Sustainability Through Spatial Architectural Design

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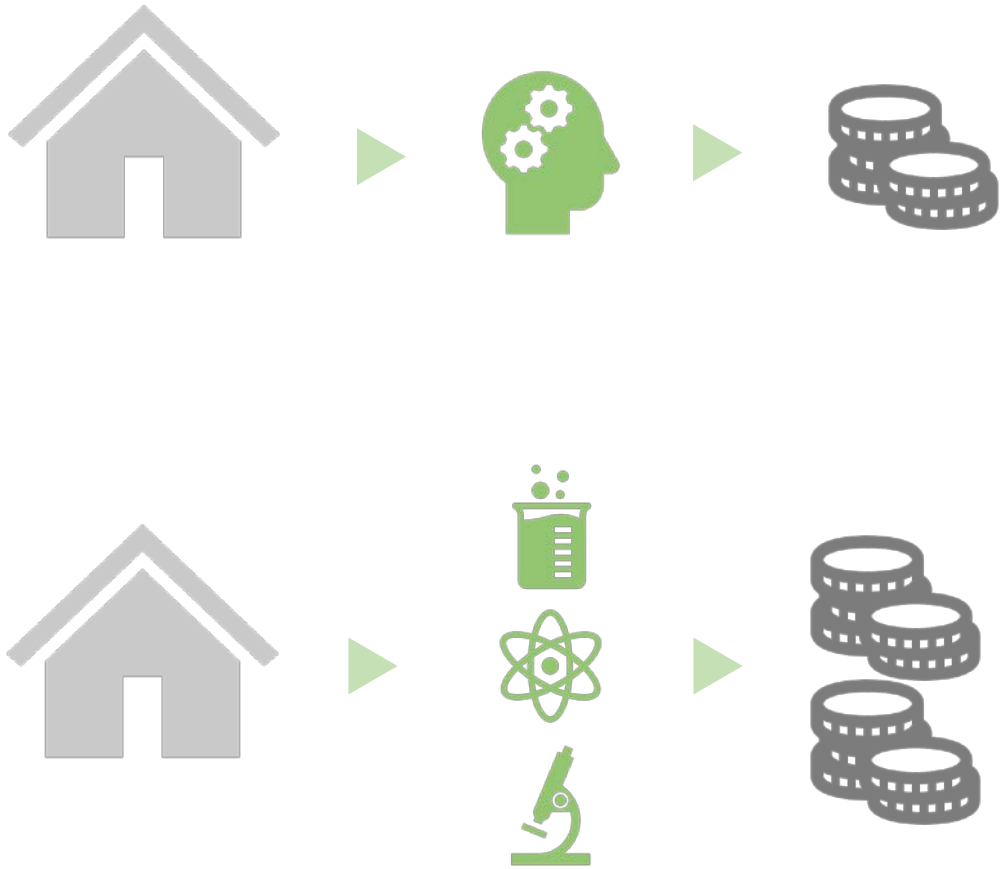
جامعة قطر
QATAR UNIVERSITY

Sustainability Through Spatial Architectural Design



Sustainable design within the architectural design profession is often seen as the incorporation of advanced technologies or the implementation of dated passive design strategies in order to achieve an overall sustainable architectural project. The previously mentioned methods are all effectively producing sustainable results that cover the environmental, social and economic aspects of sustainability within the built environment. Space is ultimately the medium in which architects manipulate to create visions of their aspire and obligations as architecture. Through research within the built environment encompassing the vernacular ideal of a multitude of spaces to allow for sustainable adaptation based upon current climatic and environmental requirements, the built environment spatial spectrum was introduced.

Built Environment and Population Analysis

Qatar 2003

Population:

668,165

Data from World Bank

Last updated: Oct 7, 2016

Qatar University , West Bay , Qatar 2003

Google Imagery 2016

Built Environment and Population Analysis

Qatar 2015

Population:

2,235,400

Data from World Bank

Last updated: Oct 7, 2016

Qatar University , West Bay , Qatar 2015

Google Imagery 2016

Built Environment and Population Analysis

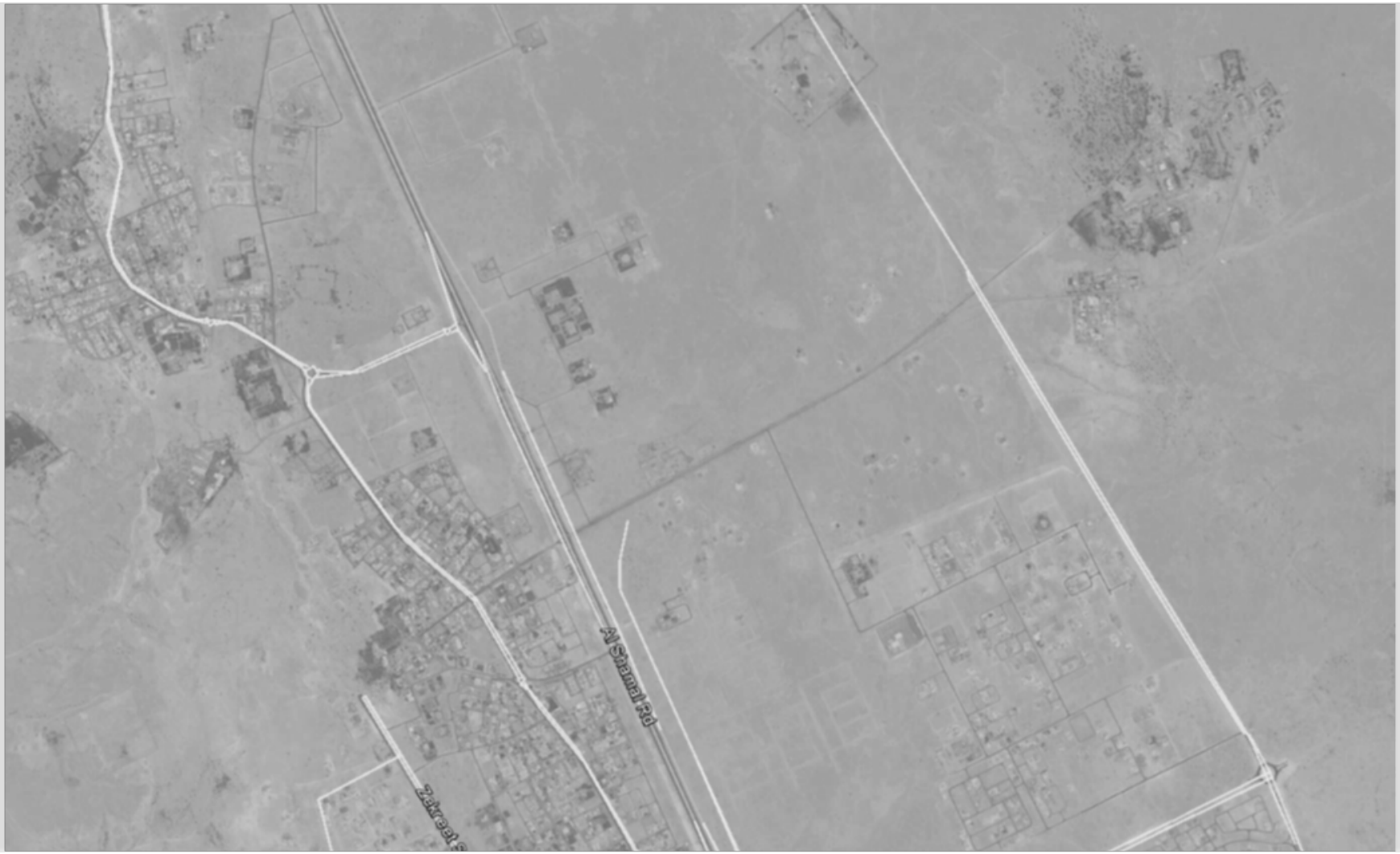
Qatar 2004

Population:

732,096

Data from World Bank

Last updated: Oct 7, 2016



Northern Alkharitiyat , Qatar 2004

Google Imagery 2016

Built Environment and Population Analysis

Qatar 2015

Population:

2,235,400

Data from World Bank

Last updated: Oct 7, 2016

Northern Alkharitiyat , Qatar 2015

Google Imagery 2016

Built Environment and Population Analysis

Qatar 2006

Population:

988,448

Data from World Bank

Last updated: Oct 7, 2016

Rawdat Alhamama , Qatar 2006

Google Imagery 2016

Built Environment and Population Analysis

Qatar 2015

Population:

2,235,400

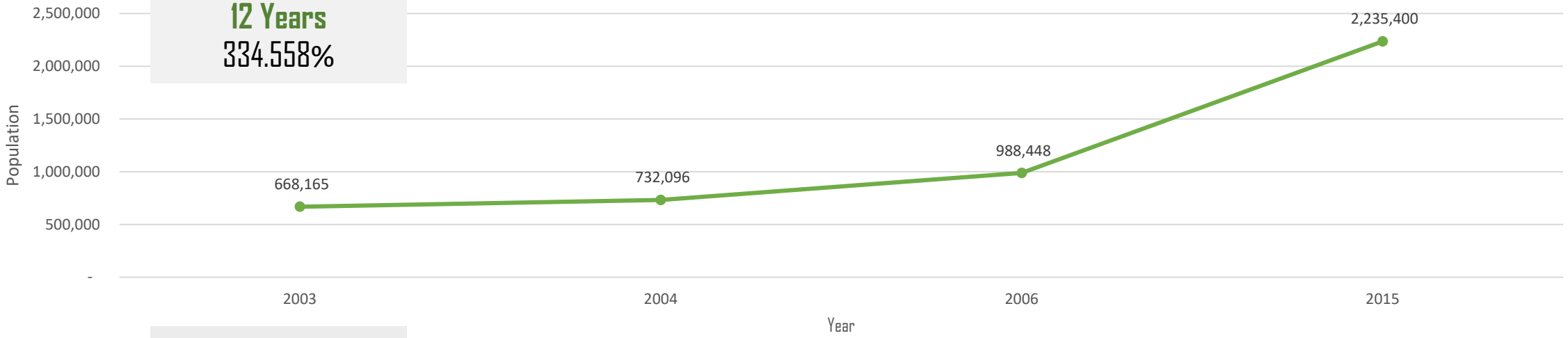
Data from World Bank

Last updated: Oct 7, 2016

Rawdat Alhamama , Qatar 2015

Google Imagery 2016

Qatar



Population Growth:
12 Years
334.558%

Qatar Household average kWh usage per Summer Month

13,000 kWH

Qatar Household average kWh usage per Winter Month

8,000 kWH

1,500.93 kWh/per.

2,439.02 kWh/per.

