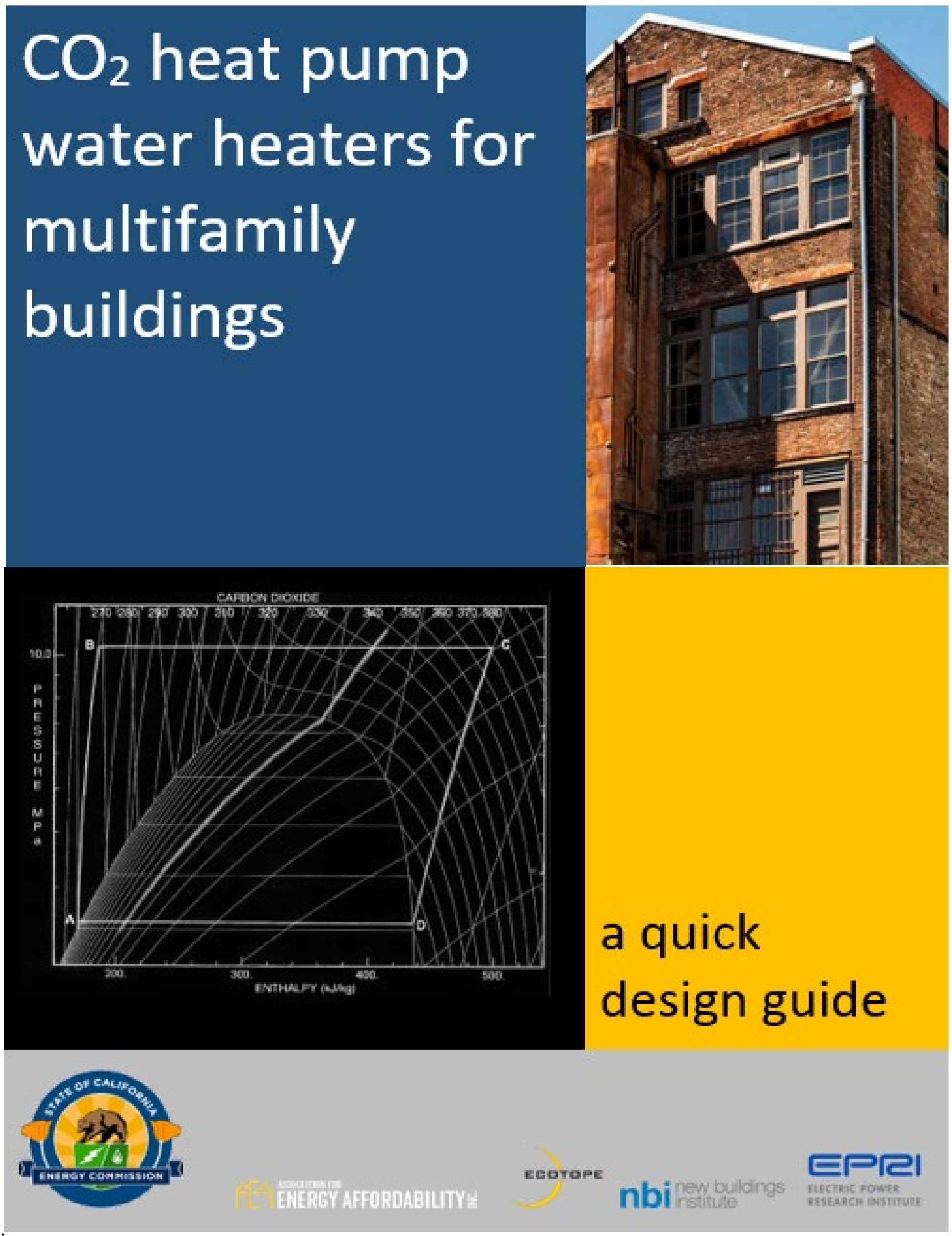
CO_2 Heat Pump Water Heaters for Multifamily Buildings

A Quick Design Guide

CEC EPC-19-030



CO_2 Heat Pump Water Heaters for Multifamily Buildings

A Quick Design Guide

CEC EPC-19-030

November 2022

THE FOLLOWING ORGANIZATIONS PREPARED THIS TECHNICAL UPDATE REPORT:

Ecotope

Association for Energy Affordability

New Buildings Institute

Electric Power Research Institute

A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

Together…Shaping the Future of Energy®

ACKNOWLEDGMENTS

The following collaborators prepared this report:

Colin Grist and Julianne MacLennan, Ecotope
Megan Ching and Andrew Brooks, Association for Energy Affordability
Mischa Egolf and Bryce Seymour, New Buildings Institute
Andrea Mammoli, Zack Allen, Herb Yaptinchay, Sara Beaini, EPRI

This publication is a corporate document that should be cited in the literature in the following manner:

CO2 heat pump water heaters for multifamily buildings: A Quick Design Guide. EPRI, Palo Alto, CA: 2022. CEC EPC-19-030.

ABSTRACT

This guide was produced as part of the 2020 grant award EPC 19-030 “Large Capacity CO_2 Central Heat Pump Water Heating Technology Evaluation and Demonstration project,” sponsored by the California Energy Commission’s Electric Program Investment Charge Program (EPIC). The guide was developed by Ecotope with the collaboration of the Association for Energy Affordability (AEA), the Electric Power Research Institute (EPRI) and New Buildings Institute (NBI). The guide is intended as a reference for designing central commercial heat pump water heating systems that use CO_2 technology. The guide focuses on system sizing and design using the Mitsubishi HEAT2O™, but the guide can be applied to other similar heat pump water heater systems. The information in this guide can be used by developers, engineers, and architects to understand how central commercial heat pump water heaters can fit into a multifamily housing project, whether it is a full renovation, a technology upgrade, or a new build.

CONTENTS

LIST OF FIGURES

1
INTRODUCTION

This Quick Design Guide is intended to serve as reference for designing central commercial heat pump water heating (CHPWH) systems that utilize CO_2 HPWH technology. It covers multiple topics including an overview of central commercial domestic hot water systems, CO_2 HPWH equipment, key design considerations for central CHPWH systems, and sizing guidelines for central CHPWH systems. The focus is on system sizing and design using the Mitsubishi Heat$_2$O™[1] CO_2 HPWH (formerly known as the QAHV). Its guidance, however, may also be applied to other single-pass CO_2-based HPWH equipment.

