DOCKETED	
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Project Title:	2022 Energy Code Exceptional Methods
TN #:	260208
Document Title:	Automated Window Shading Modeling Report
Description:	Report indicating energy usage change attributable to automation of window shading.
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Organization:	ConSol
Submitter Role:	Applicant
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Introduction

California has long been at the forefront of building energy efficiency in the United States, and globally. As a leader in addressing climate change, California has established a number of highly successful policies, particularly in the built environment. This exceptional methods application seeks to expand the set of tools available to designers and builders in the state to further those goals. Automated window shading has already seen significant globally and offers promising results throughout California. Automated shading balances solar heat gain across the year with daylighting needs. However, California's building energy codes do not currently give appropriate consideration to the level of energy savings made possible through automation. This document presents comprehensive modeling results, and offers an enabling pathway already supported by institutions including the California Building Industry Association (CBIA), Lawrence Berkeley National Laboratory (LBNL), the Attachments Energy Rating Council (AERC), and others.

Proposed solution

Based on the modelling presented in this document it is suggested that compliance credit be given to automated window shading based on the analysis and results tables herein.

Performance modeling

Performance modeling was conducted on the California Energy Commission (CEC) standard version of the 2,100 and 2,700 square foot prototype homes. For modeling of exterior shades, these models were left entirely unchanged. For modeling of interior shades, the models incorporated the minimum number of added interior walls to enable modeling of the house as 4 zones, with each zone facing a cardinal direction. CBECC-Res and CSE do not allow for independent control of the shading on each face of the house unless the house is split into one zone for each face of the home. Given that different faces of a home perform differently when automated shading is applied to them, modeling in zones was a high priority. The changes to the standard model design required to enable this multi-zone approach are covered in detail in Appendix 1.

Note that for analysis of grid drawn-electricity, the solar production from the baseline design homes is in effect. The total electricity is therefore the net of consumption and production. In cases such as climate zone 15, the initially low net consumption (~618 kwh annually in the 2,700 SF exterior model) and the impact of automated shading.

The analysis of TDV is focused purely on consumption and ignores the impact of solar production. Given that the modeling is based on adaptations of the standard models (with 0 margins), the charts regarding TDV reduction can also be interpreted as the size of the compliance margins resulting from application of the shading and automation technology.

Interior Modeling

Details on modifications made to achieve multi-zone functionality are in Appendix 1 – Residential Interior Shade Checklist .

The interior shade product modeled is the 2410+ Charcoal/Gray Fabric from Phifer.[1] This fabric features solar transmittance of 4%, 72% solar reflectance, and 3% openness. These factors are incorporated into the California Simulation Engine (CSE) according to the step-by-step directions in Appendix 2 – Customization of CSE Engine.

The scheduling of the interior shade automation is altered via the .cse model file. Step by step directions for this process are in Appendix 1. The schedule used is a variation of the AERC's schedule for cooling dominated climate zones.[2] The south and west facing shades were intended to be simulated to be open from 8:00 a.m. - 4:00 p.m. from November 1st through March 31st . However, an error in the scheduling logic , described in detail in appendix 1, made the shades stay open 24 hours a day from November through February. Any insulating properties of the shade would be ineffective in this November through February interval, and there would be more solar heat through the windows in the early morning and late afternoon/early evening. The original shade position logic is retained for the north and east facing sides.

The savings values for interior shades are the difference between 2410+ shades with automation and 2410+ shades without automation. The following three automation scenarios were considered in the analysis of energy savings:

- South facing shades only (S)
- West facing shades only (W)
- South & West facing shades (SW)

Results – Interior Modeling

The results from the interior modeling project are summarized in Figures 1-4. Changes in electricity consumption are stated in kWh or %, and changes in gas consumption are stated in kBTU or %. Columns in orange are heating related, and columns in blue are cooling related. Positive values in these charts represent an increase in energy savings.

The baseline value in this analysis is the 2410+ fabric on the two prototype homes without automation. The energy consumption reduction described reflects the difference between 2410+ fabric with automation and 2410+ fabric without automation. The non-automated windows in models with automation use 2410+ fabric with the original shade control behavior.

2,100 SF Prototype Results - Interior

Figures 1-8 below show the impact of automation on interior shades for the 2,100 SF prototype homes. Automation of the west facing window shows larger reductions in cooling energy consumption than automation of south facing windows. However, automation of south facing windows showed a greater reduction in heating energy consumption than automation of west facing windows. Automation had a net impact of reducing energy consumption in all climate zones except climate zone 1.

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[1] SHEERWEAVE Performance+ sw-performance-tech-sheet-v20-121720.pdf (phifer.com)

[2] Peng et al. 2017. Energy Performance Indices EPC and EPH Calculation Methodology and Implementation in Software tool. Retrieved at - EPC and EPH Calculation Methodology_v6_Clean (lbl.gov)

Figure 1. Heating and Cooling System Electricity Reduction from Interior Automation - kWh (2,100 SF Home)

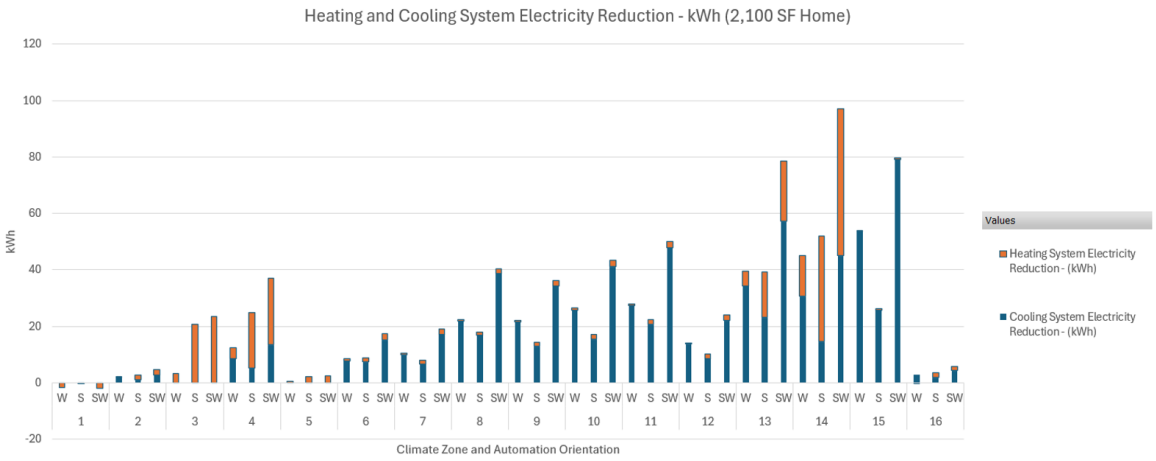


Figure 2. Heating and Cooling System Electricity Reduction from Interior Automation - % (2,100 SF Home)

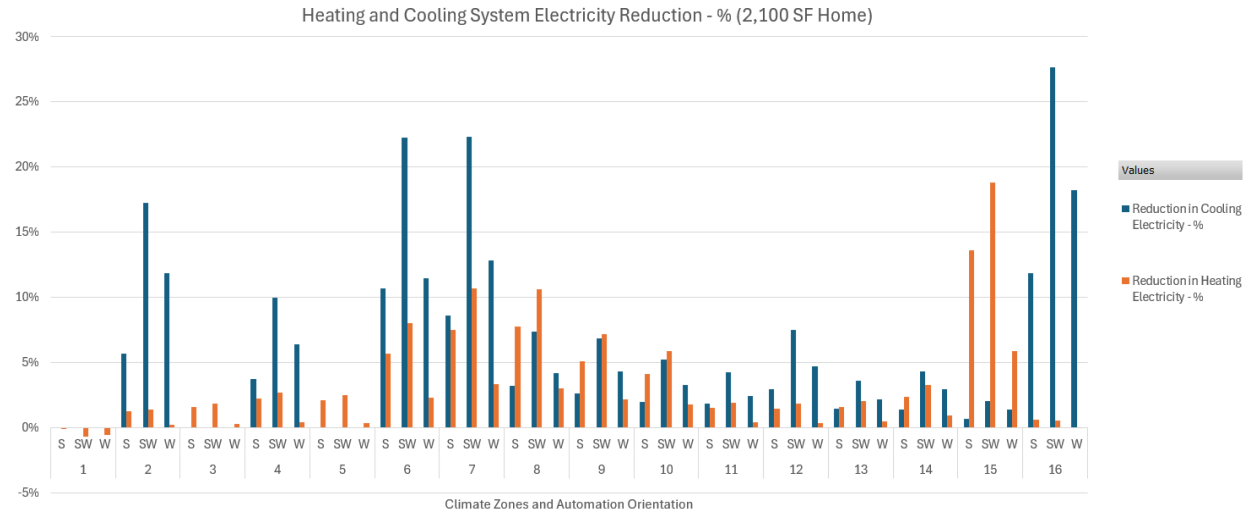


Figure 3. Heating Gas Reduction from Interior Automation - kBTU (2,100 SF Home)

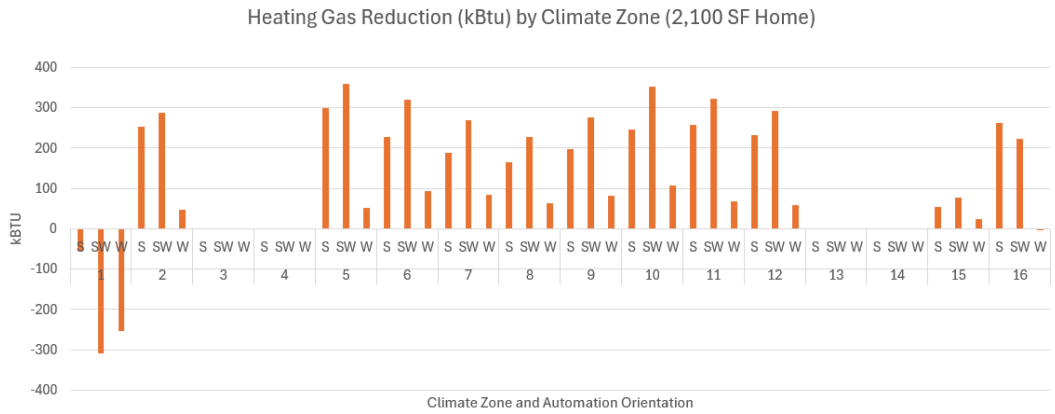


Figure 4. Heating Gas Reduction from Interior Automation - % (2,100 SF Home)

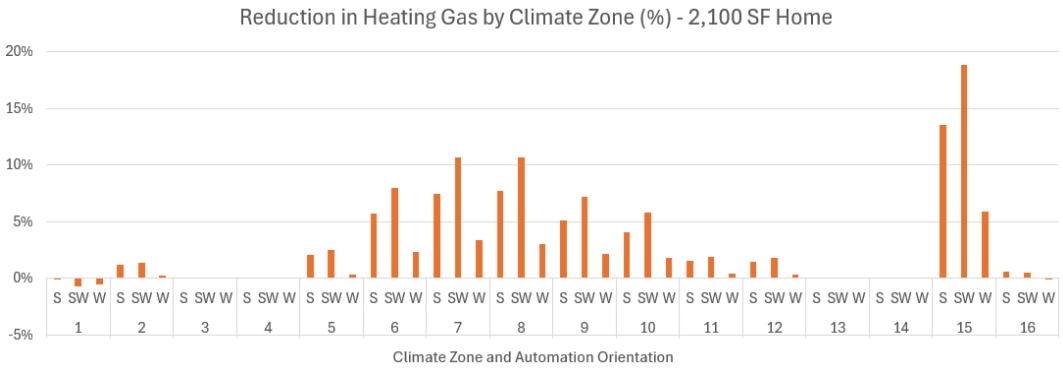


Figure 5. Reduction in Total Gas Consumption from Interior Automation (%) - 2,100 SF House

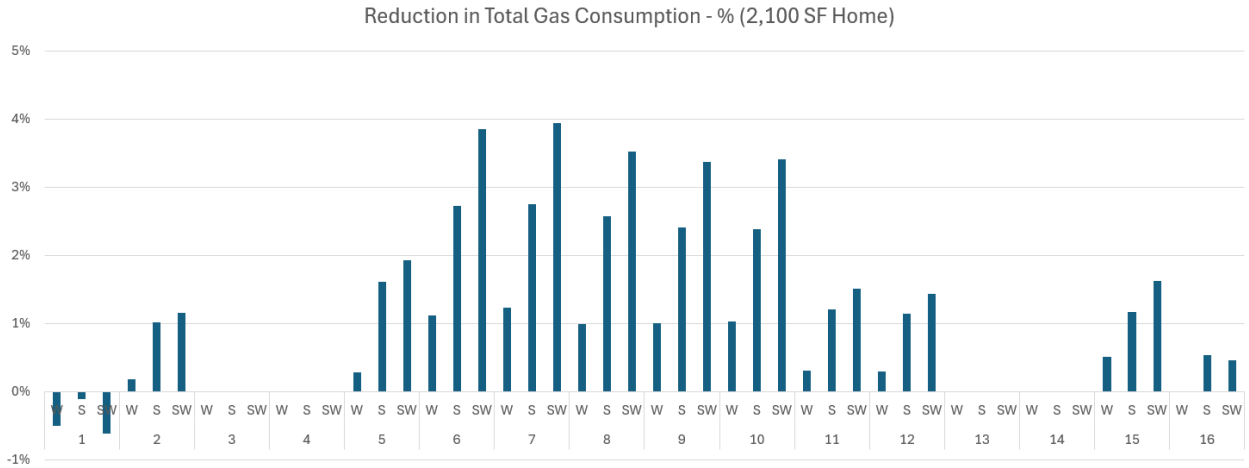


Figure 6. TDV Reduction (%) from Interior Automation (2,100 SF Home)

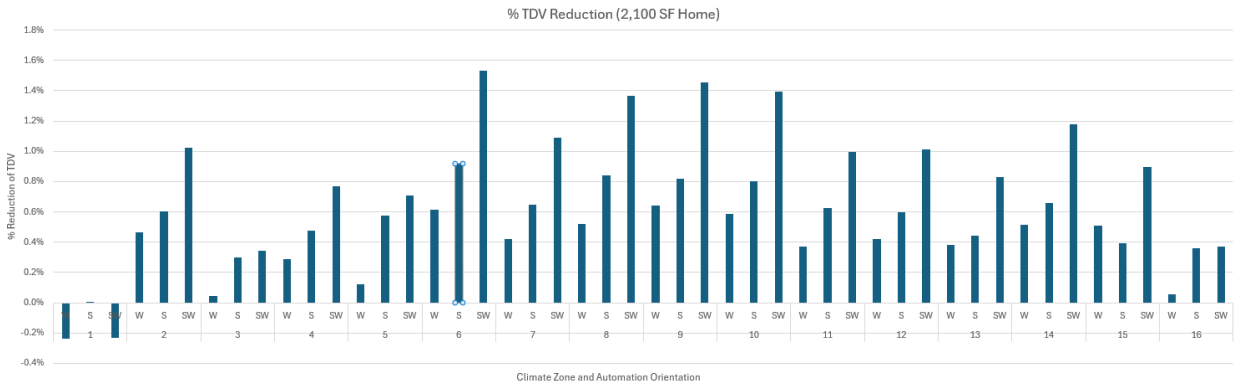


Figure 7. kTDV Reduction from Interior Automation (2,100 SF Home)

