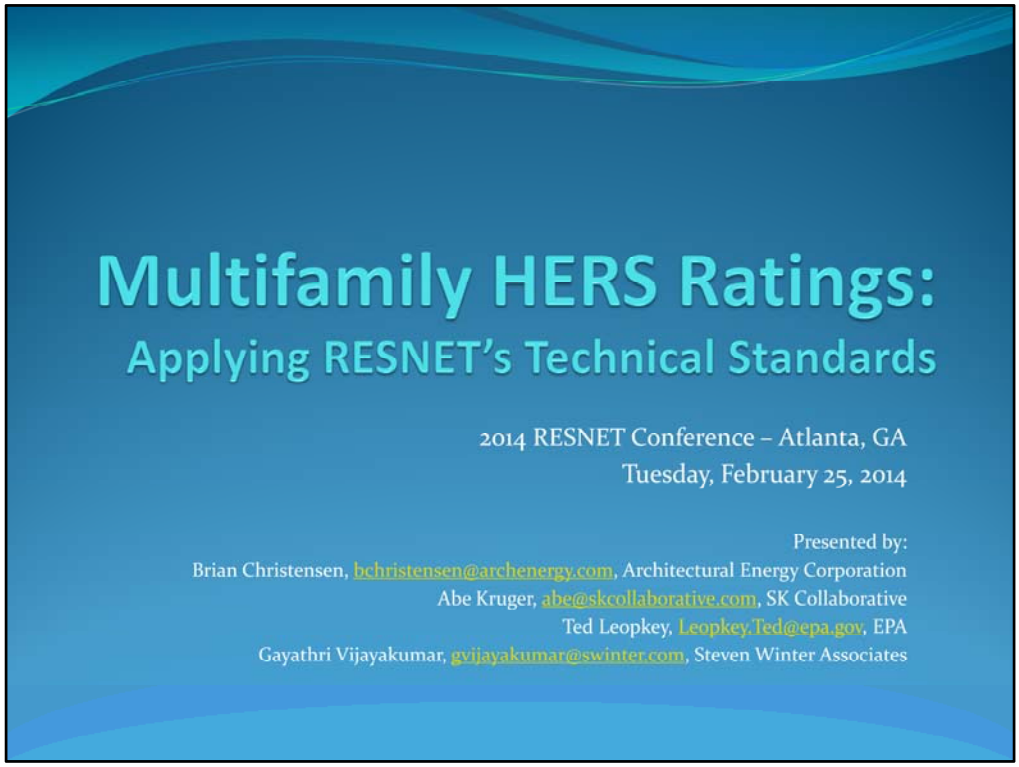
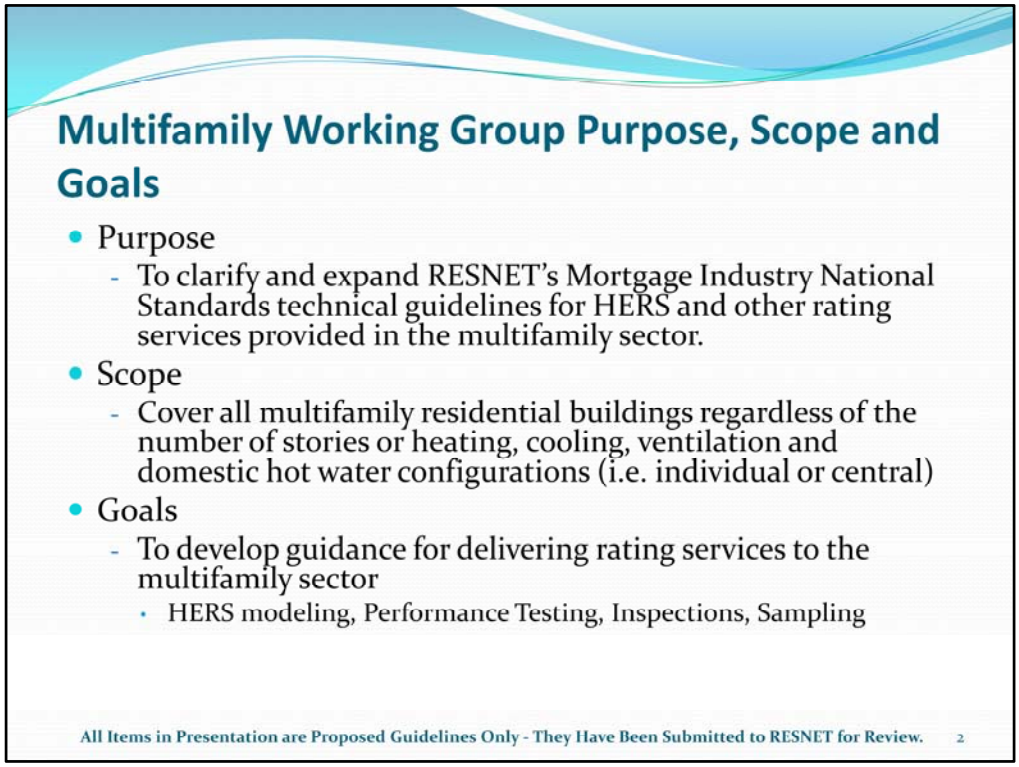


Presented by:
Brian Christensen, bchristensen@archenergy.com, Architectural Energy Corporation
Abe Kruger, abe@skcollaborative.com, SK Collaborative
Ted Leopkey, Leopkey.Ted@epa.gov, EPA
Gayathri Vijayakumar, gvijayakumar@swinter.com, Steven Winter Associates



Convened at the 2013 RESNET conference in Orlando. Chaired by Ted Leopkey, US EPA.

Proposed MF Guidelines submitted to RESNET's Standards Development Committee in February 2014. Once SDC reviews/approves, they will release for public comment.

Available here: www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

(Links in remaining PDF are not active)

Multifamily Working Group Members

Ben Adams, *MaGrann Associates*
Brian Christensen, *AEC*
Dave Epley, *DC DCRA*
Asa Foss, *U.S. Green Building Council*
Abe Kruger, *SK Collaborative*
Ted Leopkey, *U.S. EPA*
Matt Root, *Conservation Services Group*
Brian Stanfill, *MaGrann Associates*
Meghan Walsh, *USDA*
James Brauer, *U.S. Eco Logic/TexEnergy Solutions*
Krista Egger, *Enterprise Community Partners*
Patrick Fitzgerald, *NYSERDA*
Bruce Harley, *Conservation Services Group*
Scott Lee, *Southface*
Ken Owens, Jr. *Franklin Energy*
Rob Salcido, *AEC*
Gayathri Vijayakumar, *Steven Winter Associates*
Li Ling Young, *VEIC*

Agenda for Today

- Brian
  - Overview & Multifamily HERS Modeling Guidelines
- Abe
  - Multifamily Performance Testing Guidelines
- Gayathri
  - Multifamily Sampling Guidelines
  - Guidance not Discussed & Items Identified for Future Work
- Questions/Discussion

All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 4

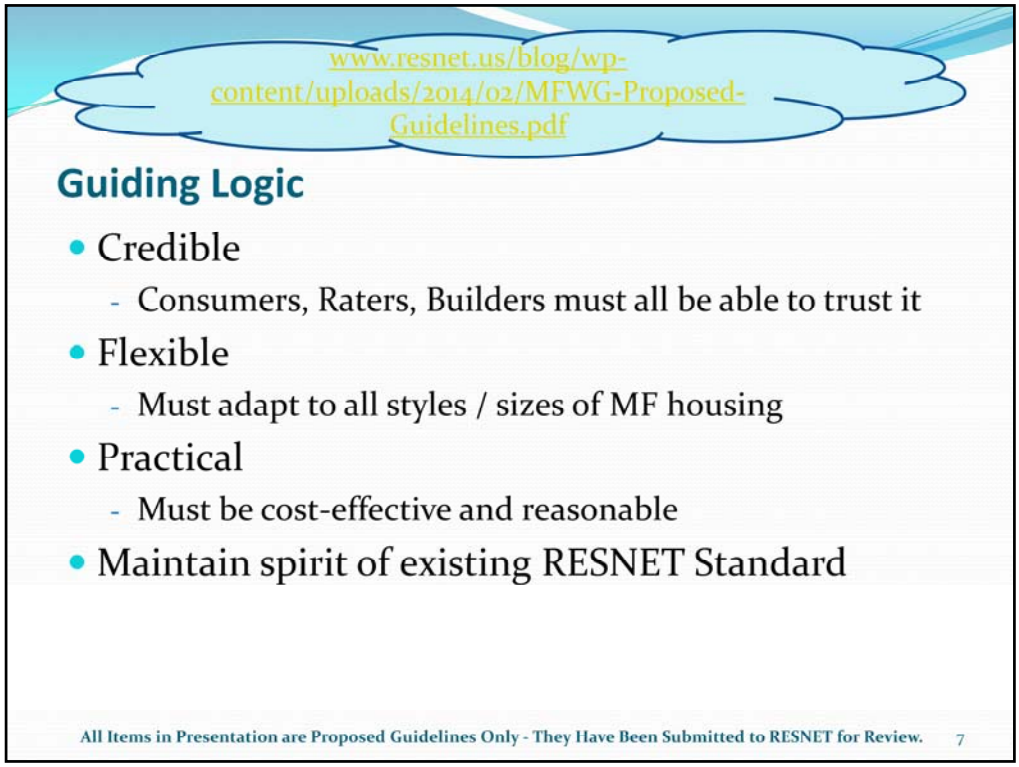
Who's tried to do MF HERS? How many struggled to adapt the SF stds to MF? **Us, too.**

www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

Overview & Multifamily Modeling Guidelines

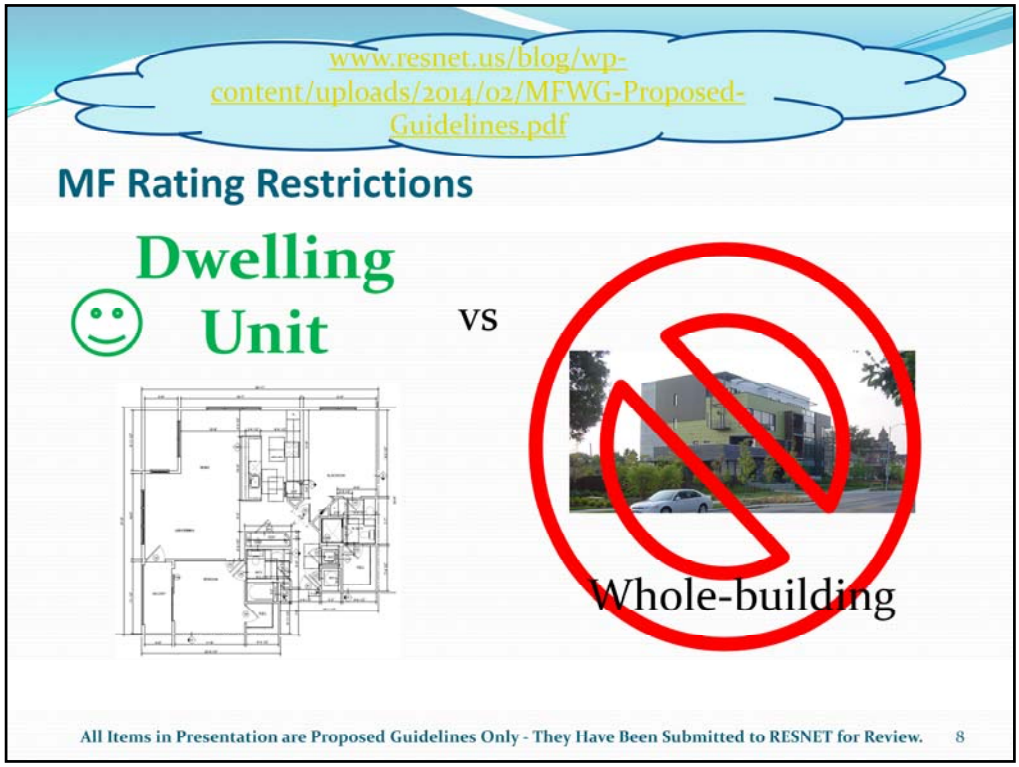
- Guiding Logic
- MF Rating Restriction
- Fixes for Existing Issues with MF Unit Ratings
- Modeling Central Systems & Other MF Challenges

All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 6



Keep in mind that we won't provide all answers in this session – please refer to the actual document whose link I show at top of screen.

