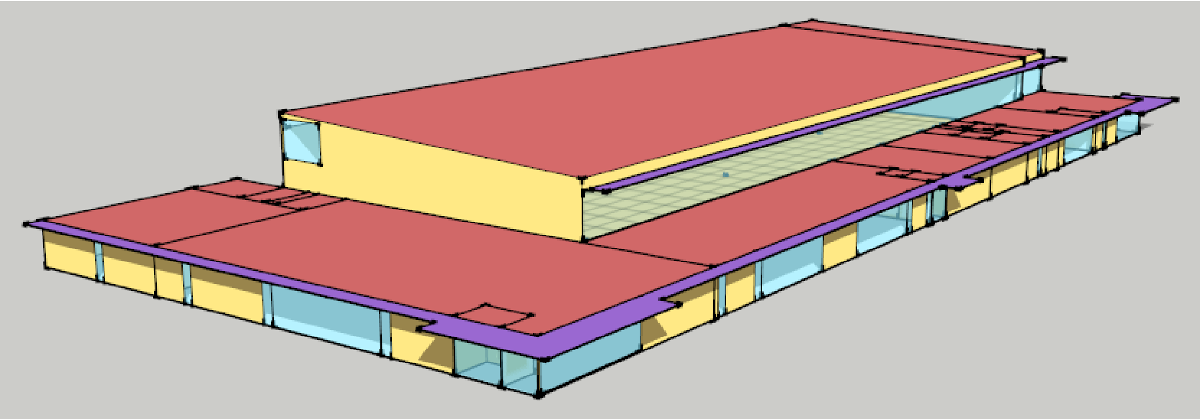
Low Energy Consulting

Preliminary Building Performance Simulation Report

Energy, Daylighting & Ventilation Analysis

Sports Complex



For:
OpeningDesign

By:
Low Energy Consulting, LLC

Date:
05/06/2015

Rev: 000

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Disclaimer: ASHRAE 90.1-2007 indicates that neither the Proposed nor the Baseline building performances are predictions of actual energy consumption or costs for the design after construction. Actual experience will differ from these calculations due to variations in occupancy, building operation, maintenance, weather file, energy use not covered by the Performance Rating Method (PRM) procedure, changes in energy rates between design of the building and occupancy, and the precision of the calculation tools.

Low Energy Consulting, LLC has taken reasonable efforts to ensure the accuracy of the energy model input and output in both the Proposed and Baseline models. However, to account for variations in operation, occupancy schedule and the control strategies implemented …etc., adjustments to the energy model will be necessary. This procedure is known as "Model Calibration" and is not included in the scope of work.

Additionally, please note that this effort does not guarantee achievement of points or certification under LEED, Estidama, BREEAM, Greenstar or other international or local rating system.

Table of Contents

Executive Summary

We highly appreciate the opportunity to start the Building Performance Simulation effort for the Sports Complex at the early stages of the design process. High-performance buildings require an integrated design approach to achieve optimal systems' integration. A holistic approach to building design has been implemented by identifying, analyzing and optimizing interrelationships and synergies between major building systems and components.

The report intends to present the input parameters modeled for the proposed and baseline models and provides design alternatives in order to optimize thermal and visual comfort in the Sports Complex.

The following tasks will be performed in the detailed analysis phase:

- Coordinate and finalize interior and exterior lighting design parameters
- Provide detailed daylighting simulation using Radiance
- Coordinate and finalize process and receptacle loads
- Provide natural ventilation analysis
- Specify As Designed Proposed HVAC (Capacities, efficiencies, fan power … etc)
- Finalize the energy performance based on 100% CD's

1 ASHRAE 90.1-2007

The Performance Rating Method PRM in ASHRAE 90.1-2007 Appendix G has been used for the energy simulation of the Sports Complex. All design Alternatives are expected to meet and exceed the ASHRAE 90.1-2007 requirements. ASHRAE's Advanced Energy Design Guides have been used to determine shading sizes, interior lighting and HVAC efficiencies.

Climate Zone 6 Recommendation Table for Small Retail Buildings

	Item	Component	Recommendation (Minimum or Maximum)	How-To Tips in Chapter 5	✓
Envelope	Roof	Insulation entirely above deck	R-20 c.i.	EN1-2, 17, 20-21	
		Metal building	R-13 + R-19	EN1, 3, 17, 20-21	
		Attic and other	R-38	EN4, 17-18, 20-21	
		Single rafter	R-38 + R-5 c.i.	EN5, 17, 20-21	
		Solar reflectance index (SRI)	No recommendation	EN1	
	Walls	Mass (HC > 7 Btu/ft^2)	R-13.3 c.i.	EN6, 17, 20-21	
		Metal building	R-13 + R-13	EN7, 17, 20-21	
		Steel framed	R-13 + R-7.5 c.i.	EN8, 17, 20-21	
		Wood framed and other	R-13 + R-7.5 c.i.	EN9, 17, 20-21	
		Below-grade walls	R-7.5 c.i.	EN10, 17, 20-21	
	Floors	Mass	R-12.5 c.i.	EN11, 17, 20-21	
		Steel framed	R-30	EN12, 17, 20-21	
		Wood framed and other	R-30	EN12, 17, 20-21	
	Slabs	Unheated	R-10 for 24 in.	EN13, 17, 19-21	
		Heated	R-10 full slab	EN14, 17, 19-21	
	Doors – Opaque	Swinging	U-0.50	EN15, 20-21	
		Non-swinging	U-0.50	EN16, 20-21	
	Vertical Glazing Including Doors	Area (percent of gross wall)	40%	EN22-23, 27, 28, 29	
		Thermal transmittance	U-0.38	EN22, 25	
		Solar heat gain coefficient (SHGC)	N, S, E, W - 0.41; N only—0.41	EN22	
		Exterior sun control (S, E, W only)	Projection factor > 0.5	EN26, DL3	
	Skylights	Area (percent of gross roof)	3%	EN24	
		Thermal transmittance	U-069		
		Solar heat gain coefficient (SHGC)	0.46	DL3-10	

Fig.1- Advanced Energy Design Guides Recommendations

2 Climate Analysis

The Sports Complex project is located in Milwaukee, Wisconsin. According to ASHRAE, Milwaukee is located in Climate Zone 6A. Heating Degree Days are equal to 4069 while Cooling Degree Days are 1327. This indicates that the building will be heating dominated and therefore passive design must enhance the solar penetration during the winter and block unwanted solar gains in the summer. This will reduce both the heating and cooling loads resulting in improved energy and daylighting performance. Daylighting design strategies will further reduce the lighting and cooling energy consumption.

