GLOBAL VASCULAR INSTITUTE

BUFFALO, NY

PENN STATE AE SENIOR CAPSTONE PROJECT

MADISON SMITH | CONSTRUCTION MANAGEMENT

DR. RILEY – CM ADVISOR

PRESENTATION OUTLINE:

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II. ANALYSIS #1: PHOTOVOLTAIC FAÇADE
    i. SYSTEM DESIGN
    ii. ELECTRICAL BREADTH
    iii. FEASIBILITY ANALYSIS
II. ANALYSIS #2 PREFABRICATED FAÇADE
    i. DESIGN
    ii. SCHEDULE/COST IMPACT
    iii. SITE CONGESTION
III. ANALYSIS #3: LEED CERTIFICATION
    i. SOFT COSTS
    ii. CREDIT CATEGORIES/COST IMPACT
IV. CONCLUSION
V. ACKNOWLEDGEMENTS

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PROJECT BACKGROUND

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PRESENTATION OUTLINE:

Location
100 High Street, Buffalo, NY

Function
Medical Research and Hospital

Size
450,000 SF

Cost
GMP: $291 Million

Construction Dates
9/2009 – 10/2011

PROJECT BACKGROUND

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PRESENTATION OUTLINE:

Project Scope

- Core Building housing labs, patient rooms, and operating rooms
- Link connecting GVI to Buffalo General Hospital
- Renovations to Central Power Plant adjacent to GVI

Building Enclosure

- Curtain Wall consisting of painted aluminum and Low-E glass panels

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

Schuco Solar Panel

Problem Identification

- High energy usage for GVI
- Few sustainable techniques being implemented

Research Goal

- Design preliminary photovoltaic façade system
- Determine feasibility of system
- Reduce the energy costs for GVI

ANALYSIS #1: PHOTOVOLTAIC FACADE

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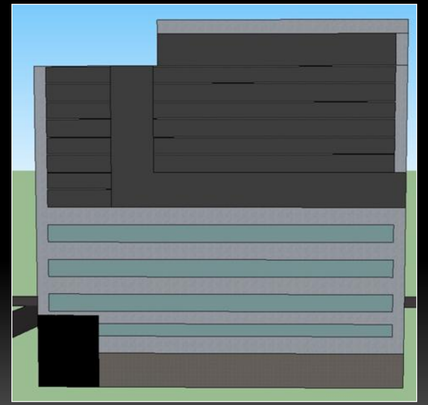
PRESENTATION OUTLINE:

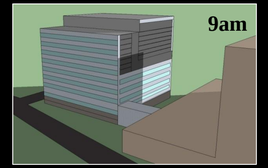


Orientation

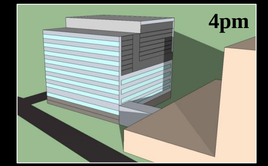
- Entire South façade faces directly South
- 35,700 SF of façade space

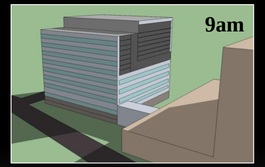
Solar Shading

- Only top 5 floors have no shading all year
- Slight shading occurs during winter solstice months

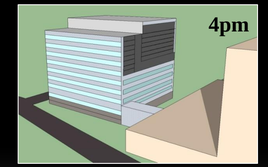


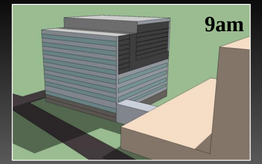
Winter Solstice



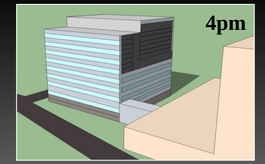


Fall/Spring Equinox





Summer Solstice



ANALYSIS #1: PHOTOVOLTAIC FACADE

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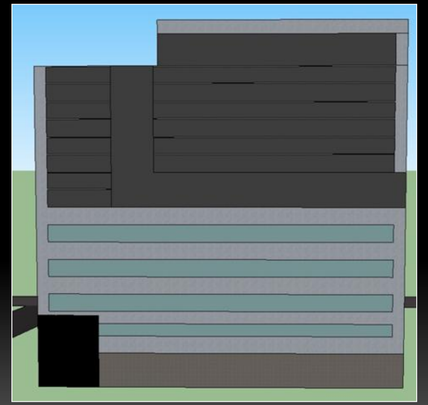
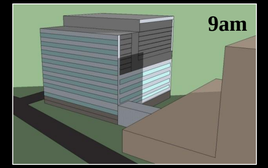
PRESENTATION OUTLINE:



SOLAR ARRAY CRITERIA	
Sun Hours Per Day	3.31
Size of Panel (SF)	54
Watts Per SF	5
Actual Produced Power Per Panel	270
# of Panels	426
Total Power Produced by Panels Per Day (Watts)	115,020



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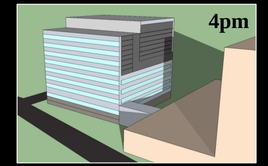

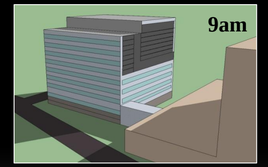

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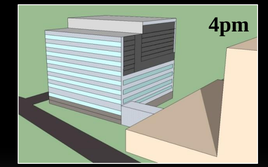
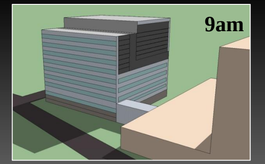
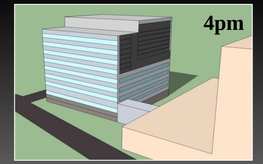




Summer Solstice



ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

STATION IDENTIFICATION	
City	Buffalo
State	New York
Latitude	42.93° N
Longitude	78.73° W
Elevation	215m
PV SYSTEM PARAMETERS	
DC Rating	115kW
DC to AC Derate Factor	.77
AC Rating	88.5kW
Array Type	Fixed
Array Tilt	90°
Array Azimuth	180°
ENERGY PARAMETERS	
Cost of Electricity	14.5 /kWh

Yearly AC Energy Produced

- 78,579kWh

Yearly Energy Value

- $11,393.95

PV WATTS ENERGY PRODUCTION RESULTS			
MONTH	**SOLAR RADIATION (kWh/m²/day)**	**AC ENERGY (kWh)**	**ENERGY VALUE ($)**
1	2.31	6473	$938.59
2	2.96	7644	$1108.38
3	3.39	9228	$1338.06
4	2.94	7133	$1034.29
5	2.84	6429	$932.21
6	2.63	5411	$784.60
7	2.72	5766	$836.07
8	3.09	7090	$1028.05
9	2.99	7005	$1015.73
10	2.77	7077	$1026.16
11	1.84	4519	$655.25
12	1.82	4806	$696.87
Year	**2.69**	**78,579**	**$11,393.95**

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

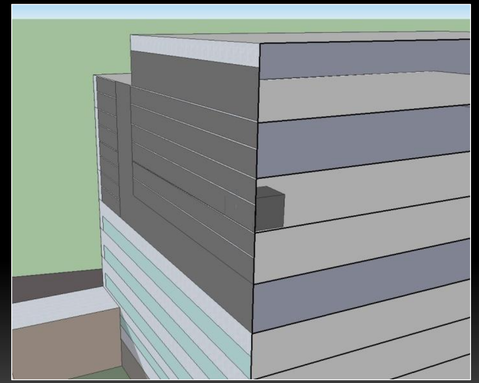
Fronius CL 55.5 Delta / 60.0 WYE277

System Set-Up

- Inverters located in 8th floor electrical room
- Minimize DC Wire Run
- AC Wire Run to Utility Power Supply in Sub-basement Level

Electrical Tie-In Components

- DC Wire Run
- DC Disconnects
- Inverters
- AC Disconnects
- AC Wire Run
- Breaker Box



Location of inverters along South façade

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

Structural Impact

- Bay 3-4 was modeled and analyzed
- STADD Pro analysis

WEIGHT OF ORIGINAL FAÇADE VS PV FACADE

Façade Type	Square Footage	Weight/SF (lbs/SF)	Weight of Aluminum Panels (lbs)	Weight of Glass Panels (lbs)	Total Weight (lbs)
Original	19,170	-	34,440	106,200	140,640
PV Panels	19,170	7	-	-	134,190
			Weight Difference		**(6,450)**