(Clickable link is on page 2 of this PDF)



Our recommendation to RESNET is that MF HERS Ratings shall apply only to dwelling units, not whole-buildings. Currently, RESNET is silent on this topic.

www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

Why only Dwelling Units?

Dwelling Unit

- Sherman-Grimsrud infiltration model
  - Central role in HERS calculation
  - Limited to single-zone buildings
  - Limited to ≤3 stories

www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

Why only Dwelling Units?

Dwelling Unit

- Limits Common Area modeling & testing complications
  - No Reference Home for common areas
- Consistent meaning for HERS
  - single family dwelling unit

All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 10

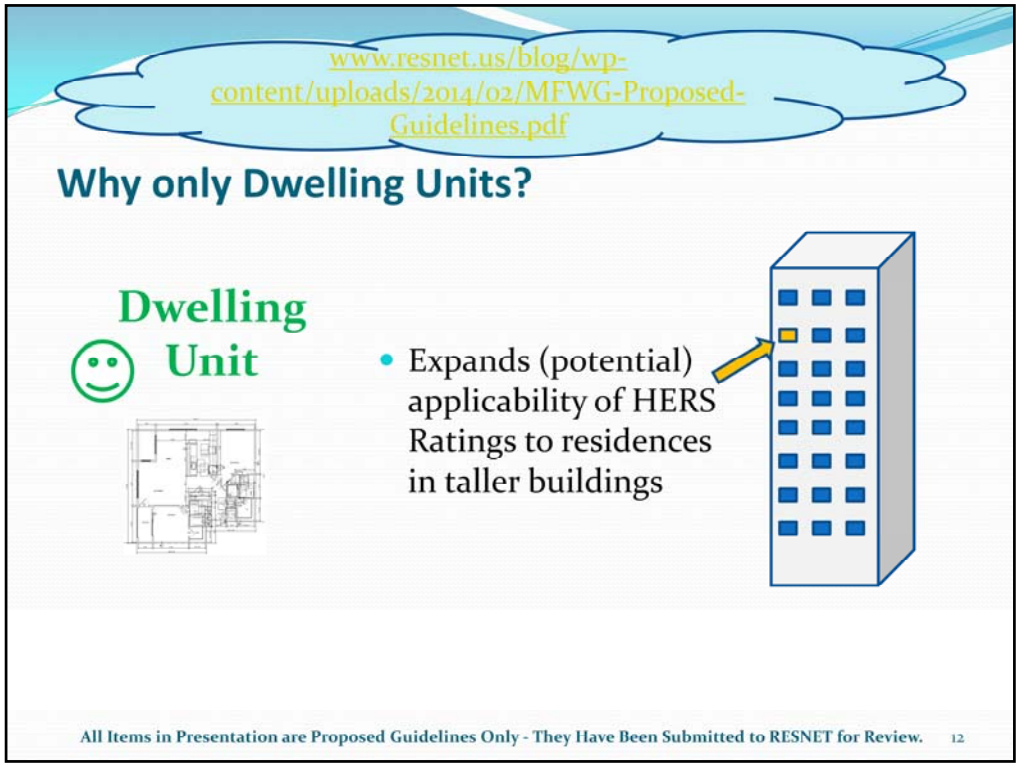
www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

Why only Dwelling Units?

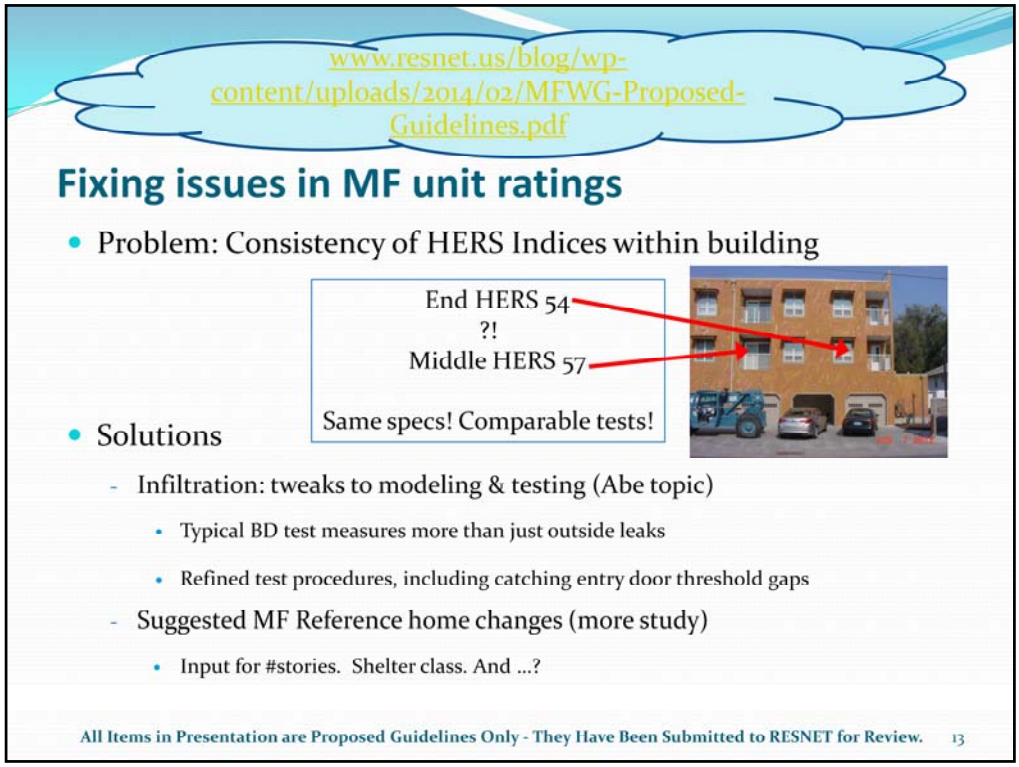
Dwelling Unit

- Emphasizes Compartmentalization!
  1. Which reduces energy losses throughout the building's interstitial spaces
  2. Which in turn makes Sherman-Grimsrud more reasonable for dwelling units
  3. And energy modeling becomes more accurate as units get tighter
  4. …and options arise for skipping duct leakage testing (Abe topic)

All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 11



By choosing these limitations, we CAN make HERS Ratings meaningful for dwelling units in buildings over 3 stories tall. (RESNET scope would need to be changed to allow it though)



"Interior unit penalty" example.

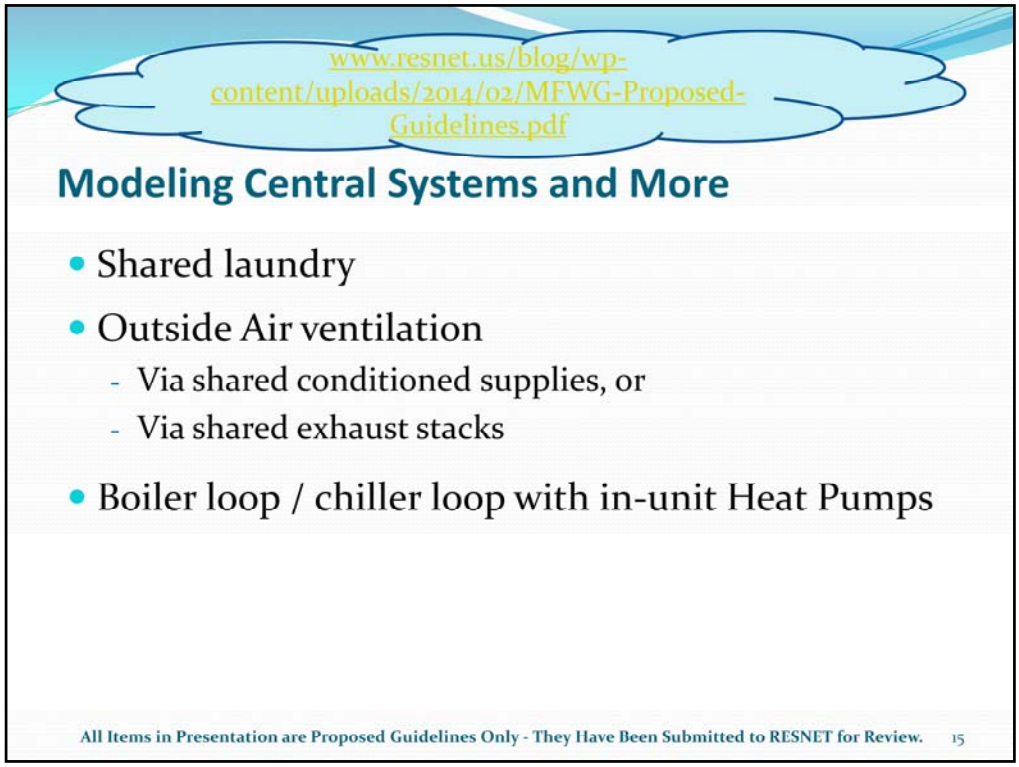
- Infiltration modeling tweaks to compartmentalization blower door test results based on unit location within building. Test procedure refinements for MF idiosyncracies. More detail in Abe's presentation.
- Modeling subgroup discussed some possible HERS Reference home changes for MF, but left them as recommendations for further study if RESNET is willing to consider them.

www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

Fixing issues in MF unit ratings

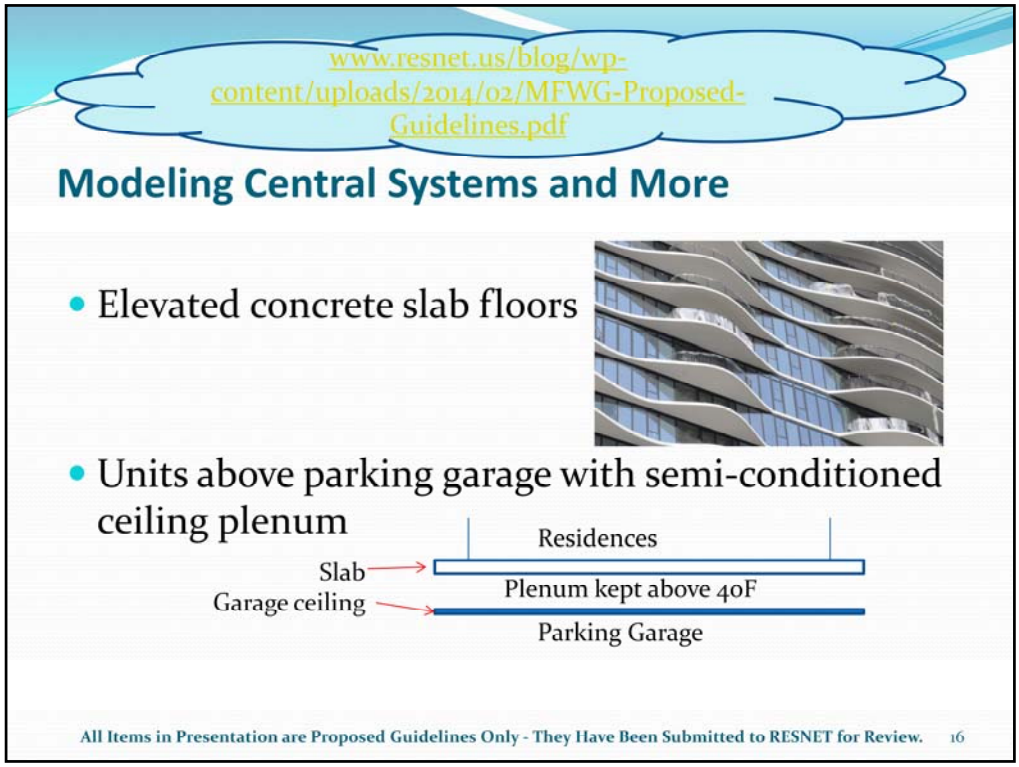
- Problem: Modeling time per building
  - All individual units ?!!
- Solution
  - MF Sampling (Gayathri topic)
    - Not every unit, only the essential ones

- Problem: Testing time per building
  - Crazy to do all individual units
- Solutions
  - New duct test exemptions
  - Sampling



For all these, see the Proposed Guidelines for details!