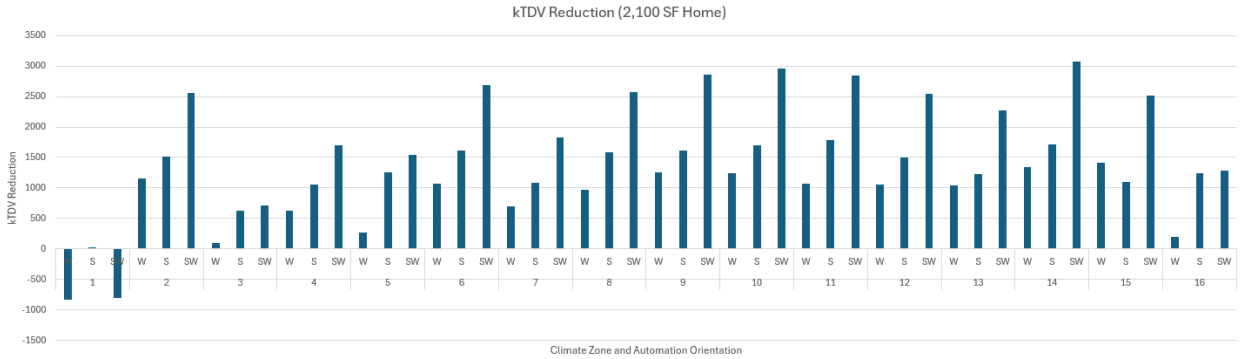
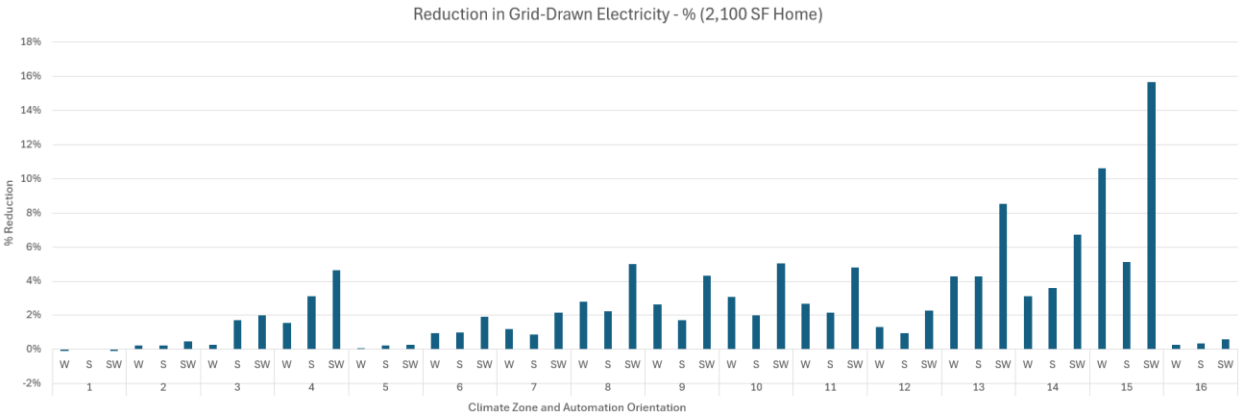


Figure 8.Reduction in Grid Drawn Electricity from Interior Automation - % (2,100 SF Home)



2,700 SF Prototype Results – Interior

The results in Figures 9-16 for the 2,700 SF prototype home are directionally similar to the results for the 2,100 SF prototype. The net impact of automation reduces energy consumption for all climate zones with the exception of climate zone 1. The magnitude of savings is greater in both absolute and percentage terms for the 2,700 SF prototype compared to the 2,100 SF prototype.

Figure 9. Heating and Cooling System Energy Savings from Interior Automation - kWh (2,700 SF Home)

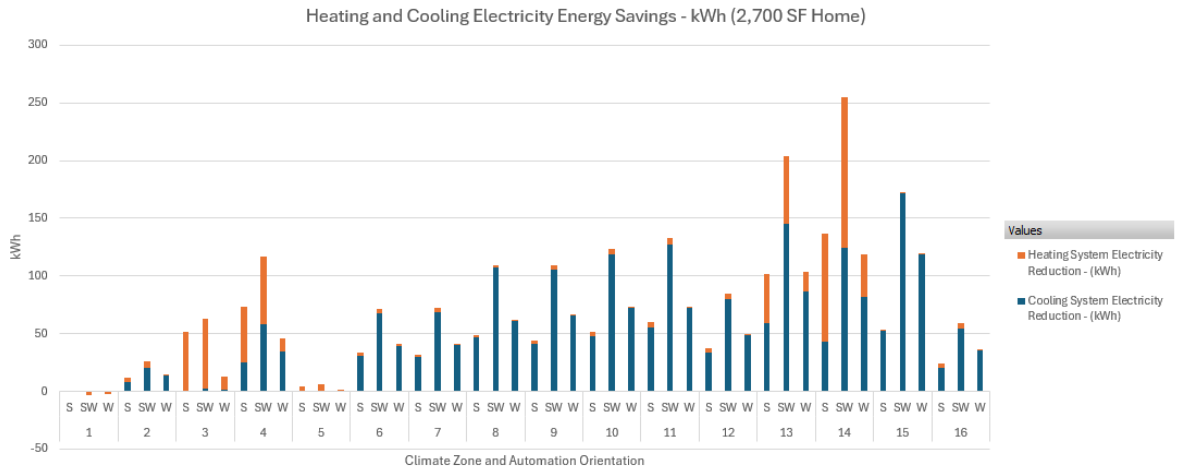


Figure 10. Heating and Cooling System Energy Reduction from Interior Automation - % (2,700 SF Home)

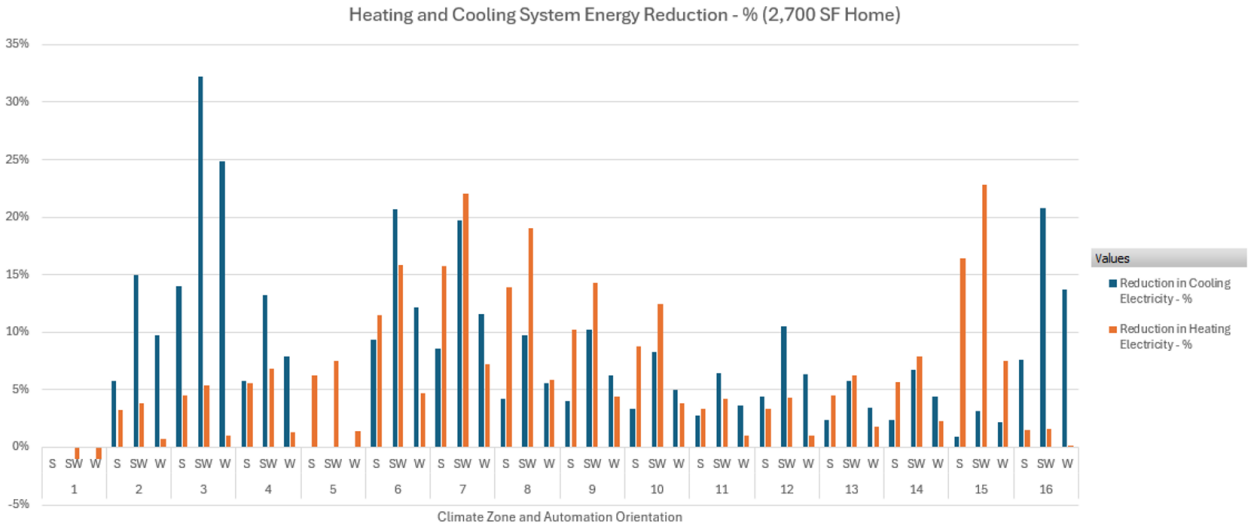


Figure 11. Heating Gas Reduction from Interior Automation - kBTU (2,700 SF Home)

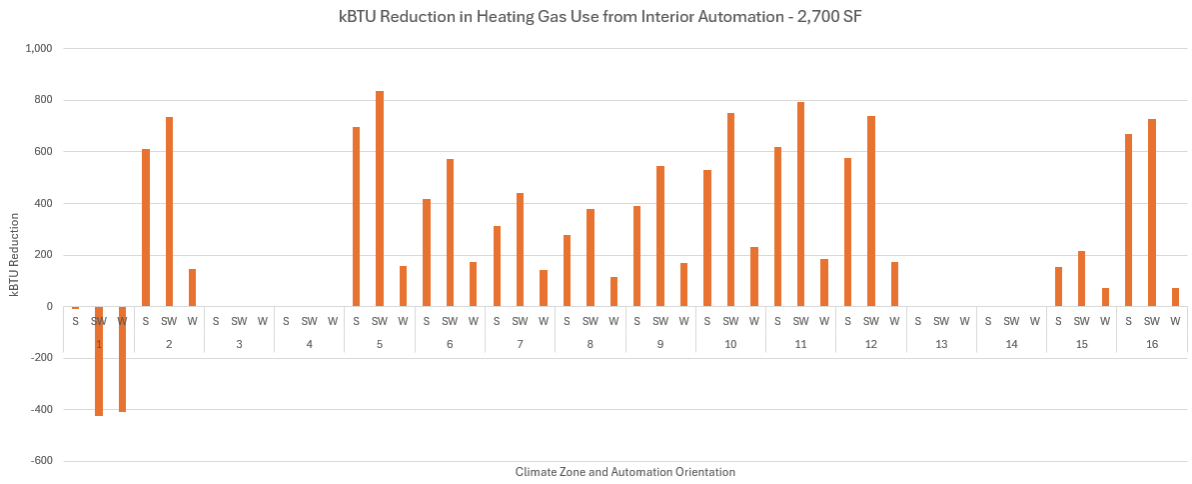


Figure 12. Heating Gas Reduction from Interior Automation - % (2,700 SF House)

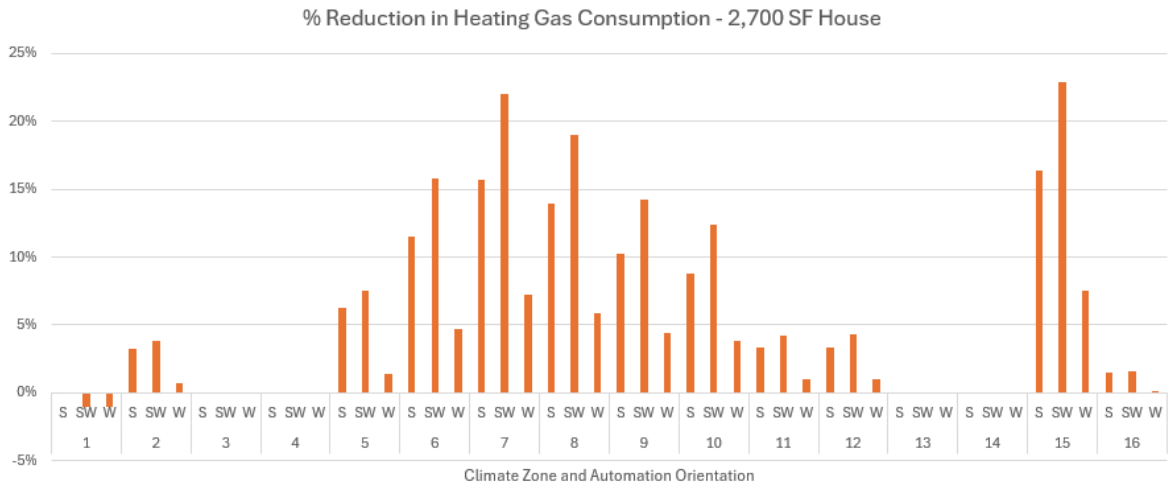


Figure 13. Total Gas Consumption Reduction (%) from Interior Automation - 2,700 SF House

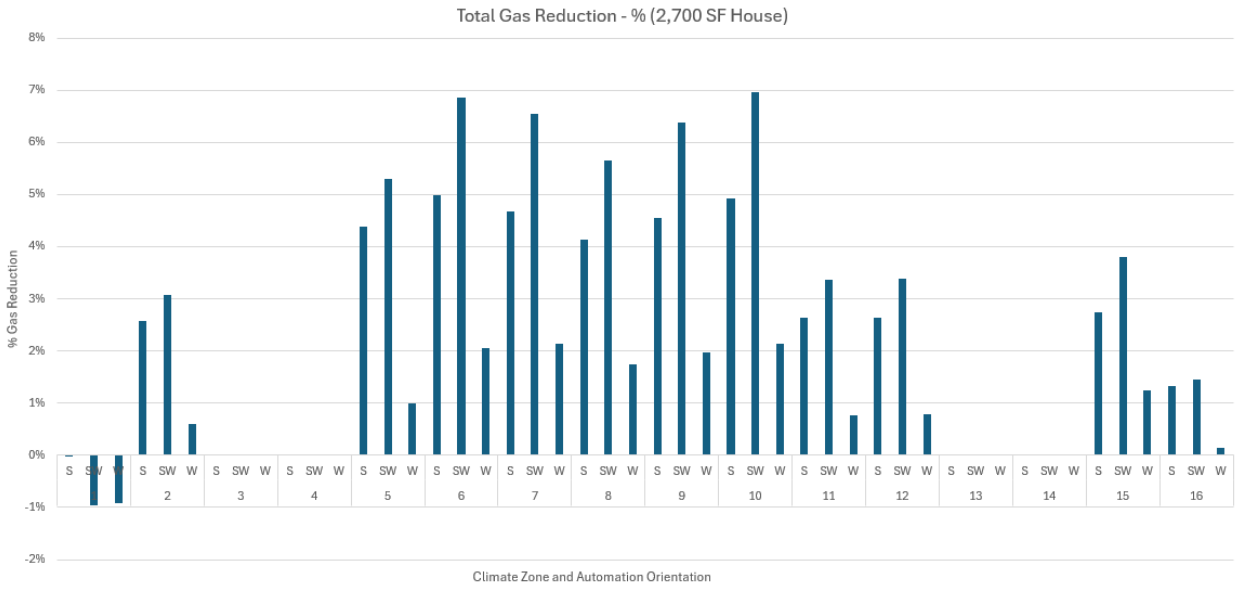


Figure 14. TDV Reduction (%) from Interior Automation (2,700 SF House)

