RESFEN6 Assumptions – Reference House for Energy Star analysis

The following table captures the differences in modeling assumptions for the Energy Star analysis reference house between RESFEN 5 and RESFEN 6 (in development).

Table 0-1. RESFEN 6 Assumptions – Reference House for Energy Star Analysis

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
Floor Area (ft² & dimensions)	Reference House: 2000 sf Specific House: Variable, from 1,000 to 4,000 square feet, input by user.	Reference House: New – 1 Story: 1700sf New – 2 Story: 2800sf Existing 1 Story: 1700sf Existing 2 Story: 2600sf	NFRC noted the following: New Construction: 2005 U.S. Census Bureau Characteristics Median New house size is 2200sf; Average is 2400. Existing Construction: Keep same default as RESFEN 5 unless new data to the contrary is presented. LBNL decided to keep with these basic numbers, but differentiate between smaller single story homes and larger two story homes. [For the Energy Star analysis, results for both 1 and 2 story homes will be generated. End results will be based on appropriate regional weightings of 1 and 2 story homes.] Using RECS 2001, an analysis of public use microdata, we came up with the following, at a national level: - For existing homes (defined as pre-1990), RECS supports an average house size of 2000 sf, as NFRC had agreed upon. Single story homes (65% of existing homes nationally) are 1700sf and Two+ story homes (35%) are 2600sf. When weighted by fractions of the population, the average comes out

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			to 2000. - For New (after 1990) homes, NFRC had chosen to go with the census data Median of 2200, not the average of 2400. We agree that it makes sense to use a Median so that the size is not skewed by the small number of very large houses. RECS comes up with a slightly different average of 2600 (2000sf for single and 3400 Sf for 2+ story). We decided we should keep the NFRC value of 2200 as the normalized area but use RECS data on 1 and 2 story to modify this average number. This leads to using 1700 sf for New - 1 story (58%) and 2800 sf for New 2-story (42%).
House Type	New Construction Existing Construction	Reference House: New Construction is frame. Existing Construction is frame. Both 1 and 2 story houses are modeled in all climates. National or regional energy impact studies will be based on the fractions of 1 and 2 story homes in each climate, for New and Existing.	For reference, see census map: http://www.eia.doe.gov/emeu/recs/census_map.html IECC Climate map at: www.energycodes.gov/implement/pdfs/color_map_climate_zones_Mar03.pdf Data on New Construction; From http://www.census.gov/const/www/charindex.html#singlecomplete Look at Number of Stories Data on Existing Construction Source: RECS 2001 Microdata, http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html

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Foundation	Foundation is based on location based on NAHB data. There are a maximum of three options per climate zone, chosen from: Basement Slab-on-Grade Crawlspace	Default foundation based on location as with RESFEN 5.	What is in RESFEN is very similar to NFRC. NFRC proposed: New and Existing Construction: Basement in climate zone 5-8; Crawlspace in climate zone 4; Slab-on-grade in climate zones 1-3. What is in RESFEN is essentially this, except that some southern Zone 4 cities have slabs and some northern Zone 4 cities have basements to better represent current practice. Foundation modeling process updated based on 1998 research: Winkelmann, FC. 1998. "Underground Surfaces: How to Get a Better Underground Surface Heat Transfer Calculation in DOE-2.1E", Building Energy Simulation Users' News, Vol. 19, No. 1 (Spring 1998), pp. 6-12, Lawrence Berkeley National Laboratory, Berkeley CA, Electronic versions of the Users' News are available at http://gundog.lbl.gov.
Insulation [(a)]	Envelope insulation levels are based on location. See RESFEN 5 documentation, Table 6-1 for a list of Packages that correspond to each location. See Tables 6-3 and 6-4 for a list of R-values for each building component for each location. See Table 6-_ for a list of U-factors that correspond to the R-value constructions. **New construction:** See Table 6-4. (Council of American Building Officials, 1993) **Existing construction:** See Table 6-5. (Ritschard, et al. 1992)	New Construction: Envelope insulation levels based on location using 2006 IECC requirements in Table 402.1.1 (except for fenestration). Existing: Same as RESFEN 5.0.	

