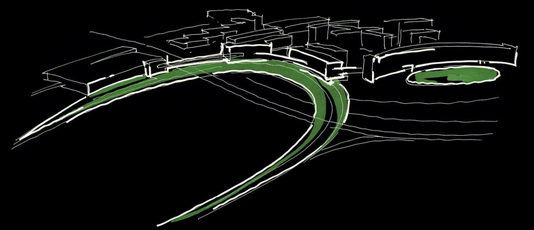
Presentation Outline

- Project Background
- ANALYSIS#1: Multi-Trade Prefabrication Study
- ANALYSIS#2: Cost Estimating Through 3D Modeling
- ANALYSIS#3: Feasibility of Solar PV-System
  - Electrical Breadth
  - Structural Breadth (Will Not Be Discussed)
- Lessons Learned
- Acknowledgements



Penn State Milton S. Hershey Medical Center
Children's Hospital
Hershey, Pa

Abdulwahab Hasan | Construction Management

Project Background

PSU AE Senior Thesis
Final Presentation
April 11th , 2011

Presentation Outline:

Courtesy of Payette Associates

Building Name:
Children's Hospital

Location:
500 University Drive, Hershey, PA 17033

Gross Building Area:
262,587 SF

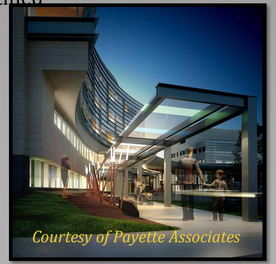
Number of Stories:
5-Stories + Underground Level

Delivery Method:
Design-Bid-Build w/ CM Agency @ Risk

Contracted GMP Amount:
$115 Million

Construction Dates:
March 17th,2010 – August 20th,2012

LEED Certification:
Certified



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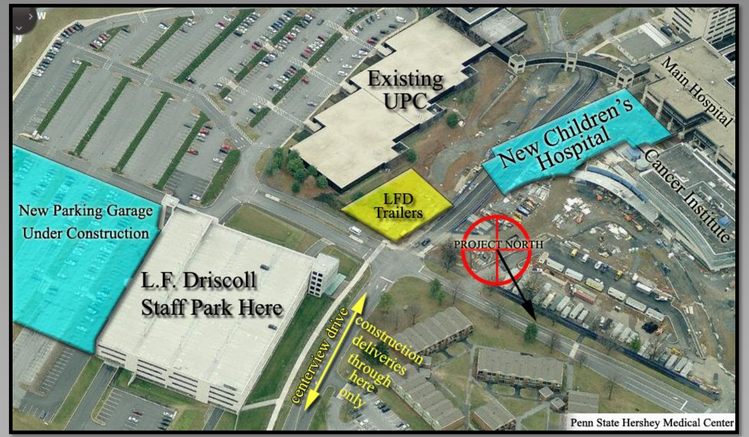

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Project Background

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Presentation Outline:

Courtesy of Payette Associates

PROJECT TEAM

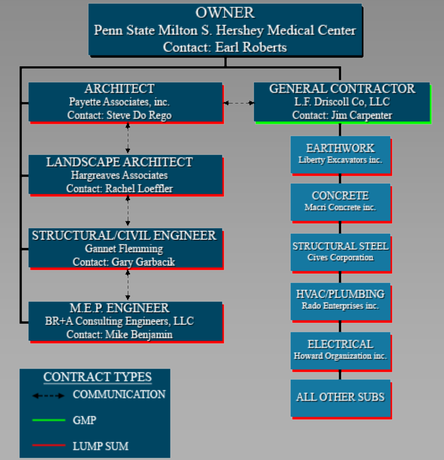
Owner:
Penn State Milton S. Hershey Medical Center

Architect:
Payette Associates

Construction Manager:
L.F. Driscoll Co, LLC

Structural Engineer:
Gannett Fleming INC

MEP Engineer:
BR+A Consulting Engineers, LLC



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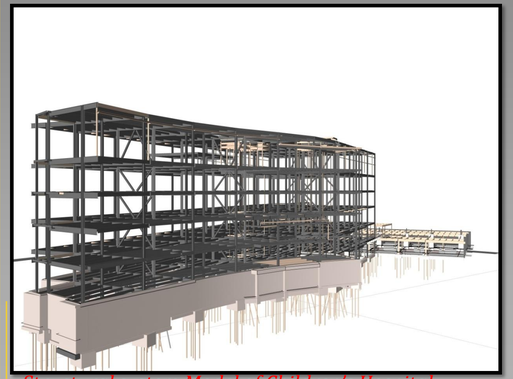


