PHIUS+ 2018 Passive Building Standard – North America

Pilot Phase Documentation

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PHIUS+ 2018: Getting to Zero

In 2014, under a grant from the U.S. Department of Energy (DOE), and in partnership with Building Science Corporation, PHIUS developed PHIUS+ 2015—the first and only climate specific passive building standard. The 2015 standard accounted not only for substantial differences between climate zones, but also for market and other variables, retaining rigorous conservation goals, while making passive building more rational and cost effective. PHIUS+ 2015 helped dramatically accelerate adoption.

PHIUS recognized that technologies, market conditions, carbon reduction goals and even climates could change over time. Consequently, PHIUS committed to revising the standard to reflect such changes. PHIUS+ 2018 is the first updated revision, and it will be phased in through 2018 and will eventually replace PHIUS+ 2015. This update focuses on adding more nuance for different building types, and supporting an overall transition to renewable energy.

What's the same:

PHIUS+ 2018 remains a pass/fail passive building standard, serving as an update to replace PHIUS+ 2015. It remains a "performance-based" energy standard that includes prescriptive quality assurance requirements adopted from U.S. government programs - Energy Star, Zero Energy Ready Home, and EPA Indoor airPLUS.

The standard has three pillars, or marquee-level requirements

- Limits on heating/cooling loads (both peak and annual)
- Limit on overall source energy use
- Air-tightness and other prescriptive quality assurance requirements

PHIUS+ 2015 recognized that there are diminishing returns on investment in energy-conserving measures, and an optimum level in a life-cycle cost sense. Climate plays a large role in determining where that point is. For PHIUS+ 2015, researchers studied optimization in 110 cities, and developed interpolation formulas to set heating and cooling (space-conditioning) energy targets for 1000+ cities across the US and Canada. The same criteria applied to buildings of all sizes.

What's the same:

The *overall* energy limit under PHIUS+ 2018 is based on *source* energy, rather than *site* energy, as it is a better proxy for resource consumption and emissions associated with the site's energy use. The source energy limit is not set based on cost optimization, but rather on the 'fair share' of carbon emissions allowed for each sector. To limit global warming with some certainty, emissions must go to zero overall and the energy system must go to 100% renewable.

New in PHIUS+ 2018:

Under the pilot release of PHIUS+ 2018, the space-conditioning targets are less granular in terms of climate - they are instead set zone-by-zone, using the 17-climate-zone system referenced in the International Energy Conservation Code (IECC).

New in PHIUS+ 2018:

Because size and occupant density influence the optimal path to a low energy building, the new criteria implement continuous adjustments for a range of different building sizes and occupant densities.

For example: A 2,000 sf single-family home does not have the same optimal space conditioning energy performance targets as a 200,000 sf tower, even if they have the same occupant density. That's because the two have different envelope-to-floor area ratios. Conservation improvements are generally applied to the envelope, but ventilation effects follow occupancy and floor area, and performance targets are set per square foot of floor area. This means that two side-by-side 10,000 sf buildings, in the same location, with different occupant densities will have slightly different space conditioning targets.

The space conditioning criteria result from optimizing based on upgrade costs vs. savings in operational energy, and guide building energy planners accordingly. (As with PHIUS+2015, the optimization studies include some forced upgrades, notably on air-sealing and windows, but window costs have come down considerably in the past few years, and designers still have flexibility to meet the resulting performance targets in different ways.)

New in PHIUS+ 2018:

In PHIUS+ 2018, the source energy criterion is tightened, with a view toward zero, but there are more options for meeting it. There is no cap on total source energy use, as long as the predicted 'annual net source energy' use meets the new (lower) target. This 'net' source energy use is the remaining source energy use, after what is offset by qualified renewable energy measures, on-site and off-site.

Previously, off-site renewable energy was not accounted for, and only a fraction of on-site renewable energy was counted to offset source energy use (exports did not count.) However, in tapering the source energy limit to zero, it is unproductive to put the entire burden on the building and its on-site production potential. Doing so may push past the point of diminishing returns in energy conservation, or prohibit projects with constrained sites from ever achieving this goal. At some point, the building has conserved and generated all it can, and the focus will shift to cleaning up the energy supply.

