LOTUS Homes C&S Pilot Guidelines

Net-zero energy-ready Homes

Guidelines for building energy simulation in LOTUS Homes C&S Pilot

CONTENTS

1. GENERAL

1.1 Background

To qualify as net-zero energy ready in LOTUS Homes C&S, projects should show that an annual onsite renewable energy system generated/produced could either balance or higher than the annual future energy use of the C&S Homes.

To estimate the future energy use of the C&S Homes, projects need to perform an energy simulation following the methodology described in the present guidelines.

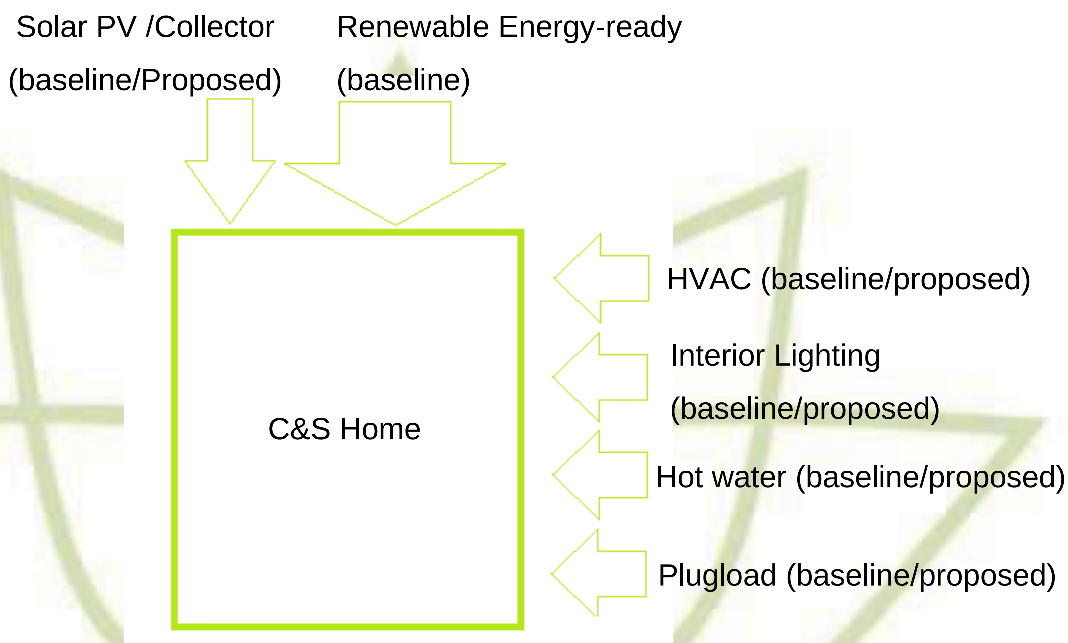

Figure 1: Energy consumption and generation of a typical C&S Home that can be defined by baseline model or proposed model (design/built).

1.2 Performance Rating

To determine the performance of the project, the total energy use (kWh/year) of the C&S Homes should be calculated using:

- an approved computer-based simulation program in line with the modelling requirements (Refer to *Section 2.1 Simulation software*).
- appropriate climatic data (Refer to *Section 2.2 Climatic data*).
- the set of modelling parameters defined by the VGBC to ensure an accurate and consistent outcome (Refer to *Section* 3)

At Provisional Certification stage of LOTUS Homes C&S, the simulation model of the project should be consistent with all design documents (drawings, specifications, manufacturer's data if any, etc.). At Full Certification stage, it should be consistent with the as-built documents representing the C&S Homes as they were built.

For all elements, equipment, systems, appliances not installed by the developer, the project will have to use standardized assumptions to complete the model. This will ensure that modelled building performance is comparable between projects. Also, these standardized assumptions aim to represent what would be the performance of an average typical building and will ensure that projects achieving net-zero energy-ready requirements actually have the potential to be net-zero energy.

