Buckhorn Medical Office Building

Shane Boyer
Construction Management

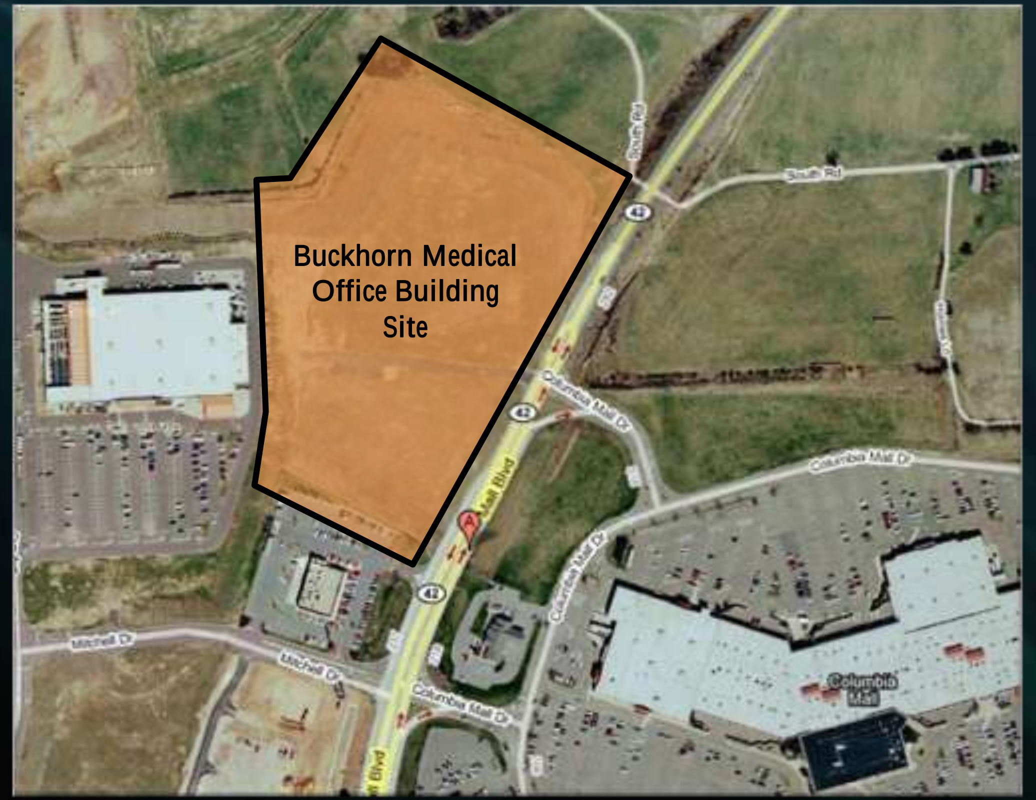
AE Senior Thesis 2010

Outline

- Project Overview
- Project Background
- Thesis Theme
- Architectural Breadth
  - Aluminum Panel vs. Pre-cast Concrete Facade
- Electrical Breadth
  - Solar Analysis
- Cost Estimating Using BIM
- Conclusions
- Questions

Outline

Project Overview



Aerial view of the project site

Client Information

- **Owner:** Geisinger Health System
- **Architect**: Borton-Lawson Architects
- **Construction Manager:** Alexander Building Construction

Project Location

- 240 Mall Boulevard, Bloomsburg, PA
- 2 Miles from the Buckhorn I-80 Exit

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Project Background

- **Building Function:** Medical Office Building
- **Site Size:** 530,300 SF
- **Building Size:** 83,245 SF
- **Construction Cost:** $11.7 million
- **Construction Period:** December 2007 – October 2009
- **Delivery Method:** Design-Bid-Build with CM-at-Risk

Rendered view of the project site

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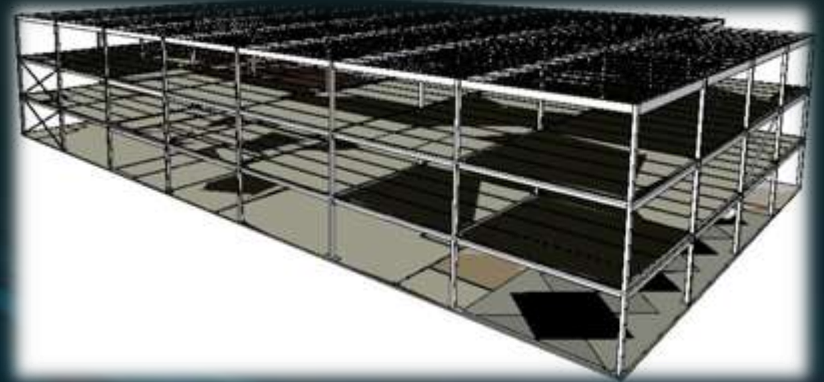

Structural system modeled in Revit

Mechanical room modeled in Revit MEP

Project Background

Architecture

- Aluminum panel curtain wall
- Employee cafeteria
- LEED Silver rating

Structure

- Structural steel building with spread footings

Mechanical

- Water-cooled heat pump system

Lighting/Electrical

- Typical 480Y/277V power system for commercial office
- Typical 277V fluorescent 2'x4' fixtures
- 125kVA on-site emergency diesel generator

Various metal panels in curtain wall system

Render of cafeteria using Revit and 3D Studio

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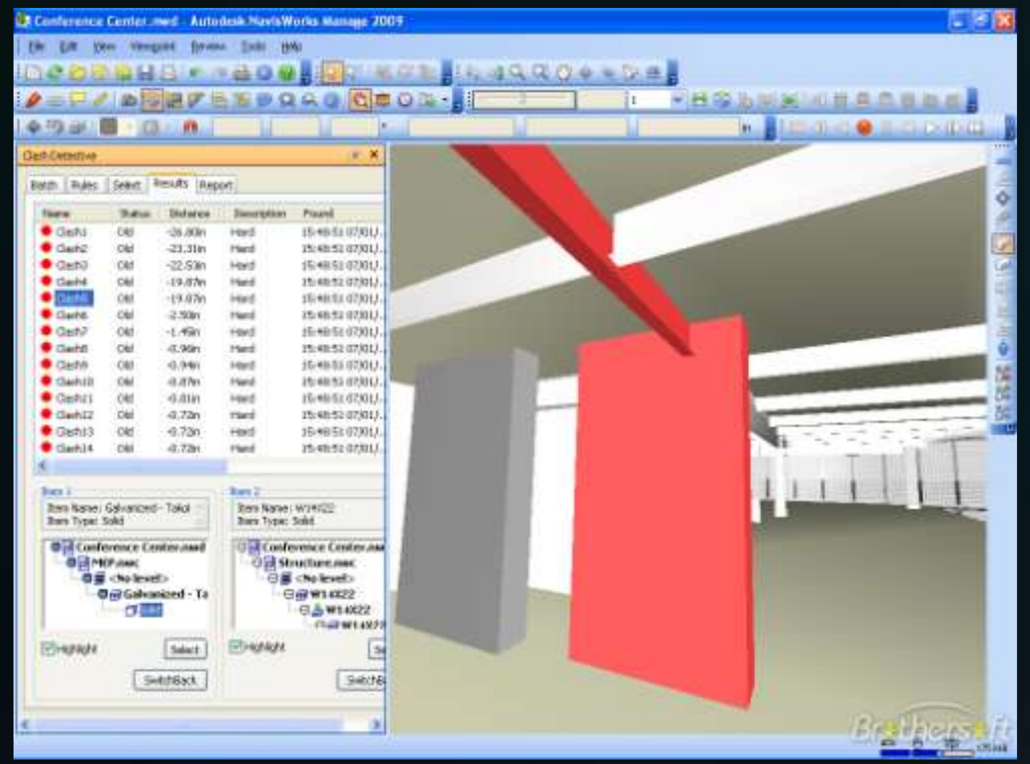
Thesis Theme

Building Information Modeling (BIM)

Owner's demands for BIM

Contractor's uses for BIM

"How do we effectively use BIM?"