TABLE D-1 US and US Territory Climatic Data *(continued)*

State City	Latitude	Longitude	Elev., m	HDD18	CDD10	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.–4 p.m. 13 < Tdb < 21
(Wisconsin cont.)									
Marinette	45.10 N	87.63 W	184	4477	1262	N.A.	N.A.	N.A.	N.A.
Milwaukee WSO AP	42.95 N	87.90 W	204	4069	1327	–22	30	22	618
Racine	42.70 N	87.77 W	181	3982	1366	N.A.	N.A.	N.A.	N.A.
Sheboygan	43.75 N	87.72 W	197	3937	1328	N.A.	N.A.	N.A.	N.A.
Stevens Point	44.50 N	89.57 W	328	4449	1292	N.A.	N.A.	N.A.	N.A.

Fig.2- ASHRAE Whether Data

3 Design Model and Zoning

The Proposed and Baseline design models have been specified in accordance with Table G3.1-1. Thermal zones have been specified in accordance with Table G3.1-7 [Thermal Blocks – HVAC Zones Designed]. All areas specified in the architect's drawings have been captured in the energy model's geometry. Please refer to the Appendix for more details.

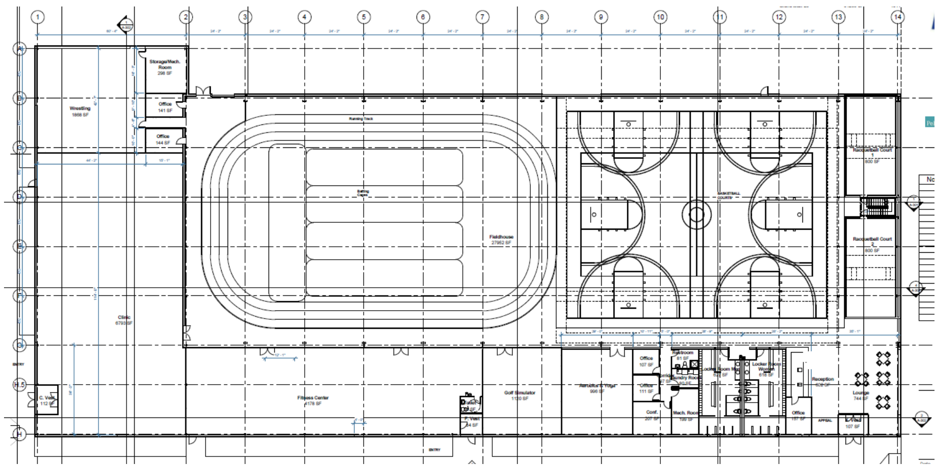


Fig.3- Floor Plan

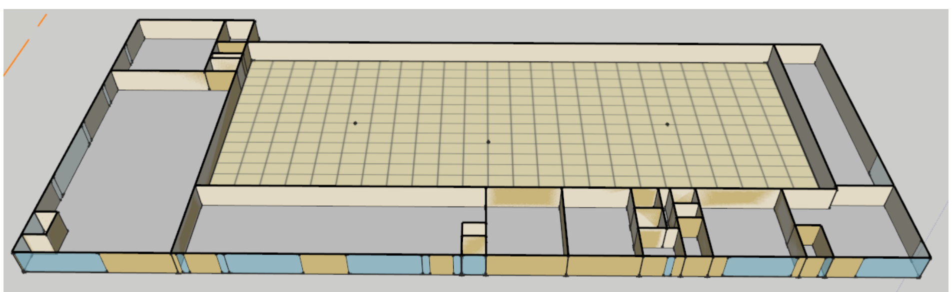


Fig.4- As Deigned Thermal Zones

4 Proposed Geometry Changes

The buildings orientation is ideal for passive heating and cooling design. The proposed geometry changes are based on the following design principles:

- Reducing glazing / openings on the north facade will reduce thermal losses and cold draught during the winter. Glazing is only provided to increase daylighting uniformity.
- Reducing the East and West opening to a minimum will reduce glare and unwanted solar gains.
- increasing the south facing glazing (solar glazing), will improve the energy performance and daylighting quality in the building without compromising thermal and visual comfort.
- Implementing solar gain management including shading (overhangs on south + vertical fins, if possible, on East and West facades + IR Treatment)

The proposed geometry changes have been closely coordinated with the architect. However, to investigate the impact of specific Energy Efficiency Measures EEMs, design alternatives were developed to test the impact of daylighting controls, shading, envelope parameters ... etc.

