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High Performance Residential Housing Units at U.S. Coast Guard Base Kodiak

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High Performance Residential Housing Units at U.S. Coast Guard Base Kodiak

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ABSTRACT

The United States Coast Guard (USCG) constructs residential housing throughout the country using a basic template that must meet the minimum Leadership in Energy and Environmental Design (LEED) Silver criteria or better for the units. In Kodiak, Alaska, USCG is procuring between 24 and 100 residential multifamily housing units. Priorities for the Kodiak project were to reduce overall energy consumption by at least 20% over existing units, improve envelope construction, and evaluate space heating options. USCG is challenged with maintaining similar existing units that have complicated residential diesel boilers. Additionally, fuel and material costs are high in Kodiak. While USCG has worked to optimize the performance of the housing units with principles of improved building envelope, the engineers realize there are still opportunities for improvement, especially within the heating, ventilation, and air conditioning (HVAC) system and different envelope measures. USCG staff also desires to balance higher upfront project costs for significantly reduced life-cycle costs of the residential units that have an expected lifetime of 50 or more years. To answer these questions, this analysis used the residential modeling tool BEoptE+ to examine potential energy-saving opportunities for the climate. The results suggest criteria for achieving optimized housing performance at the lowest cost. USCG will integrate the criteria into their procurement process.

To achieve greater than 50% energy savings, USCG will need to specify full 2x6 inch (38x140 mm) wood stud R-21 (R-3.7 m^2K/W) insulation with 2 inches (50.8 mm) of exterior foam, R-38 (R-6.7 m^2K/W) ceiling insulation or even wall insulation in the crawl space, and R-49 (R-8.6 m^2K/W) fiberglass batts in the vented attic. The air barrier should be improved to ensure a tight envelope with minimal infiltration to the goal of 2.0 ACH50. With the implementation of an air source heat pump for space heating requirements, the combination of HVAC and envelope savings in the residential unit can save up to 58% in source energy over existing residential units.

INTRODUCTION

The United States Coast Guard (USCG), the owner, utilizes a basic template for residential housing units across all its domestic bases. The housing is considered to be rental units and a social service. Similar units have been previously constructed in Cordova, Alaska; Astoria, Oregon; and Aviation Hill on Base Kodiak. USCG would like to reuse the designs of previously built units because this can increase the speed of design and construction. However, staff expressed that the new units were an opportunity to improve the energy performance of the units.

Priorities were expressed by the owner during many discussions and communications. Because the buildings will be occupied by the owner for the long-term and the units have an estimated life of 50 or more years, investigating the envelope was a first priority. The occupants are not held accountable for their energy consumption, do not pay their own energy bill, and are therefore not motivated to make energy efficient choices; constructing inherently efficient structures is the best way to drive down energy consumption. Next, because Aviation Hill on Base Kodiak is of similar construction, the owner used this development as a baseline and set the target to achieve a minimum of 20% to 30% energy reduction over this baseline. Understanding the heating, ventilation, and air conditioning (HVAC) options that correlate to the envelope and reduction were also analyzed. USCG was also interested in transitioning to "all-electric" housing, including the HVAC. Plug loads

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and lighting were not a priority because those options are controlled by the occupant, as are thermostat settings. Overall, USCG has an understanding of the balance of first cost vs. life-cycle costs. The staff knows that a higher first-cost unit may yield overall lower energy costs and operation and maintenance costs.

Additionally, USCG must work to meet federal energy eficiency mandates. In this case, U.S. Code 10 CFR 435.4 is the "energy efficiency performance standard," which states the requirements for federal residential new construction. As construction will take place after Aug. 10, 2012, the residential units must meet the requirements in the International Energy Conservation Code (IECC) (Residential) 2009 version. Also, if "life cycle cost-effective, [residential units must work to] achieve energy consumption levels … that are at least 30% below the levels of the IECC Baseline Building 2009" (10 CFR 435.4).