1,969.97 kWh/per.
Annually

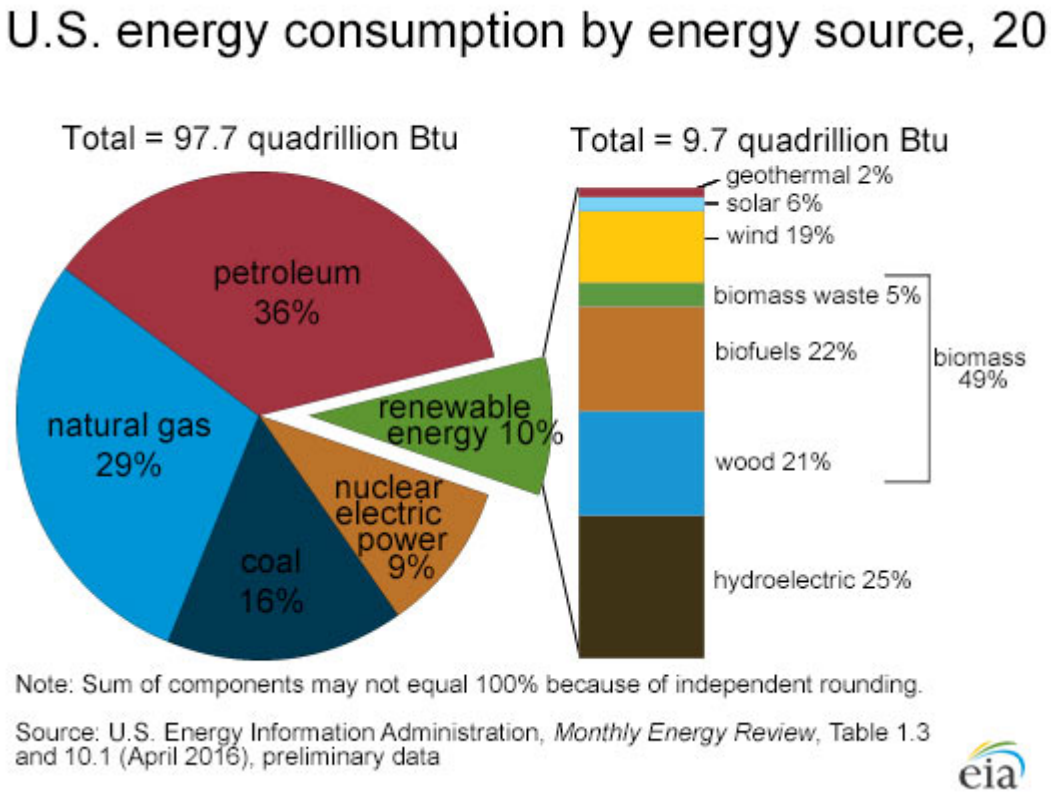
4,403,670,938 kWh
Annually

334.558%

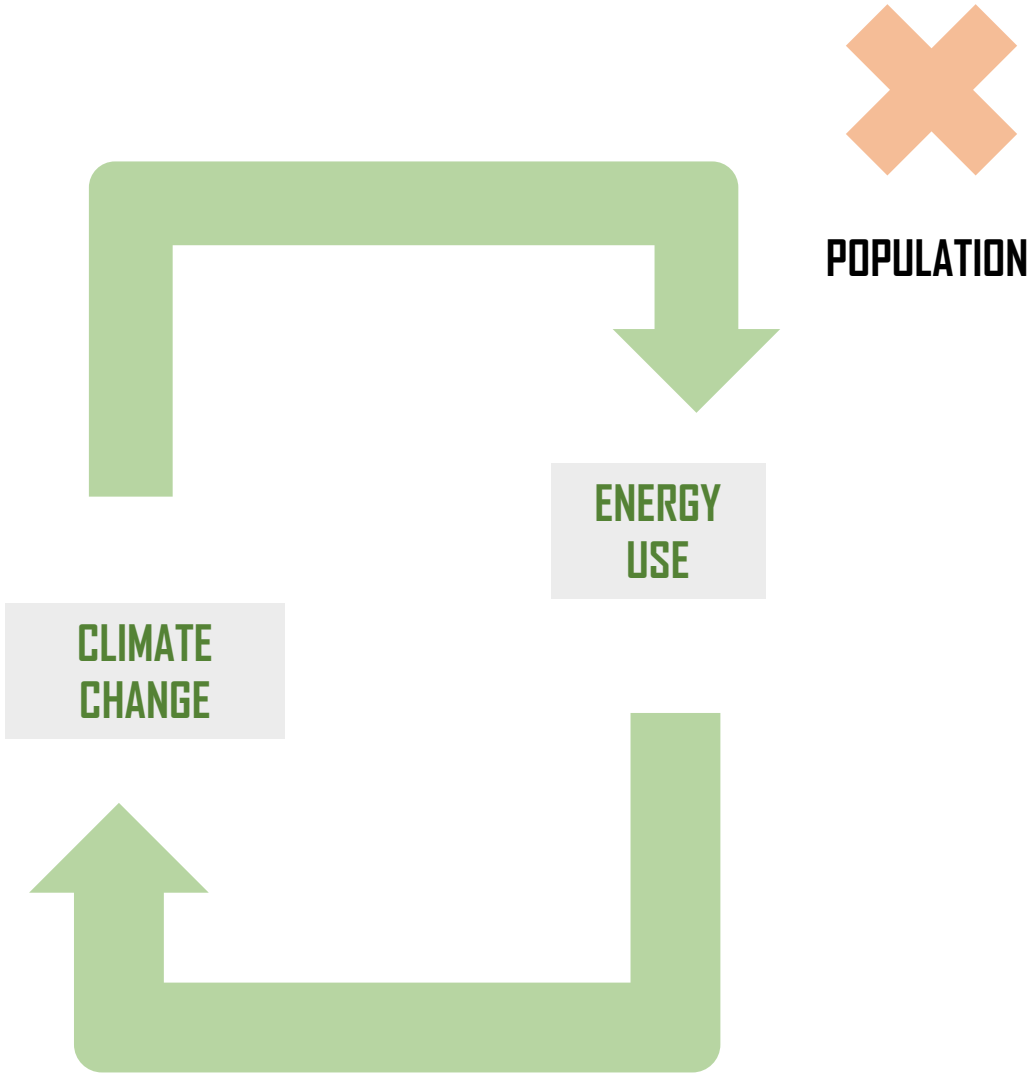
14,708,260,932 kWh
Annually

Average Household
5.33
Persons

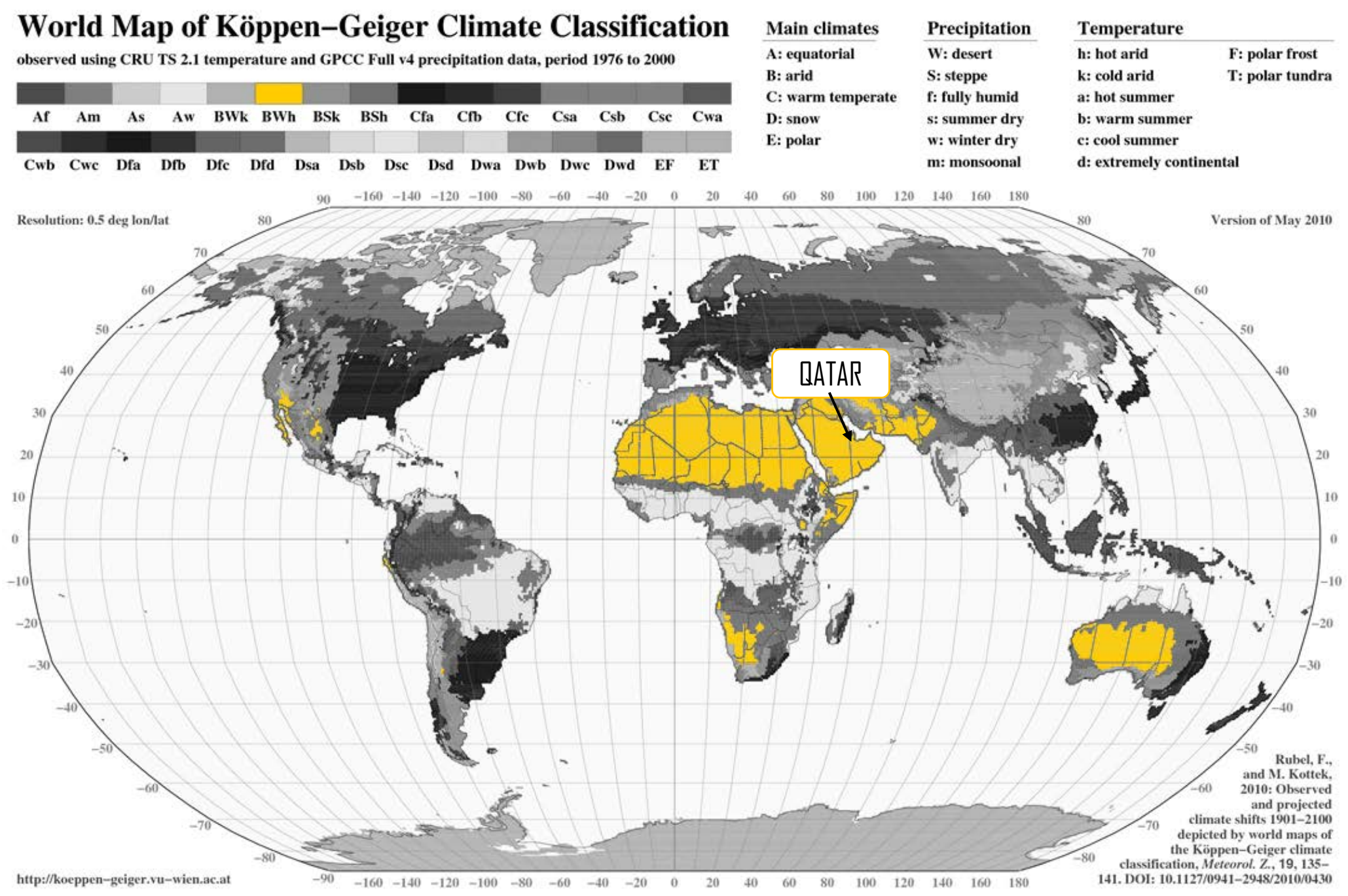
"Qatar General Electricity & water Corporation - المؤسسة العامة القطرية للكهرباء والماء." Qatar General Electricity & water Corporation - المؤسسة العامة القطرية للكهرباء والماء. Accessed December 7, 2016. http://km.qa/AboutUs/Pages/ElectricitySector.aspx



Sustainable Cycle



Unsustainable Cycle


World Map of Köppen–Geiger Climate Classification
observed using CRU TS 2.1 temperature and GPCC Full v4 precipitation data, period 1976 to 2000
Af Am As Aw BWk BWh BSk BSh Cfa Cfb Cfc Csa Csb Csc Cwa
Cwb Cwc Dfa Dfb Dfc Dfd Dsa Dsb Dsc Dsd Dwa Dwb Dwc Dwd EF ET
Main climates
A: equatorial
B: arid
C: warm temperate
D: snow
E: polar
Precipitation
W: desert
S: steppe
f: fully humid
s: summer dry
w: winter dry
m: monsoonal
Temperature
h: hot arid
k: cold arid
a: hot summer
b: warm summer
c: cool summer
d: extremely continental
F: polar frost
T: polar tundra
Resolution: 0.5 deg lon/lat
Version of May 2010
QATAR
http://koeppen-geiger.vu-wien.ac.at
Rubel, F., and M. Kottek, 2010: Observed and projected climate shifts 1901–2100 depicted by world maps of the Köppen–Geiger climate classification, Meteorol. Z., 19, 135–141. DOI: 10.1127/0941–2948/2010/0430

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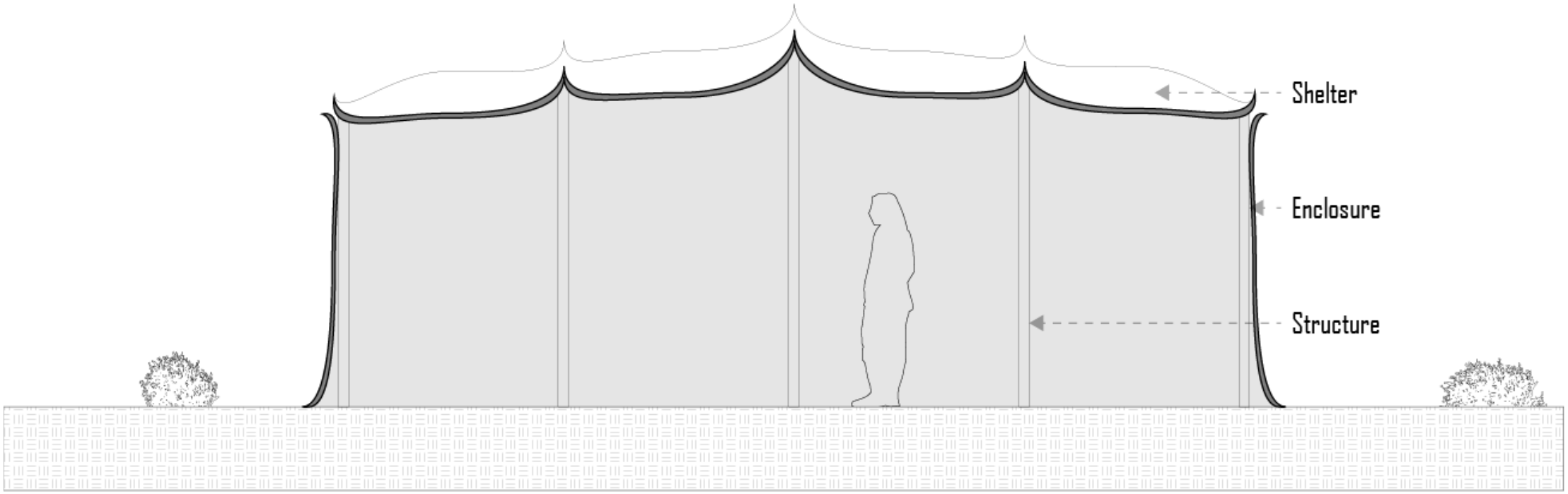
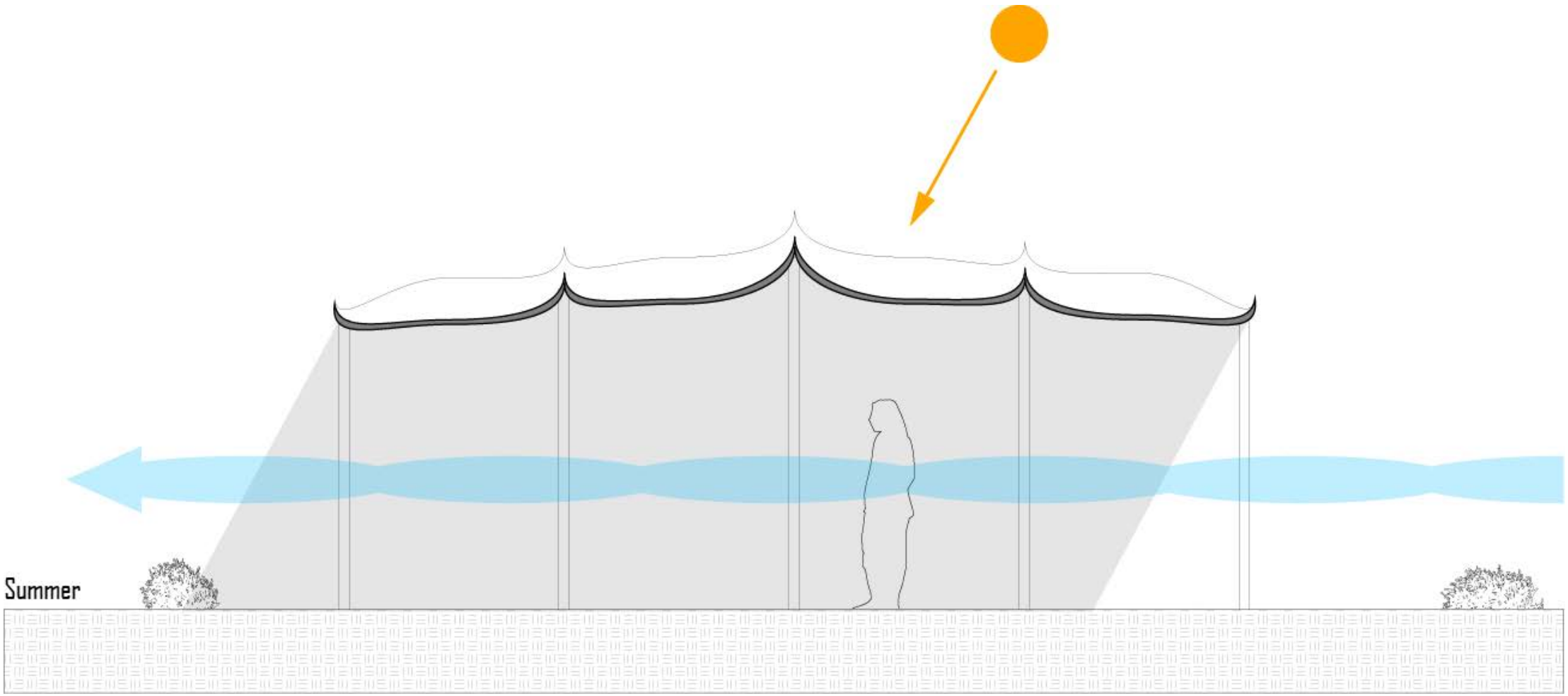
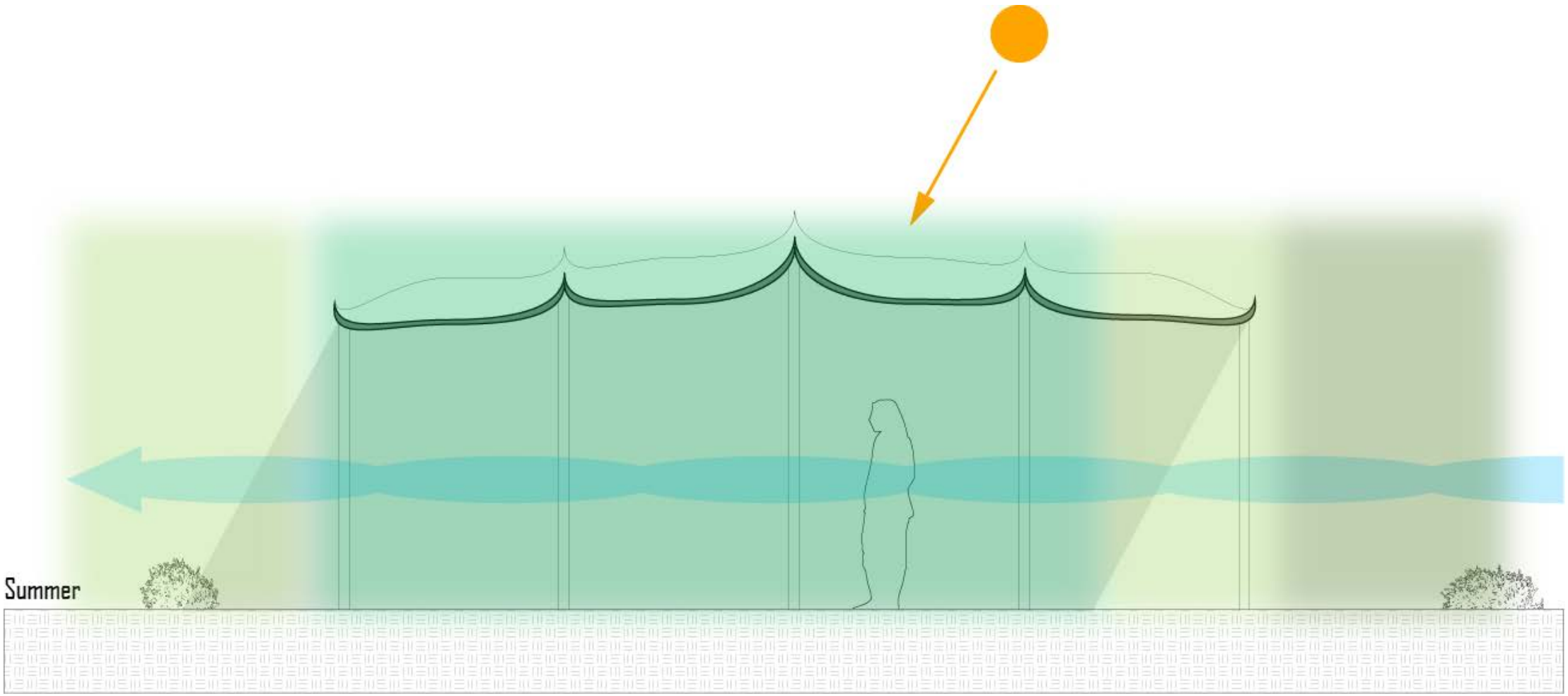
Bedouin Architecture



