considered a process load by code).

Source: TNZ

Source: TNZ

Table H.13
COMMON SPACE LIGHTING

Hour End	Corridors		Stairs	Stairways w OS*		Restrooms		Support Spaces	
	M-F	Other	All	M-F	Other	M-F	Other	M-F	Other
1	15%	15%	100%	50%	50%	0%	0%	0%	0%
2	15%	15%	100%	50%	50%	0%	0%	0%	0%
3	15%	15%	100%	50%	50%	0%	0%	0%	0%
4	15%	15%	100%	50%	50%	0%	0%	0%	0%
5	15%	15%	100%	50%	50%	0%	0%	0%	0%
6	15%	15%	100%	50%	50%	0%	0%	0%	0%
7	50%	15%	100%	100%	50%	50%	0%	25%	0%
8	100%	15%	100%	100%	50%	100%	0%	25%	0%
9	100%	15%	100%	100%	50%	100%	0%	25%	0%
10	100%	15%	100%	100%	50%	100%	0%	25%	0%
11	100%	15%	100%	100%	50%	100%	0%	25%	0%
12	100%	15%	100%	100%	50%	100%	0%	25%	0%
13	100%	15%	100%	100%	50%	100%	0%	25%	0%
14	100%	15%	100%	100%	50%	100%	0%	25%	0%
15	100%	15%	100%	100%	50%	100%	0%	25%	0%
16	100%	15%	100%	100%	50%	100%	0%	5%	0%
17	100%	15%	100%	100%	50%	100%	0%	5%	0%
18	100%	15%	100%	50%	50%	100%	0%	5%	0%
19	100%	15%	100%	50%	50%	100%	0%	0%	0%
20	100%	15%	100%	50%	50%	100%	0%	0%	0%
21	100%	15%	100%	50%	50%	100%	0%	0%	0%
22	100%	15%	100%	50%	50%	100%	0%	0%	0%
23	15%	15%	100%	50%	50%	0%	0%	0%	0%
24	15%	15%	100%	50%	50%	0%	0%	0%	0%

*Assumes 50% Turndown, lighting power assumption should not account for any control fact

Source: TNZ

Table H.14
COMMON SPACE LIGHTING - Summer & Break Periods

Hour End	Corridors		Stairs	Stairways w OS*		Restrooms		Support Spaces	
	M-F	Other	All	M-F	Other	M-F	Other	M-F	Other
1	15%	15%	100%	50%	50%	0%	0%	0%	0%
2	15%	15%	100%	50%	50%	0%	0%	0%	0%
3	15%	15%	100%	50%	50%	0%	0%	0%	0%
4	15%	15%	100%	50%	50%	0%	0%	0%	0%
5	15%	15%	100%	50%	50%	0%	0%	0%	0%
6	15%	15%	100%	50%	50%	0%	0%	0%	0%
7	50%	15%	100%	55%	50%	50%	0%	25%	0%
8	50%	15%	100%	55%	50%	100%	0%	25%	0%
9	50%	15%	100%	55%	50%	100%	0%	25%	0%
10	50%	15%	100%	55%	50%	100%	0%	25%	0%
11	50%	15%	100%	55%	50%	100%	0%	25%	0%
12	50%	15%	100%	55%	50%	100%	0%	25%	0%
13	50%	15%	100%	55%	50%	100%	0%	25%	0%
14	50%	15%	100%	55%	50%	100%	0%	25%	0%
15	50%	15%	100%	55%	50%	100%	0%	25%	0%
16	15%	15%	100%	50%	50%	100%	0%	0%	0%
17	15%	15%	100%	50%	50%	100%	0%	0%	0%
18	15%	15%	100%	50%	50%	100%	0%	0%	0%
19	15%	15%	100%	50%	50%	100%	0%	0%	0%
20	15%	15%	100%	50%	50%	100%	0%	0%	0%
21	15%	15%	100%	50%	50%	100%	0%	0%	0%
22	15%	15%	100%	50%	50%	100%	0%	0%	0%
23	15%	15%	100%	50%	50%	0%	0%	0%	0%
24	15%	15%	100%	50%	50%	0%	0%	0%	0%

*Assumes 50% Turndown, lighting power assumption should not account for any control fact