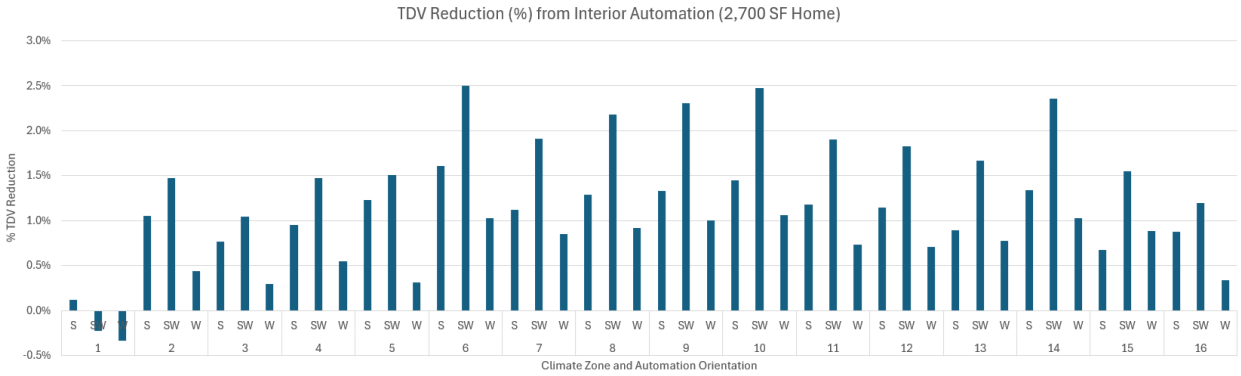


Figure 15. kTDV Reduction from Interior Automation – 2,700 SF House

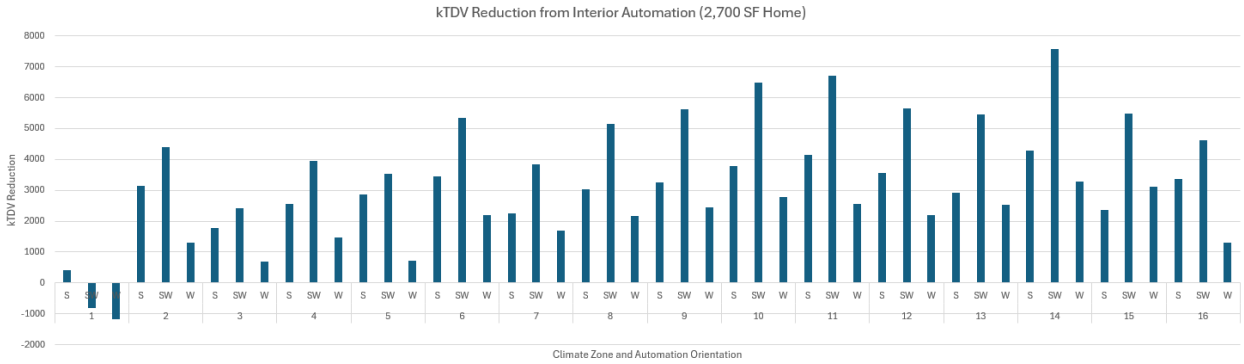
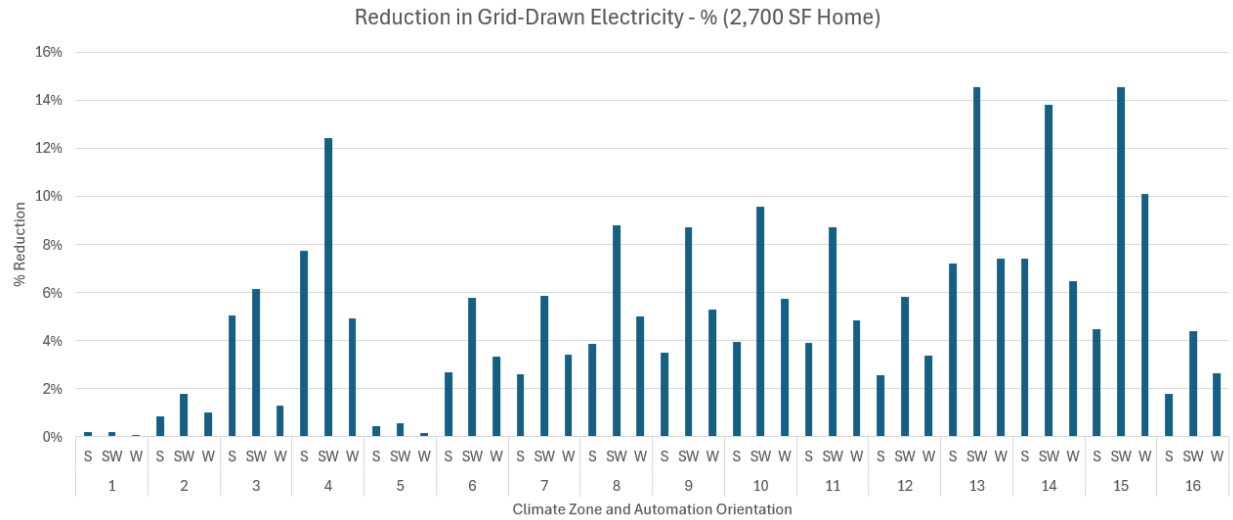


Figure 16. Reduction in Grid-Drawn Electricity from Interior Automation - 2,700 SF House



Exterior Modeling

The exterior modeling was conducted with Suntex 95 exterior shades, described in more detail in Appendix 4 - Exterior Shading Methodology.[3] Due to limitations of the California Simulation Engine (CSE), it is not possible to model the control of exterior shades independently from each other. Modeling hourly control schemes is also not possible. Therefore, the results described below are for installing automated exterior shades on all 4 sides of the single-family prototypes using a seasonal schedule. The procedure to model this schedule is described in detail in Appendix 4 – Exterior Shading Methodology.

Figure 17. Exterior Shade Schedule

	Window Orientation			
	North	South	East	West
April 1 - October 31	Closed All Day	Closed All Day	Closed All Day	Closed All Day
November 1 - March 31	Open All Day	Open All Day	Open All Day	Open All Day

The shades are open from November 1st through March 31st and closed from April 1st through October 31st .

Results – Exterior Modeling

Figures 18-33 below describe the performance of adding exterior shading and automating that exterior shading. The baseline value uses the original permanently fixed insect screen for the entire year. The energy consumption reduction represents the savings from seasonal automation and the difference in fabric properties between the exterior shade and insect screen. This comparison was included because a solar exterior shade is a very different product than the default insect screen. The original insect screen has an openness of 65% whereas Suntex95 exterior shades have an openness of 5%. Note that Figures 20, 21, 22, 28, 29, and 30 show no difference in heating system gas reduction for climate zones 3, 4, 13, and 14 since the prescriptive heating requirement for these climate zones are electric only.

[3] SunTex® 95/97 - Phifer

2,100 SF Prototype Results

Figure 18. Heating and Cooling System Electricity Reduction from Exterior Shades and Automation - kWh (2,100 SF Home)

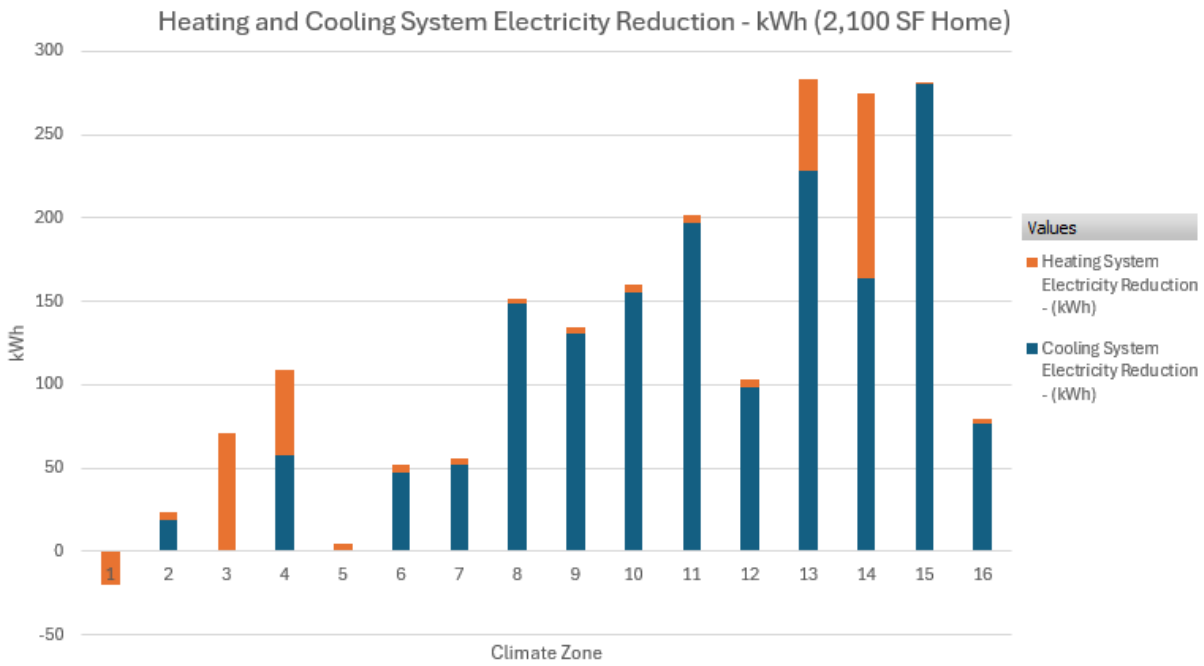


Figure 19. Heating and Cooling System Energy Reduction from Exterior Shades and Automation - % (2,100 SF Home)

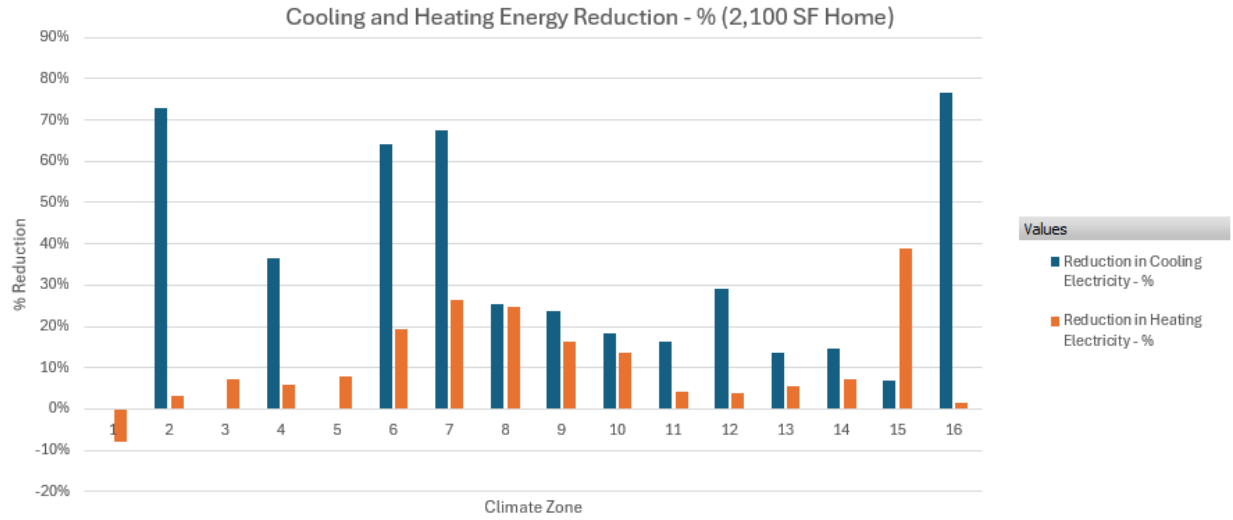


Figure 20. Heating System Gas Reduction (kBTU) from Exterior Shade and Automation (2,100 SF Home)

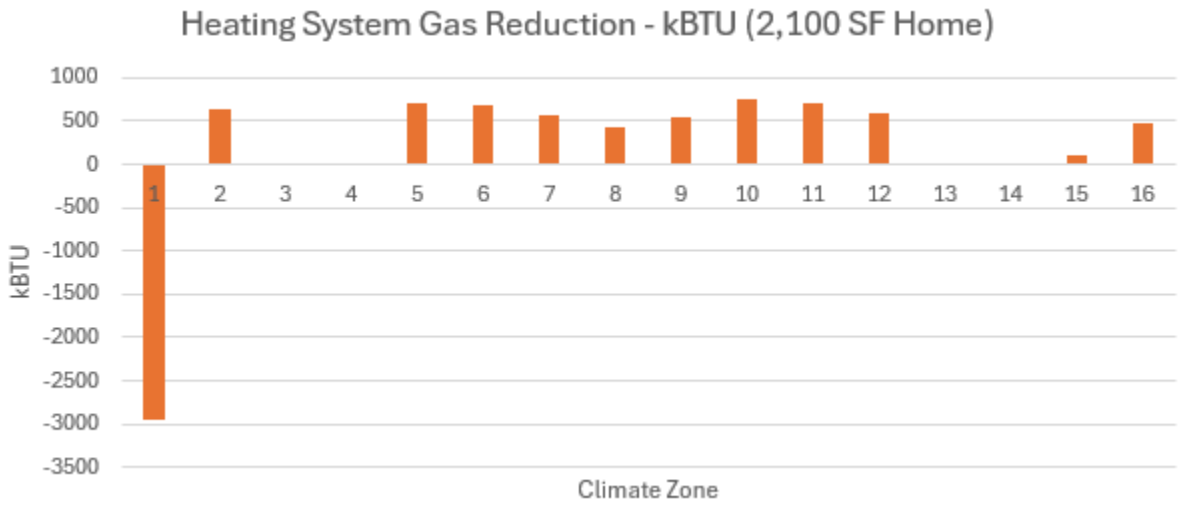


Figure 21. Heating System Gas Reduction from Exterior Shade and Automation - % (2,100 SF Home)

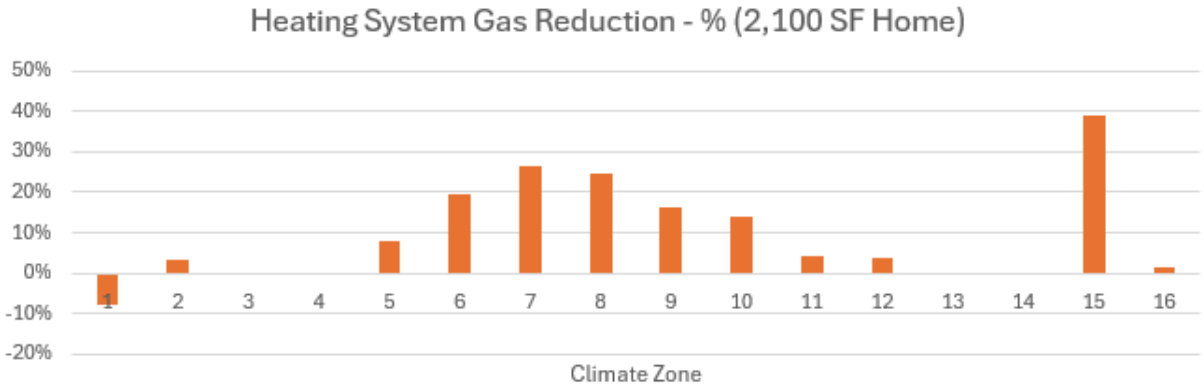


Figure 22. Total Gas Consumption Reduction from Exterior Shading - % (2,100 SF House)