Therefore, off-site options such as Virtual Power Purchase Agreements, community renewables, directly owned off-site, and renewable energy credits are valid measures of offsetting a project's source energy use under PHIUS+ 2018.

PHIUS+ 2018 is intended to guide designers toward a cost-effective investment in building envelope and other passive measures, while giving a wide range of options for the "must-do" job of contributing to an overall transition to renewable energy.

The pilot program of PHIUS+ 2018 is intended to assess how the new performance requirements fit for a variety of projects. The climate and occupant sensitivity may be revisited and refined for the final program.

PHIUS+2018 pilot phase - changes from 2015

Public comment is particularly encouraged on items highlighted in green.

Certification criteria

Heating and cooling

- The climate sensitivity is less granular - it changes from continuous to zone-by-zone, using the 17 climates of the ASHRAE 169 / IECC system. (Continuous sensitivity to climate factors may be restored for the final 2018 protocol.)
- The criteria are adjusted for building size and occupant density. The adjustments are continuous within a limited range. The sensitivities are different for each of the four criteria, in each climate zone. See the summary table at the end of this document for examples and this **Space Conditioning Criteria Estimation Tool** to estimate project criteria.
- The project's exact criteria are based on Envelope Area to Floor Area ratio:

'Envelope / iCFA' is the building's exterior envelope area divided by the interior conditioned floor area. The building envelope area and floor area must be in the same units. The envelope area can be calculated manually or found in your WUFI Passive model under the results report or visualized components branch. 'Square feet per person' must be calculated using total occupancy divided by iCFA (interior conditioned floor area).
Space Conditioning Criteria Calculator

- As before, the same targets generally apply to both residential and non-residential buildings.
- For unique non-residential buildings with significant process loads, very high internal loads, or highly variable occupancy, custom optimization may be needed to determine the appropriate targets. This will be done on a case-by-case basis using BEopt. An additional certification fee will apply.
- Exception: For the pilot phase only, certification staff has discretion to grant an exception on one of the five main performance criteria (heating/cooling or source energy).

Total energy use

- The certification limit is reduced from 6200 to 3840 kWh/p for residential, and from 38.1 to 34.8 kBtu/ft2 for non-residential.
  - This is intended to taper to zero in years to come, with downward revisions on a three year cycle, the next coming in 2021. The zero year is not yet decided.
- There is a change to the source energy metric. It is now calculated as the *net of* annual on-site *and* off-site renewable production.
  - All of the predicted annual onsite-renewable electricity generation is now regarded as offsetting source energy use, not just the fraction used right away or stored and used on-site.
- Some arrangements for procuring off-site renewable energy are now also regarded as offsetting the source energy use, as follows:
  - Directly-owned off-site renewables.
  - Community renewable energy.
  - Virtual Power Purchase Agreements.
  - Green-E Certified Renewable Energy Certificates (RECs), discounted 80%, that is, each 1 kWh purchased offsets 0.2 kWh.
- The building owner must present an actual contract for procurement of renewable energy,

sufficient to meet the target (at time of certification), for 20 years.

- The source energy multiplier for grid electricity is aligned with Energy Star Portfolio Manager - 3.14 for USA, 2.05 for Canada.
    - This factor is also intended to be rechecked every three years.
- Projects that are off-grid for indoor water supply and for wastewater treatment have a process load allowance of 800 kWh/p.yr for residential projects, 14 kWh/kgal for non-residential (half that if a project is off-grid for water supply only or wastewater treatment only.) (PHIUS Hot Water Calculator v1.1.xlsx)

Quality assurance

- The air-tightness certification limit for most buildings is increased from 0.05 to 0.06 cfm50 per ft2 of envelope. (The criterion for tall buildings of noncombustible construction remains the same.)
- The requirement that the ventilation system is capable of 0.3 ACH is removed.
- Canada projects are exempt from the Indoor airPLUS materials checklist requirements.
- Initial protocol for commissioning of nonresidential buildings is focused on energy use impacts:
    - Infiltration testing.
    - Ventilation balancing and wattage measurement.
    - Ducted heating/cooling balancing.
    - Verification of envelope, air barrier, thermal bridge mitigation, and shading - built to plans.
    - Verification of lighting, mechanical, and process load systems per plans/energy model.