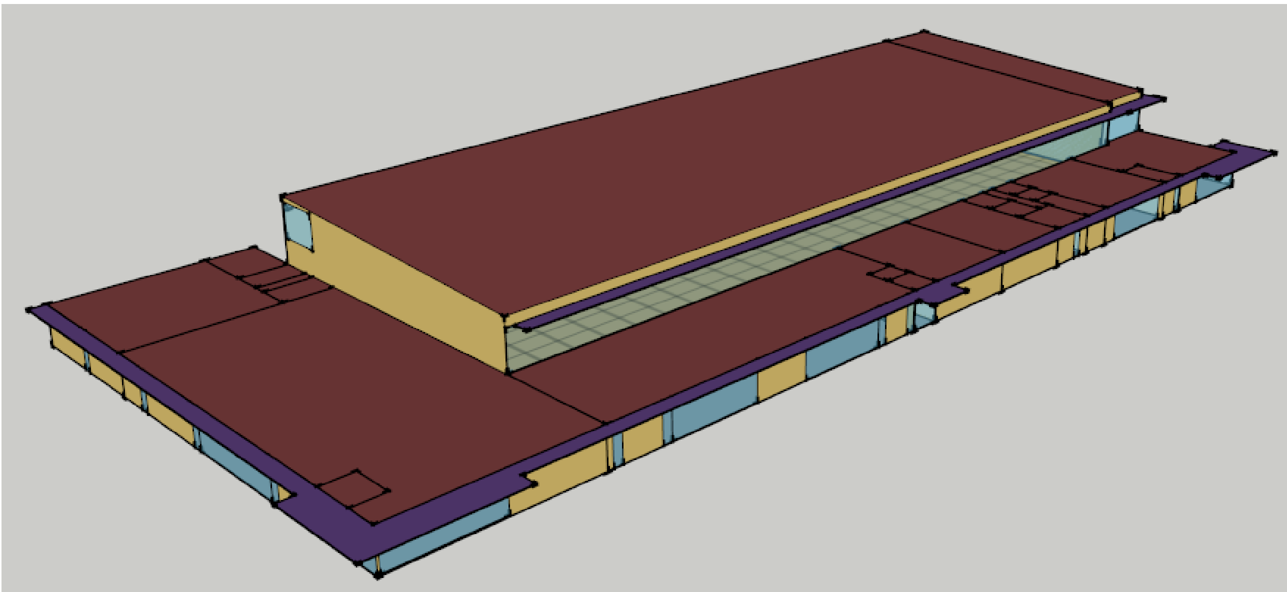


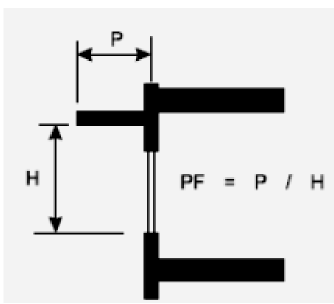
Fig.5- Proposed 3D Model

5 Shading Analysis

Shadows cast by the building and surrounding structures will vary in length and direction throughout the day and from season to season. Three conditions must be analyzed for the Shadows Cast analysis:

- Winter Solstice (December 21-22) : Shadow lengths increase during the winter season and are at a maximum on the winter solstice, which is the worst-case shadow condition.
- Summer Solstice (June 21-22) : Shadow lengths are shortest on June 21-22.
- Spring and fall equinoxes (March 20-21 and September 22-23) : Shadows are midway between the summer and winter extremes.

By definition, the projection factor (PF) is the ratio of the horizontal depth of the external shading projection divided by the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, in consistent units.



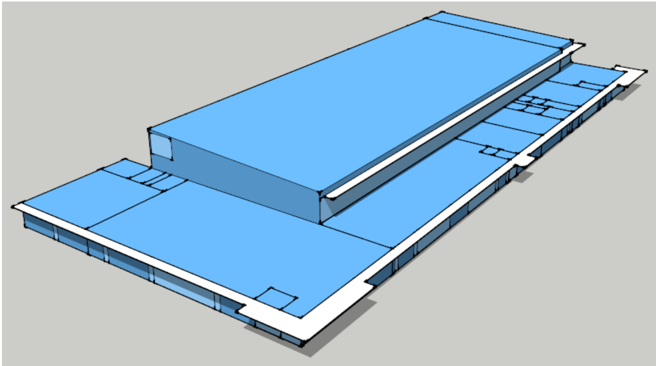
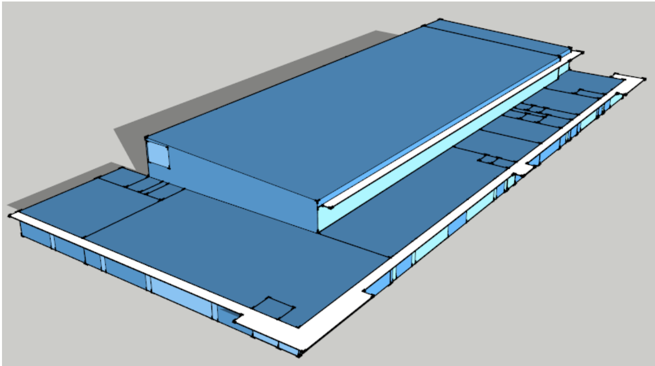
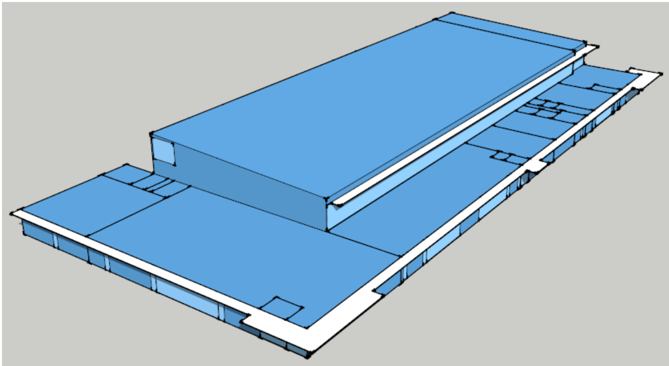
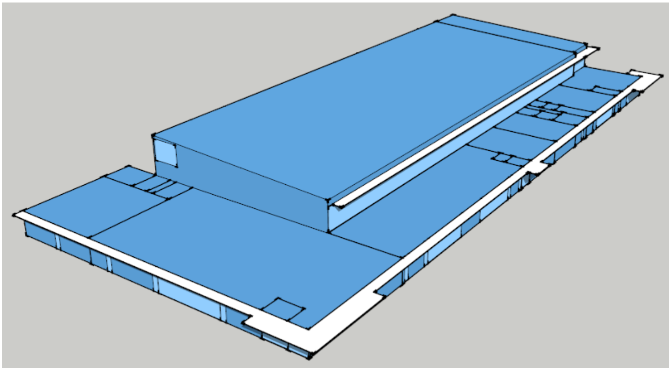
PF	H	P
0.41	**12.00**	**5.00**
0.50	12.00	6.00
0.54	12.00	6.48
0.58	12.00	6.96
0.62	12.00	7.44

After coordination with the architect, a solar gain management system has been designed. Per ASHRAE's recommendations, the projection factor PF for Climate Zone 6A should be greater than 0.5. The following calculations illustrate that with a PF of 0.5, the minimum overhang projection is 6 FT. However, due to structural restrictions and increased building construction costs, a projection of 5 FT has been specified throughout the East, South and West Facades.

Adjustable shading devices should be specified to complement the overhangs and give the occupants more control over the daylighting quality in the space.