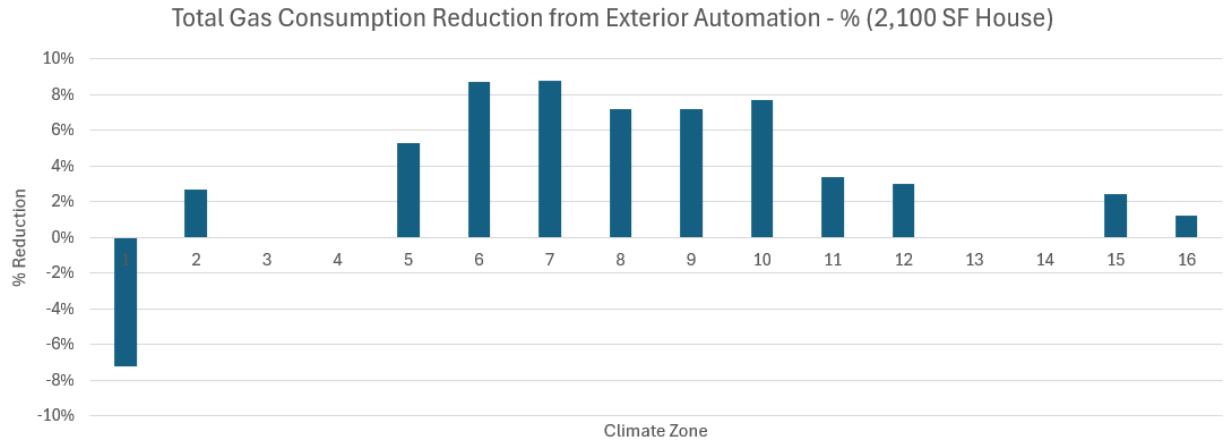


Figure 23. TDV Reduction (%) from Exterior Shading and Automation (2,100 SF House)

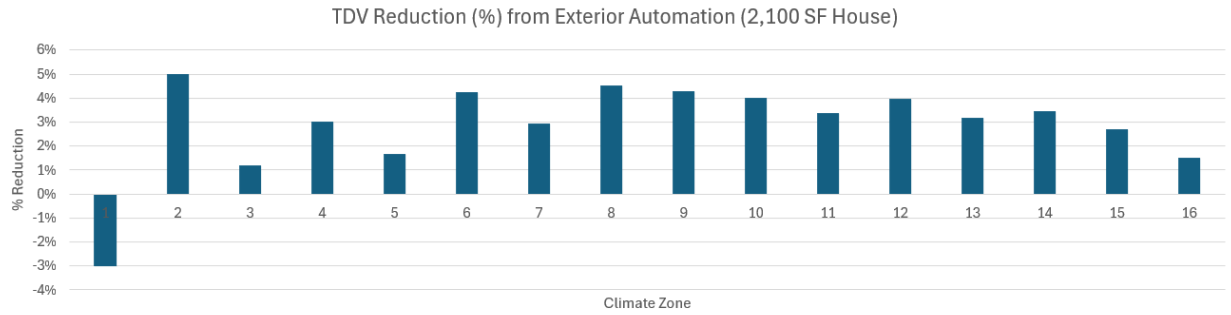


Figure 24. kTDV Reduction from Exterior Shading and Automation (2,100 SF House)

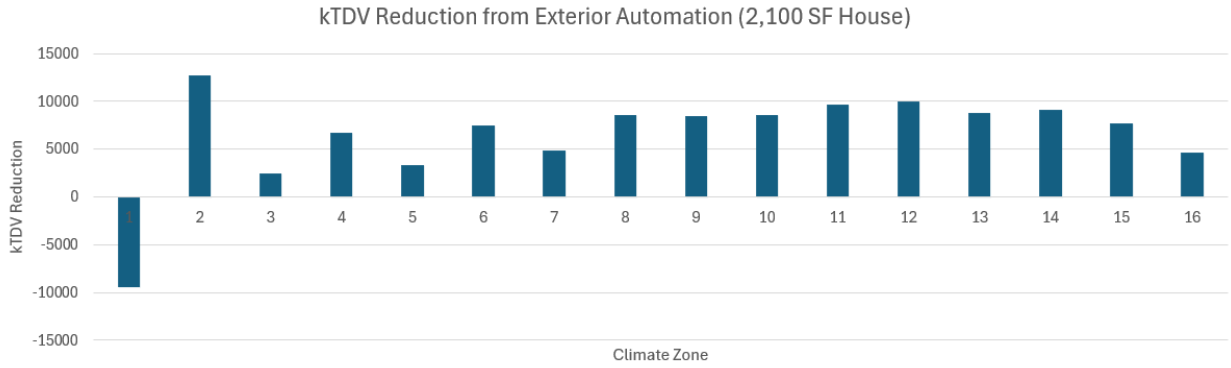
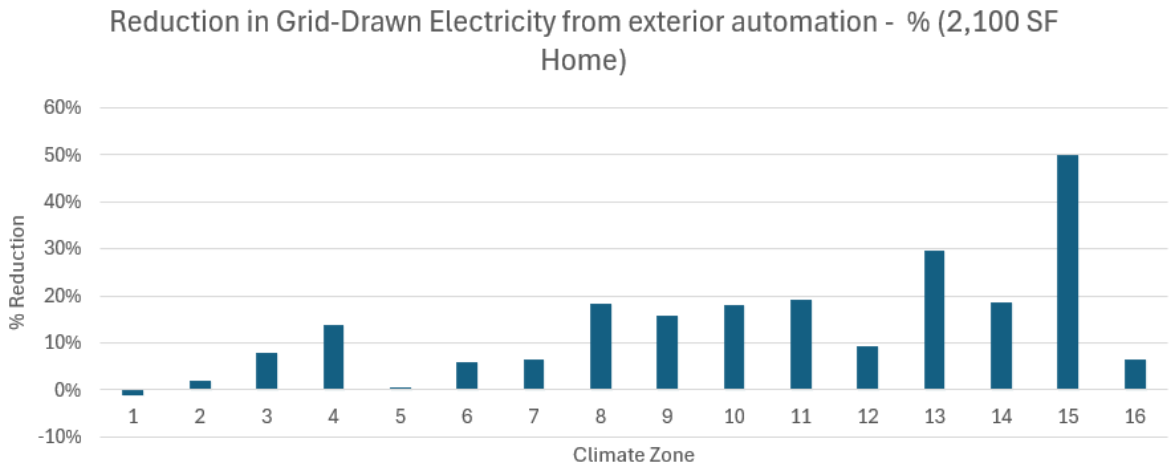


Figure 25.% Reduction in Grid-Drawn Electricity from Exterior Shading and Automation - 2,100 SF House



2,700 SF Prototype Results

Figure 26. Heating and Cooling System Electricity Use Reduction from Exterior Shade and Automation - kWh (2,700 SF Home)

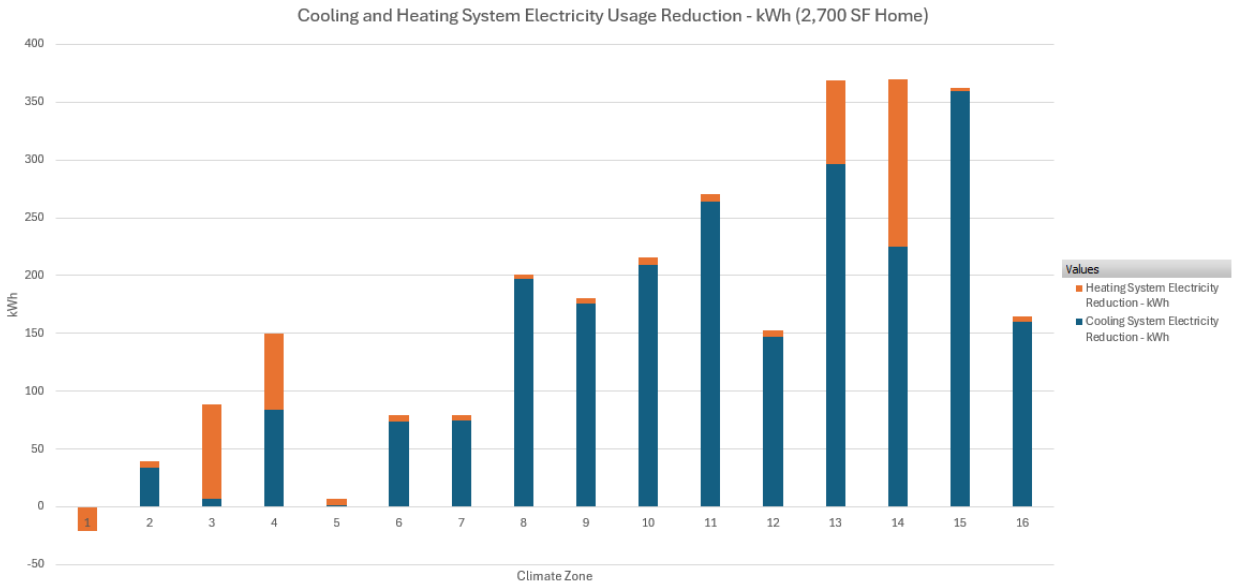


Figure 27. Heating and Cooling System Energy Use Reduction from Exterior Shade and Automation - % (2,700 SF Home)

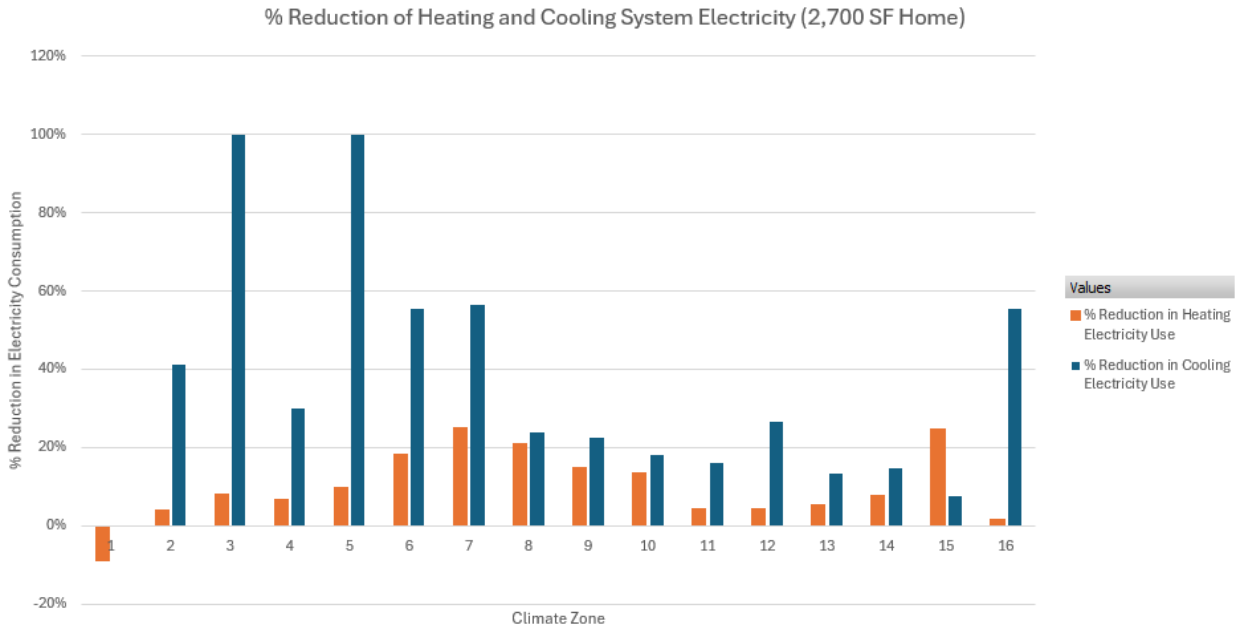


Figure 28. Heating System Gas Usage Reduction from Exterior Shade and Automation - kBTU (2,700 SF Home)

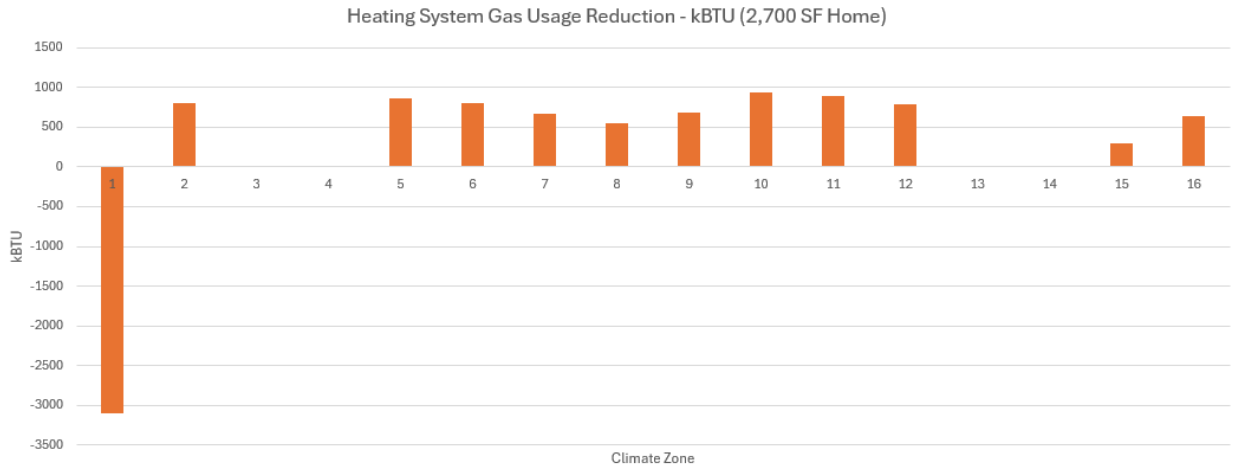


Figure 29. Heating System Gas Usage Reduction from Exterior Shade and Automation - % (2,700 SF Home)

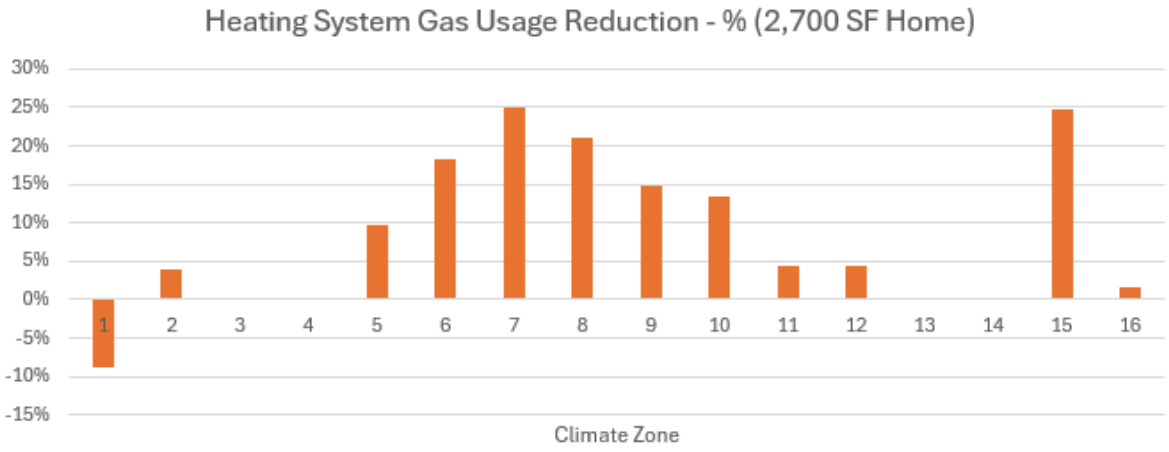


Figure 30. % Reduction in Total Gas Consumption from Exterior Shading and Automation

