RESNET
Residential Energy Services Network

# Proposed Standards Revision

Date: 01/15/10 (as modified by Aux Energy Sub: 07/16/10) Amendment #2011 -
As modified following resolution of public comments: April 11, 2011

**Title:** Lighting, Appliance and Miscellaneous Energy Usage Profiles

**Proposed Revision:** (Specify Section to be revised. ~~Line through deleted text.~~ Underline added text.)

***Add the following definition to Section 302, Definitions and Acronyms:***

*MBtu* – One million British thermal units (Btu).

***Modify Section 303.2.1 as follows:***

Step (2) Determine the HERS Index using equation 2:

HERS Index = PEfrac * (TnML / TRL) * 100 (Eq. 2)

where:

TnML = $nMEUL_{HEAT}$ + $nMEUL_{COOL}$ + $nMEUL_{HW}$ + $EUL_{LA}$ (~~Total of all normalized modified end use loads for heating, cooling and hot water as calculated using equation 1 plus $EUL_{LA}$ = [(18,842 + 25.1*CFA) * 365] / ($1*10^6$) MBtu/year, modified by allowable reductions for qualifying lighting and appliances as specified by Section 303.4.1.7.2 of this Standard~~ MBtu/yr)

TRL = $REUL_{HEAT}$ + $REUL_{COOL}$ + $REUL_{H\,W}$ + $REUL_{LA}$ (~~Total of all Reference Home end use loads for heating, cooling and hot water plus $REUL_{LA}$ = [(18,842 + 25.1*CFA) * 365] / ($1*10^6$) MBtu/year~~ MBtu/yr)

and where:

$EUL_{LA}$ = Rated Home end use loads for lighting, appliances and MELs as defined by Section 303.4.1.7.2, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293 or (therms/yr)/10, as appropriate.

$REUL_{LA}$ = Reference Home end use loads for lighting, appliances and MELs as defined by Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293 or (therms/yr)/10, as appropriate.

and where:

PEfrac = (TEU - OPP) / TEU

TEU = Total energy use of the Rated Home including all rated and non-rated energy features where all fossil fuel site energy uses are converted to Equivalent Electric Power by multiplying them by the Reference Electricity Production Efficiency of 40%

OPP = On-site Power Production as defined by Section 303.1.1.5

***Modify Table 303.4.1(1) as follows:***

| | | |
|---|---|---|
| Internal gains: | As specified by Table 303.4.1(3) ~~IGain = 17,900 + 23.8*CFA + 4104*$N_{br}$ (Btu/day per dwelling unit)~~ | Same as HERS Reference Home, except as provided by Section 303.4.1.7.2 |

**Table 303.4.1(3). Internal Gains for HERS Reference Homes [(a)]**

| End Use / Component | Sensible Gains (Btu/day) | | | Latent Gains (Btu/day) | | |
|---|---|---|---|---|---|---|
| | a | b | c | a | b | c |
| Residual MELs | | 7.27 | | | 0.38 | |
| Interior lighting | 4,253 | 7.48 | | | | |
| Refrigerator | 5,955 | | 168 | | | |
| TVs | 3,861 | | 645 | | | |
| Range/Oven (elec) [(b)] | 2,228 | | 262 | 248 | | 29 |
| Range/Oven (gas) [(b)] | 4,086 | | 488 | 1,037 | | 124 |
| Clothes Dryer (elec) [(b)] | 661 | | 188 | 73 | | 21 |
| Clothes Dryer (gas) [(b)] | 739 | | 209 | 91 | | 26 |
| Dish Washer | 219 | | 87 | 219 | | 87 |
| Clothes Washer | 96 | | 28 | 11 | | 3 |
| Gen water use | 18 | | 6 | 1,245 | | 415 |
| Occupants [(c)] | | | 3978 | | | 3,162 |

**Notes for Table 303.4.1(3)**

(a) Table values are coefficients for the following general equation: Gains = a + b*CFA + c*Nbr
where CFA = Conditioned Floor Area and Nbr = Number of bedrooms.

(b) For Rated Homes with electric appliance use (elec) values and for Rated homes with natural gas-fired appliance use (gas) values

(c) Software tools shall use either the occupant gains provided above or similar temperature dependant values generated by the software where number of occupants equals the number of bedrooms and occupants are present in home 75% of the time.

***Renumbering all following tables accordingly.***

***Modify Section 303.4.1.7 as follows:***

**303.4.1.7 Lighting, ~~and~~ Appliances and Miscellaneous Electric Loads (MELs)**

~~**303.4.1.7.1 Lighting.** Reference home annual lighting use in kWh/yr/(dwelling unit) shall be calculated as (455 + 0.80 * CFA) with an internal gain factor equal to 90% of lighting energy use (10% of lighting energy use is assumed to occur outside of the conditioned floor area of the home).~~

~~For the purpose of adjusting the annual light fixture energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by adding lighting $\Delta EUL_{LA}$, where $\Delta EUL_{LA}$ (MBtu/yr/(dwelling unit)) = [29.5 – 0.5189*CFA*$FL_{\%}$ – 295.12*$FL_{\%}$ + 0.0519*CFA] *~~

0.003413, and where $FL_{\%}$ is the ratio of Qualifying Light Fixtures to all light fixtures in Qualifying Light Fixture Locations, and CFA is the Conditioned Floor Area. For calculation purposes, the rated home shall never have $FL_{\%}$ less than 10%.

For lighting, internal gains in the Rated home shall be reduced by 90% of the lighting $\Delta EUL_{LA}$ calculated in Btu/day using the following equation: $\Delta Igain = 0.90 * \Delta EUL_{LA} * 10^6 / 365$..

**303.4.1.7.2 Refrigerators.** Reference home annual refrigerator energy use shall be 775 kWh/yr per dwelling unit.

For the purposes of adjusting the annual refrigerator energy consumption for calculating the rating, the $EUL_{LA}$ shall be adjusted by adding $\Delta EUL_{LA}$, where refrigerator $\Delta EUL_{LA}$(kWh/yr/(dwelling unit)) = Total Annual Energy Consumption of Refrigerators in Rated Home – 775.

