ENERGY SAVINGS FROM WINDOW SHADES

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HunterDouglas®

ROCKY MOUNTAIN INSTITUTE

PREPARED FOR:
Hunter Douglas
Honeycomb Business Unit
1 Duette Way
Broomfield, CO 80020

Stacy Lambright
stacy.lambright@hunterdouglas.com
303-876-3506

PREPARED BY:
Rocky Mountain Institute
1820 Folsom St.
Boulder, CO 80302
P: (303) 245-1003
www.rmi.org

Hayes Zirnhelt
hzirnhelt@rmi.org

Brett Bridgeland
bbridgeland@rmi.org

Phil Keuhn
pkeuhn@rmi.org

EXECUTIVE SUMMARY

Windows are a primary contributor to heating and cooling loads in U.S. residences, due to conductive heat loss in the heating season and unwanted conductive and solar heat gain in cooling season. Insulating window shades, can reduce window heat transfer, and if used effectively, reduce unwanted solar heat gain without reducing useful winter solar heat gain. Using test data provided by Hunter Douglas, RMI evaluated the potential energy savings of three Hunter Douglas products in representative new and existing houses in the US, through detailed whole building energy simulation. In addition, using the energy simulation model, we quantified several other benefits, including thermal comfort, potential for HVAC equipment downsizing, and electricity demand reductions.

Though results will vary for individual homes, this study demonstrates that insulating, honeycomb shades have potential to significantly reduce residential heating and cooling energy consumption, while also improving thermal comfort, reducing peak electricity demand and even potentially reducing cooling equipment size. Tables ES1 and ES2 list the maximum savings potential for new and existing homes, compared to homes with no window coverings, for the Duette® Architella® Trielle™ shade with production fit and operated per Hunter Douglas's Green Mode schedule. Results are based on PNNL's prototypical home model, a 2400 square foot, slab-on-grade home with 357 square feet of window area. Miami, Phoenix and Washington D.C. homes are assumed to have electric heating, and all other locations have natural gas furnaces. This study presents annual energy bill savings, but has not included analysis of the costs of shades or net costs of shades as an energy efficiency investment.

TABLE ES1: MAX SAVINGS IN NEW HOMES (Trielle - Production Fit - HD Green Mode)	Max Home Energy Savings	Max Energy Bill Savings	Max Heating Savings	Max Cooling Savings
Miami	5%	$120	9%	15%
Phoenix	7%	$180	11%	18%
San Francisco	4%	$60	10%	57%
Washington DC	6%	$180	8%	25%
Chicago	5%	$110	6%	26%
Denver	6%	$100	10%	25%
Minneapolis	6%	$110	9%	27%
Aspen	6%	$90	9%	44%
Anchorage	5%	$100	8%	--

TABLE ES2: MAX SAVINGS IN EXISTING HOMES (Trielle - Production Fit – HD Green Mode)	Max Home Energy Savings	Max Energy Bill Savings	Max Heating Savings	Max Cooling Savings
Miami	16%	$580	4%	26%
Phoenix	17%	$830	8%	28%
San Francisco	10%	$410	5%	66%
Washington DC	12%	$620	11%	35%
Chicago	7%	$300	6%	33%
Denver	9%	$290	9%	34%
Minneapolis	7%	$270	7%	35%
Aspen	8%	$270	8%	51%
Anchorage	6%	$260	7%	--

As demonstrated in this study, results vary with location, extent of installation, operation, house design and performance characteristics. Reducing the edge gap around the shade is also shown to provide significant additional savings, above a standard production edge gap.

In addition to the energy savings potential, we found the following additional benefits (evaluated for Denver only):

- Peak Electrical Demand reductions: 0.3 kW (9%) reduction for a new home, and 0.9 kW (15%) reduction for an existing home
- Increased thermal comfort: In the summer occupants may perceive comfort equivalent to a 2°F lower air temperatures, and 1°F warmer temperature in the winter
- Potential for smaller air-conditioning equipment: new or replacement AC units may be able to be reduced by 0.5 tons

As a result of this study, RMI has developed the following recommendations for further development related to the energy efficiency window covering space:

1. Develop a simple calculator to convey potential energy savings to homeowners
2. Translate future test results into standardized energy model inputs
3. Explore future control options such as responsive or predictive controls to tie into the budding smart home industry.

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1. INTRODUCTION

Hunter Douglas (HD) commissioned the Rocky Mountain Institute (RMI) to perform this study around the energy savings potential of the Duette® Architella® line of insulating, honeycomb window shades in typical homes in the US. A similar study was performed by RMI in 2008, albeit of smaller scope and around a different HD product. This study models three current HD products, featuring the Duette Architella Trielle™, Elan® and Reception fabrics, for which HD has performed thermal testing using a Guarded Hot Box. It also improves upon the prior study by addressing all U.S. ASHRAE climate zones, using the latest building energy modeling software (DOE's EnergyPlus), presenting a greenhouse gas emissions savings metric, modeling current new and existing home characteristics and testing several different application and operation scenarios.

Pursuant to RMI's programs around residential energy efficiency and the general scaling of building energy efficiency, this report also explores ancillary value propositions beyond electricity or gas consumption savings, such as thermal comfort, peak demand reduction and cooling equipment capacity reduction. We also suggest some areas for future development.

2. MODELING METHODOLOGY

We conducted our analysis using whole-building models for typical new and existing homes at each of the selected locations using EnergyPlus v8.3. EnergyPlus is a state of the art simulation engine developed by the Department of Energy (DOE), which carries out detailed sub-hourly timestep calculations to calculate building energy flows, temperatures and other performance metrics Typical Meteorological Year (TMY) weather data was for each location assessed.

2.1 LOCATIONS

Homes were modeled in representative cities from each of the eight ASHRAE climate zones: Miami, FL (Zone 1); Phoenix, AZ (2); San Francisco, CA (3); Washington D.C. (4); Chicago, IL (5); Denver, CO (5); Minneapolis, MN (6); Aspen, CO (7); and Anchorage, AK (8). One location, Denver, CO, was subject to further analysis, including peak electricity load reduction and the effects of partial window coverage.

2.2 BASE MODELS

For new homes, we used the Residential Prototype Building EnergyPlus models developed by Pacific Northwest National Laboratory (PNNL), which were developed for purposes of simulating energy savings associated with energy codes and standards. For each location, we used the model representing the applicable state's 2012 IECC code-compliant home, with slab-on-grade construction. The most common heating equipment was used for each location— electric resistance for zones 1, 2 and 4 and a natural gas furnace for the rest. The models are all for a two-story, 2400 square foot, single-family residence with a 0.15 glazing-to-floor-area ratio. Window, wall, roof and other properties vary by location. Table 1, below, provides a summary of key assumptions. See Table 1 in Appendix B for the complete list of characteristics for baseline new and existing home models.

TABLE 1: SUMMARY OF MODEL ASSUMPTIONS

General Description	2-story, square floor plate, slab-on-grade, gabled roof, 3 occupants
Conditioned Area	2400 sf
Glazing Area	357 sf (0.15 glazing-to-floor-area ratio); Equal distribution on all sides.
Heating System	Miami, Phoenix, Washington DC: Electric; Other Locations: Gas Furnace. See Appendix B for Efficiency.
Cooling System	Single Speed Direct Expansion Air Conditioner. See Appendix B for Efficiency.
Exterior Shading	None
Glazing	Double-paned. R-value and SHGC varies by location and vintage. See Appendix B.
Opaque Surfaces	Varies by location and vintage. See Appendix B.
Infiltration	Varies by location and vintage. See Appendix B.
Natural Ventilation	None. It is assumed that occupants do not open windows to provide free cooling

For existing homes, we started from the same PNNL new home model, but changed several key characteristics to reflect an older, less energy-efficient home: lower furnace efficiency, lower cooling coefficient of performance (COP), increased infiltration, lower wall thermal resistance (R-value), lower window R-value and increased window solar heat gain coefficient (SHGC).

For both new and existing homes, we made two adjustments to the original PNNL models in order to define an adjusted baseline, against which we make all energy savings comparisons. We removed the window blinds, so that our comparisons are all against a home that has no window coverings or that leaves coverings always open. We also linked a portion of the interior lighting operation to a daylight sensor that turns lights on and off based on indoor light levels in order to simulate the impact of reduced natural daylight that would require occupants to turn on electric lights. Tests we carried out on our baseline models show that adding standard, low-performace venetian blinds, which are always closed, have a small impact on home energy, actually increasing home energy 1-2% for new homes and 2-3% for existing homes. We did not test any other blind operation schedules. The small increase in electric lighting due to room darkening by shades—less than half a percent of overall home energy— is much smaller that the heating and cooling savings seen from insulating shades, and the rapidly increasing market share of LEDs for residential lighting is expected further minimize any such offset in energy savings associated with increased lighting energy consumption.

2.3 LOCAL UTILITY PRICES AND EMISSIONS

We used the statewide average electricity and gas prices published monthly by the U.S. Energy Information Administration (EIA).[1,2] These prices are average prices per unit of delivered energy, and due to local variability of billing schemes, we did not

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[1] Electricity prices: http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

differentiate energy charges from connection fees, demand charges or time of use pricing. For electricity-related greenhouse gas emissions, we used the emissions rates, given in lbCO_2e/MWh, published under the U.S. Department of Energy's Emissions & Generation Resource Integrated Database (eGRID).[3] See Table 2 in Appendix B for all assumed energy prices and emissions factors.

2.4 OPERATION SCENARIOS

Because energy savings from window coverings is heavily dependent upon the extent of application and operation schedule, several scenarios were tested. For all locations, scenarios were tested with all windows on all orientations being:
a) always covered,
b) operated according to HD's Green Mode automation schedules (see Appendix C for details) and,
c) always covered in summer and according to HD's Green Mode during winter.

For Denver only, we performed a deeper analysis and included additional partial-coverage schemes, with Trielle production fit shades operated per the HD Green Mode schedule and applied as follows:
d) 75% of windows covered, evenly distributed on each orientation
e) 50% of windows covered, evenly distributed on each orientation
f) 25% of windows covered, evenly distributed on each orientation
g) north completely covered
h) east completely covered
i) south completely covered
j) west completely covered
k) south and west orientations completely covered and
l) north and east orientations completely covered.

For the 75%, 50% and 25% coverage scenarios, two different arrangements were tested, using different combinations of first- versus second-floor windows, to check for model sensitivities. Complete results for all scenarios can be found in Appendix A: Detailed Results.

2.5 SHADE PROPERTIES

This study uses the shade performance properties provided by Hunter Douglas, which were the results of their internal physical testing under specific test conditions, for each of the three products and for both the production-fit and best-fit edge gap. Specifically, these properties were R-value, SHGC, which enabled us to use the WindowMaterial:SimpleGlazingSystem object within EnergyPlus to model the window with and without shades. This procedure is explained in more in section 5.3, including some suggestions for improving and simplifying the modeling of shades for energy modeling professionals.

3. CORE RESULTS

The results of this energy modeling study indicate that insulating window coverings can provide significant energy savings for a typical home and, depending on the home, could save hundreds of dollars per year in utility bills.

When a home is in cooling mode, it is advantageous to close shades as much as possible, keeping out solar gain and reducing conductive heat gain. This reduces air conditioning (A/C) electricity and represents a large economic and greenhouse gas savings opportunity because of the high price of electricity and high emissions from electricity generation relative to other home energy options. This also applies to electric heating. During cooling season, shades can also help reduce peak electricity demand, which is advantageous to utilities as they strain to meet peak demand during the hottest hours of the year.

Heating season is more complicated, and our results show that it is important to open shades when there is advantageous direct sunlight available on the window. Natural gas prices are currently relatively low, as are typically-assumed greenhouse gas emissions factors for natural gas. So for homes with natural gas, economic and environmental benefits in heating season are somewhat less pronounced than in cooling season. However, there is still a significant opportunity for savings, and furnace fan electricity can actually be a significant factor in the savings equation as well, as evident in the baseline loads shown in Figure 1 and 2, below.

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[2] Natural gas prices: http://www.eia.gov/dnav/ng/ng_pri_sum_a_epg0_prs_dmcf_m.htm

[3] Electricity emissions: http://www.epa.gov/cleanenergy/energy-resources/egrid/

3.1 SUMMARY OF RESULTS

Figures 3 through,10 below, summarize findings related to annual energy savings for the Trielle product operated according to the HD Green Mode. The other two production fit products analyzed, Reception and Elan, had fairly similar results, generally following the trends illustrated for Trielle. For complete, detailed results, refer to Appendix A.

Savings are larger for existing homes than new homes. Presented in absolute terms, energy bill and CO_2 savings in heating-dominated climates are more than double for existing homes compared to new homes. In cooling climates, they are more than triple. As a percent of total home energy, existing homes also see larger savings, especially in cooling-dominated climates where the lower solar heat gain coefficient of existing windows leaves more room for improvement by window shades.

Windows are typically the largest component of a home's cooling load, with direct solar gain being the largest factor, especially if the windows have a higher solar heat gain coefficient. Thus, we see very large percent cooling reductions from adding high performance shades. In most climates heating savings, expressed as a percent, are more modest than cooling, as shown in Figure 5 and 6. This is because a home's baseline heating loads are more evenly shared between window conductive losses, wall conductive losses and infiltration. But in absolute energy unit terms, heating savings are much larger for heating-dominated climates, as shown in Figures 3 and 4 that are dominated by heating.

Operation schedules have a major impact on the level of savings. As indicated in Figure 11, in Denver keeping shades always closed actually causes heating energy to increase, as it prevents passive solar heating when the sun shines directly onto windows. The HD Green Mode schedule greatly improves heating, but it cuts cooling savings in half because it leaves windows uncovered at inopportune times.[4] We tested a third option that used the HD Green Mode in winter and kept shades always closed during the cooling-dominated months of June through September. While not perfectly optimized, this schedule was able to regain much of the cooling savings, and it suggests that a schedule optimized solely for thermal performance would keep shades closed during all cooling hours.

Cooling loads in San Francisco and Aspen are relatively small in magnitude, making them heavily sensitive to factors such as local microclimates, building thermal mass, opening windows, cloud cover and site shading, as well as interior window coverings, as shown in our results. Mechanical air conditioning is less common in these locations. While relatively small in magnitude, the high cooling percent savings suggest that window coverings could help eliminate the need to install any mechanical A/C equipment in these locations.

[4] It should be noted that the HD Green Mode was designed not solely for thermal performance, but rather strikes a balance between thermal optimization and a user's desire for natural daylight and views.

Figure 1: Baseline Building Energy Loads (Without Window Attachments)
New Homes

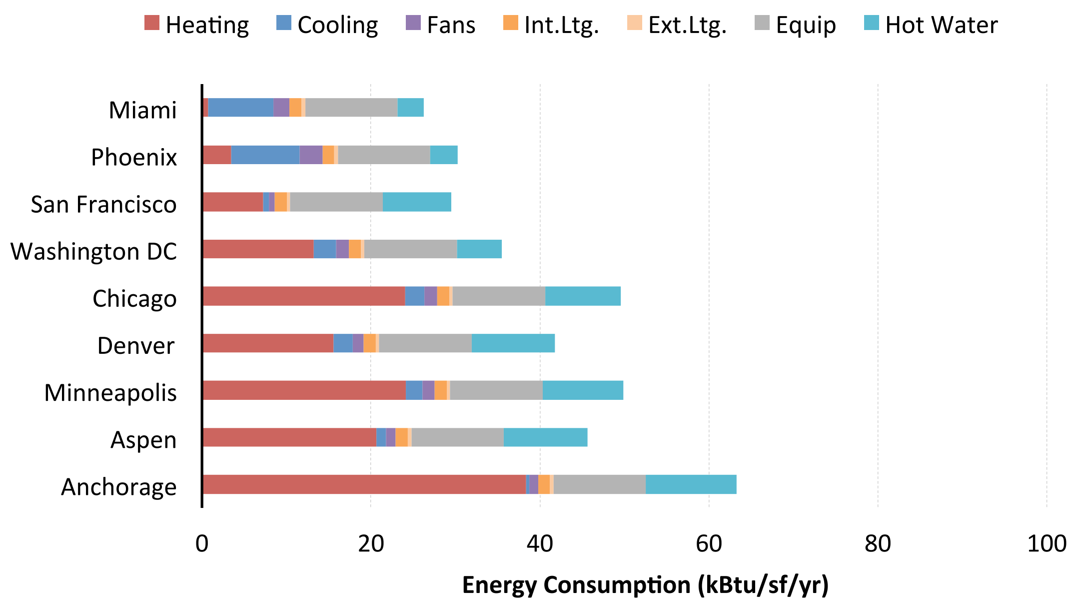
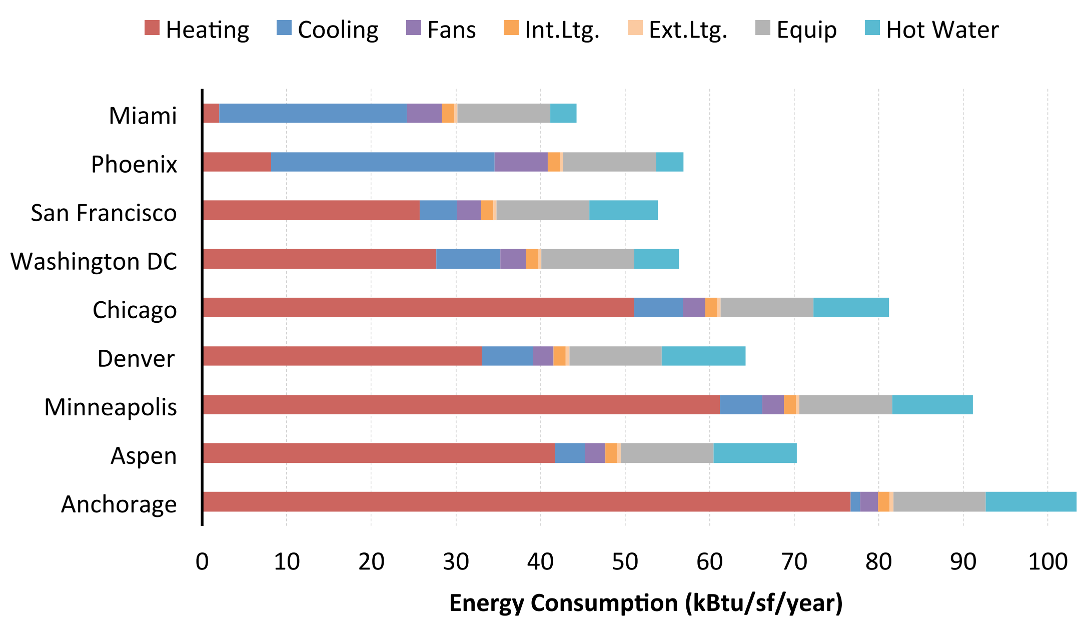


Figure 2: Baseline Building Energy Consumption (Without Window Attachments)
Existing Homes



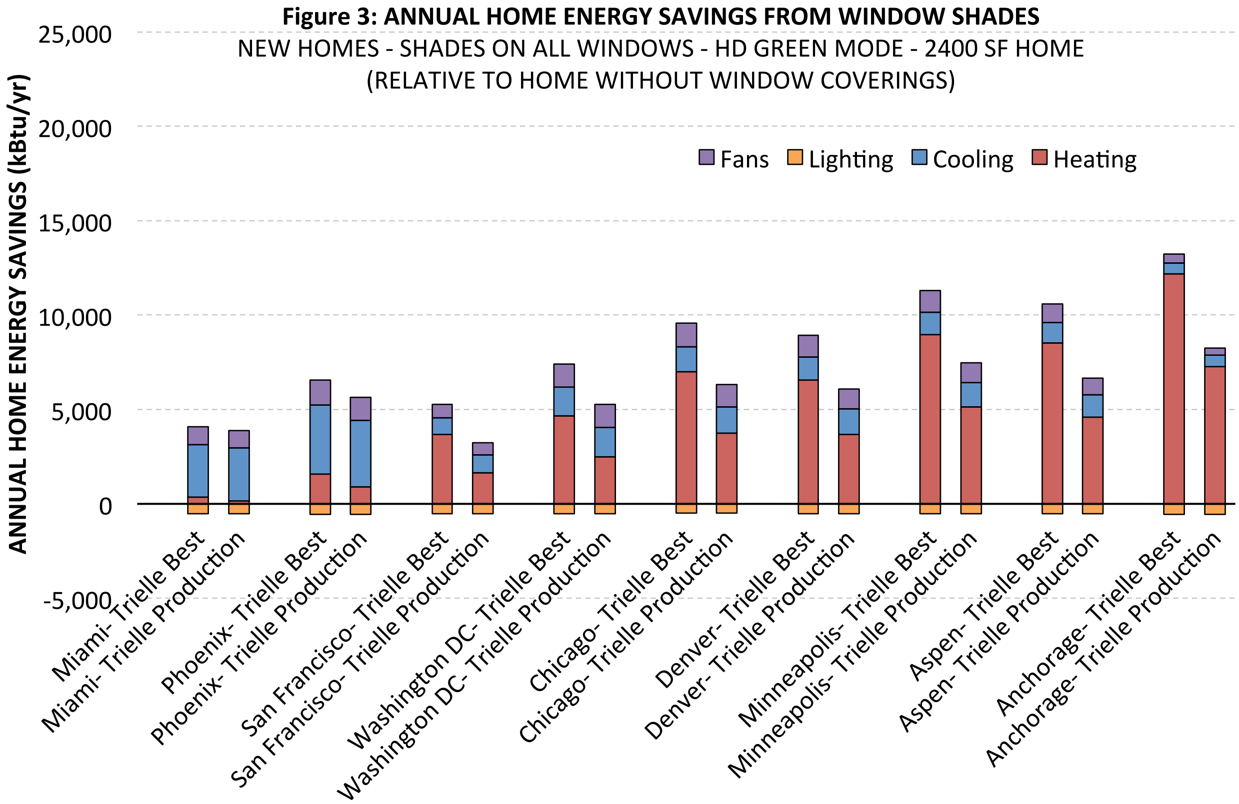


Figure 3: ANNUAL HOME ENERGY SAVINGS FROM WINDOW SHADES
NEW HOMES - SHADES ON ALL WINDOWS - HD GREEN MODE - 2400 SF HOME
(RELATIVE TO HOME WITHOUT WINDOW COVERINGS)
ANNUAL HOME ENERGY SAVINGS (kBtu/yr)
25,000
20,000
15,000
10,000
5,000
0
-5,000
Fans
Lighting
Cooling
Heating
Miami- Trielle Best
Miami- Trielle Production
Phoenix- Trielle Best
Phoenix- Trielle Production
San Francisco- Trielle Best
San Francisco- Trielle Production
Washington DC- Trielle Best
Washington DC- Trielle Production
Chicago- Trielle Best
Chicago- Trielle Production
Denver- Trielle Best
Denver- Trielle Production
Minneapolis- Trielle Best
Minneapolis- Trielle Production
Aspen- Trielle Best
Aspen- Trielle Production
Anchorage- Trielle Best
Anchorage- Trielle Production

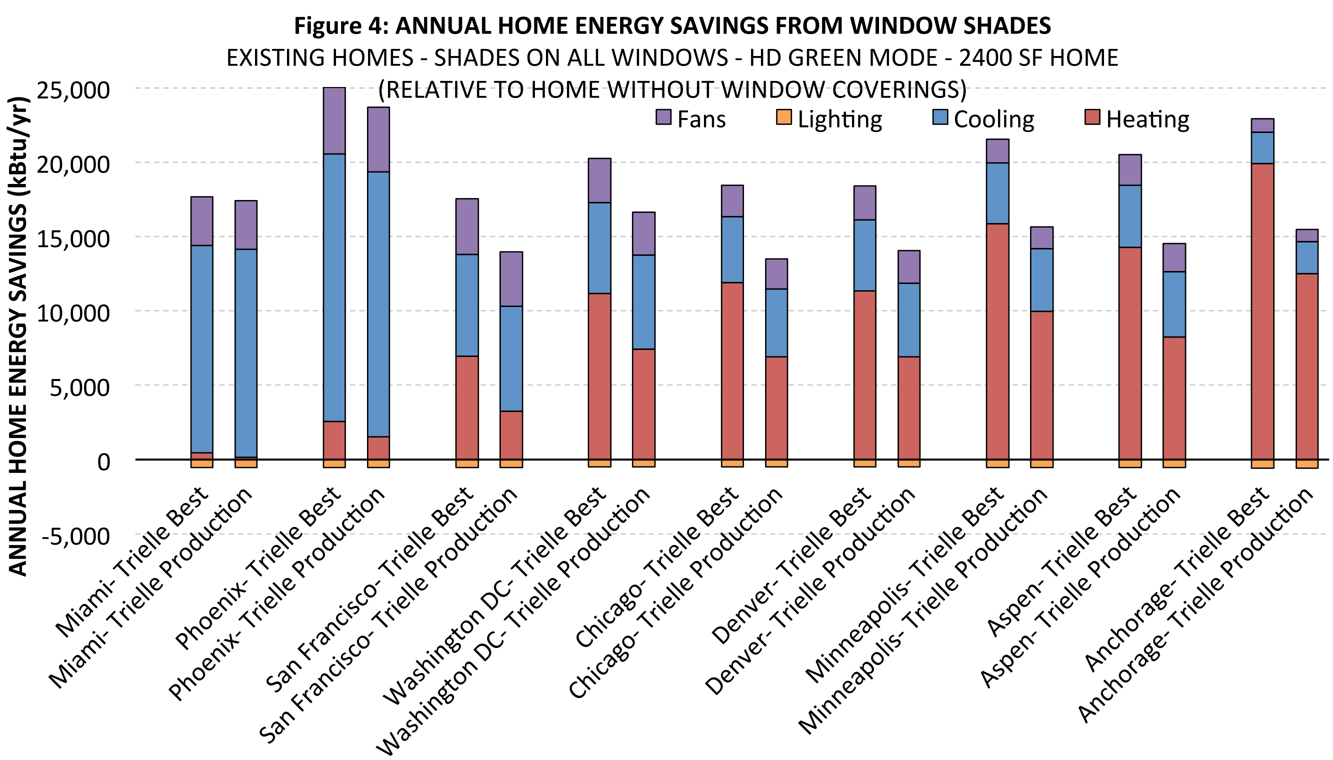


Figure 4: ANNUAL HOME ENERGY SAVINGS FROM WINDOW SHADES
EXISTING HOMES - SHADES ON ALL WINDOWS - HD GREEN MODE - 2400 SF HOME
(RELATIVE TO HOME WITHOUT WINDOW COVERINGS)
ANNUAL HOME ENERGY SAVINGS (kBtu/yr)
25,000
20,000
15,000
10,000
5,000
0
-5,000
Fans
Lighting
Cooling
Heating
Miami- Trielle Best
Miami- Trielle Production
Phoenix- Trielle Best
Phoenix- Trielle Production
San Francisco- Trielle Best
San Francisco- Trielle Production
Washington DC- Trielle Best
Washington DC- Trielle Production
Chicago- Trielle Best
Chicago- Trielle Production
Denver- Trielle Best
Denver- Trielle Production
Minneapolis- Trielle Best
Minneapolis- Trielle Production
Aspen- Trielle Best
Aspen- Trielle Production
Anchorage- Trielle Best
Anchorage- Trielle Production

Figure 5: HEATING & COOLING PERCENT SAVINGS FROM WINDOW SHADES
NEW HOMES - MAXIMUM SAVINGS SCENARIO
(SHADES ON ALL WINDOWS, OPERATED IN HUNTER DOUGLAS GREEN MODE)