The clinic and the lounge are the most critical zones to effectively shade due to East and West facing storefront and polycarbonate. Interior shading and glare control devices such as Venetian blinds or adjustable louvers should be specified to reduce unwanted solar gains and enhance daylighting quality. IR Treatment should be implemented in all East and West facing glazing.

Please see Table-1 for Shadows Cast images for the Winter Solstice, Summer Solstice and Spring and fall equinoxes. Please note that the effects of shading by surrounding buildings has not yet been evaluated. Therefore the following shading plots will change.

Table-1.Shadows Cast At 2 Pm	
Summer Solstice - Jun. 21st	
Winter Solstice - Dec. 21st	
Vernal equinox- Mar. 21st	
Autumnal Equinox -Sep. 21st	

6 Design Alternatives

Proposed design alternatives to optimize energy consumption and increase daylighting potential are provided in the following Table. The following parameters are modeled for Alt-2,3 & 4:

Table-1. Design Alternatives

Envelope / Alt #	Alt-1	Alt-2	Alt-3	Alt-4
Description	Baseline	To capture the impact of the improved envelope+ Occupancy Sensors	To capture the impact of the overhangs	To capture the impact of the daylighting controls + improved envelope
Ext. Wall - Resin Fiber Panel	R-13 + R-7.5 c.i.	Simple Saver 8" Stud - R-25	Simple Saver 8" Stud - R-25	Simple Saver 10" Stud - R-30
Ext. Wall - Metal Panel	R-13 + R-7.5 c.i			
Roof	R-20 c.i.	Simple Saver 8" Purlins - R-25	Simple Saver 8" Purlins - R-25	Simple Saver 10" Purlins - R-32
Storefront	U-0.45 SHGC - 0.4	Solarban 70 XL	Solarban 70 XL	Solarban 70 XL
Polycarbonate	U-0.45 SHGC - 0.4	arcoPlus547	arcoPlus547	arcoPlus547
Treatment	none	IR Treatment - E & W Glazing	IR Treatment - E & W Glazing	IR Treatment - E & W Glazing
Occ. Sensors	none	Yes	Yes	Yes
Daylighting Sens.	none	none	none	Yes
Overhangs	none	none	Projection =5.0 FT	Projection =5.0 FT

- The Simple Saver System is specified to control heat loss and gain through the sealed building exterior walls and roof.
- Polycarbonate arcoPlus547-Opal is specified [U-0.19 | SHGC - 0.45 | VLT-0.44]
- Solarban 70 XL + 14000 Series framing are specified for Storefronts [U-0.03 | SHGC - 0.68 | VLT-0.67]

7 Results

Table-2 below reflects Preliminary Peak loads for the different energy end uses in the building. In this analysis we will mainly focus on lighting, heating and cooling peak loads. Please refer to the Appendix for a complete Energy Cost Budget Report.

Table-2. Peak loads for the different energy end uses.

End Use	Energy Type	Alternative-1 Peak (kBtuh)	Alternative-2 Peak (kBtuh)	Alternative-3 Peak (kBtuh)	Alternative-4 Peak (kBtuh)
Lighting - Conditioned	Electricity	224	172	172	142
Lighting - Unconditioned	Electricity	2	2	2	2
Space Heating	Gas	3,782	3,643	3,524	3,219
Space Cooling	Electricity	1,186	1,157	1,100	1,055
Heat Rejection	Electricity	149	145	138	134
Fans - Conditioned	Electricity	274	245	338	326
Receptacles - Conditioned	Electricity	14	14	14	14