For refrigerators, internal gains in the Rated home shall be reduced by 100% of the refrigerator $\Delta EUL_{LA}$ calculated in Btu/day using the following equation: $\Delta Igain = \Delta EUL_{LA} * 10^6 / 365$.

**303.4.1.7.3 Mechanical Ventilation System Fans.** If ventilation fans are present, the $EUL_{LA}$ shall be adjusted by adding $\Delta EUL_{LA}$, where $\Delta EUL_{LA}$ (kWh/year/(dwelling unit)) = Total Annual Energy Consumption of the Ventilation System in the Rated Home – [0.03942*CFA + 29.565*($N_{br}$+1)]

**303.4.1.7.4 Dishwashers.** A dishwasher, with annual energy use as specified by Table 303.4.1.8 with an internal gain factor equal to 60% of dishwasher energy use, shall be assumed in the Reference home. If no labeled dishwasher energy factor is specified for the Rated home, the Rated home shall have the same dishwasher annual energy use and internal gain factor as the Reference home.

***Table 303.4.1.8***

| **Bedrooms per Dwelling Unit** | **Reference Dishwasher kWh** |
|---|---|
| 1 | 90 |
| 2 | 126 |
| 3 | 145 |
| 4 | 174 |
| 5+ | 203 |

For the purposes of calculating dishwasher energy savings and hot water energy savings for calculating the rating, the energy savings shall be calculated based on the following formula using Cycles/Year by number of Bedroom ($N_{br}$) as specified in Table 303.4.1.9

Dishwasher annual energy use for each dwelling unit in the rated home (kWh/yr) = (0.27) * (cycles/yr/(dwelling unit)) / (dishwasher rated Energy Factor)

~~***Table 303.4.1.9***~~

| ~~$N_{br}$ per Dwelling Unit~~ | ~~Cycles/Yr per Dwelling Unit~~ |
|---|---|
| ~~1~~ | ~~154~~ |
| ~~2~~ | ~~214~~ |
| ~~3~~ | ~~247~~ |
| ~~4~~ | ~~296~~ |
| ~~5+~~ | ~~345~~ |

~~$EUL_{LA}$ shall be adjusted by adding dishwasher $\Delta EUL_{LA}$, where $\Delta EUL_{LA}$ ( MBtu/yr/(dwelling unit)) = (cycles/yr)*[0.27/(dishwasher rated Energy Factor) – 0.587]*0.003413.~~

~~Internal gains in the Rated Home shall be reduced by 60% of the dishwasher $\Delta EUL_{LA}$ calculated in Btu/day using the following equation: $\Delta Igain = 0.60 * \Delta EUL_{LA} * 10^6 / 365$.~~

~~The reduction in hot water use (gallons/day) shall be based on the following formula, to be used in adjusting the hot water Use Equation given by Table 303.4.1(1):~~

~~Reduction in hot water use (gallons/day/(dwelling unit)) = [(7.4 gal/cycle) – (0.73)/(dishwasher rated Energy Factor in cycles/kWh)/(90 °F)/(0.0024 kWh/gal/F)] * [(cycles/yr/(dwelling unit))/(365 days/year)]~~

**303.4.1.7.1 HERS Reference Home.** Lighting, appliance and miscellaneous electric loads in the HERS Reference Home shall be determined in accordance with the values provided in Table 303.4.1.7.1(1) and Table 303.4.1.7.1(2), as appropriate, and equation 3:

kWh (or therms) per year = a + b*CFA + c*Nbr (Eq. 3)

where:

‘a’, ‘b’, and ‘c’ are values provided in Table 303.4.1.7.1(1) and Table 303.4.1.7.1(2)

CFA = conditioned floor area

Nbr = number of bedrooms

**303.4.1.7.1.1 Electric Reference Homes.** Where the Rated Home has electric appliances, the HERS Reference Home lighting, appliance and miscellaneous loads shall be determined in accordance with the values given in Tables 303.4.1.7.1(1).

Table 303.4.1.7.1(1). Lighting, Appliance and Miscellaneous Electric Loads (kWh/yr) in electric HERS Reference Homes

| End Use Component[(a)] | Equation Coefficients | | |
|---|---|---|---|
| | a | b | c |
| Residual MELs | | 0.91 | |
| Interior lighting | 455 | 0.80 | |
| Exterior lighting | 100 | 0.05 | |
| Refrigerator | 637 | | 18 |
| Televisions | 413 | | 69 |
| Range/Oven | 331 | | 39 |
| Clothes Dryer | 524 | | 149 |
| Dish Washer | 78 | | 31 |
| Clothes Washer | 38 | | 10 |

**Table 303.4.1.7.1(1) Notes:**

(a) For homes with garages, an additional 100 kWh per year shall be added to the HERS Reference home for garage lighting.

**303.4.1.7.1.2 Reference Homes with Natural Gas Appliances.** Where the Rated Home is equipped with natural gas cooking or clothes drying appliances, the Reference Home cooking and clothes drying loads defined above in Table 303.4.1.7(1) shall be replaced by the natural gas and electric appliance loads provided below in Table 303.4.1.7(2), as applicable.

Table 303.4.1.7(2). Natural Gas Appliance Loads (therms/yr) for HERS Reference Homes with gas appliances

| End Use Component[(a)] | Equation Coefficients | | |
|---|---|---|---|
| | a | b | c |
| Range/Oven (therms) | 22.6 | | 2.7 |
| Range/Oven (kWh) | 22.6 | | 2.7 |
| Clothes Dryer (therms) | 18.8 | | 5.3 |
| Clothes Dryer (kWh) | 41 | | 11.7 |

**Table 303.4.1.7(2) Notes:**

(a) Both the natural gas and the electric components shall be included in determining the HERS Reference Home annual energy use for the above appliances.

**303.4.1.7.1.3 Garage Lighting.** Where the Rated Home includes an enclosed garage, 100 kWh/yr shall be added to the energy use of the Reference Home to account for garage lighting.