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Infiltration	**New Construction:** ELA=0.77 ft^2 (0.58 ACH) **Existing Construction:** ELA=1.00 ft^2 (0.70 ACH)	New Construction: SLA = 0.00036 Existing Construction: SLA = 0.00054	As proposed by NFRC. Consistent with 2006 IECC reference home Table 404.5.2(1). SLA is EA/total sf. [Note: inconsistency between RESFEN 3.1/5.0 documentation and code; infiltration in code was set to SLA=.00057.]
Structural Mass (lb/ft^2)	This is a parameter used in programs that don't explicitly model internal walls. In RESFEN, we use a simple equation to estimate the amount of internal walls per floor area: interior wall area = 0.527 * floor area RESFEN then models the amount of internal walls. Since interior walls are typically 2x4 16" oc with 0.5" of gypboard on each side, the amount of material per square foot of wall is 1" x 12" x 12" or 0.08333 ft3 of gypboard 3.5" x 1.625" x 12" /16 or 0.002469 ft3 of wood The total weight per floor area of floor adds up to 2.24 lbs/ft2, which is somewhat lower than the the 3.5 lb/ft2 cited. But in a 2-story, there's also the floor that would add another 2.20 lbs/ft2, for a total of 4.44 lbs/ft2. This is consistent with the average value	Internal walls are modeled explicitly as with RESFEN 5. Where masonry floors are used: 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air. This is in addition to the 3.5 lb/ft2/ Basement walls: masonry, and include insulation located on the exterior of the walls (new construction) and the interior side of the walls (existing construction). This is in addition to above.	Consistent with 2006 IECC reference home Table 404.5.2(1) average value.

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	of 3.5 lb/ft2 in the IECC. Basement walls and slabs are modeled separately.		
Internal Mass Furniture (lb/ft^2)	8.0 lb/ft^2 of floor area, in accordance with the Model Energy Code and NFRC Annual Energy Performance Subcommittee recommendation (September 1998).	8.0 lb/ft^2 of floor area	Consistent with 2006 IECC reference home Table 404.5.2(1).
Solar Gain Reduction	**Options:** **None:** No solar gain reduction **Overhang:** 2′ Exterior Overhangs **Obstruction:** Exterior Obstructions, a completely opaque (τ=0.0), same-height obstruction 20 feet away, intended to represent adjacent buildings. **Interior:** Interior shades with a Seasonal SHGC multiplier, summer value = 0.80, winter value = 0.90. **Int+Ovh:** Interior shades & 2' overhangs **Ovh+Obs:** 2' overhangs & obstructions **All:** Interior shades, 2' overhangs, & obstructions **Typical**[(b)]**:** to represent a statistically average solar gain reduction for a generic house, this	**Same as RESFEN 5.** **Reference House uses Typical.**	RESFEN assumptions of typical should be maintained unless there is valid data to the contrary; otherwise impacts of windows are overstated

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
	option includes: Interior shades (Seasonal SHGC multiplier, summer value = 0.80, winter value = 0.90); 1' overhang; a 67% transmitting same-height obstruction 20' away intended to represent adjacent buildings. To account for other sources of solar heat gain reduction (insect screens, trees, dirt, building & window self-shading), the SHGC multiplier was further reduced by 0.1. This results in a final winter SHGC multiplier of 0.8 and a final summer SHGC multiplier of 0.7. (Note these factors are multipliers; i.e. a window with a SHGC of 0.5 is reduced to 0.4 in the winter and 0.35 in the summer.)		
Window Area (% Floor Area)	Variable	Specific House: Variable Reference House: 15%	18% is too high. A recent DOE/PNNL study from a few years ago found 13.5% to be average. IECC implies that below 12% is low and above 18% is high….which implies 15% (as used in RESFEN) is appropriate.
Window Type	Variable	Variable	
Window Distribution	Variable	Specific House: Variable Reference House: Evenly	