ANALYSIS 1

Re-developing the Curtain Wall System

Re-developing the Curtain Wall System

Curtain wall mock-up panel

Current System

- Current façade is an aluminum metal panel system
- 4 different panel designs used in curtain wall construction
- Construction consists of metal studs with insulating board, plywood sheathing, and metal panels

Current metal panel curtain wall system

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The Problem

Construction of the curtain wall system

- Material availability by Marcon Roofing
  - Delays due to supplier backlog of work
- Damaged panels upon arrival on-site
- Constructability challenges
  - Snap-on cover strips from a 3rd party manufacturer
- Cost implications
  - Expensive material costs

MARCON
R.H. Marcon Inc.
Roofing Contractors

The Result

- Multiple delays in the project schedule
- Final completion date pushed back
- Poor image of the construction manager

ALEXANDER

Missing panels on front façade of building

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The Solution: Pre-cast concrete

Exterior texturing to simulate aluminum panels

- Extremely durable for climate
- Can be cast to resemble architectural features
- Color matching using dye ad-mixtures
- Increased fire protection
- Low reflectance of concrete to fit into surroundings

Exterior texturing to simulate aluminum panels

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High's facilities – Denver, PA

The Solution: Pre-cast concrete

- Supplier: High Concrete
  - No delays in schedule (removed from the critical path)
  - 65-day savings
- Cost savings
  - Revit Quantity Schedules used for SF take-offs
  - Aluminum costs vs. *RS Means* pre-cast concrete costs
- Constructability
  - Snap-on cover plates vs. caulking

Architectural Pre-Cast Concrete Panel System			
Total SF of Wall:	24862.03		
Summary	***Cost Per Square Foot($/SF)***	***Total Cost($)***	***Percentage(%)***
Material Total	$19.95	$495,997.50	74.27
Labor Total	$4.30	$106,906.73	16.01
Equipment Total	$2.61	$64,889.90	9.72
Total Structural Estimate:	**$26.86**	**$667,794.13**	**100.00**

Architectural Panel System Cost Comparison		
Total SF of Wall:	24862.03	
Summary	***Cost Per Square Foot($/SF)***	***Total Cost($)***
Aluminum Panel System	$34.38	$854,808.00
Pre-cast Panel System	$26.86	$667,794.13
Cost Difference:	**$7.52**	**$187,013.87**
General Conditions Savings	***Cost Per Day($/Day)***	***Total Cost($)***
65 Days	$1,983.42	$128,922.30
Total Cost Savings:		**$315,936.17**

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ANALYSIS 2

Developing a Sustainable Photovoltaic Panel System

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Background

- Hundreds of high-energy consumption devices
- LEED Silver Rating
  - Construction practices and materials, NOT DESIGN
- Geisinger is a leader in “green” medical facility construction

Geisinger's Headquarters – Danville, PA

Gray's Woods – LEED Gold Certified

Objective

- Propose a grid-tied photovoltaic (PV) array that will provide an energy reduction without much physical impact on the architectural aesthetics of the building.

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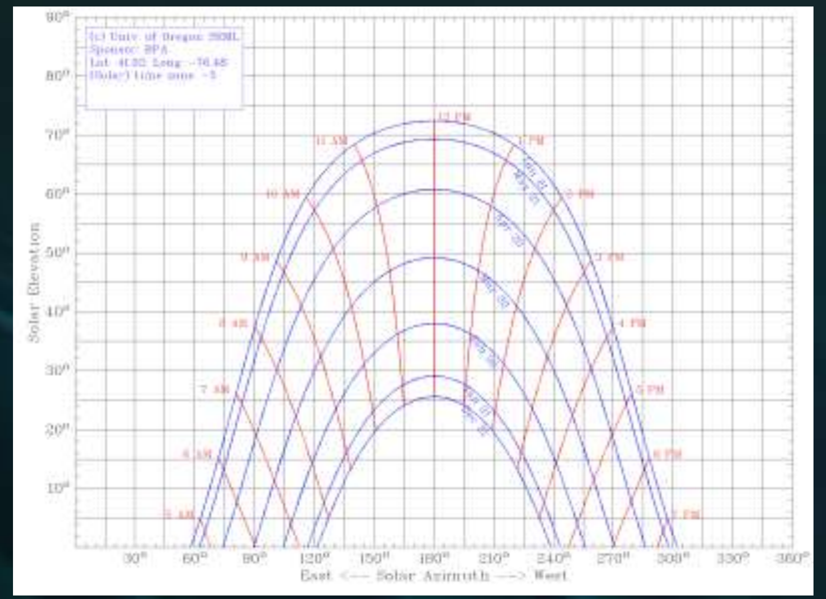
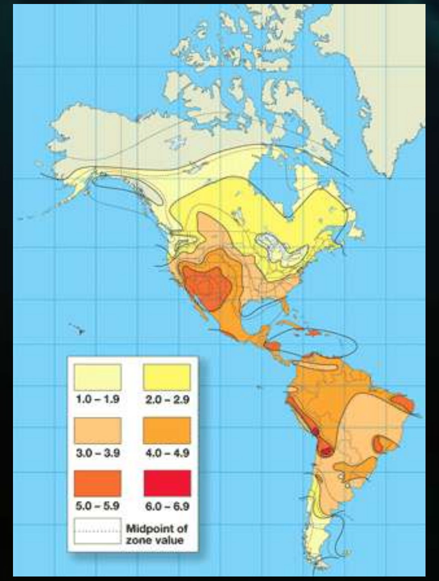


