eQuest POOL MODELING GUIDE

FOR

SCA ENERGY MODELS

01/02/2023

ASHRAE 90.1-2010 & 2020 NYCECC eQuest Templates

by:
Socotec, Inc.
50 Washington Street
Norwalk, CT 06854
Adrian Tuluca, RA
Senior Principal
Phone: 203-299-1411
Fax: 203-299-1656
E-mail: adrian.tuluca@socotec.us

TABLE OF CONTENTS

1   Purpose

The purpose of this guide is to describe the specific modeling requirements for New York City School Construction Authority (SCA) projects that contain pools and to assist in repeatable modeling processes. Only systems included in the SCA design requirements are included in this guide. Project specific systems should be modeled using generally accepted methods consistent with the software version used. Instructions on how to use the templates and other, more detailed modeling guidance is provided in the SCA Modeling Template How-To Guide, which is issued separately.

This guide should be used in conjunction with the "eQuest Input Summary for SCA Energy Models" (referred to as the SCA Input Summary) and the "eQuest How-to Guide of SCA Energy Models" (referred to as the SCA How-to guide), which contain the guidance on inputs for general school projects. All values may be updated as the Energy Code, Systems & Local Law requirements change.

1.1   Files

The typical inputs for pool projects are included in the main SCA eQuest template files.

1.2   Definitions

Proposed Design - The model of the building based on the design documents.

NYCECC 2020 Baseline - The baseline described by the Energy Cost Budget Method (Section 11) of ASHRAE 90.1-2016 with amendments per Appendix CA of the 2020 New York City Energy Conservation Code.

GSG Baseline - The baseline described by the Performance Rating Method (Appendix G) of ASHRAE 90.1-2010.

Ribbon – Major dialog box that contains multiple sub-tabs. Divides the data input into major disciplines.

Default Value – A value assumed by the modeling software to operate. Does not require user input. Shows up as "green" in the dialog box in eQuest.

Input Summary Report – Shorthand notation for the "eQuest Input Summary for SCA Energy Models", which is a report defining all major input values for a typical SCA building model.

Work Around - Non-standard modeling approach to approximate systems or equipment that cannot be directly modeled in the software package

2 Building Shell

2.1 Surface Construction, Layers, and Material Properties

2.1.1 Wall Constructions

Since pool spaces have significantly higher humidity levels than general school spaces, it is strongly recommended to perform a dewpoint analysis using software such as THERM, so as to reduce the potential of condensation within the wall assembly or on the inboard surface of the envelope.

3 Internal Loads

3.1 Occupant and Equipment Loads

Table 2. Sensible Loads from People by Space Type (SCA Input Summary Table 4)

Space Type	ASHRAE Fundamentals 2017 Activity Level	Sensible Heat Gain (BTU/hr.-person)	Latent Heat Gain (BTU/hr.-person)
Pool	(one period – 132 people) Athletic	710	1090

Table 3. Occupancy & Equipment Loads by Space Type (SCA Input Summary Table 5)

Space Type	Zone Type	Occupancy Schedule	Equipment Power Density (W/ft²)	Equipment Schedule
Pool (class period)	Conditioned	GYM-OCC-YR	0	ALWAYS-OFF-F-YR

3.2 Pool Water Latent Loads

The pool water evaporation rate depends on variables such as environmental conditions and human activity within the pool itself. This adds additional moisture content to the air in the space.

For the purpose of these Guidelines, the latent pool cooling load can be calculated with two methods: The ASHRAE Fundamentals method and the Dectron method. If the same input values are used in both methods, the ASHRAE method results in a ±2% difference relative to the Dectron method.

The ASHRAE method is more complex and requires the user to look up information in engineering water tables. It can be used as a general purpose formula for a wide range of environmental conditions.