Source: TNZ

Table H.15
OTHER COMMON SCHEDULES

Hour End	HVAC "Occupied"*		Gym HVAC		Auditorium HVAC			Elevator		DHW	
	M-F	Other	M-Fr	Other	M-Th	Fr	Other	M-F	Other	M-F	Other
	1	0	0	0	0	0	0	0	0%	0%	5%
2	0	0	0	0	0	0	0	0%	0%	5%	5%
3	0	0	0	0	0	0	0	0%	0%	5%	5%
4	0	0	0	0	0	0	0	0%	0%	5%	5%
5	0	0	0	0	0	0	0	0%	0%	5%	5%
6	0	0	0	0	0	0	0	0%	0%	5%	5%
7	1	0	1	0	1	1	0	0%	0%	5%	5%
8	1	0	1	0	1	1	0	10%	0%	34%	5%
9	1	0	1	0	1	1	0	10%	0%	60%	5%
10	1	0	1	0	1	1	0	10%	0%	63%	5%
11	1	0	1	0	1	1	0	10%	0%	72%	5%
12	1	0	1	0	1	1	0	10%	0%	79%	5%
13	1	0	1	0	1	1	0	10%	0%	83%	5%
14	1	0	1	0	1	1	0	10%	0%	61%	5%
15	1	0	1	0	1	1	0	10%	0%	65%	5%
16	1	0	1	0	1	1	0	10%	0%	10%	5%
17	0	0	1	0	1	1	0	0%	0%	10%	5%
18	0	0	1	0	0	1	0	0%	0%	5%	5%
19	0	0	1	0	0	1	0	0%	0%	5%	5%
20	0	0	1	0	0	1	0	0%	0%	5%	5%
21	0	0	1	0	0	1	0	0%	0%	5%	5%
22	0	0	1	0	0	1	0	0%	0%	5%	5%
23	0	0	0	0	0	0	0	0%	0%	5%	5%
24	0	0	0	0	0	0	0	0%	0%	5%	5%

*Hours when ventilation for occupancy is active; morning startup begins ahead of these hours.

Table H.16
OTHER COMMON SCHEDULES - Summer & Break Periods

Hour End	HVAC "Occupied"*		Aud & Gym HVAC		Elevator		DHW	
	M-F	Other	M-F	Other	M-F	Other	M-F	Other
	1	0	0	0	0	0%	0%	5%
2	0	0	0	0	0%	0%	5%	5%
3	0	0	0	0	0%	0%	5%	5%
4	0	0	0	0	0%	0%	5%	5%
5	0	0	0	0	0%	0%	5%	5%
6	0	0	0	0	0%	0%	5%	5%
7	1	0	0	0	0%	0%	5%	5%
8	1	0	0	0	5%	0%	34%	5%
9	1	0	0	0	5%	0%	60%	5%
10	1	0	0	0	5%	0%	63%	5%
11	1	0	0	0	5%	0%	72%	5%
12	1	0	0	0	5%	0%	79%	5%
13	1	0	0	0	5%	0%	83%	5%
14	1	0	0	0	5%	0%	61%	5%
15	1	0	0	0	5%	0%	65%	5%
16	1	0	0	0	5%	0%	10%	5%
17	0	0	0	0	0%	0%	10%	5%
18	0	0	0	0	0%	0%	19%	5%
19	0	0	0	0	0%	0%	25%	5%
20	0	0	0	0	0%	0%	22%	5%
21	0	0	0	0	0%	0%	22%	5%
22	0	0	0	0	0%	0%	12%	5%
23	0	0	0	0	0%	0%	5%	5%
24	0	0	0	0	0%	0%	5%	5%

*Hours when ventilation for occupancy is active; morning startup begins ahead of these hours.

Table H.17
HIGH SCHOOL LOAD FACTORS

Occupancy

Ideally, the occupant counts are based on furniture counts
 Otherwise, use the ASHRAE 62.1 default densities

Occupant Heat Loads

Teacher & Admin Spaces, Auditorium: 245 Btu/h/person sensible, 155 Btu/h/person latent
 Student Spaces: 245 Btu/h/person sensible, 200 Btu/h/person latent
 Gymnasium: 500 Btu/h/person sensible, 375 Btu/h/person latent

Lighting → Per design and IECC 2018 Table C405.4.2(2).

Office Equipment & Teach Break Rooms

See direction for office buildings

Classroom Equipment

Develop loads based on actual equipment planned for the space; the following are example average coincident peak values:

Computers	47.5 Watts	Display	19.5 Watts
Soundfield	98.8 Watts	Projector	63.3 Watts
		iPad Cart	183.0 Watts

Cooking & Servery Equipment

Develop peak demand using ASHRAE 2013 Fundamentals Tables 18.5A through 18.5E

Non-Office Equipment

Background miscellaneous loads: 0.2 W/ft² on 24/7 for corridors, stairs, and most support spaces
 IDF/MDF rooms: 4.0 W/ft² on 24/7
 Electrical closets: 0.5 W/ft² on 24/7

Gym and Auditorium Loads

Develop based on process type lighting such as stage lighting and infrequently used game lighting and displays.