Sun Path Chart for Bloomsburg, PA

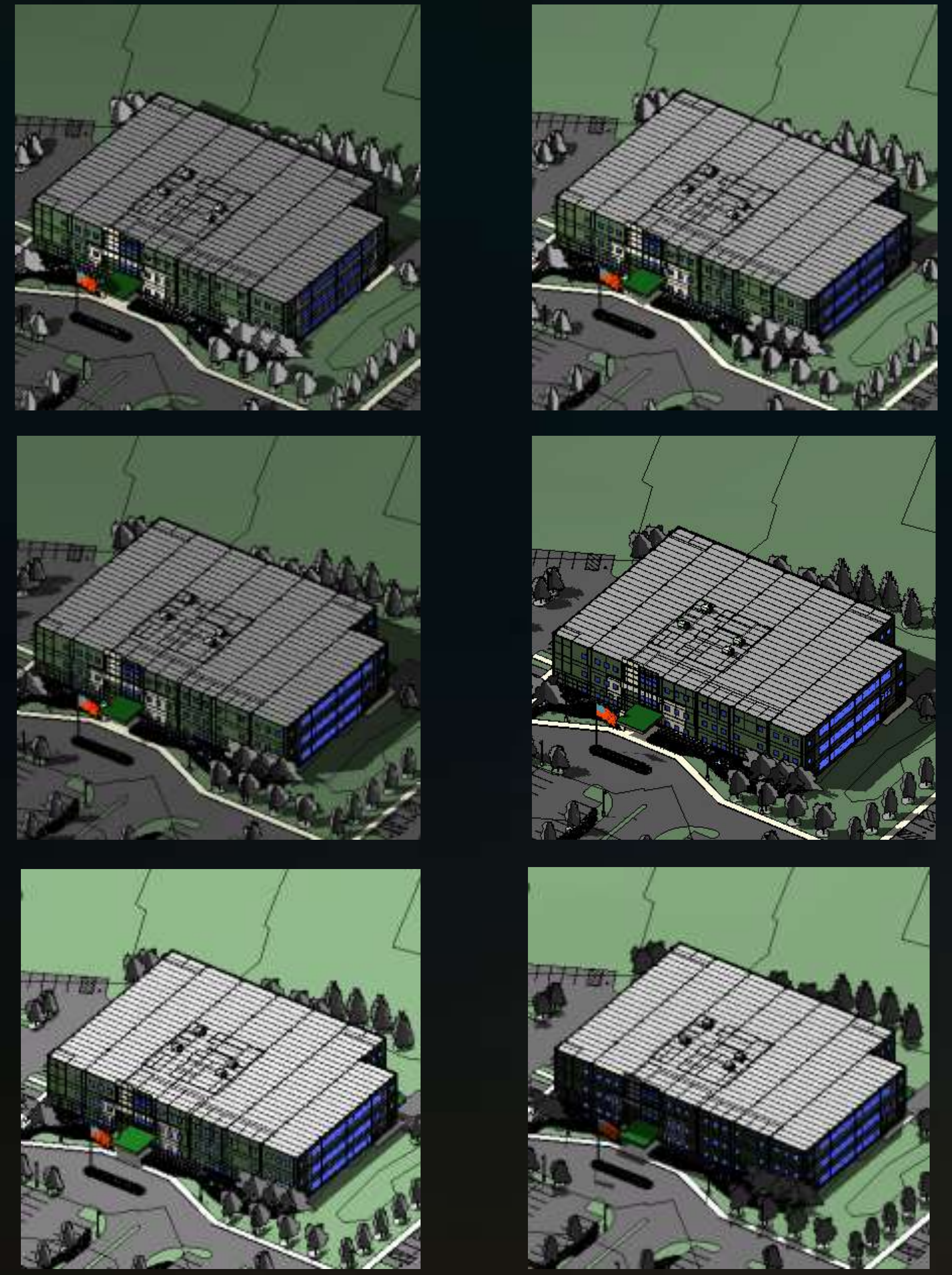


World Insolation Map

Solar Analysis

- Found peak hours of sun exposure based on location (9am-3pm)
- Used Revit model to perform shadow simulations
  - Created exact shadows based on latitude & longitude

Revit Solar Studies



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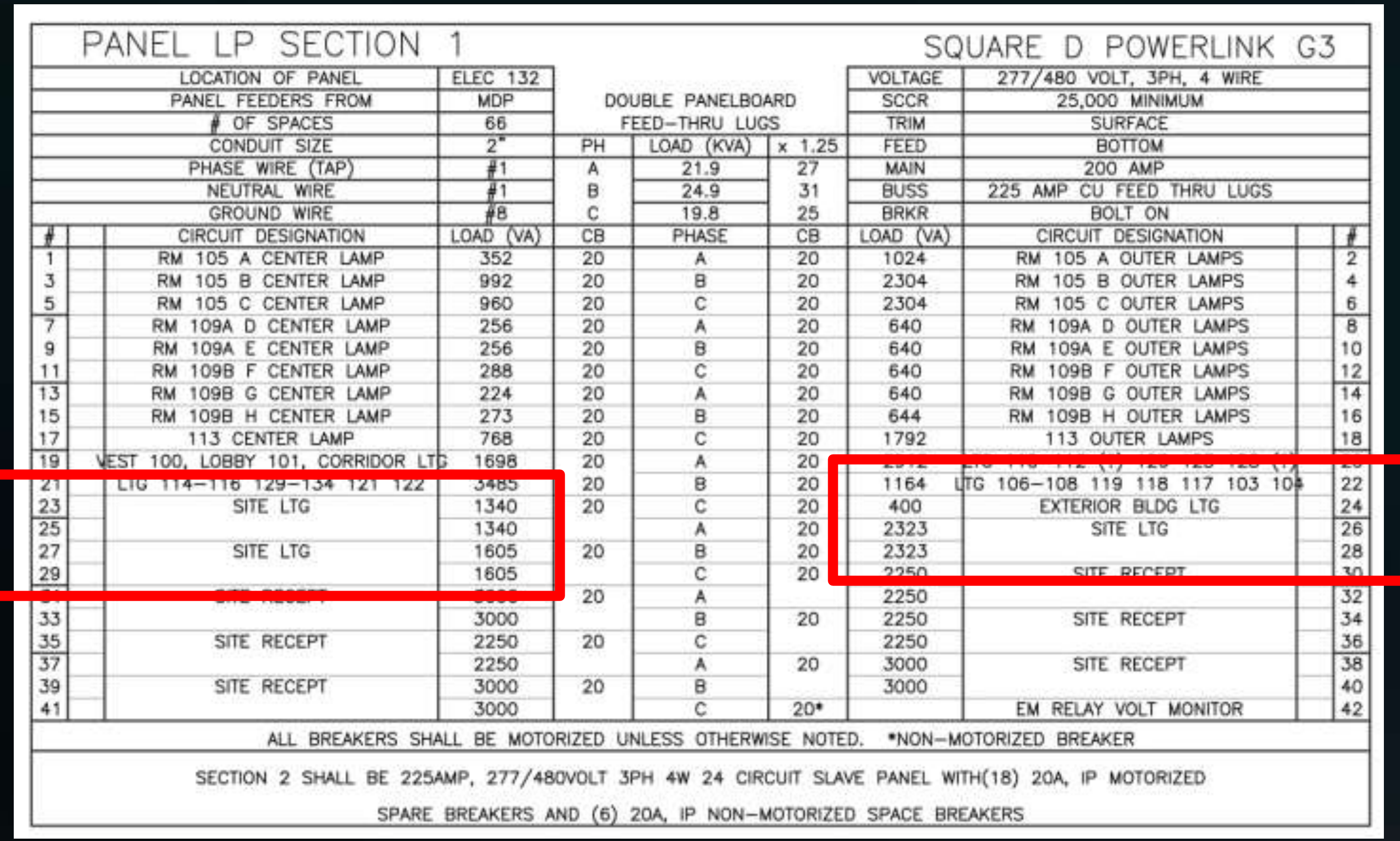
Determining the Site Lighting Load