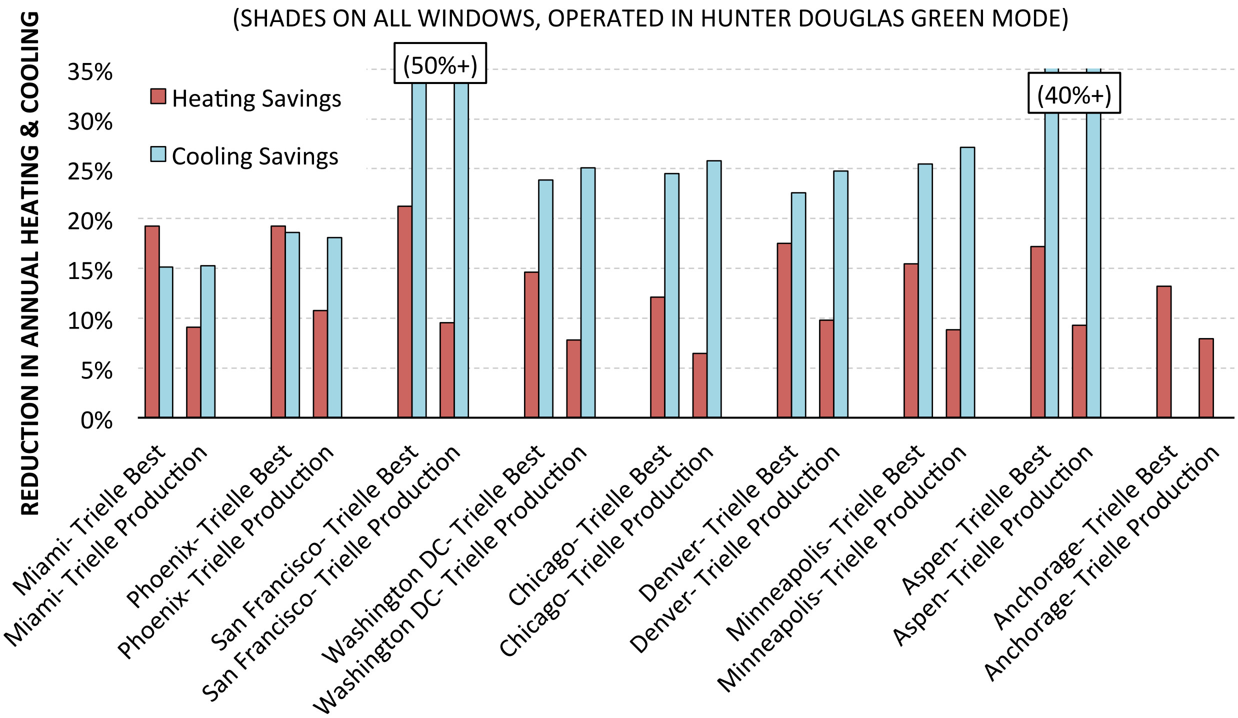
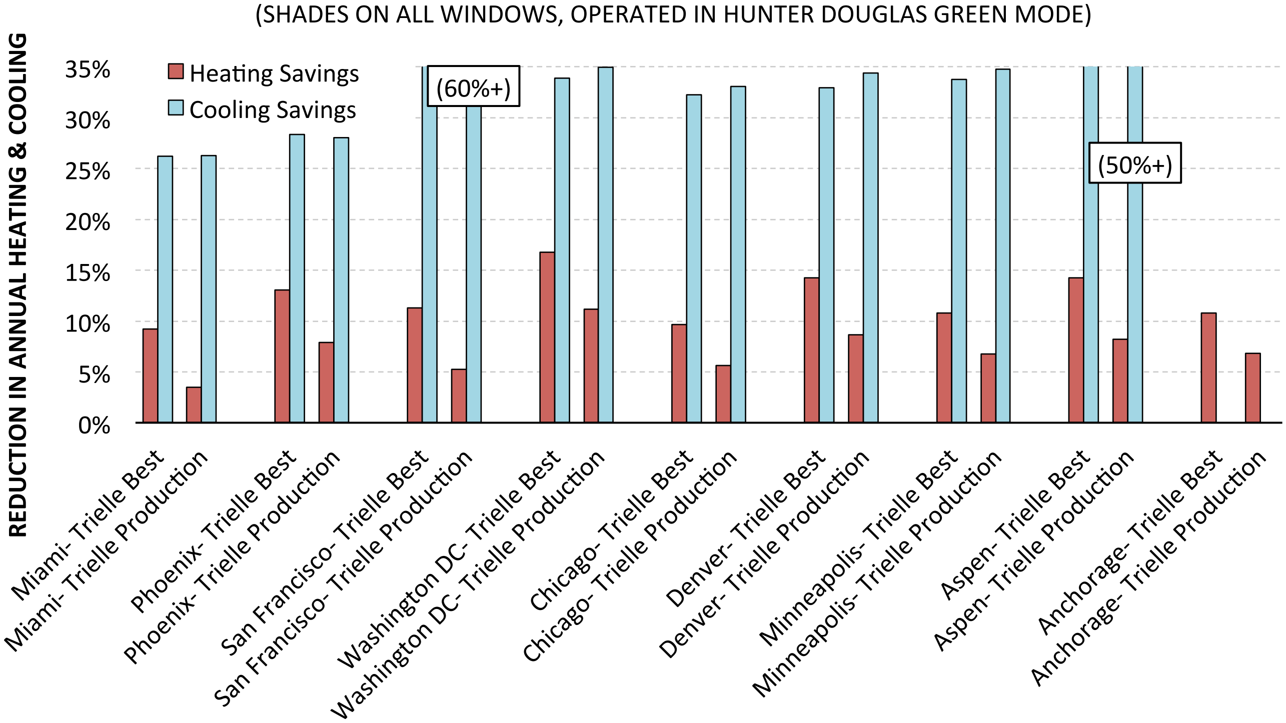


Figure 6: HEATING & COOLING PERCENT SAVINGS FROM WINDOW SHADES
EXISTING HOMES - MAXIMUM SAVINGS SCENARIO
(SHADES ON ALL WINDOWS, OPERATED IN HUNTER DOUGLAS GREEN MODE)



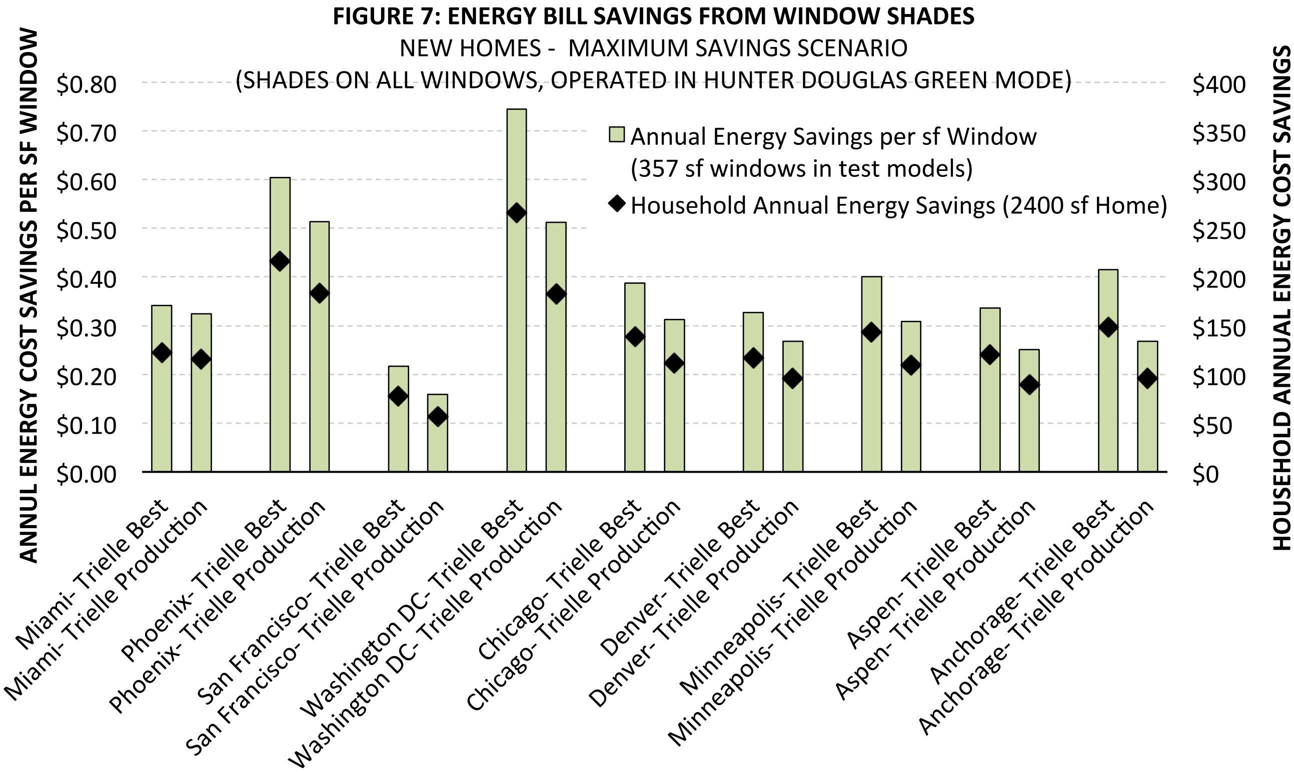


FIGURE 7: ENERGY BILL SAVINGS FROM WINDOW SHADES
NEW HOMES - MAXIMUM SAVINGS SCENARIO
(SHADES ON ALL WINDOWS, OPERATED IN HUNTER DOUGLAS GREEN MODE)
Annual Energy Savings per sf Window (357 sf windows in test models)
Household Annual Energy Savings (2400 sf Home)
ANNUL ENERGY COST SAVINGS PER SF WINDOW
HOUSEHOLD ANNUAL ENERGY COST SAVINGS
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
$400
$350
$300
$250
$200
$150
$100
$50
$0
Miami- Trielle Best
Miami- Trielle Production
Phoenix- Trielle Best
Phoenix- Trielle Production
San Francisco- Trielle Best
San Francisco- Trielle Production
Washington DC- Trielle Best
Washington DC- Trielle Production
Chicago- Trielle Best
Chicago- Trielle Production
Denver- Trielle Best
Denver- Trielle Production
Minneapolis- Trielle Best
Minneapolis- Trielle Production
Aspen- Trielle Best
Aspen- Trielle Production
Anchorage- Trielle Best
Anchorage- Trielle Production

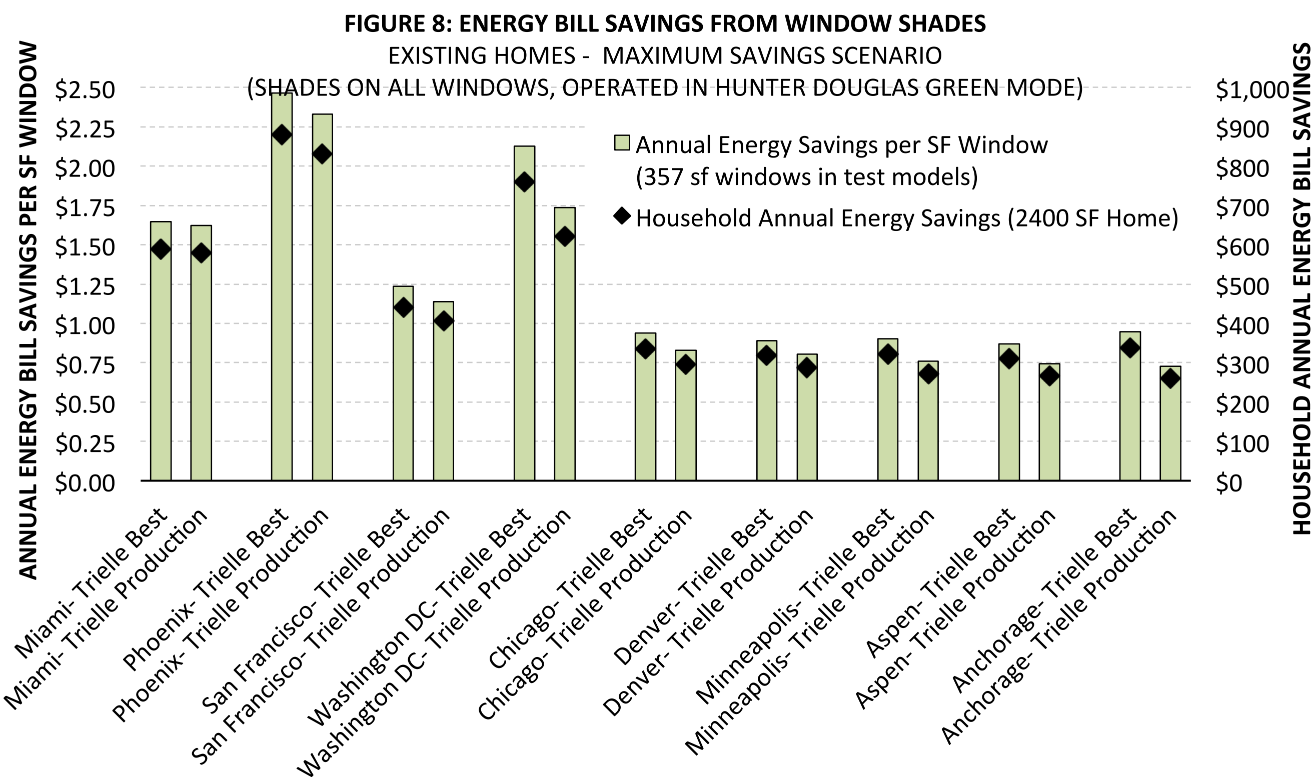


FIGURE 8: ENERGY BILL SAVINGS FROM WINDOW SHADES
EXISTING HOMES - MAXIMUM SAVINGS SCENARIO
(SHADES ON ALL WINDOWS, OPERATED IN HUNTER DOUGLAS GREEN MODE)
Annual Energy Savings per SF Window (357 sf windows in test models)
Household Annual Energy Savings (2400 SF Home)
ANNUAL ENERGY BILL SAVINGS PER SF WINDOW
HOUSEHOLD ANNUAL ENERGY BILL SAVINGS
$2.50
$2.25
$2.00
$1.75
$1.50
$1.25
$1.00
$0.75
$0.50
$0.25
$0.00
$1,000
$900
$800
$700
$600
$500
$400
$300
$200
$100
$0
Miami- Trielle Best
Miami- Trielle Production
Phoenix- Trielle Best
Phoenix- Trielle Production
San Francisco- Trielle Best
San Francisco- Trielle Production
Washington DC- Trielle Best
Washington DC- Trielle Production
Chicago- Trielle Best
Chicago- Trielle Production
Denver- Trielle Best
Denver- Trielle Production
Minneapolis- Trielle Best
Minneapolis- Trielle Production
Aspen- Trielle Best
Aspen- Trielle Production
Anchorage- Trielle Best
Anchorage- Trielle Production

FIGURE 9: OVERALL HOME ENERGY & CO2 SAVINGS FROM WINDOW SHADES

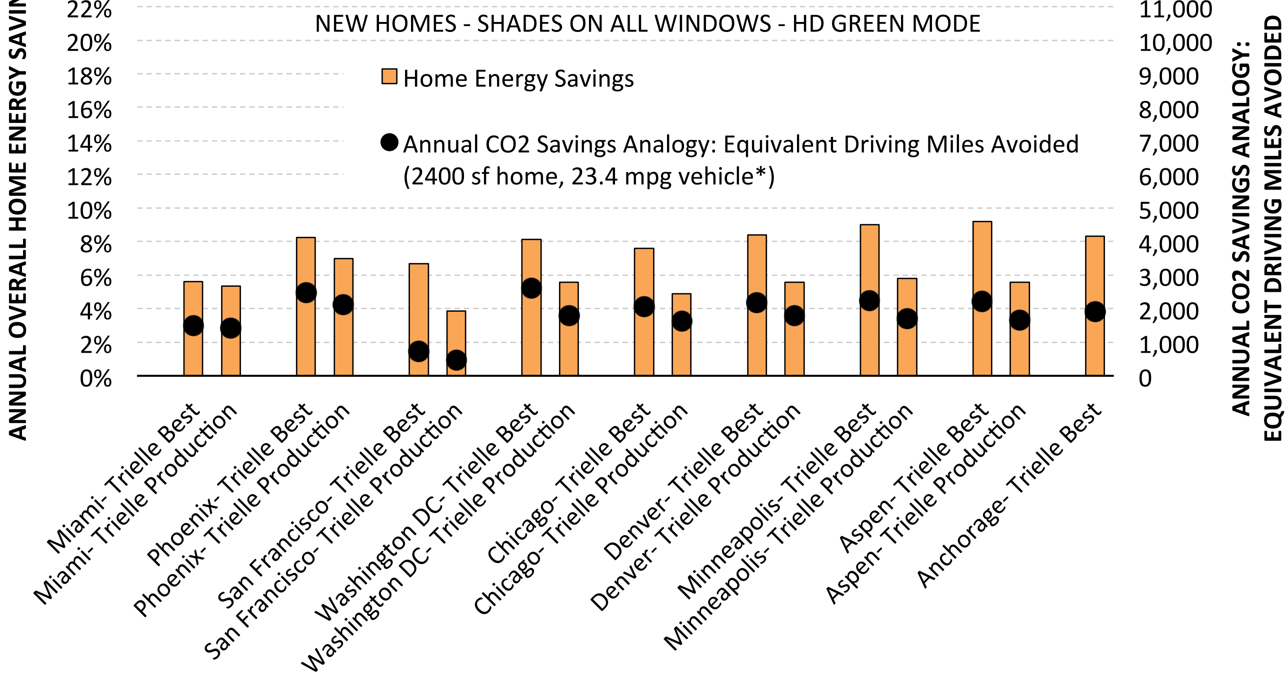
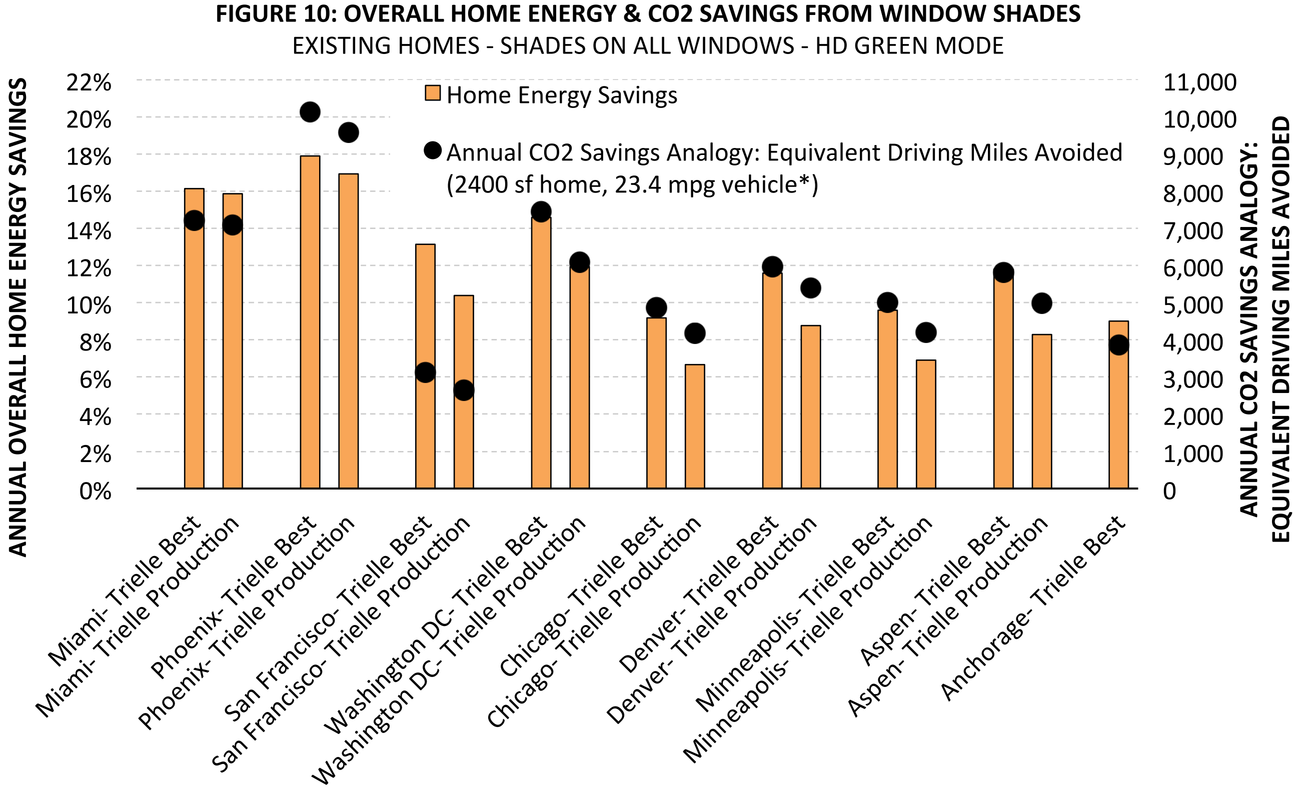
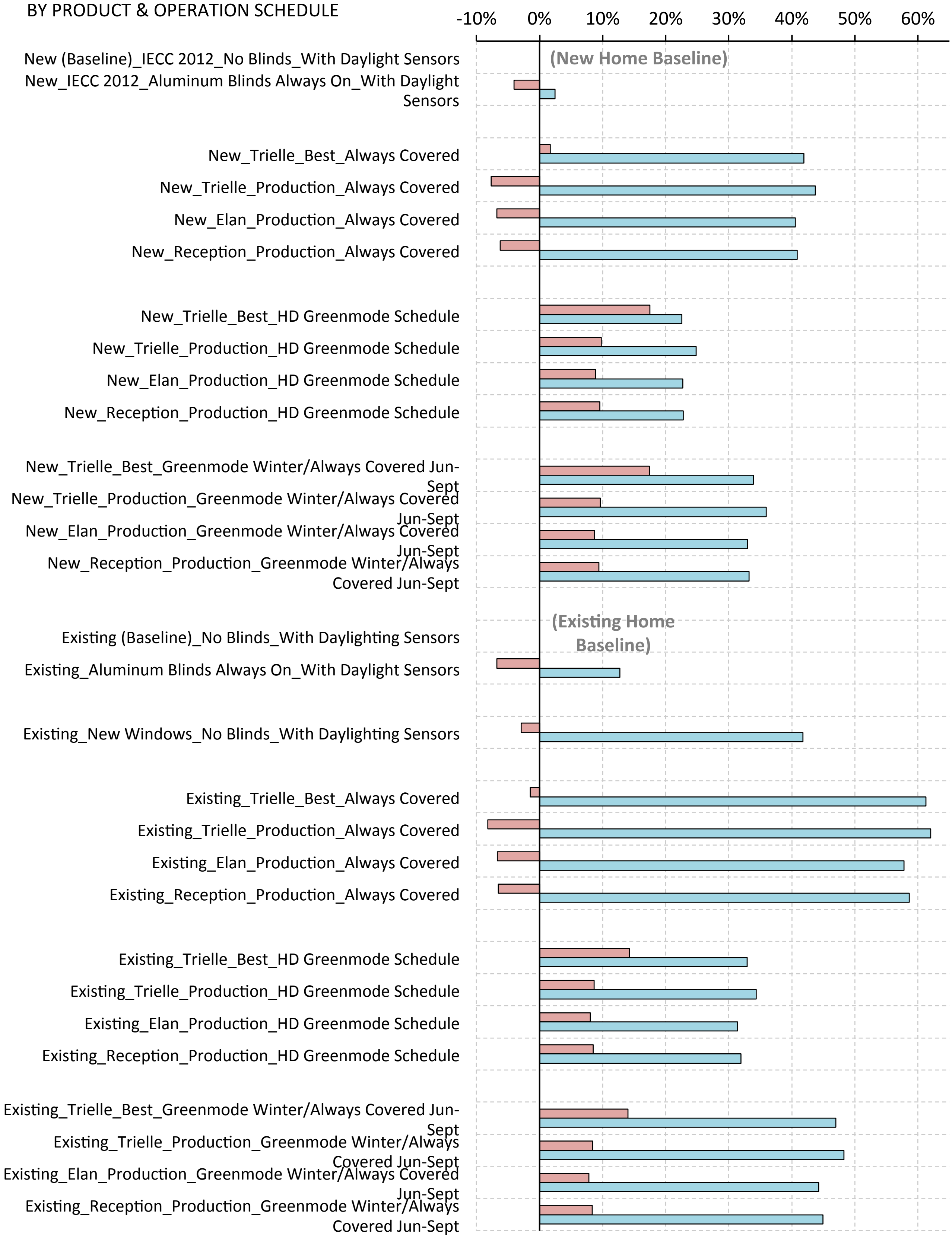


FIGURE 10: OVERALL HOME ENERGY & CO2 SAVINGS FROM WINDOW SHADES



* U.S. average fuel economy for small wheel base vehicles, from:
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

FIGURE 11 - ANNUAL HEATING & COOLING SAVINGS IN DENVER
BY PRODUCT & OPERATION SCHEDULE

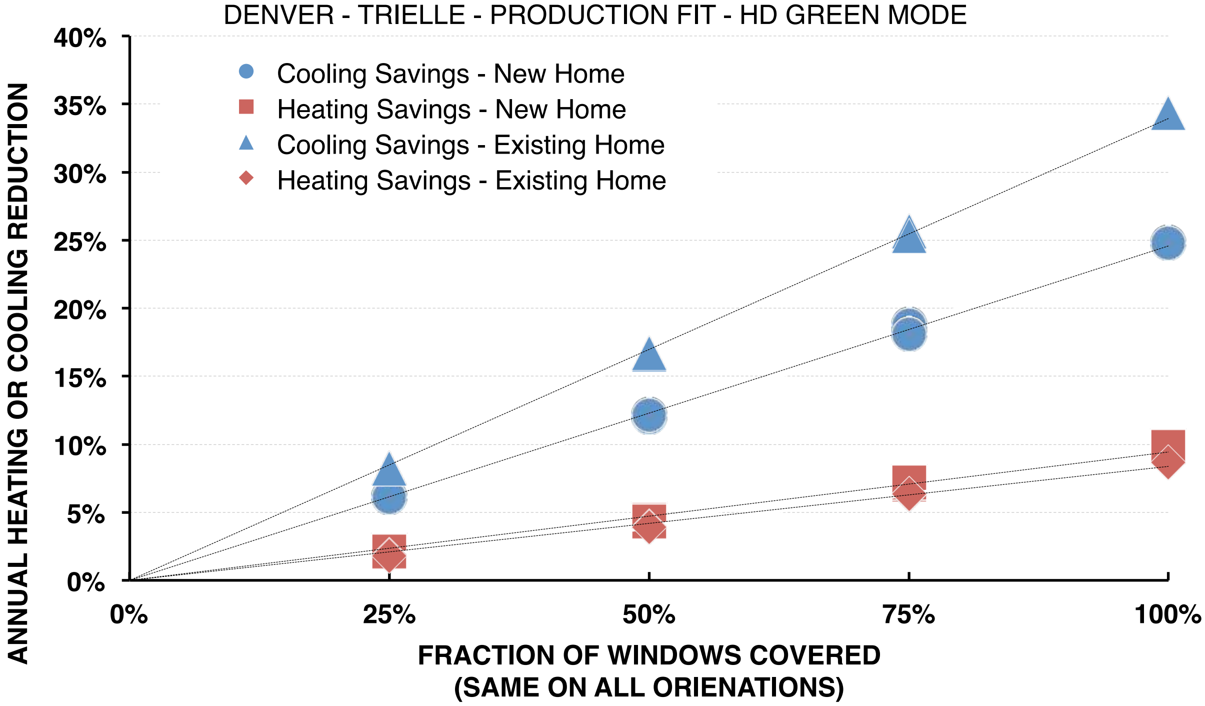


3.2 PARTIAL COVERAGE SCENARIOS

As intuitively expected, annual energy savings are proportional to the amount of window area covered, assuming the same window orientations. This is illustrated in Figure 13 for the Trielle product with production fit, operated in HD Green Mode in Denver.

