Crystal Plaza II
Arlington VA

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CONSTRUCTION MANAGEMENT
2009 SENIOR THESIS PRESENTATION
THE PENNSYLVANIA STATE UNIVERSITY

Presentation Outline

Creating Sustainability in Crystal City

1. Crystal Plaza II Overview
   - Project background, challenges, site, and team
2. Consolidation of Slab Penetrations
   - Structural conditions, resolutions, recommendations
3. Building Integrated Solar Energy System
   - Design considerations, technology, energy results
4. Peak Demand Shift and Demand Response Programs
   - Background, local programs, generator use, results
5. Financing Projects through Energy Savings
   - Goals, incentives/rebates
6. Conclusion and Questions

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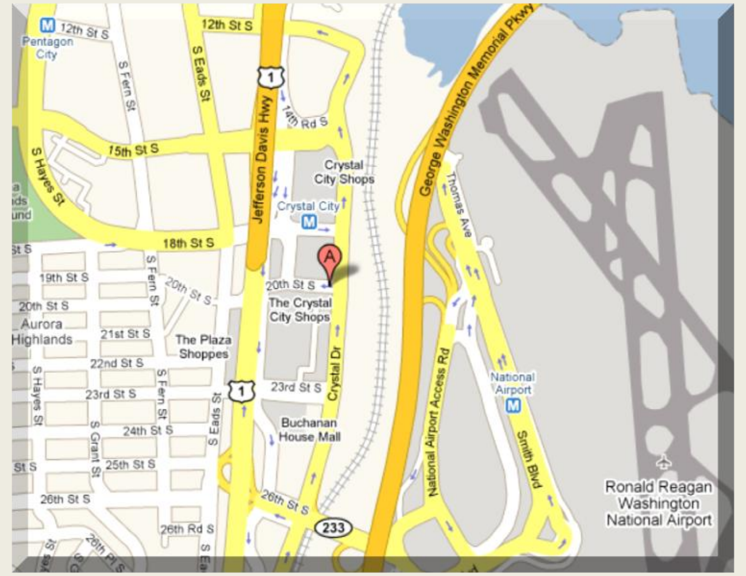
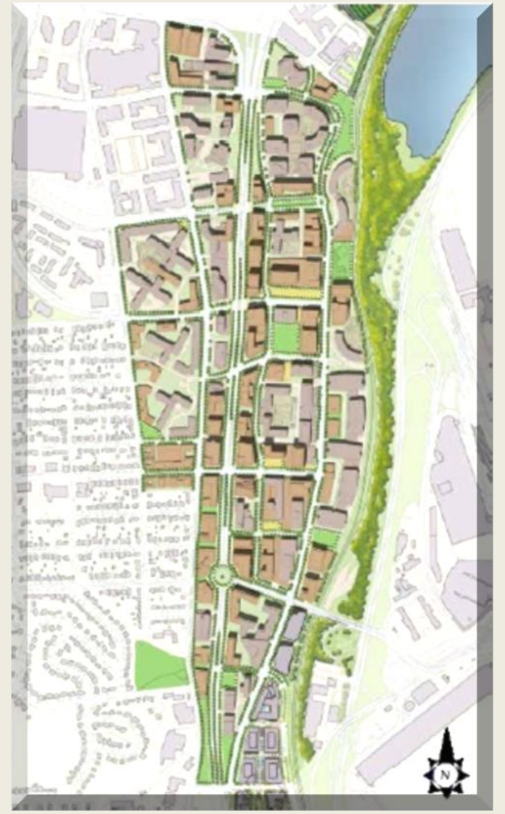
Location

220 20th Street Arlington VA





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Building History

- Originally 12 story office in commercial complex that featured similar designs and architecture
- Constructed in 1969 by Robert H Smith Group
- Now owned by Vornado/Charles E. Smith
- Originally to be demolished
- Renovation into266 unit apartment complex
- Increase from 12 to 20 stories
- Part of changing Crystal City

Location

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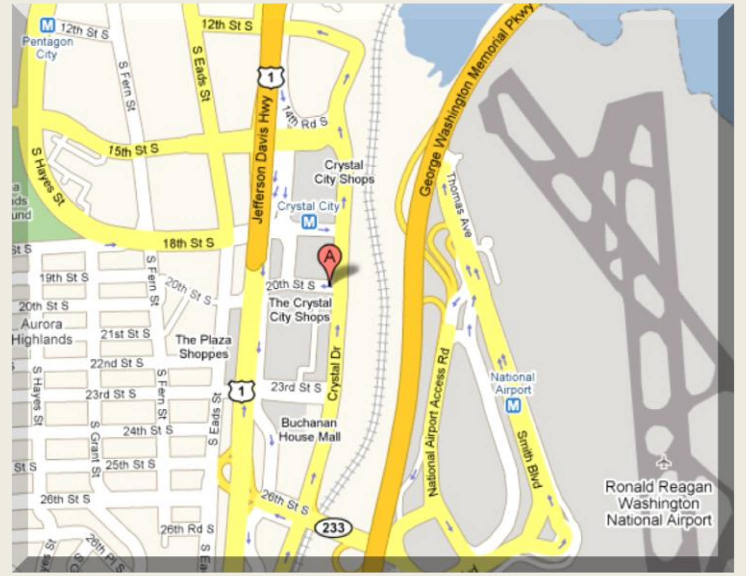

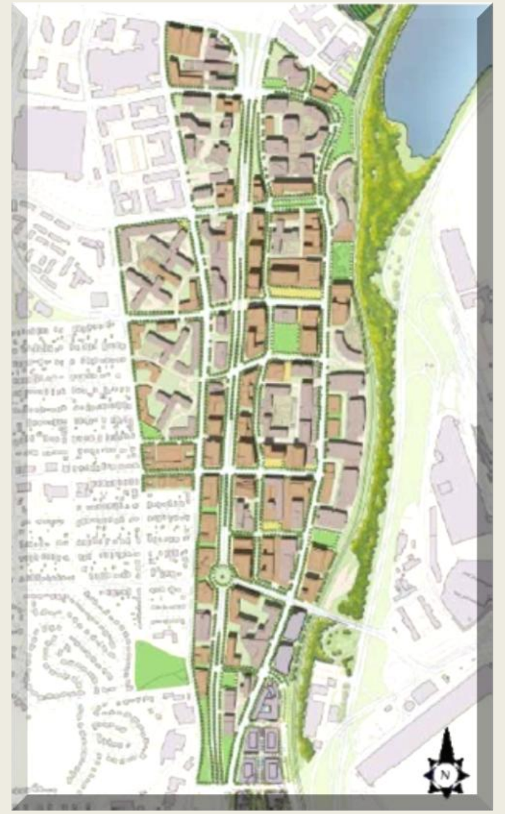

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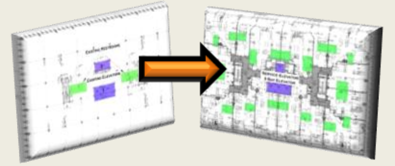
Constructability Challenges

- Renovation

- Required Delivery

- Reconfiguration



- Residential Curtain Wall

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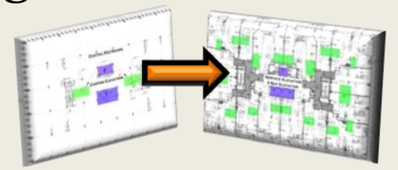
- Renovation
  - 40 year old structure
    - Deficiencies
  - Unforeseen Conditions

Constructability Challenges

- Renovation

- Required Delivery

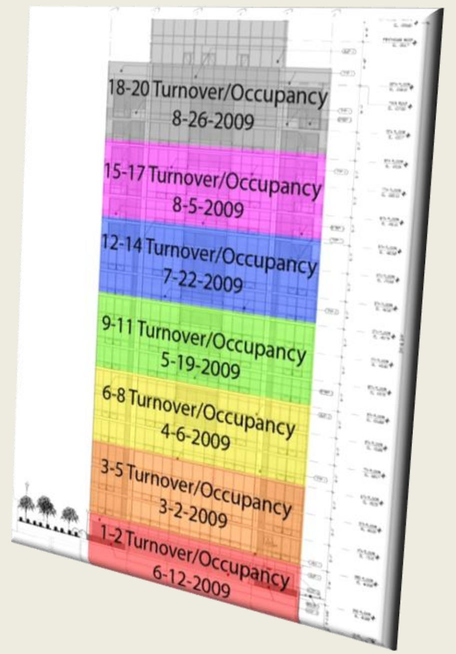
- Reconfiguration



- Residential Curtain Wall

Crystal Plaza II Overview

- Required Delivery
  - Multi phase delivery
  - Multiple inspections
  - Life Safety equipment



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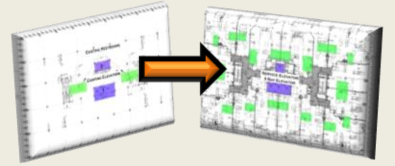
- Required Delivery

- Reconfiguration



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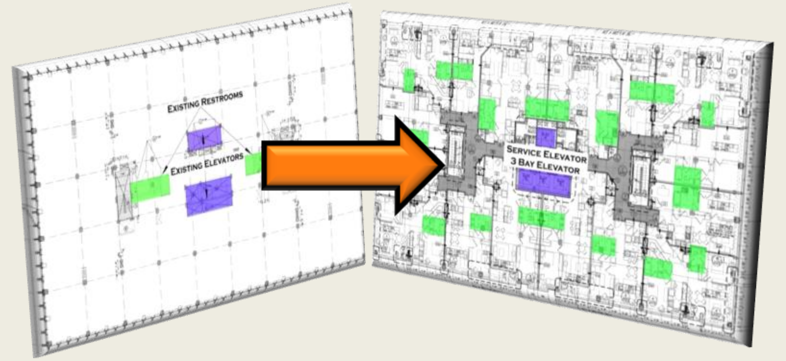
Crystal Plaza II Overview

- Reconfiguration
  - More decentralized
  - More slab penetrations
  - Structural Integrity

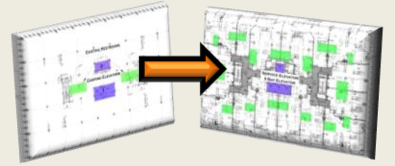


Constructability Challenges

- Renovation

- Required Delivery

- Reconfiguration



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Residential Curtain Wall

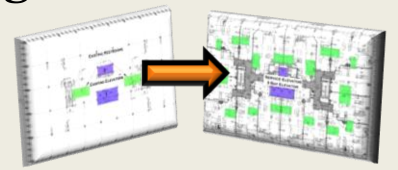
- Weather proofing
- Mechanical systems
- Lead time

Constructability Challenges

- Renovation

- Required Delivery

- Reconfiguration



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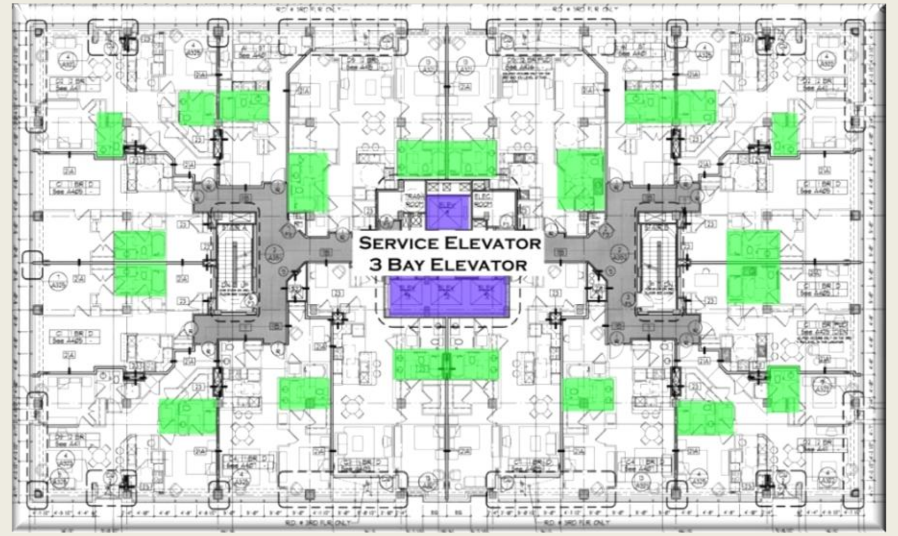
- Schedule
  - Construction Critical Path
    - Demolition
    - Concrete Structure
    - Façade/Dry-in
    - MEP Fit Out
    - Lobby Finishes

- Important Dates
  - Review/Issue Building Permit
    - March 15,2007
  - FAA Approval
    - May 18, 2007
  - Substantial Completion
    - August 31, 2009

Consolidation of Slab Penetrations

- Background
  - Change in use, commercial to residential
  - Increased slab penetrations through existing slab
  - Coordination
  - Large Risk

- Problem Statement
  - Constructability
  - Schedule
  - Cost
  - Structural Integrity



- Goal
  - Locate marginal and problematic areas to provide better information to the GC and MEP designers to mitigate risk.

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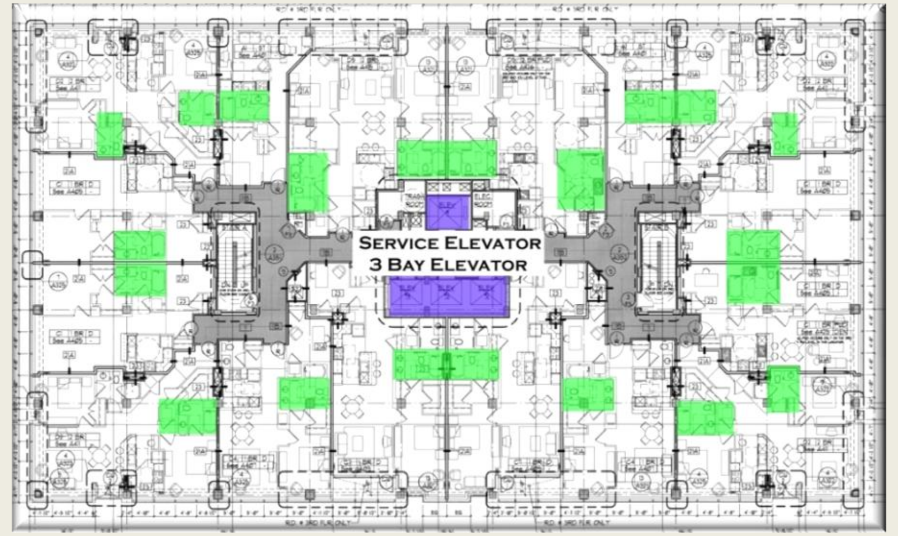
Consolidation of Slab Penetrations

- Research
  - Each bathroom has 3-9 penetrations, often 6-12 in group
  - GPR ineffective
  - Reinforcement
    - Carbon Fiber Reinforced Polymer (CFRP)
    - Large strength gains, minimal stiffness

- Problem Statement
  - Constructability
  - Schedule
  - Cost
  - Structural Integrity



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- Constructability
  - Do first, check second
  - Rework
  - Coordination

