Final Project – Reference City: Logrono

1. Project Introduction

Final Project – Reference City: Logrono

1.1 Background

The project under study is a restaurant area of a winery located in Logrono, Spain. The restaurant area is a long, thin rectangular box with top to bottom glass windows facing southeast (these windows in this report will be refered to as “south windows”) and opposite to those windows is a long, large window. The goal of these windows was to create “visibility” of both the guests and of the vines for the guests to look out at. This overexposed approach has left this space to be essentially a glass box. However, while these glass facades can allow for a lot of light to come through, there are issues of too much light and moreover the issue of energy consumption are problematic. Nowadays, when glass glazings are becoming more advanced and more people want glass boxes to feel better connected to the outdoors, what are some strategies to allow for this happen?

1.2 Project - Site

The site of the area we are simulating is located in Rioja region of Spain. The Rioja region is known as Spain’s premier wine-growing region. It an be divded into Rioja Alavesa, Rioja Alta, and Rioja Baja regions which all have their own different characteristics. The site is located in the Rioja Alta region which is a dryer region than the other Rioja region (it also produces lighter wine flavors). It is also on the Western edge of the region and is at higher elevations than other areas. The higher elevation allows for a shorter growing season.

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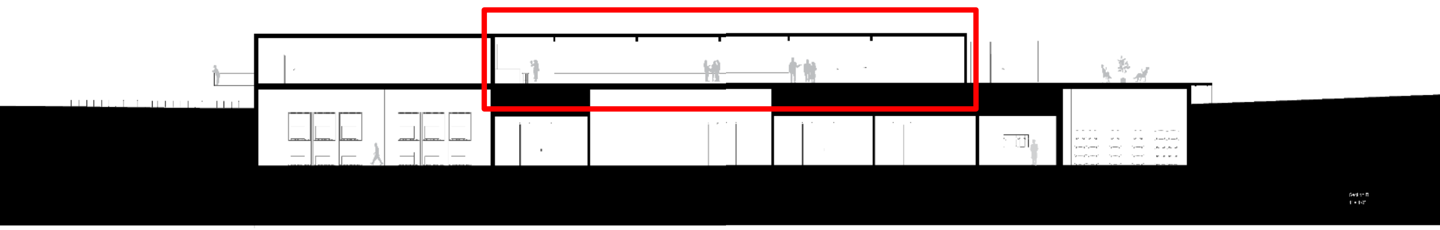
1.3 Project - Images



2. Climate Analysis

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3.1 The Climate

In a temperate zone of Europe, its climate is influenced by both the Atlantic and Mediterranean. It is also characterized as having a humid continental climate being located in the Ebro Valley.

3.2 Weather Data Summary

WEATHER DATA SUMMARY

LOCATION: **Logrono, -, ESP**
Latitude/Longitude: 42.45° North, 2.33° West, **Time Zone from Greenwich** 1
Data Source: SWEC 080840 WMO Station Number, **Elevation** 363 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	172	245	301	338	373	421	455	436	360	284	191	154	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	236	317	290	297	318	362	451	455	405	347	265	218	Wh/sq.m
Diffuse Radiation (Avg Hourly)	85	110	142	151	160	169	143	141	126	119	83	82	Wh/sq.m
Global Horiz Radiation (Max Hourly)	482	599	760	902	946	955	952	905	829	697	536	413	Wh/sq.m
Direct Normal Radiation (Max Hourly)	823	845	899	940	943	914	911	902	889	876	835	757	Wh/sq.m
Diffuse Radiation (Max Hourly)	221	278	321	386	453	414	406	403	341	296	208	205	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1599	2514	3563	4466	5408	6342	6715	5993	4437	3067	1856	1384	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2200	3221	3442	3921	4619	5453	6646	6268	4978	3725	2584	1956	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	795	1141	1684	2001	2323	2553	2120	1933	1558	1292	795	738	Wh/sq.m
Global Horiz Illumination (Avg Hourly)													lux
Direct Normal Illumination (Avg Hourly)													lux
Dry Bulb Temperature (Avg Monthly)	5	7	9	11	15	18	22	21	19	14	9	6	degrees C
Dew Point Temperature (Avg Monthly)	1	1	2	4	6	8	12	11	10	8	4	2	degrees C
Relative Humidity (Avg Monthly)	73	67	62	62	58	53	55	54	59	70	72	75	percent
Wind Direction (Monthly Mode)	0	0	0	0	0	0	0	0	0	0	0	0	degrees
Wind Speed (Avg Monthly)	6	6	6	6	6	6	6	6	6	6	6	6	m/s
Ground Temperature (Avg Monthly of 3 Depths)	8	7	8	9	12	15	17	18	18	16	13	10	degrees C

The coldest months in Logrono are during December and January. The average monthly dry bulb temperatures are 6 and 5 degrees C which is moderately cold. During the winter, Logrono has its highest relative humidity percentages. High humidity during the winter is generally not uncomfortable because its cold. Generally, Logrono is humid throughout the year with its lowest monthly averages being in the 50 percentage. Summers are one average also moderate with the average temperatures ranging in the early 20 degrees C.

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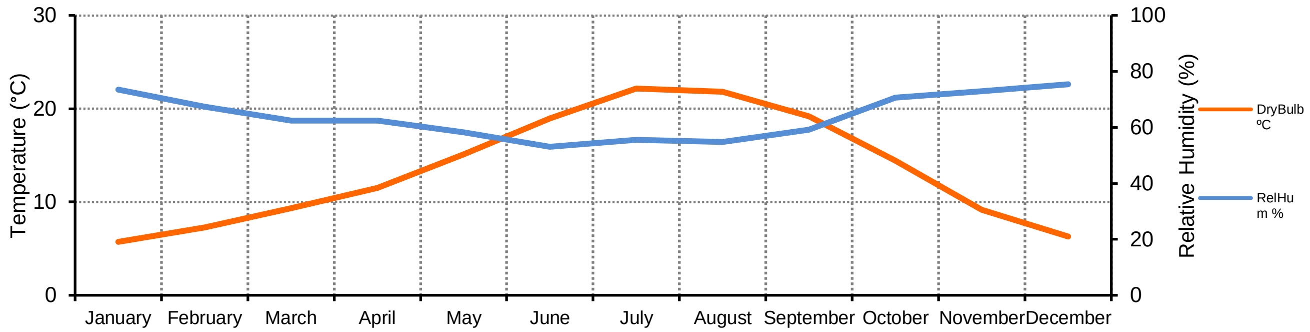
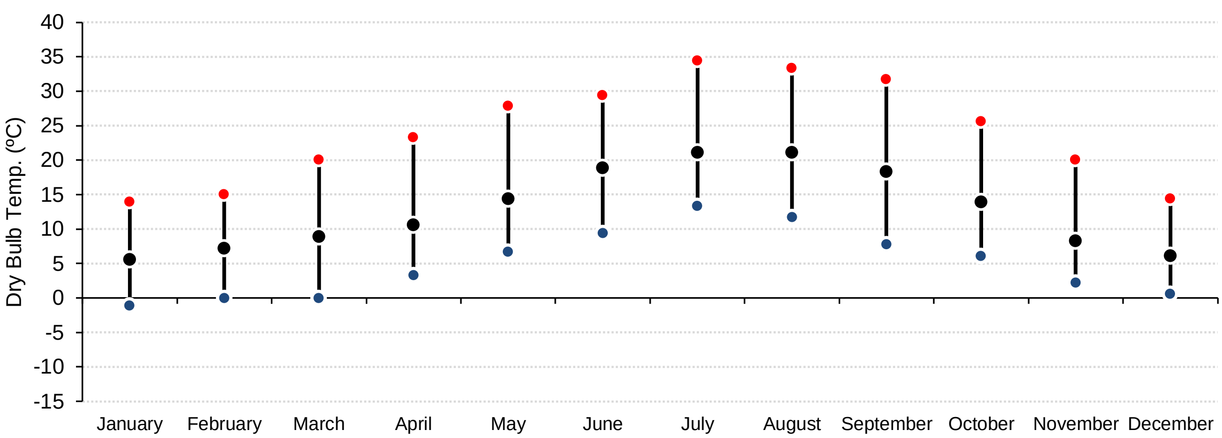
3.3 Temperature and Relative Humidity

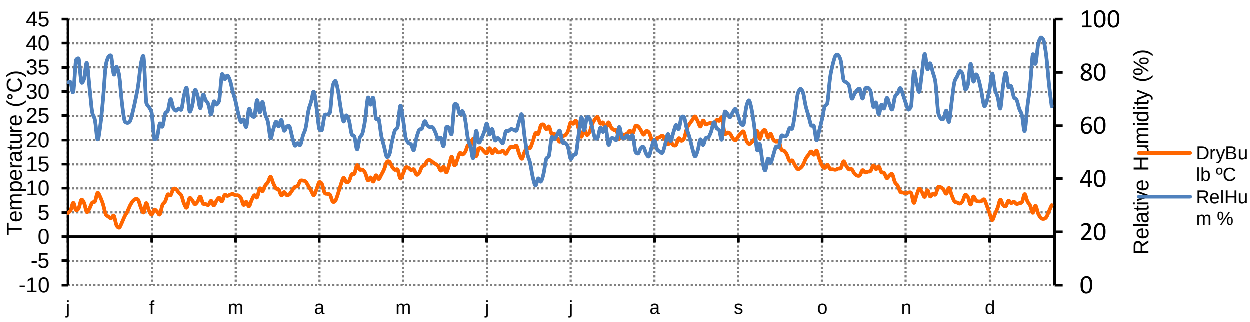
Monthly Temperature and Relative Humidity



Monthly Temperature Range

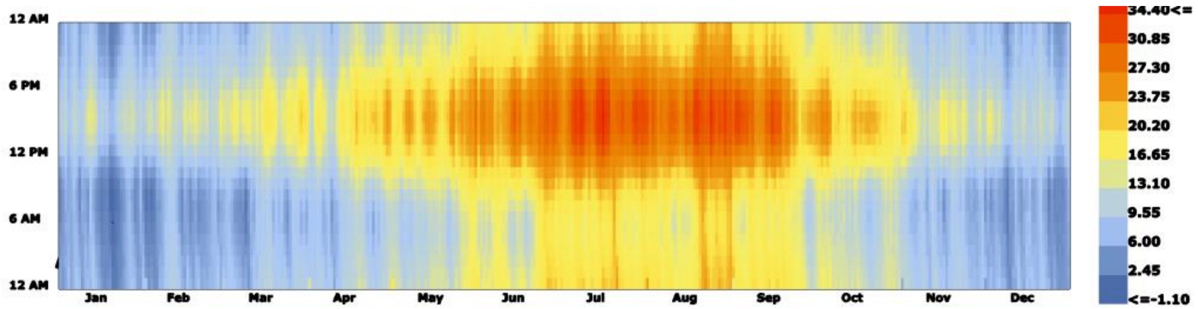


Daily Temperature average and Relative Humidity



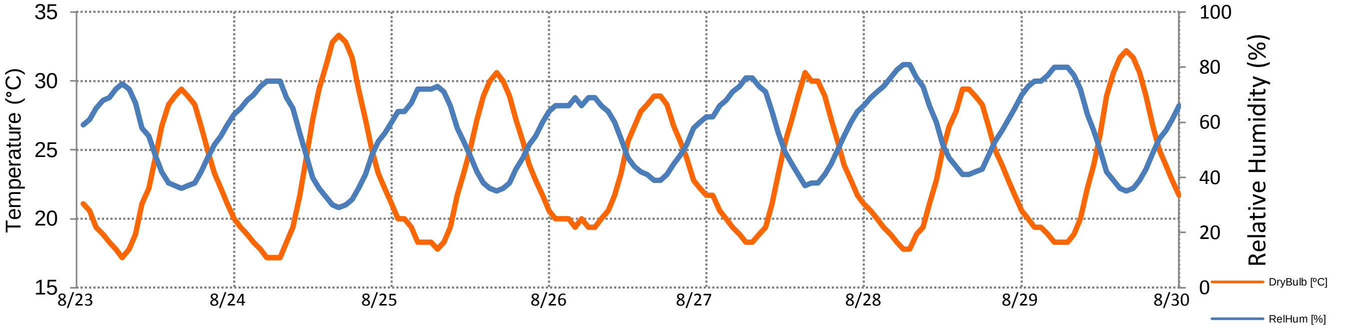
Climate Zone 5B – Ely, Nevada

Hourly Drybulb Map

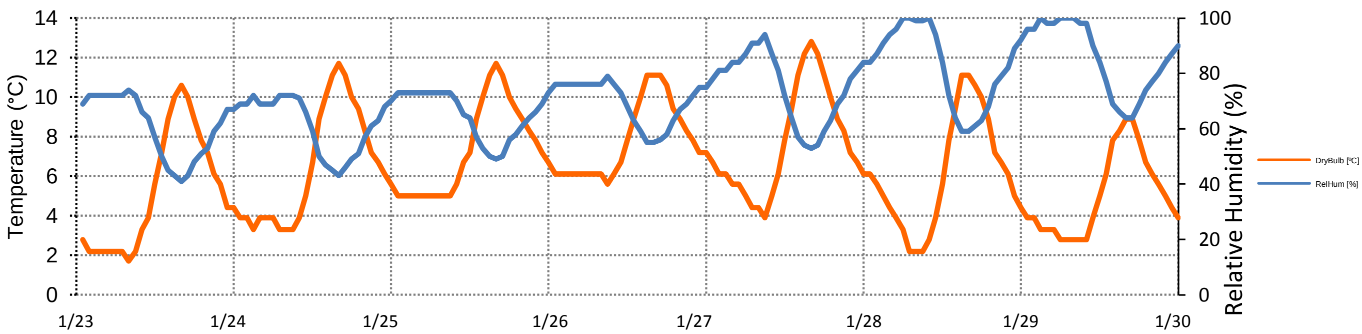


Diurnal Ranges

Hottest days



Coldest days



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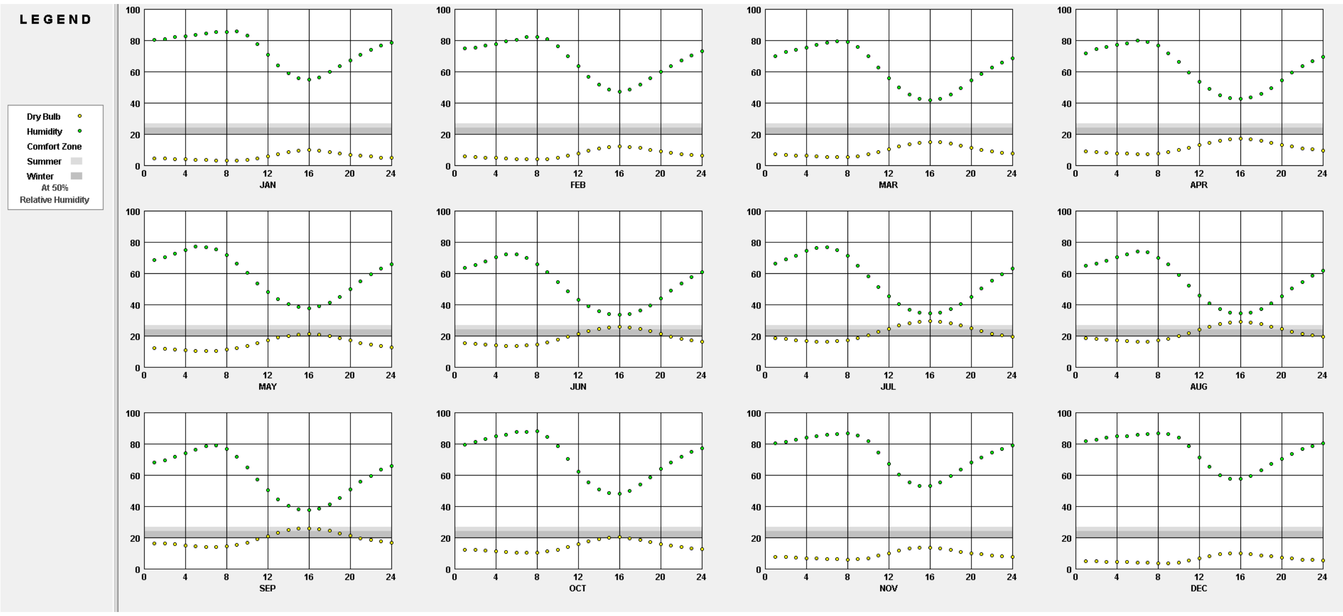
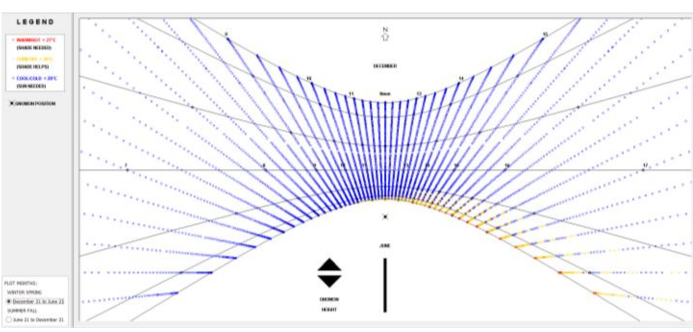
3.4 Dry Bulb x Relative Humidity