The Dectron method is a simplified version of the ASHRAE method, starting from the same basic equation but eliminating the need for referencing water tables. However, it only works for a limited range of environmental conditions (78°F - 104°F water temperatures, 78°F - 86°F air temperatures, 50% or 60% air relative humidity). This is an appropriate range for typical SCA pools.

3.2.1 Load Calculation Method 1 – ASHRAE Fundamentals

The ASHRAE HVAC Applications Handbook, Chapter 6 in the 2019 version, explains in detail key indoor pool design considerations and provides load calculation formulas. Of particular relevance for calculating energy modeling inputs are the following:

Figure 1 - Reproduction of ASHRAE Fundamentals 2019 Chapter 6 Table 1

Table 1   Typical Activity Factors for Various Pool Feature Types

Type of Pool	Typical Activity Factor (F_a)
Baseline (pool unoccupied)	0.5
Residential pool	0.5
Condominium	0.65
Therapy	0.65
Hotel	0.8
Public, schools	1.0
Whirlpools, spas	1.0
Wavepools, water slides	1.5 (minimum)

Figure 2 - Reproduction of ASHRAE Fundamentals 2019 Chapter 6 Table 2

Table 2   Typical Natatorium Design Conditions

Type of Pool	Air Temperature, °F	Water Temperature, °F	Relative Humidity, %
Recreational	75 to 85	75 to 85	50 to 60
Therapeutic	80 to 85	85 to 95	50 to 60
Competition	78 to 85	76 to 82	50 to 60
Diving	80 to 85	80 to 90	50 to 60
Elderly swimmers	84 to 90	85 to 90	50 to 60
Hotel	82 to 85	82 to 86	50 to 60
Whirlpool/spa	80 to 85	97 to 104	50 to 60

From this chapter in Fundamentals, Equation 3 is used to calculate the water evaporation losses from the pool:

$$w_p = 0.1A(p_w - p_a)F_a$$

where
w_p = evaporation rate of water, lb/h
A = area of pool surface, ft^2
p_w = saturation vapor pressure taken at surface water temperature, in. Hg. This is at pool water temperature and 100% RH.
p_a = saturation pressure at room air dew point, in. Hg. This is at pool air temperature and 60% RH.
F_a = pool activity factor

Note: This formula calculates the water evaporation rate under a single set of conditions (occupied or unoccupied). To calculate the daily evaporation rate, both the occupied and unoccupied conditions should be accounted for:

$$w_{p,occ} = 0.1 * A * (p_w - p_{a,occ}) * F_{a,occ}$$

$$w_{p,unocc} = 0.1 * A * (p_w - p_{a,unocc}) * F_{a,unocc}$$

where
$w_{p,\,occ}$ = evaporation rate of water during occupied hours, lb/h
$w_{p,\,unocc}$ = evaporation rate of water during unoccupied hours, lb/h
$F_{a,\,occ}$ = activity factor during occupied hours. Per the ASHRAE Table 1 above, this is equal to 1
$F_{a,\,unocc}$ = activity factor during unoccupied hours. Per the ASHRAE Table 1 above, this is equal to 0.5
$p_{a,\,occ}$ = saturation pressure at room air dew point during occupied hours, in. Hg. This is at pool air temperature and 60% RH.
$p_{a,\,unocc}$ = saturation pressure at room air dew point during unoccupied hours, in. Hg. This is at pool air temperature and 50% RH.
The formula below is used to calculate the latent load generated by the pool water:

$$Q_p = w_p * h_{fg}$$

where
Q_p = latent pool cooling load
h_{fg} = enthalpy of vaporization at the pool water temperature

3.2.2   Load Calculation Method 2 – Dectron Indoor Pool Design Guidelines
The ASHRAE formula relies on obtaining data from water tables. The Dectron Indoor Pool Design Guide simplifies this calculation by combining $0.1*(p_w-p_a)$ into a constant called Evaporation Rate Factor (ERF) that depends on pool water temperature, air temperature and relative humidity. This constant can be easily looked up in a table provided in the guideline.

