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SERVICE & DOMESTIC HOT WATER

TANKLESS COMBINATION SPACE AND WATER HEATER, RESIDENTIAL

SWWH030-01

CONTENTS

MEASURE NAME

Tankless Combination Space and Water Heater, Residential

STATEWIDE MEASURE ID

SWWH030-01

TECHNOLOGY SUMMARY

A combined space and water heater, or "combi" system provides both space and water heating from a single heat source. Better insulation and tighter envelopes reduce space heating loads for new and existing homes. As a result, decreased space heating loads make it possible for both space and domestic water heating loads to be provided with a single heating plant, thus saving significant amounts of energy. The combination of a hydronic air handling unit (AHU) and tankless water heater can potentially improve the energy efficiency of meeting these combined heating needs in residential applications.

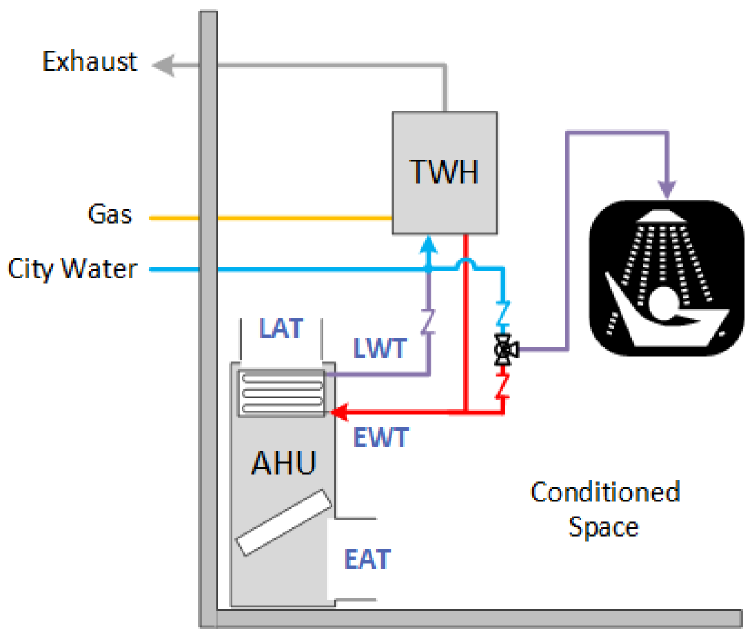

Figure 1: Forced-air Tankless Combi Configuration

The primary heating section of the hydronic AHU is a hot water coil heat exchanger. With reasonably short and insulated piping runs, the entering water temperature (EWT) into the coil is roughly the same as the Tankless water heater (TWH) outlet temperature; and the leaving water temperature (LWT) returning to the TWH varies based on water flows and airflows. The entering air temperature (EAT) into the coil is about the same as the return air from the conditioned space. Air flows across the coil and picks up heat to supply warm air to the space at the leaving air temperature (LAT). DHW is tapped directly into the hot water loop between the AHU and TWH.

An advanced forced-air tankless combi unit can achieve exceptionally high space heating performance at as much as 10:1 turndown as a result of the following design elements:

1) Using a TWH that can achieve dewpoint temperatures greater than 120°F, (Figure-2).

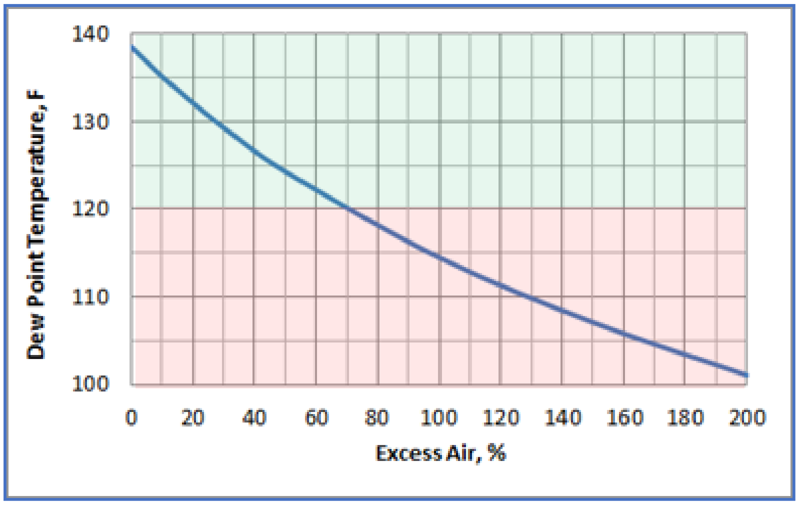

Figure 2: Flue Gas Dewpoint Temperatures

2) Maximizing the temperature difference (ΔT) across the AHU coil (EWT – LWT) thereby minimizing LWTs to induce TWH condensing operation. This can be accomplished if the AHU has a coil along with air and water flow controls that can reduce LWTs below 100 °F while maintaining required space heating capacity.

3) Flushing heat out of the AHU and TWH after space heating calls. This can be accomplished if the AHU/TWH system has controls to keep the blower and pump on and the TWH burner off until the space heating loop is reduced below 90 °F.