Shared laundry: there's probably a different DHW heater for the dwelling vs the laundry! Solution: model both DHW heaters, and assign appropriate loads to each.
OA ventilation: if the supply air is heated or cooled, need to include that conditioning equipment in the model, assigning the right % of the load to it. And, anytime ventilation equipment serves multiple dwellings, the power consumption is prorated over the dwellings based on the flowrate in each dwelling.
Boiler/chiller loop w/ in-unit HP: how much of the work is done by the boiler/chiller, and how much by the HP's? We assign 50% to each, and each gets modeled.



For all these, see the Proposed Guidelines for details!

Elevated concrete slab floors: these are not foundations, but are like "frame floors" (not touching the dirt below). Conductive, and generally not protected from outside temperatures. Here's the trick: we model the exposed ends and even some top/bottom surfaces as an additional above-grade exterior wall entry.
Elevated slabs over parking garages, with semi-conditioned plenum: is that plenum considered conditioned, or unconditioned? We recommend treating it like other buffer spaces, so call it floor above an unconditioned basement. Depending on the software, might need to model imaginary foundation walls around that unconditioned basement; see the guidance document for the details!

www.resnet.us/blog/wp-content/uploads/2014/02/MFWG-Proposed-Guidelines.pdf

To Reiterate:

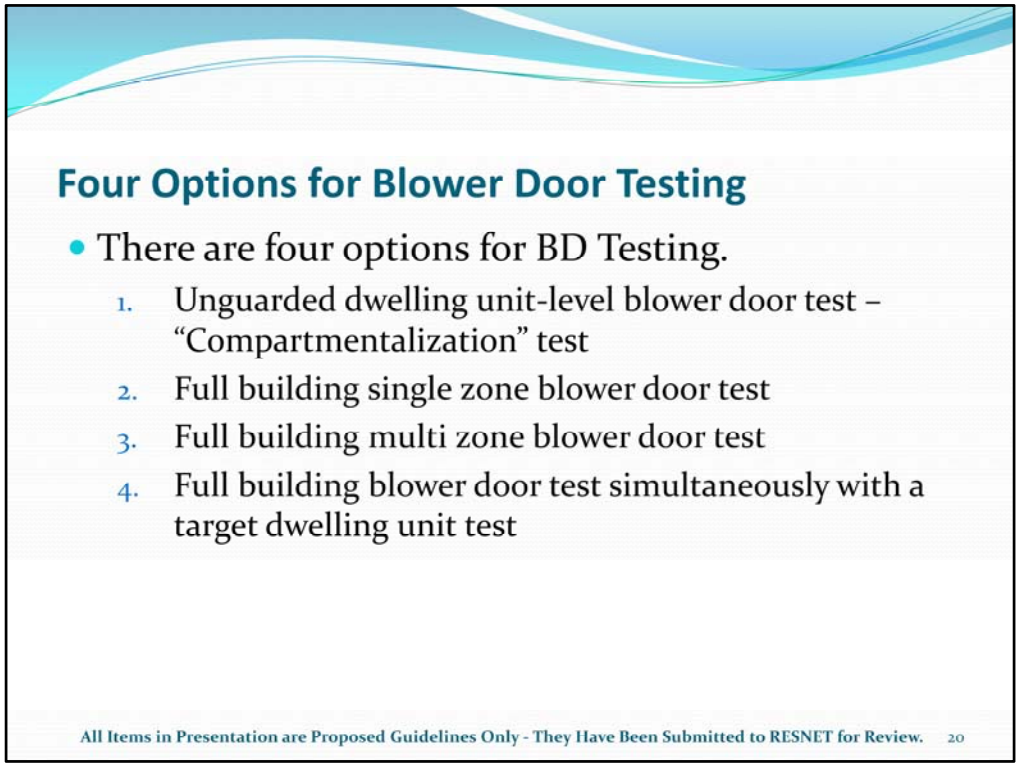
- MF ratings should be for dwelling units only
- We're tackling the "middle-unit penalty"
- We have lots of advice for MF modeling & testing

Multifamily Performance Testing Guidelines

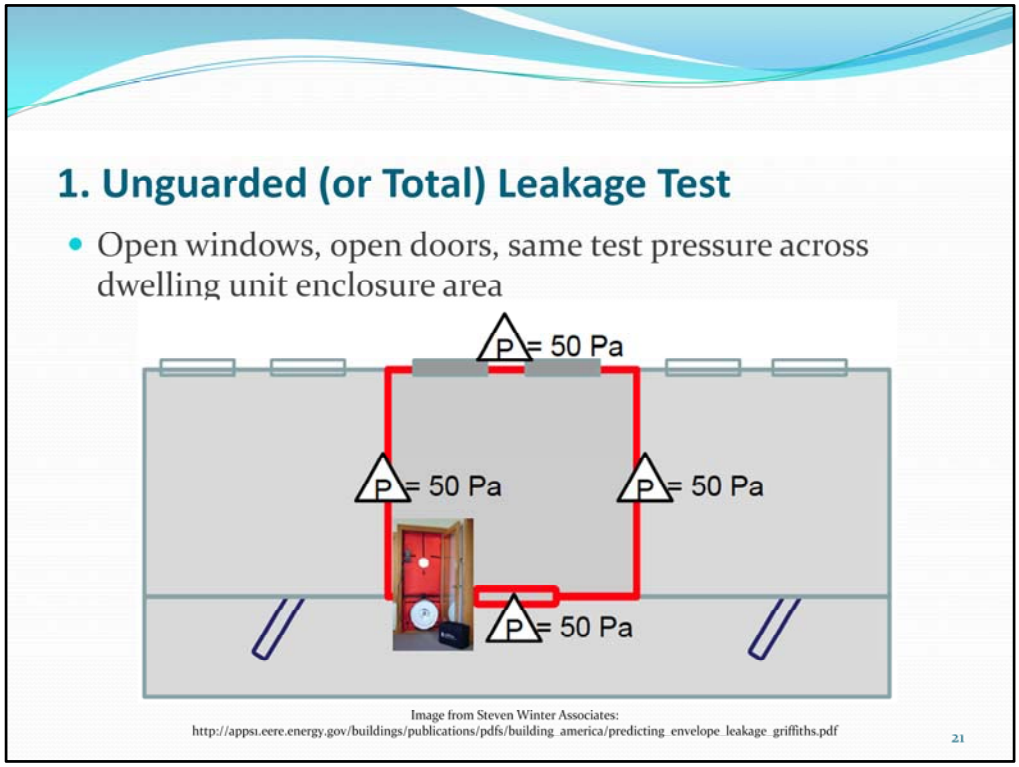
- Envelope Air Tightness Testing
  - 4 Options for Testing
  - Multifamily Infiltration Coefficient
- Duct Leakage Testing
  - Proposed Exceptions
  - Proposed procedure for non-ducted returns

Testing & Modeling Dwelling Unit Air Tightness

- HERS Ratings must use individual dwelling unit blower door test results
- It is not acceptable to use a blower door test result from a whole-building test nor is it acceptable to extrapolate the whole-building test results for application at the dwelling unit level



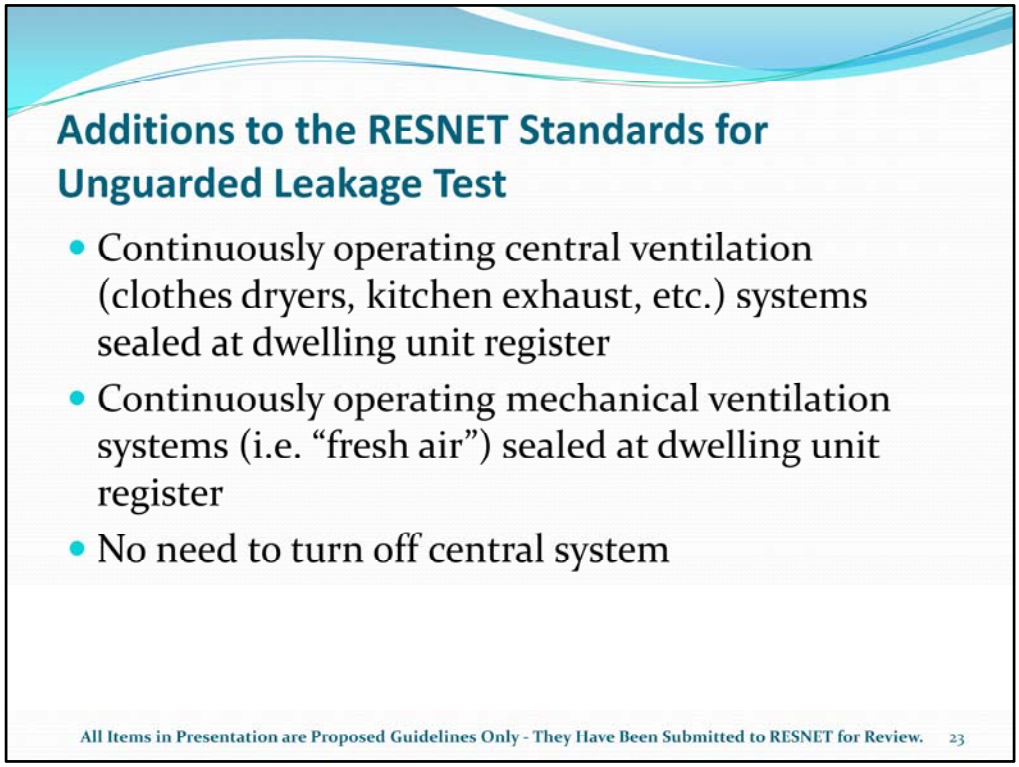
OPTION 2 CANNOT BE USED IN THE RATING



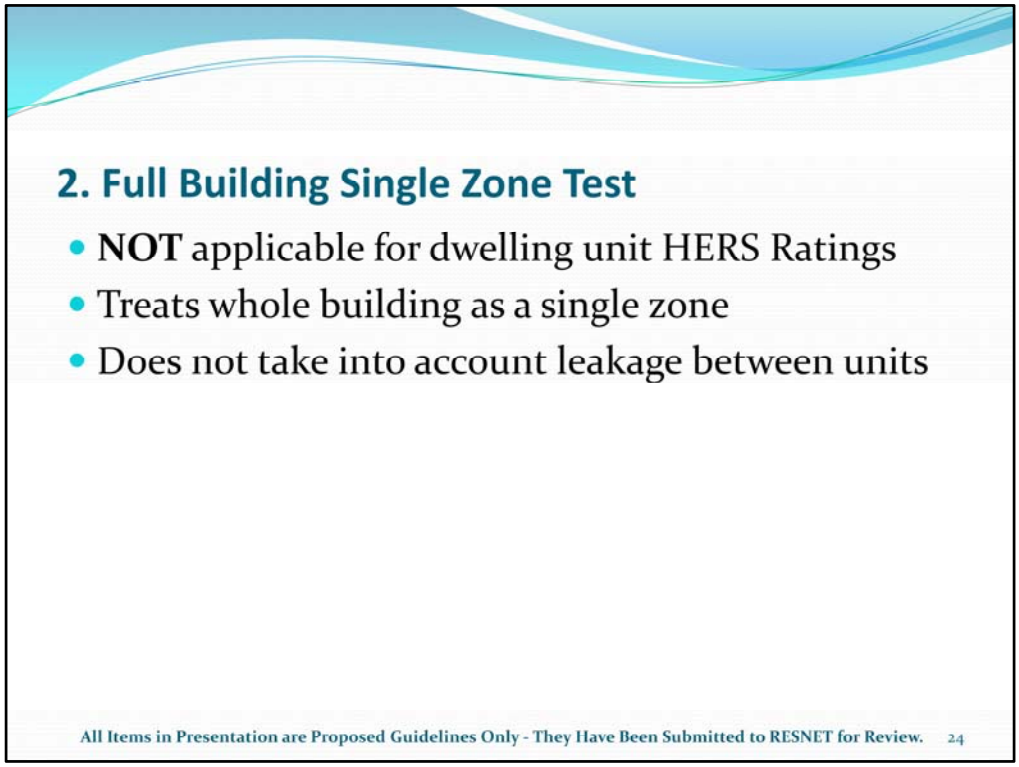
NOTE: It is also proposed that entry doors to dwelling units in multifamily residential buildings shall not be used for the blower door installation in compartmentalization tests unless the threshold is designed and adjusted to block airflow, comparable to an exterior door threshold.