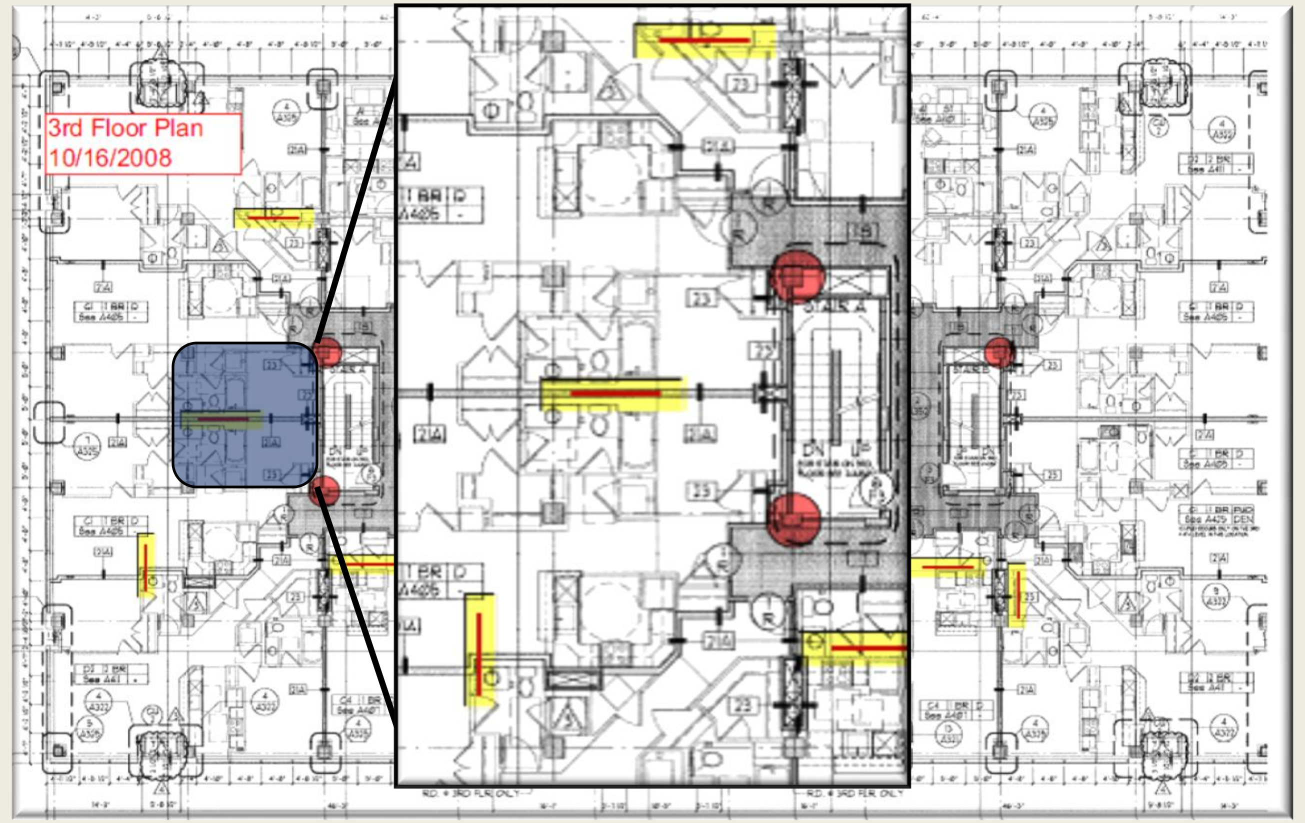
Consolidation of Slab Penetrations

- Schedule
  - Rough in of MEP and framing complete
  - CFRP
    - requires large lay down area
    - Takes 2-7 days to install
  - About a 3 week delay by process
  - Fireproofing
    - Overlooked
    - Postponed inspections
    - Rework of installed drywall
    - Delayed drywall 2 weeks

- Cost
  - CFRP
    - ~$50/sf, 840 sf, $42,000
  - Survey
    - $30,000
  - GC Review of penetrations
    - $8,000
  - Fireproofing
    - $21,000
    - Rework $25,000
  - Over $120,000 for CFRP process

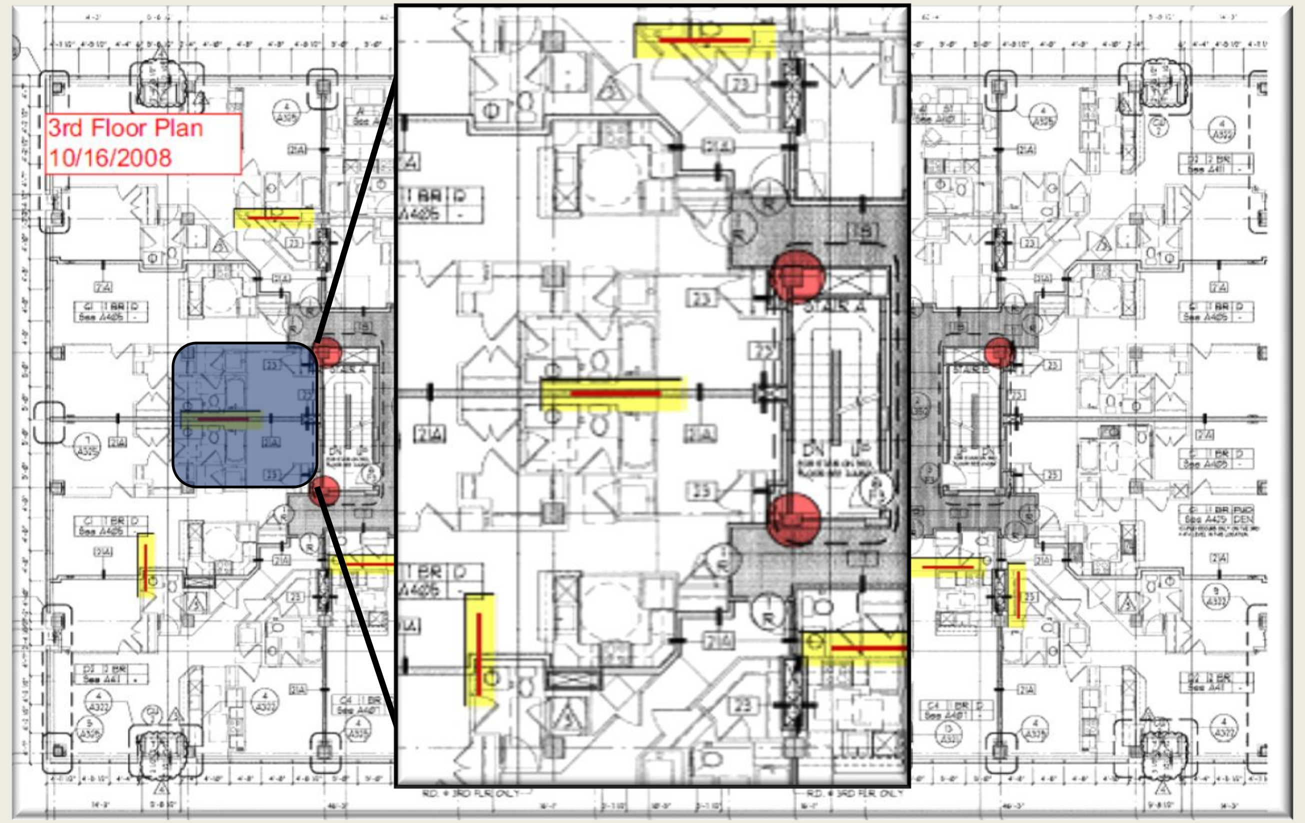
Consolidation of Slab Penetrations

- Preconstruction Structural Analysis
    - Look at single frame
    - Could be extended to entire slab
    - Uses direct design method to determine reinforcement requirements



Consolidation of Slab Penetrations

- Existing Use
  - 100 psf live load
  - 20’ x 20’ bays
  - 20” x 20” columns
  - 10” slab
  - 5000 psi concrete (125 psf dl)
  - #4 rebar



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Frame	Total Width (ft)	CS (ft)	MS (ft)	Total - Mom	CS (-M)	MS (-M)	Total + Mom	CS (+M)	MS (+M)
A	20	10	10	-182.34	-136.76	-45.59	135.45	81.27	54.18
B	10	5	5	-33.86	-33.86	0.00	67.73	40.64	27.09
				-91.17	-68.38	-22.79			
C	20	10	10	-182.34	-136.76	-45.59	135.45	81.27	54.18
D	10	5	5	-33.86	-33.86	0.00	67.73	40.64	27.09
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For Frame A Design Reinforcement For CS (Will Use #4 Bars)			
Item	Description	Span	
		M^-	M^+
1	M_u (ft-Kip)	-136.76	81.27
2	b (in)	100	100
3	d(in)	7.975	7.975
4	$M_n = M_u/0.9$ (ft-Kip)	-151.95	90.30185
5	$R = M_n/bd^2$	286.6957	170.3792
6	ρ [Table A.5a]	0.005	0.0028
7	Ast = ρbd (in^2)	3.9875	2.233
8	$A_{st,min} = 0.002bt$	2	2
9	N = #7 or #8 (Greater)/Abar	**19.9375**	**11.165**
10	Nmin = $width_{strip}/2t$	**6**	**6**
* # Bars used is greater value of 9 or 10			

For Frame A Design Reinforcement For MS (Will Use #4 Bars)			
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1	M_u (ft-Kip)	-45.59	54.18
2	b (in)	100	100
3	d(in)	7.975	7.975
4	$M_n = M_u/0.9$ (ft-Kip)	-50.6501	60.20123
5	$R = M_n/bd^2$	95.56524	113.5861
6	ρ [Table A.5a]	0.0016	0.0019
7	Ast = ρbd (in^2)	1.276	1.51525
8	$A_{st,min} = 0.002bt$	2	2
9	N = #7 or #8 (Greater)/Abar	**6.38**	**7.57625**
10	Nmin = $width_{strip}/2t$	**6**	**6**
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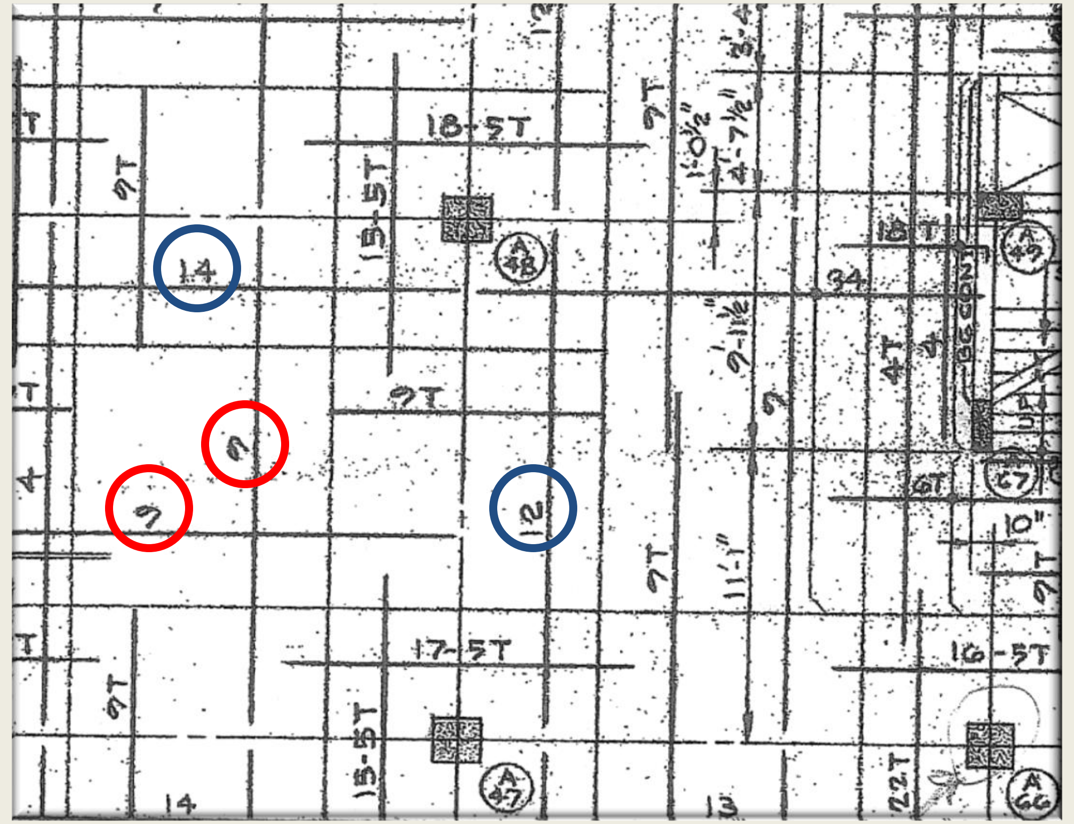
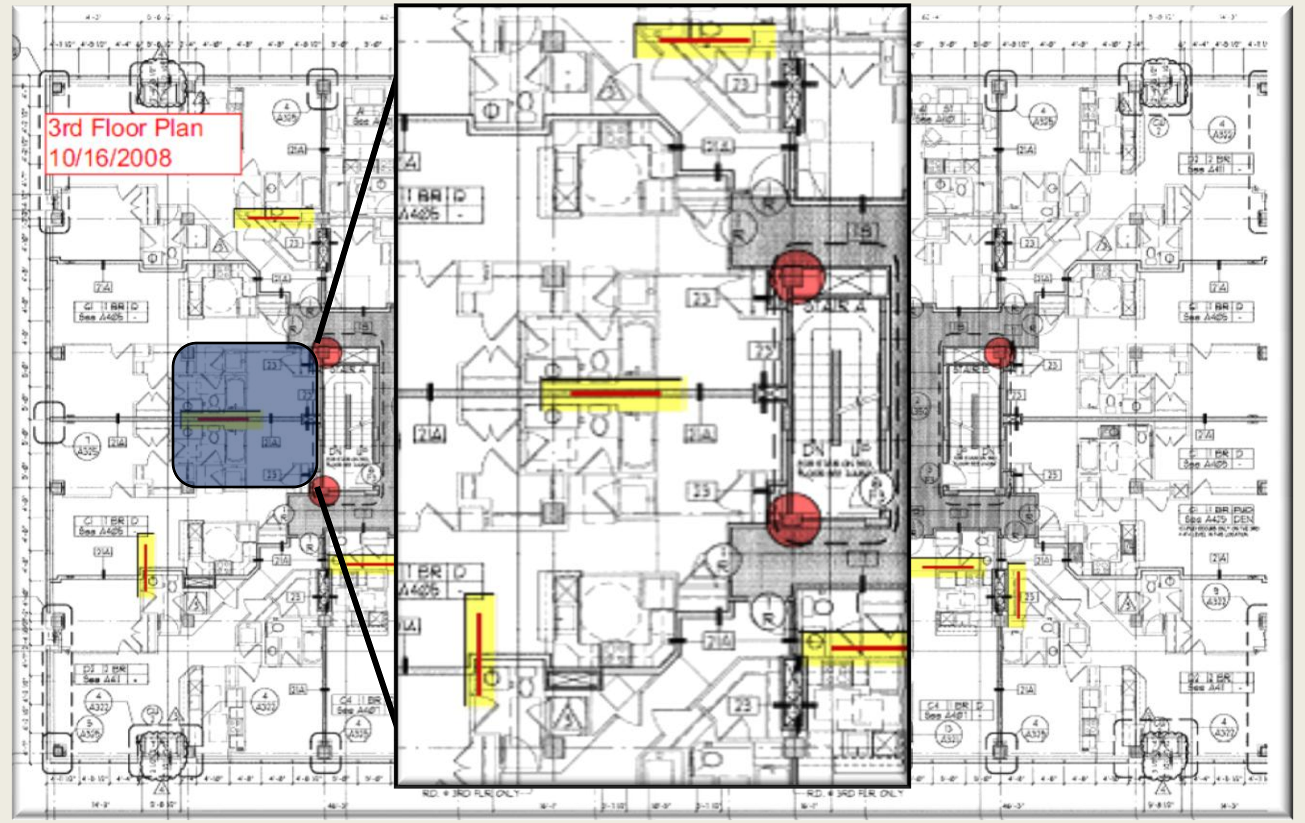


