NRUCFC Headquarters Building

Sterling, VA

Architectural Engineering Senior Thesis

Margaret McNamara | Mechanical Option

Advisor | Dr. Stephen Treado

Introduction

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- Project Overview
- Systems Overview
- Existing Mechanical System
- Depth1 | DOAS w. Chilled Beams
- Depth 2 | Hybrid PVT Solar System
- Breadth 1 | Electrical
- **Breadth 2 | Architectural**
- Conclusion
- Acknowledgements
- Questions

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Project Overview

- **Building Type** | Office Building
- **Size** | 120,000 GSF
- **Number of Stories** | 3 above grade
- **Construction Dates** | Nov. 2009-Sept. 2011
- **Project Cost** | $45 million
- **Project Delivery Method** | Design-Bid-Build

N

Location | Sterling, VA

Project Team

- **Architect** | Kishimoto.Gordon.Dalaya PC
- **Interior Architect** | Fox Architects
- **Landscape Architect** | EDAW
- **Site/Civil Engineers** | Dewberry
- **Structural Engineers** | SK&A
- **MEP Engineers** | WSP Flack + Kurtz
- **LEED Consultants** | Sustainable Design Cunsulting
- **General Contractor** | Whiting-Turner

Electrical/Lighting System

Generators | Two pad-mounted 600kW generators serve emergency power and required standby service

Microturbines | Two 65 kW microturbines serve data center

Lighting | Daylight sensors and occupancy sensors control the lighting

Architecture

Structural System

Foundation| Combination of isolated columns and strip wall footings with a 5” slab-on grade

Frame | Steel Frame that utilizes composite beams and slabs

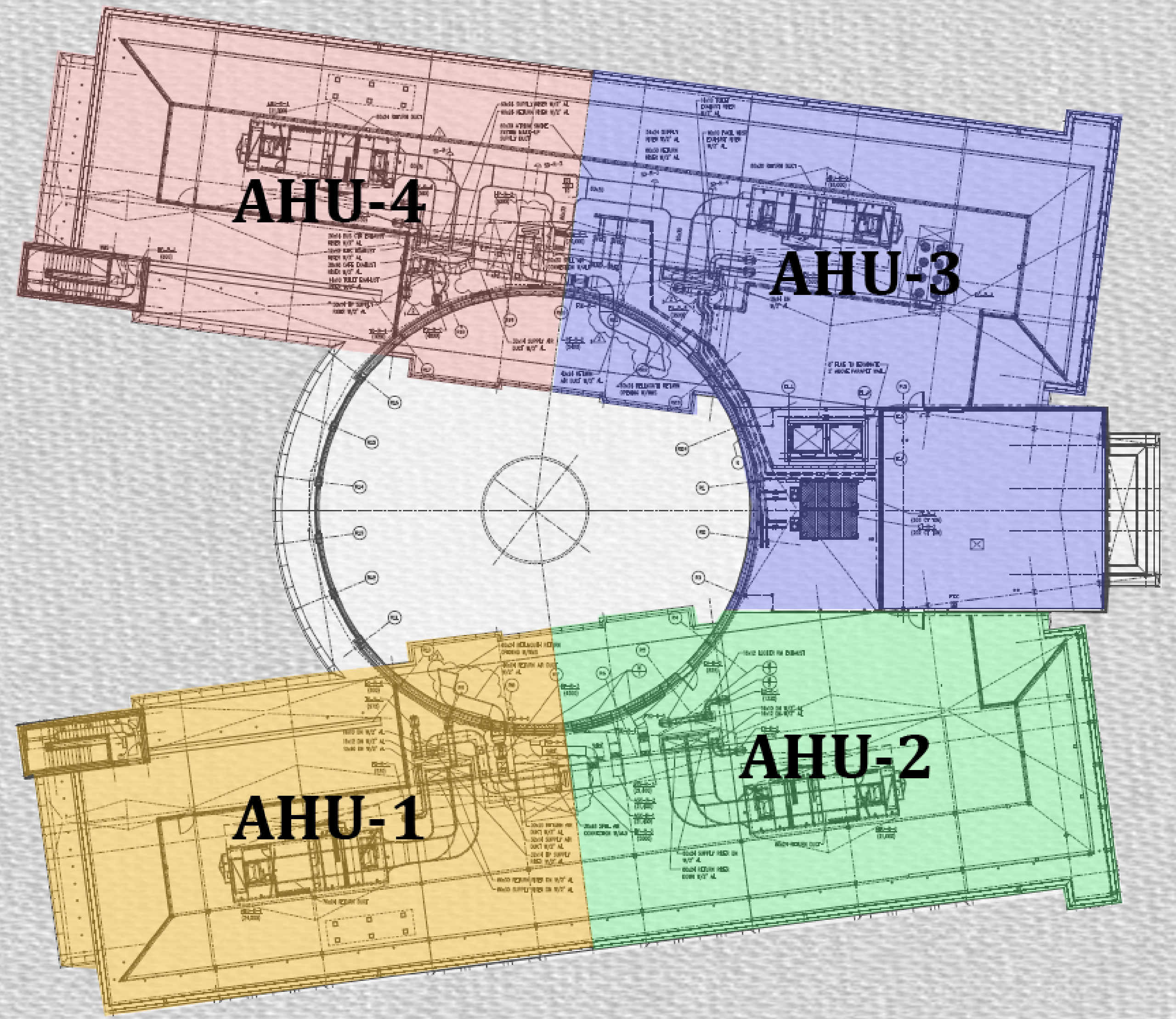
Atrium | Arched trusses made of HSS members form atrium dome with an oculus

Air Side Summary

- **Four Rooftop AHUs** | 18,000-24, 000 CFM
- **Fan Powered Boxes** | Perimeter Heating and Cooling
- **VAV Boxes** | Interior Heating and Cooling

Atrium Heating and Cooling

- **Ground Source Heat Pumps**
- **Radiant Flooring**



Water Side Summary

- **Cooling** | Two 210 ton electric centrifugal chillers located in first floor central plant
- **Heating** | Two high efficiency natural gas boilers located in the penthouse