Heat pump water heaters have the potential to reduce the energy used for water heating by a factor of approximately three, if properly designed. In addition to overall energy savings, HPWH systems naturally allow for load shift capability. A typical HPWH system is designed with less heat capacity and more storage than a traditional electric or gas water heating system. The high storage volume future-proofs the central CHPWH system for load shift and demand response scenarios.

This Guide is intended to cover design of central CHPWH systems serving multifamily buildings in tandem with the Ecosizer online tool. Together they are structured to aid in multifamily building equipment selection and sizing and may not be applicable to other building occupancy types. This Guide includes Ecosizer sizing tool instructions, a basis of design for accessory component included in a central CHPWH system, and sample schematics.

[1] Heat2O (trane.com)

2
CENTRAL COMMERCIAL HEAT PUMP WATER HEATER SYSTEM OVERVIEW

Domestic water heating consumes an average of 19% of energy across U.S. residential homes; and consumes 27-32% of energy in multifamily buildings (U.S. Energy Information Agency, 2015 data), see Figure 2-1.

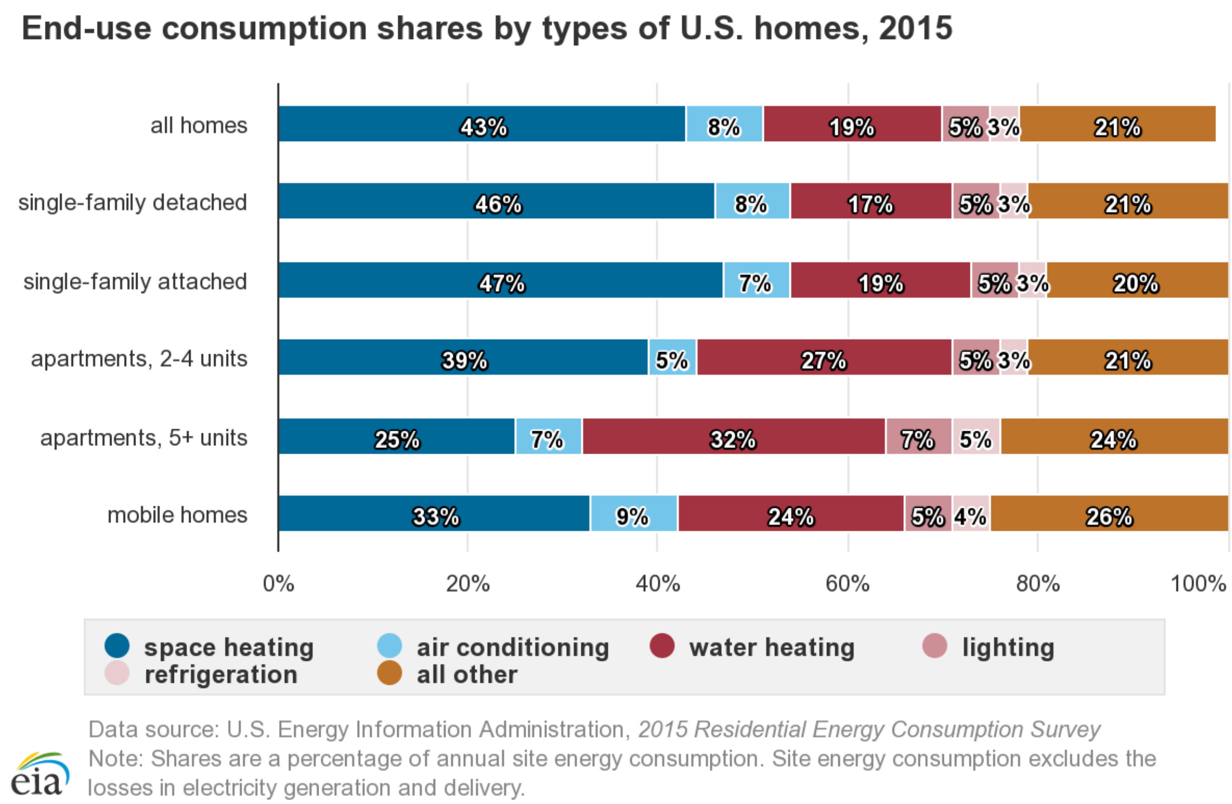


Figure 2-1
Percentage of energy consumption by end-use in U.S Residential Homes (2015). Ref: Use of energy in homes – U.S. Energy Information Administration (EIA)

The efficiency and energy use of a water heating system depends on its design and configuration. Heat pump water heater systems can be categorized into two types:

1. Single-pass: Heats water to the storage setpoint temperature in a single water pass through the refrigeration circuit, typically, a 70°F to 100°F temperature lift in a single cycle.
2. Multi-pass: Heats water to the storage setpoint temperature in a multiple water pass through the refrigeration circuit, typically, a 10°F temperature lift for each cycle.

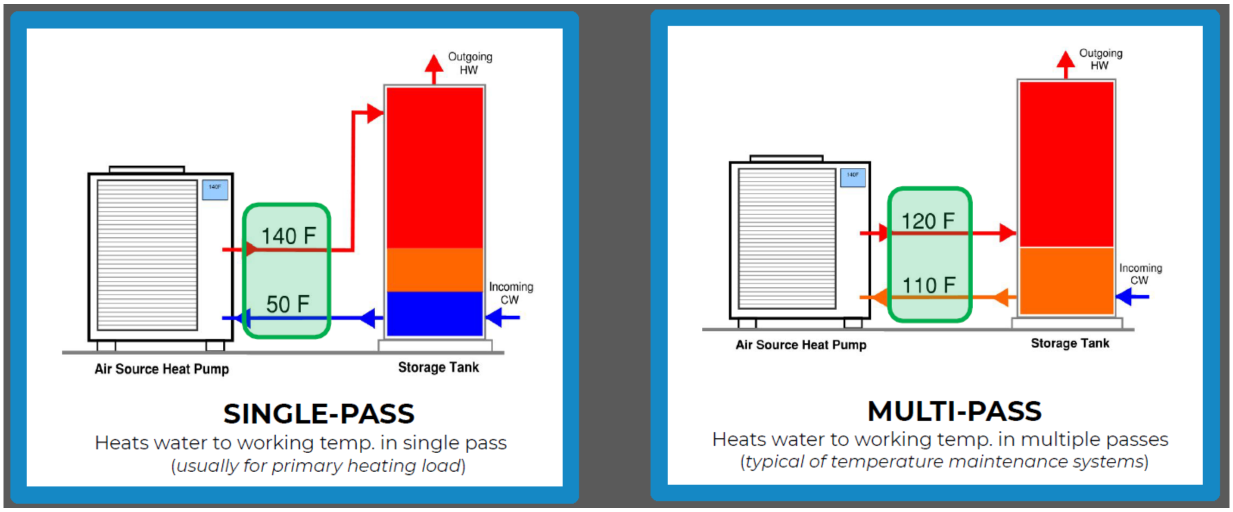


Figure 2-2
Heat pump configurations for water heating: single vs multi-pass. Photo credit: Ecotope

