Final Report Template
Attachment 4

I. Grant Award Information
  - Project Title: Net Zero Analysis for New Building at 1 Hawaii Avenue NE
  - DOEE ID #/Award Number: 2019-1912-USA-4
  - Award Period: July 22, 2019 through September 30, 2019
  - Specific Progress Reporting Period: Final Report
  - Grantee Organization name: Wesley Housing Development Corporation
  - Grantee Organization primary contact person(s) – telephone and email

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II. Status Report

Is the project complete? If not, briefly summarize the purpose and status of your project, including a statement as to whether or not the project is on time, on budget, and achieving the match.

The project is complete.

III. Activities/Outputs/Outcomes for Entire Project

Activity 1. SOLAR ANALYSIS

GRID Alternatives Mid-Atlantic evaluated the Hawaii 1 Avenue building using information provided by online remote site analysis technology, Helioscope and PVwatts, to determine the amount of solar PV suitable roof space and annual production levels. The proposed system has a capability to provide over 56.6 kW (DC) of PV power to generate approximately 64,820 kWh annually. The proposed system will generate more than $279,772 in savings over the course of 25 years, based on current utility rate schedule (GS LV ND) at $0.12. The SREC value is not calculated into this amount, as the system owner has yet to be determined.

The racking solutions implemented will include two methods; ballasted and green-roof integrated equipment. The manufacturers include Unirac ballasted racking, and a Zinco green-roof racking solution. GRID Alternatives has successfully installed both technologies on multi-family properties throughout the DMV area. As storm-water management is a priority within the District, the mandated 3 foot inter-row spacing per DCRA green-roof and solar regulations will result in a reduction in solar system size. To combat this impact, the use of 72-cell commercial modules to allow for higher efficiency and spatial optimization on the allocated roof space for solar to remain feasible, and impactful to meet the net zero goals. As the flat roof of the building is ideal for simple solutions in electrical engineering, selecting string inverters for the array will alleviate burdensome costs associated with monitoring, additional equipment, and general maintenance of the system.

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ACTIVITY 2. THERMAL BRIDGING ANALYSIS

TRUE WALL AND WINDOW R-VALUE / U-VALUE MODELING

In order to better predict the building's heating and cooling loads, detailed thermal modeling was performed to more accurately predict the actual thermal performance of the project's typical wall and window assemblies. This modeling included the following:

True R-value of typical above grade wall assembly

A 3-dimensional thermal model of the typical wall assembly accounting for the thermal bridging resulting from the wood framing and stainless-steel brick ties brick ties to predict the above grade wall's true, effective R-value.

True U-value of typical window assembly

THERM models of proposed window head, sill, and jamb wall-connection details accounting for heat loss associated at the window to wall connection, to be incorporated into the calculation of the window's true, installed U-value.

The thermal models developed for this analysis as well as calculations of the typical wall R-value and window U-value were done in accordance with standard Passive House practices.

True Wall R-Value Modeling

Typical above grade wall = R-27.1

Wall make-up (from exterior to interior)

- Exterior brick veneer and ventilated cavity (not modeled for thermal performance)
- 1.5“ of XPS insulation
- 0.5” exterior plywood sheathing
- 2 x 6 wood frame cavity with fiberglass batts

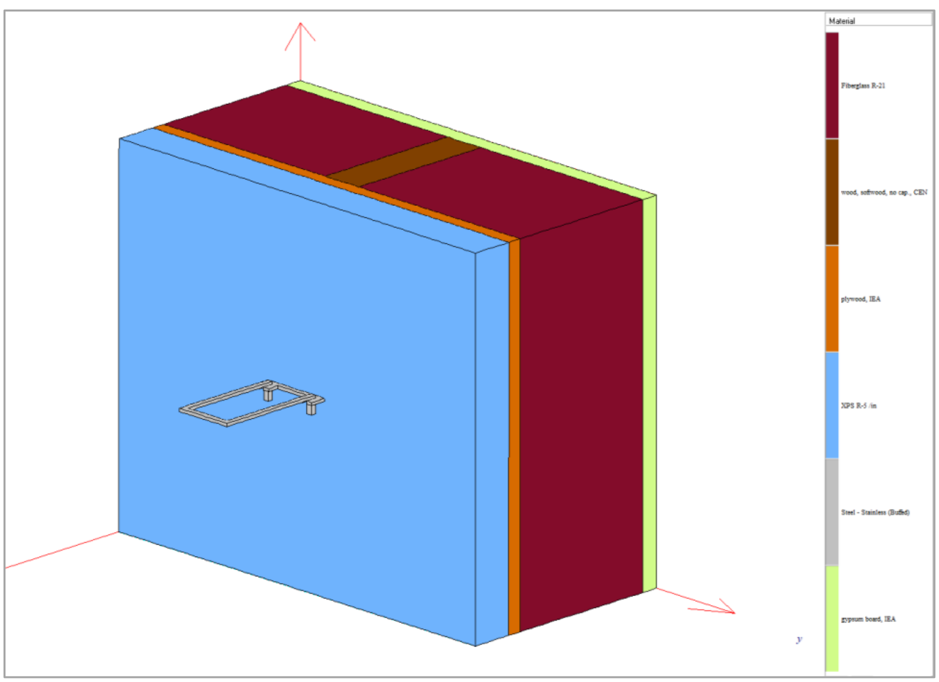

Figure 1. 3-dimensional geometry of typical above grade wall assembly thermal model (view from exterior)

True Window U-Value Modeling

Typical window assembly – Window U-value = 0.176 Btu/hr.ft².°F on average

- 4.5 ft wide x 5.25 ft tall
- uPVC frames – U-frame = 0.19 Btu/hr.ft².°F
- Triple pane glazing with Argon fill – U-glazing = 0.12 Btu/hr.ft².°F
- Thermally broken spacer
- Window to wall connection heat loss modeled; outlined in the modeling section below

