# Final 2016-2017 UDRH Inputs: Addendum to Massachusetts Multifamily High Rise Baseline Study

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SUBMITTED TO:
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# Final UDRH Inputs

The evaluation team conducted two conference calls to review the preliminary baseline findings provided in the draft Multifamily High Rise Baseline Study report.[1] The group participating in this review included Program Administrators (PAs), Energy Efficiency Advisory Council (EEAC) Consultants, and representatives from the program implementation contractor (ICF). Together, this group reviewed and developed a final set of User Defined Reference Home (UDRH) inputs that incorporates baseline study findings along with additional information based on experience administering the Multifamily High Rise (MFHR) program. This addendum documents the UDRH inputs that will be used when calculating savings retrospectively for 2016 program projects and prospectively for 2017 program projects. The tables below detail the following information:

- The current baseline inputs
- Updated inputs that will be used retrospectively to re-run savings for the 2016 program year (PY2016)
- Updated inputs that will be used prospectively to calculate savings for the 2017 program year (PY2017)
- Sources for new baseline inputs

Table 1 presents the new baseline inputs for residential and common area lighting. For in-unit residential lighting, the working group agreed to use a value 0.75 watts per square foot; this value will be used both retrospectively and prospectively. The in-unit residential lighting value was selected based on reviewing the current study results and considering the results of other lighting studies conducted by the PAs.

For common area lighting, the working group agreed to use different values retrospectively and prospectively. Retrospectively, for use in re-running the 2016 program year savings, the working group agreed to reduce the 2012 IECC lighting requirements by 27%. This decision was made based on the results of the most recent commercial code compliance baseline study[2], which found that lighting power densities are frequently lower (more energy efficient) than code requirements in commercial and industrial applications. Prospectively, for use in the 2017 program year, the group agreed to apply a 10% reduction to the 2015 IECC lighting tables. This decision has already been applied to other commercial and industrial lighting programs.

[1] NMR Group, Dorothy Conant, and DNV-GL. *Massachusetts Multifamily High Rise Baseline Study-DRAFT REPORT*. Submitted to the Massachusetts Electric and Gas Program Administrators. January 13, 2017.
[2] http://ma-eeac.org/wordpress/wp-content/uploads/Commercial-New-Construction-Energy-Code-Compliance-Follow-up-Study.pdf

## Table 1: Residential and Common Area Lighting

| UDRH Input | Current Input | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Residential Lighting Power Density (LPD)** | 1.1 W/SF | 0.75 W/SF | Working group decision | 0.75 W/SF | Working group decision |
| **Lobby LPD** | 0.9 W/SF | 0.80 W/SF (0.73* 1.1) | Working group decision; 27% reduction to 2012 IECC Table C405.5.2(2) Lobby | 0.81 W/SF (.90*0.9) | Working group decision; 10% reduction to 2015 IECC Table C405.4.2(2) Lobby: Otherwise |
| **Office LPD** | 1.11 W/SF | 0.80 W/SF (0.73* 1.1) | Working group decision; 27% reduction to 2012 IECC Table C405.5.2(2) Office-enclosed | 0.99 W/SF (.90*1.1) | Working group decision; 10% reduction to 2015 IECC Table C405.4.2(2) Office: Enclosed |
| **Fitness LPD** | 0.72 W/SF | 0.66 W/SF (0.73*0.9) | Working group decision; 27% reduction to 2012 IECC Table C405.5.2(2) Fitness center | 0.65 W/SF (.90*0.72) | Working group decision; 10% reduction to 2015 IECC Table C405.4.2(2) Fitness Center: In an exercise area |
| **Recreation LPD** | 0.73 W/SF | 0.58 W/SF (0.73* 0.8) | Working group decision; 27% reduction to 2012 IECC Table C405.5.2(2) Lounge/recreation | 0.66 W/SF (.90*0.73) | Working group decision; 10% reduction to 2015 IECC Table C405.4.2(2) Lounge/Breakroom: Otherwise |
| **Storage LPD** | 0.63 W/SF | 0.58 W/SF (0.73* 0.8) | Working group decision; 27% reduction to 2012 IECC Table C405.5.2(2) Storage | 0.57 W/SF (.90*0.63) | Working group decision; 10% reduction to 2015 IECC Table C405.4.2(2) Storage |
| **Corridor LPD** | 0.66 W/SF | 0.51 W/SF (0.73*0.7) | Working group decision; 27% reduction to 2012 IECC Table C405.5.2(1) Multifamily | 0.59 W/SF (.90*0.66) | Working group decision; 10% reduction to 2015 IECC Table C405.4.2(2) Corridor: Otherwise |

Table 2 presents the new baseline inputs for residential and common area heating systems. The bullets below detail the assumptions associated with each heating system measure.

