COMNET
Commercial Energy Services Network
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3 Software Requirements

This chapter contains the software requirements that must be implemented by COMNET accredited software. The tests fall into the following categories:

- Tests to verify that the software is evaluating thermal loads and the response of the HVAC systems to these loads in a manner that is acceptable. These tests reference *ASHRAE Standard 140-2007*, *Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs*.
- Tests to verify that the candidate building or the proposed design is modeled with the correct fixed and restricted inputs, including schedules of operation, receptacle loads, process loads and other components.
- Tests to verify that the baseline building is created correctly, e.g. that the baseline HVAC system is properly specified and that other components of the baseline are correctly defined.

3.1 General Requirements

3.1.1 Scope

The *Rating Software* must satisfy the requirements contained in this section.

The *Rating Software* shall be capable of modeling at least 50 *thermal blocks*.

The *Rating Software* shall be capable of modeling at least 15 separate HVAC systems.

3.1.2 Calculation Methods

The *Rating Software* shall calculate the annual consumption of all end uses in buildings, including fuel and electricity for:

- HVAC (heating, cooling, fans, and ventilation);
- Lighting (both interior and exterior);
- Receptacles and miscellaneous electric;
- Service water heating;
- Process energy uses;
- Commercial refrigeration systems; and
- All other energy end uses that typically pass through the building meter.

The *Rating Software* shall perform a simulation on an hourly time interval (at a minimum) over a one year period (8760 hours) with the ability to model changes in weather parameters, schedules, and other parameters for each hour of the year. This is typically achieved by specifying a 24-hour schedule for each day of the week plus holidays.

Calculating Design Loads

The software shall be capable of performing design load calculations for determining required HVAC equipment capacities and air and water flow rates using accepted industry calculation methods for both the proposed design and baseline building design.

Checking Simulation Output for Unmet Loads

The software shall be capable of checking the output of the energy analysis module for the proposed design to ensure that space conditions are maintained within the tolerances specified (maximum of 300 unmet load hours per year).

Adjusting Capacities

For the baseline building (when applicable), the software shall be capable of modifying capacities, temperatures or flow rates for baseline building HVAC system components resulting in excessive unmet loads hours meeting the criteria, following the procedures in Chapter 2.

Error Handling

The software shall identify error conditions when unmet loads fail to meet the criteria, prevent completion of the rating analysis, and provide information to the user describing the error that has occurred and what steps the user should take to remedy the situation.

3.1.3 Climate Data

The *Rating Software* shall perform simulations using hourly values of climate data, such as temperature and humidity, derived from WYEC (Weather Year for Energy Calculation), TMY (Typical Meteorological Year) or CWEC (Canadian Weather for Energy Calculations) climate data.

The *Rating Software* shall calculate solar radiation on exterior surfaces on an hourly basis from the values of direct normal irradiance and diffuse horizontal irradiance contained in the climate data, taking ground reflectance into account.

3.1.4 Utility Rates

The *Rating Software* shall be capable of simulating time-of-use rates and apply both demand and energy charges for each time period of the rate schedule.

3.1.5 Thermal Mass

The calculation procedures used in the *Rating Software* shall account for the effect of thermal mass on: loads due to occupants, lights, solar radiation, and transmission through building envelope; amount of heating and cooling required to maintain the specified space temperature schedules; and variation in space temperature.

3.1.6 Modeling Space Temperature

The *Rating Software* shall contain a dynamic simulation of space temperature which accounts for:

- Dynamics in change in heating and cooling setpoint temperatures;
- Deadband between heating and cooling thermostat settings;
- Temperature drift in transition to setback or setup thermostat schedules;
- Temperature drift in periods when heating or cooling capability are scheduled off;
- Temperature drift when heating or cooling capability of the system is limited by heating or cooling capacity, air flow rate, or scheduled supply air temperature; and
- Indirectly conditioned *thermal blocks*, where the temperature is determined by internal loads, heat transfer through building envelope, and heat transfer between *thermal blocks*.

3.1.7 Heat Transfer between Thermal Blocks

The *Rating Software* shall be capable of modeling heat transfer between a *thermal block* and adjacent *thermal blocks*.

The *Rating Software* shall account for the effect of this heat transfer on the space temperature, space conditioning loads, and resulting energy use in the *thermal block* and in the adjacent *thermal blocks*.

3.1.8 Control and Operating Schedules

The *Rating Software* shall be capable of modeling control and operating schedules which can vary by:

- The hour of the day;
- The day of the week; and
- Holidays treated as a special day of the week.

The *Rating Software* shall be capable of explicitly modeling all of the schedules specified in Appendix C of this manual.

3.1.9 Loads Calculation

The loads calculations described in this section relate to the simulation engine and not to the procedure used the design engineer to size and select equipment.

