

# RIVER VUE APARTMENTS

PITTSBURGH, PA



PENN STATE AE SENIOR CAPSTONE PROJECT  
BRIANNE KYLE | CONSTRUCTION MANAGEMENT  
DR. CHIMAY J. ANUMBA

# RIVER VUE APARTMENTS

PITTSBURGH, PA



## PRESENTATION OUTLINE:

- I. Project Background
- II. Analysis #1: Photovoltaic Glass Window System
  - I. Renewable Energy/Electrical Breadth
- III. Analysis #2: Green Roof System
- IV. Analysis #3: 3D Laser Scanning Technology
- V. Analysis #4: Lighting Occupancy Sensor Control System
- VI. Final Conclusions and Recommendations
- VII. Acknowledgements
- VIII. Questions/Comments

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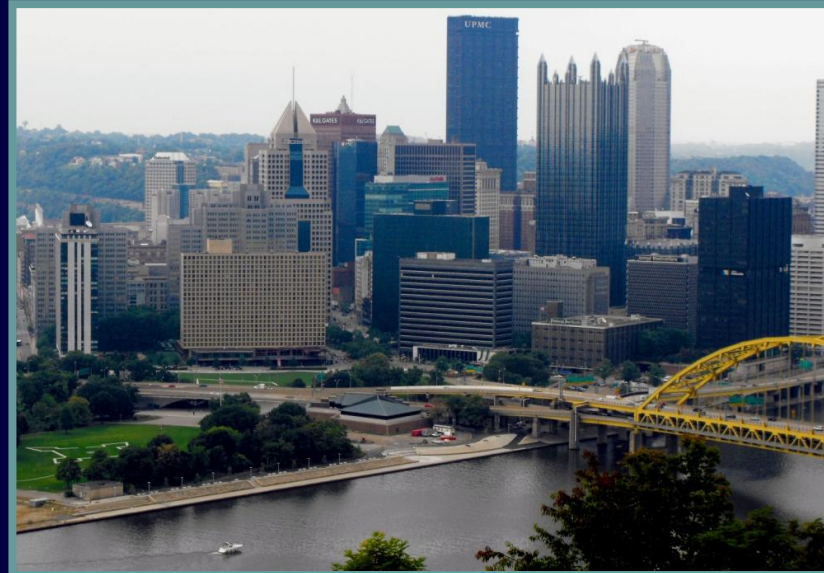
# PROJECT BACKGROUND



## PRESENTATION OUTLINE:

- I. Project Background
  - I. General Building Information
- II. Analysis #1: Photovoltaic Glass Window System
- III. Analysis #2: Green Roof System
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Pittsburgh, PA



### General Building Information

Building Name	River Vue Apartments
Location	300 Liberty Avenue, Pittsburgh, PA 15222
Construction Type	Renovation, 1B
Occupancy Type	R2 Private Apartments S2 Parking A2 Coffee Shop A3 Party Room & Recreation Room
Gross Building Area	295,000 SF
Number of Stories	16 stories & basement
Number of Apartment Units	218 units
Construction Dates	June 13, 2011 – October 2012
Total Project Cost	\$28,248,910
Project Delivery Method	Design-Bid-Build
LEED Certification	LEED Certified

Aerial View of River Vue Apartments

Project Team	
Owner	River Vue Associates, LP Millcraft Industries, Inc.
Architects	Design4Studios, Inc. Intelligent Design Group, LLP
General Contractor	Turner Construction Company
Construction Manager	Not applicable for this project
MEP/FP Engineer	Claitman Engineering Associates, Inc.
Structural Engineer	Whitely Bailey Cox & Magnani, LLC
Civil Engineer	Gateway Engineers
Hazmat	L. Robert Kimball & Associates, Inc.
Parking Car Lift	Harding Steel, Inc.
LEED Consultant	Integrated Holistic Design, Inc.

Image Courtesy of www.flashearth.com





# PHOTOVOLTAIC GLASS WINDOW SYSTEM



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  - I. System Design
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Example of Photovoltaic Glass Unit Use



Image Courtesy of [www.smartplanet.com](http://www.smartplanet.com)

## PROBLEM IDENTIFICATION:

- Project achieving LEED certification through sustainable construction methods
- Few sustainable design techniques pursued in project
- High building electrical energy consumption

## RESEARCH GOALS:

- Perform preliminary design of photovoltaic glass window system
- Determine financial feasibility of system
- Reduce electrical energy consumption

Pythagoras Solar's Photovoltaic Glass Unit



Image Courtesy of [www.getsolar.com](http://www.getsolar.com)





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Example of Photovoltaic Glass Unit Use



Image Courtesy of [www.smartplanet.com](http://www.smartplanet.com)

## PRODUCT INFORMATION:

- Pythagoras Solar's Photovoltaic Glass Unit (PVGU)
- Transparent window
- 3 3/4' x 5 1/2' PVGU that generates 101.2 W/PVGU

## APARTMENT APPLIANCE ENERGY:

- Estimated 15,156 kWh/day
- Used sun hours of 3.28
- Number of PVGUs = 45,659 PVGUs

## ACTUAL SYSTEM SIZE:

- Every-other window design
- 652 PVGUs
- Ideally generates 65.982 kW

Photovoltaic Glass Unit Diagram

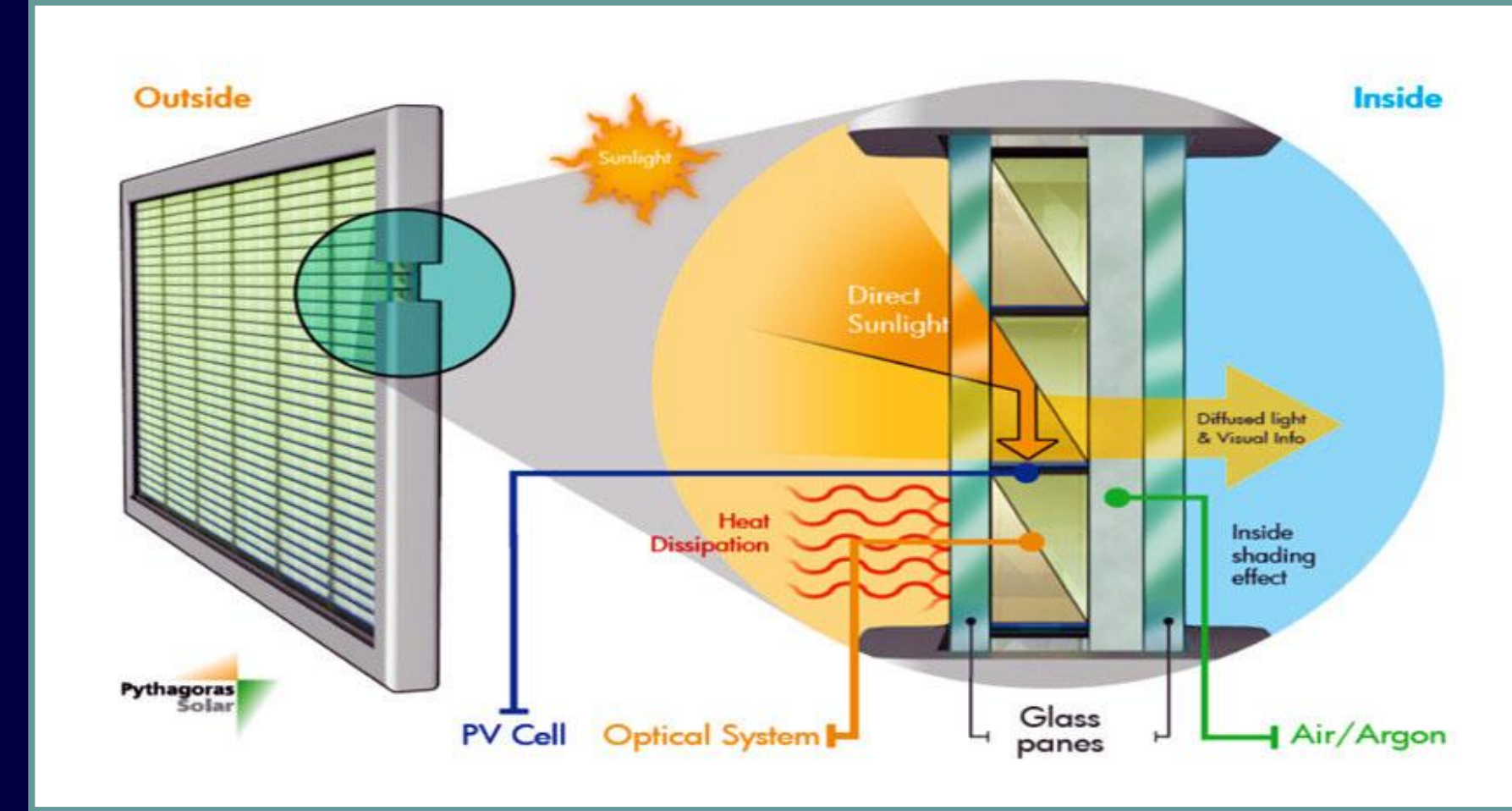


Image Courtesy of [www.pythagoras-solar.com](http://www.pythagoras-solar.com)