Window to Wall Thermal Modeling

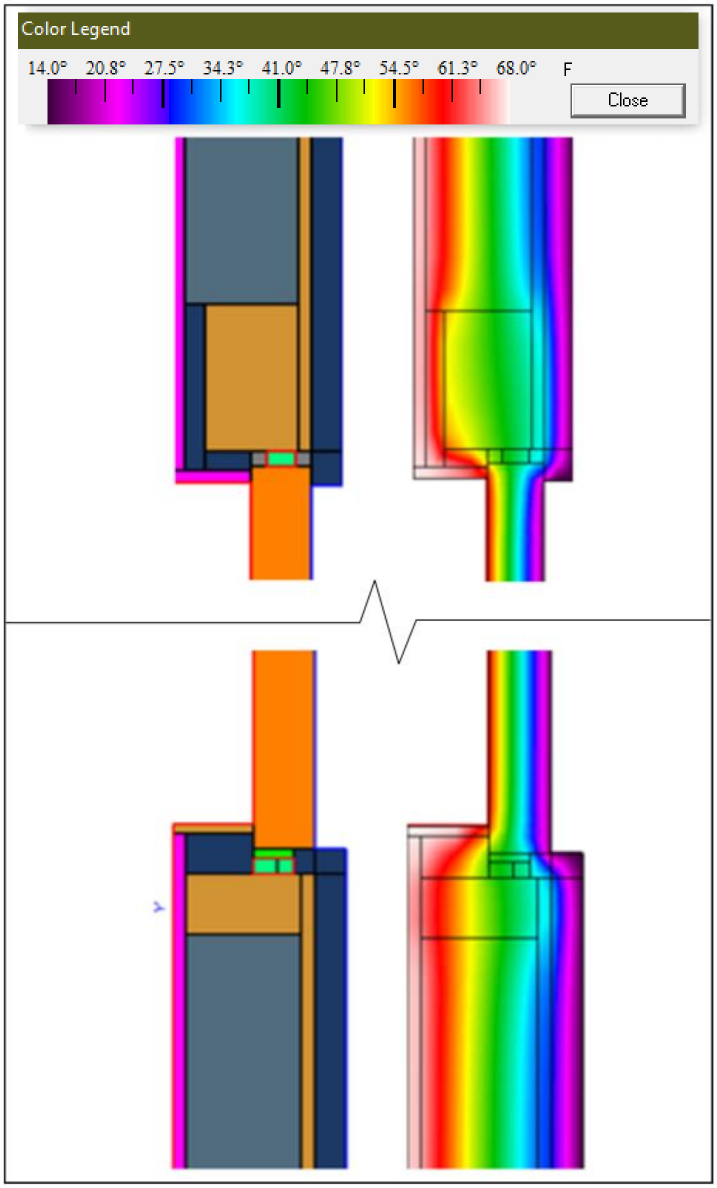

Figure 2. Window head and sill-to-wall connection THERM models (left - geometry, right - temperature output)

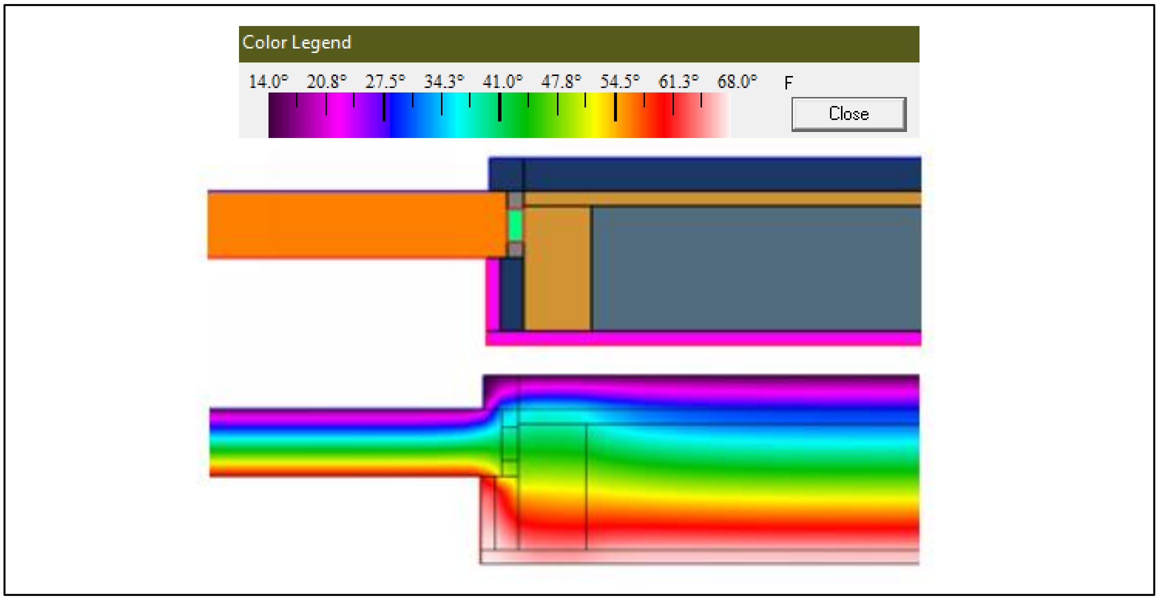

Figure 3. Window jamb-to-wall connection THERM model (top - geometry, bottom - temperature output)

ACTIVITY 3. ENERGY ANALYSIS

Energy modeling during an early stage of project conception can provide valuable feedback on estimated utility usage and an overall comparison of relative building loads for each major component. Energy modeling also has its limitations and there is little information available comparing the accuracy of different modeling tools to verified post-occupancy data.

Knowing there are biases with different tools, the team used two modeling approaches to help evaluate which tool may be faster and less expensive to use while providing robust information. OpenStudio, a whole building energy modeling tool, was used with the Grasshopper parametric analysis tool for evaluating iterations of energy conservation measures.

Because the building type is multifamily, modeling on a unit by unit basis was also completed following RESNET standards using Ekotrope software to represent the various apartment types present in the building. There are 29 unique unit types consisting of studio, one, two, and three-bedroom units. Overall 36 permutations were modeled to represent every unit in the 71-unit building. In addition, Ekotrope models of the common space areas (both conditioned and un-conditioned) within the building where also created.

ONE HAWAII NET ZERO ENERGY MODELING ANALYSIS

Parameter	Baseline Scenario 1: All electric	Baseline Scenario 2: Gas DOAS	Improvement Scenario 1: All electric	Improvement Scenario 2: Central Gas DHW	Improvement Scenario 3: Central Gas DOAS & DHW
Above Grade Walls	1.5” exterior C.I. with 2x6 batts	1.5” exterior C.I. with 2x6 batts	2” exterior C.I. with 2x6 mineral wool	2” exterior C.I. with 2x6 mineral wool	2” exterior C.I. with 2x6 mineral wool
Air Infiltration	0.25 cfm/sq.ft. @75pa (code level)	0.25 cfm/sq.ft. @75pa (code level)	0.60 ACH @ 50 Pascals (PHI level)	0.60 ACH @ 50 Pascals (PHI level)	0.60 ACH @ 50 Pascals (PHI level)
Ventilation	DOAS for supply only, electric. Intermittent bath and kitchen exhaust.	Gas fired DOAS for supply	83% centralized ERV’s, balanced supply w/ 25 CFM per kitchen + 20 CFM per bathroom exhaust	83% centralized ERV’s, balanced supply w/ 25 CFM per kitchen + 20 CFM per bathroom exhaust	Gas fired DOAS with heat recovery
Domestic Hot Water Heating	In-unit electric resistance	In-unit electric resistance	Central heat pump hot water	Central gas	Central gas
Site EUI	21.54	23.54	18	21.69	23.94
Total Costs	$51,478	$51,651	$45,451	$42,309	$44,847
Total Savings		-$173	$6,027	$9,169	$6,631
zEPI Score *(based on HERS reference)*	30.29	30.36	24.88	25.35	
HERS Score *(Weighted Avr. without solar)*	51	52	38	36	

Table 1 – Energy Modeling Iterations Analysis

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Additional Static Modeling Assumptions

Below Grade Walls – R-10 continuous
Under Slab – R-10
Roof – R-30 continuous
Heating and Cooling – Variable refrigerant flow
Windows - triple pane casement / fixed. U-window = 0.176 Btu/hr.ft².°F on average
Laundry – electric exhaust
Cooking – electric conduction
In-unit lighting – LEDs
In-unit plug loads – defaults
Common are lighting

*Common area lighting assumptions

Room Type	W/ft²	Hours/Day
Corridor	0.4	24
Offices	0.6	10
Library	0.6	12
Lobby	0.8	10
Common Stair	0.4	24
Electrical/Mechanical	0.4	4

NET ZERO ENERGY ANALYSIS

While the term "net zero building" can have many different meanings, in simple terms a net zero building is one that produces as much energy as it consumes on an annual basis. Depending on the project's goals and desired certifications, the net zero energy balance may be with respect to site energy, source energy, or carbon intensity. For the One Hawaii project, Steven Winter Associates (SWA) evaluated the feasibility of achieving both net zero with respect to site energy as well as source energy. While estimated operational carbon emissions were predicted for this project, the feasibility of achieving net zero carbon intensity was not included in this assessment.