- ***Whole building central boiler:*** Natural gas hot water boilers that are less than 300,000 Btu/h are subject to the current federal standard of 82%. Larger boilers (≥300,000 Btu/h) are subject to a baseline input of 85% Thermal Efficiency; this value comes from the gas boiler market characterization study that is not yet complete.
- ***Furnace with central A/C:*** Furnaces that are less than 225,000 Btu/h are subject to a pre-existing baseline of 85% AFUE; this value was previously agreed to by the PAs and EEAC for other programs. Larger furnaces (≥225,000 Btu/h) are subject to the current federal standard of 80% Thermal Efficiency.
- ***Ductless mini-split heat pump:*** Ductless mini-splits are subject to a new baseline value of 8.2 HSPF; this value comes from the recently completed ductless mini-split heat pump impact evaluation.[3] The new baseline values for ductless mini-split heat pumps were confirmed with the PAs.
- ***Water source heat pumps, ground source heat pumps, and variable refrigerant flow (VRF) systems:*** Retrospectively, the baseline values for these systems are based on ASHRAE 90.1-2010 and the 2012 IECC. These values will be used to re-run program savings for the 2016 program year. Prospectively, for the 2017 program year, the baseline values for these systems are based on ASHRAE 90.1-2013 and the 2015 IECC.

[3] http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf

## Table 2: Residential/Common Area Heating Systems

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Whole Building Central Boiler** | 80% Thermal Efficiency | <300,000 Btu/h 82% AFUE<br><br>≥300,000 Btu/h 85% Thermal Efficiency | <300,000 Btu/h: current federal standard*<br><br>≥300,000 Btu/h: pre-existing baseline from gas boiler market characterization study | <300,000 Btu/h 82% AFUE<br><br>≥300,000 Btu/h 85% Thermal Efficiency | <300,000 Btu/h: current federal standard*<br><br>≥300,000 Btu/h: pre-existing baseline from gas boiler market characterization study |
| **Furnace with Central A/C** | 80% Thermal Efficiency | <225,000 Btu/h, 85% AFUE<br><br>≥225,000 Btu/h, 80% Thermal Efficiency | <225,000 Btu/h: pre-existing baseline from other programs<br><br>≥225,000 Btu/h: 2012 IECC Table 403.2.3(4) | <225,000 Btu/h, 85% AFUE<br><br>≥ 225,000 Btu/h, 80% Thermal Efficiency | <225,000 Btu/h: pre-existing baseline from other programs<br><br>≥225,000 Btu/h: ASHRAE 90.1-2013 Table 6.8.1-5 |
| **Ductless Mini-Split Heat Pumps** | 7.7 HSPF | 8.2 HSPF | Pre-existing baseline from other programs; based on mini-split heat pump impact evaluation | 8.2 HSPF | Pre-existing baseline from other programs; based on mini-split heat pump impact evaluation |
| **Water Source Heat Pumps** | 4.2 COP | 4.2 COP | ASHRAE 90.1-2010 Table 6.8.1B, Water to air, water loop | 4.3 COP | ASHRAE 90.1-2013 Table 6.8.1-2, Water to air, water loop |
| **Ground Source Heat Pumps** | 3.1 COP | 3.1 COP | ASHRAE 90.1-2010 Table 6.8.1B, Brine to air, ground loop | 3.2 COP | ASHRAE 90.1-2013 Table 6.8.1-2, Brine to air, ground loop |
| **VRF-Air-Cooled** | 2.05 COP | 2.05 COP | ASHRAE 90.1-2010 Table 6.8.1J, ≥135,000 Btu/h | 2.05 COP | ASHRAE 90.1-2013 Table 6.8.1-10, ≥135,000 Btu/h |
| **VRF-Air-Cooled with Heat Recovery** | 2.05 COP | 2.05 COP | ASHRAE 90.1-2010 Table 6.8.1J, ≥135,000 Btu/h | 2.05 COP | ASHRAE 90.1-2013 Table 6.8.1-10, ≥135,000 Btu/h |

*http://www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebeee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8

Table 3 presents the new baseline inputs for residential and common area cooling systems. Retrospectively, all inputs other than ductless mini-splits, are based on ASHRAE 90.1-2010 and the 2012 IECC requirements. Prospectively, all inputs other than ductless mini-splits are based on ASHRAE 90.1-2013 and the 2015 IECC requirements. The ductless mini-split values, both retrospective and prospective, were agreed upon by the working group and are based on the recent ductless mini-split heat pump impact evaluation that was previously mentioned.