Internal Loads

The *Rating Software* shall be capable of calculating the hourly cooling loads due to occupants, lights, receptacles, and process loads.

The calculation of internal loads shall account for the dynamic effects of thermal mass.

The *Rating Software* shall be capable of simulating schedules for internal loads in the form given in Appendix C.

The simulation of cooling load due to lights shall account for:

- The effect of the proportion radiant and convective heat, which depends on the type of light, on the dynamic response characteristic; and
- A portion of heat from lights going directly to return air, the amount depending on the type and location of fixture.

Building Envelope Loads

The *Rating Software* shall calculate heat transfer through walls, roofs and floors for each *thermal block*, accounting for the dynamic response due to thermal characteristics of the particular construction as defined in the *Building Descriptors* in Chapter 6.

The calculation of heat transfer through walls and roofs shall account for the effect of solar radiation absorbed on the exterior surface, which depends on orientation, reflectance and emittance of the surface.

The *Rating Software* shall calculate heat transfer through windows and skylights, accounting for both temperature difference and transmission of solar radiation through the glazing.

Calculation of cooling load due to transmission of solar radiation through windows and skylights shall account for:

- The angular incidence of the direct beam sunlight and the angular and spectral dependence of the solar properties.
- Orientation (azimuth and tilt of surface).
- The effect of shading from overhangs side fins, louvers or neighboring buildings or terrain.

Infiltration

The *Rating Software* shall be capable of simulating infiltration that varies by the time of day and day of the week.

3.1.10 Systems Simulation

General

The *Rating Software* shall be capable of modeling:

- The baseline building systems defined in Chapter 6,
- The lighting, water heating, HVAC and miscellaneous equipment detailed in Chapter 6
- All compulsory and required features as listed in Appendix A and detailed in Chapter 6
- The capability to model multiple zone systems serving at least 15 *thermal blocks*.

The *Rating Software* shall be capable of modeling plenum air return.

Terminal Characteristics

The *Rating Software* shall be capable of simulating the effect on space temperature and energy use of:

- Limited capacity of terminal heating devices;
- Limited capacity of terminal cooling devices; and
- Limited rate of air flow to *thermal blocks*.

HVAC Systems and Equipment

The *Rating Software* shall be capable of simulating the effect on energy use and space temperature in *thermal blocks* served by the HVAC system, including:

- Limited heating capacity of an HVAC system;
- Limited cooling capacity of an HVAC system;

- Temperature rise of supply air due to heat from supply fan, depending on the location of the fan;
- Temperature rise of return air due to heat from return fan;
- Temperature rise of return air due to heat from lights to return air stream; and
- Fan power as a function of supply air flow in variable air volume systems.

Central Plant Systems and Equipment

The *Rating Software* shall be capable of simulating the effect on energy use of limited heating or cooling capacity of the central plant system.

If the *Rating Software* is not capable of simulating the effect of limited heating or cooling capacity of the central plant system on space temperature in *thermal blocks* dependent on the central plant system for heating and cooling, then it shall issue a warning message when loads on the central plant system are not met.

Equipment Performance Curves

The Rating Software shall be capable of modeling the part load efficiency and variation in capacity of equipment as follows:

- Furnaces as a function of part load;
- Boilers as a function of part load, supply hot water temperature, and return hot water temperature;
- Water-cooled compressors including heat pumps and chillers as a function of part load, evaporator fluid, or air temperature and condensing fluid temperature;
- Air-cooled compressors including heat pumps, direct expansion cooling and chillers as a function of part load, ambient dry-bulb temperature, and wet-bulb temperature returning to the cooling coil;
- Evaporative cooling systems as a function of ambient wet-bulb temperature; and
- Cooling towers as a function of range, approach and ambient wet-bulb temperature.

Economizer Control

The *Rating Software* shall be capable of modeling integrated air- and water-side economizers.

The *Rating Software* shall be capable of modeling electronic enthalpy air-side economizer controls that vary the high limit as a function of both temperature and enthalpy.

Air Side Heat-Recovery

The Rating Software shall be capable of modeling heat recovery between the exhaust air stream and the outside air stream. The software shall account for auxiliary energy uses associated with heat recovery systems, including pumping energy, frost control, and system control.

Heat-Recovery Water Heating

The *Rating Software* shall be capable of modeling heat recovery water heating from the following sources:

- Double bundled chiller;
- Refrigerant desuperheater as part of a packaged HVAC unit;
- Heat exchanger on the condenser water loop; and
- Heat-recovery water-to-water heat pump operating off of the condenser or chilled water loop.