**303.4.1.7.1.4 Mechanical Ventilation.** Where mechanical ventilation is provided in the Rated home, $REUL_{LA}$ shall be modified for the Reference Home by adding [0.03942*CFA + 29.565*($N_{br}$+1)] kWh/yr for ventilation fan operation, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

**303.4.1.7.1.5 Ceiling Fans.** Where ceiling fans are included in the Rated Home they shall also be included in the Reference Home in accordance with the provisions of Section 303.4.1.7.2.11 of this Standard.

**303.4.1.7.2 Rated Homes.** For Rated homes, the following procedures shall be used to determine lighting, appliance and residual miscellaneous electric load energy consumption.

**303.4.1.7.2.1 Residual MELs.** Residual miscellaneous electric loads in the Rated Home shall be the same as in the HERS Reference Home and shall be calculated as 0.91*CFA, where CFA is the conditioned floor area.

**303.4.1.7.2.2 Interior Lighting.** Interior lighting in the Rated home is calculated using equation 5:

$$kWh/yr = 0.8*[(4 - 3*qFF_{IL})/3.7]*(445 + 0.8*CFA) + 0.2*(455 + 0.8*CFA) \quad \text{(Eq. 5)}$$

where:

CFA = Conditioned floor area

$qFF_{IL}$ = the ratio of the Qualifying interior Light Fixtures to all interior light fixtures in Qualifying interior Light Fixture Locations.

For rating purposes, the Rated Home shall not have $qFF_{IL}$ less than 0.10 (10%).

(Informative Note: When $qFF_{IL}$ = 0.10 (10%), the above equation reduces to the standard interior lighting equation of: kWh/yr = 455 + 0.8*CFA.)

For the purpose of adjusting the annual interior lighting energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{IL}$, which shall be calculated as the annual interior lighting energy use derived by the procedures in this section minus the annual interior lighting energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For Interior lighting, internal gains in the Rated home shall be modified by 100% of the interior lighting $\Delta EUL_{IL}$ converted to Btu/day as follows: $\Delta EUL_{IL} * 10^6 / 365$.

**303.4.1.7.2.3 Exterior Lighting.** Exterior lighting in the Rated home shall be determined using equation 6:

$$kWh/yr = (100 + 0.05*CFA)*(1-FF_{EL}) + 0.25*(100 + 0\ .05*CFA)*FF_{EL} \quad \text{(Eq. 6)}$$

where

CFA = Conditioned floor area

$FF_{EL}$ = Fraction of exterior fixtures that are Qualifying Light Fixtures

For the purpose of adjusting the annual exterior lighting energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{EL}$, which shall be calculated as the

annual exterior lighting energy use derived by the procedures in this section minus the annual exterior lighting energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

Internal gains in the Rated Home shall not be modified as a result of reductions in exterior lighting energy use.

**303.4.1.7.2.4 Garage Lighting.** For Rated homes with garages, garage lighting in the Rated home shall be determined using equation 7:

$kWh = 100*(1-FF_{GL}) + 25*FF_{GL}$ (Eq. 7)

where:

$FF_{GL}$ = Fraction of garage fixtures that are Qualifying Light Fixtures

For the purpose of adjusting the annual garage lighting energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{GL}$, which shall be calculated as the annual garage lighting energy use derived by the procedures in this section minus the annual garage lighting energy use derived for the HERS Reference Home in Section 303.4.1.7.1 (i.e. 100 kWh/yr), converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

Internal gains in the Rated Home shall not be modified as a result of reductions in garage lighting energy use.

**303.4.1.7.2.5 Refrigerators.** Refrigerator energy use for the Rated Home shall be determined from either Refrigerator Energy Guide Labels or from age-based defaults provided in Table 303.4.1.7.2.5(1).

Table 303.4.1.7.2.5(1) Age-based Refrigerator Defaults

| Refrigerator/Freezer Type | Annual kWh Equation |
|---|---|
| Single-door refrigerator only | (13.5*AV + 299)*VR |
| Single-door refrigerator/freezer | (13.5*AV + 299)*VR |
| Refrigerator with top freezer | (16.0*AV + 355)*VR |
| with TDI | (17.6*AV + 391)*VR |
| Refrigerator with side-by-side freezer | (11.8*AV + 501)*VR |
| with TDI | (16.3*AV + 527)*VR |
| Refrigerator with bottom freezer | (16.6*AV + 367)*VR |
| Upright freezer only manual defrost | (10.3*AV + 264)*VR |
| Upright freezer only auto defrost | (14.0*AV + 391)*VR |
| Chest freezer only | (11.0*AV + 160)*VR |
| where:<br>AV = Adjusted Volume = (refrigerator compartment volume) + 1.63*(freezer compartment volume)<br>TDI = Through the door ice<br>VR = Vintage Ratio from Table 303.4.1.7.2.5(2) | |

Table 303.4.1.7.2.5(2) Age-based Vintage Ratios

| Refrigerator Vintage | Vintage Ratio |
|---|---|
| 1972 or before | 2.50 |
| 1980 | 1.82 |
| 1984 | 1.64 |
| 1988 | 1.39 |
| 1990 | 1.30 |
| 1993 | 1.00 |
| 2001 forward | 0.77 |

For the purposes of determining adjusted volume (AV), the following defaults may be used:

Table 303.4.1.7.2.5(3) Default Adjusted Volume Equations

| Model Type | Default Equation |
|---|---|
| Single door refrigerator only | AV = 1.00 * nominal volume |
| Single door refrigerator/freezer | AV = 1.01 * nominal volume |
| Bottom Freezer | AV = 1.19 * nominal volume |
| Top Freezer | AV = 1.16 * nominal volume |
| Side by Side | AV = 1.24 * nominal volume |
| Freezer only | AV = 1.73 * nominal volume |

For the purpose of adjusting the annual refrigerator energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{FRIG}$, which shall be calculated as the annual refrigerator energy use derived by the procedures in this section minus the annual refrigerator energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For refrigerator energy use, internal gains in the Rated home shall be modified by 100% of the refrigerator $\Delta EUL_{FRIG}$ converted to Btu/day as follows: $\Delta EUL_{FRIG} * 10^6 / 365$. Internal gains shall not be modified for refrigerators located in unconditioned spaces (e.g. unconditioned garages, etc.)

