

**BSR/RESNET Addendum ‘a’ to ANSI/RESNET 301-2014
Continuous Maintenance Proposal (CMP) on Domestic Hot Water (DHW) Systems**

Add new definitions to Section 3.2

Approved Hot Water Operational Control Device – A means of controlling the waste hot water in residences that is approved for use based on empirical test data and where the control effectiveness of the device is clearly labeled in terms of its overall reduction of operational waste hot water.

Drain Water Heat Recovery (DWHR) – A heat exchanger unit that uses outgoing warm drain water to pre-heat incoming cold freshwater, is rated for efficiency and pressure loss according to CSA B55.1, and complies with CSA B55.2.

T_{mains} – The temperature of the potable water supply entering the residence.

Add new Normative References to Section 6

CSA B55.1-12, (2012). “Test method for measuring efficiency and pressure loss of drain water heat recovery units.” CSA Group, Mississauga, Ontario, Canada L4W 5N6.

CSA B55.2-12, (2012). “Drain water heat recovery units.” CSA Group, Mississauga, Ontario, Canada L4W 5N6.

Revise Table 4.2.2(1) as follows:

Table 4.2.2(1) Specification for the HERS Reference and Rated Homes

Building Component	HERS Reference Home	Rated Home
Service water heating systems ^{(i), (n), (p)}	Fuel type: same as Rated Home Efficiency Electric: EF = 0.97 - (0.00132 * store gal) Fossil fuel: EF = 0.67 - (0.0019 * store gal) Use (gal/day): 30*N_{du} + 10*N_{br} where: N_{du} = number of dwelling units determined in accordance with Section 4.2.2.5.1.4 Tank temperature: 120-125 F	Same as Rated Home ⁽ⁿ⁾ Same as Rated Home Same as Rated Home Same as HERS Reference Home <u>Determined in accordance with Section 4.2.2.5.2.1.1</u> Same as HERS Reference Home

Add new section 4.2.2.5.1.4 and renumber following sections and equations as necessary

4.2.2.5.1.4 Service Hot Water Use. Service hot water system use in gallons per day for the HERS Reference Home shall be determined in accordance with Equation 4.2-2

$$\mathbf{HWgpd = (refDWgpd + refCWgpd + F_{mix} * (refFgpd + refWgpd)) * Ndu} \quad \mathbf{Eq. 4.2-2}$$

where:

HWgpd = gallons per day of hot water use

refDWgpd = reference dishwasher gallons per day = ((88.4 + 34.9 * Nbr) * 8.16) / 365

refCWgpd = reference clothes washer gallons per day =

$$(4.52 * (164 + 45.6 * Nbr)) * ((3 * 2.08 + 1.59) / (2.874 * 2.08 + 1.59)) / 365$$

where

CAPw = clothes washer capacity in cubic feet

$$\mathbf{F_{mix} = 1 - ((T_{set} - T_{use}) / (T_{set} - T_{mains}))}$$

Where5

T_{set} = Water heater set point temperature = 125 F
 T_{use} = Temperature of mixed water at fixtures = 105 F
 $T_{mains} = (T_{amb,avg} + offset) + ratio * (\Delta T_{amb,max} / 2) * \sin(0.986 * (day\# - 15 - lag) - 90)$

where

T_{mains} = temperature of potable water supply entering residence (°F)
 $T_{amb,avg}$ = annual average ambient air temperature (°F)
 $\Delta T_{amb,max}$ = maximum difference between monthly average ambient temperatures (e.g., $T_{amb,avg,july} - T_{amb,avg,january}$) (°F)
 0.986 = degrees/day (360/365)
 day# = Julian day of the year (1-365)
 offset = 6°F
 ratio = $0.4 + 0.01(T_{amb,avg} - 44)$
 lag = $35 - 1.0(T_{amb,avg} - 44)$

$refWgpd = 16.5 + 9.24 * Nbr$ = reference climate-normalized daily fixture water use in Reference Home (in gallons per day)

$refWgpd = 10 * Nbr^{0.4}$ = reference climate-normalized daily hot water waste due to distribution system losses in Reference Home (in gallons per day)

where

Nbr = number of bedrooms in each dwelling unit

Ndu = number of dwelling units

Add new section 4.2.2.5.2.11 and renumber following section and equations as necessary

4.2.2.5.2.11 Service Hot Water Use. Service hot water system use in gallons per day for the Rated Home shall be determined in accordance with Equation 4.2-11

$$HWgpd = (DWgpd + CWgpd + F_{eff} * adjF_{mix} * (refWgpd + oWgpd + sWgpd * WD_{eff})) * Ndu \quad \text{Eq. 4.2-11}$$

where:

$HWgpd$ = gallons per day of hot water use in Rated home
 $DWgpd = \text{dishwasher gallons per day (see Section 4.2.2.5.2.9)} = ((88.4 + 34.9 * Nbr) * 12 / dWcap * (4.6415 * (1/EF) - 1.9295)) / 365$
 $CWgpd = \text{clothes washer gallons per day (see Section 4.2.2.5.2.10)} = 60 * ((LER * (\$/kWh) - AGC) / (21.9825 * (\$/kWh) - (\$/therm)) / 392) * ACY / 365$
 F_{eff} = fixture effectiveness in accordance with Table 4.2.2.5.2.11(1)

