WESTINGHOUSE BUILDING 4

Cranberry, PA

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FINAL PRESENTATION | APRIL 11, 2010 | DR. LEICHT - ADVISOR

Presentation Outline

I. Project Overview
II. Introduction to Analyses
III. Analysis I: Short Interval Production Scheduling
IV. Analysis II: Rooftop Photovoltaic Array
    - Electrical Breadth
V. Analysis III: Lightweight Precast Facade
    - Structural Breadth
VI. Recommendations
VII. Acknowledgements
VIII. Questions

Westinghouse

WESTINGHOUSE BUILDING 4
Cranberry, PA

Presentation Outline

Project Overview

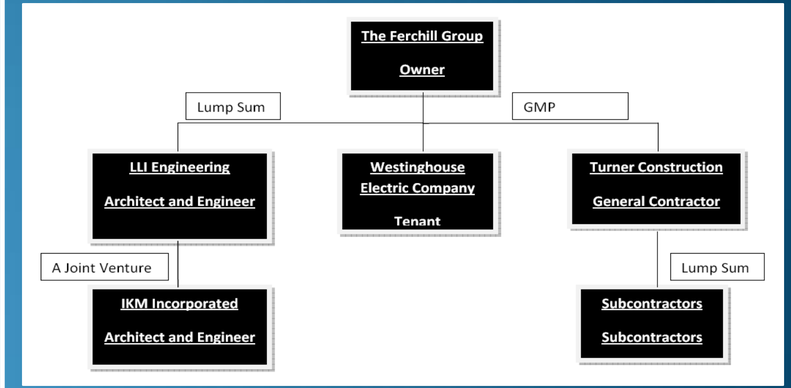
- Location
  - Cranberry, PA
  - Cranberry Woods Complex
- Owner
  - The Ferchill Group
- Tenant
  - Westinghouse Electric Company
  - 500 employees
- General Contractor
  - Turner Construction Company

WESTINGHOUSE BUILDING 4
Cranberry, PA

Presentation Outline

Project Overview

- Occupancy Type
  - Office
- Size
  - 121,000 square feet
- Number of Stories
  - 3 total stories
- Construction Dates
  - December 2009 – September 2010
- Building Cost
  - $18 million
- Delivery Method
  - Design-Bid-Build



Presentation Outline

Introduction to Analyses

- Analysis I: Short Interval Production Scheduling
  - Quantities, Durations, Cost
- Analysis II: Rooftop Photovoltaic Array
  - Benefits to Westinghouse, Elec. Calcs., Payback Period
- Analysis III: Lightweight Precast Panels
  - Structural Analysis, Durations, Costs

Presentation Outline

Analysis I: Short Interval Production Scheduling

- Problem Statement:
  - 2 weeks lost due to documentation issues
  - Westinghouse occupancy ASAP
- Goal:
  - Recover 2 weeks in overall project duration

Distinguish Between Standard SIPs and Parade of Trades

- Standard SIPs Schedule
  - Standard SIPs schedules generally involve one specific trade.
- Parade of Trades
  - Involves multiple trades
  - Requires precise coordination between trades

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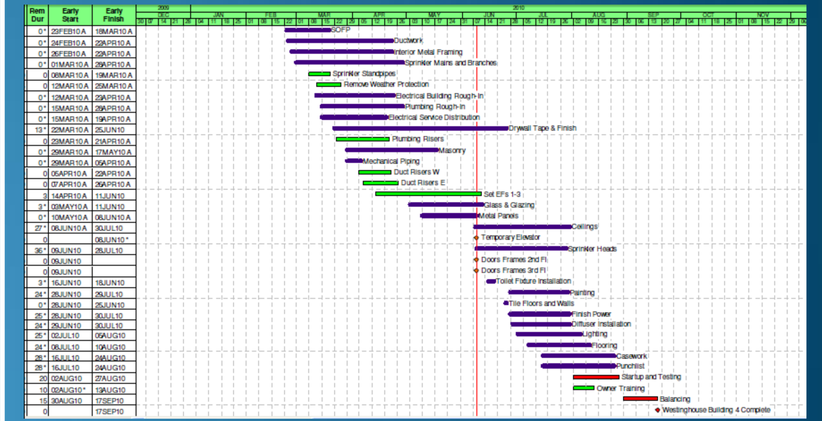
Current Project Schedule