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

Structural Impact

- Bay 3-4 was modeled and analyzed
- STADD Pro analysis

BEAM DEFLECTION	
Load Case	**Max. Deflection**
Original Façade	0.025
PV Façade	0.023

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

System Cost

ESTIMATED COST OF PV SYSTEM		
Size (kW)	**$/W**	**Cost**
115	$10,00	$1,150,000

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

System Cost

ESTIMATED COST OF PV SYSTEM		
Size (kW)	**$/W**	**Cost**
115	$10,00	$1,150,000

Rebates/Incentives

- New York State Energy Research and Development Authority - $1.75/Watt (max. $87,500)
- Federal Tax Credit – 30% of gross system installation cost

ANALYSIS #1: PHOTOVOLTAIC FACADE

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PRESENTATION OUTLINE:

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ESTIMATED COST OF PV SYSTEM		
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115	$10,00	$1,150,000

Rebates/Incentives

- New York State Energy Research and Development Authority - $1.75/Watt (max. $87,500)
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ACTUAL ESTIMATED COST OF PV SYSTEM	
Description	**Cost**
Entire PV System	$717,500
Not including Original Facade	$170,600

- Cost of Original Façade = $546,900

PROJECT BACKGROUND

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PRESENTATION OUTLINE:

Payback Period

- $0.01477/kWh cost of electricity (New York State)
- 5% inflation rate for cost of energy

PAYBACK PERIOD	
Description	**Payback Period**
Entire PV System	24 Years
Not including Original Facade	9 Years

PROJECT BACKGROUND

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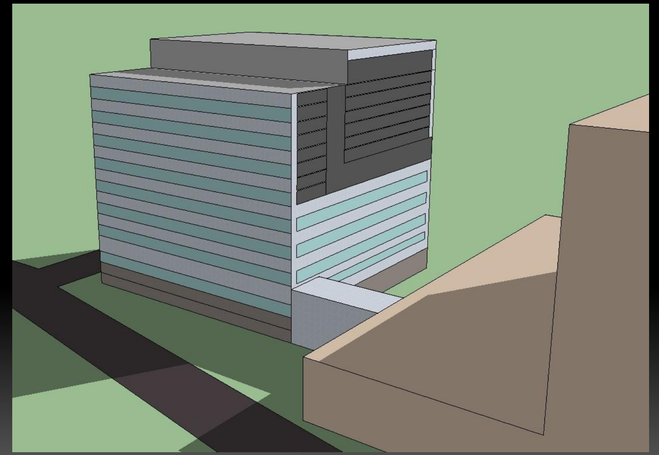
PRESENTATION OUTLINE:

Recommendation

- South façade optimal for solar array
- 115kW, 426 panel system



ANALYSIS #2: PREFABRICATED FAÇADE

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PRESENTATION OUTLINE:

Problem Identification

- Delays from façade installation
- Site congestion

Research Goal

- Design preliminary design of prefabrication panels
- Reduce installation schedule
- Reduce site congestion

ANALYSIS #2: PREFABRICATED FAÇADE

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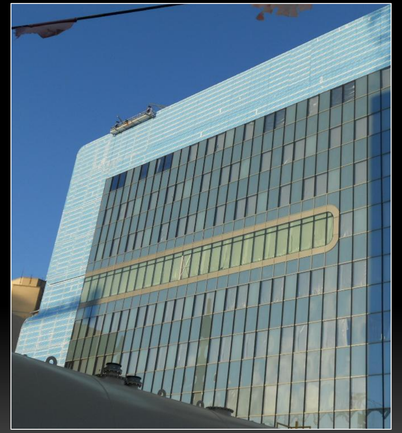
PRESENTATION OUTLINE:



West Façade

Original Façade

- 9’ x 5’ aluminum and glass panels
- East and West - glass panels
- South and North - aluminum and glass panels

North Façade

ANALYSIS #2: PREFABRICATED FAÇADE

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PRESENTATION OUTLINE:

Panel Design

- Only East and West Facades prefabricated
- 6 different prefabricated panel types
- Based on arrangement of glass panels

Panel Information	
Module	Size
	36’ x 5’
	36’ x 5’
	36’ x 5’
	18’ x 5’
	18’ x 5’

ANALYSIS #2: PREFABRICATED FAÇADE

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PRESENTATION OUTLINE:

Schedule Impact

- Original Installation Duration = 204
- Prefabricated Erection = 12 panels/day
- Prefabricated Installation Duration = 113

SCHEDULE REDUCTION DUE TO PREFABRICATED MODULES

Elevation	# of Individual Panels	Individual Panels/Day	Individual Panel Duration (Days)	Prefabricated Module Duration (Days)	Schedule Savings (Days)
East	440	5	88	49	(39)
West	580	5	116	64	(52)
Total	**1020**	**5**	**204**	**113**	**(91)**

ANALYSIS #2: PREFABRICATED FAÇADE

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PRESENTATION OUTLINE:

Cost Impact

- Additional cost to project due to shop fabrication
- Material costs remain the same

COST OF PREFABRICATED FAÇADE			
Square Footage of façade	**Cost/SF**	**Total Cost to Project**	**% of Overall Project Cost**
71,442	$5/SF	$357,210	.12%

ANALYSIS #2: PREFABRICATED FAÇADE

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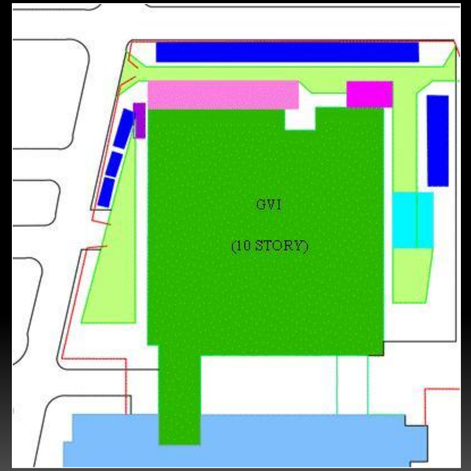
PRESENTATION OUTLINE:

Site Congestion

- Increased Efficiency
- Decreased amount of on-site material storage
- Panels installed directly off of trucks



ANALYSIS #2: PREFABRICATED FAÇADE

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PRESENTATION OUTLINE:

Recommendation

- Prefabricated glass panels on East and West Facades
- Eliminates site congestion during installation
- Schedule Reduction

ANALYSIS #3: LEED CERTIFICATION

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PRESENTATION OUTLINE:

Problem Identification

- No LEED rating pursued due to the cost
- Healthy function, Healthy building

Research Goal

- Determine the feasibility of obtaining each LEED rating

POINT REQUIREMENTS FOR LEED RATINGS	
LEED Rating	**Points**
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80-110

ANALYSIS #3: LEED CERTIFICATION

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PRESENTATION OUTLINE:

Soft Costs

- Costs not directly involved in the construction of the building

SOFT COSTS ESTIMATE			
Cost Description	**% of Construction Cost**	**Total Construction Cost**	**Cost to Project**
Design Costs	.5	$291,000,000	$1,455,000
Documentation & Application Fees	.5	$291,000,000	$1,455,000
Energy Modeling	.1	$291,000,000	$291,000
		Total	**$3,201,000**

ANALYSIS #3: LEED CERTIFICATION

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PRESENTATION OUTLINE:

Cost Impact

- 46 points obtained from original design
- Soft costs included
- Platinum is not obtainable from the point-by-point analysis performed

COST OF OBTAINING EACH LEED RATING			
LEED Rating	**Cost**	**% Construction Cost Increase**	**Total Points**
Certified	$ -	0%	46
Silver	$3,27,226	1.12%	54
Gold	$3,811,226	1.31%	60
Platinum	-	-	-

ANALYSIS #3: LEED CERTIFICATION

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PRESENTATION OUTLINE:

Recommendation

- Incorporate LEED early into the project
- A LEED rating can be obtained at little cost to the project