The energy uses calculated with the simulation are not a prediction of the actual energy uses of the C&S Homes but rather aims to represent the typical energy use that the C&S Homes would have considering:

- installation of standard-efficiency equipment and systems
- typical occupancy (number of occupants, time spent home, behavior)
- typical weather
- effective maintenance (to maintain performance through the life of the building)

1.3 Building performance documentation

The simulated performance of the building should be documented and then submitted for assessment. The information submitted should include the following:

- A brief description of the project, the key energy efficiency improvements, the simulation program used, and the results of the energy analysis. This summary shall contain the calculated values (kWh/year) for the proposed building performance.
- A space summary of the building including the total area, the conditioned and unconditioned areas and the space usage type for all the different spaces.
- A diagram showing the thermal zones used in the computer simulation
- Schedules with hourly variations used for occupancy, lighting and HVAC systems
- An explanation of any significant modeling assumptions

- Back-up calculations for U-values and documentation to support data inputs. U-values in the model should be in line with the R-values calculated in credit E-3 Building Envelope.
- Input and output report(s) from the simulation program or compliance software including a breakdown of energy usage by at least the following components: internal and external lighting, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of unmet load hours.
- An explanation of any error messages noted in the simulation program output.
- For any exceptional calculation method(s) employed, document the predicted energy savings by energy type, a narrative explaining the exceptional calculation method performed, and the theoretical or empirical information supporting the accuracy of the method.

2. MODELLING REQUIREMENTS

2.1 Simulation software

The energy use of the project should be calculated using a computer-based simulation program in line with following requirements.

Whichever modelling tool is chosen, the program is required to undertake building performance calculations for all the building components being modelled. The simulation program should have the ability to directly determine the energy performance, and at a minimum model all the following:

- 8760 hours per year (i.e. 24 hours a day)
- Hourly variations in occupancy, lighting power, small and large equipment power, thermostat set points and HVAC system operation, defined separately for each day of the week and holydays
- Thermal mass transfer
- 4~~10~~ or more thermal zones

- Part-load capacity and efficiency correction curves for mechanical and HVAC equipment
- Input and output evidence; including a breakdown of energy uses ~~usage~~ by at least the following components: lights, internal equipment loads, service water heating equipment, space heating, space cooling, and other HVAC equipment (such as fans and pumps)

2.2 Climatic data

The simulation program should use climate data from either the province or city where the building is located. If facing difficulty to find the appropriate climatic data, projects should contact the VGBC.

Also, the climate data should cover a full calendar year (8,760 hours) and should reflect approved coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.

3. MODELLING PARAMETERS

The simulation model of the C&S Homes should be developed in accordance with the following parameters:

3.1 Building and zone type

Space usage in the building shall be specified to differentiate living rooms, bedrooms, kitchen and other spaces.

These classifications will be used to differentiate areas within the building that may have different operating schedules and characteristics (thermostat settings, ventilation rates, etc.)

3.2 Occupancy and Consumption Schedules

The project should consider the following occupancy in the house: 2 occupants for the 1st bedroom and 1 additional occupant for each bedroom thereafter.

If there is no definition for schedule, Default schedules capable of modelling hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points and HVAC system operation should be used and should match with schedules defined in Appendix 1: Default Schedules.

3.3 Building Envelope

3.3.1. General

All components of the building envelope should be modelled as designed/built.

3.3.2. Orientation

The building performance should be generated by simulating the C&S Homes with their actual orientation.

3.3.3. Opaque Assemblies

All opaque external wall and roof assemblies should be modelled as designed/built.

External and internal surface heat transfer coefficients from Annex 3 of QCVN 09:2017/BXD should be used to calculate U-values of assemblies.

If available in manufacturer's data, the actual thermal conductivity values for roof and wall materials should be used. Else, values from Annex 2 of QCVN 09:2017/BXD should be used.

3.3.4. Opaque surfaces solar reflectance

If available in manufacturer's data, the actual surface solar reflectance values for roof and wall surfaces should be used.

Else, roof and wall surfaces should be modelled with surface solar reflectance values from Annex 5 of QCVN 09:2017/BXD.

3.3.5. Vertical Fenestration

a. All vertical fenestrations should be modelled as designed/built.

b. Fenestration Solar Heat Gain Coefficient (SHGC) should be modelled using:

- values specified in the design at Provisional Certification stage
- values from manufacturer's data of the installed fenestration at Full Certification stage

c. Fenestration U-values should be modelled using:

- values specified in the design at Provisional Certification stage
- values from manufacturer's data of the installed fenestration at Full Certification stage

3.3.6. Shading

a. Manual internal shading devices such as blinds or shades should not be modelled.

b. Permanent shading devices such as fins, overhangs, and light shelves should be modelled as designed/built.

c. Adjustable external shading devices (whether automated or manual) can be modelled.

d. Shaded roofs should be modelled as designed/built.

e. Shading from surroundings as existing buildings should be modelled

3.3.7. Skylights

a. All skylights should be modelled as shown on architectural drawings.

b. Skylight SHGC values should be modelled using:

- values specified in the design at Provisional Certification stage
- values from manufacturer's data at Full Certification stage

c. Skylight U-values should be modelled using:

- values specified in the design at Provisional Certification stage
- values from manufacturer's data at Full Certification stage

3.3.8. Infiltration

Infiltration shall be modelled as a fixed rate of 0.20 L/s/m² at operating pressure only for conditioned areas and is to be applied to the modelled above-ground wall area (i.e. walls and windows).