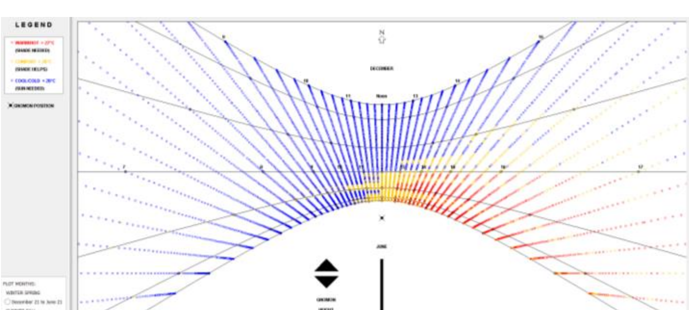


3.5 Sun Charts

Sun Chart - WINTER SPRING (December 21 – June 21)



Sun Chart - SUMMER FALL(June 21 – December 21)

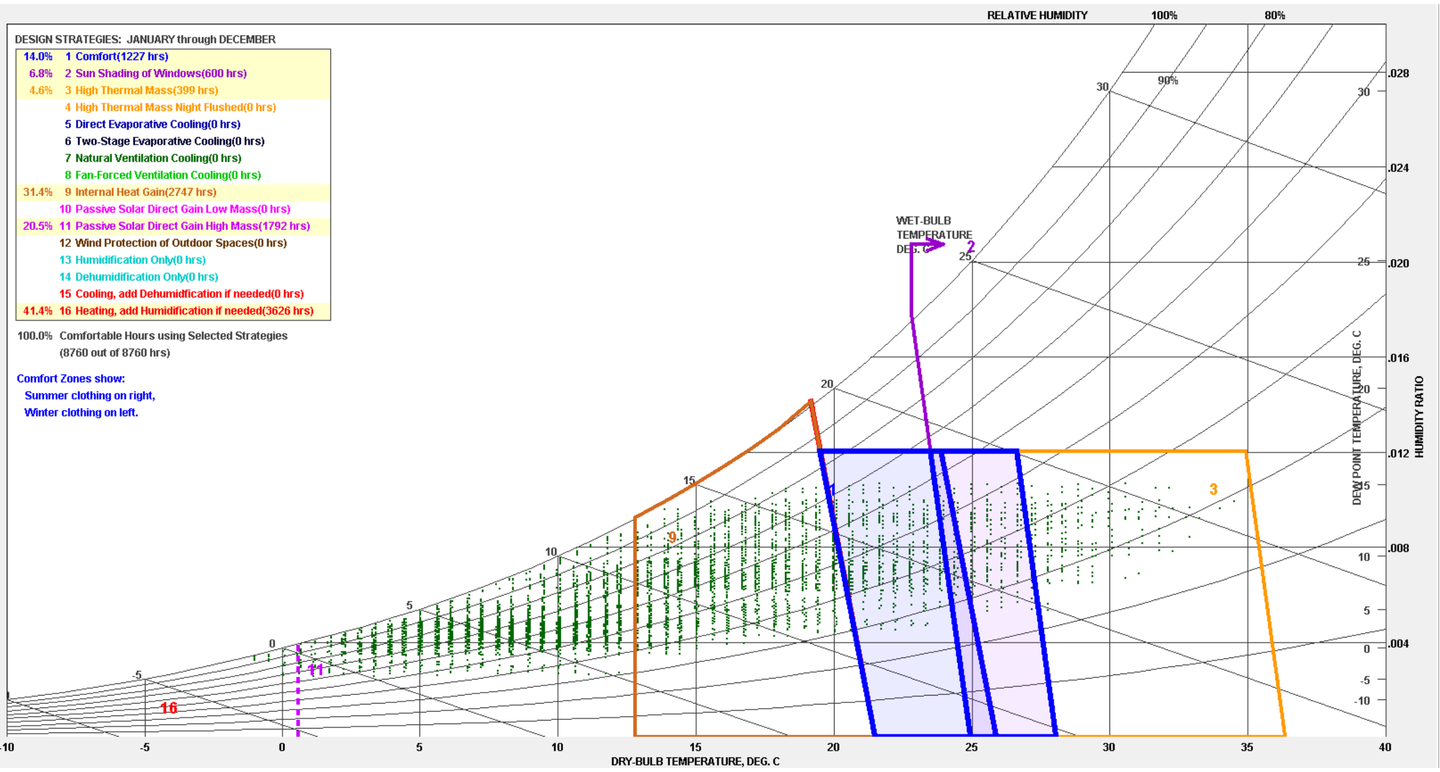


The winter spring sun chart illustrates that in the it is generally colder than what people are comfortable with in Logrono during this time period. Comfort is depicted in yellow and we see very little of it. Thus, energy consumption for heating is likely to be high to combat the cold weather. The summer fall chart is also dominated by the blue that signifies it is too cold. There is more yellow, but we also begin to see some red for when it is too hot. There will also be energy consumption for cooling during the late summer. However, looking at how there is some yellow, there will be times during the year when the climate will be comfortable on its own without extra energy consumption.

4. Possible Design Strategies

Final Project – Reference City: Logrono

4.1 Design Strategies from Climate Consultant



This chart illustrates some of the best design strategies for increasing comfort. The climate is temperate with cool winters and warm summers. Heating has the biggest effect on comfort because as shown in the climate analysis charts, it was too cold for comfort. The lowest dry bulb temperature was 6 degrees C in January followed by 7 degrees C in December. The highest temperature on the averaged monthly dry bulb was 22 degrees C in July which is not necessarily unbearably hot but to be comfortable requires some cooling.

Targeting Internal Heat Gain is also a design strategy that may be effective. To reject excess heat generation such as deploying shading devices and selecting the right optical properties of glazing. In addition, the fenestration size and orientations can also be an effective design strategy. Since this room is made mostly of glass, an efficient glazing will play a big factor.

Passive Solar Direct Gain High Mass is also an effective design strategy. Direct solar gain is important for any site that needs heating because it is the simplest and least costly way of passively heating a building with solar heat gain. More heat gain is desired in the winter when the sun is low and less is desired in the summer. Also, more heat gain is desired in the morning than in the afternoon. Thermal mass absorbs and retains heat, slowing the rate at which the sun heats the space and the rate as which the space loses heat when the sun is gone. Without thermal mass, heat that has entered a space will simply re-radiate back out quickly, making the space overly hot with sunlight and overly cold without. However, the majority of the test area is glass and the amount of wall is little in comparison.

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19	For passive solar heating face most of the glass area south to maximize winter sun exposure, and design overhangs to fully shade in summer 2030
20	Provide double pane high performance glazing (Low-E) on west, north, and east, but clear on south for maximum passive solar gain 2030
11	Heat gain from lights, occupants, and equipment greatly reduces heating needs so keep building tight, well insulated (to lower Balance Point temperature)
3	Lower the indoor comfort temperature at night to reduce heating energy consumption (lower thermostat heating setback) (see Comfort Low criteria)
24	Use high mass interior surfaces like slab floors and high mass walls to store winter passive heat and summer night 'coolth' 2030
31	Organize floorplan so winter sun penetrates into daytime use spaces with specific functions that coincide with solar orientation 2030
8	Sunny wind-protected outdoor spaces can extend occupied areas in cool weather (enclosed patios, courtyards or verandas) 2030
63	Climate responsive buildings in cool overcast climates used low mass tightly sealed, well insulated construction to provide rapid heat buildup in morning
18	Keep the building small (right-sized) because excessive floor area wastes heating, cooling, and lighting energy
15	High Efficiency heators or boilers (at least Energy Star) should prove cost effective in this climate
62	Climate responsive buildings in temperate climates used light weight construction with slab on grade and operable walls and shaded outdoor spaces
16	Trees (neither conifer or deciduous) should not be planted in front of passive solar windows, but are OK beyond 45 degrees from each corner
2	If a basement is used it must be at least 18 inches below frost line and insulated on the exterior (foam) or on the interior (fiberglass in furred wall)
13	Pitched roof, vented to the exterior with a well insulated ceiling below, works well in cold climates (sheds rain and snow, and helps prevent ice dams)
14	Locate storage areas or garages on the side of the building facing the coldest wind to help insulate
4	Extra insulation (super insulation) might prove cost effective, and will increase occupant comfort by keeping indoor temperatures more uniform
23	Small well-insulated skylights (less than 3% of floor area in clear climates, 5% in overcast) reduce daytime lighting energy and cooling loads
12	Insulating blinds, heavy draperies, or operable window shutters will help reduce winter night time heat losses if automatically controlled
5	Carefully seal building to minimize infiltration and eliminate drafts, especially in windy sites (wrap, weather stripping, tight windows)
22	Super tight buildings need a fan powered HRV or ERV (Heat or Energy Recovery Ventilator) to ensure indoor air quality while conserving energy

This chart from climate consultant provides some design strategies. The current design somewhat follows 19, as the largest window faces south/southeast. 20 and 24 will be tested to some extent in this project.

5. Base Case Anlysis

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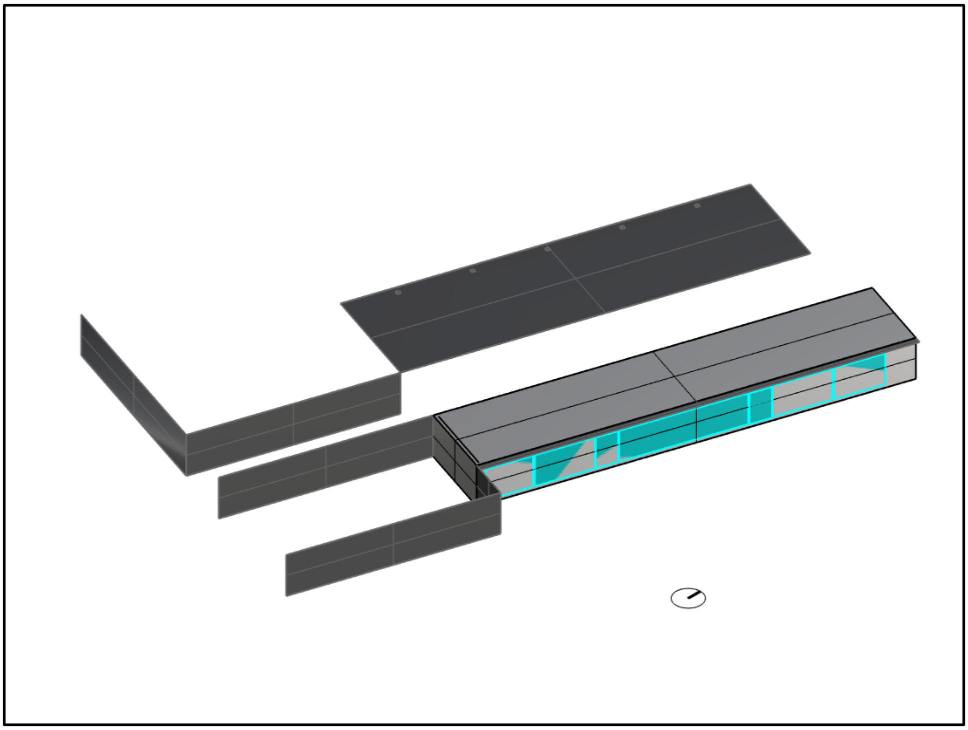
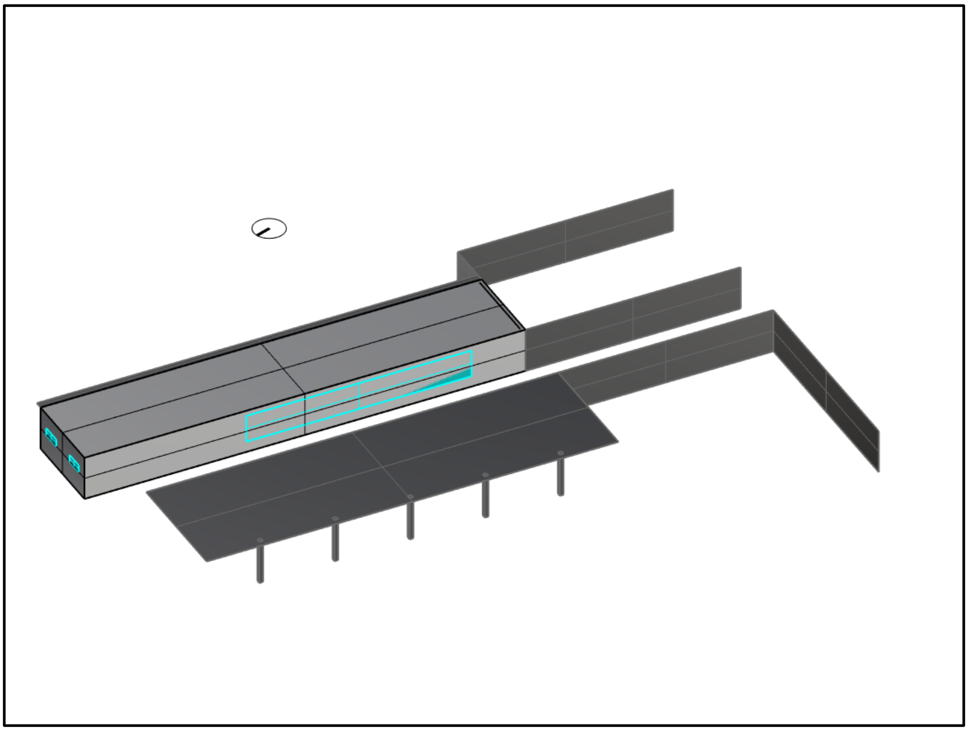
5.1 Base Case: geometry

Perspective



Perspective



Description:

The piece of the winery that is being simulated is the front bar on the ground floor of the winery which functions as a restaurant. The dimensions are 35.8m x 7.068m x 3.658m. The front south façade of the bar has long, almost top to bottom, spanning the front façade. The north of the building has a long window measuring 18.288m x 2.286m. To west lies the kitchen and the east side are two small windows bathroom windows measuring 1.477m x 0.610m. The depth of the south overhang is 0.610m.

The placement of these windows were decided for views. The goal of the south windows was to create visibility for the restaurant goers and the north windows were made large so that guests who were seated could peer out onto the crush pad. However, this construction leaves many thermal and daylighting problems.