The Dectron formula for the water evaporation rate is:

$$ER = ERF * AF * A_p$$

where
ER = pool evaporation rate, lb/h
ERF = evaporation rate factor, from the table below
AF = activity factor (from the table below)

Figure 3 - Reproduction of Activity Factors from Dectron

Activity Factor (AF)

Type of Pool	Activity Factor
Residential	0.5
Fitness Club/Condominium	0.65
Therapy/Aquafit/Elderly Swim	0.65
Hotel	0.8
Institutional (School)	0.8
Public Pools (with family programs)	1.0
Spas and Whirlpools	1.0
Water Slides, Wave Pools, Water Cannons, Fountains	Contact Dectron Representative

Figure 4 - Reproduction of Evaporation Rate Factors from Dectron

Evaporation Rate Factor (lb/h • sq.ft., kg/h • m²)

Pool Water Temp.   Air Temperature   Relative Humidity 50% / 60%

°F (°C)	86 °F 50%/60%	30 °C 50%/60%	84 °F 50%/60%	29 °C 50%/60%	82 °F 50%/60%	28 °C 50%/60%	80 °F 50%/60%	27 °C 50%/60%	78 °F 50%/60%	26 °C 50%/60%
78 (25.5)	.034/.020	.166/.098	.038/.026	.186/.127	.040/.030	.196/.147	.044/.034	.205/.719	.048/.038	.225/.088
80 (27)	.042/.026	.205/.127	.046/.032	.225/.157	.048/.036	.235/.176	.050/.040	.245/.186	.054/.046	.254/.215
82 (28)	.048/.034	.235/.166	.052/.038	.254/.186	.054/.044	.264/.215	.058/.048	.274/.225	.062/.052	.293/.245
84 (29)	.056/.040	.274/.196	.060/.046	.293/.225	.062/.050	.303/.245	.066/.056	.313./.264	.070/.060	.333/.284
86 (30)	.062/.048	.303/.235	.068/.054	.333/.264	.070/.060	.342/293	.074/.064	.352/.293	.076/.068	.372/.323
88 (31)	.072/.058	.352/.284	.076/.062	.372/.303	.078/.066	.381/.323	.082/.072	.391/.342	.086/.076	.411/.362
90 (32)	.080/.066	.391/.323	.084/.070	.411/.342	.086/.076	.421/.372	.90/.080	.430/.381	.094/.084	.450/.401
92 (33)	.090/.074	.440/.362	.094/.080	.460/.391	.098/.084	.479/.411	.100/.090	.479/.430	.102/.094	.489/.450
94 (34)	.098/.084	.479/.411	.104/.090	.509/.440	.106/.094	.518/.460	.108/.098	.528/.469	.112/.104	.538/.489
96 (35.5)	.110/.094	.538/.460	.114/.100	.558/.489	.116/.104	.567/.509	.120/.110	.577/.518	.122/.114	.587/.548
98 (37)	.120/.106	.587/.518	.124/.112	.606/.548	.126/.116	.616/.567	.130/.120	.626/.577	.134/.124	.597/.597
100 (38)	.132/.118	.645/.577	.136/.122	.665/.597	.138/.128	.675/.626	.142/.132	.685/.636	.146/.136	.704/.655
102 (390	.144/.130	.704/.636	.148/.134	.724/.655	.150/.140	.734/.685	.154/.144	.743/.694	.158/.148	.763/.714
104 (40)	.156/.142	.763/.694	.160/.146	.782/.714	.162/.152	.792/.743	.166/.156	.802/.753	.170/.160	.831/.773

The formula above gives the water evaporation rate under a single set of conditions. To calculate the water evaporation rates for occupied and unoccupied conditions, the following formulas should be used:

$$ER_{occ} = ERF_{60} * AF * A_p$$
$$ER_{unocc} = ERF_{50} * 0.5 * A_p$$

where
Ap = pool water surface area
AF = activity factor
ERF_{60} = evaporation rate factor during active hours (at 60% RH)
ERF_{50} = evaporation rate factor during non-active hours (at 50% RH)