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
		Distributed on All four orientations.	
HVAC System	Furnace & A/C, Heat Pump	Gas furnace & A/C. Heat Pump with A/C in South and SW	There are a significant number of Heat Pumps in the South (half of new construction in the south) and some in the West (presumably the SW). From http://www.census.gov/const/www/charindex.html#singlecomplete Look at Type of Heating Fuel; Data on Existing Construction There is also Oil Heating in the NorthEast (49% in New England and 24% in Mid-Atlantic) in Existing Homes. Rather than model Oil homes in the NE region in Existing houses; or we can account for this later in the speadsheet part of this project. (Not much in New Construction.)
HVAC System Sizing	For each climate, system sizes are fixed for all window options. Fixed sizes are based on the use of DOE-2 auto-sizing for the same house as defined in the analysis, with the most representative window for that specific climate. An auto-sizing multiplier of 1.3 used to account for a typical safety factor. (e)	Same as RESFEN 5 for Existing homes. Autosizing is used for New homes – they are sized with the specific windows chosen.	Consistent with 2006 IECC reference home Table 404.5.2(1). Section M1401.3 of the International Residential Code says " Heating and cooling equipment shall be sized based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies."
HVAC Efficiency	**New Construction:** AFUE = 0.78, A/C SEER=10.0 **Existing Construction:**	**New:** Gas furnace: AFUE = 0.80 in climate zones 1-3,	**For New, as per NFRC:** Gas furnace: 2005 Gas Appliance Manufacturers Association data showed 34% of all U.S. furnaces sold are

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	AFUE = 0.70, A/C SEER= 8.0	0.90 in climate zones 4-8. A/C SEER = 13. Heat pump HSPF = 7.7; Oil furnace AFUE = 0.80 **Existing**: Gas furnace AFUE = 0.78; A/C (& Heat Pump) SEER = 10; Heat pump HSPF = 6.8	condensing (AFUE 90+%). We assume most of these are used in the north, so use new federal minimum (0.80) in zones 1-3, and condensing furnace (0.90) in zones 4-8. A/C: New federal minimum. Heat pump: New federal minimum. Conversion from SEER or HPSF to COP (1/CEIR) for use in DOE2 using updated research: http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-413-04/
Duct Losses	Heating: 10% (fixed) Cooling: 10% (fixed)	12% for basement foundation 20% for crawlspace and slab-on-grade foundations	Consistent with 2006 IECC proposed design default distribution efficiencies (Table 404.5.2(2). As proposed by NFRC. Duct losses entered into DOE2 by modifying efficiencies.
Part-Load Performance	New part-load curves for DOE2 (Henderson 1998) for both new and existing house types	Same as RESFEN 5.	
Thermostat Settings	Heating: 70°F, Cooling: 78°F Basement (partially conditioned): Heating 62°F, Cooling 85°F	Heating: 70°F, Cooling: 78°F Basement (partially conditioned): Heating 62°F, Cooling 85°F	
Night Heating Setback	65°F (11 PM – 6 AM[d])	65°F (11 PM – 6 AM)	
Cooling Setup	N/A	N/A	
Internal Loads	Sensible: 43,033 Btu/day + (floor area * 8.42 Btu/ft²-day for lighting)	Use IECC [Table 404.5.2(1)] proposal of: Internal gain (Btu/day) = 17,900	This includes latent as well as sensible, as well as lighting loads (per conversation with Phil Fairey, 1/11/08).