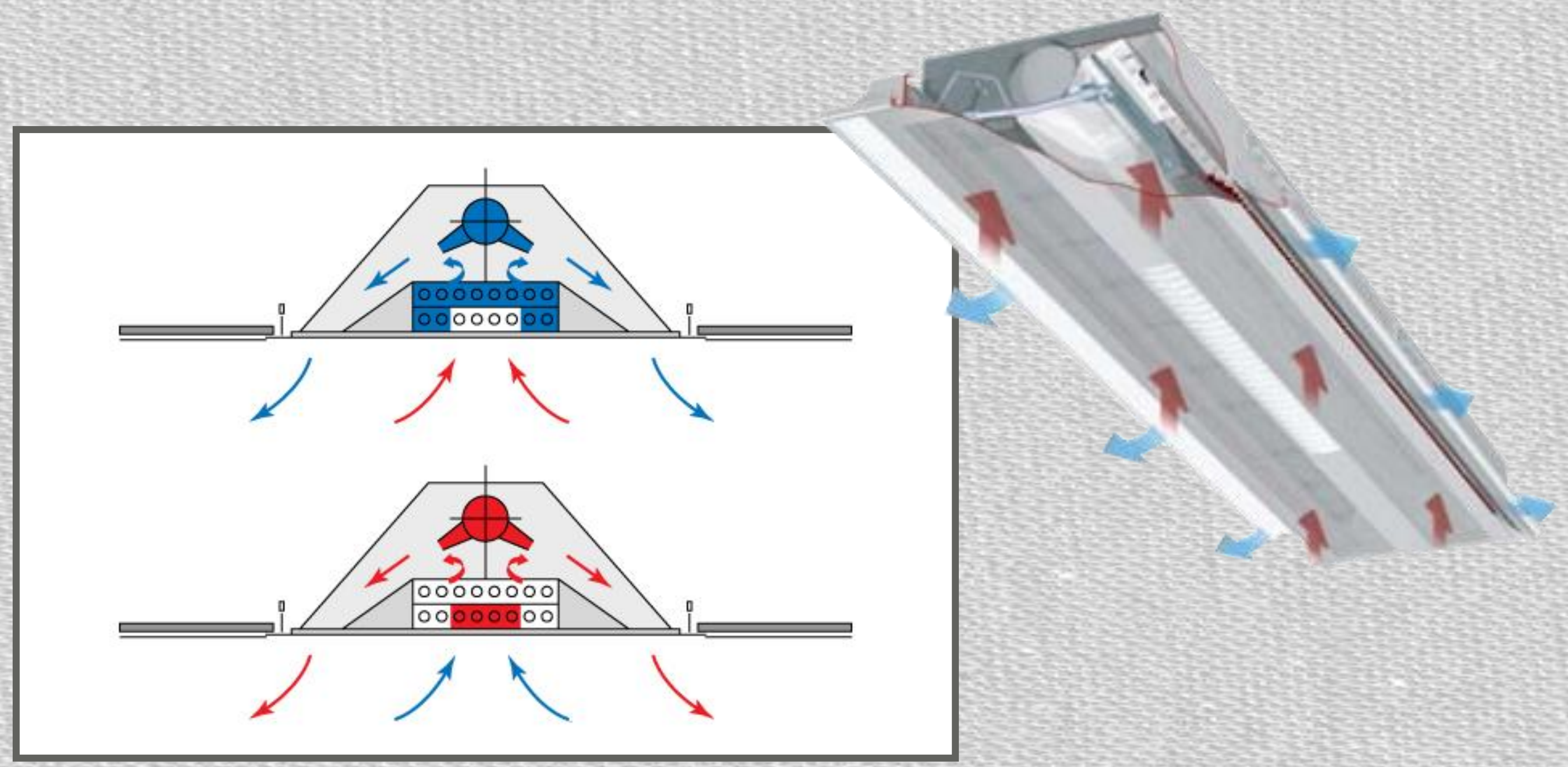
Depth 1 | DOAS with Chilled Beams

Redesign Proposal

- Replace four existing AHUs with DOAS unit
- Replace VAVs and FPBs with Chilled Beams

Redesign Goal

- Reduce energy consumption
- Reduce airflow



Active Chilled Beams (ACBs)

Active Chilled Beams Advantages

- Uses less air and allows for smaller duct work and AHUs
- Lower floor to floor height
- Requires minimum maintenance
- Reduces energy consumption

Active Chilled Beam Disadvantages

- Higher initial cost
- Larger than tradition diffuser
- Sensitive to humidity

Depth 1 | DOAS with Chilled Beams

DOAS w. ACBs Design Conditions

	Supply Air	Outdoor Air	Space Design
T_{DB} (F˚)	64	93.2	75.2
Humidity (Grains)	44	154	65.7
Dew Point (F˚)	45	-	-

CHW Supply | 57 ˚F | 1 gpm

Chilled Beam Sizing and Selection

- Latent and Sensible Load from TraneTRACE
- ASHRAE Standard 62.1 | Ventilation Requirements
- Ventilation Requirements to meet Latent Load
- ExSel Air Chilled Beam Calculator