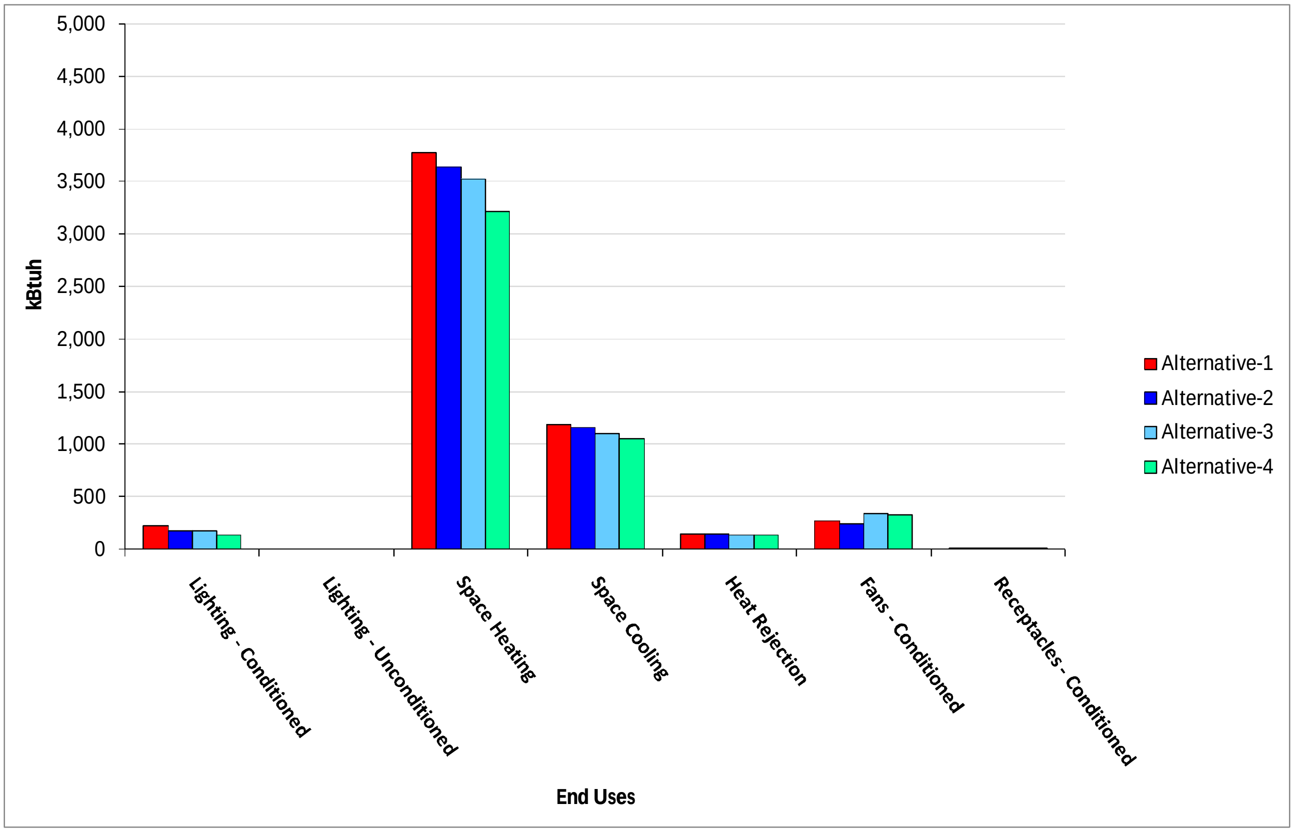


Fig.6- Peak Loads Comparaison

8 Interpretations

The following table provides the percent reduction on peak loads for all end uses. Alternative 2 is compared to Alternative 1. Alternative 3 to 2 and Alternative 4 to 3.

Table-2. Peak loads for the different energy end uses.

	Alternative-1	Alternative-2	Alternative-3	Alternative-4
Lighting - Conditioned	-	23%	0%	17%
Lighting - Unconditioned	-	0%	0%	0%
Space Heating	-	4%	3%	9%
Space Cooling	-	3%	5%	4%
Heat Rejection	-	3%	5%	3%
Fans - Conditioned	-	11%	-38%	3%
Receptacles - Conditioned	-	0%	0%	0%

In Alternative-2, the use of increased thermal insulation for exterior walls and roof and occupancy sensors result in both electric lighting and cooling savings. About 23% improvement on electric peak loads can be attributed to occupancy sensors controls alone. Heating and cooling peak reductions are 4 %T and 3% respectively.

In Alternative-3, the use of overhangs results in cooling peak reduction of 5% in comparison with Alternative-2.

In Alternative-4, the use of increased thermal insulation for exterior walls and roof and daylighting sensors result in both electric lighting and cooling savings. 17% improvement on electric peak loads can be attributed to daylighting sensors controls alone. Heating and cooling peak reductions are 9 %T and 4% respectively.

9 Recommendations

As expected from the climate analysis above, the building will be heating dominated. Therefore increased roof and wall insulation levels are highly recommended to reduce thermal losses during the heating season. Overhangs will reduce the cooling load by blocking solar gains during the cooling season. Occupancy sensors and Daylighting controls will further reduce the electrical lighting demand and cooling loads.

The following are general recommendations to further increase the projects' environmental performance. Utilizing these strategies singularly or in combination could result in energy and cost savings over the life of the sports complex.

- Natural Ventilation
- Increased HVAC systems' efficiencies
- Reduced HVAC Fan and Pump Power
- Demand Control Ventilation
- Optimum start/stop control strategies

Adding skylights or roof monitors will help increase the daylighting potential in areas where daylighting penetration is obstructed or reduced due to orientation, shading from existing and future surrounding structures. For example - when the new building to the north is built, daylighting uniformity will be reduced because the north wall of the fieldhouse will be 100% opaque. Adjustable shading devices should be specified to complement the overhangs and give the occupants more control over the daylighting quality.

Natural and/or hybrid ventilation could be used to passively cool / ventilate the buildings. This is usually materialized by exposing as much concrete (thermal mass) as possible. Exposing thermal mass will help mitigate high internal loads which are very common in sports facilities. Ceilings are usually removed to expose thermal mass, increase the room height and enhance the stack effect.

Low, high operable glazing and stacks are usually specified depending on the space type, occupancy and required fresh air rates. Night time ventilation is always used to regenerate the building's structure / thermal mass, cooling it for the next day.

Airscoop terminals are suitable for large open spaces and buildings. The passivent unit includes motorised insulated four-way volume control dampers within sub-base, controlled by single actuator. The dampers simultaneously control the flow of air into and out of the unit.

Night cooling: Passivent Airscoop can also be used for secure and weatherproof night cooling, in which daytime heat build-up is dissipated from the structure during the night, reducing the need for mechanical cooling or air conditioning.

A detailed natural ventilation analysis is not in the scope of this report. However, it could help determine the intake and exhaust flow rates and operable windows sizes resulting in significant HVAC energy savings.

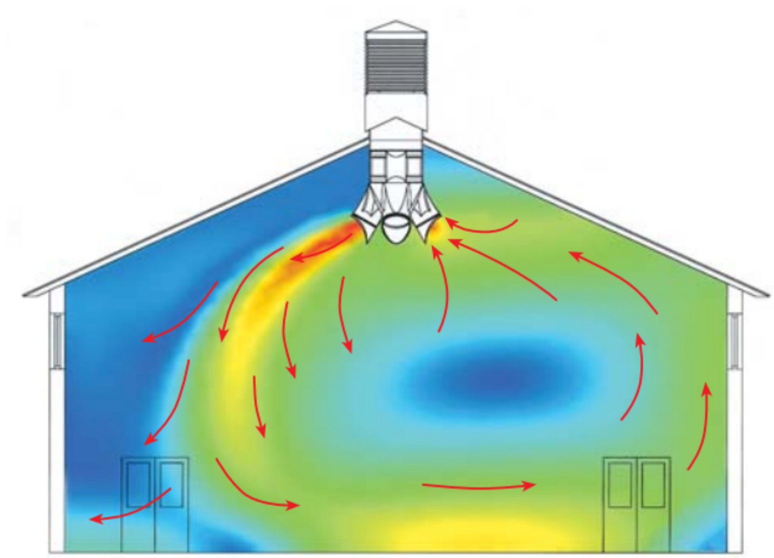
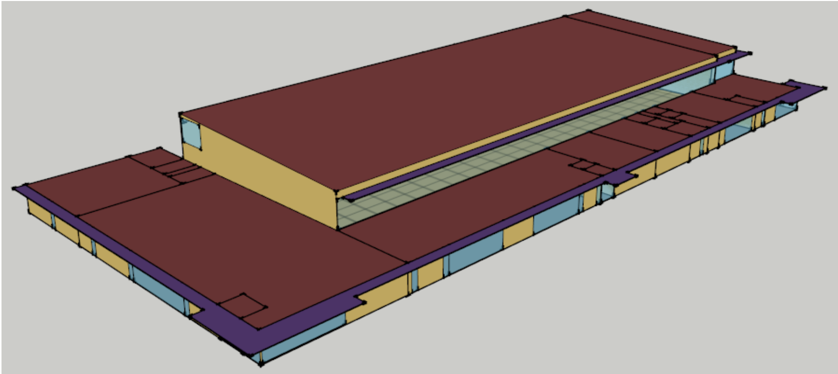