CHARACTERISTICS OF HIGH PERFORMANCE RESIDENTIAL BUILDINGS

When looking into high performance residential housing, the Building America program under the U.S. Department of Energy (DOE) and the Passive House standard are leaders in the industry. The Building America program focuses on residential building performance. Kodiak is classified under the cold and very cold Building America climate category. One guide for the climate focuses on building envelope as the primary way to reduce energy consumption (PNNL 2011). Advanced framing was recommended for installing more insulation, while maintaining the structural integrity. For air sealing, the IECC 2009 code was mentioned, but three methods were suggested for ensuring a tight air barrier: "conditioning crawl spaces and basements, or using slabs; installing insulated exterior sheathing with sealed seams; and conditioning attics" (PNNL 2013). For HVAC, right-sizing of equipment was emphasized, in accordance with Air Conditioning Contractors of America Manuals S and J. While the recommendations provided by Building America were excellent, the unique climate and fuel mix found in Kodiak were incompatible with the "typical" recommendations to reach a specific percentage of energy savings.

The extreme end of the high performance residential housing spectrum was the passive house standard. This design signifies a house that seeks to be a "well-insulated, virtually air-tight building that is primarily heated by passive solar gain and by internal gains from people, electrical equipment, etc" (Passive House Institute U.S. 2011). One recommendation from the case studies that stood out was to test the home for air tightness prior to sheetrock installation. Then an air-tight seal was ensured prior to covering up insulation. Overall, the passive house presents a means of achieving significant energy savings, but costs are not necessarily life cycle cost-effective. The factor for air tightness is beyond anything the USCG has achieved to date. The USCG is working toward the passive house standard with high insulation levels and plans to use triple-pane windows. While the information provides a guiding principle, it may not be practical for USCG to employ this in its housing construction.

Residential Metrics

On previous projects, the owner has used Leadership in Energy and Environmental Design (LEED) to qualify homes as sustainable. With new projects, USCG is interested in employing the Home Energy Rating System (HERS). The LEED for Homes rating system assigns a home a score based on points accumulated in water conservation, energy efficiency, material selection, and other criteria to create an integrated, sustainable building. Currently, USCG requires contractors to meet LEED Silver criteria without expressing priorities on which points to aim for in the home construction, which typically leaves out the energy performance component and has achieved mixed results. Too often, the contractor focuses less on energy efficiency and more on the resource efficiency and healthy portions, which while important, do not affect the bottom line of energy. The HERS Index is an industry standard by which energy efficiency of homes is measured and was created by the Residential Energy Services Network (RESNET 2012). A home with a HERS index of 100 is considered to be a standard home; a HERS index of 70 means the home is 30% more efficient than a standard home. Currently, the owner does not specify a HERS rating on their housing units.

PROJECT OVERVIEW

In an effort to achieve energy efficiency goals, the objective of this project was to identify energy saving opportunities in existing housing units and then recommend how to execute those opportunities into the new housing design. To complete this effort, the following steps were executed:

1. A meeting was held to discuss and develop goals with the owner for optimization parameters
2. A baseline model was developed based on previous installments of residential housing units and discussions
3. The optimal design package strategies were developed for the Base Kodiak residential units.

Kodiak Weather

Kodiak, Alaska, is located on Kodiak Island, the second largest island in the United States, and is labeled as a DOE climate zone 7 or IECC climate zone 8; both indicate cold and very cold climates. Kodiak Island is south of the main land of Alaska. The city and USCG Base Kodiak are located on the northeastern side of the island. The weather is moderated by the marine climate, with temperature lows in the 0°F to 10°F (-18°C to -12°C) range and highs in the low 70°F (21°C) range. The mean annual temperature is around 42°F (6°C). Using the Adaptive Comfort Model from ASHRAE Standard 55-2004, 0.5% of the time the climate is considered comfortable. Kodiak also experiences high humidity at the cold temperatures.

Energy Sources

Approximately 90% of electricity in Kodiak is provided by a combination of hydroelectric and wind generation. However, when the demand is not met by these sources, diesel fuel is used to implement electricity generation. Diesel generator use often occurs in the winter because the hydroelectricity generation sources freeze. There are six wind turbines that generate a total of 9 megawatts of electricity. The cost of electricity in January 2013 was $0.138/kilowatt-hour (kWh) without charges. The utility in Kodiak adds a cost of power adjustment to cover the costs of the utility when using expensive diesel to supplement the electricity supply, and that charge averages about an additional $40/month on average for the owner. For heating, diesel is trucked to housing units, and tanks are filled every couple of months. One tank may serve two or more housing units. The cost of diesel in January 2013 was $3.28 per gallon ($0.86/L).