5.2 Base Case: Material Properties

Window Properties

U-factor [W/m² .K]	SHGC	VT
2.720	0.764	0.812

Windows: Dbl Clr 3mm/13mm Air

Roof

	Material	Thickness [m]
Layer 1	Roof Membrane	0.0095
Layer 2	ASHRAE Roof Insulation	0.1500
Layer 3	ASHRAE: Metal Decking	0.0015

Walls

	Material	Thickness [m]
Layer 1	Heavyweight Concrete	1.0000
Layer 2	ASHRAE: Wall Insulation	0.1500
Layer 3	Plaster: Gypsum board	0.0127

Floors

	Material	Thickness [m]
Layer 1	ASHRAE: MAT-CC05 8 HW CONCRETE	0.2032
Layer 2	ASHRAE: Floor Insulation	0.1500
Layer 3	CONCRETE: Heavyweight Concrete	0.1000

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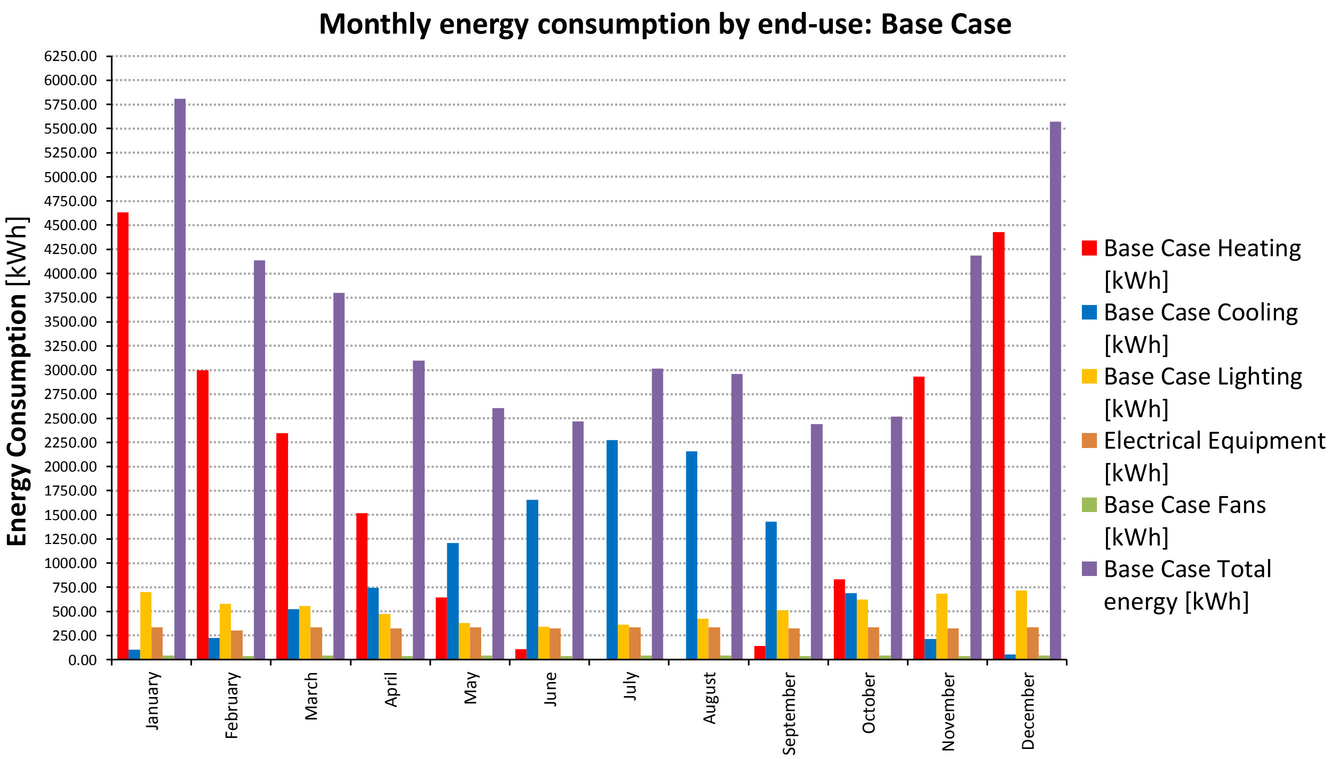
5.3 Base Case: energy performance



	Base Case					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	4630.57	103.48	701.97	333.17	40.53	5809.71
February	2996.46	222.21	578.51	300.93	36.61	4134.71
March	2346.55	524.09	555.11	333.17	40.53	3799.45
April	1515.14	743.50	474.13	322.42	39.22	3094.41
May	643.93	1210.56	378.69	333.17	40.53	2606.88
June	110.14	1652.98	340.73	322.42	39.22	2465.49
July	0.30	2274.85	364.63	333.17	40.53	3013.48
August	4.17	2155.19	425.71	333.17	40.53	2958.76
September	139.94	1427.63	509.52	322.42	39.22	2438.73
October	829.86	690.68	623.52	333.17	40.53	2517.75
November	2931.04	211.26	680.87	322.42	39.22	4184.81
December	4428.48	54.94	715.86	333.17	40.53	5572.98

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16	168.35

Zone - total Window Heat Gains	5.12e+4 kWh
Zone - total Window Heat Losses	1.70e+4 kWh

Analysis of Base Case

Taking a look at the monthly energy consumption chart for the base case, the majority of the energy consumption is for cooling and heating purposes. During the winter months, heating accounts for the most energy consumption. The months with the highest total energy consumption are in January and December and the high energy consumer is heating. From January until June there is a downward trend in the energy consumption as months get warmer. Total energy increases when months get warmer and cooling is needed. During July we have the highest amount of energy consumption for cooling and the lowest amount for heating, but the energy consumption to meet our cooling needs are lower than the maximum needs for heating. Since the windows are so large we lose a lot of the energy we need to heat the building. However, since the graph fluctuates, it shows we need a solution that can allow for us to keep in the heat during the winter and cool the building during the summer. Despite the building having a lot of glass, energy is still being used for lighting. Slightly more energy is used during the winter months for lighting.

6. Testing of Design Strategies

Final Project – (Climate Zone 5B) | Reference City: Logrono

6.1 Improving window construction assembly – climate consultant recommended strategy

Climate consultant recommended that we provide double pane high performance glazing (Low-E) on the North, West, and East windows and a clear glass in the South for maximum passive solar heat gain. To do this I will first test the base case with the North and East windows having the Low-E glass.

Window Properties for South Windows

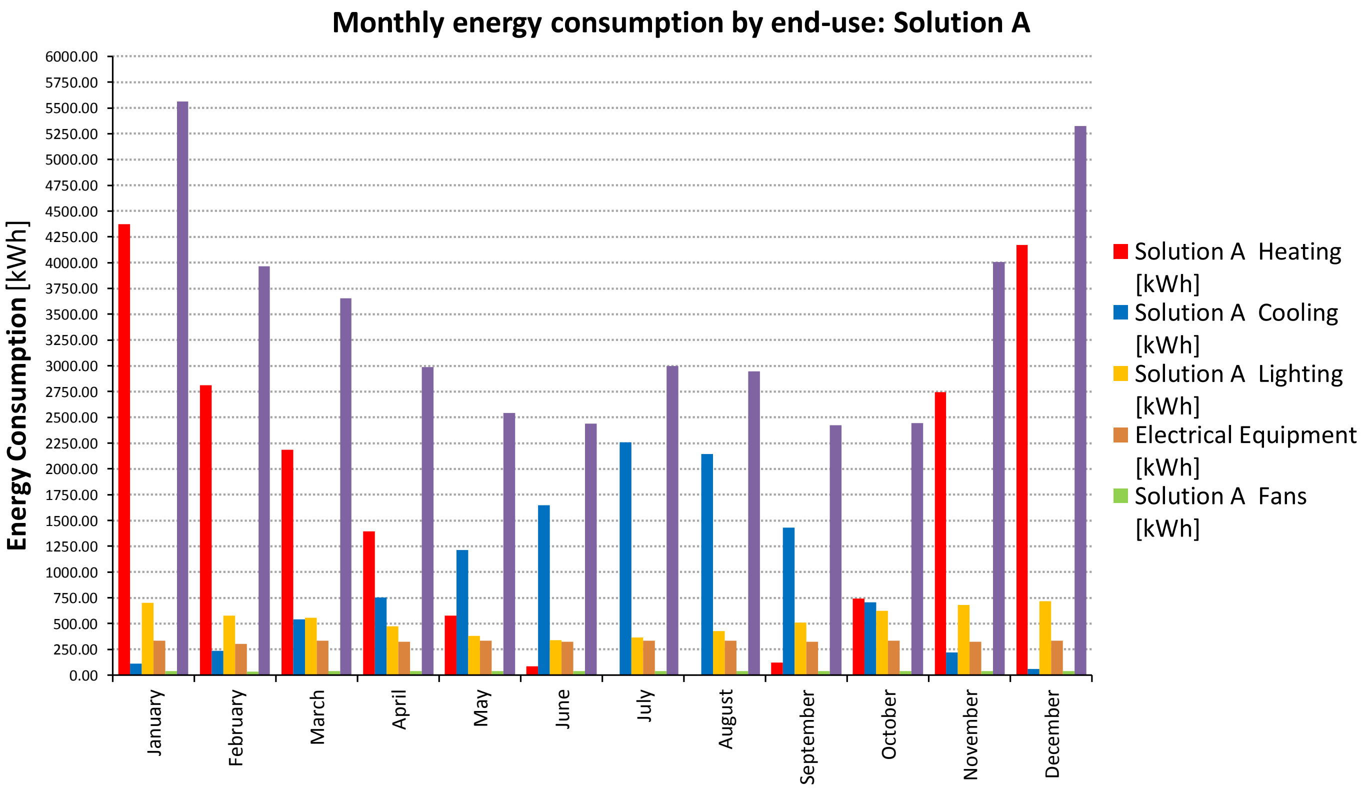
U-factor [W/m² .K]	SHGC	VT
2.720	0.764	0.812

Windows: Dbl Clr 3mm/13mm Air

Window Properties for North, East Windows

U-factor [W/m² .K]	SHGC	VT
2.285	.697	.771

Windows: Dbl LoE (e2 = .2) Clr 3mm/13mm Air



Final Project – (Climate Zone 5B) | Reference City: Logrono

	Solution A					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	4370.83	114.00	702.56	333.17	40.53	5561.08
February	2812.32	236.30	578.85	300.93	36.61	3964.99
March	2187.58	540.21	555.48	333.17	40.53	3656.97
April	1395.89	753.19	474.73	322.42	39.22	2985.44
May	576.12	1214.07	379.47	333.17	40.53	2543.35
June	87.02	1647.42	341.19	322.42	39.22	2437.27
July	0.01	2260.18	365.02	333.17	40.53	2998.90
August	1.77	2145.83	425.90	333.17	40.53	2947.20
September	120.64	1432.30	509.94	322.42	39.22	2424.52
October	743.28	705.77	624.07	333.17	40.53	2446.81
November	2742.67	221.76	681.32	322.42	39.22	4007.39
December	4173.13	61.92	716.40	333.17	40.53	5325.15

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution A	19211.24	11332.94	6354.93	3922.78	477.18	40821.89	163.22

Zone - total Window Heat Gains	5.12e+4 kWh
Zone - total Window Heat Losses	1.56e+4 kWh

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Using this design strategy we managed to improve energy consumption by 4.17%. This solution managed to cut down heating energy consumption by about 1300 kWh. The intent of this strategy was to maximize passive solar heat gain.

6.2 Improving window construction assembly – Facade Design Tool on South Windows

Facade Design Tool Analysis – south windows

The Building		Glazing System						Light & Shade		Performance					
WWR	Building Projections	Glass	Panes	Features	U-factor	SHGC	VT	Lighting Controls	Shades	Energy	Peak	Carbon	Daylight	Glare	Comfort
60	None	J	3	Low-E, low VT, low SHGC, argon	0.12	0.21	0.34	None	None						
60	None	F	2	Low-E, low VT, low SHGC, argon	0.25	0.24	0.37	None	None						
60	None	D	2	Reflective, low VT, low SHGC	0.44	0.18	0.1	None	None						
60	None	H	2	Lowe-E, high VT, low SHGC, argon	0.24	0.27	0.64	None	None						
60	None	E	2	Low-E tint, moderate VT, moderate SHGC, argon	0.24	0.29	0.52	None	None						
60	None	I	3	Low-E, high VT, moderate SHGC, argon	0.13	0.32	0.6	None	None						
60	None	G	2	Low-E, high VT, moderate SHGC, argon	0.24	0.38	0.7	None	None						
60	None	C	2	Tint, moderate VT, moderate SHGC	0.47	0.5	0.48	None	None						
60	None	L	2	Clear, applied film	0.47	0.55	0.54	None	None						
60	None	K	1	Clear, applied film	0.99	0.48	0.6	None	None						
60	None	B	2	Clear, high VT, high SHGC	0.47	0.7	0.79	None	None						
60	None	A	1	Clear, high VT, high SHGC	1.03	0.82	0.88	None	None						
										worst				best	

The second test tests the impact of improving the south windows. Using the facade tool to pick an improved glass for the south facade glass F was chosen.Facade design tool marked this glass as one of the best performers for energy. A low U-factor to reduce heat loss in the winter was important and this glass had a U-factor of .25. We also wanted a glass with a lower SHGC because the less solar heat it transmits the greater its shading ability, especially since this is a south window. During the summer, it would reduce cooling loads. This configuration is not the best for comfort though it is still good. A higher SHGC would be more effective for collecting solar heat during the winter.

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Window Properties for South Windows

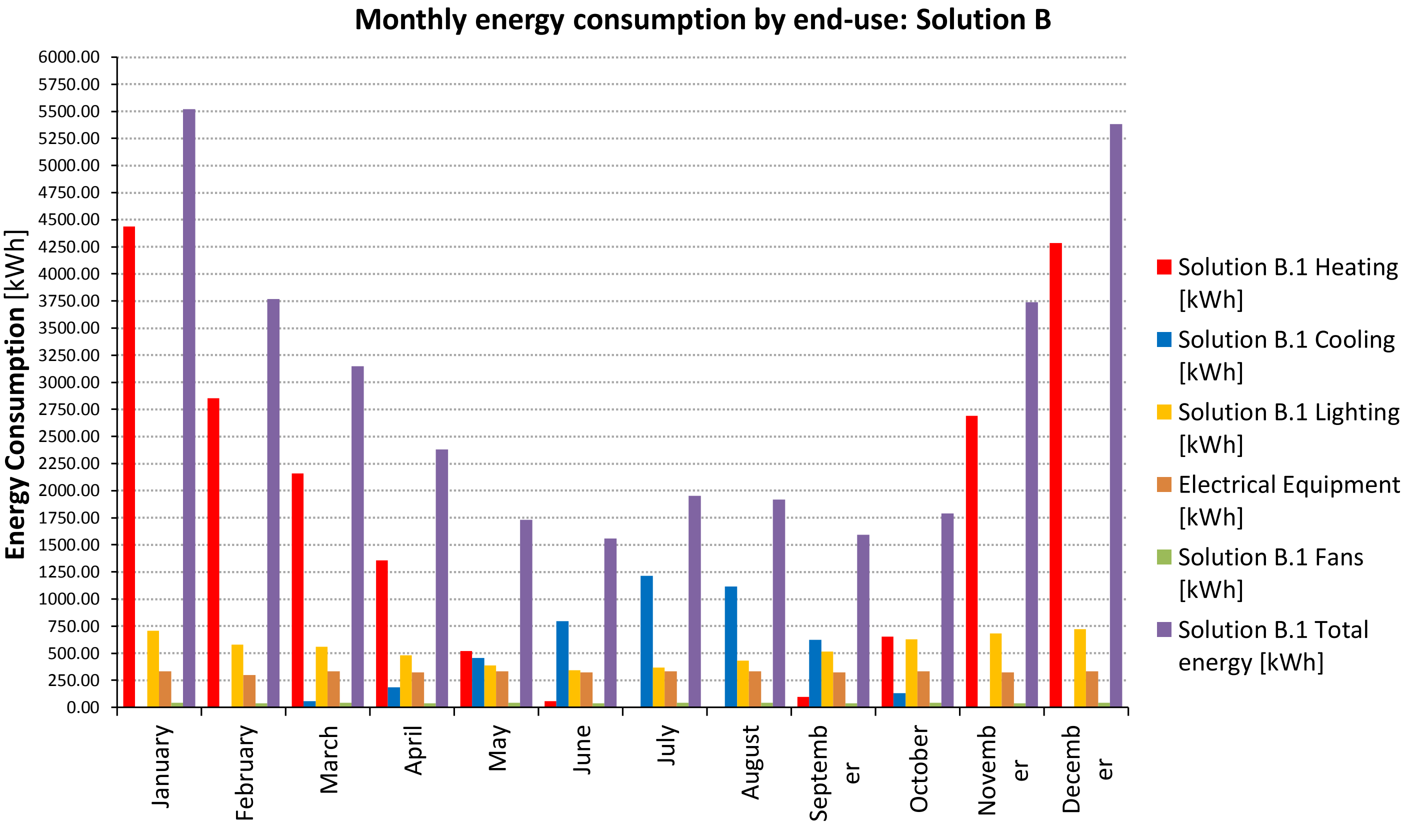
U-factor [W/m² .K]	SHGC	VT
0.250	0.240	0.370

Windows: Glass F

Window Properties for North, East Windows

U-factor [W/m² .K]	SHGC	VT
2.285	.697	.771

Windows: Dbl LoE (e2 = .2) Clr 3mm/13mm Air



Final Project – (Climate Zone 5B) | Reference City: Logrono

	Solution B.1					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	4439.81	0.00	706.04	333.17	40.53	5519.55
February	2850.99	0.42	581.12	300.93	36.61	3770.07
March	2159.71	56.94	559.26	333.17	40.53	3149.61
April	1356.45	183.94	478.88	322.42	39.22	2380.91
May	518.66	455.87	384.95	333.17	40.53	1733.18
June	57.82	794.79	344.73	322.42	39.22	1558.98
July	0.00	1212.17	368.63	333.17	40.53	1954.49
August	0.06	1114.64	429.41	333.17	40.53	1917.81
September	94.57	625.03	513.53	322.42	39.22	1594.77
October	653.10	132.48	628.31	333.17	40.53	1787.58
November	2688.36	5.78	684.38	322.42	39.22	3740.17
December	4286.93	0.00	719.78	333.17	40.53	5380.40

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution B	19106.45	4582.07	6399.03	3922.78	477.18	34487.51	136.3

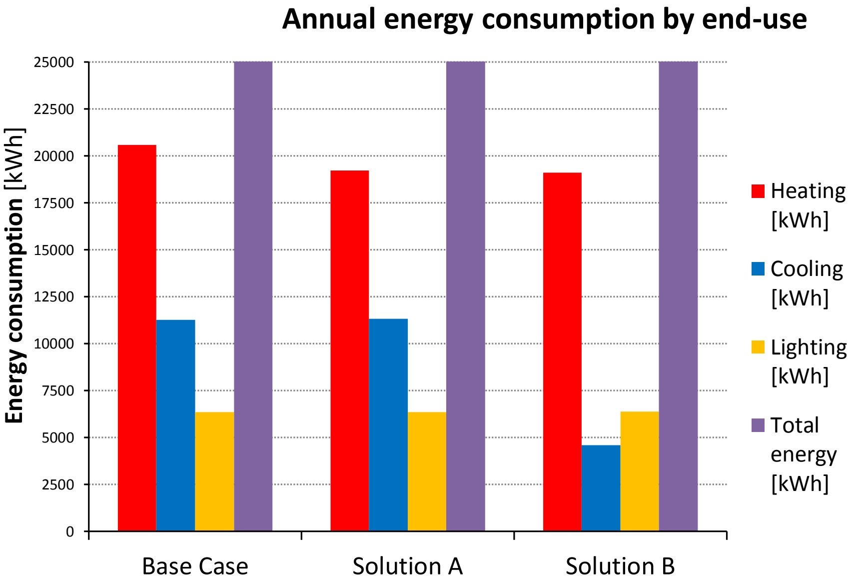
Zone - total Window Heat Gains 2.36e+4 kWh

Zone - total Window Heat Losses 1.21e+4 kWh

Using this strategy, we managed to cut down cooling consumption by almost half. This is very effective for summer months when the majority of the energy consumption is for cooling. There is almost no heating consumption during the summer months. Total energy consumption is also halfed. September has the lowest energy consumption at 1594.77 kWh.