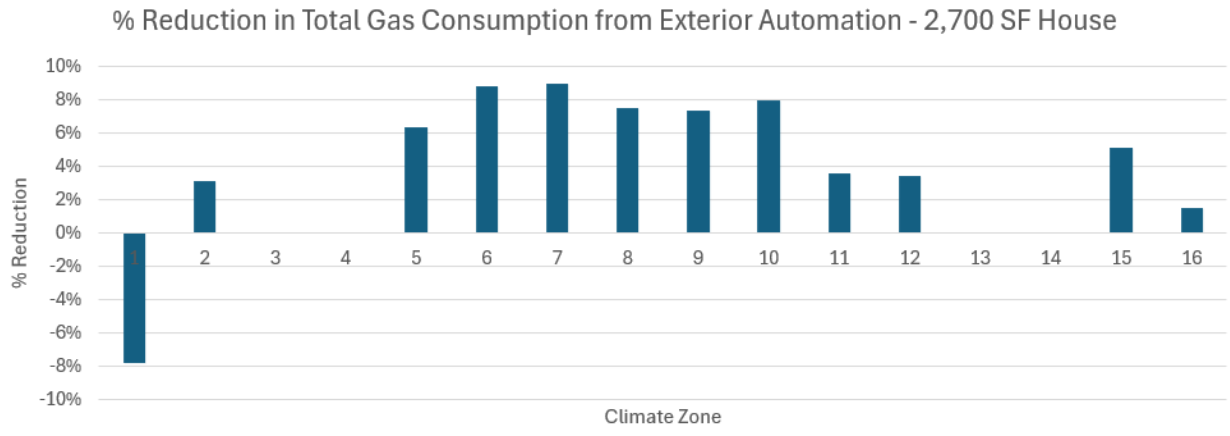


Figure 31. % Reduction in TDV from Exterior Shading and Automation

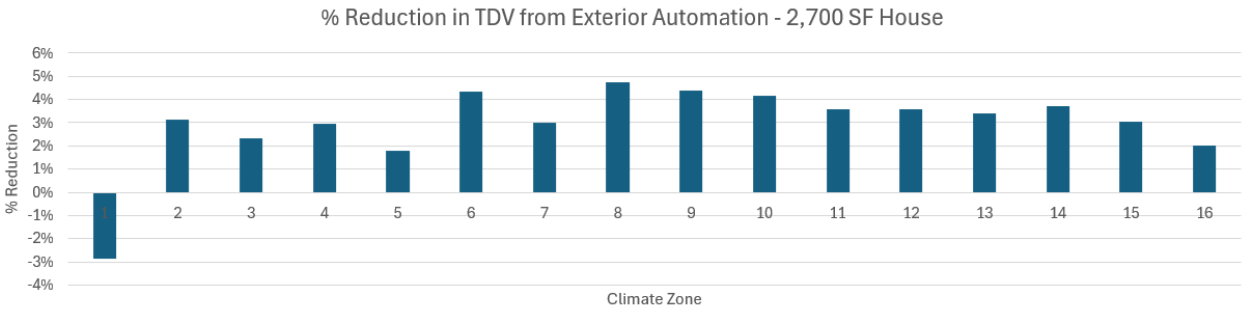


Figure 32. Total kTDV Reduction from Exterior Shading and Automation

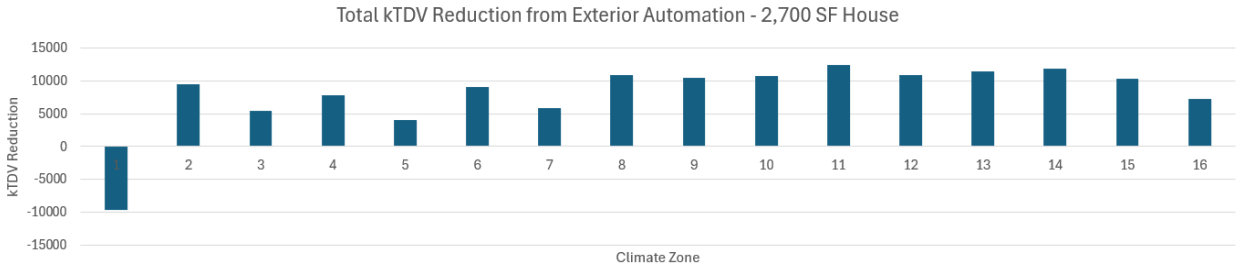
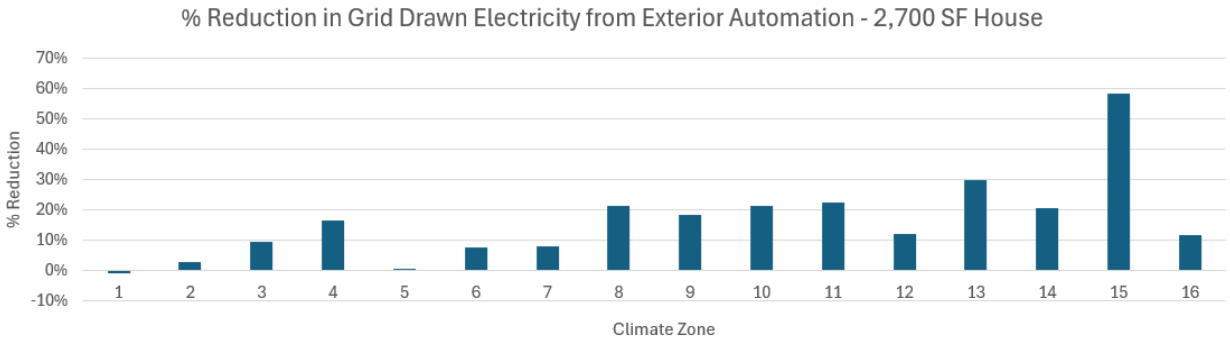


Figure 33. % Reduction in Grid Drawn Electricity from Exterior Shading and Automation - 2,700 SF House



Discussion

Automation System Design Life versus Warranty

Common industry warranty for automated shading system motors is 5-years. Somfy, a leading global automation and motor manufacturer in the shading industry uses a 10-year design life for their products, minimizing the number of units that need to be repaired or replaced under warranty. This exhibits a 2-to1 ratio of design life to warranty. This ratio of design life to warranty is conservative when compared to other ubiquitous consumer electronics products. Computer and smartphone manufacturers generally warranty their products for one year, but those products are commonly functional for 3+ years (a 3-to-1 ratio of design life to warranty).

As described in Appendix 3, shading fabrics typically have warranty durations between 5 and 10 years. Applying the same conservative doubling of warranty period to represent design life, a reasonable design life would be between 10-20 years for an ordinary shading fabric product. Given that the design life of both motors and shades is 10 years+, a term of 10 years of full performance (behavior based derating notwithstanding) may be considered. Appendix 3 research shows that homeowners in California will own their homes for 10+ years on average, further supporting an expected 10 year performance period.

Conclusion

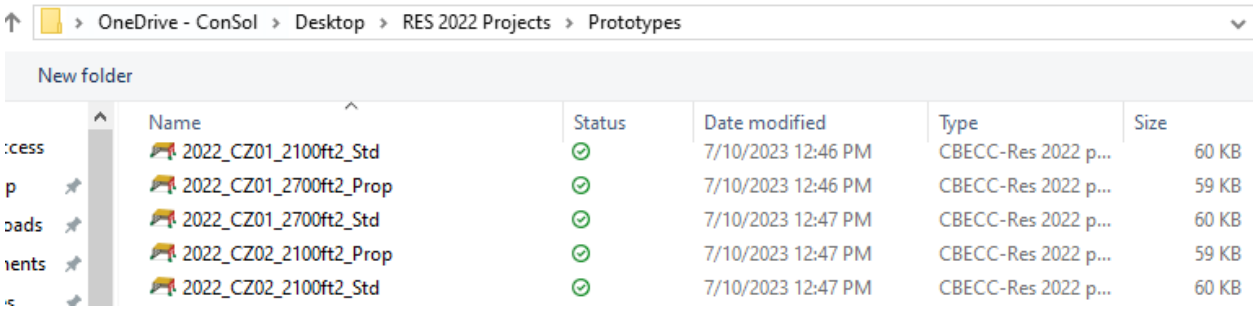
Appropriately modeled and rated automated window shading offers substantial benefits to California homeowners and ratepayers. Automated shading can aid in reducing summer peak energy loads while balancing beneficial winter heat gain. Automation supports and maximizes both consumer comfort and energy efficiency.

Appendix 1 – Residential Interior Shade Instructions

The following are example step-by-step instructions of the residential interior shade modeling performed.

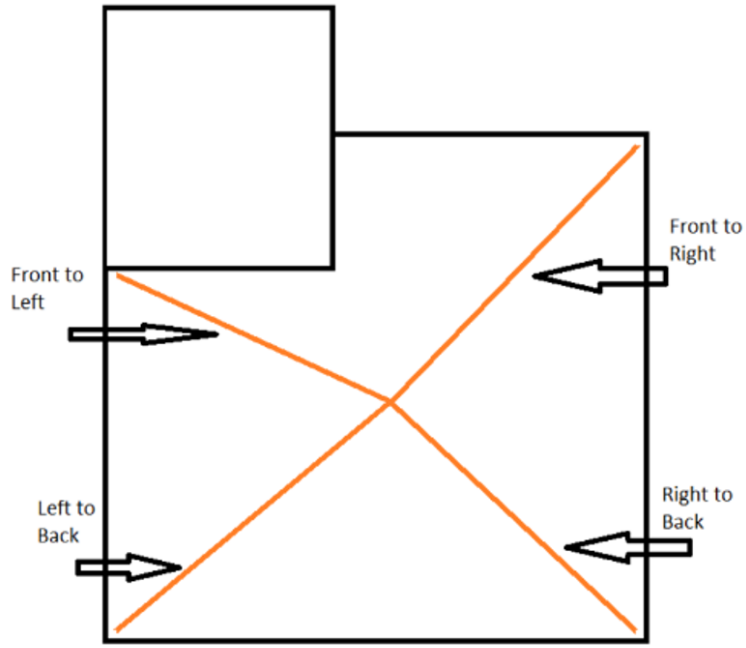
1. Start with the “standard prototype” CBECC-Res 2022 file. The location of these prototype files are chosen upon installation of CBECC-Res.

Figure A1-1. Location of CBECC-RES Prototypes Within RES 2022 File Structure



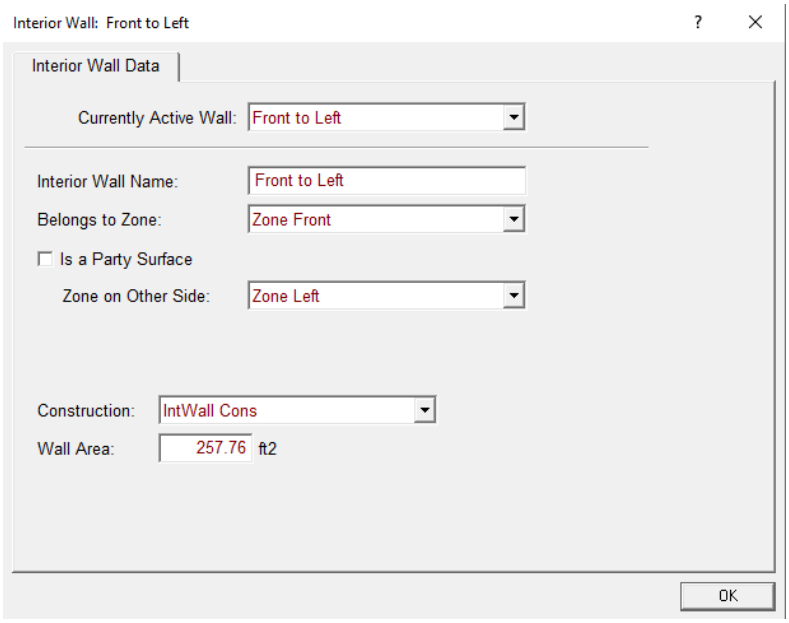
2. Add interior walls
    a. The standard models are a perfect square with 9 foot walls. The home needs to be split into 4 triangles to segment each façade cardinal direction for multizone modeling. In the 2,100 square foot prototype model, each exterior wall is 40.5 feet in length. Splitting the 40.5 feet per edge square into 4 right isosceles triangles, the lengths of the “interior” portions of those triangles is ~28.6 feet long (~364.5 square feet of wall). [1]

Figure A1-2. Multizone Model False Interior Walls



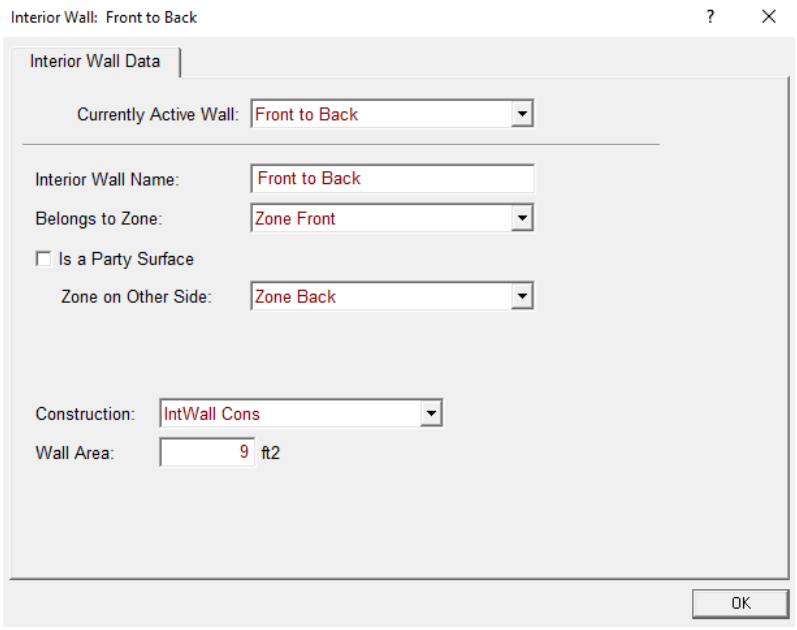
b. The house is split into four zones along these “false” interior walls. The “Front to Left” wall in Figure A1-2 above counts as a wall for both the front and the left zones of the building. The default interior wall construction assembly was used. To create the “Front to Left” wall, an interior wall is added to the front zone, and specified that the “Zone on Other Side” value is set to the Left Zone.

Figure A1-3. False Interior Wall "Front to Left" 2,100 SF Prototype



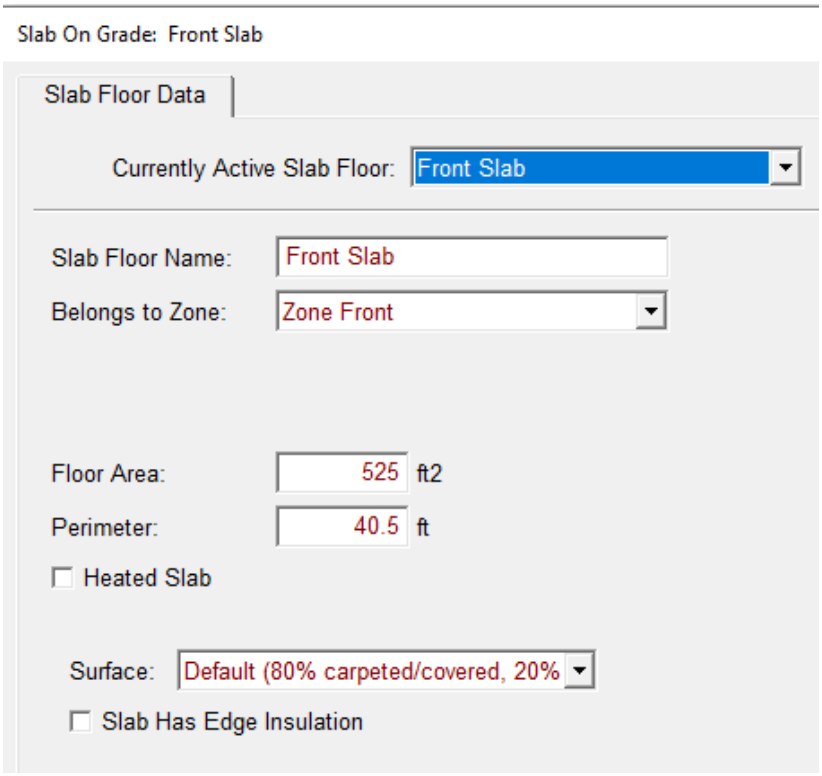
c. Two additional “false” walls are created. They are imaginary 1 foot long walls (9 square feet) so that each zone has six surfaces. These connect the front section to the back section, as well as the left section to the right section.