Since Kodiak has a unique fuel mix as well as location, the site-to-source ratios were significant and differ from those of the mainland United States. Per the owner's direction, the community electricity is 90% wind and hydroelectric generation and 10% diesel generation. Using electricity ratios for Kodiak, the renewables site-to-source ratio was one and the diesel burned-for-electricity ratio was 3.15. This yielded a site-to-source ratio in Kodiak of 1.21 for electricity. For imported fuel oil, 1.19 was used (Deru et. al).

ENERGY MODEL

Modeling Tool

BEoptE+, developed by DOE's National Renewable Energy Laboratory (NREL), was selected as the modeling tool for the project. The tool evaluates "residential building designs and identifies cost-optimal efficiency packages at various levels of whole-house energy savings along the path to zero net energy" (BEopt 2012). In addition, the tool has the ability to complete signal design computations, parametric analysis, and optimizations based on cost. BEoptE+ 1.4 was built to work with EnergyPlus Version 7.2 simulation engine.

Baseline Energy Model

The baseline model is derived from plans and details of previously constructed units on Aviation Hill in Kodiak, which has a predefined layout. **Figure 1** shows the floor plans, which include three bedrooms, 2.5 baths, and a two-car garage attached to an opposite-configuration second unit. The square footage of the home is 1,712 ft^2 (159 m^2) plus a garage that is 486 ft^2 (45 m^2). Only one unit was modeled. The wall on the right-hand portion of the unit is listed as having a unit attached to simulate the heat transfer through the wall to the connecting unit and different wall properties per BEoptE+. Additionally, neighboring homes were placed 20 ft away (6 m) from the modeled unit to simulate the proximity of other homes to the unit.

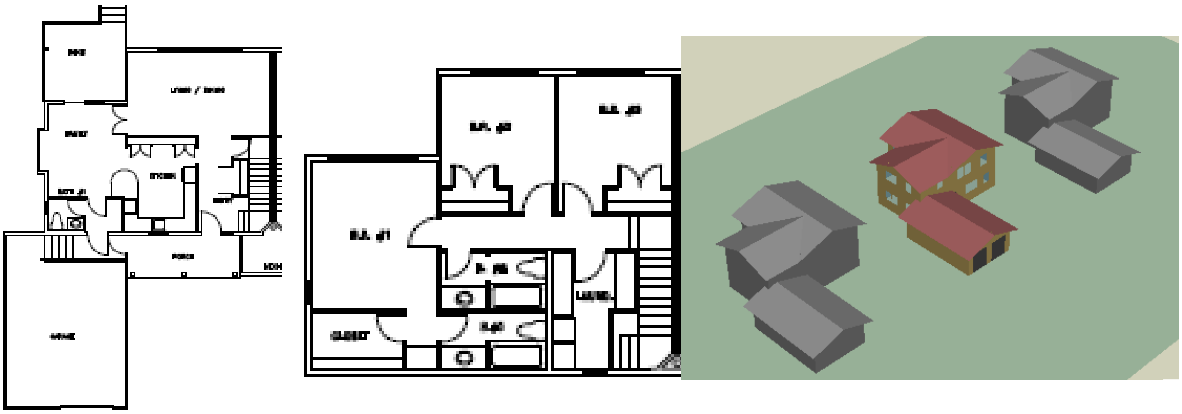

Figure 1 (a) The three bedroom duplex first floor plan, (b) second floor plan part, and (c) representative model layout of Figure 1.

Inputs. The current envelope for the existing units was R-21 (R-3.7 m^2K/W) batt with 2x6 inch (38x140 mm) 16-inch (40.6 cm) on-center studs and an additional one inch of foam on the exterior. The attic insulation was R-45 cellulose blown-in and then vented to eliminate moisture issues. The units had vented crawl spaces with R-30 (R-5.3 m^2K/W) insulation in between the floor joists and two inches of rigid insulation on the inside of the exterior concrete foundation walls.

The owner specified decent large appliances as the base standard: conventional electric range, ENERGY STAR top load freezer, ENERGY STAR dishwasher, an ENERGY STAR washing machine, and a conventional electric dryer. The contractor has the option to improve the base standard appliances installed. The plug loads are specified at 1 W/ft^2 (10.76 W/m^2) for miscellaneous electrical loads; there are no diesel or gas miscellaneous loads in the unit. Miscellaneous loads cover all plug loads and loads not covered under major appliances. These plug load values are unchanging in the models because they are occupant controlled and not regulated by owner.