**303.4.1.7.2.6 Televisions.** Television energy use in the Rated Home shall be the same as television energy use in the HERS Reference Home and shall be calculated as TVkWh/yr = 413 + 69*Nbr, where Nbr is the number of bedrooms in the Rated Home.

**303.4.1.7.2.7 Range/Oven.** Range/Oven (cooking) energy use for the Rated Home shall be determined as follows:

1) For electric cooking:
   kWh/yr = BEF * OEF * (331 + 39*Nbr) (Eq. 12a)
2) For natural gas cooking:
   Therms/yr = OEF*(22.6 + 2.7*Nbr) (Eq. 12b)
   plus:
   kWh/yr = 22.6 + 2.7*Nbr (Eq. 12c)

where:

BEF= Burner Energy Factor = 0.91 for induction ranges and 1.0 otherwise.
OEF = Oven Energy Factor = 0.95 for convection types and 1.0 otherwise

Nbr = Number of bedrooms

For the purpose of adjusting the annual Range/Oven energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{RO}$, which shall be calculated as the annual Range/Oven energy use derived by the procedures in this section minus the annual Range/Oven energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For Range/Oven energy use, internal gains in the Rated Home shall be modified by 80% of the Range/Oven $\Delta EUL_{RO}$ converted to Btu/day as follows: $\Delta EUL_{RO} * 10^6 / 365$. Of this total amount, internal gains shall be apportioned as follows, depending on fuel type:

a) For electric Range/Ovens, 90% sensible internal gains and 10% latent internal gains
b) For gas Range/Ovens, 80% sensible internal gains and 20% latent internal gains.

**303.4.1.7.2.8 Clothes Dryers.** Clothes Dryer energy use for the Rated Home shall be determined by the following equation.

$$kWh/yr = 12.5*(164+46.5*Nbr)*FU/EFdry*(CAPw/MEF - LER/392)/(0.2184*(CAPw*4.08+0.24)) \quad \textbf{(Eq. 13)}$$

where:

Nbr = Number of bedrooms in home
FU = Field Utilization factor =1.18 for timer controls **or** 1.04 for moisture sensing
EFdry = Efficiency Factor of clothes dryer (lbs dry clothes/kWh) from the CEC database [1] or use following electric clothes dryer default: 3.01
CAPw = Capacity of clothes washer ($ft^3$) from the manufacturer's data or the CEC database **or** the EPA Energy Star website [2] **or** use default of 2.874 $ft^3$
$MEF^3$ = Modified Energy Factor of clothes washer from Energy Guide Label **or** use default of 0.817
$LER^3$ = Labeled Energy Rating of clothes washer (kWh/yr) from Energy Guide Label **or** use default of 704

For natural gas clothes dryers the following equations shall be used:

Therms/yr = (result of Eq. 13)*3412*(1-0.07)*(3.01/EFdry-g)/100000 (Eq. 13a)
kWh/yr = (result of Eq. 13)*0.07*(3.01/EFdry-g) (Eq. 13b)

where:

EFdry-g = Efficiency Factor for gas clothes dryer from the CEC database[1] or use the following gas clothes dryer default: 2.67.

For the purpose of adjusting the annual Clothes Dryer energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{CD}$, which shall be calculated as the annual

[1] http://www.energy.ca.gov/appliances/database/excel_based_files/
[2] http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers
[3] This value must be determined from the energy rating for clothes washer as it determines the amount of moisture remaining in the clothes after the washer cycle is completed.

Clothes Dryer energy use derived by the procedures in this section minus the annual Clothes Dryer energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For Clothes Dryer energy use, total internal gains in the Rated Home shall be modified by 15% of the Cloths Dryer $\Delta EUL_{CD}$ converted to Btu/day as follows: $\Delta EUL_{CD} * 10^6 / 365$. Of this total amount, 90% shall be apportioned to sensible internal gains and 10% to latent internal gains. Internal gains shall not be modified for Clothes Dryers located in unconditioned spaces (e.g. unconditioned garages, etc.)

**303.4.1.7.2.9 Dishwashers.** Dishwasher energy use for the Rated Home shall be determined using the following equation.

**kWh/yr = [(86.3 + 47.73/EF)/215]*dWcpy (Eq. 14a)**

where:

EF = Labeled dishwasher energy factor

or

EF = 215/(labeled kWh/year)

dWcpy = (88.4 + 34.9*Nbr)*12/dWcap

where:

dWcap = Dishwasher place setting capacity; Default = 12 settings for standard sized dishwashers and 8 place settings for compact dishwashers

And the change (Δ) in daily hot water use (GPD – gallons per day) for dishwashers shall be calculated as follows:[1]

**$\Delta GPD_{DW}$ = [(88.4+34.9*Nbr)*8.16 - (88.4+34.9*Nbr) *12/dWcap*(4.6415*(1/EF) - 1.9295)]/365 (Eq. 14b)**

For the purpose of adjusting the annual Dishwasher energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{DW}$, which shall be calculated as the annual Dishwasher energy use derived by the procedures in this section minus the annual Clothes Dishwasher energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 or (therms/yr) / 10, whichever is applicable.

For the purpose of adjusting the daily hot water use for calculating the rating, the daily hot water use change shall be '$\Delta GPD_{DW}$' as calculated above.

For Dishwasher energy use, total internal gains in the Rated Home shall be modified by 60% of the Dishwasher $\Delta EUL_{DW}$ converted to Btu/day as follows: $\Delta EUL_{DW} * 10^6 / 365$. Of this total amount, 50% shall be apportioned to sensible internal gains and 50% to latent internal gains.

**303.4.1.7.2.10 Clothes Washers.** Clothes Washer annual energy use and daily hot water use for the Rated Home shall be determined as follows.