Figure A1-4. False Interior Walls "Front to Back" 2,100 SF Prototype



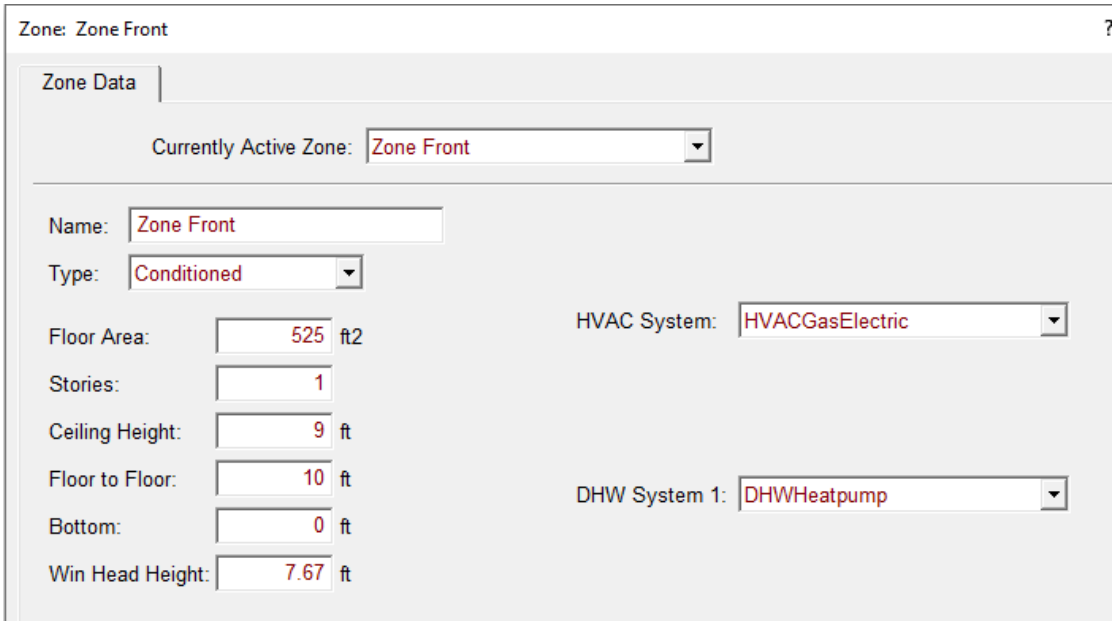
d. Split the ceiling and slab into each zone
    i. Floor area and perimeter for slab

Figure A1-5. Front Slab 2,100 SF Prototype



e. Attach HVAC and domestic hot water to each zone

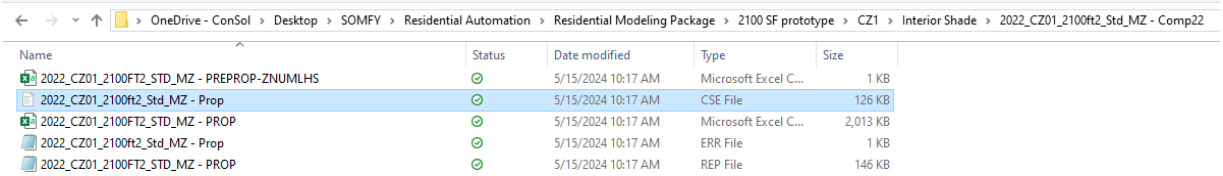
Figure A1-6. Front Zone 2,100 SF Prototype



f. Ensure each zone has 15 square feet of windows and 5 square feet of door on the exterior walls.

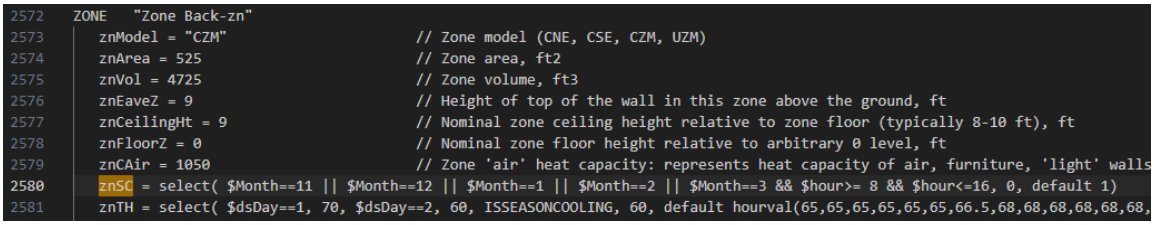
3. Run the model in CBECC-Res 2022. This will generate CSE input files that can be modified to reflect automation of the interior shades.
    a. In the “Comp22” folder generated from the CBECC-Res run there is a proposed (“Prop”) CSE file. This version contains all the modifications made in CBECC-Res.

Figure A1-7. Proposed CSE File 2,100 SF Prototype



4. Under the default settings, the left zone of the building is facing west and the back zone of the building is facing south. The shade control logic for these zones are in “ZONE "Zone Left-zn""[2] and “ZONE “Zone Back-zn””. Note that the interior quotations are part of the name in the CSE file.

Figure A1-8. "Zone Back" parameters



    a. Within this larger Zone object there is “znSC” equation, which contains the logic for shade control. The following expression is the default setting for all zones.

znSC = select($radDiff >1., 0.5, default 0.8)

    b. The following expression is used to describe the modified AERC schedule for west and south facing windows. The || symbol indicates a logical “OR” and the && symbol indicates a logical “AND”.

znSC = select($Month==11 || $Month==12 || $Month==1 || $Month==2 || $Month==3 && $hour>= 8 && $hour<=16, 0, default 1)

Note that the statement above actually indicates that during Nov, Dec, Jan, and Feb, the shades are open 24 hours a day. During March, the shades are only open from 8:00 a.m. – 4:00 p.m. , . During all other times, the shades are closed.

This logical statement was intended to be read as : “From 8:00 a.m. to 4:00 p.m. during the months of Nov, Dec, Jan, Feb, or Mar, the shades should be open. Otherwise they should be closed.”

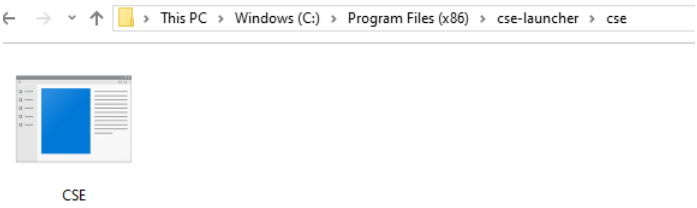
This error in the scheduling expression leaves the shades open all day from November through February. This allows more light and heat into the home during the early morning and evening than intended. Any impact that the shading

fabric may add to insulation during the night from November – February is negated as well.

As currently modeled, the back/south zone is modeled with the same znSC statement.

5. Four versions of that CSE file are made.
    a. West Only
    b. South Only
    c. West & South
    d. Original default schedule
6. Run these files in CSE launcher running on the custom CSE engine featuring the interior shade fabric of choice.

Figure A1-9. Location of CSE Engine within CSE Launcher



a. In order to run CSE the .EPW file (the weather file for the area of interest), the DHWDU2 text file, and the “Prop-tdv” .csv files are needed. These files will be in the output from originally running the CBECC-Res model. These supporting files and the .cse file should then be sent to a folder for that model run.

Figure A1-10. Required Supporting Files to run CSE

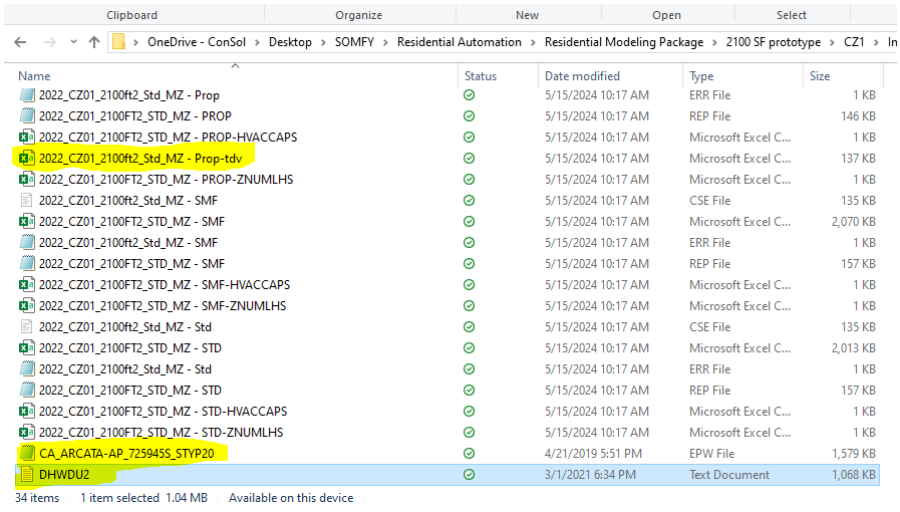
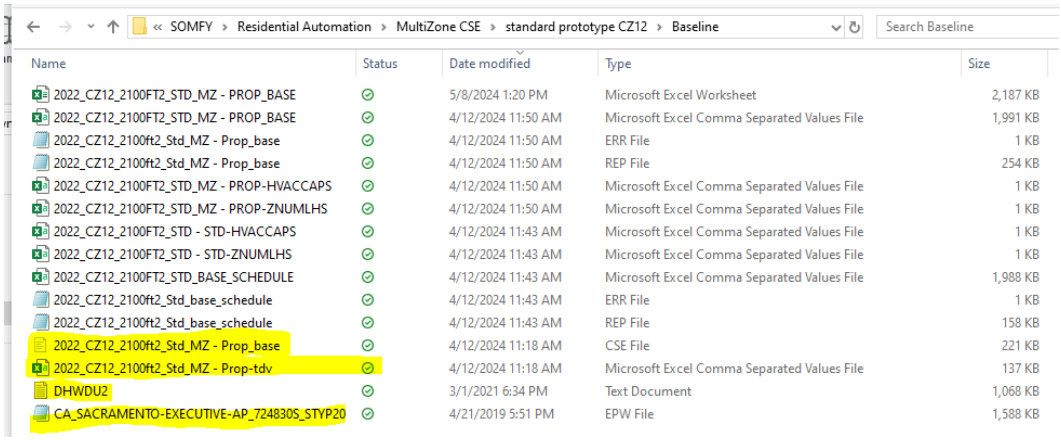
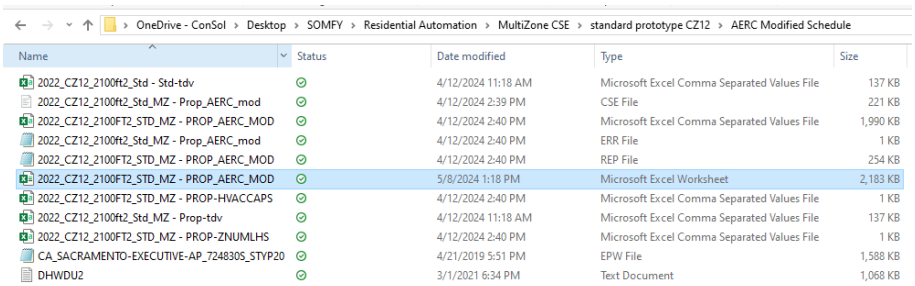


Figure A1-11. CSE Model Run Folder after Successfully running a .CSE File with CSE Launcher



7. Running the cse files will produce a .csv file with the hourly results in kBTU. If any calculations are made on the document, it should be saved as an excel file so that calculations are preserved.

Figure A1-12. Results File from CSE output



   a. The Clg and FanC columns are summed together to estimate “Cooling System Energy Use”
   b. The Htg and FanH columns are summed together to estimate “Heating System Energy Use”. In zones 3,4,13, and 14, the hpbu (heat pump backup) column also needs to be incorporated.
      i. Most climate zones have gas heating systems in their prescriptive models, so it will be necessary to keep a separate tracking of electricity use for heating fans and gas consumption in the furnace
   c. Four sets of results are tracked for a single prototype in a single climate zone (No Automation, West Only, South Only, South & West)
      i. The performance of the automation is evaluated via the change in energy consumption of the heating and cooling systems. The automated shading run with new fabric is compared to a run with the original shade scheduling and new fabric.

Appendix 2 – Customization of CSE Engine

The following are instructions for the required customization of the CSE engine to perform the modeling analysis. The source code for the California Simulation Engine (CSE) is hosted on GitHub

GitHub - cse-sim/cse: California Simulation Engine

The version used in the analysis conducted on interior and exterior shades is version 0.922.1. Release v0.922.1 · cse-sim/cse · GitHub

Git was used to clone this version of the software. Alterations to the software that reflect different fabric properties are made in the “ashwface.cpp” file.