The Mitsubishi HEAT2O™ is intended to be used as a single-pass HPWH. This Quick Design Guide covers the use of the HEAT2O™ in a single-pass heating cycle configuration with a dedicated temperature maintenance tank in series, commonly referred to as a “swing tank”.

CO2 Heat Pump Water Heaters

The most common refrigerants used in heat pump water heaters are R-134a and R-410a. These are hydrofluorocarbons (HFCs) with high Global Warming Potential (GWP) and are being scheduled for phase-out over the next several years by international accords. As markets shift toward lower GWP refrigerants, policy makers are promoting natural refrigerants with a GWP of less than 3. The Mitsubishi HEAT2O™ uses the natural refrigerant R-744 (CO2), which has a GWP of 1.

The HEAT2O™ is designed to be a high-lift system, meaning the inlet and outlet water temperature delta is large. CO_2 operates with a transcritical refrigeration cycle that performs well with a high lift. As such, the HEAT2O™ operates extremely efficiently for heating incoming city water (typically 50°F to 70°F) to a water storage temperature of 140°F to 160°F – making it a single-pass HPWH. The HEAT2O™ does not work well heating water requiring a low lift, such as temperature maintenance loop, which requires heating from 115°F to only 125°F.

Depending on the scale of the building, hot water distribution system, and the associated temperature maintenance losses, arguably the most reliable and efficient design strategy for single-pass HPWH systems is to separate the primary and temperature maintenance heating loads. This separation means decoupling primary heating of city water from the heating required to maintain the water temperature in the distribution piping due to hot water circulation losses. As hot water circulates through the building, the hot water pipe loses heat to the air and the water cools. If hot water is sent to the building at 125°F, it may return at a temperature closer to 115°F. Separating these two loads allows the single-pass HPWH to only heat incoming city water to a storage temperature above the building 125°F setpoint temperature. As hot water is used, the primary storage water flows into the temperature maintenance side of the system and adds heat.

A temperature maintenance tank and equipment are needed to maintain the hot water circulation loop temperature during periods of low hot-water use. The temperature maintenance tank also allows for secondary storage to isolate the primary storage and prevent temperature maintenance losses from disrupting the thermal stratification in the primary storage tank(s), which impacts the amount of available hot water. The temperature maintenance equipment, either a multi-pass heat pump or an electric resistance heater, keeps the secondary storage warm during periods of low water use when hotter water from thermal storage tanks is not entering the temperature maintenance tank.

This Quick Design Guide focuses on a dedicated electric resistance temperature maintenance tank, in series with the primary storage. This equipment and piping configuration for central CHPWH systems is commonly referred to as a “swing tank” design. The swing tank piping configuration is designed so that the electric resistance tank operates purely as back-up in the event of extended durations of no hot water draw (6+ hours). During normal operation, the temperature maintenance losses are indirectly reheated by the primary heat pumps, not by the electric element.

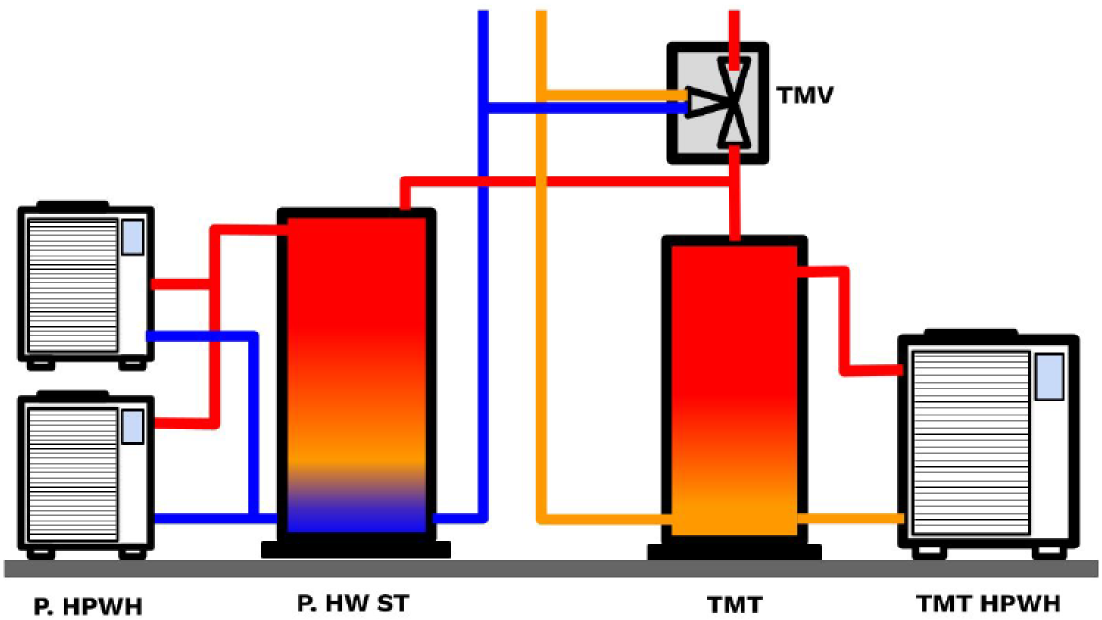


Figure 2-3
Primary components of a CHPWH system: Primary heat pump water heater (P.HPWH), primary hot water storage (P. HW ST), temperature maintenance tank (TMT), temperature maintenance water heater (TMT HPWH), and thermostatic mixing valve (TMV).) Photo credit: Ecotope

3

KEY DESIGN CONSIDERATIONS

There are several multifamily building types that warrant different design considerations. Key building characteristics include building height, space constraints, electrical constraints, and hot water distribution system.