[1] http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dishwasher.xls

Annual energy use shall be calculated using the following equation:

**kWh/yr = ((LER/392)-((LER*($/kWh)-AGC)/(21.9825*($/kWh) - ($/therm))/392)*21.9825)*ACY (Eq. 15a)**

where:

LER = Label Energy Rating (kWh/yr) from Energy Guide Label

$/kWh = Electric Rate from Energy Guide Label

AGC = Annual Gas Cost from Energy Guide Label

$/therm = Gas Rate from Energy Guide Label

ACY = Adjusted Cycles per Year

and where:

ACY = NCY * ((3.0*2.08+1.59)/(CAPw*2.08+1.59))

where:

NCY = (3.0/2.847) * (164 + Nbr*45.6)

CAPw = washer capacity in cubic feet from the manufacturer's data or the CEC database[1] **or** the EPA Energy Star website [2] **or** use default of 2.874 ft$^3$

And daily hot water use shall be calculated as follows:

**DHWgpd = 120.5* therms/cyc * ACY / 365 (Eq. 15b)**

where:

therms/cyc = (LER * $/kWh - AGC) / (21.9825 * $/kWh - $/therm) / 392

For the purpose of adjusting the annual Clothes Washer energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{CW}$, which shall be calculated as the annual Clothes Washer energy use derived by the procedures in this section minus the annual Clothes Washer energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293 **or** (therms/yr) / 10, whichever is applicable.

For the purpose of adjusting the daily hot water use for calculating the rating, the daily hot water use change shall be calculated as the daily hot water use derived by the procedures in this section minus 7.94 gallons per day for the reference standard clothes washer.

For Clothes Washer energy use, total internal gains in the Rated Home shall be modified by 30% of the Clothes Washer $\Delta EUL_{CW}$ converted to Btu/day as follows: $\Delta EUL_{CW} * 10^6 / 365$. Of this total amount, 90% shall be apportioned to sensible internal gains and 10% to latent internal gains. Internal gains shall not be modified for Clothes Washers located in unconditioned spaces (e.g. unconditioned garages, etc.)

Rating and label data on clothes washer may be found at the following web sites:

EPA: www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers
CEC: www.energy.ca.gov/appliances/database/excel_based_files/Clothes_Washers/

[1] http://www.energy.ca.gov/appliances/database/excel_based_files/
[2] http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

~~**303.4.1.7.5**~~**303.4.1.7.2.11 Ceiling Fans.** If ceiling fans are included in the Rated home, they shall also be included in the Reference home. ~~Three (3)~~The number of bedrooms plus one (Nbr+1) ceiling fans shall be assumed in both the Reference Home and the Rated Home. A daily ceiling fan operating schedule equal to ~~14~~ 10.5 full-load hours shall be assumed in both the Reference Home and the Rated Home during periods when ceiling fans are operational. Ceiling fans shall be assumed to operate only during the cooling season, which may be estimated to be all months with an average temperature greater than 63 $^{o}$F. The cooling thermostat (but not the heating thermostat) shall be set up by 0.5 $^{o}$F in both the Reference and Rated Home during periods when ceiling fans are assumed to operate.

The Reference Home shall use number of bedrooms plus one (Nbr+1)~~three (3)~~ Standard Ceiling Fans of 42.6 watts each ~~for total full-load fan wattage of 128 watts (42.6 * 3 = 128)~~. The Rated Home shall use the Labeled Ceiling Fan Standardized Watts (LCFSW), also multiplied by number of bedrooms plus one (Nbr+1)~~three (3)~~ fans to obtain total ceiling fan wattage for the Rated Home. The Rated Home LCFSW shall be calculated as follows:

**LCFSW = (3000cfm) / (cfm/watt as labeled at medium speed)**

Where installed ceiling fans in the Rated Home have different values of LCFSW, the average LCFSW shall be used for calculating ceiling fan energy use in the Rated Home.

During periods of fan operation, the fan wattage, at 100% internal gain fraction, shall be added to internal gains for both the Reference and Rated Homes. In addition, annual ceiling fan energy use, in MBtu/y~~ear~~ [(kWh/y~~ear~~)/293] ~~* 3.413x10$^{-3}$~~), for both the Rated and Reference homes shall be added to the lighting and appliance end use loads ($EUL_{LA}$ and $REUL_{LA}$, as appropriate) ~~given in~~as specified by Equation 2, Section 303.2.1 of this Chapter.

**303.4.1.7.2.12 Mechanical Ventilation System Fans.** If ventilation fans are present in the Rated Home, $EUL_{LA}$ shall be adjusted by adding total annual kWh energy consumption of the ventilation system in the Rated Home, converted to MBtu/yr, where MBtu/yr = (kWh/yr) / 293.

**303.4.1.8** If the Rated Home includes On-site Power Production, the Purchased Energy Fraction for the Rated Home (see Section 303.2.2) shall be used to determine the impact of the On-site Power Production on the HERS Index.

**Effective Date**

The effective date of this standards revision shall be 180 days following approval of these revisions by the RESNET Board of Directors.

**Justification:** (Must be provided. Supporting documents may be attached.)

The proposed change results from the findings of a comprehensive DOE-funded study of miscellaneous loads in residential buildings conducted by the Florida Solar Energy Center and National Renewable Energy Laboratory which found that these loads are significantly over predicted by the procedures required by the current RESNET standards.[1] In addition to recommending changes to rating procedures for end uses already rated by RESNET standards, this report recommends procedures to rate the relative efficiency of additional end uses that are not included in the current standards. These additional end uses are clothes washers and clothes dryers.

The report, which is available online (see footnote 1, below) serves as the supporting document for this proposal.

***Justification for Modifications by Technical Committee***

The original proposed change was modified by the Technical Committee to remove televisions from the rated features of a home. This modification was the result of the following ballot of the Technical Committee.

**TVs <u>shall be</u> considered a rated feature in homes.**

| | |
|---|---|
| Favor: | 2 |
| Opposed: | 14 |
| Abstain: | 0 |
| Not voting: | 2 |

The alternatives considered by the Auxiliary Energy Subcommittee and the Technical Committee in arriving at this vote are provided on the following pages.

[1] Parker, D., P. Fairey and R. Hendron, January 2010. "Updated Miscellaneous Electricity Loads and Appliance Energy Usage Profiles for Use in Home Energy Ratings, the Building America Benchmark Procedures and Related Calculations." Report # FSEC-CR-1837-10, Florida Solar Energy Center, Cocoa, FL. http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1837-10-R01.pdf

# Alternatives for Treatment of TVs in Home Energy Ratings

For Consideration of the Auxiliary Energy Use Subcommittee
of the RESNET Technical Committee

P. Fairey
May 13, 2010

**Alternative #1:** Leave treatment of TVs as proposed in original amendment. (The relevant sections of the proposed amendment are repeated below for convenience.)