Table 1
ELEVATORS

Hour End	Offices			Schools		Hotel/MF	Hospital			Outpatient		
	M-F	Sat	Sun	M-F	Other	All	M-F	Sat	Sun	M-F	Sat	Sun
1	0%	0%	0%	0%	0%	2%	8%	8%	8%	2%	2%	2%
2	0%	0%	0%	0%	0%	2%	8%	8%	8%	2%	2%	2%
3	0%	0%	0%	0%	0%	2%	8%	8%	8%	2%	2%	2%
4	0%	0%	0%	0%	0%	2%	8%	8%	8%	2%	2%	2%
5	0%	0%	0%	0%	0%	4%	8%	8%	8%	2%	2%	2%
6	0%	0%	0%	0%	0%	8%	8%	8%	8%	2%	2%	2%
7	0%	0%	0%	0%	0%	16%	8%	8%	8%	2%	2%	2%
8	14%	6%	0%	0%	0%	20%	20%	16%	8%	20%	16%	2%
9	28%	6%	0%	12%	0%	20%	30%	28%	16%	30%	18%	16%
10	17%	8%	0%	12%	0%	14%	40%	28%	16%	40%	28%	16%
11	15%	7%	0%	12%	0%	6%	40%	28%	16%	40%	28%	16%
12	17%	10%	0%	12%	0%	6%	40%	20%	16%	40%	20%	16%
13	23%	8%	0%	12%	0%	6%	40%	20%	16%	40%	20%	16%
14	19%	5%	0%	12%	0%	6%	40%	20%	16%	40%	20%	16%
15	15%	3%	0%	12%	0%	6%	40%	20%	16%	40%	20%	16%
16	15%	2%	0%	6%	0%	6%	40%	20%	16%	40%	20%	16%
17	18%	2%	0%	0%	0%	14%	40%	20%	8%	40%	20%	16%
18	25%	2%	0%	0%	0%	20%	40%	10%	8%	40%	10%	16%
19	5%	0%	0%	0%	0%	20%	21%	8%	8%	21%	2%	2%
20	2%	0%	0%	0%	0%	16%	21%	8%	8%	21%	2%	2%
21	2%	0%	0%	0%	0%	16%	21%	8%	8%	21%	2%	2%
22	0%	0%	0%	0%	0%	12%	11%	8%	8%	11%	2%	2%
23	0%	0%	0%	0%	0%	8%	8%	8%	8%	2%	2%	2%
24	0%	0%	0%	0%	0%	4%	8%	8%	8%	2%	2%	2%

Source: BC Hydro Modeling Guide

Appendix B: BDL Programming

BDL programming is a powerful tool that can help ensure consistency within a complex model. The most useful functions arise through use of the activity description field. This information is included in these guidelines since BDL programming is not very well described in DOE 2.2 reference manuals and since many energy models suffer from internal inconsistencies.

The following guidelines are recommended when assigning activity descriptions:

- Activity codes need to be at least 4 letters long, and it is recommended that 4-letter codes be used. eQuest only references the first 4 letters in the activity type field.
- When BDL functions are used in user defined default fields, all spaces need to have an activity code.

There are two approaches that can be used: IF/THEN statements and switches. Switches can be more elegant than IF/THEN statements but may also be difficult to use in some fields. The following examples illustrate how BDL functions can be used to accelerate model manipulation:

1. Assign peak load factors based on activity descriptions

```
IF (#L("C-ACTIVITY-DESC") == "OFFC") THEN 0.98 ELSE
IF (#L("C-ACTIVITY-DESC") == "MEET" .OR.
    #L("C-ACTIVITY-DESC") == "CLAS") THEN 1.23 ELSE
no_def
ENDIF ENDIF
```

In this example, lighting power densities are being assigned to space W/ft² fields as a user defined default. Note the use of .OR. to reduce the number of IF statements. Each IF requires an ENDIF. Input fields in eQuest that are blank by default are able to be assigned no_def. Fields that are not blank by default require an input. The code word 'unused' could be used instead of no_def but this locks out the program from automatically populating the field with default values. Some fields require a numerical entry (e.g. window frame width).

An equivalent example of a switch is as follows:

```
switch (#L("C-ACTIVITY-DESC"))
case "OFFC": 0.98
case "MEET": 1.23
case "CLAS": 1.23
default: no_def
endswitch
```

In this methodology, the field defined by switch () is referenced to see what to do when the value of the field matches the listed cases. A default always needs to be defined.

2. Assign load schedules based on activity descriptions

```
IF (#L("C-ACTIVITY-DESC") == "OFFC") THEN
    #SI("LGHT OFFC YR", "SPACE", "LIGHTING-SCHEDUL" ) ELSE
IF (#L("C-ACTIVITY-DESC") == "MEET") THEN
    #SI("LGHT MEET YR", "SPACE", "LIGHTING-SCHEDUL" ) ELSE
IF (#L("C-ACTIVITY-DESC") == "CIRC" .OR.
    #L("C-ACTIVITY-DESC") == "REST") THEN
    #SI("CRS CIRC YR", "SPACE", "LIGHTING-SCHEDUL" ) ELSE
no_def
ENDIF ENDIF ENDIF
```

In this example, user defined schedule names (e.g. LGHT OFFC YR) are being applied to the lighting schedule field. #SI stands for 'symbol index' and is generally used for anything that references non-numeric inputs. The switch version of this is as follows:

```
switch (#L("C-ACTIVITY-DESC"))
  case "OFFC": #SI("LGHT OFFC YR", "SPACE", "LIGHTING-SCHEDUL" )
  case "MEET": #SI("LGHT MEET YR", "SPACE", "LIGHTING-SCHEDUL" )
  case "CIRC": #SI("CRS CIRC YR", "SPACE", "LIGHTING-SCHEDUL" )
  case "REST": #SI("CRS CIRC YR", "SPACE", "LIGHTING-SCHEDUL" )
  default: no_def
endswitch
```

3. Assign window frame characteristics based on glass type

```
IF(#L("GLASS-TYPE") == #SI("CURTAINWALL","WINDOW","GLASS-TYPE"))
THEN #PA("CFRAMEU") ELSE
IF(#L("GLASS-TYPE") == #SI("WINDOWS","WINDOW","GLASS-TYPE"))
THEN #PA("WFRAMEU") ELSE 1.00
ENDIF ENDIF
```

In this example, two different global parameter (designated by #PA) are being assigned to windows based on the glass type. This is a required entry, so no_def cannot be used. Instead, a value of 1.00 is assigned for windows that do not have glass type "curtainwall" or "windows". This same approach can be used to assign frame widths.