Building Size: In retrofit applications, the new system should be located as close as possible to the existing system to minimize the pipe runs needed to tie into the existing distribution. The most commonly seen locations by building type are listed below:

- Highrise (10+ stories): Rooftop or garage installation.
- Midrise (5-9 stories): Likely most flexible building type. DHW room, garage, or courtyard.
- Lowrise (<4 stories) or Scattered Site: Courtyard, DHW room.

Space Constraints: A property's limiting factor is likely to be the type and amount of space available.

- Space-constrained buildings may need higher ratio of heat pump capacity to storage tank since tanks require more space.
- Ensuring adequate airflow can be especially challenging in retrofit applications. If the heat pumps are located in an enclosed area, exhaust ducting and supply air louvers may be required to allow for adequate airflow.
- Locate away from walls (follow manufacturers guidelines on minimum clearance requirements).

Electrical Constraints: The age of a building can be a good indicator of whether there will be enough electrical capacity to accommodate a heat pump system. Newer buildings are subject to stricter and more future-proof building codes, which lead to larger service panels that often have additional capacity to take on new loads. Older buildings may have been retrofitted and had their panels updated. In situations where electrical capacity is the primary constraint, the heat pump to storage ratio will be lower. This configuration maximizes storage to hold excess hot water, so that fewer heat pumps are needed to meet the building's peak hot water demand.

Hot Water Distribution: Some buildings have a main trunk with several risers and one or several corresponding returns, while others will have multiple recirculation loops with separate pumps. The level of insulation and location of the recirculation system will influence the CHPWH and/or swing tank sizing.

4
SYSTEM SIZING

Providing appropriately sized central CHPWHs is an important aspect of designing HPWH systems. Often heat pump capacity is more expensive per BTU/hr than fossil gas or electric resistance water heating equipment. Therefore, it can be economical to prioritize larger storage volumes and less heat pump water heater capacity to meet a building's hot water load. Systems with greater storage volume to heat pump capacity will be better candidates for load shifting due to their large hot water storage availability. Appropriately sized central CHPWHs have equipment life cycle benefits and reduce equipment cycling.

Another important aspect of designing HPWH systems is thermal storage and maintaining stratification in thermal storage tank(s). Not only does this allow for more efficient equipment heating cycles, but also reduces the required storage volume, which leads to more economical CHPWH system installations.

Ecosizer

The Ecosizer (https://ecosizer.ecotope.com/) is a free online tool for sizing central heat pump water heater systems for multifamily building occupancies. The tool is designed to support the building industry's adoption of CHPWH systems to improve energy efficiency and reduce greenhouse gas emissions. It allows designers to select heat pump water heating output capacity and associated storage volume needed to meet peak hot water demand for multifamily buildings. A summary of the online selection process is illustrated below. For more information on the Ecosizer algorithm, refer to the online documentation at https://ecosizer.ecotope.com/sizer/docs/.

The Ecosizer calculates a total daily hot water demand using either the total number of people (ppl) and peak gallons per day per person (gal/day/ppl) or the number of apartments and California Residential Appliance Saturation Study (RASS) data. The number of people can also be calculated by occupancy rate and number of apartments. Figure 4-1 and Figure 4-2**Error! Reference source not found.** show options for calculating total hot water load. Users must also input number of apartments in this section, which is used in distribution energy loss calculations.

1. If the designer knows how many people will occupy the building, they may directly enter the number of people into the tool, shown in Figure 4-1.

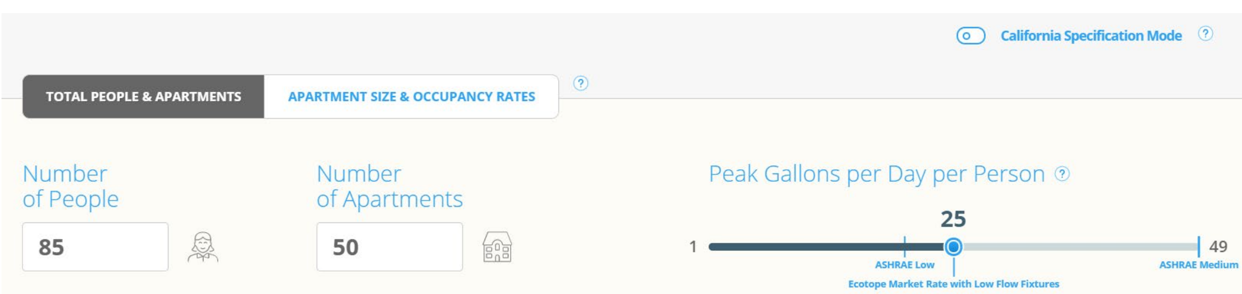


Figure 4-1
Total People & Apartments Option for Calculating Daily Hot Water Load

2. If the designer does not know how many people will occupy the building, there is an option to use available data sources for occupancy estimates. This will be based on the number of bedrooms and the occupancy rate (number of people per unit by the number of bedrooms). The “California Specification Mode” may be toggled to provide pre-set inputs on occupancy rates per unit type.