- Offset the energy load of the site lighting using PV panel array
- Use panel board schedules to determine lighting load
  - Total load: ~11kW



PANEL LP SECTION 1 — SQUARE D POWERLINK G3

LOCATION OF PANEL	ELEC 132	DOUBLE PANELBOARD FEED–THRU LUGS			VOLTAGE	277/480 VOLT, 3PH, 4 WIRE
PANEL FEEDERS FROM	MDP				SCCR	25,000 MINIMUM
# OF SPACES	66				TRIM	SURFACE
CONDUIT SIZE	2"	PH	LOAD (KVA)	x 1.25	FEED	BOTTOM
PHASE WIRE (TAP)	#1	A	21.9	27	MAIN	200 AMP
NEUTRAL WIRE	#1	B	24.9	31	BUSS	225 AMP CU FEED THRU LUGS
GROUND WIRE	#8	C	19.8	25	BRKR	BOLT ON

#	CIRCUIT DESIGNATION	LOAD (VA)	CB	PHASE	CB	LOAD (VA)	CIRCUIT DESIGNATION	#
1	RM 105 A CENTER LAMP	352	20	A	20	1024	RM 105 A OUTER LAMPS	2
3	RM 105 B CENTER LAMP	992	20	B	20	2304	RM 105 B OUTER LAMPS	4
5	RM 105 C CENTER LAMP	960	20	C	20	2304	RM 105 C OUTER LAMPS	6
7	RM 109A D CENTER LAMP	256	20	A	20	640	RM 109A D OUTER LAMPS	8
9	RM 109A E CENTER LAMP	256	20	B	20	640	RM 109A E OUTER LAMPS	10
11	RM 109B F CENTER LAMP	288	20	C	20	640	RM 109B F OUTER LAMPS	12
13	RM 109B G CENTER LAMP	224	20	A	20	640	RM 109B G OUTER LAMPS	14
15	RM 109B H CENTER LAMP	273	20	B	20	644	RM 109B H OUTER LAMPS	16
17	113 CENTER LAMP	768	20	C	20	1792	113 OUTER LAMPS	18
19	VEST 100, LOBBY 101, CORRIDOR LTG	1698	20	A	20	[illegible]	[illegible]	[illegible]
21	LTG 114–116 129–134 121 122	3485	20	B	20	1164	LTG 106–108 119 118 117 103 104	22
23	SITE LTG	1340	20	C	20	400	EXTERIOR BLDG LTG	24
25		1340		A	20	2323	SITE LTG	26
27	SITE LTG	1605	20	B	20	2323		28
29		1605		C	20	2250	SITE RECEPT	30
31	SITE RECEPT	[illegible]	20	A		2250		32
33		3000		B	20	2250	SITE RECEPT	34
35	SITE RECEPT	2250	20	C		2250		36
37		2250		A	20	3000	SITE RECEPT	38
39	SITE RECEPT	3000	20	B		3000		40
41		3000		C	20*		EM RELAY VOLT MONITOR	42

ALL BREAKERS SHALL BE MOTORIZED UNLESS OTHERWISE NOTED. *NON–MOTORIZED BREAKER

SECTION 2 SHALL BE 225AMP, 277/480VOLT 3PH 4W 24 CIRCUIT SLAVE PANEL WITH(18) 20A, IP MOTORIZED SPARE BREAKERS AND (6) 20A, IP NON–MOTORIZED SPACE BREAKERS

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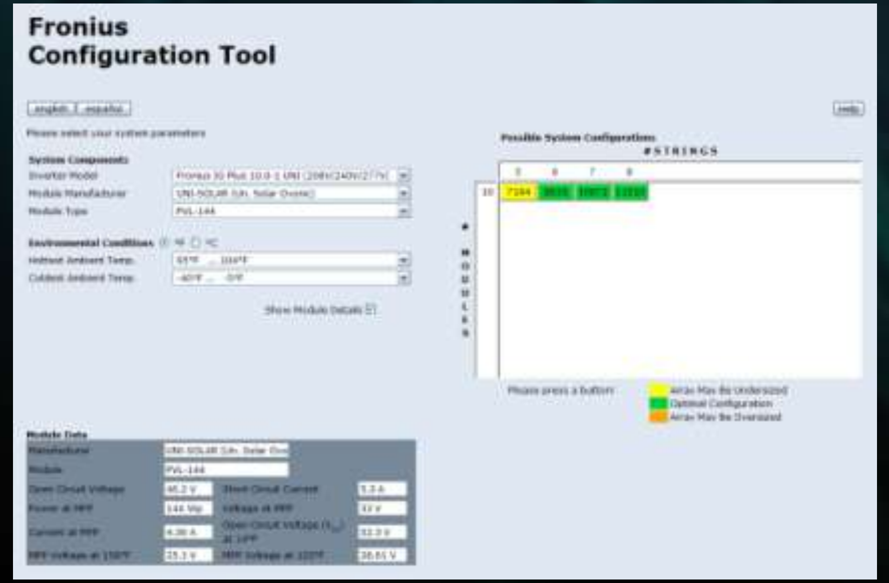
Fronius Inverter