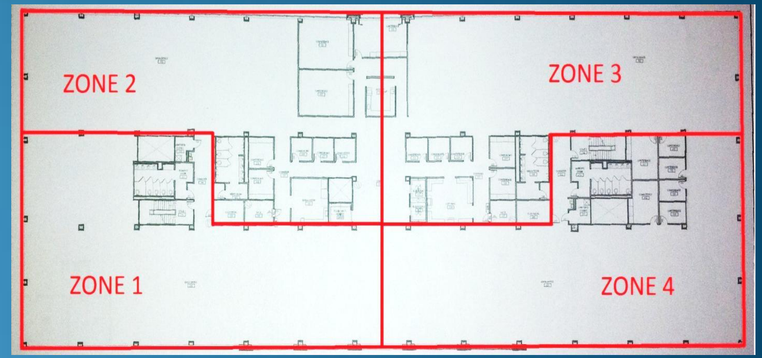
- February 2010 – September 2010
  - 26 Week Duration
- First – Ductwork, Finish - Flooring
- Exterior drywall is dependant on acceleration of metals and glazing
- Involves the following finish trades:
  - Ductwork
  - Framing
  - Sprinkler branches
  - Elect. Plumb. Rough-ins
  - Drywall
  - Ceiling
  - Sprinkler Heads
  - Painting
  - Lighting
  - Flooring



Presentation Outline

Determining Zones

- Floors were broken up into 4 zones
  - 2nd floor was chosen for analysis
  - 4 zones on all 3 floors for 12 total zones
- Similar Spaces
  - Meeting rooms, open office space
- Varying Spaces
  - Bathrooms, mechanical room, electrical room



Presentation Outline

Calculate Quantities, Manpower, and Durations

- Zone 1 on Floor 2 was taken as standard
  - Quantities determined from building drawings
- Manpower and crew size was determined using RS Means
  - Crews were multiplied to meet necessary durations
- Durations were determined using the original schedule and RS Means
  - Original durations were divided by 12 zones
- Matrix durations were kept to 5 day intervals
  - Extra time allowed for inspections or zone variation

Material Takeoff for 1 Section

Material	Material Description	Quantity	Units	Crew	Dainly Output	Crew Mult.	Total Duration	Matrix Duration
5/8" GWB	4'X8'X5/8" Gypsum Wall Board	5,133	sqft	6	360 sqft	2	7.1 days	10 days
Ductwork	Varying Sizes	727	LF	3	55 LF	3	3.8 days	5 days
Spinkler Branches	Branches	699	LF	2	53 LF	3	4.4 days	5 days
Sprinkler Heads	Concealed Overhead Sprinklers	57	Sprinklers	4	16 Sprin. Heads	1	3.6 days	5 days
Interior Framing	3 5/8" metal studs at 16"O.C.	336	LF	2	66 LF	1	5 days	5 days
Plumbing electrical rough in	Complete Necesssary Rough-ins	688	LF	4	70 LF	2	4.5 days	5 days
Ceilings	2'X4' Accoustic Ceiling Tiles	10,008	sqft	1	380 sqft	6	4.4 days	5 days
Painting	PPG 'Heavy Cream 314-2' Eggshell Finish	5,133	sqft	1	2750 sqft	1	1.9 days	4 days
Lighting	Direct/Indirect Pendant Lighting	146	Lights	1	5 lights	6	4.9 days	5 days
Flooring	Mohawk Commercial Floor tiles	10,008	sqft	1	720 sqft	3	4.6 days	5 days

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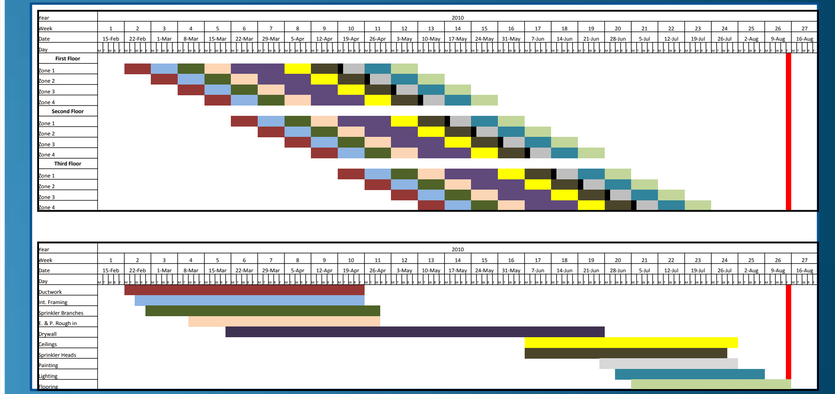
Presentation Outline