Energy modeling protocol

- Building energy models must be submitted in WUFI® Passive, using a version which supports the new solar shading algorithm.
- The requirement that the ventilation system is modeled at a minimum of 0.3 ACH is removed. (Supply per person and exhaust-room minimums still apply, per Certification Guidebook section 6.7.)
- If a cooling system is planned, no natural ventilation cooling is to be included in the model.

- The following changes to the calculation protocol for hot water energy use are implemented in a new accessory calculator workbook:
  - Calculation support for meeting EPA Watersense delivery time requirement.
  - Revised pipe heat loss calculation scales more realistically to larger buildings.
  - Alignment with RESNET on low-flow fixture credit, drain water heat recovery, washer/dryer/dishwasher energy calculations, and monthly cold water inlet temperature variation.

PHIUS+ 2018, target-setting process for heating and cooling

As for PHIUS+ 2015, the basic process for setting the heating and cooling criteria was:

1. Life-cycle cost optimization: Model study buildings in BEopt, giving its optimizer various energy-saving upgrades to weigh.
2. Crossover: Model the study buildings again in WUFI® Passive, with the chosen upgrade packages. This is necessary to tune the criteria to the calculation methods actually used in project certification.
3. Statistical smoothing: Note the resulting annual demands and peak loads for heating and cooling and do curve-fitting on that data to find interpolation formulas. Those formulas then determine the criteria for all cases.

For 2018, there were five different study buildings:

- a small 24x25 foot two-story house of about 1000 square feet floor area
- a typical 26x40 foot two-story house of about 1800 sf, and
- three apartment buildings - all 152x56 foot, but in 4,6, and 10 story versions, up to about 82000 sf.

In terms of size and window-to-wall ratio, the large apartments correspond to the US DOE Commercial Prototype buildings for Mid-rise and High-rise Apartment.

Each of these five geometries was set up for three different occupant densities, corresponding as closely as possible to 235, 370, and 875 square feet per person, making for a total of 15 "base buildings" in BEopt. In some cases the density was adjusted by changing the number of bedrooms per unit, and in some cases by changing the number of units per floor.

By default, BEopt runs its dynamic simulations according to Building America House Simulation

Protocol. Some global overrides were applied to align with PHIUS modeling protocol, such as the heating and cooling setpoint temperatures, and the lighting, plug load, and hot water usage assumptions. Some significant energy-saving upgrades were also imposed - ducts inside, stringent air-sealing, and window U-values low enough to keep their inside surface temperature within 4°C (7.2F) of the indoor air, at a winter extreme condition (12-hour mean minimum outdoor temperature.)

PV generation was essentially excluded from the calculation; that is, the optimization looked only at the diminishing returns behavior of the conservation measures, both envelope and HVAC. Each of the 15 base buildings was optimized in the 17 representative cities for the climate zones (which are also listed on the DOE Commercial Prototype Buildings website), for a total of 255 individual cases studied.

To choose the upgrade package, the optimal, minimum life-cycle cost point was chosen for all cases, rather than manually choosing a point of diminishing returns on the cost curve as before.

In the first round of the crossover study, the 255 optimized buildings were re-modeled in WUFI® Passive, adding only a few effects from PHIUS protocol that BEopt neglects, such as window installation thermal bridge coefficients, and corridor ventilation.

After review by the Tech Committee, some additional adjustments were made to the WUFI® Passive models in two areas where correspondence with BEopt was deemed most problematic: natural ventilation was removed, and "perimeter" type foundation insulation was replaced with thin whole-slab insulation. Also, air-sealing was further tightened and IECC 2015 code minimums were consistently imposed for the main assemblies (floor, wall, roof).