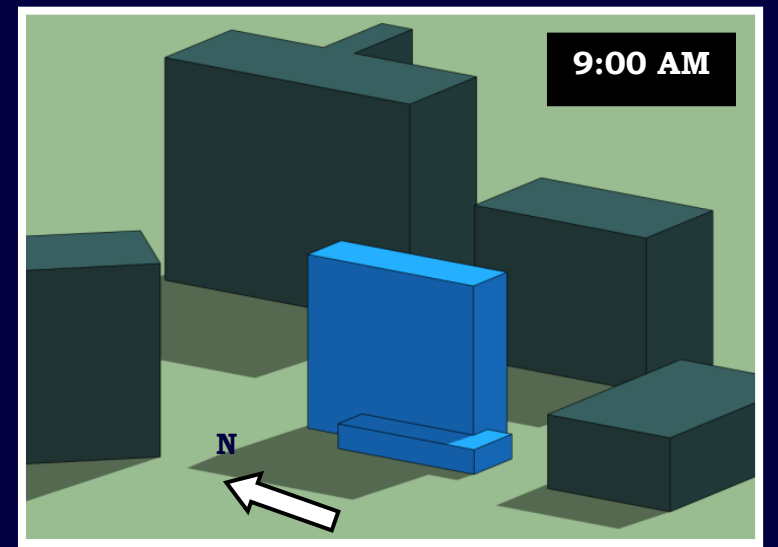


# PHOTOVOLTAIC GLASS WINDOW SYSTEM

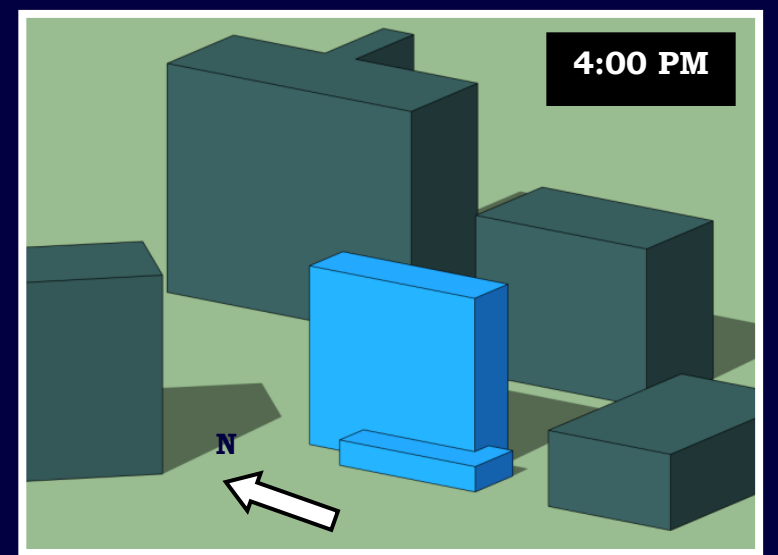


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Summer Solstice (June 20)

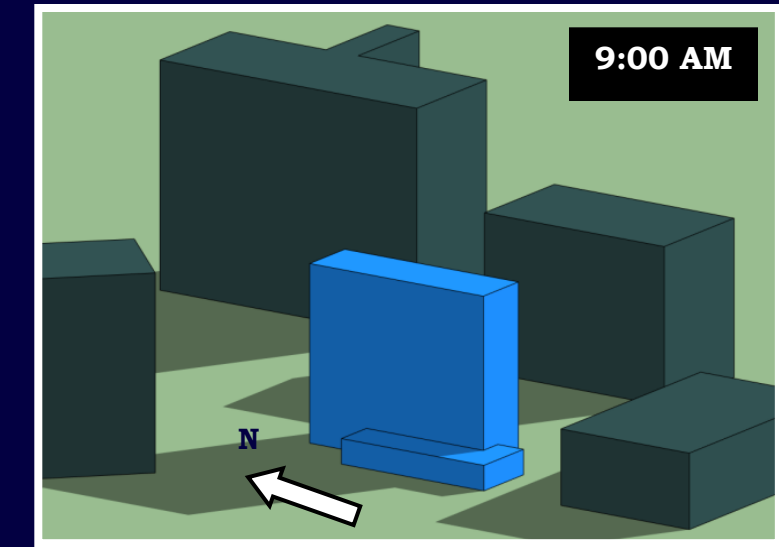


## SYSTEM DESIGN:

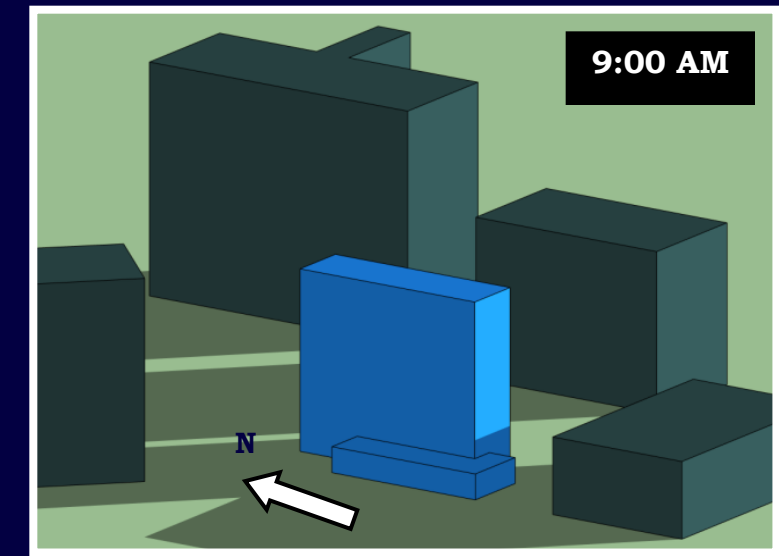
- Three systems (South, East, and West)
- South – 100 PVGUs
- East – 224 PVGUs
- West – 328 PVGUs

## RENEWABLE ENERGY:

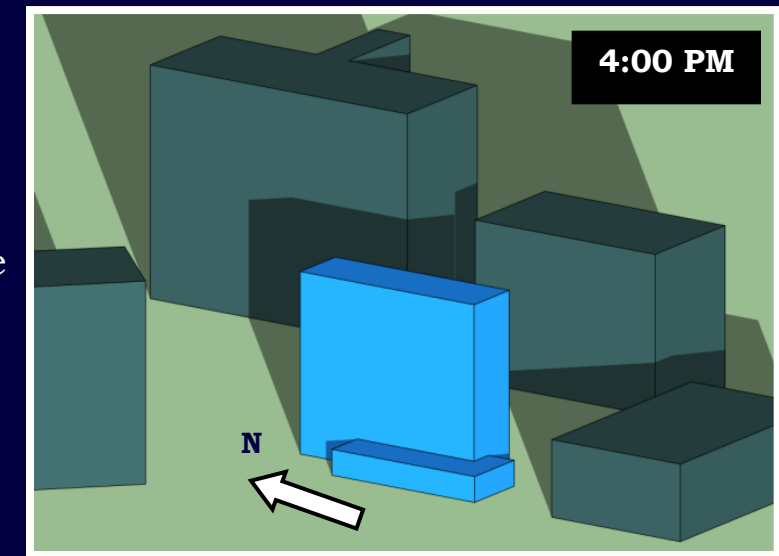
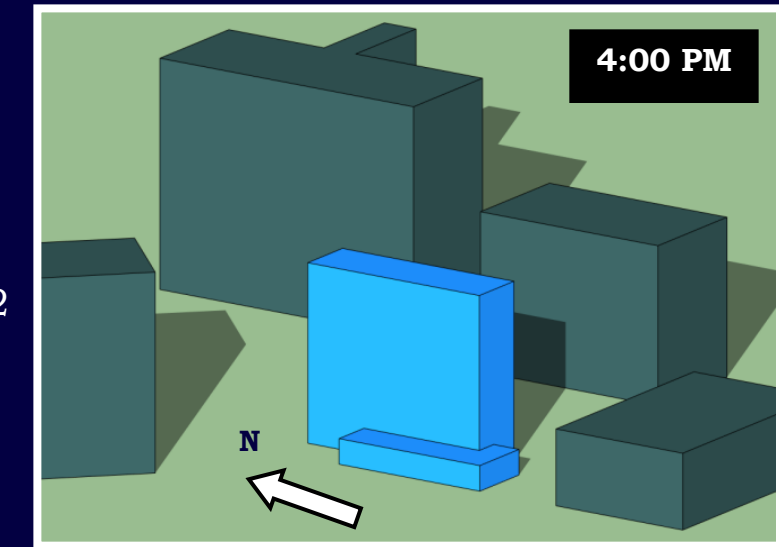
Overall Renewable Energy Production Results with Shading		
System	DC Energy (kWh)	AC Energy (kWh)
South-Facing Side	11,404.81	10,689.73
East-Facing Side	8,661.09	7,949.78
West-Facing Side	11,629.98	10,643.63
<b>TOTAL</b>	<b>31,695.88/year</b>	<b>29,283.14/year</b>