4) Minimizing short cycling even at high turndowns. This can be accomplished if the system has outdoor temperature reset – or if it can reduce its capacity as outdoor temperatures rise.

All four of these design elements must be achieved while maintaining comfortable supply air LATs.

The system can also serve the space cooling needs by incorporating an electric air conditioning (AC) unit. Figure-3 shows the AHU/TWH configuration along with an electric AC unit and refrigerant coil. Combi evaluations for this project did not include the AC cooling effect. However, the electric AC along with the refrigerant "A-coil" are used for space cooling and can be used in a hybrid configuration with the TWH to provide space heating in mild conditions.

Combi systems served by condensing tankless water heaters of 93% UEF or higher have the potential to significantly reduce home energy use. A properly installed combi system can provide both space and water heating with 90+% efficiency compared to a minimum efficiency 80% AFUE furnace and a 0.62 EF (HD 0.64 UEF) water heater. Additionally, replacing a natural gas storage water heater with a direct-vent heating plant allows the home to be more airtight without causing combustion safety issues and eliminates combustion makeup air. This measure can further improve the energy performance of a home by adding state-of-the-art control system to the AHU to maximize the efficiency of the condensing TWH, as shown previously in Figure-3.

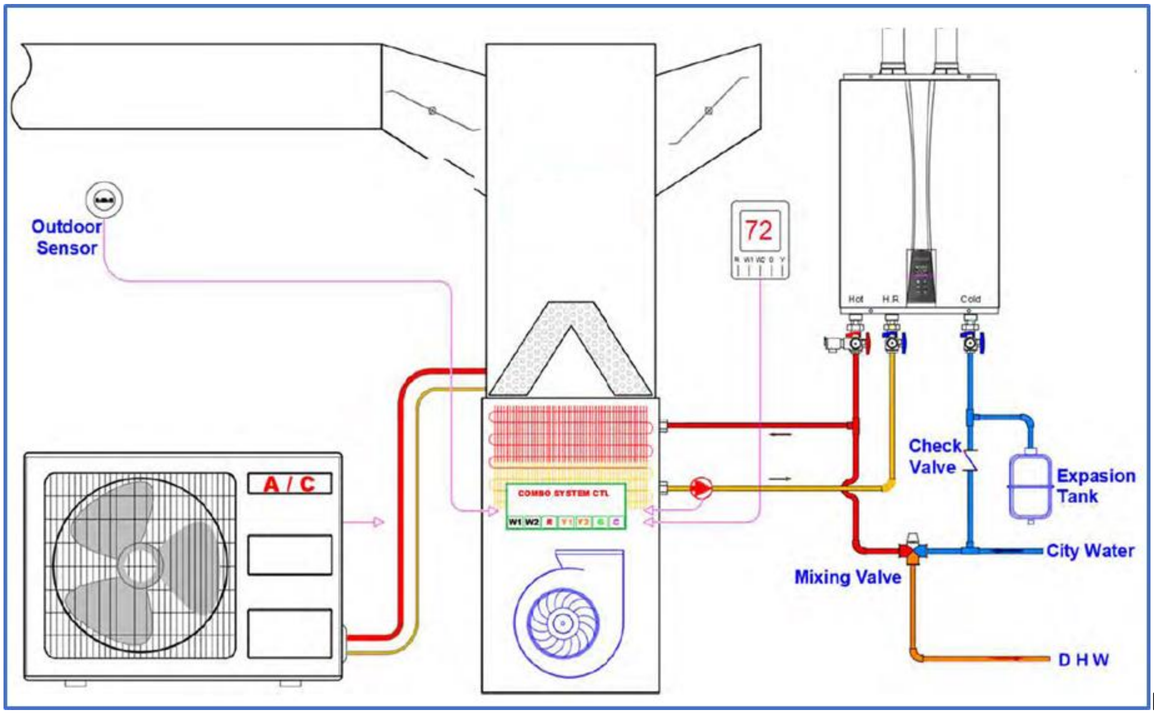

Figure 3

Figure 3- Combi Configuration (Including A/C)

MEASURE CASE DESCRIPTION

The measure case is defined as the installation of a combination space and water, or "combi" system to replace a standard efficiency gas-fired furnace and a standard efficiency gas storage water heater. The combi system consists of a water heater teamed with a hydronic air handling unit (AHU) that includes a water coil, and a water pump to circulate water between the heating source and the coil. Measure offerings are defined by AHU control strategy. The advanced tier specifies integrated controls temperature setpoint control (outdoor reset and/or turndown after heating season), space-heating modulation (both water flow and airflow) and DHW priority.

Measure Offerings

Statewide Measure Offering ID	Measure Offering Description
SWWH030A	Combined Hydronic Heating System, Residential (Tier-1) with basic controls for fan-coil or an AHU
SWWH030B	Advanced Combined Hydronic Heating System, Residential (Tier-2) with advanced AHU with integrated controls

BASE CASE DESCRIPTION

The base case is defined as a standard efficiency gas-fired furnace serving the space heating and a standard efficiency gas storage tank water heater that serve the domestic water heating in single-family residential home. The minimum base case efficiencies are consistent with the federal U.S. Department of Energy (DOE) standards (see Code Requirements).