Structural system Model of Children's Hospital

Structural System:

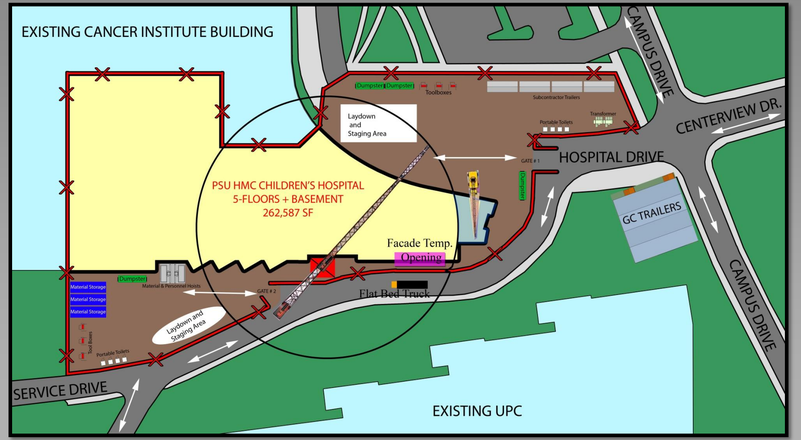
- Column Piers + Grade Beams on Micropiles
- Structural Steel Framing
- Elevated Slabs on Metal Decks

Building Façade:

- CMU Back-Up
- Limestone and Granite Cladding with Metal Panels
- Curtain Wall with LED Fitted Mullions

Construction Phases:

- Mobilization
- Sub-Grade Preparation
- Superstructure Erection
- Structural Skin Erection
- Building Water-Tight and Fitouts
- Site Improvements



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Multi-Trade Prefabrication

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Presentation Outline:

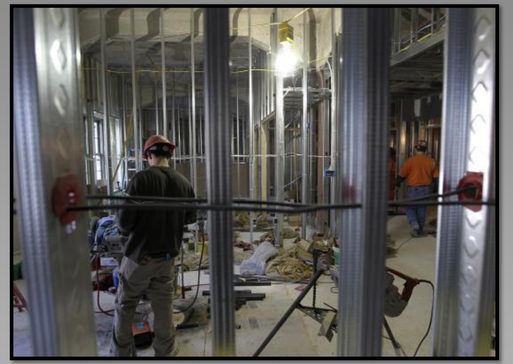
Prefabricated Bathroom Pods at Miami Valley Hospital

Problem Identification

- Site Congestions
- Limited Material Laydown Areas
- Reduced Productivity

Research Goal

- Determine Systems That Could be Prefabricated
- Reduce Schedule
- Cost Implications



Typical Congested Interior Fit-out work

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Multi-Trade Prefabrication

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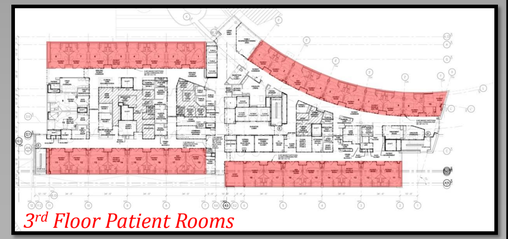
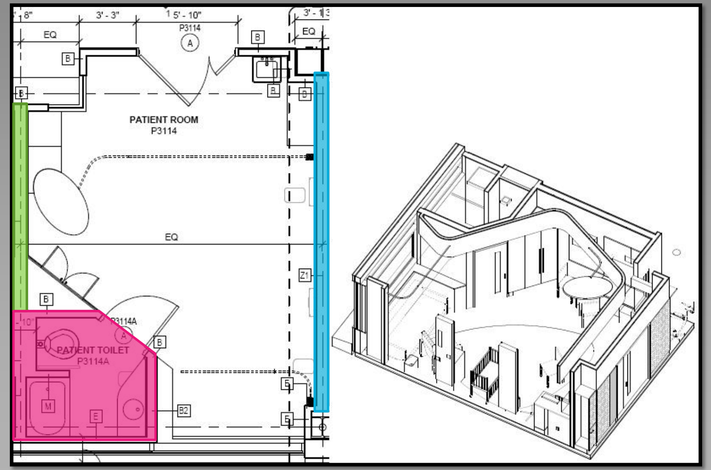
Presentation Outline:

WHAT TO PREFABRICATE?