Fall/Spring Solstice  
(September 22 & March 20)



Winter Solstice  
(December 21)





# PHOTOVOLTAIC GLASS WINDOW SYSTEM



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Pythagoras Solar's Photovoltaic Glass Unit



Image Courtesy of [www.getsolar.com](http://www.getsolar.com)

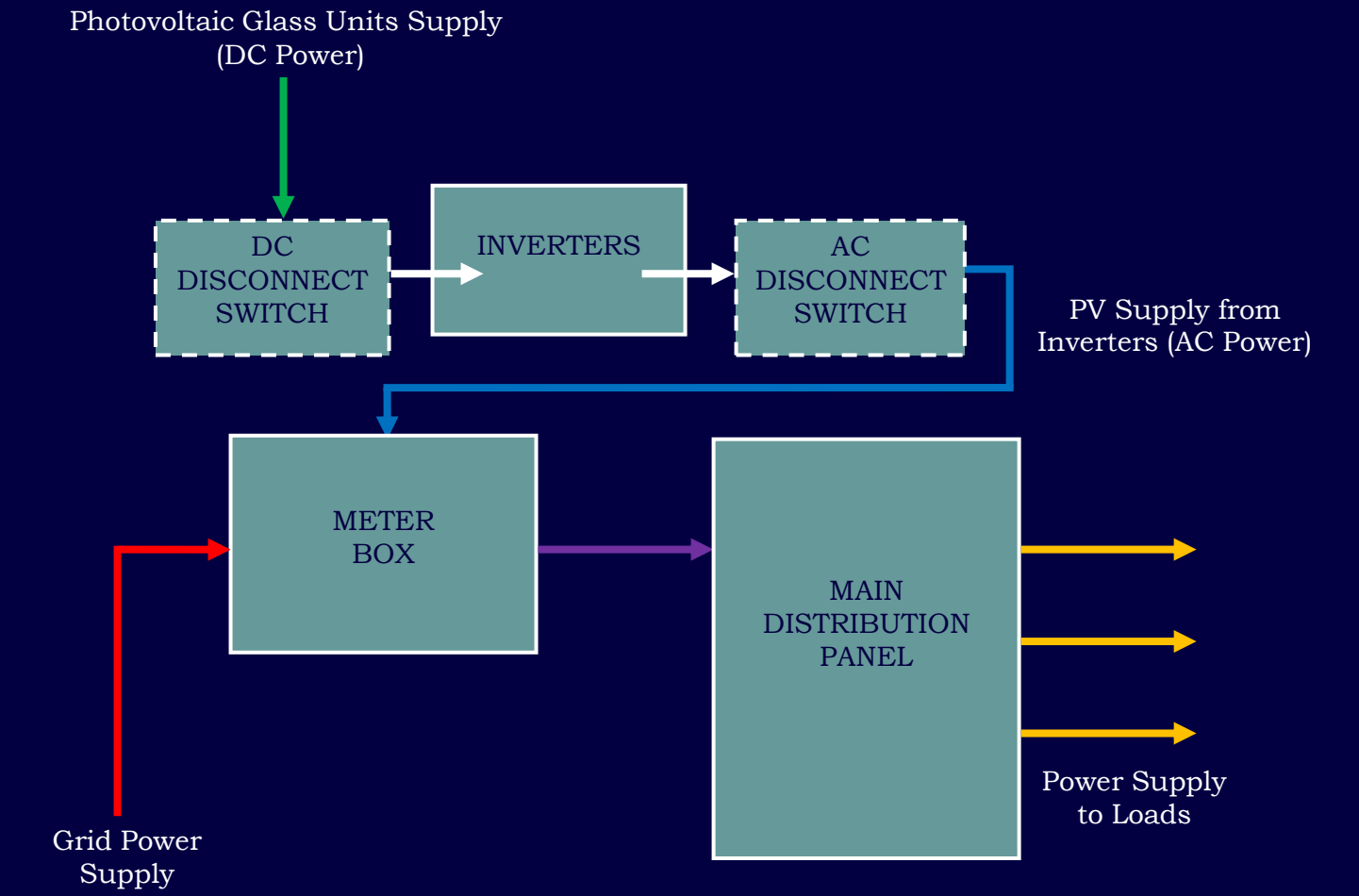
## GRID CONNECTION:

- System too large for load-side interconnection

## ELECTRICAL COMPONENTS:

- DC wire runs
- DC disconnects
- Inverters
- AC disconnects
- AC wire runs
- Service-tap meter box

Supply-Side Interconnection Diagram





# PHOTOVOLTAIC GLASS WINDOW SYSTEM



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Pythagoras Solar's Photovoltaic Glass Unit



Image Courtesy of [www.getsolar.com](http://www.getsolar.com)

## SYSTEM COST PARAMETERS:

- Obtained from Moana Reynau (Pythagoras Solar engineer)
- Cost of PVGU = \$75/SF
- Fronius IG Plus 10.0-1<sub>UNI</sub> inverters cost = \$4,173/inverter

## INITIAL COST WITH REBATES AND INCENTIVES:

Initial Cost of Photovoltaic Glass Window System After Incentives and Rebates			
Incentive & Rebate Name	Description	Cost Reduction	Adjusted Cost
-	Initial Cost	-	\$1,033,562.50
PA Sunshine Solar Rebate	35% of cost (up to \$5,000)	\$5,000.00	\$1,028,600.50
PA Alternative Energy Production	15% after all other incentives	\$154,290.10	\$874,310.40
		<b>FINAL COST</b>	<b>\$874,310.40</b>

## PVGU COST CALCULATION:

- Number of PVGUs = 652 PVGUs
- SF/PVGU = 3 ¾' x 5 ½' = 20.625 SF/PVGU
- Total SF of PVGUs = 13,447.5 SF
- **Total cost of PVGUs = \$1,008,562.50**

## INVERTERS COST CALCULATION:

- Number of inverters = 6 inverters
- **Total cost of 6 Fronius IG Plus 10.0-1<sub>UNI</sub> inverters = \$25,0238**







# PHOTOVOLTAIC GLASS WINDOW SYSTEM



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Pythagoras Solar's Photovoltaic Glass Unit



Image Courtesy of [www.getsolar.com](http://www.getsolar.com)

## LIFE-CYCLE COST PARAMETERS:

- 25-year lifespan for PVGUs
- Electricity cost = \$0.17 (1% market increase each year)
- Assumed AEC value = 0.4
- Total AC energy savings = 29,284 kWh/year

## LIFE-CYCLE COST:

- After 25-years, photovoltaic glass window system energy savings = **\$399,754.22**
- System's initial cost = \$874,310.40
- Difference = \$474,556.18
- Owner does not receive initial cost back in lifespan

## RECOMMENDATION:

- **PHOTOVOLTAIC GLASS WINDOW SYSTEM IS NOT RECOMMENDED**





# GREEN ROOF SYSTEM



## PRESENTATION OUTLINE:

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LiveRoof® System's Green Roof Modules



Image Courtesy of [www.prweb.com](http://www.prweb.com)