Industry standard practice (ISP) for space heating and domestic water heating in a single-family home does not include a combined space and water heating system. As this was the facility's practice prior to installation, a home with standard space and water heating was used as the baseline for this measure.

Base Case Descriptions

Statewide Measure Offering ID	Baseline Space Heating Efficiency (AFUE)	Baseline Water Heating Efficiency (UEF
SWWH030A	80%	0.64
SWWH030B	80%	0.64

CODE REQUIREMENTS

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
California Appliance Efficiency Regulations - Title 20 (2019)	Gas-fired storage water heater: Section 1605.1(f), Table F-2 and Table F-4) Residential Gas-fired Central Furnace < 225,000 Btu/hr: Table E-6	January 1, 2018
California Building Energy Efficiency Standards - Title 24 (2019) Residential Compliance Manual	Section 4.7.1 Hydronic Heating Systems Section 4.7.1.3 for its Performance Compliance Options	December 2018
Federal Standards – Code of Federal Regulations	Water heaters: 10 CFR 430.32(d) Furnaces and boilers: 10 CFR 430.32(e)	

NORMALIZING UNIT

Per Household

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
New Construction (NC)	DnDeemed	Res
New Construction (NC)	DnDeemDI	Res
Normal Replacement (NR)	DnDeemed	Res
Normal Replacement (NR)	DnDeemed	Res

Implementation and installation requirements are as follows:

- Contractors must adhere to the installation and operation practices provided for the program
- Design requirements for system selection: each site is classified based on the required heating load, occupancy, quantity of hot water required, frequency of hot water fixture use, and predetermined system stress level (based on historical heating requirements).
- The selected combination system must meet the established design requirements
- The 'as installed' system components, installation, and commissioning must match the 'as tested' system results

The best practice for a combi system installation involves the following four steps:

- Home to be assessed to determine the heating and DHW needs
- Combi system components need to be sized and selected properly
- System can be installed and function as described
- System needs to be optimized and set up to perform at the highest efficiency possible while still meeting the needs and comfort of the occupants

Eligible Products

Eligible Building Types and Vintages

This measure is applicable for any existing or new single-family home.

Eligible Climate Zones

This measure is applicable in any California climate zone.

PROGRAM EXCLUSIONS

None.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Service & domestic hot water

ELECTRIC SAVINGS (kWh)

There are negative electric savings associated with this measure due to the addition of a circulating hot water pump from the tankless water heater to the fan coil unit. See Gas Savings.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Not applicable.

GAS SAVINGS (Therms)

The unit energy savings (UES) of this measure were derived from building energy use simulations and laboratory testing conducted by the Gas Technology Institute (GTI) study under the Utilization Technology Development (UTD), (projects 1.16.E and 1.17.E) and co-funded by the Northwest Energy Efficiency Alliance (NEEA). The GTI research results indicated that an optimized combi generated an estimated 30% to 40% annual gas savings (Figure-4) in low-capacity homes in CA, with ≤ 60,000 Btuh heating demand, compared to a typical 95% AFUE condensing furnace and NAECA standard 0.62 EF tank water heater.

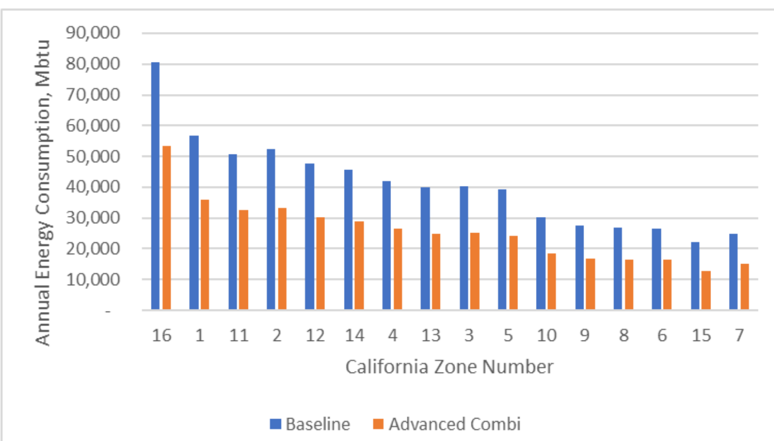

Figure 4 - GTI Projected Savings, by Climate Zone

Baseline and Measure Case Simulations

The building models used to estimate energy savings were developed based on the GTI laboratory test report on combi system performance assessment that focused on gas space heating research and its performance at part-load conditions, and more importantly, what can be done to improve low-load performance.[1] Using the Building Energy Optimization Tool (BEopt version 2.8) developed by the National Renewable Energy Laboratory (NREL) and the energy use was simulated for two building types and two different orientations for each of the 16 California climate zones. The Type 1 building represents a high use scenario and the Type 2 represents a low use scenario. Two orientations were used to account for differences in annual loads that would occur due to variations in external building loads such as solar irradiation and infiltration. The characteristics of both building types are summarized in Table 1.