3rd Floor Patient Rooms



Total Amount of Prefabricated Units:

Unit	3rd Floor		4th Floor		Total
Bathrooms	34	+	34	=	68 units
HEADWALL	21	+	21	=	42 units
FOOTWALL	17	+	17	=	34 units

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Multi-Trade Prefabrication

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Presentation Outline:

Courtesy of Google Images

Schedule Impact

250 SF of Wall Per Day Using RS MEANS Productivity Data

TOTAL TIME NEEDED TO CONSTRUCT UNITS (ON-SITE)

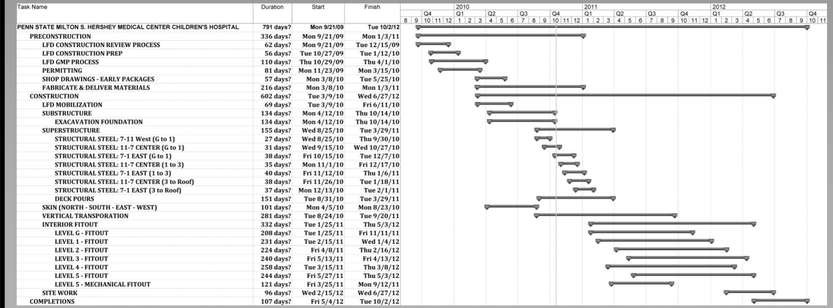
	UNIT	QUANTITY	SF OF WALL PER UNIT	TOTAL SF	TIME TO CONSTRUCT
3RD FLOOR	BATHROOM POD	34	180 SF	6120 SF	16 DAYS
	HEADWALL	21	160 SF	3360 SF	9 DAYS
	FOOTWALL	17	90 SF	1530 SF	4 DAYS
	SUB TOTAL			11010 SF	29 DAYS
4TH FLOOR	BATHROOM POD	34	180 SF	6120 SF	16 DAYS
	HEADWALL	21	160 SF	3360 SF	9 DAYS
	FOOTWALL	17	90 SF	1530 SF	4 DAYS
	SUB TOTAL			11010 SF	29 DAYS
TOTAL	3RD AND 4TH			22020 SF	58 DAYS

29 DAYS SAVED PER FLOOR FITOUT!

General Conditions Impact

GC Calculated to be $6.62 Millions over 31 Months

58 Days of Project Schedule Saving = $427,131 of GC Savings



Task Name	Duration	Start	Finish
PENN STATE MILTON S. HERSHEY MEDICAL CENTER CHILDREN'S HOSPITAL	791 days?	Mon 9/21/09	Tue 10/2/12
PRECONSTRUCTION	336 days?	Mon 9/21/09	Mon 1/3/11
LFD CONSTRUCTION REVIEW PROCESS	62 days?	Mon 9/21/09	Tue 12/15/09
LFD CONSTRUCTION PREP	56 days?	Tue 10/27/09	Tue 1/12/10
LFD GMP PROCESS	110 days?	Thu 10/29/09	Thu 4/1/10
PERMITTING	81 days?	Mon 11/23/09	Mon 3/15/10
SHOP DRAWINGS - EARLY PACKAGES	57 days?	Mon 3/8/10	Tue 5/25/10
FABRICATE & DELIVER MATERIALS	216 days?	Mon 3/8/10	Mon 1/3/11
CONSTRUCTION	602 days?	Tue 3/9/10	Wed 6/27/12
LFD MOBILIZATION	69 days?	Tue 3/9/10	Fri 6/11/10
SUBSTRUCTURE	134 days?	Mon 4/12/10	Thu 10/14/10
EXACAVATION FOUNDATION	134 days?	Mon 4/12/10	Thu 10/14/10
SUPERSTRUCTURE	155 days?	Wed 8/25/10	Tue 3/29/11
STRUCTURAL STEEL: 7-11 West (G to 1)	27 days?	Wed 8/25/10	Thu 9/30/10
STRUCTURAL STEEL: 11-7 CENTER (G to 1)	31 days?	Wed 9/15/10	Wed 10/27/10
STRUCTURAL STEEL: 7-1 EAST (G to 1)	38 days?	Fri 10/15/10	Tue 12/7/10
STRUCTURAL STEEL: 11-7 CENTER (1 to 3)	35 days?	Mon 11/1/10	Fri 12/17/10
STRUCTURAL STEEL: 7-1 EAST (1 to 3)	40 days?	Fri 11/12/10	Thu 1/6/11
STRUCTURAL STEEL: 11-7 CENTER (3 to Roof)	38 days?	Fri 11/26/10	Tue 1/18/11
STRUCTURAL STEEL: 7-1 EAST (3 to Roof)	37 days?	Mon 12/13/10	Tue 2/1/11
DECK POURS	151 days?	Tue 8/31/10	Tue 3/29/11
SKIN (NORTH - SOUTH - EAST - WEST)	101 days?	Mon 4/5/10	Mon 8/23/10
VERTICAL TRANSPORATION	281 days?	Tue 8/24/10	Tue 9/20/11
INTERIOR FITOUT	332 days?	Tue 1/25/11	Thu 5/3/12
LEVEL G - FITOUT	208 days?	Tue 1/25/11	Fri 11/11/11
LEVEL 1 - FITOUT	231 days?	Tue 2/15/11	Wed 1/4/12
LEVEL 2 - FITOUT	224 days?	Fri 4/8/11	Thu 2/16/12
LEVEL 3 - FITOUT	240 days?	Fri 5/13/11	Fri 4/13/12
LEVEL 4 - FITOUT	258 days?	Tue 3/15/11	Tue 3/6/12
LEVEL 5 - FITOUT	244 days?	Fri 5/27/11	Thu 5/3/12
LEVEL 5 - MECHANICAL FITOUT	121 days?	Fri 3/25/11	Mon 9/12/11
SITE WORK	96 days?	Wed 2/15/12	Wed 6/27/12
COMPLETIONS	107 days?	Fri 5/4/12	Tue 10/2/12

