EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA

PENN STATE AE SENIOR CAPSTONE PROJECT

ERIC FEDDER | CONSTRUCTION MANAGEMENT
DR. CHRIS MAGENT - CM ADVISOR

PRESENTATION OUTLINE:

I. PROJECT BACKGROUND
II. ANALYSIS #1: CONTRACT STRATEGIES
    I. CRITICAL INDUSTRY ISSUE
III. ANALYSIS #2: PRECAST FAÇADE RE-DESIGN
    I. STRUCTURAL BREADTH #1
IV. ANALYSIS #3: PV ARRAY FEASIBILITY STUDY
    I. STRUCTURAL BREADTH #2
    II. ENERGY/ELECTRICAL BREADTH
    III. MAE RESEARCH
V. LESSONS LEARNED
VI. ACKNOWLEDGEMENTS

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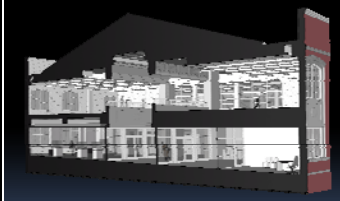

IMAGE COURTESY OF CANNON DESIGN

LOCATION:

- 1200 North Quaker Lane, Alexandria, VA
- Private High School Campus – Episcopal High School

BUILDING PARAMATERS:

- 99,044 SF gross building area
- 60,000 new construction, 39,000 renovation

PROJECT PARAMETERS:

- Negotiated GMP: $22,457,189
- Dates of Construction: 3/6/2009 – 9/3/2010
- Delivery Method: Design-Bid-Build with CM Agency
- LEED Certification: Silver

IMAGES COURTESY OF GOOGLE MAPS

PROJECT BACKGROUND

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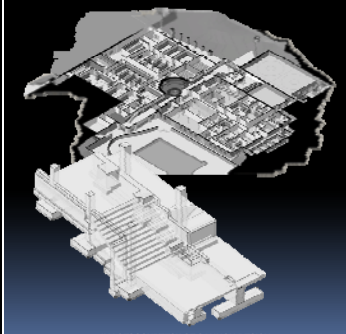


IMAGES COURTESY OF CANNON DESIGN

STRUCTURAL SYSTEM:

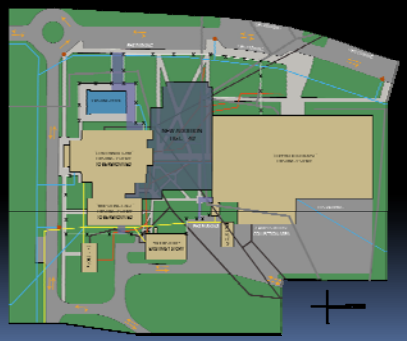
- AGGREGATE PIER SOIL REINFORCEMENT
- CAST-IN-PLACE CONCRETE
- 108' STEEL ROOF TRUSSES

BUILDING ENCLOSURE:

- "DELMARVA" STYLE BRICK WITH CMU BACK-UP
- GLAZED ALUMINUM CURTAIN WALL AT ATRIUM
- STANDING-SEAM METAL ROOF PANELS

CONSTRUCTION LOGISTICS:

- PHASE ONE: UTILITY RELOCATION, CAGE REN., NEW GYM CONST.
- PHASE TWO: NEW GYM CONST., FITNESS ROOM DEMOLITION
- PHASE THREE: NEW GYM CONSTRUCTION, EXISTING GYM REN.



SHIFT IN CONTRACT STRATEGIES

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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PRESENTATION OUTLINE:

IMAGE COURTESY OF WWW.POSTELLILAW.COM/CONTRACTS_LAW.JPG

PROBLEM IDENTIFICATION:

- MANY COMPANIES BEING FORCED SHIFT INTO DIFFERENT MARKET SECTORS
- LESS NEGOTIATED GMP AND MORE HARD BID LUMP SUM CONTRACTS
- COMPANIES INEXPERIENCED WITH HARD BID PROCUREMENT TECHNIQUES

RESEARCH GOAL:

- INVESTIGATE INFLUENCES THAT SHIFT COMPANIES TO DIFFERENT MARKETS
- ASSESS CHANGES IN STRATEGIES FOR PROCURING HARD BID LUMP SUM PROJECTS

INDUSTRY MEMBER INTERVIEWS:

- MIKE PITTSMAN..... DAVIS CONSTRUCTION
- MIKE ARNOLD..... FOREMAN GROUP
- BARRY PERKINS..... DAVIS CONSTRUCTION
- DOMINIC ARGENTERI..... DAVIS CONSTRUCTION
- JOHN BECHTEL..... PENN STATE OPP
- MICHAEL BARNHARDT..... FORRESTER CONSTRUCTION

IMAGE COURTESY OF WWW.SOTON.AC.UK/RIS/IMG/CONTRACTS_JPG

SHIFT IN CONTRACT STRATEGIES

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PRESENTATION OUTLINE:

IMAGE COURTESY OF WWW.POSTELLILAW.COM/CONTRACTS_LAW.JPG

ISSUES DISCUSSED IN INTERVIEWS:

- FACTORS INFLUENCING SHIFTS IN STRATEGY
- PROCUREMENT TECHNIQUES
- COST, DURATION AND AWARD RATE
- ASSOCIATED RISK
- VALUE OF RELATIONSHIPS
- SUCCESS FACTORS FOR PROCURING HARD BID LUMP SUM CONTRACTS
- BENEFITS OF EACH CONTRACT TYPE

IMAGE COURTESY OF WWW.SOTON.AC.UK/RIS/IMG/CONTRACTS.JPG

SHIFT IN CONTRACT STRATEGIES

EPISCOPAL HIGH SCHOOL
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PRESENTATION OUTLINE:

IMAGE COURTESY OF WWW.POSTELLLAW.COM/CONTRACTS_LAW.JPG

EPISCOPAL HIGH SCHOOL CENTENNIAL GYMNASIUM:

- DAVIS CONSTRUCTION
- ALEXANDRIA, VA
- NEGOTIATED GMP CONTRACT
- MARCH 2009 – SEPTEMBER 2010

WOODGROVE HIGH SCHOOL:

- DAVIS CONSTRUCTION
- PURCELLVILLE, VA
- HARD BID LUMP SUM CONTRACT
- FEBRUARY 2009 – AUGUST 2010

PROJECT CASE STUDY COMPARISON		
	EPISCOPAL HIGH SCHOOL	WOODGROVE HIGH SCHOOL
CONTRACT TYPE	Negotiated GMP	Hard Bid Lump Sum
BID PERIOD	12 weeks	3 weeks
COST TO ESTIMATE/BID	$50,000 (< 1% of contract)	$110,000 (< 1% of contract)
NUMBER OF BIDDERS	4	10
REQUEST FOR PROPOSAL	Yes	No
PREQUALIFICATION REQUIREMENTS	Pre-selected list, proposal submission, interview and presentation	None
BID INSTRUCTIONS	None	245 pages
AWARD CRITERIA	Best value	Absolute lowest price
FEE	Performance based aggreement	Standard percentage
CONTRACT MODIFICATIONS	8 pages of alterations	None allowed
VALUE OF RELATIONSHIPS	High	Low
BOND REQUIREMENTS	None required	Contractor submit bid bond and 100% performance and payment bond
PRODUCT SUBSTITUTIONS	Permitted throughout project, pending Architect approval	Have to be submitted a least ten days prior to bid date
SUBCONTRACTOR BUY-OUT	Best value decided by EHS	Absolute lowest subcontractor had to be listed on bid date and awarded contract
PROJECT SAVINGS CLAUSE	75% to Owner, 25% to DAVIS	0% to Owner, 100% to DAVIS
CHANGE ORDER VALUE (To Date)	$725,000	$2,000,000

SHIFT IN CONTRACT STRATEGIES

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IMAGE COURTESY OF WWW.POSTELLILAW.COM/CONTRACTS_LAW.JPG

GENERAL GUIDELINES FOR HARD BID PROJECTS:

1. CONTRACTOR MUST TAKE INITIATIVE TO REVIEW DOCUMENTS
2. FORM SUBCONTRACTOR PARTNERSHIPS TO ENSURE DISCOUNTS
3. IDENTIFY AND SOLICIT ALL POSSIBLE BIDDING SUBCONTRACTORS
4. DISTRIBUTE BID WORK AMONG SEVERAL INDIVIDUALS
5. PROPERLY ALLOCATE TIME AND MONEY SPENT ON LOST BIDS

IMAGE COURTESY OF WWW.SOTON.AC.UK/RIS/IMG/CONTRACTS.JPG

PRECAST FAÇADE RE-DESIGN

EPISCOPAL HIGH SCHOOL
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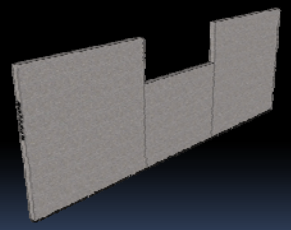

IMAGE COURTESY OF WWW.PRECON.CA

PROBLEM IDENTIFICATION:

- Site congestion due to concrete and masonry overlap
- Inefficient work lead to subcontractor demobilization
- over three weeks of delays encountered due to inefficiencies

RESEARCH GOAL:

- Perform preliminary design of precast façade
- Reduce site congestion and trade coordination on-site

PRECAST FAÇADE RE-DESIGN

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ERIC FEDDER | CONSTRUCTION MANAGEMENT

PRESENTATION OUTLINE:

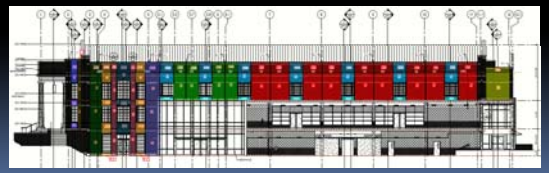
IMAGE COURTESY OF CANNON DESIGN

ORIGINAL FACADE:

- DELMARVA FACE BRICK WITH 8" CMU BACK-UP
- $2 MILLION MASONRY PACKAGE
- 4 MONTH CONSTRUCTION DURATION

PRECAST FACADE:

- SPAN FROM SPANDREL BEAM TO SPANDREL BEAM
- TYPICAL PANEL HEIGHT OF 14'-0"
- 429 TOTAL PIECES
- 18,300 SF OF PANELS
- 75 DIFFERENT SIZES



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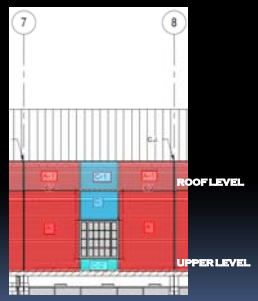

STRUCTURAL WEIGHTS:

- PRECAST SIGNIFICANTLY LIGHTER THAN MASONRY WALL
- ASSUME 5" THICK PANEL WITH NORMAL WEIGHT CONCRETE

SPANDREL BEAM LOADS:

- 36% REDUCTION IN LINE LOADS
- POSSIBLE REDUCTION IN SIZE DUE TO SMALLER LOAD

SPANDREL BEAM DEFELCTION:

- GOVERNING FACTOR OF DESIGN
- ALLOWABLE DEFLECTION = L/180 = 1.67"
- MATCH EXISTING DEFLECTION AS CLOSE AS POSSIBLE

STRUCTURAL WEIGHTS			
MASONRY WALL		ARCH. PRECAST	
MATERIAL	WEIGHT (PSF)	MATERIAL	WEIGHT (PSF)
CMU	55.0	5" Thick Panel	62.5
Brick	42.0		
TOTAL	97.0	TOTAL	62.5

SPANDREL BEAM DEFLECTION		
BEAM SIZE	LOAD CASE	MAX DEFLECTION
2.16' x 1.5'	Masonry Wall Loads	0.027
	Precast Panel Loads	0.017
2.0' x 1.0'	Precast Panel Loads	0.033
1.75'x1.0'	Precast Panel Loads	0.076

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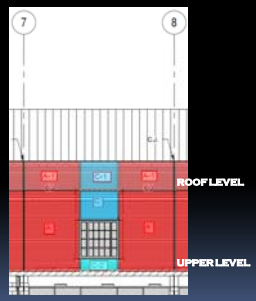

STRUCTURAL RECOMMENDATION:

- REDUCE SPANDREL BEAMS TO 2.0' x 1.0'
- 38% REDUCTION IN SIZE
- MAINTAIN 18" x 18" COLUMN SIZES
- APPROXIMATELY $37,000 SAVINGS