In the curve-fitting, each of the four criteria was fitted to a *nonlinear* but *piecewise-continuous* function of the Envelope-to-Floor-area ratio. The function has three pieces - covering the two small buildings, the three large buildings, and in-between. The sensitivity to occupancy is modeled as an additive (superimposed) effect, but it can act differently in each of the three "size" ranges of Envelope-to-Floor-area ratio. This was done separately for each climate zone, for a total of 4x17=68 fittings. The model formula has <u>ten</u> adjustable parameters and there are <u>fifteen</u> data points per zone, thus 15 minus 10 = <u>five</u> "degrees of freedom for estimation of error," in statistics jargon. In more familiar terms, what's been done statistically is *similar* to fitting a *straight line* through *three* data points, for each of the four heating/cooling criteria, in each climate zone, though in fact some nonlinear (quadratic) effects are captured.

	Building Size (ft2)	2,000			5,000			10,000			20,000			50,000			100,000			200,000		
	Occupancy	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low
	Occupancy (ft2/person)	235	450	875	235	450	875	235	450	875	235	450	875	235	450	875	235	450	875	235	450	875
1A	Heating Demand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cooling Demand	37.5	31.2	29.0	30.3	25.4	22.8	28.9	24.0	21.5	27.7	22.9	20.3	26.6	21.7	19.1	25.8	21.0	18.4	28.3	23.7	21.6
	Heating Load	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cooling Load	6.0	5.2	4.9	4.4	3.9	3.6	4.0	3.4	3.2	3.6	3.1	2.8	3.2	2.7	2.4	3.0	2.4	2.2	3.3	2.8	2.6
1B	Heating Demand	0.4	0.5	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cooling Demand	45.5	40.3	38.9	36.2	31.1	28.3	33.3	28.1	25.4	30.9	25.8	23.0	28.4	23.2	20.5	26.8	21.7	19.0	29.6	24.3	22.1
	Heating Load	2.3	2.1	2.1	1.6	1.4	1.3	1.3	1.1	1.0	1.1	0.9	0.8	0.8	0.6	0.5	0.6	0.5	0.4	0.5	0.4	0.3
	Cooling Load	10.6	9.8	9.6	8.1	7.3	6.9	7.2	6.4	5.9	6.4	5.6	5.1	5.6	4.7	4.3	5.1	4.2	3.8	5.5	4.7	4.4
2A	Heating Demand	3.0	3.2	3.4	2.6	2.5	2.4	2.0	1.9	1.8	1.5	1.4	1.3	0.9	0.8	0.7	0.6	0.5	0.4	0.0	0.0	0.0
	Cooling Demand	23.5	18.7	18.3	18.4	15.5	13.9	17.7	14.7	13.2	17.1	14.1	12.6	16.4	13.5	11.9	16.0	13.1	11.5	19.7	16.4	14.8