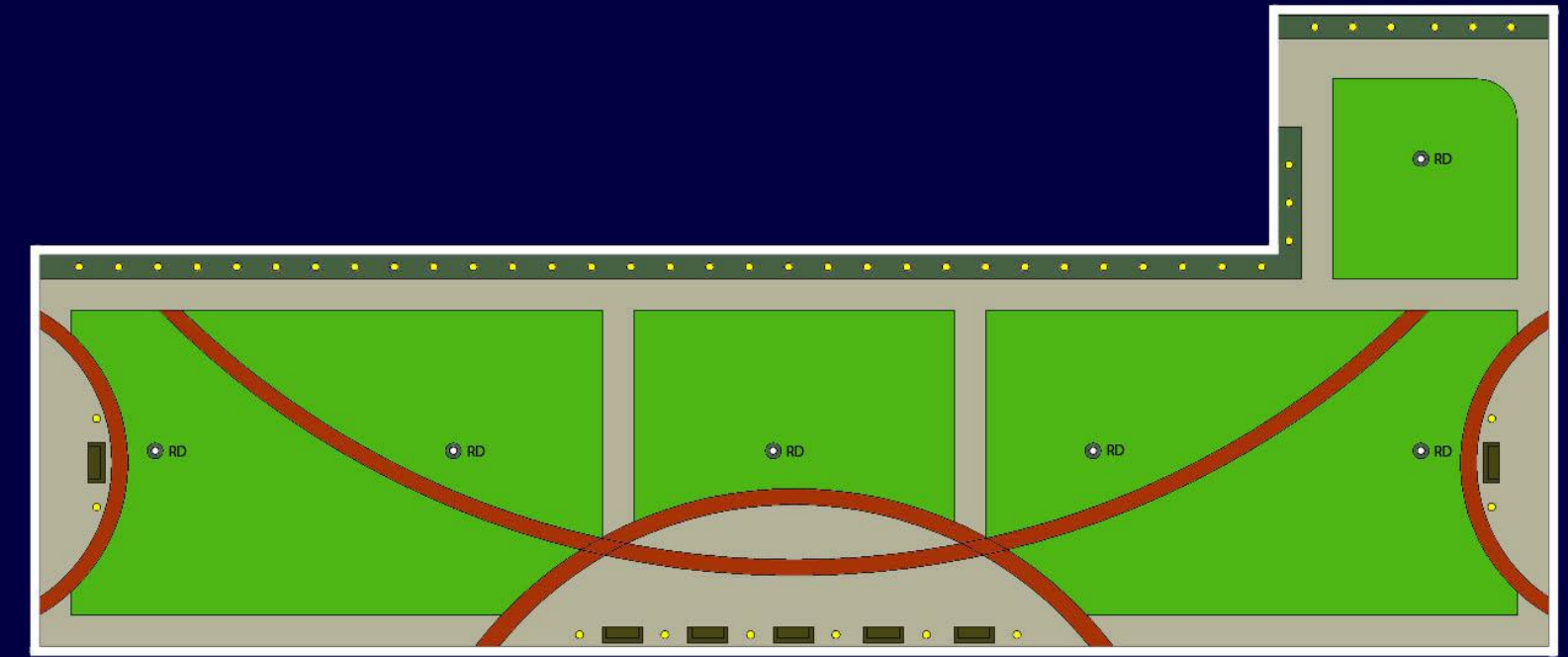
## PROBLEM IDENTIFICATION:

- Project is achieving LEED certification through sustainable construction methods
- Few sustainable design techniques pursued in project

## RESEARCH GOALS:

- Develop preliminary resident-accessible design of green roof system
- Determine financial feasibility of system

River Vue Apartments Green Roof Design





# GREEN ROOF SYSTEM



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LiveRoof® System's Green Roof Modules



Image Courtesy of [www.prweb.com](http://www.prweb.com)

## DESIGN:

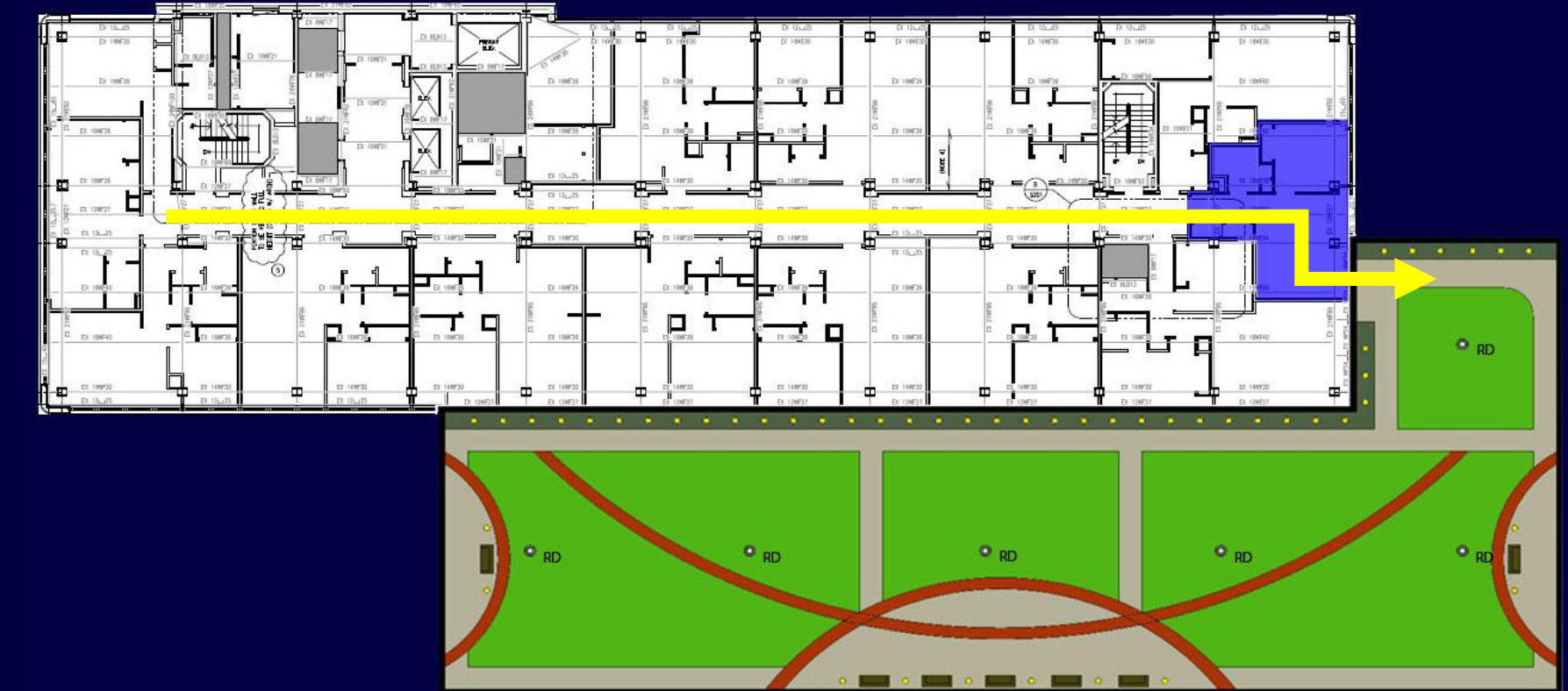
- LiveRoof® Maxx System (Intensive)

Green Roof System Square-Foot Takeoffs		
Green Roof System Component	Square Footage	Percentage of Level 2 Roof
Aggregate/ Stone Gravel	536.25 SF	5.22%
Brick Pavers	718.95 SF	7.00%
Concrete Tile Pavers	3,094.90 SF	30.14%
Vegetation	5,918.66 SF	57.64%
<b>TOTAL SF</b>	<b>10,268.76 SF</b>	<b>100%</b>

## GREEN ROOF ACCESSIBILITY:

- From 3<sup>rd</sup> floor
- Losing end apartment
- Roof line approximately 2 ft below 3<sup>rd</sup>-floor floor line
- Stairs and handicap ramp added

River Vue Apartments Green Roof Accessibility





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LiveRoof® System's Green Roof Modules



Image Courtesy of [www.prweb.com](http://www.prweb.com)

## SYSTEM COST:

- Obtained from Corsos Perennials

Initial Total Cost of the Green Roof System Without Incentives and Rebates	
Component	Total Cost
Materials Cost	\$240,560.53
Equipment & Installation Cost	\$164,278.17
<b>TOTAL</b>	<b>\$404,838.68</b>

## RENT ANALYSIS:

- Rent income without increase = \$3,024,000/year
- Rent increase per month = \$45.00/month per apartment
- **Rent income with increase = \$3,127,980/year**

## RECOMMENDATION:

- **GREEN ROOF SYSTEM IS RECOMMENDED**

## Third-Floor Apartment Unit:

- 3<sup>rd</sup>-floor apartment unit rent per month = \$1,100/month
- Rent increase = \$1,100/217 apartments units = \$5.07 ~ \$10.00

## Green Roof System Maintenance:

- Green roof maintenance cost per year = \$7,102.39
- Rent increase = \$7,102.39/217 apartments units = \$32.73 ~ \$35.00





# 3D LASER SCANNING TECHNOLOGY



## PRESENTATION OUTLINE:

- I. Project Background
- II. Analysis #1: Photovoltaic Glass Window System
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- IV. **Analysis #3: 3D Laser Scanning Technology**
  - I. 3D Laser Scanning Implementation Areas
  - II. Feasibility Analysis
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Leica Geosystems, Inc.'s ScanStation C10



Image Courtesy of [www.leica-geosystems.us/en/index.htm](http://www.leica-geosystems.us/en/index.htm)

## PROBLEM IDENTIFICATION:

- As-built drawing inconsistencies caused constructability challenges
- MEP coordination took an extensive amount of time
- BIM was not used on project

## RESEARCH GOALS:

- Analyze how 3D laser scanning technology evaluates existing building conditions
- Determine financial feasibility of technology
- Analyze how 3D laser scanning technology contributes to 3D coordination