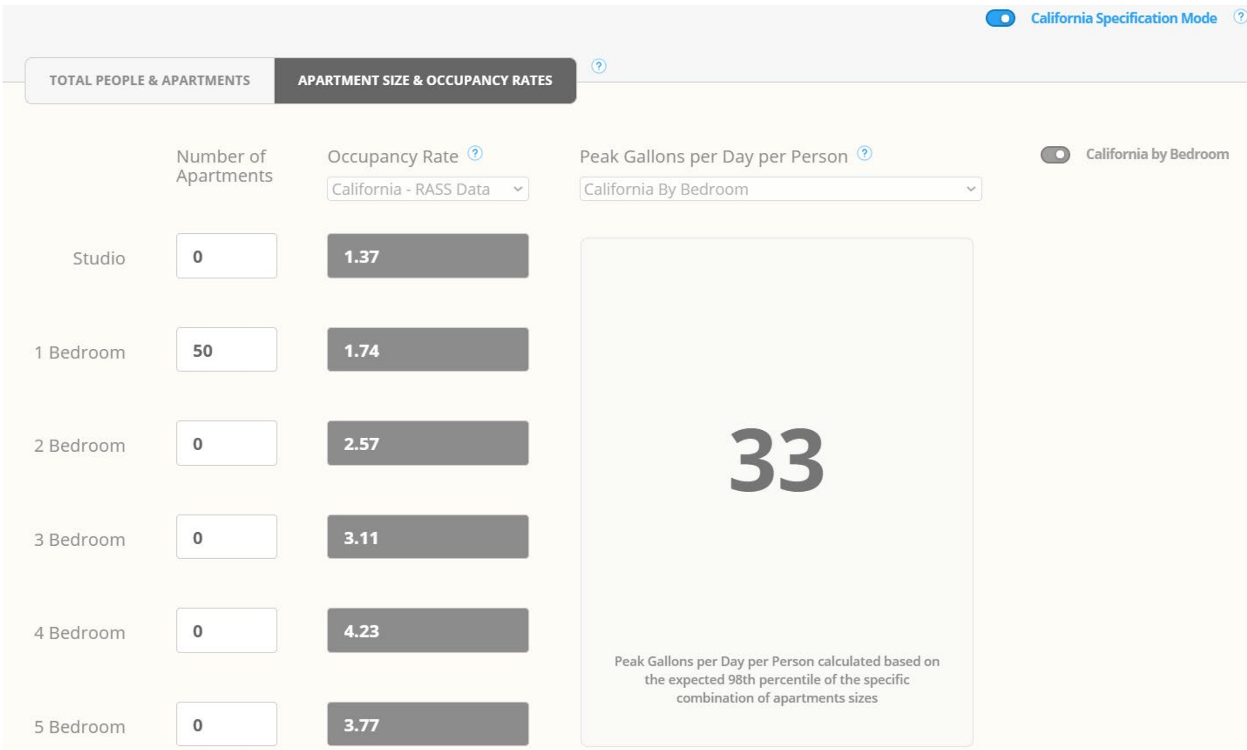


Figure 4-2
Apartment Size and Occupancy Rates Option for Calculating Daily Hot Water Load

Next, the user must input information about water temperatures[2] and thermal storage. Figure 4-3 shows the fields and example inputs for a HEAT2O™ packaged system.

- “Design Cold” indicates city water temperature at design conditions and depends on geographic location.
- “Supply” is the temperature supplied to fixtures; it will be the designed hot water setpoint.
- “Hot Storage” is the temperature setpoint for primary thermal storage; it will be the thermal storage setpoint temperature or the HPWH supply output.

Advanced options in this section allow the user to modify thermal storage system parameters. The aquastat fraction[3] is the position in the tank at which the heat pump will turn on. The storage efficiency is the fraction of primary storage at setpoint temperature when the heating call is satisfied, or the tanks are fully charged. Roughly 30% of the tank volume is located below this thermistor, so the aquastat fraction should be set to 30%.

[2] QAHV Note: Mitsubishi recommends a hot storage setpoint of 149°F in systems utilize the QAHV model.

[3] QAHV Note: When using the storage tank options available as part of the packaged QAHV system, these parameters should be modified to reduce overall storage volumes required and corresponding equipment cost. When using the standard packaged system, this should be the third thermistor up from the bottom of the tank.

Additionally, thermal storage tanks have been specifically designed to increase stratification and should be set at 85% for most standard tank sizes (285-gallon, 500-gallon).

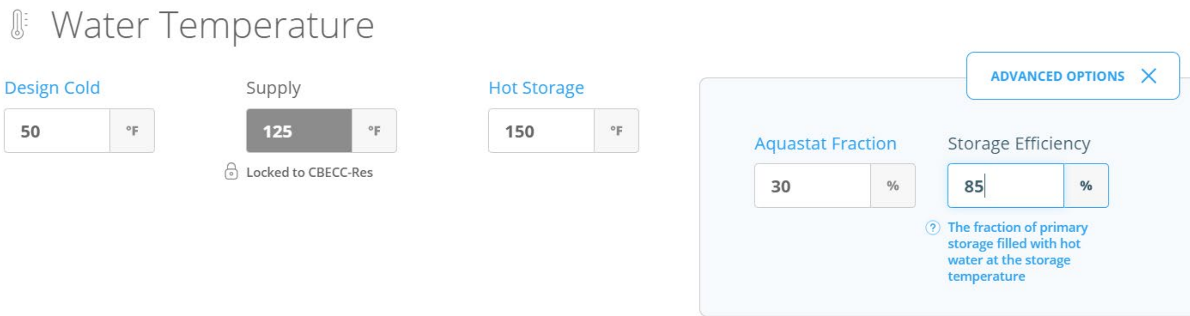


Figure 4-3
Water Temperature and Thermal Storage Inputs

After selecting the HPWH technology and identifying its temperature setpoint limitations, select the configuration for the temperature maintenance system. In most cases, “swing tank” should be selected for the temperature maintenance system as shown in Figure 4-4**Error! Reference source not found.**. A swing tank configuration allows the HEAT2O™ to offset a portion of the distribution losses. If the building has no recirculation loop, select “primary - no recirculation”.

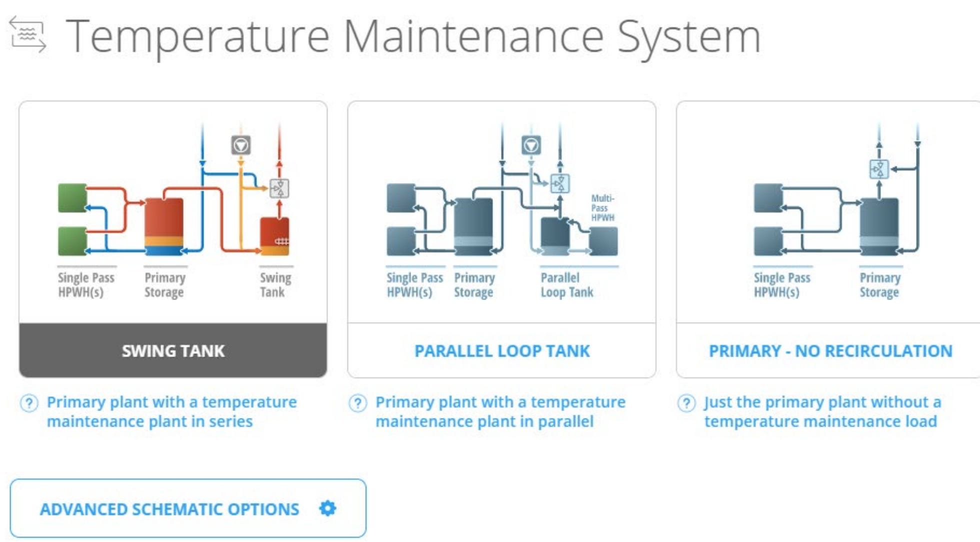


Figure 4-4
Temperature Maintenance System Selection

Advanced options under temperature maintenance allow the user two options for determining the energy loss through distribution piping. For new construction, it is recommended to leave the standard input of 100 W/apartment and a safety factor of 1.75, as shown in Figure 4-5. For retrofit projects it is possible to measure the recirculation flow rate and temperature change. Measuring the recirculation flow rate and temperature change, when possible, will lead to a more accurately sized temperature maintenance system.