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Children's Hospital
Hershey, Pa

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Multi-Trade Prefabrication

PSU AE Senior Thesis
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Presentation Outline:

Courtesy of Google Images

Where to Prefabricate the Systems?

- 20,000 SF Warehouse in Harrisburg, PA
- 11 Miles from Jobsite
- Rental Rate = $5.25/SF Per Month
- 2 Months of Rental
- Total Cost of **$105,000**

Truck Loads Required

- Bathroom Pods = 2 Per Truck TOTAL 34 Deliveries
- Headwalls = 2 Per Truck TOTAL 21 Deliveries
- Footwalls = 4 Per Truck TOTAL 9 Deliveries

- Total Miles 1408 @ $3.20 per mile = **$4,500** For Deliveries

Site Logistics

Multi-Trade Prefabrication

Final Conclusion

- 58 Days of Schedule Reduction
- $427K Worth of GC Savings
- Major Reduction in site congestions

Recommendation

- Pursue Prefabrication of Patient Rooms
- Met goals of reducing schedule and site congestions

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3D ESTIMATING

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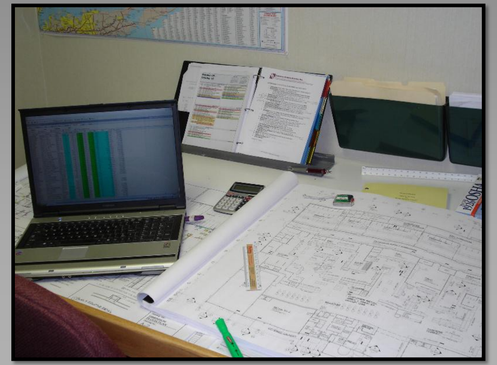
Presentation Outline:



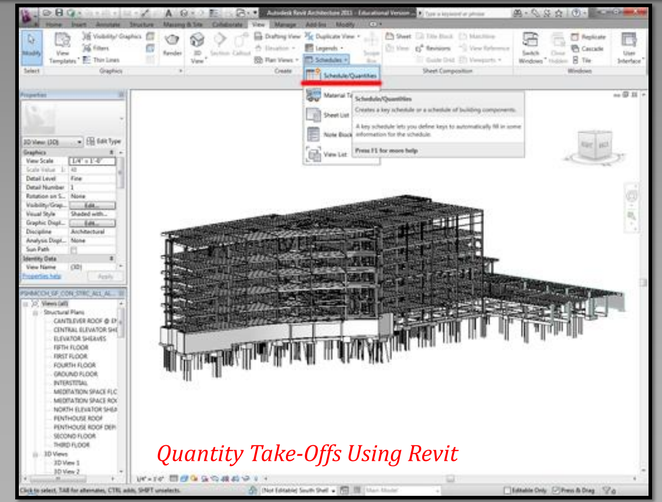
Courtesy of Google Images

Problem Identification

- Excessive Time to Quantify Materials
- Less Time for Constructability Reviews
- Less Time for Planning