SEMCO IQID Series

Chilled Beam Summary

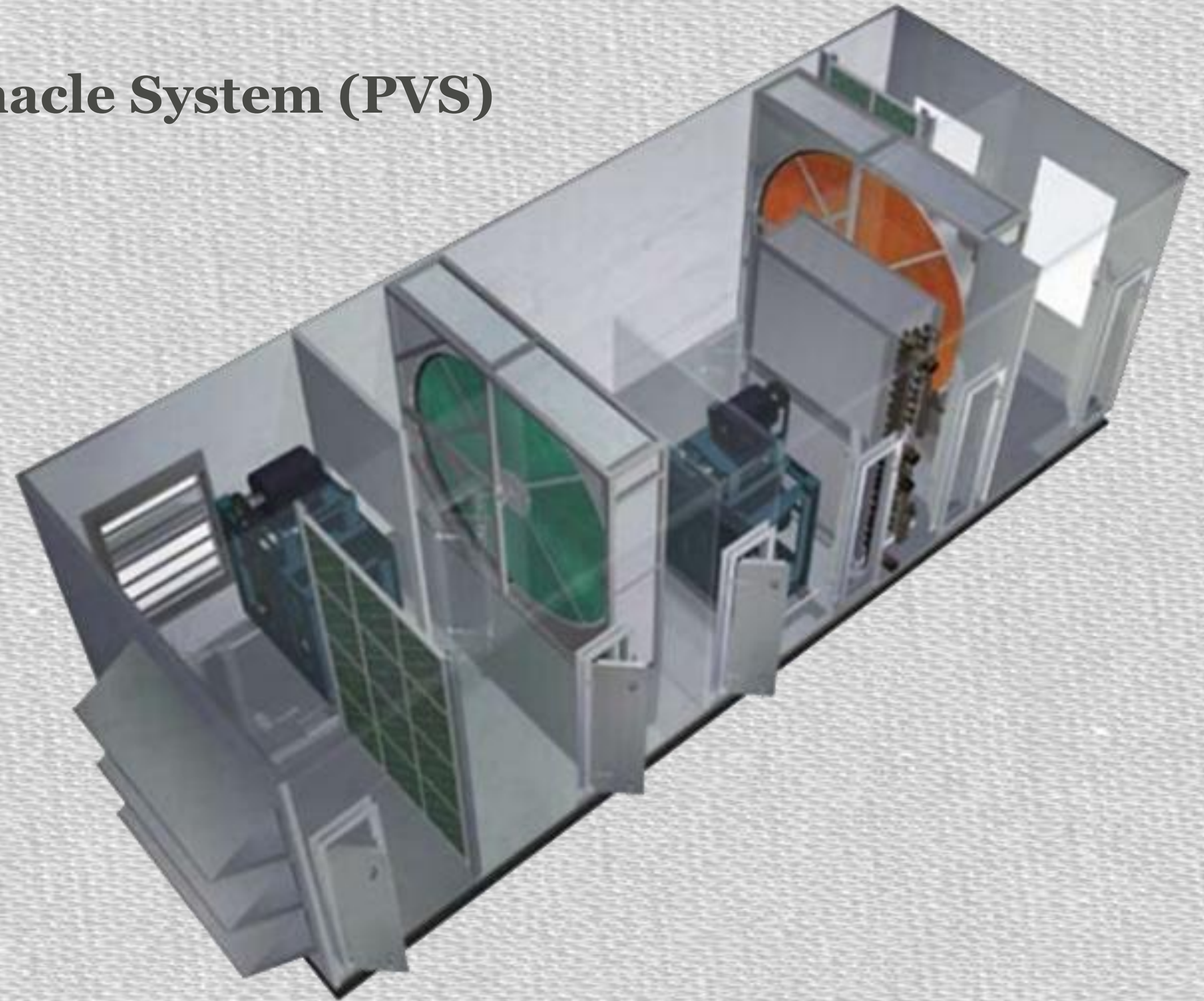
Model	Quantity	Length	Total Cost
IQIC-4	85	4'	$ 72,250.00
IQIC-6	98	6'	$ 93,100.00
IQIC-8	68	8'	$ 71,400.00
Total	**251**		**$ 236,750.00**

Depth 1 | DOAS with Chilled Beams

DOAS Unit Selection

40,000 CFM

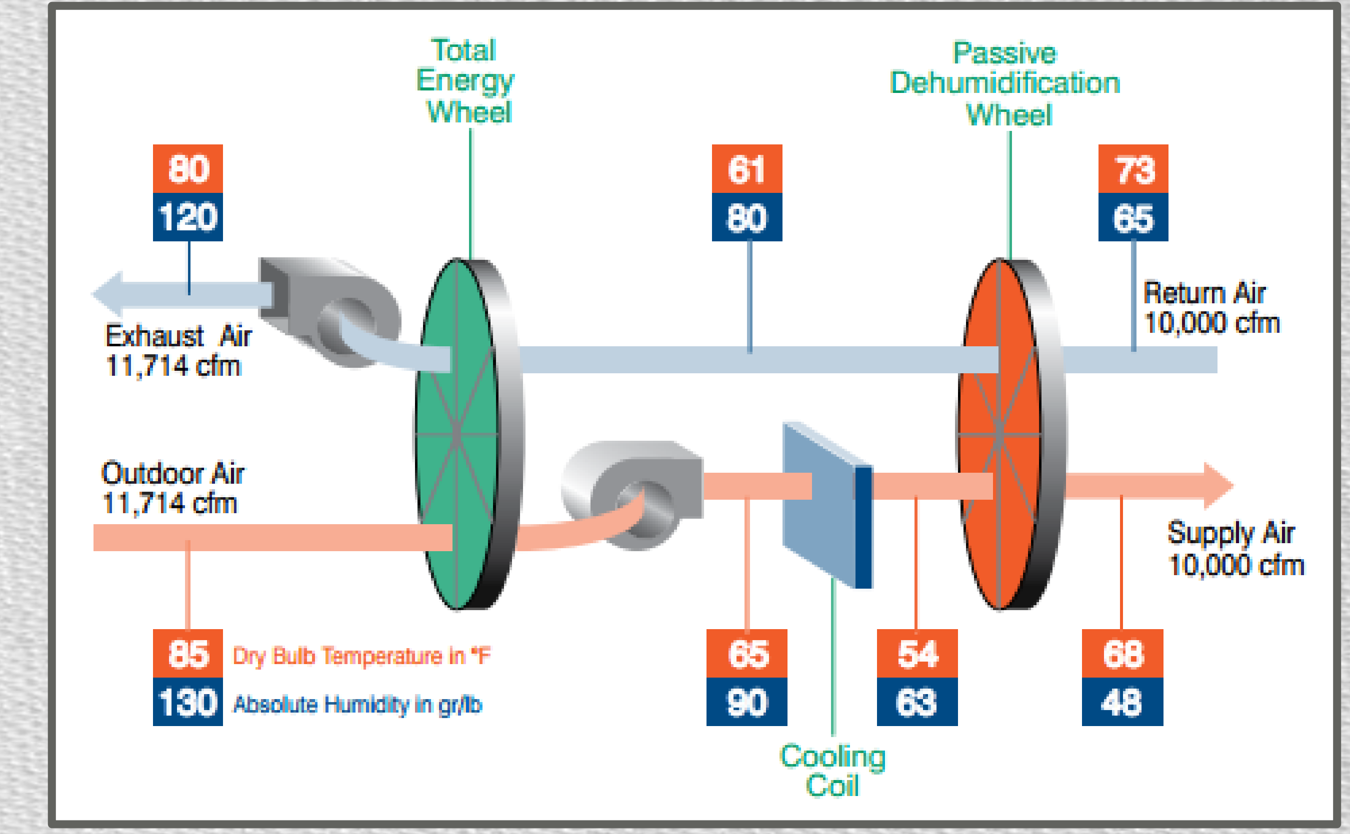
SEMCO Pinnacle System (PVS)



