

Successfully Demonstrating an Integrated Roofing and BIPV Solution for an Historic Building Renovation at the United States Air Force Academy

Abstract Number: 12623

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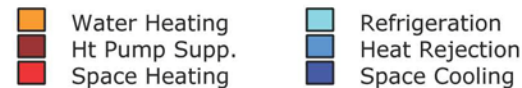
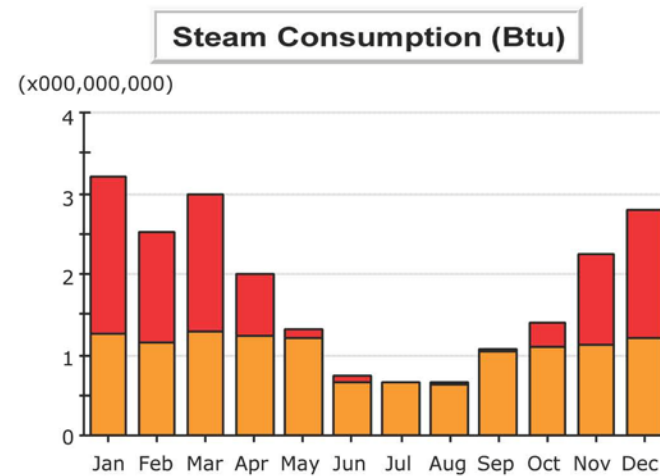
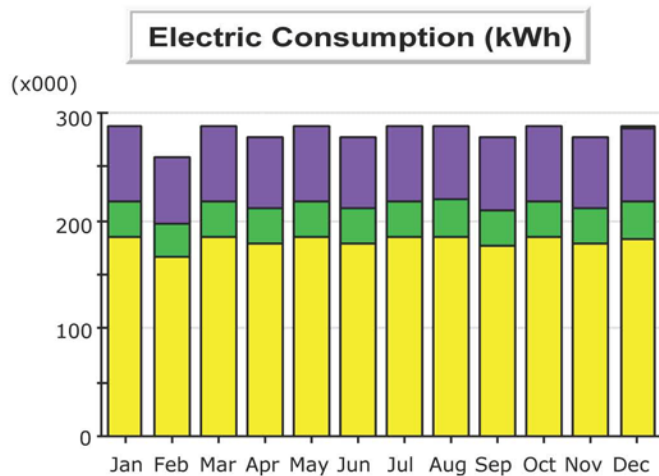
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Vandenberg Hall

- Six Stories + Basement
- Quarter of a Mile Long
- Window Wall System – 50 Years Old
- Reduce Energy Consumption