Fronius Array Configuration Tool

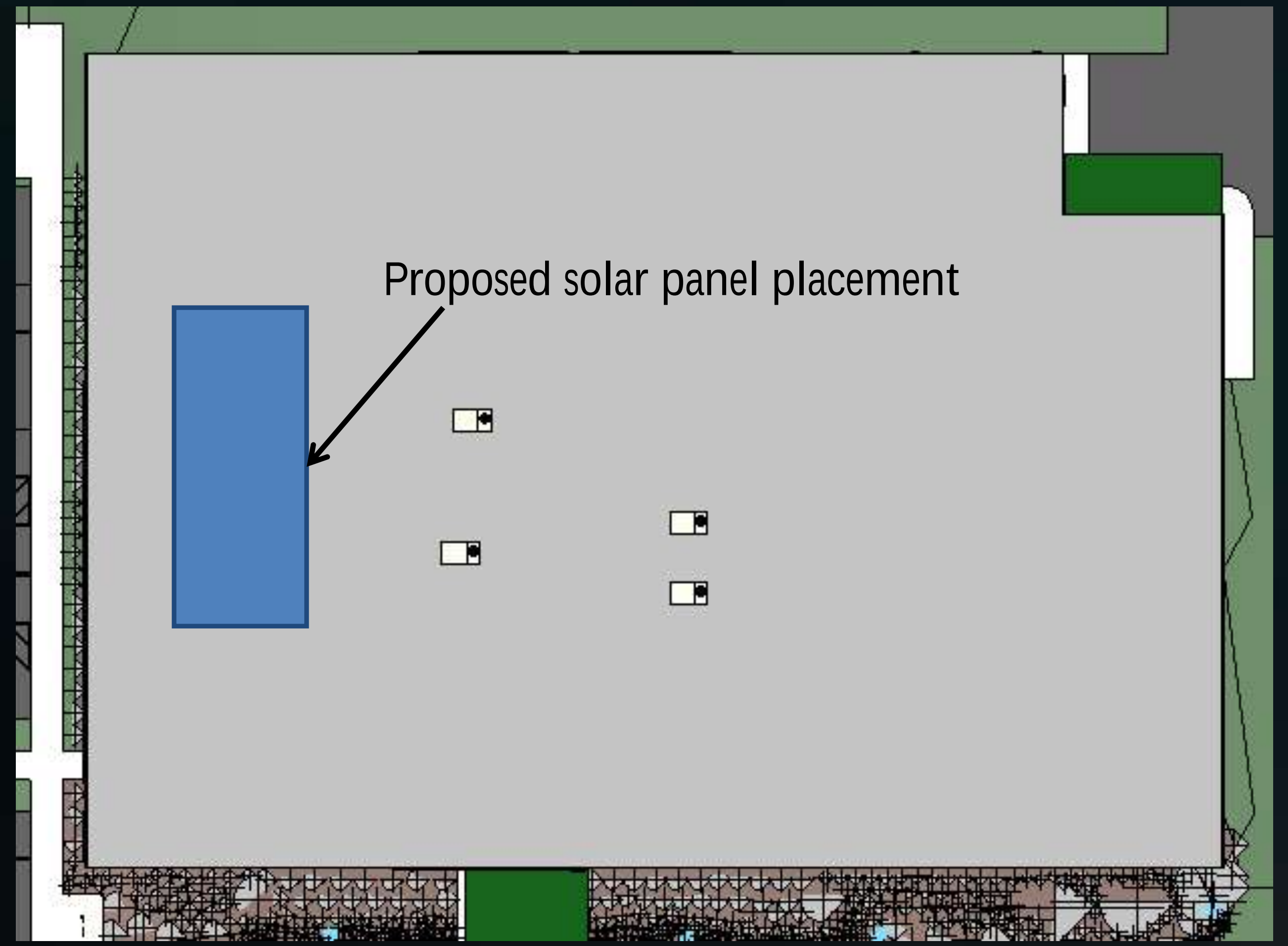
Choosing a PV System

- Uni-Solar PVL-144 Panel
  - "Peel-and-stick" technology
  - Minimal installation required
  - No additional structural design considerations
- Fronius IG Plus 10.0-1 Inverter
  - Max 11.5kW power
- Creating the array
  - Configuration Tool – 10 modules x 8 strings = 11.5kW

Installation of Uni-Solar panels

Placing the Array

- Optimal solar gains along west portion of roof
- Minimal shadows from rooftop mechanical units



Aerial view of roof with solar panel placement

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Developing a Sustainable Photovoltaic Panel System

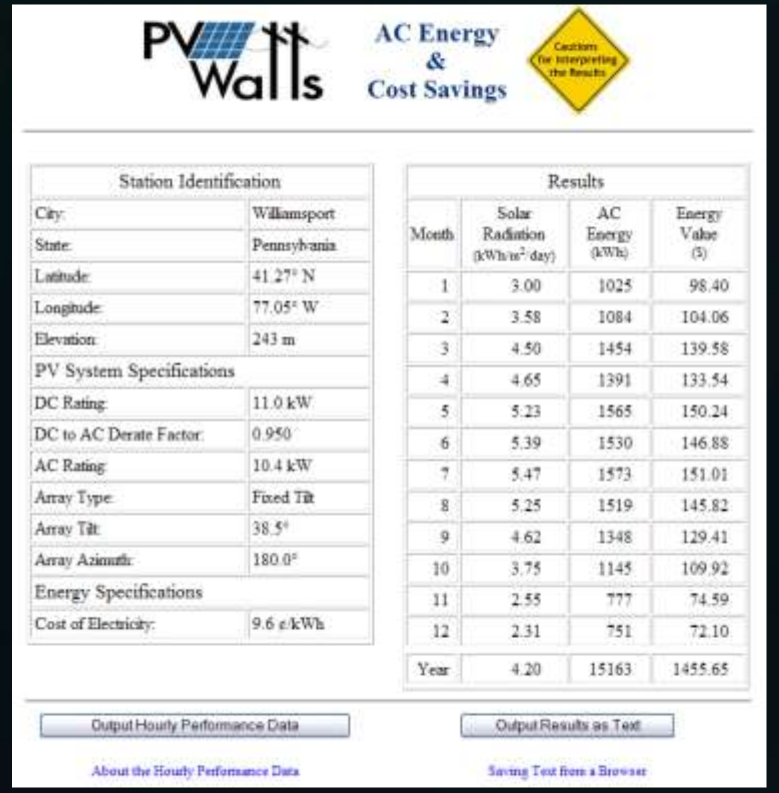
Inverter Estimate		
(1) Fronius IG Plus 10.0-1 Inverter	(80) Uni-Solar PVL-144 Panels	Total
$6,796	$64,000	**70,796.00**

Cost Impact

- Total cost of materials for system: **$70,796**
  - Does not include installation costs

Payback Period

- PV Watts by National Renewable Energy Labs
- Payback period: **49 years**



PV Watts AC Energy & Cost Savings

Station Identification	
City:	Williamsport
State:	Pennsylvania
Latitude:	41.27° N
Longitude:	77.05° W
Elevation:	243 m
PV System Specifications	
DC Rating:	11.0 kW
DC to AC Derate Factor:	0.950
AC Rating:	10.4 kW
Array Type:	Fixed Tilt
Array Tilt:	38.5°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	9.6 ¢/kWh

Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.00	1025	98.40
2	3.58	1084	104.06
3	4.50	1454	139.58
4	4.65	1391	133.54
5	5.23	1565	150.24
6	5.39	1530	146.88
7	5.47	1573	151.01
8	5.25	1519	145.82
9	4.62	1348	129.41
10	3.75	1145	109.92
11	2.55	777	74.59
12	2.31	751	72.10
Year	4.20	15163	1455.65

Output Hourly Performance Data
Output Results as Text
About the Hourly Performance Data
Saving Text from a Browser

PV Watts output data screen

Initial (Life-Cycle) Cost of System	Energy Savings per Year	Payback Period
$70,796	$1,455.64	**49 Years**

Recommendations

- Sustainable systems are important for our environment
- Geisinger should consider a PV system
- The proposed system's payback period is too long

Typical PV panel array

ANALYSIS 3

Estimating Cost Using Building Information Modeling

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Estimating Cost Using Building Information Modeling

Background

- No model was provided prior to estimating
- Three significant hand estimates were performed
  - Total time spent: 43 days

Critical Industry Issue

- PACE Seminar: *"How can BIM be used in estimating?"*
- Implementing BIM into the CM estimating process