Create SIPs Matrix

- Durations taken from takeoff chart
- SIPs schedule key created
- Comparison with original schedule (bottom chart)
- Schedule savings
  - 3 weeks saved on the finish schedule
  - Finishes are on the critical path
  - Overall schedule reduced by 3 weeks

SIPS Schedule Key

Order	Color	Activity
1		Ductwork
2		Interior Framing
3		Sprinkler Branches
4		Elec. & Plumbing Rough In
5		Drywall
6		Ceilings
7		Sprinkler Heads
8		Painting
9		Lighting
10		Flooring
11		Unforeseen Delays



Presentation Outline

Conclusions

- General Conditions savings of $78,000
- 3 weeks of schedule savings
- Early move in for Westinghouse
- Added time on site for individual trades
- Small projects are not as good for SIPs schedules

Short Interval Production Schedule Results

Results of using SIPS schedule	Entity Effected	Effect
Decrease the finish schedule by 3 weeks	Turner Construction	Turner can subtract 3 weeks of general conditions costs (around $78,000) from the project cost and report that as extra profit. This also takes away some of the fear of incurring liquidated damages from Tuner as they will have 3 extra weeks to deal with any short-comings.
Decrease overall project by 3 weeks	Westinghouse	Westinghouse will be able to move its employees into their new building 3 weeks earlier. This will save them $5,000 days in rent and be much more convenient for the employees
Stretch out individual trades	Subcontractors	By using a SIPS schedule some of the contractors will be on this job longer than originally planned. In tough times when work is hard to come by this is seen as a good thing to hard working subcontractors.
Predictability of SIPS schedule	All	SIPS schedule make a job very predictable. The subcontractors know exactly where in the building they will be working and when. By the same token this also makes the subcontractors very easy for the project manager to find should the need to meet with them arise. And for the customer is provides a very confident look into when the project will be completed.

Presentation Outline

Analysis II: Rooftop Photovoltaic Array

- Problem Statement:
  - Westinghouse promotes itself as a "green" company
- Goal:
  - Prove monetary benefits for Westinghouse
  - Prove non-monetary benefits for Westinghouse

Presentation Outline

Solar Panel Research

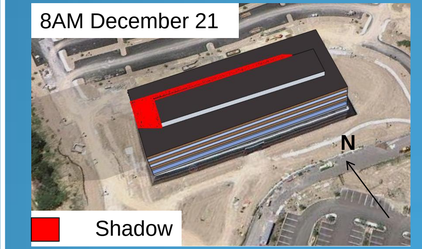
- Design Parameters for PV Array
- Monocrystaline Panels were chosen
  - More Expensive
  - 14% - 17% efficient
- Topray Solar panel selected

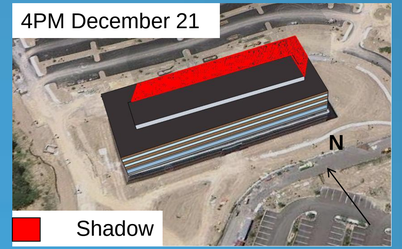
Parameters for PV Design	
Location	Cranberry, PA
Latitude	40.7° N
Roof Orientation	Directly South
Available Roof Space	12,000 sqft
Roof Pitch	Flat
Solar Hours	4.4 kWh/m^2/day
Wind Conditions	Mild
Snow Loads	20 psf