## 3D Laser Scanning Technology Work Flow

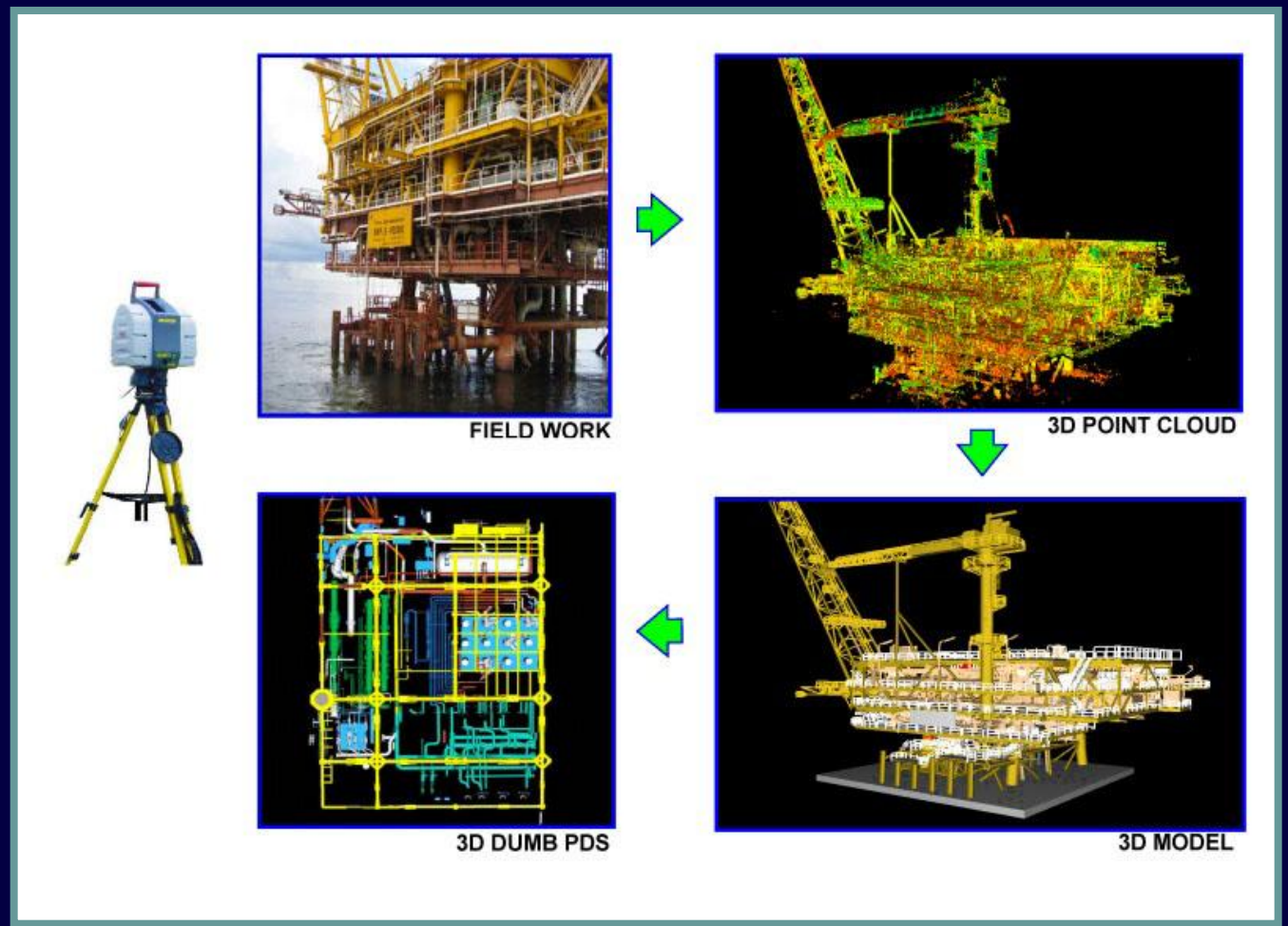


Image Courtesy of <http://mademunarda.blogspot.com>





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Leica Geosystems, Inc.'s ScanStation C10



Image Courtesy of [www.leica-geosystems.us/en/index.htm](http://www.leica-geosystems.us/en/index.htm)

## AS-BUILT DRAWING GENERATION:

- Creates 2D drawings (plans, elevations, and sections)
- Benefits architects, other designers, and contractors

## 3D MODEL GENERATION:

- Creates 3D model for visual reference, design, and coordination
- Benefits owner, architects, and MEP designer

## QUALITY CONTROL:

- Guarantees highest level of quality is maintained throughout the construction process
- Benefits contractor and owner

Example of a Laser Scan to 3D Revit BIM Model

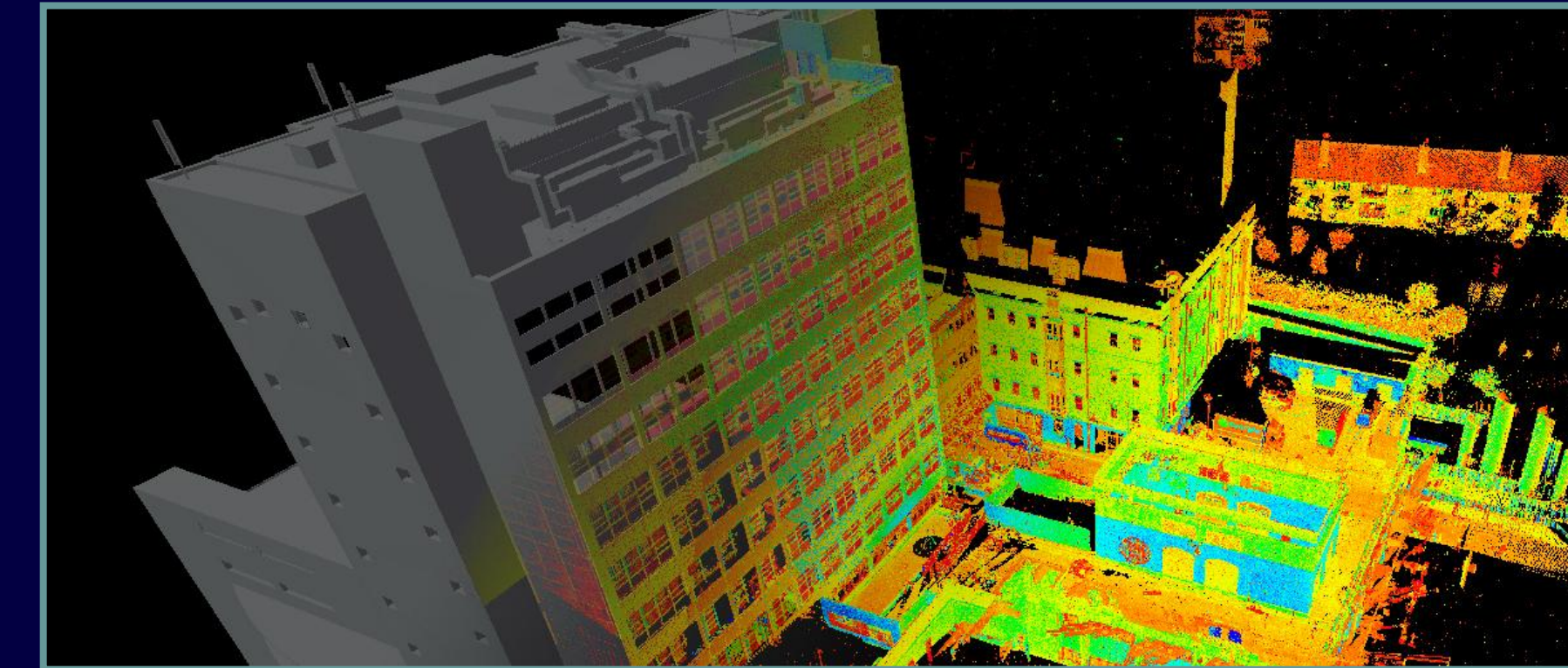


Image Courtesy of <http://http://severnpartnership.blogspot.com>





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Image Courtesy of [www.leica-geosystems.us/en/index.htm](http://www.leica-geosystems.us/en/index.htm)

## COST OF 3D LASER SCANNING PROCESS:

- Obtained from Dr. Craig Dubler
- Does not include BIM services
- Cost of 3D laser scanning process = \$147,500

## CHANGE ORDERS COST:

- Estimated cost of changes orders = \$82,954.80

## COST COMPARISON:

- Difference = \$64,545.20
- Laser scanning process cost is more than the change order costs

## RECOMMENDATION:

- **3D LASER SCANNING TECHNOLOGY IS NOT RECOMMENDED**





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Sensor Switch's WSD-PDT



Image Courtesy of [www.acuitybrands.wordpress.com/](http://www.acuitybrands.wordpress.com/)