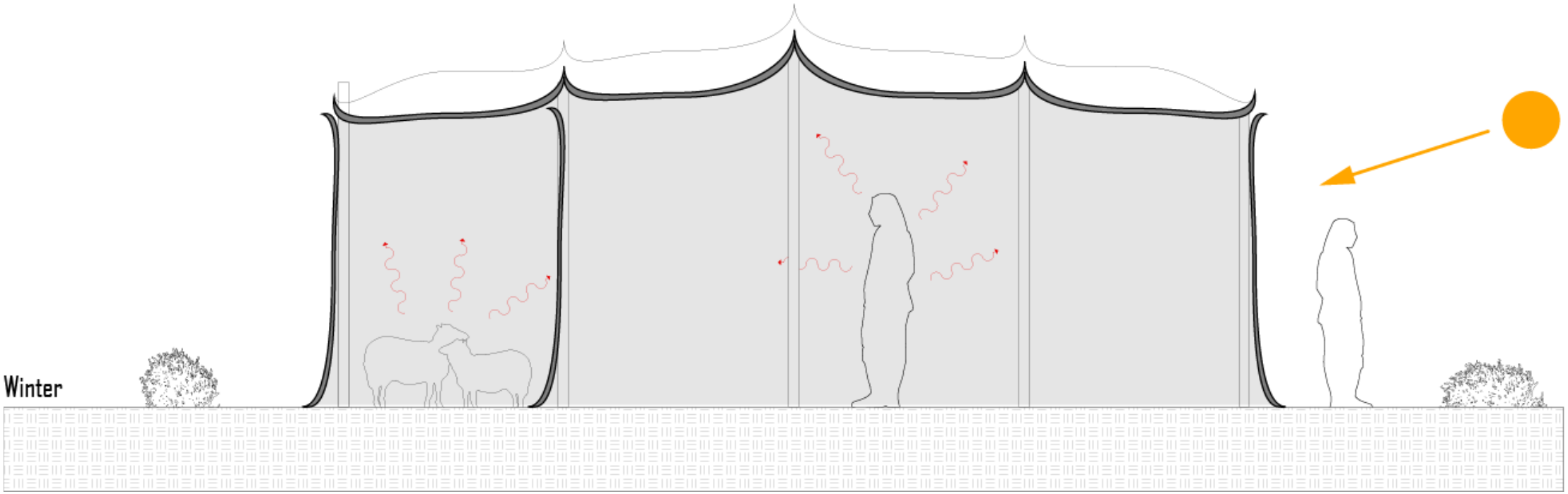
Qatar Bedouin Tent Architecture



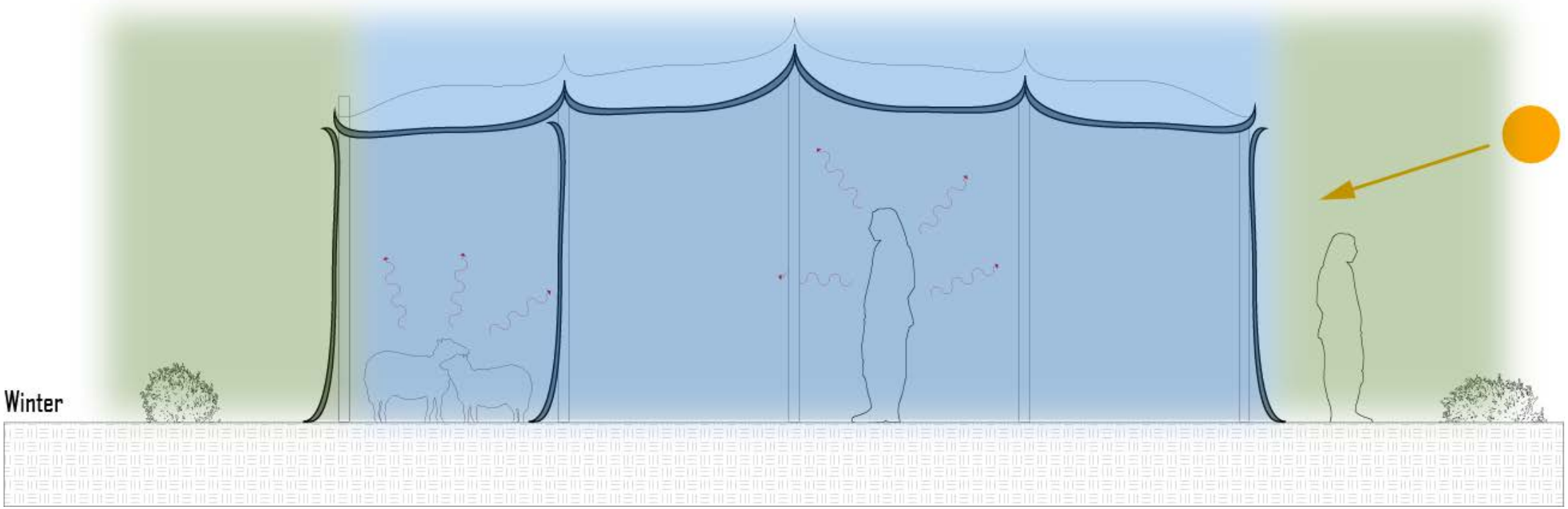
Qatar Bedouin Tent Architecture



Qatar Bedouin Tent Architecture

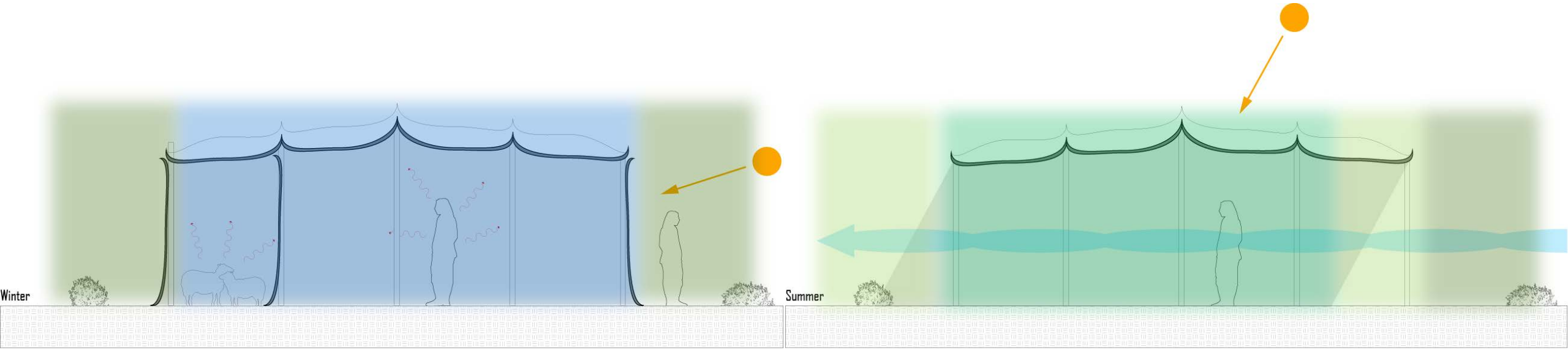


Qatar Bedouin Tent Architecture



Qatar Bedouin Tent Architecture

Interior | Semi-Interior | Semi-Exterior | Exterior

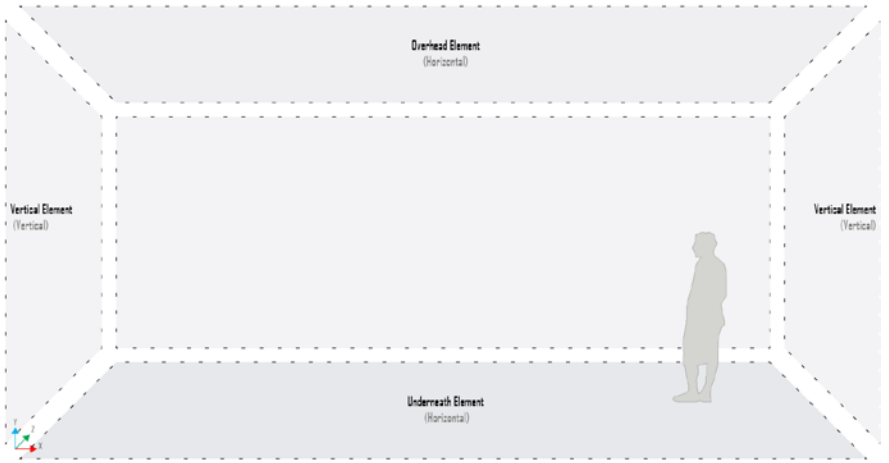


Built Environment Spatial Layers

Connection Layer

Landscape Layer

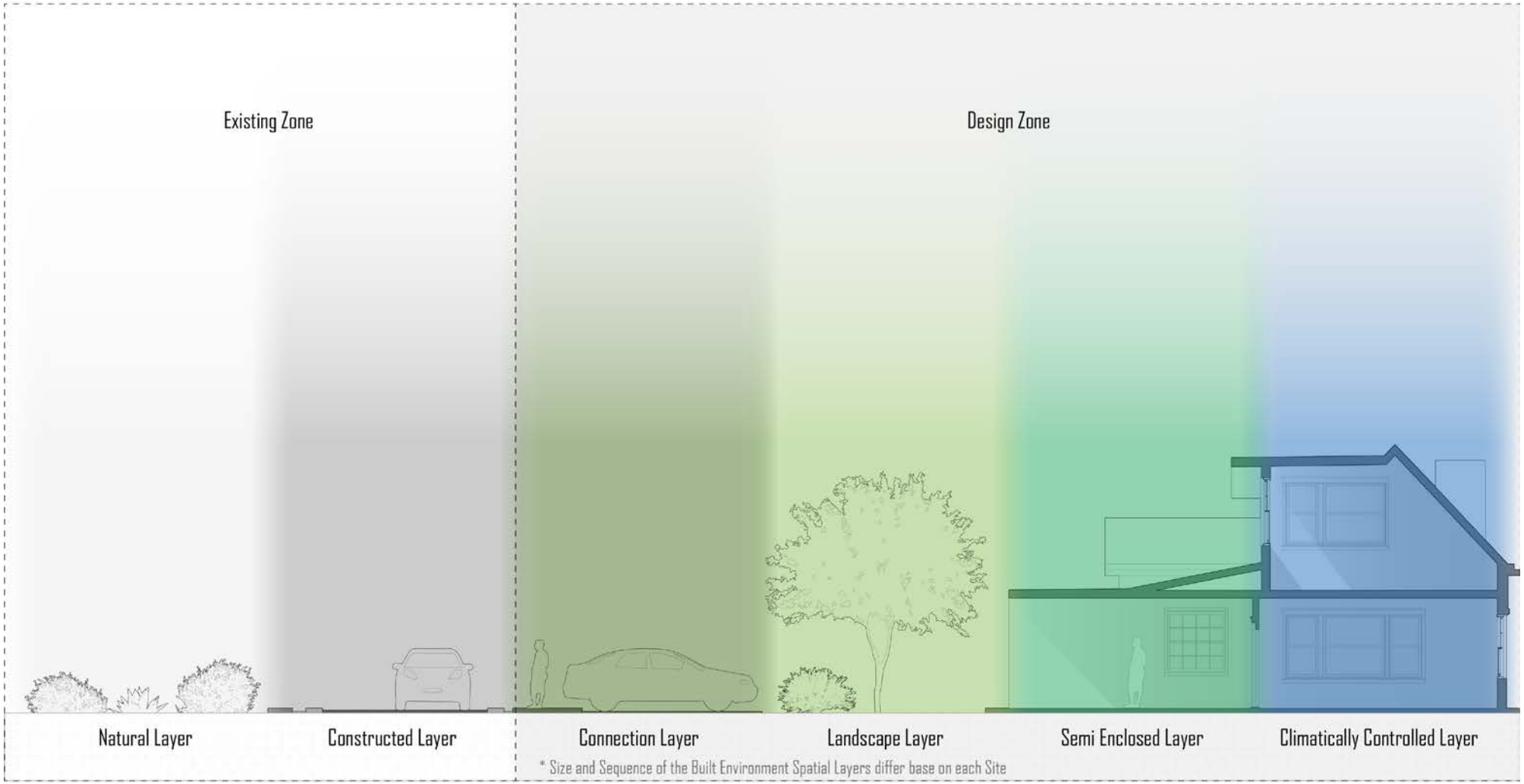
Semi Enclosed Layer



Climatically Controlled Layer

Olgyay, V. (1969). Desing with climate. Princeton university press.
Lechner, N. (2014). Heating, cooling, lighting: Sustainable design methods for architects. John wiley & sons.
American Society of Heating, Refrigerating, & Air-Conditioning Engineers. (2006). ASHRAE greenguide: the design, construction, and operation of sustainable buildings. Butterworth-Heinemann.
Standard, A. S. H. R. A. E. (2010). Standard 55-2010:"Thermal Environmental Conditions for Human Occupancy"; ASHRAE. Atlanta USA

Built Environment Spatial Layers



Built Environment Spatial Layers

Connection Layer	Landscape Layer	Semi Enclosed Layer	Climatically Controlled Layer

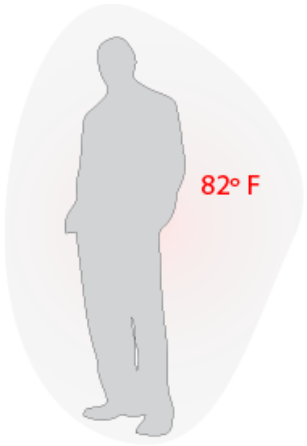
Built Environment Spatial Layers

Connection Layer	Landscape Layer	Semi Enclosed Layer	Climatically Controlled Layer

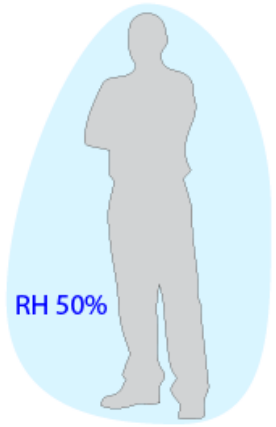
Built Environment Spatial Layers

Connection Layer	Landscape Layer	Semi Enclosed Layer	Climatically Controlled Layer

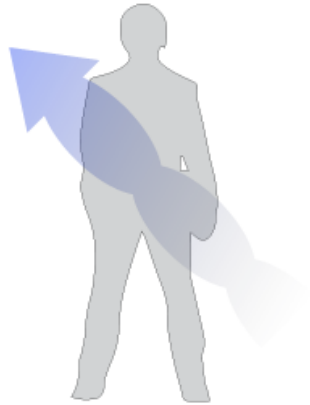
Human Thermal Comfort with Architectural Design



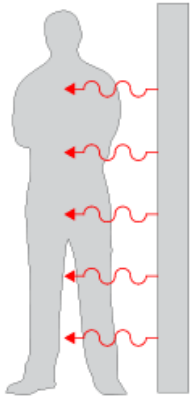
Air Temperature



Relative Humidity



Air Movement

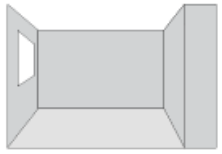


Mean Radiant Temperature

Clothing Insulation Ratio

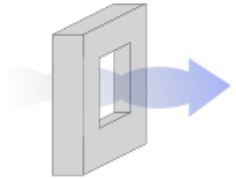
Metabolic Equivalent of Task

Spatial Design

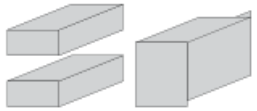


Ventilation

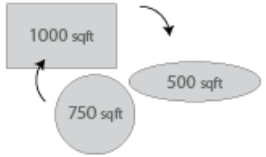
Fenestration Design



Material Composition



Program



Activity

Olgyay, V. (1969). Desing with climate. Princeton university press.
Lechner, N. (2014). Heating, cooling, lighting: Sustainable design methods for architects. John wiley & sons.
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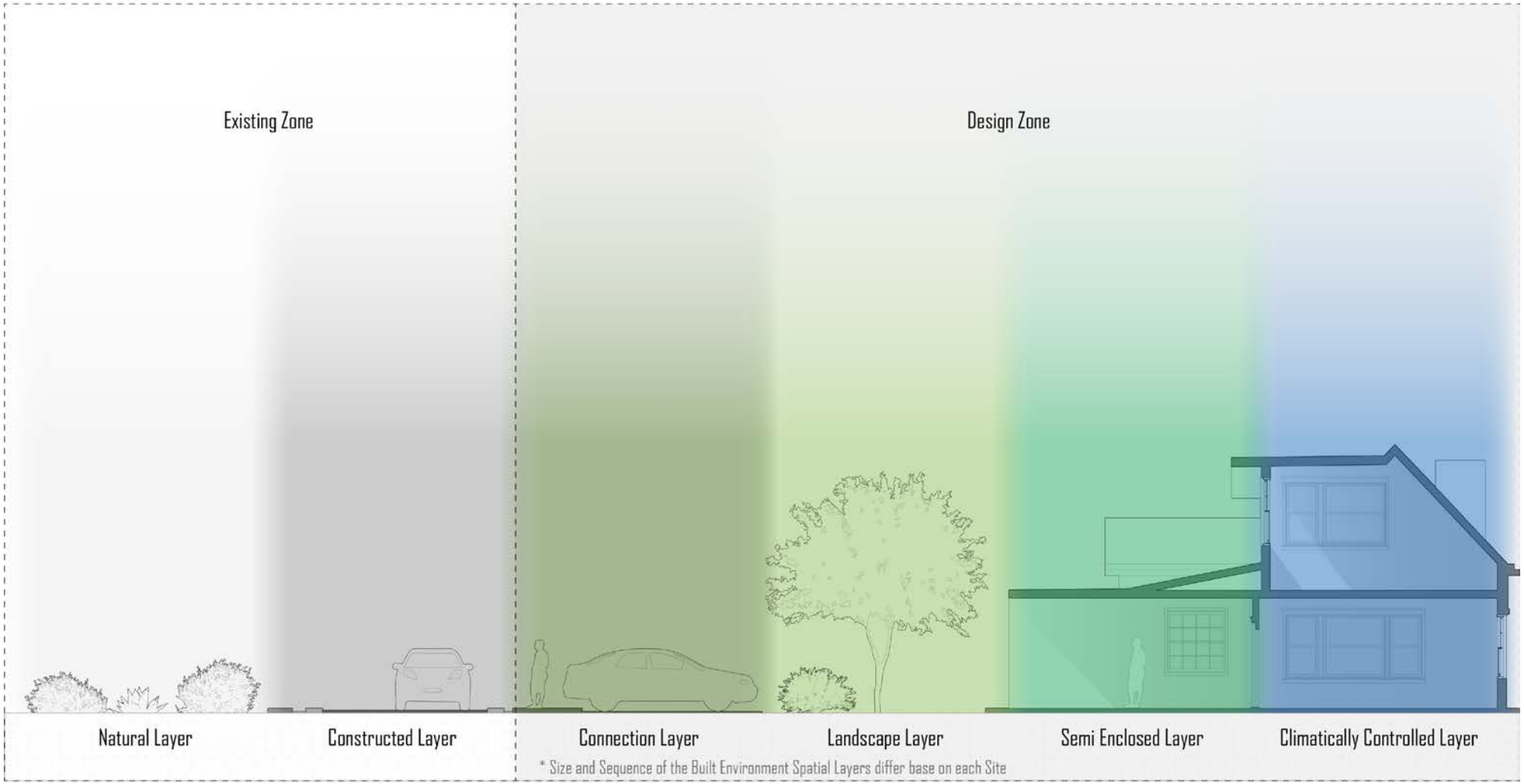
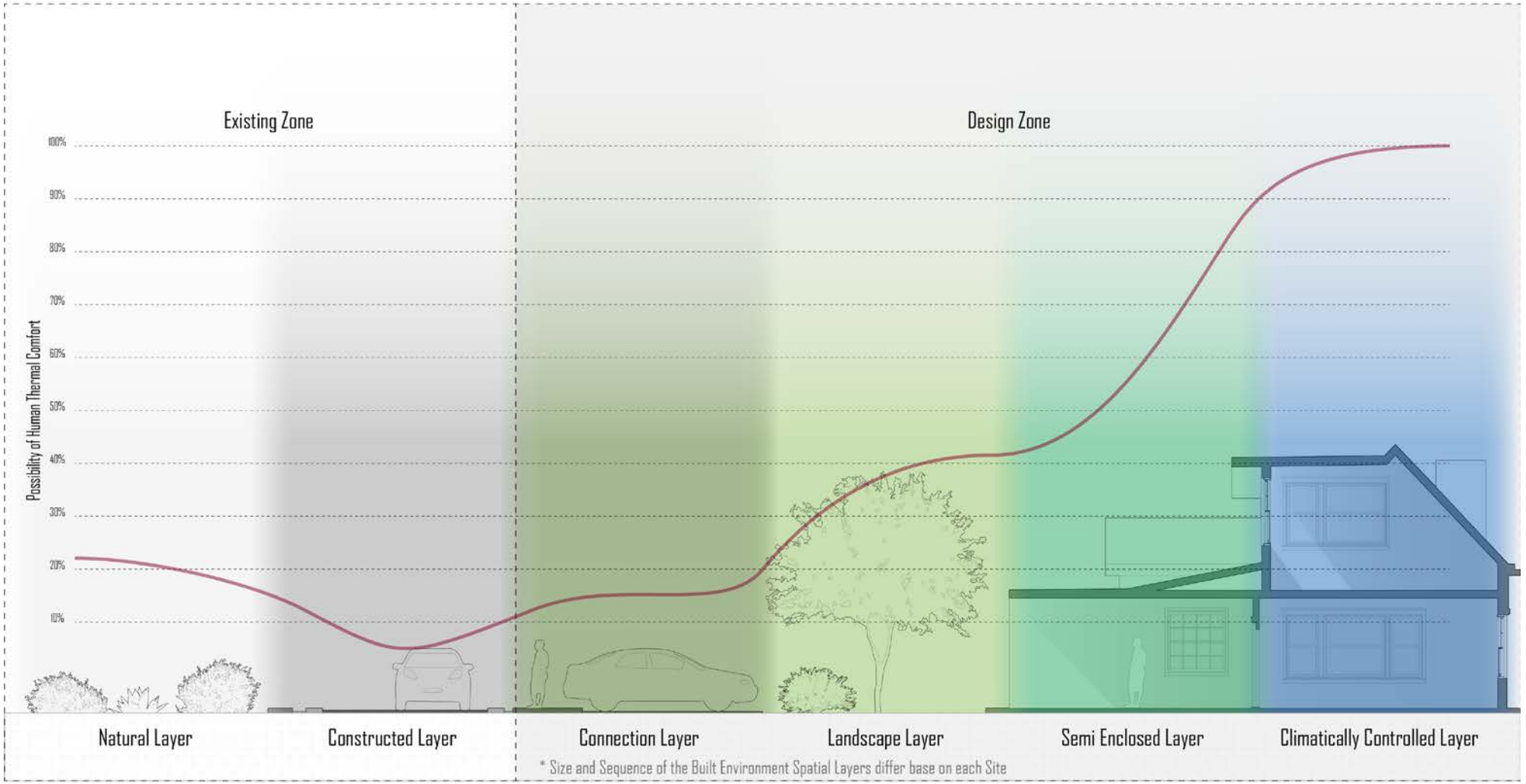
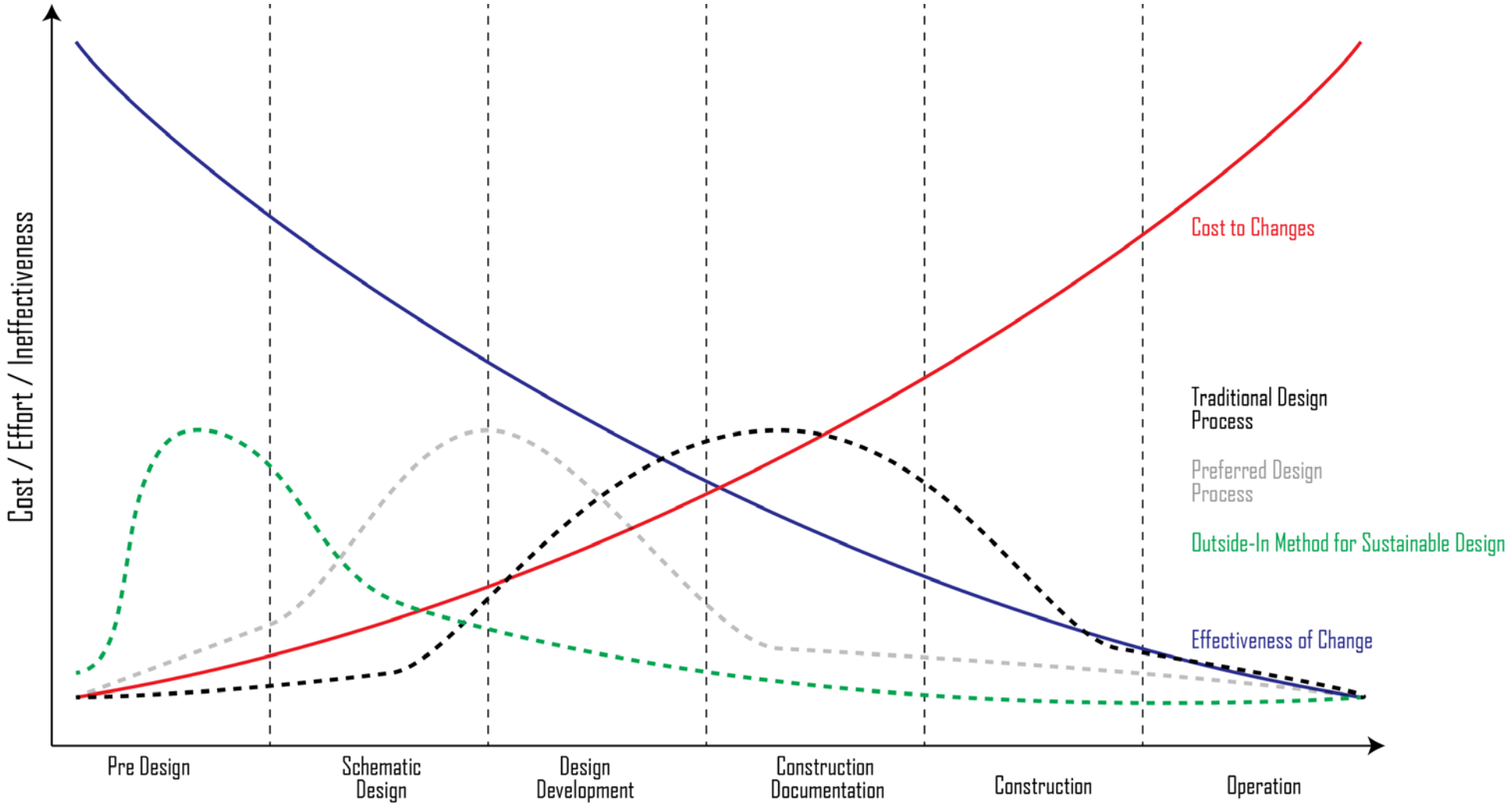
Built Environment Spatial Layers