The formula below is used to calculate the latent load generated by the pool water:

$$Q_p = ER * h_{fg}$$

where
Q_p = latent pool cooling load
h_{fg} = enthalpy of vaporization at the pool water temperature

3.2.3 eQuest Pool Load Input Methodology

For eQuest input, the peak latent cooling load must be calculated, along with an accompanying fractional schedule that uses the value of 1 for occupied hours and the fraction of the latent pool cooling load (Q_p) at unoccupied conditions relative to the occupied conditions (Q_p unoccupied/Q_p occupied).

Table 4. Internal Energy Sources Loads by Space Type

Space Type	Source Schedule	Source Type	Input Power (Btu/h)	Sensible HG (ratio)	Latent HG (ratio)
Pool	POOL-VAP-YR	Process	[Q_p, occupied]	0	1

Since the pool water evaporates as calculated above, make-up is needed to maintain the same water level in the pool. This water is to be delivered at the pool water temperature (typically 82°F), which requires mixing the water coming out of the DHW or dedicated pool water heater (typically 140°F) with cold water (55°F on average in the NYC area).

As the make-up water flow rate is equal to the rate of evaporation, the same POOL-VAP-YR schedule can be used for both inputs.

The Pool inputs tab of the attached Appendix A calculator has a calculator that generates the following eQuest inputs:
- Peak latent cooling load
- The daily POOL-VAP-SCH schedule
- Peak DHW make-up load

To account for the thermal mass of the pool water, a new construction type called WATER-CON was created, with density, specific heat and conductivity of water and thickness of 1 foot. This is because eQuest has limits on the mass of the constructions it can simulate. Increasing the thickness of this assembly to more than 1 foot may cause the simulation to crash.

To model the water volume of the pool, the recommended approach is:
1. Define an interior adiabatic wall with the same length as the pool and the height equal to the average pool depth.
2. Copy the 1 foot thick wall as many times as needed so that the total width adds up to the pool width.

Other approaches can be employed as long as the total volume of the WATER-CON adiabatic walls add up to the total pool volume.

3.3 Lighting Loads

Interior lighting requirements are per the SCA Design Requirements 7.2.1B. As a starting point, the values are given for the poolside area only. If bleachers are present in the project, then area weighted averages should be used for the LPD and illuminance inputs. The entire pool space should be modeled as a single thermodynamic zone; it is not necessary to split it up into poolside and bleachers.

Table 5. Lighting Power Density by Space Type (SCA Input Summary Table 12)

Space Type	Model Input Lighting Power Density Parameter	Proposed Design		GSG Baseline (ASHRAE 90.1 2010)		NYCECC 2020 Baseline	
		Controls	LPD (W/sq ft)	Controls	LPD* (W/sq ft)	Controls	LPD* (W/sq ft)
Pool – bleachers	POOL-B-LPD	Occupancy	0.40	Timer	0.40	Timer	0.40

Table 6. Lighting Schedules by Space Type (SCA Input Summary Table 13)

Space Type	Proposed Design	GSG Baseline (ASHRAE 90.1 2010)	NYCECC 2020 Baseline
Pool – poolside	POOL -LT-TIM-YR	POOL-LT-TIM-YR	POOL-LT-TIM-YR
Pool – bleachers	POOL-B-LT-YR	POOL-B-LT-YR	POOL-B-LT-YR

Daylighting requirements and controls are covered in Table 6. The SCA Design Requirements call for daylight harvesting in all rooms with windows. Daylighting in the baseline is provided in spaces that comply with ASHRAE 90.1-2010, Sections 9.4.1.4 & 9.4.1.5, or 2020 NYCECC, Section C405.2.2.3.2. The daylight illuminance settings shown in 6 are based on the DR 7.2.1B minimum illuminance requirements and 2020 NYCECC respectively. These values are provided in the Code to assist the modeler and do not represent mandatory illuminance levels. The eQuest daylighting algorithm for California Title 24-2008 can be used to place the sensors and determine the controlled load.