Research Goal

- Accuracy of Building Models for Estimation
- Time Savings in Software Based QTO.
- Develop a Guideline for Implementing 3D Estimating



Quantity Take-Offs Using Revit

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3D ESTIMATING

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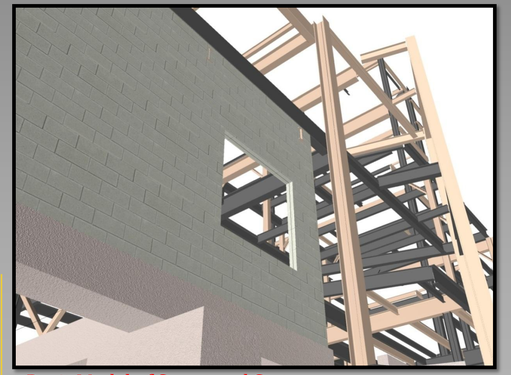

Revit Model of Structural System

Methodology Used

- Traditional Quantity Take-offs
- Revit Quantity Take-offs
- Determine Time Savings and Accuracy of Each Method

SUMMARY OF RESULTS

	Traditional QTO	Revit QTO	LFD Contract
Time Required	25 hrs	2 hrs	-
Cost of System	**$5,380,000**	**$5,200,900**	**$5,597,000**
% Difference to Actual	- 3.87%	- 7.1%	0%
Percentage of Discrepancy	15%	0%	-

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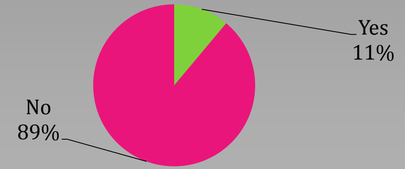
Presentation Outline:

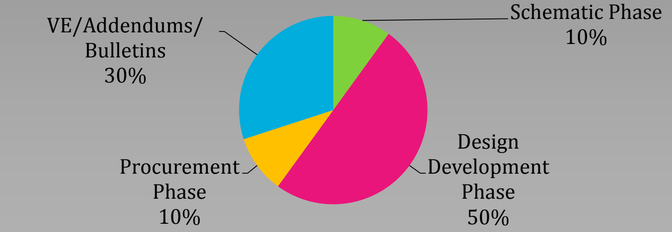
Can 3D Estimating Eliminate the Traditional Manual Methods?



ANALYSIS OF SURVEY

Based on 25 Completed Surveys

When Do You See Greatest Advantage in 3D Estimating?



COMMENTS MADE

- Waste of Time
- Models Not Created the way Building is Built
- Better Visualization
- The Older People Not Been Exposed to 3D Estimating

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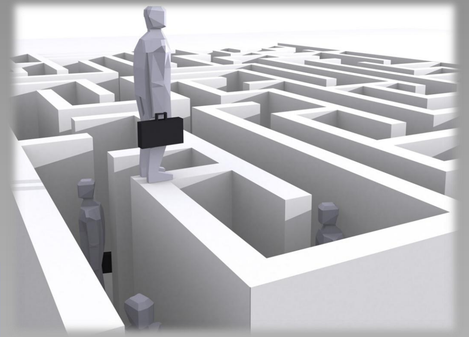

Courtesy of Google Images

Guide Lines For Implementing 3D Estimating Methods

- BIM only Aids in Estimation and is not a Total Solution
- Initially Attempt utilizing Digital Take-Offs
- Test Accuracy of BIM Quantity Take-Offs
- Do Not Attempt Linking Models with Other Softwares

Final Conclusion

- Less Time Counting Building Materials
- Allows More Time for Critical Planning
- Ease in Updating Estimates
- Increase Competitive Advantage

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Presentation Outline:

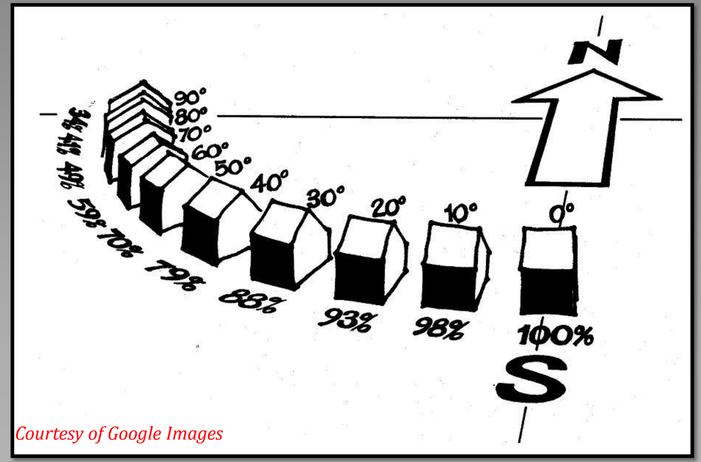
Courtesy of Google Images

Problem Identification

- Borderline of LEED Silver Certification
- Few Sustainable Systems Incorporated
- Great Potential for Sustainable Systems

Research Goal

- Eliminate a Diesel Generator
- Determine Feasibility of a PV System



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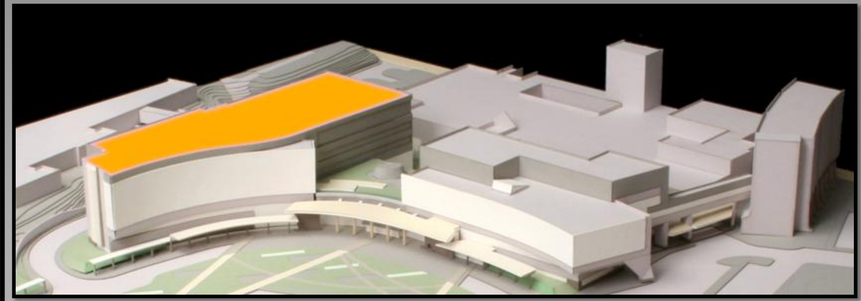
Presentation Outline:

Solar Analysis

Building Location	Hershey, Pa
Elevation at Roof	85 Ft
Latitude and Longitude	N 40°15' / W 76°46'
Sun Hours Per Day for Building Location	(4.44)
Optimum System Orientation	South Facing Side
Optimum System Tilt Angles	Summer: 25°15' *Latitude ± 15°* Winter: 55°'



Roof has no Shadowing Effects

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PHOTOVOLTAIC SYSTEM

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Presentation Outline:

Electric Demand

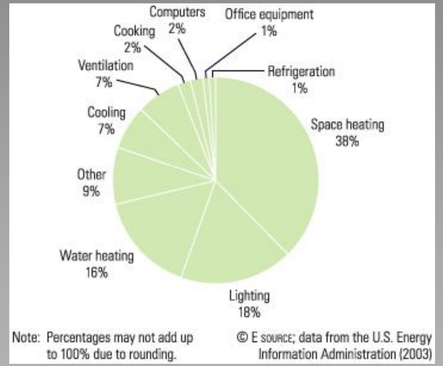
- **Annually** 7,221,143 kWh
- **Monthly** 601,762 kWh
- **Daily** 19,784 kWh

Manufacturers and Panels Needed

- Kyocera (KD235GX-LP) 18961 Panels
- BP Solar (BP3230T) 19373 Panels
- Suntech (STP210-18) 21218 Panels

More Realistic Approach (Electric Breadth)

- 4200 SF Roof Space
- 240 Panels



Courtesy of U.S. Energy Information Administration

Panels Required Per End Use

DIVISION	End Use Percentage	Watt Hours Per Day	# of Panels Req'd	Is it Feasible?
Office Equipment	1%	197840	189.61	YES
Refrigeration	1%	197840	189.61	YES
Space Heating	38%	7517920	7205.18	NO
Lighting	18%	3561120	3412.98	NO
Water Heating	16%	3165440	3033.76	NO
Cooling	7%	1384880	1327.27	NO
Ventilation	7%	1384880	1327.27	NO
Cooking	2%	395680	379.22	YES
Computers	2%	395680	379.22	YES
Others	8%	1582720	1516.88	NO
TOTAL	**100%**	**19784000**	**18961**	