**303.4.1.7.1 HERS Reference Home.** Lighting, appliance and miscellaneous electric loads in the HERS Reference Home shall be determined in accordance with the values provided in Table 303.4.1.7.1(1), Table 303.4.1.7.1(2) and Table 303.4.1.7.1(3), as appropriate, and equation 3 (except for televisions):

kWh (or therms) per year = a + b*CFA + c*Nbr (Eq. 3)

where:

'a', 'b', and 'c' are values provided in Table 303.4.1.7.1(1) or Table 303.4.1.7.1(3)
CFA = conditioned floor area
Nbr = number of bedrooms

Television energy use in the HERS Reference Home shall be determined in accordance with Table 303.4.1.7.1(2) or the following equation:

$$TVkWh/yr = \Sigma(actWatts_{STD},i * onHours,i + offWatts_{STD},i * offHours,i) + p*(actWatts_{STD},m * onHours,m + offWatts_{STD},m * offHours,m) \quad \text{(Eq. 4)}$$

where:

i = 1, n = TV#
n = INT(1.1 + 0.51*Nbr)
o = 1.1 + 0.51*Nbr
p = o – n (a fractional TV)
m = n +1 = TV# for partial TV

and where:

$actWatts_{STD} = 124 – 69.1*\log_{(10)}TV\#$ (or 50 watts, whichever is greater)
$offWatts_{STD} = 4$
$onHours = 6.876 – 7.054*\log_{(10)}TV\#$ (or 0.5 hours, whichever is greater)
offHours = 24 – onHours

**303.4.1.7.1.1 All Electric Reference Homes.** Where the Rated Home has all electric appliances, the HERS Reference Home lighting, appliance and miscellaneous loads shall be determined in accordance with the values given below in Tables 303.4.1.7.1(1) and 303.4.1.7.1(2).

Table 303.4.1.7.1(1). Lighting, Appliance and Miscellaneous Electric Loads in all electric HERS Reference Homes

| End Use Component[(a)] | Equation Coefficients | | |
|---|---|---|---|
| | a | b | c |
| Residual MELs | | 0.91 | |
| Interior lighting | 455 | 0.80 | |
| Exterior lighting | 100 | 0.05 | |
| Refrigerator | 637 | | 18 |
| Televisions | See Table 303.4.1.7.1(2) | | |
| Range/Oven | 331 | | 39 |
| Clothes Dryer | 524 | | 149 |
| Dish Washer | 78 | | 31 |
| Clothes Washer | 38 | | 11 |

**Table 303.4.1.7.1(1) Notes:**

(a) For homes with garages, an additional 100 kWh per year shall be added to the HERS Reference home for garage lighting.

Table 303.4.1.7.1(2). Annual Television Energy Use for HERS Reference Home [(a)]

| Nbr | TVkWh/yr | Nbr | TVkWh/yr |
|---|---|---|---|
| 1 | 463 | 7 | 858 |
| 2 | 561 | 8 | 898 |
| 3 | 636 | 9 | 933 |
| 4 | 705 | 10 | 966 |
| 5 | 762 | 11 | 994 |
| 6 | 814 | 12 | 1020 |

**Table 303.4.1.7.1(2) Notes:**

(a) For homes with more than 12 bedrooms, the equation provided in Section 303.4.1.7.1 may be used

**303.4.1.7.2.6 Televisions.** Television energy use in the Rated Home shall be determined using the following protocol:

1) No TV information available – same annual TV energy use as the Reference home in accordance with Section 303.4.1.7.1 of this standard
2) EPA Label information[1] **or** number and size of TVs available
   a. TVs shall be ordered in a list to determine TV# by decreasing screen size and within the same screen size by decreasing active wattage
   b. The number of Rated TVs in the Rated home shall be a minimum of 1.1 + 0.51*Nbr
   c. If number of Rated TVs is less than 1.1 + 0.51*Nbr, then remaining TVs (i.e.

[1] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=TV

1.1 +0.51*Nbr minus number of Rated TVs), including partial TVs, shall be included in the ordered TV list calculated as standard TVs using the following formula:

$$actWatts_{STD} = 124 - 69.1*\log_{(10)}TV\# \quad \text{or 50 watts, whichever is greater} \qquad \text{(Eq. 8)}$$

d. If number of TVs is greater than 1.1 + 0.51*Nbr, then each TV shall be included in the calculation of Rated home annual TV energy use
e. If label information is available, active wattage and standby wattage as reported on label shall be used for the calculation of annual TV energy use
f. If label information is not available, standby wattage shall be 4 watts and active wattage shall be determined from the diagonal screen size using the following formula:

$$actWatts_{TV} = 9.21 + 1.17*diag + 0.110*diag^2 \qquad \text{(Eq. 9)}$$

g. Viewing hours shall be determined on a unit by unit basis using the following formula:

$$onHours = 6.876 - 7.054*\log_{(10)}TV\# \quad \text{or 0.5 hours, whichever is greater} \qquad \text{(Eq. 10)}$$

h. Total annual Rated home TV energy use shall be calculated using the following formula:

$$TVkWh/yr = \Sigma(actWatts_{TV,i} * onHours,i + offWatts_{TV,i} * offHours,i) + p*(actWatts_{STD,m} * onHours,m + offWatts_{STD,m} * offHours,m) \qquad \text{(Eq. 11)}$$

where:

i = 1, n = TV#
n = INT(1.1 + 0.51*Nbr) **or** total number of Rated TVs, whichever is greater
o = 1.1 + 0.51*Nbr **or** total number of Rated TVs, whichever is greater
p = o – n (a fractional TV)
m = n +1 = TV# for partial TV

For the purpose of adjusting the annual television energy consumption for calculating the rating, $EUL_{LA}$ shall be adjusted by $\Delta EUL_{TV}$, which shall be calculated as the annual television energy use derived by the procedures in this section minus the annual television energy use derived for the HERS Reference Home in Section 303.4.1.7.1, converted to MBtu/yr, where MBtu/yr = (kWh/yr)/293.