Figure A2-1 Successful Clone of CSE Repository Using Git Bash

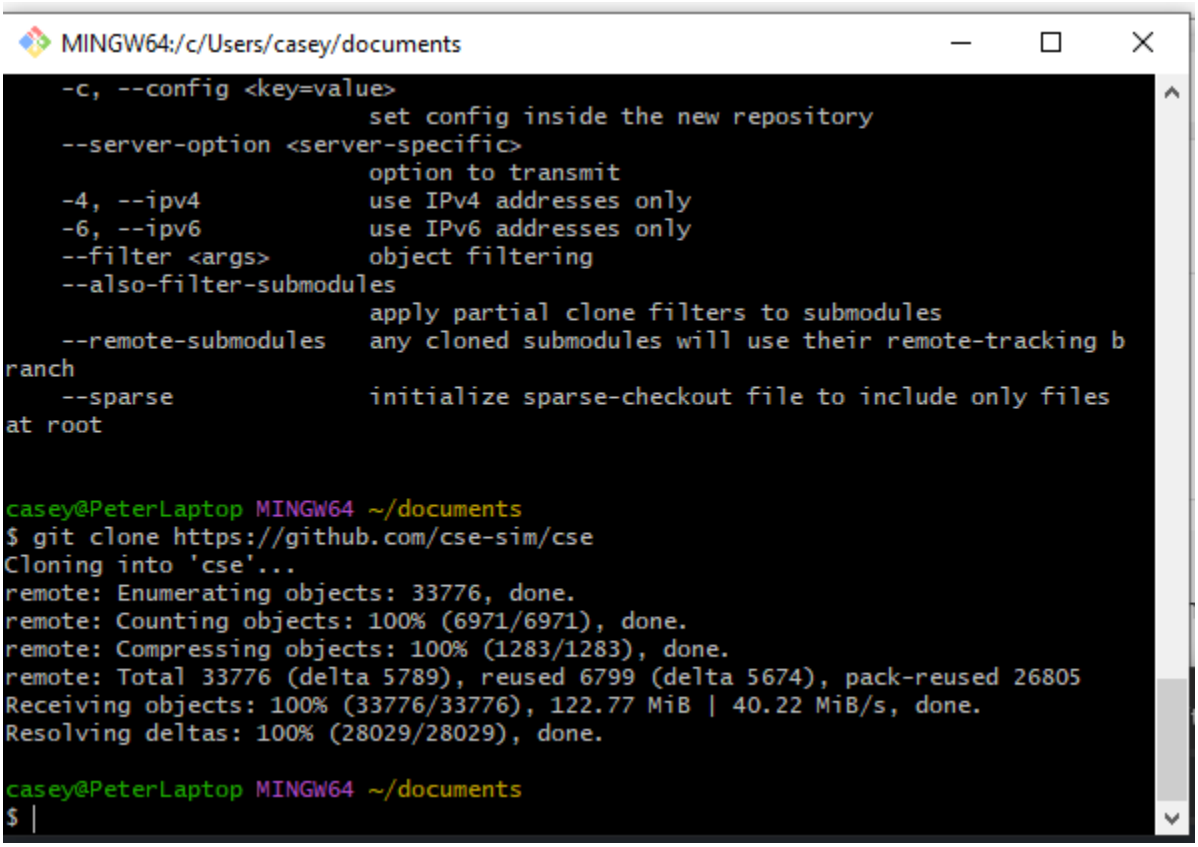
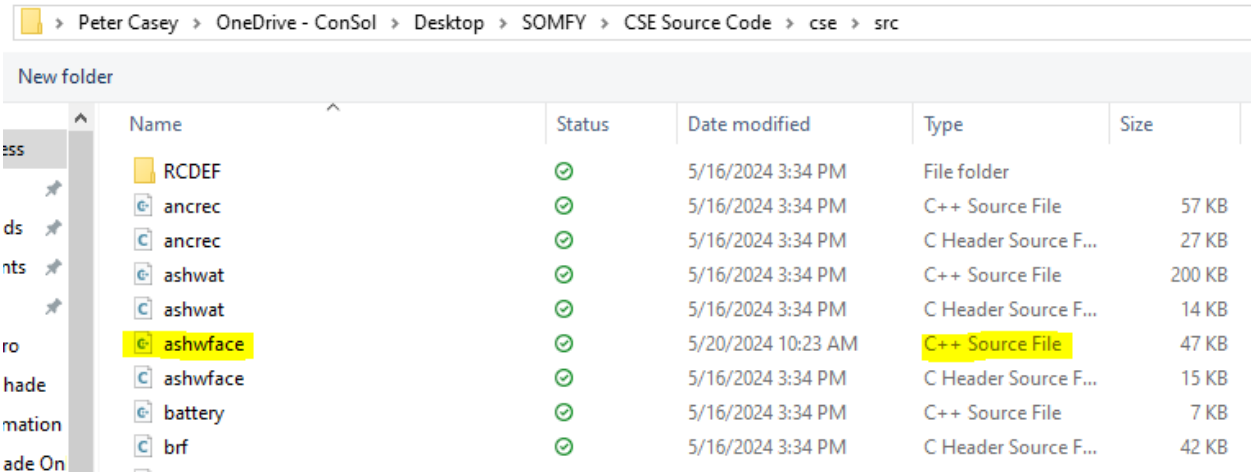


Figure A2-2. Location of ashwface.cpp file within CSE source code file structure



Line 1,328 of this file defines the interior shades. The rightmost parameter is defined by subtracting the openness value from the beam total transmittance value.

Figure A2-3. Location of DrapeMed within ashwface.cpp file

```
1325    // Openness = tauBB =  0.01
1326    // Beam total transmittance = tauBT = 0.11
1327    // Beam total reflectance     = rhoBT = 0.38
1328            xw_layerLib.push_back( CFSLAYER( "DrapeMed",  ltyDRAPE, 0.01f, 0.38f, 0.10f));
```

Note that the original fabric's rightmost value is defined by subtracting the openness from the total transmittance. This subtraction is used to define the rightmost value for all custom engines (interior and exterior)

The original fabric was replaced by 2410+ Charcoal/Gray Fabric from Phifer.[4] Using CSE's terminology, this fabric has an openness of 0.03, a total transmittance of 0.04, and a total reflectance value of 0.72

Figure A2-4. Performance Parameters of 2410+ Charcoal/Gray Fabric

STYLE 2410+ FABRIC	Solar Transmittance	Solar Reflection Out	Light Transmittance	Light Reflection	% Open	UV Transmittance	Color Rendering Index
Glazing Performance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
P12 Oyster	5	73	5	72	3	3	99
P13 Oyster/Beige	5	73	5	72	3	4	99
P14 Oyster/Pearl Gray	4	73	4	72	3	4	99
Q20 Beige	5	73	5	72	3	4	98
Q21 Beige/Pearl Gray	5	72	5	71	3	4	99
V20 Pearl Gray	4	75	4	74	3	4	99
V21 Charcoal	4	71	4	70	3	4	100
V22 Charcoal/Gray	4	72	4	71	3	4	100
V24 Charcoal/Chestnut	4	72	4	71	3	4	100
V32 Charcoal/Alpaca	4	75	4	74	3	4	99

[4] SHEERWEAVE Performance+ sw-performance-tech-sheet-v20-121720.pdf (phifer.com)

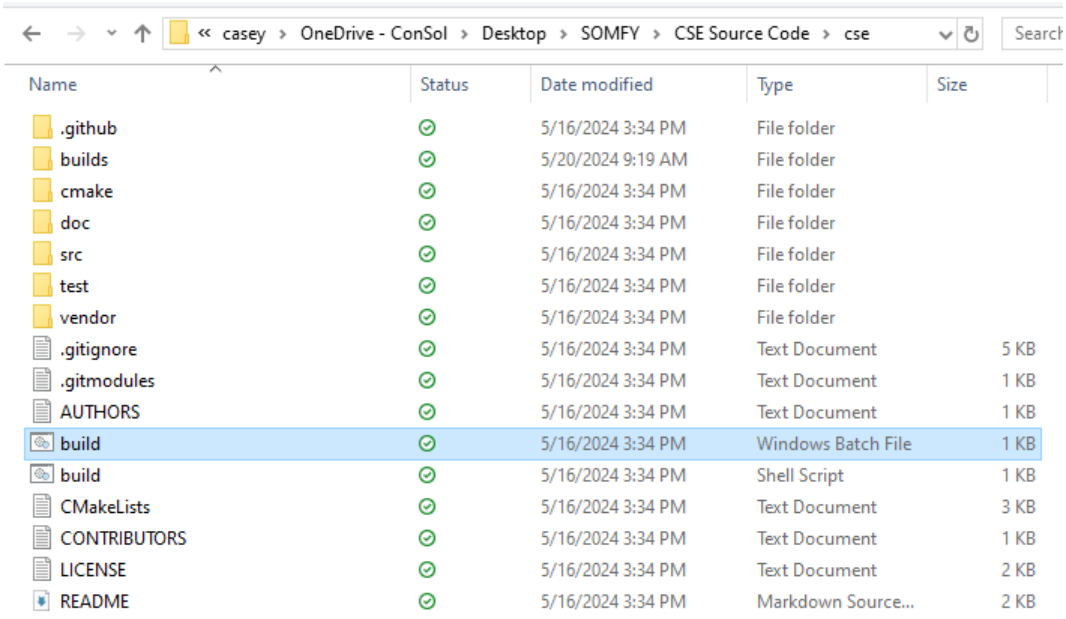
Within CSE, this fabric is represented via the following expression.

Figure A2-5. 2410+ Charcoal/Gray Fabric Represented in ashwface.cpp File

```
1340    // Performance+ 2410+ (Metalized) Charcoal/Gray
1341    // Openness = .03
1342    // Transmittance = .04
1343    // Reflectance = 0.72
1344    // The rightmost value is generated by subtracting the openness from the total solar transmittance
1345
1346        xw_layerLib.push_back( CFSLAYER( "DrapeMed",  ltyDRAPE, 0.03f, 0.72f, 0.01f));
```

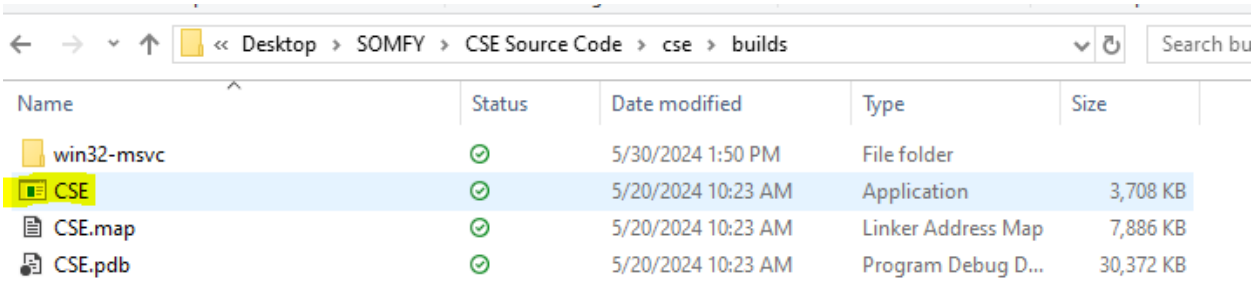
Once this change has been made and saved, it is now possible to build the executable (.exe) model engine by double clicking the “build” windows batch file

Figure A2-6. Location of "build" Windows Batch File within CSE source code



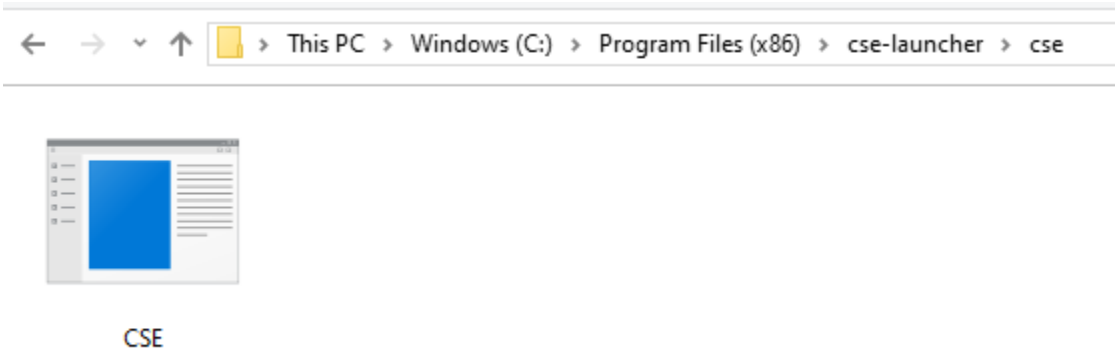
If the build is successful, a CSE.exe file will be generated that will overwrite the prior CSE .exe file in the “builds” folder. The “Date modified” column will indicate if the CSE.exe file is new.

Figure A2-7. Location of CSE.exe File Within CSE Source Code



In order to use this new engine, the CSE.exe file needs to replace the engine used for the CSE Launcher.

Figure A2-8. Location of CSE.exe File Within CSE Launcher File Structure



A similar process is performed to create custom engines for the exterior shades. The insect screen or “InsScrn” within the source code is defined in a similar fashion as the interior shades. Openness is on the left, reflectance is in the middle and (transmittance minus openness) on the right. It is found on line 1,312 of the ashwface.cpp file within the source code.

Figure A2-9. Location of Insect Screen Parameters Within ashwface.cpp file

```
1312            xw_layerLib.push_back( CFSLAYER( "InsScrn",  ltyINSCRN, .65f, .06f, .03f));
```

The fabric used in the analysis is Suntex 95 Carbon and is highlighted in the image below.

Figure A2-10. Suntex 95 Carbon Parameters

	SOLAR OPTICAL PROPERTIES				SHGC/G VALUE g-tot (glass & blind)					
					Single			Insulating		
	TS	RS	AS	TV	1/8CL	1/4CL	1/4HA	1/2CL	1CL	1HA
SunTex 95 *0 Degree Profile Angle, Fabrics Installed Externally*										
SunTex 95 White	17	70	13	16	0.17	0.17	0.16	0.15	0.14	0.12
SunTex 95 White/Grey	12	54	34	12	0.14	0.14	0.13	0.12	0.12	0.10
SunTex 95 Stucco	14	48	38	13	0.16	0.16	0.15	0.14	0.14	0.12
SunTex 95 Sand	12	44	44	7	0.15	0.15	0.14	0.13	0.12	0.11
SunTex 95 Alpaca	11	39	50	11	0.15	0.15	0.14	0.12	0.12	0.10
SunTex 95 Chestnut	11	39	50	9	0.15	0.15	0.14	0.12	0.12	0.11
SunTex 95 Mocha	8	22	70	9	0.14	0.14	0.14	0.11	0.11	0.10
SunTex 95 Dark Bronze	8	5	87	11	0.16	0.16	0.16	0.12	0.12	0.11
SunTex 95 Carbon	6	10	84	10	0.14	0.14	0.13	0.10	0.10	0.10
SunTex 95 Black	7	3	90	10	0.16	0.16	0.15	0.12	0.12	0.11

In the software, this fabric is represented as follows:

Figure A2-11. Suntex 95 Carbon Parameters

```
1323        xw_layerLib.push_back( CFSLAYER( "InsScrn",  ltyINSCRN, .05f, .10f, .01f));
```

Appendix 3 Requests from the CEC Regarding Warranties, Homeowner Occupancy, Install Costs

The following are questions received and answers provided during this modeling analysis process.

Request: What is the warranty and design life of the motor actuator?

Response:

- Typical window shading motor systems have a multi-year warranty with a manufacturer's operating design life that exceeds that warranty. For example, on the website of a leading window shading motor provider, Somfy, their interior and exterior motors have a warranty of 5-years[5] and Somfy confirmed their products have a design life of 10 years. HunterDouglas also offers a 5 year warranty on their motor products.[6] Another supplier, Smartwings offers a 3-year warranty.[7] Motor warranties appear consistent among manufacturers and there was no difference found between warranties for internal versus external motors.

Request: What is the warranty and design life of shade fabric.

Response:

- Mermet T Screen has a 5 year exterior and 10 year interior warranty.[8]
  - Exterior Screens with warranties up to 10 years are available.
- Sheerweave 2410 has a 5 year exterior and 10 year interior warranties.[9]
  - High Performance metalized version has 5 year interior warranty.[10]
- Suntex 80/90 exterior screens have a 10 year warranty.[11]
- Pella offers a ten year warranty on their "between the glass" shades.[12]
  - Note that this type of "between the glass" shade cannot currently be modeled with CBECC-RES or CSE.