CONCLUSION

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PRESENTATION OUTLINE:

Analysis #1

- Rebates/Incentives make PV systems affordable
- Perform feasibility study early in project development

Analysis #2

- Prefabrication can be time effective
- Solution to small and congested sites

Analysis #3

- Incorporate LEED early in project development

PRESENTATION OUTLINE:

ACKNOWLEDGEMENTS

Special Thanks To

Mark Dowling at Turner
Global Vascular Institute Project Team
PACE Industry Members
My Family and Friends

Industry Acknowledgements

Turner

CANNONDESIGN

Academic Acknowledgements

Penn State AE Faculty
Dr. David Riley – CM Advisor

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PRESENTATION OUTLINE:

QUESTIONS

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PRESENTATION OUTLINE:

ADDITIONAL INFORMATION

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PRESENTATION OUTLINE:

PAYBACK PERIOD - ADDITIONAL COST TO PROJECT ONLY

Year	Installation	1	2	3	4	5	6
$/kW Electricity (Assume 5% Inflation)	$ -	$ 0.1477	$ 0.1551	$ 0.1628	$ 0.1710	$ 0.1795	$ 0.1885
Cost	$ 603,100	$ -	$ -	$ -	$ -	$ -	$ -
Federal Tax Credit (30% of Cost)	$ 345,000	$ -	$ -	$ -	$ -	$ -	$ -
New York State Incentive ($1.75/W)	$ 87,500	$ -	$ -	$ -	$ -	$ -	$ -
Utility Savings	$ -	$ 16,985.50	$ 17,834.78	$ 18,726.51	$ 19,662.84	$ 20,645.98	$ 21,678
Yearly Cash Flow	$ (170,600.00)	$ 16,985.50	$ 17,834.78	$ 18,726.51	$ 19,662.84	$ 20,645.98	$ 21,678
Cumulative Cash Flow	$ (170,600.00)	$(153,614.50)	$ (135,780)	$ (117,053)	$ (97,390)	$ (76,744)	$ (55,066)

Year	7	8	9
$/kW Electricity (Assume 5% Inflation)	$ 0.1979	$ 0.2078	$ 0.2182
Cost	$ -	$ -	$ -
Federal Tax Credit (30% of Cost)	$ -	$ -	$ -
New York State Incentive ($1.75/W)	$ -	$ -	$ -
Utility Savings	$ 22,762	$ 23,900	$ 25,095
Yearly Cash Flow	$ 22,762	$ 23,900	$ 25,095
Cumulative Cash Flow	$ (32,304)	$ (8,404)	$ 16,692

ADDITIONAL INFORMATION

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PRESENTATION OUTLINE:

PAYBACK PERIOD - ENTIRE COST OF PV SYSTEM

Year	Installation	1	2	3	4	5	6
$/kW Electricity (Assume 5% Inflation)	$ -	$ 0.1477	$ 0.1551	$ 0.1628	$ 0.1710	$ 0.1795	$ 0.1885
Cost	$ 1,150,000	$ -	$ -	$ -	$ -	$ -	$ -
Federal Tax Credit (30% of Cost)	$ 345,000	$ -	$ -	$ -	$ -	$ -	$ -
New York State Incentive ($1.75/W)	$ 87,500	$ -	$ -	$ -	$ -	$ -	$ -
Utility Savings	$ -	$ 16,986	$ 17,835	$ 18,727	$ 19,663	$ 20,646	$ 21,678
Yearly Cash Flow	$ (717,500)	$ 16,986	$ 17,835	$ 18,727	$ 19,663	$ 20,646	$ 21,678
Cumulative Cash Flow	$ (717,500)	$ (700,515)	$ (682,680)	$ (663,953)	$ (644,290)	$ (623,644)	$ (601,966)