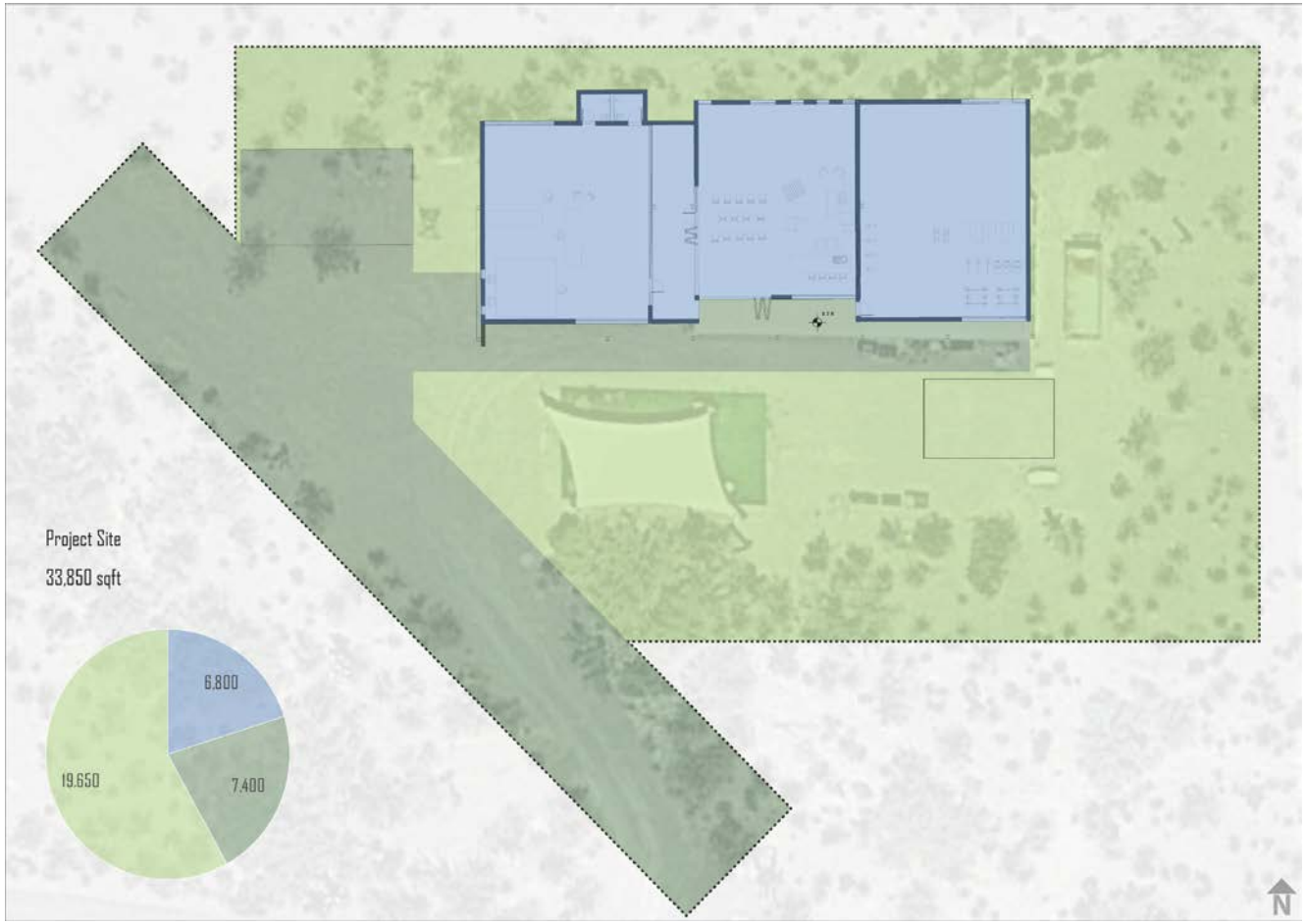
Built Environment Spatial Layers



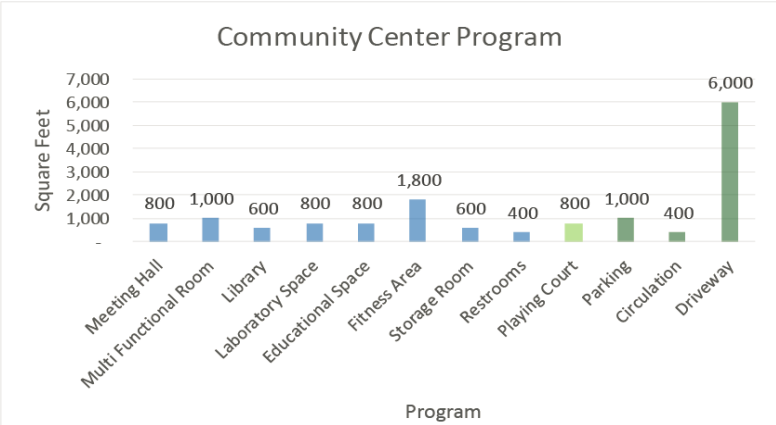


MacLeamy, P. (2004). MacLeamy Curve. Collaboration, Integrated Information, and the Project Lifecycle in Building Design and Construction and Operation (WP-1202).

Community Center Base Case



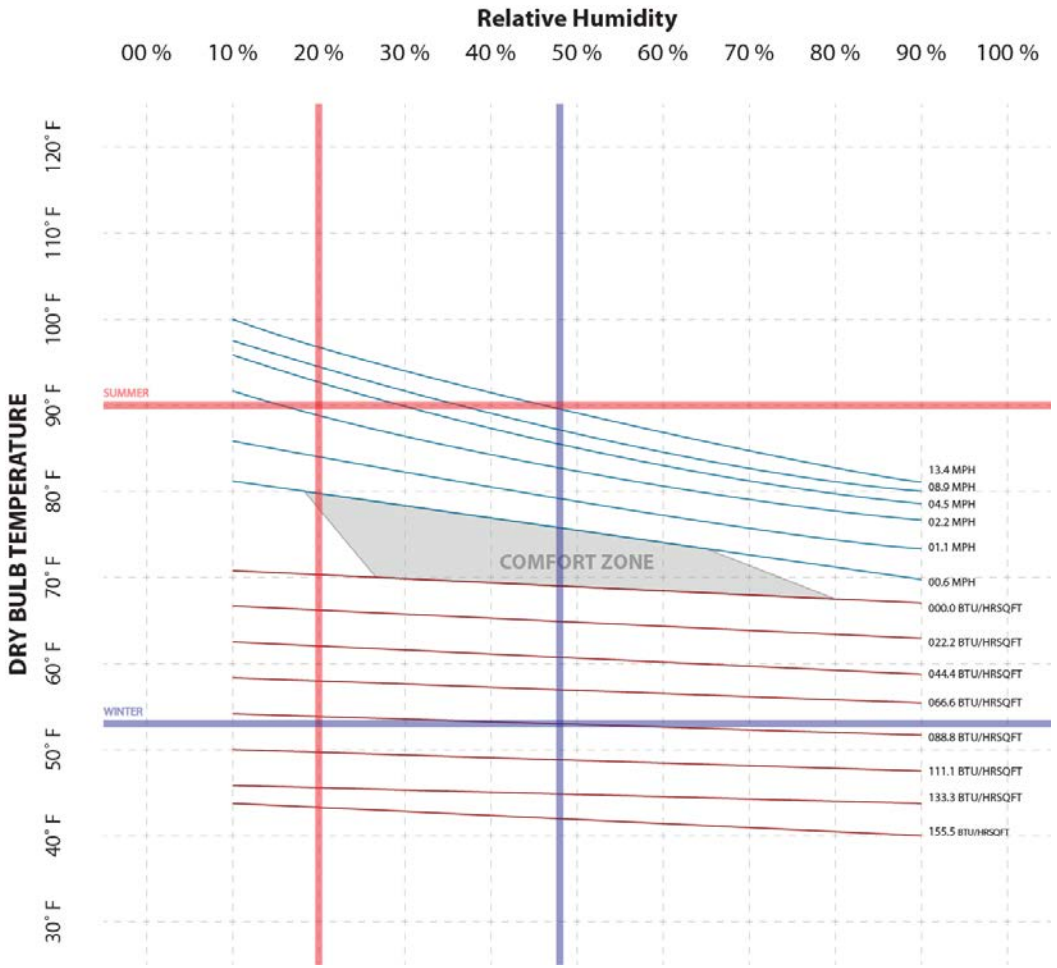
Meeting Hall	800
Multi Functional Room	1,000
Library	600
Laboratory Space	800
Educational Space	800
Fitness Area	1,800
Storage Room	600
Restrooms	400
Playing Court	800
Parking	1,000
Circulation	400
Driveway	6,000
TOTAL	**15,000**



Connection Layer	Landscape Layer	Semi Enclosed Layer	Climatically Controlled Layer

The site where the design is take place and is located in Southern Arizona on the Organ Pipe Cactus National Monument. The designated design for this specific site is that of a Community Center. the site area is approximately 33,850 square feet. This area is the total extent of the site boundaries and is the basis for the design. all the Built Environment Spatial Layers will be allocated within the boundaries of this site. The boundaries will allow for a limitation in space allocation to occur which will be the basis of the analysis in terms of sustainability through the Built Environment Spatial Layers.

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	102	126	147	177	187	185	177	172	163	141	112	94	Btu/sq.ft
Direct Normal Radiation (Avg Hourly)	152	172	171	198	203	199	170	179	193	198	167	161	Btu/sq.ft
Diffuse Radiation (Avg Hourly)	34	38	44	45	43	42	51	47	39	33	34	27	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	222	256	305	333	340	342	338	324	310	269	228	194	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	321	317	322	316	315	308	311	304	306	307	302	311	Btu/sq.ft
Diffuse Radiation (Max Hourly)	124	118	143	179	144	156	168	165	150	141	112	112	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	1030	1363	1743	2284	2574	2625	2480	2274	1993	1580	1160	927	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	1532	1853	2033	2547	2807	2823	2381	2370	2363	2210	1723	1590	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	342	415	526	589	597	599	716	619	480	377	356	268	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	3190	3955	4611	5526	5822	5796	5655	5471	5130	4425	3507	2938	footcandles
Direct Normal Illumination (Avg Hourly)	4151	4763	4822	5629	5823	5710	4809	5077	5516	5539	4570	4367	footcandles
Dry Bulb Temperature (Avg Monthly)	53	54	65	71	78	90	92	90	85	72	63	52	degrees F
Dew Point Temperature (Avg Monthly)	31	29	35	32	34	40	57	56	53	41	38	28	degrees F
Relative Humidity (Avg Monthly)	48	44	37	26	22	20	35	34	36	36	46	45	percent
Wind Direction (Monthly Mode)	100	120	120	100	270	270	270	100	110	110	100	100	degrees
Wind Speed (Avg Monthly)	5	6	6	7	7	7	7	7	6	6	5	5	mph
Ground Temperature (Avg Monthly of 3 Depths)	59	60	64	68	77	82	85	84	79	73	66	61	degrees F



SUMMER **90° F 20 % RH**

WINTER **52° F 48 % RH**

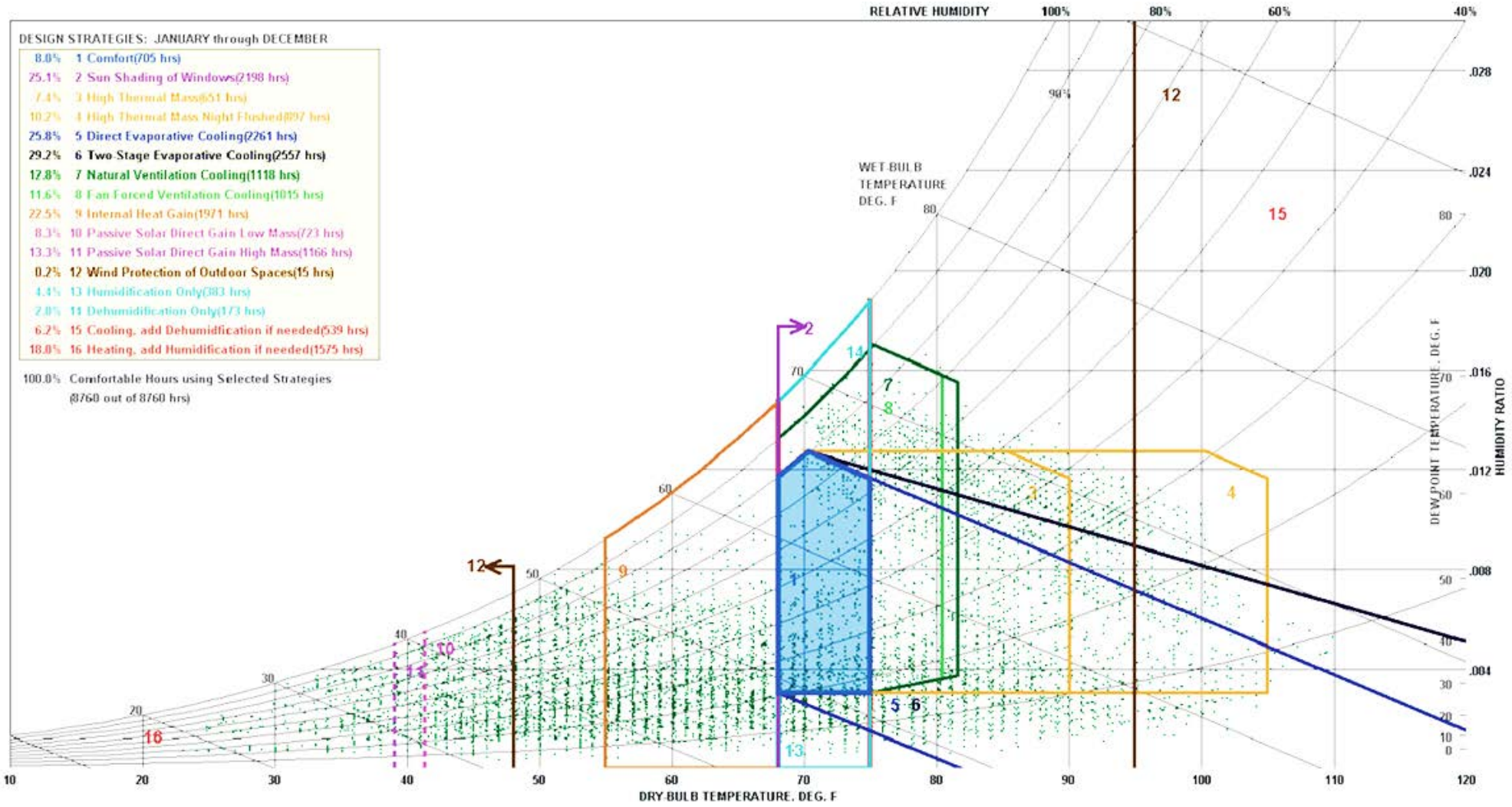
Olgyay, V. (1969). Desing with climate. Princeton university press.