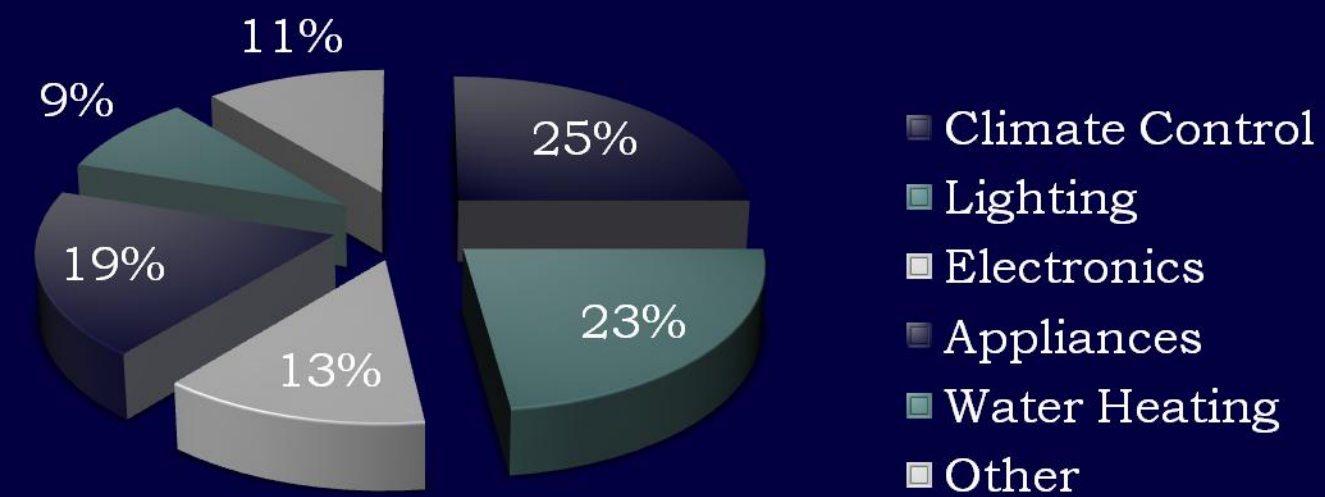
**PROBLEM IDENTIFICATION:**

- Critical Industry Issue – Energy Management
- Lighting uses 23% of typical residential electricity usage

**RESEARCH GOALS:**

- Utilize an efficient and simple-to-use electrical and lighting systems control
- Reduce electrical consumption in apartment units

Typical Residential Electricity Usage Breakdown







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Sensor Switch's WSD-PDT



Image Courtesy of [www.acuitybrands.wordpress.com/](http://www.acuitybrands.wordpress.com/)

**PRODUCT INFORMATION:**

- Sensor Switch's Wall Switch Decorator sensor (WSD-PDT)
- Uses both passive infrared and microphonics detection technology
- Operates on "automatic on" and "predictive off mode"

**SENSOR APARTMENT LOCATIONS:**

- Bathrooms
- Laundry/utility rooms
- Walk-in closets

**SYSTEM SIZE:**

- 670 WSD-PDTs



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Sensor Switch's WSD-PDT



**ENERGY LOADS:**

- Includes bathroom, laundry/utility room, and walk-in closet lighting
- Total energy load = 165,945.06 kWh/year

**PERCENT SAVINGS:**

- Bathrooms = 40%
- Laundry/utility rooms = 50%
- Walk-in closets = 60%

**ENERGY SAVINGS FROM OCCUPANCY SENSORS:**

- Energy savings = 71,504.38 kWh/year

Image Courtesy of [www.acuitybrands.wordpress.com/](http://www.acuitybrands.wordpress.com/)



# LIGHTING OCCUPANCY SENSOR CONTROL SYSTEM



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Sensor Switch's WSD-PDT



Image Courtesy of [www.acuitybrands.wordpress.com/](http://www.acuitybrands.wordpress.com/)

## SYSTEM COST PARAMETERS:

- Obtained from Global Industrial
- Includes Duquesne Light Company's \$16.50 rebate per sensor

Initial Cost of Lighting Occupancy Sensor Control System After Rebates			
Rebate Name	Description	Cost Reduction	Adjusted Cost
-	Initial Cost	-	\$62,946.50
Duquesne Light Company Rebate	\$16.50 rebate per sensor	\$11,055	\$51,891.50
-	Shipping	-	\$10,190.70
		<b>FINAL COST</b>	<b>\$62,082.20</b>

## OCCUPANCY SENSORS COST:

- Number of WSD-PDTs = 670
- Cost per WSD-PDT = \$93.95/sensor
- **Total cost of WSD-PDTs = \$62,946.50**

## SHIPPING COST:

- Number of WSD-PDTs = 670
- Shipping cost per WSD-PDT = \$15.21/sensor
- **Total shipping cost = \$10,190.70**



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Sensor Switch's WSD-PDT



**LIFE-CYCLE COST PARAMETERS:**

- Electricity cost = \$0.17 (1% market increase each year)
- Energy savings = 71,504.38 kWh/year
- 15-year lifespan for occupancy sensors

**LIFE-CYCLE COST:**

- After 15-years, occupancy sensor system energy savings = **\$195,635.97**
- System's initial cost = \$62,082.20
- Owner does receive initial cost back in 5 ½ years

**RECOMMENDATION:**

- **LIGHTING OCCUPANCY SENSOR CONTROL SYSTEM IS RECOMMENDED**



Image Courtesy of [www.acuitybrands.wordpress.com/](http://www.acuitybrands.wordpress.com/)



# FINAL CONCLUSIONS AND RECOMMENDATIONS



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## PHOTOVOLTAIC GLASS WINDOW SYSTEM:

- The system does not recover its initial cost within the 25-year lifespan
- **NOT RECOMMENDED**

## GREEN ROOF SYSTEM:

- A rent increase accommodates for the yearly roof maintenance and loss of third-floor apartment costs
- **RECOMMENDED**

## 3D LASER SCANNING TECHNOLOGY:

- Change order costs are \$64,545.20 lower than laser scanning process cost
- **NOT RECOMMENDED**

## LIGHTING OCUPANCY SENSOR CONTROL SYSTEM:

- The system recovers its initial cost within 5 ½ years of the 15-year lifespan
- **RECOMMENDED**

## OVERALL SENIOR THESIS GOAL:

- Incorporate value engineering design and construction techniques that are financial benefits to the owner



RIVER VUE APARTMENTS  
PITTSBURGH, PA

BRIANNE KYLE | CONSTRUCTION MANAGEMENT

# ACKNOWLEDGMENTS

RIVER VUE APARTMENTS  
PITTSBURGH, PA

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## PRESENTATION OUTLINE:

- I. Project Background
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- VI. Final Conclusions and Recommendations

## VII. Acknowledgements

VIII. Questions/Comments

## ACADEMIC ACKNOWLEDGMENTS:

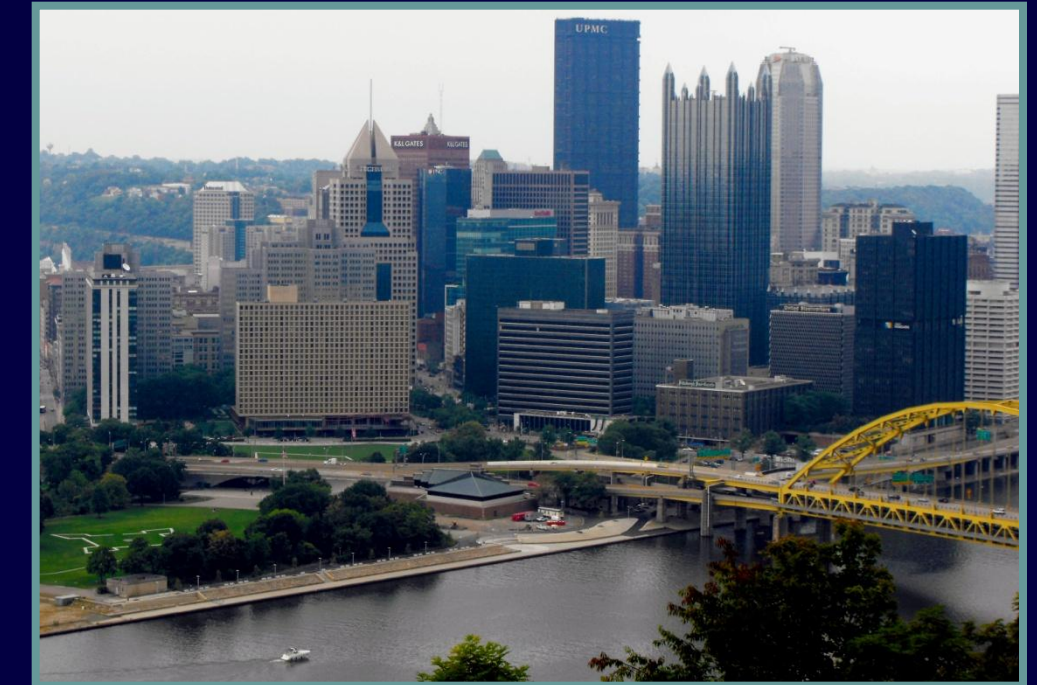
Penn State AE Faculty  
Dr. Chimay J. Anumba

## INDUSTRY ACKNOWLEDGMENTS:



## SPECIAL THANKS TO:

Kevin Ludwick – Turner Construction Company  
Chris DiLorenzo – Turner Construction Company  
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Moana Reynau – Pythagoras Solar, Inc.  
Dr. Craig Dubler – Penn State University  
My Family and Friends