Fig.7- Airscoop terminal flow pattern

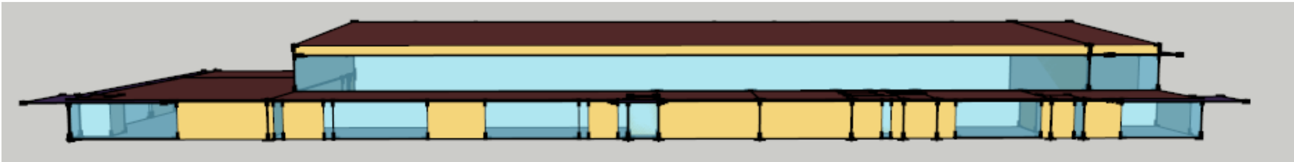
Source: Passivent

10 Appendix

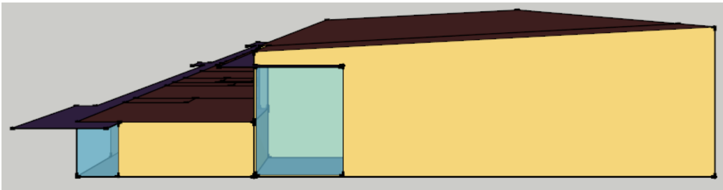
10.1 Elevations



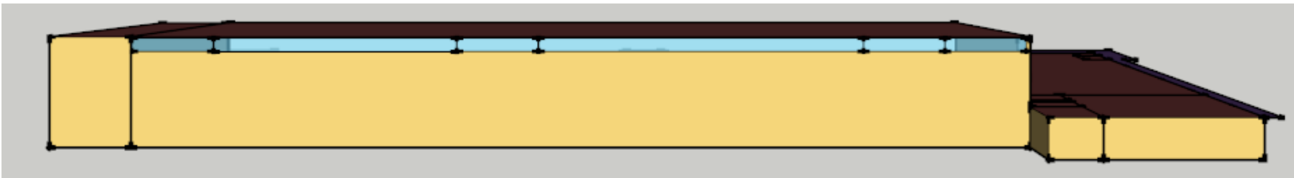
3D Model



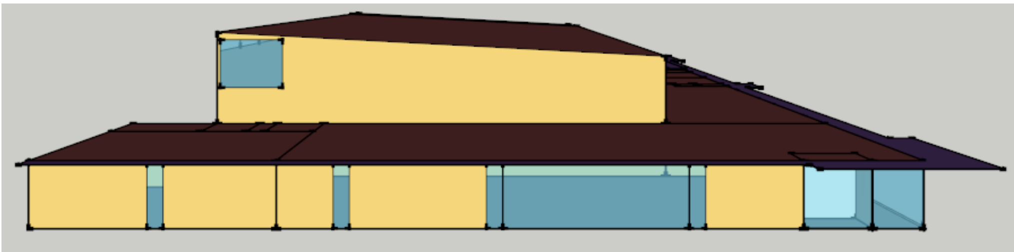
South Elevation



East Elevation



North Elevation



West Elevation

10.2 Space Types and Thermal Zones

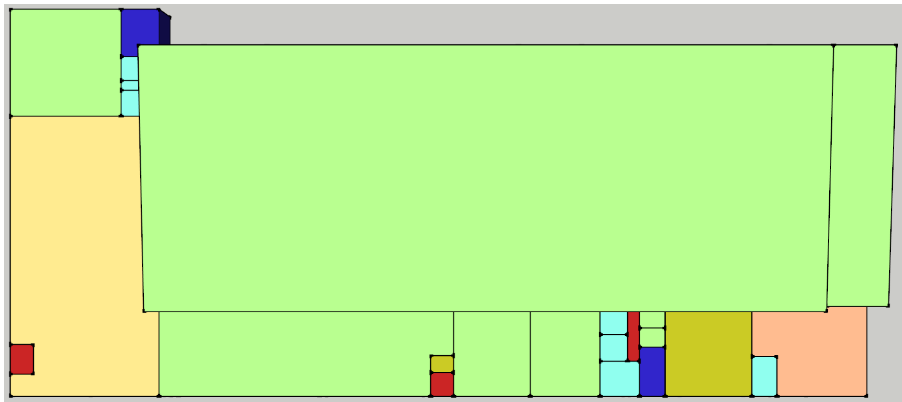


Fig.2.3- Space Types

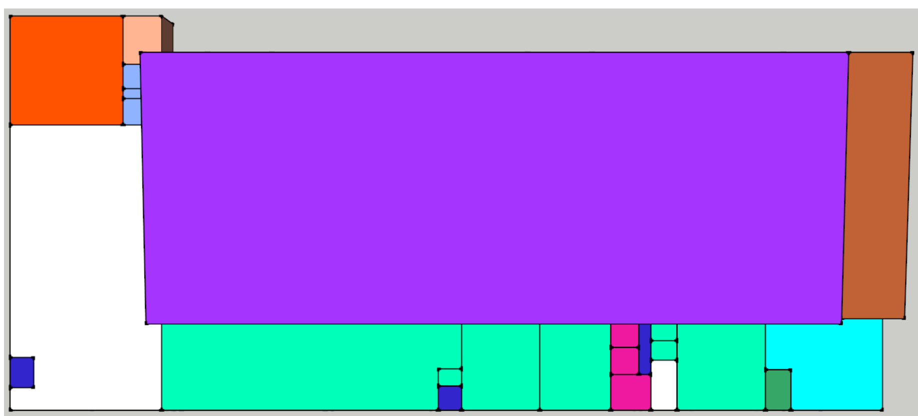


Fig.2.4- As Deigned Thermal Zones

10.3 Envelope Parameters

Simple Saver® Wall Systems	
Preinstalled R-Value	Thickness
R-10	3"
R-11	3 1/2"
R-13	4"
R-19	6"
R-25	8"
R-30	9"
R-38**	12"

Simple Saver® Roof Systems		
Pre-installed R-value	Lower Layer(s)	Upper Layer(s)
R-19	6"	-
R-25	8"	-
R-29	6"	3"
R-30	9"	-
R-30	6"	3 1/2"
R-32	6"	4"
R-35	8"	3"
R-38	8"	4"
R-43	9"	4"
R-49	9"	6"
R-49	12"	3 1/2"
R-52	12"	4"
R-57	12"	6"
R-60	9"	9"
R-68	12"	9"
R-76	12"	12"

Simple Saver Wall Systems: Two insulation layers and stand-off brackets may be required to provide necessary insulation depth.