SAVINGS DUE TO REDUCTION OF SPANDREL BEAMS						
EXISTING BEAM SIZE (CY)	REDUCED BEAM SIZE (CY)	% REDUCTION	INITIAL BEAM TOTAL CY	REDUCED BEAM TOTAL CY	$/CY	SAVINGS
3.06	1.89	38.27%	399.00	246.30	$244.00	$37,259.70

IMAGE COURTESY OF CANNON DESIGN

PRECAST FAÇADE RE-DESIGN

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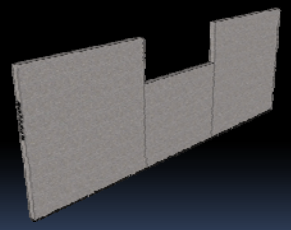


IMAGE COURTESY OF WWW.PRECON.CA

SCHEDULE REDUCTION:

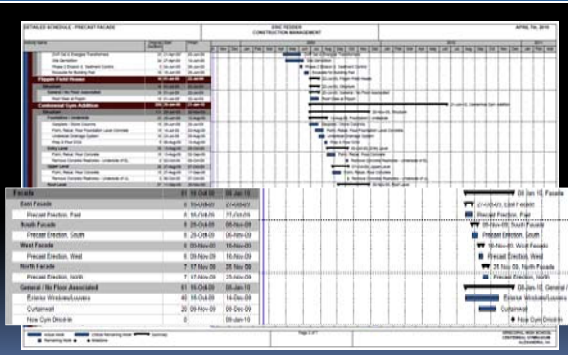
- ORIGINAL MASONRY FAÇADE DURATION = 86 DAYS
- PRECAST ERECTION = 12 PIECES/DAY
- PRECAST FAÇADE DURATION = 36 DAYS

IMPACT ON PROJECT:

- NO OVERLAP OF CONCRETE AND FAÇADE TRADES
- FAÇADE IS NOT ON CRITICAL PATH – NO OVERALL SAVINGS

SCHEDULE REDUCTION DUE TO PRECAST FAÇADE

ELEVATION	FAÇADE SF	MASONRY DURATION (DAYS)	TOTAL # OF PRECAST PANELS	PANELS/DAY	PRECAST DURATION (DAYS)	SCHEDULE SAVINGS (DAYS)
South	4222.25	25.00	86.00	12	7.17	(17.83)
North	4461.38	25.00	81.00	12	6.75	(18.25)
East	4659.59	18.00	90.00	12	7.50	(10.50)
West	3054.06	18.00	72.00	12	6.00	(12.00)
Corners	1911.00	0.00	100.00	12	8.33	8.33
TOTAL	18308.28	86.00	429.00	12.00	35.75	(50.25)



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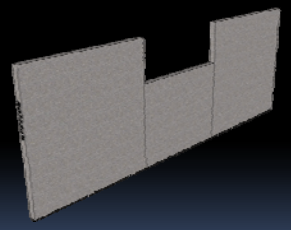

IMAGE COURTESY OF WWW.PRECON.CA

MATERIAL PRICING:

- $75.00/SF DEDUCT FOR MASONRY WALL ASSEMBLY
- $50.00/SF COST FOR PRECAST PANEL
- $65.00/SF COST FOR PRECAST CORNER PIECES

COST REDUCTION:

- PRECAST FAÇADE COSTS APPROXIMATELY 32% LESS THAN MASONRY
- $466,301.77 OVERALL SAVINGS FROM FAÇADE RE-DESIGN

OVERALL SAVINGS	
Precast Panel Cost	$944,079.13
Masonry Wall Deduct	($1,373,121.20)
Spandrel Beam Deduct	($37,259.70)
TOTAL SAVINGS	**$466,301.77**

COST REDUCTION DUE TO PRECAST FAÇADE						
ELEVATION	FAÇADE SF	MASONRY COST/SF	MASONRY TOTAL COST	PRECAST COST/SF	PRECAST TOTAL COST	COST SAVINGS
South	4222.25	$75.00	$316,669.02	$50.00	$211,112.68	$105,556.34
North	4461.38	$75.00	$334,603.21	$50.00	$223,068.81	$111,534.40
West	3054.06	$75.00	$229,054.43	$50.00	$152,702.96	$76,351.48
East	4659.59	$75.00	$349,469.54	$50.00	$232,979.69	$116,489.85
Corners	1911.00	$75.00	$143,325.00	$65.00	$124,215.00	$19,110.00
TOTAL	**18308.28**	**$75.00**	**$1,373,121.20**	**$65.00**	**$944,079.13**	**$429,042.07**

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PRECAST FAÇADE RE-DESIGN

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PRESENTATION OUTLINE:

SITE CONGESTION:

- REDUCED FAÇADE SCHEDULE ALLOWS FOR NO TRADE OVERLAP
- CONCRETE/STEEL OCCUPY SITE SOLELY
- NO MASONRY STAGING AREAS OR SCAFFOLDING
- INCREASED EFFICIENCY
- ONLY METAL DECKING WILL OCCUR DURING PRECAST ERECTION

PRECAST ERECTION SEQUENCE:

- ADDITIONAL PHASE TO CONSTRUCTION
- ERECTION BEGINS ON EAST FAÇADE, WORKS CLOCKWISE
- TWO DELIVERY TRUCK LOCATIONS
- FOUR PRECAST CRANE LOCATIONS

PRECAST FAÇADE RE-DESIGN

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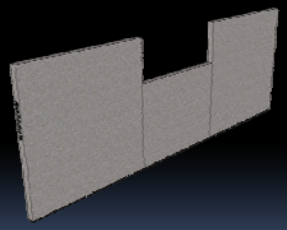
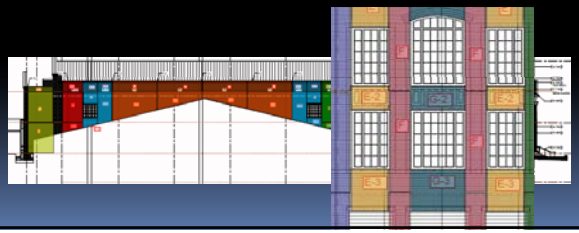


IMAGE COURTESY OF WWW.PRECON.CA

ARCHITECTURAL IMPLICATIONS:

- HIGHER COST/SF TO ACHIEVE DETAIL
- STANDARDIZE WINDOW/LOUVER DIMENSIONS
- CHANGE INTERIOR WALL SURFACE IN GYMNASIUM
- COMPLEX INTERFACES