The following graphics show the net zero energy balance, on both a site energy and source energy basis, for two of the design scenarios outlined in Table 1. The bar on the left side of the graph represents the modeled energy consumption of the building (according to the Ekotrope model). The bar on the right side of the graph represents the building's energy use that will be offset by the project's rooftop solar array according to the solar analysis outlined in Activity 1 of this report as well as the additional amount of offsite renewable energy that would be needed to achieve net zero.

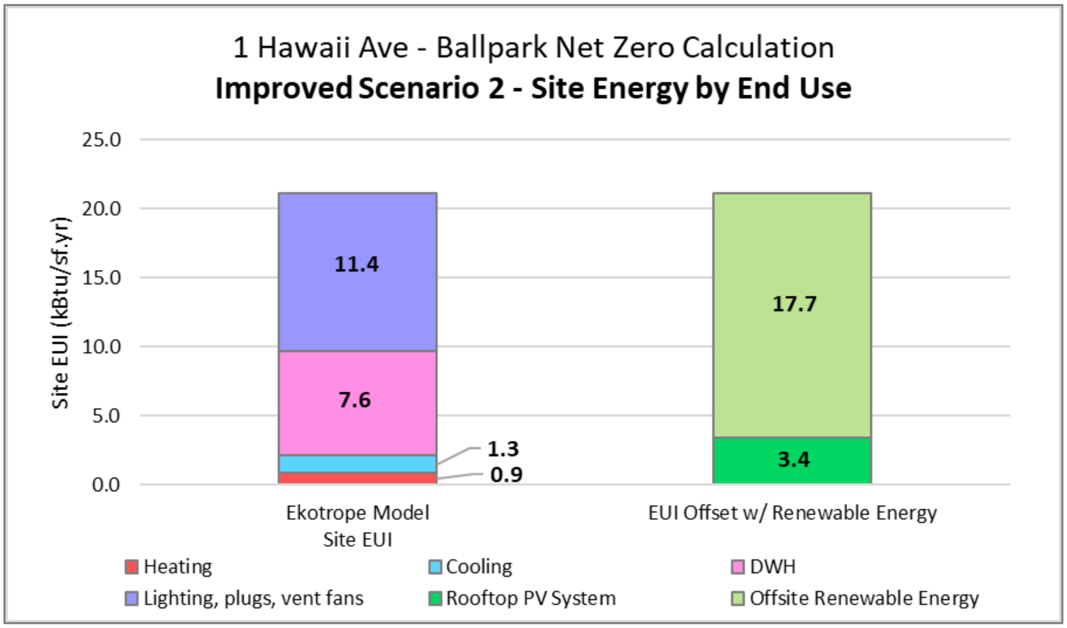

Figure 4. Net Zero Energy Balance: Improved Scenario 2 - Site Energy by End Use

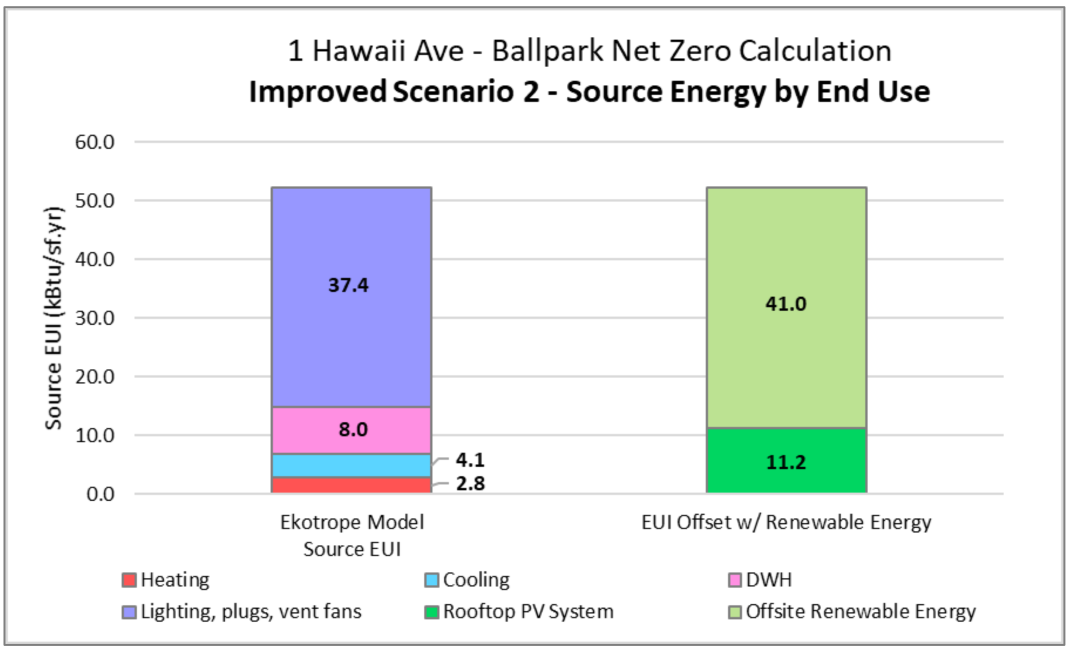

Figure 5. Net Zero Energy Balance: Improved Scenario 2 - Source Energy by End Use