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Energy Model



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Glazing Scenario Modeling

VANDENBERG GLAZING SCENARIO ENERGY MODELING RESULTS

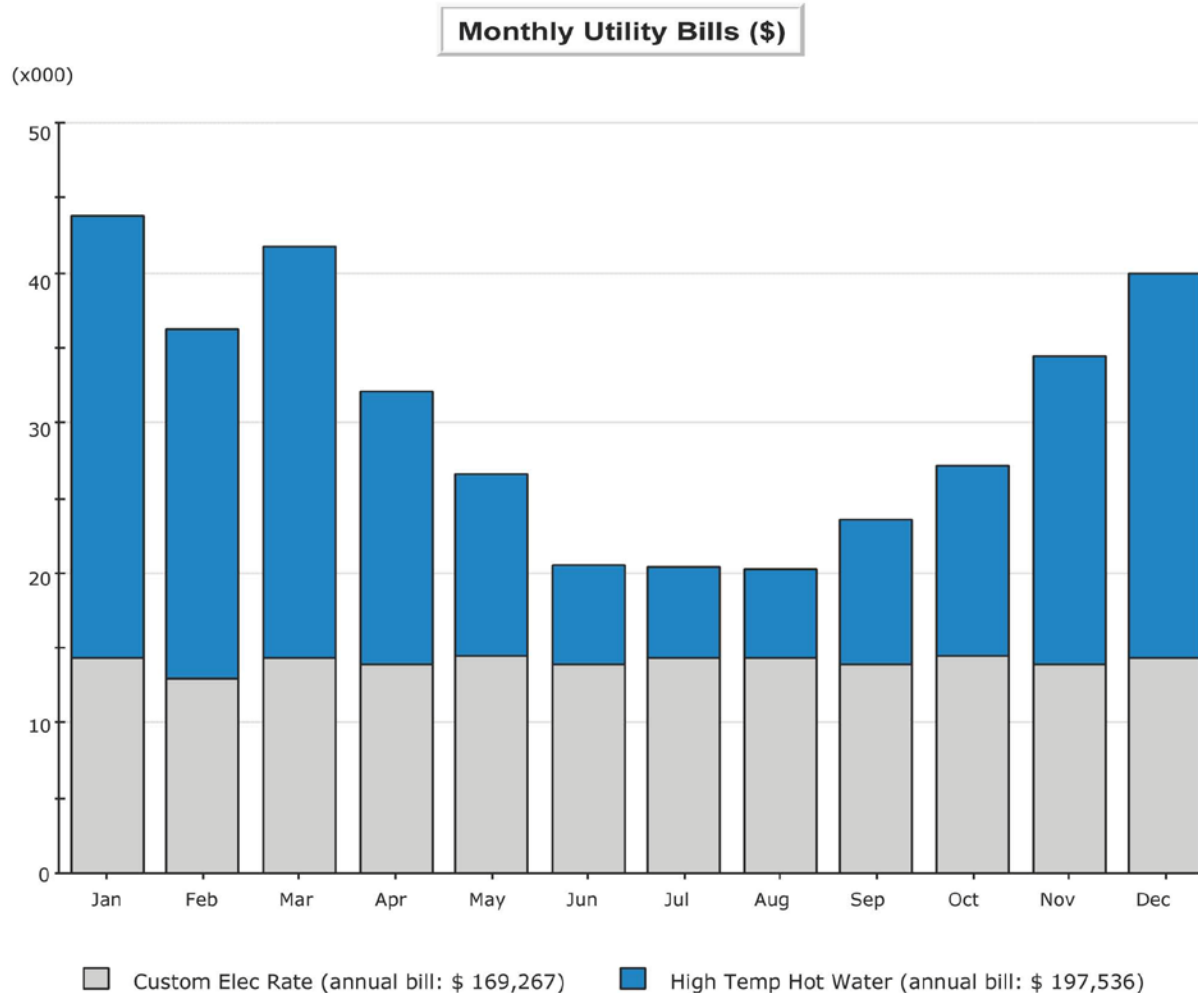
	Glass Scenario 1 Base Design	Glass Scenario 2 Thermal Performance	Glass Scenario 3 Non Low-E	Glass Scenario 4 Existing
Electric Consumption (kWh x 000)	3389.4	3384	3389.9	3417.2
Annual Electric Bill	\$ 169,539	\$ 169,267	\$ 169,562	\$ 170,928
Gas Consumption (Btuh x 000,000,000)	23.4	21.57	24.19	40.94
Annual Gas Bill	\$ 214,351	\$ 197,536	\$ 221,618	\$ 375,005
Total Consumption (Btu x 000,000,000)	34.96	33.12	35.76	52.60
Total Annual Bill	\$ 383,890	\$ 366,803	\$ 391,180	\$ 545,933
Savings compared to Existing Design				
Energy Savings (Btu x 000,000,000)	33.53% 17.63	37.04% 19.48	32.02% 16.84	---
Annual Dollar Savings	29.68% \$ 162,043	32.81% \$ 179,130	28.35% \$ 154,753	---

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Vandenberg Hall

- Estimated Costs for Utilities - \$ 545,933.00 / year
- Scenario 2 Costs for Utilities - \$ 366,803.00 / year
- Energy Consumption Reduction by 32.81%
- Energy Conservation – Use of Renewable Energy

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Total Annual Bill Across All Rates: \$ 366,803

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Vandenberg Hall

- Thin Film Solar Array
- Direct Application on Roofing Membrane
- Wind Gusts of 110 mph
- Single Source 25 Year Warranty
- Return On Investment 17 years

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Year	2010	2027	2028
Crude Oil	12.16	20.46	20.77
\$ - kW/hr	\$ 0.1400	\$ 0.2356	\$ 0.2391
Total Consump in kWh	2,110,590	2,110,590	2,110,590
Total Energy Cost	\$ 295,482.60	\$ 497,168.91	\$ 504,701.78
RE Production kWh	305,268	257,324	254,751
RE Energy Investment	\$ 42,737.59	\$ 60,615.04	\$ 60,918.11
Non RE Complimentary Production kWh	1,805,322	1,853,266	1,855,839
Non RE Energy Cost	\$ 252,745.01	\$ 436,553.88	\$ 443,783.67
Actual Energy Cost	\$ 252,745.01	\$ 436,553.88	\$ 443,783.67
Amortization of PV Array's Initial Cost (ROI)	\$ 962,819.41	\$ 2,857.03	\$ (58,061.08)
\$	1,005,557.00		
Solar Insolation Value	6.0		