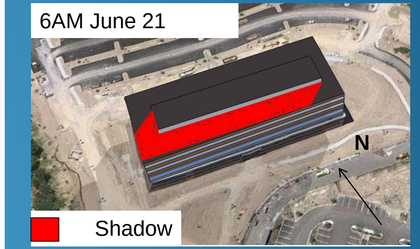
Presentation Outline

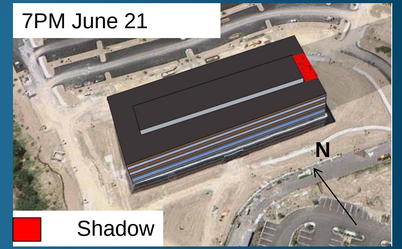
Solar Study

- Google Sketchup used to conduct solar study









Presentation Outline

Panel Layout

- Solar array was designed for maximum output
- Maximum number of panels = 440

- Max amperage 4.41 A
- Max Voltage 41.67 V
- Max Panels * 440

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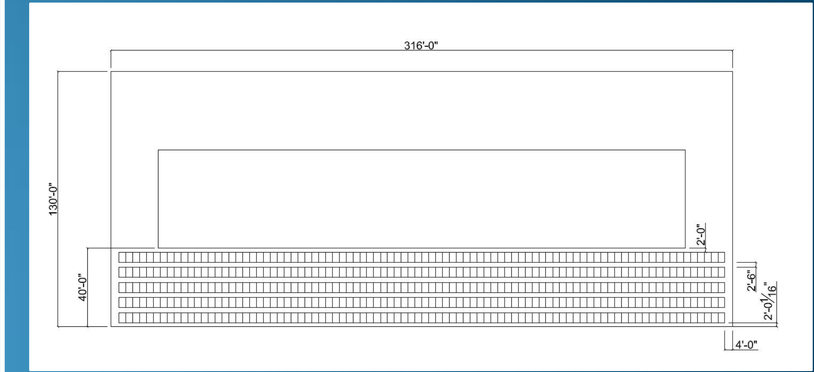
81 kW * 5 hr/day * 365 days/year * .94

Inverter Efficiency

Total Output = 139,000 kWh/year



Presentation Outline

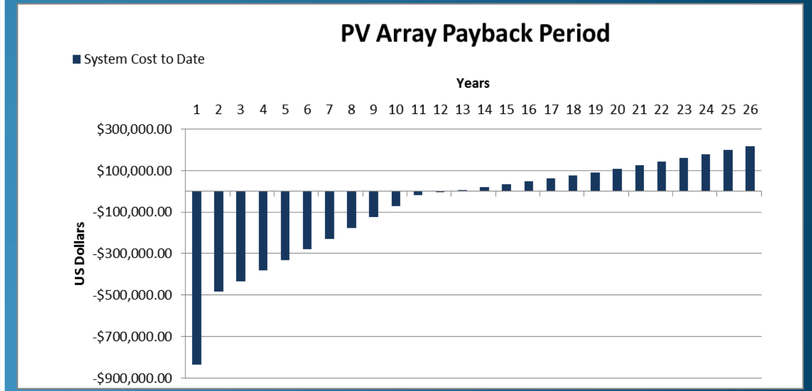
Payback Period

- Study of PV array output over the 25 year warrantee

- Initial Cost = $834,000
- Final Earnings = $218,000

- Up front funding
  - Federal – 30%
  - State – 6%
  - Utility - $300/MW for 10 years

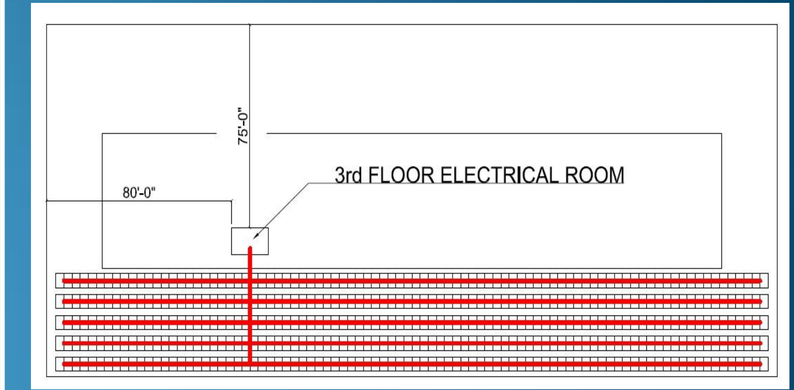
- 11 yr payback



Presentation Outline

System Tie-In

- Utility Interactive Inverter System
- 20 panels per inverter = 22 inverters total
- Inverters will be housed in the 3rd floor electrical room
- Array will tie into the 3rd floor main bus



Presentation Outline

Conclusions

- Westinghouse employees thought highly of PV proposal
- $218,000 of revenue
- High up front cost
- Funding is constantly changing