This field is an example where the switch approach may not work.

4. Assign zone temperature schedules based on activity description

```
IF (#LR("SPACE","C-ACTIVITY-DESC") == "OFFC" .OR.
  #LR("SPACE","C-ACTIVITY-DESC") == "COMM" .OR.
  #LR("SPACE","C-ACTIVITY-DESC") == "CIRC" .OR.
  #LR("SPACE","C-ACTIVITY-DESC") == "MEET" .OR.
  #LR("SPACE","C-ACTIVITY-DESC") == "STOR") THEN
  #SI("HEAT AHU YR","ZONE","HEAT-TEMP-SCH") ELSE
no_def
ENDIF
```

In this example, zone associated with five different types of space activities are being assigned the same temperature schedule. Referencing space attributes from the zone side of the program requires the use of #LR("SPACE","C-ACTIVITY-DESC"). The switch version is as follows:

```
switch (#L("C-ACTIVITY-DESC"))
  case "OFFC": #SI("HEAT AHU YR", "ZONE", "HEAT-TEMP-SCH")
  case "COMM": #SI("HEAT AHU YR", "ZONE", "HEAT-TEMP-SCH") )
  case "CIRC": #SI("HEAT AHU YR", "ZONE", "HEAT-TEMP-SCH")
  case "MEET": #SI("HEAT AHU YR", "ZONE", "HEAT-TEMP-SCH")
  case "STOR": #SI("HEAT AHU YR", "ZONE", "HEAT-TEMP-SCH")
  default: no_def
endswitch
```

5. Assign system %OA schedules based on fan schedule, including the impact of an ECM switch

```
MIN-AIR-SCH =
{IF(#L("FAN-SCHEDULE")==#SI("A1 F YR","SYSTEM","FAN-SCHEDULE"))
THEN IF(#PA("ECM5_I_ZCDCV")==0) THEN
  #SI("A1 O YR","SYSTEM","MIN-AIR-SCH") ELSE
  #SI("A3 5 YR","SYSTEM","MIN-AIR-SCH") ENDIF ELSE
#SI("A2 O YR","SYSTEM","MIN-AIR-SCH") ENDIF}
```

This approach aligns system-level schedules based on one entered schedule (FAN-SCHEDULE). It also illustrates how global parameters can be used to activate a particular ECM. In this case, the MIN-AIR-SCH is being set for a DOAS zone FCU where the schedules are developed in response to vacancy and degree of occupancy. When the global variable ECM5-I_ZCDCV is 0, then the availability of ventilation air is set by A1 O YR. When the value is something other than 0 (e.g. 1), the schedule changes to A3 5 YR.

6. Assign ASHRAE 62.1 ventilation rates based on space area and number of people, including exclusions for unventilated zones

```
IF(#P("TYPE") = #SI("UHT","SYSTEM","TYPE") .OR.
#P("TYPE") = #SI("PTAC","SYSTEM","TYPE"))
THEN no_def ELSE
switch (#L("C-ACTIVITY-DESC"))
case "CIRC": (#LR("SPACE","AREA")*0.06 + #LR("SPACE","NUMBER-OF-PEOPLE")*0.0) / 0.80
case "CLAS": (#LR("SPACE","AREA")*0.12 + #LR("SPACE","NUMBER-OF-PEOPLE")*10.0) / 0.80
case "CONF": (#LR("SPACE","AREA")*0.06 + #LR("SPACE","NUMBER-OF-PEOPLE")*5.0) / 0.80
case "OFFC": (#LR("SPACE","AREA")*0.06 + #LR("SPACE","NUMBER-OF-PEOPLE")*5.0) / 0.80
endswitch ENDIF
```

In this example, zone ventilation rates (cfm) are being calculated based on space area and the maximum number of people using factors taken from ASHRAE 62.1. If the ventilation rates for zones are not known, this approach is recommended since eQuest only looks at the ventilation rate associated with the peak occupancy rather than both cfm/person and cfm/ft². Both the floor area and the number of people are from the loads side of the program and require the use of #LR. The value of 0.80 is the Ez input from ASHRAE 62.1 Table 6-2 (ceiling supply/ceiling return). There is also an exclusion to not assign fresh air to zones that are served by unit heaters or PTAC units.

7. Change chiller capacity control to reflect the use of a VFD on a centrifugal chiller:

```
switch #PA("CHILLER")
case 1: #SIT("YES","CHILLER","VARIABLE-SPEED",#L("TYPE"))
default: #SIT("NO","CHILLER","VARIABLE-SPEED",#L("TYPE"))
endswitch
```

In this example, a global parameter called CHILLER is used as a switch to activate the use of a VFD on a particular chiller. Some entries, such as chillers and week schedules, require the use of an #SIT schedule rather than an #SI schedule. This generally is the case for DOE 2 entries where the available options are dependent upon the type of item being considered. In this case, there are different chiller models, some of which have VFD capacity control as an option. The expression #L("TYPE") pulls the local chiller type assignment into the expression so a more specific entry does not need to be entered.