Preconstruction		278	10-Dec-07	31-Dec-08
		278	10-Dec-07	31-Dec-08
A1090	Sitework Schematic Design	54	10-Dec-07	21-Feb-08
A1100	Building Schematic Design	45	14-Jan-08	14-Mar-08
A1110	CM Kickoff Meeting	0	17-Jan-08	
A1120	Sitework Land Development Preparation	40	14-Feb-08	09-Apr-08
A1130	Building Schematic Design Dwgs. Issued	0		04-Apr-08
A1140	Schematic Design Estimate	14	07-Apr-08	24-Apr-08
A1150	Building Design Development	[illegible]	[illegible]	[illegible]
A1160	Issue CD Drawings - Structural Steel	0	16-May-08	
A1170	Steel Contractor Procurement	25	16-May-08	19-Jun-08
A1180	Sitework Construction Documents	30	16-May-08	26-Jun-08
A1190	Issue Building DD Drawings	0	30-May-08	
A1200	Design Development Estimate	15	30-May-08	19-Jun-08
A1210	Issue CD Drawings - Site	0	13-Jun-08	
A1220	Sitework Contractor Procurement	20	13-Jun-08	10-Jul-08
A1230	Building Construction Documents	33	18-Jun-08	01-Aug-08
A1240	Issue CD Drawings - Building	0	05-Aug-08	
A1250	Develop Control Budget / Bidding	35	05-Aug-08	22-Sep-08
A1260	Addition Construction Documents	15	03-Oct-08	23-Oct-08
A1270	Addition Steel Drawings	15	03-Oct-08	23-Oct-08
A1280	Negotiate Addition Change Orders	30	20-Nov-08	31-Dec-08

Estimating Cost Using Building Information Modeling

Objective

- Compare traditional estimating methods against BIM estimating methods for accuracy and efficiency in the structural system estimate.

Outline

Traditional Estimate

- Taken off with ruler and scale
- Accurate to only nearest foot due to quality of drawings
- Prices generated from *RS Means*
- Estimated Cost: **$1,166,098**
- Total estimate time: **6 hours**

Structural Steel System Estimate Comparison - Hand Estimate					
Item	*Unit Cost*	*Actual Cost*	*Estimated Cost*	*Difference*	*% Difference*
Steel System	3,325.41/TON	$1,335,233	$1,166,098	-$169,135	-12.67

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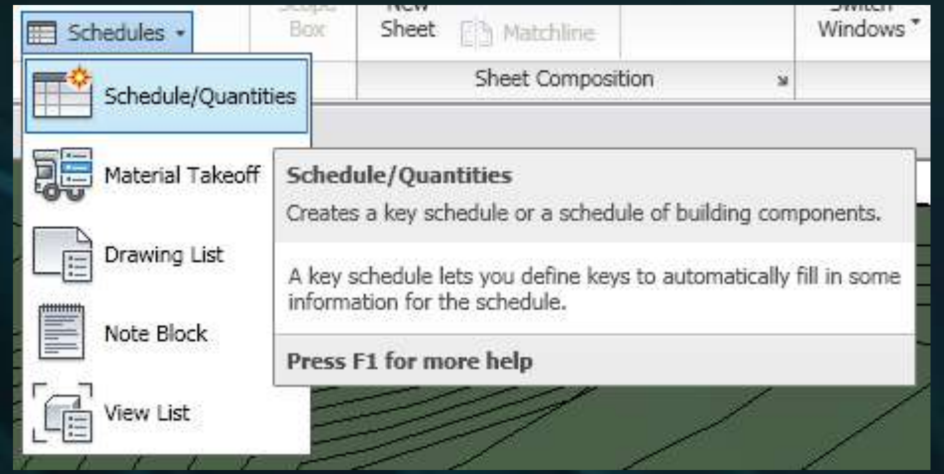
Estimating Cost Using Building Information Modeling

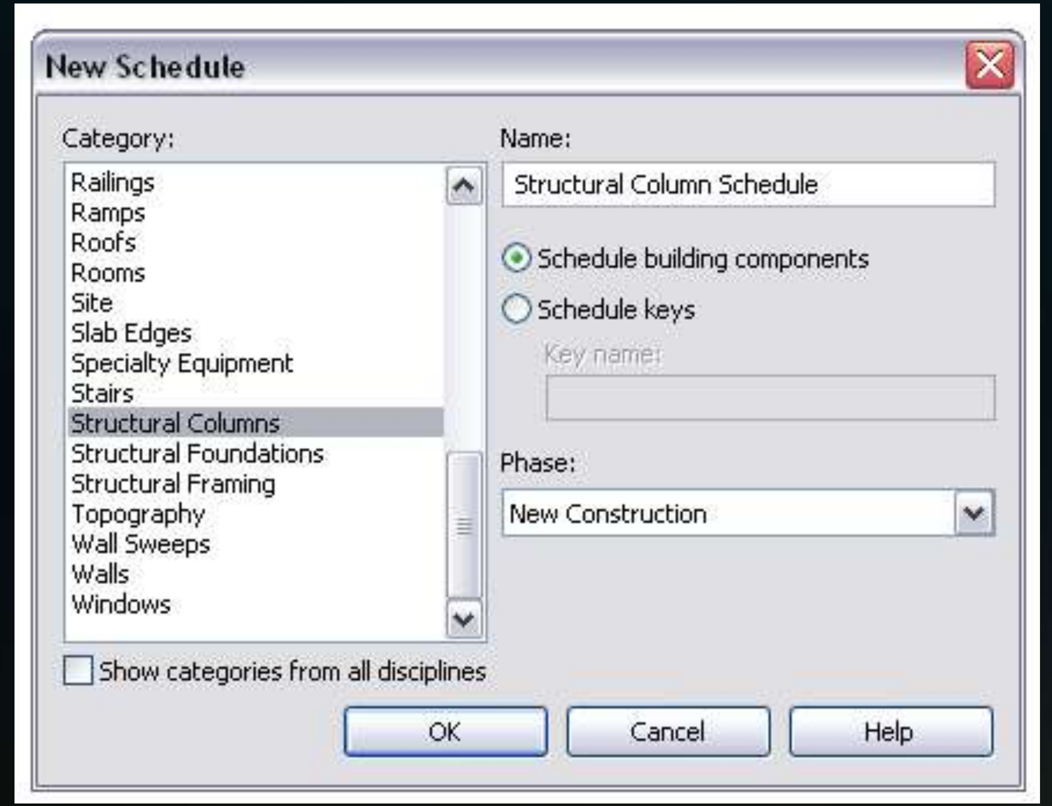


Creating a Quantity Schedule in Revit

Revit Quantity Schedules Estimate

- Created a schedule in Revit
- Sorted columns and beams by size and length
- Exported spreadsheet to Microsoft Excel
- Estimated Cost: **$1,166,129**
- Total estimate time: **45 minutes**

Structural Steel System Estimate Comparison - Revit Estimate					
Item	*Unit Cost*	*Actual Cost*	*Estimated Cost*	*Difference*	*% Difference*
Steel System	$3,324.38/TON	$1,335,233	$1,166,129	-$169,104	-12.66



