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	Same as Rated Home [(n)]
	Electric: EF = 0.97 - (0.00132 * store gal)	Same as Rated Home
	Fossil fuel: EF = 0.67 - (0.0019 * store gal)	Same as Rated Home
	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	~~Same as HERS Reference Home~~ Determined in accordance with Section 4.2.2.5.2.11
	Tank temperature: ~~120~~ 125 F	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

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

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

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

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 (ºF)
$T_{amb,avg}$ = annual average ambient air temperature (ºF)
$\Delta T_{amb,max}$ = maximum difference between monthly average ambient temperatures (e.g., $T_{amb,avg,july} - T_{amb,avg,january}$) (ºF)
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)

refFgpd = 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

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

where:
HWgpd = gallons per day of hot water use in Rated home
DWgpd = 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 = 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 ºF = water heater set point temperature
T_{use} = 105 ºF = 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

oWgpd = refWgpd * oFrac * (1-oCD$_{eff}$) Eq. 4.2-12

where

oWgdp = 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)

sWgpd = (refWgpd – refWgpd * bFrac) * pRatio * sysFactor 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 = $2*(CFA/Nfl)^{0.5} + 10*Nfl + 5*Bsmt$ = 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

Distribution System Description	**sysFactor**	
	No pipe insulation	≥R-3 pipe insulation
Standard systems	1.00	0.90
Recirculation systems	1.11	1.00

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

Distribution System Description	WD_{eff}
Standard systems	1.00
Recirculation systems	0.10

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.

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

where

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

Ifrac = $0.56 + 0.013*Nbr - 0.0004*Nbr^2$ = 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

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

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

pumpkWh/y = pumpW * Efact **Eq. 4.2-15**

where:

pumpW = pump power in watts (default 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

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

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.

$EC_{HW} = stdEC_{HW} * (E_{waste} + 128) / 160$ **Eq. 4.2-16**

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

$E_{waste} = oEW_{fact} * (1-oCD_{eff}) + sEW_{fact} * pEratio$ **Eq. 4.1-17**

where

$oEW_{fact} = EW_{fact} * oFrac$ = 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

$sEW_{fact} = EW_{fact} – bEW_{fact}$ = structural portion of hot water energy waste

pEratio = piping length energy ratio

where

for standard system: pEratio = PipeL / refpipeL

for recirculation systems: pEratio = LoopL / 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.

refLoopL = refPipeL * 2.0

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

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