RIVER VUE APARTMENTS  
PITTSBURGH, PA

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# QUESTIONS/COMMENTS

RIVER VUE APARTMENTS  
PITTSBURGH, PA

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## PRESENTATION OUTLINE:

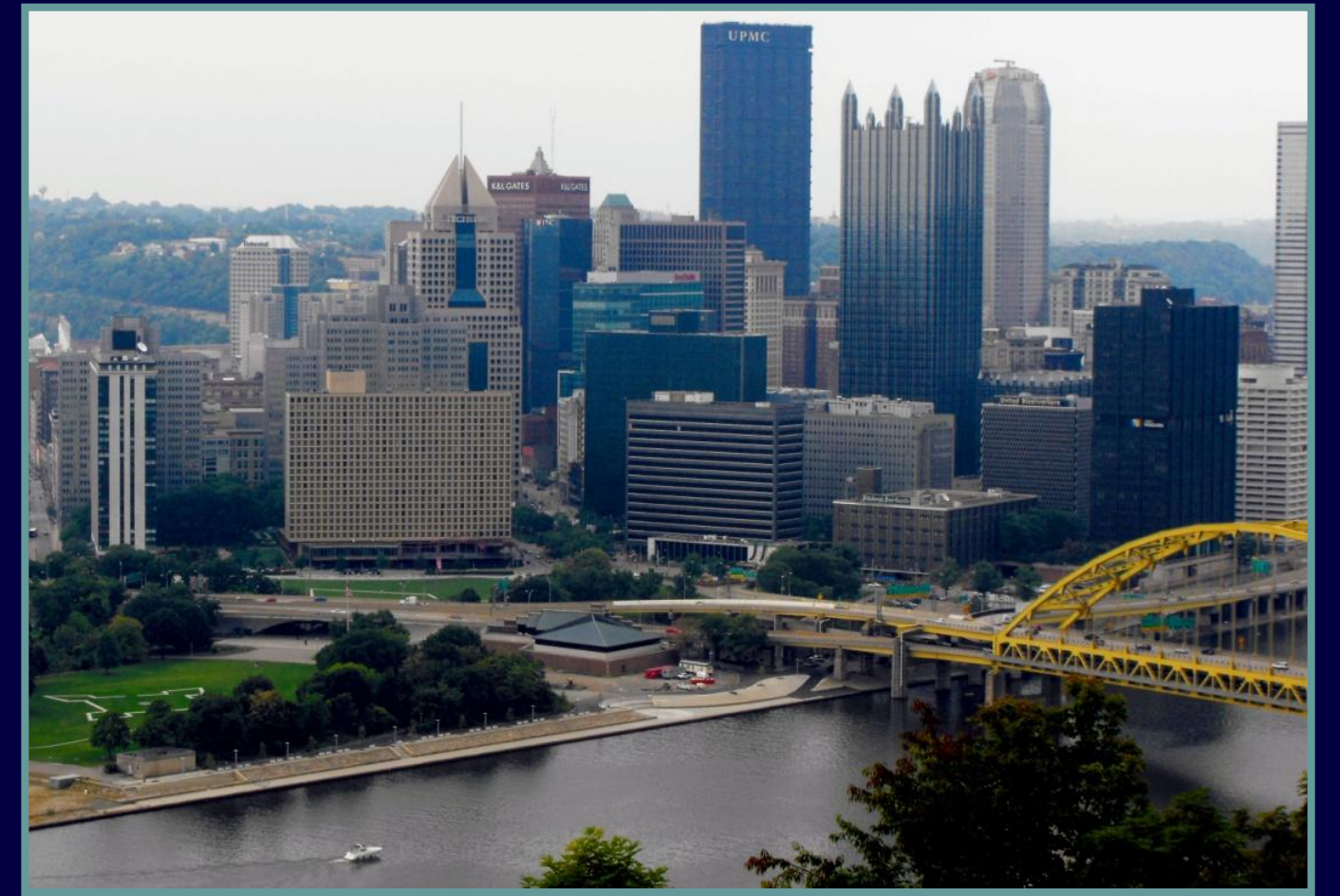
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# THANK YOU!

# QUESTIONS/COMMENTS





# ADDITIONAL INFORMATION



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Photovoltaic Glass Window System Information	
Station Identification	
City	Pittsburgh
State	Pennsylvania
Latitude	40.50°N
Longitude	80.22°W
PV System Specifications	
Array Type	Fixed Tilt
Array Tilt	90°
Array Azimuth (South, East, West)	180°, 135°, 225°
Energy Specifications	
Cost of Electricity	9.6 cents/kWh

**SOUTH:**

Beam Shading Factor																								
0=Full Shading, 1=No Shading																								
	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	0	0	0	0	0	0	0	0	0.84	0.71	0.76	0.82	0.84	0.88	0.94	0.96	0.94	0.92	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0.94	0.84	0.92	0.92	0.92	0.95	0.97	0.96	0.92	0.92	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	1	1	1	1	1	1	0.99	0.98	0.96	0.94	0.92	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	1	1	1	1	1	1	0.99	0.98	0.96	0.94	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	1	1	1	1	1	0.99	0.98	0.96	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0.99	0.98	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0.99	0.98	0.96	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0.99	0.98	0.96	0.94	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	1	1	1	1	1	1	0.99	0.98	0.96	0.94	0.92	0	0	0	0	0	0
Oct	0	0	0	0	0	0	1	0.84	0.88	0.92	0.95	0.95	0.96	0.95	0.94	0.92	0.9	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0.79	0.76	0.78	0.8	0.82	0.88	0.9	0.92	0.92	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0.72	0.76	0.76	0.76	0.78	0.84	0.9	0.94	0.92	0	0	0	0	0	0	0	0

**EAST:**

Beam Shading Factor																								
0=Full Shading, 1=No Shading																								
	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	0	0	0	0	0	0	0	0	0.75	0.98	0.99	0.98	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0.65	0.86	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0.24	0.7	0.95	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0.26	0.5	0.82	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0.35	0.65	0.9	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0.48	0.75	0.95	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0.5	0.8	0.92	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0.24	0.5	0.75	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0.24	0.7	0.95	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0.24	0.7	0.99	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0.75	0.96	0.98	0.98	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0.8	0.94	0.96	0.98	0	0	0	0	0	0	0	0	0	0	0	0	0

**WEST:**

Beam Shading Factor																								
0=Full Shading, 1=No Shading																								
	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.95	0.92	0.9	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.99	0.98	0.92	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0.98	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0.96	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.99	0.98	0.92	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.98	0.95	0.92	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.92	0.9	0	0	0	0	0	0	0







# ADDITIONAL INFORMATION



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Life-Cycle Energy Savings Cost for the Photovoltaic Glass Window System						
Year	Energy Cost (\$/kWh)	AEC Value (\$/kWh)	Energy Savings (kWh)	Total Savings (\$)	Yearly Maintenance Cost (\$/kWh)	Total Savings Cost (\$)
1	0.170	0	29,283.14	4,978.13	0.03	4,099.64
2	0.172	0.4	29,283.14	16,741.17	0.03	15,862.68
3	0.173	0.4	29,283.14	16,791.45	0.03	15,912.96
4	0.175	0.4	29,283.14	16,842.23	0.03	15,963.74
5	0.177	0.4	29,283.14	16,893.52	0.03	16,015.03
6	0.179	0.4	29,283.14	16,945.32	0.03	16,066.83
7	0.180	0.4	29,283.14	16,997.65	0.03	16,119.15
8	0.182	0.4	29,283.14	17,050.49	0.03	16,172.00
9	0.184	0.4	29,283.14	17,103.86	0.03	16,225.37
10	0.186	0.4	29,283.14	17,157.77	0.03	16,279.27
11	0.188	0.4	29,283.14	17,212.21	0.03	16,333.72
12	0.190	0.4	29,283.14	17,267.20	0.03	16,388.71
13	0.192	0.4	29,283.14	17,322.74	0.03	16,444.25
14	0.193	0.4	29,283.14	17,378.84	0.03	16,500.34
15	0.195	0.4	29,283.14	17,435.49	0.03	16,557.00
16	0.197	0.4	29,283.14	17,492.71	0.03	16,614.22
17	0.199	0.4	29,283.14	17,550.51	0.03	16,672.02
18	0.201	0.4	29,283.14	17,608.88	0.03	16,730.39
19	0.203	0.4	29,283.14	17,667.84	0.03	16,789.34
20	0.205	0.4	29,283.14	17,727.38	0.03	16,848.89
21	0.207	0.4	29,283.14	17,787.53	0.03	16,909.03
22	0.210	0.4	29,283.14	17,848.27	0.03	16,969.77
23	0.212	0.4	29,283.14	17,902.62	0.03	17,031.12
24	0.214	0.4	29,283.14	17,971.58	0.03	17,093.09
25	0.216	0.4	29,283.14	18,034.16	0.03	17,155.67
<b>TOTAL</b>						<b>\$399,754.22</b>



## ADDITIONAL INFORMATION



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### STRUCTURAL BREADTH:

- Existing roof deck = 1.5B20 metal roof deck
- Change to 1.5B16 metal roof deck and 22KCS4 open-web steel joists

### SCHEDULE ANALYSIS:

- Level 2 roof is undergoing 20 days of construction starting July 25, 2011 and ending August 19, 2011.
- With the metal roof deck and steel joist changes, it is assumed that the Level 2 roof construction will take an extra 30 days.
- Therefore, the ending date of construction will be approximately September 19, 2011.
- The interiors phase for the second floor starts on September 5, 2011 and ends 30 days later (approximately October 5, 2011).
- The schedule will be delayed by 14 days.