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Energy at USAFA

- USAFA commissions leaders of character
 - Mission conducted as balance between built and natural environment
 - Relies on Innovation, Education, Conservation
 - Reduce Demand via Facility Improvement and Policy
 - Innovation in Technology and Application
 - Symbiosis Between Research and Application
 - Educate! Spread the Awareness and Knowledge
 - Involve Cadets in Development of Renewable Energy
 - Civil Engineering is at forefront of this mission

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Energy Management Program

- Falcon Green Program
 - Conservation Initiative to Shut-Down Computers at Night:
 - Yielding ~2% Electrical Energy Reduction from 2009
 - USAFA Energy Triad involving 10 ABW, USAFA DF and Cadets kicked-off in July 2010
 - Energy policy implemented – regulates temperature set points; limits personal coffee pots, refrigerators, etc.

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Energy Management Program

- American Recovery and Reinvestment Act of 2009 (ARRA)
 - Received \$18.3M to develop a Solar Array
- AF's FY10-15 Energy Conservation Focus Fund - \$250M per year - \$1.5B total
 - FY10 – USAFA first Command/DRU to award 100% of projects
 - FY11 – USAFA slated to receive \$2.7M

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Conservation Projects Funded Centrally by HAF

- **FY10 Energy Conservation Projects**
 - **Repair Lighting/Cooling Community Center Bldgs**
 - **Repair/Replace Lighting Falcon Athletic Center**
 - **Repair/Replace Lighting Cadet Gym**
 - **Repair/Replace Lighting Fairchild and Sijan Halls**
 - **Repair/Replace Chillers-Fairchild Hall**
- **Estimated Total Annual Energy Savings 7,000 MBTU**

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Conservation Projects Funded Centrally by HAF

- **FY 11 Energy Conservation Projects**
 - **Optimize HVAC Harmon Hall**
 - **Lighting retrofit Cadet Chapel & Aero Lab**
 - **Lighting retrofit Airmen's Dining Hall & Enlisted Dorm**
 - **Lighting retrofit Vehicle Maint & Sailplane Hangar**
 - **Optimize EMCS Multiple Buildings**
- **Estimated Total Annual Energy Savings 57,000 MBTU**

Photovoltaic System and Components

Phase 1

- Design Challenges
 - Historic Building (USAFA wanted no visual interruptions)
 - Heavy winds and large hail in area also directed against using crystalline panels in this application
 - Construction of building left no room for system wiring to basement of 6 story facility. We routed conduit and wire via elevator shaft and provided shunt trip roof mounted breakers to isolate power in the event of alarm.