8. Change day schedules used in a week schedule:

```
switch #PA("DHW")  
case 1: #SIT("HW RESET DAY - PROP","WEEK-SCHEDULE","DAY-SCHEDULES",#L("TYPE"))  
default: #SIT("HW RESET DAY - BASE","WEEK-SCHEDULE","DAY-SCHEDULES",#L("TYPE"))  
endswitch
```

In this example, a global parameter called DHW is used as a switch to activate the use of a different reset schedule. This is another #SIT example where the #L("TYPE") entry pulls in the type of schedule from the week schedule definition (RESET-TEMP).

9. Automatically set air-cooled unitary equipment EIR value:

```
(1/(0.0000000784 * #PA("RTUEER") * #L("COOLING-CAPACITY") + 0.338 * #PA(RTUEER)))
```

In this example, a global parameter called RTUEER is assumed to be a specific value but it can also be a switch that activates different EER values for different cases per the example below. The underlying expression is taken from ASHRAE 90.1-2016 G3.1.2.1.

```
(1/(0.0000000784 * IF(#PA("ECM7_RTU")==0) THEN 10.4 ELSE 11.5 ENDIF * #L("COOLING-CAPACITY") + 0.338 *  
IF(#PA("ECM7_RTU")==0) THEN 10.4 ELSE 11.5 ENDIF)
```

Appendix C: Guidelines for Core & Shell Buildings

Incentivizing core & shell building is difficult since tenant activities and design choices can significantly impact loads on core building systems. Core & shell labs are a particularly difficult situation. This guideline is developed to provide consistency across projects and to define a methodology that will bracket the likely range of savings that can be expected.

There are five primary sources of uncertainty in core & shell studies:

- Tenant buildout schedules
- Tenant plug and lighting load intensities
- Tenant process ventilation requirements, primarily applies to labs
- Tenant space type distribution and zoning
- Tenant zone system selections

Taking each factor in turn:

1. Tenant buildout schedules may or may not be known. The core & shell model shall assume full tenant occupancy with the target tenant type mix estimated by the owner at the time of final design.
 - a. The modeling report shall include a clearly labeled description of the tenant buildout schedule and tenant type mix as it is understood at the time of the release of the final modeling report.
2. Tenant plug and lighting load intensities drive interior heat gain and overall facility energy use more than any other two end use categories.
 - a. Plug load and lighting intensities used for sizing tenant space conditioning equipment shall be based on the same W/ft² basis used by the HVAC design engineer.
 - b. Lighting power densities used by the design engineer should reflect the maximum allowable LPDs under the code that will govern tenant fitouts. Lighting schedules should assume a value of 1.0 corresponds to the HVAC designer's peak power lighting power density (W/ft²) and all fixtures being active. If the LPDs are based on code, then this approach prevents double-claiming of energy savings should the tenant optimize their lighting design and apply for incentives through a separate application.
 - c. Plug load schedules should assume the design power densities (W/ft²) correspond to a diversity of 1.0. Actual hourly diversity values should be scaled down by the the ratio of actual likely future plug load density to sizing plug load density. This is intended to more accurately capture the tendency for core & shell projects to oversize cooling capacities.
 - i. As an example, a common power density allowance in core & shell office construction is 2.0 W/ft² while a typical office is likely to have full-occupancy power densities closer to 1.5 W/ft². The scaling factor in this case would be $1.5 \div 2.0 = 75\%$. This scaling factor would be applied to all of the hourly load diversities appearing in Appendix A Table O.1.
 - ii. Actual peak power density assumptions can be set at the discretion of the energy modeler but should be substantiated in the report text by stating the assumed maximum occupant density (ft²/occ) and a power demand budget per person (e.g. ASHRAE's estimate of 115 W/occ having a desktop computer and two monitors).
3. Process ventilation loads installed to support tenant activities are generally limited to lab spaces but could also be required for large printing operations in offices. Lab exhaust rates are dominated by background occupied and unoccupied air change requirements, though it is possible for zones with high concentrations of fume hoods

and/or bio safety cabinets to elevate the overall process ventilation rate. The simulation shall assume the following:

- a. For spaces that are to be classified as 'lab' tenants, the tenant space shall be broken into the following space types and distribution.