For television energy use, internal gains in the Rated Home shall be modified by 100% of the television $\Delta EUL_{TV}$ converted to Btu/day as follows: $\Delta EUL_{TV} * 10^6 / 365$. Internal gains shall not be modified for televisions located in unconditioned spaces (e.g. unconditioned garages, porches, etc.)

**Alternative #2:** Modify treatment of TVs to use the simplified equation as all other end uses. (Michael Blasnik proposal[1])

The Blasnik proposal is quite straight forward for the Reference Home (Section 303.4.1.7.1). Table 303.4.1.7.1(1) would be altered to include the proper coefficient data for TVs and Table 303.4.1.7.1(2) would be deleted.

[1] Personal communication via e-mail from M. Blasnik to P. Fairey, dated 05/05/2010.

One can regress the TV energy use data provided in Table 303.4.1.7.1(2) of the original proposal to determine a reasonable set of coefficients for a simplified equation. Blasnik has pointed out that the equations used in the original proposal are not necessarily valid beyond about 6 bedrooms due to the fact that the RECS dataset from which they were derived "has just 4% of homes with more than 4 bedrooms, less than 1% with more than 5 bedrooms, and no homes with more than 8 bedrooms. In addition, fewer than 1% of the RECS homes have more than 6 TVs." On this point, I have to agree with Michael. Thus, we take only the data for homes with one through six bedrooms for the regression.

Two regressions are performed. The first is a straight line fit performed using the annual estimated energy use data as the y-variable and the number of bedrooms as the x-variable (SL-Fit). The second regression adds a square root term for the x-variable (NL-Fit). Results are shown in Figure 1 below.

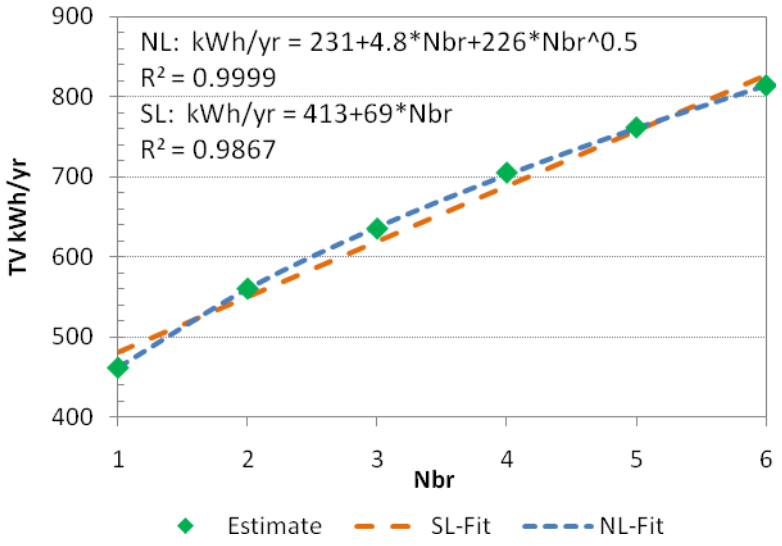


**Figure 1.** Results of regression analysis of estimated annual energy use of standard TVs as a function of the number of bedrooms in homes.

The regression correlation coefficient ($R^2$) is larger (virtually perfect) for the non linear fit (NL-Fit) than for the linear fit (SL-Fit). However, the linear fit is a very good reasonable approximation and the non-linear fit does not resolve the objective of reducing the estimate to the general form of the equation used for all other end uses, namely kWh/yr = a + b*CFA + c*Nbr. Thus, the linear fit is proposed as follows:

$$TVkWh/yr = 413 + 69*Nbr \qquad \text{(Eq. 1)}$$

With this simplification achieved for the Reference Home, the question becomes how TVs can be "rated" in the Rated Home? Blasnik has suggested that raters "count the fraction of TVs that are Energy Star compliant and assume a 30% reduction in usage for that fraction of the TV load. Rated Home TVkWh = (1 - 0.3 * % ES TVs) * Reference Home TVkWh -- assuming Energy Star TVs save 30% as claimed."[1]

[1] Personal communication via e-mail from M. Blasnik to P. Fairey, dated 05/07/2010.

The original proposal uses a detailed method of evaluating rated TVs that is dependent on a list of TVs that range from largest to smallest. This is done because the literature[1] strongly suggests that the number of hours a TV is used (OnHours) is a function of which TV it is (i.e. where it falls on a ranked list of TVs, with the largest TV being most used and the smallest TV being least used.) In addition, the ranking on the list also greatly impacts the energy use of the various TVs, with the largest, most-used TV having a greater power demand than the smallest, least-used TV. These two facts cause TV use to be a non-linear function of the number of TVs in a household.

These issues are discussed in greater detail in the reference cited in the justification for the proposal.[2] The following section (in italics) is extracted from this reference.

---

***6.2 Issues with Energy Rating for Televisions***

*While, televisions comprise an estimated 4% of growing household energy use, there are some significant issues associated with rating televisions within HERS ratings. TV energy use is tied to more factors than the number of sets in the residence. First, the fact that a second (or third, etc.) TV exists in a home does not mean that it will be used as often as the primary television. Second, the primary TV set will likely be larger and use more power than second or third TVs. Both of these facts are revealed in recent research on home electronics energy use by Roth and McKenney (2007). The core data for analog TVs from this study is as follows:*

| *TV:* | *hrs/day* | *avgSize* | *activeW* | *stdbyW* |
|---|---|---|---|---|
| *primary* | *7.1* | *30* | *115* | *4* |
| *secondary* | *4.3* | *24* | *93* | *4* |
| *third* | *3.3* | *21* | *79* | *4* |
| *forth* | *3.2* | *21* | *78* | *4* |
| *fifth* | *2.0* | *18* | *67* | *4* |
| *sixth* | *1.2* | *18* | *67* | *4* |

*These data clearly show that the primary TV is both larger and is used more often than secondary and following TVs, confounding a simplified rating methodology that would use average annual energy consumption for each TV. Fortunately, these data are well characterized by an equation that is based on the logarithm (base 10) of the TV numbers in the home.*

[1] Roth, K. W. and K. McKenney, December 2007, "Energy Consumption by Consumer Electronics in U.S. Residences." Final Report to Consumer Electronics Association, TIAX Reference D5525, TIAX LLC, Cambridge, MA.