The owner completed several blower door tests on existing units in Kodiak with a rate between 11.05 and 14.09 air changes per hour (ACH) at 50 Pa. In BEoptE+, leaky was qualified as 14.5 ACH 50 Pa based on the area of the house. The typical infiltration value was 10.3 ACH 50 Pa. The typical infiltration was the low end of what the owner was achieving at the Aviation Hill homes. For the mechanical ventilation, the house is 100% exhaust.

The occupants of the unit have control of the thermostat for heating, so the model was set at 72°F (22.2°C) per the owner's direction. The cooling was artificially set to 80°F (26.6°C) to ensure that cooling was not called for in the model. Operable windows are employed in the units, so natural ventilation was allowed year-round, as staff mentioned they often find occupants with the windows open in the winter. All of these parameters are unchanging in the models because they are occupant controlled and not regulated by the owner.

The heating is provided via a fuel oil boiler. The hydronic heating is distributed through baseboard heaters in the zone. The owner currently employs the high efficiency System 2000 boiler for heating. The nominal annual fuel utilization efficiency (AFUE) is 85%. Because of the heating-dominated nature of the climate, housing units do not have mechanical cooling. Ceiling fans are not installed either, so natural ventilation is the only means of cooling. The model correctly indicates zero tons cooling capacity and 30 kBtu/hr (8.7 kW) for the heating unit.

For domestic hot water, the fuel oil boiler supplies the hot water. BEoptE+ cannot model the two together, so a standard fuel oil boiler for hot water was used. The assumed 40-gallon (151 L) boiler energy factor is 0.66. Sink aerators and low flow showerheads reduced the miscellaneous hot water loads.

Construction Costs. Costs for materials and construction in Kodiak are known to be significantly different than the continental United States, especially since Kodiak is an island in Alaska. The Department of Defense has developed a "program to unify all technical criteria and standards pertaining to planning, design, construction, and operation and maintenance of real property facilities" (Department of Defense 2012). Military construction, or MILCON, for Base Kodiak has a multiplier of 3.54.

Economic Parameters. Financial parameters significantly affect the outcome of the annual energy-related costs and therefore, the overall savings in the model. For the economic parameters, the DOE discount and inflation rates for 2012 were used according to the federally mandated parameters (Rushing et al. 2012): real rate (excluding general price inflation) at 3.0 %, nominal rate (including general price inflation) at 3.5%, and implied long-term average rate of inflation at 0.5%.

In regards to the mortgage, because this is federally funded housing, the whole cost was paid up front, and there was no interest related to a loan for the project. BEoptE+ allowed for three economic inputs when looking at the mortgage of the home: the mortgage term, the interest rate, and the income tax rate. A mortgage term of zero years yields errors in calculations, so the mortgage was set at a one-year term, with a 3% interest rate without any income tax. This should fundamentally reflect the way the owner pays for the units.

Baseline Model Results. Kodiak is a heating-dominated climate and heating energy was the largest end-use in the unit. There was additional electricity for the heating. Hot water was also a large consumer and generated from the same source as the heating water—the boiler. Lights and appliances consume a small portion of the overall house energy, and while miscellaneous loads are shown to be a contributor to overall energy consumption, this is the area where the owner has the least control over the occupants.

Based on the baseline results and the owner's priorities, focus of the optimizations were placed on the envelope and HVAC system, especially to achieve a reduction in heating energy consumption.

To validate the data, using the same weather data and housing layout, a BEoptE+ model was generated using the existing Building America benchmark model. The B10 Benchmark "defines a new construction (2010) building, based on the 2009 IECC code." USCG is required by federal mandates to at least comply with the IECC 2009.

Energy Model Optimization

Using BEoptE+, energy models were optimized for envelope parameters and HVAC parameters; sensitivity analyses were performed to understand how energy prices and construction costs influenced the final design.

Envelope Optimizations. In regards to envelope, a continuous air barrier in conjunction with appropriate insulation and fenestration values are the areas in which the focus was placed, as this was where the owner has the most control.

The preliminary optimizations looked at various envelope options available when employing a diesel heating option and an electric heating option. Wall options investigated wood stud, double stud, concrete masonry unit, structural insulated panels, and insulating concrete forms at various insulation values. Roof and crawl space insulation values were varied. Window area options were 12% to 18% window-to-wall ratio with double- and triple-pane window options. Infiltration was from typical at 10.3 ACH50 to tightest at 1.9 ACH50, which would require confirmation by a blower door test. Mechanical ventilation was chosen to be either 100% exhaust or energy recovery ventilation. Finally, all other options remained the same as the baseline case; the heating system varied for each optimization as described below.