Simple Saver Roof Systems: Multiple layers and appropriate space is required for any of these systems.

Source: [Thermal Design]

Production Standards

- thickness – 40mm
- structure- 7 walls
- effective modular width – 333mm (347) – 500mm (547)
- panel length – no limit
- colors available – **see page 11 of our catalog**

Technical Features

- Thermal insulation – 1.1 W/m^2K
- U-Value (R=1/U) – 0.188
- Acoustic insulation – 22 dB
- Linear thermal expansion – 0.065 mm/m°C
- Temperature range – -40°C +120°C
- U.V. rays protection – Coextrusion
- Fire reaction ASTM E84 Class A

Plastic Glazing Specifications

Download / View Our Plastic Glazing Specifications

Color	Light transmission (LT) %	Solar Heat Gain Coefficient (SHGC)	Shading coefficient (SC)
Clear	67	68	0.78
Green	60	57	0.66
Bronze	45	50	0.57
Opal	44	45	0.52

Source: gallinausa

All Heat Transfer Coefficient Conversion

Convert from: 1.1 $W/m^2 \cdot K$ = Convert to: 0.19372120010978047 $BTU/h \cdot ft^2 \cdot °F$

Convert from		Convert to	
Common units		***Common units***	
Calorie/Second Square Centimeter °C	$cal/s \cdot cm^2 \cdot °F$	Calorie/Second Square Centimeter °C	$cal/s \cdot cm^2 \cdot °F$
Joule/Second Square Meter K	$J/s \cdot m^2 \cdot K$	Joule/Second Square Meter K	$J/s \cdot m^2 \cdot K$
Kilocalorie/Hour Square Foot °C	$kcal/h \cdot ft^2 \cdot °C$	Kilocalorie/Hour Square Foot °C	$kcal/h \cdot ft^2 \cdot °C$
Kilocalorie/Hour Square Meter °C	$kcal/h \cdot m^2 \cdot °C$	Kilocalorie/Hour Square Meter °C	$kcal/h \cdot m^2 \cdot °C$
Watt/Square Meter °C	$W/m^2 \cdot °C$	Watt/Square Meter °C	$W/m^2 \cdot °C$
Watt/Square Meter K	$W/m^2 \cdot K$	Watt/Square Meter K	$W/m^2 \cdot K$
Other units		***Other units***	
BTU/Hour Square Foot °F	$BTU/h \cdot ft^2 \cdot °F$	BTU/Hour Square Foot °F	$BTU/h \cdot ft^2 \cdot °F$
CHU/Hour Square Foot °C	$CHU/h \cdot ft^2 \cdot °C$	CHU/Hour Square Foot °C	$CHU/h \cdot ft^2 \cdot °C$

U-value SI conversion: 1.0 W/m2K = 0.176 Btu/hr/ft2/°F

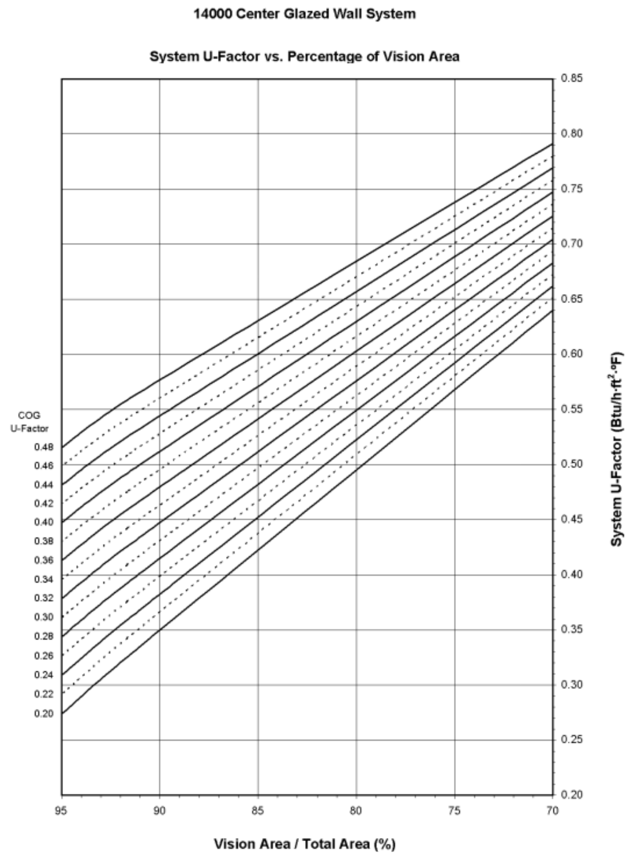
Glazing Treatments

IR Natural Illumination without the Solar Heat

The control of the temperature and the management of heat are essential elements in maintaining a desired level of comfort within buildings. They are also critical elements for cost control and to maximize energy savings.