Heat-Pump Water Heaters

The *Rating Software* shall be capable of modeling heat-pump water heaters. The algorithm must allow the evaporator coil to be located in:

- Any thermal block;
- Any plenum; and
- Outside.

3.1.11 Managing User Input

This section addresses the processes of data entry and the validation of user input data that can be performed prior to and independent of the energy simulation.

Building Descriptor Inputs and Restrictions

Building descriptors are discussed in Chapter 6 and listed in tabular form in Appendix A. Building descriptors are classified in one of several ways:

- **Reference**. Information that does not affect the energy rating results, such as the name of the architect, the address of the building, or rating authority applications numbers.
- **Trigger**. A building descriptor that turns on or turns off the applicability of other building descriptors. An example is the daylight modeling method.
- **Asset**. Information about the rated building that does affect the results such as insulation levels, window construction or equipment efficiency.
- **Special Asset**. Information about the rated building that is considered an asset, but requires special documentation of performance. Examples include reduced infiltration or credit for natural ventilation.
- **Neutral Dependent**. Information that is the same for both the rated building and the baseline building. The baseline building assumes the same conditions specified for the rated buildings. Examples are schedules of operation, temperature settings, etc. For purposes that do not use a modeled baseline building, such as Design to Earn ENERGY STAR, the designation of “neutral dependent” means that the rating

use a modeled baseline building, such as Design to Earn ENERGY STAR, the designation of "neutral dependent" means that the rating process attempts to neutralize for this variable.
- **Use-or-Lose**. This is a special case of a neutral dependent classification except that baseline value has a floor or ceiling. An example is retail display lighting whereby the baseline building is equal to the rated building up to a maximum power limit. When the rated building value is within an acceptable range, the use-or-lose" variable is neutral dependent. When the value for the rated building is outside the acceptable range, the building descriptor is an asset.
- **Neutral Independent**. Information that is the same for both the rated building and the baseline building, but is prescribed. Examples are schedules of operation when the purpose is federal tax credits.
- **Defaults** are provided for many building descriptors. A common default is provided for convenience and may be overridden by the user with no special documentation. However, when a default is provided for a special asset, the value must be used unless special documentation is provided.

Building descriptors may also be classified by the **level of software support** that is required: compulsory, required, optional, and unsanctioned. Compulsory inputs must always be supported by the software and specified by the user. Required inputs shall be supported by the rating software but they may not be applicable for all ratings. Optional inputs are addressed in this anual and restrictions may apply, but it is up to the software vendor as to whether the inputs are supported. Unsanctioned inputs are inputs that are not addressed in this manual; these are not listed in Appendix A or discussed in Chapter 6.

Restrictions may apply to all compulsory and required inputs. Appendix A specifies the compulsory building descriptors. Examples of compulsory inputs are climate zone, floor area, and space-by-space classification. If the software provides a means for the user to input building descriptors listed as optional in Appendix A, all input conditions and restrictions shall apply.

The software user interface shall: 1) clearly indicate when a building descriptor has an associated default, 2) indicate what the default value is, and 3) provide a convenient means for the user to over-ride the default. When default values for special assets are overridden, the software interface shall notify the user that documentation is required.

For neutral independent building descriptors, the software is not required to provide a means for users to enter data since the software will automatically assign the prescribed value. However, if the user is permitted to input values for prescribed inputs, the software must inform the user that a prescribed value and not the value input by the user will be used in calculating the rating.

No restrictions are specified for unsanctioned inputs. If the software uses unsanctioned inputs, the software documentation or help system shall specify the applicability of the building descriptors, its definition, the units in which it is expressed, restrictions on input for the proposed design, and, if applicable, how the building descriptor is defined for the baseline building.

The software may assist the user in describing the proposed design by displaying typical values for building descriptors, provided deliberate action by the user is necessary before a displayed value is used.

Data Validation

Compulsory Input Checks

The software shall check to ensure that valid entries have been made for all compulsory building descriptors before the user is permitted to proceed with the next step in the rating process.

Handling of Missing Inputs

If a required input is missing or invalid, the software shall: 1) notify the user that the input is missing or invalid, 2) identify the input field(s) with missing or invalid data, and 3) prevent the user from moving to the next step of the rating process. The software may provide additional information designed to help the user correct the deficiency.

Validity Checks

The software shall check all user inputs to ensure that the following conditions are met:

- *Simulation Tool Limits.* Inputs do not exceed the minimums or maximums for the parameters permitted by the simulation engine.
- *Rating Rule Limits.* Inputs do not exceed minimums or maximums for the descriptors specified in Chapter 6 of this document.
- S*imulation Tool Discrete Options.* Inputs correspond with valid discrete or list options for parameters available in the simulation engine.
- *Rating Rule Discrete Options.* Inputs correspond with valid discrete options provided for in Chapter 6.