1. Unguarded Leakage Test, continued

- Doors and/or windows do not need to be opened in adjacent spaces if pressure between the target dwelling unit and the adjacent space is ≥ 90% of the induced pressure difference between the target dwelling unit with respect to outside
  - For example, if the target is 50 Pa, 45 Pa is acceptable



Not really a CHANGE to the Standard, just adding language to address CENTRAL systems



We include this test in our Proposed Guidelines because the test can still be valuable, though not appropriate for HERS Ratings.

In other sections, our guidelines include guidance on airflow testing, inspections and other tests that are not included in the modeling (don't impact the HERS Index) but are provided for Raters to use to improve consistency.

3. Full Building Multi Zone Test

- Does not include leakage between units
- Measures individual unit leakage to outside
- Most applicable to townhouses and MF buildings with open corridors

Image from Steven Winter Associates:
http://appsi.eere.energy.gov/buildings/publications/pdfs/building_america/predicting_envelope_leakage_griffiths.pdf

25

All zones must be depressurized/pressurized (basically a blower door per zone).

If you have a shared entrance, you would not use this test, but the next test (#4).

You enter results from each unit's blower door into that unit's HERS Rating. Since this is a "guarded" result, this CFM50 gets entered as-is into the rating software.

4. Full Building Multi Zone Test & Target Dwelling Unit

- Does not include leakage between units
- Measures individual unit leakage to outside
- Most applicable to MF buildings with double loaded corridors
- 1 whole-building blower door + 1 dwelling unit blower door
- Results for target dwelling unit entered into HERS Rating

4. Full Building Multi Zone Test & Target Dwelling Unit

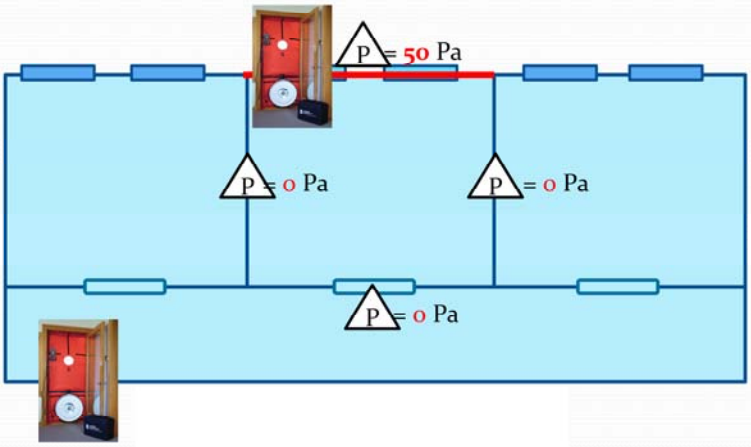
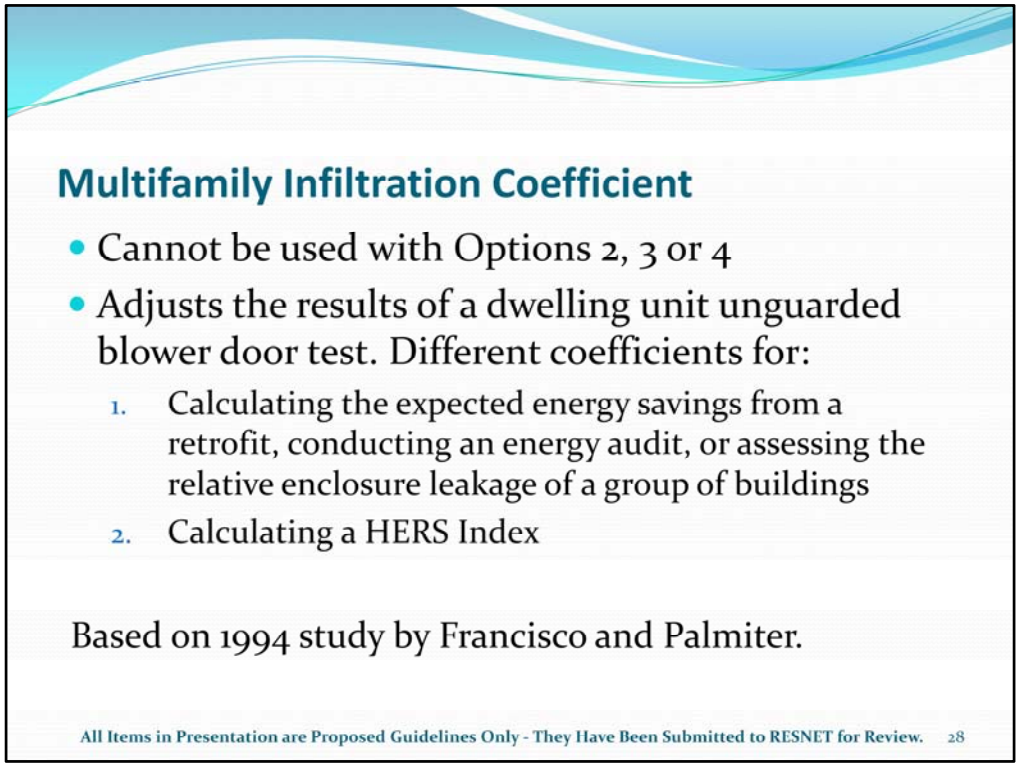


Image from Steven Winter Associates:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/predicting_envelope_leakage_griffiths.pdf

27



1994 Study by Francisco and Palmiter is available here:
http://aceee.org/files/proceedings/1994/data/papers/SS94_Panel5_Paper10.pdf

Multifamily Infiltration Coefficient, continued

- Coefficients for energy audit
  - Dwelling units built on a slab, or with no conditioned space below (0.98)
  - Non-slab with <50% of the dwelling unit enclosure area is exposed (0.65)
  - Non-slab with >50% of the dwelling unit enclosure area is exposed (e.g. top corner unit) (0.70)

    Example: 450 CFM50 x 0.70 = 315 CFM50

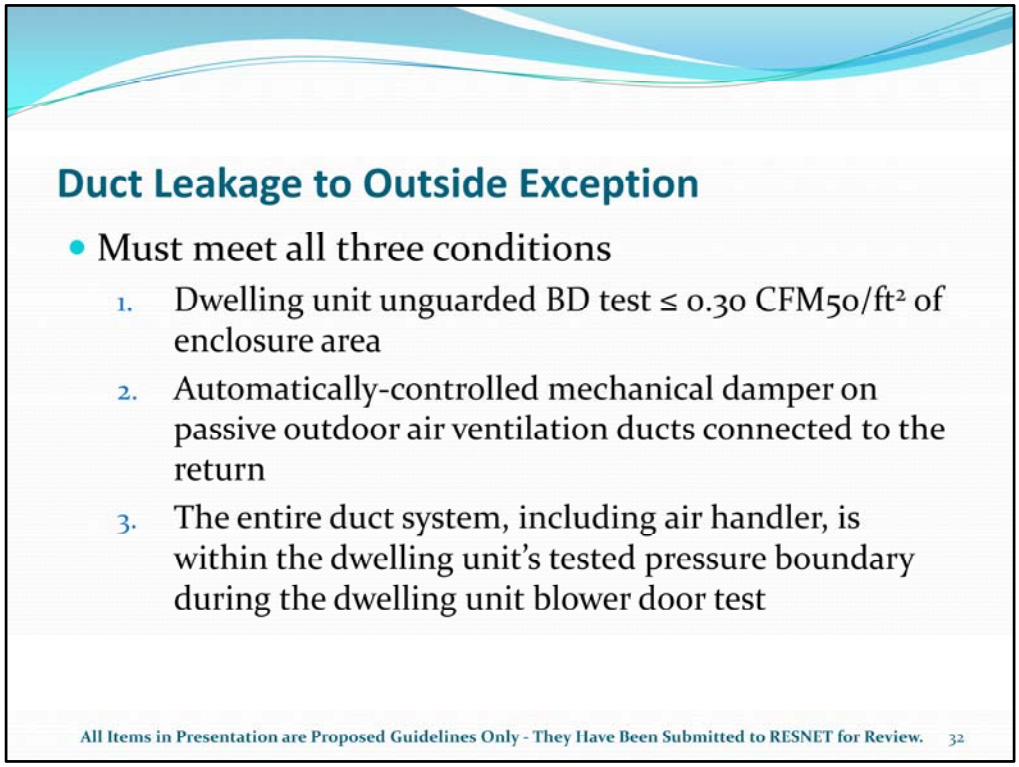
Multifamily Infiltration Coefficient, continued

- Coefficients for HERS Rating
  - Dwelling units built on a slab, or with no conditioned space below (1.0)
  - Dwelling units that indirectly use corridor air as ventilation supply air (1.0)
  - All other dwelling units (0.85)

    Example: 450 CFM50 x 0.85 = 382.5 CFM50

Multifamily Dwelling Unit Duct Leakage Testing

- Testing Total Duct Leakage & Leakage to Outside
  - Follow Section 804 of the RESNET Standards



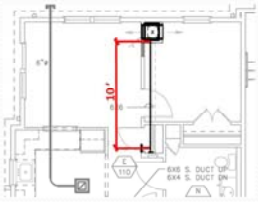
#3 is different from the current RESNET Standards because the system does NOT have to be 100% visible at the time of testing. Also, this would be modeled as "zero" duct leakage, not the RESNET default.

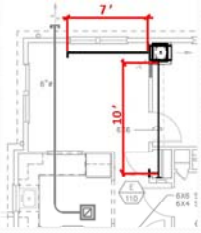
Example: a duct system in a vented attic does not qualify, but one located entirely in the interstitial space between conditioned units may qualify. Similarly, systems may qualify when the air handler is in a mechanical closet located on a balcony or accessed via the corridor, if that mechanical closet is within the tested pressure boundary during the dwelling unit blower door test (ie. pressure in the closet must be within 10% of the living space during the test, so 45-55 Pa if testing at 50 Pa).

This is only proposed for HERS Ratings thus far – programs and code officials would have to determine if this meets their requirements for duct leakage testing.

Duct Leakage Testing Exception

- If system has ≤10 ft. of supply duct work, it can be modeled as "ductless"
  - When measuring length, 10 ft. is measured from the source to the register, including all trunks and branches
  - The 10 ft. is a total system allowance, and not the allowance for each supply run





All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 33

Image on the left meets the exception; image on the right must be tested for leakage

This is only proposed for HERS Ratings thus far – programs and code officials would have to determine if this meets their requirements for duct leakage testing.