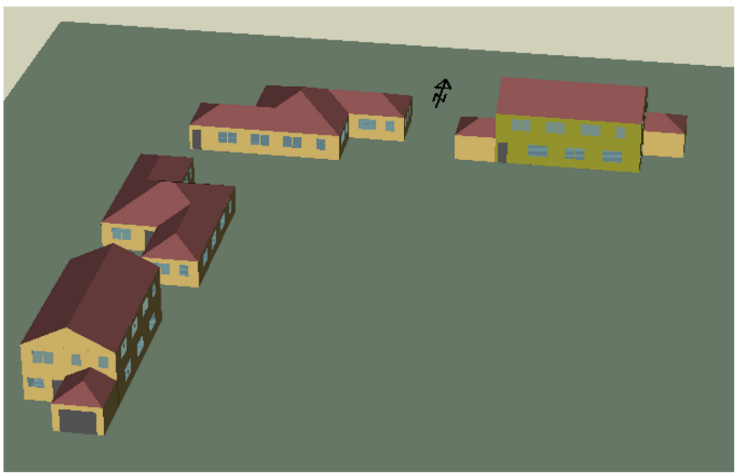

Figure 5 – Building Simulation Geometries and Orientations (Two Building Types Two Orientations)

Table 1 -- Summary of building model characteristics for Type 1 and Type 2

Characteristic	Building Type 1	Building Type 2
Finished sq-ft	2,500	1,700
Stories	2	1
Bedrooms	5	3
Bathrooms	3	1.5
Garage	2-car attached	N/A
Foundation	Slab on grade	
Vintage	~2009	

[1] GTI Laboratory Test Report: Combi System Assessment, August 29, 2019

Characteristic	Building Type 1	Building Type 2
Construction/schedules/internal loads	Tightened building insulation, fenestration, and infiltration to match ~IECC 2009 code year "International Energy Conservation Code" (IECC) Default assumptions from BEopt 2.8, the 2014 Building America House Simulation Protocols, were used if other sources of information were not available	

Both building types were configured with a forced-air condensing combi utilizing a 160 MBH condensing TWH and AHU with hydronic coil. To account for higher DHW demands in the larger two-story building, a second standalone TWH was used in addition to the one used for the combi system. Baseline equipment efficiency is based on the current minimum code requirement for the State of California (Title-24). Additional baseline and measure case assumptions are provided in the following three tables:

Table 2 – Baseline and Measure Case Water Heater Assumptions

Water Heater	Baseline	EE Measure
Type	40 gallon tank	Tankless Combi
Efficiency	0.64 UEF (Hi Draw)	0.93 UEF
Recovery Efficiency	76%	96%
Capacity	40 MBH	160 MBH
Supply water setpoint	135°F	140°F
Location	Indoor	Indoor
Hot water usage	NREL. (2017). BEopt 2.8 modeling	

Table 3 – Baseline and Measure Case Space Heating Assumptions

Space Heater	Baseline	EE Measure
Type	Furnace	Tankless Combi
Efficiency	80%AFUE	0.93 UEF
Capacity	80 MBH	60 MBH
Thermostat setpoint	70°F	70°F
Location	Indoor	Indoor
Hot water usage	NREL. (2017). BEopt 2.8 modeling	

Table 4 – Measure Case Control Strategies

Measure Offering	Measure Offering Description
Tier-1	Basic controls for fan-coil or an AHU
Tier-2	Advanced AHU with integrated controls. Controls include temperature set point control (outdoor reset and/or turndown after heating season), space-heating modulation (both water flow and airflow) and DHW priority.

Measure Case Control Strategy. Table-4 shows that a combi system efficiency is largely a factor of the water temperature returning to the heating plant from the AHU and burner cycling characteristics. Lower return water temperatures and longer cycles produce higher system efficiency. Basic AHUs have a constant airflow rate and a constant water circulation flow rate for the heating mode. To achieve the best performance, the flow rates must be adjusted to meet the house design heating load and minimize the return water temperature. Variable air and water flow rate control would allow a single AHU to provide more efficient performance over a wider range of heating loads and should eliminate time-consuming manual adjustments to the water flow rate. The advanced controls improve efficiency by allowing the system to operate at a lower average return water temperature and longer cycles, as stated in a 2106 U.S. Department of Energy report on improving combi system performance.[2]

Baseline Calibration. Hourly space heating and domestic hot water loads were generated using the building models described in Tables 1 thru 4. The loads were then post-processed using the performance characterizations developed in the GTI lab, as previously described to estimate baseline and combi systems energy consumption. For validation, the average baseline space heating and domestic hot water energy consumption of the models were compared to values reported in the 2009 *California Residential Appliance Saturation Study* (RASS) and the U.S. DOE IECC 2009 prototype residential building models for California (https://www.energycodes.gov/development/residential/iecc_models). The comparisons are summarized in Figure 6 and Figure 7.