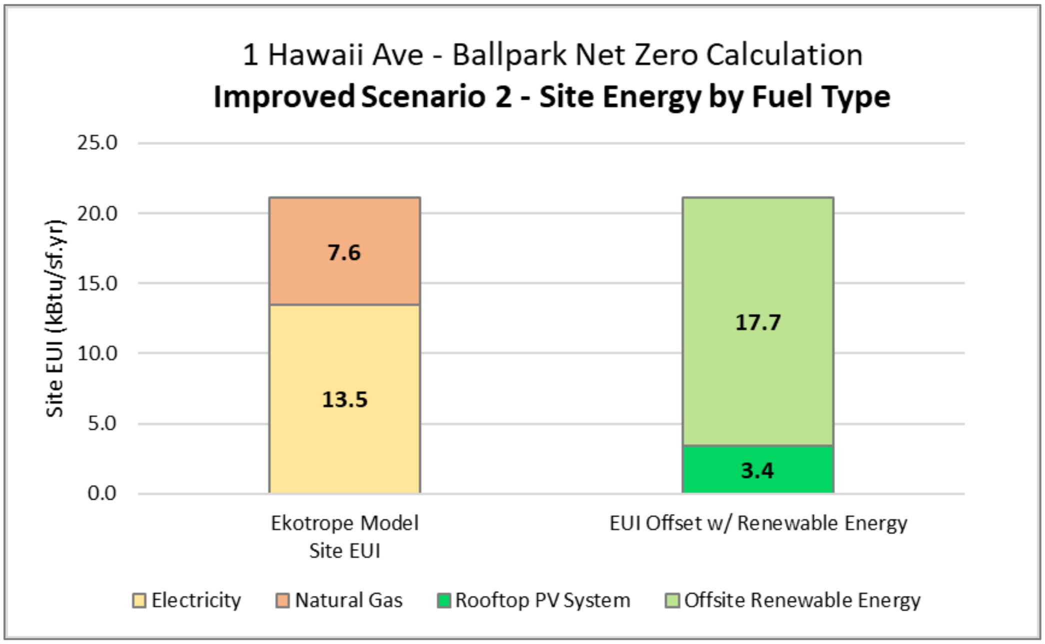

Figure 6. Net Zero Energy Balance: Improved Scenario 2 - Site Energy by Fuel Type

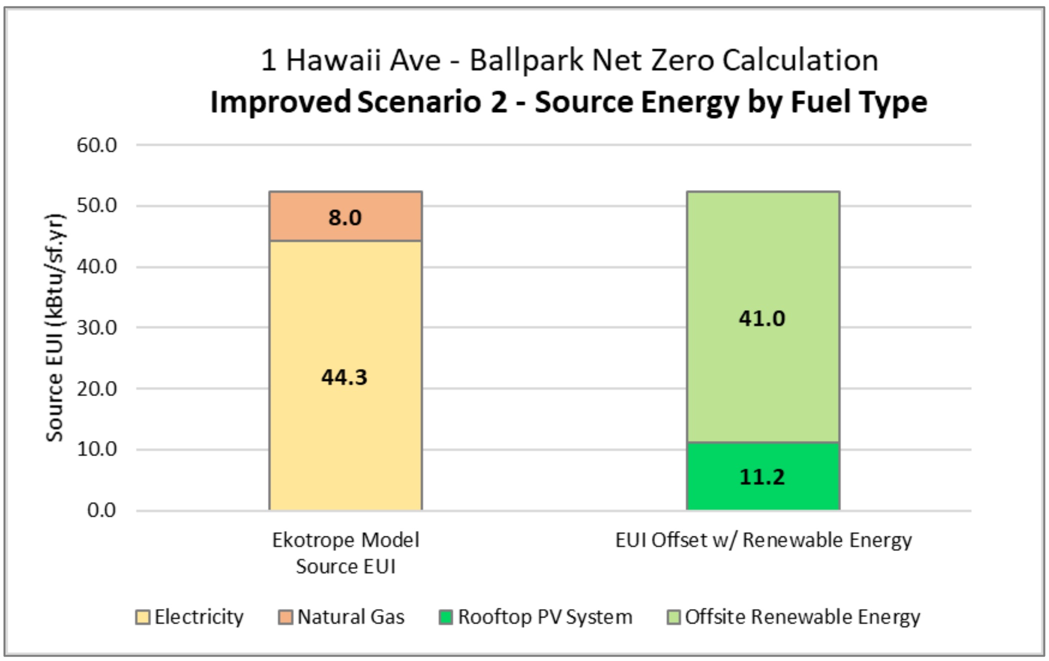

Figure 7. Net Zero Energy Balance: Improved Scenario 2 - Source Energy by Fuel Type

Given the assumed design of Improved Scenario 2 and the estimated renewable energy production from the rooftop PV array, One Hawaii will offset approximately 16% of the building's site energy use and 21% of the building's source energy use. The majority of the building's energy consumption, both site and source, will be electricity consumption. In order to offset the remainder of the building's site energy consumption, One Hawaii would need to procure at least 334,049 kWh/yr of offsite renewable energy production to achieve site net-zero.

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In order to achieve net zero with just on-site renewable energy production, One Hawaii will need to explore options to both reduce the building's energy consumption as well as maximize its on-site renewable production. As part of this net zero study, SWA analyzed the impact of the following two potential design improvements over the Improved Scenario 2:

1. Switching from a ballasted rooftop PV system to a roof mounted racking system. Given the more available area for PV panels as well as the improved PV capacity density (kW/sf), SWA performed rough estimates the roof top PV system could produce approximately 3-fold more on-site renewable energy.
2. Utilizing a centralized heat pump water heater for domestic water heating (DWH). This was modeled in Ekotrope assuming a COP of 2.5. This is referred to as the "Improved Scenario 1" building design in this report.

Below are the results of this hypothetical analysis, represented by similar energy balance graphs that were introduced in the previous section of this report.

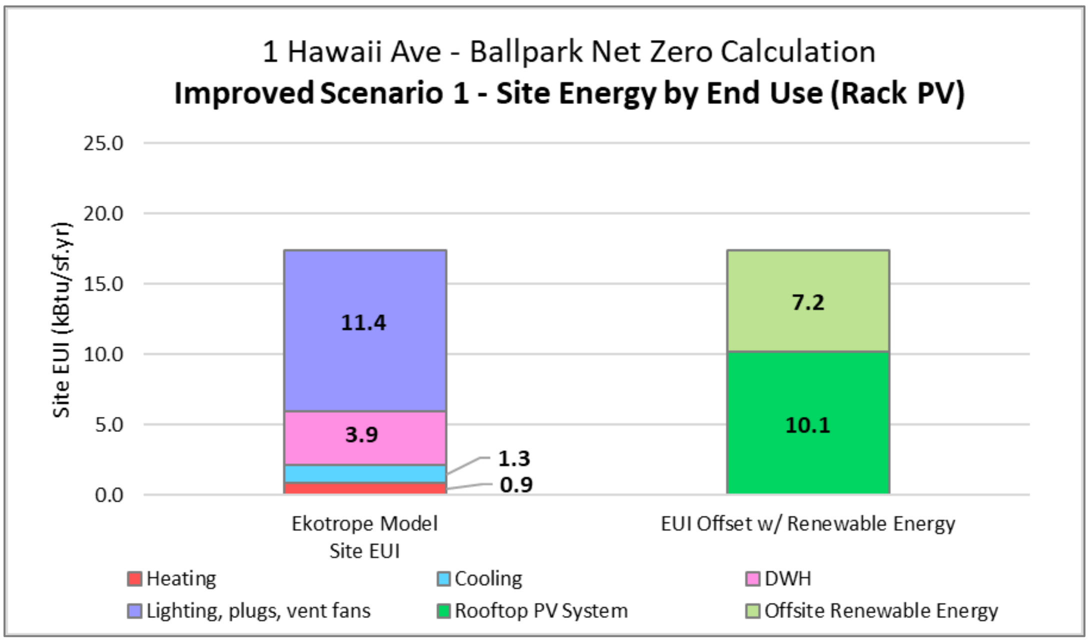

Figure 8. Net Zero Energy Balance: Improved Scenario 1 w/ Rack PV System - Site Energy by End Use