Another thing to notice is that July is the month with 0 heating energy consumption but it is the month with the highest cooloing consumption. Nevertheless, it is still one of the months with the lowest total energy consumption. On the other hand, January and December have 0 cooling consumption,but the the highest amount of heating consumption. The total energy consumption is still very high because the less energy we use on cooling was not enough to balance the heating energy consumption. One thing to note is that the Glass F windows had almost no effect on heating consumption which was to be expected since Glass F's features are more useful for Summer shading. However, as this is a restaurant for a vineyard, the peak season when there would be the most guests would be the summer; therefore focusing on Summer months when it would be more inhabited is a good strategy.

6.3 Comparative Analysis of Base Case, Solution A and Solution B



Energy Improvement (%)

	Total Energy [kWh]	% Improvement compared with base-case
Base Case	42597.16	N.A.
Solution A	40821.89	4.17
Solution B	34487.51	19.04

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution A (Dbl LoE on North and East)	19211.24	11332.94	6354.93	3922.78	477.18	40821.89
Solution B (improved South window, Dbl LoE on North and East)	19106.45	4582.07	6399.03	3922.78	477.18	34487.51

The improved south windows improved the energy consumption by 19.04%. By using Glass F, we managed to reduce cooling needs by almost half.

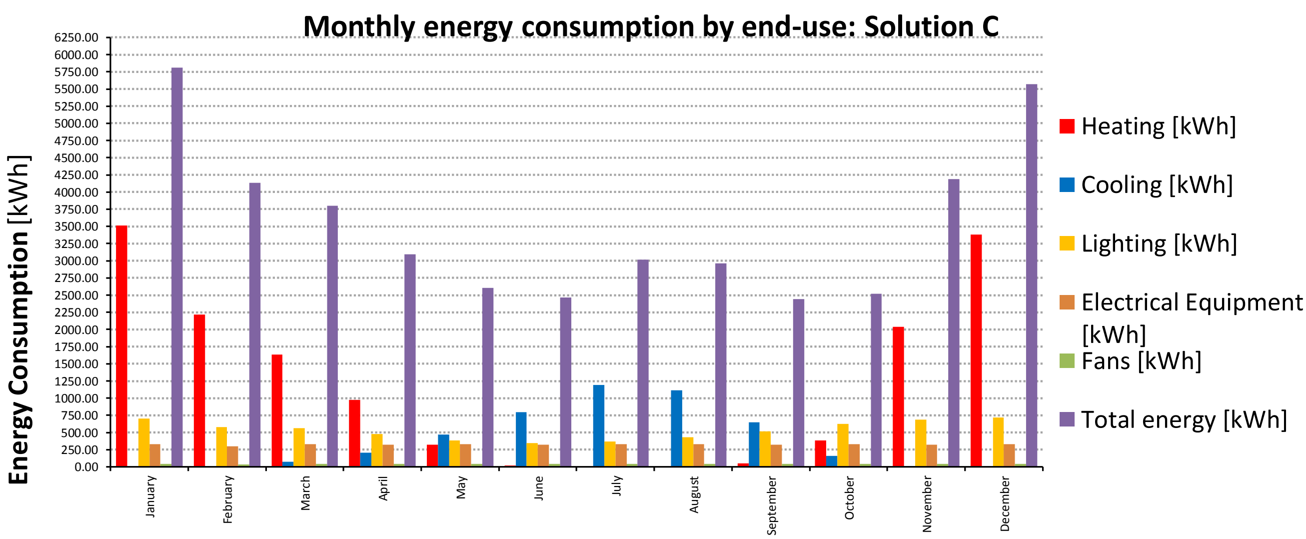
Final Project – (Climate Zone 5B) | Reference City: Logrono

6.4 Testing Extreme Insulation

Insulation Thickness Comparison

	Floor [cm]	Walls [cm]	Roofs [cm]
Base-case	Adiabatic	15	15
Solution C (improved windows + extreme insulation)	Adiabatic	60	60

	Solution C					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	3513.29	0.00	706.04	333.17	40.53	4593.02
February	2214.17	2.65	581.12	300.93	36.61	3135.48
March	1635.30	75.61	559.26	333.17	40.53	2643.87
April	971.33	206.26	478.88	322.42	39.22	2018.12
May	322.74	473.51	384.95	333.17	40.53	1554.90
June	17.47	799.27	344.73	322.42	39.22	1523.11
July	0.00	1191.15	368.63	333.17	40.53	1933.47
August	0.00	1112.23	429.41	333.17	40.53	1915.34
September	51.70	645.36	513.53	322.42	39.22	1572.22
October	387.92	161.59	628.31	333.17	40.53	1551.51
November	2036.96	11.38	684.38	322.42	39.22	3094.37
December	3379.97	0.00	719.78	333.17	40.53	4473.44



	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution C	14530.85	4679	6399.03	3922.78	477.18	30008.84	118.6

Final Project – (Climate Zone 5B) | Reference City: Logrono

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution A (Dbl LoE on North and East)	19211.24	11332.94	6354.93	3922.78	477.18	40821.89
Solution B (improved South window, Dbl LoE on North and East)	19106.45	4582.07	6399.03	3922.78	477.18	34487.51
Solution C (improved South window, Dbl LoE on North and East, extreme insulation)	14530.85	4679.00	6399.03	3922.78	477.18	30008.84

Based off of this test we saw an improvement in total energy. With the extreme insulation we are able to lower the heating consumption. Total cooling consumption has increased by about 100 kWh, but heating has dropped significantly and has improved 24% from Solution B. Thermal mass is a good design strategy to address the heating issues.

Energy Improvement (%)

	Total Energy [kWh]	% Improvement compared with base-case
Base Case	42597.16	N.A.
Solution A	40821.89	4.17
Solution B	34487.51	19.04
Solution C	30008.84	26.49

6.5 Searching for Feasible Thicknesses

We will now test to find the best feasible solutions for insulation thickness for the roof and for the walls.

Roof Thickness (cm)	EUI (kWh/m²)	Change in EUI from Previous
15	136.3	N.A.
20	130.84	5.46
25	128.37	2.47
30	127.13	1.24
35	126.27	0.86
40	125.61	0.66
45	124.97	0.64
50	124.34	0.63
55	123.78	0.56
60	123.42	0.36

Walls Thickness (cm)	EUI (kWh/m²)	Change in EUI from Previous
15	136.3	N.A.
20	134.89	1.41
25	133.95	0.94
30	133.27	0.68
35	132.79	0.48
40	132.41	0.38
45	132.09	0.32
50	131.83	0.26
55	131.62	0.21
60	131.49	0.13

After these selected thicknesses, the change in EUI is not as significant. Floor is adiabatic.

Final Project – (Climate Zone 5B) | Reference City: Logrono

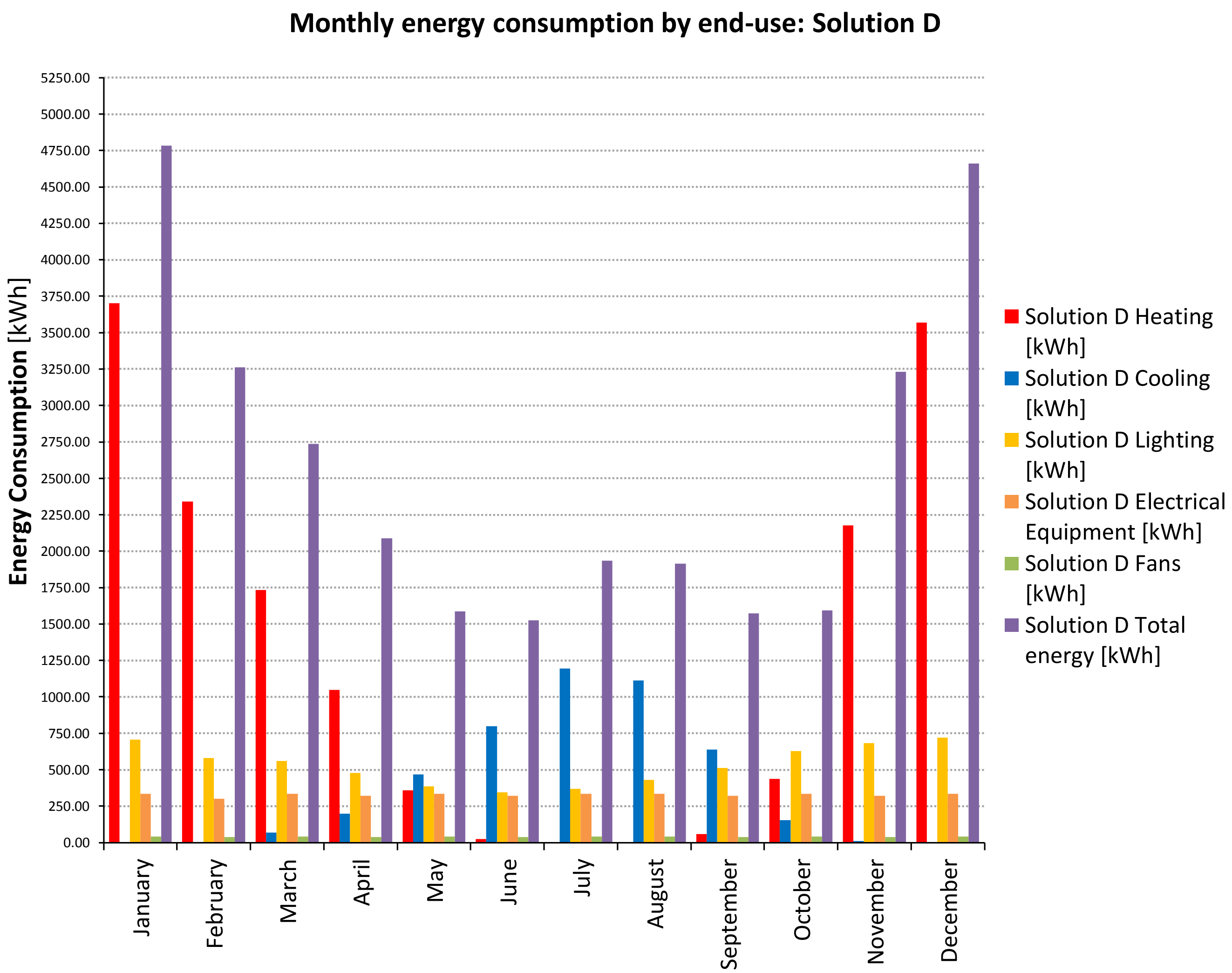
6.6 Testing more Feasible Thicknesses

Insulation Thickness Comparison

	Floor [cm]	Walls [cm]	Roofs [cm]
Base-case	Adiabatic	15	15
Solution D (improved windows + feasible insulation)	Adiabatic	35	40

	Solution D					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	3702.49	0.00	706.04	333.17	40.53	4782.23
February	2340.28	1.50	581.12	300.93	36.61	3260.44
March	1733.93	69.64	559.26	333.17	40.53	2736.53
April	1047.96	199.29	478.88	322.42	39.22	2087.77
May	359.87	468.19	384.95	333.17	40.53	1586.71
June	22.95	797.58	344.73	322.42	39.22	1526.90
July	0.00	1193.93	368.63	333.17	40.53	1936.25
August	0.00	1112.14	429.41	333.17	40.53	1915.25
September	59.45	639.37	513.53	322.42	39.22	1573.99
October	437.95	153.81	628.31	333.17	40.53	1593.76
November	2176.13	9.47	684.38	322.42	39.22	3231.62
December	3567.59	0.00	719.78	333.17	40.53	4661.06

Final Project – (Climate Zone 5B) | Reference City: Logrono



Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution D	15448.59	4644.91	6399.03	3922.78	477.18	30892.49	122.09

Final Project – (Climate Zone 5B) | Reference City: Logrono

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution A (Dbl LoE on North and East)	19211.24	11332.94	6354.93	3922.78	477.18	40821.89
Solution B (improved South window, Dbl LoE on North and East)	19106.45	4582.07	6399.03	3922.78	477.18	34487.51
Solution C (improved South window, Dbl LoE on North and East, extreme insulation)	14530.85	4679	6399.03	3922.78	477.18	30008.84
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	15448.59	4644.91	6399.03	3922.78	477.18	30892.49

Energy Improvement (%)

	Total Energy [kWh]	% Improvement compared with base-case
Base Case	42597.16	N.A.
Solution A	40821.89	4.17
Solution B	34487.51	19.04
Solution C	30008.84	29.55
Solution D	30892.49	27.48

We have improved our energy consumption by almost 30%! Insulation is important in our climate because it helps keep in our solar gains during the winter but it can also help keep out some of the excess heat we do not want.

6.7 Testing South Shade Depth

Overhang Depth [m]	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m^2]
0	15420.04	4781.08	6398.84	3922.78	477.18	30999.92	122.52
0.6	15446.53	4650.6	6399.03	3922.78	477.18	30896.11	122.11
1	15495.48	4435.18	6399.34	3922.78	477.18	30729.96	121.45
1.4	15583.56	4191.53	6399.65	3922.78	477.18	30574.69	120.84

Base case overhang is 0.610 m.

EUI decrease the longer the shade is, but the amount is not that much. Especially since glass can conduct a lot of heat during the summer, shades are important to block these excessive solar gains.