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	Latent: 12.2 kBtu/day	+ 23.8×floor area + 4104×number of bedrooms. 3 bedrooms shall be used.	The way FSEC uses the equation is for the total internal loads of the house. They then subtract out the people heat gain, which they model as per standard DOE-2/ASHRAE assumption (255 sensible/200 latent per person per hour, etc.). The remainder is then assumed to be 0.80 sensible and 0.20 latent. The hourly profile is based on modeling assumptions developed by the California Energy Commission in 1980 (Mickey Horn and Cynthia Helmich 1980. "Assumptions Used with Energy Performance Computer Programs", Project Report No. 7 for "1980 Residential Building Standard Development Project", June 1980, P400-80-026, pp. 33-48).
Natural Ventilation	Enthalpic – Sherman-Grimsrud (78^{o}F / 72^{o}F based on 4 days' history[(e)]) Windows closed from 11pm to 6am. Only 25% of window area can be open for ventilation. Windows will only open if outdoor temperature has been below the setpoint for prior 4 days.	Maximum operable window area reduced from 25% to 12.5%. Max ACH capped at 10. Based on California research on use of windows for ventilation.	RESFEN 6 algorithm updated based on the reported operation of windows in the recent Sherman and Price report, "Study of Ventilation Practices and Household Characteristics in New California Homes:" http://www.arb.ca.gov/research/apr/past/03-326.pdf
Weather Data	All TMY2[(f)]		
Number of Locations	239 US cities[(f)] 4 Canadian cities	For E* analysis: 97 EWC climates plus Charlotte NC, Amarillo TX, and Prescott AZ	
Calculation Tool	DOE-2.1E	DOE 2.1E version 1.14	

Footnotes

(a) Insulation values do not include exterior siding, structural sheathing, and interior drywall. For examples, an R-19 requirement could be met EITHER by R-19 cavity insulation OR R-13 cavity insulation plus R-6 insulating sheathing. Wall requirements apply to wood-frame or mass (concrete, masonry, log) wall constructions, but do not apply to metal-frame construction."

(b) These assumptions are intended to represent the average solar heat gain reduction for a large sample of houses. A one-foot overhang is assumed on all four orientations in order to represent the average of a two-foot overhang and no overhang. A 67% transmitting obstruction 20 feet away on all four orientations represents the average of obstructions (such as neighboring buildings and trees) 20 feet away on one-third of the total windows and no obstructions in front of the remaining two-thirds of windows. An interior shade is assumed to have a Solar Heat Gain Coefficient multiplier of 0.9 during the winter and 0.8 during the summer. To account for solar heat gain reducing effects from other sources such as screens, trees, dirt, and self-shading of the building, the SHGC multiplier was further reduced by 0.1 throughout the year. This amounts to a 12.5% decrease in the summer and an 11.1% decrease in the winter. The final SHGC multipliers (0.8 in the winter and 0.7 in the summer) thus reflect the combined effects of shading devices and other sources.

(c) RESFEN 5: For each climate, DOE-2's auto-sizing feature was used with the window most likely to be installed in new construction (assumed to be the MEC default). Tables 6.4 and 6.5 show the required prescriptive U-factors for windows for the 52 climates. For climates where the U-factor requirement is greater than or equal to 1.0, an aluminum frame window with single glazing (U-factor = 1.30; SHGC = 0.74) is used. For climates where the U-factor requirement is between 0.65 and 1.0, an aluminum frame window with double glazing (U-factor = 0.87; SHGC = 0.66) is used. For climates where the U-factor requirements are below 0.65, as well as in the four Canadian climates, a vinyl frame window with double glazing (U-factor = 0.49; SHGC = 0.57) is used for the sizing calculation.

(d) RESFEN models a moderate setback of 65° F in recognition that some but not all houses may use night setbacks. Recent studies of residential indoor conditions have shown that, during the heating season, nighttime temperatures are significantly lower than daytime temperatures (Ref: "Occupancy Patterns and Energy Consumption in New California Houses," Berkeley Solar Group for the California Energy Commission, 1990).

(e) RESFEN uses a feature in DOE-2 that allows the ventilation temperature to switch between a higher heating (or winter) and a lower cooling (or summer) temperature based on the cooling load over the previous four days.

(f) RESFEN uses Typical Meteorologcal Year (TMY2) weather tapes from the National Renewable Energy Laboratory. There are 239 TMY2 locations with average weather data compiled from 30+ years of historical weather data. (National Renewable Energy Laboratory, 1995).

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