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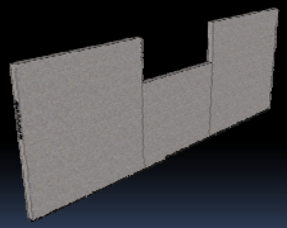


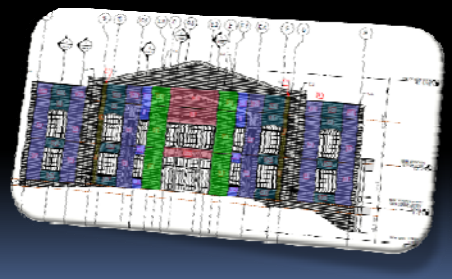
IMAGE COURTESY OF WWW.PRECON.CA

FINAL CONCLUSIONS:

- PRECAST FAÇADE REDUCES SCHEDULE AND COST
- ELIMINATES SITE CONGESTION AND INEFFICIENCIES
- POSSIBLE REDUCTION OF STRUCTURAL SPANDREL BEAMS
- MINOR ARCHITECTURAL IMPLICATIONS

RECOMMENDATION:

- PURSUE PRECAST FAÇADE BASED ON CONSTRUCTABILITY CONCERNS
- MET GOAL OF ANALYSIS TO REDUCE SITE CONGESTION ISSUES
- ULTIMATELY OWNER/ARCH. MUST MAKE DECISION



PHOTOVOLTAIC ARRAY SYSTEM

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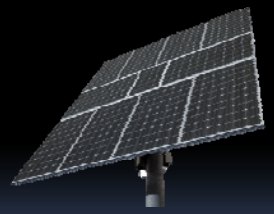


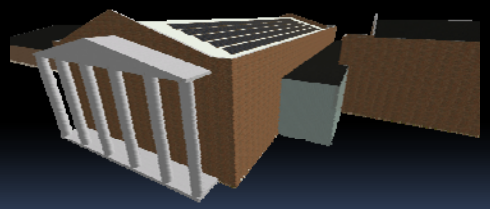
IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

PROBLEM IDENTIFICATION:

- PROJECT IS PURSUING LEED SILVER CERTIFICATION
- FEW SUSTAINABLE TECHNIQUES PURSUED IN PROJECT
- PV SYSTEM ELIMINATED FROM SCOPE

RESEARCH GOAL:

- PERFORM PRELIMINARY DESIGN OF A BUILDING INTEGRATED PV SYSTEM
- DETERMINE FINANCIAL FEASIBILITY OF SYSTEM
- REDUCE ENERGY COSTS FOR EHS



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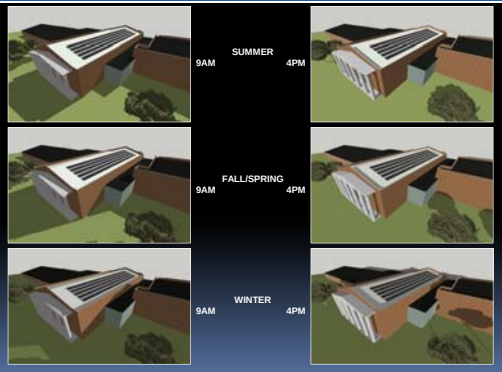
PRESENTATION OUTLINE:

ORIENTATION:

- HALF OF NEW ADDITION ROOF FACES DIRECTLY SOUTH
- 9000 SF OF ROOF SPACE
- ROOF PITCHED 3:12 (APPROX. 15 DEGREES)

SOLAR SHADING:

- NO SHADING AT 9AM AND 4PM FOR EACH CASE
- MAINTAIN 5' PERIMETER TO AVOID SHADING FROM PARAPET WALL



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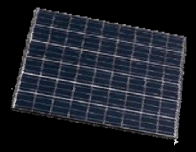
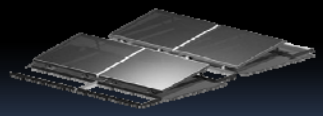




KYOCERA

PRODUCT SELECTION:

- KYOCERA SOLAR PRODUCTS CATALOG
- KD210GX-LP PANEL (59"x 39")
- "RAPIDRAC" UNITIZED MOUNT (15 DEGREE TILT)

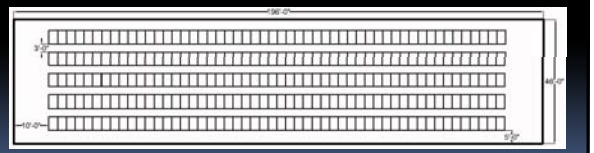
TOTAL BUILDING ENERGY:

- ESTIMATE 500kWH PER DAY FOR BUILDING LOAD
- REQUIRES 1000 PANELS = 210 kW SYSTEM
- REQUIRES 25,000 SF OF ROOF SPACE

ACTUAL SYSTEM SIZE:

- 52.5 kW
- 250 PV PANELS
- FIXED AT 30 DEGREE TILT

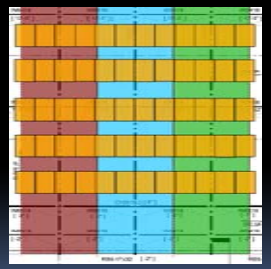
SOLAR ARRAY SIZING CALCULATION		
Sun Hours Per Day	4.90	Reference chart on pg. 6 Kyocera Catalog
Watt-Hours Per Day	125000	From Energy Load Table
Watts per Hour of Sunlight	25510	Daily watt-hours divided by sun hours per day
Actual Produced Power Per Panel	102.70	Amperage x charging voltage for KD210GX-LP panel
# of Panels Required	248.40	Watts/hour divided by actual power of panel



PHOTOVOLTAIC ARRAY SYSTEM

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
ERIC FEDDER | CONSTRUCTION MANAGEMENT

PRESENTATION OUTLINE:



UNIT WEIGHTS:

- PV PANELS = 40 LBS. EACH
- MOUNTS = 12 LBS. EACH

TRIBUTARY AREA:

- 12.5' TRUSS SPACING
- TRIB. AREA = 6.25' IN EACH DIRECTION = 12.5' TOTAL
- 20 PANELS AND MOUNTS PER TRUSS

RESULTING LOAD:

- 19.26 PLF PER ROOF TRUSS
- EXISTING TRUSSES ARE ABLE TO SUPPORT ADDITIONAL LOAD

LOADS ON TRUSS FROM PV SYSTEM

COMPONENT	WEIGHT (LBS.)	TRIB. AREA (SF)	#/TRUSS	LOAD (LBS.)	TRUSS LENGTH (FT)	LINE LOAD (PLF)
PV Panel	40.00	675.00	20.00	800.00	54.00	14.81
Mount	12.00	675.00	20.00	240.00	54.00	4.44
TOTAL	**52.00**	**675.00**	**20.00**	**1040.00**	**54.00**	**19.26**

PHOTOVOLTAIC ARRAY SYSTEM

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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PRESENTATION OUTLINE:

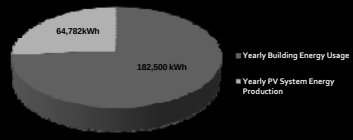
PV WATTS FACTOR RESULTS			
MONTH	SOLAR RADIATION ($kWh/m^2/day$)	AC ENERGY (kWh)	ENERGY VALUE ($)
1	3.36	4346	347.68
2	4.11	4681	374.48
3	4.76	5849	467.92
4	5.44	6236	498.88
5	5.56	6257	500.56
6	5.98	6531	522.48
7	5.74	6299	503.92
8	5.53	6182	494.56
9	5.08	5605	448.40
10	4.56	5369	429.52
11	3.35	3957	316.56
12	2.81	3469	277.52
Year	4.69	64782	5182.56
PV WATTS FACTOR = Annual AC Energy/System DC Rating = 64782/52.5 = 1234			

SYSTEM PRODUCTION:

- 64,782 kWh per year
- 5400 kWh average per month
- 180 kWh average per day
- PV Watts factor = 1234

OVERALL ENERGY PRODUCTION:

- 35% of building usage
- 100% of gymnasium overhead lights



OVERHEAD GYM LIGHTING ENERGY LOADS				
COMPONENT	QUANTITY	WATTS	HRS/DAY	kWH
New Gym Overhead Lights - 4'-0" 277V Fluorescent Pendants	45	32.00	6.00	8.64
Existing Gym Overhead Lights - Pulse-Start Hi-Bay Pendants	65	400.00	4.00	104.00
TOTAL	110			112.64

PHOTOVOLTAIC ARRAY SYSTEM

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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PRESENTATION OUTLINE:

SMA

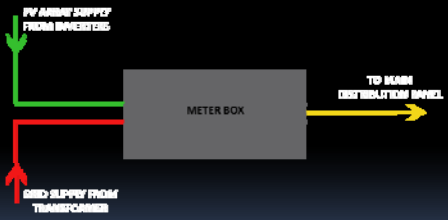
IMAGES COURTESY OF SMA CATALOG

GRID CONNECTION:

- Additional 250A load on main panel for load-side connection
- Use Supply-side interconnection

ELECTRICAL COMPONENTS REQUIRED:

- DC Wire Run
- DC Disconnects
- Inverter
- AC Disconnects
- AC Wire Run
- Service-Tap Meter Box



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EPISCOPAL HIGH SCHOOL
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ALEXANDRIA, VA
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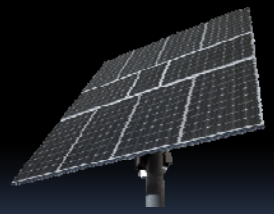
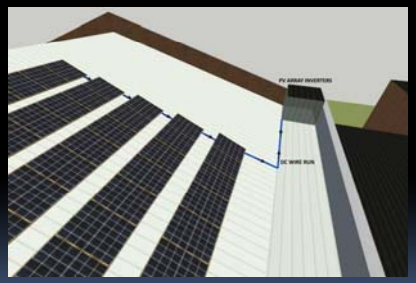


IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

SYSTEM SET-UP:

- LOCATE INVERTER ON ROOF LEVEL AT SOUTHEAST CORNER
- MINIMIZE DC RUN
- COVER INVERTER TO MINIMIZE SUN/MOISTURE EXPOSURE
- 53' DC WIRE RUN
- 115' AC WIRE RUN
- 68% LESS WIRE DUE TO LOCATING INVERTERS ON ROOF



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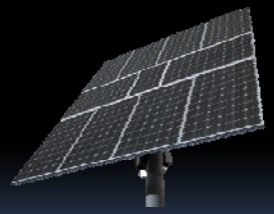

IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

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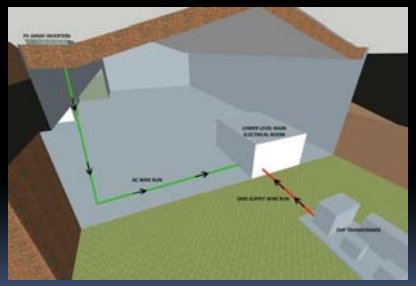

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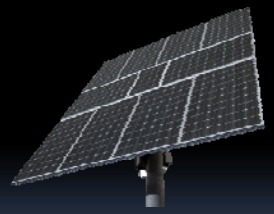


IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

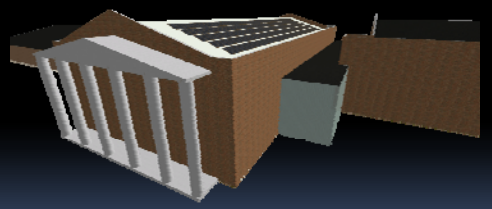
SYSTEM COST:

- US DEPT. OF ENERGY ANNUAL ENERGY REPORT
- SYSTEM < 250KW IN MID-ATLANTIC REGION = $7.50/WATT

REBATES/INCENTIVES:

- VIRGINIA STATE ENERGY PROGRAM - $2000/KW SYSTEM UP TO 10KW
- FEDERAL TAX CREDIT – 30% OF GROSS INSTALLATION COST
- VIRGINIA ALTERNATIVE ENERGY CREDIT – 0.20$/KWH PRODUCED

ESTIMATED COST OF PV SYSTEM		
SIZE (kW)	$/W	COST
52.5	$7.50	$393,750.00



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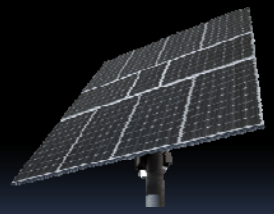