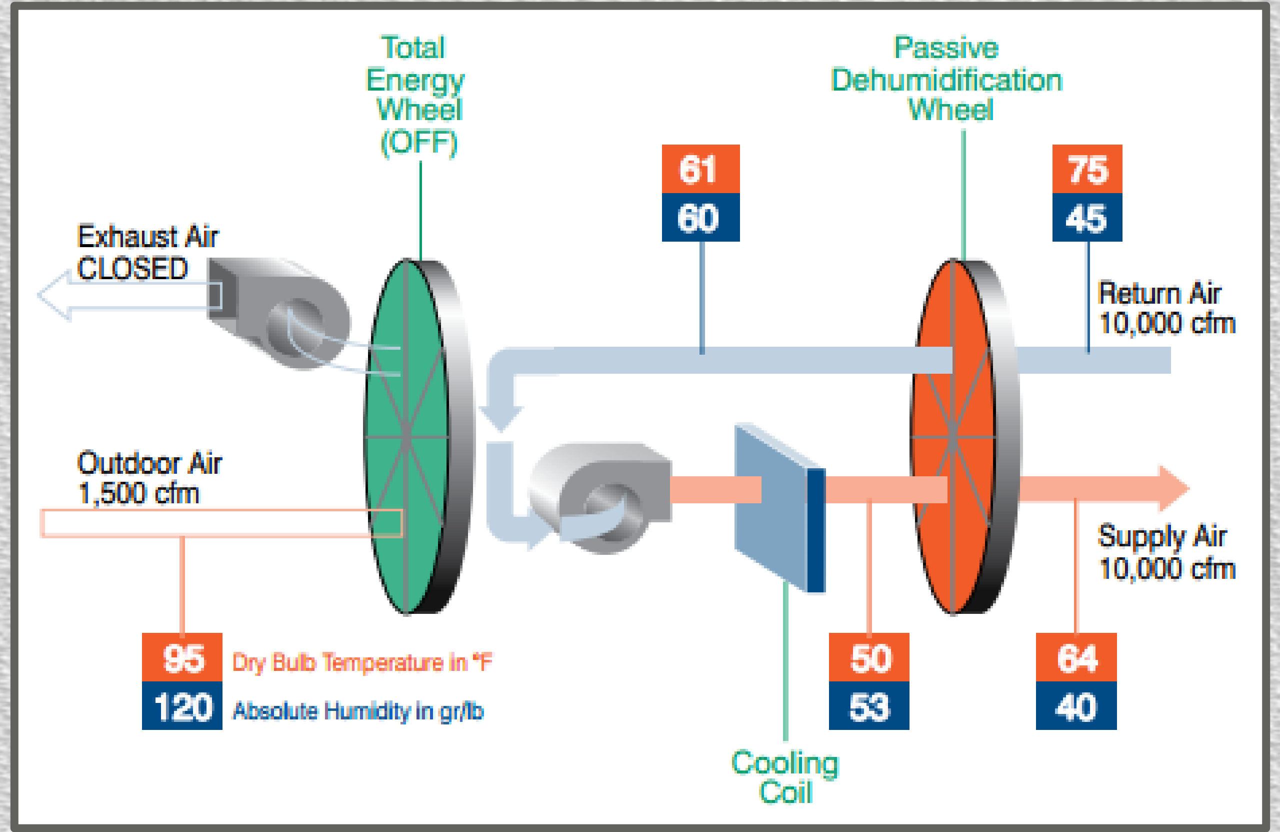
PVS Advantages

- Total Energy Wheel & Passive Dehumidification Wheel
- Delivers low dew points
- Provides high levels of OA and controls humidity
- Large latent load capacity