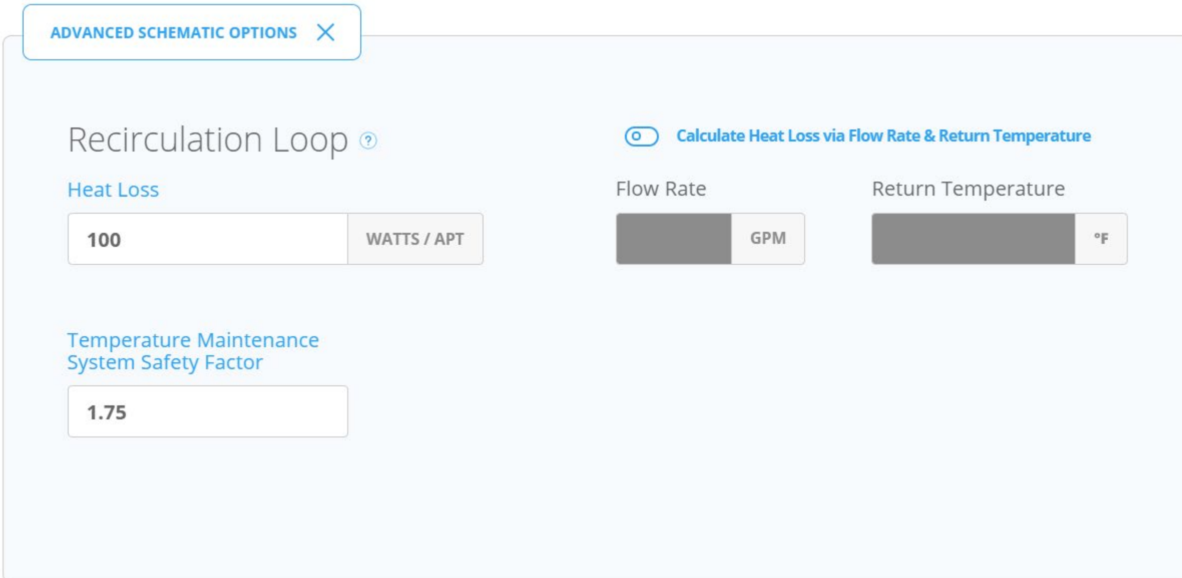


Figure 4-5
Advanced Schematic Options

Various load shifting capabilities may be selected as well, as shown in Figure 4-6.

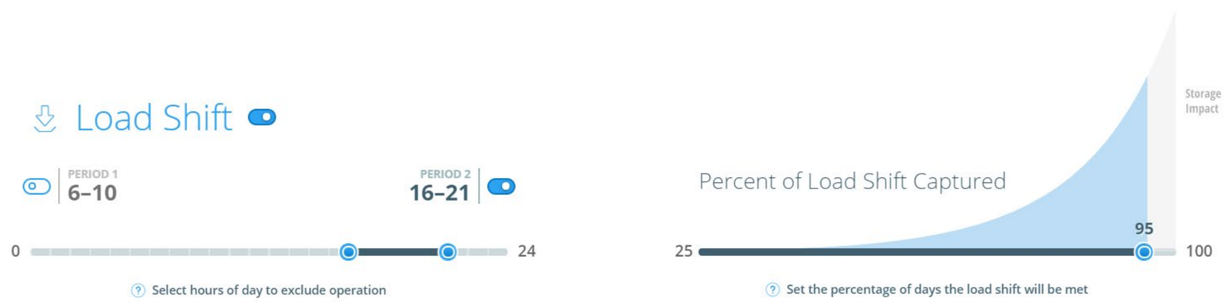


Figure 4-6
Load Shift Selection

After selecting “Size your System” the Ecosizer produces a primary sizing curve, equipment sizing recommendations, and a hot water simulation. The design engineer is responsible for determining the heat pump water heater capacity at the design air and water conditions needed, based on the primary sizing curve to meet the building DHW load[4].

The Ecosizer provides a sizing curve (Primary Sizing Curve shown in Figure 4-7) to determine required HPWH heating capacity and associated storage volume according to HPWH and storage equipment characteristics. Users select the quantity of HPWHs and storage volume according to their heating capacity under the design-day weather conditions (usually the coldest day). The blue marker initially shows the recommended sizing point. The ratio of heat pump

[4] QAHV Note: Mitsubishi has capacity vs. temperature plots provided in the QAHV Databook. In Energy Saving Operation, the unit has a maximum output capacity of 40 kW or 136.4 kBtu.

capacity to storage volume can be adjusted on the curve itself or using the sliding toggle beneath “Primary System Size”.