### Table 3: Residential/Common Area Cooling Systems

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Furnace with Central A/C** | 13.0 SEER | 13.0 SEER | Current federal standard* | 13.0 SEER | Current federal standard* |
| **Hydronic Heating with Central A/C** | 13.0 SEER | 13.0 SEER | Current federal standard* | 13.0 SEER | Current federal standard* |
| **Ductless Mini-Split Heat Pumps** | 13.0 SEER | 14.5 SEER and 12.0 EER | Pre-existing baseline from other programs; based on mini-split heat pump impact evaluation | 14.5 SEER and 12.0 EER | Pre-existing baseline from other programs; based on mini-split heat pump impact evaluation |
| **Water Source Heat Pumps** | 12.0 EER | 12.0 EER | ASHRAE 90.1-2010 Table 6.8.1B, Water to air, water loop | 13.0 EER | ASHRAE 90.1-2013 Table 6.8.1-2, Water to air, water loop |
| **Ground Source Heat Pumps** | 13.4 EER | 13.4 EER | ASHRAE 90.1-2010 Table 6.8.1B, Brine to air, ground loop | 14.1 EER | ASHRAE 90.1-2013 Table 6.8.1-2, Brine to air, ground loop |
| **VRF-Air-Cooled** | 10.6 EER | 10.6 EER | ASHRAE 90.1-2010 Table 6.8.1J, ≥135,000 Btu/h | 10.6 EER | ASHRAE 90.1-2013 Table 6.8.1-10, ≥135,000 Btu/h |
| **VRF-Air-Cooled with Heat Recovery** | 10.4 EER | 10.4 EER | ASHRAE 90.1-2010 Table 6.8.1J, ≥135,000 Btu/h | 10.4 EER | ASHRAE 90.1-2013 Table 6.8.1-10, ≥135,000 Btu/h |
| **Hydronic Baseboard with Through-Wall A/C** | 12.0 SEER | 12.0 SEER | ASHRAE 90.1-2010 Table 6.8.1A | 12.0 SEER | ASHRAE 90.1-2013 Table 6.8.1-2, Through the wall, air cooled |

*http://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8

Table 4 presents the new baseline inputs for in-unit water heating technologies. Retrospectively, the program will use the energy factors specified in the commercial section of the 2012 IECC. These are federal standards that were in place prior to April 16, 2015. For the 2017 program year, the program will use new federal standards that went into place on April 16, 2015 as the baseline inputs for the program. It is likely that buildings enrolled in the 2016 program year installed water heaters that were manufactured before the new federal efficiency standards went into place. Therefore, the Team feels it is reasonable to use the previous federal standards when re-running savings for the 2016 program year.

## Table 4: In-Unit Water Heating

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **In-Unit Natural Gas Storage Water Heater** | 0.67 Thermal Efficiency | 0.67-0.0019V EF | 2012 IECC Table C404.2 | ≤55 gallons, 0.675-.0015V EF;<br><br>>55 gallons, 0.8012-0.00078V EF | Effective federal standard on or after April 16, 2015* |
| **In-Unit Natural Gas On-Demand Water Heater** | 0.62 Thermal Efficiency | 0.62-0.0019V EF | 2012 IECC Table C404.2 | 0.82-0.0019V EF | Effective federal standard on or after April 16, 2015* |
| **In-Unit Electric Storage Water Heater** | 0.97-0.00132V EF | 0.97-.00132V EF | 2012 IECC Table C404.2 | ≤55 gallons, 0.960-.0003V EF;<br><br>>55 gallons, 2.057-0.00113V EF | Effective federal standard on or after April 16, 2015* |
| **In-Unit Electric On-Demand Water Heater** | 0.97-0.00132V EF | 0.97-.00132V EF | 2012 IECC Table C404.2 | 0.93-0.00132V EF | Effective federal standard on or after April 16, 2015* |
| **In-Unit Electric Heat Pump Water Heater** | 0.97-0.00132V EF | 0.93-.00132V EF | 2012 IECC Table C404.2 | ≤55 gallons, 0.960-.0003V EF;<br><br>>55 gallons, 2.057-0.00113V EF | Effective federal standard on or after April 16, 2015* |