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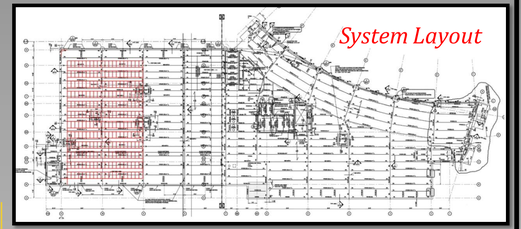
Presentation Outline:

Electric Energy Production
(Electric Breadth)



Month	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value ($)
1	3.12	4679	$ 436.08
2	3.75	5040	$ 469.73
3	5.03	7298	$ 680.17
4	5.14	6960	$ 648.67
5	5.43	7239	$ 674.67
6	5.54	6962	$ 648.86
7	5.33	6876	$ 640.84
8	5.25	6813	$ 634.97
9	4.93	6316	$ 588.65
10	4.49	6180	$ 575.98
11	3.27	4495	$ 418.93
12	2.79	4111	$ 383.15
Year	**4.51**	**72969**	**$ 6800.71**

Summary of Calculations

- Adequate AC Energy for Office Equipment
  - 72969 kWh Produced • Only 72211 kWh Needed
  - Savings of $6800 Annually on Electric Bill
  - Covers 1% of Total Electric Demand

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Presentation Outline:

Courtesy of Google Images

Cost of System

- @ $7500 / KW-DC *(U.S. Department of Energy Figure)*
- Designed System 56.4 kW-DC

Incentives

- PA Sunshine PV Rebate (com.> 10-100 kW) = $25,000
- PA Sunshine PV Rebate (com.> 3-10 kW) = $7,500
- Federal PV Tax Credit = $135,000

Total System Cost

- $423,000 System Cost
- Federal Incentives Totaling $154,307
- Final System Cost Less Incentives **$268,693**

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PHOTOVOLTAIC SYSTEM

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Presentation Outline:

Assumptions Made

- Owner will pay Costs Up-Front
- Cost of Electricity = $0.093/KWh
- Annual Escalation % = 1.5%
- Value of SREC= $250 per 1000 KWh

YEAR	$/KWH	SREC	$ Savings/yr	Total Savings/yr	Cumulative Savings	Cash Flow
1	$0.09	$18,000.00	$6,713.15	$24,713.15	$24,713.15	-$243,979.85
2	$0.09	$18,000.00	$6,813.85	$24,813.85	$49,526.99	-$219,166.01
3	$0.09	$18,000.00	$6,916.05	$24,916.05	$74,443.05	-$194,249.95
4	$0.10	$18,000.00	$7,019.79	$25,019.79	$99,462.84	-$169,230.16
5	$0.10	$18,000.00	$7,125.09	$25,125.09	$124,587.93	-$144,105.07
6	$0.10	$18,000.00	$7,231.97	$25,231.97	$149,819.90	-$118,873.10
7	$0.10	$18,000.00	$7,340.45	$25,340.45	$175,160.34	-$93,532.66
8	$0.10	$18,000.00	$7,450.55	$25,450.55	$200,610.90	-$68,082.10
9	$0.10	$18,000.00	$7,562.31	$25,562.31	$226,173.21	-$42,519.79
10	$0.11	$18,000.00	$7,675.75	$25,675.75	$251,848.95	-$16,844.05
11	$0.11	$18,000.00	$7,790.88	$25,790.88	$277,639.84	$8,946.84
12	$0.11	$18,000.00	$7,907.75	$25,907.75	$303,547.58	$34,854.58
13	$0.11	$18,000.00	$8,026.36	$26,026.36	$329,573.94	$60,880.94
14	$0.11	$18,000.00	$8,146.76	$26,146.76	$355,720.70	$87,027.70
15	$0.11	$18,000.00	$8,268.96	$26,268.96	$381,989.66	$113,296.66
16	$0.12	$18,000.00	$8,392.99	$26,392.99	$408,382.65	$139,689.65
17	$0.12	$18,000.00	$8,518.89	$26,518.89	$434,901.54	$166,208.54
18	$0.12	$18,000.00	$8,646.67	$26,646.67	$461,548.21	$192,855.21
19	$0.12	$18,000.00	$8,776.37	$26,776.37	$488,324.58	$219,631.58
20	$0.12	$18,000.00	$8,908.02	$26,908.02	$515,232.60	$246,539.60
21	$0.12	$18,000.00	$9,041.64	$27,041.64	$542,274.24	$273,581.24
22	$0.13	$18,000.00	$9,177.26	$27,177.26	$569,451.50	$300,758.50
23	$0.13	$18,000.00	$9,314.92	$27,314.92	$596,766.42	$328,073.42
24	$0.13	$18,000.00	$9,454.64	$27,454.64	$624,221.06	$355,528.06
25	$0.13	$18,000.00	$9,596.46	$27,596.46	$651,817.53	$383,124.53
TOTAL		$450,000.00	$201,817.53	$651,817.53		