Duct Leakage Testing For Non-Ducted Returns

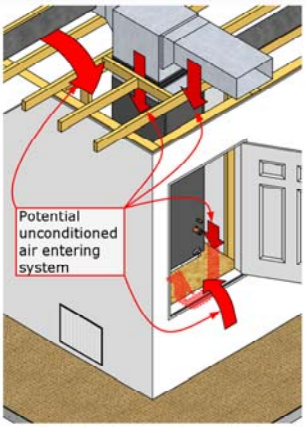
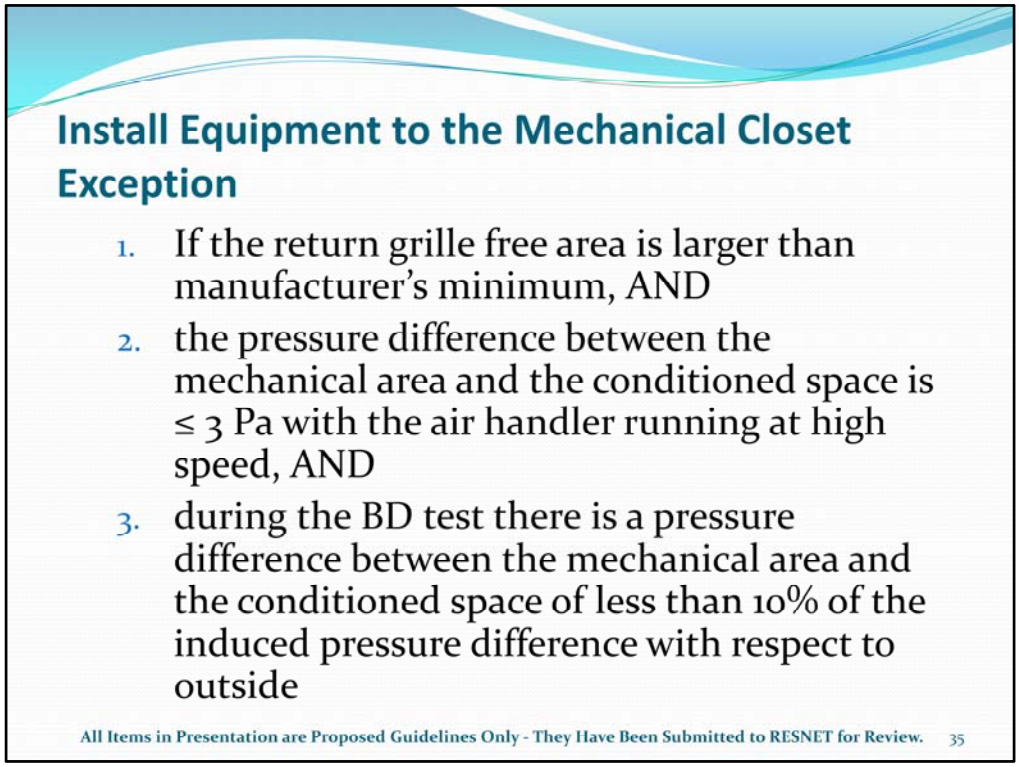


Image from DOE Measure Guideline: Air Sealing
Mechanical Closets in Slab-On-Grade Homes

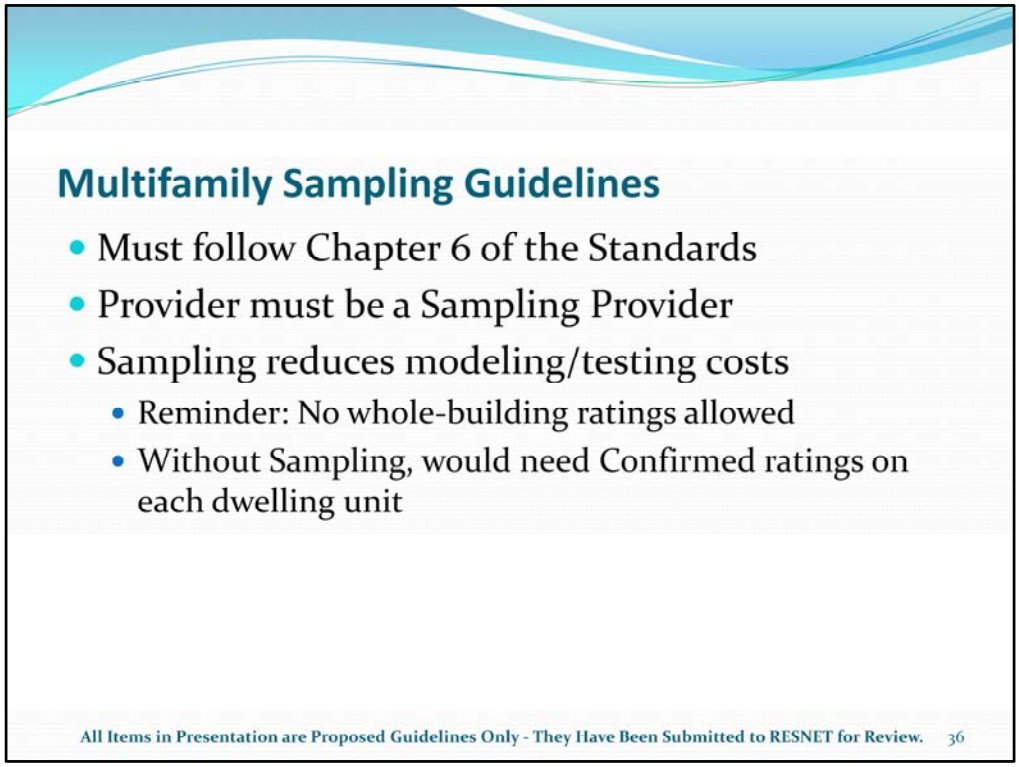
All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 34

Examples of non-ducted returns strategies:
Installing a register in the mechanical closet wall that meets the manufacturer's specifications for minimum return grille size ;
Installing a louvered door on the mechanical closet;
Leaving the ceiling of the closet open and using a dropped ceiling plenum and ceiling registers as the return pathway back to the air handler.



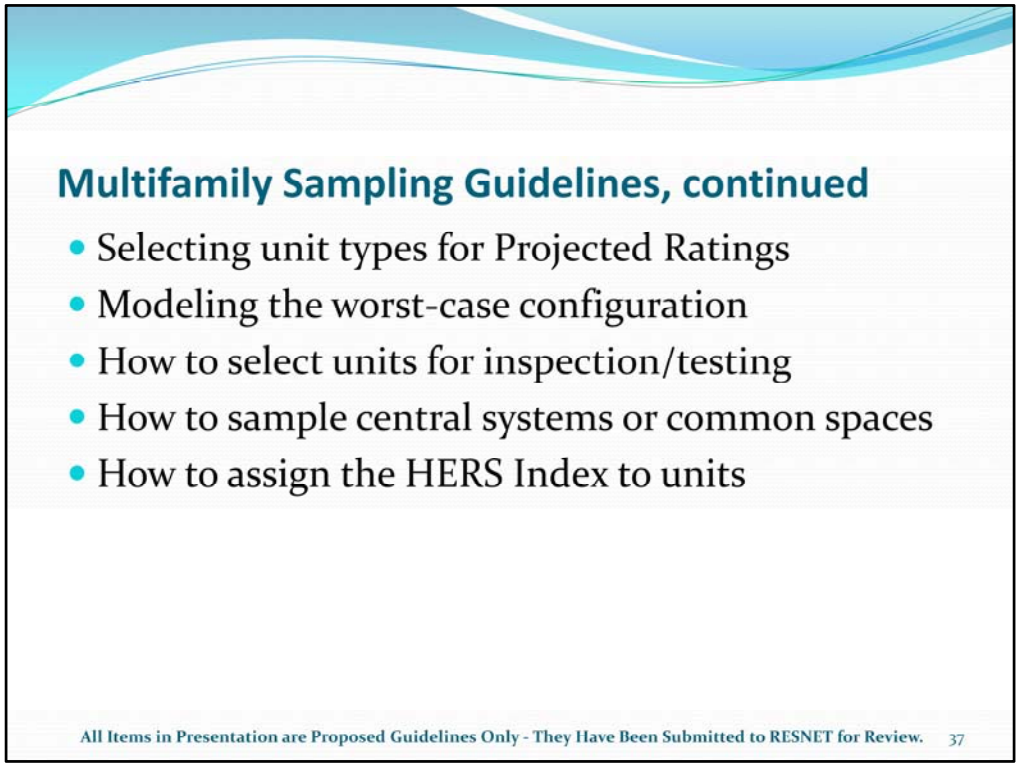
If all three criteria are met, the duct blaster fan may be hooked directly to the return side of the air handler during the duct leakage test excluding the rest of the mechanical area from the duct leakage results.

Otherwise, the duct blaster must be attached to the grille leading into the mechanical closet or furr-down plenum, essentially including any leakage in the closet or furr-down in the duct leakage results. Any building cavity plenums – ceiling, wall, floor – being used to direct air from the conditioned space to these mechanical areas must be left open to the mechanical area. Transfer grilles in the conditioned space leading to these ancillary plenums shall be sealed off. The duct blaster fan must be connected to a transfer grille in the ceiling plenum. This would result in the mechanical closet and ceiling plenum being included as part of the duct testing requirements.

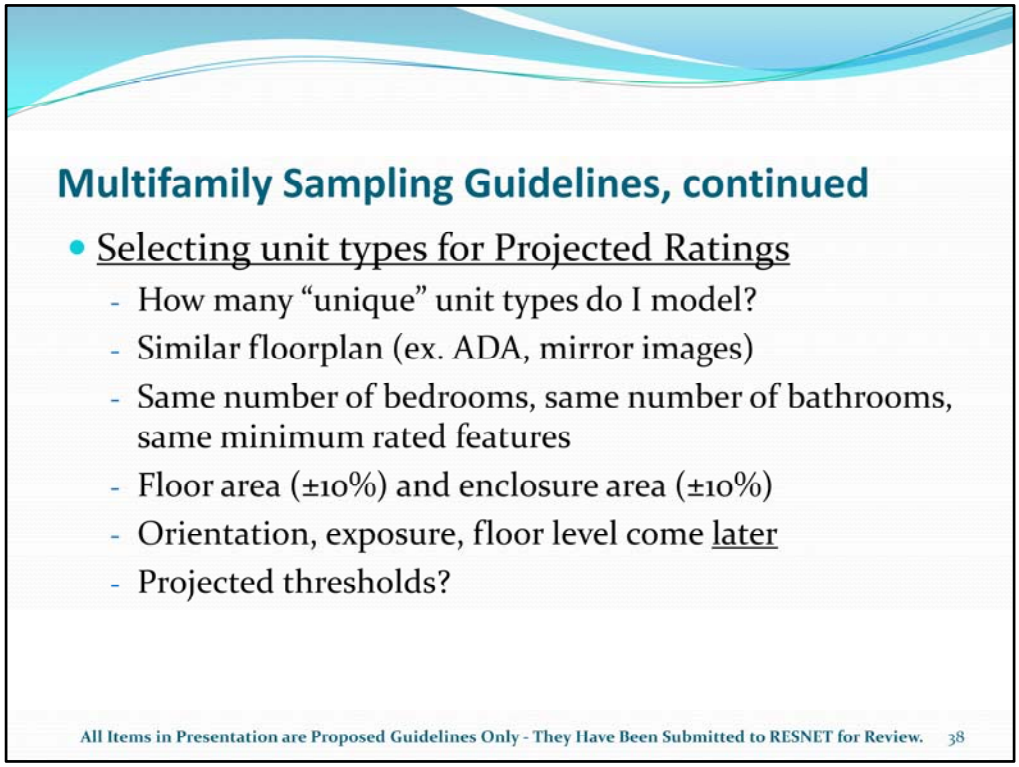


Reminder: our Proposed Guidelines require in-unit ratings, not whole building ratings. To reduce modeling, inspection and testing costs, sampling is highly recommended, but your Rating Provider has to also be a Sampling Provider.

Chapter 6 of the Standards that covers sampling, is more applicable to large single family developments, rather than multifamily buildings. The goal of this portion of the guidelines is to provide some consistent interpretations of Chapter 6 and how it applies to MF. Chapter 6 is still required, and this guidance just supplements that Chapter.



These 5 bullets don't cover all the sampling guidance developed – see Proposed Guidelines for full text.