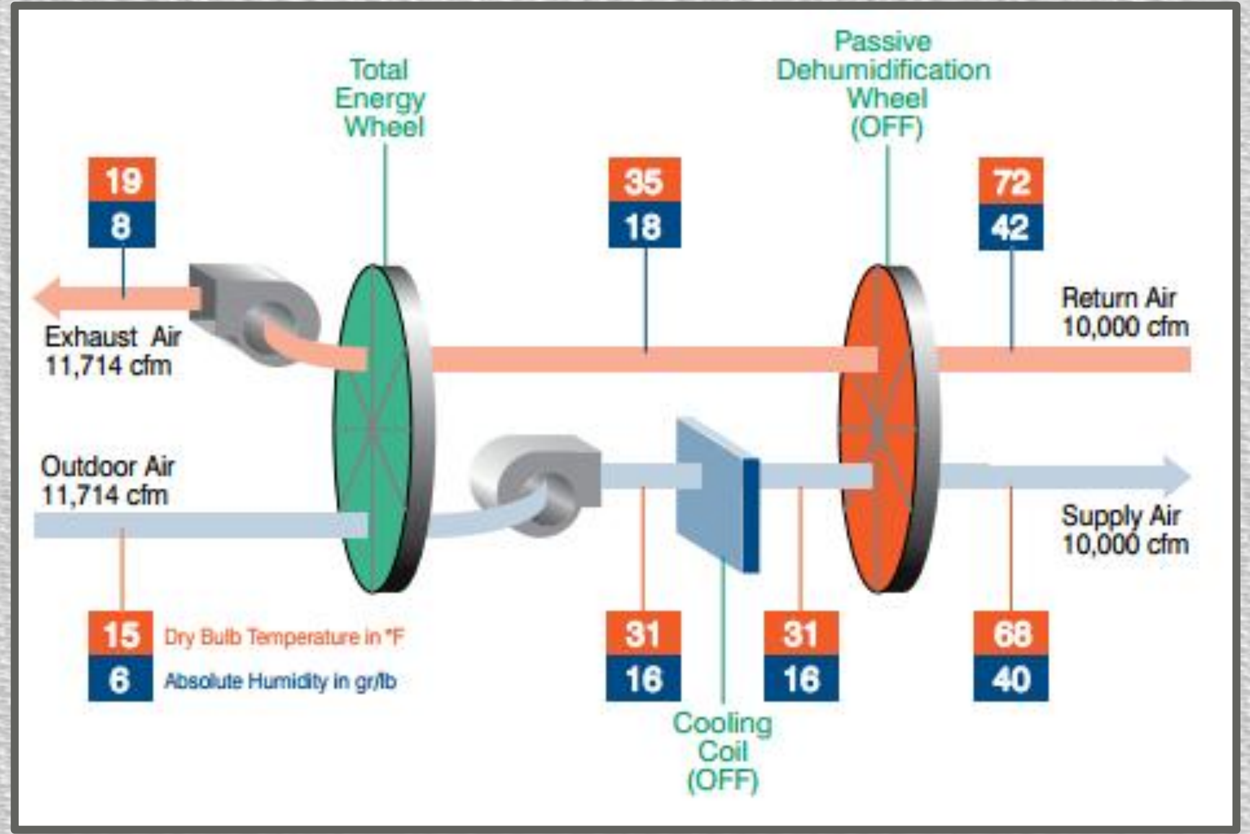
Depth 1 | DOAS with Chilled Beams



PVS Cooling Mode



PVS Unoccupied Mode



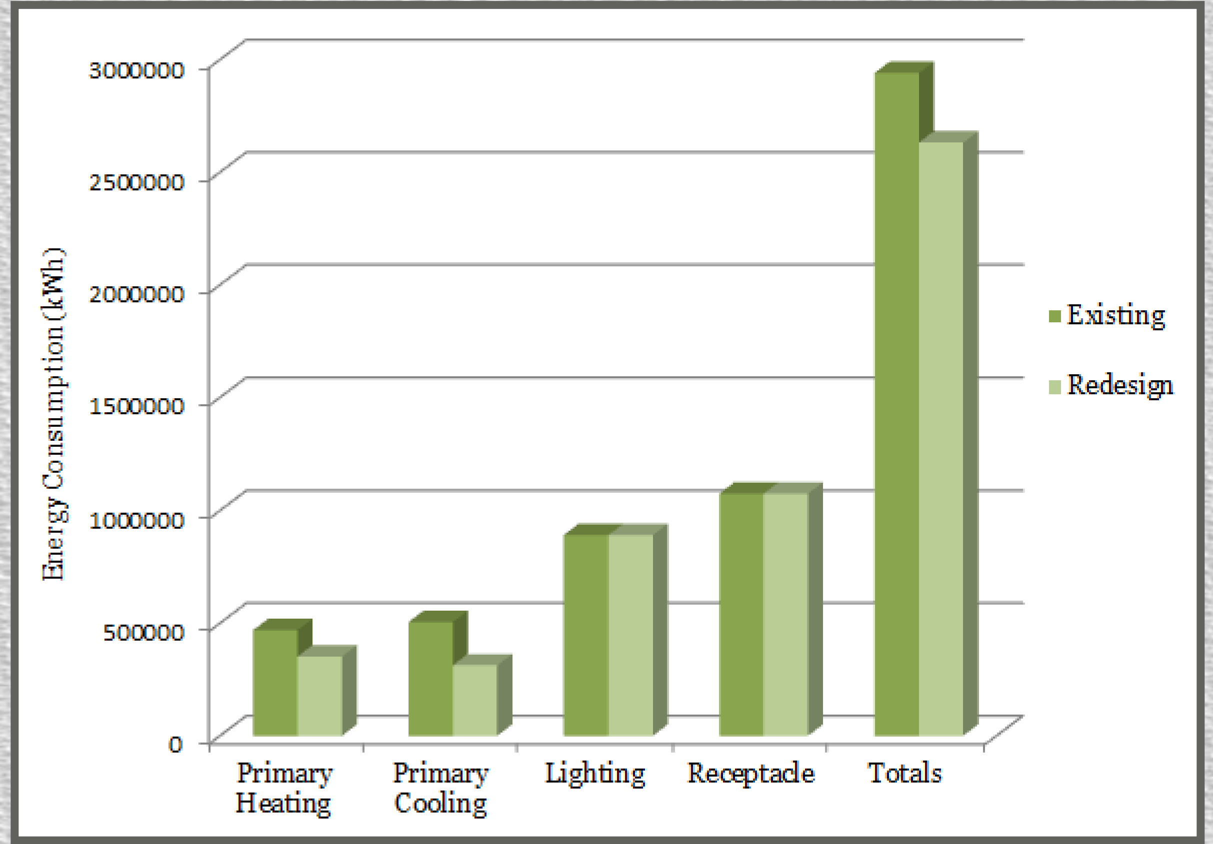
PVS Heating Mode

Depth 1 | DOAS with Chilled Beams

First Cost Comparison

Existing System				
Quantity	Item	Equipment	Installation	Total
132	VAV/FPB Boxes	$ 56,628.00	$ 24,507.00	$ 81,135.00
4	AHUs	$ 700,000.00	$ 48,000.00	$ 748,000.00
			Total	$ 748,000.00
Redesigned System				
251	Chilled Beams	$ 236,750.00	$ 32,881.00	$ 269,631.00
1	Pinnacle DOAS Unit	$ 278,874.00	$ 18,000.00	$ 296,874.00
			Total	$ 566,505.00

Energy Consumption Comparison



Cost Savings

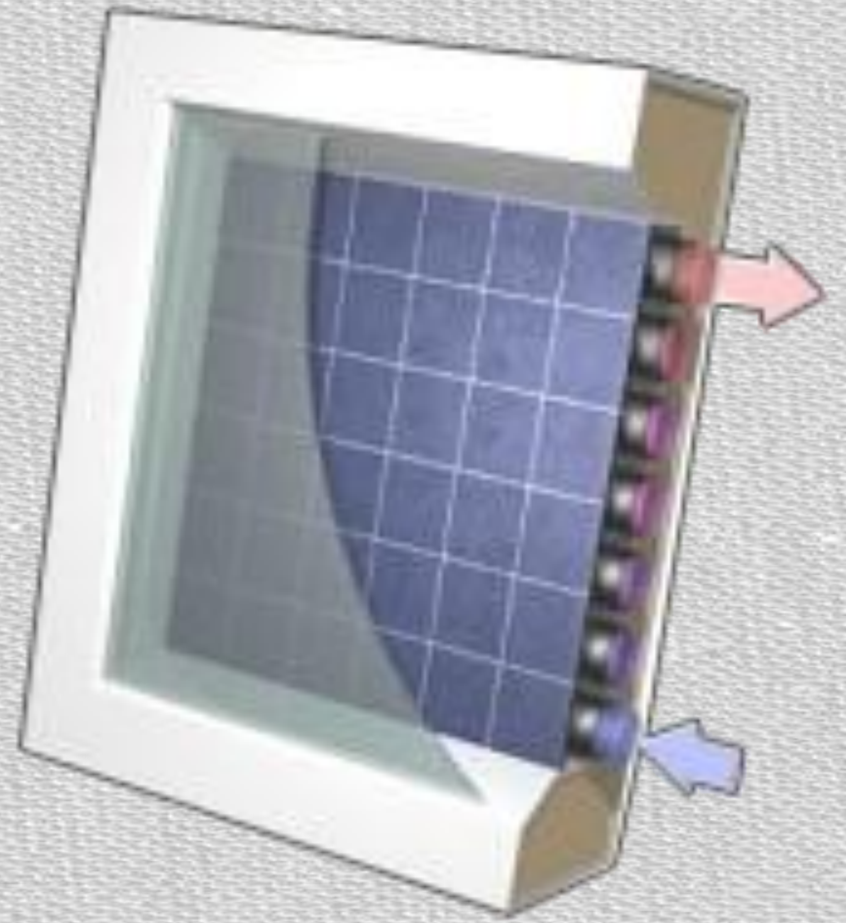
First Cost Savings	$ 181,495.00
Utility Cost Savings	$ 24,727.03
Total	$ 206,222.03