Handling Invalid Input

When invalid data is entered, the software shall: 1) notify the user of the invalid input, 2) identify the nonconforming input field, and 3) prevent execution of the next step of the rating process; i.e., generating the input description for the proposed design. The software may provide additional information designed to help the user correct the deficiency.

Consistency Checks

The consistency checks described above are intended to identify errors and oversights in user input and thereby help ensure that the building description is complete and interpretable by the energy analysis program. Examples of consistency checks include making sure that total window description is complete and interpretable by the energy analysis program. Examples of consistency checks include making sure that total window area does not exceed the wall area in which they are contained and that the necessary plant equipment has actually been connected to the secondary HVAC systems. The software may include additional consistency checks provided these are clearly documented in the user documentation or on-line help system.

Handling Inconsistent Input

If the proposed design fails a consistency check, the software shall: 1) notify the user that an inconsistency exists, 2) identify the specific consistency check that has been failed, 3) identify the inconsistent input fields, if feasible, and 4) prevent execution of the next step of the rating process; i.e., generating the input description for the proposed design. The software may provide additional information designed to help the user correct the deficiency.

3.2 ASHRAE Standard 140-2007 Tests

This method of testing is provided for analyzing and diagnosing building energy simulation software using software-to-software and software-to-quasi-analytical-solution comparisons. The methodology allows different building energy simulation programs, representing different degrees of modeling complexity, to be tested by comparing the predictions from other building energy programs to the simulation results provided by the Rating Software in question.

The specifications for determining input values, the weather data required and an overview for all the test cases containing information on those building parameters that change from case to case is provided in the Standard 140-2007 documentation. The cases are grouped as:

- Building Thermal Envelope and Fabric Load Base Case
- Building Thermal Envelope and Fabric Load Basic Tests
  - Low mass
  - High mass
  - Free float
- Building Thermal Envelope and Fabric Load In-Depth Tests
- Space-Cooling Equipment Performance Analytical Verification Base Case
- Space-Cooling Equipment Performance Parameter Variation Analytical Verification Tests
- Space-Cooling Equipment Performance Comparative Test Base Case
- Space-Cooling Equipment Performance Comparative Tests
- Space-Heating Equipment Performance Analytical Verification Base Case
- Space-Heating Equipment Performance Analytical Verification Tests
- Space-Heating Equipment Performance Comparative Tests

COMNET software is required to perform the ASHRAE Standard 140-2007 suite of software tests and the results of these tests shall conform to the COMNET acceptance requirements. All tests shall be completed in accord with the requirements of ASHRAE Standard 140-2007. The resulting estimates of energy consumption shall fall between the minimum and maximum values established by COMNET, unless a valid explanation is provided. The portfolio folder for Appendix E contains spreadsheets wherein the software vendor enters the results of the Standard 140 simulations for comparison against the criteria. When results from candidate software fall outside the COMNET acceptance range or when candidate software is unable to perform one of the tests, the vendor shall provide an explanation of the reason as per ASHRAE Standard 140-2007 requirements. The portfolio folder for Appendix E also contains a methodology paper that describes how the acceptance criteria were developed.

3.2.1 Using the Spreadsheets

Four spreadsheets are provided in Appendix E for documenting results from candidate software and comparing to the COMNET acceptance ranges. These parallel the spreadsheets provided with ASHRAE Standard 140-2007. For each of the spreadsheets, the fields where data is entered are shaded pale yellow. The tabs where data is entered and where results are reviewed are shown in Table 3.2.1-1 [1].

Table 3.2.1-1: *"Spreadsheets for Verifying Standard 140 Tests"*

Spreadsheet	Enter Data on Tab	Check Results on Tab
COMNET Acceptance Range Results 5-2.xls	A	A
COMNET Acceptance Range Results 5-3A.xls	YD	A
COMNET Acceptance Range Results 5-3B.xls	YD	Q
COMNET Acceptance Range Results 5-4.xls	YD	Q

3.3 Modeling Assumptions and Baseline Building Tests

The previous suite of tests, based on ASHRAE Standard 140-2007, verifies that the simulation engine produces results that are reasonable. Each test requires a simulation to be run. The tests in this section are intended to verify that the software correctly constructs the proposed design and baseline buildings and correctly applies the proposed design input restrictions specified in Chapter 6 and Appendix A.

The simulations described in this section use five prototype buildings. Prototypes A1, A3 and A20 are all the same five-zone, 150 ft x 150 ft, floor plate, but with one, three and 20 stories. Prototypes B1 and C1 are five-zone, one-story, square prototype buildings measuring 200 ft x 200 ft and 400 ft x 400 ft respectively. Prototype D is a more complex, mixed use building with a below-grade garage, retail on the first level, office space on levels two and three, and four stories of multi-family housing over the office. Figure 3.3-1 [2] is an image of all of the prototype buildings, positioned next to each other. Appendix E has a Google Sketchup file with the detailed geometry for each of the prototypes. Appendix E also has a spreadsheet with tabular detail on each of the prototype buildings along with forms for the software vendor to complete.