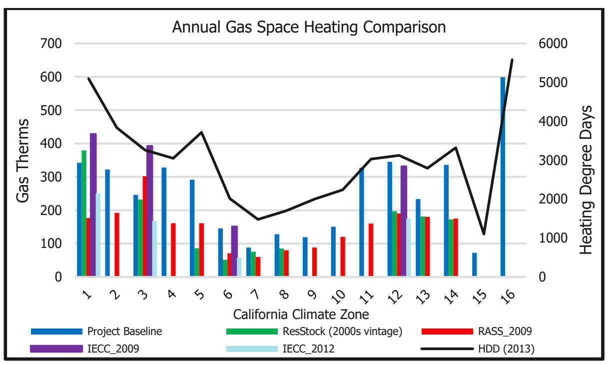

Figure 6. Comparison of Modeled Space Heating Load Predictions to RASS Averages and DOE IECC 2009 Prototype Residential Building Models

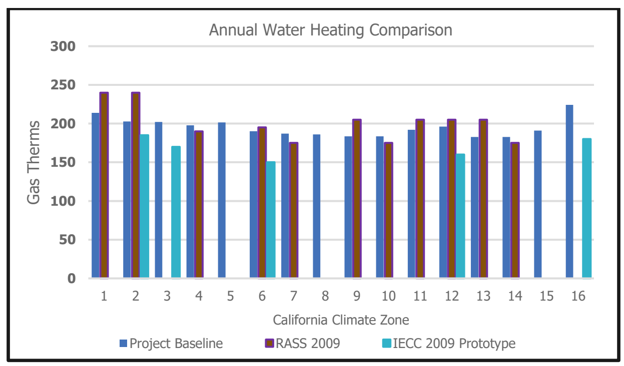

Figure 7. Comparison of Modeled Water Heating Load Predictions to RASS Averages and DOE IECC 2009 Prototype Residential Building Models

The modeled predictions compare favorably with the results of the RASS. Discrepancies can be attributed to two primary factors. First, there are inconsistencies between the zones used in the RASS and the 16 California climate zones. Effort was made to match the zones where possible, however it cannot be determined that the climate regions represented match exactly. Second, the RASS energy use data was averaged for a region, while the model predictions were averaged for the two types of buildings.

The results of the International Energy Conservation Code (IECC) 2009 prototype building models are on average higher than the predictions of the project models for space heating. The IECC 2009 prototype models are 2,400 ft^2 models, use Typical Meteorological Year 3 data

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[2] U.S. Department of Energy (DOE). 2016. *Combined Space and Water Heating: Next Steps to Improved Performance.* Prepared for the National Renewable Energy Laboratory (NREL) by B. Schoenbauer, D. Bohac, and P Huelman (Northern*STAR* Building America Partnership).

(http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3), and used different modeling assumptions than those in the House Simulation Protocols. However, the orders of magnitude and trends with heating degree hours are consistent. The comparison of the present model predictions and literature values indicate that the models provide a reasonable estimate of energy consumption in all California climate zones.

The results from the energy use simulations are presented in Table 5 and Table 6 .

Table 5 – Average Single-Family Home Predicted Annual Gas and Electricity Consumptions and Savings for Basic Combi system (Tier-1)

California	Average Building Energy Use (SH and DHW) for an 80% AFUE Furnace and 0.64 UEF Water Heater Baseline and a Basic Combi as EE Measure (**Tier-1**)											
Weather	Baseline (MMBtu)			EE Measure (MMBtu)			Savings (MMBtu)			Savings (Percentage)		
Zone	Gas	Electricity	Total	Gas	Electricity	Total	Gas	Electricity	Total	Gas	Electricity	Total
1	55.6	1.1	56.7	50.0	2.8	52.8	5.6	(1.6)	4.0	10%	-145%	7%
2	52.5	1.1	53.6	43.5	2.4	45.9	8.9	(1.3)	7.7	17%	-118%	14%
3	44.8	0.8	45.6	38.8	2.0	40.9	6.0	(1.2)	4.8	13%	-141%	10%
4	52.6	1.1	53.7	45.7	2.6	48.3	6.8	(1.5)	5.4	13%	-131%	10%
5	49.3	1.0	50.3	43.3	2.4	45.7	6.0	(1.4)	4.6	12%	-140%	9%
6	33.6	0.5	34.1	25.8	1.2	26.9	7.8	(0.6)	7.2	23%	-111%	21%
7	27.5	0.4	27.9	19.5	0.7	20.2	8.0	(0.3)	7.6	29%	-89%	27%
8	31.4	0.5	31.9	23.4	1.0	24.4	8.0	(0.5)	7.5	26%	-99%	24%
9	30.3	0.5	30.7	22.4	0.9	23.4	7.8	(0.5)	7.4	26%	-101%	24%
10	33.4	0.6	33.9	25.2	1.2	26.4	8.1	(0.6)	7.6	24%	-102%	22%
11	51.9	1.1	53.0	43.0	2.4	45.4	9.0	(1.3)	7.7	17%	-115%	14%
12	54.1	1.2	55.3	45.1	2.5	47.6	9.0	(1.4)	7.7	17%	-116%	14%
13	41.6	0.8	42.4	33.2	1.7	34.9	8.4	(0.9)	7.5	20%	-110%	18%
14	51.9	1.1	53.0	42.5	2.4	44.9	9.4	(1.3)	8.1	18%	-112%	15%
15	26.3	0.3	26.6	18.5	0.6	19.1	7.8	(0.3)	7.5	30%	-81%	28%
16	82.3	1.9	84.3	70.7	4.2	75.0	11.6	(2.3)	9.3	14%	-118%	11%