	Heating Load	5.4	4.9	4.9	4.3	3.8	3.5	3.6	3.1	2.9	3.1	2.6	2.3	2.5	2.0	1.8	2.1	1.7	1.4	1.3	1.1	0.9
	Cooling Load	6.0	5.2	5.1	4.7	4.2	3.9	4.2	3.7	3.4	3.8	3.3	3.0	3.4	2.9	2.6	3.2	2.6	2.3	3.4	2.9	2.7
2B	Heating Demand	1.2	1.2	1.4	0.9	0.9	0.9	0.6	0.6	0.6	0.4	0.4	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	Cooling Demand	34.0	29.6	28.8	28.9	24.0	21.3	26.5	21.6	19.0	24.6	19.6	17.0	22.5	17.6	15.0	21.3	16.4	13.7	22.7	19.4	18.0
	Heating Load	3.3	2.9	2.9	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.4	1.3	1.2	1.0	0.9	0.9	0.7	0.6	0.8	0.6	0.5
	Cooling Load	9.4	8.4	8.3	7.2	6.6	6.2	6.4	5.7	5.3	5.6	5.0	4.6	4.9	4.2	3.8	4.4	3.7	3.4	4.8	4.2	3.9
3A	Heating Demand	7.0	5.8	6.2	4.3	4.3	4.4	3.2	3.3	3.3	2.4	2.5	2.5	1.5	1.6	1.6	0.9	1.0	1.1	0.4	0.5	0.5
	Cooling Demand	17.9	17.0	15.4	14.6	12.1	10.9	14.0	11.6	10.3	13.6	11.2	9.9	13.2	10.7	9.4	12.9	10.5	9.2	15.2	12.3	10.5
	Heating Load	7.0	5.7	5.7	5.0	4.4	4.2	4.2	3.7	3.4	3.6	3.1	2.8	3.0	2.5	2.2	2.6	2.1	1.8	2.2	1.8	1.7
	Cooling Load	4.8	4.5	2.9	3.4	2.8	2.5	3.3	2.7	2.4	3.1	2.6	2.3	3.0	2.5	2.2	3.0	2.4	2.1	3.2	2.7	2.5
3B	Heating Demand	4.5	5.0	5.3	3.9	4.1	4.1	2.9	3.0	3.1	2.1	2.2	2.3	1.2	1.3	1.4	0.6	0.8	0.8	0.3	0.3	0.3
	Cooling Demand	17.8	14.9	14.3	13.4	11.4	10.4	12.8	10.8	9.7	12.3	10.3	9.2	11.7	9.7	8.7	11.4	9.4	8.4	14.3	12.2	11.3
	Heating Load	4.5	4.3	4.3	3.8	3.5	3.4	3.2	2.9	2.7	2.6	2.4	2.2	2.1	1.8	1.6	1.8	1.5	1.3	1.5	1.2	1.0
	Cooling Load	6.1	5.5	5.4	4.8	4.3	4.0	4.3	3.8	3.5	3.9	3.3	3.1	3.4	2.9	2.6	3.2	2.6	2.4	3.6	3.1	2.9
3C	Heating Demand	6.7	7.0	6.9	4.2	4.3	4.3	3.1	3.2	3.3	2.2	2.3	2.4	1.3	1.4	1.5	0.8	0.9	0.9	0.3	0.4	0.4
	Cooling Demand	3.0	2.0	1.8	2.6	1.4	0.9	2.7	1.6	1.0	2.8	1.7	1.1	3.0	1.9	1.3	3.1	1.9	1.3	4.9	3.4	2.9
	Heating Load	3.2	2.9	2.8	2.4	2.1	2.0	2.1	1.8	1.7	1.8	1.5	1.4	1.5	1.2	1.1	1.3	1.1	0.9	0.9	0.8	0.7
	Cooling Load	0.2	-0.1	0.0	0.5	0.2	0.1	0.7	0.4	0.2	0.8	0.5	0.4	0.9	0.7	0.5	1.0	0.8	0.6	1.4	1.1	1.0
4A	Heating Demand	5.9	7.6	7.4	7.3	6.9	6.7	5.8	5.4	5.2	4.6	4.2	4.0	3.3	2.9	2.7	2.5	2.2	2.0	1.6	1.6	1.7
	Cooling Demand	12.6	9.6	9.5	8.5	7.4	6.8	8.3	7.2	6.7	8.2	7.1	6.5	8.0	7.0	6.4	8.0	6.9	6.3	9.8	8.3	7.5