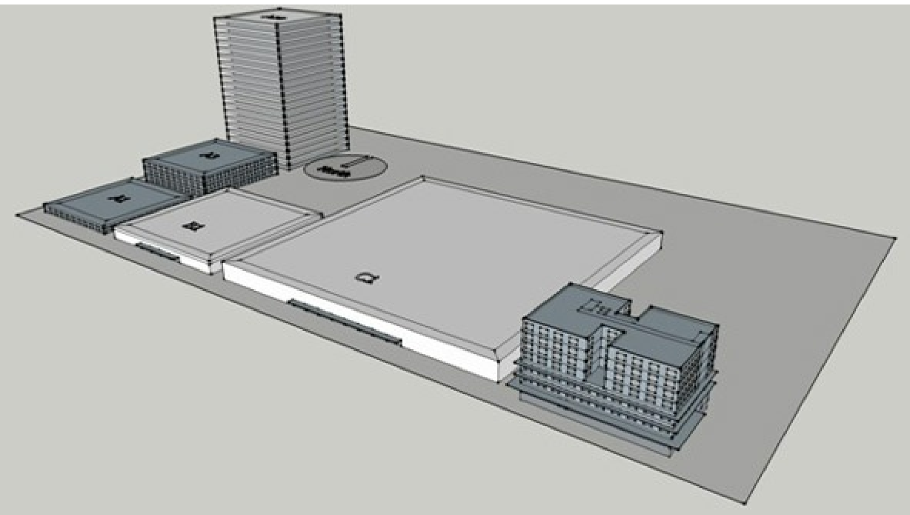

Figure 3.3-1: *"Prototype Buildings for Modeling Assumptions and Baseline Building Tests"*

Evaluation of the modeling assumptions and baseline building tests is **qualitative**. The software developer shall use the candidate software and make the simulations described in this section for the proposed design and the baseline building. The input and output files for each of these cases shall then be evaluated by the software developer to verify that:

- Default schedules of operation are applied for both the baseline building and the proposed design.
- The baseline building use the correct system types as prescribed in Chapter 6.
- An economizer (of the right type) is included in the baseline building if required.
- The primary and secondary baseline building systems are properly specified and sized.
- Fan brake horsepower is correctly specified for the baseline building.
- The baseline building is correctly rotated and the equipment is re-sized for each rotation.
- The baseline building envelope constructions are correctly substituted for exterior opaque surfaces, partitions and fenestration.
- Fenestration area in the baseline building is reduced, when the proposed design fenestration area is greater than the limit.
- The baseline building lighting system is correctly specified and that exterior lighting is modeled.
- Receptacle loads, refrigeration equipment and other equipment is modeled according to the rules in this manual.
- Prescribed modeling assumptions are applied for both the baseline building and the proposed design.
- Elevators in Prototypes A20 and D are included.
- Overhangs are modeled in the proposed design for Prototype D but not the baseline building.
- The models make a reasonable estimate of unmet load hours.
- Unconditioned spaces are modeled.
- Other baseline building specifications and/or modeling assumptions are correctly applied.

As the software developer verifies the above and other conditions, the input and output files should be annotated with comments (or by some other means) to demonstrate that the modeling rules specified in Chapter 6 and Appendix A are correctly applied. Software developers should use the output format spreadsheets, included in Appendix E, to report the results of these tests. These annotated files are then submitted to COMNET for further evaluation. Any errors discovered shall be corrected by making modifications to the software; the simulations shall be repeated; and the new results shall be annotated for submittal to COMNET.

3.3.1 Summary of Required Simulations

Separate rating analyses are required for each purpose. Runs 1 through 20 are required when software is accredited for green building ratings that use ASHRAE Standard 90.1-2007 as the baseline. Runs 21 through 29 are required for tax credits that use ASHRAE Standard 90.1-2001 as the baseline. See Table 3.3.1-1 [3]. Runs 30 through 49 are required when software is accredited for green building ratings that use ASHRAE Standard 90.1-2010 as the baseline.