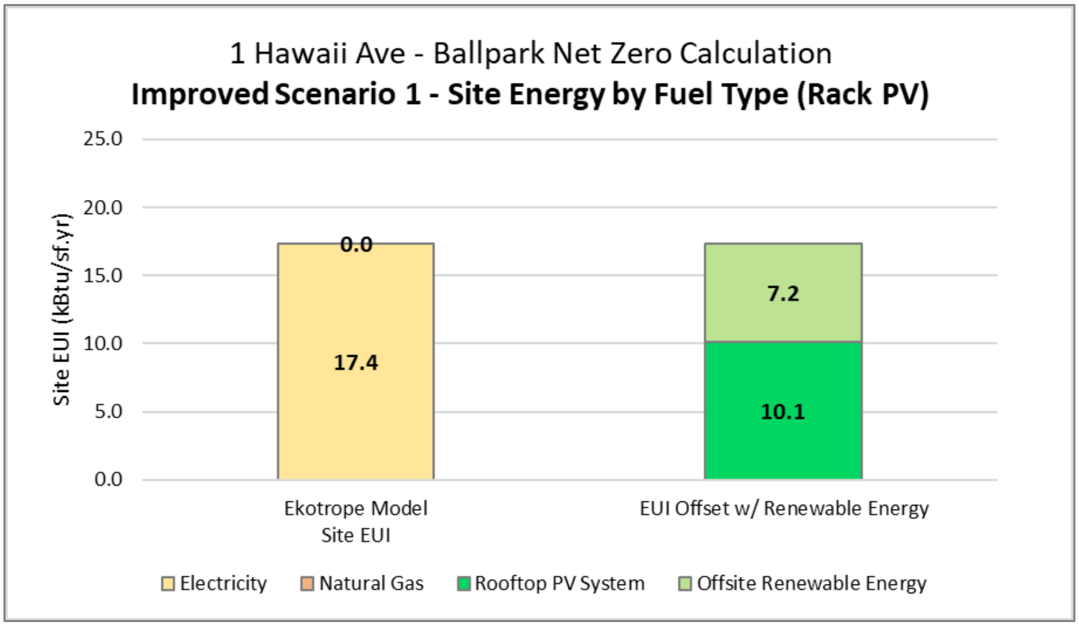

Figure 9. Net Zero Energy Balance: Improved Scenario 1 w/ Rack PV System - Site Energy by Fuel Type

As shown in Figures 8 and 9, there is a substantial improvement in the net zero energy balance by utilizing heat pump water heaters and a rack PV system. Although One Hawaii would still fall short of achieving site net zero with these two design modifications, the project would need to procure substantially less offsite renewable energy, only 136,453 kWh/yr, in order to achieve site net zero.

In order to achieve site net zero with just on-site renewable energy production, SWA recommends further evaluating the following:

1. The feasibility of achieving a heat pump water heater COP that is greater than 2.5. This will be dependent on multiple factors including cold-weather performance of the water heaters and availability of units that are large enough and achieve such efficiency goals.
2. Ways to increase on-site renewable energy production. This may be achieved by a more refined analysis of the estimated energy production for a rack PV system on the roof, evaluating the potential for vertical building integrated PV (BIPV), or utilizing ground mount PV if space is available.
3. Further refining the dwelling unit lighting and plug load assumptions in the Ekotrope model. It is possible that the standard assumptions in Ekotrope are over-predicting dwelling unit lighting and plug load energy use. These loads can vary depending on the apartments' occupants and are often hard to predict. As a result, certain modeling tools such as Ekotrope must make assumptions, that can sometimes be overly conservative.

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APPENDIX Z REVIEW

Appendix Z is a proposed net zero pathway within the soon to be released District building energy code. SWA evaluated compliance for One Hawaii against Appendix Z sections Z2 – Z5.

Z2 – Minimum Performance Requirements
Z3 – Renewable Energy
Z4 – Energy Metering, Monitoring and Reporting
Z5 – Energy Reporting

REQUIREMENT	**ANALYSIS**
Using predictive modeling, demonstrate the building site's net zero achievement through a zEPI score of 30 or less. $$zEPI = 50.4 \times \frac{EUI_p}{EUI}$$	The zEPI scores reported in Table 1 were generated using the Home Energy Rating System (HERS) reference home's source EUI as a substitute for the EUI of an ASHRAE 90.1-2016 baseline building that appendix Z requires. It isn't possible to report whether the zEPI scores are accurate with the HERS reference. zEPI scores and HERS scores are similar in that they both compare the as-designed building to a fixed universal baseline. Traditionally a HERS score was only available to homes 3 stories and under but with the recent publication of ANSI/RESNET/ICC Standard 301-2019 dwelling units in any height building are eligible for rating under the HERS methodology. The new standard also defines how those individual scores would be averaged together to arrive a score for the entire building. Multifamily buildings often need to show compliance using a HERS score with other energy programs such as ENERGY STAR. A HERS pathway within appendix Z should be provided for this building type so as to not require separate ASHRAE 90.1 modeling for the building.
Maximum annual heating demand of $4.21\ kBtu/ft^2$	Projected at 2.8 $kBtu/ft^2$ source
Maximum annual cooling demand of $6.4\ kBtu/ft^2$	Projected at 4.1 $kBtu/ft^2$ source
Energy systems commissioning shall be performed on the following systems and controls • Building envelope • HVAC • Lighting and control systems • DHW • Renewable energy systems	Can be met
Whole building pressurization testing shall be conducted in accordance with the Energy Conservation Code and demonstrate the airtightness specified in the energy model was achieved in the field	Low-energy buildings like those appendix Z requires will need to have assemblies that greatly resist heat transfer and therefore have a lower drying potential. A building with both high R-value assemblies and high infiltration into those assemblies will suffer from reduced durability. Establishing an infiltration limit consistent with the low heating and cooling demands such as PHIUS or PHI targets is needed.
On-site combustion of fossil fuels is prohibited unless specified by the code official	The building is currently designed and modeled with options for gas ventilation and central hot water to evaluate impact on oper-

	ating costs. The site EUI calculated for hot water was than multiplied by a source energy factor of 1.05. This converted source energy EUI for the hot water was used to determine the total amount of off-site renewable energy needed to meet the requirements of this appendix Z.
The following renewable energy sources are acceptable to reach net zero compliance; PV, solar thermal systems, wind turbines, biogas	The building is designed for roughly 275 solar panels on the roof of the building.
Off-site renewable energy may be procured only after meeting 1 of the following • Minimum 5% of building energy consumption is met by acceptable on-site renewable energy • If using PV, minimum 25% of total site area shall be allocated for PV	Solar PV on the roof is projected to produce 16% of the buildings predicted energy consumption in a typical year Only 22% of the total site area (6,000 SF of roof area) is being allocated for PV due to conflicts with stormwater management and zoning requirements. At present, the team cannot utilize land beyond the building restriction line for stormwater management, thus necessitating a green roof and limiting the efficiency of a solar PV system. Further, the team is investigating zoning and height regulations to explore a racked PV system.
Off-site renewable energy must meet the following • Be procured through a qualified electricity supplier • Be from tier 1 renewable sources meeting the minimum percentages of the District's Renewable Portfolio Standard • Be bought through a power purchase agreement • Have a minimum 5-year legal agreement for the purchase • Electricity generated from wind or solar facilities located within DC, MD or VA.	At the time of this report only two energy companies (Clean Choice and WGL) have been identified as possibly being able to meet all of the requirements within appendix Z. The two biggest hurdles are generation within DC, MD or VA, followed by the ability to purchase via power purchase agreement. Allowing Green-e® certified RECs and/or generation outside the areas specified would increase the number of companies able to provide energy compliant with appendix Z.
Z4 Energy Metering, Monitoring and Reporting • All forms of energy delivered and produced on the building site must be metered • All centrally ventilated building systems must collect real-time and historical ventilation flow rate data	To be evaluated
Z5 Energy Reporting • Energy and water performance must be benchmarked using the Energy Star Portfolio Manager tool • Within 24 months of occupancy demonstration of energy consumed by the building site are equal to or less than the renewable energy associated with the site (at not less than 90% occupancy).	Benchmarking to be completed