3.4 Artificial Lighting

3.4.1. Interior Lighting System

a. Where an interior lighting system has been designed/installed:

- lighting power density should be modelled in accordance with design documents at Provisional Certification stage
- lighting power density should be modelled in accordance with as-built documents at Full Certification stage
- lighting system power should include all lighting system components shown on drawings.

b. Where no lighting system has been designed/installed, a default lighting power density of 8 W/m2 should be modelled in all the spaces.

Exception: for parking/garage area, a lighting power density of 2 W/m2 should be modelled.

3.4.2. Exterior Lighting System

a. Where an exterior lighting system has been designed/installed:

- Lighting power for building exteriors (including parking areas) should be modelled in accordance with design documents at Provisional Certification stage
- Lighting power for building exteriors (including parking areas) should be modelled in accordance with as-built documents at Full Certification stage

b. Where no exterior lighting system has been designed/installed, no exterior lighting system should be modelled.

3.4.3. Lighting operation schedule

a. If no lighting schedules is set, a default lighting schedules for exterior and interior lighting should be set following Schedule 2 in Appendix 1: Default Schedules .

b. In case automatic lighting controls are installed in the building and are not directly modelled in the building simulation, it is possible to make some schedule adjustments (subject to VGBC approval)

3.4.4. Lighting Controls

a. No lighting controls for daylight should be modelled.

b. No automatic lighting control should be modelled.

3.5 Thermal Blocks

a. Where an HVAC system has been designed/installed, all the spaces served by the HVAC system should be modelled as conditioned spaces and each separate space should be modeled as a separate thermal block.

b. Where no HVAC system has been designed/installed, living rooms, dining rooms and bedrooms should be modeled as conditioned spaces. All other spaces should be modeled as unconditioned. Also, each living room, dining room and bedroom should be modeled as separate thermal blocks.

3.6 HVAC Systems

3.7.1. General

a. Where an HVAC system has been designed/installed, the HVAC system type and all related performance parameters in the model, such as equipment capacities and efficiencies, should be consistent with design/as-built documents.

b. Where no HVAC system has been designed/installed, the project should model a HVAC system of the type and description specified in Section 3.7.3 and should meet the general HVAC system requirements specified in Section 3.7.4.

3.7.2. Schedule and setpoints

Temperature control setpoints and schedules should be simulated following default schedules in Appendix 1.and a temperature control throttling range (dead band) of +/- 2°F (+/- 1.11°C) should be set.

3.7.3. Type of HVAC system

The type of HVAC system to model should be based on climate as follows:

- System 1 - Split-HP (SHP) for all locations where the average monthly temperature in the coolest months is below 18°C (based on Table A.2 – Nhiệt độ không khí trung bình tháng và năm (°C) of QCVN 02:2022/BXD)
- System 2 - Split-AC (SAC) for all other locations

  The types of HVAC system to model should conform with the system descriptions in Table 3.7.1A.

Table 3.7.1A – Types of HVAC systems				
System	System Type	Fan Control	Cooling Type	Heating Type
System 1 - SHP	Split heat pump	Constant volume	Direct expansion	Electric heat pump
System 2 - SAC	Split air conditioner	Constant volume	Direct expansion	/

3.7.4. HVAC system requirements

This section only applies to projects where no HVAC system has been designed/installed.

3.7.4.1 Equipment Efficiencies

All HVAC equipment should be modeled at the efficiency levels, indicated in Tables 3.7.2.1A and 3.7.2.1B using the test procedures as listed. In these Tables, COP and COP_C are the HVAC system cooling energy efficiency and COP_H is the HVAC system heating energy efficiency. These values exclude supply fan power that should be modelled separately following section 3.7.4.7.