Consolidation of Slab Penetrations

- New Use
  - **40 psf live load, 10 psf dead load**
  - 20' x 20' bays
  - 20" x 20" columns
  - 10" slab
  - 5000 psi concrete (125 psf dl)
  - #4 rebar



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B	10	5	5	-24.69	-24.69	0.00	49.37	29.62	19.75
				-66.47	-49.85	-16.62			
C	20	10	10	-132.93	-99.70	-33.23	98.75	59.25	39.50
D	10	5	5	-24.69	-24.69	0.00	49.37	29.62	19.75
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1	M_u (ft-Kip)	-99.70	59.25
2	b (in)	100	100
3	d(in)	7.975	7.975
4	$M_n = M_u/0.9$ (ft-Kip)	-110.777	65.83296
5	$R = M_n/bd^2$	209.0104	124.2119
6	ρ [Table A.5a]	0.0036	0.0021
7	Ast = ρbd (in²)	2.871	1.67475
8	$A_{st,min}$ = 0.002bt	2	2
9	N = #7 or #8 (Greater)/Abar	**14.355**	**8.37375**
10	Nmin = $width_{strip}$/2t	6	6

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4	$M_n = M_u/0.9$ (ft-Kip)	-36.9255	43.88864
5	$R = M_n/bd^2$	69.67015	82.80794
6	ρ [Table A.5a]	0.0012	0.0014
7	Ast = ρbd (in²)	0.957	1.1165
8	$A_{st,min}$ = 0.002bt	2	2
9	N = #7 or #8 (Greater)/Abar	**4.785**	**5.5825**
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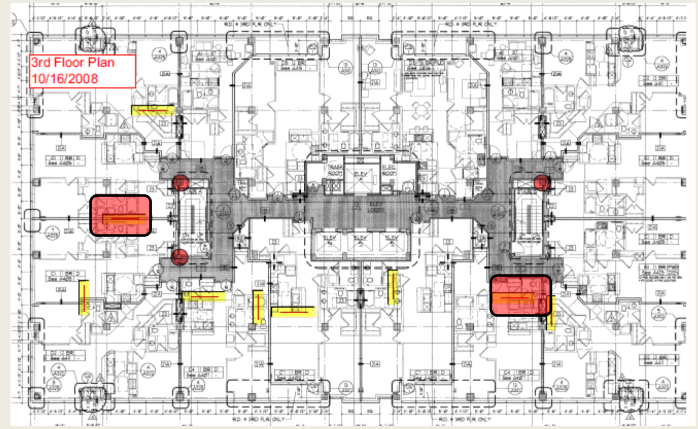
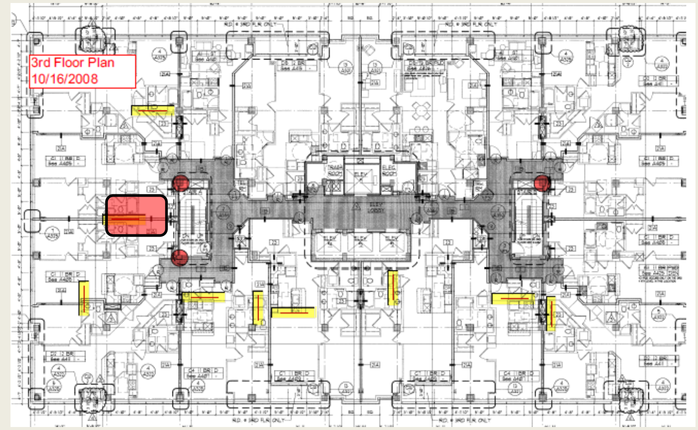
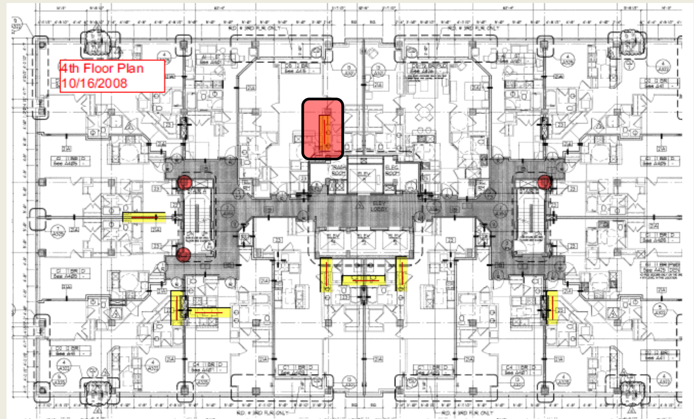
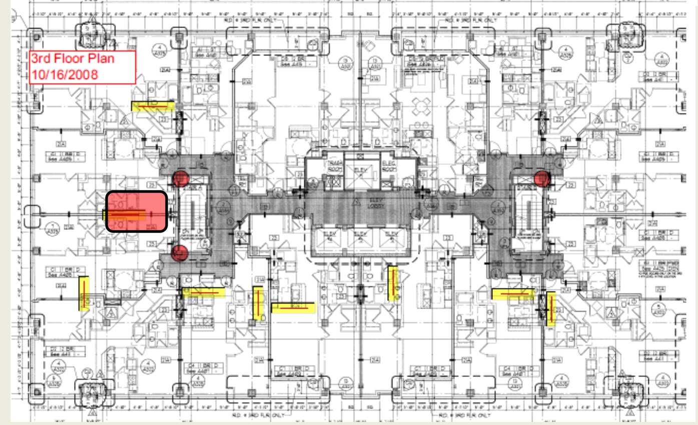
Frame Type	Direction	Strip	Bars Required Existing	Bars Required New	Bars from Existing Drawing	# Bars Removable	
						From Charts	From Drawing
A	NS	Column	20	15	12	5	-3
A	NS	Middle	8	6	9	2	3
C	EW	Column	20	15	14	5	-1
C	EW	Middle	8	6	9	2	3

Consolidation of Slab Penetrations









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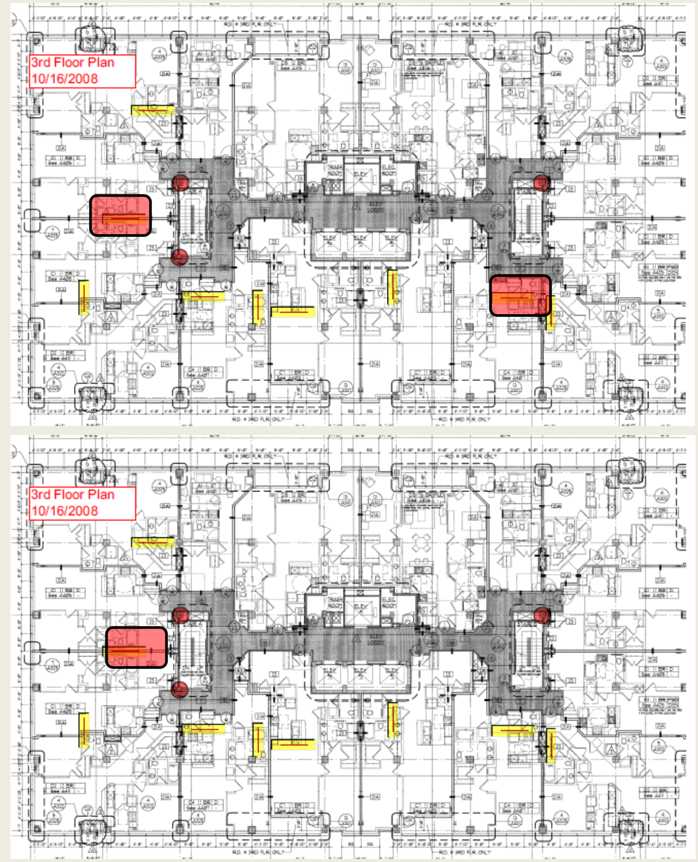

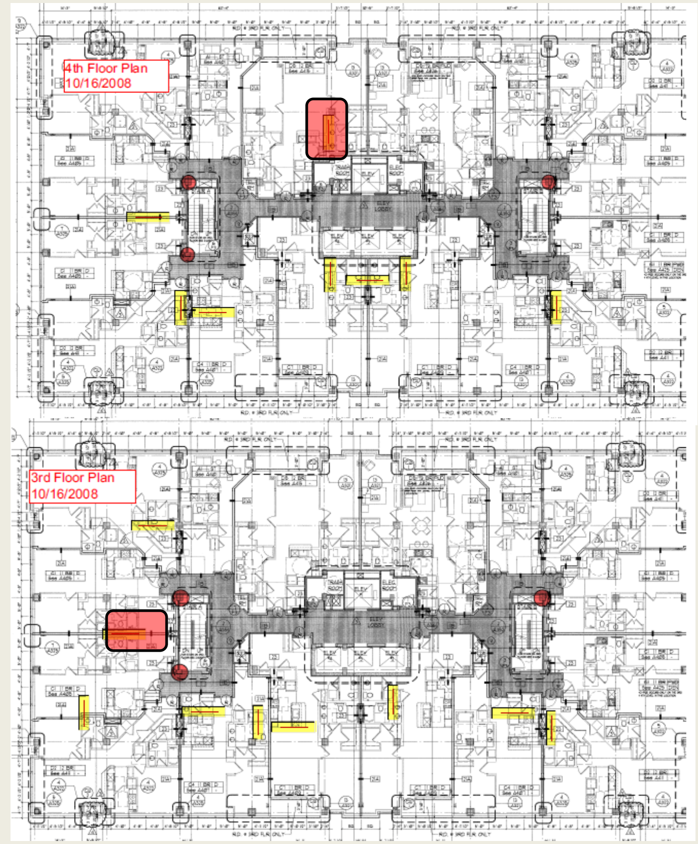

- Summary
  - Use preconstruction structural analysis to locate problematic areas
  - In marginal areas, consider minor redesign to lower reinforcing requirements
  - Reducing marginal areas
    - $3,000 material savings
  - Overall process understanding and utilizing knowledge of problem areas
    - Save about 5 weeks
    - Eliminate rework, save $55,000

Building Integrated Solar Energy Systems

Creating Sustainability in Crystal City

1. Crystal Plaza II Overview
2. Consolidation of Slab Penetrations
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- Background
  - Rising energy cost
  - Non typical façade
  - Building Integrated Photovoltaics (BIPV)

- Problem Statement
  - Use non typical façade to advantage
  - Offset energy needs through BIPV
  - Minimize schedule increase

- Goal
  - Develop a BIPV system that could be implemented to save energy demand required and provide a schematic for the required components.

Building Integrated Solar Energy Systems

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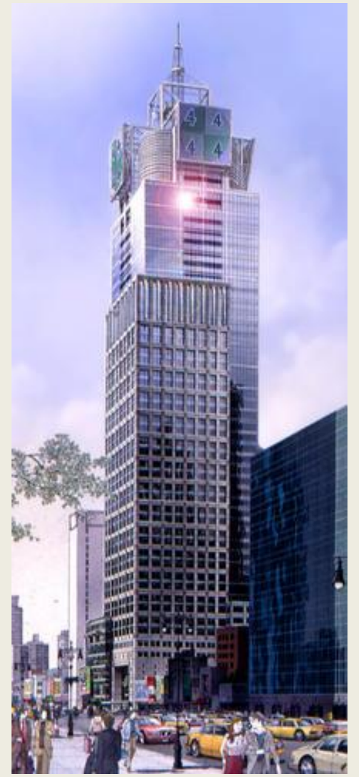
- ## Products and Design
    - BIPV
        - Integrated into building component, such as curtain wall or shingles
        - Typically thin film
            - Cheaper
            - Mass production
        - 3-5 W/sf production (WBDG)

- ## Case Studies
    - 4 Times Square, NYC
    - Solaire, NYC

Replaces spandrel panels
Located on upper floors
35kW system
Designed to provide 5%
Produces 24/7
Can power about 20 units
20kW system
Powers about 5 offices



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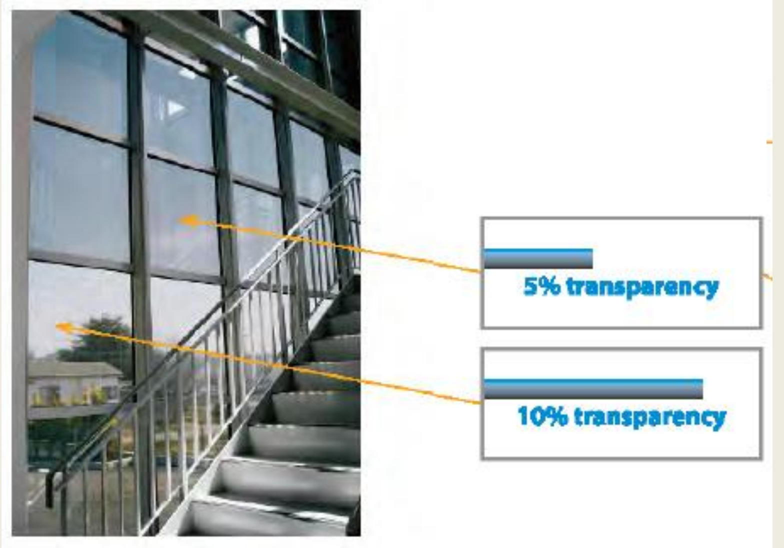
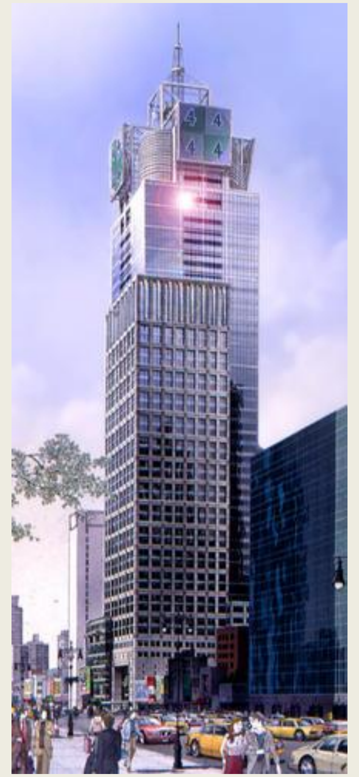
- Products and Design
    - Modeled after SeeThru system by SUNTECH
        - Various, custom sizes
        - Transparency 1-10%
        - Can easily match non-BIPV glazing
        - $8,500/installed kW



- Case Studies
    - 4 Times Square, NYC
    - Solaire, NYC

Replaces spandrel panels
33kW system
Designed to provide 5%
Can power about 20 units