Creating a Quantity Schedule in Revit

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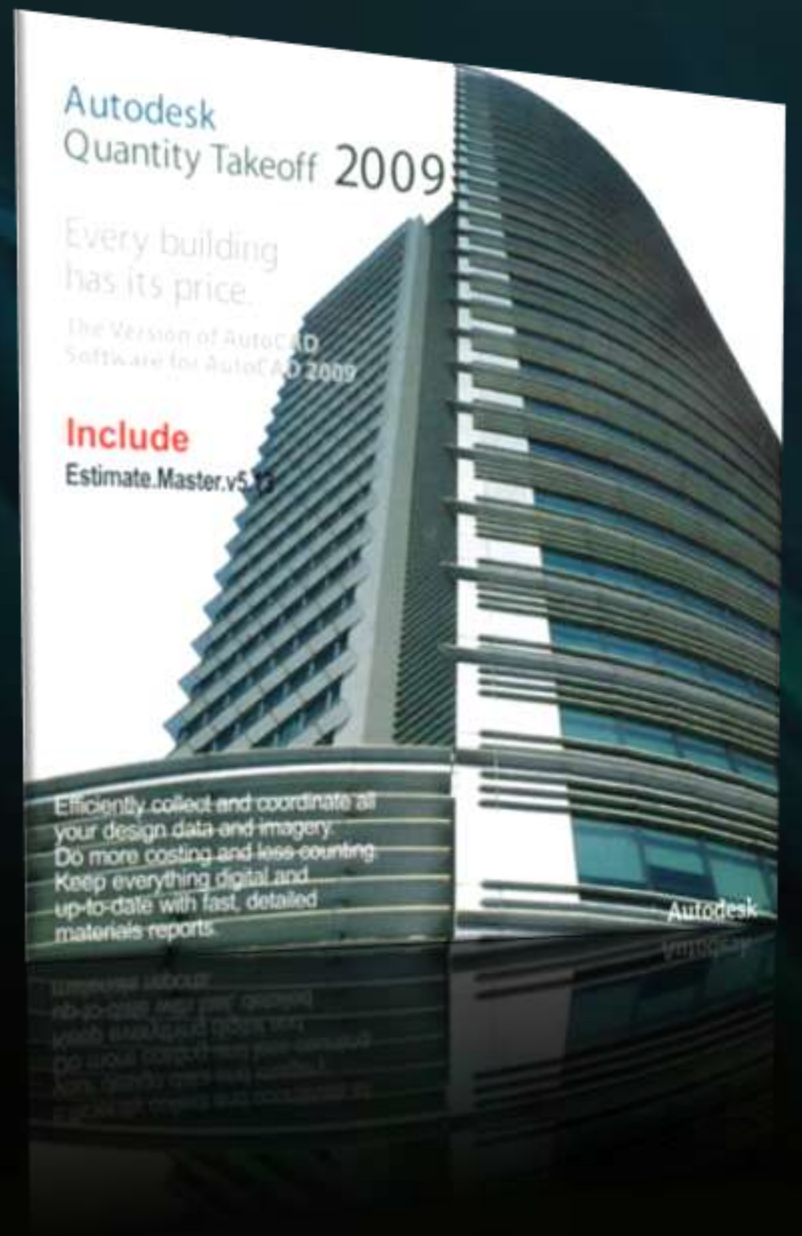
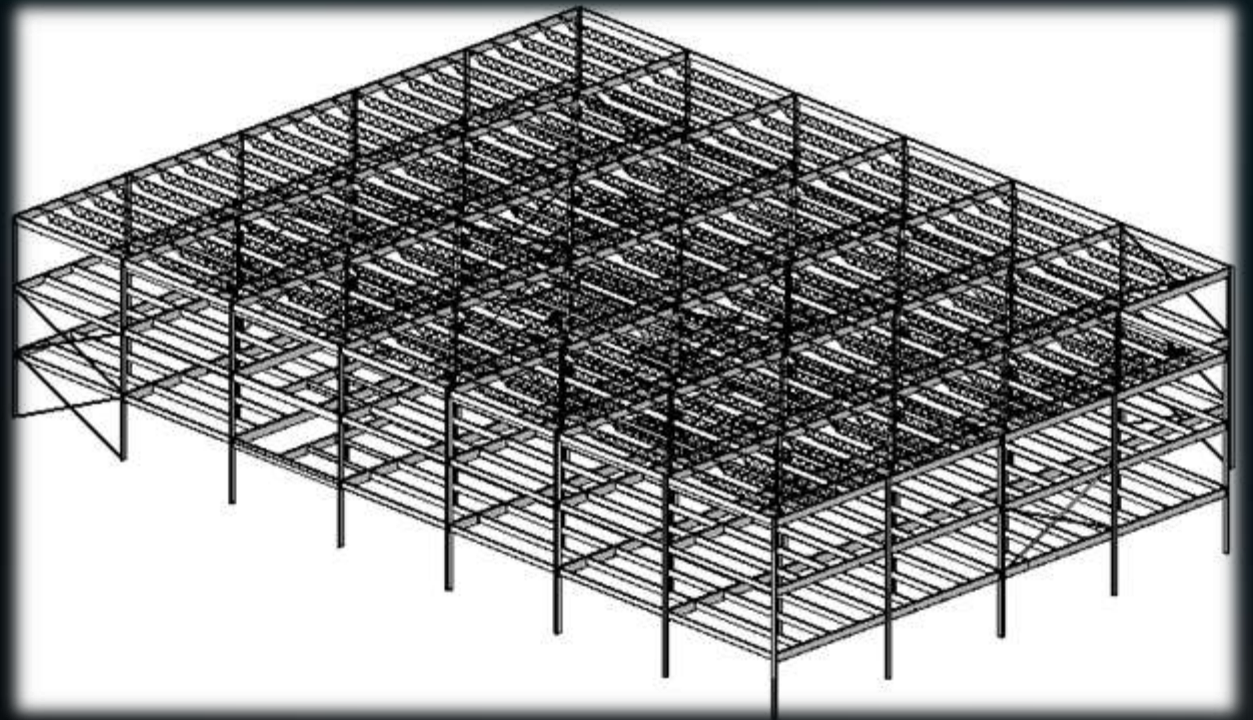


Estimating Cost Using Building Information Modeling

Autodesk Quantity Takeoff Estimate

- Exported Revit structural model to DWFs
- Opened DWF in QTO
- Extremely easy to visualize the takeoff
- Additional time for software instruction and installation
- Identical quantities as Revit Quantity Schedule
- Total estimate time: **5.5 hours**