Payback Period

- Payback in Just 11 Years
- System Warranted for 25 Years
- Generate Money After 11th Year

PHOTOVOLTAIC SYSTEM

Final Conclusion

- Diesel Generator Cannot be Eliminated
- 1% Electric Demand Sustainably Generated
- $6,800 Direct Electric Bill Savings Annually
- $18,000 Worth of SRECs Annually
- Payback in just 11 Years

Recommendation

- Owner Should Consider Incorporating Solar PV-Panels
- Incentives may not be Available in the Future

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LESSONS LEARNED

PSU AE Senior Thesis
Final Presentation
April 11th , 2011

Presentation Outline:

Analysis # 1: Multi-Trade Prefabrication
- The Benefits Out Number the Risks and Increased Costs

Analysis # 2: 3D Estimating
- 3D Estimating Saves Critical Time BUT IS NOT a Total Solution!
- Will not Fully Work Till Models are Modeled As-Built

Analysis # 3: Photovoltaic System
- High Incentives Makes it a No Brainer to Invest in Photovoltaic

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Pennsylvania State University – Office of Physical Plant

PENNSTATE Office of Physical Plant

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APPENDIX

Presentation Outline:

ELECTRIC DEMAND CALCULATION

Annually $27.5\frac{kWh}{Sq.Ft} \times 262{,}587\ Sq.Ft = 7{,}221{,}143\frac{kWh}{year}$

Monthly $7{,}221{,}143\frac{kWh}{Year} \times \frac{1\ year}{12\ months} = 601{,}762\frac{kWh}{month}$

Daily $7{,}221{,}143\frac{kWh}{Year} \times \frac{1\ year}{365\ days} = 19{,}784\frac{kWh}{day}$

NUMBER OF PANEL REQUIRED PER SYSTEM

	Kyocera KD235GX-LP	BP Solar BP 3230T	Suntech STP210-18
Sun Hours Per Day	4.44	4.44	4.44
Watt Hours Per Day	19784000	19784000	19784000
Watts Per Hour of Sunlight	4455856	4455856	4455856
Rate of Power Per Panel	235W	230W	210W
# of Panels Required	**18961**	**19373**	**21218**

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APPENDIX

PSU AE Senior Thesis
Final Presentation
April 11th, 2011

Presentation Outline:

The structural calculations were performed as outlined below:

- Determine the weight of the PV-Panels based on the layout used
- Determine roof assembly weight
- Calculate load combinations
- Determine ultimate moment, M_u
- Calculate required cross-section $Z_{x\text{-req'd}}$ and compare with AISC values to ensure safe range
- Calculate maximum deflection and compare with AISC values to ensure safe range

SUMMARY OF STRUCTURAL CALCULATIONS

BEAM W16X36	Shear, V_x	Max Shear, V_{px}	Conclusion
	21.959 kips	140 kips	Within Range ∴ OK
	Moment, M_u	Max Moment, M_{px}	Conclusion
	189.399 k-ft	240 k-ft	Within Range ∴ OK
	Cross-Section, $Z_{x\text{-req'd}}$	Max Cross-Section, Z_x	Conclusion
	33.675 in^3	64 in^3	Within Range ∴ OK
	Deflection, Δ	Max Deflection, Δ_{max}	Conclusion
	0.006705 in^2	0.4 in^2	Within Range ∴ OK
GIRDER W16X36	Shear, V_x	Max Shear, V_{px}	Conclusion
	21.96 kips	140 kips	Within Range ∴ OK
	Moment, M_u	Max Moment, M_{px}	Conclusion
	175.68 k-ft	240 k-ft	Within Range ∴ OK
	Cross-Section, $Z_{x\text{-req'd}}$	Max Cross-Section, Z_x	Conclusion
	46.857 in^3	64 in^3	Within Range ∴ OK
	Deflection, Δ	Max Deflection, Δ_{max}	Conclusion
	0.5298 in^2	1.725 in^2	Within Range ∴ OK