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- Products and Design
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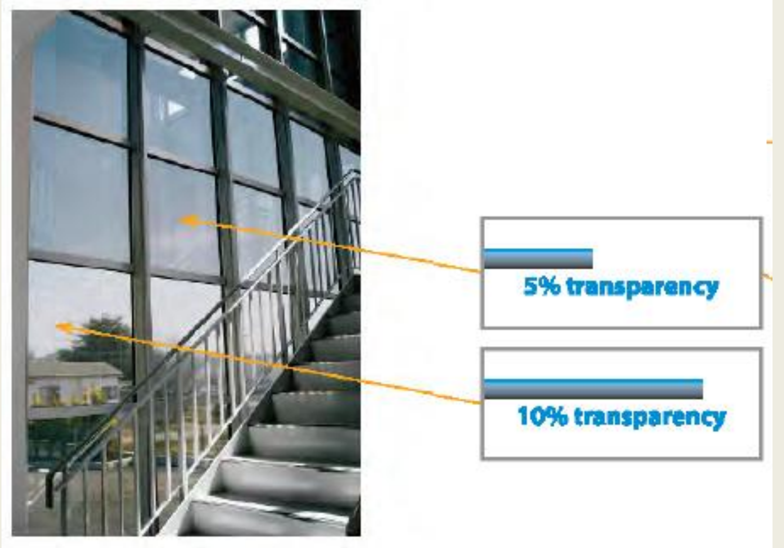
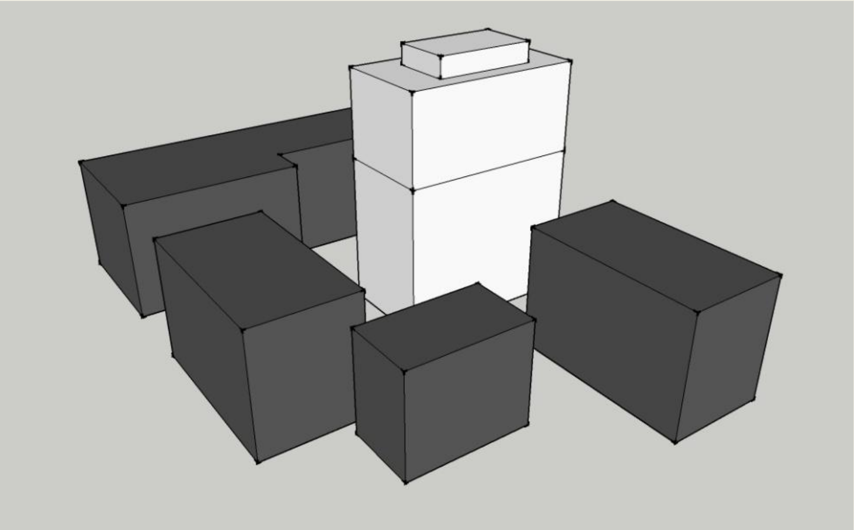


- Shadow Study
  - Uses Google SketchUp
  - No shading above 12th floor from surroundings
  - Even North façade receives sun



	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Service Charge	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862	$1,862
Dist Charge	$8,523	$7,699	$8,523	$8,248	$8,523	$8,248	$8,523	$8,523	$8,248	$8,523	$8,248	$8,523
Supply Charge	$21,667	$19,571	$21,667	$20,968	$21,667	$39,559	$40,878	$40,878	$39,559	$21,667	$20,968	$21,667
Total	$32,052	$29,132	$32,052	$31,079	$32,052	$49,669	$51,263	$51,263	$49,669	$32,052	$31,079	$32,052
Total/ unit	$120	$110	$120	$117	$120	$187	$193	$193	$187	$120	$117	$120

- Production Analysis
  - Dominion of Virginia Residential Schedule 1
  - 120/240V system demand of 1513 kW
  - Adjusted demand in 908 kW
  - Daily usage about 21,800 kWh
    - About 80 kWh/unit

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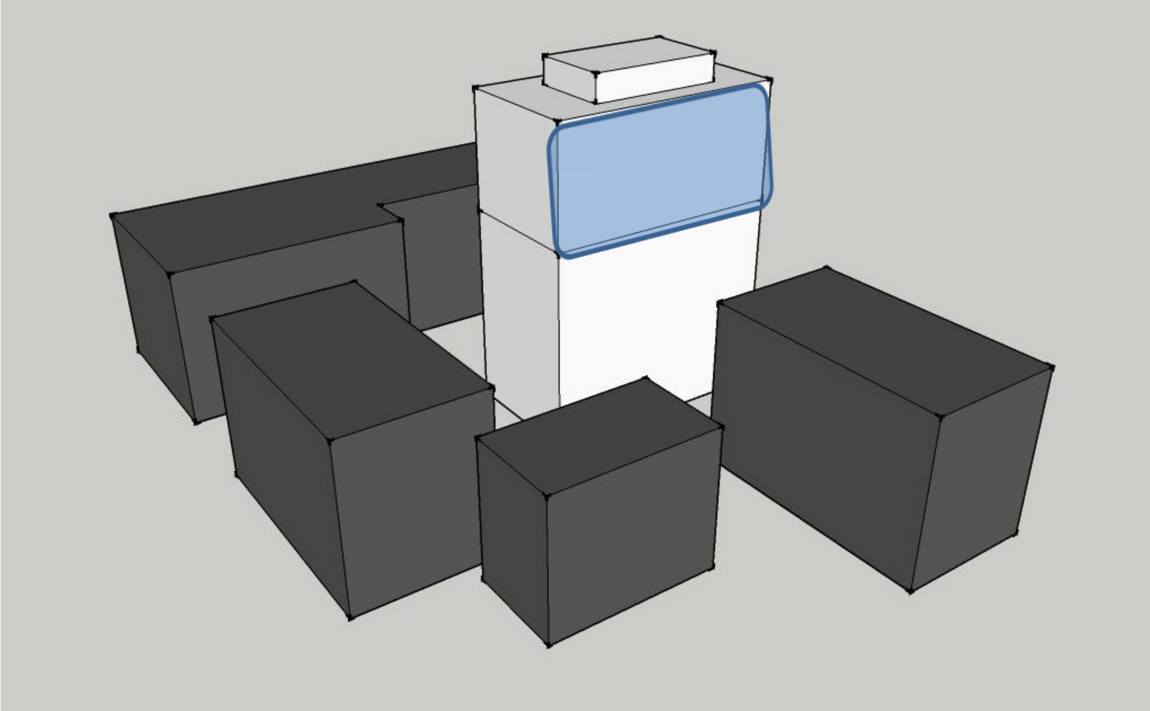
- South Façade Analysis



Location	Area (sq meters)	Area (sq feet)	Efficiency Material	Efficiency Orientation
South	1,655.38	17,818.51	7.0%	67.0%

South Façade													
	Sun Hours(kWh/m2/day)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr Avg
	3.4	3.7	3.5	3.1	2.6	2.5	2.6	2.9	3.3	3.7	3.3	3	3.13
Days	31	28	31	30	31	30	31	31	30	31	30	31	365
kWh/mon	8182.97	8043.23	8423.65	7220.27	6257.57	5822.80	6257.57	6979.60	7686.09	8905.00	7686.09	7220.27	7390.43
Monthly kWh	675,818.35	610,416.58	675,818.35	654,017.76	675,818.35	654,017.76	675,818.35	675,818.35	654,017.76	675,818.35	654,017.76	675,818.35	
Monthly kWh after Solar	667,635.38	602,373.35	667,394.70	646,797.49	669,560.78	648,194.96	669,560.78	668,838.76	646,331.67	666,913.35	646,331.67	668,598.08	7,868,530.97
Monthly Bill w/o solar	$32,052.02	$29,131.83	$32,052.02	$31,078.62	$32,052.02	$49,669.20	$51,263.04	$51,263.04	$49,669.20	$32,052.02	$31,078.62	$32,052.02	453413.63
Bill/unit	$120.50	$109.52	$120.50	$116.84	$120.50	$186.73	$192.72	$192.72	$186.73	$120.50	$116.84	$120.50	
Monthly Bill w/solar	$31,686.65	$28,772.70	$31,675.90	$30,756.24	$31,772.62	$49,243.49	$50,805.55	$50,752.76	$49,107.27	$31,654.41	$30,735.44	$31,729.63	448692.65
Bill/unit	$119.12	$108.17	$119.08	$115.62	$119.45	$185.13	$191.00	$190.80	$184.61	$119.00	$115.55	$119.28	
													Total
Savings	$365.37	$359.13	$376.12	$322.39	$279.40	$425.70	$457.49	$510.28	$561.93	$397.61	$343.18	$322.39	$4,720.98

Building Integrated Solar Energy Systems

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- South Façade Analysis

Size kW	Total kWh	Efficiency of Grid System	kWh/Year	Cost/kW Installed	Cost of System	Payback
89	88685.11	0.90	79,816	$8,500.00	$757,286	160.41

Total yearly savings of $4,720 (79,800 kWh at $0.06/kWh)

Location	Area (sq meters)	Area (sq feet)	Efficiency Material	Efficiency Orientation
South	1,655.38	17,818.51	7.0%	67.0%

South Façade													
	Sun Hours(kWh/m2/day)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr Avg
	3.4	3.7	3.5	3.1	2.6	2.5	2.6	2.9	3.3	3.7	3.3	3	3.13
days	31	28	31	30	31	30	31	31	30	31	30	31	365
kWh/mon	8182.97	8043.23	8423.65	7220.27	6257.57	5822.80	6257.57	6979.60	7686.09	8905.00	7686.09	7220.27	7390.43
Monthly kWh	675,818.35	610,416.58	675,818.35	654,017.76	675,818.35	654,017.76	675,818.35	675,818.35	654,017.76	675,818.35	654,017.76	675,818.35	
Monthly kWh after Solar	667,635.38	602,373.35	667,394.70	646,797.49	669,560.78	648,194.96	669,560.78	668,838.76	646,331.67	666,913.35	646,331.67	668,598.08	7,868,530.97
Monthly Bill w/o solar	$32,052.02	$29,131.83	$32,052.02	$31,078.62	$32,052.02	$49,669.20	$51,263.04	$51,263.04	$49,669.20	$32,052.02	$31,078.62	$32,052.02	453413.63
Bill/unit	$120.50	$109.52	$120.50	$116.84	$120.50	$186.73	$192.72	$192.72	$186.73	$120.50	$116.84	$120.50	
Monthly Bill w/solar	$31,686.65	$28,772.70	$31,675.90	$30,756.24	$31,772.62	$49,243.49	$50,805.55	$50,752.76	$49,107.27	$31,654.41	$30,735.44	$31,729.63	448692.65
Bill/unit	$119.12	$108.17	$119.08	$115.62	$119.45	$185.13	$191.00	$190.80	$184.61	$119.00	$115.55	$119.28	
													Total
Savings	$365.37	$359.13	$376.12	$322.39	$279.40	$425.70	$457.49	$510.28	$561.93	$397.61	$343.18	$322.39	$4,720.98

Presentation Outline

Building Integrated Solar Energy Systems

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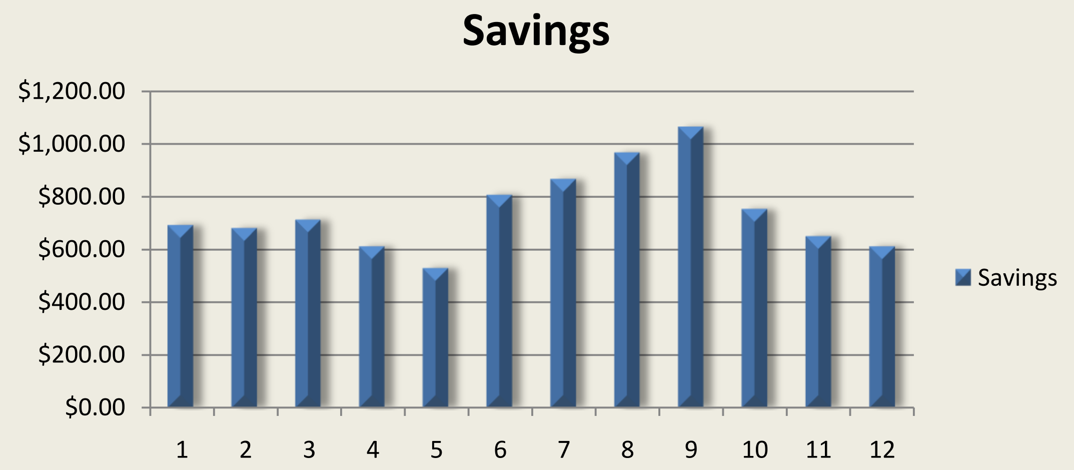
- South, East, & West Façade Analysis

Size kW	Total kWh	Efficiency of Grid System	kWh/Year	Cost/kW Installed	Cost of System	Payback
89	88685.11	0.90	79,816	$8,500.00	$757,286	
50	39324.42	0.90	35,391	$8,500.00	$424,493	
50	39324.42	0.90	35,391	$8,500.00	$424,493	
				Total	$1,606,273	180.32

Location	Area (sq meters)	Area (sq feet)	Efficiency Material	Efficiency Orientation
South	1,655.38	17,818.51	7.0%	67.0%
East	927.92	9,988.08	7.0%	53.0%
West	927.92	9,988.08	7.0%	53.0%



Total yearly savings of $9,000
(150,600 kWh at $0.06/kWh)

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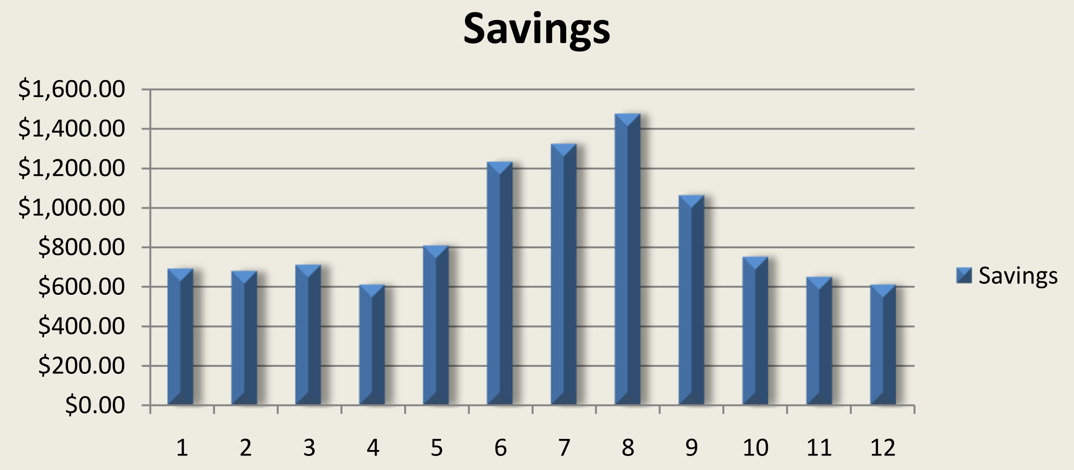
- All Façades Analysis

Size kW	Total kWh	Efficiency of Grid System	kWh/Year	Cost/kW Installed	Cost of System	Payback
89	88685.11	0.90	79,816	$8,500.00	$757,286	
50	39324.42	0.90	35,391	$8,500.00	$424,493	
50	39324.42	0.90	35,391	$8,500.00	$424,493	
89	25,317.53	0.90	22,785	$8,500.00	$757,286	
				Total	$2,363,559	223.39

Location	Area (sq meters)	Area (sq feet)	Efficiency Material	Efficiency Orientation
South	1,655.38	17,818.51	7.0%	67.0%
East	927.92	9,988.08	7.0%	53.0%
West	927.92	9,988.08	7.0%	53.0%
North	1,655.38	17,818.51	7.0%	25.0%



Total yearly savings of $10,380
(173,000 kWh at $0.06/kWh)