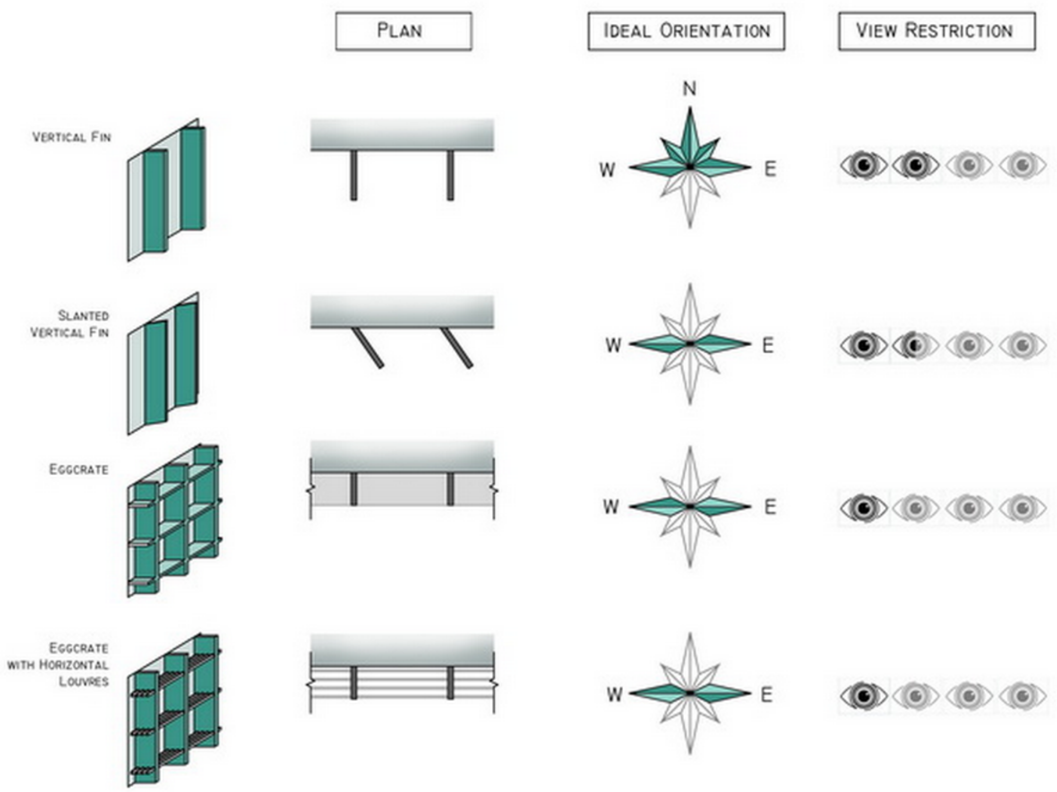
The products of the IR line absorb the part of the light relative to the infra-red rays (from 780 to 1400nm), blocking effectively the solar heat, while letting the solar light through. The result is a reduction of the internal transmission of heat and a reduction of the cost for cooling the area. In fact all the products from the IR line can contribute to reduce the temperature increase up to 25% while increasing the light transmission by up to 60% with respect to other window products.

Source: [gallinausa]



Source: [Tubelite]

10.4 General Types Of Shading Devices



10.5 Natural Ventilation

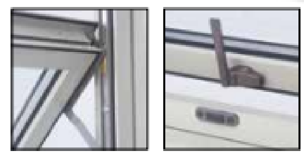
3700 SERIES WINDOWS

Let fresh air into the building through a storefront or curtainwall. 3700 Series windows can be easily incorporated with Tubelite's other framing systems. Special glazing pocket adapters make installation a breeze.

These AW60 / HC60 rated windows have a frame depth of 2" with a maximum size of 3'0" x 5'0" and mitred corners epoxied and crimped on an "L" shaped clip.

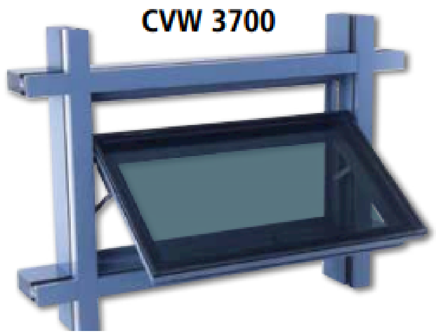
Standard [VW] and concealed project-out vent [CVW] design, standard project-in [HW] and casement [CW] options are available. The concealed vent design is virtually invisible from the outside of the building, with no visible frame.

VW 3700



CW 3700

CVW 3700



HW 3700

10.6 Energy Cost Budget

Energy Cost Budget / PRM Summary

By LOW ENERGY CONSULTING. LLC

Project Name:	Date: May 06, 2015
City:	Weather Data: Milwaukee, Wisconsin

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 Baseline			Alt-2 (USEALT1FANSIZES)			Alt-3			Alt-4		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	492.1	18	224	376.0	76	172	376.0	76	172	234.4	48	142
Lighting - Unconditioned	Electricity	3.8	0	2	3.8	100	2	3.8	100	2	3.9	100	2
Space Heating	Gas	622.9	23	3,782	158.0	25	3,643	179.8	29	3,524	129.6	21	3,219
Space Cooling	Electricity	739.6	27	1,186	958.8	130	1,157	861.2	116	1,100	824.3	111	1,055
Heat Rejection	Electricity	92.3	3	149	121.0	131	145	109.3	118	138	104.4	113	134
Fans - Conditioned	Electricity	779.5	28	274	690.0	89	245	941.7	121	338	905.5	116	326
Receptacles - Conditioned	Electricity	20.1	1	14	20.1	100	14	20.1	100	14	20.1	100	14
Total Building Consumption		**2,750.5**			**2,327.7**			**2,491.8**			**2,222.2**		

		* Alt-1 Baseline	Alt-2 (USEALT1FANSIZES)	Alt-3	Alt-4
Total	**Number of hours heating load not met**	0	0	0	0
	Number of hours cooling load not met	0	0	0	0

	* Alt-1 Baseline			Alt-2 (USEALT1FANSIZES)			Alt-3			Alt-4		
	Energy 10^6 Btu/yr	Cost/yr	$/yr	Energy 10^6 Btu/yr	Cost/yr	$/yr	Energy 10^6 Btu/yr	Cost/yr	$/yr	Energy 10^6 Btu/yr	Cost/yr	$/yr
Electricity	2,127.6	31,168		2,169.7	31,786		2,312.0	33,871		2,092.6	30,657	
Gas	622.9	4,236		158.0	1,074		179.8	1,223		129.6	881	
Total	**2,750**	**35,404**		**2,328**	**32,860**		**2,492**	**35,094**		**2,222**	**31,538**	

Project Name:
Dataset Name: 150506_SC-FINAL.TRC

TRACE® 700 v6.3.1 calculated at 09:04 PM on 05/06/2015
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