Table 7. Lighting Daylight Controls by Space Type (SCA Input Summary table 14)

Space Type	Minimum Foot Candles for Daylighting Control
	All Cases- Use 30" as eQuest height input otherwise unless noted
Pool – poolside	30
Pool – bleachers	20

4 HVAC Loads

4.1 Temperature Setpoints

The 2022 NYC Building Construction Code, Table BC 1204.1, requires that the minimum indoor pool space air temperature to be 75°F.

Table 8. Heating/Cooling Schedules & System Assignments by Space Type

Space Type	System Type	Heating		Cooling		Heating Schedule	Cooling Schedule
		Set point	Set back	Set point	Set back		
Pool	POOL-SYS	82	82	84	84	POOL-HT-YR	POOL-CL-YR

Pool spaces are typically held at constant temperatures with no setback. However, the simulation program encounters problems when the heating and cooling setpoints are equal. Therefore a difference of at least 2°F should be used to differentiate the heating and the cooling modes.

Some facilities could choose to turn off the HVAC system at night to save energy. In this case, setback temperatures should be modeled so that no additional unmet load hours are reported by the software. This will require modification of the heating and cooling schedules.

4.2 Input for Pool HVAC System (POOL-SYS)

4.2.1 General Considerations

The default starting point for HVAC systems serving pool spaces should be a Constant Air Volume system. A Variable Air Volume system should be modeled only if there is confirmation from the design team (pool consultant and MEP engineer) that such a system is intended. If the preliminary energy modeling results show that the building is not meeting the minimum performance requirements with a CAV system, a VAV alternative should be explored. At a minimum, the VAV AHU should reduce the flow rate during unoccupied hours, when chlorine pooling concerns and ventilation demands are lower.

4.2.2 Pool System - Electric Heating

Table 10. Pool System Properties, Electric Heat

	Design	NYCECC 2020 Baseline	GSG Baseline
eQuest System Type	Early stages, CAV: Packaged Single Zone (default) Early stages, VAV: Packaged Variable Air Volume (only if confirmed by design team)	System Type #9: Packaged Rooftop Heat Pump, Modeled as PSZ	System Type #4: Packaged Rooftop Heat Pump, Modeled as PSZ

Fan Control	Early stages: Constant Volume, unless specifically mentioned otherwise. Late stages: Per design documents.	Constant Volume, Two-Speed for units greater than 65k BTUh cooling capacity (model as FAN-EIR)	Constant Volume
Fan EIR = f(PLR)	SZ-VSD-RESET-SP	Constant volume fans: NA 2 Speed fans: 2-SPD-CRV	NA
Minimum Flow Ratio	Early stages: Greater of Outdoor Air Flow Rate and a value resulting in 6 ACH for the pool space. Late stages: per design documents	Constant volume fans: NA 2 Speed fans: Greater of Outdoor Air Flow Rate and 66%	NA
Minimum Fan Ratio	Early stages, CAV: NA. Early stages, VAV: Greater of Outdoor Air Flow Rate and a value resulting in 6 ACH for the pool space. Late stages: per design documents	Constant volume fans: NA 2 Speed fans: Greater of Outdoor Air Flow Rate and 66%	NA
Night Cycle Control	CYCLE-ON-ANY (if design documents call for the unit to be off at night this is STAY-OFF)	CYCLE-ON-ANY	CYCLE-ON-ANY
Cooling Efficiency	Per NYCECC 2020 at early phase. Project specific at AHRI conditions in later phase.	Per NYCECC 2020 Appendix CA Table 6.8.1-2	Per ASHRAE 90.1-2010 Table 6.8.1B