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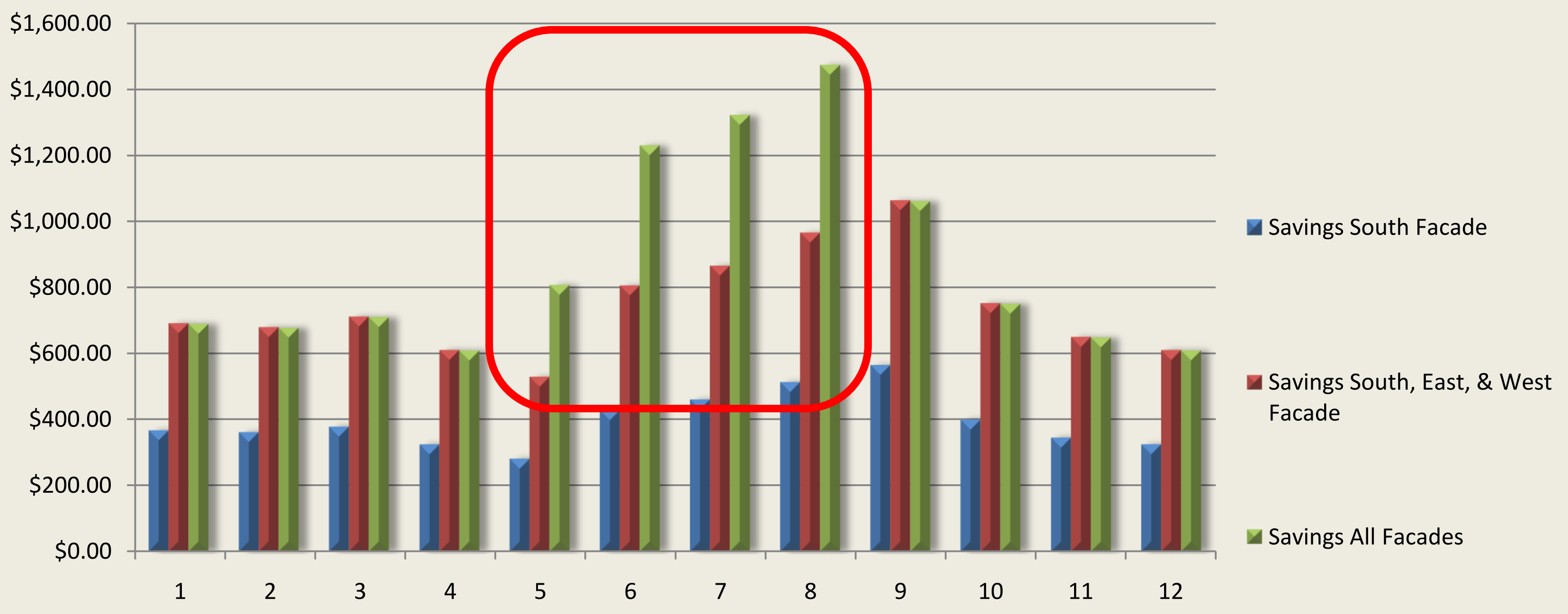

Total yearly savings of $10,380
(173,000 kWh at $0.06/kWh)

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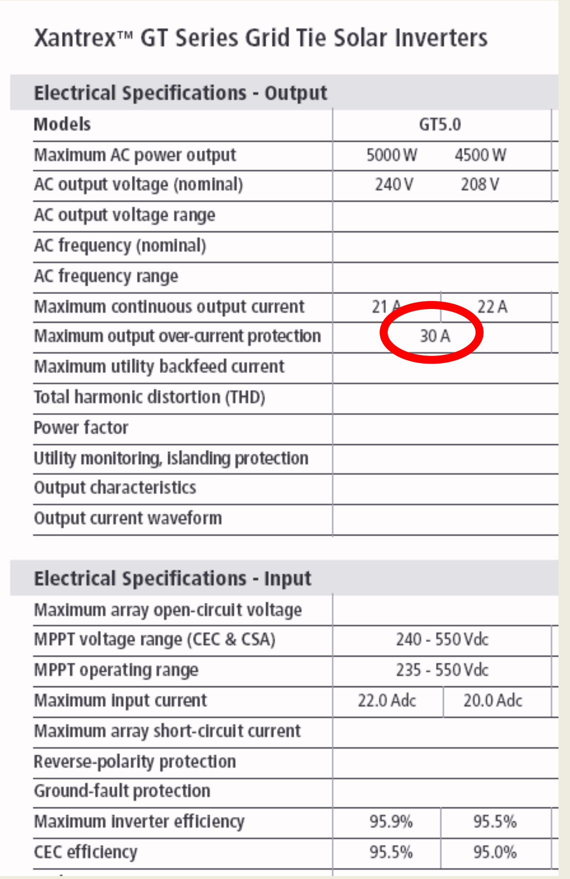
- Inverter
  - Panel
    - 40 sf, produces about 200 W
    - 60 V_{oc}
    - South façade, single floor
      - 1,320 V_{oc} (60 V_{oc} x 22 panels)
  - Inverter
    - Xantrex GT5.0
    - Max V_{oc} of 600 V
    - Need 3 inverters per floor
    - 27 overall for south façade

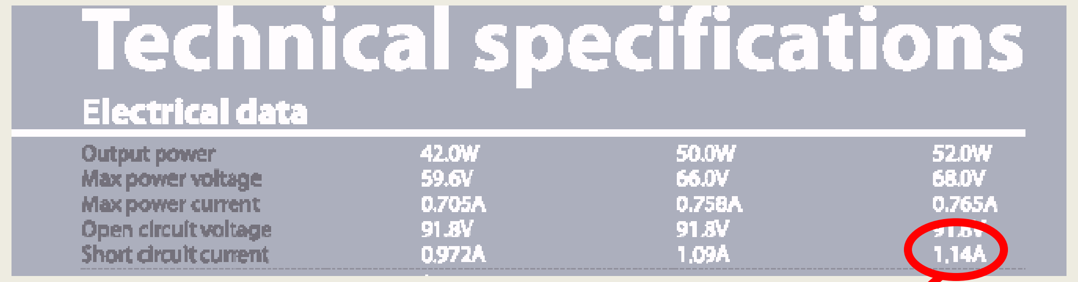


Xantrex™ GT Series Grid Tie Solar Inverters

Electrical Specifications - Output		
Models	GT5.0	
Maximum AC power output	5000 W	4500 W
AC output voltage (nominal)	240 V	208 V
AC output voltage range		
AC frequency (nominal)		
AC frequency range		
Maximum continuous output current	21 A	22 A
Maximum output over-current protection	30 A	
Maximum utility backfeed current		
Total harmonic distortion (THD)		
Power factor		
Utility monitoring, islanding protection		
Output characteristics		
Output current waveform		

Electrical Specifications - Input		
Maximum array open-circuit voltage		
MPPT voltage range (CEC & CSA)	240 - 550 Vdc	
MPPT operating range	235 - 550 Vdc	
Maximum input current	22.0 Adc	20.0 Adc
Maximum array short-circuit current		
Reverse-polarity protection		
Ground-fault protection		
Maximum inverter efficiency	95.9%	95.5%
CEC efficiency	95.5%	95.0%

- Wire
  - NEC
  - Panel to Inverter
    - AWG 14
  - Inverter to Controller
    - AWG 10
  - Controller to Electrical Panel
    - AWG 3



Technical specifications

Electrical data

Output power	42.0W	50.0W	52.0W
Max power voltage	59.6V	66.0V	68.0V
Max power current	0.705A	0.758A	0.765A
Open circuit voltage	91.8V	91.8V	[illegible]
Short circuit current	0.972A	1.09A	1.14A

Inverter	Short Circuit Amp PV	# of Panels in Series	Total Amp
1	1.14	7	7.98
2	1.14	7	7.98
3	1.14	8	9.12

Building Integrated Solar Energy Systems

- Summary
    - Generating capabilities
    - Best scenario is South, East, and West facades
    - Large capital cost
    - Long payback
    - Not feasible without rebates, incentives, and tax credits

Peak Demand Shift and Demand Response

- Background
  - Rising energy cost
  - Efficient systems
  - Utilization of generation equipment
- Problem
  - Energy peaks, costly
  - Better use of generation equipment
- Goal
  - Identify local programs for demand response
  - Evaluate use of generator to shave demand

Presentation Outline

Peak Demand Shift and Demand Response

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4. **Peak Demand Shift and Demand Response Programs**
   - Background, local programs, generator use, results
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- Peak Demand Shift
  - Use 450 kW emergency generator
  - More interaction from owner with utility
  - Use installed equipment, avoid additional costs
  - Use during peak times, 6-9 am and 4-7 pm
    - Heavy elevator and mechanical use

		Fuel Use (gal/hr)			Cost/hr		Runtime till empty (hr)	
Power	kW	Standby	Prime	Fuel Cost/gal*	Standby	Prime	Standby	Prime
100%	450	35	32	3.76	$130.10	$121.45	16.24	17.40
75%	337.5	26	24	3.76	$99.26	$91.37	21.29	23.13
50%	225	18	16	3.76	$68.43	$61.66	30.88	34.27
25%	112.5	9	8	3.76	$34.22	$30.83	61.76	68.54

*average from Jan 08-Jan 09

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Equipment Name	Type	Service	Phase	V	A	HP	kW	% used/hr	hours used	kW/hr	kWh
P-5	vertical inline pump	HP Loop	3	480	155.00	125	103.09	100%	5	103.09	515.46
RTU-1	RTU		3	480	71.40		47.49	60%	5	28.49	142.47
RTU-2	RTU		3	480	71.40		47.49	60%	5	28.49	142.47
RTU-3	RTU		3	480	71.40		47.49	60%	5	28.49	142.47
RTU-4	RTU		3	480	71.40		47.49	60%	5	28.49	142.47
CT-1	cooling tower fan	cooling tower	3	480	56.07	50	37.29	50%	5	18.65	93.23
CT-2	cooling tower fan	cooling tower	3	480	56.07	50	37.29	50%	5	18.65	93.23
P-3	Double Suction	cooling tower	3	480	52.00	40	34.59	50%	5	17.29	86.46
P-1	vertical inline pump	cooling tower	3	480	40.00	30	26.60	50%	5	13.30	66.51
Elevator 1			3	480	29.00	26	19.29	90%	5	17.36	86.80
Elevator 2			3	480	29.00	26	19.29	90%	5	17.36	86.80
Elevator 3			3	480	29.00	26	19.29	90%	5	17.36	86.80
RTU-5	RTU		3	480	17.60		11.71	60%	5	7.02	35.12

		Fuel Use (gal/hr)			Cost/hr		Runtime till empty (hr)	
Power	kW	Standby	Prime	Fuel Cost/gal*	Standby	Prime	Standby	Prime
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Distribution Service Charge		
cost per kw	*kw*	*cost*
1	1830	$1,830.00
Basic Customer Charge		$127.60
Supply Service Charges		
On Peak Supply Demand Charge		
cost per kw	*kw*	*cost*
12.003	1098	$13,179.29
11.715	1098	$12,863.07
Off Peak Supply Demand Charges		
0.632	1098	$693.94
Supply Adjustment Demand Charge		
0.421	1830	$770.43
On peak kWh		
0.404	428220	$173,000.88
Off peak kWh		
0.272	362340	$98,556.48
Total		$301,021.69

		Fuel Use (gal/hr)			Cost/hr		Runtime till empty (hr)	
Power	**kW**	**Standby**	**Prime**	**Fuel Cost/gal***	**Standby**	**Prime**	**Standby**	**Prime**
100%	450	35	32	3.76	$130.10	$121.45	16.24	17.40
75%	337.5	26	24	3.76	$99.26	$91.37	21.29	23.13
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Distribution Service Charge		
cost per kw	*kw*	*cost*
1	1830	$1,830.00
Basic Customer Charge		$127.60
Supply Service Charges		
On Peak Supply Demand Charge		
cost per kw	*kw*	*cost*
12.003	1098	$13,179.29
11.715	1098	$12,863.07
Off Peak Supply Demand Charges		
0.632	1098	$693.94
Supply Adjustment Demand Charge		
0.421	1830	$770.43
On peak kWh		
0.404	428220	$173,000.88
Off peak kWh		
0.272	362340	$98,556.48
Total		$301,021.69

Distribution Service Charge			Difference
cost per kw	*kw*	*cost*	
1	1430	$1,430.00	***$400.00***
Basic Customer Charge		$127.60	
Supply Service Charges			
On Peak Supply Demand Charge			
cost per kw	*kw*	*cost*	
12.003	698	$8,378.09	***$4,801.20***
11.715	698	$8,177.07	***$4,686.00***
Off Peak Supply Demand Charges			
0.632	858	$542.26	***$151.68***
Supply Adjustment Demand Charge			
0.421	1430	$602.03	***$168.40***
On peak kWh			
0.404	371865.56	$150,233.69	***$22,767.19***
Off peak kWh			
0.272	362340.00	$98,556.48	
Total		$268,047.22	***$32,974.47***

Total	$32,974.47
Fuel Cost	$17,295.00
Savings	**$15,679.47**

Peak Demand Shift and Demand Response

- Summary
  - Suggest demand response due to net metering issues
  - Evaluate on small scale, mandatory vs. volunteer
  - Saving on demand creates large savings
  - Not most sustainable way to curtail loads

Financing Projects through Energy Savings

- Background
  - Financing projects is hard, especially in today's economy
  - Use savings to help finance
    - Performance contractors
    - Guaranteed savings
    - Unique marketing approach to owner?
  - Rebates, Incentives, and Tax Credits
  - Critical Issue

- Problem Statement
  - Availability of programs to assist in sustainable and energy saving endeavors
  - Move towards renovations for facility savings

- Goal
  - Evaluate programs for application to Crystal Plaza II, especially in the areas of previous analyses, and show how these systems can create a unique marketing tool to assist in financing.