Table 3.3.1-1: *"Summary of Analyses for Modeling Assumptions and Baseline Building Tests"*

Run	Purpose	Prototype	Climate	Occupancy Option	Lighting Power Density (W/ft²)	Equipment Power Density (W/ft²)	HVAC System	Default Schedules
1	Points07	A1	Chicago	Office	1.00	1.00	PSZ-AC	Yes
2	Points07	A1	Chicago	Office	1.20	1.50	PSZ-HP	No
3	Points07	A1	Chicago	Office	1.40	2.00	PVAV	No

4	Points07	A1	Denver	Office	1.00	1.00	PSZ-AC	Yes
5	Points07	A1	Miami	Office	1.00	1.00	PSZ-AC	Yes
6	Points07	A3	Chicago	Office	1.00	1.00	PVAV	Yes
7	Points07	A3	Denver	Office	1.00	1.00	PVAV	Yes
8	Points07	A3	Miami	Office	1.00	1.00	PVAV	Yes
9	Points07	A20	Chicago	Office	1.00	1.00	VAV	Yes
10	Points07	A20	Denver	Office	1.00	1.00	VAV	Yes
11	Points07	A20	Miami	Office	1.00	1.00	VAV	Yes
12	Points07	B1	Chicago	Supermarket	2.10	0.20	PSZ-AC	Yes
13	Points07	B1	Denver	Retail	1.90	0.90	PSZ-AC	Yes
14	Points07	B1	Miami	Manufacturing	1.30	1.00	PSZ-HP	Yes
15	Points07	C1	Chicago	Retail	1.50	0.90	PSZ-AC	Yes
16	Points07	C1	Denver	Warehouse	0.80	0.40	PSZ-AC	Yes
17	Points07	C1	Miami	Manufacturing	1.30	1.00	PSZ-HP	Yes
18	Points07	D	Chicago	See detail	See detail	See detail	See detail	Yes
19	Points07	D	Denver	See detail	See detail	See detail	See detail	Yes
20	Points07	D	Miami	See detail	See detail	See detail	See detail	Yes
21	Tax	A1	Chicago	Office	1.00	1.00	PSZ-AC	Yes
22	Tax	A1	Denver	Office	1.00	1.00	PSZ-AC	Yes
23	Tax	A1	Miami	Office	1.00	1.00	PSZ-AC	Yes
24	Tax	B1	Chicago	Supermarket	2.10	0.20	PSZ-AC	Yes
25	Tax	B1	Denver	Retail	1.90	0.90	PSZ-AC	Yes
26	Tax	B1	Miami	Manufacturing	1.30	1.00	PSZ-HP	Yes
27	Tax	D	Chicago	See detail	See detail	See detail	See detail	Yes
28	Tax	D	Denver	See detail	See detail	See detail	See detail	Yes
29	Tax	D	Miami	See detail	See detail	See detail	See detail	Yes
30	Points10	A1	Chicago	Office	1.00	1.00	PSZ-AC	Yes
31	Points10	A1	Chicago	Office	1.20	1.50	PSZ-HP	No
32	Points10	A1	Chicago	Office	1.40	2.00	PVAV	No
33	Points10	A1	Denver	Office	1.00	1.00	PSZ-AC	Yes
34	Points10	A1	Miami	Office	1.00	1.00	PSZ-AC	Yes
35	Points10	A3	Chicago	Office	1.00	1.00	PVAV	Yes
36	Points10	A3	Denver	Office	1.00	1.00	PVAV	Yes
37	Points10	A3	Miami	Office	1.00	1.00	PVAV	Yes
38	Points10	A20	Chicago	Office	1.00	1.00	VAV	Yes
39	Points10	A20	Denver	Office	1.00	1.00	VAV	Yes
40	Points10	A20	Miami	Office	1.00	1.00	VAV	Yes
41	Points10	B1	Chicago	Supermarket	2.10	0.20	PSZ-AC	Yes
42	Points10	B1	Denver	Retail	1.90	0.90	PSZ-AC	Yes
43	Points10	B1	Miami	Manufacturing	1.30	1.00	PSZ-HP	Yes
44	Points10	C1	Chicago	Retail	1.50	0.90	PSZ-AC	Yes
45	Points10	C1	Denver	Warehouse	0.80	0.40	PSZ-AC	Yes
46	Points10	C1	Miami	Manufacturing	1.30	1.00	PSZ-HP	Yes
47	Points10	D	Chicago	See detail	See detail	See detail	See detail	Yes
48	Points10	D	Denver	See detail	See detail	See detail	See detail	Yes
49	Points10	D	Miami	See detail	See detail	See detail	See detail	Yes

3.3.2 Prototypes A1, A3 and A20

Prototypes A1, A3 and A20 are all office buildings. They have the same 150 ft by 150 ft floor plate with a simple 15 ft perimeter zone. The main difference between the prototypes is the number of stores. A1 is a single story, A3 has three stories and A20 has twenty stories.