6.8 Testing Infiltration

Infiltration [ACH]	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m^2]
1 (leaky)	25732.3	4059.06	6399.03	3922.78	477.18	40590.35	160.42
0.25 (tight)	10705.52	5073.38	6399.03	3922.78	477.18	26577.89	105.04

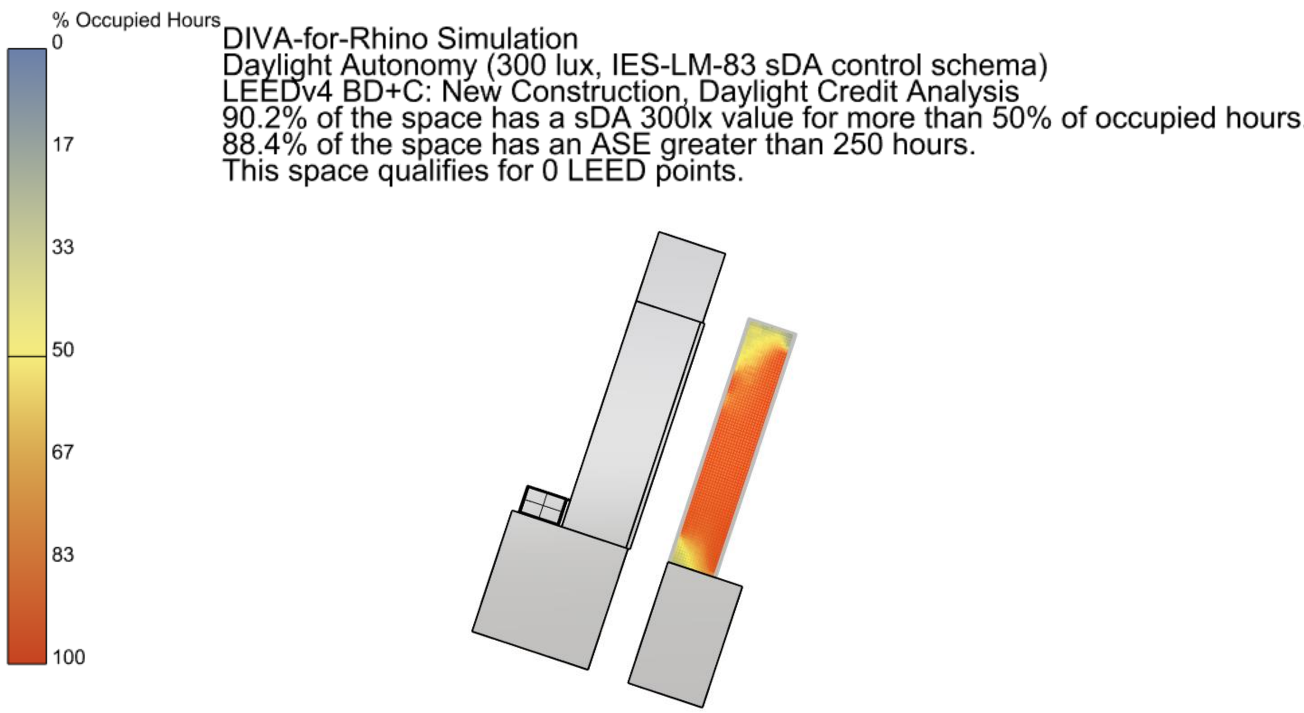
As expected, tighter construction reduces the total energy consumption while a leaky infiltration increases consumption. Tighter allows us to keep our solar heat gains which reduces the heating consumption, but one thing to know is that in a tighter construction the cooling consumption is increased because we are keeping our solar heat gains in. However, our biggest problem is heating and cooling we can control though glazing and shades. Our base case infiltration is 0.5 ACH.

7. Daylighting Tests

7.1 Base Case – Daylight Autonomy

Assigned Materials (same for all daylight simulations unless noted)

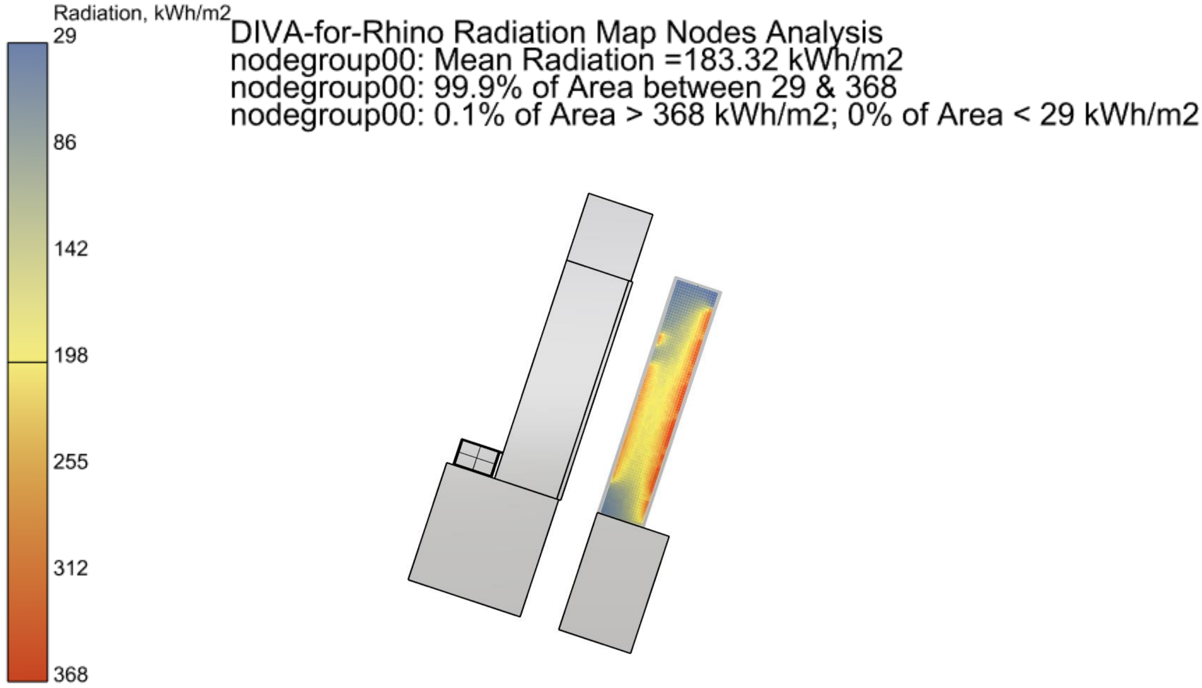
Adiabatic: GenericInteriorWall_50PercentReflectance
Glass north, east: DoublePane_Low_e
Glass South: DoublePane_Clear_64
Mullion: Matte_Silver
Roof: GenericCeiling_80PercentReflectance
Walls: Concrete_40PercentReflectance
Ground: GenericFloor_20PercentReflectance
Shading: GenericInteriorWall_65PercentReflectance



As this place is a restaurant, it is important that it is day lit. This room is basically a glass box with large top-to-bottom windows facing southeast and a large long window on the other end. The areas where we see blue are at the top northern corner where we have two small windows. Since that area is for restrooms, less light is needed. Overall, receiving light does not seem to be a problem for this space. The problem with this space is that it receives too much direct daylight which is why it fails the LEED credit. Because the windows are all around there is too much direct daylight exposure. This can be minimized through curtains, blinds, or other shading devices.

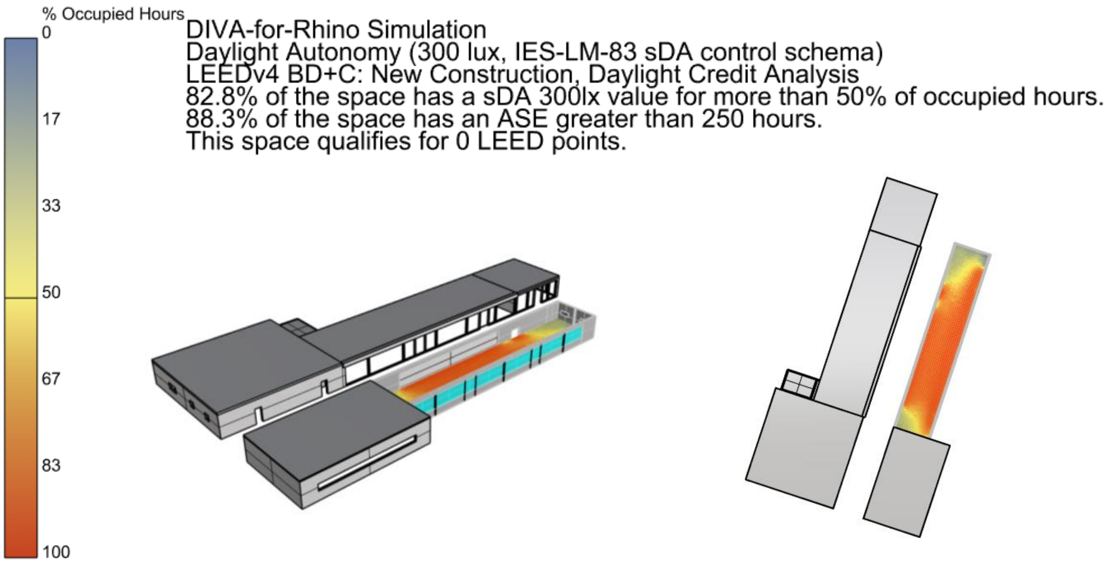
Final Project – Reference City: Logrono

7.2 Base Case – Radiation Map



From this radiation map we can see that the high radiation areas are where there are openings. Both the northwest and southwest facades have large window spaces. Also to note are the small windows in the north east that do not have a big effect on the radiation. A possible solution maybe be to raise the height of the windows and maintain the length.

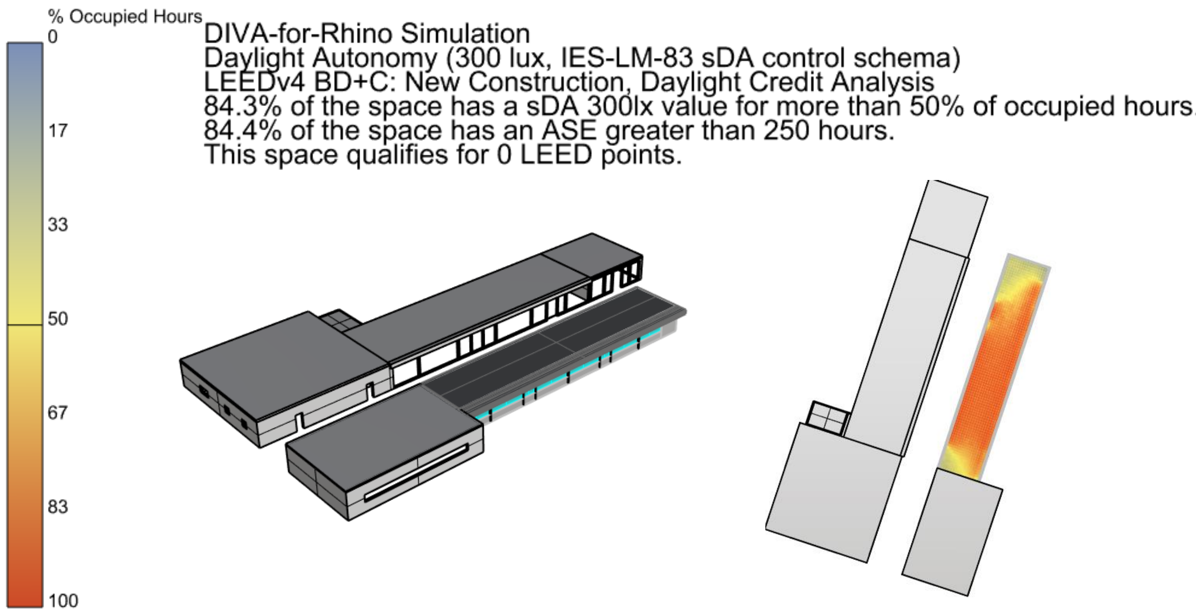
7.3 2m in Length South Windows – Daylight Autonomy



The length of all front windows are 2m. The base case's window to wall ratio for the South façade was 80%. For this configuration, the window to wall ratio for the south façade is 60%. However, the new configuration did not have much of an effect on the ASE and it decreased the percent of space with an sDA 300lx. Therefore I feel that the best solution to tackling this area without changing the design too much is by adding curtains or blinds. During the summer when there is too much direct daylight, blinds or a curtain can filter the daylight. It will also reduce solar heat gain and in turn decrease cooling consumption.

Final Project – Reference City: Logrono

7.3 1.4m Long Overhang – Daylight Autonomy



1.4m depth overhangs have improved the ASE a small amount from the base case and was more effective than making the south windows a little smaller. However is was not effective enough because the space does not qualify for LEED points. To quality for LEED points, other than external shading devices, another look at windows' optical properties would probably be a better factor for improving ASE.

8. Reevaluated Design Tests

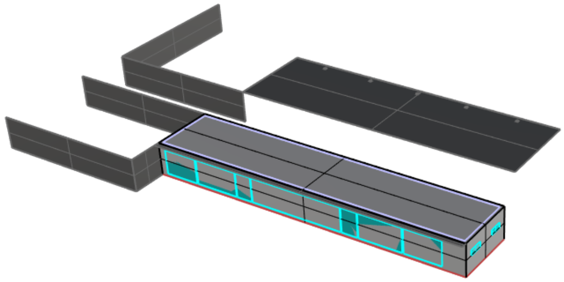
Final Project – (Climate Zone 5B) | Reference City: Logrono

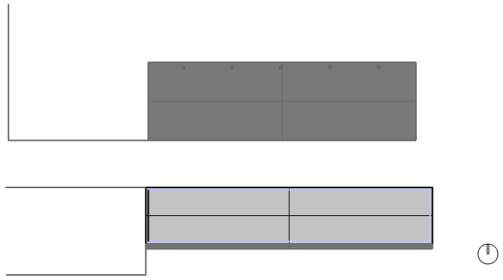
7.1 Outline of Strategy

The initial tests have demonstrated some of the issues of glass box architecture. The energy consumption is still high despite the improvements. Our Solution D case's EUI is 122.09 kWh/m2 which is still high. The problem is that solutions have not been tackling heating which is the main energy consumer even though cooling consumption has been reduced by almost half. In addition, ASE is too high. In order to address these problems, the following tests will be run in this section.

- Orientation
    - Reorienting building so that south west façade faces completely south
- Testing lower U-Value performances for windows
- Testing different sizes of windows for south façade.

7.2 Orientation



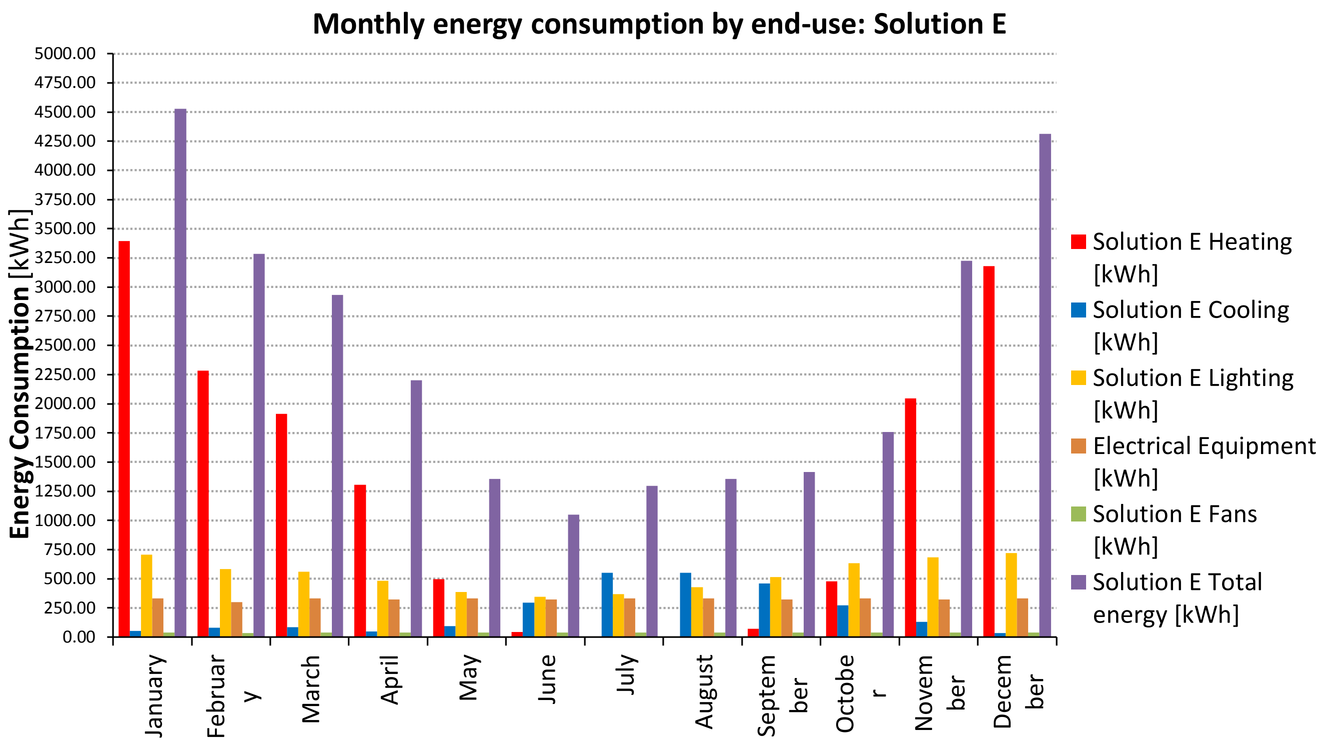


In this test the entire geometry of the building was rotated so that the southeast windows now directly face south. The material configurations are the same as in Solution D. The infiltration rate for this Solution is .25 ACH.