Table 3.7.2.1A – Cooling efficiency values for System 1 - HPS *(Source: ASHRAE 90.1-2019)*			
Equipment Type	Size Category (Input)	Minimum Efficiency	Test Procedure
Air cooled (cooling mode)	< 19 kW	3 COP_C	AHRI 210/ 240
Air cooled (heating mode)	< 19 kW (cooling capacity)	3.4 COP_H	AHRI 210/ 240

Table 3.7.2.1B – Cooling efficiency values for System 2 – SAC *(Source: ASHRAE 2019)*			
Equipment Type	Capacity	Minimum Efficiency	Test Procedures
Split air-conditioner	< 19 kW	3 COP	AHRI 210/240

3.7.4.2 Equipment Capacities

The equipment capacities should be based on one sizing run and shall be oversized by 15% for cooling and 25% for heating, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing run shall be 1.15 for cooling and 1.25 for heating.

Unmet load hours for the model should not exceed 300 (of the 8760 hours simulated).

Weather conditions used in the sizing run to determine equipment capacities may be based either on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% dry-bulb and 1% wet-bulb cooling design temperatures.

3.7.4.3 Fan System Operation

Supply and return fans should operate continuously whenever spaces are occupied. During unoccupied periods, outdoor air ventilation shall be set to zero.

3.7.4.4 Ventilation

Minimum outdoor air ventilation rates (fresh air supply) should meet minimum outdoor air ventilation rates from TCVN 5687:2024:

- 35 m3/hour/occupant for bedrooms
- 30 m3/hour/occupant for living rooms
- 25 m3/hour/occupant for other habitable rooms (including kitchen)

3.7.4.5 Economizers

Outdoor air economizers should not be included in the model.

3.7.4.6 Design Airflow Rates

System design supply airflow rates should be based on a supply-air-to-room-air temperature difference of 11°C or the required ventilation air or makeup air, whichever is greater.

3.7.4.7 System Fan Power

System fan electrical power should be calculated using the following formula:

$P_{fan} = L_S \times 0.64$

Where L_S is the maximum design supply fan airflow rate in L/s (calculated following section 3.7.4.6 Design Airflow Rates)

3.7.4.8 Heat Pumps (System 1)

Electric air-source heat pumps should not be modeled with electric auxiliary heat.

3.7.4.9 Split-units (Systems 1 and 2)

In each thermal zone, only one split HVAC system shall be modeled.

3.8 Service hot water systems

Service hot-water system should be idential with the design/installation. Where no service hot-water system in the project, the below definition should be set to the model. Service hot-water energy consumption should be calculated based on:

- an entering makeup water temperature set to 14°C
- a leaving service hot-water temperature of 40°C
- a daily service hot water consumption of 45 liters per resident

The service hot-water system modelled should be an Electric Water Heater with an energy factor EF = 0.93 - 0.00035V

where

V is the rated volume in liters.

3.9 Plug loads

Plug loads for household appliances should be included in simulations of the building. A peak load of 5 W/m² associated with the default hourly profile in schedule 3 of Appendix 1 should be set to model the energy consumption of the plug loads.

3.10 Onsite Renewable and recovered Energy

a. Where non-electrical renewable energy (including solar collector) or recovered energy (including energy recovery ventilator) is designed/installed, it should be directly modelled by reducing the energy loads in the building performance model (i.e. hot water load, cooling load, ...). Else, no non-electrical renewable energy or recovered energy should be modelled.

b. For C&S Homes with a renewable energy generation system already designed/installed (including solar PV rooftop), the renewable energy generation system should be modelled as designed/installed. It can be either modelled within the building energy simulation or modelled in a separate simulation.

c. For solar PV-ready homes, the solar system should be modelled in accordance with the following:

- Total area of solar panels modelled should not be higher than the area available on the roof (and/or carport) for installing solar PV panels and with an electrical conduit installed nearby.
- Monocrystalline solar PV modules of 450 W under Standard Test Conditions (STC) with a Module Efficiency of 20% and dimensions of 2.1 m x 1.0 m should be modelled.

4. GLOSSARY

All the terms below are completing the terms already defined in the LOTUS Homes C&S Pilot Technical Manual.

Automatic control device - a device capable of automatically turning loads off and on.

Conditioned space - an enclosed space within a building which is a cooled space, heated space, or indirectly conditioned space.

COP (Coefficient of performance) - The ratio of the rate of heat removal to the rate of energy input in consistent units, for a complete cooling system or factory assembled equipment, as tested under a nationally recognized standard or designated operating conditions. COP for air-cooled electrically driven air conditioners includes compressor, evaporator, and condenser. COP for water chilling packages does not include chilled water or condenser water pumps or cooling tower fans.