Exporting Structural Revit Model to QTO

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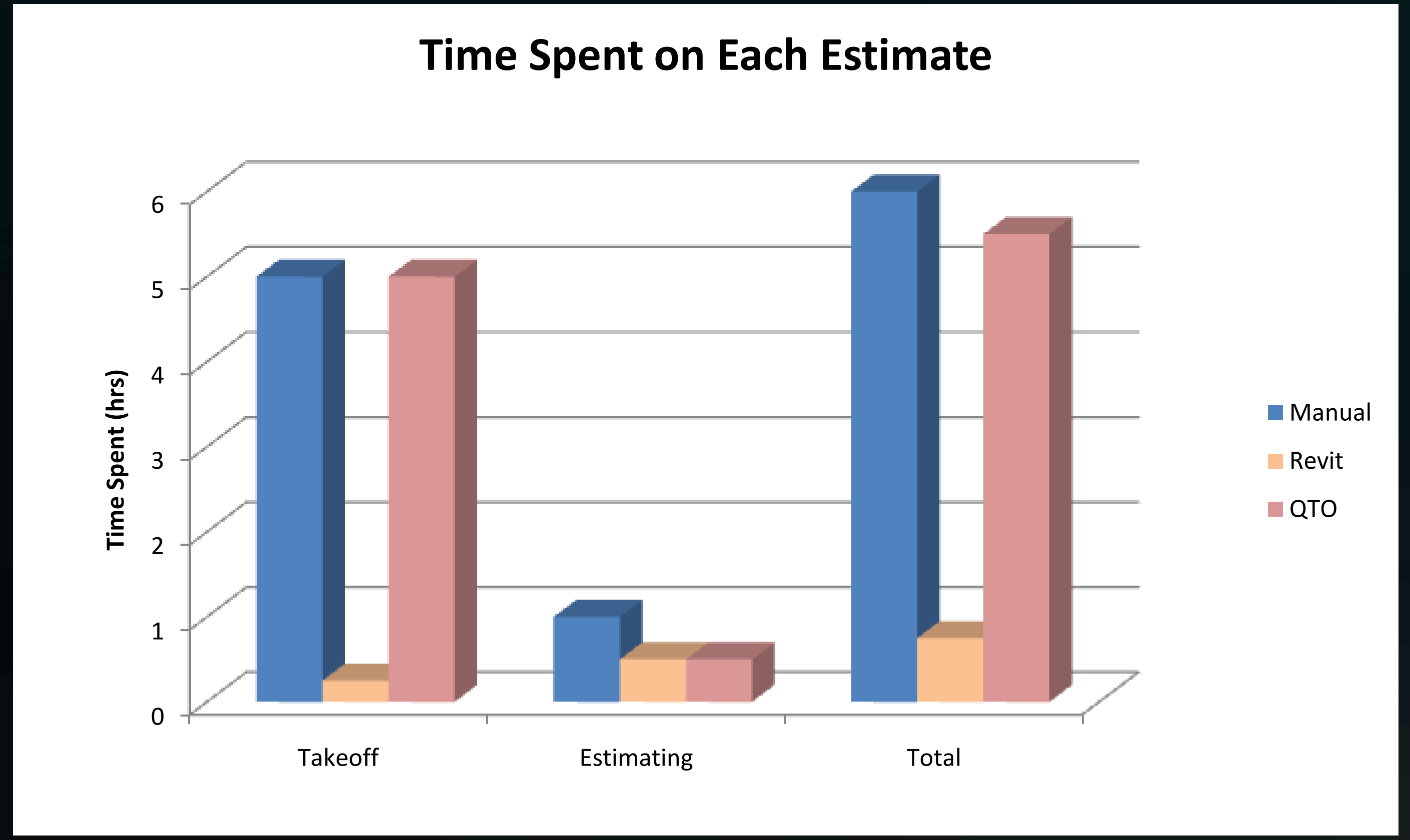
Comparison of Methods

- Revit Quantity Schedule was the fastest method
- QTO only took 30 minutes after training
- All methods were within 0.01% of each other
  - May not apply for more complex estimates (curved surfaces)
- Currently BIM takeoffs are only used as verification
  - Have potential to soon be trusted as alternative method
- Large savings in project schedule
  - Can accelerate the preconstruction phase



Bar chart showing time spent on each estimate

Conclusions

Conclusions

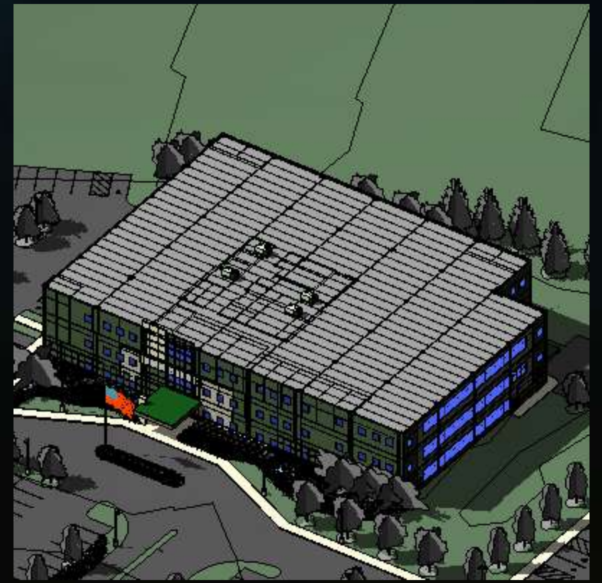
Outline

Pre-Cast Concrete Façade

- Good architectural substitute
- Substantial cost and schedule savings
- Revit used to generate total SF of curtain wall

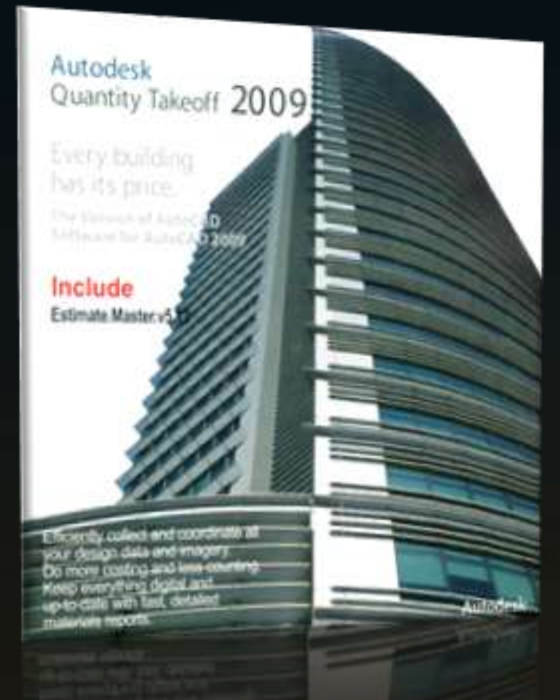
Sustainable Photovoltaic Panel System

- Important to consider sustainability in construction practices
- Initial design to use "peel-and-stick" PV panel system
- Quantify the energy return – Site lighting
- Re-evaluate sustainable PV system for faster ROI
- Revit used to perform solar shading studies for maximum sun exposure



Estimating Using BIM

- Critical Industry Issue – *"How do we use BIM for estimating?"*
- Faster, more accurate estimates
- QTO allows for more detailed, complex schedules
- Transition to automated takeoffs is the future
- Revit and QTO used to perform quantity estimates



Outline

Conclusions

The Future of Building Information Modeling

- BIM technology becoming a new industry standard
  - LEED, 3D MEP Coordination, Electronic Document Sharing
  - Becoming more accepted by subcontractors

What does this mean for construction managers?

- More efficient projects
- More money and time saved

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Questions

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Acknowledgements

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Tim Kay
Tina Petrie
Erica Craig

Geisinger Health System

High Concrete Group

Industry Professionals from the PACE Roundtable