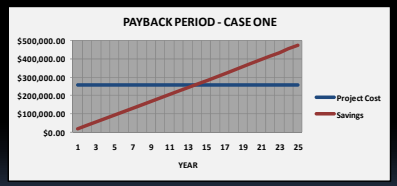
IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

FINANCING OPTIONS:

- OPTION ONE: 0% BORROWED
- OPTION TWO: 50% BORROWED
- OPTION THREE: 100% BORROWED

FINANCING PARAMATERS:

- 0.082$/KWH RETAIL COST OF ELECTRICITY (VIRGINIA)
- 1% MARKET RATE INCREASE EACH YEAR
- 2.00% APY INTEREST RATE OVER 25 YEAR LOAN PERIOD



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CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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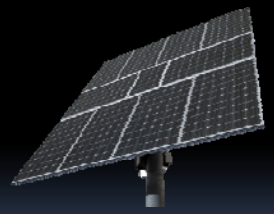

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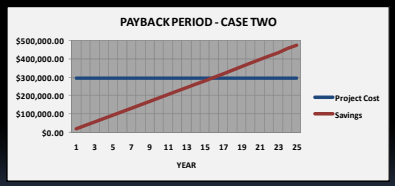

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ALEXANDRIA, VA
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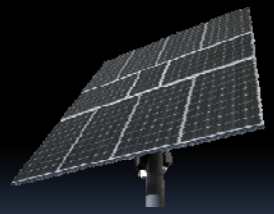

IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

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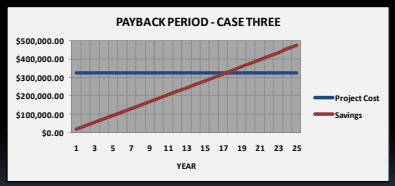
PV ARRAY FEASIBILTY ANALYSIS OPTION SUMMARY					
OPTION	UP-FRONT COST	LOAN AMOUNT	YEARLY ENERGY SAVINGS	25-YEAR VALUE	PAYBACK PERIOD
1	$255,625.00	$0.00	$20,000.00	$218,338.33	14 years
2	$107,813.00	$187,953.00	$20,000.00	$178,198.92	16 years
3	$0.00	$325,043.00	$20,000.00	$148,920.00	18 years



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CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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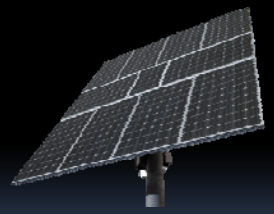


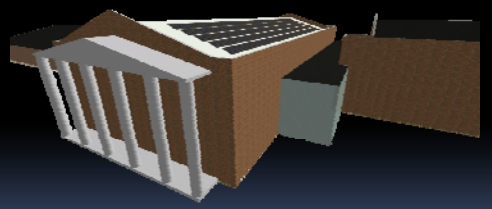
IMAGE COURTESY OF WWW.RESIDENTSOLAR.COM

RECOMMENDATION:

- NEW CENTENNIAL ROOF OPTIMAL FOR SOLAR ARRAY
- 52.5KW, 250 PANEL SYSTEM
- FULLY FUND UP-FRONT COSTS, I.E. NO LOAN

MAE RESEARCH:

- AE 572: PROJECT DEVELOPMENT AND DELIVERY PLANNING
  - LIFE-CYCLE COST ANALYSIS
  - FINANCIAL FEASIBILITY
- AE 597D: SUSTAINABLE BUILDING METHODS
  - BUILDING ORIENTATION/OPTIMAL TILT ANGLE
  - REBATES/INCENTIVES FOR SOLAR ENERGY
  - CURRENT SOLAR TECHNOLOGIES



EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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LESSONS LEARNED

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
ERIC FEDDER | CONSTRUCTION MANAGEMENT

PRESENTATION OUTLINE:

ANALYSIS #1:

- SUBCONTRACTOR PARTNERSHIPS ARE KEY TO SUCCESS
- HARD BID CONTRACT STIPULATIONS FOR SUBCONTRACTOR BUY-OUT

ANALYSIS #2:

- PRECAST PANELS CAN BE COST AND TIME EFFECTIVE
- MUST ANALYZE SCHEDULE BENEFITS BEYOND CRITICAL PATH

ANALYSIS #3:

- CRITICAL TO PERFORM FEASIBILITY STUDY EARLY IN PROJECT DEVELOPMENT
- REBATES/INCENTIVES AVAILABLE THAT MAKE PV SYSTEMS AFFORDABLE

ACKNOWLEDGEMENTS

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CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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PRESENTATION OUTLINE:

ACADEMIC ACKNOWLEDGEMENTS:

PENN STATE AE FACULTY
DR. CHRIS MAGENT – CM ADVISOR

INDUSTRY ACKNOWLEDGEMENTS:

SPECIAL THANKS TO:

BRYAN QUINN AT DAVIS
GRANT ROGERS AT CANNON DESIGN
EPISCOPAL HIGH SCHOOL PROJECT TEAM
ANDY MACKEY – AE GRAD STUDENT
PACE INDUSTRY MEMBERS
MY FAMILY AND FRIENDS

ADDITIONAL INFORMATION

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
ERIC FEDDER | CONSTRUCTION MANAGEMENT

PRESENTATION OUTLINE:

POINT LOAD FROM TRUSS ON ROOF SPANDREL BEAM			
TYPE	LOAD (PSF)	TRIB. AREA (SF)	POINT LOAD (LBS.)
ROOF LIVE	20.0	690.0	13800.0
SNOW	20.0	690.0	13800.0
SELF WEIGHT			
DECKING	2.8	690.0	1932.0
TRUSS	N/A	N/A	5000.0
TOTAL	42.8		34532.0

STRUCTURAL LOADS ON SPANDREL BEAMS AT BAY 7-8 FROM MASONRY					
ROOF SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A-1	47.5	4607.5	100.00%	4607.5	180.69
C-1	33.75	3273.75	100.00%	3273.75	128.38
A-1	47.5	4607.5	100.00%	4607.5	180.69
			TOTAL	12488.75	489.75
UPPER SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A	133	12901	100.00%	12901	505.92
C	35.43	3436.71	100.00%	3436.71	134.77
C-2	15.18	1472.46	100.00%	1472.46	57.74
A	133	12901	100.00%	12901	505.92
			TOTAL	30711.17	1204.36