FIGURE 13: ENERGY SAVINGS UNDER PARTIAL WINDOW COVERAGE

DENVER - TRIELLE - PRODUCTION FIT - HD GREEN MODE



3.3 SAVINGS CONTRIBUTION PER WINDOW ORIENTATION

The performance of the window coverings does depend significantly on the orientation of the window, as shown in Figures 14 and 15. In our Denver model, east and west windows are the most important for cooling savings, providing around twice the benefit of north or south windows. This is because morning or evening solar radiation strikes those windows very directly, and homes benefit from blocking that direct solar heat gain. North windows have much less direct solar incidence, as do south windows during cooling season in Denver, when the sun's path is nearly straight overhead. As demonstrated later in this report, if the goal is to reduce cooling electricity consumption specifically during summer afternoon hours when utility peak electric demand occurs, this is almost exclusively achieved in Denver by shading west-facing windows.

FIGURE 14: WINDOW ORIENTATION SHARE OF TOTAL ENERGY SAVINGS
Denver - New Home - Trielle - Production Fit - HD Green Mode

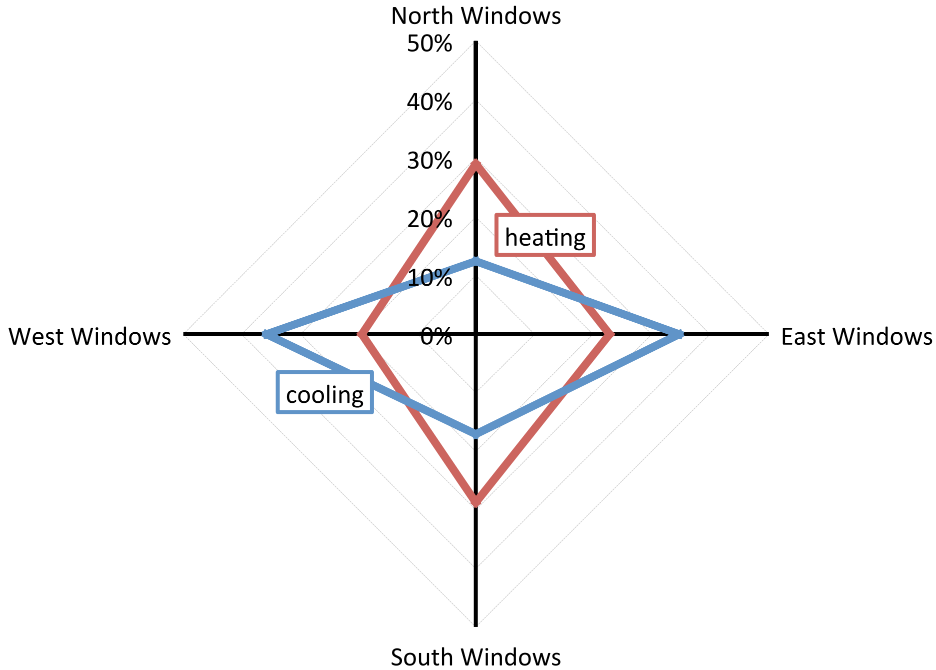
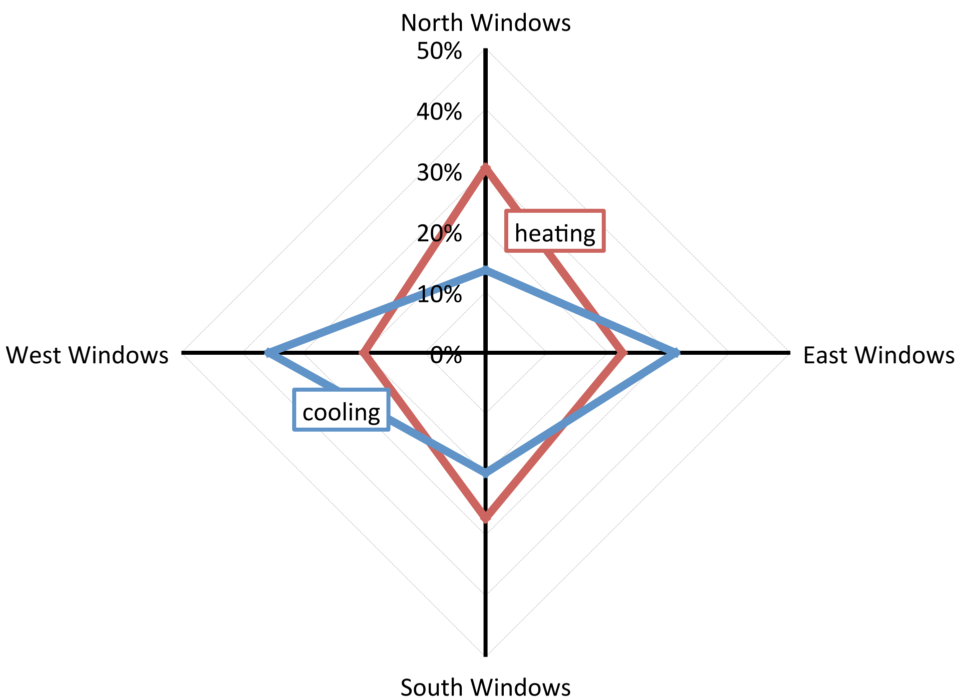


FIGURE 15: WINDOW ORIENTATION SHARE OF TOTAL ENERGY SAVINGS
Denver - Existing Home - Trielle - Production Fit - HD Green Mode



During heating season, savings are similar between the different orientations because heat loss is mostly via conduction, which is irrespective of orientation. In heating season, the optimal thermal strategy would close shades (to improve R-value) whenever conductive heat losses are greater than direct solar gain. In our orientation tests, shades were operated in HD Green Mode, and thus were generally left open at appropriate hours to capture beneficial direct solar gain. North windows make the largest contribution to savings, since per the HD Green Mode in heating season they are covered for all hours of the day, unlike other orientations; this is strategic, since there no beneficial direct solar gain hours for north windows. South window savings are nearly as large as north, despite only being closed sixteen hours per day during heating season; this suggests that nighttime heat losses dominate heating loads, making nighttime shade closure very important. East and west windows in our tests show about 25% less saving, suggesting the HD Green Mode schedule may be leaving shades open at times in the morning or evening when conductive heat losses are greater than direct solar gain, despite a schedule that generally opens shades when the solar angle points at the window. This could be because in morning and evening the air temperature is quite low, making conductive losses greater, or could be the result of morning and evening cloud cover in Denver.

4. OTHER MODELED BENEFITS

Thus far we have only discussed benefits in terms of annual energy savings, but our model scenarios demonstrated additional benefits, including improvements in thermal comfort, peak electricity demand reduction and the potential for reducing the required size of cooling equipment.

4.1 THERMAL COMFORT

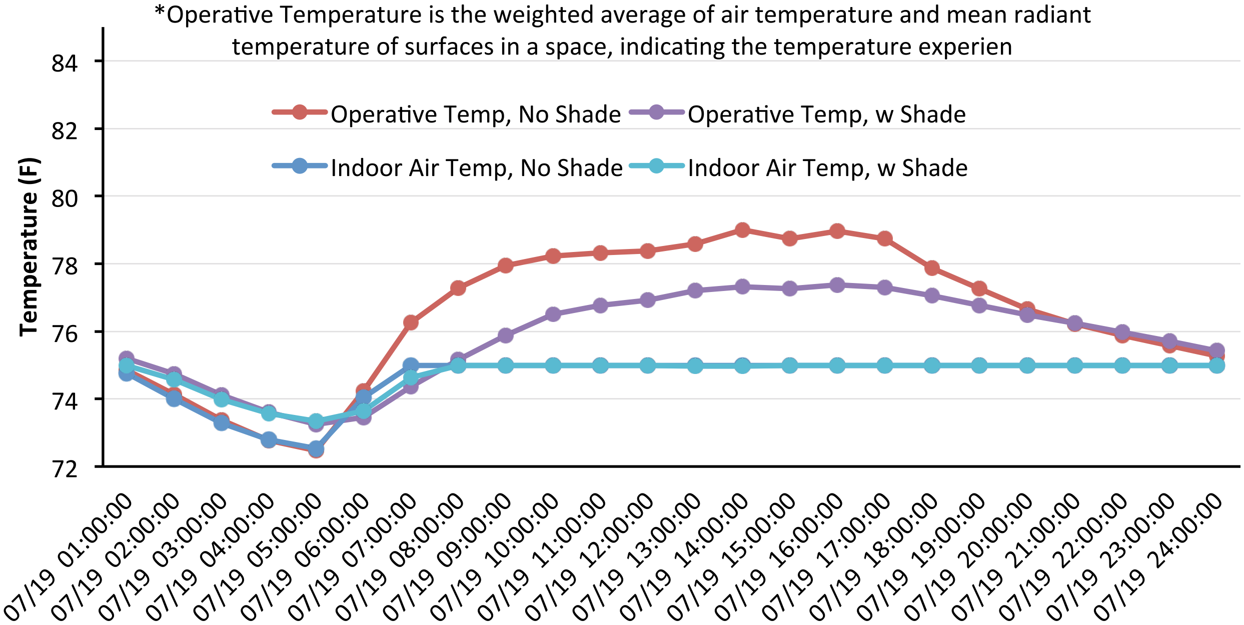
Most people equate thermal comfort solely with air temperature, which is related to convective heat loss or gain through the occupant's skin. Extensive research has been done showing a larger set of factors that contribute to thermal comfort, and this has been collectively developed into a strategy that was adopted into the Adaptive Comfort Method of compliance for ANSI/ASHRAE Standard 55 – Thermal Environmental Conditions for Human Occupancy. One such factor is mean radiant temperature (MRT), which is the average temperature of all the surfaces in a room to which an occupant has line-of-site view and will exchange radiant heat energy. For example a large, cold window surface can make an occupant feel too cold, even if the air temperature is within the generally accepted range. Similarly, direct sunlight through a window, or even a hot floor or wall surface that was recently subject to direct sunlight, will make a user feel warmer than they would otherwise. The combined effect of MRT and indoor air temperature is captured in a single, weighted-average number called operative temperature. To demonstrate how thermal comfort is improved by insulating window shades, we show air temperature and operative temperature on two indicative days in Denver. The operative temperature is indicative of the temperature that a person would perceive the space to be when exposed to surfaces that have different temperatures than the room air temperature.

Figure 16 illustrates a typical summer day, when the air conditioner maintains the cooling setpoint temperature of 75°F. But the operative temperature, the temperature an occupant will actually 'feel', drifts up to 79°F during the day when sunlight is streaming through windows. Adding shades brings this temperature back down by 2°F.

FIGURE 16: INDOOR AIR TEMPERATURE & OPERATIVE TEMPERATURE*

DENVER - EXISTING HOME - TYPICAL SUMMER DAY

*Operative Temperature is the weighted average of air temperature and mean radiant temperature of surfaces in a space, indicating the temperature experien



The reverse occurs on a typical winter day, as illustrated in Figure 17. The furnace maintains the 72°F heating setpoint temperature, but the cool window surfaces drop the MRT to 68°F. Adding shades brings MRT back up by a degree. This diagram understates the comfort effects of shades as window coverings also prevent cold downdrafts as cold air falls down the cold window surface onto occupants sitting near the window.

FIGURE 17: INDOOR AIR TEMPERATURE & OPERATIVE TEMPERATURE

DENVER EXISTING HOME - TYPICAL WINTER DAY

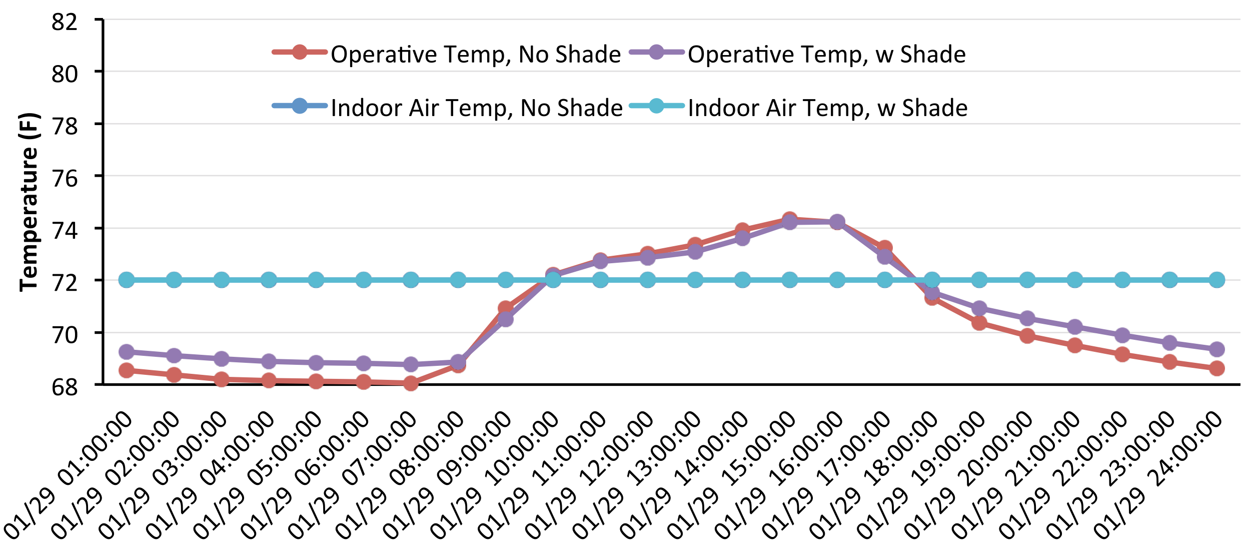
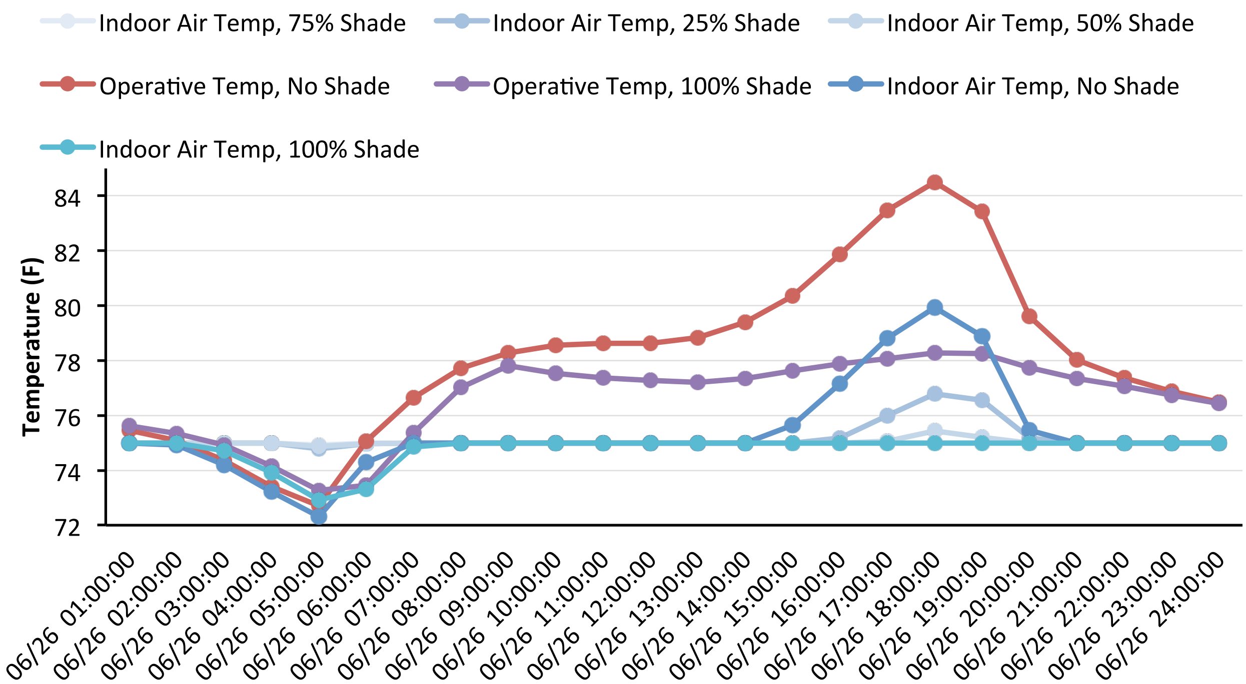


Figure 18 illustrates a related value of shades, which is to help meet the thermostat temperature on the hottest hours of the year, when an A/C system, correctly designed per the industry-standard ACCA Manual J, may not be able to keep up with the load. Adding window shades can reduce cooling loads to the point where the air conditioner can maintain the setpoint temperature for the hottest few hours of the year (reducing the corresponding operative temperature by more than 4°F).

FIGURE 18: INDOOR AIR TEMPERATURE & OPERATIVE TEMPERATURE
DENVER - EXISTING HOME - PEAK kW DAY



4.2 PEAK DEMAND REDUCTION

Related to cooling load reduction, window shades have the potential to reduce a home's peak instantaneous electricity demand, which typically coincides with summer afternoons when the electric grid is strained under its largest load and utilities incentivize load reduction. In some locations, residences are charged a higher rate for electricity consumed during these afternoon hours on summer days, and in yet other locations residences are charged a separate "demand charge" tied to their largest instantaneous electricity demand each month. In the short term, peak demand reduction can reduce utility bills for some customers, and can reduce the use of "peaker" power plants. In the long term, it can help avoid the need to build new transmission and distribution, as well as new power plants.

In our Denver home models, peak electric loads are around 3.2 kW for a new home and 5.7 kW for an existing home, both occurring around 7:00pm on a hot summer evening when temperatures are over 100°F, as air conditioning load is still high and evening lights and plug loads are coming on as well. We modeled the potential for peak reduction using the Trielle product with production fit and operated per the HD Green Mode. Results show that this strategy can reduce peak electricity by up to 9% (0.3 kW) for new homes and 15% (0.9 kW) for existing homes, as shown in Figures 19 and 20. It also shifts the peak to earlier in the evening, as late evening cooling loads are reduced by blocking solar heat gain through west-facing windows. In fact, covering only west-facing windows shows practically the same effect on peak load reduction as covering all windows on all orientations. While we did not explicitly limit our peak electricity analysis to a specific time window, our model's peak intrinsically occurs within Xcel's Critical-Peak Period of 2:00 to 8:00pm.[5]

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[5] See sheet 38B of Xcel's electric tariff index:
https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/rates/CO/psco_elec_entire_tariff.pdf

FIGURE 19: ANNUAL PEAK POWER, UNDER PARTIAL COVERAGE SCENARIOS

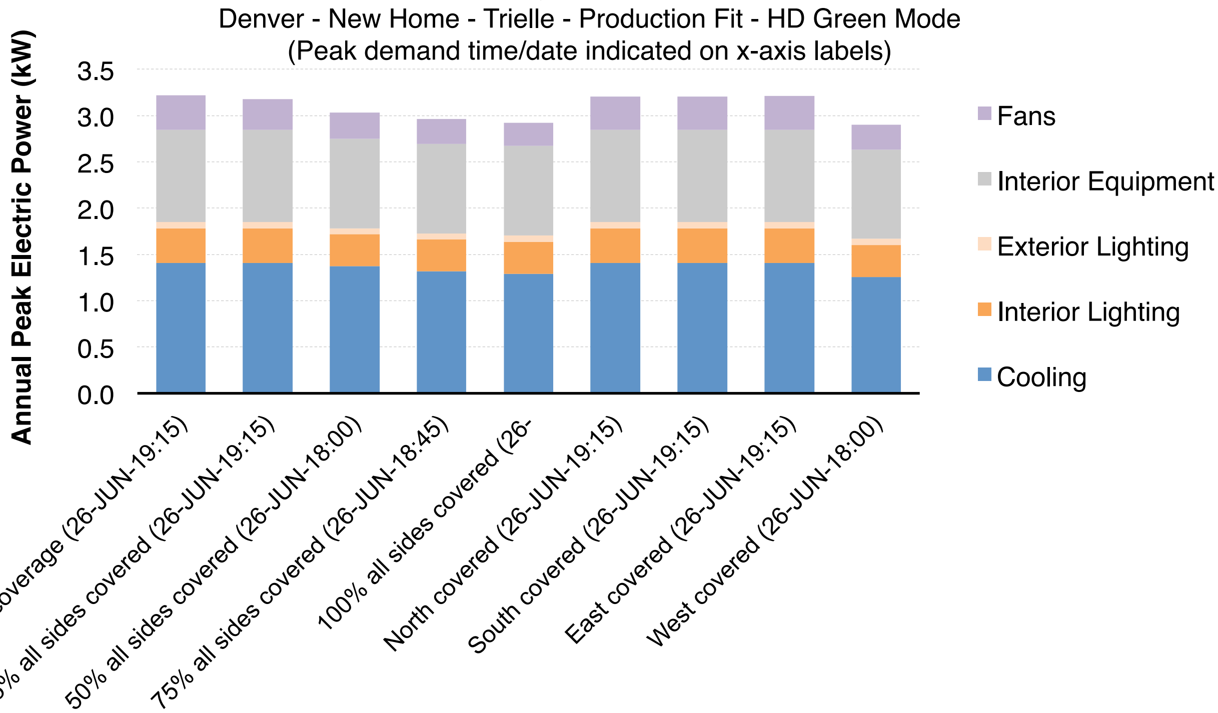
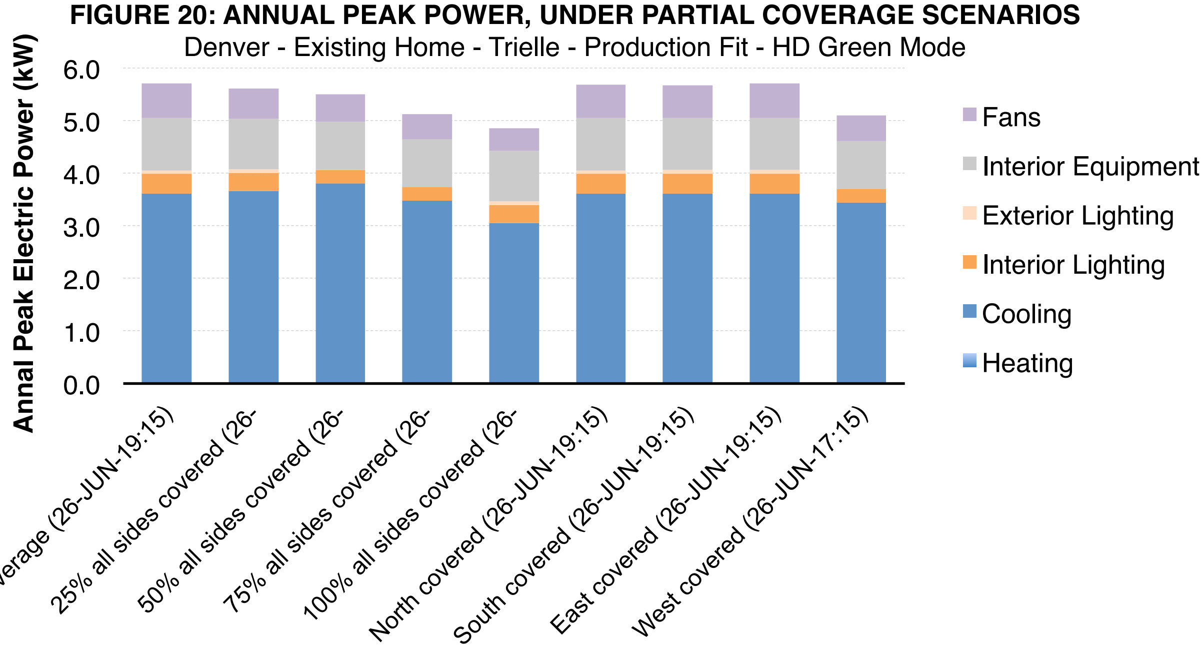


FIGURE 20: ANNUAL PEAK POWER, UNDER PARTIAL COVERAGE SCENARIOS

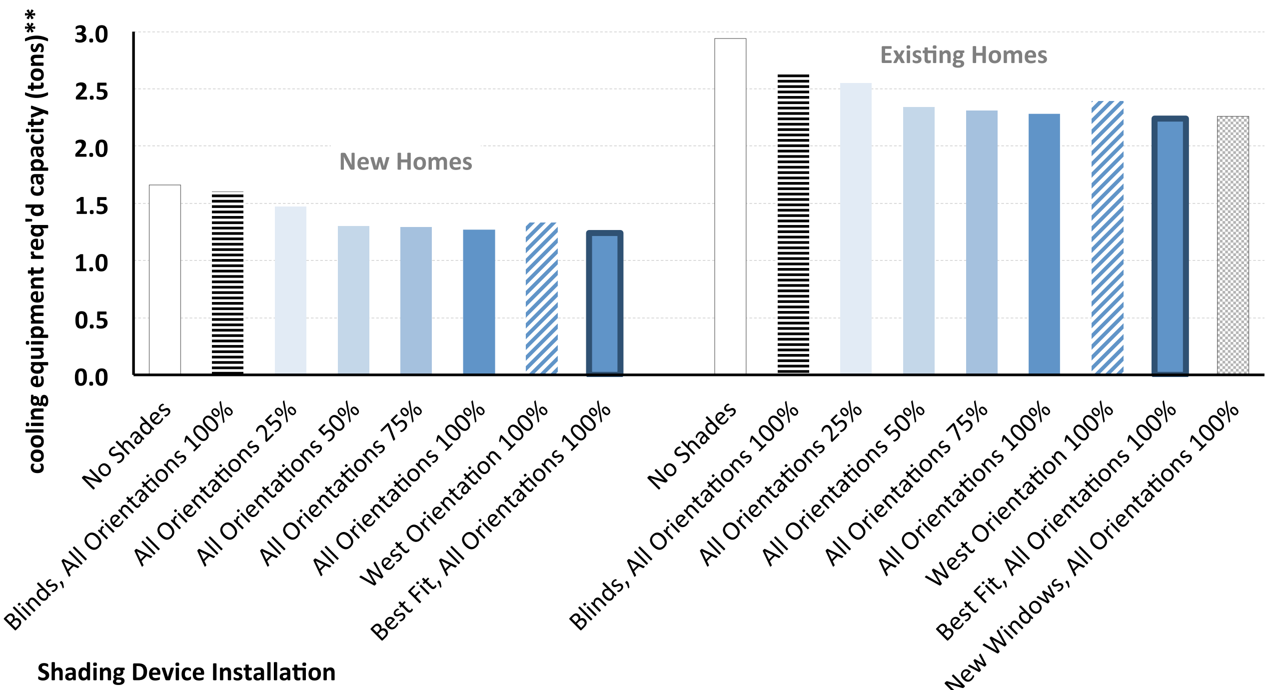


While the trend of peak load reduction is clear, particularly when covering west-facing windows, our model tests show that the time and date of the peak will vary with a host of factors, beyond the obvious factors of weather, fenestration design and site shading. Coincidence with other loads will impact the magnitude and exact time of peak total home load reduction, especially in the evening as lighting and other loads are turning on per an irregular schedule. The air conditioner itself can induce some unpredictability in the load reduction. For oversized A/C systems, the compressor may cycle on and off on 15- or 30-minute intervals, causing the peak electricity moment to shift times as well. Also, air conditioners do not constantly operate at their peak load efficiency; rather, their efficiency varies based on load, further complicating prediction of whole-home peak kW reduction. Smaller systems may run constantly for the few peak hours without meeting the full load, and adding shades may not reduce the load enough to actually cycle off the compressor. This was the case in our Denver model, which has its cooling system size fixed at the size required for the baseline model with no window shades.

4.3 COOLING EQUIPMENT DOWNSIZING

For a homeowner replacing or adding A/C, high-performance window shades may enable the purchase of a smaller capacity system. Many contractors size A/C systems based on rules of thumb and end up oversizing systems, which costs more upfront and also means less efficient operation because of increased cycling during part-loads. An optimally designed A/C system is sized based on the home's peak instantaneous cooling load on the location's design day. For this test, we utilized EnergyPlus's Autosize feature which sizes the cooling system according to the location's design day. As shown in Figure 21, window shades in Denver have the potential to reduce the design cooling load in an existing home by approximately a half ton, enabling dropping one standard A/C unit size increment. For new homes, shades likely will not drop load by the requisite half-ton increment of whole-home air conditioners, but they could enable buying smaller, or a smaller number of, modular window units or mini-split A/C systems.