For the diesel heating option, the fuel oil boiler choice was the typical efficiency at 85% AFUE or the high efficiency boiler at 95% efficiency with hydronic heating distributed through baseboard heaters in the zone.

For the electric heating option, an electric furnace with an AFUE of 98% was selected to investigate what the envelope would be if electric heating was in the unit instead of diesel heating. Additionally, with the removal of the diesel boiler, a standard electric water heater was selected.

For the diesel heating optimization, the minimum cost optimization occurred at 42.1% source energy savings and a difference of 24% reduced annual energy-related costs, which meets the goals of the owner, at an estimated upfront cost of $17,184. The electric heating option shows to be less total life-cycle cost over the baseline model at 42% source energy savings, 27% reduction in annual energy-related costs, and an estimated $12,887 in upfront costs over their base unit. Thus, electric heating is a possible option for Base Kodiak.

Specifically, for the envelope parameters, the minimum cost models for both heating types increased the insulation to 2 inches of exterior foam. The attic insulation increased to the highest value of R-60 (R-10.6 m^2K/W) blown-in insulation, which is an R-10 (R-1.8 m^2K/W) increase over existing insulation. The crawl space insulation increased to R-38 (R-6.7 m^2K/W) over the existing R-30 (R-5.3 m^2K/W) insulation. Overall, this was an increase in envelope insulation in all parts to create the high thermal barrier.

Across all models, the lowest total window area was chosen. Over the base case, double-pane air-filled windows with a medium solar heat gain coefficient (SHGC), double-pane argon windows with a high SHGC were the choice; triple-pane windows, while included, did not factor into the low-cost, high-savings models.

Infiltration decreased to the tightest value. Because of the tight air barrier at 1.9 ACH50, energy recovery ventilation was employed at 50% of ASHRAE Standard 62.2.

HVAC Optimizations. One of the priorities was to look into alternative heating systems over their current diesel boiler. Using the envelope from the envelope optimization, a variety of HVAC parameters were selected to investigate the most cost-effective HVAC combination without the envelope interactions. HVAC options included an AFUE 78% gas furnace, AFUE 92.5% gas furnace, AFUE 98% electric furnace, a variety of heat pumps from seasonal energy efficiency ratio (SEER) 14 to 22 (COP 4.1 to 6.5) and heating seasonal performance factor (HSPF) 7.7 to 10. The SEER 14 (COP 4.1) heat pump with an HSPF 8.2 was the minimum cost option with the most savings with the improved envelope combination. This optimization also employed a premium electric water heater because the house was all electric; the water heater had an energy factor or 0.95.

Sensitivity Analysis. Energy prices in Kodiak can be volatile based on its island location. For this reason, a sensitivity analysis was performed to see how the optimization on envelope and HVAC might change when the electricity and fuel prices increased. A variety of envelope, infiltration, mechanical ventilation, window type, and diesel and electric HVAC inputs were included as input parameters. The analysis was completed for a 10% or 20% increase in just electricity, 10% or 20% increase in just fuel, and then a combination of both. The results in source energy savings per year show that the same savings were yielded for almost all the optimizations despite an increase in energy prices. The minimum cost optimal design did not differ either; annualized energy-related costs varied due to the energy costs varying.

Additionally, a sensitivity analysis was performed on the cost multiplier (CM) because the optimization costs strongly depend on this value and, at 3.54, the value was high compared to typical locations. For comparison, the CM is 1.02 in Colorado. The same optimization parameters were employed as used in the previous analysis. The CM was set at a value of 2, 2.5, and 3. The design only varied in the air barrier tightness value for infiltration.

DESIGN RECOMMENDATIONS

In summary, the optimizations resulted in a recommended design as shown in **Table 1**.