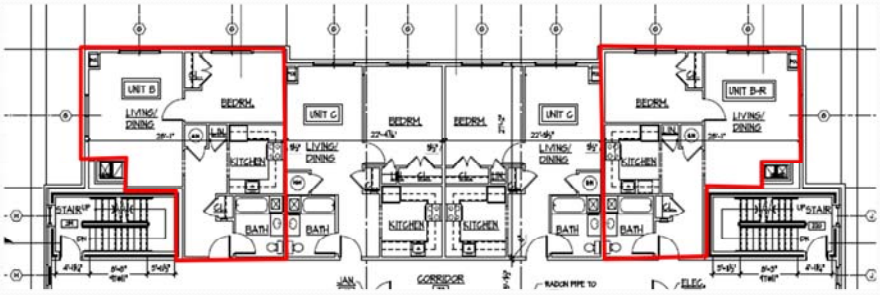


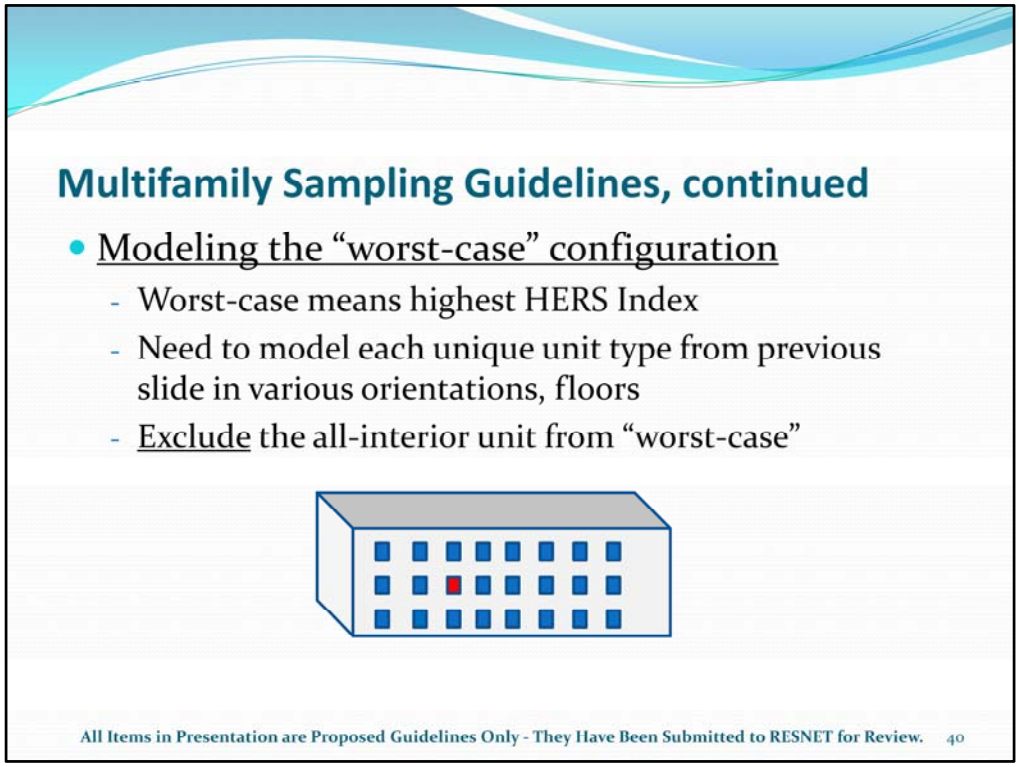
When it comes to sampling in MF, there is a lot of confusion on how many Projected Ratings or models you actually need. It was even more confusing when we were operating under ENERGY STAR Version 2, because they had slightly different guidance where you could model one unit per floor, and have that represent all the units on the same floor.

What our guidelines propose is that floorplans with the same number of bedrooms, same number of bathrooms, same conditioned floor area (±10%), and same enclosure area (±10%) can be considered the same unit type.

Multifamily Sampling Guidelines, continued

- Example: a MF bldg, with Type B, B-R, and C. If B is within 10% of B-R in terms of area, don't create a separate model…yet



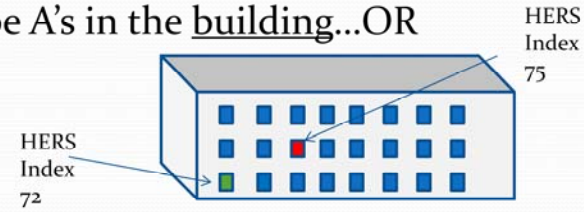


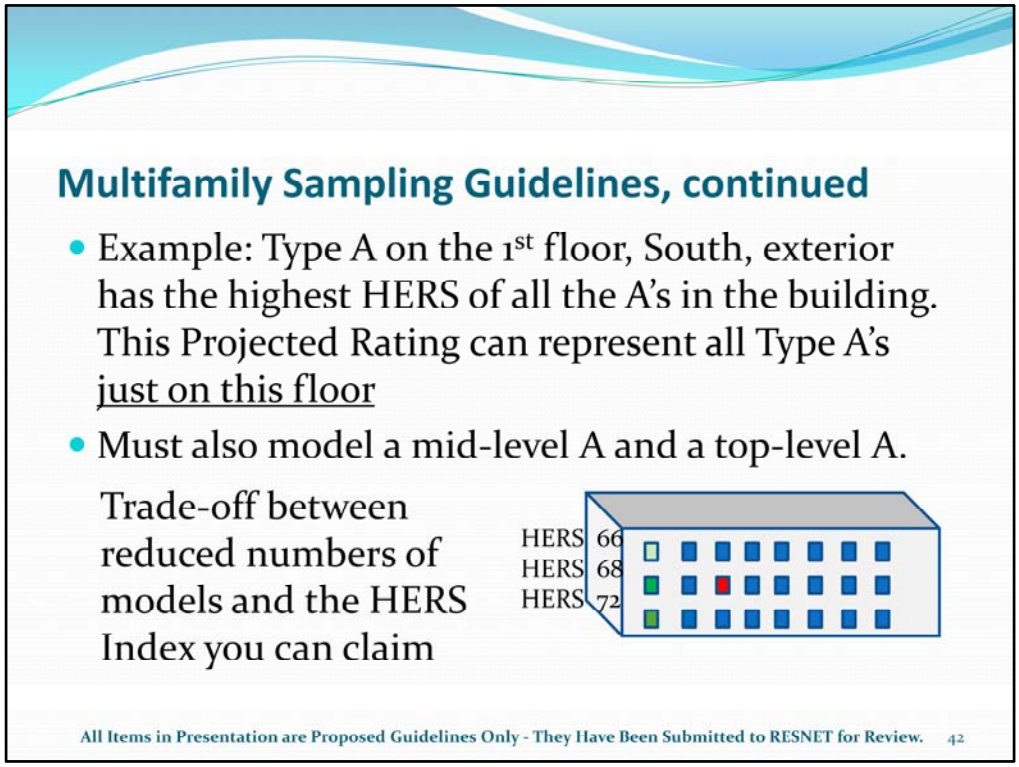
For each unique unit type, an evaluation must be performed using the various exposures, orientations and levels within the building, to determine the configuration that results in the highest HERS Index for that unit type. The Projected Rating with the highest HERS Index for that unit type may then be used to represent all sampled units of that same unit type, regardless of actual exposure, orientation or level in the building. This is different than the Attached Housing guidelines from ENERGY STAR Version 2, where you selected the unit on the floor with the most wall area.

Until changes can be made to the Reference Home to reduce the inequality between interior and exterior units, interior units which typically have the highest HERS Index, can be EXCLUDED from this analysis.

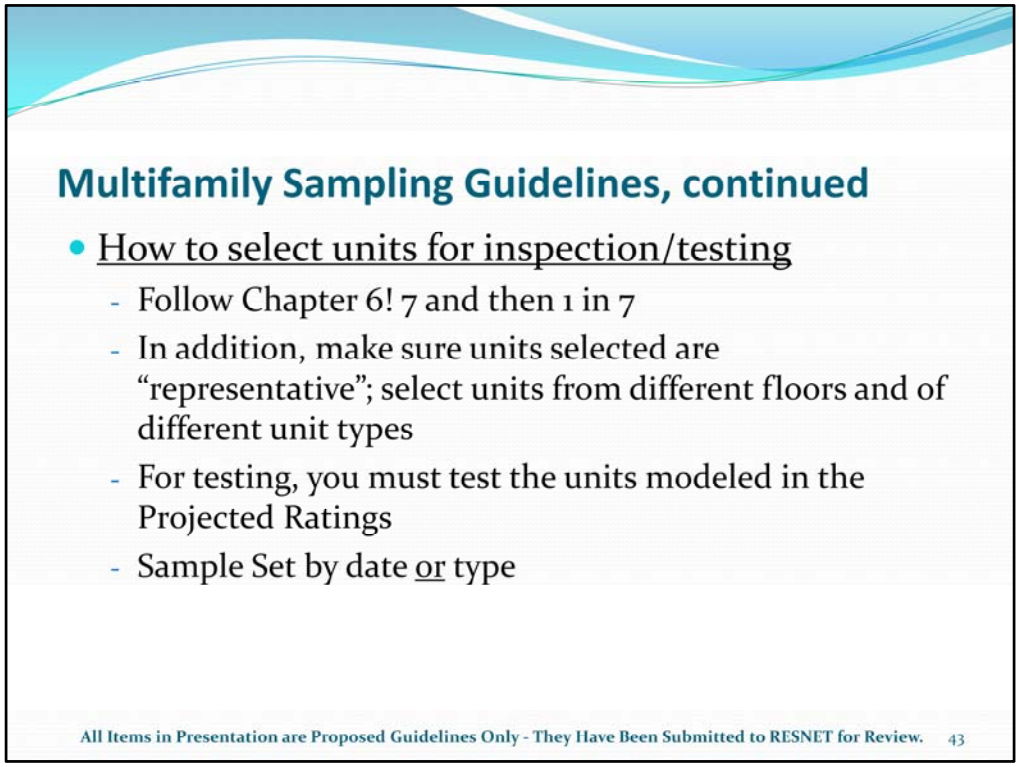
Multifamily Sampling Guidelines, continued

- Example: Type A on the 2nd floor, South, interior has the highest HERS of all the A's in the building. This configuration can be excluded. The configuration with the next highest HERS index will be the Projected Rating that represents all Type A's in the building…OR





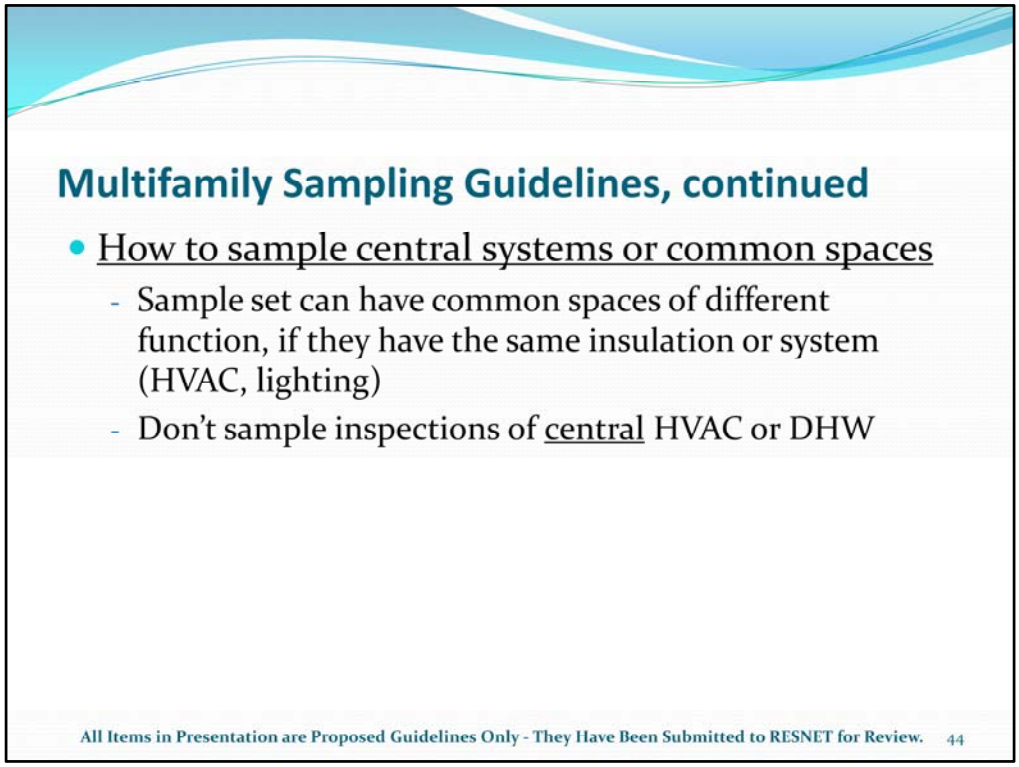
Alternatively, a given unit type can have multiple Projected Ratings based on the various exposures, orientations, and/or levels within the building, but that Projected Rating can then only be used to represent sampled units of that same unit type with the SAME exposure, orientation and/or level. For example, a Projected Rating for a mid-level unit type A could be created, along with a Projected Rating for a top-level unit type A, such that the HERS index for the mid-level unit type A will only be applied to other mid-level unit type A's.