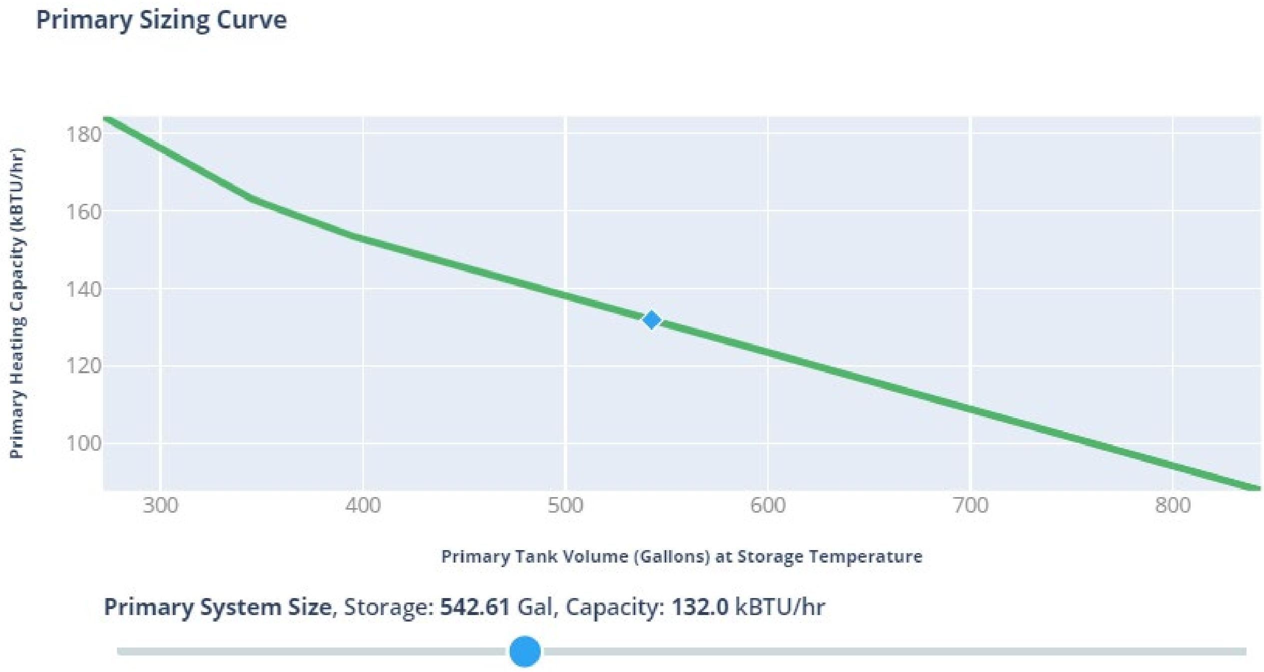


Figure 4-7
Ecosizer Output – Primary Sizing Curve

Figure 4-7 shows an Ecosizer output with the recommended setpoint of 132 kBTU/hr of heat pump capacity and storage size of 543 gallons. A single HEAT2O™ and a Nile Steel Tank storage tank with a nominal capacity of 575 gallons would meet these requirements.

Ecosizer recommendations provide swing tank capacity requirements under “Swing Resistance Element”. When using the packaged HEAT2O™ product, select swing tanks so that the “Swing Resistance Element” kW value can be covered using one element from each tank[5]. In the example below, Figure 4-8 shows 8.7 kW of electric resistance required. Therefore, one 36 kW tank should be used as the swing tank. During normal operation, only 12 kW of electric resistance will be used, but 36 kW is available as backup[6].

[5] QAHV Note: Fully Packaged heat pump skids are being developed. The fully packaged skid system will likely have options for electric resistance swing tanks with 36kW or 54kW of capacity. The 36 kW tanks have three 12 kW elements, and the 54 kW tanks have three 18 kW elements. During normal operation only one element will be used. The remaining elements are included as electric resistance backup for N+1 redundancy in the system.

[6] In retrofit scenarios it may be necessary to utilize a smaller electric water heater element to maintain under the existing building electrical threshold.

RECOMMENDATIONS

The recommended minimum heating capacity shown below is the **minimum** needed average output capacity of the selected equipment at the design cold air temperature in your climate zone. Note that you must also account for manufacturer specific defrost penalty.

Tank Volume

543.00 Gallons

Heating Capacity

132.00 kBTU/hr

Swing Tank Volume

120 - 300 Gallons

Swing Resistance Element

8.7 kW · **29.9** kBTU/hr

CA Title 24 Swing Tank Volume

288 Gallons

Figure 4-8
Ecosizer Recommendations

Results from the Ecosizer may be downloaded in PDF form, giving the design engineer a record of inputs used and the resulting system.

5
MITSUBISHI HEAT2O™ EQUIPMENT SELECTION

Once initial system sizing has been completed, ancillary equipment must be selected to complete the Heat2O™ system design. In addition to the Heat2O™, the following equipment must be selected:

- Secondary Heat Exchnager and Pump
- Storage Tanks
- Swing Tank

Secondary Heat Exchanger and Pump

The Mitsubishi HEAT2O™ is designed to operate most efficiently and reliably as a single-pass water heater. Therefore, the secondary heat exchanger selected by Mitsubishi potable water heating also operates in single pass. This aligns with the manufacturer's recommendations for domestic hot water systems.

A brazed plate heat exchanger is used for DHW applications. Brazed plate heat exchangers are designed to operate efficiently between 50 -150°F and are a compact solution. The heat exchanger is piped in a counter flow arrangement and the flowrates are controlled to achieve a given discharge water temperature. Mitsubishi provides control capabilities in the HEAT2O™ for the secondary pump based on temperature and flowrate. This is an optional package from the manufacturer but necessary in most DHW applications.

Secondary Loop Control

During the start of the heating cycle, the incoming water temperature is approximately 50°F and raised to 150°F—a 100°F temperature rise. At the end of the heating cycle the incoming water temperature is warmer at 100°F and raised to the same discharge water temperature of 150°F. This is only a 50°F temperature rise and therefore the flowrate must be controlled to maintain the constant discharge water temperature of 150°F (assuming the equipment heat capacity does not change). Mitsubishi provides the means for secondary circuit control. However, optional parts must be purchased, including a temperature and flow sensor. The HEAT2O™ outputs a 0-10V signal to the secondary circuit pump, based on the flow and temperature sensors to maintain a target outlet water temperature.

Secondary Heat Exchanger and Pump Sizing Criteria

The secondary heat exchanger and secondary pump should be sized to meet the following criteria. The values listed are the design conditions; the values within the brackets are the operational points at the end of the heating cycle.

Heating load: 136,500 BTU/HR			
Side 1 (HEAT2O™)	Inlet Temperature:	60°F	[112.7°F]
	Outlet Temperature:	160°F	[175°F]
	Flowrate:	2.76 GPM	[4.5 GPM]
	Pressure difference:	1.57 psi	[3.48 psi]
Side 2 (Secondary loop, potable, DHW)	Inlet Temperature:	50°F	[109°F]
	Outlet Temperature:	150°F	[165°F]
	Flowrate:	2.75 GPM	[5.0 GPM]
	Pressure difference:	1.59 psi	[4.26 psi]
	Basis of Design recommendation	SWEP, B85Hx33/2P	
Secondary Pump Sizing Criteria	Flowrate:	0.79 to 7.9 GPM per MFG lit., 2.75 to 5.0 GPM	
	Head Pressure:	1.59 psi to 4.26 psi plus additional allowances for pipes and fittings	
	Power Supply:	0-10V	
	Control:	0-10V analog (from HEAT2O™)	
	Basis of Design Recommendation:	Bell & Gossett, Ecocirc XL N 20-35	

Storage Tanks

Thermal stratification within the storage tanks (hot water at the top, cool water at the bottom and a small mixed/transition layer between the two) is crucial for good HPWH system design. A well stratified storage tank with a small mixed layer has more high-grade heat available (exergy) than that of a well-mixed thermal storage tank.