	Heating Load	6.2	6.2	6.1	5.7	5.1	4.8	4.9	4.2	3.9	4.2	3.5	3.2	3.4	2.8	2.4	2.9	2.3	2.0	2.7	2.2	2.0
	Cooling Load	5.2	4.4	4.4	3.8	3.4	3.2	3.4	3.0	2.8	3.1	2.7	2.5	2.8	2.4	2.1	2.6	2.2	1.9	2.9	2.5	2.3
4B	Heating Demand	5.8	5.6	5.6	5.9	5.7	5.6	4.8	4.6	4.5	3.9	3.7	3.6	2.9	2.7	2.6	2.3	2.1	2.0	1.3	1.2	1.3
	Cooling Demand	12.2	9.8	9.2	7.9	6.7	6.0	7.4	6.2	5.6	7.1	5.8	5.2	6.7	5.5	4.8	6.5	5.2	4.6	8.9	7.3	6.4
	Heating Load	5.8	5.3	5.2	4.9	4.4	4.2	4.1	3.7	3.4	3.5	3.1	2.8	2.9	2.4	2.2	2.5	2.1	1.8	2.3	1.9	1.7
	Cooling Load	5.0	4.3	4.2	3.5	3.1	2.9	3.2	2.8	2.6	2.9	2.5	2.3	2.6	2.2	2.0	2.4	2.0	1.8	2.8	2.4	2.2
4C	Heating Demand	9.8	9.0	8.5	5.4	5.7	5.9	4.2	4.6	4.7	3.2	3.6	3.8	2.2	2.6	2.8	1.6	2.0	2.2	1.2	1.2	1.4
	Cooling Demand	5.1	4.1	4.2	4.6	3.5	2.9	4.5	3.4	2.8	4.5	3.4	2.8	4.4	3.3	2.7	4.4	3.2	2.6	5.6	4.9	4.2
	Heating Load	7.6	6.5	6.1	5.1	4.7	4.4	4.4	4.0	3.7	3.9	3.4	3.2	3.3	2.8	2.6	2.9	2.5	2.2	2.8	2.3	2.1
	Cooling Load	3.8	3.4	3.5	3.1	2.7	2.5	2.9	2.5	2.2	2.6	2.2	2.0	2.4	2.0	1.7	2.2	1.8	1.6	2.6	2.3	2.1
5A	Heating Demand	9.5	9.7	9.3	7.6	7.2	7.0	6.2	5.8	5.6	5.0	4.6	4.4	3.8	3.4	3.2	3.1	2.7	2.5	2.3	2.0	2.1
	Cooling Demand	9.4	7.7	7.5	7.0	6.1	5.6	7.1	6.2	5.7	7.2	6.3	5.8	7.3	6.4	5.9	7.4	6.4	6.0	9.6	8.3	8.0
	Heating Load	6.7	6.0	5.8	5.5	4.7	4.3	4.8	4.0	3.6	4.2	3.4	3.0	3.6	2.8	2.4	3.2	2.5	2.1	3.0	2.4	2.2
	Cooling Load	4.9	4.3	4.2	3.7	3.2	3.0	3.4	2.9	2.7	3.1	2.7	2.5	2.9	2.4	2.2	2.7	2.3	2.1	3.3	2.8	2.7
5B	Heating Demand	9.6	8.8	9.1	6.6	6.5	6.5	5.3	5.2	5.2	4.3	4.2	4.1	3.2	3.1	3.0	2.5	2.4	2.4	1.4	1.6	1.8
	Cooling Demand	9.7	7.9	7.4	5.8	5.3	5.1	5.7	5.3	5.1	5.7	5.3	5.1	5.7	5.3	5.0	5.7	5.3	5.0	8.2	6.8	5.9
	Heating Load	7.4	6.3	6.2	5.5	4.9	4.6	4.8	4.2	3.8	4.2	3.6	3.2	3.5	2.9	2.6	3.2	2.5	2.2	2.7	2.4	2.2
	Cooling Load	5.3	4.6	4.4	3.5	3.3	3.2	3.2	3.0	2.9	2.9	2.7	2.6	2.6	2.4	2.3	2.5	2.3	2.2	2.9	2.6	2.3
5C	Heating Demand	11.2	11.1	11.0	7.9	8.2	8.4	6.1	6.5	6.6	4.7	5.0	5.2	3.1	3.5	3.6	2.2	2.5	2.7	1.8	2.0	2.2
	Cooling Demand	4.5	3.3	3.2	3.1	2.3	1.9	3.2	2.4	2.0	3.3	2.5	2.0	3.3	2.5	2.1	3.4	2.6	2.1	4.7	3.8	3.3
	Heating Load	7.6	7.0	6.8	5.6	5.2	5.0	4.7	4.3	4.1	4.0	3.5	3.3	3.2	2.7	2.5	2.7	2.3	2.0	2.7	2.4	2.2
	Cooling Load	2.9	2.4	2.4	2.2	1.8	1.7	2.0	1.7	1.5	1.9	1.6	1.4	1.8	1.4	1.3	1.7	1.4	1.2	2.1	1.8	1.6