STRUCTURAL LOADS ON SPANDREL BEAMS AT BAY 7-8 FROM PRECAST					
ROOF SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A-1	47.5	2968.75	100.00%	2968.75	116.42
C-1	33.75	2109.375	100.00%	2109.375	82.72
A-1	47.5	2968.75	100.00%	2968.75	116.42
			TOTAL	8046.875	315.56
UPPER SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A	133	8312.5	100.00%	8312.5	325.98
C	35.43	2214.375	100.00%	2214.375	86.84
C-2	15.18	948.75	100.00%	948.75	37.21
A	133	8312.5	100.00%	8312.5	325.98
			TOTAL	19788.125	776.00

ADDITIONAL INFORMATION

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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PRESENTATION OUTLINE:

DEFLECTION AT SPANDREL BEAMS (2.16'x1.5')

BEAM	LOAD CASE	DISTANCE (FT)	X DEFLECTION (IN.)	Y DEFLECTION (IN.)	RESULTANT DEFLECTION (IN.)
Upper	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.015	0.015
		12.75	0	-0.027	0.027
		19.125	0	-0.015	0.015
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.01	0.01
		12.75	0	0.017	0.017
		19.125	0	-0.01	0.01
		25.5	0	0	0
Roof	Masonry Wall Loads	0	0	0	0
		6.375	0	0.006	0.006
		12.75	0	-0.011	0.011
		19.125	0	-0.006	0.006
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.004	0.004
		12.75	0	-0.007	0.007
		19.125	0	-0.004	0.004
		25.5	0	0	0

DEFLECTION AT SPANDREL BEAMS (2.0'x1.0')

BEAM	LOAD CASE	DISTANCE (FT)	X DEFLECTION (IN.)	Y DEFLECTION (IN.)	RESULTANT DEFLECTION (IN.)
Upper	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.029	0.029
		12.75	0	-0.051	0.051
		19.125	0	-0.029	0.029
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.018	0.018
		12.75	0	-0.033	0.033
		19.125	0	-0.018	0.018
		25.5	0	0	0
Roof	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.012	0.012
		12.75	0	-0.021	0.021
		19.125	0	-0.012	0.012
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.007	0.007
		12.75	0	-0.013	0.013
		19.125	0	-0.007	0.007
		25.5	0	0	0

DEFLECTION AT SPANDREL BEAMS (1.75'x1.0')

BEAM	LOAD CASE	DISTANCE (FT)	X DEFLECTION (IN.)	Y DEFLECTION (IN.)	RESULTANT DEFLECTION (IN.)
Upper	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.043	0.043
		12.75	0	-0.076	0.076
		19.125	0	-0.043	0.043
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.027	0.027
		12.75	0	-0.049	0.049
		19.125	0	-0.027	0.027
		25.5	0	0	0
Roof	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.017	0.017
		12.75	0	-0.031	0.031
		19.125	0	-0.017	0.017
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.011	0.011
		12.75	0	-0.02	0.02
		19.125	0	-0.011	0.011
		25.5	0	0	0

ADDITIONAL INFORMATION

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
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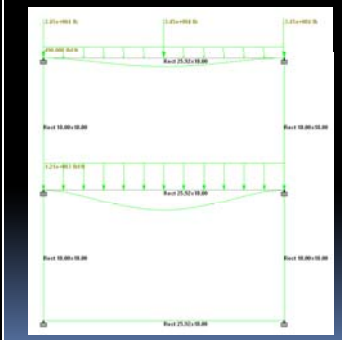
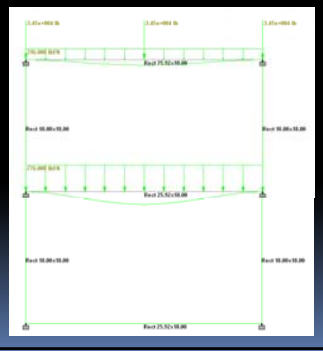
PRESENTATION OUTLINE:

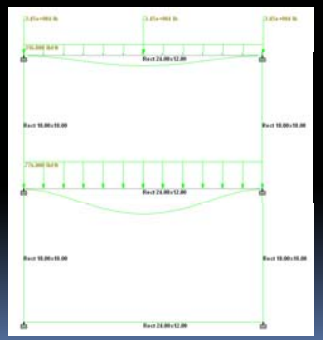
EXISTING SPANDREL BEAMS UNDER MASONRY WALL LOADS:



EXISTING SPANDREL BEAMS UNDER PRECAST PANEL LOADS:



2' x 1' SPANDREL BEAMS UNDER PRECAST PANEL LOADS:



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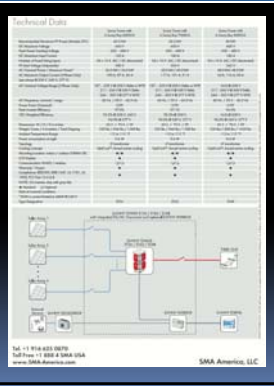
EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA
ERIC FEDDER | CONSTRUCTION MANAGEMENT

PRESENTATION OUTLINE:



ADDITIONAL INFORMATION

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PRESENTATION OUTLINE:

FEASIBILITY ANALYSIS FOR PV SYSTEM - CASE ONE

MARKET RATES		
Retail Cost of Electricity	0.082	$/kWh from electricitypricecomparison.org/
Elec. Rate increase	1.00%	
AECs Value	0.2	$/kWh
LOAN		
Percentage Borrowed	0.00%	
Loan Value	$0.00	
Interest Rate	2.00%	APR
Period	25	Years
CRF	0.004238543	Capital-Recovery Factor (CRF) = r(1+r)^n/[(1+r)^n-1]
Monthly Payments	$0.00	
Total Loan cost	$0.00	
Cost of Capital	$0.00	
REBATES/INCENTIVES		
Federal Tax Credit	30.00%	of total installation cost
VA State Energy Program	$20,000.00	$2000/kW up to 10kW
SYSTEM SIZE		
Size	52.5	kW DC
Cost/W	$7.50	$/W
Total Cost	$393,750.00	
PVWatts Factor	1234	based on 30 deg. Tilt in 22301 at 180 deg. Azimuth
Annual AC production	64785	kWh
SAVINGS		
Monthly Savings/Rev	$1,522.45	year 1
25 Year Savings/Rev	$473,963.33	
OVERALL VALUE		
Up Front Expense	$255,625.00	
Loan Cost	$0.00	
Total Expense	$255,625.00	
25 Year Value	$218,338.33	