To maintain thermal stratification, inlet and outlet connections from the HEAT2O™ to storage tanks should be as close to bottom and top (respectively) of the storage tank as is practical. The tank outlet from storage to hot water delivery is at the very top of the storage tank.

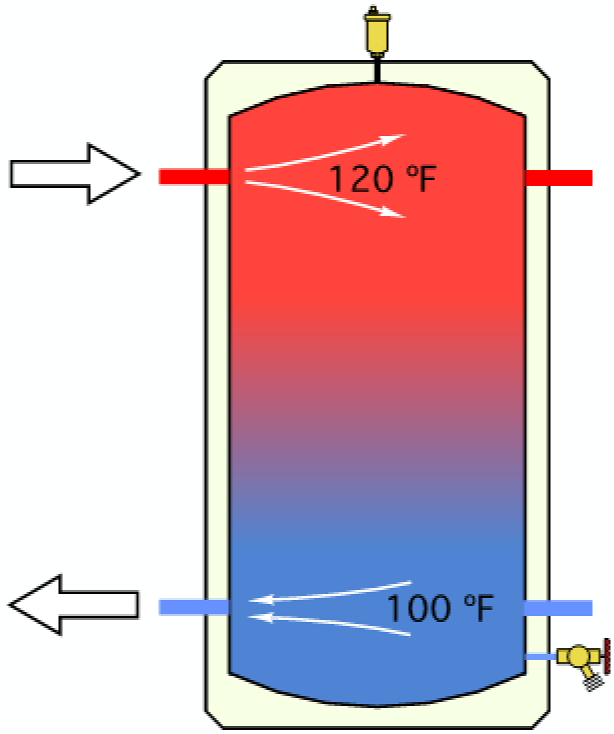


Figure 5-1
Example of a Well-Stratified Thermal Storage Tank[7]

Control points within storage tanks control the HEAT2O™ on/off. There are three sensors within storage tanks (approximately 25%, 50%, 75% volume marks). The temperature difference between sensors controls the HEAT2O™.

Hot water for the HEAT2O™ system is optimally stored at 149°F. To minimize tank losses from this hot water to the surroundings, storage tanks should be insulated at R-16 or above.

Series Temperature Maintenance Storage Tank (Swing Tank)

Series Temperature Maintenance Tank (Swing Tank) Sizing

The swing tank volume should be sized to meet the temperature maintenance load for the longest duration of limited hot water draw from occupants, typically 4 to 6 hours in duration. This maximizes the system efficiency and provides a reliable and efficient solution to maintain the temperature in the distribution piping. The electrical element serves as backup in the event of an extended duration of no hot water draw.

The Ecosizer has a built-in calculation to aid in sizing the minimum required tank volume and element for the series temperature maintenance swing tank.

---

[7] Siegenthaler, John, *Appropriate Designs*. Holland Patent, NY. www.hydronicpros.com

Swing Tank Element Control

- Thermal on-point for electrical elements in the swing tank should be set to 20°F below the primary storage water temperature (20°F less than 149°F, or <129°F).
- Electric element sensor located in top two-thirds of tank to prioritize HPWH reheat of temperature maintenance losses.

Accessory Equipment

Expansion Tank

The thermal expansion tank shall be sized to provide thermal expansion for all components of the central commercial heat pump water heating system. This includes but is not limited to the primary storage volume, temperature maintenance storage volume, and distribution piping. As previously noted, CHPWH systems often include more storage than conventional domestic hot water systems. Therefore, the minimum required size of the thermal expansion tank may be different than previous expansion tank selections for more conventionally sized domestic hot water systems.

Electronic Mixing Valve

Both the cold supply side and hot supply side of the mixing valve will see temperature fluctuations of approximately 10-20°F during normal operation. It is imperative that the mixing valve is selected to respond to these temperature fluctuations and reliably discharge at approximately 120°F to the building hot water distribution piping. Electronic mixing valves appropriately sized for the building load are recommended as they typically preform more reliably and respond quicker and more accurately than mechanical thermostatic mixing valves. The electronic mixing valve should be appropriately sized to meet the building loads. This includes review of both the low flow and high flow scenarios typically experienced for the project.

Sample Schematics

Refer to the Mitsubishi Databook and installation manual for all installation requirements when using the HEAT2O™ CO_2 HPWH for domestic hot water applications.

6
FINAL NOTES

At the time of this writing, the Mitsubishi HEAT2O™ was one of the few CO_2 heat pump water heaters on the U.S. market. Alternatives at this time are limited, and include the Lync Aegis, the LYD COTWO range of products, and the Mayekawa Unimo. This guide focuses on the Mitsubishi product due to its availability for the scale of the project, but the design procedures described in this guide are applicable for equipment with similar configuration.

Export Control Restrictions

Access to and use of this EPRI product is granted with the specific understanding and requirement that responsibility for ensuring full compliance with all applicable U.S. and foreign export laws and regulations is being undertaken by you and your company. This includes an obligation to ensure that any individual receiving access hereunder who is not a U.S. citizen or U.S. permanent resident is permitted access under applicable U.S. and foreign export laws and regulations.

In the event you are uncertain whether you or your company may lawfully obtain access to this EPRI product, you acknowledge that it is your obligation to consult with your company's legal counsel to determine whether this access is lawful. Although EPRI may make available on a case by case basis an informal assessment of the applicable U.S. export classification for specific EPRI products, you and your company acknowledge that this assessment is solely for informational purposes and not for reliance purposes.

Your obligations regarding U.S. export control requirements apply during and after you and your company's engagement with EPRI. To be clear, the obligations continue after your retirement or other departure from your company, and include any knowledge retained after gaining access to EPRI products.

You and your company understand and acknowledge your obligations to make a prompt report to EPRI and the appropriate authorities regarding any access to or use of this EPRI product hereunder that may be in violation of applicable U.S. or foreign export laws or regulations.

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com