Space Type	% of Tenant Area
Non-Lab Circulation	15%
Conference Rooms	10%
Laboratories	45%
Offices	25%
Storage & Support	5%

- b. The spaces with process ventilation shall be limited to the laboratory areas. Other areas shall be considered to have standard commercial HVAC characteristics.
 - c. Laboratory ventilation rates shall be assumed to have space ventilation air change rate setback during scheduled unoccupied periods per the schedules in Appendix A for laboratories.
 - i. If no other information is available regarding the characteristics of tenant ventilation requirements, assume 8 ACH during occupied periods and 4 ACH during unoccupied periods.
 - ii. The model shall assume that hood operation does not drive ventilation rates. This will result in lower overall ventilation rates and less aggressive savings for optimization of the core building systems.
4. Tenant space type distribution concerns the mix of potential tenant areas in a typical floor. It is unreasonable to assume 100% office-type occupancy given the need for conference, break, storage, and support spaces. This will impact the lighting and plug loads as well as ventilation rates given the requirement for DCV in conference rooms.
- a. Core spaces for stairs, restrooms, voids, and support rooms included in the core & shell design scope shall be modeled as designed. Multiple similar spaces can be bundled together as an equivalent zone representing the total floor area for that particular space type.
 - b. Tenant spaces shall assume 15 ft deep perimeter zones with separate zones located at corners and along each perimeter.
 - c. Walls in perimeter zones are to be modeled to support daylighting calculations (floor, ceiling, exterior and interior vertical walls).
 - d. Perimeter zones are to be modeled as being separated from interior zones with wall assemblies consisting of 5/8" gypsum drywall, thermally bridged batt insulation, and 5/8" gypsum drywall. The overall assembly U-value shall be $U-0.115 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$ (R-8.7)¹

¹ Based on ASHRAE 90.1-2013 Table A3.3.3.1 for 16" o.c. steel stud walls with R-11 infill batt ($U-0.132 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$) and R-0.56 for each layer of drywall

- e. For spaces that are to be classified as ‘office’ tenants, the tenant space shall be broken into the following space types and distribution. Office spaces shall be modeled as ‘open office’.

Space Type	% of Tenant Area
Break Room	3%
Circulation	10%
Conference Rooms	10%
Offices	60%
Storage & Support	7%

For lab tenants, see the previous table for tenant space use distribution.

- 5. Tenant zone system type can be defined either by the core & shell design or left to the tenants. If the core building design does not include installation of floor-by-floor AHUs, the core & shell energy model shall assume the type of HVAC system that the core building systems are design to support.
 - a. As an example, a core design that provides fresh air, hot water, and chilled water could potentially be used to support 4-pipe FCUs, chilled beams with reheat, or tenant-installed VAV systems. The modeling report shall include a description of the design intent and any limitations that constrain tenant HVAC system options.
 - b. Savings for the core & shell project shall not be claimed for changing tenant level system type.