Table 1. Recommended Design vs. Baseline Source Energy Consumption

Category	Baseline Design	Recommended Design
Source Energy Savings Over Baseline	-	58%
Ceiling/Roof: Unfinished Attic	Ceiling R-49 (R-8.6 m^2K/W) Fiberglass Batts (R-19 [R-3.3 m^2K/W] + R-30 [R-5.3 m^2K/W]) Vented	Ceiling R-60 (R-10/6 m^2K/W) Fiberglass Blown-In Vented
Windows: Area and Type	15.0% WWR 2-Pane Low-e NM Air Med.-SHGC	12.0% WWR 2-Pane Low-e NM Argon; U-0.365; SHGC-0.529

Airflow: Infiltration	10.3 ACH50	1.9 ACH50
Airflow: Mechanical Ventilation	Exhaust 100% of ASHRAE 62.2	ERV 50% of A-62.2; Efficiency 0.72
Heating	Fuel Oil 85% AFUE Boiler	SEER 14 HSPF 8.2
Water Heater	Fuel Oil Premium	Electric Premium
Annualized Energy Related Costs	$6,555	$4,481
Percent Annualized Energy-Related Costs Difference from Baseline	-	32%

For the recommend design, the model shows the 58% source energy savings at $4,481 annual energy-related costs per year compared to the $6,555 of the baseline. According to BEoptE+, this could cost up to $25,096 in upfront costs, which is an estimated 3% of the total residence cost, mainly due to the tighter envelope, the heat pump, and the addition of the energy recovery ventilation (ERV). This model yields a site energy use intensity (EUI) for the whole house at 18.8 kBtu/ft^2/yr (59.3 kWh/m^2/yr) compared to the baseline that consumed 45 kBtu/ft^2/yr (142 kWh/m^2/yr). **Figure 2** shows the breakdown of the end uses from the baseline that uses diesel fuel for heating to an all-electric residential unit. Energy dedicated to heating was dramatically reduced.

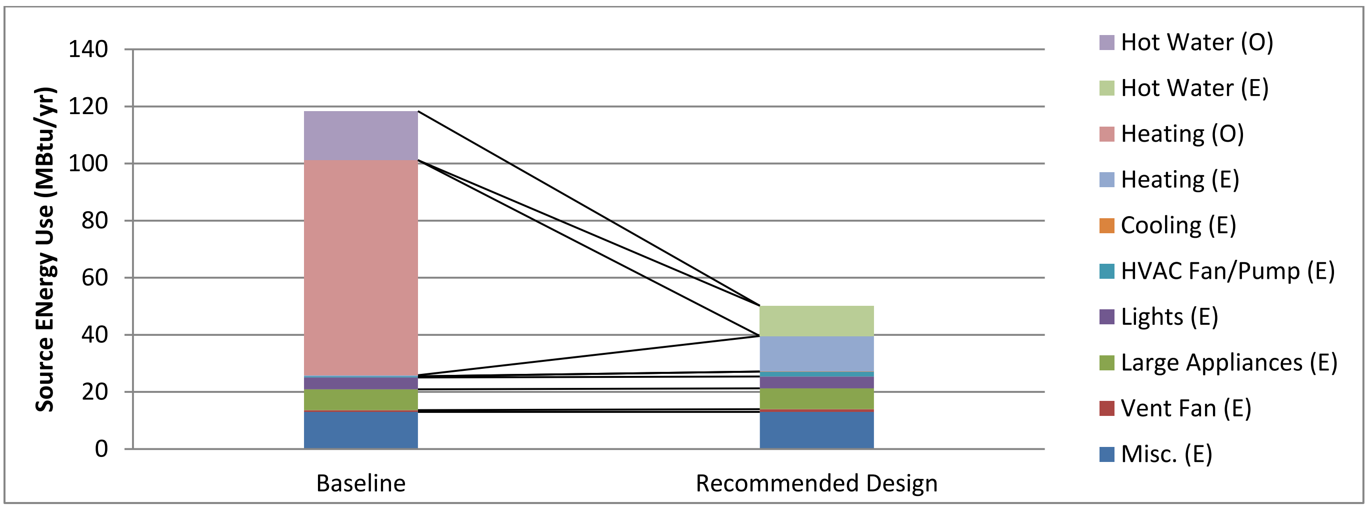

Figure 2 End use comparison of the baseline modeled from existing Aviation Hill units to the recommended design; (O) signifies fuel oil as the end use, while (E) signifies electricity as the energy source.

Design Recommendations

Program recommendations. Based on the expected percent savings and the baseline model's compatibility with the Building America Benchmark, prescribing a HERS rating of 40 at the aggressive end to 50 at the conservative should not be difficult to achieve; a HERS rating of 40 would be 60% more energy efficient than a standard new home constructed today. A less efficient home would have lower upfront costs and the HERS rating would need to be adjusted accordingly.