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution E	10498.92	3069.18	6349.26	3922.78	477.18	24395.63	96.42

Final Project – Reference City: Logrono

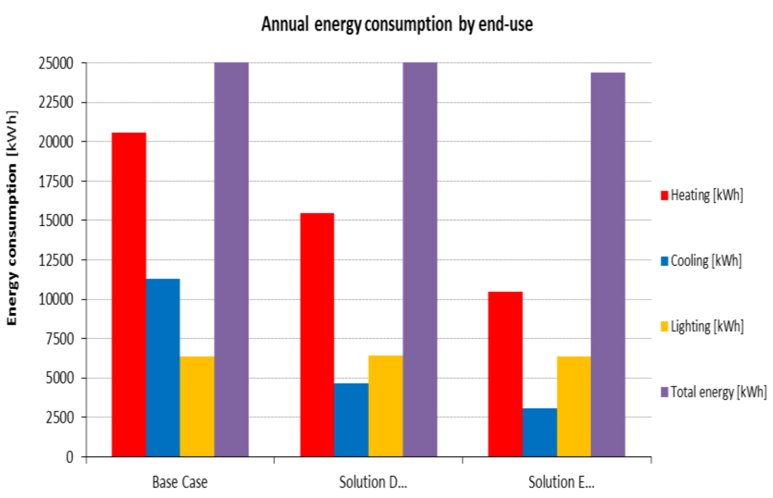


	Solution E					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	2490.50	85.80	707.17	333.17	40.53	3657.16
February	1616.88	118.83	583.16	300.93	36.61	2656.40
March	1306.19	122.90	562.61	333.17	40.53	2365.39
April	833.72	78.64	483.86	322.42	39.22	1757.86
May	256.80	132.09	387.79	333.17	40.53	1150.39
June	7.48	336.87	347.48	322.42	39.22	1053.46
July	0.00	572.43	369.93	333.17	40.53	1316.06
August	0.00	577.66	430.20	333.17	40.53	1381.55
September	32.08	499.90	516.82	322.42	39.22	1410.45
October	226.79	318.72	631.57	333.17	40.53	1550.77
November	1414.34	162.99	685.14	322.42	39.22	2624.11
December	2314.14	62.34	721.85	333.17	40.53	3472.02

7.3 Comparative Analysis of Base Case, Solution D and Solution E

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	15448.59	4644.91	6399.03	3922.78	477.18	30892.49
Solution E (Solution D Orientated South)	10498.92	3069.18	6349.26	3922.78	477.18	24395.63

	Total Energy [kWh]	% Improvement compared with base-case
Base Case	42597.16	N.A.
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	30892.49	27.48
Solution E (Solution D Orientated South, .25 ACH)	24395.63	42.73

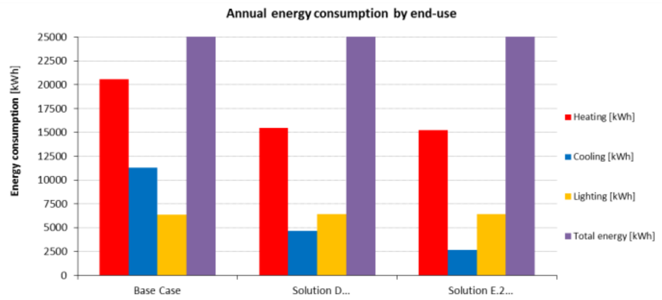


Changing the orientation of the building has improved the energy consumption of the space. One of the biggest issues was heating and having the south east windows face directly south now allows for the windows have better solar heat gain. The previous orientation mirrored the terrace it sat on; however there is a lot of space on the site so it is free to be oriented in any direction. In addition to heating, it has also lowered some of the cooling consumption. However, another thing to note about this solution is that this building has a tight construction. This has significantly improved the performance of this building.

Final Project – Reference City: Logrono

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	15448.59	4644.91	6399.03	3922.78	477.18	30892.49
Solution E.2 (Orientated South, .5 ACH)	15222.78	2665.93	6427.58	3922.78	477.18	28716.24

Base Case	42597.16	N.A.
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	30892.49	27.48
Solution E.2 (Orientated South, .5 ACH)	28716.24	32.59



From these charts with Solution E.2 with a .5 ACH infiltration, the heating reduction is actually very low. Cooling has improved quite a bit though. A tight building is better in our case because it keeps in our solar gains we need for heating.

7.4 U-value Test

This test will test the effect of changing the current south facing windows' U-factor. Space is oriented as it is in Solution D and infiltration is .25 ACH.

Window Properties for South Windows

U-factor [W/m² .K]	SHGC	VT
0.250	0.240	0.370

North and East Windows will have the Same Dbl LoE properties as in previous tests

Final Project – Reference City: Logrono

U-Value	EUI (kWh/m²)	Change in EUI from Previous	Heating Energy Consumption
0.3	100.16	N.A.	11576.45
0.25	96.42	3.74	10498.92
0.2	92.66	3.76	9378.39
0.15	88.9	3.76	8227.58
0.1	85.19	3.71	7058.61
0.05	81.59	3.6	5876.29
0	80.71	0.88	8257.66

This tests the effectiveness of changing the current south facing windows' U-factor. Space is oriented as it is in Solution D and infiltration is .25 ACH.

This test proved that the U-value is important for reducing heating consumption. I will now revisit the Façade Design Tool Analysis tool and try the glass that has the lowest U-factor. In this case is Glass J.

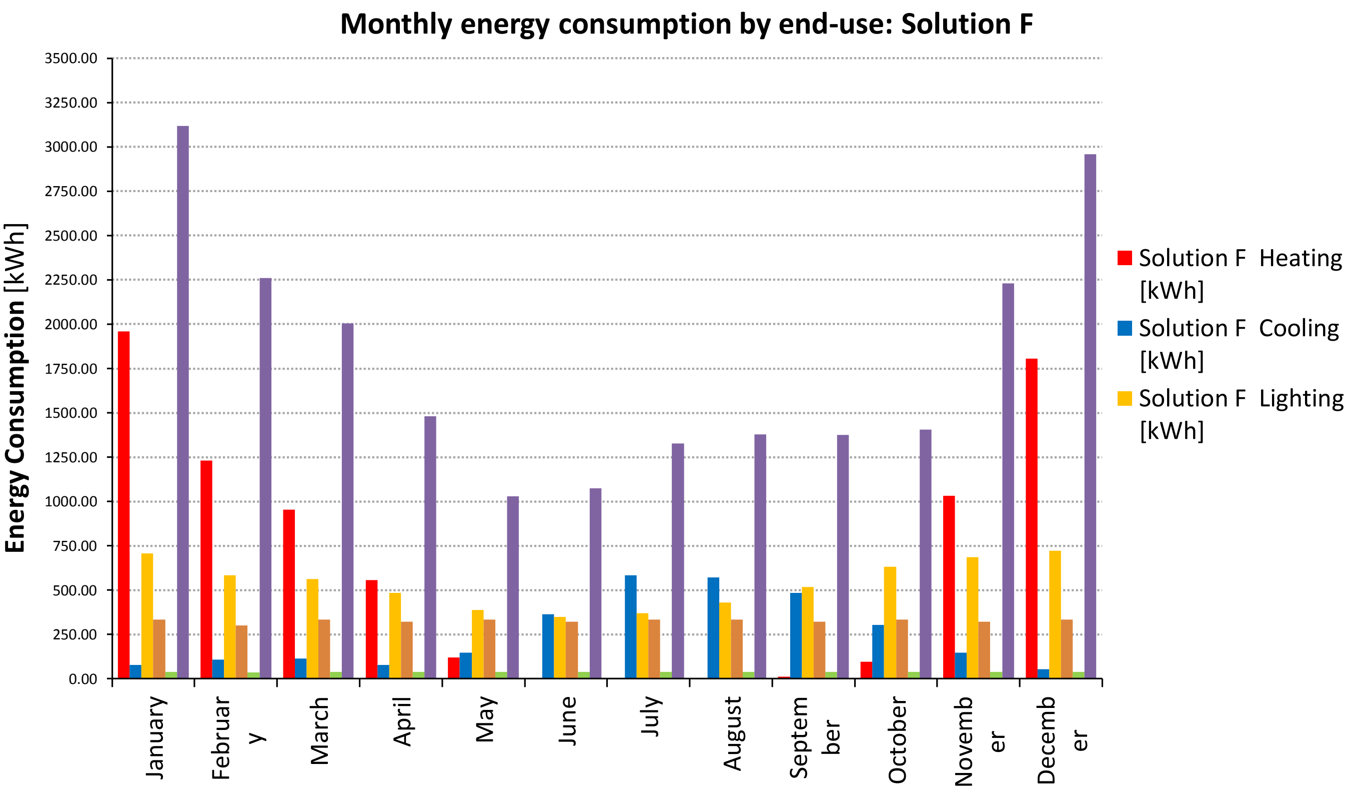
The current glass' properties (SHGC 0.240, VT .340) with a U-value of .12's EUI is 86.66, heating is 7527.46 kWh.

Revisiting Facade Design Tool Analysis – south windows

The Building		Glazing System						Light & Shade		Performance					
WWR	Building Projections	Glass	Panes	Features	U-factor	SHGC	VT	Lighting Controls	Shades	Energy	Peak	Carbon	Daylight	Glare	Comfort
60	None	J	3	Low-E, low VT, low SHGC, argon	0.12	0.21	0.34	None	None						
60	None	F	2	Low-E, low VT, low SHGC, argon	0.25	0.24	0.37	None	None						
60	None	D	2	Reflective, low VT, low SHGC	0.44	0.18	0.1	None	None						
60	None	H	2	Lowe-E, high VT, low SHGC, argon	0.24	0.27	0.64	None	None						
60	None	E	2	Low-E tint, moderate VT, moderate SHGC, argon	0.24	0.29	0.52	None	None						
60	None	I	3	Low-E, high VT, moderate SHGC, argon	0.13	0.32	0.6	None	None						
60	None	G	2	Low-E, high VT, moderate SHGC, argon	0.24	0.38	0.7	None	None						
60	None	C	2	Tint, moderate VT, moderate SHGC	0.47	0.5	0.48	None	None						
60	None	L	2	Clear, applied film	0.47	0.55	0.54	None	None						
60	None	K	1	Clear, applied film	0.99	0.48	0.6	None	None						
60	None	B	2	Clear, high VT, high SHGC	0.47	0.7	0.79	None	None						
60	None	A	1	Clear, high VT, high SHGC	1.03	0.82	0.88	None	None						

worst best

Final Project – Reference City: Logrono



	Solution F					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	1958.29	76.96	707.67	333.17	40.53	3116.61
February	1231.52	107.17	583.59	300.93	36.61	2259.81
March	953.50	115.07	563.21	333.17	40.53	2005.48
April	557.23	78.79	484.42	322.42	39.22	1482.07
May	120.14	147.25	388.37	333.17	40.53	1029.46
June	0.05	363.85	347.81	322.42	39.22	1073.35
July	0.00	582.59	370.25	333.17	40.53	1326.54
August	0.00	572.86	430.56	333.17	40.53	1377.11
September	10.64	485.51	517.24	322.42	39.22	1375.03
October	96.58	303.48	632.08	333.17	40.53	1405.84
November	1033.62	148.22	685.59	322.42	39.22	2229.07
December	1805.42	55.63	722.44	333.17	40.53	2957.19

Final Project – Reference City: Logrono

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution F	7767.00	3037.40	6433.22	3922.78	477.18	21637.57	85.51

7.5 Comparative Analysis of Base Case, Solution D, Solution E, and Solution F

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	15448.59	4644.91	6399.03	3922.78	477.18	30892.49
Solution E (Orientated South, .25 ACH)	10498.92	3069.18	6349.26	3922.78	477.18	24395.63
Solution F (Solution E with lower U-value South Windows)	7767.00	3037.40	6433.22	3922.78	477.18	21637.57

	Total Energy [kWh]	% Improvement compared with base-case
Base Case	42597.16	N.A.
Solution D (improved South window, Dbl LoE on North and East, feasible insulation)	30892.49	27.48
Solution E (Orientated South, .25 ACH)	24395.63	42.73
Solution F (Solution E with lower U-value South Windows)	30008.84	49.20

These improved windows with a lower U-value have decreased the heating consumption by 71%. The lower U-value indicates that the window has a greater resistance to heat flow and that it has better insulating properties which is important for retaining heat. Now that the windows face south we can receive solar gains and glass with a better U-value helps us retain the heat gains.

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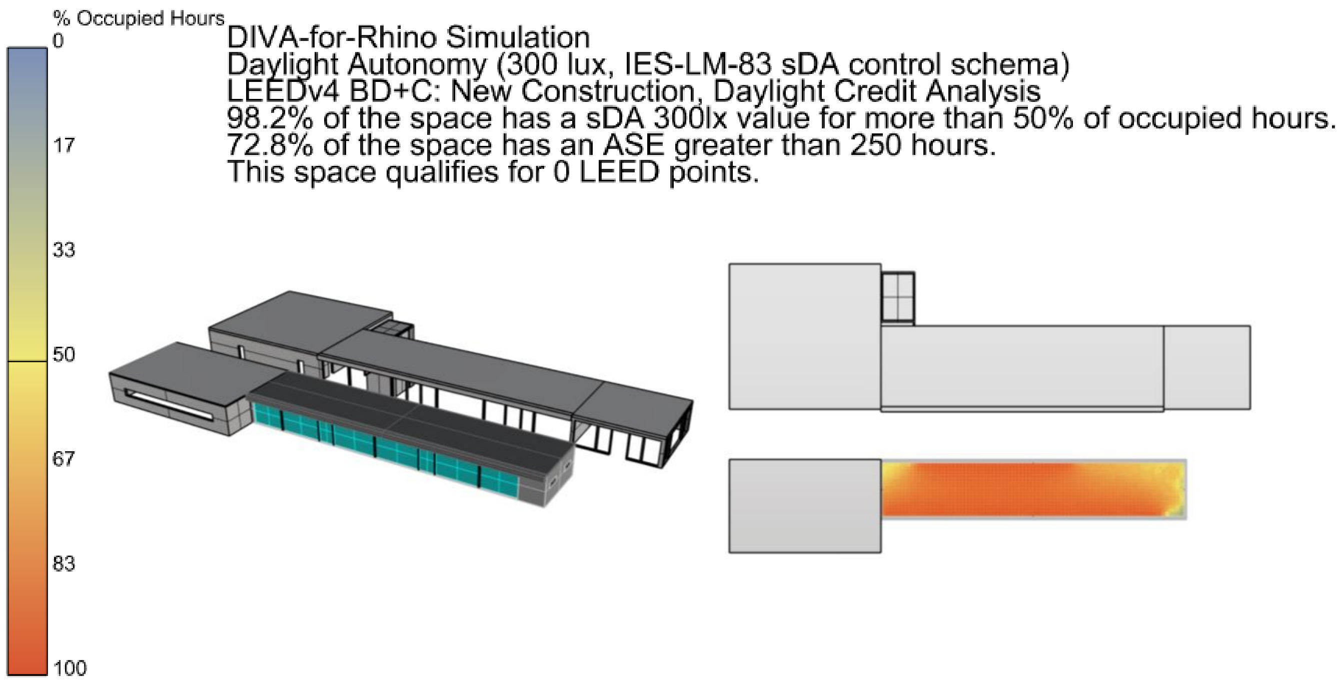
7.6 Daylighting Tests - Adjusted Windows

The reevaluated thermal tests have decreased our energy consumption and have found some solutions to decreasing the heating consumption our initial tests failed to address. However, there is still the issue of having too much light in this space. For these daylight tests we will first test the base case with the front windows oriented south and then we will test the model with adjusted south windows. The current window to wall ratio is 80%. We will have to concurrent tests of the window to wall ratio at 40% and at 20%.