All three prototypes have a 12 floor-to-floor height and a plenum with a height of 3 ft 6 in. Ceiling height is 8 ft 6 in. Prototypes A1 and A3 have a window wall ratio of 31%; fenestration consists of 10 ft by 5 ft 6 in. windows spaced around the perimeter at 15 ft. Prototype A20 has a window-wall-ratio of 71% with floor-to-ceiling glass on all sides. Figure 3.3.2-1 [4] is a visual image of the three prototype buildings.

Prototype A1 is a wood framed building while prototypes A3 and A20 are steel framed.

Detailed specifications for each of the prototype building models are presented in spreadsheets included in Portfolio Appendix E.

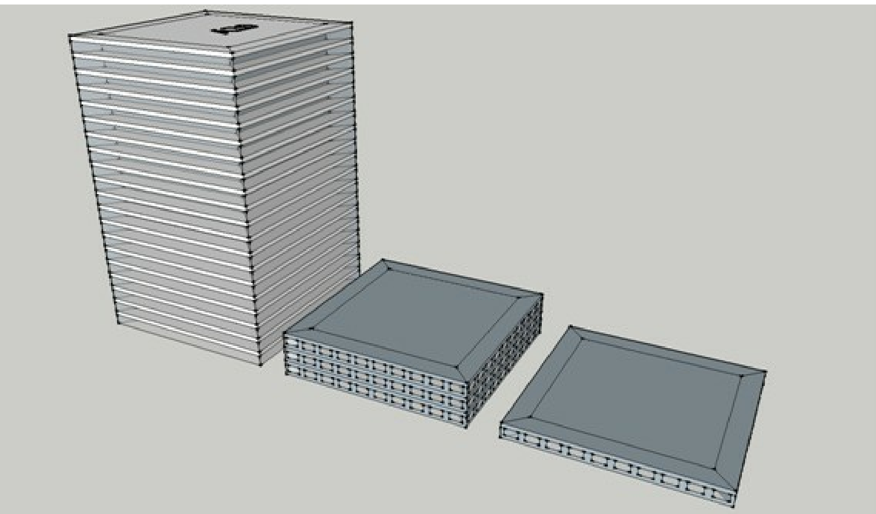

Figure 3.3.2-1: *"Prototypes A1, A3 and A20"*

3.3.3 Prototypes B1 and C1

Prototypes B1 and C1 are both single story, large floor plate buildings. Prototype B1 measures 200 ft x 200 ft with an 18 ft height and a 4 ft plenum. Prototype C1 measures 400 ft x 400 ft with a 24 ft height and no plenum. Figure 3.3.3-1 [5] is a visual image of the two prototypes. Prototypes B1 and C1 each have fenestration on just one side. Prototype B1 has a store front glazing system that is 8 ft high by 80 ft wide. Prototype C1 has a store front glazing system that is 8 ft high by 160 ft wide. Both curtain wall systems have an horizontal overhang located at the top of the glazing that extends a distance of 8 ft. Both prototypes have mass walls (8 inch solid grouted CMU blocks, interior insulation and gypsum board). Detailed specifications for each of the prototype building models are presented in spreadsheets included in Appendix E.

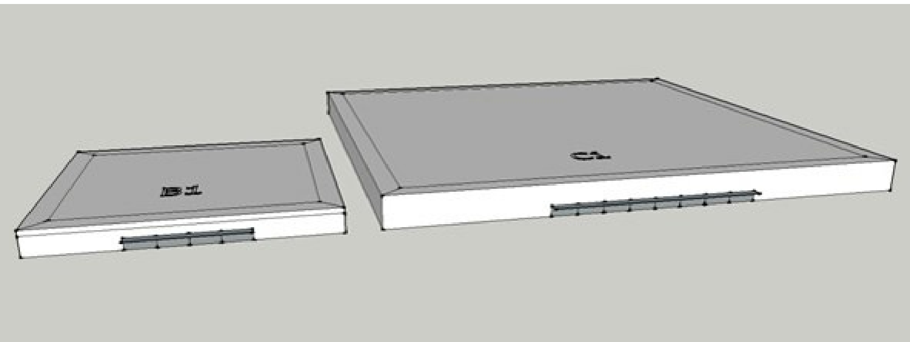

Figure 3.3.3-1: *"Prototypes B1 and C1"*

3.3.4 Prototype D

Prototype D is a mixed use building with a clear specification. Prototype D is the case study building used in the User's Manual for ASHRAE Standard 90.1-2007 to demonstrate the use of the Performance Rating Method (PRM). The building has seven above-ground stories and an underground garage. The building's footprint is 150 ft x 90 ft with the long axis oriented due east-west. The first floor contains retail spaces with large display windows that have overhangs projecting 10 ft on the south, east, and west exposures. The second and third floors contain offices that have similarly oriented overhangs, although the overhangs project only 5 ft. Above the offices are apartments on floors four through seven. To provide more daylight and fresh air, the four floors of apartments have two 20 ft x 30 ft notches taken out of the floor plan; therefore, these levels have 1,200 ft² less floor area than floors one, two, and three. The building also has an unconditioned stairwell.