The overall EUI target could be specified in addition to the LEED certification parameters. The EUI value would help the owner to ensure that the house is being designed to the level of efficiency that the owner expects. To ensure the most accurate EUI goal, an additional study should be conducted of what the homes in Kodiak are truly consuming and then combine that with the ability to save up to 58% with the design recommendations seen here over the baseline. Based on the values here, an EUI target of 20 kBtu/ft^2/yr (63 kWh/m^2/yr) would be aggressive, while 30 kBtu/ft^2/yr (95 kWh/m^2/yr)would be a conservative target.

Envelope recommendations. Modeling incorporated advanced framing with 2x6 in (38x140 mm) walls over 2x4 (38x89 mm) framing, which then allowed for the increase of insulation. Insulation values at either R-19 to R-21 (R-3.3 to

R-3.7 m²K/W) with 1 to 2 in (2.54 to 5 cm) of exterior foam were the top choices. The highest R-value wall option that the model optimized to was the R-19 (R-3.3 m^2K/W) with 2 inches (5 cm) of foam, which was a total assembly R-value of 28.4 (R-5.0 m^2K/W); assembly includes studs, top and bottom plates, corners, and framing around the windows and doors. This value is almost equivalent to current practice. If the staff feels that source energy savings in the residential units is a top priority, then the higher level of insulation levels would be the first step to meeting the goal. This same rule is also relevant for the attic insulation.

Structural insulated panels came up several times as being a cost-effective option with similar savings to the wood stud walls. The owner should investigate if this would be a possibility for the future of Kodiak in terms of materials and construction. Currently, the owner is practicing using wood studs, and there is no need to change at this time.

In regard to the other areas, a small increase in insulation, as shown per the models, at the ceiling level in the crawl space and in the vented attic could help with both comfort and energy consumption.

Infiltration recommendations. The owner had planned to specify 2.0 ACH50 minimum. For the Kodiak residential unit, that is equivalent to 0.27 cfm/ft^2 (0.0014 $m^3/s/m^2$) at a 50 Pa difference between the inside and outside. Decreasing the infiltration in the unit is directly related to the heating requirements; by providing a tighter air barrier, the residential unit requires less heat. This energy conservation measure was employed in all optimizations to some level, from tight to tightest, depending on the type of heating. Tightest was a value of 1.9 ACH50 for this unit. As the air barrier and the tightness improve in the unit, exhaust air becomes a concern. The optimizations showed that when the tightness increases, then the ERV becomes an integral part of the ventilation. The current 2.0 ACH50 is an excellent target and staff should ensure that the homes reach this air-tightness level via air barrier testing during construction.

Space conditioning recommendations. The electric heat pump was the optimal result for the optimizations. The owner hopes to have all-electric units, which is a major change from the prior existing Aviation Hill residential units in Kodiak. All-electric units will ensure an air source heat pump, which yielded more savings at 58%. Currently, the ENERGY STAR label requires units to have a SEER value of 12 (COP 3.5) or greater and HSPFs of 7 or greater. Starting Jan. 1, 2015, the new minimum efficiency standard for split system heat pumps will be SEER 14 (COP 4.1) and 8.2 HSPF (McCrudden 2011). In colder climates, staff should focus on getting the highest HSPF feasible (Energy.gov 2012).

CONCLUSION

The owner has done an excellent job implementing high efficiency equipment and envelope. For the residential units, there is an opportunity to improve the design for improved energy efficiency for the life of the home. The unique fuel combination that Kodiak, Alaska, employs brings down the life-cycle costs of electric heating and assists the owner with decreasing the need to fill diesel boiler tanks at housing units. The owner can definitely achieve source energy savings over the current homes on Aviation Hill that were used as the baseline for modeling here.

This study successfully influenced the design for new housing in Kodiak and is expected to provide greatly enhanced energy performance, along with building durability and occupant comfort. The recommended measures for air tightness, wall assemblies, insulation levels, and HVAC systems have informed the basis of design to ensure that the owner cost-effectively builds low load homes that can withstand the harsh Kodiak climate. The study was used to provide prescriptive requirements to the Design Build contractor to ensure that USCG achieved at least LEED Silver Certification by achieving the credits that are most important to USCG in Kodiak. The study confirmed that the point-of-use energy cost of electricity is lower than that of heating oil in Kodiak, and it supported the desire of the owner to cost-effectively build all-electric homes that use renewable hydroelectric and wind power as opposed to fossil fuels for space heating. The comprehensive optimization analysis will impact the design of USCG housing projects throughout the northwest.

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