Measurements to Test

Window to Wall					
Case	Wall Area	Window Area	Window to Wall	Area of %	Length of South Window
	[m2]	[m2]	[%]	[%]	[m]
Base	130.96	105.32	80	78.576	2.286
Case A	130.96	52.384	40	52.384	1.475
Case B	130.96	26.192	20	26.193	0.737

Base Case



As expected we see that receiving daylight is no problem, but there is too much light

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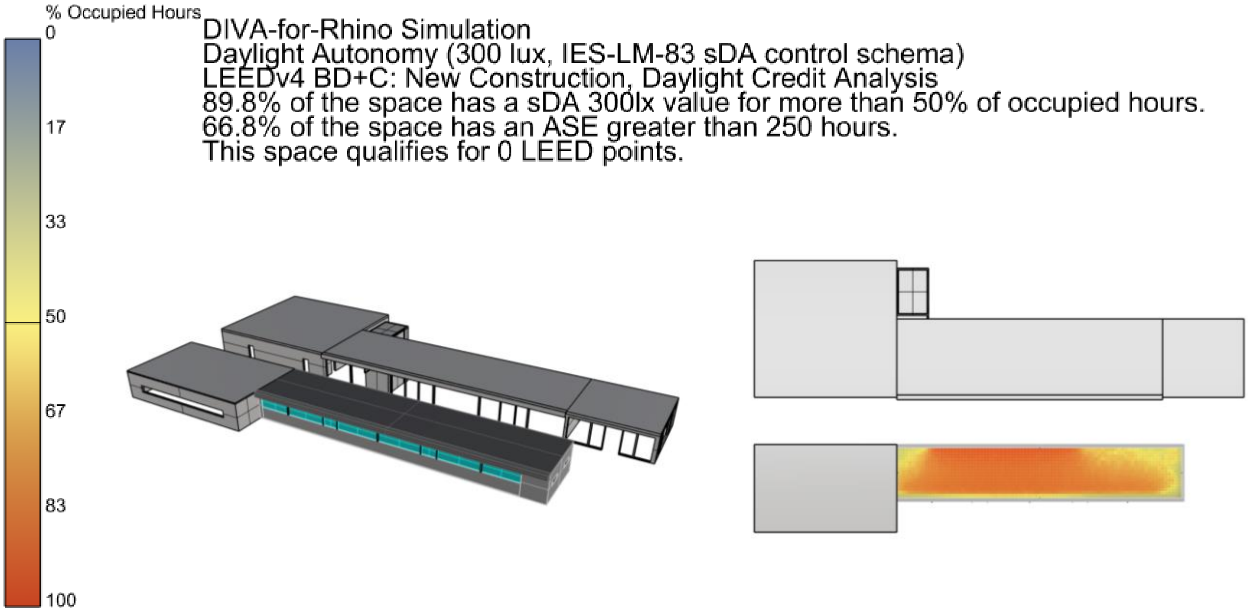
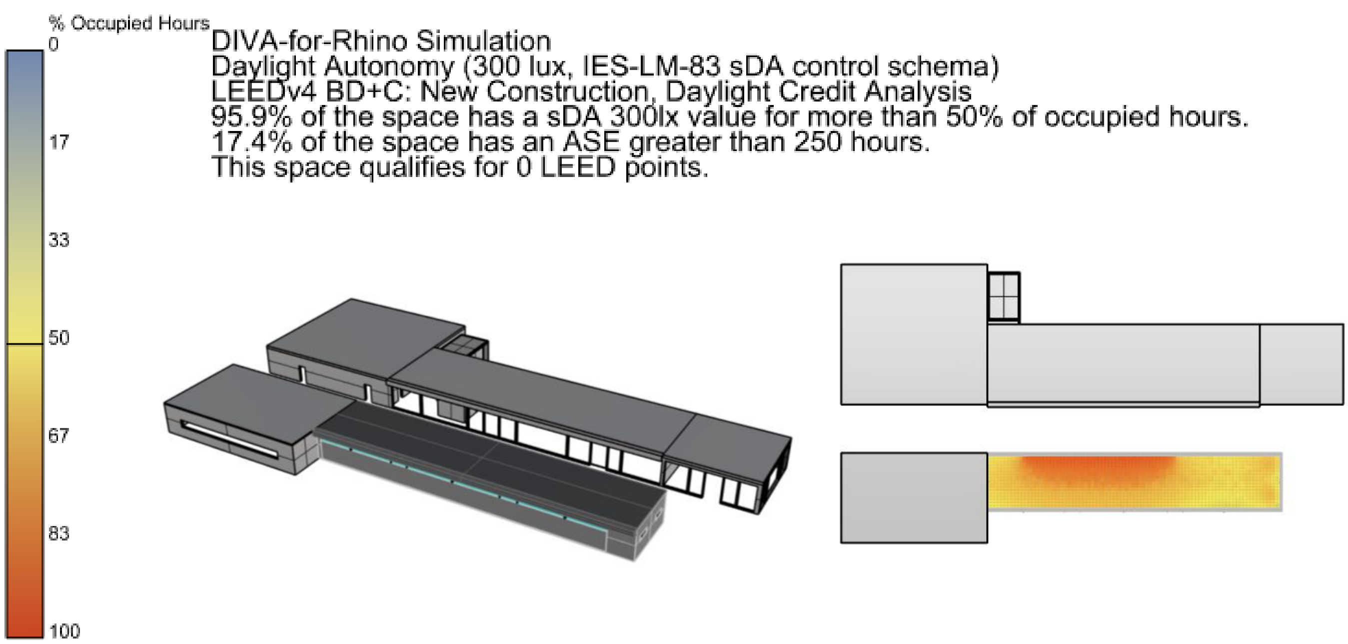
Case A – 40% Windows to Wall



One thing to note about this test is that we have only changed the south façade. The north windows still contribute to the high ASE as the area near the north windows is in the red 90% area. However, the area directly near the south façade is now 50% range when before it was in the darker orange range. Raising the and lessening the window range has lessened the percentage of the space that has an ASE greater than 250 hours by 6. The area next to the south façade was intended to be a seating area for guest so the harsh daylight would have made sitting there unbearable during the day and during the summer.

Case B – 20% Windows to Wall



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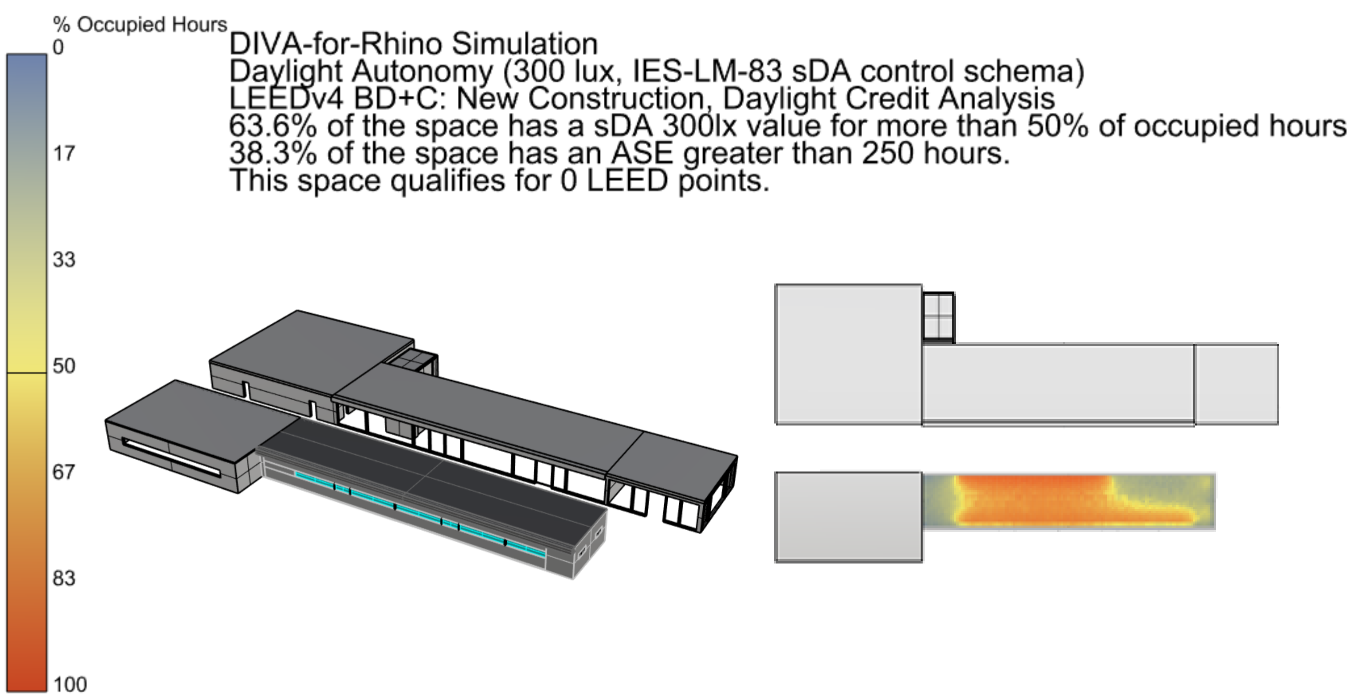
The higher windows and smaller window and wall to ratio has significantly improved the ASE percentage by decreasing it by 49.4! However, we have completely lost any view that was possible to have on the south side. The bottom panes of the windows are at 2.213 meters, above the height of any person. This configuration has a better ASE possibly also because the window's length is smaller and the overhang on the south which was .610m is more influential. In the north we still have the large window which has a large percentage and falls under the red, but other than that area, the overall space falls into the yellow and orange area. Light seems to be dispersed more evenly minus the north window area.

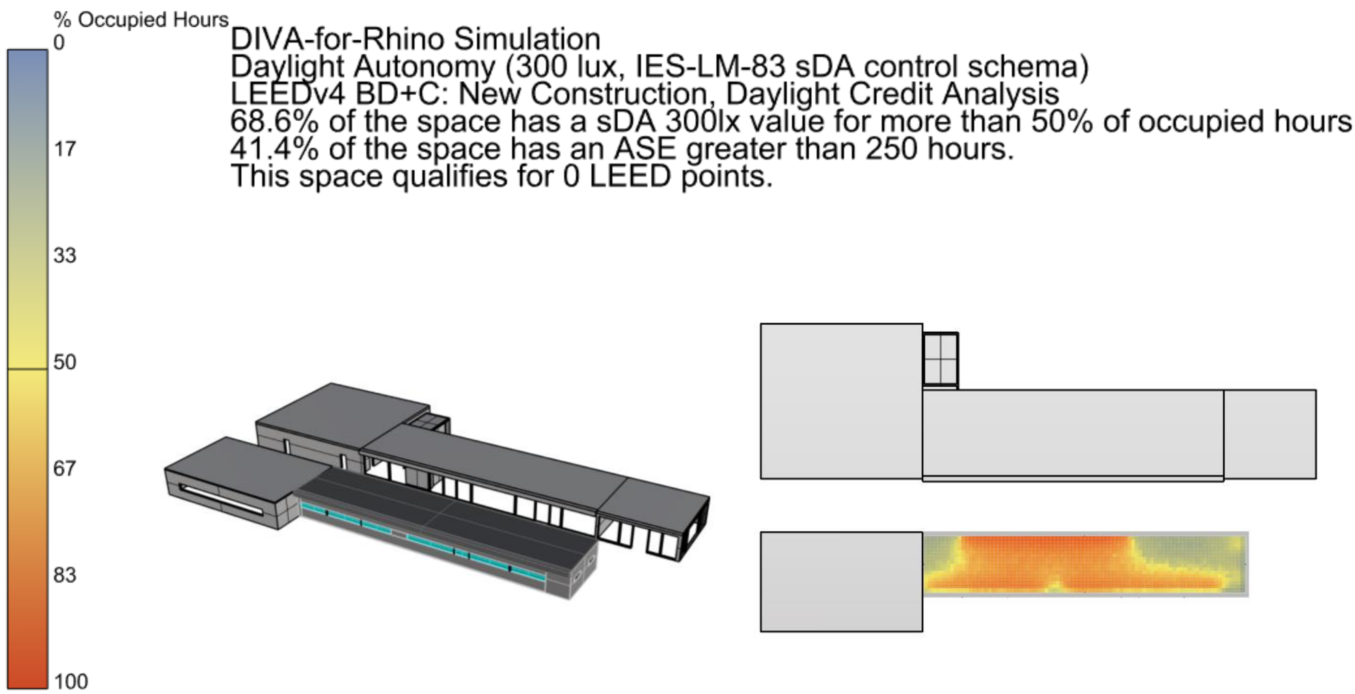
For our Case C test, we will test the windows at slightly below 20% window to wall by removing the window on the far east of the bar. In order to better address view, the window will be viewable from 2m to 1.267m (measuring from the bottom). This will allow for viewers to have a view of the south while standing, but while sitting they will not have a view (so people outside won't be able to see what they're eating). There were originally glass doors (modeled here with the same properties as the glass windows), but to solve that issue, a door can be added to the eastern end where windows were extracted.

Case C – 20%< Windows to Wall on the South, Window extends from 2m to 1.264m



Unfortunately this solution was worst than Case B. The long linear window line helpful because it provided light to the areas that were not illuminated by the northern light. For Case D, we will return to having the windows span throughout at this length. In addition, we will have a break in the windows in the middle area of windows where it will be wall or a hallow door since that area would receive light from the north. In addition, because the ASE rose, it seems the overhang did have an effect.

Case D – 20%< Windows to Wall on the South, Window extends from 2m to 1.264m, Wall Breaks through middle of South Window Line



This case still proves to not be ideal. ASE has slightly improved, but this does address the blue area to the top right that receives very little light. If Case C and Case D were successful, they would have provided us with a solution that would have allowed us to solve the issue of having a linear view of the south and having more usable daylight. However, this configuration has made lighting slightly more tolerable, but to a completely sound solution, we must tweak the northern windows and possibly add a small window in the north to bring some light to the top right corner. To keep the line of windows, having the windows high up helps disperse light more evenly and reach the problem corner we created by bringing it down.

These tests do not address the energy consumption effects, however.

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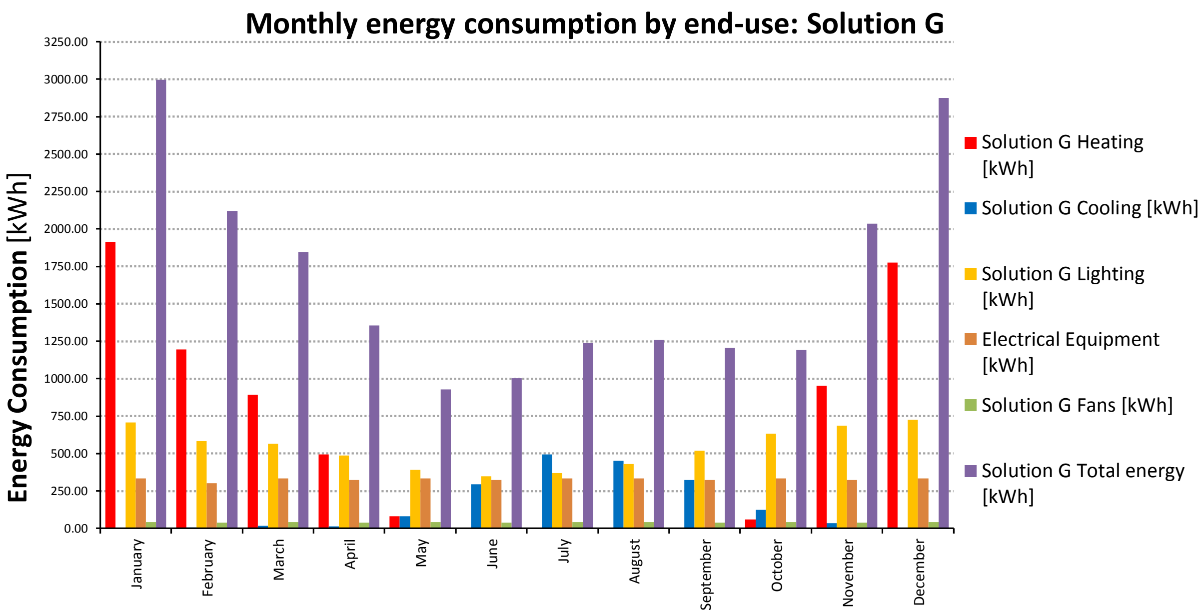
7.7 Thermal Tests - Adjusted Windows

40% Windows to Wall (Case A/ Solution G)