FIGURE 21: Required Cooling Equipment Design Capacity
Denver - Trielle - Production Fit* - HD Green Mode



*Trielle Production Fit unless noted otherwise

5. LOOKING FORWARD

In performing this study, we have recognized several areas for future development, as described below.

5.1 PRODUCT DEVELOPMENT

As seen in the energy savings results above, shades installed using best fit (no edge gaps) provide a sizeable improvement in heating season compared to shades with production fit. This should be touted as the highest performance, maximum thermal comfort solution. It is also clear that savings are strongly tied to shade schedule, and it may be beneficial to strategically provide daylight even when shades are in place, via translucent materials or by lowering the top of the shade. This could eliminate one reason why users might override automated schedules or open blinds when thermally disadvantageous, as well as reduce the need for electric lighting when shades are down.

5.2 OPTIMIZED OPERATION & DEMAND RESPONSE

On the topic of operation schedules, another area for future development would be optimized automation of shade schedules. This could be a responsive control system, which reacts to real-time conditions such as occupancy, outdoor temperatures, indoor temperature, cloud cover, etc. Or it could be predictive control, taking into account real-time site conditions, thermal lag behavior of the home and A/C performance characteristics, then predicting heating and cooling loads based on weather forecasts and optimizing operation. Both of these functions could potentially participate in the cutting-edge space of home automation systems and, extrapolating further, could help serve utility demand response functions.

We already discussed above the inherent reduction in peak electricity demand that comes from lower cooling load on summer evenings, but we could imagine more direct ways for window shades to supplement utility demand response programs. Current voluntary utility programs like as Xcel's Saver's Switch directly control A/C units, cycling them off for short periods of time to reduce peak electricity loads, with the expectation that any thermal discomfort will be minimal or short-lived. Window shades, whether automated or manually controlled, could be supplemental to such programs, helping homes to maintain thermal comfort in the times where A/C is cycled off, or potentially allowing A/C to be cycled off even longer.

5.3 IMPROVED MODELING METHODS

While EnergyPlus has some rigorous tools built into its software for purposes of modeling window shades, our experience shows that there is room for improvement in making modeling of shades simple and accessible. Our modeling method used the three simple inputs of thermal conductivity (U-value), solar heat gain coefficient (SHGC) and visible light transmittance (VLT) for window assemblies with and without shades, within the EnergyPlus object WindowMaterial:SimpleGlazingSystem. We first attempted to model shade operation using scheduled toggling between complete window assemblies with and without shades (using the property WindowProperty:ShadingControl with type SwitchableGlazing). However, we discovered a glitch in the SwitchableGlazing function, which prevented it from correctly switching the U-value of the construction when switching shades on and off. We have reported this and expect it to be corrected in a subsequent version of EnergyPlus. Though this would be the most straightforward method of modeling shades, using common, industry-standard properties of U-value, SHGC and visible light transmittance, it seems the function is currently only built out to represent changes in SHGC and is geared toward modeling switchable glazing, e.g. electrochromic or thermochromic. However, for this study, we were able to develop a workaround using EnergyPlus's Energy Management System (EMS) to perform the same function as we intended with the SwitchableGlazing function. See Appendix D for a detailed explanation of this solution.

EnergyPlus does have other another object, WindowMaterial:Shade, that is more directly intended for modeling interior window shades, modeled as layers added on top of detailed window constructions according to a schedule. This method is more rigorous and expected to be more accurate, however the inputs for this object are also much more detailed and less intuitive or familiar to most energy modelers. Product-specific characteristics are not available without elaborate prior testing. We understand that Hunter Douglas is currently undergoing such product testing to define these detailed characteristics, and suggest making these values available to energy modelers in the form of a downloadable specification sheet. Another way to make the data available to modelers is within LBNL's WINDOW, which is used for modeling window performance metrics used for standardized window ratings. WINDOW contains a large library of manufacturer-specific, window-related products with tested material characteristics and is used to generate detailed EnergyPlus inputs for energy modelers.

Even given simple modeling procedures and accurate shade material characteristics, energy modelers may still be wary of the uncertainty around user operation of window shades. It would be beneficial, perhaps via the Attachments Energy Ratings Council (AERC) of the Window Covering Manufacturers Association (WCMA), to produce standard schedules that can be used by energy modelers. While we used the automated HD Green Mode as our standard operation schedule, we could also envision developing a behavioral, research-based typical user schedule.

5.4 AUTOMATED CALCULATOR RECOMMENDATIONS

There are a number of web-based calculator tools available for homeowners interested in understanding the energy savings available for window shades, with varying degrees of specificity and usefulness. As Hunter Douglas or the AERC pursue improved calculators, it may be useful to envision a hypothetical calculator under a taxonomy like the one described in Table 3, below:

TABLE 3: TAXONOMY OF TYPES OF SAVINGS CALCULATORS

User Time Commitment	Potential Application	User Inputs	Modeling Method
10 sec	• In-store kiosk • Online calculator	• Zip code • Decade when windows were installed • Square feet of home	Use zip code to determine ASHRAE climate zone. Then use results from this study, scaled proportionately to square footage of home.
10 min	• In-store kiosk (detailed option) • Online calculator (detailed option)	• Zip code • Decade when windows were installed • Number of windows, per orientation	Assume (or user input) a typical window size. Then use results from this study that are normalized to square feet of window.
1 hour	• With detailed sales quotes • Pursuing utility rebates	• Number and exact size of window per orientation • Type of window • Major site shading (buildings, trees, etc) • Electric vs gas heating	Build a simple calculator with energy savings normalized to square feet of window.
1 week	• Rarely needed, except in the design/retrofit of high-performance homes.	• Detailed home energy model	Generate a full EnergyPlus model, applying detailed shade characteristics. Executed by home designer or modeling professional.

APPENDIX A: DETAILED RESULTS

FIGURE A1a - ZONE 1 (MIAMI) - HOME ENERGY CONSUMPTION

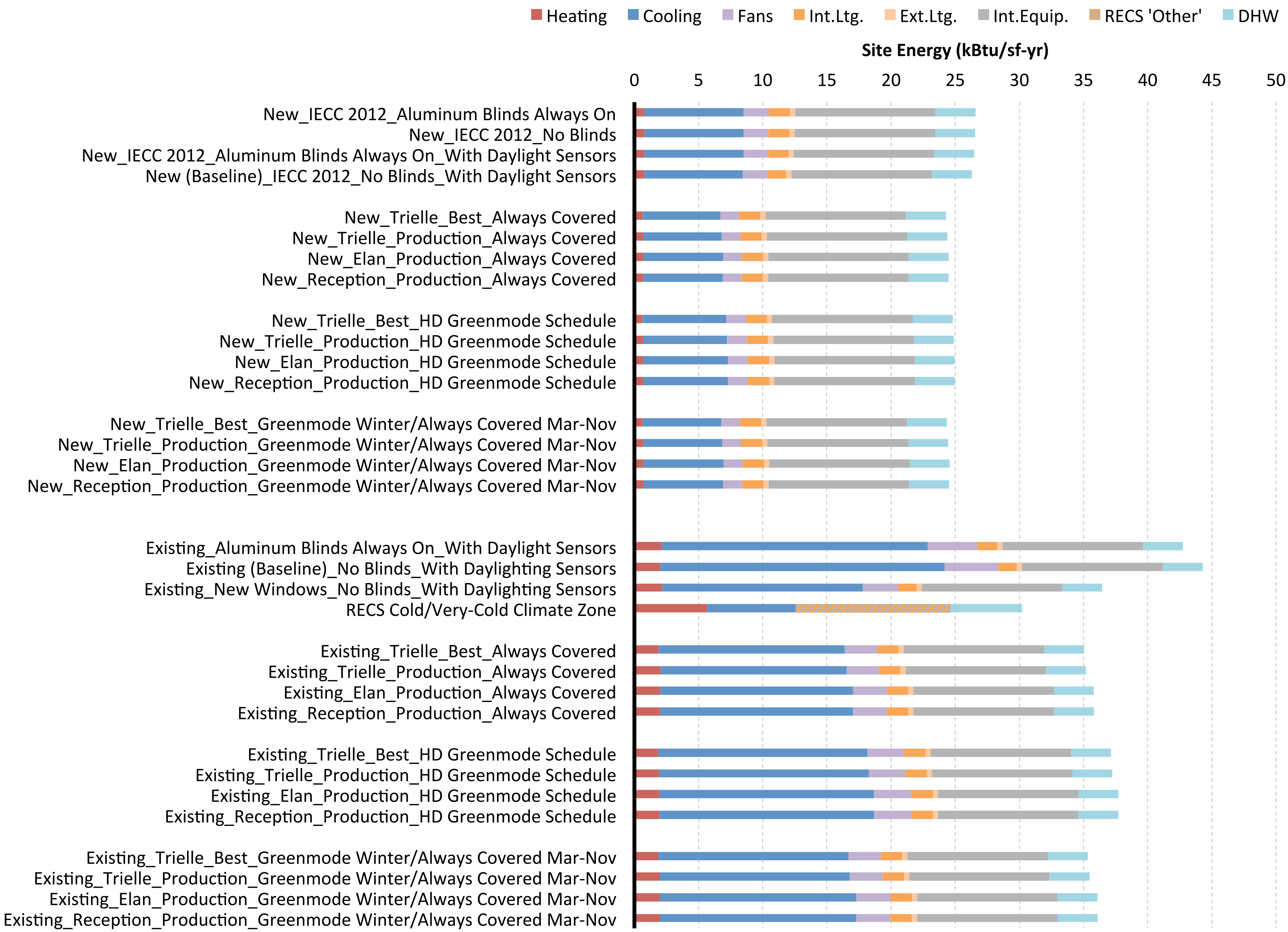


FIGURE A1b - ZONE 1 (MIAMI) - HEATING & COOLING SAVINGS

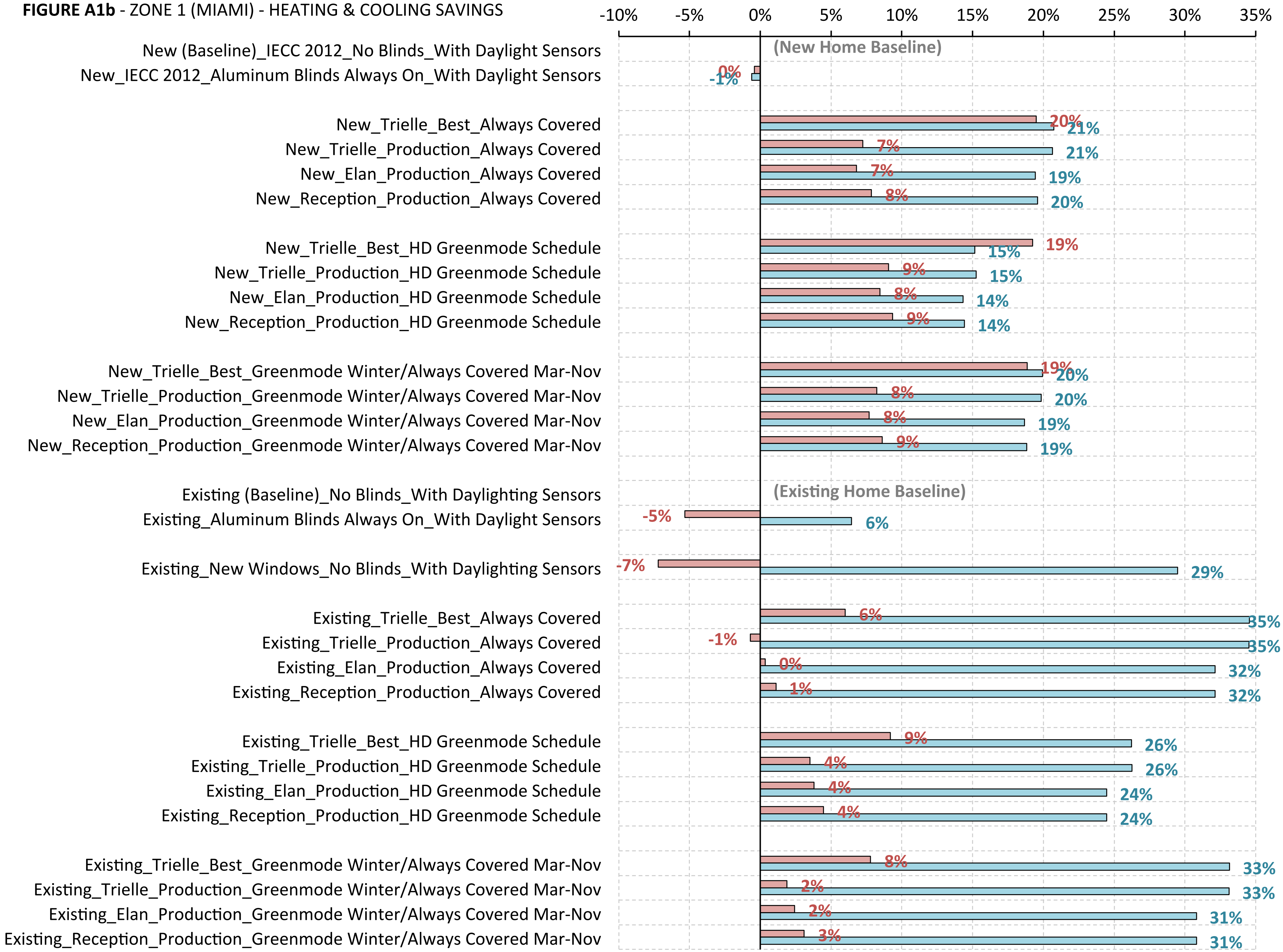


TABLE A1a – ZONE 1 (MIAMI) COMPLETE SAVINGS RESULTS		**kBtu /sf**	**overall savings**	**heating savings**	**cooling savings**	**CO2 Savings[1] (lb/yr)**	**Equivalent Driving Miles Avoided[1,2]**	**$ savings[1]**	**$ savings per sf floor**	**$ savings per sf window**	**Elec Use[1] (kWh/yr)**	**Gas Use[1] (therms/ yr)**	**Elec Savings[1] (kWh/yr)**	**Gas Savings[1] (therms/ yr)**
Baseline New (No Coverings)		26.3	-	-	-	-	-	-	-	-	18,495	0	0	0
New with Aluminum Blinds		26.5	-0.7%	-0.4%	-0.6%	-163	-194	-$16	-$0.007	-$0.04	18,630	0	-135	0
Always Covered	**Trielle-Best Fit**	24.3	7.6%	19.5%	20.7%	1,704	2,035	$166	$0.069	$0.46	17,077	0	1,418	0
	Trielle-Production	24.4	7.3%	7.2%	20.7%	1,612	1,925	$157	$0.065	$0.44	17,153	0	1,342	0
	Elan	24.5	6.8%	6.8%	19.4%	1,505	1,796	$146	$0.061	$0.41	17,243	0	1,252	0
	Reception	24.5	6.8%	7.8%	19.6%	1,526	1,822	$149	$0.062	$0.42	17,225	0	1,270	0
HD Green Mode	**Trielle-Best Fit**	24.8	5.6%	19.2%	15.1%	1,254	1,497	$122	$0.051	$0.34	17,451	0	1,044	0
	Trielle-Production	24.9	5.4%	9.1%	15.3%	1,190	1,421	$116	$0.048	$0.32	17,505	0	990	0
	Elan	25.0	5.0%	8.5%	14.3%	1,106	1,320	$108	$0.045	$0.30	17,575	0	920	0
	Reception	25.0	5.1%	9.3%	14.4%	1,122	1,339	$109	$0.045	$0.31	17,561	0	933	0
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	24.3	7.4%	18.9%	20.0%	1,644	1,962	$160	$0.067	$0.45	17,127	0	1,368	0
	Trielle-Production	24.4	7.0%	8.2%	19.9%	1,561	1,863	$152	$0.063	$0.43	17,196	0	1,299	0
	Elan	24.6	6.5%	7.7%	18.7%	1,455	1,737	$142	$0.059	$0.40	17,284	0	1,211	0
	Reception	24.5	6.6%	8.6%	18.8%	1,476	1,762	$144	$0.060	$0.40	17,267	0	1,228	0

TABLE A1b – ZONE 1 (MIAMI) COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/ yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline Existing (No Coverings)		44.3	-	-	-	-	-	-	-	-	31,158	0	0	0
Existing with Aluminum Blinds		42.7	3.5%	-5.3%	6.5%	1,300	1,552	$127	$0.053	$0.35	30,076	0	1,082	0
Existing with New R-2.00/SHGC-0.25 (IECC 2012) Windows		36.5	17.7%	-7.2%	29.5%	6,607	7,888	$643	$0.268	$1.80	25,660	0	5,498	0
Always Covered	**Trielle- Best Fit**	35.0	20.9%	6.0%	34.6%	7,813	9,328	$761	$0.317	$2.13	24,656	0	6,501	0
	Trielle- Production	35.2	20.5%	-0.7%	34.5%	7,686	9,176	$748	$0.312	$2.10	24,762	0	6,396	0
	Elan	35.8	19.1%	0.3%	32.1%	7,160	8,549	$697	$0.290	$1.95	25,199	0	5,958	0
	Reception	35.8	19.2%	1.1%	32.1%	7,174	8,565	$698	$0.291	$1.96	25,188	0	5,970	0
HD Green Mode	**Trielle- Best Fit**	37.1	16.1%	9.2%	26.2%	6,039	7,210	$588	$0.245	$1.65	26,133	0	5,025	0
	Trielle- Production	37.3	15.9%	3.5%	26.3%	5,944	7,096	$579	$0.241	$1.62	26,212	0	4,946	0
	Elan	37.7	14.8%	3.8%	24.5%	5,538	6,611	$539	$0.225	$1.51	26,550	0	4,608	0
	Reception	37.7	14.8%	4.5%	24.5%	5,548	6,624	$540	$0.225	$1.51	26,541	0	4,617	0
Winter: Green Mode Summer: Always On	**Trielle- Best Fit**	35.3	20.2%	7.8%	33.2%	7,556	9,021	$736	$0.306	$2.06	24,870	0	6,288	0
	Trielle- Production	35.5	19.9%	1.9%	33.1%	7,437	8,879	$724	$0.302	$2.03	24,969	0	6,188	0
	Elan	36.1	18.5%	2.4%	30.8%	6,922	8,264	$674	$0.281	$1.89	25,398	0	5,760	0
	Reception	36.1	18.5%	3.1%	30.8%	6,935	8,279	$675	$0.281	$1.89	25,387	0	5,771	0

[1]2400 sf home
[2]23.4 mpg vehicle

FIGURE A2a - ZONE 2 (PHOENIX) - HOME ENERGY CONSUMPTION

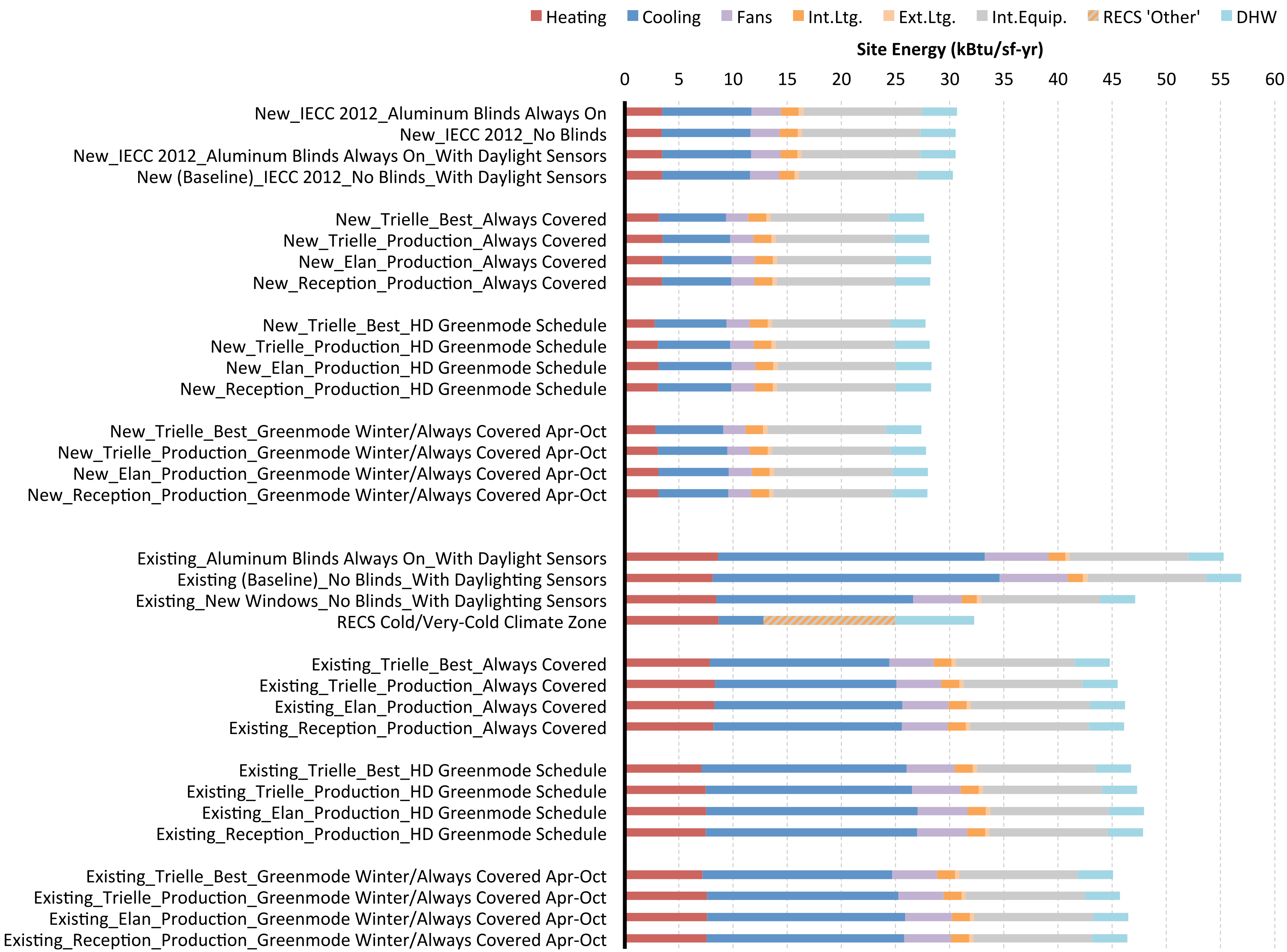


FIGURE A2b - ZONE 2 (PHOENIX) - HEATING & COOLING SAVINGS

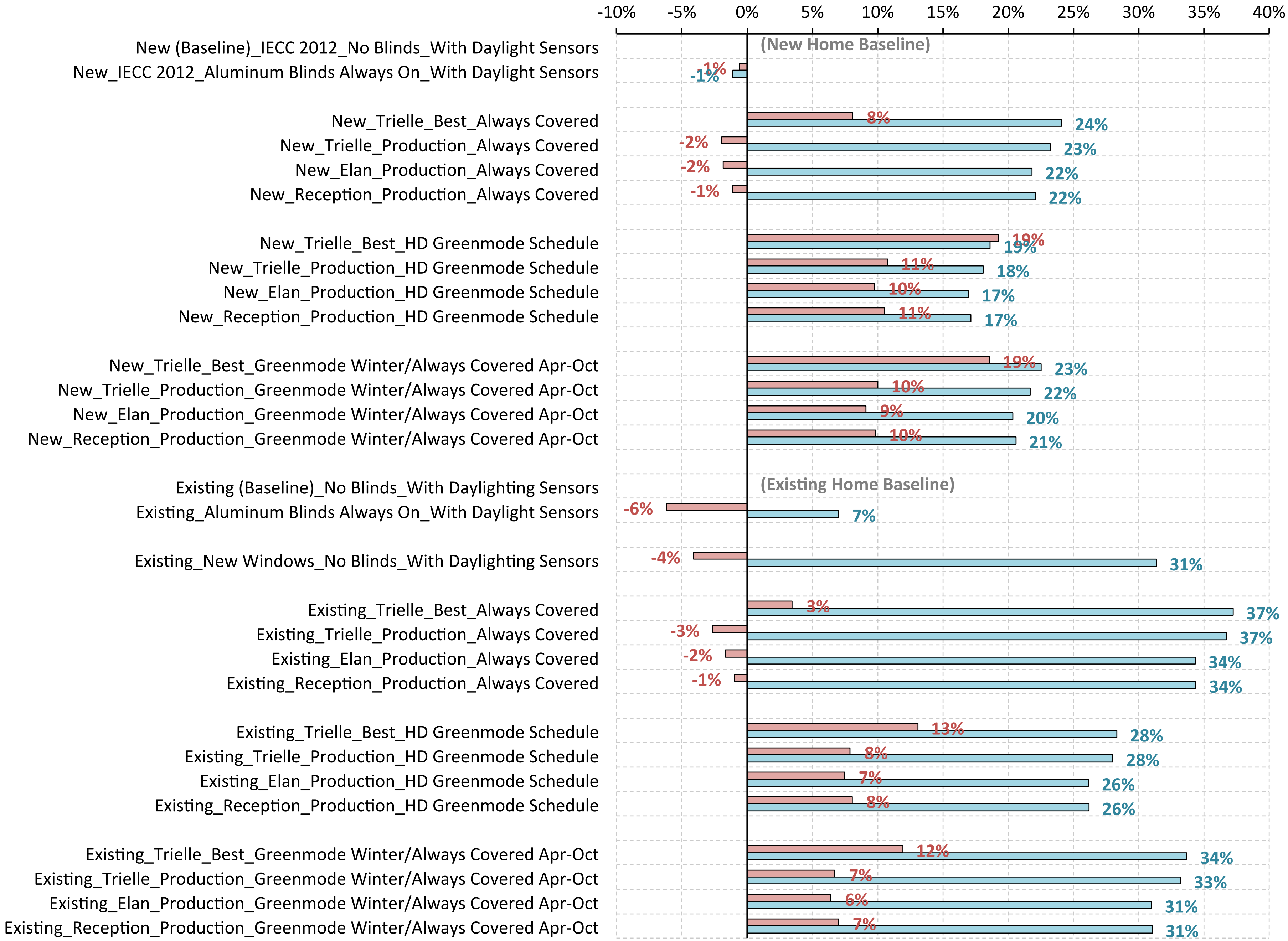


TABLE A2a – ZONE 2 (PHOENIX) COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline New (No Coverings)		30.3	-	-	-	-	-	-	-	-	21,309	0	0	0
New with Aluminum Blinds		30.5	-0.8%	-0.6%	-1.1%	-206	-246	-$21	-$0.009	-$0.06	21,483	0	-174	0
Always Covered	**Trielle-Best Fit**	27.7	8.7%	8.1%	24.1%	2,186	2,609	$227	$0.094	$0.63	19,461	0	1,848	0
	Trielle-Production	28.1	7.1%	-2.0%	23.2%	1,800	2,148	$187	$0.078	$0.52	19,787	0	1,521	0
	Elan	28.3	6.7%	-1.8%	21.8%	1,680	2,006	$174	$0.073	$0.49	19,888	0	1,420	0
	Reception	28.2	6.8%	-1.1%	22.1%	1,725	2,059	$179	$0.074	$0.50	19,851	0	1,458	0
HD Green Mode	**Trielle-Best Fit**	27.8	8.3%	19.3%	18.6%	2,082	2,486	$216	$0.090	$0.60	19,548	0	1,761	0
	Trielle-Production	28.2	7.0%	10.8%	18.1%	1,768	2,111	$183	$0.076	$0.51	19,814	0	1,495	0
	Elan	28.3	6.5%	9.8%	17.0%	1,637	1,954	$170	$0.071	$0.47	19,925	0	1,384	0
	Reception	28.3	6.7%	10.5%	17.1%	1,677	2,002	$174	$0.072	$0.49	19,891	0	1,418	0
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	27.4	9.5%	18.6%	22.5%	2,407	2,873	$249	$0.104	$0.70	19,274	0	2,035	0
	Trielle-Production	27.8	8.2%	10.0%	21.7%	2,065	2,466	$214	$0.089	$0.60	19,563	0	1,746	0
	Elan	28.0	7.6%	9.1%	20.4%	1,915	2,287	$199	$0.083	$0.56	19,689	0	1,619	0
	Reception	27.9	7.8%	9.9%	20.6%	1,960	2,340	$203	$0.085	$0.57	19,651	0	1,657	0