Presentation Outline

Creating Sustainability in Crystal City

Financing Projects through Energy Savings

- Programs
    - Arlington County Green Building Incentive Program
        - Based on USGBC's LEED ratings
        - Grants density and height bonuses
            - 0.15 increase for Certified
            - 0.25 increase for Silver
            - 0.35 increase for Gold/Platinum
        - Green Building Fund created for education of developers
            - $0.03/sf mandatory contribution for non-LEED buildings
        - Application at Crystal Plaza II
            - Saves $9,750 from contribution, no effect of FAR
    - TVA Green Power Switch Generation Partners
        - Limited to TVA service area
        - Green energy produced by participant is bought by TVA and used in their green pricing program for customers
        - $0.20/kWh compensation on 10 year contract
        - Application at Crystal Plaza II
            - Not applicable, outside service area
            - Suggest program to local utility and negotiate rate/contract

Financing Projects through Energy Savings

Creating Sustainability in Crystal City

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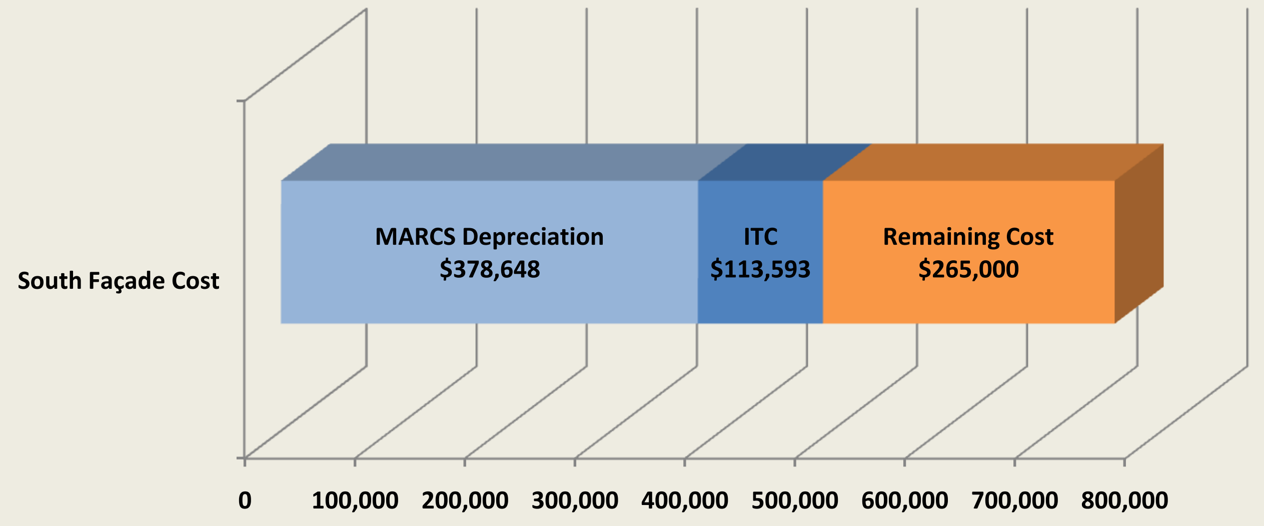
4. Peak Demand Shift and Demand Response Programs
5. **Financing Projects through Energy Savings**
   - Goals, incentives/rebates
6. Conclusion and Questions

- Application
  - South Façade BIPV- $757,286



- Modified Accelerated Cost Recovery System (MARCS)
  - Allows for solar to depreciate over 5 years
  - Bonus of 50% depreciation as part of Economic Stimulus Act in Feb 2008
- Business Energy Investment Tax Credit (ITC)
  - Tax credit for 30% of solar, with no limit

Financing Projects through Energy Savings

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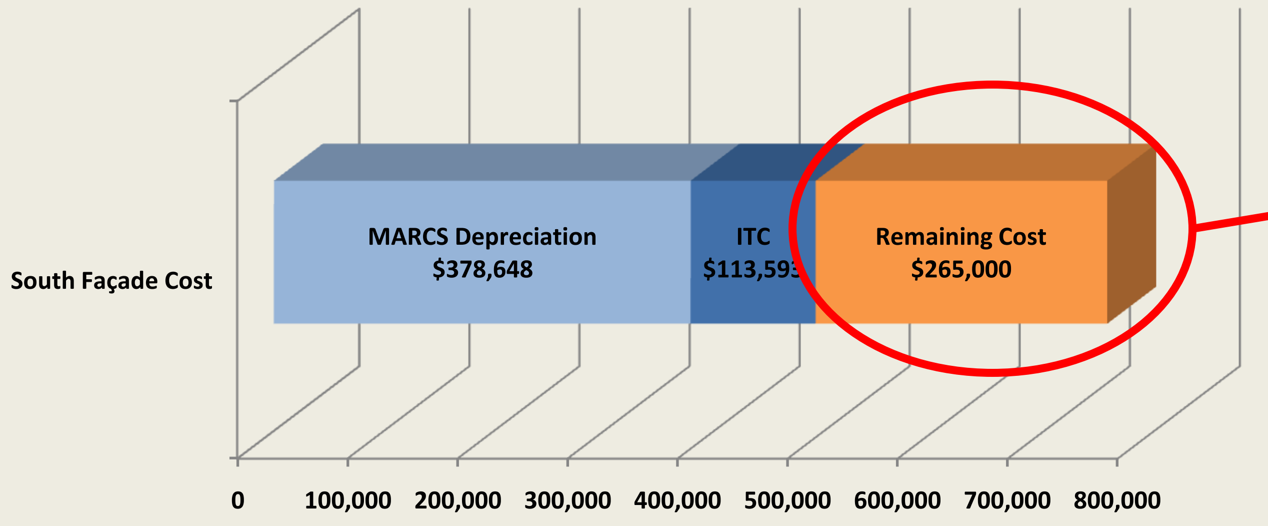
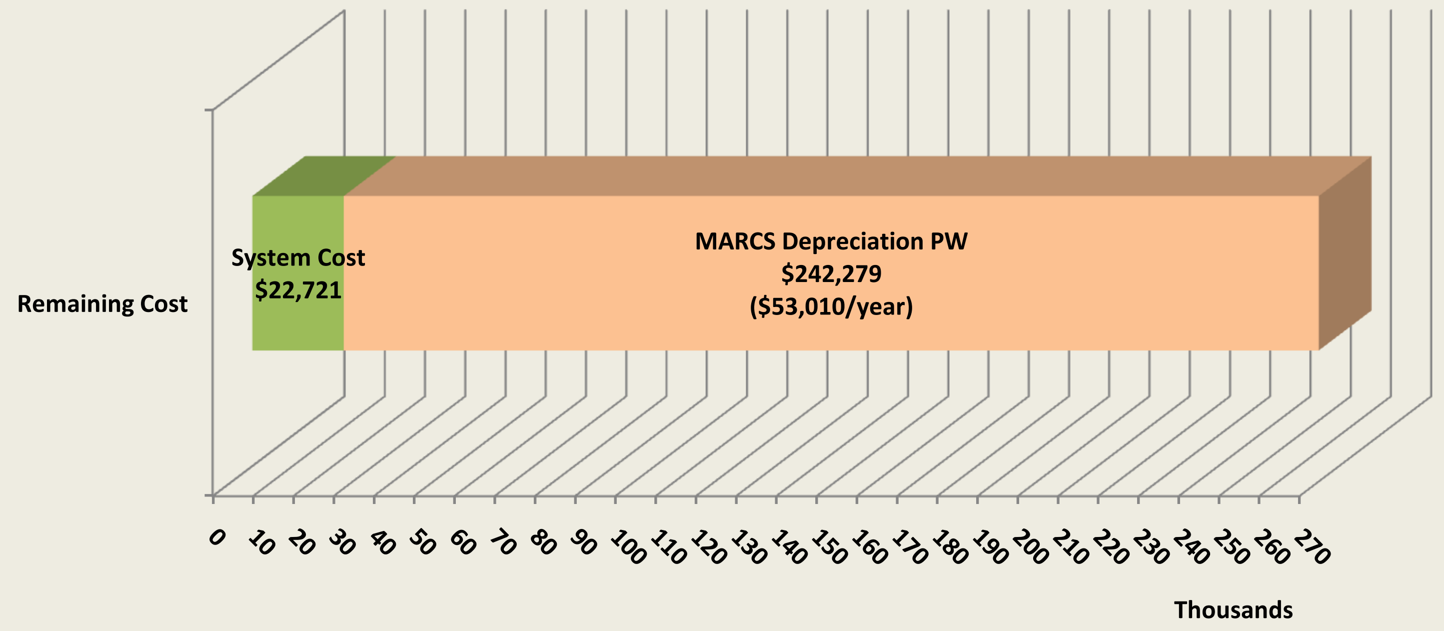
- ## Application
  - South Façade BIPV- $757,286





- Payback period using only energy savings is 4.72 years

Financing Projects through Energy Savings

- Application

- Crystal Plaza II, $70,000,000 on 20 year loan at 6.5%
  - $6,352,950/year or $529,412/month
- Use energy savings to help finance
  - Demand response- $8,000
  - Net metering "green" power- $16,000 (assuming TVA program)
  - Demand shave- $180,000
  - Total- $204,000
- Now, $6,148,950/year or $512,413 (basic analysis)
  - PW analysis shows savings of $3,035,000 over life of loan at 3% inflation rate
  - Saves 4.34% on loan

Presentation Outline

Creating Sustainability in Crystal City

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   - Goals, incentives/rebates
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Financing Projects through Energy Savings

- Summary
  - Using incentives, rebates, and tax credits BIPV becomes feasible
  - Basic analysis shows a savings of about 4% on loan
    - Market strategy to owner?
    - Higher returns with efficient systems or more programs
  - Owner had interest in "bundled" packages that included rebates, incentives, and credits that could help bottom line and use green/sustainable measures

- Crystal Plaza II, $70,000,000 on 20 year loan at 6.5%
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- Use energy savings to help finance
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Presentation Outline

Creating Sustainability in Crystal City

Conclusions and Questions

- Summary
  - Consolidation of Slab Penetrations
    - Use structural analysis tool to locate problematic and marginal areas
    - Savings in rework of $55,000, and over $3,000 in material
  - Building Integrated Solar Energy System
    - Best case scenario is South, East, and West facades
    - Feasible with rebates, incentives, and tax credits
  - Peak Demand Shift and Demand Response
    - Demand response better program to start with
    - Peak demand shift has higher return, but is not as sustainable

- Acknowledgements

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Richard Smith

Others
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Arif Mahmood, TCE
Tim Tarr, GHT
Andy Lau, Penn State University
Dr. David Riley, Penn State University
PACE Industry Members
Joseph Wilcher
Marissa Gesell

- Questions?

Crystal Plaza II Overview

Creating Sustainability in Crystal City

1. **Crystal Plaza II Overview**
   - Project background, challenges, site, and team
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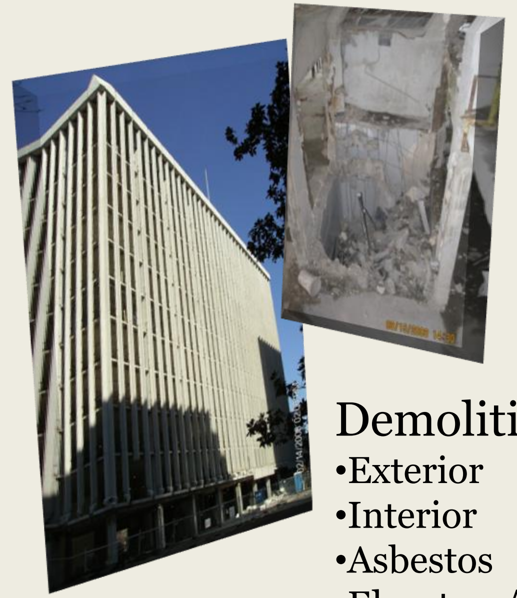
Project Details



Demolition
- Exterior
- Interior
- Asbestos
- Elevators/Stairs

Cast in Place Concrete
- Post tensioned
- Crane and Bucket
- 200 CY/pour, ~5 day floor cycle
- Two mixes

Electrical
- 19 meter centers
- Bus duct
- 1514 kW demand 120/208V
- 1831 kW demand 277/480V

Mechanical
- 4 RTU for fresh air
- Individual Water source heat pumps
- (2) 400 t cooling towers
- (4) Natural gas fired boilers

Curtain Wall
- Unitized
- Low-e glass
- Large risk

Crystal Plaza II Overview

Creating Sustainability in Crystal City

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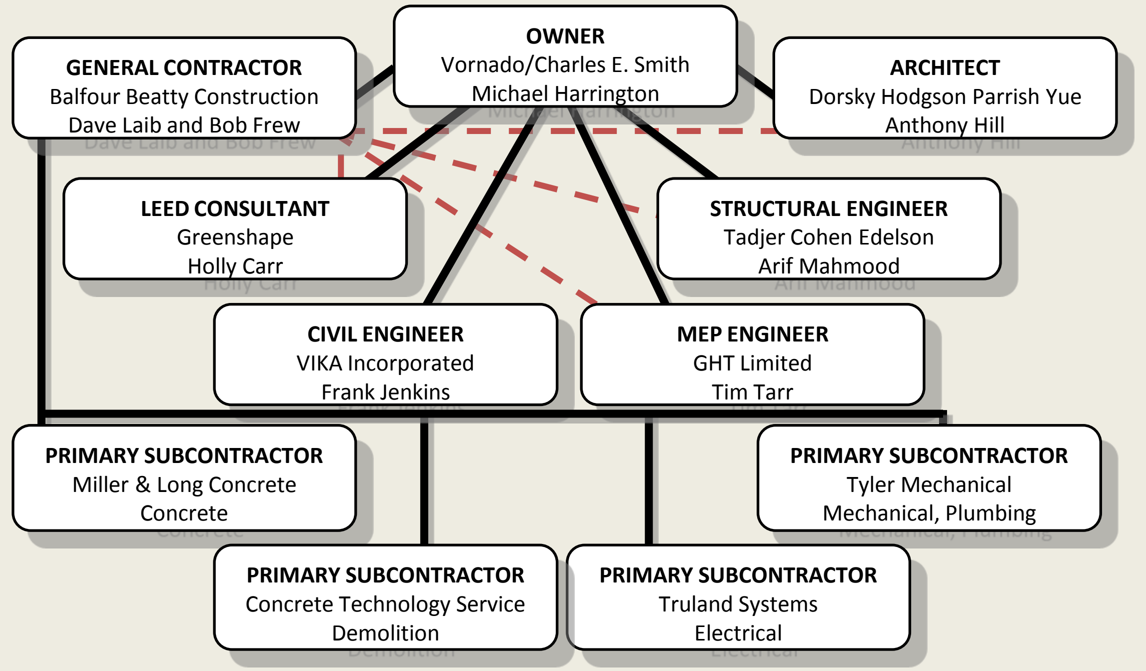
Owner/Delivery System



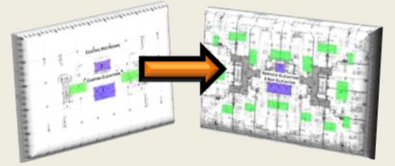
Negoiated GMP
$67 million for construction
Preconstruction Services
Balfour Beatty as GC

Constructability Challenges

- Renovation

- Required Delivery

- Reconfiguration



- Residential Curtain Wall

Creating Sustainability in Crystal City

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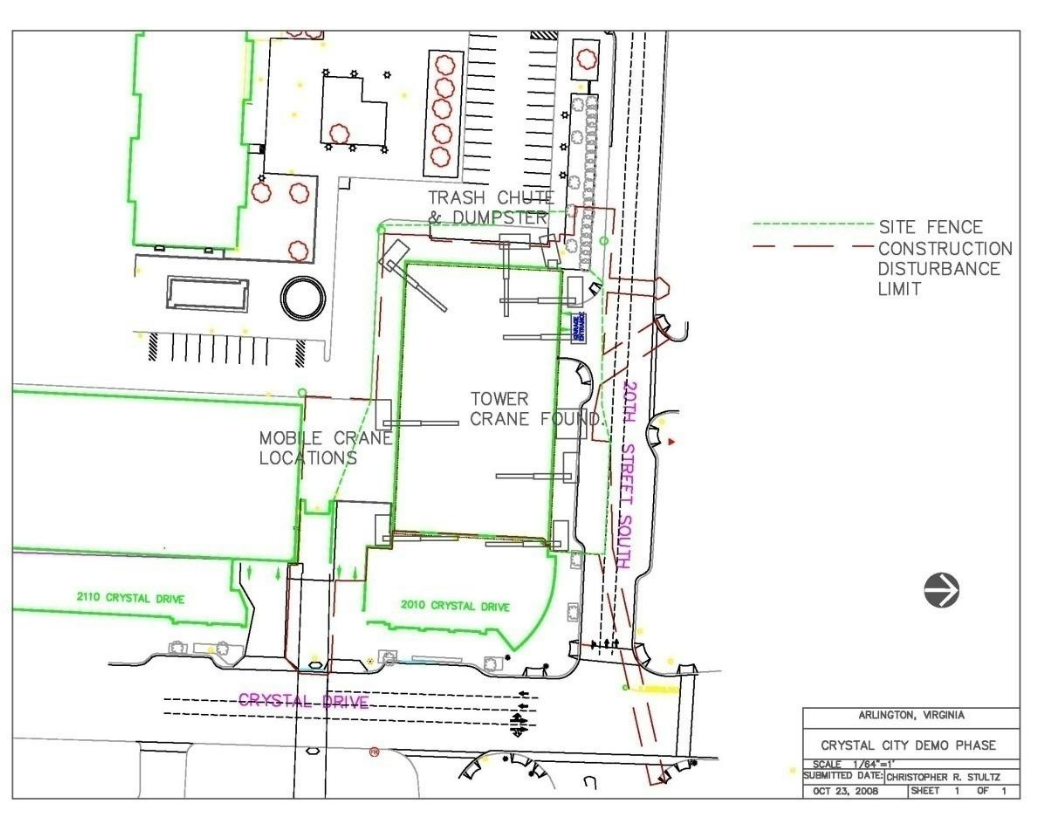