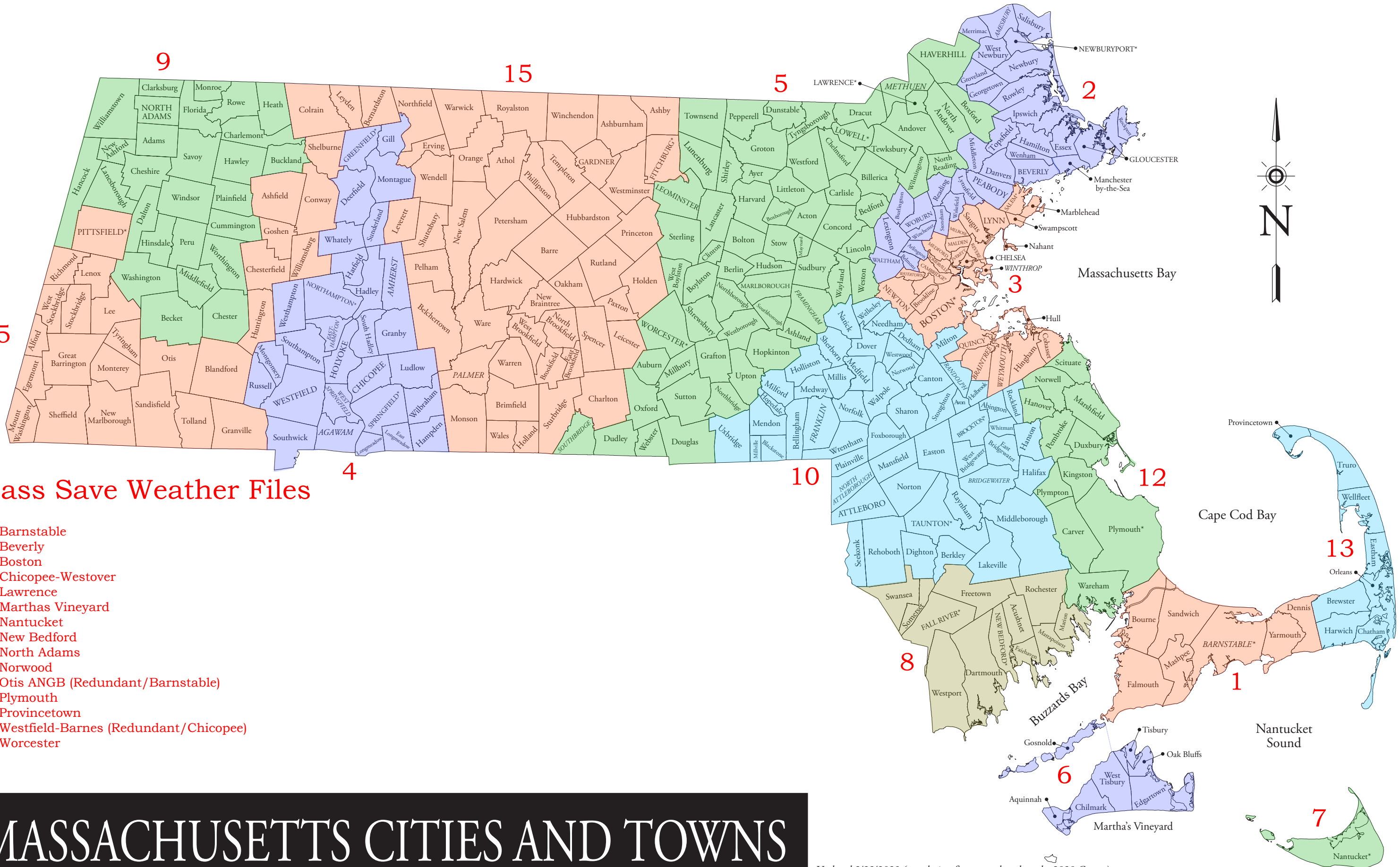
Appendix D: TMYx Weather File Map

Estimating the average year's weather is a challenging task, and energy models seeking to estimate how a building will perform in an average year have used 'Typical Meteorological Year' (TMY) files. While any one year may have anomalous months, a TMY file is composed of months from different years that represent the average month for a range of at least 12 years. The first standardized TMY files were developed for 229 locations using data gathered between 1948 and 1980. TMY2 files are the next generation and were developed for 239 locations using data gathered from 1961 and 1990. TMY3 files were developed for 1,020 locations and used data from 1976-2005 data. As the climate has shifted, the standard TMY files are less likely to reliably predict energy consumption in the near and intermediate future.

Mass Save has chosen to use a set of observations gathered from 2007 to 2021 for fifteen airports located in Massachusetts. These files can be downloaded from the following link: <https://www.masssavedata.com/public/home>. Go to the 'Technical Reference Manual' (TRM) link in the upper right corner and use the link in the middle of the page to access the eTRM portal. Once in the portal, click on the three horizontal bars in the upper left corner to access 'Supporting Documents'. There you will find a folder with the TMYx files. The data is in .bin, .xlsx, and .epw formats.

The attached map has been developed to provide guidance regarding which of the TMYx weather files to use for each town. The pages that follow provide background regarding how the boundaries were selected. Weather in central and western Massachusetts is heavily influenced by altitude, and the topographic map helps determine how to delineate which communities are in the microclimate of the Pioneer Valley versus the elevated central plateau typical of western Worcester County. Much of the climate is similar in eastern Massachusetts but observations are apportioned relative to the various data sources. Massachusetts is neither a large state or subject to significant elevation differences, but the weather in Harwich is certainly different than in Natick or Petersham. The TMYx files seek to capture these differences.

Note that the TMYx files have not been warped to predict future climate patterns. It is unclear how long the 2007 to 2021 window will be a reasonable estimate of our climate in southern New England. At some point the TMYx files will be updated again.



Mass Save Weather Files

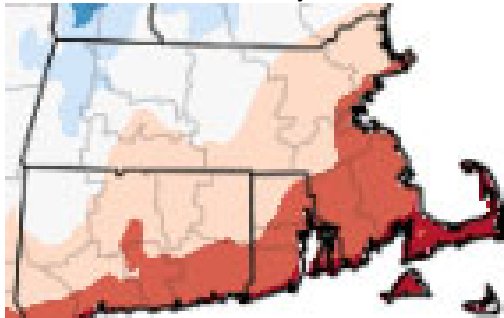
1. Barnstable
2. Beverly
3. Boston
4. Chicopee-Westover
5. Lawrence
6. Marthas Vineyard
7. Nantucket
8. New Bedford
9. North Adams
10. Norwood
11. Otis ANGB (Redundant/Barnstable)
12. Plymouth
13. Provincetown
14. Westfield-Barnes (Redundant/Chicopee)
15. Worcester

MASSACHUSETTS CITIES AND TOWNS

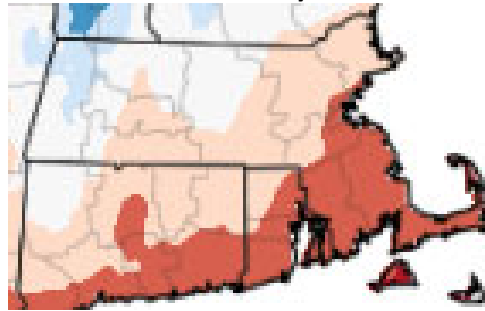
Updated 2/22/2023 (population figures are based on the 2020 Census)

NRCC.Cornell.edu Northeast Regional Climate Center – Normal Average Temperatures 1991-2020