Lechner, N. (2014). Heating, cooling, lighting: Sustainable design methods for architects. John wiley & sons.

American Society of Heating, Refrigerating, & Air-Conditioning Engineers. (2006). ASHRAE greenguide: the design, construction, and operation of sustainable buildings. Butterworth-Heinemann.

Standard, A. S. H. R. A. E. (2010). Standard 55-2010:"Thermal Environmental Conditions for Human Occupancy"; ASHRAE. Atlanta USA

< 0.1 m/s | 50 % RH | MET 1.0 | CLO 0.6 | MRT | DB Temp



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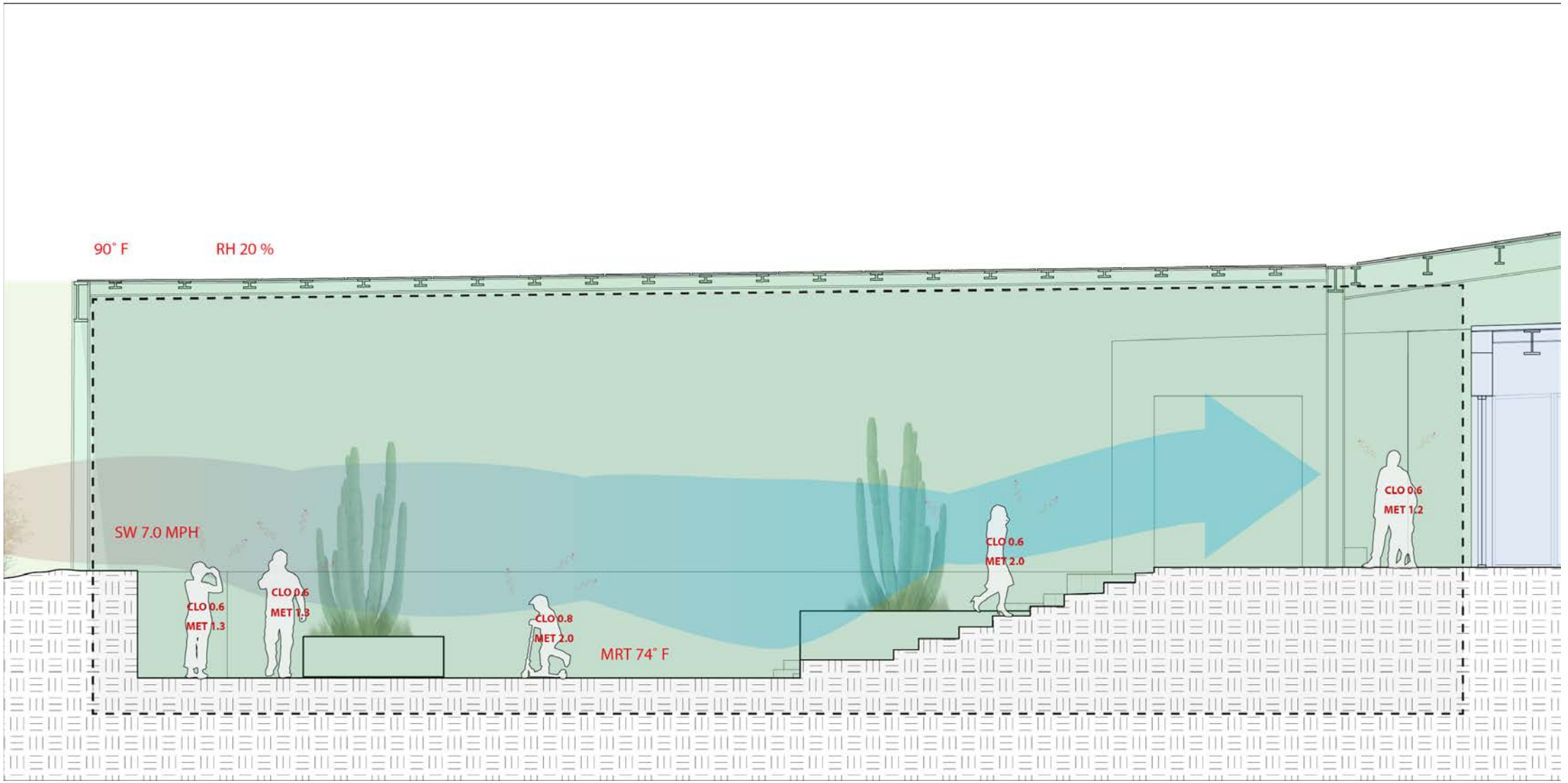
Multi Functional Area

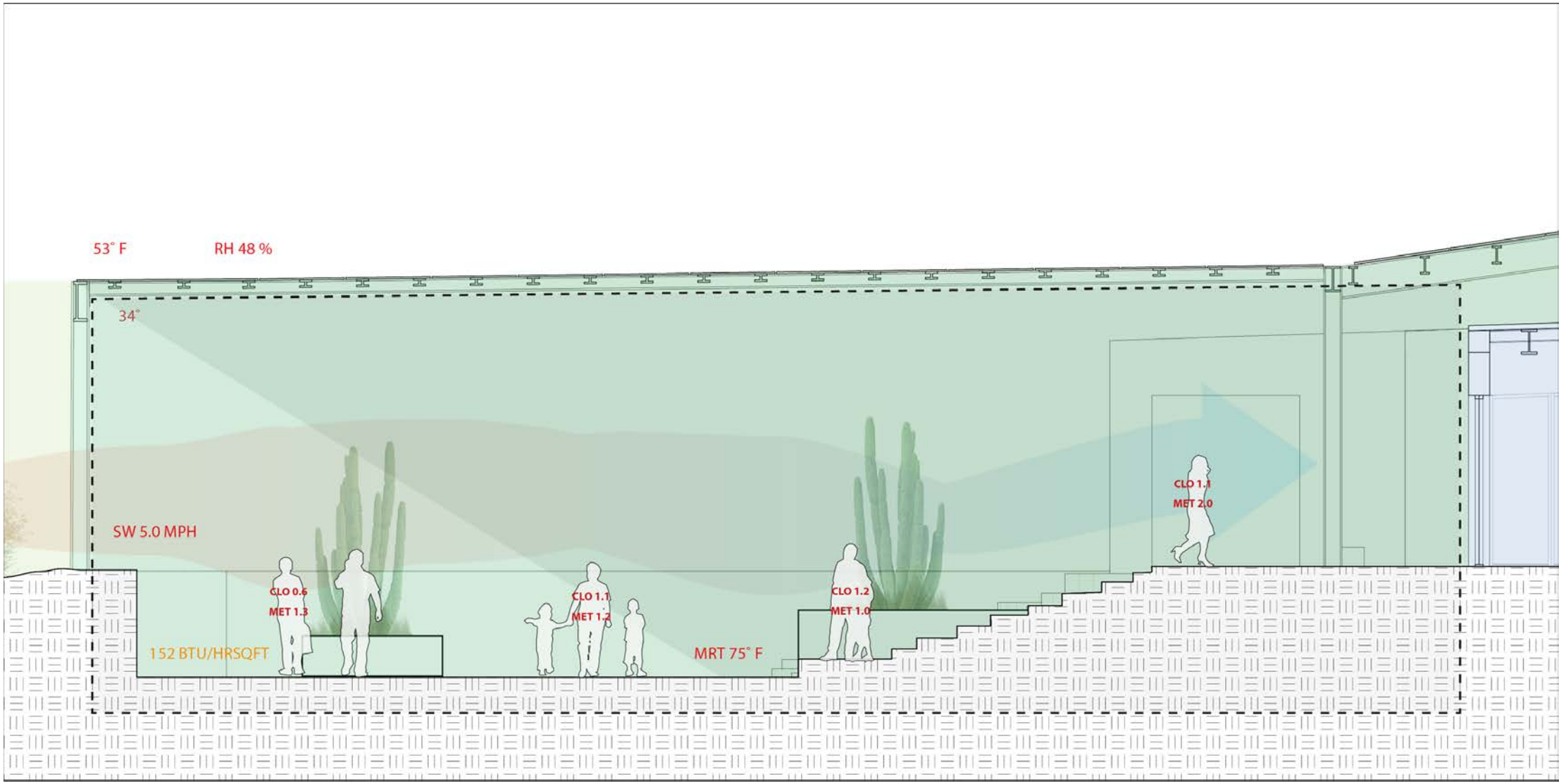
The Multi-Functional Area within the Community Center Design in Organ Pipe Cactus National Monument is one of the Architectural program functions that has been allocated from a space within the Climatically Controlled Layer into the Semi Enclosed Layer within the Designed Case Scenario. Through the Spatial Composition Concept analysis of the spatial requirements, the activities, conditions, and components are all understood. Activities that would be conducted within the Multi-Functional Area in this Community Center Design are such as gathering events, social meetings, and community day instances. These activities all require a space that is expansive in nature that allows for larger gatherings. The conditions where these activities could exist are not exclusive to an interior setting if Human Thermal Comfort is achieved. Human Thermal Comfort is achieved due to the fact that there exist and semi enclosure of components that mitigate the external climatic conditions in order to achieve the Human Thermal Comfort range within these design spaces. Therefore, utilizing the components that create the space and their manipulation achieves the Spatial Standards and Human Thermal Comfort making the Multi-Functional Area an acceptable space within the Semi Enclosed Layer.



South

12:00 PM Solar Time

North



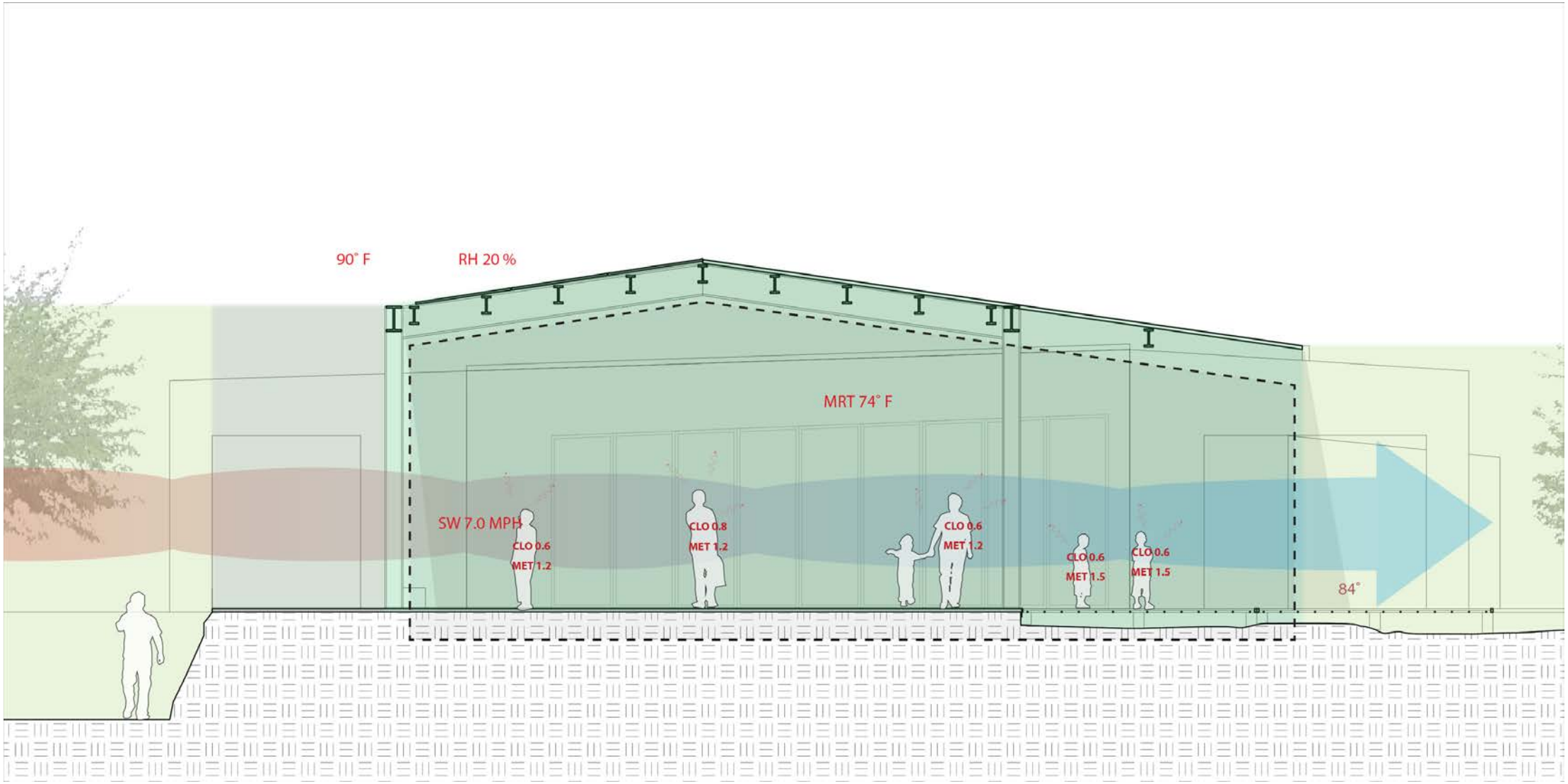
South

12:00 PM Solar Time

North

Educational Spaces

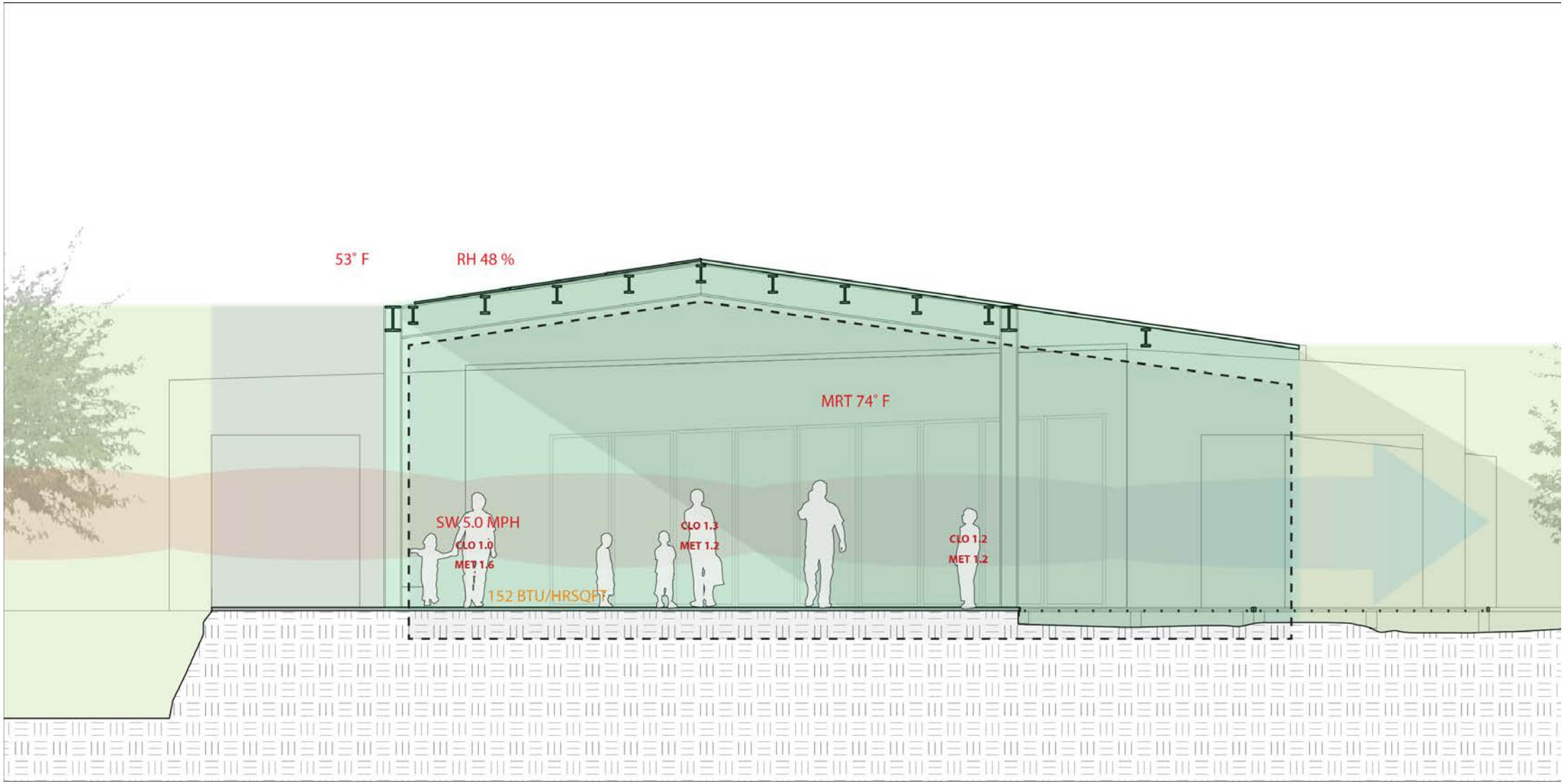
The Educational Spaces within the community center design and Organ Pipe Cactus National Monument is intended to be spaces where both adults and children can have educational seminars and gatherings in order to explore the Sonoran Desert and understand the science behind its many facets. The Educational Space is part of Architectural program functions that has been shifted from a space within the Climatically Controlled Layer into a space in the Semi Enclosed Layer within the Designed Case Scenario. Through analyzing the spatial requirements through the Spatial Composition Concept method, the activities, conditions, and components can be derived. The activities that are conducted within this space are gatherings that occur on a semi daily basis of one to two hour long periods as well as some educational seminars that take tours through the Sonoran Desert. The conditions required in order to conduct these activities are of minimum enclosure as well as the maintenance of Human Thermal Comfort. Thought the design and manipulation of the components within the spatial composition to serve Human Thermal Comfort and the spatial requirements the Educational Space is able to exist within the Semi Enclosed Layer without a compromise on the value of that space.