# ADDITIONAL INFORMATION



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Green Roof System Material Cost			
Component	SF	Cost/SF (\$/SF)	Total Cost (\$)
Aggregate/Stone Gravel	536.25	2.00	1,072.50
Brick Pavers	718.95	15.00	10,784.25
Concrete Pavers	3,094.90	10.00	30,949.00
LiveRoof® Maxx System Trays	5,918.66	19.00	112,454.54
Roof Accessories	-	-	30,000
Slip Sheet/Root Barrier	10,268.76	0.70	7,188.13
Metal Roof Deck & Steel Joists	-	-	48,112.11
TOTAL			\$240,560.53

Green Roof System Equipment and Installation Cost			
Component	SF	Cost/SF (\$/SF)	Total Cost (\$)
Aggregate/Stone Gravel	536.25	2.00	1,072.50
Brick Pavers	718.95	20.00	14,379.00
Concrete Pavers	3,094.90	10.00	30,949.00
LiveRoof® Maxx System Trays	5,918.66	3.80	22,490.91
Roof Accessories	-	-	33,000
Slip Sheet/Root Barrier	10,268.76	0.77	7,906.95
Metal Roof Deck & Steel Joists	-	-	54,479.79
TOTAL			\$164,278.14

Green Roof System Maintenance Cost			
Time / Year	SF	Cost/SF (\$/SF)	Total Cost (\$)
1	5,918.66	0.30	1,775.60
2	5,918.66	0.30	1,775.60
3	5,918.66	0.30	1,775.60
4	5,918.66	0.30	1,775.60
TOTAL			\$7,102.39



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Total Rent Paid Without Green Roof System				
Apartment Type	No. of Apartments	Rent Price (\$)	Rent Paid/Month (\$)	Rent Paid/Year (\$)
<b>Floors 2-14:</b>				
1 Bedroom, No Balcony	43	800	34,400	412,800
	43	900	38,700	464,400
	42	1,000	42,000	504,000
	42	1,100	46,200	554,400
2 Bedrooms, No Balcony	4	1,200	4,800	57,600
	4	1,300	5,200	62,400
	4	1,400	5,600	67,200
	4	1,500	6,000	72,000
1 Bedroom Studio, No Balcony	3	1,600	4,800	57,600
	3	1,700	5,100	61,200
	3	1,800	5,400	64,800
	3	1,900	5,700	68,400
<b>Floor 15:</b>				
1 Bedroom, Small Balcony	3	2,000	6,000	72,000
	3	2,100	6,300	75,600
1 Bedroom, Large Balcony	1	2,200	2,200	26,400
	2	2,300	4,600	55,200
2 Bedrooms, Small Balcony	2	2,400	4,800	57,600
	2	2,500	5,000	60,000
	3	2,600	7,800	93,600
1 Bedroom Studio, Small Balcony	1	2,700	2,700	32,400
1 Bedroom Studio, Large Balcony	1	2,800	2,800	33,600
2 Bedrooms, 2 Floors, Large Balcony	1	2,900	2,900	34,800
3 Bedrooms, 2 Floors, Large Balcony	1	3,000	3,000	36,000
<b>TOTAL</b>	<b>218</b>		<b>\$252,000</b>	<b>\$3,024,000</b>

Total Rent Paid to Accommodate for Green Roof Maintenance Cost and Loss of Third Floor Apartment Unit				
Apartment Type	No. of Apartments	Rent Price (\$)	Rent Paid/Month (\$)	Rent Paid/Year (\$)
<b>Floors 2-14:</b>				
1 Bedroom, No Balcony	43	845	36,335	436,020
	43	945	40,635	487,620
	42	1,045	43,890	526,680
	41	1,145	46,945	563,340
2 Bedrooms, No Balcony	4	1,245	4,980	59,760
	4	1,345	5,380	64,560
	4	1,445	5,780	69,360
	4	1,545	6,180	74,160
1 Bedroom Studio, No Balcony	3	1,645	4,935	59,220
	3	1,745	5,235	62,820
	3	1,845	5,535	66,420
	3	1,945	5,835	70,020
<b>Floor 15:</b>				
1 Bedroom, Small Balcony	3	2,045	6,135	73,620
	3	2,145	6,435	77,220
1 Bedroom, Large Balcony	1	2,245	2,245	26,940
	2	2,345	4,690	56,280
2 Bedrooms, Small Balcony	2	2,445	4,890	58,680
	2	2,545	5,090	61,080
	3	2,645	7,935	95,220
1 Bedroom Studio, Small Balcony	1	2,745	2,745	32,940
1 Bedroom Studio, Large Balcony	1	2,845	2,845	34,140
2 Bedrooms, 2 Floors, Large Balcony	1	2,945	2,945	35,340
3 Bedrooms, 2 Floors, Large Balcony	1	3,045	3,045	36,540
<b>TOTAL</b>	<b>217</b>		<b>260,665</b>	<b>\$3,127,980</b>



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## 3D Laser Scanning Process Cost:

- Total gross building area = 295,000 SF
- Cost per SF = \$0.50 SF
- Total cost of 3D laser scanning process = \$147,500

Total Cost of Change Orders			
Change Orders	Magnitude of Issue	Percentage of Magnitude (%)	Change Order Cost (\$)
Demolition for Door 109/1	Medium	0.5	5,530.32
Clash Between Trash Chute and Existing Steel	High	3	33,181.92
Column in New Apartment Space	High	1	11,060.64
Existing Beam in New Tenant Space	Low	0.3	3,318.19
Existing Steel Beam in Stair 1510	Low	0.1	1,106.06
Overhead Beam in Unit 1519	Medium	0.6	6,636.38
Waterproofing Details Unknown	High	2	22,121.28
<b>TOTAL</b>			<b>\$82,954.80</b>

## 3D Laser Scanning Process Schedule Impact:

- Using Leica's ScanStation C10, process takes a half a day to scan one floor
- Using Cyclone software, it takes one day per floor to process the information



# ADDITIONAL INFORMATION



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Energy Loads for Bathroom, Laundry, and Walk-In Closet Lighting

Light Fixture	Location Used	Watts/Light Fixture	Quantity	kW	Hours/Day	kWh/Day	kWh/Year
Vanity Light	Bathroom	39	239	9.321	12	111.852	40,825.98
Exhaust Fan/Light	Bathroom	75	238	17.85	12	214.2	78,183
Surface Fluorescent	Laundry/Utility Room	64	152	9.728	12	116.736	42,608.64
Decorative Glass	Walk-In Closets	26	38	0.988	12	11.856	4,327.44
<b>TOTAL</b>		<b>204</b>	<b>667</b>	<b>37.887</b>		<b>454.644</b>	<b>165,945.06</b>

Energy Savings from Occupancy Sensors

Location Used	Quantity	Watts/Light Fixture	kW	Hours/Day	kWh/Day	Percent Savings (%)	Daily Energy Savings	Annual Energy Savings
Bathroom	239	39	9.321	12	111.852	40	44.7408	16,330.392
Bathroom	238	75	17.85	12	214.2	40	85.68	31,273.2
Laundry/Utility Room	152	64	9.728	12	116.736	50	58.368	21,304.32
Walk-In Closets	38	26	0.988	12	11.856	60	7.1136	2,596.464
<b>TOTAL</b>	<b>667</b>	<b>204</b>	<b>37.887</b>		<b>454.644</b>		<b>195.90</b>	<b>71,504.38</b>



# ADDITIONAL INFORMATION



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Life-Cycle Savings Cost of Lighting Occupancy Sensor Control System			
Year	Energy Cost (\$/kWh)	Energy Savings (kWh)	Total Savings (\$)
1	0.170	71,504.38	12,155.74
2	0.172	71,504.38	12,298.75
3	0.173	71,504.38	12,370.26
4	0.175	71,504.38	12,513.27
5	0.177	71,504.38	12,656.27
6	0.179	71,504.38	12,799.28
7	0.180	71,504.38	12,870.79
8	0.182	71,504.38	13,013.80
9	0.184	71,504.38	13,156.81
10	0.186	71,504.38	13,299.81
11	0.188	71,504.38	13,442.82
12	0.190	71,504.38	13,585.83
13	0.192	71,504.38	13,728.84
14	0.193	71,504.38	13,800.34
15	0.195	71,504.38	13,943.35
		<b>TOTAL</b>	<b>\$195,635.97</b>