So, now you have your projected Ratings (maybe you kept it simple with 3 or 4, maybe you have 7 or 8), how do you select units for testing or inspection? Follow Chapter 6! 7 and then 1 in 7. In addition, make sure units selected are "representative"; select units from different floors and of different unit types. For testing, you must test the units modeled in the Projected Ratings.

Sample Set by date or type
Chapter 6 allows units to be in the same sample set if they are ready within 30 days of each other. To try and reduce the number of site visits required, our Proposed Guidelines provide an alternative, where the 30-day rule doesn't apply, if the units in the sample set are of the same TYPE and shared the same contractors and same rated features.

In this approach, a 50 unit-building could wait until all 50 units are completed, and then do testing. Or you can visit the site once a month and do testing, based on what is ready. It's whatever works best for the Rater and the Builder. With Sample Sets of the same type, if you have a failure, you must test another 2 units of the same type.

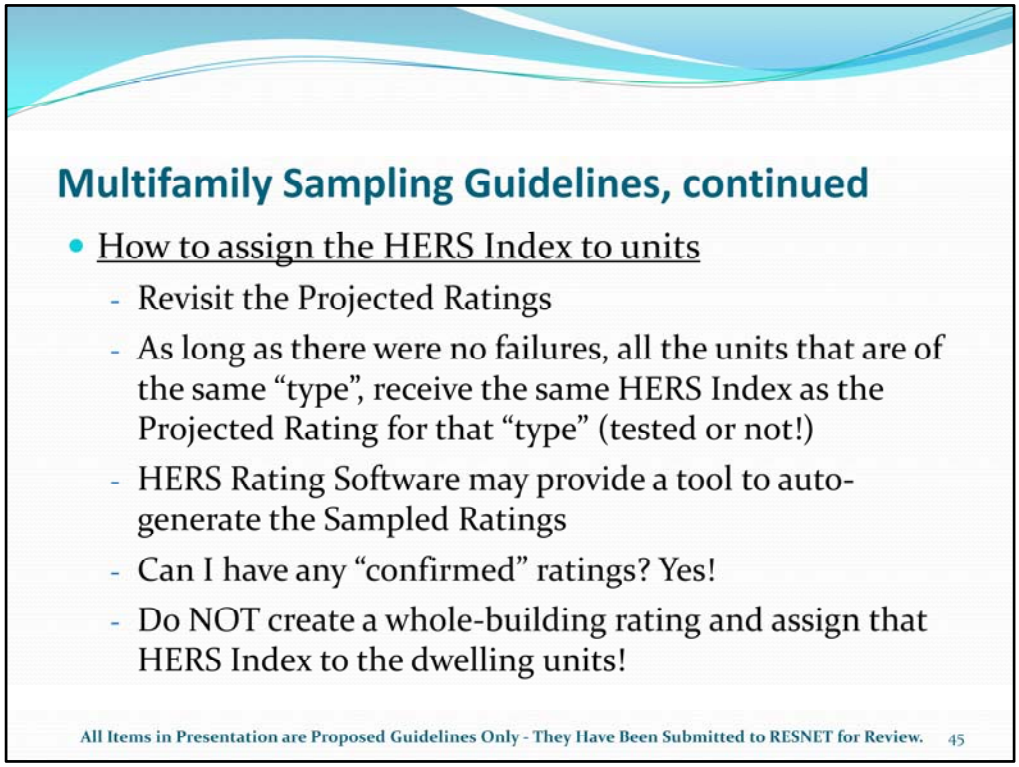


This sampling language is provided for Programs that may require it, but might not ultimately impact the inputs of your HERS Rating.

Sample set can have common spaces of different function, if they have the same insulation or system (HVAC, lighting)
For example, if inspecting exterior wall insulation, a stairwell, corridor, lobby, office, bathroom, community room and closet can be in the same sample set, if they have the same envelope systems. If verifying HVAC equipment efficiencies, it is likely that spaces with the same function, such as stairwells, will have the same HVAC system and can be in a sample set together, but could not be in the same sample set as a community room, if it has a different HVAC system

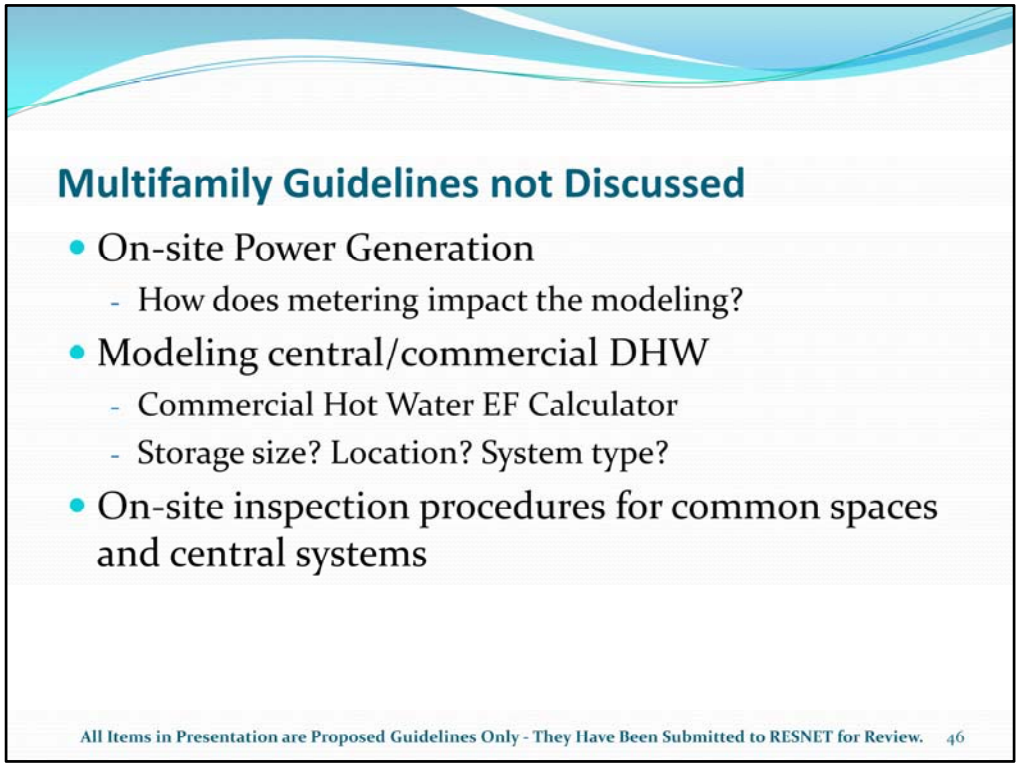
Don't sample inspections of central HVAC or DHW
If there is a central boiler room or equipment room, it's generally not much extra effort to inspect each piece of equipment.

This doesn't mean you have to inspect 100 condensers on a roof, or 100 rooftop exhaust fans. If the systems are repetitive and serve more than one unit, sample.



When the project is complete, all the units in the building will get a Sampled Rating (you can issue "Confirmed Ratings" for units that have had all inspections/testing completed).

The Projected Rating for each unit type is used to represent all the units in the building of that same type.

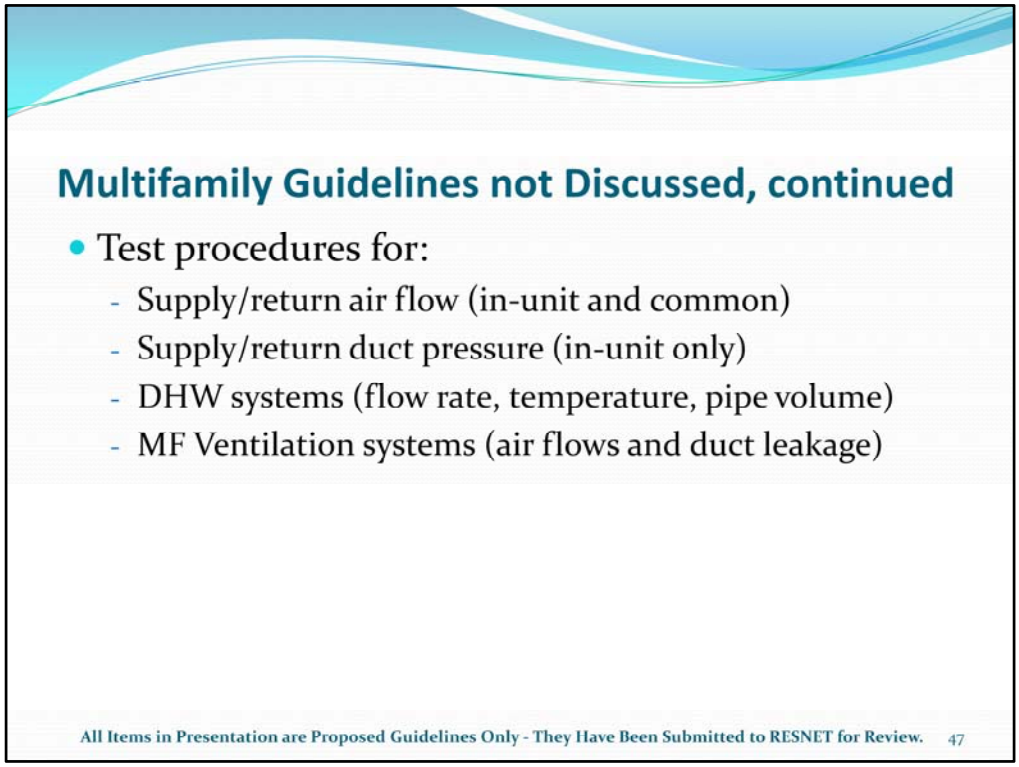


On-site Power Generation

How does metering impact the modeling? *In a multifamily building, there are two common metering configurations. The apartments are direct-metered and the common spaces have a "house" meter. Or, the entire building shares one "master" meter. On-site power generation, generally needs to be associated with a meter. With limited roof area in some MF, a large PV array may be installed that is just attached to the "house" meter. Since this does not directly benefit the dwelling units, this on-site power generation cannot be modeled in the dwelling unit rating. If it's associated with a "master" meter for the building, the on-site power generation can be distributed to each apartment. Or, if each unit has it's own meter and dedicated array and inverter, it could be modeled in the rating for that unit.*

Modeling central/commercial DHW: *In MF buildings, often there will be a central hot water system serving the units. If this is a central heat pump water heater, you model it like in single family. If it's a space heating boiler with an indirect tank, you will use the boiler's rated efficiency in the "calculator" and the standby loss of the indirect tank to get the EF. If it's a commercial storage water heater, you use the AHRI to get the efficiency and the standby loss to use in the calculator to get the EF. Storage should be modeled as 40 gallons regardless of the actual tank size and location should be outside the apartment (if you model it inside the apartment, the internal gains will affect the results).*