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CARBON EMISSIONS PROJECTIONS

The goal of Net Zero design is ultimately to reduce the greenhouse gas (GHG) emissions of a project. The proposed packages were evaluated against current and future projected carbon emissions. Washington, DC has goals in place to transition power grids to all renewable energy meaning emissions attributed to the use of electricity will significantly decrease. Emissions from burning fossil fuels will essentially never change, therefore installing gas burning equipment such as a hot water boiler will eventually have much greater emissions impact than an electric option, even if the electric option is less efficient.

In order to estimate the emissions from electricity consumption for a given region, emissions rates must be used to convert site energy consumption into emissions in CO2 equivalent. Estimates of these factors can be looked up using the EPA's Emissions & Generation Resource Integrated Database (eGRID) for various fuel types. The emissions rate referenced for Washington, DC comes from the currently published values which are technically for 2016. This rate is 0.1416 kg of CO2 equivalent emissions per kBtu of electricity consumed (kgCO2e/kBtu). In order to project future emissions rates, it is assumed that DC will reach its goal of achieving a 100% renewable grid by 2032 based on the Clean Energy DC Act. Although a grid might be 100% renewable, there will still be emissions associated with the energy production, so a value of 0.0027 kgCO2e/kBtu was assumed for 2032 based on an emissions factor calculated for Seattle which claims to have a 100% renewable grid.

To simplify the equation, it is assumed that DC will undergo constant improvements between now and then, and the rate will decrease linearly while the rate for natural gas will remain constant as seen in Figure 10. Although a perfectly linear decrease will likely not be the case, this calculation is meant to give a rough estimate of the decrease in emissions for electricity consumption in DC over the next 13 years.

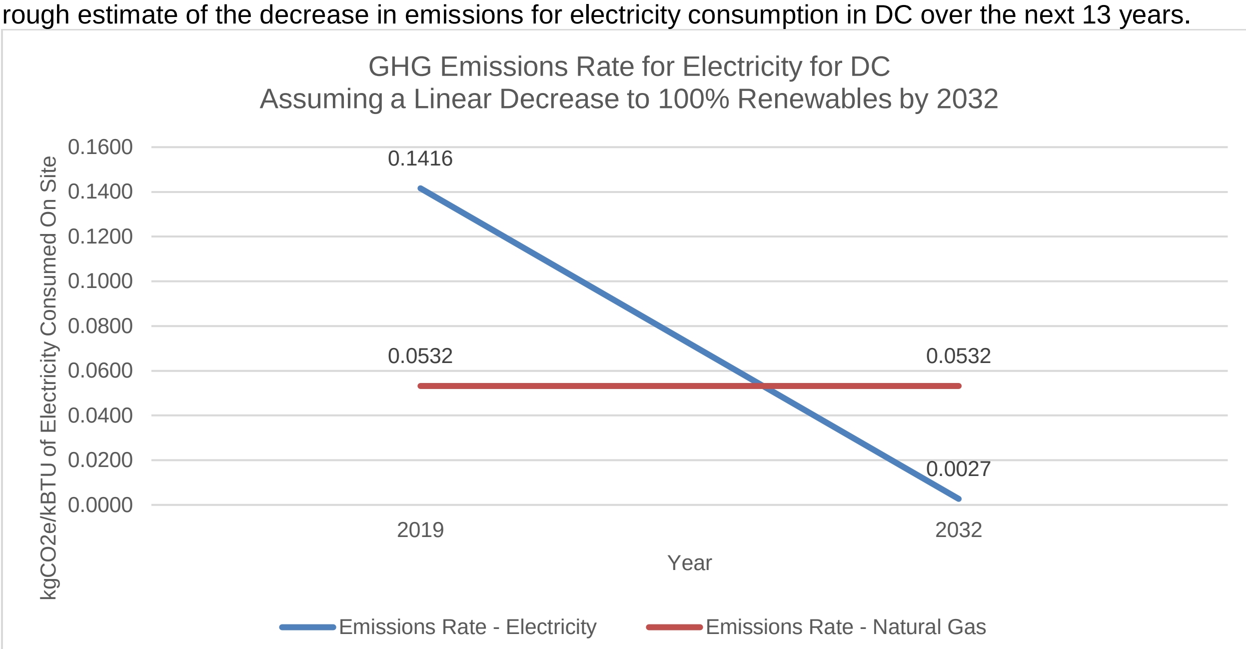

Figure 10: Emissions rates from eGrid2016 used in emissions analysis.

Applying these emissions rates to the energy use results from the energy analysis, Figure 11 shows the cumulative emissions of each package between today and 2040. Based on today's emissions rates, the case with the lowest emissions is the improved case with a natural gas, condensing boiler, while the worst case is the baseline building with gas ventilation. Looking over the next few years however, as the grid becomes cleaner, the natural gas consumption of the domestic hot water will push the cumulative emissions of this case above the improved all electric case by 2027 and will ultimately be responsible for 26% more total emissions by 2040, assuming the grid transitions to all renewable generation by 2032 as expected.