TABLE A2b – ZONE 2 (PHOENIX) COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline Existing (No Coverings)		56.9	-	-	-	-	-	-	-	-	40,051	0	0	0
Existing with Aluminum Blinds		55.3	2.9%	-6.2%	7.0%	1,367	1,632	$142	$0.059	$0.40	38,895	0	1,156	0
Existing with New R-2.50/SHGC-0.25 (IECC 2012) Windows		47.1	17.2%	-4.1%	31.4%	8,161	9,743	$846	$0.352	$2.37	33,151	0	6,899	0
Always Covered	**Trielle-Best Fit**	44.8	21.3%	3.5%	37.2%	10,101	12,060	$1,047	$0.436	$2.93	31,511	0	8,540	0
	Trielle-Production	45.5	20.1%	-2.6%	36.7%	9,520	11,366	$987	$0.411	$2.76	32,002	0	8,048	0
	Elan	46.2	18.9%	-1.7%	34.3%	8,949	10,684	$928	$0.386	$2.60	32,485	0	7,566	0
	Reception	46.1	19.0%	-1.0%	34.4%	9,015	10,762	$934	$0.389	$2.62	32,429	0	7,621	0
HD Green Mode	**Trielle-Best Fit**	46.7	17.9%	13.1%	28.3%	8,486	10,131	$880	$0.366	$2.46	32,876	0	7,174	0
	Trielle-Production	47.3	16.9%	7.9%	28.0%	8,023	9,579	$832	$0.346	$2.33	33,267	0	6,783	0
	Elan	47.9	15.8%	7.5%	26.2%	7,481	8,932	$775	$0.323	$2.17	33,726	0	6,325	0
	Reception	47.9	15.9%	8.0%	26.2%	7,534	8,994	$781	$0.325	$2.19	33,682	0	6,369	0
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	45.1	20.8%	11.9%	33.7%	9,846	11,755	$1,021	$0.425	$2.86	31,726	0	8,324	0
	Trielle-Production	45.7	19.7%	6.7%	33.2%	9,331	11,141	$967	$0.403	$2.71	32,162	0	7,889	0
	Elan	46.5	18.4%	6.4%	31.0%	8,704	10,392	$902	$0.376	$2.53	32,692	0	7,359	0
	Reception	46.4	18.5%	7.0%	31.0%	8,763	10,462	$908	$0.378	$2.54	32,642	0	7,408	0

[1]2400 sf home
[2]23.4 mpg vehicle

FIGURE A3a - ZONE 3 (SAN FRANCISCO) - HOME ENERGY CONSUMPTION

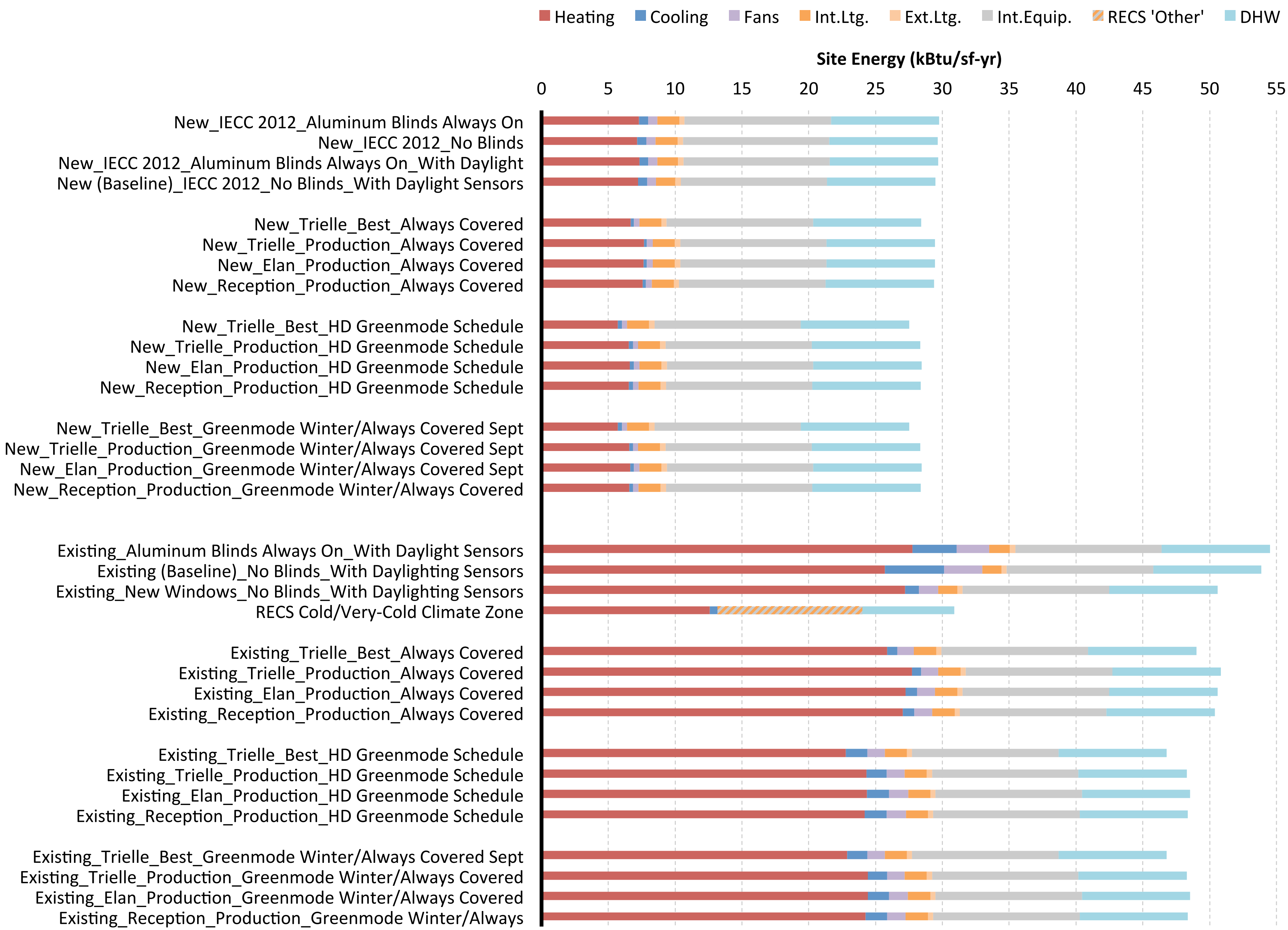


FIGURE A3b - ZONE 3 (SAN FRANCISCO) - HEATING & COOLING SAVINGS

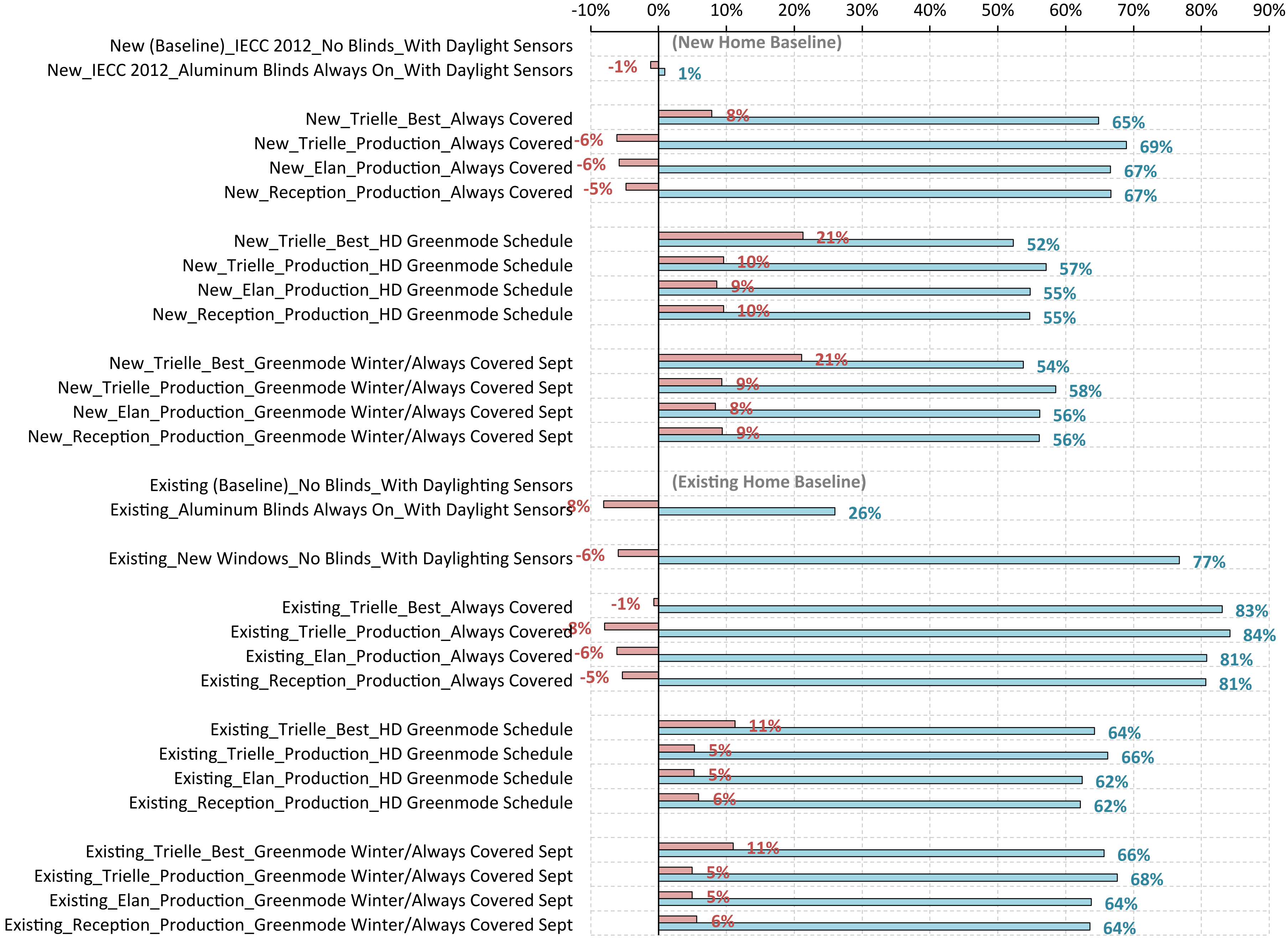


TABLE A3a – ZONE 3 (San Francisco) COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/yr)
Baseline New (No Coverings)		29.5	-	-	-	-	-	-	-	-	9,955	368	0	0
New with Aluminum Blinds		29.7	-0.7%	-1.2%	0.9%	-75	-89	-$13	-$0.005	-$0.04	10,038	370	-83	-2
Always Covered	**Trielle-Best Fit**	28.4	3.5%	7.9%	64.9%	365	436	$57	$0.024	$0.16	9,613	355	342	13
	Trielle-Production	29.5	0.1%	-6.2%	68.9%	83	99	$32	$0.013	$0.09	9,606	379	349	-11
	Elan	29.4	0.1%	-5.8%	66.6%	80	95	$30	$0.012	$0.08	9,625	379	330	-10
	Reception	29.4	0.4%	-4.8%	66.6%	101	121	$32	$0.013	$0.09	9,623	377	332	-9
HD Green Mode	**Trielle-Best Fit**	27.5	6.7%	21.3%	52.3%	619	739	$77	$0.032	$0.22	9,648	331	307	37
	Trielle-Production	28.3	3.9%	9.6%	57.1%	386	460	$57	$0.024	$0.16	9,639	352	316	16
	Elan	28.5	3.5%	8.6%	54.7%	352	420	$52	$0.022	$0.15	9,661	353	294	15
	Reception	28.4	3.8%	9.6%	54.7%	374	446	$54	$0.023	$0.15	9,659	352	296	16
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	27.5	6.7%	21.1%	53.7%	620	740	$78	$0.033	$0.22	9,639	332	316	36
	Trielle-Production	28.4	3.8%	9.3%	58.5%	385	460	$57	$0.024	$0.16	9,631	352	324	16
	Elan	28.5	3.5%	8.4%	56.1%	353	421	$53	$0.022	$0.15	9,653	354	302	14
	Reception	28.4	3.7%	9.4%	56.1%	374	447	$55	$0.023	$0.15	9,650	352	305	16

TABLE A3b – ZONE 3 (San Francisco) COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline Existing (No Coverings)		53.9	-	-	-	-	-	-	-	-	14,140	811	0	0
Existing with Aluminum Blinds		54.5	-1.2%	-8.1%	26.0%	40	47	$74	$0.031	$0.21	13,118	861	1,022	-50
Existing with New R-2.86/SHGC-0.25 (IECC 2012) Windows		50.6	6.1%	-5.9%	76.7%	1,646	1,966	$383	$0.160	$1.07	10,746	848	3,394	-37
Always Covered	**Trielle-Best Fit**	49.0	9.0%	-0.7%	83.0%	2,130	2,543	$439	$0.183	$1.23	10,571	816	3,569	-5
	Trielle-Production	50.8	5.6%	-7.9%	84.2%	1,622	1,937	$395	$0.164	$1.11	10,548	861	3,592	-50
	Elan	50.6	6.1%	-6.1%	80.8%	1,656	1,977	$387	$0.161	$1.08	10,707	850	3,433	-38
	Reception	50.4	6.5%	-5.3%	80.6%	1,713	2,045	$392	$0.163	$1.10	10,710	844	3,430	-33
HD Green Mode	**Trielle-Best Fit**	46.8	13.1%	11.3%	64.3%	2,619	3,126	$441	$0.184	$1.23	11,193	742	2,947	69
	Trielle-Production	48.3	10.4%	5.3%	66.2%	2,210	2,638	$407	$0.169	$1.14	11,150	779	2,990	32
	Elan	48.6	9.9%	5.2%	62.4%	2,096	2,502	$384	$0.160	$1.07	11,332	779	2,808	32
	Reception	48.4	10.2%	5.9%	62.2%	2,142	2,557	$388	$0.161	$1.09	11,337	775	2,803	36
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	46.8	13.1%	11.0%	65.6%	2,628	3,137	$445	$0.185	$1.25	11,144	744	2,996	68
	Trielle-Production	48.3	10.4%	4.9%	67.6%	2,216	2,646	$411	$0.171	$1.15	11,101	781	3,039	30
	Elan	48.6	9.9%	5.0%	63.8%	2,107	2,516	$388	$0.162	$1.09	11,282	781	2,858	30
	Reception	48.4	10.2%	5.6%	63.5%	2,154	2,572	$392	$0.163	$1.10	11,287	777	2,853	35

[1] 2400 sf home

[2] 23.4 mpg vehicle

NOTE: Cooling loads in San Francisco are relatively small in magnitude, making them heavily sensitive to factors such as coastal microclimates, building thermal mass, opening windows, cloud cover and site shading, as well as interior window coverings, as suggested here. Mechanical air conditioning is less common that other locations. While relatively small in magnitude, the high cooling percent savings suggest that window coverings could help eliminate the need to install any mechanical A/C equipment in mild, coastal locations.

FIGURE A4a - ZONE 4 (WASHINGTON DC) - HOME ENERGY CONSUMPTION

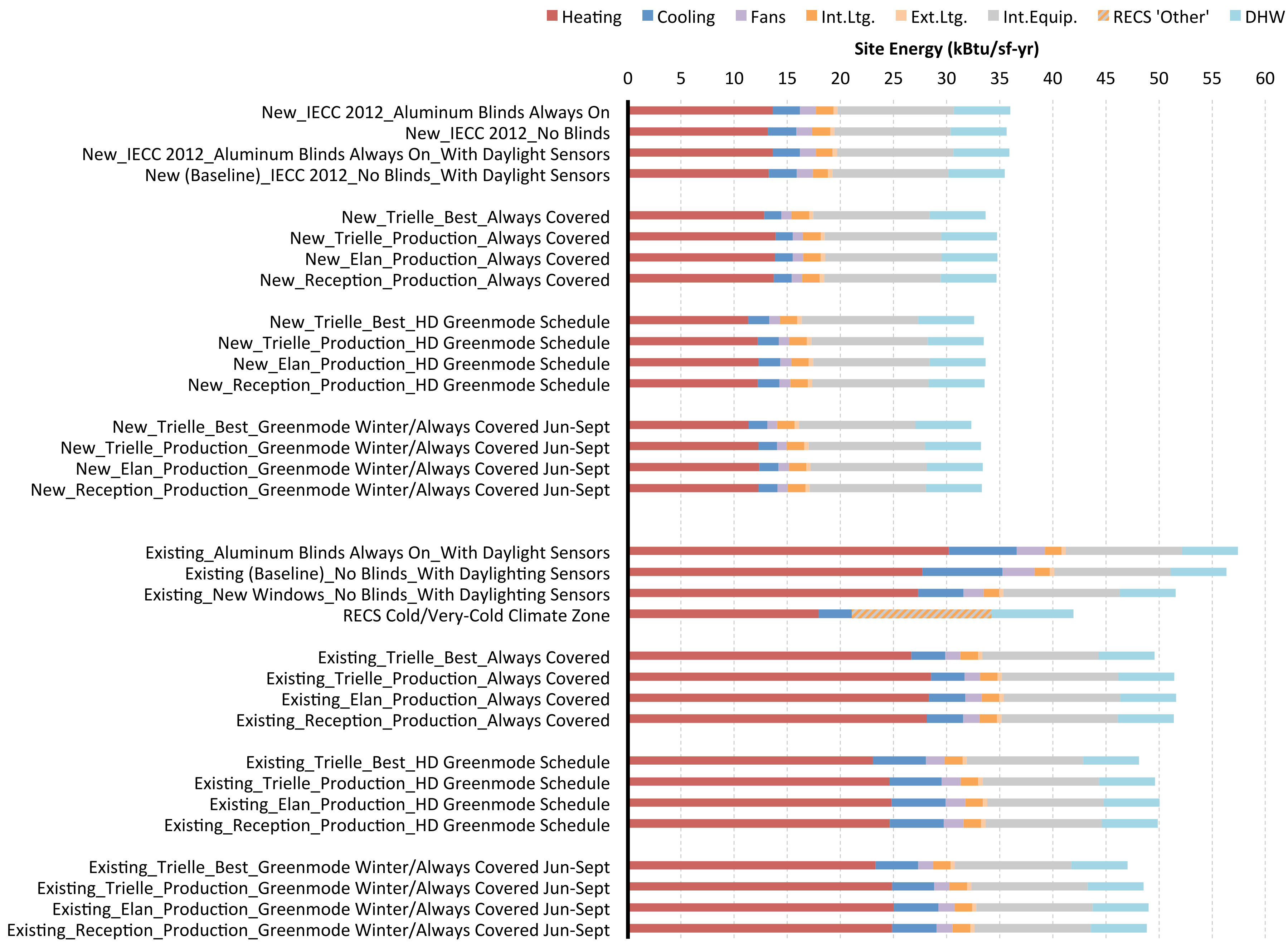


FIGURE A4b - ZONE 4 (WASHINGTON DC) - HEATING & COOLING SAVINGS

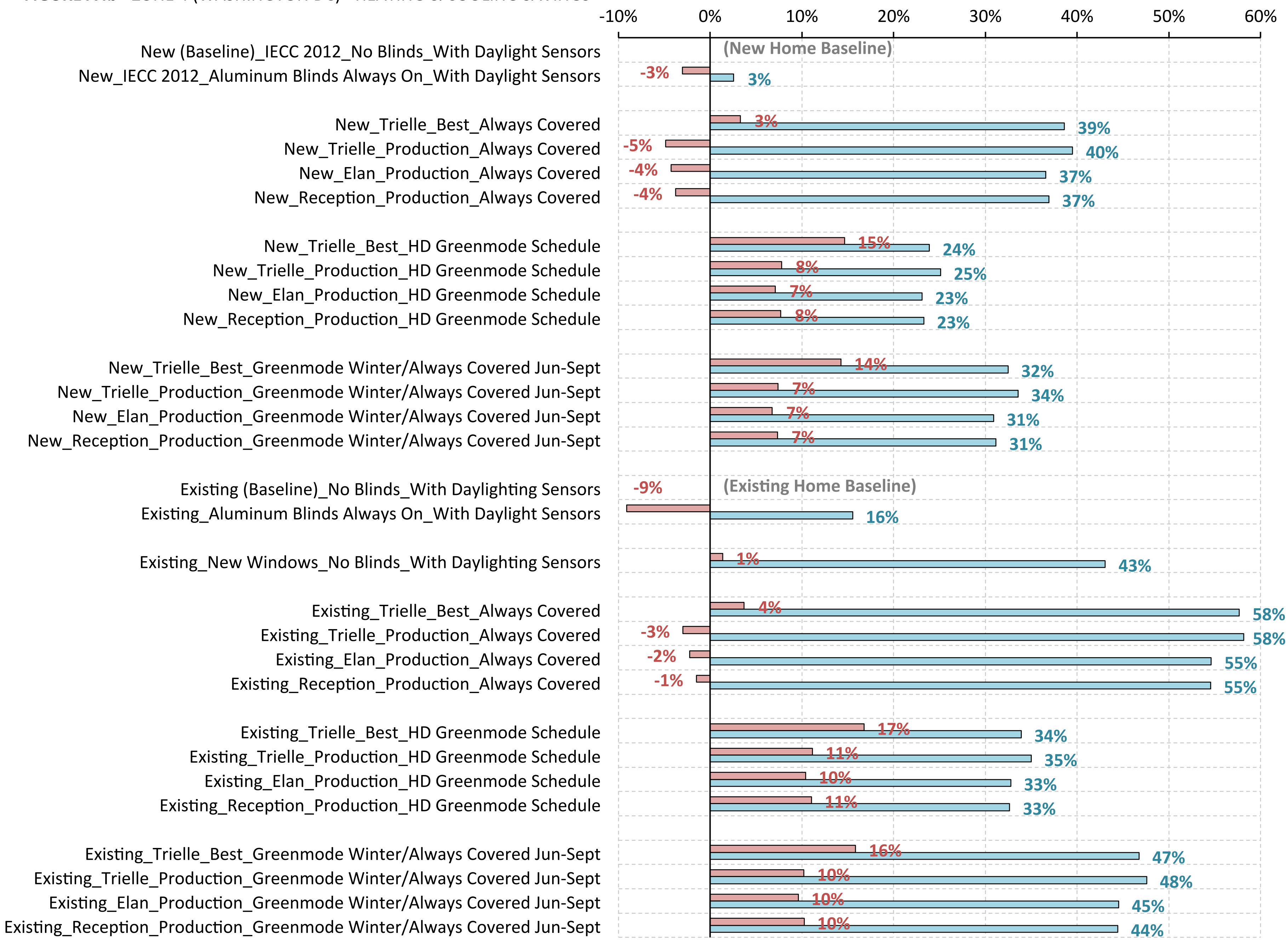


TABLE A4a – ZONE 4 -Washington DC COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline New (No Coverings)		35.5	-	-	-	-	-	-	-	-	24,963	0	0	0
New with Aluminum Blinds		35.9	-1.2%	-3.0%	2.6%	-333	-397	-$40	-$0.017	-$0.11	25,271	0	-308	0
Always Covered	**Trielle-Best Fit**	33.7	5.0%	3.3%	38.6%	1,362	1,626	$165	$0.069	$0.46	23,702	0	1,261	0
	Trielle-Production	34.8	2.0%	-4.9%	39.5%	543	649	$66	$0.027	$0.18	24,460	0	503	0
	Elan	34.8	1.9%	-4.3%	36.6%	516	616	$63	$0.026	$0.18	24,485	0	478	0
	Reception	34.7	2.1%	-3.7%	36.9%	579	691	$70	$0.029	$0.20	24,427	0	536	0
HD Green Mode	**Trielle-Best Fit**	32.6	8.1%	14.6%	23.9%	2,187	2,611	$266	$0.111	$0.74	22,937	0	2,026	0
	Trielle-Production	33.5	5.6%	7.8%	25.1%	1,504	1,796	$183	$0.076	$0.51	23,569	0	1,394	0
	Elan	33.7	5.1%	7.1%	23.1%	1,367	1,632	$166	$0.069	$0.47	23,697	0	1,266	0
	Reception	33.6	5.3%	7.7%	23.3%	1,434	1,712	$174	$0.073	$0.49	23,635	0	1,328	0
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	32.3	8.9%	14.3%	32.5%	2,387	2,849	$290	$0.121	$0.81	22,752	0	2,211	0
	Trielle-Production	33.2	6.3%	7.4%	33.6%	1,698	2,027	$206	$0.086	$0.58	23,390	0	1,573	0
	Elan	33.4	5.7%	6.8%	30.9%	1,547	1,847	$188	$0.078	$0.53	23,530	0	1,433	0
	Reception	33.3	6.0%	7.3%	31.2%	1,617	1,930	$197	$0.082	$0.55	23,465	0	1,498	0

TABLE A4b – ZONE 4 -Washington DC COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline Existing (No Coverings)		56.4	-	-	-	-	-	-	-	-	39,658	0	0	0
Existing with Aluminum Blinds		57.5	-2.0%	-9.1%	15.5%	-839	-1,002	-$102	-$0.042	-$0.29	40,435	0	-777	0
Existing with New R-2.86/SHGC-0.4 (IECC 2012) Windows		51.6	8.4%	1.4%	43.1%	3,619	4,320	$440	$0.183	$1.23	36,306	0	3,352	0
Always Covered	**Trielle-Best Fit**	49.6	12.0%	3.7%	57.7%	5,133	6,128	$624	$0.260	$1.75	34,903	0	4,755	0
	Trielle-Production	51.4	8.7%	-2.9%	58.2%	3,733	4,456	$454	$0.189	$1.27	36,200	0	3,458	0
	Elan	51.6	8.4%	-2.2%	54.6%	3,603	4,301	$438	$0.182	$1.23	36,321	0	3,337	0
	Reception	51.4	8.8%	-1.5%	54.5%	3,762	4,492	$457	$0.190	$1.28	36,173	0	3,485	0
HD Green Mode	**Trielle-Best Fit**	48.1	14.6%	16.8%	33.9%	6,248	7,459	$759	$0.316	$2.13	33,870	0	5,788	0
	Trielle-Production	49.6	11.9%	11.2%	35.0%	5,106	6,095	$621	$0.258	$1.74	34,929	0	4,730	0
	Elan	50.1	11.2%	10.4%	32.8%	4,785	5,713	$582	$0.242	$1.63	35,225	0	4,433	0
	Reception	49.9	11.5%	11.0%	32.6%	4,916	5,870	$598	$0.249	$1.67	35,104	0	4,554	0
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	47.0	16.5%	15.9%	46.7%	7,087	8,460	$861	$0.359	$2.41	33,094	0	6,564	0
	Trielle-Production	48.6	13.8%	10.2%	47.6%	5,917	7,064	$719	$0.299	$2.01	34,177	0	5,481	0
	Elan	49.1	13.0%	9.6%	44.5%	5,550	6,626	$674	$0.281	$1.89	34,517	0	5,141	0
	Reception	48.9	13.3%	10.2%	44.4%	5,683	6,784	$691	$0.288	$1.93	34,394	0	5,264	0