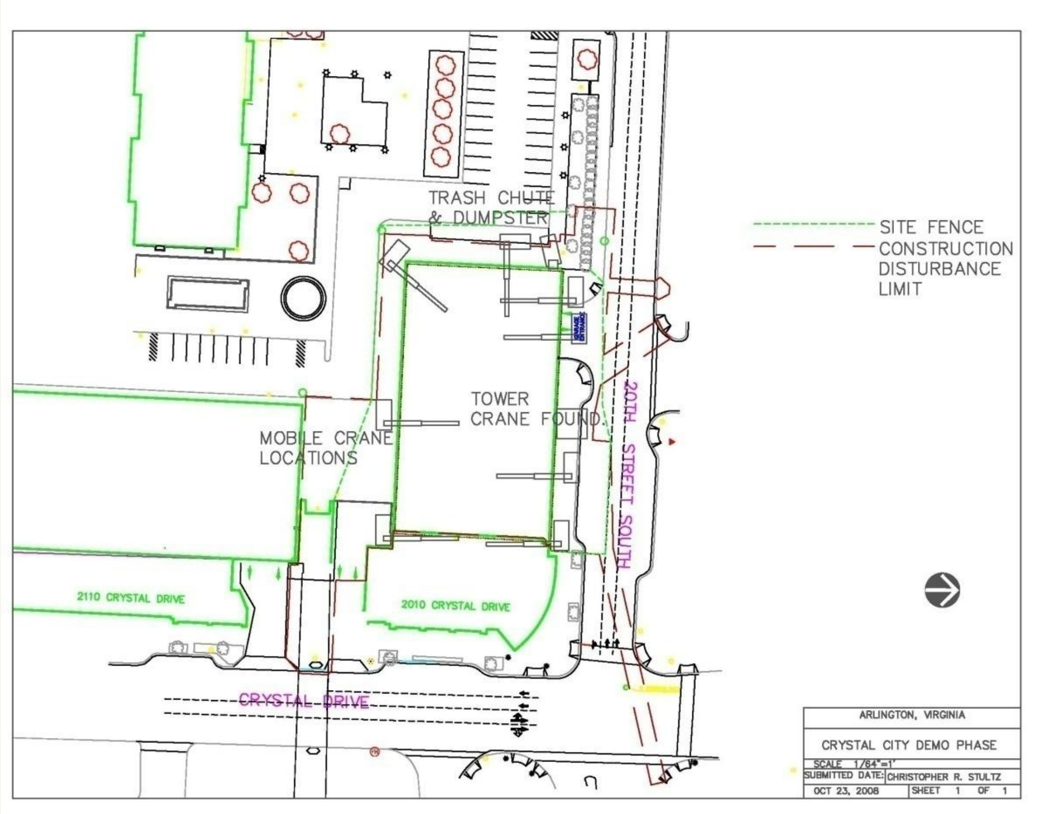

Presentation Outline

Creating Sustainability in Crystal City

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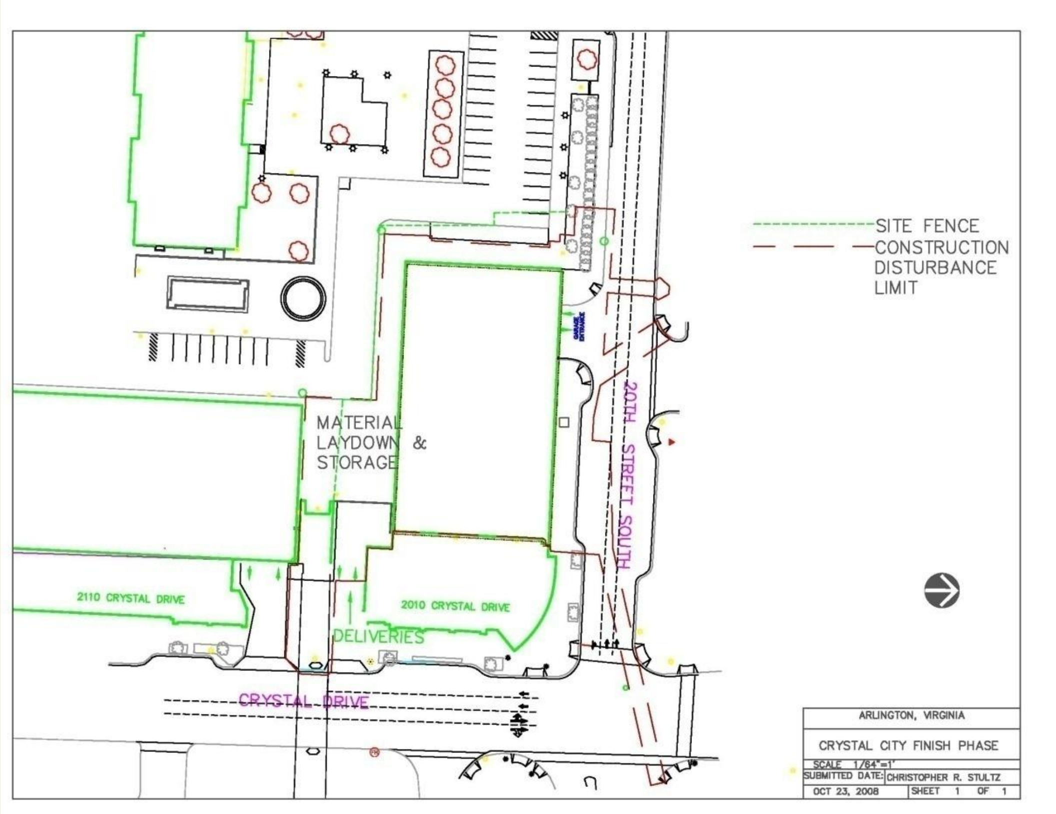
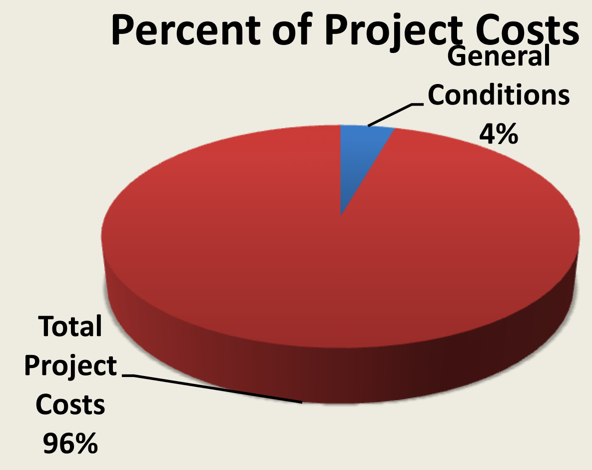


Presentation Outline

- Cost
- The following is a breakdown of specific building systems in the Crystal Plaza II project. Each category is representative of a specification division and other items from varying divisions have been included as noted.
  - Mechanical System Cost: $13 Million
  - Mechanical System Cost/SF: $40/SF
  - Electrical System Cost: $7.5 Million
  - Electrical System Cost/SF: $23.08/SF
  - Structural System Cost (Concrete only): $4.1 Million
  - Structural System Cost/SF: $12.62/SF
  - Curtain Wall System (As part of Doors/Windows): $11.2 Million
  - Curtain Wall System Cost/SF: $34.46/SF

- General Conditions
  - **Grand Total** $3,095,115.25



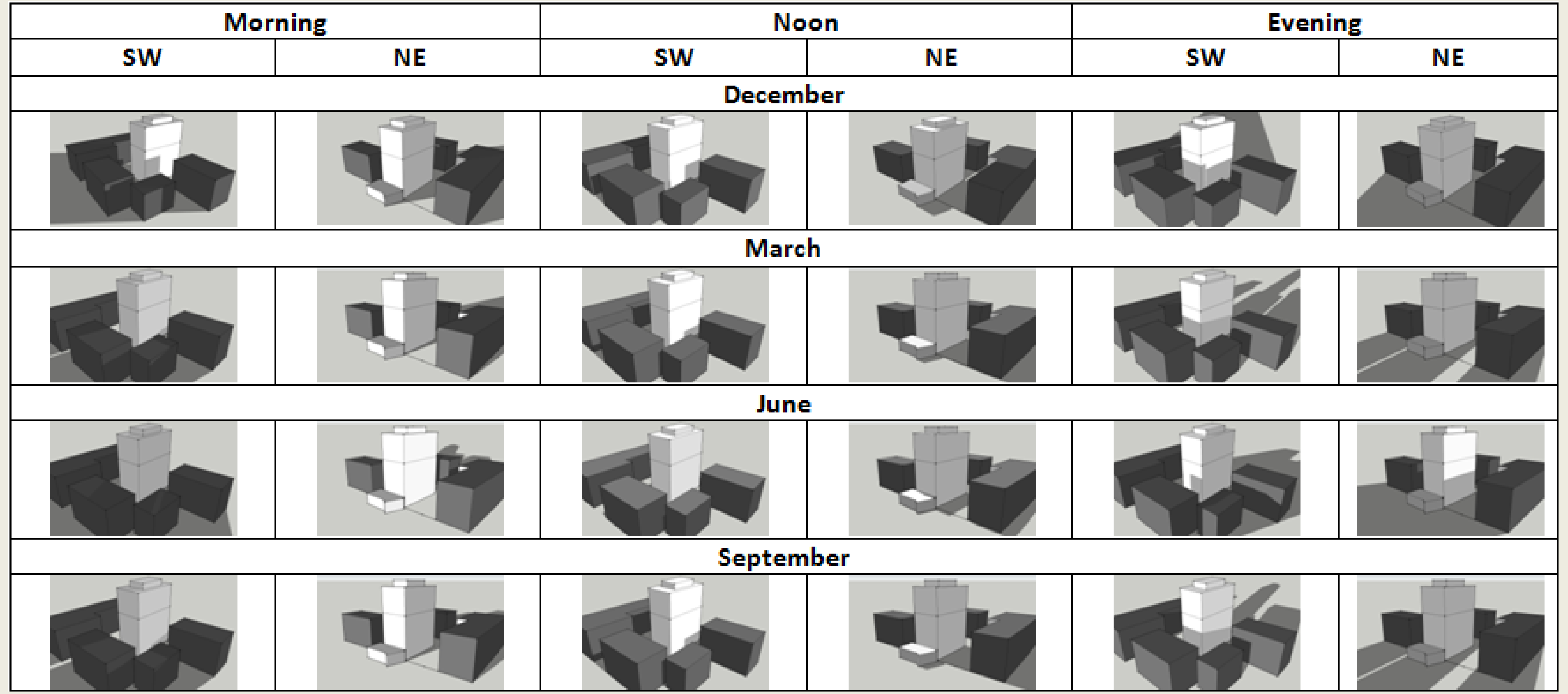
Presentation Outline

Dominion of Virginia does offer net metering,

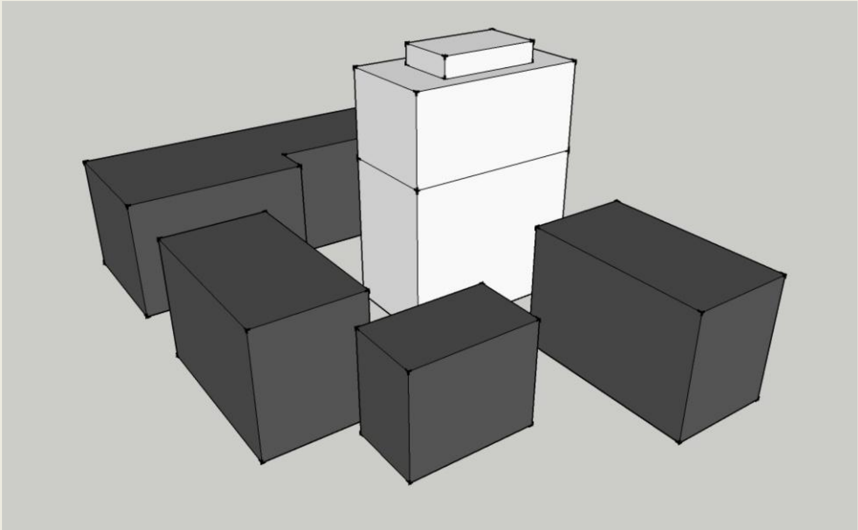
- Limited/restricted
- Terms and Conditions for net metering, it is available to “customer-generator” using a “renewable energy facility” for the first 0.2% of Company’s North Carolina jurisdictional peak load during the previous year.