Depth 2 | Hybrid Photovoltaic/Thermal (PVT) Solar System

Redesign Proposal and Goals

- Add hybrid PVT Collectors to the roof
- Produce heat and electricity from solar radiation

PVTWINS Schematic Liquid Collector



Advantages

- More efficient than traditional PV modules
- One unit instead of two | Installation, Materials, Energy

Disadvantages

- Not used frequently
- Costly and little to no incentives

Depth 2 | Hybrid Photovoltaic/Thermal (PVT) Solar System

Design Information

# of Collectors | 10 Collectors

Area | 6.4 m² each collector

Tilt | 40˚

PVTWIN Series 1025 | PVT Liquid Collector

Solar Thermal Energy Output

Month	Solar Radiation (kWh/m²/day)	Energy Output (kWh)	Therms	Cost
January	3.59	4825.0	164.6	$ 189.33
February	4.28	5752.3	196.3	$ 225.72
March	4.80	6451.2	220.1	$ 253.14
Ap[illegible]	[illegible]	[illegible]	[illegible]	[illegible]52
May	[illegible]	[illegible]	[illegible]	[illegible]
June	5.66	7607.0	259.6	$ 298.50
July	5.46	7338.2	250.4	$ 287.95
August	4.38	5886.7	200.9	$ 230.99
September	5.07	6814.1	232.5	$ 267.38
October	4.72	6343.7	216.5	$ 248.92
November	3.56	4784.6	163.3	$ 187.75
December	3.03	4072.3	139.0	$ 159.80
			Total Savings	**$ 2,911.66**

Total Solar Thermal Savings | $2,911.66

Depth 2 | Hybrid Photovoltaic/Thermal (PVT) Solar System

Cost Summary

Total Collector Cost | $98,350

Total PVT Savings | $7,544

Simple Payback | 13 Years

PVTWIN Series 1025 | PVT Liquid Collector

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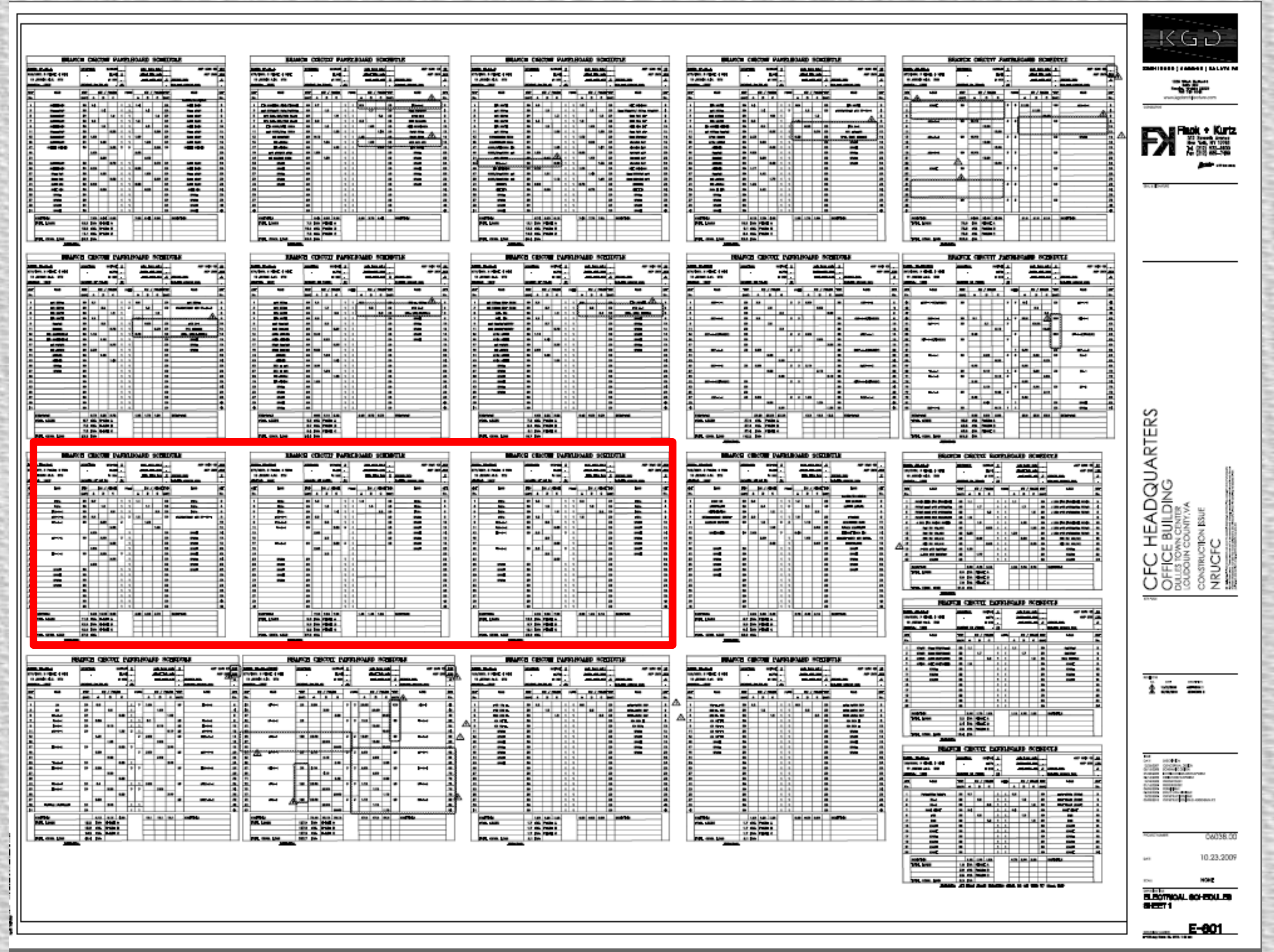
Breadth 1 | Electrical