[1] 2400 sf home
[2] 23.4 mpg vehicle

FIGURE A5a - ZONE 5 (CHICAGO) - HOME ENERGY CONSUMPTION

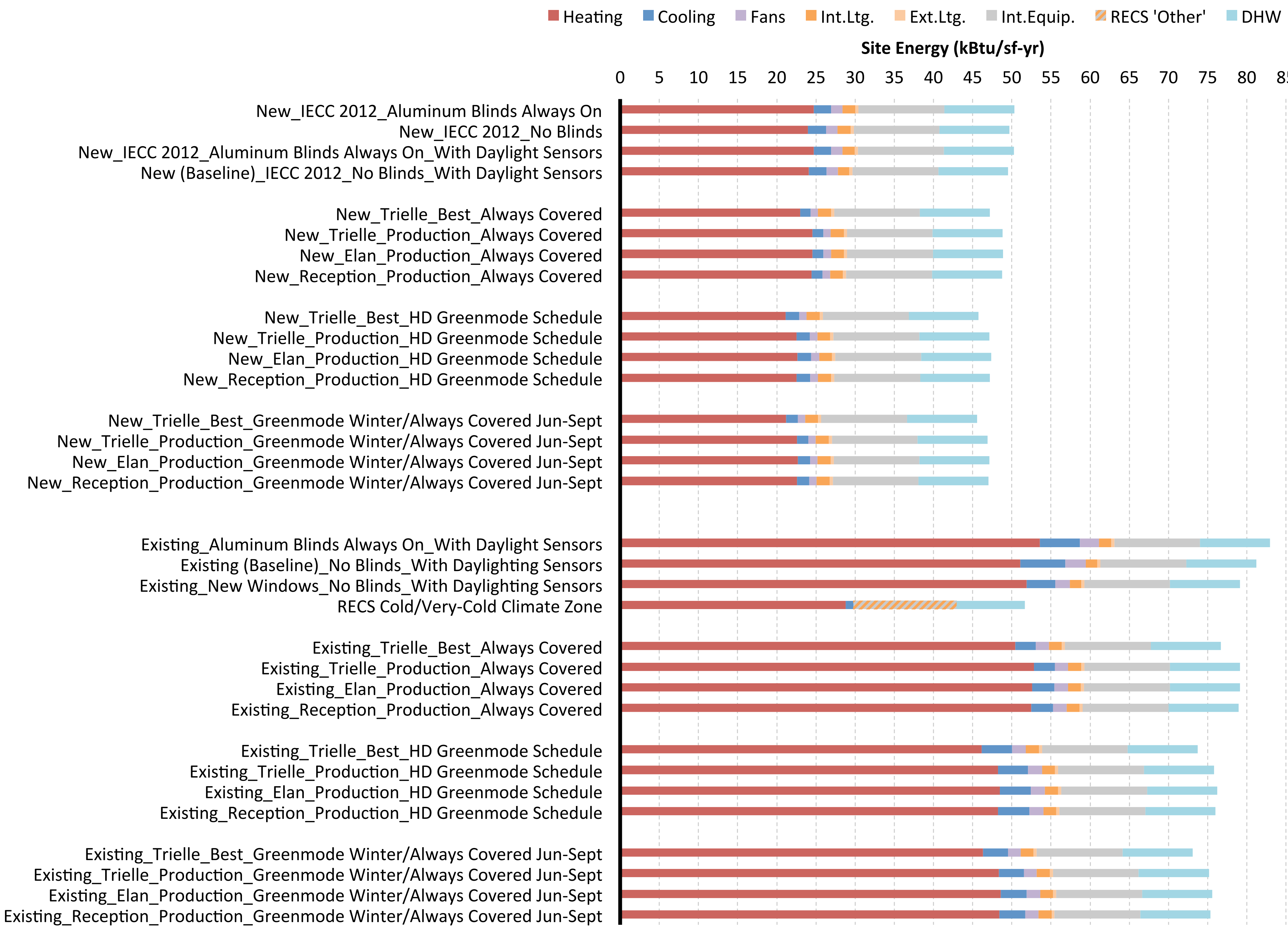


FIGURE A5b - ZONE 5 (CHICAGO) - HEATING & COOLING SAVINGS

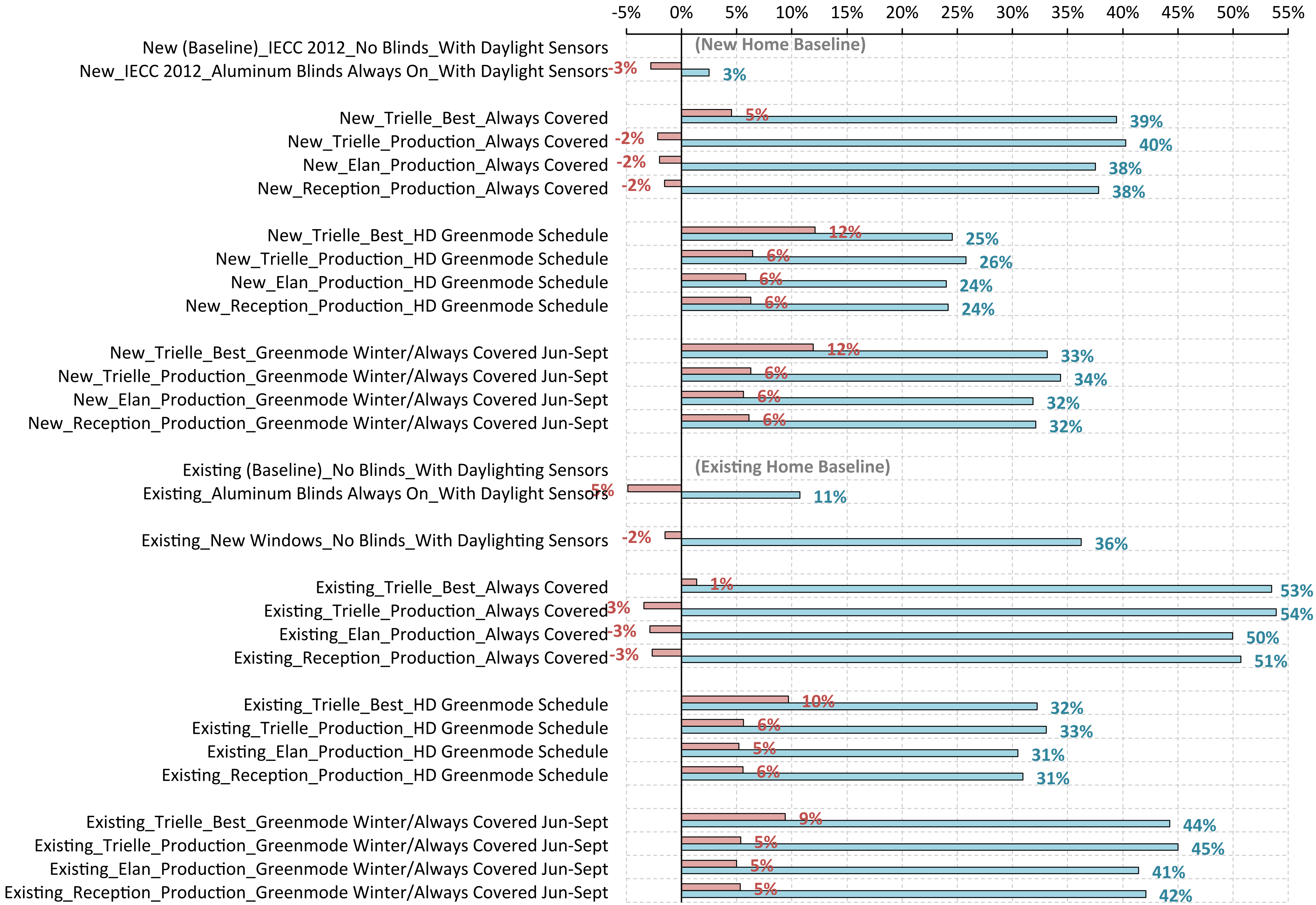


TABLE A5a – ZONE 5 (CHICAGO) COMPLETE SAVINGS RESULTS		**kBtu /sf**	**overall savings**	**heating savings**	**cooling savings**	**CO_2 Savings[1] (lb/yr)**	**Equivalent Driving Miles Avoided[1,2]**	**$ savings[1]**	**$ savings per sf floor**	**$ savings per sf window**	**Elec Use[1] (kWh/yr)**	**Gas Use[1] (therms/yr)**	**Elec Savings[1] (kWh/yr)**	**Gas Savings[1] (therms/ yr)**
Baseline New (No Coverings)		49.6	-	-	-	-	-	-	-	-	11,648	792	0	0
New with Aluminum Blinds		50.3	-1.5%	-2.8%	2.5%	-234	-279	-$17	-$0.007	-$0.05	11,678	809	-30	-16
Always Covered	**Trielle- Best Fit**	47.2	4.7%	4.6%	39.4%	1,630	1,946	$139	$0.058	$0.39	10,772	766	876	26
	Trielle- Production	48.9	1.4%	-2.1%	40.3%	1,159	1,383	$105	$0.044	$0.29	10,784	805	864	-13
	Elan	48.9	1.3%	-2.0%	37.5%	1,084	1,294	$99	$0.041	$0.28	10,840	804	808	-12
	Reception	48.8	1.6%	-1.5%	37.8%	1,128	1,346	$102	$0.042	$0.29	10,832	801	816	-9
HD Green Mode	**Trielle- Best Fit**	45.8	7.6%	12.1%	24.5%	1,736	2,072	$138	$0.058	$0.39	11,041	722	607	70
	Trielle- Production	47.1	4.9%	6.5%	25.8%	1,355	1,618	$112	$0.047	$0.31	11,040	755	608	37
	Elan	47.4	4.4%	5.8%	24.0%	1,244	1,486	$103	$0.043	$0.29	11,084	759	564	34
	Reception	47.2	4.7%	6.3%	24.2%	1,288	1,538	$106	$0.044	$0.30	11,077	756	571	36
Winter: Green Mode Summer: Always On	**Trielle- Best Fit**	45.6	8.0%	12.0%	33.2%	1,989	2,374	$161	$0.067	$0.45	10,867	723	781	69
	Trielle- Production	46.9	5.3%	6.3%	34.4%	1,604	1,915	$134	$0.056	$0.38	10,867	756	781	36
	Elan	47.2	4.8%	5.6%	31.9%	1,479	1,766	$124	$0.052	$0.35	10,921	760	727	32
	Reception	47.0	5.1%	6.1%	32.1%	1,523	1,818	$127	$0.053	$0.36	10,914	757	734	35

TABLE A5b – ZONE 5 (CHICAGO) COMPLETE SAVINGS RESULTS		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline Existing (No Coverings)		81.2	-	-	-	-	-	-	-	-	14,895	1,442	0	0
Existing with Aluminum Blinds		83.0	-2.2%	-4.9%	10.8%	63	75	$19	$0.008	$0.05	14,391	1,502	504	-60
Existing with New R-3.12/SHGC-0.4 (IECC 2012) Windows		79.2	2.5%	-1.5%	36.2%	2,803	3,346	$252	$0.105	$0.71	12,896	1,461	1,999	-19
Always Covered	**Trielle-Best Fit**	76.7	5.6%	1.4%	53.5%	4,289	5,120	$376	$0.157	$1.05	12,185	1,426	2,710	16
	Trielle-Production	79.2	2.5%	-3.4%	53.9%	3,572	4,265	$325	$0.135	$0.91	12,206	1,484	2,689	-42
	Elan	79.1	2.6%	-2.8%	50.0%	3,374	4,028	$306	$0.128	$0.86	12,390	1,477	2,505	-35
	Reception	79.0	2.8%	-2.6%	50.7%	3,461	4,132	$313	$0.131	$0.88	12,353	1,475	2,542	-33
HD Green Mode	**Trielle-Best Fit**	73.8	9.2%	9.7%	32.2%	4,079	4,870	$335	$0.140	$0.94	13,115	1,324	1,780	119
	Trielle-Production	75.8	6.7%	5.6%	33.1%	3,506	4,186	$295	$0.123	$0.83	13,111	1,373	1,784	69
	Elan	76.2	6.2%	5.2%	30.5%	3,251	3,881	$274	$0.114	$0.77	13,240	1,378	1,655	64
	Reception	76.0	6.4%	5.6%	31.0%	3,339	3,986	$281	$0.117	$0.79	13,215	1,374	1,680	68
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	73.1	10.0%	9.4%	44.2%	4,898	5,848	$409	$0.170	$1.14	12,549	1,327	2,346	116
	Trielle-Production	75.2	7.5%	5.3%	45.0%	4,312	5,149	$368	$0.153	$1.03	12,549	1,377	2,346	66
	Elan	75.6	6.9%	5.0%	41.4%	3,998	4,773	$341	$0.142	$0.95	12,724	1,381	2,171	61
	Reception	75.4	7.2%	5.3%	42.1%	4,097	4,892	$349	$0.145	$0.98	12,690	1,377	2,205	65

[1] 2400 sf home
[2] 23.4 mpg vehicle

FIGURE A6a - ZONE 6 (MINNEAPOLIS) - HOME ENERGY CONSUMPTION

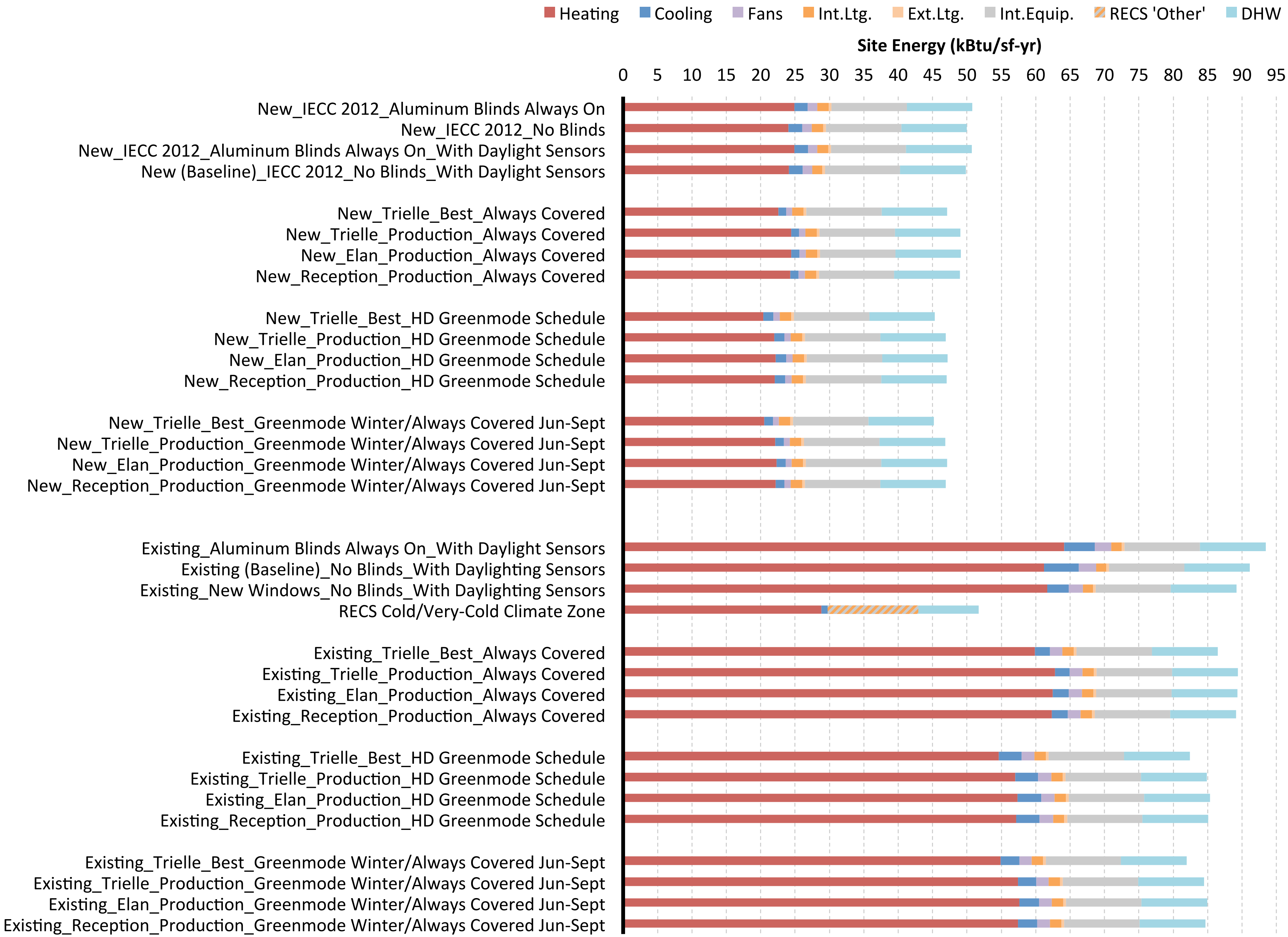


FIGURE A6b - ZONE 6 (MINNEAPOLIS) - HEATING & COOLING SAVINGS

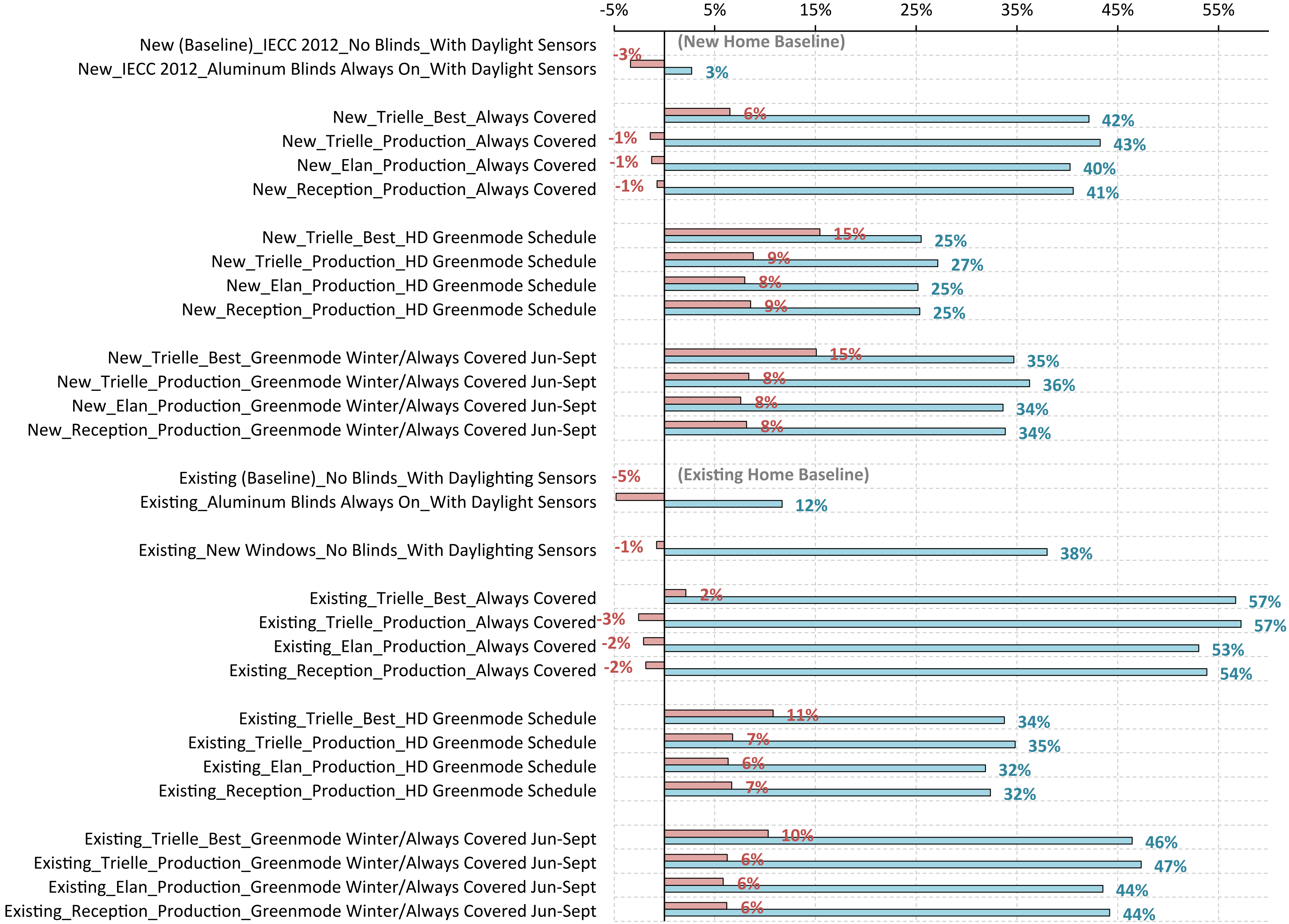


TABLE A6a – ZONE 6 (MINNEAPOLIS) COMPLETE SAVINGS RESULTS		kBtu/sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/yr)
Baseline New (No Coverings)		49.8	-	-	-	-	-	-	-	-	11,381	808	0	0
New with Aluminum Blinds		50.7	-1.7%	-3.4%	2.7%	-284	-339	-$21	-$0.009	-$0.06	11,417	828	-36	-20
Always Covered	**Trielle-Best Fit**	47.2	5.4%	6.5%	42.1%	1,669	1,993	$130	$0.054	$0.36	10,584	771	797	37
	Trielle-Production	49.1	1.5%	-1.4%	43.3%	1,114	1,330	$89	$0.037	$0.25	10,597	817	784	-8
	Elan	49.1	1.4%	-1.3%	40.3%	1,039	1,241	$83	$0.034	$0.23	10,651	816	730	-8
	Reception	49.0	1.7%	-0.7%	40.6%	1,089	1,300	$86	$0.036	$0.24	10,643	813	738	-4
HD Green Mode	**Trielle-Best Fit**	45.4	9.0%	15.5%	25.5%	1,878	2,242	$143	$0.060	$0.40	10,844	719	537	90
	Trielle-Production	47.0	5.8%	8.8%	27.1%	1,430	1,707	$110	$0.046	$0.31	10,843	757	538	51
	Elan	47.2	5.3%	8.0%	25.1%	1,308	1,562	$101	$0.042	$0.28	10,884	762	497	46
	Reception	47.1	5.6%	8.6%	25.3%	1,357	1,620	$104	$0.043	$0.29	10,878	759	503	50
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	45.2	9.3%	15.1%	34.7%	2,104	2,512	$161	$0.067	$0.45	10,680	721	701	87
	Trielle-Production	46.8	6.0%	8.4%	36.3%	1,649	1,969	$128	$0.053	$0.36	10,681	760	701	48
	Elan	47.1	5.5%	7.6%	33.6%	1,515	1,809	$117	$0.049	$0.33	10,733	765	649	44
	Reception	47.0	5.8%	8.2%	33.8%	1,565	1,869	$121	$0.050	$0.34	10,726	761	656	47

TABLE A6b – ZONE 6 (MINNEAPOLIS) COMPLETE SAVINGS RESULTS		**kBtu/ sf**	**overall savings**	**heating savings**	**cooling savings**	**CO2 Savings[1] (lb/yr)**	**Equivalent Driving Miles Avoided[1,2]**	**$ savings[1]**	**$ savings per sf floor**	**$ savings per sf window**	**Elec Use[1] (kWh/yr)**	**Gas Use[1] (therms/yr)**	**Elec Savings[1] (kWh/yr)**	**Gas Savings[1] (therms/ yr)**
Baseline Existing (No Coverings)		91.2	-	-	-	-	-	-	-	-	14,366	1,699	0	0
Existing with Aluminum Blinds		93.5	-2.5%	-4.8%	11.7%	-123	-146	-$5	-$0.002	-$0.02	13,912	1,769	453	-70
Existing with New R-3.12/SHGC-0.4 (IECC 2012) Windows		89.2	2.1%	-0.8%	38.0%	2,508	2,994	$199	$0.083	$0.56	12,653	1,711	1,712	-12
Always Covered	**Trielle-Best Fit**	86.5	5.2%	2.1%	56.7%	4,060	4,847	$319	$0.133	$0.89	11,975	1,668	2,391	31
	Trielle-Production	89.4	1.9%	-2.6%	57.2%	3,205	3,827	$256	$0.107	$0.72	12,002	1,737	2,364	-38
	Elan	89.3	2.0%	-2.1%	53.0%	3,029	3,616	$242	$0.101	$0.68	12,174	1,729	2,191	-31
	Reception	89.1	2.2%	-1.8%	53.8%	3,122	3,727	$249	$0.104	$0.70	12,138	1,726	2,228	-27
HD Green Mode	**Trielle-Best Fit**	82.4	9.6%	10.8%	33.8%	4,199	5,013	$323	$0.134	$0.90	12,848	1,540	1,518	158
	Trielle-Production	84.9	6.9%	6.8%	34.8%	3,513	4,194	$272	$0.113	$0.76	12,846	1,599	1,520	100
	Elan	85.3	6.4%	6.3%	31.9%	3,228	3,854	$250	$0.104	$0.70	12,978	1,606	1,388	93
	Reception	85.1	6.7%	6.7%	32.4%	3,329	3,974	$257	$0.107	$0.72	12,952	1,601	1,414	98
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	82.0	10.1%	10.3%	46.4%	4,929	5,885	$381	$0.159	$1.07	12,318	1,548	2,047	151
	Trielle-Production	84.5	7.3%	6.2%	47.3%	4,222	5,041	$329	$0.137	$0.92	12,323	1,608	2,042	91
	Elan	84.9	6.8%	5.8%	43.5%	3,901	4,657	$304	$0.126	$0.85	12,490	1,613	1,876	86
	Reception	84.7	7.1%	6.2%	44.2%	4,011	4,789	$312	$0.130	$0.87	12,457	1,608	1,909	91