South

12:00 PM Solar Time

North



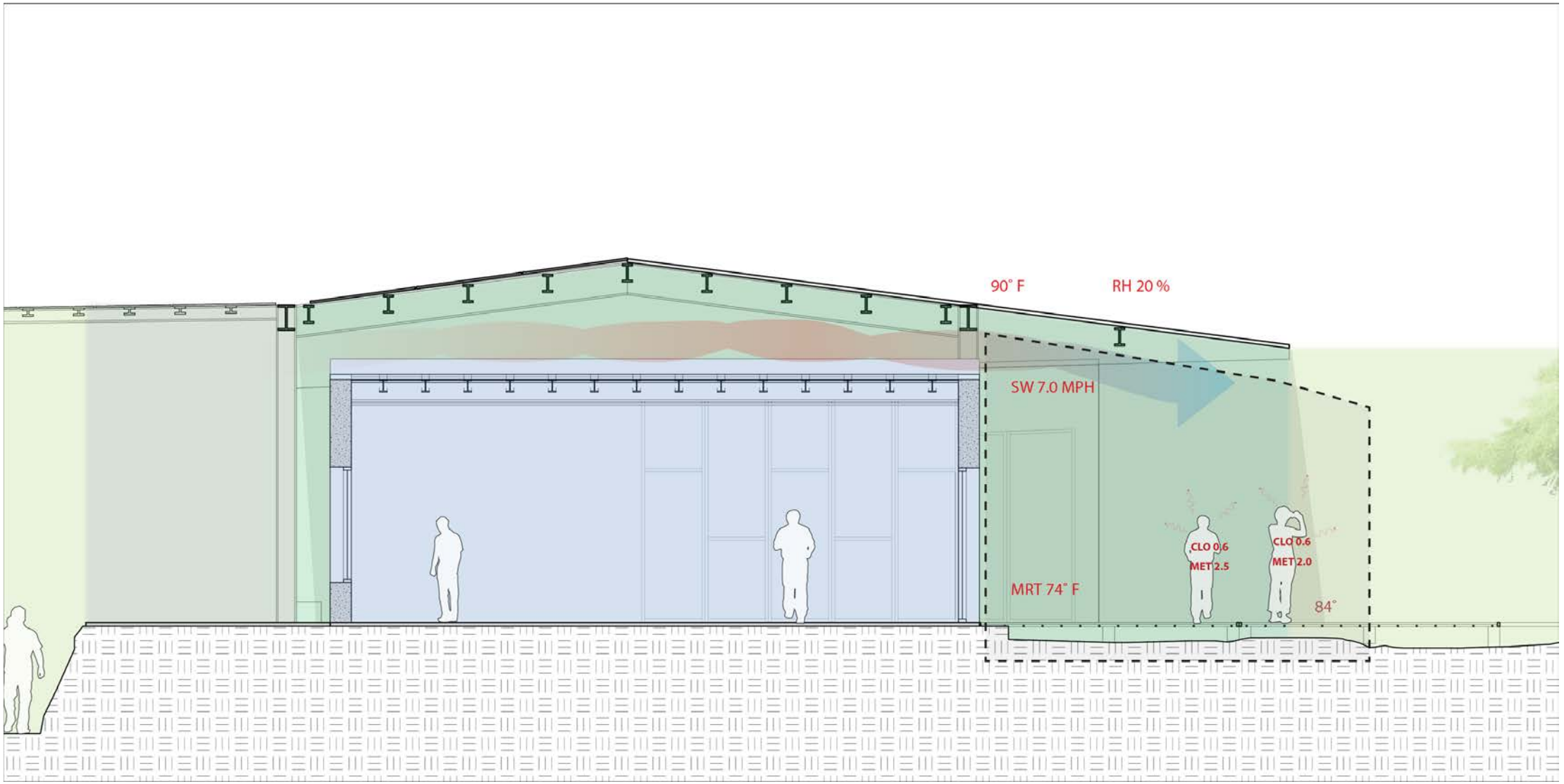
South

12:00 PM Solar Time

North

Fitness Area

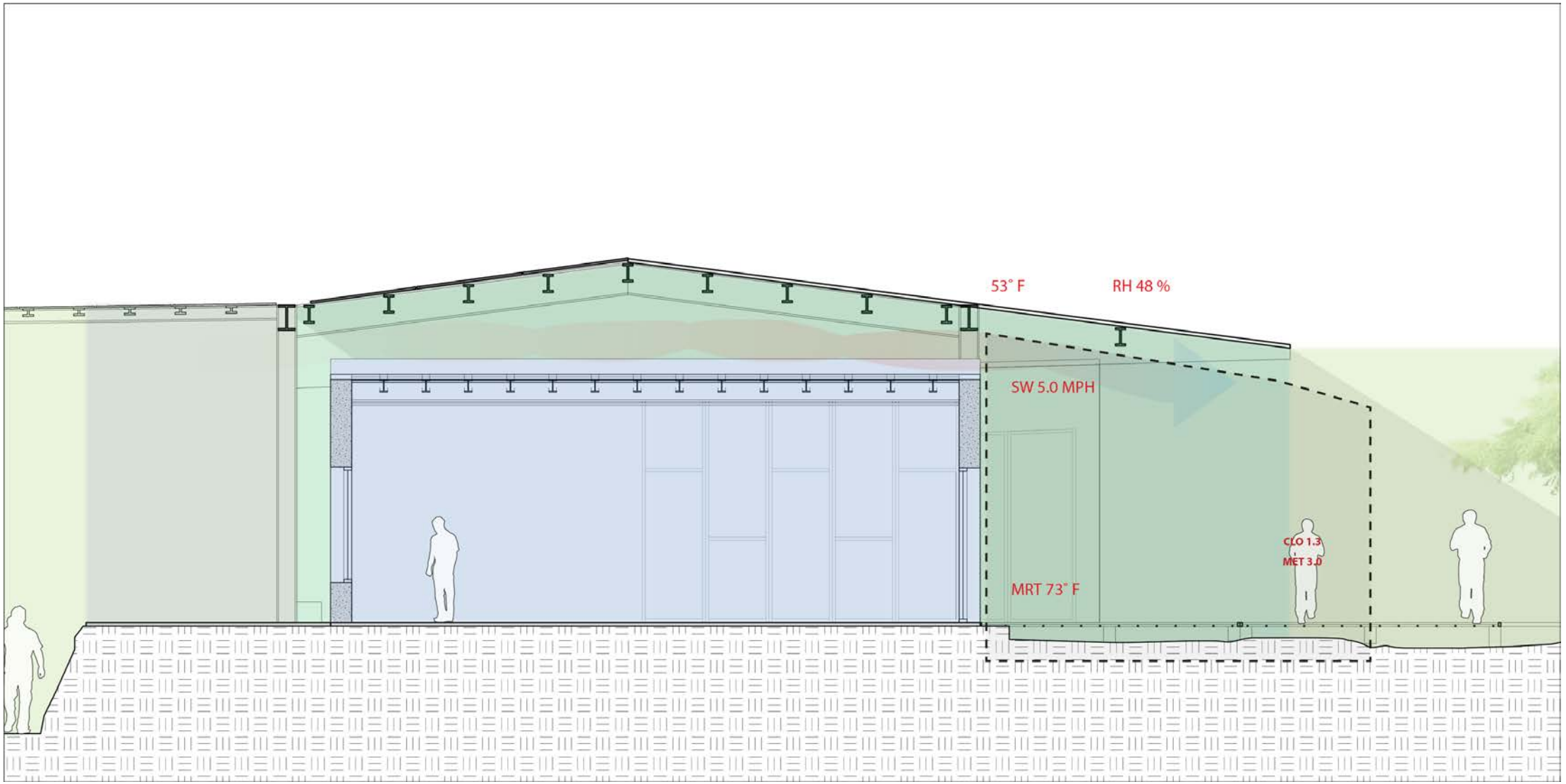
The Fitness Area is one of the Architectural program functions that has been shifted from a space within the Climatically Controlled Layer into a space in the Semi Enclosed Layer within the Designed Case Scenario. Through analyzing the spatial requirements through the Spatial Composition Concept method, the activities, conditions, and components can be derived. Activities that would be conducted within the Fitness Area in this Community Center design are body stretching, cardio activities, and weight resistance training. These activities all require the inhabitants to have a high MET value as well as fitness clothing attire. The condition where these activities could exist are not exclusive to an interior setting as long as Human Thermal Comfort is achieved. Typically, Human Thermal Comfort is achieved due to the fact that when engaging in fitness activities the Human Thermal Comfort range is greatly expanded. Therefore, throughout the design and manipulation of the components to achieve the spatial requirements and Human Thermal Comfort, the Fitness Area space is acceptable to exist within the Semi Enclosed Layer.



South

12:00 PM Solar Time

North

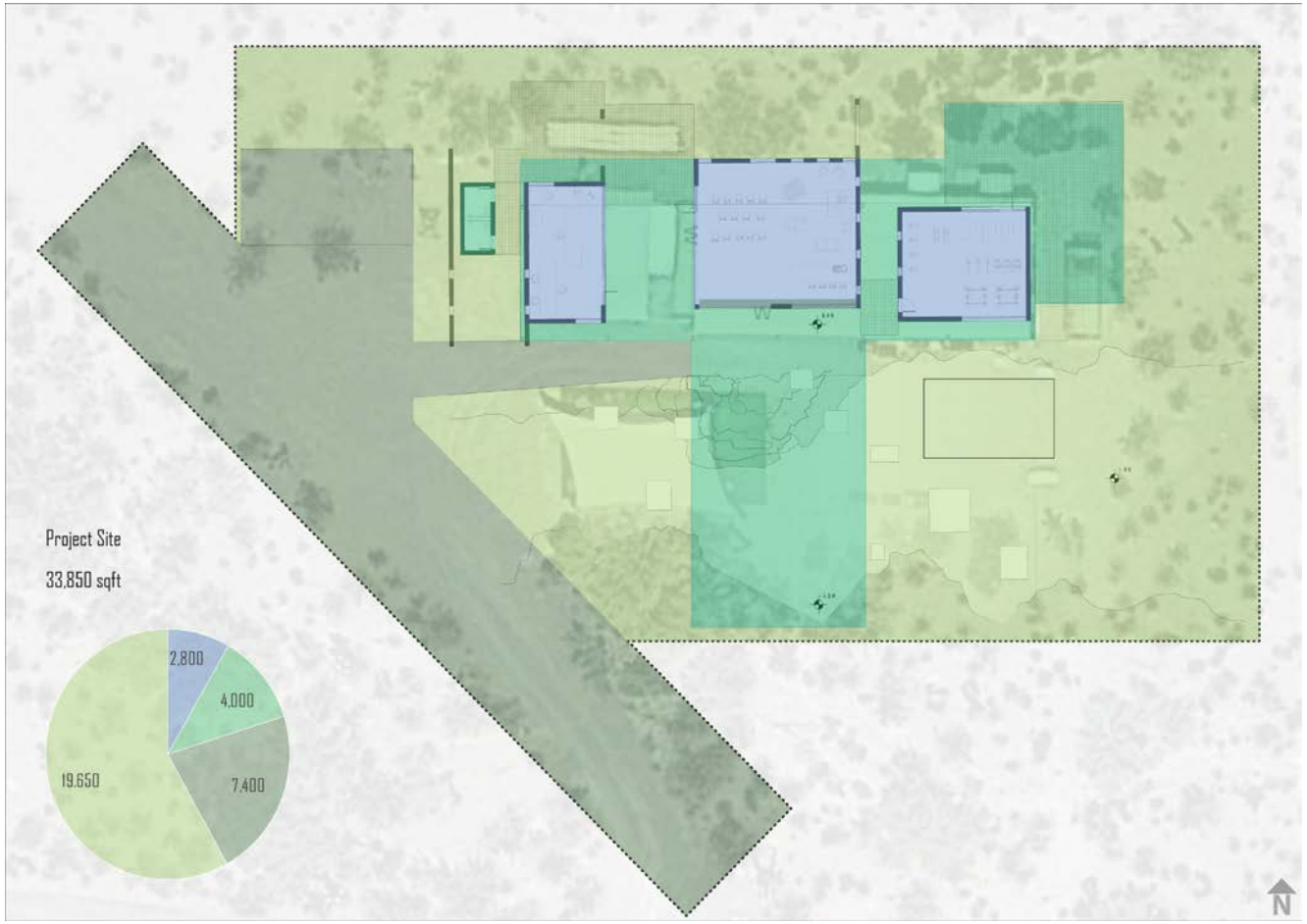


South

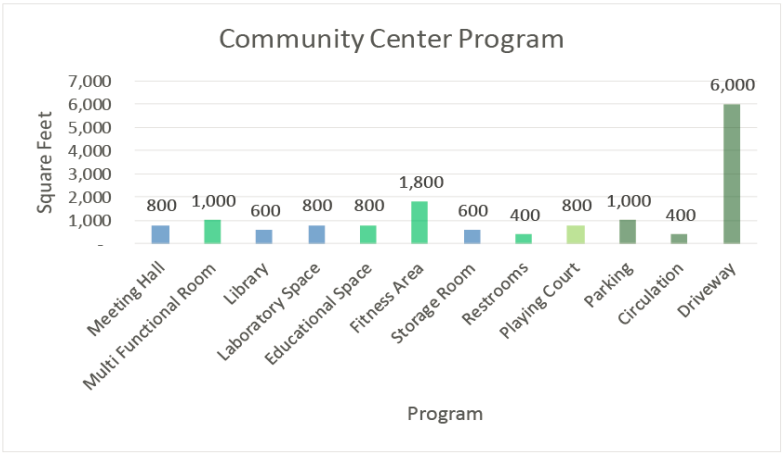
12:00 PM Solar Time

North

Community Center Designed Case

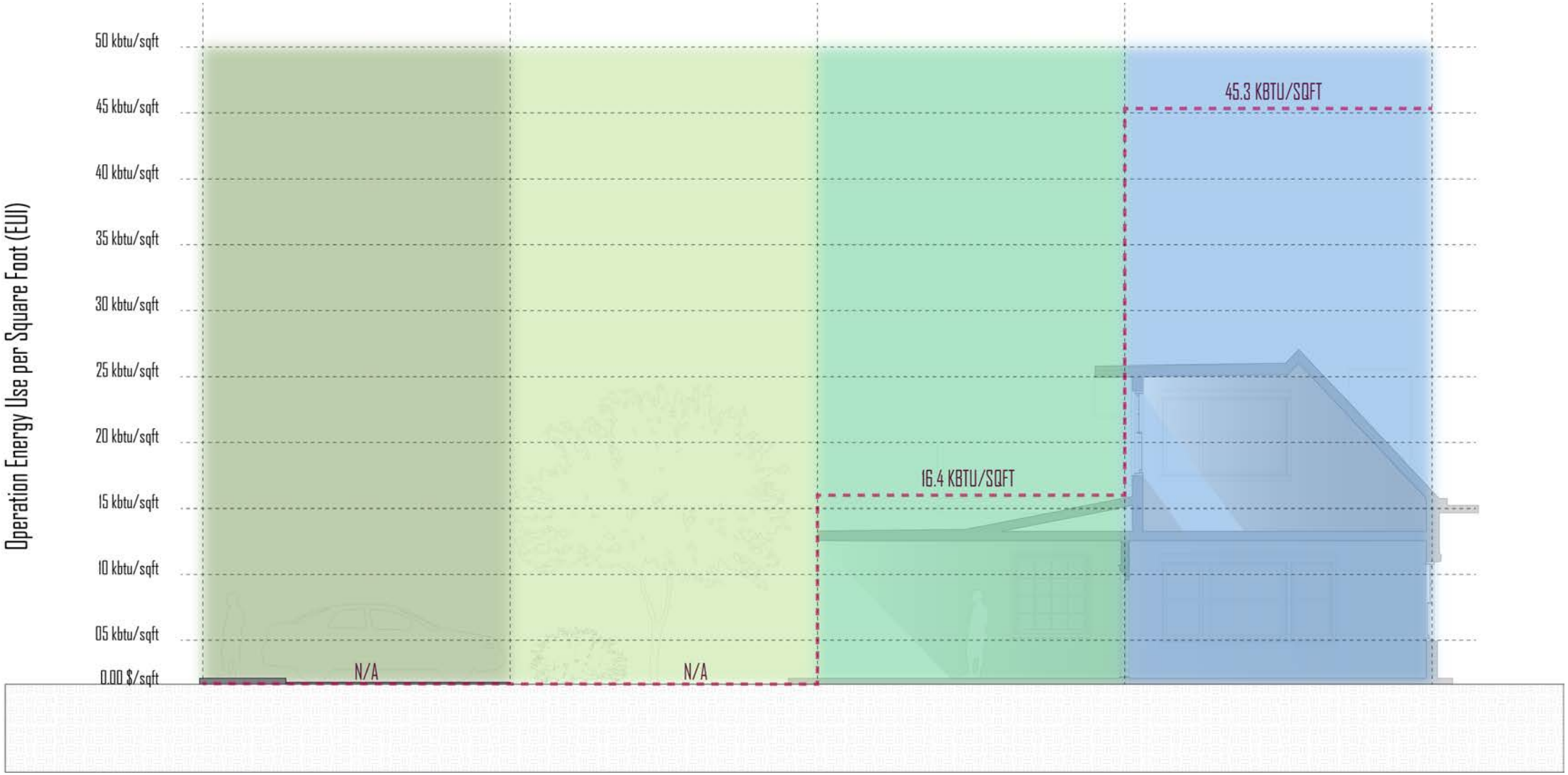


Meeting Hall	800
Multi Functional Room	1,000
Library	600
Laboratory Space	800
Educational Space	800
Fitness Area	1,800
Storage Room	600
Restrooms	400
Playing Court	800
Parking	1,000
Circulation	400
Driveway	6,000
TOTAL	**15,000**