Redesign Goals

- Condense Panel Boards | Remove FPBs
- Electrical Production of PVT Collectors

Condense Panel Boards



New Feeder Size

(4) #4 + (1) #8 G. in 1-1/4" C. [Type THHN/THWN]

BRANCH CIRCUIT PANELBOARD SCHEDULE

PANEL: PP-1C-C
277/480V, 3 PHASE, 4 WIRE
10,000 A.I.C. SYM
NEUTRAL: 100%

MOUNTING: SURFACE X; FLUSH; IN MCC
NUMBER OF POLES: 42
MAIN LUGS ONLY; SHUNT TRIP MAIN; FEED THRU LUG X
GROUND BUS: X; ISOLATED GROUND BUS:
AMP MAIN CB: 100; AMP BUS: 100

CKT NO.	LOAD	TRIP (AMP)	KW/PHASE A	KW/PHASE B	KW/PHASE C	POLES	POLES	KW/PHASE A	KW/PHASE B	KW/PHASE C	TRIP (AMP)	LOAD	CKT NO.
1				2.80				1.20					2
3	HP-1-1	20			2.80	3	3		1.20		20	TRANSFORMER FOR RP-1C-E	4
5			2.80							1.20			6
7				2.80				2.80					8
9	HP-1-2	20			2.80	3	3		2.80		20	HP-2-1	10
11			2.80							2.80			12
13				2.80				2.80					14
15	HP-1-3	20			2.80	3	3		2.80		20	HP-2-2	16
17			2.80							2.80			18
19				2.80				2.80					20
21	HP-3-1	20			2.80	3	3		2.80		21	HP-3-2	22
23			2.80							2.80			24
25													26
27													28
29													30
31													32
33													34
35													36
37													38
39													40
41													42
	SUBTOTALS		11.20	11.20	11.20			9.60	9.60	9.60		SUBTOTALS	
	TOTAL LOADS (KVA)	20.80	PHASE A										
		20.80	PHASE B										
		20.80	PHASE C										
	TOTAL CONN. LOAD	62.40	KVA										