FEASIBILITY ANALYSIS FOR PV SYSTEM - CASE TWO

MARKET RATES		
Retail Cost of Electricity	0.082	$/kWh from electricitypricecomparison.org/
Elec. Rate increase	1.00%	
AECs Value	0.2	$/kWh
LOAN		
Percentage Borrowed	50.00%	
Loan Value	$147,312.57	
Interest Rate	2.00%	APR
Period	25	Years
CRF	0.004238543	Capital-Recovery Factor (CRF) = r(1+r)^n/[(1+r)^n-1]
Monthly Payments	$626.53	
Total Loan cost	$187,952.91	
Cost of Capital	$40,640.91	
REBATES/INCENTIVES		
Federal Tax Credit	30.00%	of total installation cost
VA State Energy Program	$20,000.00	$2000/kW up to 10kW
SYSTEM SIZE		
Size	52.5	kW DC
Cost/W	$7.50	$/W
Total Cost	$393,750.00	
PVWatts Factor	1234	based on 30 deg. Tilt in 22301 at 180 deg. Azimuth
Annual AC production	64785	kWh
SAVINGS		
Monthly Savings/Rev	$1,522.45	year 1
25 Year Savings/Rev	$473,963.33	
OVERALL VALUE		
Up Front Expense	$107,812.50	
Loan Cost	$187,952.91	
Total Expense	$295,765.41	
25 Year Value	$178,197.92	

FEASIBILITY ANALYSIS FOR PV SYSTEM - CASE THREE

MARKET RATES		
Retail Cost of Electricity	0.082	$/kWh from electricitypricecomparison.org/
Elec. Rate increase	1.00%	
AECs Value	0.2	$/kWh
LOAN		
Percentage Borrowed	100.00%	
Loan Value	$255,625.00	
Interest Rate	2.00%	APR
Period	25	Years
CRF	0.004238543	Capital-Recovery Factor (CRF) = r(1+r)^n/[(1+r)^n-1]
Monthly Payments	$1,083.48	
Total Loan cost	$325,043.30	
Cost of Capital	$69,418.30	
REBATES/INCENTIVES		
Federal Tax Credit	30.00%	of total installation cost
VA State Energy Program	$20,000.00	$2000/kW up to 10kW
SYSTEM SIZE		
Size	52.5	kW DC
Cost/W	$7.50	$/W
Total Cost	$393,750.00	
PVWatts Factor	1234	based on 30 deg. Tilt in 22301 at 180 deg. Azimuth
Annual AC production	64785	kWh
SAVINGS		
Monthly Savings/Rev	$1,522.45	year 1
25 Year Savings/Rev	$473,963.33	
OVERALL VALUE		
Up Front Expense	$0.00	
Loan Cost	$325,043.30	
Total Expense	$325,043.30	
25 Year Value	$148,920.03	

ADDITIONAL INFORMATION

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
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PRESENTATION OUTLINE:

25 YEAR FINANCIAL CALCULATIONS

YEAR	COST $/kWh	SAVINGS/YR	AECs	TOTAL/YR	MONTHLY SAVINGS	CUMULATIVE SAVINGS	SYSTEM COST
1	0.082	$5,312.37	$12,957.00	$18,269.37	$1,522.45	$18,269.37	$325,043.30
2	0.083	$5,365.49	$12,957.00	$18,322.49	$1,526.87	$36,591.86	$325,043.30
3	0.084	$5,419.15	$12,957.00	$18,376.15	$1,531.35	$54,968.01	$325,043.30
4	0.084	$5,473.34	$12,957.00	$18,430.34	$1,535.86	$73,398.35	$325,043.30
5	0.085	$5,528.07	$12,957.00	$18,485.07	$1,540.42	$91,883.43	$325,043.30
6	0.086	$5,583.35	$12,957.00	$18,540.35	$1,545.03	$110,423.78	$325,043.30
7	0.087	$5,639.19	$12,957.00	$18,596.19	$1,549.68	$129,019.97	$325,043.30
8	0.089	$5,695.58	$12,957.00	$18,652.58	$1,554.38	$147,672.55	$325,043.30
9	0.089	$5,752.54	$12,957.00	$18,709.54	$1,559.13	$166,382.08	$325,043.30
10	0.090	$5,810.06	$12,957.00	$18,767.06	$1,563.92	$185,149.14	$325,043.30
11	0.091	$5,868.16	$12,957.00	$18,825.16	$1,568.76	$203,974.31	$325,043.30
12	0.091	$5,926.84	$12,957.00	$18,883.84	$1,573.65	$222,858.15	$325,043.30
13	0.092	$5,986.11	$12,957.00	$18,943.11	$1,578.59	$241,801.26	$325,043.30
14	0.093	$6,045.97	$12,957.00	$19,002.97	$1,583.58	$260,804.23	$325,043.30
15	0.094	$6,106.43	$12,957.00	$19,063.43	$1,588.62	$279,867.66	$325,043.30
16	0.095	$6,167.50	$12,957.00	$19,124.50	$1,593.71	$298,992.16	$325,043.30
17	0.096	$6,229.17	$12,957.00	$19,186.17	$1,598.85	$318,178.33	$325,043.30
18	0.097	$6,291.46	$12,957.00	$19,248.46	$1,604.04	$337,426.80	$325,043.30
19	0.098	$6,354.38	$12,957.00	$19,311.38	$1,609.28	$356,738.17	$325,043.30
20	0.099	$6,417.92	$12,957.00	$19,374.92	$1,614.58	$376,113.10	$325,043.30
21	0.100	$6,482.10	$12,957.00	$19,439.10	$1,619.93	$395,552.20	$325,043.30
22	0.101	$6,546.92	$12,957.00	$19,503.92	$1,625.33	$415,056.12	$325,043.30
23	0.102	$6,612.39	$12,957.00	$19,569.39	$1,630.78	$434,625.51	$325,043.30
24	0.103	$6,678.52	$12,957.00	$19,635.52	$1,636.29	$454,261.03	$325,043.30
25	0.104	$6,745.31	$12,957.00	$19,702.31	$1,641.86	$473,963.33	$325,043.30
	TOTAL	$150,038.33	$323,925.00	$473,963.33			