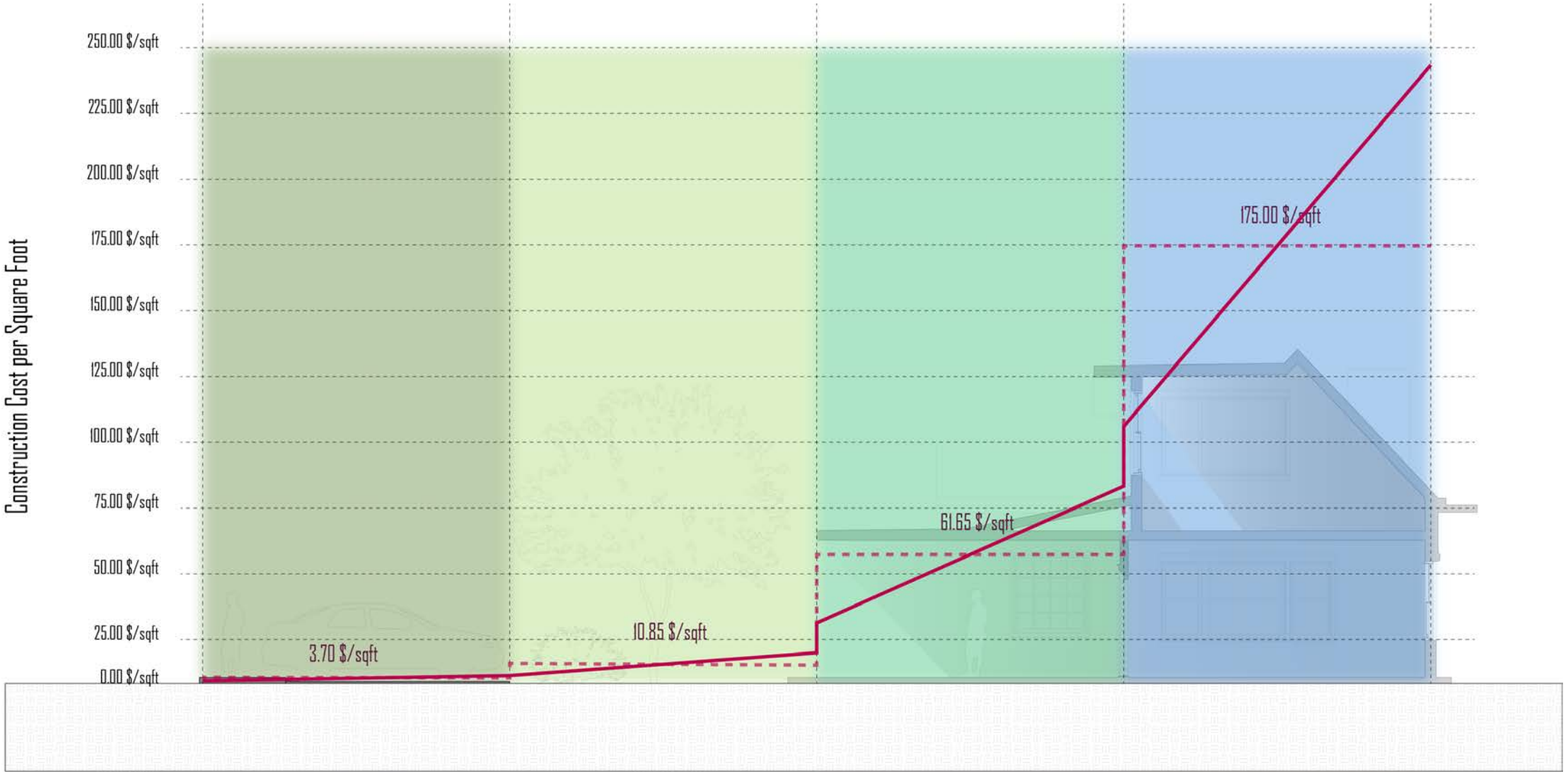
Connection Layer	Landscape Layer	Semi Enclosed Layer	Climatically Controlled Layer

The site where the design is take place and is located in Southern Arizona on the Organ Pipe Cactus National Monument. The designated design for this specific site is that of a Community Center. the site area is approximately 33,850 square feet. This area is the total extent of the site boundaries and is the basis for the design. all the Built Environment Spatial Layers will be allocated within the boundaries of this site. The boundaries will allow for a limitation in space allocation to occur which will be the basis of the analysis in terms of sustainability through the Built Environment Spatial Layers.



Star, Energy. (2013). Energy Use Intensity (EUI). US DOE.

EPA (2015) eGRID, U.S. annual non-baseload CO2 output emission rate, year 2012 data. U.S. Environmental Protection Agency, Washington, DC.



Schittich, C. (2007). Cost-effective building: Economic concepts and constructions. München;Boston;Basel;: Edition Detail, Institut für internationale Architektur Dokumentation.
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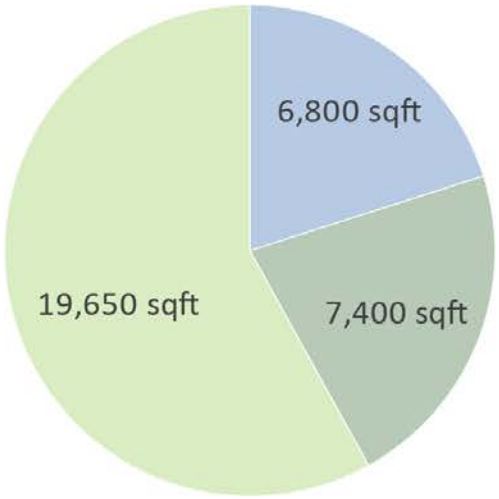
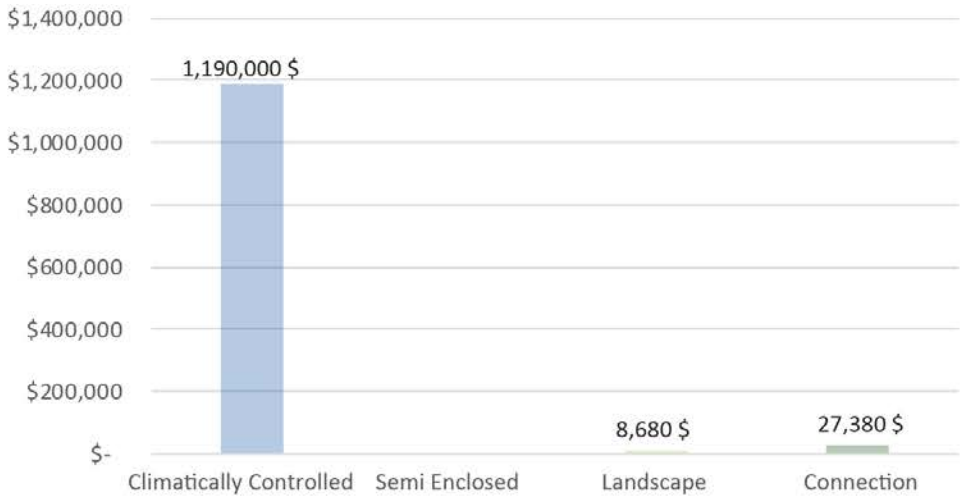
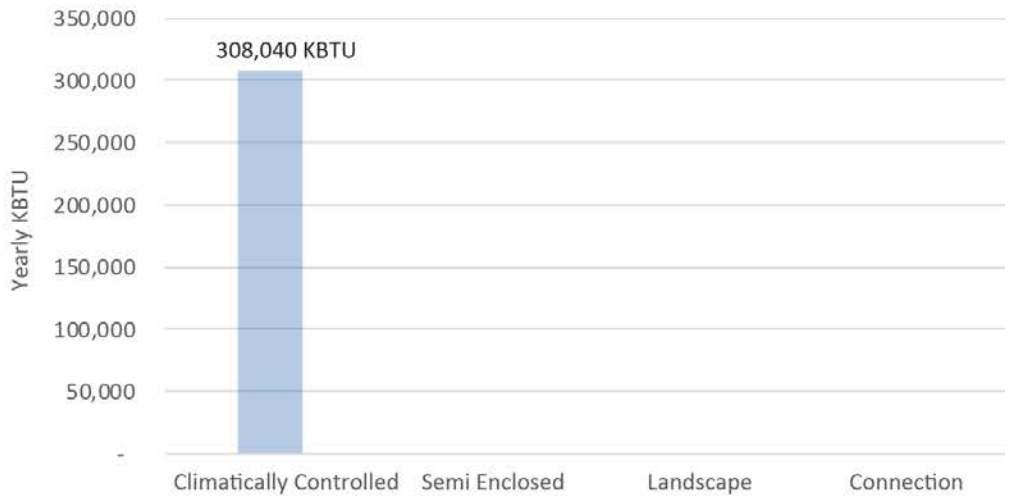
Community Center Base Case

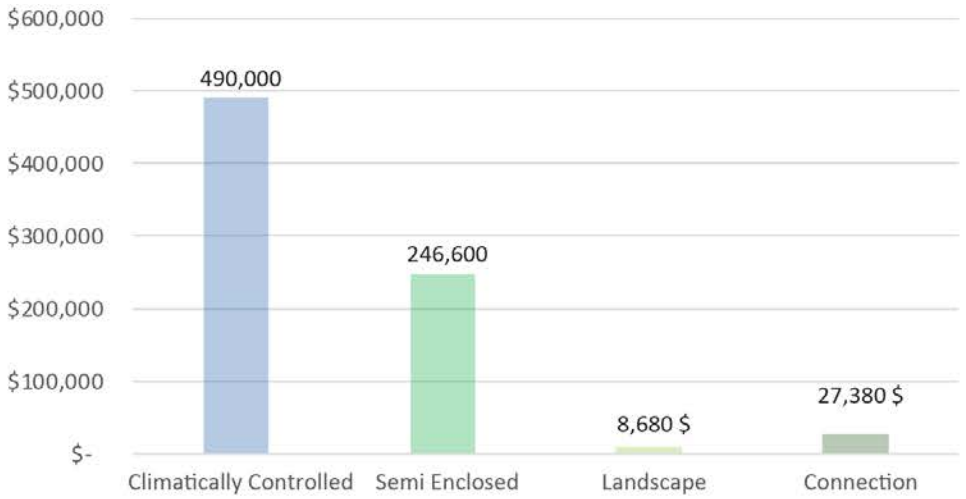


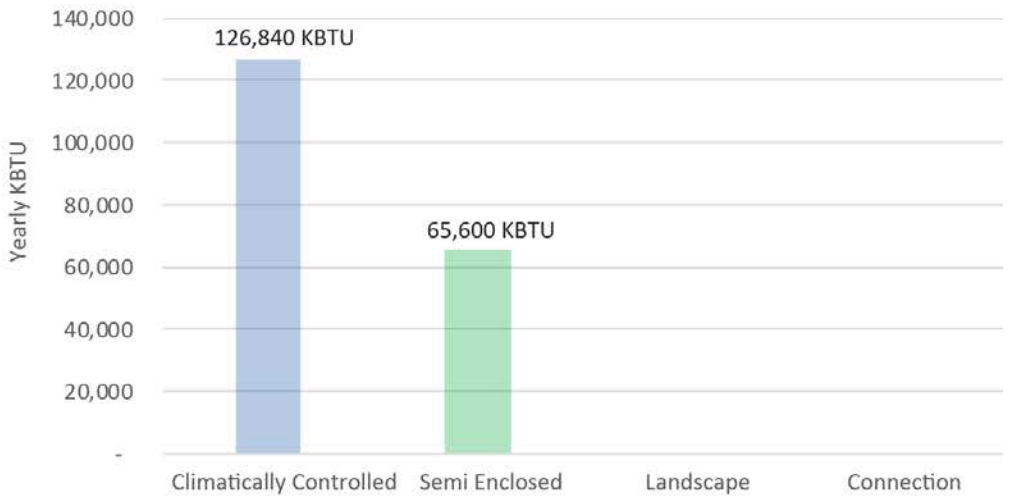




TOTAL Total Construction Cost **1,226,060** $ Total Energy Consumption **308,040** KBTU/YEAR

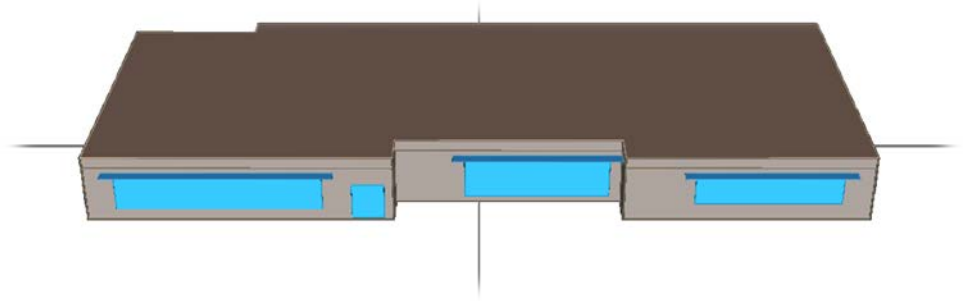
Community Center Designed Case

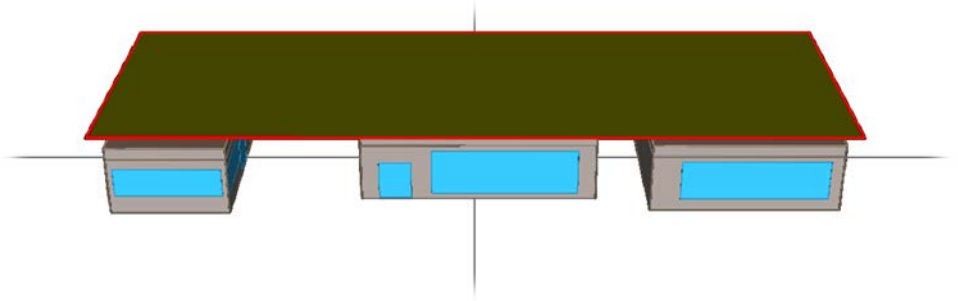


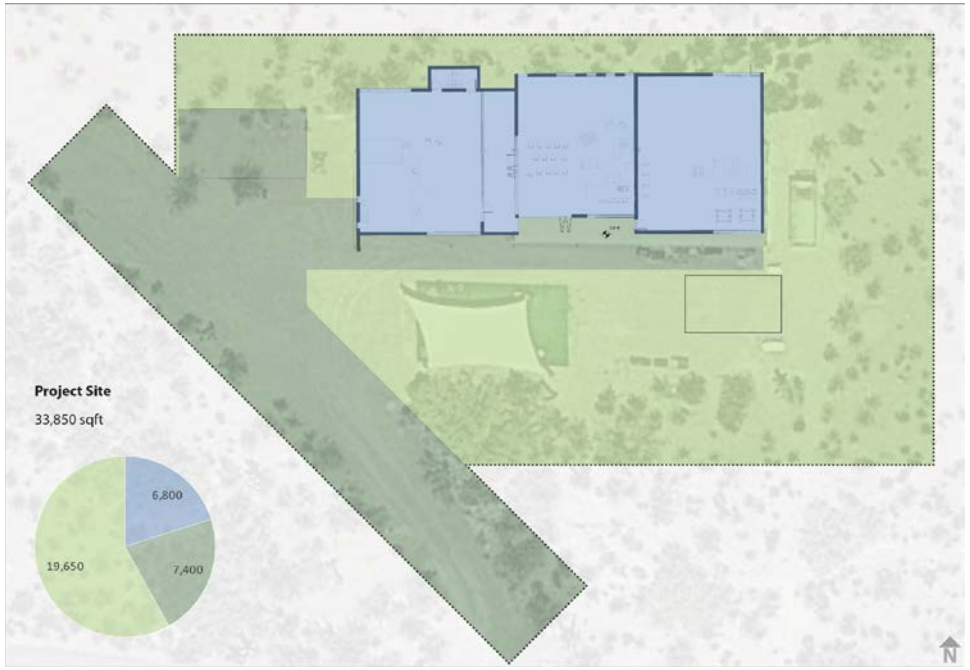


TOTAL Total Construction Cost **772,660** $ Total Energy Consumption **192,440** KBTU/YEAR