On-site inspection procedures for common spaces and central systems: *This section adds guidance on inspections of common spaces and central HVAC and hot water systems that are not currently called out in the current Appendix A of the Standards. Again, some of these may not ultimately impact what you enter into the model, but some MF programs require inspections outside of the dwelling unit, and some limited components in the common spaces (like parking garages, ventilation, and laundry rooms) CAN affect what's modeled in the rating for the dwelling unit, so the guidelines were developed.*



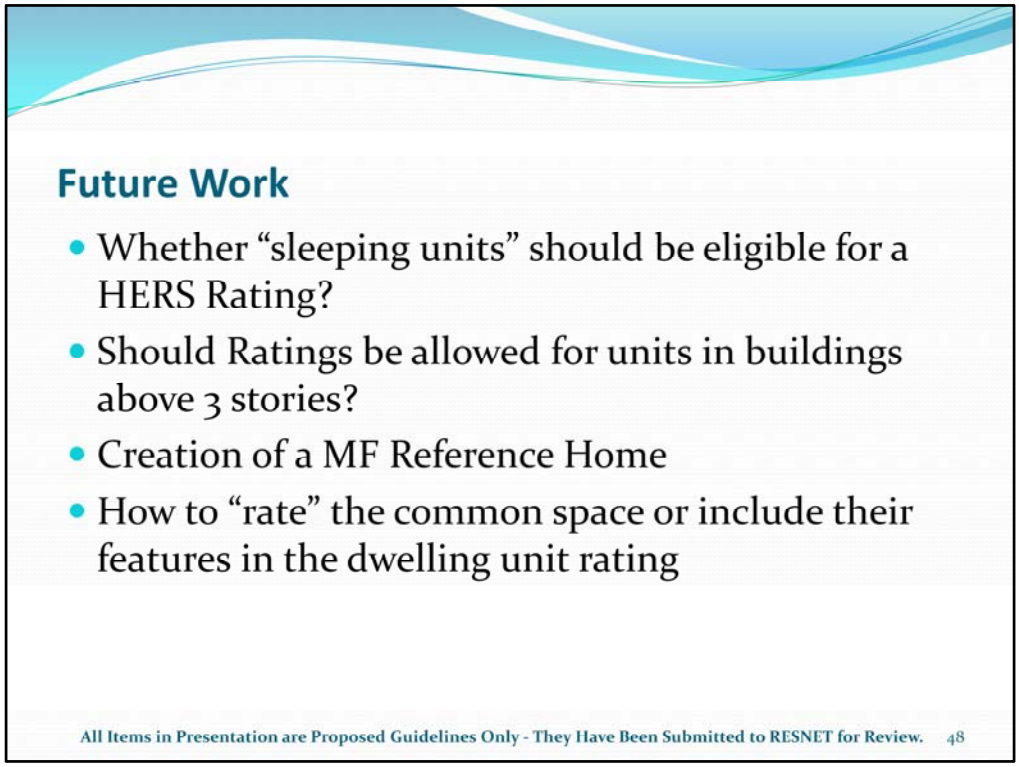
Test procedures for:

Supply/return air flow (in-unit and common): *This air flow is not part of the HERS Rating, but Raters are allowed to do these measurements for the ESv3 HVAC Checklist so it was called out. It is similar to the air flow measurements of section 804 of the RESNET Standards, just extends them to the residential-associated common space.*

Supply/return duct pressure (in-unit only): *This is also another measurement not called out in the RESNET Standards and is not part of the HERS Rating, but was included in the guidelines because it is a measurement done for ESV3. It is also not limited to MF.*

DHW systems (flow rate, temperature, pipe volume): *The DHW measurements are also currently not part of the HERS Rating, but are required in some green building programs and WaterSense, so they were called out in these guidelines. It is also not limited to MF buildings*

MF Ventilation systems (air flows and duct leakage): *You are likely familiar with duct leakage testing on in-unit forced air systems, but duct leakage testing can also be conducted on central ventilation risers. This leakage is not part of the HERS Rating, and not in the Standard, but since some high-performance building programs require it, like ENERGY STAR MFHR, it was included in the guidelines. The air flows are part of the HERS Rating, and the guidelines now extend to the residential-associated common space, to complement the modeling guidance Brian discussed.*

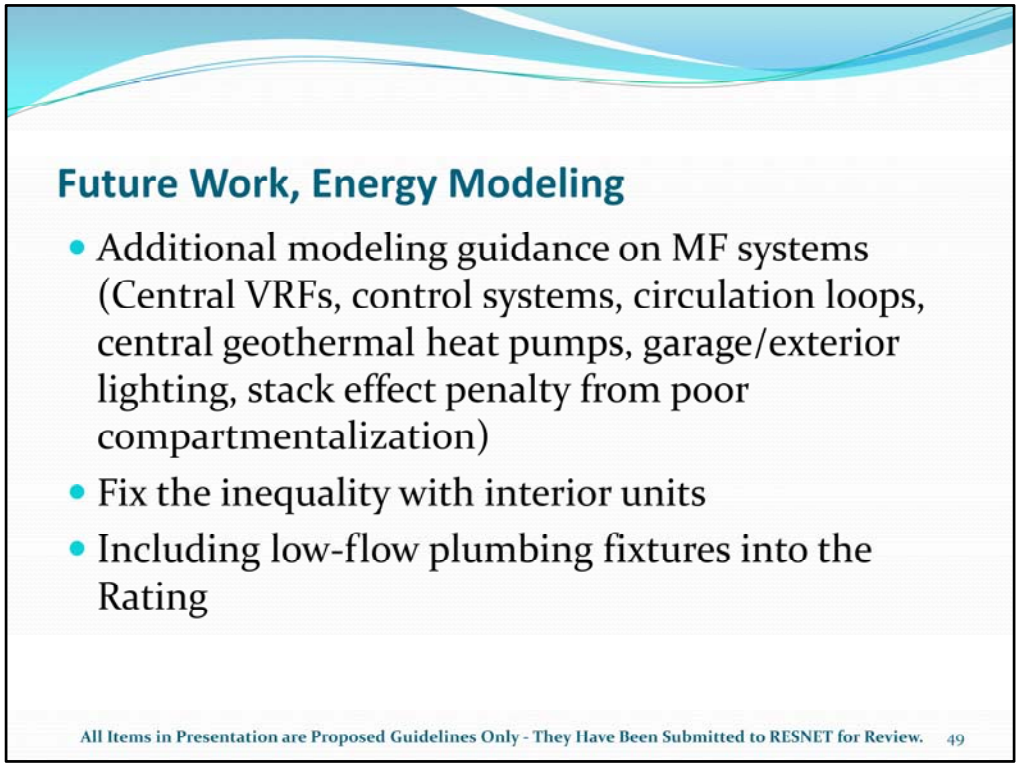


Whether "sleeping units" should be eligible for a HERS Rating: *There isn't a clear distinction between sleeping units and dwelling units in the Standards, so future work could involve a change to the scope to either include these units or exclude them. Sleeping units tend to be units in dormitories or group homes that are residential in nature, but don't have full kitchens or full bathrooms and aren't necessarily apartments. If they are eligible, maybe there should be some research to change the Reference Home for these units.*

Should Ratings be allowed for units in buildings above 3 stories? *Similar to above, the scope is currently limited to units in buildings 3 stories and less, but with ENERGY STAR Certified Homes allowing some 4 and 5 stories, some research could be done to revise this scope and maybe increase the number of stories.*

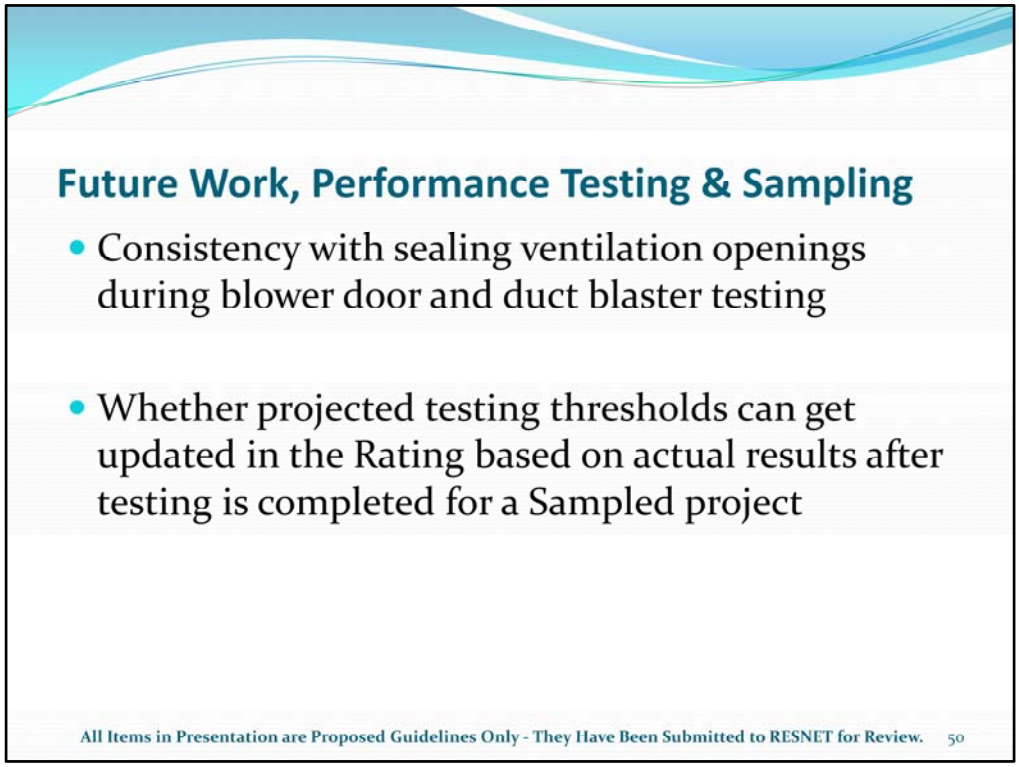
Creation of a MF Reference Home: *Like sleeping units, maybe there should be a new reference home specific to Multifamily and Single Family.*

Including low-flow plumbing fixtures into the Rating: *We provided the testing procedures for the low-flow rates, so maybe it can be incorporated into the HERS Rating, so there can be credit for the reduction in hot water usage compared to the reference home.*



Additional modeling guidance on MF systems: *A lot of great guidance was developed for modeling systems common to MF buildings. We couldn't address them all, so future research could tackle central VRF systems, controls, circulation loops, central geothermal heat pumps, garage/exterior lighting, and a penalty in relation to the reference home for having poor levels of compartmentalization, beyond the CFM50 that gets entered)*

Consistency with sealing ventilation openings during blower door and duct blaster testing: *Language related to ventilation openings like passive inlets, or outside air dampers, need to be improved in Chapter 8 to consistently seal, close or leave open.*



Updating projected thresholds: *The Sampling chapter is a little unclear on how test results are incorporated into the sampled ratings at the completion of a project. Unlike single family developments, often, an entire building will have their test results, before you issue a single HERS Rating. So, is there a way that Raters can use the actual test results in the HERS Rating rather than the initial projected thresholds they started with, pre-construction?*

How to "rate" the common space OUTSIDE the unit, but inside the building, or include their features in the dwelling unit rating: *The modeling guidelines tried to capture some elements in the common space within the rating for the dwelling unit, but perhaps there are other components that could be captured as well or maybe there could be a completely separate "Index" that evaluates the efficiency of the envelope and systems in the common space. Some multifamily buildings have common areas that exceed more than 20% of the building area and consume a lot of energy that is currently not evaluated in the HERS Rating.*

Fix the inequality with interior units: *Interior units tend to have higher HERS Index, yet lower energy consumption than the same unit on the exterior. This inequality needs to be addressed.*

Next Steps

- For You
  - Review the Proposed Guidelines
  - Discuss it with colleagues
  - Provide written feedback during RESNET public comment period

Questions/Discussion

All Items in Presentation are Proposed Guidelines Only - They Have Been Submitted to RESNET for Review. 52