Table 6 – Average Single-Family Home Predicted Annual Gas and Electricity Consumptions and Savings for Advanced Combi system (Tier-2)

California	Average Building Energy Use (SH and DHW) for an 80% AFUE Furnace and 0.64 UEF Water Heater Baseline and an Advanced Combi as EE Measure (**Tier-2**)											
Weather	Baseline (MMBtu)			EE Measure (MMBtu)			Savings (MMBtu)			Savings (Percentage)		
Zone	Gas	Electricity	Total	Gas	Electricity	Total	Gas	Electricity	Total	Gas	Electricity	Total
1	55.6	1.1	56.7	37.5	1.5	39.0	18.1	-0.4	17.7	33%	-32%	31%
2	52.5	1.1	53.6	33.5	1.3	34.8	19.0	-0.2	18.8	36%	-20%	35%
3	44.8	0.8	45.6	29.6	1.1	30.8	15.2	-0.3	14.9	34%	-33%	33%
4	52.6	1.1	53.7	35.1	1.4	36.5	17.5	-0.3	17.2	33%	-26%	32%
5	49.3	1.0	50.3	32.9	1.3	34.2	16.4	-0.3	16.0	33%	-31%	32%
6	33.6	0.5	34.1	20.3	0.7	21.0	13.2	-0.1	13.1	39%	-26%	38%
7	27.5	0.4	27.9	16.1	0.5	16.5	11.4	-0.1	11.3	42%	-26%	41%
8	31.4	0.5	31.9	18.8	0.6	19.4	12.6	-0.1	12.5	40%	-24%	39%
9	30.3	0.5	30.7	17.9	0.6	18.5	12.3	-0.1	12.2	41%	-26%	40%
10	33.4	0.6	33.9	20.1	0.7	20.8	13.3	-0.1	13.2	40%	-22%	39%
11	51.9	1.1	53.0	33.2	1.3	34.5	18.8	-0.2	18.5	36%	-19%	35%
12	54.1	1.2	55.3	34.8	1.4	36.2	19.3	-0.2	19.1	36%	-19%	34%
13	41.6	0.8	42.4	25.8	1.0	26.9	15.8	-0.2	15.6	38%	-21%	37%
14	51.9	1.1	53.0	32.9	1.3	34.3	19.0	-0.2	18.8	37%	-16%	35%
15	26.3	0.3	26.6	15.7	0.4	16.1	10.6	-0.1	10.6	40%	-27%	40%
16	82.3	1.9	84.3	55.3	2.2	57.5	27.0	-0.3	26.7	33%	-14%	32%

The breakdown of the space heating and domestic water heating loads for the baseline and two proposed combi systems are shown in Figures 8 and 9 and the total usage for space heating and domestic water heating are shown in Figure 10.