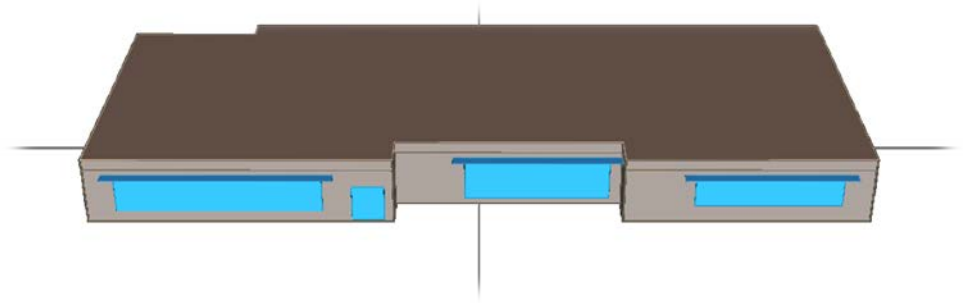
Energy Modeling Simulation

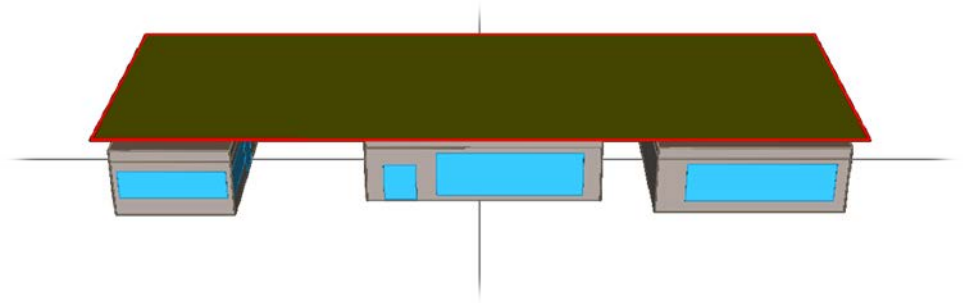






Energy Modeling Simulation





Building Envelope Constructions

	Roof Surfaces		Above Grade Walls	
Construction:	Metal Frame, > 24 in. o.c.		8 in. CMU	
Ext Finish / Color:	Roof, built-up	'Medium' (al	CMU (no ext finish)	'Medium' (al
Exterior Insulation:	3 in. polyurethane (R-18)		- no board insulation -	
Add'l Insulation:	- no batt or rad barrier -		Perlite Filled	
Interior Insulation:			R-6 wd furred insul	

Ground Floor

Exposure:	Earth Contact	Interior Finish:	- no surface finish -
Construction:	6 in. Concrete		
Ext/Cav Insul.:	- no perimeter insulation -		

Infiltration (Shell Tightness): Perim: 0.038 CFM/ft2 (ext wall area) | Core: 0.001 CFM/ft2 (floor area)

HVAC System Definition

System Type Name: HVAC System 1

Cooling Source: DX Coils

Heating Source: Furnace

System Type: Packaged Multizone with Furnace

System per Area: System per Floor

Return Air Path: Ducted

Component Name Prefix: S1

Suffix:

(# Prefix+Suffix characters must be <= 4)

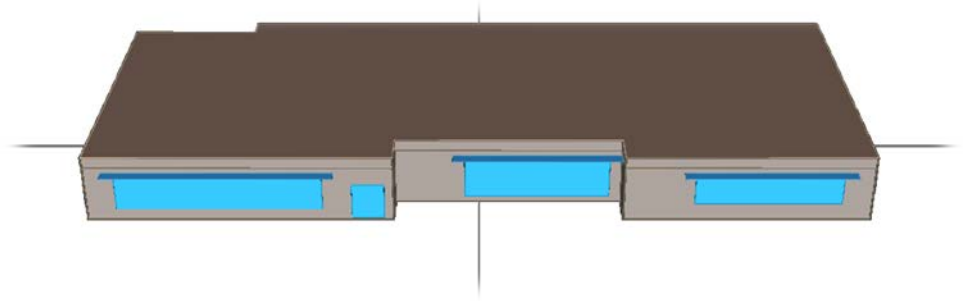
☑ Prevent duplicate model components

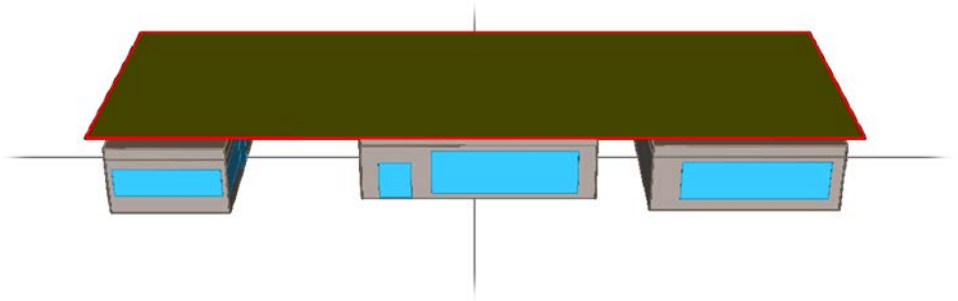
System Assignment to Thermal Zones*

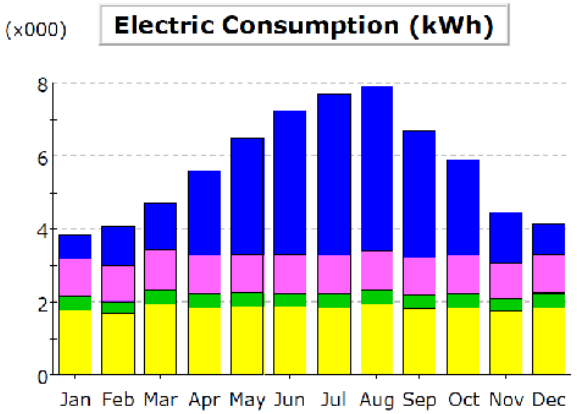
	Shell Component(s)	Description of Assigned Zones
1	Bldg Envelope & Loads 1	All Zones
2	- undefined -	

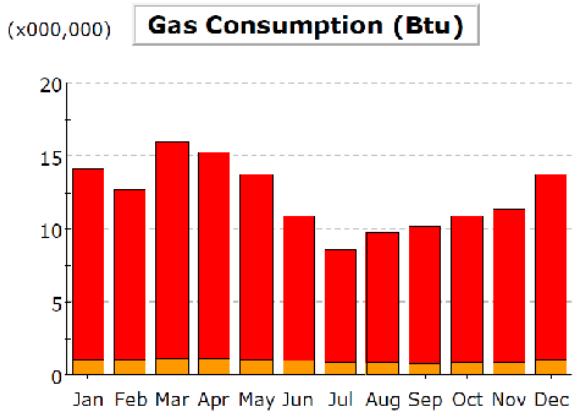
* Assignments here are superseded by HVAC assignments made on the zone group screen (by shell)

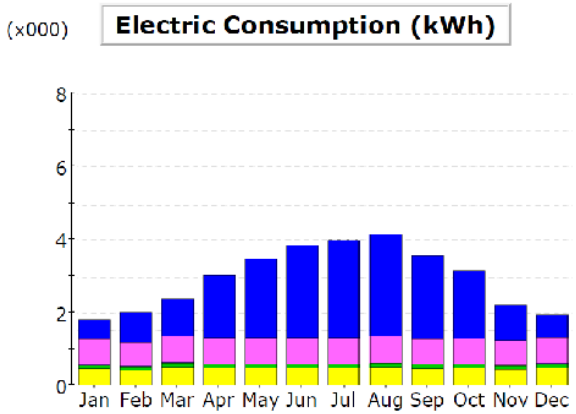
Energy Modeling Simulation

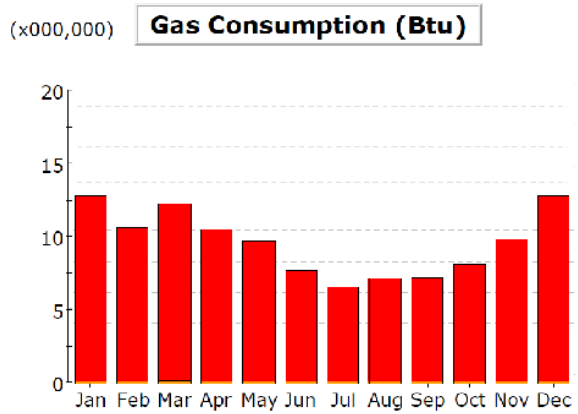




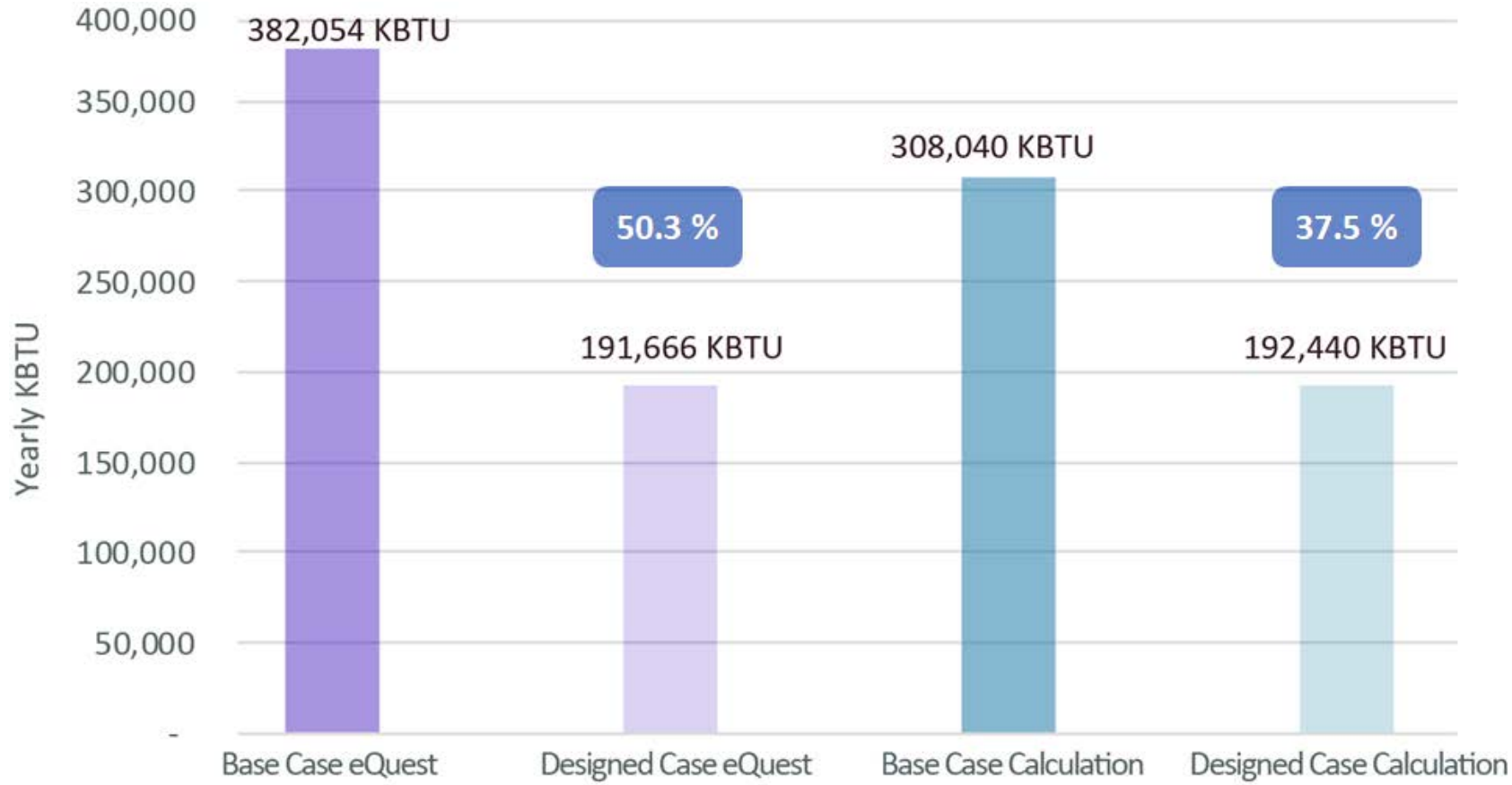


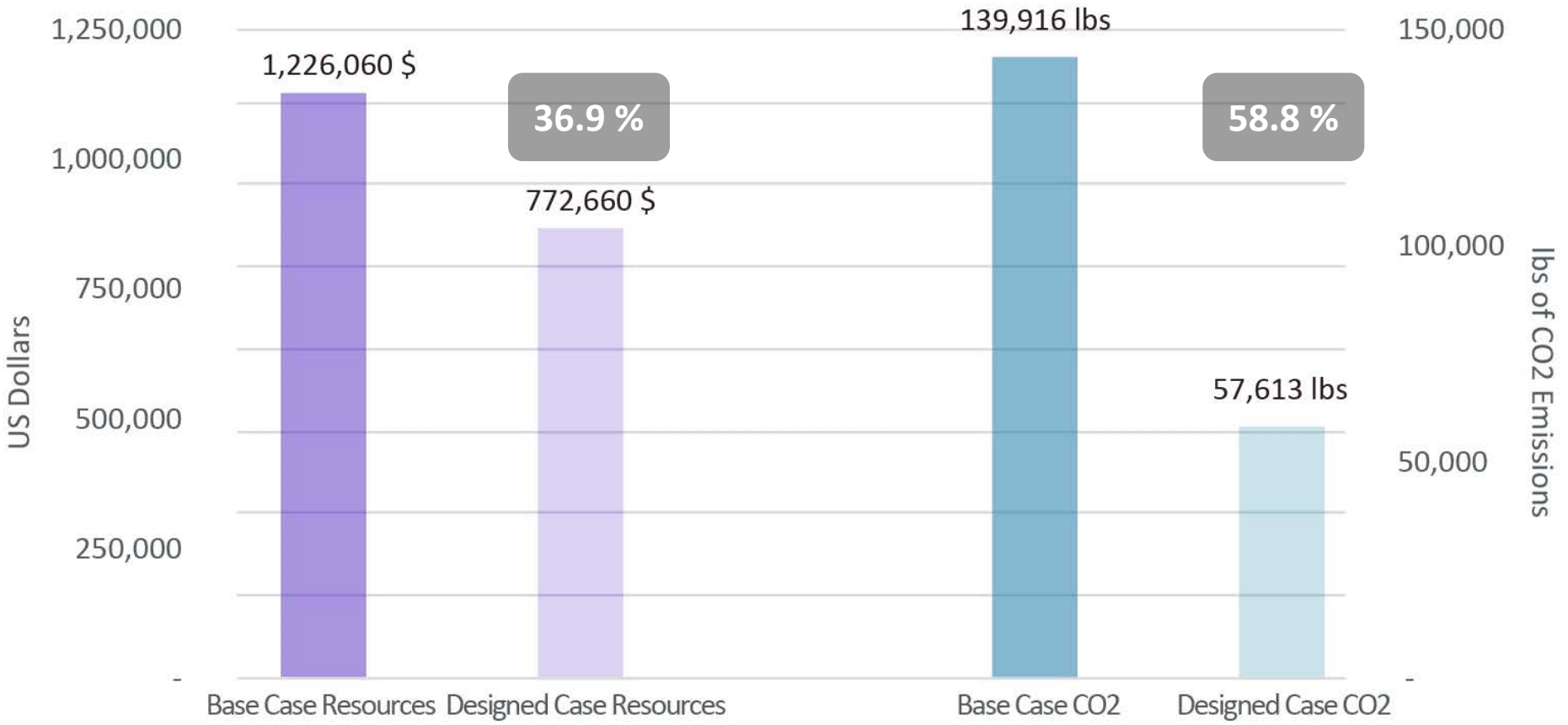






TOTAL Total Energy Consumption **382,054** KBTU/YEAR Total Energy Consumption **191,666** KBTU/YEAR


400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
Yearly KBTU
382,054 KBTU
50.3 %
191,666 KBTU
308,040 KBTU
37.5 %
192,440 KBTU
Base Case eQuest
Designed Case eQuest
Base Case Calculation
Designed Case Calculation



TOTAL	Total C02 Emissions	**139,916**	lbs	Total C02 Emissions	**57,612**	lbs
TOTAL	Total Construction Cost	**1,226,060**	$	Total Construction Cost	**772,660**	$

Conclusion

Through the understating of spaces and means of sustainable adaptation within them. The Outside-In Method engages the composition of these spaces within the Built Environment Spatial Layers advancing the notions of Sustainable Design.

Conclusion

This Application looked at Sustainability through Energy consumption. The Framework of the Built Environment Spatial Layers allows for further engaging in such fields as resources, emissions, embodied energy, etc. touching upon all the Dimensions of Sustainability. Pushing the notions of Green Engineering to the future

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THANK YOU

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