Year	7	8	9	10	11	12	13
$/kW Electricity (Assume 5% Inflation)	$ 0.1979	$ 0.2078	$ 0.2182	$ 0.2291	$ 0.2406	$ 0.2526	$ 0.2652
Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Federal Tax Credit (30% of Cost)	$ -	$ -	$ -	$ -	$ -	$ -	$ -
New York State Incentive ($1.75/W)	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Utility Savings	$ 22,762	$ 23,900	$ 25,095	$ 26,350	$ 27,668	$ 29,051	$ 30,504
Yearly Cash Flow	$ 22,762	$ 23,900	$ 25,095	$ 26,350	$ 27,668	$ 29,051	$ 30,504
Cumulative Cash Flow	$ (579,204)	$ (555,304)	$ (530,208)	$ (503,858)	$ (476,191)	$ (447,140)	$ (416,636)

Year	14	15	16	17	18	19	20
$/kW Electricity (Assume 5% Inflation)	$ 0.2785	$ 0.2924	$ 0.3071	$ 0.3224	$ 0.3385	$ 0.3555	$ 0.3732
Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Federal Tax Credit (30% of Cost)	$ -	$ -	$ -	$ -	$ -	$ -	$ -
New York State Incentive ($1.75/W)	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Utility Savings	$ 32,029	$ 33,630	$ 35,312	$ 37,077	$ 38,931	$ 40,878	$ 42,922
Yearly Cash Flow	$ 32,029	$ 33,630	$ 35,312	$ 37,077	$ 38,931	$ 40,878	$ 42,922
Cumulative Cash Flow	$ (384,607)	$ (350,977)	$ (315,666)	$ (278,588)	$ (239,657)	$ (198,780)	$ (155,858)

Year	21	22	23	24
$/kW Electricity (Assume 5% Inflation)	$ 0.3919	$ 0.4115	$ 0.4321	$ 0.4537
Cost	$ -	$ -	$ -	$ -
Federal Tax Credit (30% of Cost)	$ -	$ -	$ -	$ -
New York State Incentive ($1.75/W)	$ -	$ -	$ -	$ -
Utility Savings	$ 45,068	$ 47,321	$ 49,687	$ 52,171
Yearly Cash Flow	$ 45,068	$ 47,321	$ 49,687	$ 52,171
Cumulative Cash Flow	$ (110,791)	$ (63,470)	$ (13,783)	$ 38,389

ADDITIONAL INFORMATION

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PRESENTATION OUTLINE:

SUSTAINABLE SITES

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	21		$ -	21
Certified	21		$ -	21
Silver	21		$ -	21
Gold	21		$ -	21
Platinum				

WATER EFFICIENCY

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	4		$ -	4
Certified	4		$ -	4
Silver	4	6	$ 39,370	10
Gold	4	6	$ 39,370	10
Platinum				

ENERGY AND ATMOSPHERE

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	5		$ -	5
Certified	5		$ -	5
Silver	5	2	$ 30,856	7
Gold	5	5	$ 210,856	10
Platinum				

MATERIALS AND RESOURCES

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	2		$ -	2
Certified	2		$ -	2
Silver	2		$ -	2
Gold	2	3	$ 360,000	5
Platinum				

INDOOR ENVIRONMENTAL QUALITY

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	12		$ -	12
Certified	12		$ -	12
Silver	12		$ -	12
Gold	12		$ -	12
Platinum				

INNOVATION IN DESIGN

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	1		$ -	1
Certified	1	0	$ -	1
Silver	1	0	$ -	1
Gold	1	0	$ -	1
Platinum				

REGIONAL PRIORITY

LEED Rating	Points from Original Design	Points Obtained at a Cost	Cost of Points	Section Total Points
Original Design	1		$ -	1
Certified	1		$ -	1
Silver	1		$ -	1
Gold	1		$ -	1
Platinum				

TOTAL

LEED Rating	Total Additional Cost	% Construction Cost Increase	Point Range	Section Total Points
Original Design	$ -	0%		46
Certified	$ -	0%	40-49	46
Silver	$ 3,271,226	1.12%	50-59	54
Gold	$ 3,811,226	1.31%	60-79	60
Platinum			80-110	