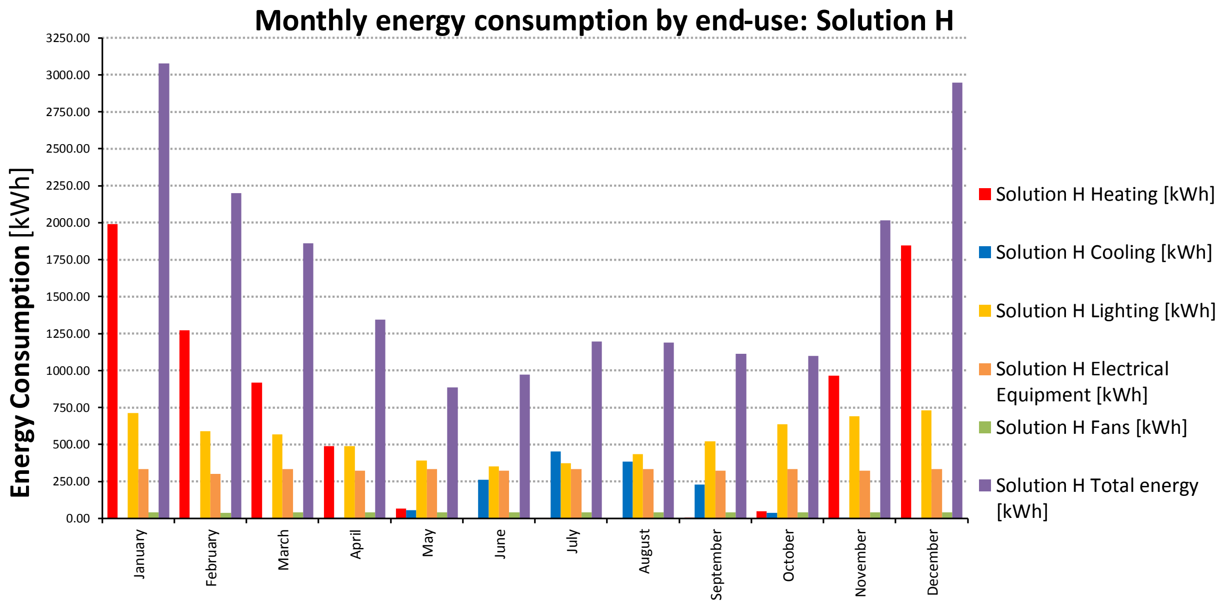
	Solution G					
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
January	1913.22	2.08	708.73	333.17	40.53	2997.73
February	1194.15	5.09	584.69	300.93	36.61	2121.47
March	892.92	15.90	564.60	333.17	40.53	1847.12
April	492.77	13.85	485.71	322.42	39.22	1353.97
May	81.50	81.94	389.62	333.17	40.53	926.76
June	0.00	293.11	348.51	322.42	39.22	1003.26
July	0.00	494.80	370.95	333.17	40.53	1239.45
August	0.00	452.48	431.35	333.17	40.53	1257.52
September	3.62	322.91	518.35	322.42	39.22	1206.53
October	59.77	123.39	633.23	333.17	40.53	1190.08
November	953.84	33.11	686.57	322.42	39.22	2035.17
December	1775.44	0.35	724.68	333.17	40.53	2874.16

Final Project – Reference City: Logrono

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution G	7367.25	1839.02	6446.99	3922.78	477.18	20053.22	79.25

20% Windows to Wall (Case B/ Solution H)



Solution H					
Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
1989.01	0.00	712.83	333.17	40.53	3075.53
1271.89	0.00	588.51	300.93	36.61	2197.94
918.81	0.00	567.71	333.17	40.53	1860.21
489.70	2.45	489.04	322.42	39.22	1342.83
66.08	54.47	392.60	333.17	40.53	886.84
0.00	260.71	349.90	322.42	39.22	972.25
0.00	451.64	372.51	333.17	40.53	1197.84
0.00	382.86	433.23	333.17	40.53	1189.79
1.50	229.95	520.85	322.42	39.22	1113.94
49.62	36.86	637.69	333.17	40.53	1097.86
963.60	1.15	689.87	322.42	39.22	2016.26
1844.78	0.00	729.25	333.17	40.53	2947.72

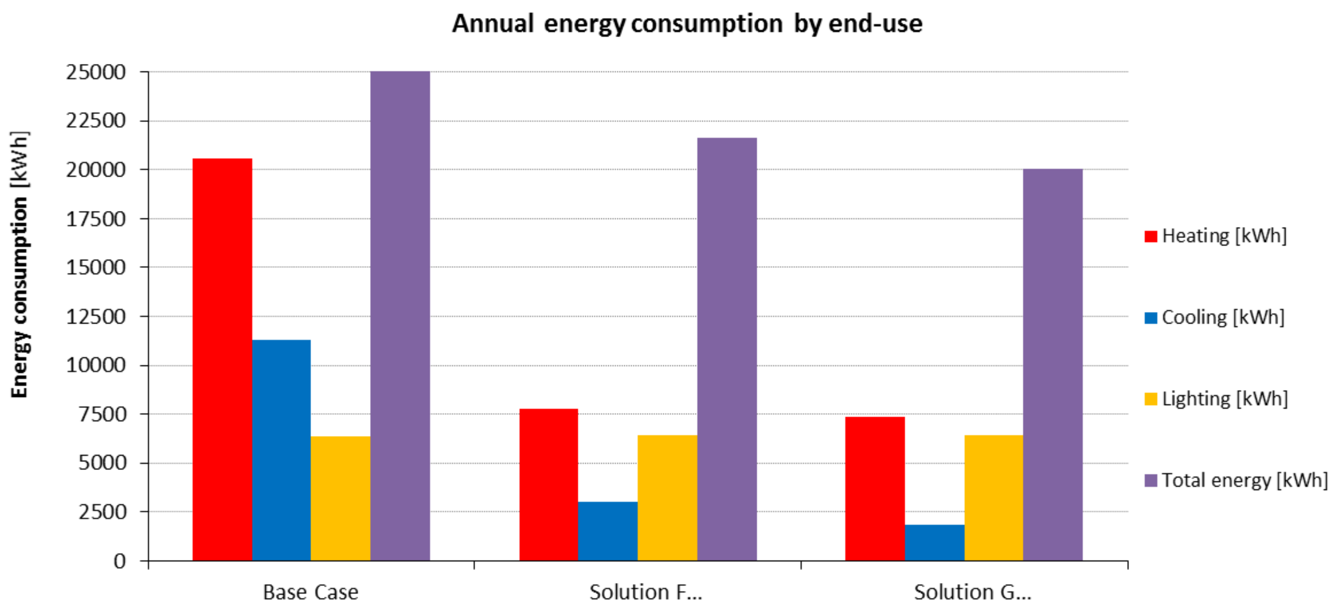
Final Project – Reference City: Logrono

Annual summary

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution H	7594.98	1420.08	6483.99	3922.78	477.18	19899.01	78.64

7.8 Comparative Analysis of Base Case, Solution G and Solution H

	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Electrical Equipment [kWh]	Fans [kWh]	Total energy [kWh]
Base Case	20576.59	11271.36	6349.26	3922.78	477.18	42597.16
Solution F (Solution E with lower U-value South Windows)	7767.00	3037.40	6433.22	3922.78	477.18	21637.57
Solution G (Solution F with 40% Windows)	7367.25	1839.02	6446.99	3922.78	477.18	20053.22
Solution H (Solution F with 20% Windows)	7594.98	1420.08	6483.99	3922.78	477.18	19899.01



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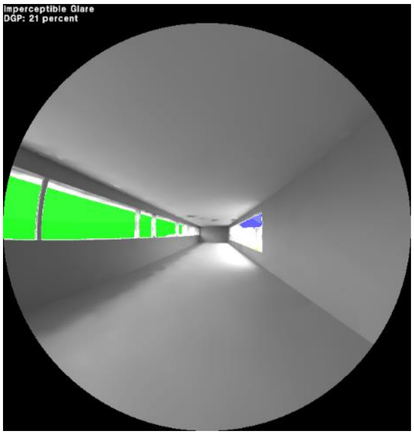
	Heating [kWh]	Cooling [kWh]	Lighting [kWh]	Elec. Equip. [kWh]	Fans [kWh]	Total energy [kWh]	EUI [kWh/m2]
Solution H.2 (top of window at 2m)	7564.49	1517.89	6496.43	3922.78	477.18	19978.78	78.96

Energy Improvement (%)

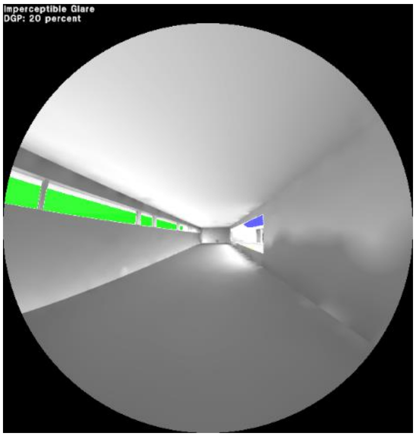
	Total Energy [kWh]	% Improvement compared with base-case
Base Case	42597.16	N.A.
Solution F (Solution E with lower U-value South Windows)	21637.57	49.20
Solution G (Solution F with 40% Windows)	20053.22	52.92
Solution H (Solution F with 20% Windows)	19899.01	53.29
Solution H.2 (top of window at 2m)	19978.78	53.10

Changing the size of the window has had some impact on the total energy consumption and has brought it down. However, going from 40% to 20%, there is not a big change in energy consumption. The smaller window has decreased some of the heating consumption and has almost cut the cooling consumption by half. The chart below shows that shifting down Solution H also did not have a big effect on energy consumption.

7.9 Glare



June 21, 3pm
Solution G



June 21, 3pm
Solution H

Glare was expected. Most of the glare seems to be coming from the north so having less windows only reduced glare by 1%.

7.11 Visualization of Solution H

	Winter solstice	Equinox	Summer solstice
9:00 a.m.			
12:00 p.m.			
3:00 p.m.			

8. PV Panels

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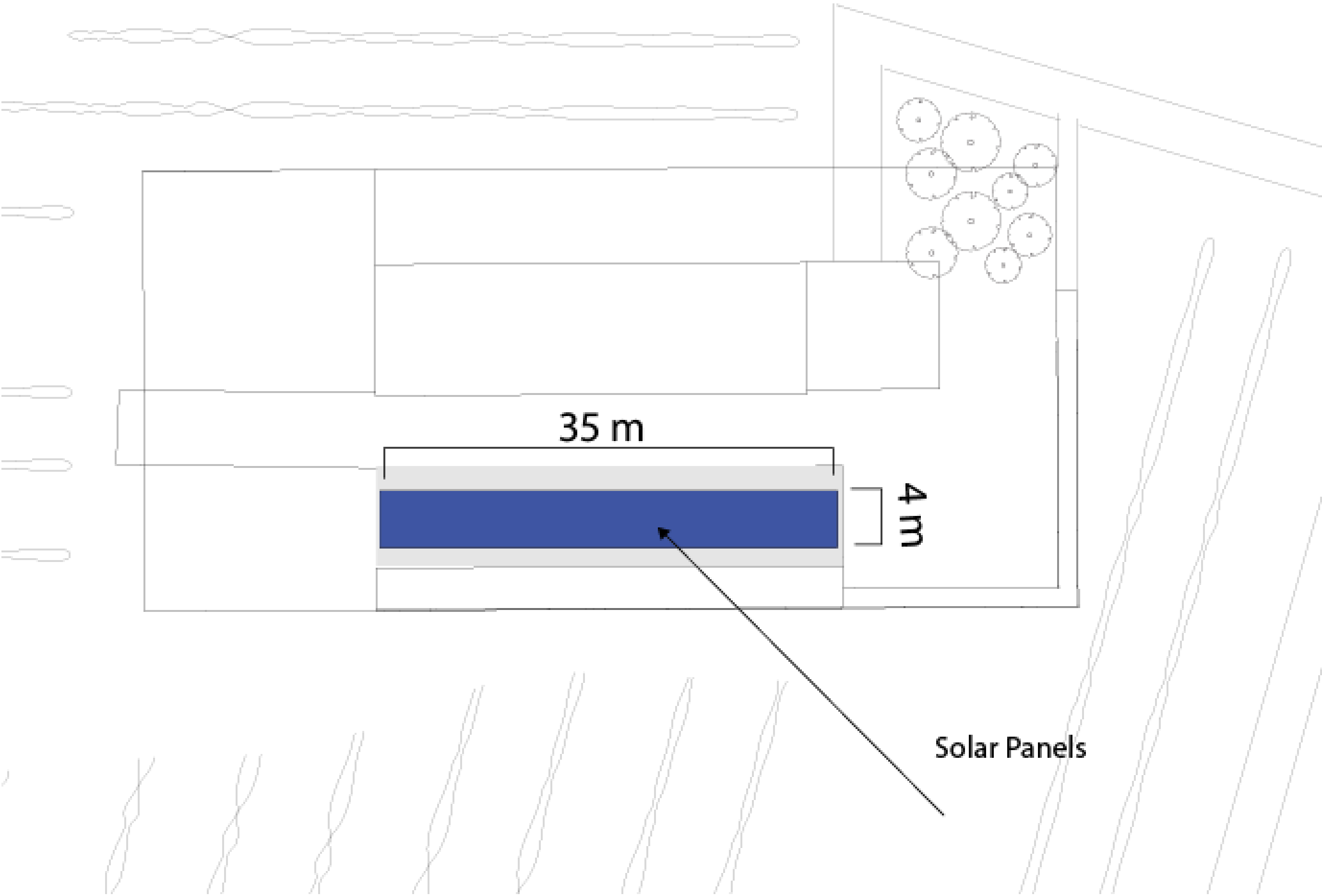
7.9 PV Panels

The area of our roof is 253.03m2 which can have a 37.9kW DC System Size if the whole roof is covered with pv panels. This would provide us with more energy than what we need as long as the energy we gained during the summer can be stored in the winter.

DC System Size 37.9 k (0 tilt, 180 azimuth14% system losses) Comparison			
	Solar Radiation (kWh/m2/day)	AC Energy (kWh)	Solution H Total Energy Consumption (kWh)
January	1.32	1225	3076
February	2.33	1992	2198
March	3.26	3150	1860
April	4.19	3851	1343
May	4.83	4589	887
June	5.35	4805	972
July	5.25	4795	1198
August	4.89	4511	1190
September	3.72	3304	1114
October	2.54	2345	1098
November	1.47	1327	2016
December	1.20	1094	2948
Annual	3.36	36988	19899

DC System Size 21k (0 tilt, 180 azimuth14% system losses) Comparison			
	Solar Radiation (kWh/m2/day)	AC Energy (kWh)	Solution H Total Energy Consumption (kWh)
January	1.32	679	3076
February	2.33	1104	2198
March	3.26	1746	1860
April	4.19	2134	1343
May	4.83	2543	887
June	5.35	2662	972
July	5.25	2657	1198
August	4.89	2499	1190
September	3.72	1831	1114
October	2.54	1300	1098
November	1.47	735	2016
December	1.20	606	2948
Annual	3.36	20496	19899

What we probably need is a DC System Size of 21kWdc. For a system capacity of 21kWdc, the area would be 140m2. The common size for solar panels for residential is 65 by 39 inches and for commercial it is 77 by 39 inches, but lengths can be adjustable. I would have the solar panels in a long strip that is 4 x 35m.



Solar panels can be a very effective tool in reducing energy consumption because we are able to get enough sun. After bringing down our energy consumption in the previous tests, the energy consumption is low enough that it can all be provided by using pv panels. This is also because of the climate we are located in.

However, we have only tested one space and have only reduced energy consumption in one area. If we were to look at the whole building in picture, the results would be different and pv panels might not be enough.

9. Conclusions

Ending Remarks

The glass box has been used throughout architecture because of its transparency, but it has many draw backs mostly energy consumption and too much daylight. From my original design I was able to reduce energy consumption from 42597.16 kWh to 19899.01 kWh, 53.29%. The majority of energy consumption is heating with some cooling. The most effective method to reducing the heating and cooling consumptions are through the glass glazing, especially by finding a low U-value. We also changed the orientation of the building so that the south east windows would face directly south which helped with some of the heating consumption. When concerned with daylighting, the space still does not meet the LEED standards for ASE, but are close (17.4%) with Solution H which eliminates the frontal views. The problem lies mostly in the north façade, but I would like to keep the north view at least for the design concept. The north view faces the crush pad and being able to see the crush pad from inside the building is important. In addition, vines would be hanging between the area of the crush pad and the north face which would provide some shading. In addition adding curtains or blinds would also help. The area to the north is also open and mostly a walk and lounge area so guests would not constantly be there so having a lot of light in that area would not be as detrimental as having too much light in the south. Design wise, having only one view further frames the one large view because of the contrast with the bare room.

Having a glass box, especially when the space is in an open area can be problematic. Many of the glass box architecture buildings we’re familiar with are next to other buildings that are able to provide shade which would reduce the heating consumption that I struggled to reduce. In this climate and for this site, a space with two sided glass would not be efficient. To answers my early study questions, completely keeping the view on both the south and the north and being efficient is not possible. To further strengthen this design however would require more studies on the north windows as this study focused primarily on the south façade.