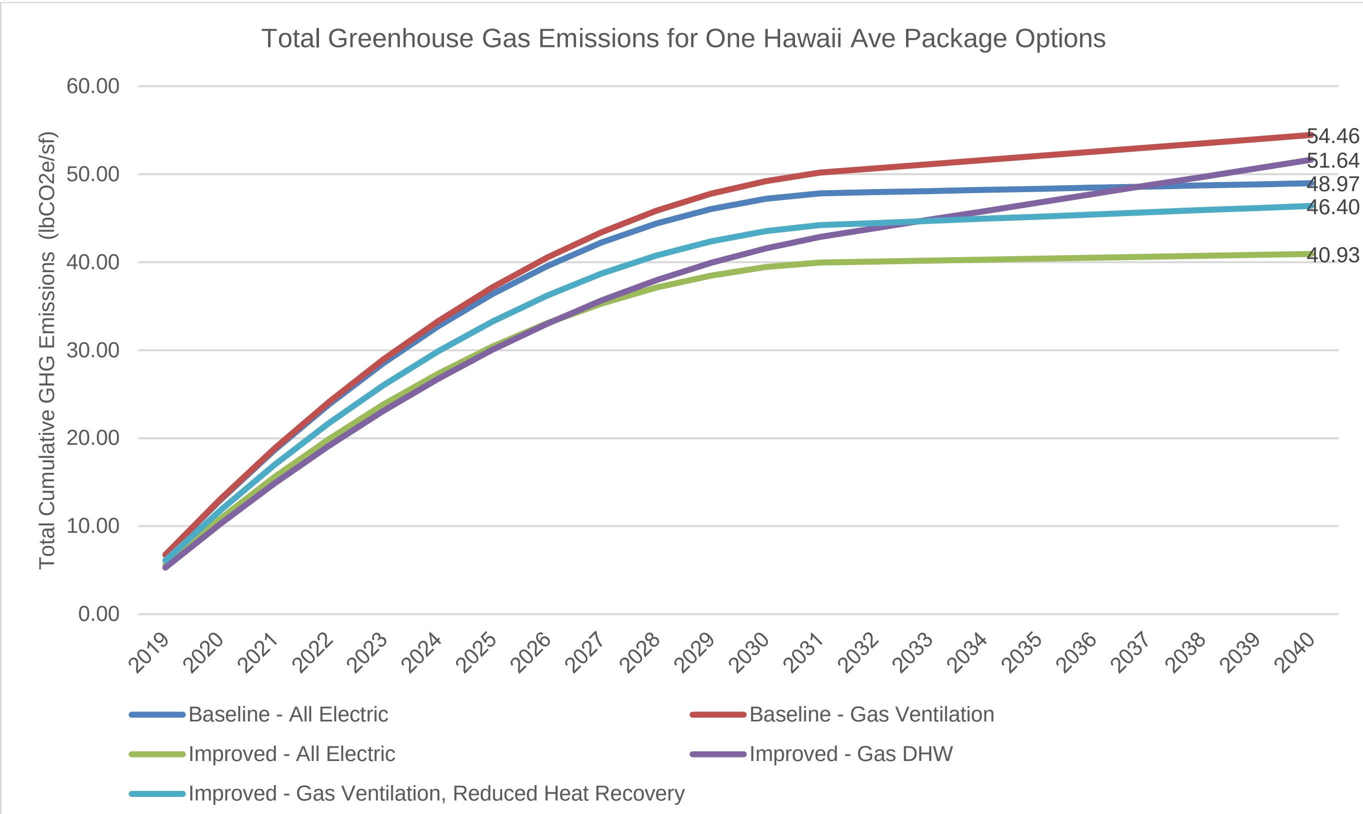

Figure 11: Total GHG emissions of each package between 2019 and 2032 assuming 100% renewable grid by 2032.

Although a natural gas condensing boiler may be the best option today as far as utility costs, the emissions of such a system over the lifetime of the equipment will eventually overtake the all-electric systems. Based on the cumulative emissions between today and 2040, it is highly recommended that any fossil fuel burning equipment be considered only with a phase out plan for its eventual replacement.

ACTIVITY 4. TECHNICAL ASSISTANCE

IMPROVEMENT ANALYSIS REVIEW

Prior to beginning energy modeling, the project team considered several strategies for further evaluation based on cost, feasibility, ability to incorporate into current design, availability and impact on overall load reductions. SWA provided the below list of products and materials for consideration based on use on similar high performance projects and research on available and emerging technologies.

1. Triple paned windows, such as these recommended brands:
    a. Intus (uPVC)
    b. Yaro (uPVC)
    c. European Architectural Supply (uPVC)
    d. Mavrik (uPVC)
    e. Cascadia (fiberglass)
2. Central ERV with dehumidification, such as the following brands. Start with electric.
    a. Swegon (most common on our projects) - GOLD RX series
    b. Ventacity
    c. Blauberg
    d. FlaktGroup
    e. Heat recovery efficiency should probably be ≥ ~83%.
3. Heating / cooling - VRF or ducted minisplits with minimum COP of 3 (sizing TBD – the more we can bring the loads down the smaller and cheaper the equipment)
    a. For the VRF system price an ADD ALT of heat recovery
4. Exterior rigid foam – price options for 1.5”, 2” and 3”
5. Stainless steel, galvanized steel brick ties, and thermally broken
6. Price current option with most efficient electric tank water heaters available, add option for central heat pump water heating
    a. For heat pump water heater option we’re seeing Sanden as the best system currently available
7. Advanced air sealing package to compartmentalize units and limit air infiltration from exterior
8. Drain water heat recovery - https://ecodrain.com/en/products/
9. 2 pipe hydronic distribution layout + central air to water heat pump (Aermec or Colmec makes units, one likely on the roof) + terminal water sourced heat pumps (1 per unit; probably ¾-1.5 ton range: https://www.climatemaster.com/commercial/products)

Beyond products and materials, additional recommendations on the envelope design were provided to reduce thermal bridging potential and improve constructability.

1. Evaluate fewer jogs in the building façade
    i) Due to site constraints and lot size, the building is not optimally oriented, and a T-design was chosen to maximize the shape of the given site. Reducing the architectural bumpots and jogs was evaluated however not selected due to aesthetic concerns.
2. Reduce window to wall ratio
    i) The design team reduced window sizes on the northwest and southeast facades and simplified window design which reduced overall window costs which allowed for savings to be applied toward higher performing triple paned windows

1 HAWAII AVE, ALTERNATE COSTS

	Summary of Value Engineering	Added Costs	Cost per unit
1	Triple pane glass in reduced area design	$45,000.00	$642.86
2	Add 3" foam insulation	$144,000.00	$2,057.14
3	Add 2" foam insulation	$96,000.00	$1,371.43
4	Thermally broken stainless steel brick ties	$15,000.00	$214.29
5	Advanced air seal/blower door tests	$32,000.00	$457.14
6	Central water heating system all electric	$165,000.00	$2,357.14
7	All electric building from electric and gas construction		$0.00
8	Drain water heat recovery, Ecodrain at each unit bath. Preheats cold water	$67,000.00	$957.14
9	VRF or VRV system	$38,000.00	$542.86
10	HVAC heat recovery system approximately 83%	$58,000.00	$828.57
11	Central ERV with dehumidification , ilo heat recovery	$97,200.00	$1,388.57
12	2 pipe Hydronic system w/central air	$241,000.00	$3,442.86
13	Non-argon-filled windows	-$20,000.00	-$285.71
14	Add 1.5" foam insulation	$51,000.00	$728.57
15	Blown-in fiberglass ilo of batts for cavity insulation	$62,000.00	$885.71
16	Mineral wool for ilo of batts cavity insulation	$13,000.00	$185.71

Figure 10. Add Alternate Pricing
NOTE: These added costs represent the most informed estimate possible by the general contractor, given current information and historic pricing. These costs are subject to change.

The project team including owner, architect, general contractor, MEP and Steven Winter Associates met on August 23, 2019 to discuss options and ultimately selected the measures evaluated in the energy modeling analysis as the most viable for the project. The team reviewed potential strategies and cost implications and discussed envelope and air barrier issues most common with similar high-performance buildings.