Presentation Outline

Analysis III: Use of Lightweight Precast Panels

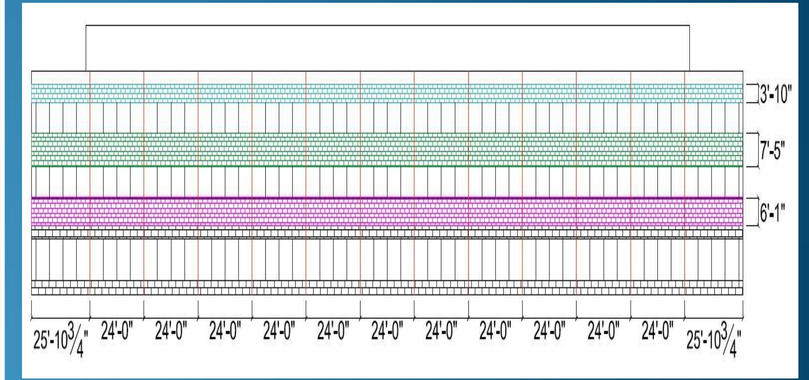
- Problem Statement:
  - Initial façade deemed too plain
  - Penetrations through vapor barrier to add aluminum strips
- Goal:
  - Decrease façade cost
  - Decrease façade schedule duration
  - Eliminate aluminum accent complications

Presentation Outline

Determining Panel Layout and Sizing

- 3 bands of brick masonry
  - Each band is a different height
- Corner panels need to be wider than the others
- Panel size and quantity were determined

Precast Panels				
	Length (ft)	Height (ft)	Quantity of Panels	Total (sqft)
Top Band	25.9	4.8	8	995
	24	4.8	28	3,226
Middle Band	25.9	7.4	8	1,533
	24	7.4	28	4,973
Bottom Band	25.9	6.1	8	1,264
	24	6.1	28	4,099
	Grand Total		108	16,089



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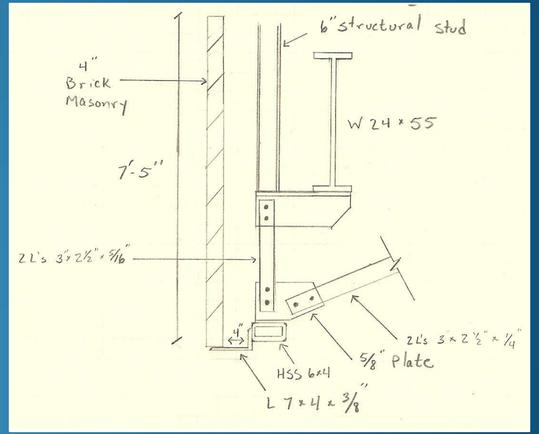
Analysis of Current Structural System

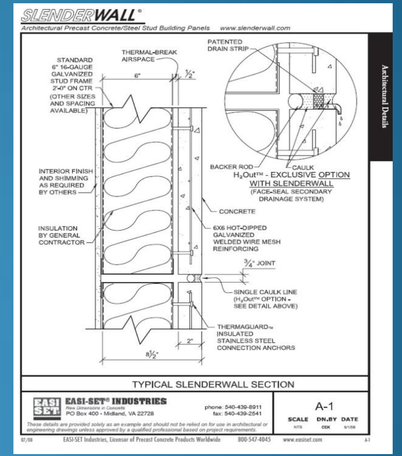
- W24 X 55 outer spandrel beam
  - Each band is a different height
- L 7 X 4 X 3/8" support bracket
  - 8" of total space
- 6" structural steel studs for lateral support

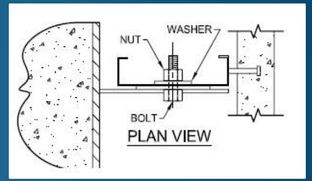


Presentation Outline

SlenderWall System

- ½” face brick
- 2” concrete backing
- 6” galvanized steel studs
- Pivoting steel stud connects the concrete to the 2 x 6
  - Allows for shifting in the differing façade materials
- Connections spaced at 24” O.C. both vertically and horizontally





Presentation Outline

Weight comparison

- Original brick masonry is 42 pounds per square foot
- Chosen SlenderWall system is 30 pounds per square foot
- Precast is 193,000 pounds lighter overall

Weight Comparison

	Quantityof Panels	Masonry Unit Weight (lb/sqft)	Total Masonry Weight (lbs)	Precast Unit Weight (lb/sqft)	Precast Panel Weight (lbs)	Total Precast Weight (lbs)
Top Band	8	42	41,772	30	3,730	29,837
	28	42	135,475	30	3,456	96,768
Middle	8	42	64,398	30	5,750	45,998
Band	28	42	208,858	30	5,328	149,184
Bottom	8	42	53,085	30	4,740	37,918
Band	28	42	172,166	30	4,392	122,976
Total	108	42	675,753	30	482,681	482,681