Table 4.2.2.5.2.11(1) Hot water fixture effectiveness

Plumbing Fixture Description	F_{eff}
Standard-flow: showers <2.5 gpm and faucets <2.2 gpm	1.00
Low-flow: all showers and faucets <2.0 gpm	0.95

$adjF_{mix} = 1 - ((T_{set} - T_{use}) / (T_{set} - WH_{in}T))$

where

$T_{set} = 125$ °F = water heater set point temperature
 $T_{use} = 105$ °F = temperature of mixed water at fixtures
 $WH_{in}T$ = water heater inlet temperature

where

$WH_{in}T = T_{mains} + WH_{in}T_{adj}$ for DWHR systems and where $WH_{in}T_{adj}$ is calculated in accordance with equation 4.1-14

$WH_{in}T = T_{mains}$ for all other hot water systems

T_{mains} = temperature of potable water supply entering the residence calculated in accordance with Section 4.2.2.5.1.4

refFgdp = reference climate-normalized daily fixture water use calculated in accordance with Section 4.2.2.5.1.4

$$\mathbf{oWgpd = refWgpd * oFrac * (1 - oCD_{eff})} \quad \mathbf{Eq. 4.2-12}$$

where

oWgpd = daily standard operating condition waste hot water quantity

oFrac = 0.25 = fraction of hot water waste from standard operating conditions

oCD_{eff} = Approved Hot Water Operating Condition Control Device effectiveness (default = 0.0)

$$\mathbf{sWgpd = (refWgpd - refWgpd * bFrac) * pRatio * sysFactor} \quad \mathbf{Eq. 4.2-13}$$

where

sWgpd = daily structural waste hot water quantity

refWgpd = reference climate-normalized distribution system waste water use calculated in accordance with Section 4.2.2.5.1.4

pRatio = hot water piping ratio

where

for Standard systems:

$$pRatio = PipeL / refPipeL$$

where

PipeL = measured length of hot water piping from the hot water heater to the farthest hot water fixture, measured longitudinally from plans, assuming the hot water piping does not run diagonally, plus 10 feet of piping for each floor level, plus 5 feet of piping for unconditioned basements (if any)

$$refPipeL = 2 * (CFA / Nfl)^{0.5} + 10 * Nfl + 5 * Bsmt = \text{hot water piping length for Reference Home}$$

where

CFA = conditioned floor area

Nfl = number of conditioned floor levels in the residence, including conditioned basements

Bsmt = presence = 1.0 or absence = 0.0 of an unconditioned basement in the residence

for recirculation systems:

$$pRatio = BranchL / 10$$

where

BranchL = measured length of the branch hot water piping from the recirculation loop to the farthest hot water fixture from the recirculation loop, measured longitudinally from plans, assuming the branch hot water piping does not run diagonally, plus 10 feet of piping for each floor level, plus 5 feet of piping for unconditioned basements (if any)

sysFactor = hot water distribution system factor from Table 4.2.2.5.2.11(2)

Table 4.2.2.5.2.11(2) Hot Water Distribution System Insulation Factors

<u>Distribution System Description</u>	<u>sysFactor</u>	
	<u>No pipe insulation</u>	<u>≥R-3 pipe insulation</u>
<u>Standard systems</u>	<u>1.00</u>	<u>0.90</u>
<u>Recirculation systems</u>	<u>1.11</u>	<u>1.00</u>

WD_{eff} = distribution system water use effectiveness from Table 4.2.2.5.2.11(3)

Table 4.2.2.5.2.11(3) Distribution system water use effectiveness

<u>Distribution System Description</u>	<u>WD_{eff}</u>
<u>Standard systems</u>	<u>1.00</u>
<u>Recirculation systems</u>	<u>0.10</u>

Ndu = number of dwelling units

4.2.2.5.2.11.1 Drain Water Heat Recovery (DWHR) Units

If DWHR unit(s) is (are) installed in the Rated Home, the water heater potable water supply temperature adjustment (WH_{in}T_{adj}) shall be calculated in accordance with Equation 4.2-14.

$$\mathbf{WH_{in}T_{adj} = Ifrac * (DWHR_{in}T - T_{mains}) * DWHR_{eff} * PLC * LocF * FixF} \quad \mathbf{Eq. 4.2-14}$$

where

WH_{in}T_{adj} = adjustment to water heater potable supply inlet temperature (°F)

Ifrac = 0.56 + 0.013*Nbr - 0.0004*Nbr² = fraction of hot water use impacted by DWHR