Photovoltaic System and Components

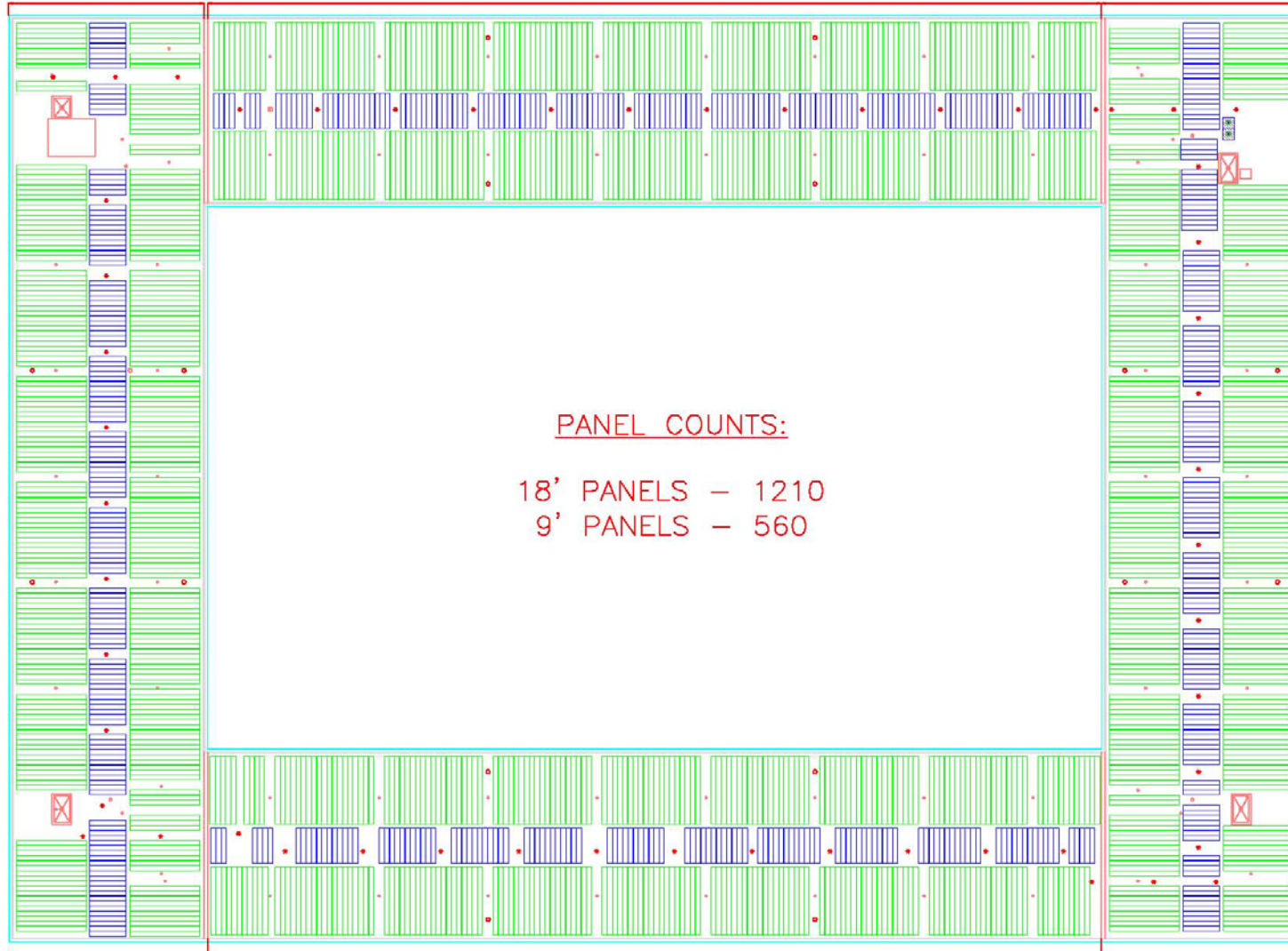
Phase 1

- Total installed production capacity: 212.320 KW DC
- Panels type and quantity:
 - Unisolar Thin Film Amorphous Silicon Panels
 - 1210 – Power Bond PVL-144 (144 watts each)
 - 560 – Power Bond PVL-68 (68 watts each)

2 ROWS 18' PANELS: 154 & 143
 PANELS, 27 STRINGS OF 11
 1 ROW OF 9' PANELS 144 PANELS,
 9 STRINGS OF 16

2 ROWS OF 18' PANELS 154 PANELS, 28 STRINGS OF 11
 1 ROW OF 9' PANELS, 144 PANELS 9 STRINGS OF 16

2 ROWS 18' PANELS: 154 & 143
 PANELS, 27 STRINGS OF 11
 1 ROW OF 9' PANELS 144 PANELS,
 9 STRINGS OF 16



PANEL COUNTS:

18' PANELS – 1210
 9' PANELS – 560

2 ROWS OF 18' PANELS 154 PANELS, 28 STRINGS OF 11
 1 ROW OF 9' PANELS, 128 PANELS 8 STRINGS OF 16



310 QUADRAL DRIVE
 WADSWORTH, OHIO 44281
 (330) 334-0066

TITLE USAFA – Vandenberg Hall max PV Layout

SCALE 1/16" = 1' DWN TM CHK GP APPROVAL DATE 04/22/10

DRAWING NUMBER ----- REV 1

Photovoltaic System and Components

Phase 1

- Inverters type and quantity:
 - Solectria – Grid Tied Commercial Inverters
 - 2 – PVI 95 KW
 - 2 – PVI 15 KW

Photovoltaic System and Components

Phase 1

System Efficiencies

- Total system efficiency of 84% (based on actual field testing)
- Inverter efficiency = 96% (conversion of DC power to AC)
- Calculated Production
 - Expected at 305,268 (kilowatt hours) year 1, based on irradiance factor of 1437 kWh AC per DC watt for Colorado Springs.

Photovoltaic System and Components

Phase 1

- Panel Characteristics
 - High Temperature and Low Light Performance
 - Bypass diodes for Shadow Tolerance
 - 80% Output Power maintained at 25 years
 - Tolerant from -40 degree F and 185 degrees F
 - .2” thick for minimal to no visual presence

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Vandenberg Hall Roof Waterproofing System

Application over existing granule surface modified bitumen membrane and roofing assembly:

- Base Coat = Alsan RS 230 (75mil)
- Reinforcement = Alsan Polyfleece (fully embedded)
- Top Coat = Alsan RS 230 (40mil)

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QUESTIONS?