		Max Capacity	EER	Max Capacity	EER
		65 kBtu/h	14.0 SEER	65 kBtu/h	13.0 SEER
		135 kBtu/h	11.0 EER 12.2 IEER	135 kBtu/h	10.8 EER 11.0 IEER
		240 kBtu/h	10.6 EER 11.6 IEER	240 kBtu/h	10.4 EER 10.5 IEER
		>240 kBtu/h	9.5 EER 10.6 IEER	>240 kBtu/h	9.3 EER 9.4 IEER

Cooling Efficiency, Part Load Curve f(part load ratio)	NY20-HP-CL-EIR-FPLR (all capacities)	NY20-HP-CL-EIR-FPLR (all capacities)	A10-HP-EIR-FPLR (all capacities)
Other cooling curves	eQuest default	eQuest default	eQuest default
Heat Source	HEAT-PUMP	HEAT-PUMP	HEAT-PUMP
Heating Efficiency	Project specific at AHRI conditions in later phase, per NYCECC 2020 Appendix CA Table	Per NYCECC 2020 Appendix CA Table 6.8.1-2. Efficiency input at heat pump chiller (see How-to Guide)	Per ASHRAE 90.1-2010 Table 6.8.1B. Efficiency input at heat pump chiller (see How-to Guide)

|	6.8.1-2 early phase[1]. Efficiency at heat pump chiller (see How-to Guide)					
	Max Capacity	COP	Max Capacity	COP	Max Capacity	COP
	65 kBtu/h	8.0 HSPF	65 kBtu/h	8.0 HSPF	65 kBtu/h	7.7 HSPF
	135 kBtu/h	3.3 @ 47°F	135 kBtu/h	3.3 @ 47°F	135 kBtu/h	3.3 @ 47°F
	>135 kBtu/h	3.2 @ 47°F	>135 kBtu/h	3.2 @ 47°F	>135 kBtu/h	3.2 @ 47°F
Baseboard Heating	NA		NA		NA	
Supplemental heat source on temperature (mix HP & electric resistance heating)	20°F (Place holder- use project specific value based on HP selection)		40°F		40°F	
Minimum HP Temperature (100% electric resistance heating)	10°F (Place holder- use project specific value based on HP selection)		10°F		10°F	
Cooling Available	As needed		As needed		As needed	
Demand Controlled Ventilation?	NO for early design, Project specific for later designs		Where required by Section 6.4.3.8.		No	
Economizer Control?	Differential-Enthalpy		Differential Enthalpy with fixed dry-bulb temp of 75°F		None (not required)	
Energy Recovery Efficiency (sensible & latent)	30% for early design, sensible only. Project specific for later designs		50%		50%	
Fan Power Credits			Fully ducted return MERV 13 filters Heat recovery device Exhaust Filter		Fully ducted return MERV 13 filters Heat recovery device Exhaust Filter	
Humidity control	60%		60%		60%	
Condenser heat recovery for free reheat	Used only if the unit is capable - 30% or as specified by manufacturer		None (not required)		None (not required)	

---

[1] Heat pumps must meet mandatory minimum efficiencies at both 47°F and 17°F, but only the operating characteristics at 47°F will be input into eQuest.

Condenser Heat Recovery for Free Reheat (MAX-COND-RCVRY)

eQuest can model waste heat recovery from the compressor for the purpose of reducing reheat energy use in systems using dehumidification. This keyword should only be used if the design documents indicate that the HVAC unit is design to have this capability. The keyword only applies to the Packaged Variable Volume (PVAVS) and Packaged Single Zone (PSZ) system types. It can be found in the Heating > Cap Curves/Waste Heat tab (screenshot below).

The feature is usually disabled, even if the correct system type is selected and the Maximum Humidity value is specified in the Basics tab. To enable the keyword, the user should either input it manually in the INP file for the appropriate system or right click on the value in the eQuest interface and specify its value as a User Expression.