[1]2400 sf home
[2]23.4 mpg vehicle

FIGURE A7a - ZONE 7 (ASPEN) - HOME ENERGY CONSUMPTION

FIGURE A7b - ZONE 7 (ASPEN) - HEATING & COOLING SAVINGS

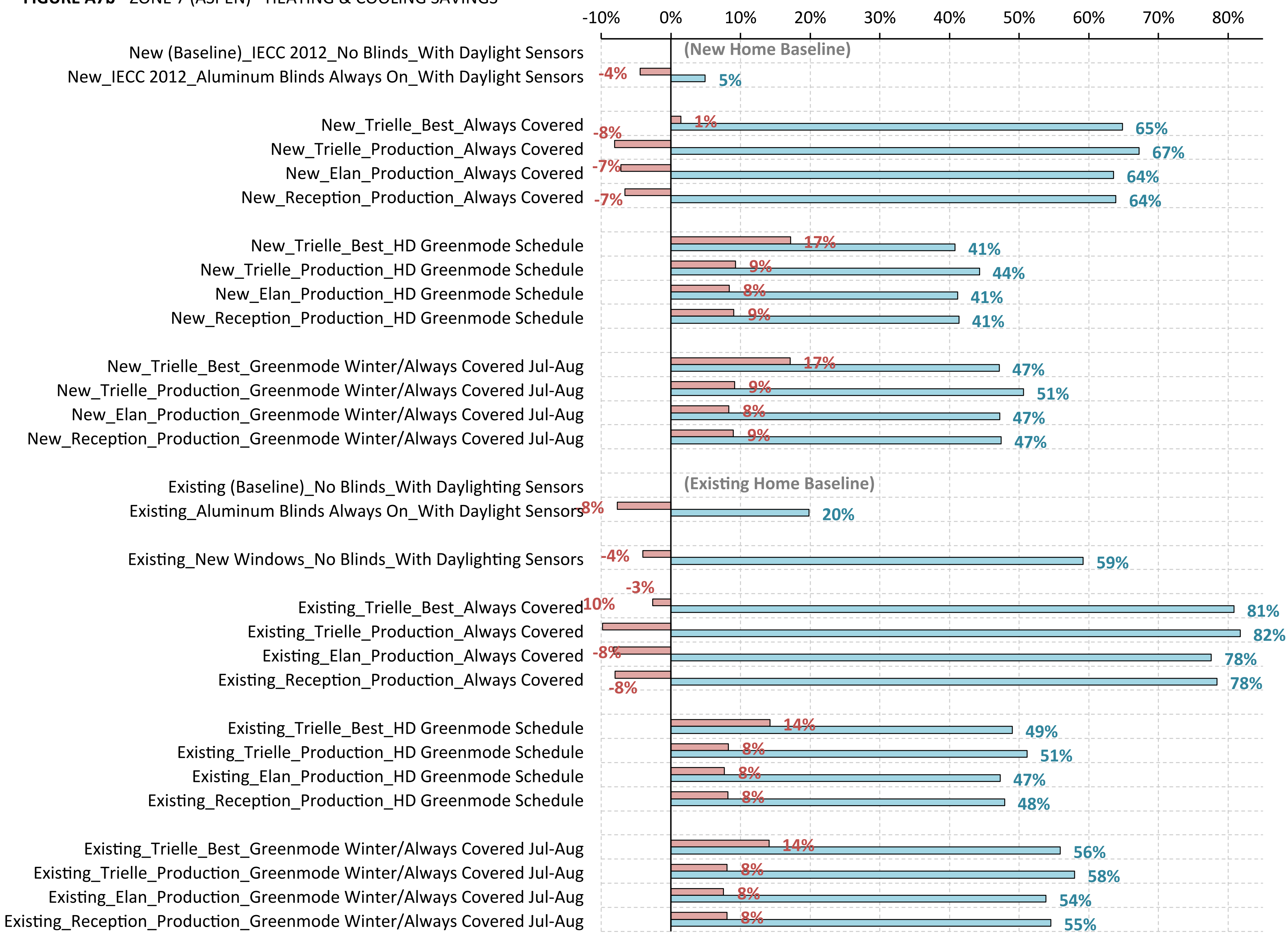


TABLE A7a – ZONE 7 (ASPEN) COMPLETE SAVINGS RESULTS		kBtu/sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/yr)
Baseline New (No Coverings)		45.6	-	-	-	-	-	-	-	-	10,624	733	0	0
New with Aluminum Blinds		46.6	-2.1%	-4.4%	4.9%	-302	-361	-$20	-$0.008	-$0.06	10,649	755	-25	-22
Always Covered	**Trielle-Best Fit**	44.5	2.6%	1.5%	64.8%	1,276	1,524	$81	$0.034	$0.23	9,997	727	627	7
	Trielle-Production	46.5	-1.8%	-8.1%	67.2%	681	813	$41	$0.017	$0.12	10,017	774	607	-41
	Elan	46.3	-1.5%	-7.2%	63.5%	673	804	$41	$0.017	$0.11	10,051	769	573	-36
	Reception	46.2	-1.2%	-6.6%	63.9%	717	856	$44	$0.018	$0.12	10,044	767	579	-33
HD Green Mode	**Trielle-Best Fit**	41.5	9.2%	17.2%	40.8%	1,861	2,222	$120	$0.050	$0.34	10,170	648	454	85
	Trielle-Production	43.1	5.6%	9.3%	44.3%	1,398	1,669	$90	$0.037	$0.25	10,172	688	452	46
	Elan	43.3	5.1%	8.4%	41.2%	1,277	1,524	$82	$0.034	$0.23	10,208	692	415	41
	Reception	43.2	5.4%	9.0%	41.3%	1,326	1,583	$85	$0.035	$0.24	10,203	689	421	45
Winter: Green Mode Summer: Always On	**Trielle-Best Fit**	41.4	9.4%	17.1%	47.1%	1,981	2,365	$128	$0.053	$0.36	10,106	649	518	85
	Trielle-Production	43.0	5.7%	9.2%	50.6%	1,515	1,809	$97	$0.040	$0.27	10,107	688	517	45
	Elan	43.3	5.2%	8.3%	47.2%	1,390	1,660	$89	$0.037	$0.25	10,147	692	477	41
	Reception	43.1	5.5%	9.0%	47.4%	1,440	1,719	$92	$0.038	$0.26	10,141	689	483	44

TABLE A7b – ZONE 7 (ASPEN) COMPLETE SAVINGS RESULTS		kBtu/ sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline Existing (No Coverings)		70.3	-	-	-	-	-	-	-	-	13,198	1,239	0	0
Existing with Aluminum Blinds		72.7	-3.4%	-7.7%	19.8%	242	289	$12	$0.005	$0.03	12,597	1,316	601	-77
Existing with New R-3.12/SHGC-0.4 (IECC 2012) Windows		69.2	1.6%	-4.0%	59.2%	3,292	3,931	$206	$0.086	$0.58	11,221	1,279	1,978	-41
Always Covered	Trielle-Best Fit	67.9	3.5%	-2.6%	80.8%	4,452	5,315	$279	$0.116	$0.78	10,700	1,265	2,499	-27
	Trielle-Production	71.0	-0.9%	-9.8%	81.7%	3,531	4,215	$218	$0.091	$0.61	10,740	1,337	2,459	-99
	Elan	70.4	-0.1%	-8.2%	77.6%	3,512	4,193	$218	$0.091	$0.61	10,850	1,321	2,348	-82
	Reception	70.3	0.0%	-8.0%	78.4%	3,581	4,276	$222	$0.093	$0.62	10,824	1,319	2,374	-81
HD Green Mode	Trielle-Best Fit	62.0	11.8%	14.2%	49.0%	4,865	5,808	$311	$0.130	$0.87	11,520	1,096	1,678	142
	Trielle-Production	64.5	8.3%	8.2%	51.1%	4,179	4,989	$266	$0.111	$0.74	11,511	1,156	1,687	82
	Elan	64.9	7.7%	7.7%	47.3%	3,879	4,631	$247	$0.103	$0.69	11,634	1,162	1,564	77
	Reception	64.7	8.0%	8.2%	47.9%	3,983	4,755	$254	$0.106	$0.71	11,610	1,157	1,588	82
Winter: Green Mode Summer: Always On	Trielle-Best Fit	61.8	12.2%	14.1%	55.9%	5,244	6,260	$335	$0.139	$0.94	11,313	1,098	1,886	141
	Trielle-Production	64.3	8.6%	8.0%	58.0%	4,549	5,431	$289	$0.120	$0.81	11,306	1,158	1,893	80
	Elan	64.7	8.0%	7.5%	53.9%	4,243	5,065	$270	$0.112	$0.75	11,435	1,163	1,763	75
	Reception	64.5	8.4%	8.0%	54.6%	4,350	5,193	$277	$0.115	$0.77	11,409	1,158	1,789	80

[1] 2400 sf home

[2] 23.4 mpg vehicle

NOTE: Cooling loads in Aspen are relatively small in magnitude, making them heavily sensitive to factors such as local microclimates, building thermal mass, opening windows, cloud cover and site shading, as well as interior window coverings, as suggested here. Mechanical air conditioning is less common that other locations. While relatively small in magnitude, the high cooling percent savings suggest that window coverings could help eliminate the need to install any mechanical A/C equipment in Zone 7 locations.

FIGURE A8a - ZONE 8 (ANCHORAGE) - HOME ENERGY CONSUMPTION

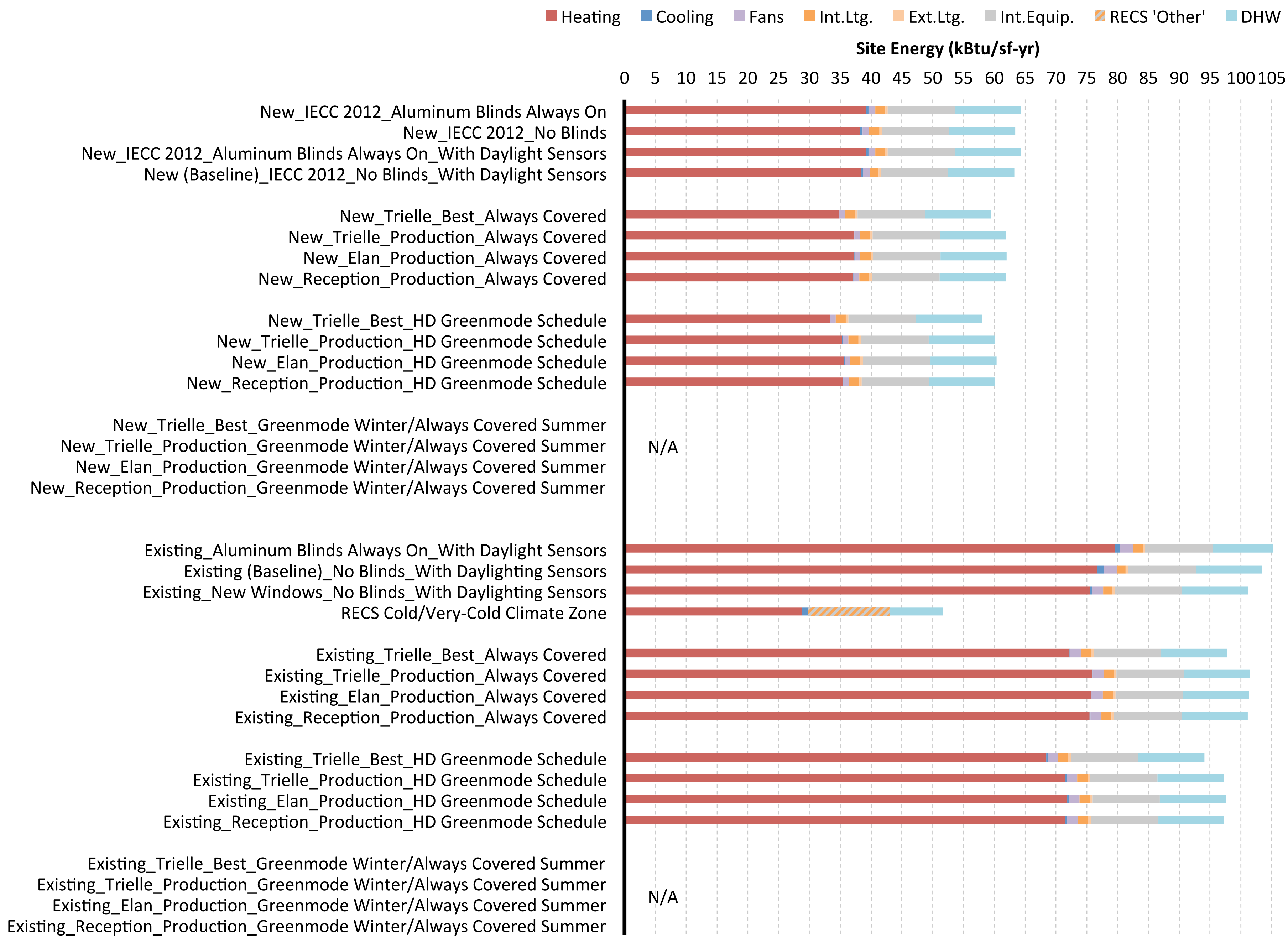


FIGURE A8b - ZONE 8 (MIAMI) - HEATING & COOLING SAVINGS

TABLE A8a – ZONE 8 (ANCHORAGE) COMPLETE SAVINGS RESULTS		kBtu/ sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms/yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)
Baseline New (No Coverings)		63.3	-	-	-	-	-	-	-	-	9,998	1,178	0	0
New with Aluminum Blinds		64.3	-1.7%	-2.3%	-	-412	-492	-$46	-$0.019	-$0.13	10,125	1,199	-127	-22
Always Covered	**Trielle-Best Fit**	59.5	6.0%	9.3%	-	1,214	1,449	$117	$0.049	$0.33	9,830	1,092	167	86
	Trielle-Production	61.9	2.1%	3.0%	-	493	589	$54	$0.022	$0.15	9,862	1,150	135	28
	Elan	62.0	2.0%	2.8%	-	455	543	$49	$0.020	$0.14	9,877	1,152	121	26
	Reception	61.8	2.3%	3.3%	-	511	610	$54	$0.023	$0.15	9,872	1,148	125	30
HD Green Mode	**Trielle-Best Fit**	58.0	8.3%	13.2%	-	1,608	1,920	$148	$0.062	$0.41	9,851	1,056	146	122
	Trielle-Production	60.1	5.1%	7.9%	-	1,008	1,203	$96	$0.040	$0.27	9,873	1,105	125	73
	Elan	60.4	4.6%	7.2%	-	910	1,087	$86	$0.036	$0.24	9,892	1,111	105	66
	Reception	60.2	4.9%	7.7%	-	966	1,153	$91	$0.038	$0.25	9,888	1,107	110	71

TABLE A8b – ZONE 8 (ANCHORAGE) COMPLETE SAVINGS RESULTS		**kBtu/ sf**	**overall savings**	**heating savings**	**cooling savings**	**CO2 Savings[1] (lb/yr)**	**Equivalent Driving Miles Avoided[1,2]**	**$ savings[1]**	**$ savings per sf floor**	**$ savings per sf window**	**Elec Use[1] (kWh/yr)**	**Gas Use[1] (therms/yr)**	**Elec Savings[1] (kWh/yr)**	**Gas Savings[1] (therms/ yr)**
Baseline Existing (No Coverings)		103.4	-	-	-	-	-	-	-	-	11,251	2,099	0	0
Existing with Aluminum Blinds		106.2	-2.7%	-3.7%	-	-709	-847	-$53	-$0.022	-$0.15	11,174	2,168	77	-69
Existing with New R-3.12/SHGC-0.4 (IECC 2012) Windows		101.2	2.1%	1.6%	-	1,227	1,465	$167	$0.070	$0.47	10,544	2,070	707	29
Always Covered	**Trielle-Best Fit**	97.8	5.4%	5.8%	-	2,275	2,716	$264	$0.110	$0.74	10,439	1,992	812	107
	Trielle-Production	101.5	1.8%	1.1%	-	1,192	1,423	$169	$0.070	$0.47	10,490	2,079	761	20
	Elan	101.3	2.0%	1.4%	-	1,208	1,442	$167	$0.070	$0.47	10,521	2,074	730	25
	Reception	101.1	2.2%	1.6%	-	1,277	1,525	$174	$0.073	$0.49	10,511	2,069	740	29
HD Green Mode	**Trielle-Best Fit**	94.1	9.0%	10.8%	-	3,242	3,871	$338	$0.141	$0.95	10,524	1,900	728	199
	Trielle-Production	97.2	6.0%	6.8%	-	2,341	2,795	$260	$0.108	$0.73	10,553	1,974	698	125
	Elan	97.6	5.6%	6.4%	-	2,186	2,609	$242	$0.101	$0.68	10,607	1,981	644	117
	Reception	97.3	5.9%	6.7%	-	2,275	2,716	$250	$0.104	$0.70	10,594	1,975	657	124

FIGURE A9a - ZONE 5 (DENVER) - HOME ENERGY CONSUMPTION

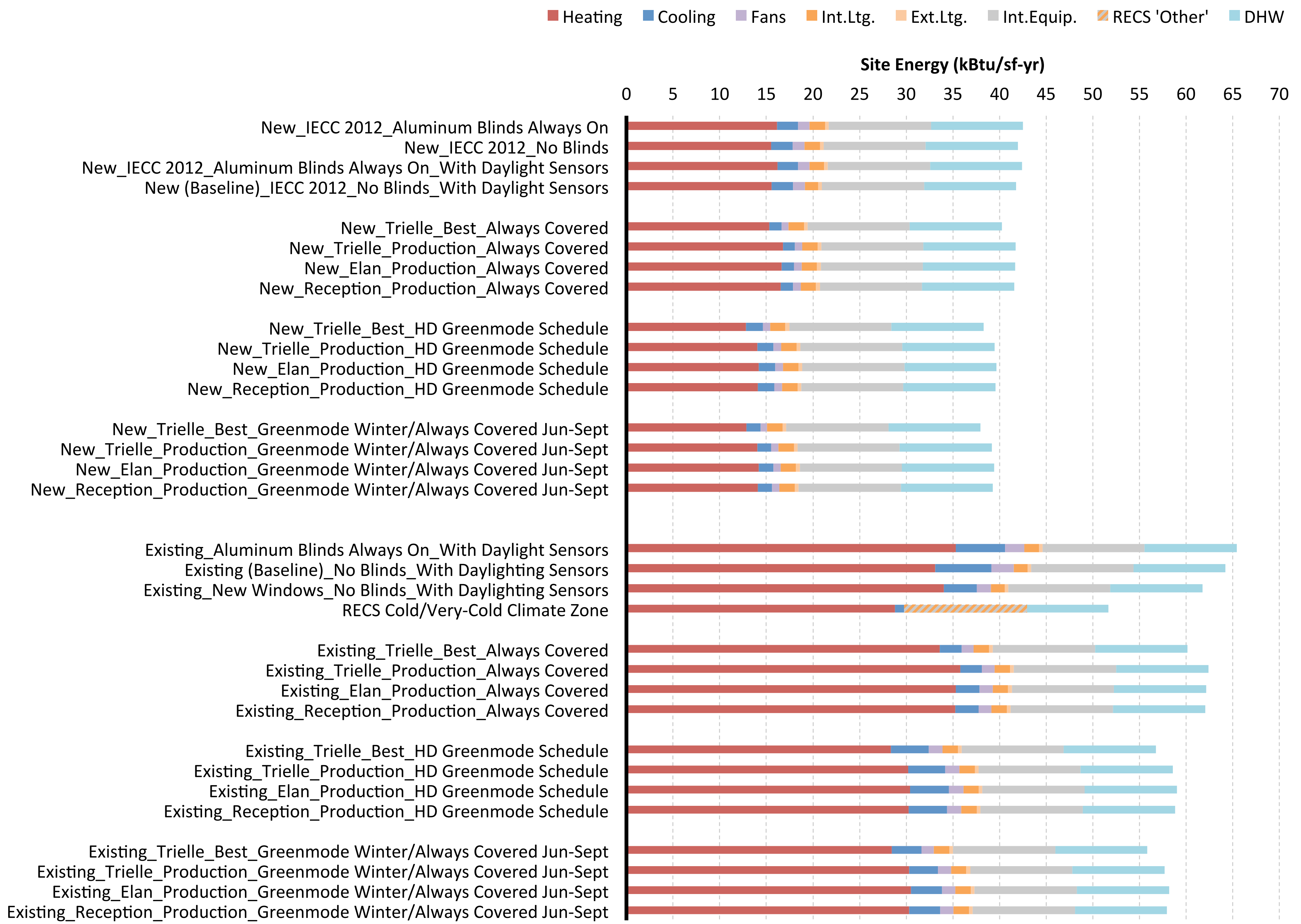


FIGURE A9b - ZONE 5 (DENVER) - HEATING & COOLING SAVINGS

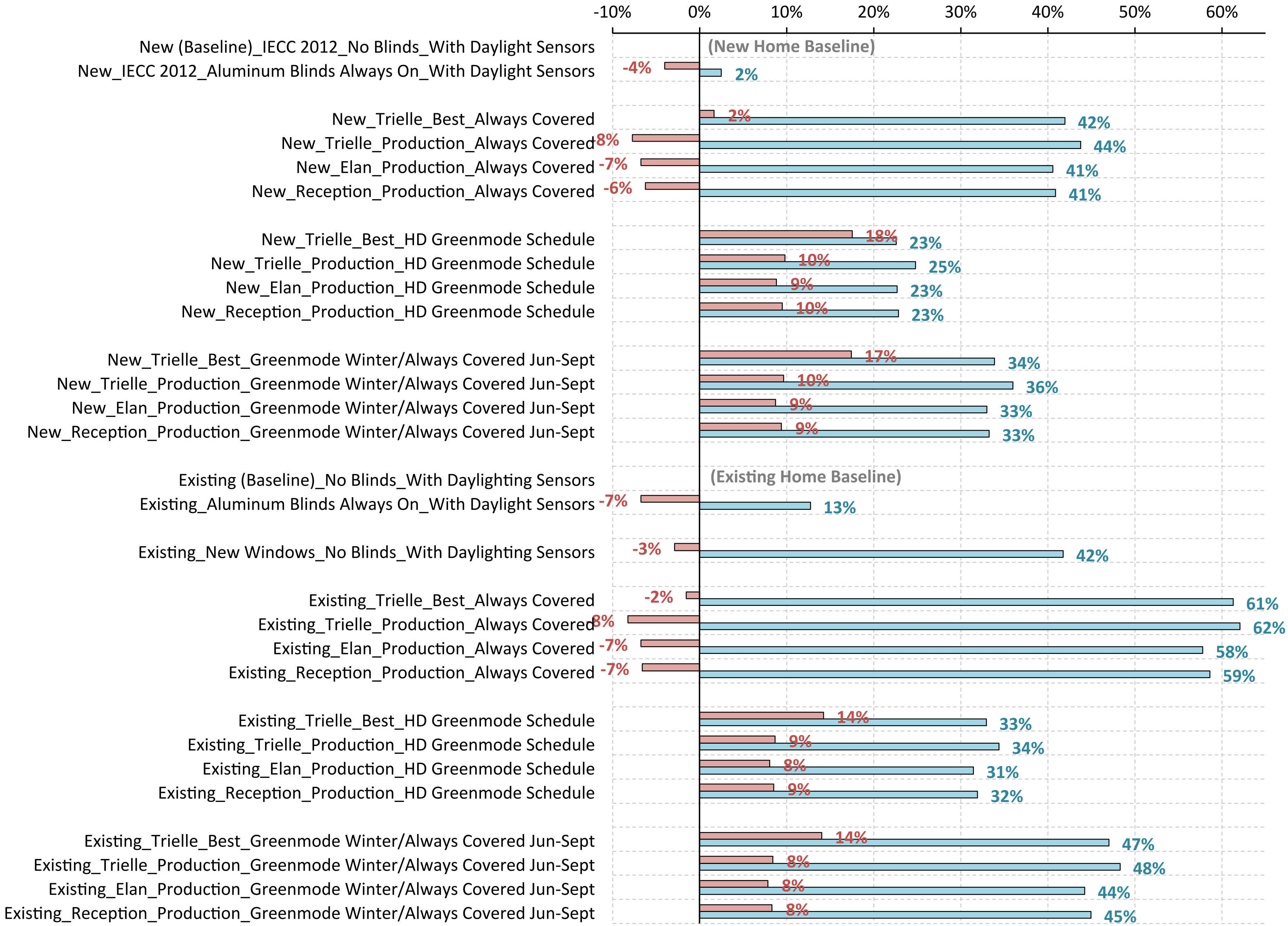


TABLE A9a – ZONE 5 (DENVER) COMPLETE SAVINGS RESULTS		kBtu/ sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equiv. Driving Miles Avoided [1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms /yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms /yr)	Peak Elec[1] (kW)	Time of Peak	Peak Reduc-tion	Cooling Equip Downsize Potential
Baseline New (No Coverings)		41.8	-	-	-	-	-	-	-	-	11,506	611	-	-	3.22	26-JUN-19:15	-	-
New with Aluminum Blinds		42.4	-1.5%	-4.0%	2.5%	-188	-224	-$12	-$0.005	-$0.03	11,512	626	-6	-15	3.21	26-JUN-19:15	0%	4%
Always Covered	**Trielle-Best Fit**	40.3	3.7%	1.7%	41.9%	1,779	2,124	$112	$0.047	$0.31	10,610	605	896	6	2.78	26-JUN-18:15	14%	31%
	Trielle-Production	41.8	0.1%	-7.7%	43.8%	1,358	1,622	$84	$0.035	$0.24	10,615	640	891	-29	2.82	26-JUN-18:15	12%	27%
	Elan	41.7	0.3%	-6.7%	40.6%	1,285	1,534	$80	$0.033	$0.22	10,675	637	830	-26	2.87	26-JUN-18:15	11%	27%
	Reception	41.6	0.5%	-6.2%	40.9%	1,325	1,582	$82	$0.034	$0.23	10,667	635	839	-24	2.86	26-JUN-18:15	11%	27%
HD Green Mode	**Trielle-Best Fit**	38.3	8.4%	17.5%	22.6%	1,817	2,169	$117	$0.049	$0.33	10,955	545	551	66	2.89	26-JUN-18:15	10%	25%
	Trielle-Production	39.5	5.6%	9.8%	24.8%	1,501	1,792	$96	$0.040	$0.27	10,944	574	562	37	2.92	26-JUN-18:15	9%	23%
	Elan	39.7	5.0%	8.9%	22.7%	1,371	1,637	$87	$0.036	$0.24	10,990	578	516	33	2.97	26-JUN-18:15	8%	23%
	Reception	39.6	5.3%	9.5%	22.8%	1,411	1,685	$90	$0.038	$0.25	10,984	575	522	36	2.96	26-JUN-18:15	8%	23%
Winter Green Mode/ Summer Always On	**Trielle-Best Fit**	38.0	9.1%	17.4%	33.9%	2,236	2,669	$143	$0.060	$0.40	10,733	546	773	65	2.80	26-JUN-18:15	13%	25%
	Trielle-Production	39.2	6.3%	9.7%	36.0%	1,915	2,286	$122	$0.051	$0.34	10,723	575	783	36	2.83	26-JUN-18:15	12%	23%
	Elan	39.4	5.7%	8.7%	33.0%	1,754	2,094	$112	$0.046	$0.31	10,786	578	720	33	2.88	26-JUN-18:15	11%	23%
	Reception	39.3	6.0%	9.4%	33.3%	1,799	2,147	$114	$0.048	$0.32	10,778	576	728	35	2.87	26-JUN-18:15	11%	23%

TABLE A9b – ZONE 5 (DENVER) COMPLETE SAVINGS RESULTS		kBtu/ sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equiv. Driving Miles Avoided [1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms /yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms /yr)	Peak Elec[1] (kW)	Time of Peak	Peak Reduc-tion	Cooling Equip Downsize Potential
Baseline Existing (No Coverings)		64.2	-	-	-	-	-	-	-	-	14,968	1,032	-	-	5.72	26-JUN-19:15	-	-
Existing with Aluminum Blinds		65.5	-1.9%	-6.7%	12.7%	734	876	$44	$0.018	$0.12	14,254	1,085	714	-54	5.70	26-JUN-18:15	0%	10%
Existing with New R-3.12/SHGC-0.4 (IECC 2012) Windows		61.8	3.8%	-2.9%	41.8%	4,310	5,145	$270	$0.113	$0.76	12,565	1,055	2,403	-23	5.18	26-JUN-17:15	9%	23%
Always Covered	**Trielle-Best Fit**	60.2	6.4%	-1.5%	61.3%	6,037	7,207	$379	$0.158	$1.06	11,725	1,044	3,243	-12	4.36	26-JUN-18:15	24%	29%
	Trielle-Production	62.4	2.9%	-8.2%	62.1%	5,380	6,423	$336	$0.140	$0.94	11,741	1,098	3,227	-66	4.45	26-JUN-18:15	22%	26%
	Elan	62.2	3.2%	-6.7%	57.8%	5,138	6,135	$321	$0.134	$0.90	11,942	1,086	3,026	-54	4.60	26-JUN-18:15	20%	26%
	Reception	62.1	3.4%	-6.6%	58.6%	5,233	6,248	$327	$0.136	$0.92	11,900	1,084	3,068	-53	4.56	26-JUN-18:15	20%	26%
HD Green Mode	**Trielle-Best Fit**	56.8	11.6%	14.2%	32.9%	4,999	5,968	$319	$0.133	$0.89	13,040	919	1,927	113	4.80	26-JUN-18:15	16%	24%
	Trielle-Production	58.6	8.8%	8.7%	34.4%	4,529	5,408	$287	$0.120	$0.80	13,014	963	1,954	69	4.85	26-JUN-18:15	15%	22%
	Elan	59.0	8.1%	8.0%	31.4%	4,183	4,994	$265	$0.111	$0.74	13,165	968	1,803	64	4.97	26-JUN-18:15	13%	22%
	Reception	58.8	8.4%	8.5%	31.9%	4,283	5,113	$272	$0.113	$0.76	13,137	964	1,831	68	4.94	26-JUN-18:15	14%	22%
Winter Green Mode/ Summer Always On	**Trielle-Best Fit**	55.9	13.0%	14.1%	47.0%	6,298	7,519	$400	$0.167	$1.12	12,349	920	2,619	112	4.40	26-JUN-18:15	23%	24%
	Trielle-Production	57.7	10.2%	8.4%	48.3%	5,812	6,939	$368	$0.153	$1.03	12,330	965	2,638	67	4.47	26-JUN-18:15	22%	22%
	Elan	58.2	9.4%	7.9%	44.2%	5,367	6,407	$340	$0.142	$0.95	12,535	969	2,433	62	4.62	26-JUN-18:15	19%	22%
	Reception	58.0	9.8%	8.3%	45.0%	5,487	6,551	$348	$0.145	$0.97	12,495	966	2,472	66	4.58	26-JUN-18:15	20%	22%