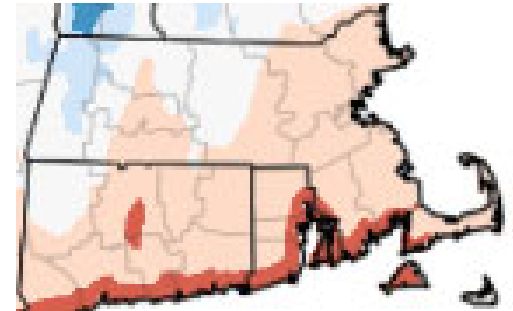
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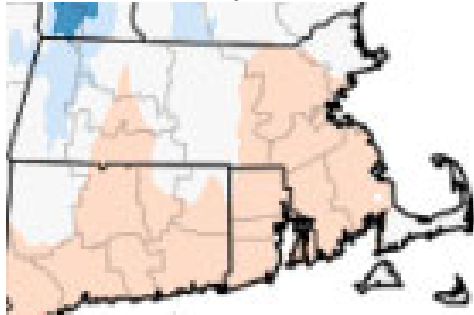
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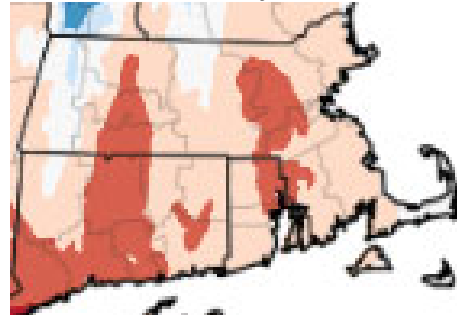
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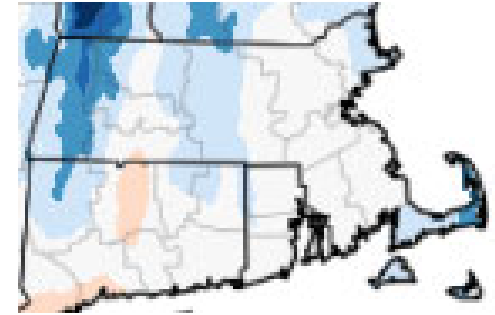
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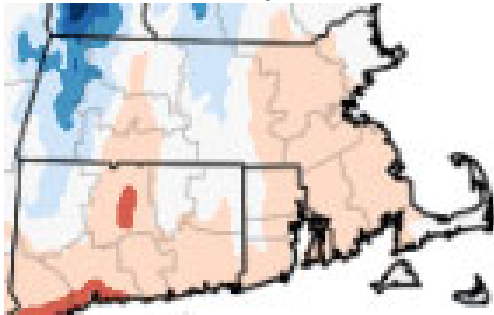
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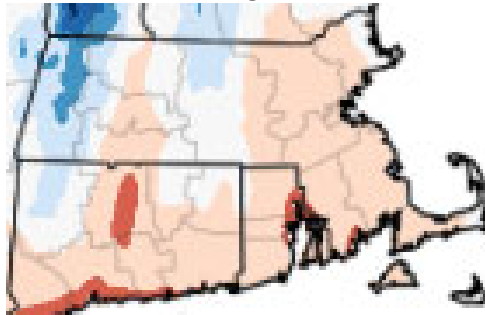
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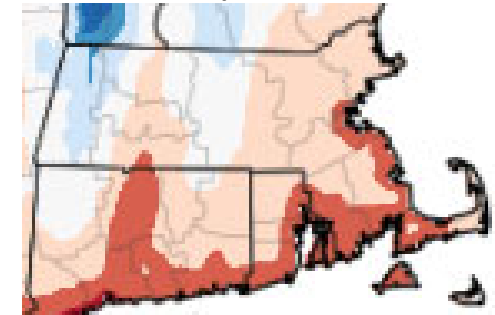
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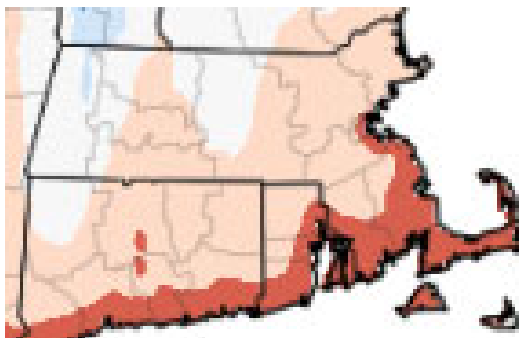
August



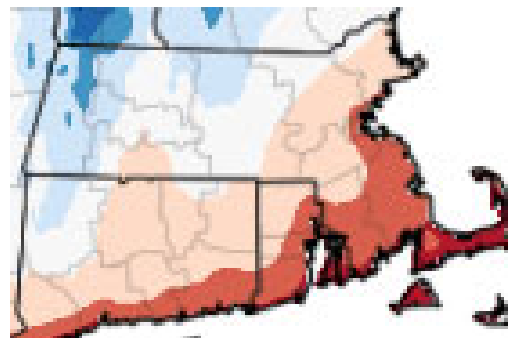
September



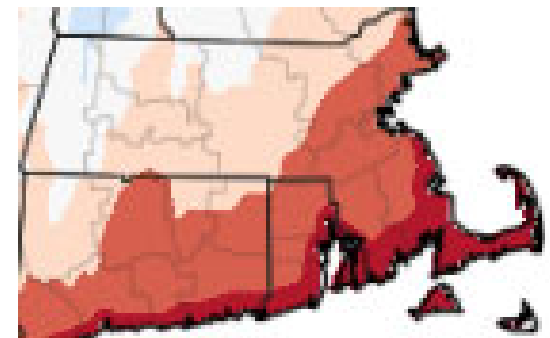
October



November



December



Massachusetts Topography