Figure 4 – eQuest Location for Condenser Heat Recovery Keyword
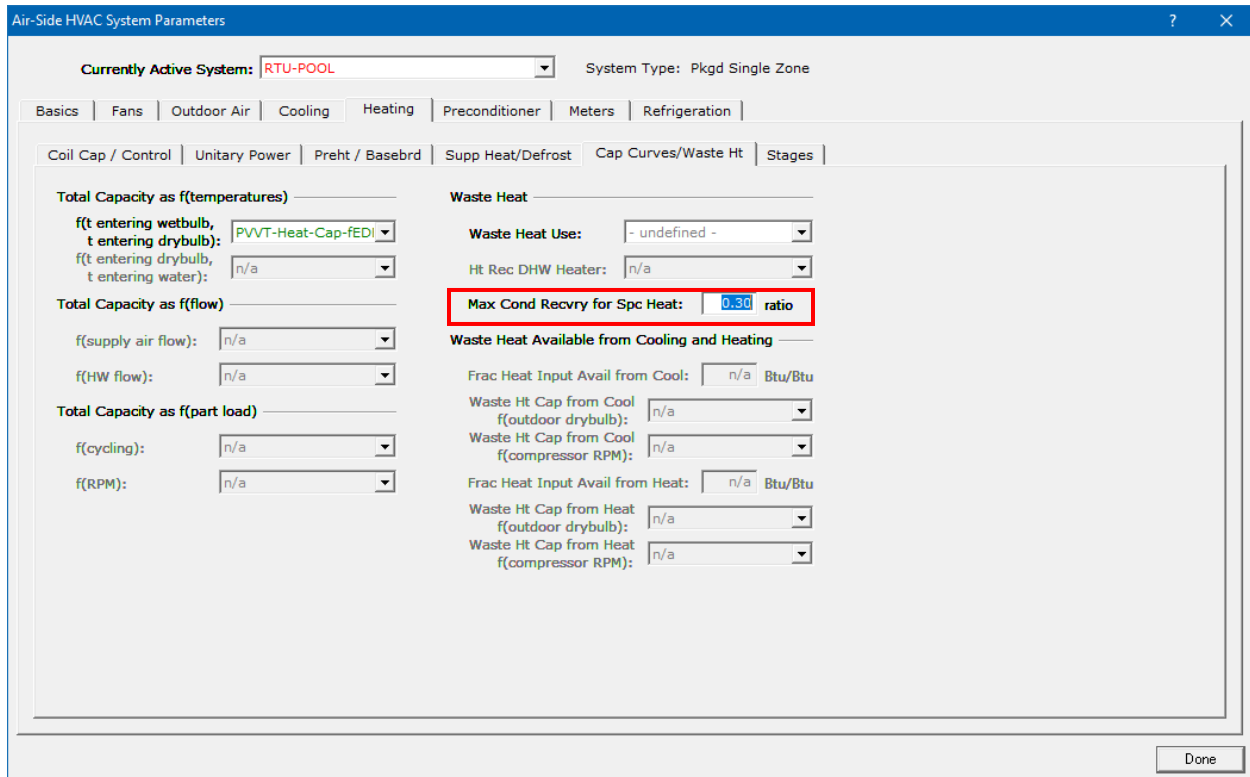
4.3   Domestic Hot Water Heaters

A new entry is added for the DHW loads to account for the pool water make-up. Since the energy model is created to account for typical building operating conditions, the pool hot water make-up is calculated by the SCA Appendix A spreadsheet for typical days.

Events such as draining and re-filling of the pool are not captured.

Table 11. DHW Loop Load Inputs (SCA Input Summary Table 14)

Load	Schedule	Description
Restroom Hot Water Load	TOTHW-SCH	Hot water load from faucets and showers calculated based on W2.1P and W2.2P GSG credits.
Kitchen Hot Water Loads	KITHW-SCH	Based on number of meals served.
Pool Make-up Hot Water Loads	POOL-VAP-YR	Based on the pool water evaporation rate