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RISA Structural Analysis of Existing Brick Masonry

- .355 kips per foot for glass storefront and precast system
- **Max moment** = 346 k-ft
- **Max deflection** = .934 inches
- Verified Hand Calculations

RISA Structural Analysis of Precast System

- .265 kips per foot for glass storefront and precast system
- **Max moment** = 339 k-ft
- **Max deflection** = .917 inches
- Verified Hand Calculations

Presentation Outline

Cost Comparison

- Precast Cost = $42.00/sqft
- Brick Masonry = $47.24/sqft
- Total Savings = $84,000

Cost Comparison

	Quantityof Panels	Masonry Unit Cost ($/sqft)	Masonry Total Cost	Precast Unit Cost ($/sqft)	Precast Total Cost	Cost Savings
Top Band	8	$47.24	$46,979.22	$42.00	$41,771.52	$5,207.70
	28	$47.24	$152,365.04	$42.00	$135,475.20	$16,889.84
Middle	8	$47.24	$72,426.30	$42.00	$64,397.76	$8,028.54
Band	28	$47.24	$234,896.11	$42.00	$208,857.60	$26,038.51
Bottom	8	$47.24	$59,702.76	$42.00	$53,084.64	$6,618.12
Band	28	$47.24	$193,630.57	$42.00	$172,166.40	$21,464.17
Total	108	$47.24	$760,000.00	$42.00	$675,753.12	$84,246.88

Duration Comparison

- 22 days saved using precast system
- Overall project schedule would not change

Duration Comparison

	Quantityof Panels	Masonry Duration (days)	Precast Duration (days)	Schedule Reduction (days)
Top Band	8	2	1	1
	28	7	4	4
Middle	8	3	1	2
Band	28	11	4	7
Bottom	8	3	1	2
Band	28	9	4	5
Total	108	35	14	22

Presentation Outline

Conclusions

- $84,000 saved
- Façade duration reduced by 22 days
- .017” less deflection in spandrel beam
- Beam moment reduced by 7 k-ft

Presentation Outline

Recommendations

- Analysis I – SIPs schedule - **RECOMMENDED**
- Analysis II – Rooftop PV array - **RECOMMENDED**
- Analysis III – Lightweight Precast Façade - **RECOMMENDED**

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QUESTIONS?

Presentation Outline

Building Usage

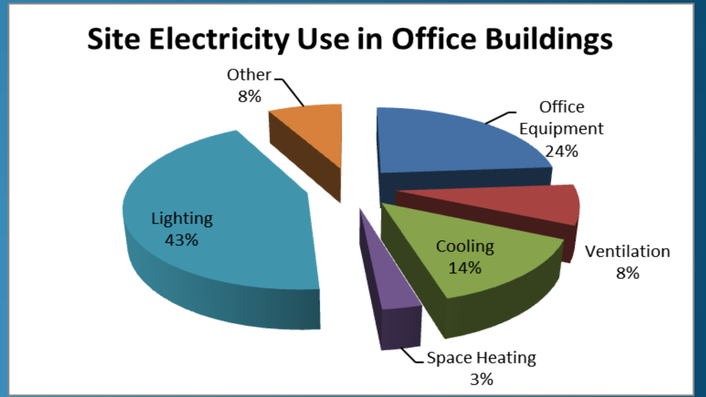
- To compare panel output to building consumption

- Office Bldg usage .0517 k Wh/sqft/day
- Bldg sqft. * 121,000 sqft

  6,300 kWh/day

Ventilation usage = 500kW
Panel Output = 405 kW

PV array will cover the majority of the ventilation load on the building



Presentation Outline

RISA Structural Analysis of Existing System

- Reduced live load = 79.13 psf
- Dead Load = 68 psf

- Wu = 1.2(68) + 1.6(79.13 = 208.2 psf
- Pu = 208.2/1000 * (8 * 48/2) = 40 kips per floor beam
- .355 kips per foot for glass storefront and brick masonry

- **Max moment** = 346 k-ft
- **Max deflection** = .934 inches

- Verified Hand Calculations

Deflection Checks

- Δ TL = (24' * 12)/240 = 1.2 " OK
- Δ LL = (24' 8 12)/360 = .8 " No