[2] Parker, D., P. Fairey and R. Hendron, January 2010, "Updated Miscellaneous Electricity Loads and Appliance Energy Usage Profiles for Use in Home Energy Ratings, the Building America Benchmark and Related Calculations." FSEC-CR-137-10, Florida Solar Energy Center, Cocoa, FL.

*Figure 4 presents the results from a regression analysis of these data showing that viewing hours for multiple TVs in homes are well correlated to the logarithm of the TV number. For these purposes TVs are listed from their largest screen size to their smallest screen size and within a given screen size from their largest active wattage to their smallest active wattage. As seen in Figure 4, the correlation coefficient (R Square) for the resulting regression is reasonable. Thus, we recommend that this procedure for ordering multiple TVs in homes and the resulting regression equation be used to determine the number of hours that multiple TVs will be used in homes.*

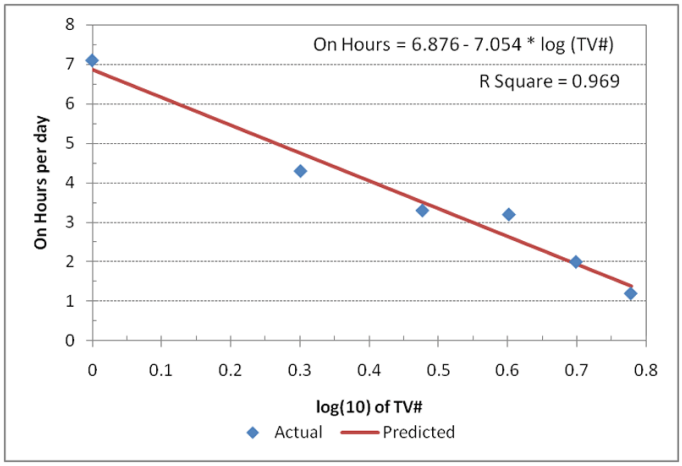


***Figure 4.*** *Showing the regression fit of TV viewing hours as a function of the logarithm of primary and secondary TVs in homes.*

$$onHours = 6.876 - 7.054 * \log_{(10)} TV\#$$
$$\text{or } 0.5 \text{ hours, whichever is greater}$$

*The source data also show that TV size and active power are related to TV order. The active power data can be correlated to the logarithm of the TV number. However, prior to performing such a regression, it is useful to note that the multiple TV data (Roth and McKenney, 2007) are for analog TVs. The authors are not aware of a corresponding set of data for digital TVs. While digital TVs are not likely to exhibit a significantly different pattern of use with respect to viewing hours, their size and power demand can be significantly larger than for analog TVs. Roth, et al. (2008) report average unit energy consumption (UEC) for analog TVs at 216 kWh/yr per unit with a saturation of 2.05 analog TVs per home. For digital TVs, they report UEC at 392 kWh/yr per unit with a saturation of 0.35 TVs per home. Thus, total average energy consumption for homes becomes 580 kWh per year with a saturation of 2.4 TVs per home, or an average use of 242 kWh/yr per TV set.*

*This annual average TV energy use value is used along with the viewing hour data to modify the active power demand such that the TV energy use value for a typical 3-bedroom home with (1.1 + 0.51*Nbr = 2.63) TVs equals 636 kWh/year or 242 kWh/yr per TV set. To accomplish this equivalency requires that the active power wattage in the above list be increased by 10% per TV set. This adjustment results in a correlation for the active wattage of standard TVs as follows:*

$$actWatts_{STD} = 124 - 69.1 * \log_{(10)} TV\#$$
$$\text{or } 50 \text{ watts, whichever is less}$$

*The above regression results a correlation coefficient (adjusted R Square) of 0.975. Thus, for the first TV, the active wattage would be 124 watts and the daily viewing time would be 6.88 hours. We propose that the standard TV standby power be maintained as found by Roth and McKenney (2007) at 4 watts. Thus, the standard primary TV would consume (124 watts * 6.88 hours + 4 watts * 17.12 hours =) 922 watt-hours/day or 336 kWh/year.*

Thus, while it is fairly easy to establish a reasonable estimate of annual TV energy use in the Reference Home using a simplified equation (a + b*CFA + c*Nbr), it becomes a very much more complicated task to determine the energy impact of one or more TVs in the Rated Home. In reality, we are largely forced back to the original proposed methodology of constructing a rank-ordered list of TVs (including standard TVs if the actual list is smaller than the number of TVs in the standard home) and then apportioning OnHours (and wattage) to the various TVs based on this list.

If we are going to go to the trouble to rate the TVs in the Rated Home using a detailed methodology (because we don't have another way to treat multiple TVs), then why forgo the detailed methodology for the Reference Home. In fact, if we do forgo the detailed methodology in the Reference Home, there will be an internal inconsistency introduced by the simplified equation.

**Alternative #3:** Do not include TVs as a rated feature. (Dave Roberts' proposal)

This proposal would be relatively simple to implement. Table 303.4.1.7.1(1) would be modified to strike the row containing TVs and the 'a' and 'c' coefficients derived above in Alternative #2 would be added to the Residual MELs row in Table 303.4.1.7.1(1). Table 303.4.1.7.1(2) would be stricken and the materials related to calculation of TV energy use in both the Reference and the Rated home would be stricken. Tables related to internal gains would be modified accordingly.

However, this alternative would also mean that the selection and purchase of high-efficiency TVs would go unrewarded in home energy ratings. Since TV energy use now comprises approximately 4% of average household energy use, this could have negative implications with respect to efforts to achieve Zero Energy Homes (ZEH), requiring the purchase of additional power production rather than high-efficiency TVs in order to reach qualification. While this may seem a small matter in typical homes, its significance increases as one approaches smaller and smaller energy use in homes.