[1] 2400 sf home
[2] 23.4 mpg vehicle

TABLE A9c – ZONE 5 (DENVER) PARTIAL COVERAGE RESULTS TRIELLE - PRODUCTION FIT - HD GREEN MODE		**kBtu /sf**	**overall savings**	**heating savings**	**cooling savings**	**CO2 Savings[1] (lb/yr)**	**Equivalent Driving Miles Avoided[1,2]**	**$ savings[1]**	**$ savings per sf floor**	**$ savings per sf window**	**Elec Use[1] (kWh/yr)**	**Gas Use[1] (therms /yr)**	**Elec Savings[1] (kWh/yr)**	**Gas Savings[1] (therms/ yr)**	**Peak Elec[1] (kW)**	**Time of Peak**	**Peak Elec Redu-ction**	**Cooling Equip Downsize Potential**
Baseline New (No Coverings)		41.8	-	-	-	-	-	-	-	-	11,506	611	-	-	3.2	26-JUN-19:15	-	-
Same On All Sides (Home has 4 windows per side)	**100% Coverage** (all 4 windows)	39.5	5.6%	9.8%	24.8%	1,501	1,792	$96	$0.040	$0.27	10,944	574	562	37	2.92	26-JUN-18:15	9.3%	23%
	75% Coverage (2 upstairs & 1 downstairs)	39.9	4.4%	7.0%	18.8%	1,336	1,596	$85	$0.035	$0.32	10,966	585	540	26	2.96	26-JUN-18:45	8%	22%
	75% Coverage (1 upstairs & 2 downstairs)	40.1	4.2%	7.2%	18.1%	1,166	1,392	$74	$0.031	$0.28	11,059	584	447	27	3.06	26-JUN-18:15	5%	22%
	50% Coverage (1 upstairs & 1 downstairs)	40.5	3.0%	4.4%	12.0%	963	1,149	$61	$0.025	$0.34	11,103	594	403	17	3.04	26-JUN-18:00	6%	22%
	50% Coverage (1 upstairs & 1 downstairs, alt)	40.5	3.1%	4.3%	12.1%	1,000	1,194	$63	$0.026	$0.36	11,081	595	425	16	3.04	26-JUN-18:00	6%	22%
	25% Coverage (1 upstairs)	41.1	1.6%	2.2%	6.1%	526	628	$33	$0.014	$0.37	11,280	603	226	8	3.18	26-JUN-19:15	1%	11%
	25% Coverage (1 downstairs)	41.2	1.6%	2.1%	6.1%	513	612	$33	$0.014	$0.36	11,286	603	220	8	3.18	26-JUN-19:15	1%	11%
South & West Walls Covered		40.4	3.3%	4.7%	13.7%	1,063	1,269	$67	$0.028	$0.38	11,057	593	449	18	2.86	26-JUN-18:00	11.1%	20%
North & East Walls Covered		40.7	2.6%	4.9%	11.6%	656	783	$42	$0.017	$0.23	11,273	593	233	18	3.20	26-JUN-19:15	1%	5%
Single Side Covered	**North**	41.2	1.3%	2.7%	3.1%	308	368	$20	$0.008	$0.22	11,406	601	100	10	3.20	26-JUN-19:15	1%	4%
	South	41.2	1.5%	2.7%	4.3%	373	446	$24	$0.010	$0.27	11,372	601	134	10	3.20	26-JUN-19:15	1%	4%
	East	41.2	1.4%	2.1%	8.7%	411	491	$26	$0.011	$0.29	11,339	603	167	8	3.22	26-JUN-19:15	0%	1%
	West	41.0	1.9%	1.8%	9.0%	750	896	$47	$0.020	$0.53	11,154	604	352	7	2.90	26-JUN-18:00	10.0%	20%

TABLE A9d – ZONE 5 (DENVER) PARTIAL COVERAGE RESULTS TRIELLE - PRODUCTION FIT - HD GREEN MODE		kBtu /sf	overall savings	heating savings	cooling savings	CO2 Savings[1] (lb/yr)	Equivalent Driving Miles Avoided[1,2]	$ savings[1]	$ savings per sf floor	$ savings per sf window	Elec Use[1] (kWh/yr)	Gas Use[1] (therms /yr)	Elec Savings[1] (kWh/yr)	Gas Savings[1] (therms/ yr)	Peak Elec[1] (kW)	Time of Peak	Peak Elec Redu-ction	Cooling Equip Downsize Potential
Baseline Existing (No Coverings)		64.2	-	-	-	-	-	-	-	-	14,968	1,032	-	-	5.72	26-JUN-19:15	-	0%
Same On All Sides (Home has 4 windows per side)	**100% Coverage - all 4 windows**	58.6	8.8%	8.7%	34.4%	4,529	5,408	$287	$0.120	$0.80	13,014	963	1,954	69	4.85	26-JUN-18:15	15%	22%
	75% Coverage - 2 upstairs & 1 downstairs	59.9	6.8%	6.3%	25.6%	3,658	4,367	$232	$0.097	$0.87	13,357	982	1,611	50	5.12	26-JUN-17:15	10%	21%
	75% Coverage - 1 upstairs & 2 downstairs	60.0	6.6%	6.3%	25.3%	3,488	4,164	$221	$0.092	$0.83	13,447	982	1,521	50	5.22	26-JUN-18:15	9%	21%
	50% Coverage - 1 upstairs & 1 downstairs	61.3	4.6%	4.0%	16.6%	2,565	3,062	$162	$0.068	$0.91	13,815	1,000	1,152	31	5.50	26-JUN-17:15	4%	20%
	50% Coverage - 1 upstairs & 1 downstairs (alt)	61.3	4.6%	3.9%	16.7%	2,601	3,105	$165	$0.069	$0.92	13,794	1,001	1,173	31	5.50	26-JUN-17:15	4%	20%
	25% Coverage -1 upstairs	62.7	2.4%	1.9%	8.2%	1,392	1,662	$88	$0.037	$0.99	14,329	1,017	639	15	5.61	26-JUN-18:00	2%	13%
	25% Coverage - 1 downstairs	62.7	2.3%	1.8%	8.2%	1,375	1,641	$87	$0.036	$0.97	14,335	1,017	633	14	5.61	26-JUN-18:00	2%	13%
South & West Walls Covered		61.0	5.0%	4.2%	19.2%	2,837	3,387	$180	$0.075	$1.01	13,684	999	1,284	33	4.89	26-JUN-17:15	15%	19%
North & East Walls Covered		61.7	4.0%	4.3%	14.9%	1,957	2,337	$124	$0.052	$0.70	14,152	998	816	34	5.68	26-JUN-19:15	1%	6%
Single Side Covered	**North**	63.0	2.0%	2.5%	4.5%	829	989	$53	$0.022	$0.59	14,655	1,012	313	20	5.68	26-JUN-19:15	1%	5%
	South	62.9	2.2%	2.2%	6.7%	1,085	1,296	$69	$0.029	$0.77	14,508	1,014	460	18	5.67	26-JUN-19:15	1%	6%
	East	62.9	2.1%	1.9%	10.5%	1,196	1,427	$76	$0.032	$0.85	14,431	1,017	537	15	5.71	26-JUN-19:15	0%	1%
	West	62.4	2.9%	1.7%	12.0%	1,898	2,266	$120	$0.050	$1.34	14,053	1,019	915	13	5.09	26-JUN-17:15	11%	19%

[1]2400 sf home

[2]23.4 mpg vehicle

Note on comparison of savings from replacing windows:
Our modeling of existing homes suggests that in some locations and under some shade operation schedules, adding insulating shades can provide more annual energy savings than replacing windows with IECC 2012 compliant windows. This is due to two factors in our energy model: 1) The insulating shade, when in place, adds a higher R-value than the incremental R-value of new windows and 2) In winter, the insulating shade is raised during hours of direct sunlight to allow for beneficial solar heat gain, while the new window, which has a low SHGC intended in part to reduce cooling season solar heat gain, is unable to capture that beneficial winter solar heat gain. While the results reinforce that insulating window shades can be a very promising energy savings measure, we note that this result is not universal and depends on an optimal operation schedule, as well as window properties and site shading conditions. We encourage further study of this comparison to new windows, including more rigorous modeling of spectral selection of new windows and placement of low-e coatings within the window construction, as well as the impacts of site solar shading on savings results.

APPENDIX B: DETAILED MODEL INPUTS

FIGURE B1: DETAILED MODEL INPUTS

	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 5		Zone 6		Zone 7		Zone 8	
	Miami		Phoenix		San Francisco		Washington DC		Chicago		Denver		Minneapolis		Aspen		Anchorage	
Parameter	New	Exist.	New	Exist.	New	Exist.	New	Exist.	New	Exist.	New	Exist.	New	Exist.	New	Exist.	New	Exist.
Description	2-Story, square floorplate, gabled roof with E/W gable ends, slab on grade																	
Conditioned Area (ft2)	2401																	
Number of Occupants	3																	
Roof U-value	0.543 Btu/hr-ft2-yr (Not including effect of unconditioned attic)																	
Roof Reflectance	0.25																	
Wall U-value, with film (Btu/hr-ft2-yr)	0.087	0.259	0.087	0.259	0.061	0.2	0.061	0.087	0.061	0.087	0.053	0.071	0.053	0.071	0.053	0.071	0.053	0.071
Wall Reflectance	0.3																	
Effective Leakage Area (cm^2)	602	1,202	602	1,202	361	1,202	361	1,202	361	1,202	361	1,202	205	1,202	361	1,202	361	1,202
Resulting Infiltration ACH	*0.321*	*0.640*	*0.292*	*0.582*	*0.259*	*0.854*	*0.219*	*0.729*	*0.27*	*0.897*	*0.249*	*0.826*	*0.16*	*0.94*	*0.245*	*0.815*	*0.267*	*0.889*
Total Glazing Area (ft2)	357																	
Glazing/Floor Area Ratio	Window area equal to 15% of floor area																	
Glazing Distribution	Evenly distributed on all sides.																	
Window R-Value (hr-ft2-yr/Btu)	2.00	1.28	2.50	1.28	2.86	1.28	2.86	1.28	3.12	1.96	3.12	1.96	3.12	1.96	3.12	1.96	3.12	1.96
Window SHGC	0.25	0.87	0.25	0.87	0.25	0.87	0.4	0.87	0.4	0.76	0.4	0.76	0.4	0.76	0.4	0.76	0.4	0.76
Window Tvis	0.88	0.87	0.88	0.87	0.88	0.87	0.88	0.87	0.88	0.87	0.88	0.87	0.88	0.87	0.88	0.87	0.88	0.87
Lighting Power Density	1.7 (Watts per sf of zone floor area)																	
Heat Source	Electric		Electric		Gas Furnace		Electric		Gas Furnace		Gas Furnace		Gas Furnace		Gas Furnace		Gas Furnace	
Heat Source Efficiency	100%		100%		78%	75%	100%		78%	75%	78%	75%	78%	75%	78%	75%	78%	75%
Cooling System	DX Single-Speed, autosized for ASHRAE design day																	
Gross Rated Cooling COP	3.97	2.74	3.97	2.74	3.97	2.74	3.97	2.74	3.97	2.74	3.97	2.74	3.97	2.74	3.97	2.74	3.97	2.74
Thermostat Setpoints	Cooling: 23.88C; Heating: 22.22C																	

FIGURE B2: UTILITY PRICES AND EMISSIONS FACTORS

	Miami	Phoenix	San Francisco	Washington DC	Chicago	Denver	Minneapolis	Aspen	Anchorage
Electricity Price ($/kWh)[1]	$0.1170	$0.1226	$0.1246	$0.1312	$0.1338	$0.1199	$0.1223	$0.1199	$0.1962
Gas Price ($/Mcf)[2]	$18.75	$19.06	$10.93	$12.70	$8.42	$7.94	$8.89	$7.94	$10.09
Electricity Emissions Factor (lbCO_2e/MWh)[3]	1,201.79	1,182.89	613.28	1,079.57	1,511.52	1,906.27	1,545.11	1,906.27	1,259.64

[1] From: http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

[2] From: http://www.eia.gov/dnav/ng/ng_pri_sum_a_epg0_prs_dmcf_m.htm

[3] From: http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf

APPENDIX C: HD GREEN MODE OPERATION SCHEDULES

FIGURE B1 – HD GREEN MODE SCHEDULES
Indicated times are start/end solar times of periods when shades are open.

Miami

26° Latitude – Hot Dec-Jan Lows in 60's or Higher

	Start Day	End Day	North		South		East		West	
	1	6	7:00	17:00	7:00	9:00	12:00	17:00	7:00	12:00
Jan	7	37	7:00	17:00	7:00	8:00	12:00	17:00	7:00	12:00
Feb	38	39	7:00	17:00	7:00	8:00	12:00	17:00	7:00	12:00
Mar	66	67	7:00	17:00	7:00	8:00	12:00	17:00	7:00	12:00
Apr	97	98	7:00	14:00	6:00	9:00	12:00	18:00	6:00	12:00
May	127	128	8:00	12:00	6:00	10:00	12:00	18:00	6:00	12:00
Jun	158	159	11:00	13:00	6:00	10:00	13:00	18:00	6:00	11:00
Jul	188	189	9:00	13:00	6:00	10:00	13:00	18:00	6:00	11:00
Aug	219	220	7:00	14:00	6:00	9:00	12:00	18:00	6:00	12:00
Sep	250	251	7:00	14:00	7:00	8:00	12:00	17:00	7:00	12:00
Oct	280	281	7:00	17:00	7:00	8:00	12:00	17:00	7:00	12:00
Nov	311	312	7:00	17:00	7:00	8:00	12:00	17:00	7:00	12:00
Dec	341	365	7:00	17:00	7:00	9:00	12:00	17:00	7:00	12:00

Phoenix

34° Latitude – Hot Dec-Jan Lows in Low 40's or Higher

	Start Day	End Day	North		South		East		West	
	1	6	Closed		8:00	12:00	8:00	10:00	12:00	16:00
Jan	7	37	Closed		8:00	12:00	8:00	11:00	12:00	16:00
Feb	38	39	12:00	14:00	8:00	12:00	7:00	10:00	14:00	17:00
Mar	66	67	13:00	15:00	8:00	13:00	7:00	10:00	15:00	17:00
Apr	97	98	14:00	18:00	7:00	10:00	6:00	9:00	10:00	14:00
May	127	128	12:00	18:00	8:00	10:00	6:00	8:00	10:00	12:00
Jun	158	159	11:00	13:00	6:00	10:00	13:00	18:00	6:00	11:00
Jul	188	189	9:00	13:00	6:00	9:00	13:00	18:00	6:00	11:00
Aug	219	220	7:00	14:00	6:00	9:00	13:00	18:00	6:00	11:00
Sep	250	251	7:00	14:00	7:00	8:00	12:00	17:00	7:00	12:00
Oct	280	281	11:00	13:00	7:00	9:00	12:00	17:00	8:00	12:00
Nov	311	312	14:00	16:00	8:00	11:00	8:00	10:00	10:00	14:00
Dec	341	365	Closed		8:00	12:00	8:00	10:00	12:00	16:00

San Francisco

38° Latitude – Pacific Coastal Climate

	Start Day	End Day	North		South		East		West	
	1	6	15:00	17:00	8:00	13:00	8:00	11:00	12:00	15:00
Jan	7	37	15:00	16:00	8:00	12:00	8:00	11:00	12:00	15:00
Feb	38	39	15:00	17:00	8:00	12:00	7:00	11:00	12:00	15:00
Mar	66	67	15:00	17:00	8:00	12:00	7:00	11:00	12:00	15:00
Apr	97	98	14:00	18:00	8:00	12:00	6:00	10:00	12:00	14:00
May	127	128	14:00	17:00	8:00	12:00	6:00	9:00	17:00	18:00
Jun	158	159	12:00	17:00	8:00	12:00	6:00	8:00	17:00	18:00
Jul	188	189	12:00	17:00	7:00	12:00	6:00	7:00	17:00	18:00
Aug	219	220	12:00	18:00	7:00	10:00	6:00	7:00	10:00	12:00
Sep	250	251	12:00	17:00	8:00	10:00	7:00	8:00	10:00	12:00
Oct	280	281	14:00	17:00	8:00	11:00	7:00	9:00	11:00	14:00
Nov	311	312	15:00	17:00	8:00	12:00	8:00	11:00	12:00	15:00
Dec	341	365	15:00	17:00	8:00	13:00	8:00	11:00	12:00	15:00

Washington DC

38° Latitude – Cold Dec-Jan Lows in Low 20's or Lower

	Start Day	End Day	North		South		East		West	
	1	6	Closed		8:00	16:00	8:00	11:00	13:00	16:00
Jan	7	37	Closed		8:00	16:00	8:00	11:00	13:00	16:00
Feb	38	39	Closed		8:00	16:00	7:00	11:00	13:00	17:00
Mar	66	67	Closed		8:00	16:00	7:00	11:00	13:00	17:00
Apr	97	98	Closed		8:00	16:00	6:00	11:00	15:00	18:00
May	127	128	12:00	16:00	8:00	12:00	6:00	9:00	16:00	18:00
Jun	158	159	12:00	18:00	7:00	12:00	6:00	8:00	8:00	12:00
Jul	188	189	8:00	13:00	6:00	12:00	13:00	18:00	7:00	12:00
Aug	219	220	8:00	14:00	6:00	10:00	13:00	18:00	6:00	11:00
Sep	250	251	13:00	17:00	8:00	11:00	7:00	9:00	9:00	13:00
Oct	280	281	Closed		8:00	14:00	7:00	11:00	14:00	17:00
Nov	311	312	Closed		8:00	16:00	8:00	11:00	13:00	16:00
Dec	341	365	Closed		8:00	16:00	8:00	11:00	13:00	16:00

Chicago

42° Latitude – Cold Dec-Jan Lows in the Teens or Lower

	Start Day	End Day	North		South		East		West	
	1	6	Closed		8	16	8	11	13	16
Jan	7	37	Closed		8	16	8	11	13	16
Feb	38	39	Closed		8	16	7	11	13	17
Mar	66	67	Closed		8	16	7	12	12	17
Apr	97	98	Closed		8	16	6	12	12	18
May	127	128	Closed		8	16	6	10	16	19
Jun	158	159	13:00	19:00	7	11	6	9	10	13
Jul	188	189	10:00	14:00	6	10	12	19	8	12
Aug	219	220	10:00	14:00	6	10	12	18	8	12
Sep	250	251	14:00	17:00	8	12	7	10	10	14
Oct	280	281	Closed		8	16	7	11	14	17
Nov	311	312	Closed		8	16	8	11	13	16
Dec	341	365	Closed		8	16	8	11	13	16

Minneapolis

46° Latitude – Cold Dec-Jan Lows in the Single Digits or Lower

	Start Day	End Day	North		South		East		West	
	1	6	Closed		9	15	9	11	13	15
Jan	7	37	Closed		8	16	8	11	13	16
Feb	38	39	Closed		8	16	8	11	13	16
Mar	66	67	Closed		8	17	7	12	12	17
Apr	97	98	Closed		8	16	6	12	12	18
May	127	128	Closed		8	16	6	10	16	19
Jun	158	159	14	19	7	11	6	9	10	14
Jul	188	189	13	19	7	10	6	7	8	13
Aug	219	220	13	18	7	10	6	8	8	13
Sep	250	251	15	17	8	12	7	10	11	15
Oct	280	281	Closed		8	16	7	11	13	17
Nov	311	312	Closed		8	16	8	11	13	16
Dec	341	365	Closed		8	15	9	11	13	15

Denver & Aspen

40° Latitude – Cold Dec-Jan Lows in the Teens or Lower

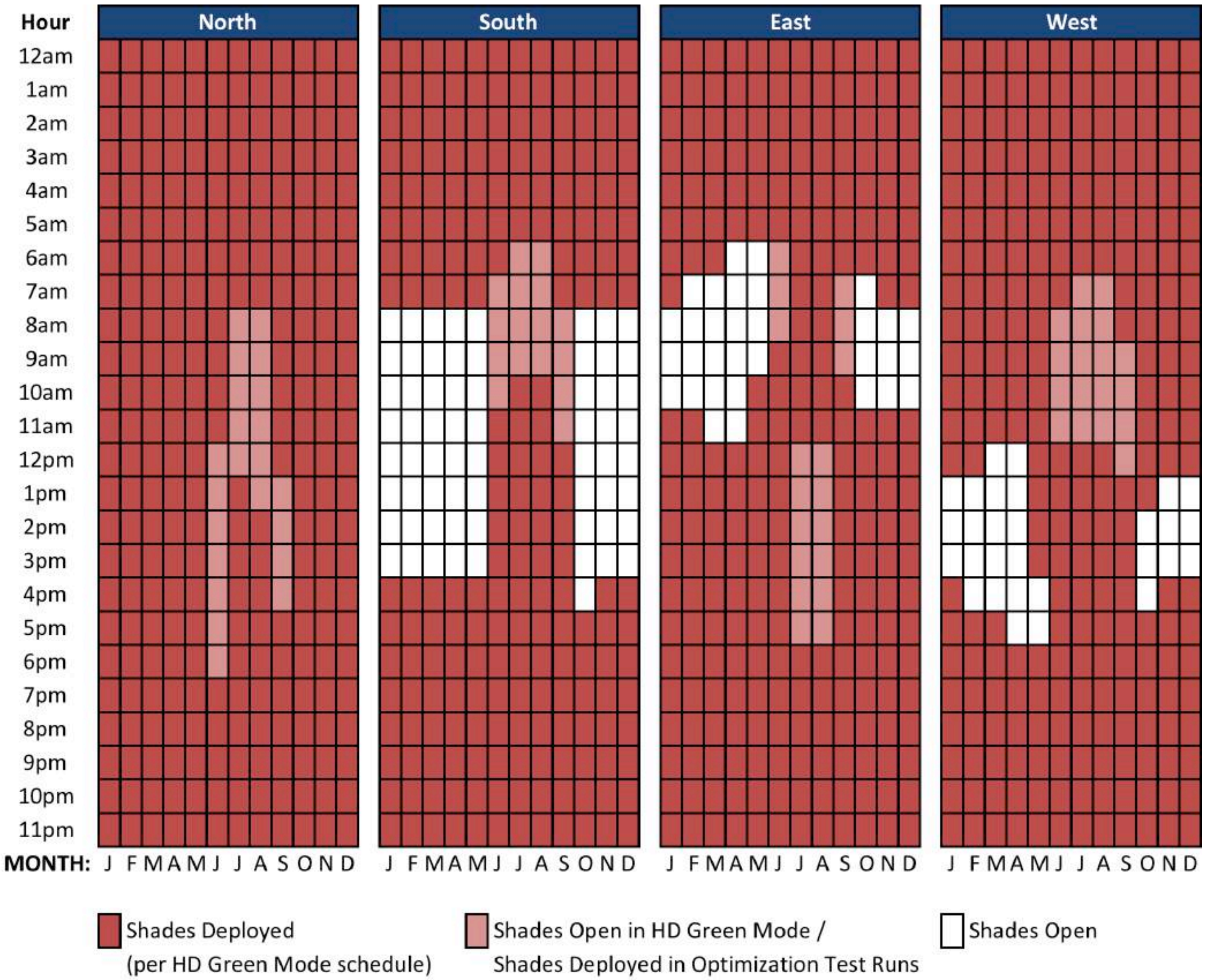
	Start Day	End Day	North		South		East		West	
	1	6	Closed		8	16	8	11	13	16
Jan	7	37	Closed		8	16	8	11	13	16
Feb	38	39	Closed		8	16	7	11	13	17
Mar	66	67	Closed		8	16	7	12	12	17
Apr	97	98	Closed		8	16	6	12	12	18
May	127	128	Closed		8	16	6	10	16	18
Jun	158	159	12	19	7	11	6	9	8	12
Jul	188	189	8	13	6	10	12	18	7	12
Aug	219	220	8	14	6	10	12	18	7	12
Sep	250	251	13	17	8	12	7	10	9	13
Oct	280	281	Closed		8	17	7	11	14	17
Nov	311	312	Closed		8	16	8	11	13	16
Dec	341	365	Closed		8	16	8	11	13	16

Anchorage

61.2°N - (Used 48° Latitude – Cold Dec-Jan Lows in the Single Digits or Lower)

	Start Day	End Day	North		South		East		West	
	1	6	Closed		9	15	9	11	13	15
Jan	7	37	Closed		9	15	8	11	13	16
Feb	38	39	Closed		8	16	8	11	13	16
Mar	66	67	Closed		8	17	7	12	12	17
Apr	97	98	Closed		8	16	6	12	12	18
May	127	128	Closed		8	16	6	10	16	19
Jun	158	159	14	19	7	11	6	9	10	14
Jul	188	189	13	19	7	10	6	7	8	13
Aug	219	220	13	18	7	10	6	8	8	13
Sep	250	251	15	17	8	12	7	10	11	15
Oct	280	281	Closed		8	16	7	11	13	17
Nov	311	312	Closed		9	15	8	11	13	16
Dec	341	365	Closed		9	15	9	11	13	15

FIGURE B2 – VISUALIZATION OF HD GREEN MODE SCHEDULE AND OPTIMIZED TEST RUNS FOR DENVER



APPENDIX D: ENERGYPLUS SIMPLE GLAZING EMS WORKAROUND

The following is an excerpt from an EnergyPlus IDF file from our analysis, using the Energy Management System (EMS) to perform scheduled switching between window constructions with and without the window shade.

```
EnergyManagementSystem:ConstructionIndexVariable,
  EXTERIOR_WINDOW_WITH_HD_SHADE,  !- Name
  EXTERIOR_WINDOW_WITH_HD_SHADE;  !- Construction Object Name

EnergyManagementSystem:ConstructionIndexVariable,
  Exterior_Window,             !- Name
  Exterior_Window;             !- Construction Object Name

EnergyManagementSystem:Sensor,
  EMS_N_ShadeSchedule,      !- Name
  Shade_N,     !- Output:Variable or Output:Meter Index Key Name (references a Schedule:Compact with 1/0 values)
  Schedule Value;  !- Output:Variable or Output:Meter Name

Output:Variable,Shade_N,Schedule Value,hourly; !- Zone Average

EnergyManagementSystem:Actuator,
  WinN1_Construct,         !- Name
  Window_ldb_1.unit1,    !- Actuated Component Unique Name (window construction name)
  Surface,                      !- Actuated Component Type
  Construction State;       !- Actuated Component Control Type

EnergyManagementSystem:ProgramCallingManager,
  Window shade deployment emulator,  !- Name
  BeginTimestepBeforePredictor,          !- EnergyPlus Model Calling Point
  North_Win_Control1,                          !- Program Name 1

EnergyManagementSystem:Program,
  North_Win_Control1,                    !- Name
  IF EMS_N_ShadeSchedule == 1,      !- Program Line 1...
  SEt WinN1_Construct = EXTERIOR_WINDOW_WITH_HD_SHADE,
  ELSE,
  SET WinN1_Construct = Exterior_Window,
  ENDIF;

Output:EnergyManagementSystem,
  verbose,              !- Actuator Availability Dictionary Reporting
  verbose,              !- Internal Variable Availability Dictionary Reporting
  verbose;              !- EMS Runtime Language Debug Output Level

Output:Variable,Window_ldb_1.unit1,Surface Construction Index,hourly;
```