ACTIVITY 5. COMPLETE A COST-BENEFIT STUDY

a. Request construction cost estimates for baseline and proposed strategies and systems;

   The project team's preferred design strategy was Improvement Scenario 2: Central Gas Domestic Hot Water. The strategies taken together represented a $400,000 cost premium over the Baseline Scenario 1 – or approximately $5 per square foot.

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b. Establish baseline performance of building and compare against predicted energy usage;

   Complete, see Activity 3 above.

c. Estimate annual operating costs and savings;

   The analysis indicates that Improvement Scenario 2 would generate annual total operating cost savings of just over $9,000 when compared to the baseline scenario. Importantly, however, the modeled energy savings significantly (positively) altered Wesley Housing's assumed operating costs above and beyond the savings shown between the modeled baseline and improvement scenario. Previous experience motivated Wesley Housing to assume a relatively conservative per-unit, per-annum operating cost. The modeled energy savings for this project, however, dropped those anticipated costs to by eight percent per unit, per annum. This per unit savings, multiplied over a 70-unit property, enabled the project to notably increase its net operating income.

d. Evaluate renewable energy credit availability and costs;

   Complete, see "Renewable Energy Credit Availability" section directly below.

e. Evaluate net operating income.

   In direct correlation with the lower per unit operating costs, the project net operating income was shown to increase, in this case by approximately eight percent as well. The higher NOI could support much more permanent debt and reduce its request for District affordable housing funds (hopefully making the funding application much more competitive).

RENEWABLE ENERGY CREDIT AVAILABILITY

SWA investigated several options for renewable energy credits beginning with Green-E certified to offset site EUI. Estimated pricing depends on the length of the contract. Initial pricing reflects an offset of 184 MWh/year, which assumes additional solar via a rack mounting system.

Green-E Certified REC Pricing

5 years	10 years
920 MWh	1,840 MWh
$1,150	$2,250

Additionally, SWA investigated options for renewable energy credits in compliance with Appendix Z. However at the time of this report we have not received pricing estimates from any companies. Only two energy companies, Clean Choice and WGL, have been identified as potentially able to provide RECs meeting the requirements within appendix Z including generation within Washington, DC, MD or VA and the ability to purchase via a power purchase agreement.

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ACTIVITY 6. REPORT ON WORK PERFORMED AND RESULTS

Complete

PROJECT OUTPUTS

1. Prepared project work plan developed in coordination with DOEE.
2. Participated in monthly status reports discussing actions taken in the previous period, progress and next steps.
3. Performed solar feasibility analysis to determine ranges of expected solar photovoltaic potential available at the site and resulting offset for energy usage.
4. Completed energy analysis and documented findings.
5. Developed package of recommendations for building to meet net zero target and general strategies multifamily buildings in the District should consider.
6. Evaluated costs of recommended strategies as well as expected operational savings to determine cost-benefit.
7. Documented design assistance provided and delivered final report of solar, energy and cost/benefit analysis to DOEE.

PROJECT OUTCOMES

1. Identified package of strategies to reduce operating costs and building loads with potential to achieve net zero operation for 1 Hawaii Ave, pending information from available power purchase agreements.
2. Provided design and construction team strategies to consider for affordable multifamily housing to meet net zero targets.
3. Advancing the goals of the *Solar for All* and *Clean Energy DC* to offset the utility costs of low-income households through the use of solar energy and energy efficiency.
4. Evaluation of effectiveness of grant in helping to pursue net zero energy performance.

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KEY TAKEAWAYS AND LESSONS LEARNED

In summary of points made above:

1. **Domestic Hot Water Heating**
   Domestic hot water heating remains the biggest challenge for meeting net zero targets, particularly for multifamily housing. There is a need for a heat pump water heater COP that is greater than 2.5. This will be dependent on multiple factors including cold-weather performance of the water heaters and availability of units that are large enough and achieve such efficiency goals. A few central heat pump water heaters are beginning to be piloted in this climate zone and results will be closely monitored. However, the higher upfront cost and higher operating costs make it an unattractive option.

2. **Solar Design**
   - **a.** At present, the team cannot utilize land beyond the building restriction line for stormwater management, thus necessitating a green roof and limiting the efficiency of a solar PV system. Further, zoning and height restrictions may limit the ability to pursue a rack mounted option.
   - **b.** Early design of onsite renewable energy strategies is critical and needs to be considered during project conception to maximize layout and output. Further analysis for One Hawaii should include feasibility of a rack PV system on the roof, evaluating the potential for vertical building integrated PV (BIPV), or utilizing ground mount PV if possible.

3. **Energy Modeling**
   - a. Verified performance data trued up to energy model assumptions is needed to better refine accuracy of predicted energy model loads. It is understood that different modeling tools over or under predict usage, but to ensure a building is not over or under designing to meet its overall net zero targets it is critical to better understand accuracy of modeling tools.
   - **b.** The Grasshopper and OpenStudio modeling was ultimately not used for the analysis in this report. Since this was a non-standard process and much of the building details were already set, too much time was needed to QA the model outputs to allow for parametric modeling within the project timeline. While this process ultimately did not produce the desired results, many insights were gained. Future Net Zero feasibility studies should first look at the stage of design of the project and then determine the level of detail needed to be included in the energy modeling study. If the geometry, windows, and layout of the building have been set and a high level of accuracy is preferred, a more detailed model should be created. In this scenario, the modeling process will be longer, but the results will be more reliable and very specific iterations can be analyzed. If it is determined that some of the higher-level details are open for discussion, a Simple Box Modeling approach can be used. Less specific parameters such as window to wall ratio and overall assembly R-values can be evaluated for inclusion into a more detailed design, but total energy use results will be less reliable.
   - **c.** It is possible that the standard assumptions in Ekotrope are over-predicting dwelling unit lighting and plug load energy use. These loads can vary depending on the apartments' occupants and are often hard to predict. As a result, certain modeling tools such as Ekotrope must make assumptions, that can sometimes be overly conservative.

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4. Appendix Z Review

- **a.** A HERS pathway within appendix Z should be provided for multifamily building types so as to not require separate ASHRAE 90.1 modeling for the building.
- **b.** Meeting a zEPI 30 following the 90.1 modeling pathway without incorporating renewables into the calculation will be very challenging if not impossible for larger multifamily buildings. OpenStudio modeling is estimating a zEPI 40.25 based on the Improvement Scenario 1 all electric option.
- **c.** Establishing an infiltration limit consistent with the low heating and cooling demands such as PHIUS or PHI targets is needed. Low-energy buildings like those appendix Z requires will need to have assemblies that greatly resist heat transfer and therefore have a lower drying potential. A building with both high R-value assemblies and high infiltration into those assemblies will suffer from reduced durability.
- **d.** At the time of this report only two energy companies (Clean Choice and WGL) have been identified as possibly being able to meet all of the requirements within appendix Z for procurement of qualified Renewable Energy Credits. This leaves the overall cost for compliance with Appendix Z and meeting net zero targets unknown.

IV. <u>NEP/LEP</u>

Not Applicable

V. Include in this final report copies of any materials produced as part of this project (marketing pieces, curriculum, interpretive signage, etc.). If you have submitted these materials with previous Progress Reports, you do not need to resubmit.

a. Not Applicable