$$A = \frac{VA}{V} = \frac{62.4\ kVA}{\sqrt{3} * 480V} * 1000$$

$$= \mathbf{75\ Amps}$$

Breadth 1 | Electrical

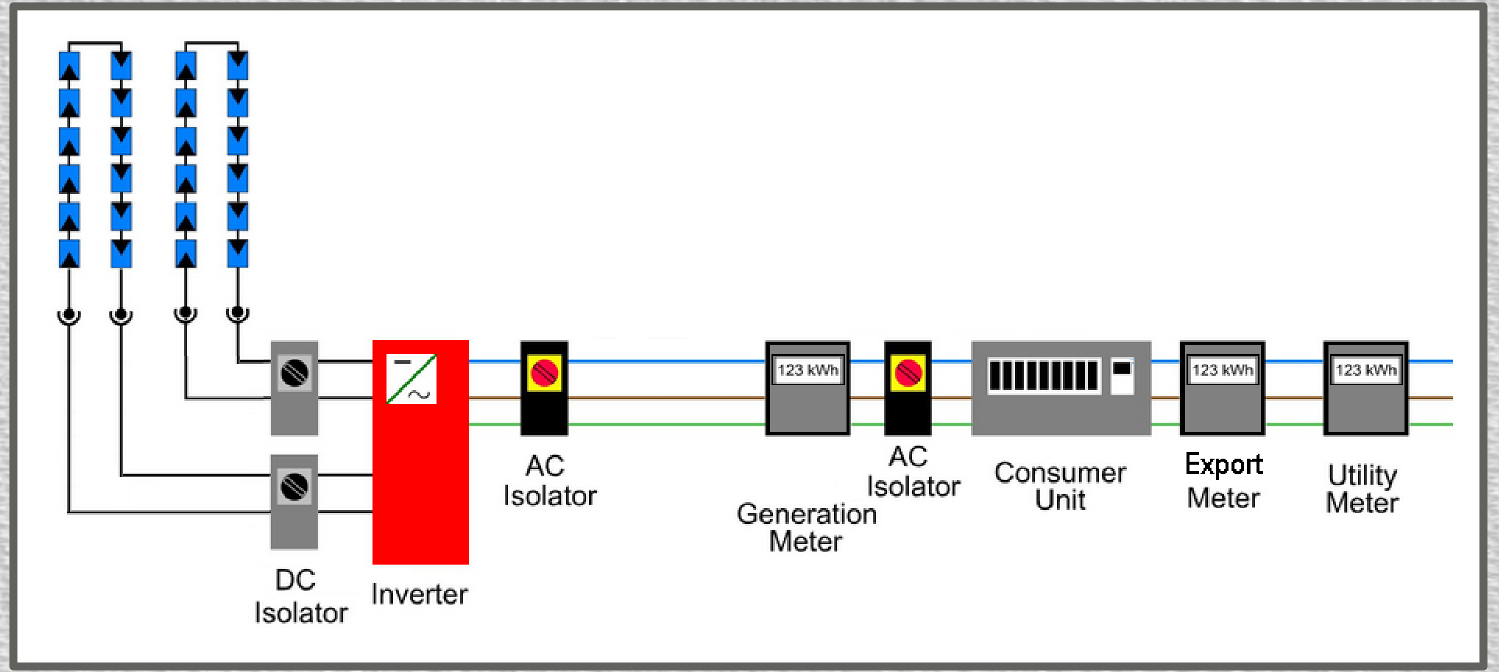
Redesign Goals

- Condense Panel Boards | Remove FPBs
- Electrical Production of PVT Collectors

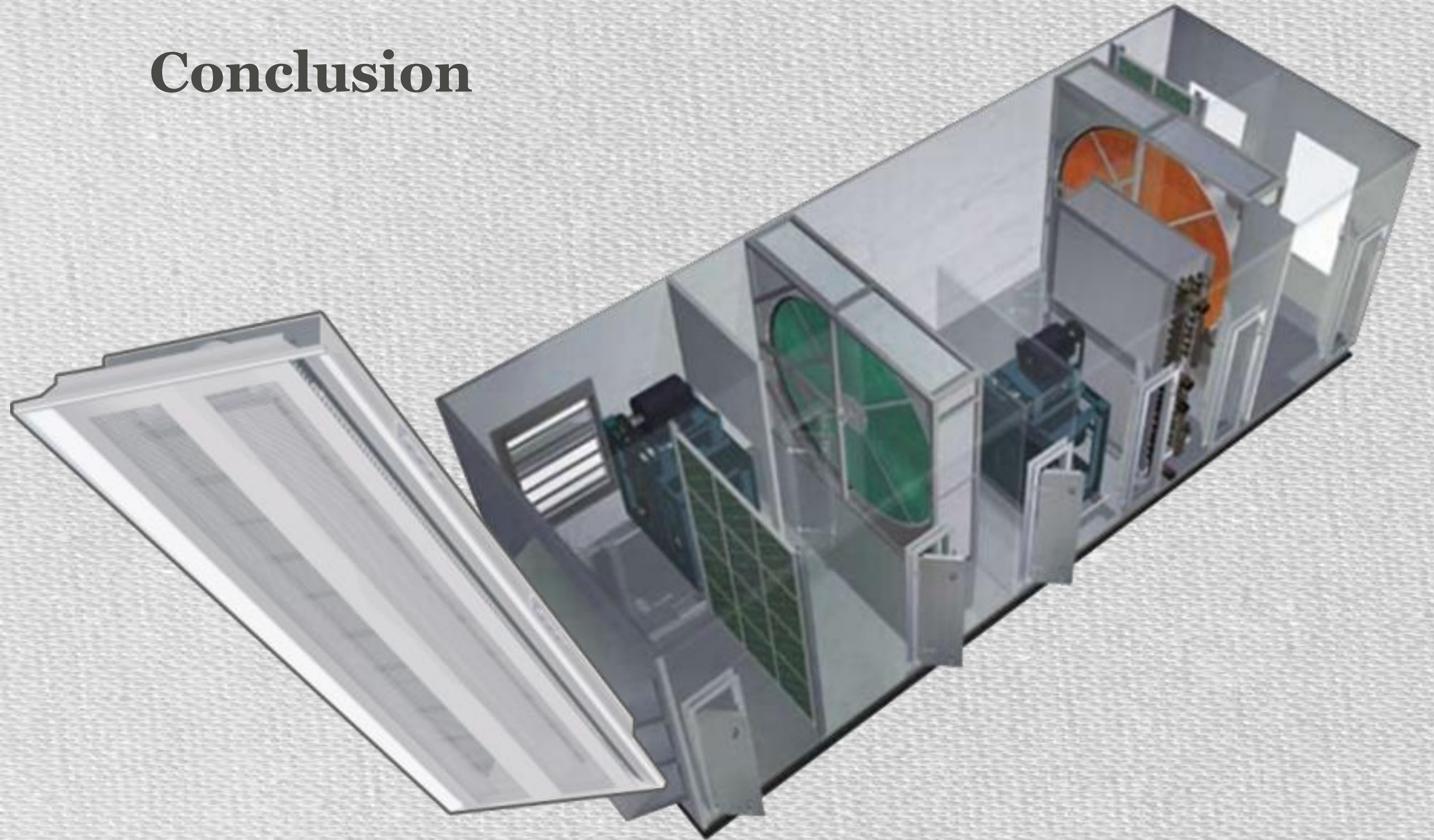
PVT Collector Electric Energy Output

Month	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value ($)
January	3.59	4,164	$ 333.12
February	4.28	4,370	$ 349.60
March	4.80	5,278	$ 422.24
April	5.34	5,457	$ 436.56
May	5.32	5,328	$ 426.24
June	5.66	5,495	$ 439.60
July	5.46	5,354	$ 428.32
August	4.38	5,369	$ 429.52
September	5.07	5,004	$ 400.32
October	4.72	4,967	$ 397.36
November	3.56	3,767	$ 301.36
December	3.03	3,354	$ 268.32
	Total	57,907	**$ 4,632.56**

PV Schematic



Conclusion

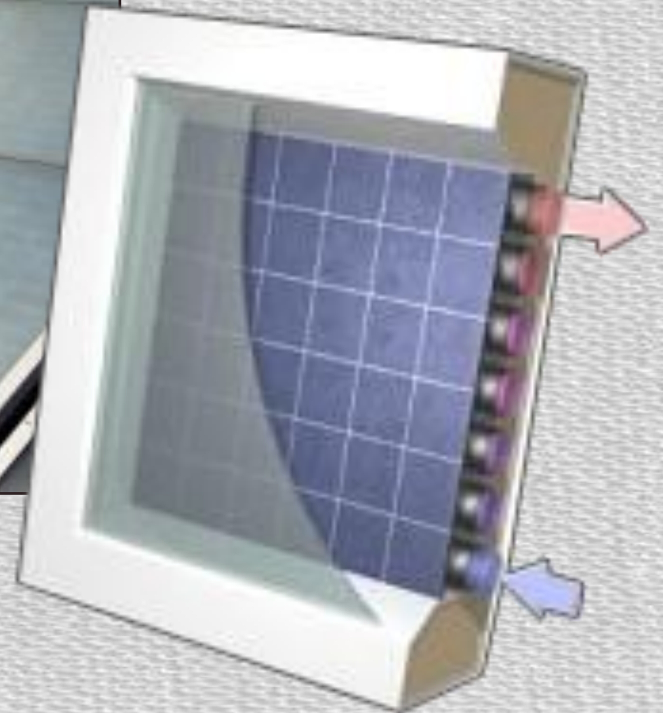


Depth 1 | DOAS w. Chilled Beams

- **Total Savings** | $206,222.03
- **Simple Payback** | 4 years
- **Recommendations**

Depth 2 | Hybrid PVT Solar System

- **Total Savings** | $7,544.22
- **Simple Payback** | 13 years
- **Recommendations**



Acknowledgements

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Alexandra Parris | KGD Architecture

Penn State AE Class of 2012

Friends & Family

Thank you!

Questions?