1. Alternating current capacity of no more than 100 kW for nonresidential customers
2. Its total fuel source is solar PV, wind power, micro-hydro, or biomass
3. Is for the customer-generator’s use and not for sale to a third party
4. Is interconnected and operated in parallel with the electric distribution system provided by the company (Virginia Electric and Power Company, 2006)

Building Integrated Solar Energy Systems



- Shadow Study
  - Uses Google SketchUp
  - No shading above 12th floor from surroundings
  - Even North façade receives sun



Creating Sustainability in Crystal City

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3. **Building Integrated Solar Energy System**
   - Design considerations, technology, energy results
4. Peak Demand Shift and Demand Response Programs
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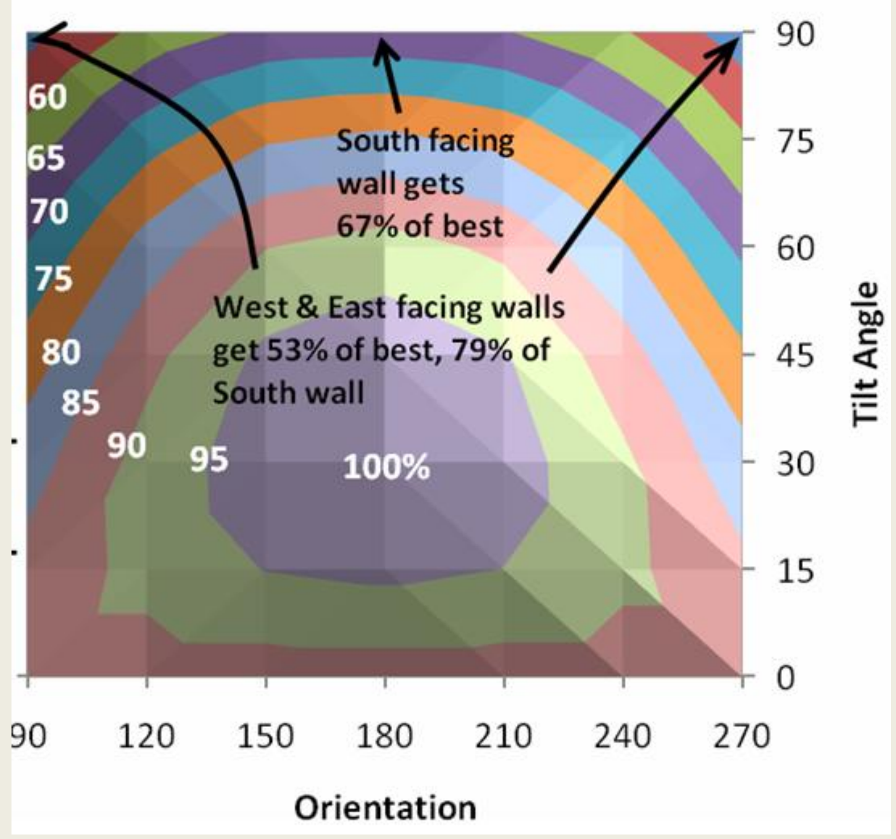
- Equations
  - $E_{sol} = I_t \, A \, \eta \, t \, e$

  where:
  - I_t = long-term average solar per day per unit area at specific tilt and orientation from insolation table (W/m²-day)
  - A = total area receiving sun
  - η = annual efficiency of converting sunlight to useful energy
  - t = time
  - e= orientation efficiency



Peak Demand Shift and Demand Response

Creating Sustainability in Crystal City

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4. **Peak Demand Shift and Demand Response Programs**
    - Background, local programs, generator use, results
5. Financing Projects through Energy Savings
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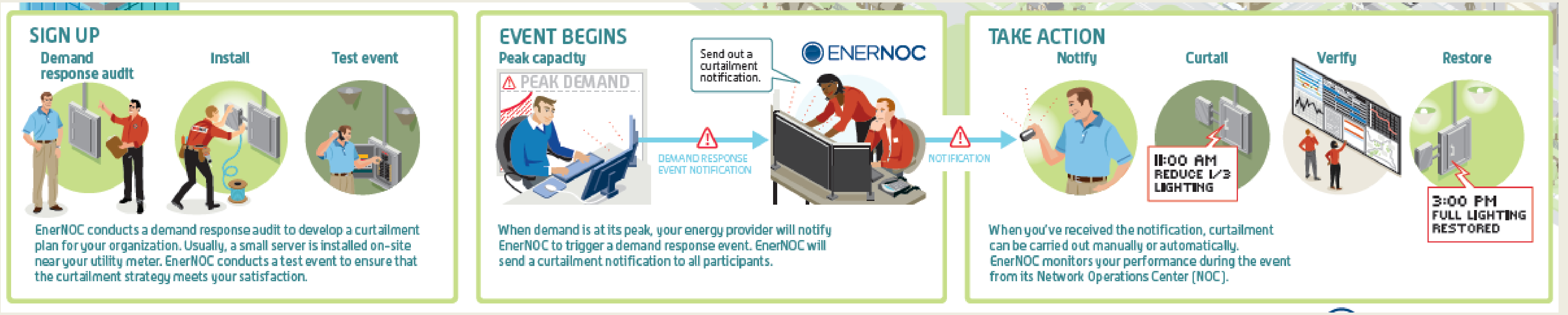
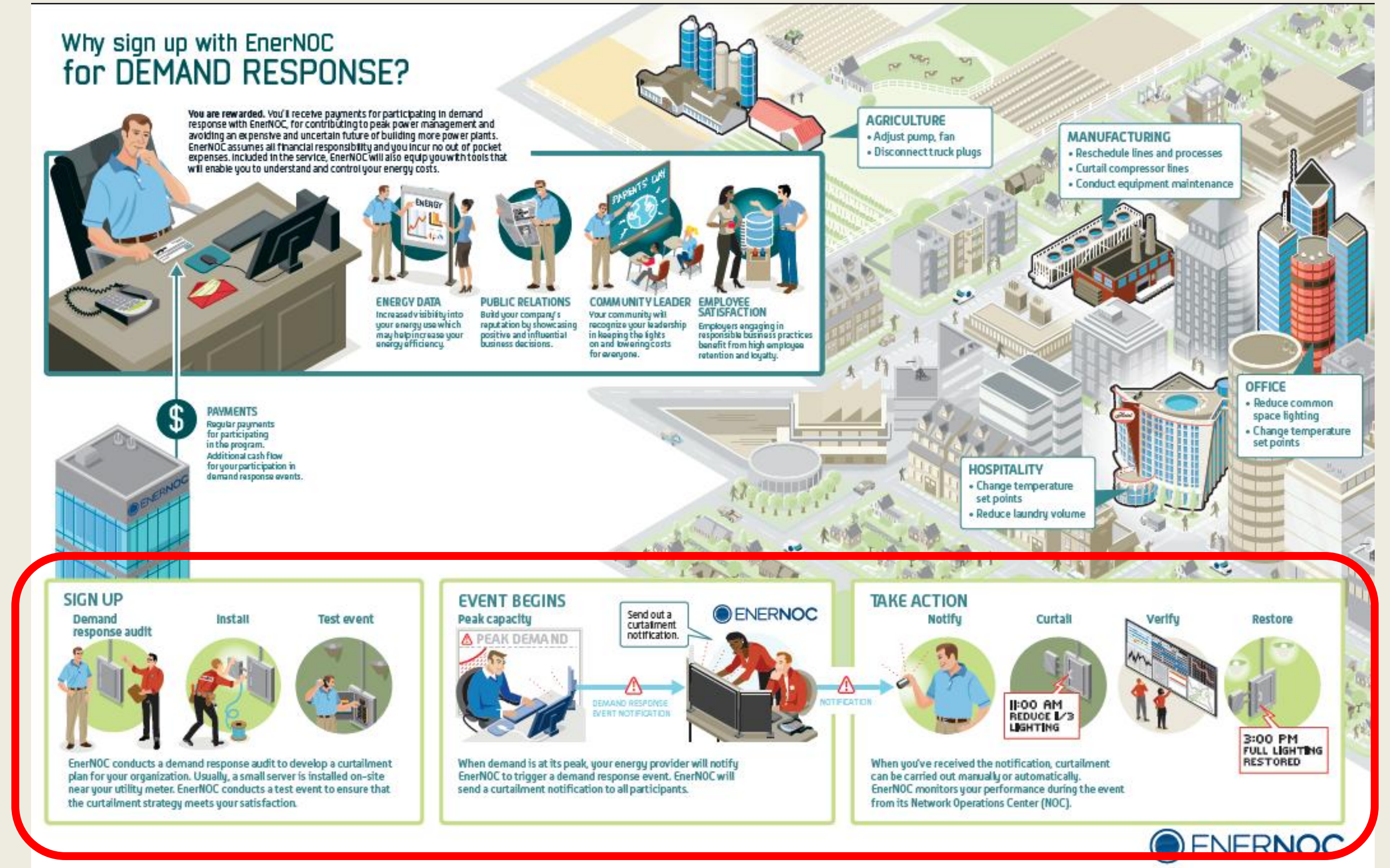
- Demand Response





Peak Demand Shift and Demand Response

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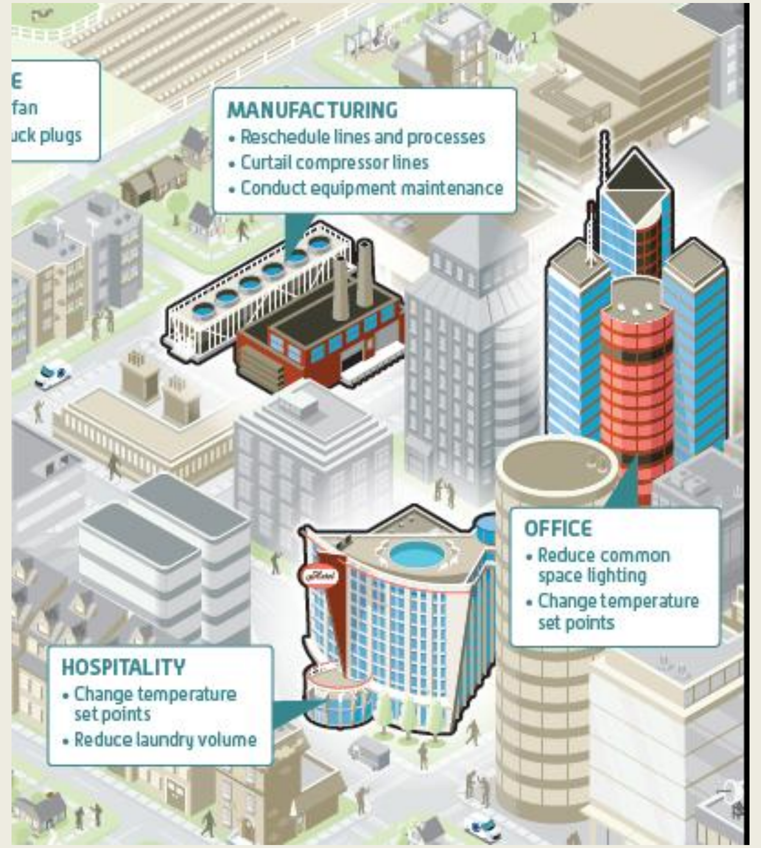
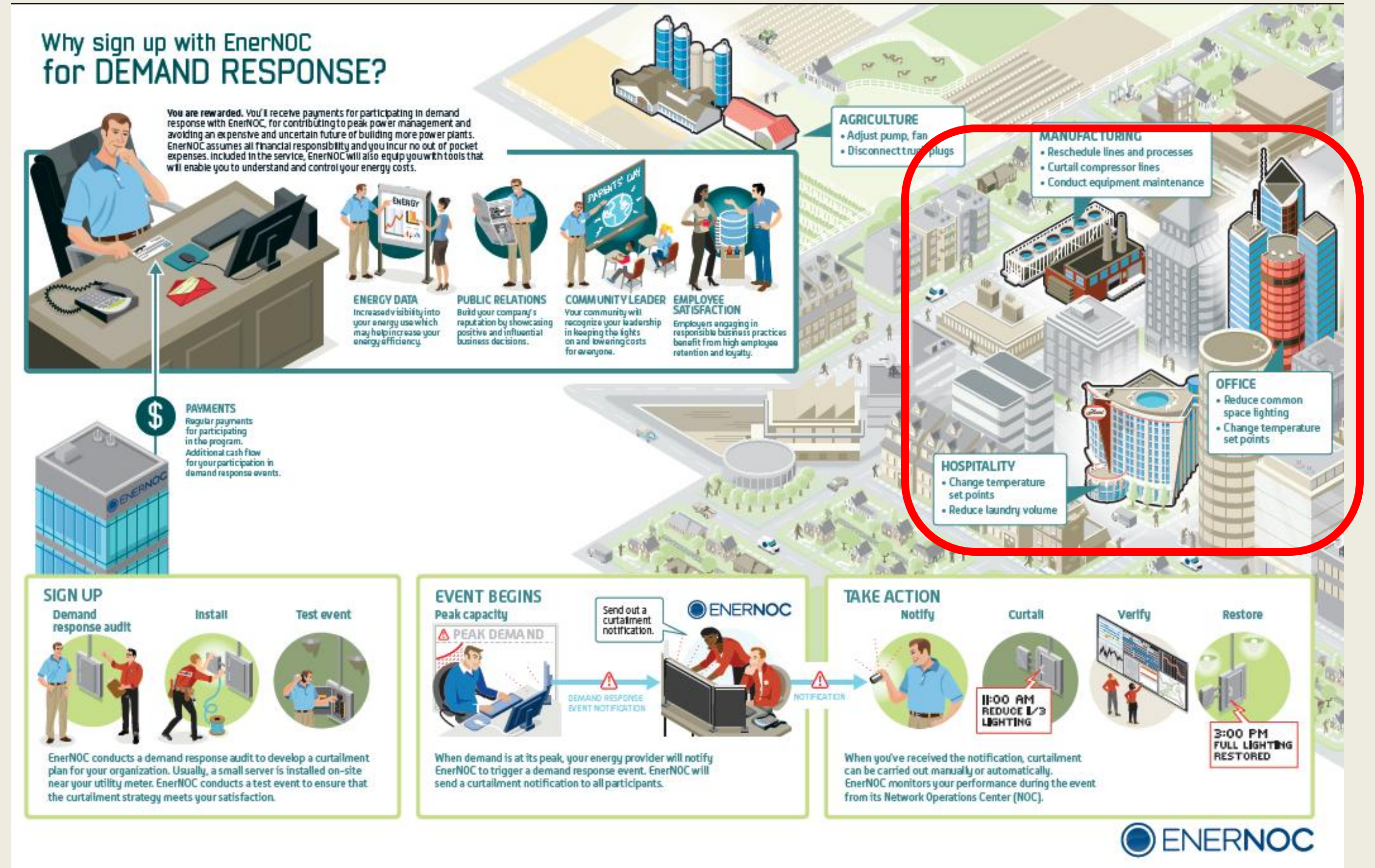
- Demand Response





Peak Demand Shift and Demand Response

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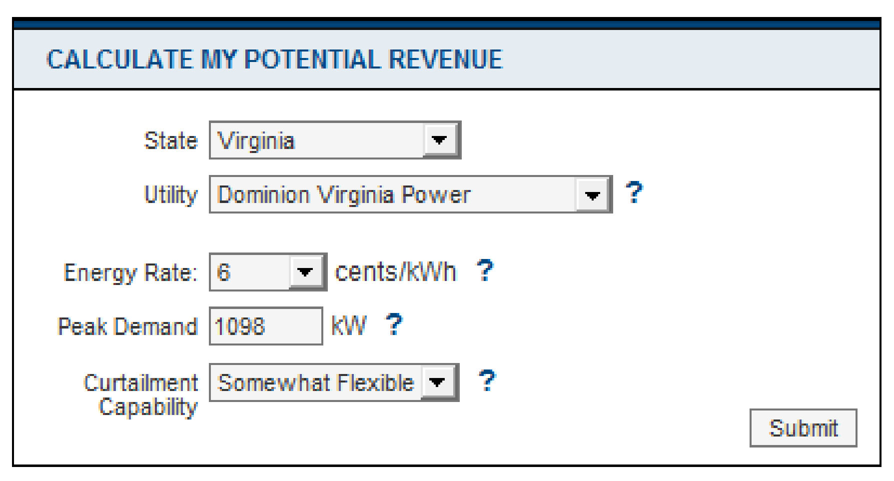
- Demand Response
    - EnergyConnect
        - EventConnect
            - Reservation Fee
            - Compensation for curtailed energy
        - FlexConnect
            - Paid wholesale price according to PJM
            - Fee removed by EnergyConnect for service



Potential Revenue
$8,138

Financing Projects through Energy Savings

- ## Programs
  - Local Property Tax Assessment for Energy Efficient Buildings
    - Comprehensive, whole building program
    - Evaluates property tax at reduced rate
    - Must exceed the energy efficiency standards of VA Uniform Building Code by 20%, or meet standards in Green Globes, LEED, or the EarthCraft program
  - Application at Crystal Plaza II
    - Qualifies for program if offered by Arlington County
    - No response from program without tax information, withheld by owner
  - Modified Accelerated Cost Recovery System (MARCS)
    - Allows for solar to depreciate over 5 years
    - Bonus of 50% depreciation as part of Economic Stimulus Act in Feb 2008
  - Business Energy Investment Tax Credit (ITC)
    - Tax credit for 30% of solar, with no limit
  - U.S. Department of Treasury renewable Energy Grants
    - Alternative to ITC, allowing for 30% of basis property for solar with no limit