Design conditions - specified environmental conditions, such as temperature and light intensity, required to be produced and maintained by a system and under which the system must operate.

Economizer, air - a duct or damper arrangement and automatic control system that together allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

EF (Energy factor) - a measure of water heater overall efficiency.

Energy loads - quantity of energy needed by the building to operate (cooling load, lighting load, hot water load, receptacle load…)

Evaporative Cooling - reducing the temperature of air through the evaporation of water. Evaporative cooling uses the fact that water will absorb a relatively large amount of heat in order to evaporate. Evaporative cooling differs from typical air conditioning systems which use vapor-compression refrigeration cycles.

Fan system power - the sum of the motor nameplate kilowatts (kW) of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it to the source or exhaust it to the outdoors.

HVAC (Heating, Ventilating and Air Conditioning) - the equipment, distribution network, and terminals that provides either collectively or individually the processes of heating, ventilating, or air conditioning to a building.

HVAC zone - a space or group of spaces within a building with heating and cooling requirements that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., thermostat or temperature sensor).

LPD (Lighting Power Density) - The ratio of electric lighting output to the illuminated area, measured in W/m^2.

Outdoor air - air taken from outside the building that has not been previously circulated through the building (also named fresh air or outside air).

Process energy - energy consumed by household appliances and exhaust fans in wet areas.

Process load - the load on a building resulting from the consumption or release of process energy.

SHGC (Solar Heat Gain Coefficient) - The SHGC of a glass is the percentage of solar energy incident on the glass that is transferred indoors both directly and indirectly through the glass.

Service water heating - heating water for domestic or commercial purposes other than space heating and process requirements

Setpoint - point at which the desired temperature (°C) of the heated or cooled space is set.

Solar reflectance (or reflectivity) - the ability of a material to reflect solar energy from its surface back into the atmosphere, it is the percentage of solar energy reflected by a surface. Solar reflectance is equal to 1.0 - solar absorptance.

Thermal block - a collection of one or more HVAC zones grouped together for simulation purposes. Spaces need not be contiguous to be combined within a single thermal block.

Unconditioned space - an enclosed space within a building that is not a conditioned space. Crawlspaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

Unmet load hour - an hour in which one or more zones is outside of the thermostat setpoint range.

U-value (Thermal transmittance) - The intensity of a time-constant heat flux going through a surface area unit of the enclosing structure when the temperature difference of the air on both sides of the structure is 1 K, measured in $W/m^2.K$

5. APPENDIX 1: DEFAULT SCHEDULES

The following schedules are adapted from National Energy Code of Canada for Buildings 2011.

Schedule 1: Occupants (fraction occupied)

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Weekend & Holiday	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Schedule 2: Lighting (fraction "on")

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	0	0	0	0	0	0.2	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.9	0.9	0.9	0.8	0.6	0.3
Weekend & Holiday	0	0	0	0	0	0.2	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.9	0.9	0.9	0.8	0.6	0.3

Schedule 3: Receptacle Equipment (fraction of load)

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	0.2	0.2	0.2	0.2	0.2	0.2	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.2	0.9	0.9	0.7	0.5	0.5	0.5	0.3
Weekend & Holiday	0.2	0.2	0.2	0.2	0.2	0.2	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.2	0.9	0.9	0.7	0.5	0.5	0.5	0.3

Schedule 4: Ventilation fans (fraction of load)

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Weekend & Holiday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on

Schedule 5: Cooling System (°C)

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Weekend & Holiday	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26

Schedule 6: Heating System (°C)

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Weekend & Holiday	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Schedule 7: Service Water Heating System (fraction of load)

	12-1AM	1-2AM	2-3AM	3-4AM	4-5AM	5-6AM	6-7AM	7-8AM	8-9 AM	9-10AM	10-11AM	11AM-12PM	12-1PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM	8-9PM	9-10PM	10-11PM	11-12PM
Weekday	0.05	0.05	0.05	0.05	0.05	0.2	0.8	0.7	0.5	0.4	0.2	0.2	0.2	0.3	0.5	0.5	0.7	0.7	0.4	0.4	0.2	0.2	0.1	0.1
Weekend & Holiday	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.3	0.3	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.4	0.3	0.2	0.2	0.2	0.2	0.1