Request: What is the typical duration that a homeowner will stay in a home

Response:

- 11.9 years is the duration a typical homeowner stays in their home in the U.S.[13]

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[5] https://www.somfypro.com/warranty
[6] Learn More About Hunter Douglas Warranty | Hunter Douglas Help & Support
[7] Warranty & Guarantee – SmartWings (smartwingshome.com)
[8] https://mermetusa.com/site/user/files/1/dc_sm_107-mermet-fabric-limited-warranty-rev_1-_4_.pdf

[9] https://www.phifer.com/product/sheerweave-2360-2390-2410-2500/
[10] https://www.phifer.com/wp-content/uploads/2021/12/sw-performance-tech-sheet-v20-121720.pdf
[11] https://www.phifer.com/product/suntex-80-90/
[12] https://assets.contentstack.io/v3/assets/bltf589e66bcaecd79c/blt1f615fe1a10c202b/wood-window-door-warranty.pdf

- A study from the National Association of Realtors asserts that California homeowners generally stay in their home for an average of 10-15 years depending on the county.[14]
- Home tenure in California and design life of automation and shade products both align at 10+ years.

Request: Apart from homeowner change and shade fabrics or automation reaching the end of their useful life, what other conditions would prompt change of fabric?

Response: According to Fannie Mae, the useful life of a window is ~30 years.[15] Homeowners commonly replace associated hardware and fabric when replacing the window itself or if the hardware or fabric needs replacement at the end of their useful life. Homeowners also change shade fabrics during the change of ownership of the home. Window shading is most commonly changed at the same time windows are changed since the window shading is sized specifically to match the window and new frame. Windows shades that are replaced typically perform equal to or better than prior shades given the use of more modern and higher performing shading materials.

It is uncommon for customers to take window shading products with them from a prior home to a new home since the new home window quantities and sizes are different, so the window shading would not fit those quantities and sizes.

Request: What is the warranty for a typical window

Response:

- Milgard has 20 year warranty for insulated glass unit (IGU) and components, and lifetime warranty for mainframe in residential applications.[16]
- Alside: has lifetime limited warranty for sash and mainframe, 10-year warranty for moving parts and screen frame, 20 year warranty for IGU.[17]
- Andersen: 20 year warranty on glass, 10 year warranty on non-glass hardware.[18]

Request: What is the impact on energy consumption of installing blind automation on a prototype house in CZ12

Response: A multizone version of the CZ12 2,100 SF prototype home was simulated with updated fabric material (Mermet T-Screen) and 3 different schedules. The original CBECC-RES

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[13] https://investors.redfin.com/news-events/press-releases/detail/1050/homeowners-today-stay-in-their-homes-twice-as-long-as-they
[14] https://www.nar.realtor/blogs/economists-outlook/how-long-do-homeowners-stay-in-their-homes
[15] https://multifamily.fanniemae.com/sites/g/files/koqyhd161/files/2019-08/4099f.pdf
[16] Microsoft Word - 211213 DRAFT Lifetime Limited Warranty (milgard.com)
[17] Window Warranty for Alside New Construction Window System
[18] Andersen Limited Warranty, 400 & 200 Series Owner2Owner (sitecorecloud.io)

schedule assumes shades are half-closed when diffuse radiation exceeds 1 BTU/hr/square foot on the window. Otherwise, they are assumed to be 80% closed.

AERC provides a baseline schedule with shade operation that leaves the shades closed during winter months, increasing required heating loads for the year. In order to address the increased winter heating loads, a third schedule was used that opened the west facing shades from 8:00 a.m. to 4:00 p.m. and the south facing shades from 8:00 a.m. to 4:00 p.m. during the heating season (winter, or November to March) in CZ12to beneficially leverage solar heat gain. The impacts of these schedules on energy use (gas and electricity) are as follows in Tables 1 and 2.

Table A3-1. Electricity Usage for Air Conditioning Unit, Cooling Fan Usage, and Heating Fan Usage

	Total Annual Electricity (kWh)	% change from original
Original schedule	324.99	
AERC Base Schedule	310.34	-4.5%
Modified AERC Schedule	301.87	-7.1%

Table A3-2. Natural Gas Consumption of Furnace

	Therms Gas Heating	% change from original
Original schedule	159.66	
AERC Base Schedule	166.9	4.5%
Modified AERC Schedule	154.39	-3.3%

Request: What is the cost of equipping a home with internal automation and shading

Response:

The prototype 2,100 SF home modeled in CZ12 features a 3x5 window on the west and south sides of the home. These are the most cost effective sides of the home to equip with automated shading. The automated window shading industry estimates the price to install motorization and shading on a 3x5 window to be ~$1,100 in California. The total cost to equip the west and south facing windows with automated shading is ~$2,200.[19] The cost component to purchase and install shades is ~$400 per window, and the cost component of automation and motorization of those two windows would be ~$700 per window. The cost is $1,400 total to automate and

[19] https://www.somfysystems.com/en-us/blog/post/how-much-do-motorized-blinds-cost

motorize the west and south facing windows of the prototype 2100 SF house with existing shades. Larger windows will be more cost effective on a $/square foot basis than the 3x5 windows in the prototype house.

Request: What is the energy savings from installing automated exterior shading on a prototype 2,100 SF home in CZ12

Response: CBECC-RES and CSE have an insect screen by default that provides some level of shading. The properties of this shade are defined in the source code for CSE. The properties used for the initial test window shade are from the Suntex 90 Beige at 0 degree profile angle.[20] Other shading fabrics such as Suntex 95 may be more appropriate for outdoor use. These properties were used for the cooling season (April - October). During the heating season (November- March), the AERC schedule indicates that the exterior screens should not be in use. In order to simulate this, a version of CSE that features a totally transparent exterior screen was generated. The results of two model runs (one for the transparent shade and one for the Suntex 90 shade) were combined to examine the impact of the AERC schedule. This could not be done in one single run, as there is no ability to control exterior screens within CSE. This combined data was compared with the results of a model run with the baseline insect screen.

The impact of the Suntex 90 exterior screen while using AERC's schedule was a 15.7% (54 kWh) reduction in the electricity consumption for cooling, distribution of cool air, and distribution of hot air. Most (47 kWh) of that 54 kWh reduction is from cooling and cool air distribution. When looked at alone, cooling and cold air distribution energy use declines by 19.3%. There was also a 6.5% (9.2 therms) reduction in the amount of natural gas required to heat the home.

Request: What is the cost of installing automation for exterior screens.

Response: Many motors are rated for both interior and exterior applications. As such, automation and motorization cost for the exterior shades are expected to stay the same at $700 per 3x5 window.

Request: What are the parameters that impact the performance of an automated shading system?

Response: The parameters that impact the performance of shade within CBECC-RES are solar transmittance, fabric openness, solar reflectance, and the solar absorptance of the fabric. The openness of the fabric is dependent on how tightly woven the fabric is. A fabric marketed purely as an insect screen may have very high openness, letting in much more light than a solar screen with a low openness factor. These parameters are often available on a technical document on the manufacturer's website.[21] The thickness of the fabric (and the associated U-factor) also impacts performance. However, that parameter is not able to be altered within CSE and is not incorporated into any of the modeling analysis from this document.

[20] SunTex® 80/90 | Exterior Insect Solar Screens | Phifer

[21] https://www.phifer.com/product/suntex-80-90/

The way these parameters impact performance is also dependent on whether the shade is external or internal. An external shade with a high absorptance value can absorb more solar energy and release it into the atmosphere later without that heat passing into building. An internal shade with a high level of absorptance would release that heat into conditioned space later, reducing its efficacy at controlling solar heat gain.

Another parameter impacting performance is the scheduling system. For the sake of simplicity, all modeling has been performed using AERC's scheduling or a modified AERC schedule. Schedules that incorporate weather conditions and HVAC operations into their scheduling algorithm may have performance that exceeds the simplified or modified AERC schedules.

Appendix 4 – Exterior Shading Methodology

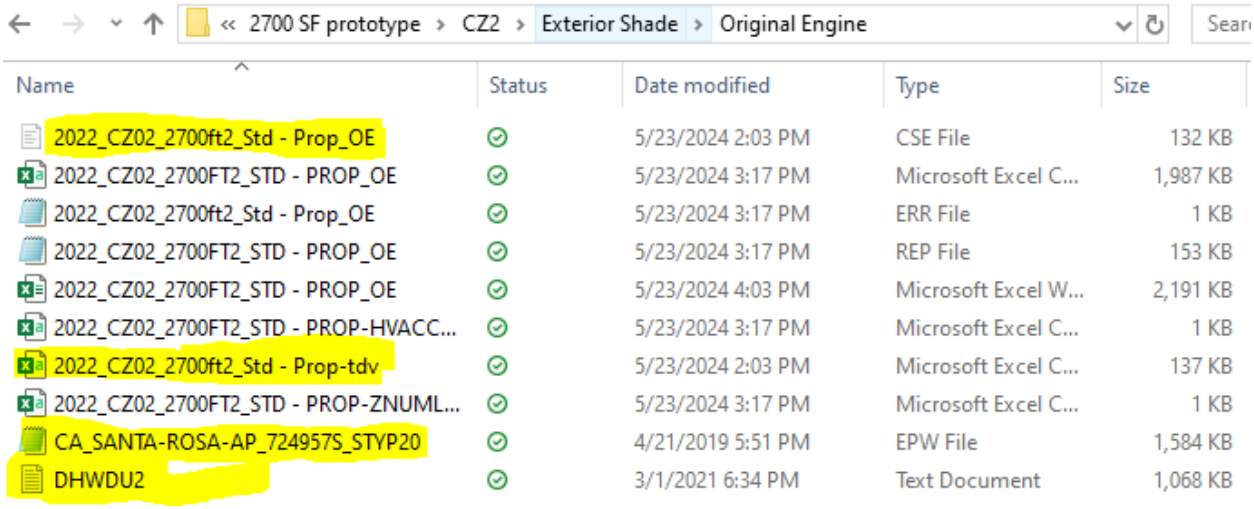
Exterior products cannot be simulated in a single CBECC-Res/CSE run. The original exterior shade in place for the entire year will serve as the performance baseline. In order to simulate the Exterior shade being removed during the winter season, two models are run. One will have the Suntex 95 Beige exterior shade, and the other will have an effectively transparent exterior shade. Combining the results of April through October with the Suntex shade, and November through March with no shade will approximate the schedule given in the table below.

Figure A4-1 AERC Exterior Shade Schedule

	Window Orientation			
	North	South	East	West
April 1 - October 31	Closed All Day	Closed All Day	Closed All Day	Closed All Day
November 1 - March 31	Open All Day	Open All Day	Open All Day	Open All Day

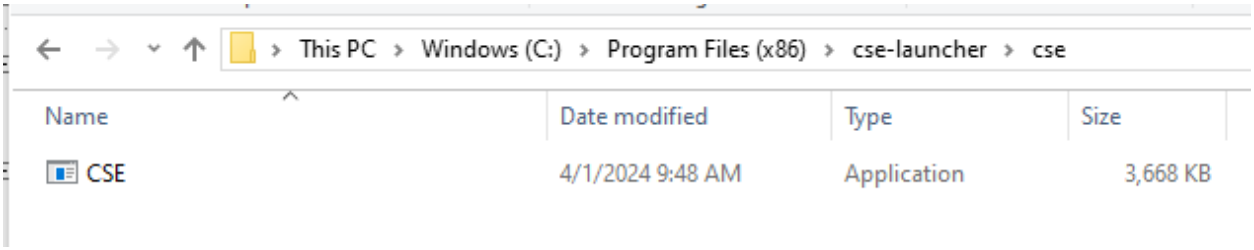
1. Start with the standard prototype residential model ("_Std" is at the end)
2. Run that model through CBECC-Res in order to generate the .cse file. Select the "Prop" CSE file, in addition to the weather file (EPW file type), the DHWDU2 text file, and the "Prop-tdv" .csv file.

Figure A4-2 Required Files to Run CSE



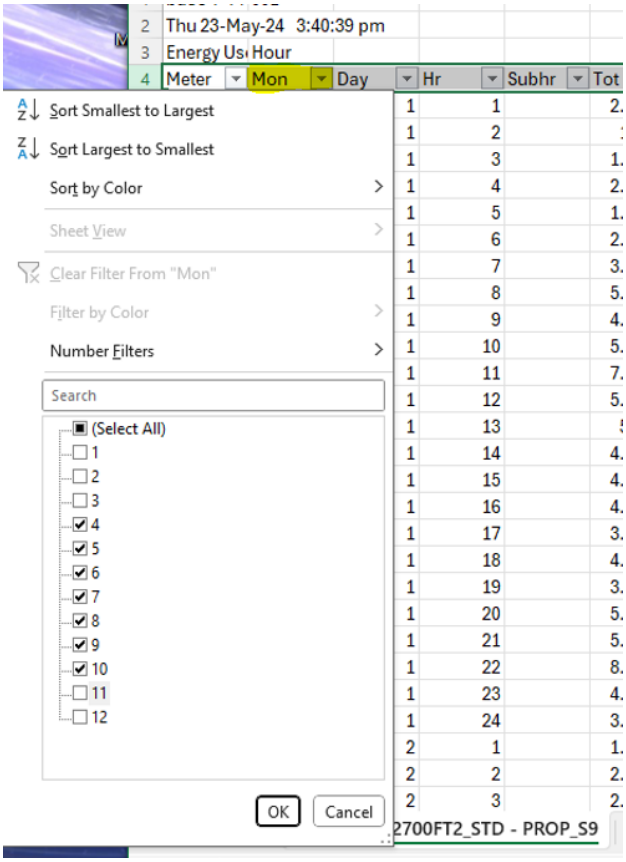
3. Copy these files to two folders.
    a. One folder is for running the .cse file with the intended fabric
    b. The other folder is for running the .cse file with a totally transparent fabric, simulating an “open” exterior shade.
    c. It is necessary to swap in the CSE modeling engine that corresponds to the intended fabric and the transparent fabric.

Figure A4-3 Location of Simulation Engine for CSE Launcher



4. With both models ran, compile the results into a single composite dataset. Filter the dataset with the shades of interest (Suntex 95) to the months from April to October. Months 1,2,3,11, and 12 are filtered out. Likewise, filter the transparent screen data output to the same time period. Then paste the filtered data from the Suntex 95 run into the transparent screen data output.

Figure A4-4 Months to Filter Out of Suntex 95 Run Before Pasting to Transparent Run Output



5. This composite model will be compared to a model ran with the original insect screen as the exterior shades. The savings value represents the savings from adding the shades and adding automation. On the interior shades, only the gains relative to adding automation are measured. If only the gains from automation for exterior are measured, there would be no change in cooling system energy usage because the behavior of the exterior shades is unchanged during the cooling season.
    a. Three different engines are used – Original, Transparent Screen, Fabric of Interest (Suntex 95)
6. This process needs to be performed for both gas and electricity.

Appendix 5 – Prior Modeling Studies

Automated shading system benefits have been extensively studied in real buildings, testbeds and simulations. The variety of buildings, shading materials, control algorithms, and climates considered result as expected in a range of energy savings. The table below summarizes the results of various studies on residential buildings.

Study Name	Building type	Size	Location	New build or retrofit	Modeling or case study	Control	Savings measure(s)	Savings
RMI Residential Shades	Residential	2400 sqft	Various, USA	Both	Modeling	Automatic	Total energy	4% to 7% new build 6% to 17% retrofit
LBNL Control Algorithms	Residential	2400 sqft	Various, USA	Retrofit	Case study	Automatic	HVAC	11-13%
PNNL 2018 Evaluation of Cellular Shades	Residential	1500 sqft	Richland, WA	Retrofit	Case study	Automatic and Manual	HVAC	15%