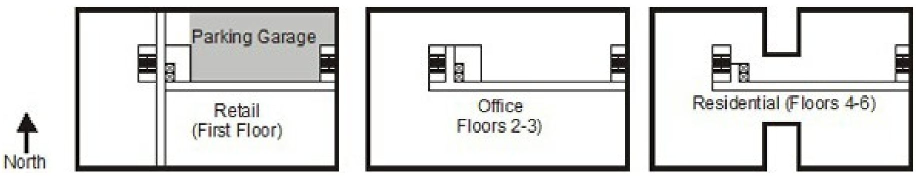

Figure 3.3.4-1: *"Prototype D Floor Plans"*

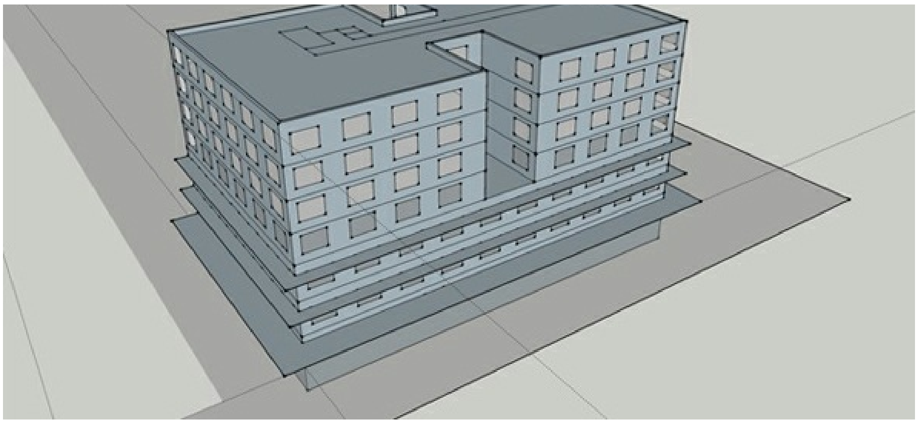

Figure 3.3.4-2: *"Prototype D Exterior View"*

Prototype D is a steel-framed building with steel stud walls with R-7 insulation in the cavities and ⅝ in. sheetrock. The windows are single glazed with clear glass in all areas except the offices, which have single-pane windows with gray glass. All windows have thermally broken metal frames. Only the windows on the residential levels are operable.

A fluorescent electric lighting system is used throughout the commercial sections of the building. Lighting power density is 1.38 W/ft² in retail areas, 1.16 W/ft² in office areas, 0.25 W/ft² in the underground parking, and 0.5 W/ft² in stairwells. The perimeter zones of the office have automatic daylight dimming controls.

Retail spaces are served by a four-pipe fan coil system so that they can be independently shut down if the stores' operating hours differ significantly. A variable air volume (VAV) air-handling system served by the same centrifugal chiller and a boiler provides space conditioning in the office levels. The apartments are heated and cooled by four-pipe fan coil systems, which are also served by the chiller and boiler. The underground parking is ventilated during retail business hours.

A 160-ton, chiller with a rating of 0.6 kW/ton and a 2,250,000 Btu/h boiler serve all of the heating and cooling loads in the building.

Table 3.3.4-1: *"Prototype D Surface Areas"*

Space Category	Orientation	Wall Area	Window Area	Window-Wall-Ratio	Proposed U-Value/SHGC
	North	6,600	1,202		
Residential	Non-North	30,360	5,389		1.22/0.82
		36,960	6,591	18%	1.22/0.82
Residential total					
Nonresidential					
Retail	North	1,600	534		
Office	North	3,200	1,000		1.22/0.82
Retail	Non	4,293	2,920		1.22/0.43
Office		8,587	2,054		1.22/0.82
Nonresidential total		17,680	6,508	37%	1.22/0.43

Table 3.3.4-2: *"Prototype D Lighting and Equipment Power"*

		Lighting Power		Equipment Power	
Area Description	Area	Watts	W/ft^2	Watts	W/ft^2
Parking	15,700	3,925	0.25	4,710	0.30
Retail	11,300	15,594	1.38	16,950	1.50
Office	27,000	31,320	1.16	27,000	1.00
Apartment Units	43,600	71,940	1.65	71,940	1.65
Multi-family hallway	5,600	4,480	0.80	3,920	0.70
Totals	103,200	127,258	1.23	124,520	1.21

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