DWHR_{in}T = 97 °F

T_{mains} = calculated in accordance with Section 4.2.2.5.1.4

DWHR_{eff} = Drain Water Heat Recovery Unit efficiency as rated and labeled in accordance with CSA 55.1

where

DWHR_{eff} = DWHR_{eff} * 1.082 if low-flow fixtures are installed in accordance with Table 4.2.2.5.2.11(1)

PLC = 1 - 0.0002*pLength = piping loss coefficient

where

for standard systems:

pLength = pipeL as measured accordance with Section 4.1.1.5.2.11

for recirculation systems:

pLength = branchL as measured in accordance with Section 4.2.2.5.2.11

LocF = a performance factor based on the installation location of the DWHR determined from Table 4.2.2.5.2.11(4)

Table 4.2.2.5.2.11(4) Location factors for DWHR placement

<u>DRHR Placement</u>	<u>LocF</u>
<u>Supplies pre-heated water to both the fixture cold water piping and the hot water heater potable supply piping</u>	<u>1.000</u>
<u>Supplies pre-heated water to only the hot water heater potable supply piping</u>	<u>0.777</u>
<u>Supplies pre-heated water to only the fixture cold water piping</u>	<u>0.777</u>

FixF = Fixture Factor

where

FixF = 1.0 if all of the showers in the home are connected to DWHR units

FixF = 0.5 if there are 2 or more showers in the home and only 1 shower is connected to a DWHR unit.

4.2.2.5.2.11.2 Hot Water System Annual Energy Consumption

Service hot water energy consumption shall be calculated using Approved Software Tools and the provisions of Section 4.2.2.5.1.4, Section 4.2.2.5.2.11 and Section 4.2.2.5.2.11.1 shall be followed to determine appropriate inputs to the calculations.

If the Rated Home includes a hot water recirculation system, the annual electric consumption of the recirculation pump shall be added to the total hot water energy consumption. The recirculation pump kWh/y shall be calculated using Equation 4.2-15

$\text{pumpkWh/y} = \text{pumpW} * \text{Efact}$ **Eq. 4.2-15**

where:

pumpW = pump power in watts (default $\text{pumpW} = 50$ watts)

Efact = factor selected from Table 4.2.2.5.2.11(5)

**Table 4.2.2.5.2.11(5) Annual electricity consumption factor
for hot water recirculation system pumps**

<u>Recirculation System Description</u>	<u>Efact</u>
<u>Recirculation without control or with timer control</u>	<u>8.76</u>
<u>Recirculation with temperature control</u>	<u>1.50</u>
<u>Recirculation with demand control (motion sensor)</u>	<u>0.46</u>
<u>Recirculation with demand control (manual)</u>	<u>0.16</u>

Results from standard hot water energy consumption calculations considering only tested Energy Factor data (stdEC_{HW}) shall be adjusted to account for the energy delivery effectiveness of the hot water distribution system in accordance with equation 4.2-16.

$\text{EC}_{\text{HW}} = \text{stdEC}_{\text{HW}} * (\text{E}_{\text{waste}} + 128) / 160$ **Eq. 4.2-16**

where E_{waste} is calculated in accordance with equation 4.2-17.

$\text{E}_{\text{waste}} = \text{oEW}_{\text{fact}} * (1 - \text{oCD}_{\text{eff}}) + \text{sEW}_{\text{fact}} * \text{pEratio}$ **Eq. 4.1-17**

where

$\text{oEW}_{\text{fact}} = \text{EW}_{\text{fact}} * \text{oFrac}$ = standard operating condition portion of hot water energy waste

where

EW_{fact} = energy waste factor in accordance with Table 4.2.2.5.2.11(6)

oCD_{eff} is in accordance with Section 4.2.2.5.2.11.1

$\text{sEW}_{\text{fact}} = \text{EW}_{\text{fact}} - \text{bEW}_{\text{fact}}$ = structural portion of hot water energy waste

pEratio = piping length energy ratio

where

for standard system: $\text{pEratio} = \text{PipeL} / \text{refPipeL}$

for recirculation systems: $\text{pEratio} = \text{LoopL} / \text{refLoopL}$

and where

LoopL = hot water recirculation loop piping length including both supply and return sides of the loop, measured longitudinally from plans, assuming the hot water piping does not run diagonally, plus 10 feet of piping for each floor level plus 5 feet of piping for unconditioned basements.

$\text{refLoopL} = \text{refPipeL} * 2.0$

**Table 4.2.2.5.2.11(6) Hot water distribution system
relative annual energy waste factors**

<u>Distribution System Description</u>	<u>EW_{fact}</u>	
	<u>No pipe insulation</u>	<u>≥R-3 pipe insulation</u>
<u>Standard systems</u>	<u>32.0</u>	<u>28.8</u>
<u>Recirculation without control or with timer control</u>	<u>467.2</u>	<u>233.6</u>
<u>Recirculation with temperature control</u>	<u>78.4</u>	<u>39.2</u>
<u>Recirculation with demand control (motion sensor)</u>	<u>14.4</u>	<u>7.2</u>
<u>Recirculation with demand control (manual)</u>	<u>4.8</u>	<u>2.4</u>