* http://buildingsdatabook.eere.energy.gov/TableView.aspx?table=7.5.3

Table 5 and Table 6 present the new baseline inputs for wall and roof insulation. Once again, the retrospective baseline values are based on ASHRAE 90.1-2010 and the 2012 IECC while the prospective values are based on ASHRAE 90.1-2013 and the 2015 IECC. The only difference between the two codes is for flat roof insulation that is entirely above the roof deck. The on-site results for these measures were reviewed as part of this process, but the working group ultimately decided to use code as the baseline given the small sample sizes associated with this study.

## Table 5: Wall Insulation

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Mass** | R-13.3 c.i. | R-13.3 c.i. | 2012 IECC Table C402.2 | R-13.3 c.i. | 2015 IECC Table C402.1.3 |
| **Wood Stud** | R-13.0 + R-7.5 c.i. | R-13 + R-7.5 c.i. or R-20 + R-3.8 c.i. | 2012 IECC Table C402.2 | R-13 + R-7.5 c.i. or R-20 + R-3.8 c.i. | 2015 IECC Table C402.1.3 |
| **Steel Frame** | R-13.0 + R-7.5 c.i. | R-13 + R-7.5 c.i. | 2012 IECC Table C402.2 | R-13 + R-7.5 c.i. | 2015 IECC Table C402.1.3 |

## Table 6: Roof Insulation

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Flat Roof** | R-20.0 c.i. | R-25 c.i. | 2012 IECC Table C402.2 | R-30 c.i. | 2015 IECC Table C402.1.3 |
| **Attic** | R-38.0 | R-49 | 2012 IECC Table C402.2 | R-49 | 2015 IECC Table C402.1.3 |

Table 7 presents the new baseline inputs for fenestration. There are no differences between the 2012 IECC and 2015 IECC and both codes cover fixed fenestration, operable fenestration, and entrance doors.

**Table 7: Fenestration Efficiency**

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Fenestration U-Factor** | U-0.35 | Fixed fenestration U-0.38<br><br>Operable fenestration U-0.45<br><br>Entrance Doors U-0.77 | 2012 IECC Table C402.3 | Fixed fenestration U-0.38<br><br>Operable fenestration U-0.45<br><br>Entrance Doors U-0.77 | 2015 IECC Table C402.4 |

Table 8 presents the new baseline inputs for showerhead and faucet flow rates. The baseline study findings suggest that the current baseline inputs are not reflective of the market. The working group was not comfortable directly applying the study results as the baseline due to the makeup of the study sample being disproportionately weighted towards the largest multi-family projects. As a result, the working group agreed to use values recommended by ICF based on their industry experience. The same values will be used retrospectively and prospectively for showerhead and faucet flow rates.

**Table 8: Showerheads and Faucet Flow Rates**

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Showerheads** | 2.5 GPM | 2.2 GPM | Working group decision | 2.2 GPM | Working group decision |
| **Lavatory Faucets** | 2.2 GPM | 2.0 GPM | Working group decision | 2.0 GPM | Working group decision |
| **Kitchen Faucets** | 2.2 GPM | 2.2 GPM | Working group decision | 2.2 GPM | Working group decision |

Table 9 presents the new baseline inputs for whole building infiltration and ventilation. The new infiltration rate baseline value is specified in both ASHRAE 90.1-2010 and ASHRAE 90.1-2013. Ventilation was not discussed by the working group but the evaluation team recommends that the program continue to use the current baseline assumption that no ERV or HRV units are installed for corridor ventilation supply air.

### Table 9: Infiltration and Ventilation

| UDRH Inputs | Current Inputs | Retrospective Baseline | | Prospective Baseline | |
|---|---|---|---|---|---|
| | | Inputs for PY2016 | Source | Inputs for PY2017 | Source |
| **Whole Building Infiltration Rate** | 0.35 CFM75/SF of exterior surface area | 0.40 CFM75/SF of exterior surface area | ASHRAE 90.1-2010 Section 5.4.3.1.3 | 0.40 CFM75/SF of exterior surface area | ASHRAE 90.1-2013 Table C3.5.5.3 |
| **ERV/HRV** | None installed on corridor ventilations supply air | None installed on corridor ventilations supply air | Evaluator Recommendation | None installed on corridor ventilations supply air | Evaluation Recommendation |