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POINTS USED FOR ACHIEVING EACH LEED RATING			Original Building	Certified	Silver	Gold
Sustainable Sites	**Possible Points: 26**					
Prereq 1	Construction Activity Pollution Prevention	Prerequisite				
Credit 1	Site Selection	1				
Credit 2	Development Density and Community Connectivity	5				
Credit 3	Brownfield Redevelopment	1				
Credit 4.1	Alternative Transportation-Public Transportation Access	6				
Credit 4.2	Alternative Transportation-Bicycle Storage and Changing Rooms	1				
Credit 4.3	Alternative Transportation-Low-Emitting and Fuel-Efficient Vehicles	3				
Credit 4.4	Alternative Transportation-Parking Capacity	2				
Credit 5.1	Site Development-Protect or Restore Habitat	1				
Credit 5.2	Site Development-Maximize Open Space	1				
Credit 6.1	Stormwater Design-Quantity Control	1				
Credit 6.2	Stormwater Design-Quality Control	1				
Credit 7.1	Heat Island Effect-Non-roof	1				
Credit 7.2	Heat Island Effect-Roof	1				
Credit 8	Light Pollution Reduction	1				

Water Efficiency	**Possible Points: 10**	
Prereq 1	Water Use Reduction-20% Reduction	Prerequisite
Credit 1	Water Efficient Landscaping	2 to 4
Credit 2	Innovative Wastewater Technologies	2
Credit 3	Water Use Reduction	2 to 4
Energy and Atmosphere	**Possible Points: 35**	
Prereq 1	Fundamental Commissioning of Building Energy Systems	Prerequisite
Prereq 2	Minimum Energy Performance	Prerequisite
Prereq 3	Fundamental Refrigerant Management	Prerequisite
Credit 1	Optimize Energy Performance	1 to 19
Credit 2	On-Site Renewable Energy	1 to 7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement and Verification	3
Credit 6	Green Power	2
Materials and Resources	**Possible Points: 14**	
Prereq 1	Storage and Collection of Recyclables	Prerequisite
Credit 1.1	Building Reuse-Maintain Existing Walls, Floors, and Roof	1 to 3
Credit 1.2	Building Reuse-Maintain 50% of Interior Non-Structural Elements	1
Credit 2	Construction Waste Management	1 to 2
Credit 3	Materials Reuse	1 to 2
Credit 4	Recycled Content	1 to 2
Credit 5	Regional Materials	1 to 2
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	1

Indoor Environmental Quality	**Possible Points: 15**	
Prereq 1	Minimum Indoor Air Quality Performance	Prerequisite
Prereq 2	Environmental Tobacco Smoke (ETS) Control	Prerequisite
Credit 1	Outdoor Air Delivery Monitoring	1
Credit 2	Increased Ventilation	1
Credit 3.1	Construction IAQ Management Plan-During Construction	1
Credit 3.2	Construction IAQ Management Plan-Before Occupancy	1
Credit 4.1	Low-Emitting Materials-Adhesives and Sealants	1
Credit 4.2	Low-Emitting Materials-Paints and Coatings	1
Credit 4.3	Low-Emitting Materials-Flooring Systems	1
Credit 4.4	Low-Emitting Materials-Composite Wood and Agrifiber Products	1
Credit 5	Indoor Chemical and Pollutant Source Control	1
Credit 6.1	Controllability of Systems-Lighting	1
Credit 6.2	Controllability of Systems-Thermal Comfort	1
Credit 7.1	Thermal Comfort-Design	1
Credit 7.2	Thermal Comfort-Verification	1
Credit 8.1	Daylight and Views-Daylight	1
Credit 8.2	Daylight and Views-Views	1
Innovation and Design	**Possible Points: 6**	
Credit 1.1	Innovation in Design: Specific Title	1
Credit 1.2	Innovation in Design: Specific Title	1
Credit 1.3	Innovation in Design: Specific Title	1
Credit 1.4	Innovation in Design: Specific Title	1
Credit 1.5	Innovation in Design: Specific Title	1
Credit 2	LEED Accredited Professional	1
Regional Priority Credits	**Possible Points: 4**	
Credit 1.1	Regional Priority: Specific Credit: SSc6.1	1
Credit 1.2	Regional Priority: Specific Credit: SSc7.1	1
Credit 1.3	Regional Priority: Specific Credit: SSc7.2	1
Credit 1.4	Regional Priority: Specific Credit: EAc2	1

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