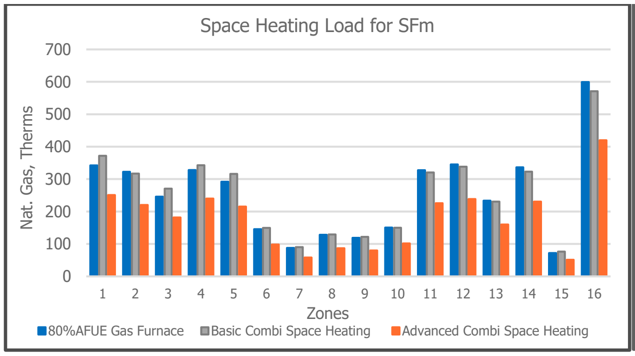

Figure 8. Comparison of Modeled Space Heating

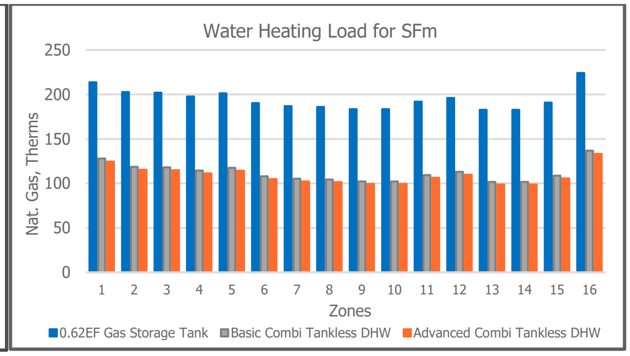

Figure 9. Comparison of Modeled Water Heating

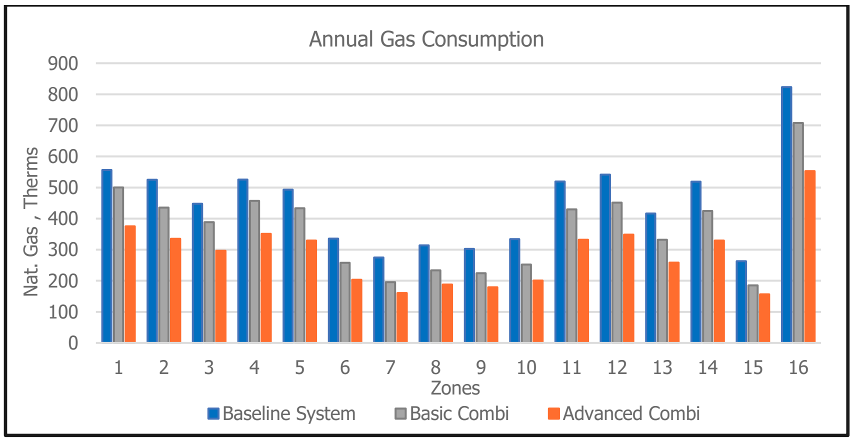

Figure 4 – Annual gas usage by the Baseline and the two tiers Combi systems

Unit Energy Savings

Table-7 shows the annual gas and electricity savings in therms and kWh, respectively.

Table 7 – Predicted Annual Gas and Electricity Savings

California Climate Zone	Basic Combi System		Advanced Combi System	
	Gas Savings (Therms)	Electric Savings (kWh)	Gas Savings (Therms)	Electric Savings (kWh)
CZ01	56.2	-483.4	180.9	-106.1
CZ02	89.4	-377.5	189.7	-63.9
CZ03	59.5	-349.4	151.7	-81.9
CZ04	68.4	-427.4	174.6	-85.9
CZ05	59.6	-406.1	163.6	-89.7
CZ06	78.1	-177.4	132.5	-41.8
CZ07	79.6	-98.5	114.3	-29.1
CZ08	80.4	-146.2	126.0	-35.3
CZ09	78.4	-139.4	123.5	-35.4

CZ10	81.5	-171.1	133.0	-37.5
CZ11	89.7	-376.3	187.6	-62.9
CZ12	90.2	-399.6	193.0	-65.9
CZ13	84.2	-267.3	157.7	-50.2
CZ14	94.2	-374.3	189.6	-55.0
CZ15	77.8	-80.9	106.5	-27.2
CZ16	115.6	-672.1	270.3	-81.9

LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The EUL and RUL for this measure is assumed to equal that of a tankless water heater, as specified below. The RUL value is only applicable to the first baseline period for a retrofit measure with an applicable code baseline.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)_WtrHt-Instant-Res	20.0	California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0.* Page. 16. California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx"
RUL (yrs)	6.67	

BASE CASE MATERIAL COST ($/UNIT)

The base case material costs for standard efficiency gas furnaces and storage water heaters were adopted from the statewide measures SWHC031-01 (Furnace, Residential) and SWWH012-01 (Storage Water Heater, Residential), respectively.

Storage Water Heater, Residential (SWWH012-01). The base case material costs for the residential storage water heater were derived from data drawn from the *2010-2012 WO017 Ex Ante Measure Cost Study Final Report* prepared by Itron, Inc.[3] Because this study presents material and labor cost for water heaters units rated with energy factor (EF), the EF values were converted to UEF and a regression analysis was completed to determine the cost for each corresponding UEF rating.[4]

[3] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission. Page 11.

[4] Southern California Gas Company (SCG). 2018. "WPSCGREWH180207A-Rev00_Att. A - Cost Regression.xlsx"

Furnace, Residential (SWWH031-01). The base case material cost for a residential gas furnace was derived from furnace cost data obtained in 2017 from online list prices of HVAC equipment vendors that sell residential gas furnaces nationwide. The base case furnace cost per kBtu/hr was calculated as the average cost per kBtu/hr across all units in the database that meet the base case furnace specification. (Note that the base equipment cost of an 80% AFUE central natural gas furnace is not provided in the Database for Energy Efficient Resources, DEER.)

The average cost per kBtu/hr was then multiplied by the average furnace size per household assumed for the DEER2020 building prototypes to derive the average base case cost per household.[5] The average furnace size per each residential building type (below) was calculated as the average furnace size used in the DEER building prototypes across all climate zones and AFUE rating for each building type. See SWWH031-01 for details.

Base Case Material Cost Inputs

Parameter	Value	Source
Water heating by a natural gas 40 gallons storage WH of EF rating 62% (UEF 64% High Draw)	$870	SWWH012-01 EAD - Storage water Heater, Residential.
Space heating by a forced-air natural gas furnace, AFUE rating 80%	$690	SWHC-031-01 EAD – Furnace Residential

MEASURE CASE MATERIAL COST ($/UNIT)

Measure Case cost information for Condensing Gas Tankless Water Heater was obtained in June of 2020 from online retailers of water heaters (Home Depot, ACE Hardware, etc.) As a backup for the cost data, a comparison with data from U.S. EIA report on Buildings Sector Appliance and Equipment Costs and Efficiencies[6], showing the cost information for tankless water heaters (on page 63) confirms the retail pricing data as representative of measure case material costs.

The Tier 1 measure case material cost for space heating includes the estimated cost for a fan coil or an air handling unit (AHU) were obtained from the 2014 RSMeans Mechanical Cost Data.[7] The Tier 2 cost of an AHU was obtained from the 2019 Combi System Assessment conducted by the Gas Technology Institute (GTI).[8]

[5] Southern California Gas Company (SCG). 2017. "SWHC031-01 Res Furnaces Cost Data v2.xlsm."