	Building Size (ft2)	2,000			5,000			10,000			20,000			50,000			100,000			200,000		
	Occupancy	**High**	**Med**	**Low**	**High**	**Med**	**Low**	**High**	**Med**	**Low**	**High**	**Med**	**Low**	**High**	**Med**	**Low**	**High**	**Med**	**Low**	**High**	**Med**	**Low**
	Occupancy (ft2/person)	**235**	**450**	**875**	**235**	**450**	**875**	**235**	**450**	**875**	**235**	**450**	**875**	**235**	**450**	**875**	**235**	**450**	**875**	**235**	**450**	**875**
6A	**Heating Demand**	8.4	8.3	7.3	6.4	5.9	5.7	5.6	5.1	4.8	4.8	4.3	4.1	4.1	3.6	3.3	3.6	3.1	2.9	3.0	2.6	2.5
	Cooling Demand	7.0	5.4	5.1	4.3	3.7	3.4	4.5	3.9	3.6	4.7	4.1	3.8	4.9	4.3	3.9	5.0	4.4	4.0	6.3	5.8	5.5
	Heating Load	6.5	5.7	5.2	5.4	4.5	4.0	4.8	4.0	3.5	4.4	3.5	3.1	3.9	3.1	2.6	3.7	2.8	2.3	3.5	2.8	2.4
	Cooling Load	4.4	3.9	3.7	3.3	2.9	2.6	3.0	2.6	2.3	2.8	2.3	2.1	2.5	2.1	1.8	2.4	1.9	1.7	2.7	2.4	2.2
6B	**Heating Demand**	11.8	11.3	13.3	8.9	8.4	8.1	7.4	6.9	6.6	6.1	5.6	5.3	4.8	4.2	4.0	4.0	3.4	3.2	3.2	2.8	2.8
	Cooling Demand	4.7	3.9	2.6	4.0	3.2	2.8	4.0	3.2	2.8	4.1	3.2	2.8	4.1	3.2	2.8	4.1	3.3	2.8	5.5	4.8	4.3
	Heating Load	7.9	7.3	7.7	6.4	5.6	5.1	5.5	4.7	4.3	4.8	4.0	3.5	4.1	3.2	2.8	3.6	2.8	2.3	3.5	2.8	2.5
	Cooling Load	2.9	2.6	2.2	2.4	2.1	1.9	2.3	1.9	1.7	2.1	1.8	1.6	2.0	1.6	1.5	1.9	1.5	1.4	2.3	2.0	1.9
7	**Heating Demand**	11.4	10.3	9.6	7.3	7.0	6.9	6.2	5.9	5.7	5.2	4.9	4.8	4.2	3.9	3.8	3.6	3.3	3.2	3.2	2.9	2.7
	Cooling Demand	5.0	4.0	3.4	3.5	2.9	2.6	4.0	3.4	3.1	4.4	3.8	3.5	4.8	4.2	3.9	5.1	4.5	4.2	7.3	6.4	6.3
	Heating Load	7.4	6.3	6.0	5.5	4.8	4.4	4.9	4.1	3.7	4.3	3.6	3.2	3.8	3.0	2.6	3.4	2.7	2.3	3.4	2.7	2.3
	Cooling Load	3.8	3.3	3.1	2.8	2.4	2.2	2.7	2.3	2.1	2.5	2.2	2.0	2.4	2.0	1.8	2.4	2.0	1.8	2.9	2.6	2.4
8	**Heating Demand**	19.7	19.7	20.8	12.4	13.2	13.6	9.6	10.3	10.7	7.3	8.0	8.4	4.8	5.6	6.0	3.4	4.1	4.5	3.7	4.0	5.2
	Cooling Demand	7.0	5.0	4.3	5.9	4.2	3.2	6.4	4.7	3.8	6.8	5.1	4.2	7.3	5.5	4.6	7.5	5.8	4.9	9.6	6.5	6.2
	Heating Load	11.8	10.7	10.8	8.2	7.6	7.2	6.9	6.3	5.9	5.8	5.2	4.9	4.7	4.1	3.7	4.0	3.4	3.1	4.2	3.5	3.5
	Cooling Load	3.5	2.9	2.6	2.8	2.2	1.9	2.7	2.2	1.9	2.7	2.1	1.8	2.6	2.1	1.8	2.6	2.0	1.7	3.1	2.3	2.2