[6] U.S. Energy Information Administration, Updated Buildings Sector Appliance and Equipment Costs and Efficiencies, April 2018 https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

[7] RSMeans Engineering Department. 2014. *RSMeans Mechanical Cost Data 2014.* 37th Annual Edition.

[8] GTI Laboratory Test Report: Combi System Assessment, August 29, 2019.

Measure Case Material Cost Inputs

Parameter	Value	Source
Condensing natural gas tankless water heater with power vent, 180 kBtuh capacity (EF ≥ 0.94 or UEF ≥ 0.93)	$1,345	Average cost from online retailers, June 2020, "Res Tankless WH cost estimate.xls"
(Tier-1): Basic Fan-coil or an Air Handling Unit (AHU) sized for 1200 CFM airflow and 60,000 Btuh heating capacity	$1,500	2014 RSMeans Mechanical Book
(Tier-2): Advanced Air Handling Unit (AHU) sized for 1200 CFM airflow and 60,000 Btuh heating capacity	$2,500	From GTI's "Combi System Assessment report; 8-29-2019

BASE CASE LABOR COST ($/UNIT)

The base case labor cost for standard efficiency gas furnaces and storage water heaters were adopted from the statewide measures SWHC031-01 and SWWH012-01, respectively. Base case labor costs were derived using the same methodology to develop base case material costs. The labor cost is assumed to be equal for the base and measure case, as the process of installation is the same.

Base Case Installation Labor Cost Inputs

Parameter	Value	Source
Water heating by a natural gas water heater, 40 gallons storage WH of EF rating 62% (64% UEF High Draw)	$330	2020 SWWH012-01 EAD - Storage water Heater, Residential.
Space heating by a forced-air natural gas furnace, AFUE rating 80%	$340	2020 SWHC031-01 EAD – Furnace Residential

MEASURE CASE LABOR COST ($/UNIT)

Measure case labor cost information for condensing gas tankless water heater was adopted from SWWH013-01 and was derived using the same methodology and sources as measure case materials costs.

The Tier 1 and Tier 2 measure case material cost for space heating include the estimated cost for a fan coil or an air handling unit (AHU) were obtained from the 2014 RSMeans Mechanical Cost Data. [9]

[9] RSMeans Engineering Department. 2014. *RSMeans Mechanical Cost Data 2014.* 37th Annual Edition.

Measure Installation Labor Cost Inputs

Parameter	Value	Source
Condensing natural gas tankless water heater with power vent, 180 kBtuh capacity (UEF ≥ 0. 94 or UEF ≥ 0.93)	$960	2020 SWWH013-01 EAD - Tankless Water Heater, Residential.
(Tier-1): Basic Fan-coil or an Air Handling Unit (AHU) sized for 1200 CFM airflow and 60,000 Btuh heating capacity	$400	2014 RSMeans Mechanical Cost Data
(Tier-2): Advanced Air Handling Unit (AHU) sized for 1200 CFM airflow and 60,000 Btuh heating capacity	$600	2014 RSMeans Mechanical Book Data

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. This NTG value is based upon the average of all NTG ratios for all evaluated 2006 – 2008 residential programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. This sector average NTG ("default NTG") is applicable to all energy efficiency measures that have been offered through residential sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Value	Source
ET-Default	0.85	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5.* Page 21. *For measures added to the portfolio as a direct result of Emerging Technology Program activities (Emerging Technology measures) the IOUs may request in their non-DEER work paper submissions that a measure be assigned a NTG value at or above 0.85*

Gas Technology Institute (GTI) tested and assessed the performance of Combi system in Single-family homes in CA based on a project sponsored by SoCalGas and paid for by Emerging Technology group[10].

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current "default" rate specified for measures for which an alternative GSIA has not been estimated and approved.

[10] GTI Project Number 22512; SoCalGas Project ID ET19SCG0001

https://www.etcc-ca.com/reports/lab-test-report-combi-system-assessment

Gross Savings Installation Adjustment Rates

Parameter	Value	Source
GSIA	1.0	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31.

NON-ENERGY IMPACTS

Non-energy benefits for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods used from the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	No
Reason for Deviation from DEER	N/A
DEER Measure IDs Used	N/A
NTG	Source: DEER2020. The NTG of 0.85 is associated with NTG ID: *ET-Default*
GSIA	Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	Source: DEER2020. The value of 20 years is associated with EUL ID: *WtrHt-Instant-Res*

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	5/19/2020	• Raad Bashar, Sr. Engineer, SoCalGas.	Draft of consolidated text for this statewide measure is based upon: • GTI's Laboratory Test Report: Combi System Assessment, 8/29/2019 • GTI's software modeling (EnergyPlus) • DOE_EERE: Combined Space and Water Heating: Next Steps to Improved Performance, 8/2016

	6/25/2020	• Raad Bashar, Sr. Engineer, SoCalGas.	Revised the measure cost for condensing tankless water heater using the current pricing available on the market