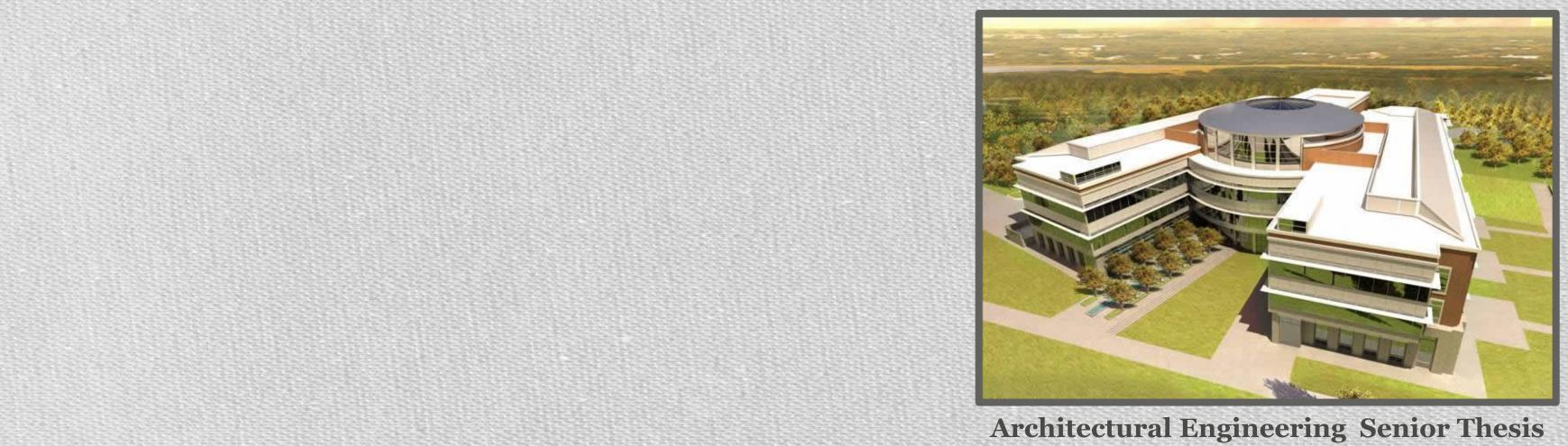
NRUCFC Headquarters Building Sterling, VA



rchitectural Engineering Senior Thesis Margaret McNamara | Mechanical Option Advisor | Dr. Stephen Treado

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Existing Mech. System

Depth 1



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- **Breadth 2 | Architectural**



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- Breadth 2 | Architectural



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- Breadth 1 | Electrical
- Breadth 2 | Architectural





Existing Mech. System

Depth 1

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



Location | Sterling, VA

NRUCFC Headquarters Building | Margaret McNamara | Mechanical | Advisor Dr. Stephen Treado

Acknowledgements



Existing Mech. System

Depth 1

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



Depth 2

Breadth 1

Conclusion

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

Acknowledgements

Systems Overview

Existing Mech. System

Depth 1

Air Side Summary

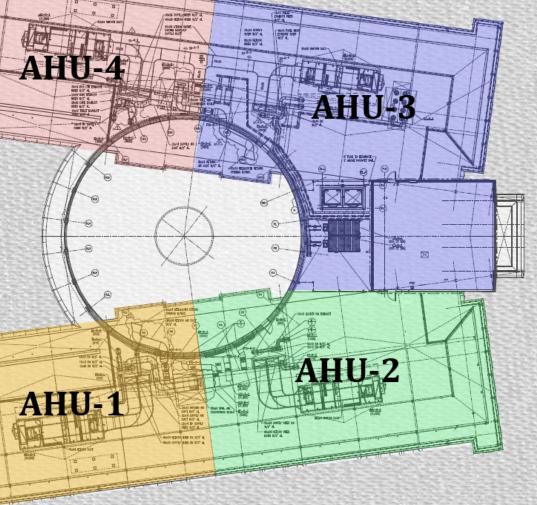
Four Rooftop AHUs | 18,000-24, 000 CFM **Fan Powered Boxes** | Perimeter Heating and Cooling **VAV Boxes** | Interior Heating and Cooling

Atrium Heating and Cooling Ground Source Heat Pumps Radiant Flooring









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

Acknowledgements

Existing Mech. System

Depth 1

Depth 1 | **DOAS** with Chilled Beams

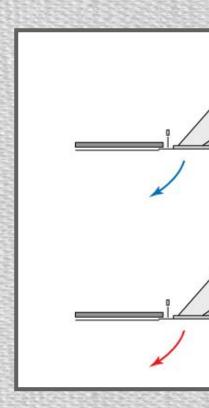
Redesign Proposal

Replace four existing AHUs with DOAS unit

Replace VAVs and FPBs with Chilled Beams

Redesign Goal

Reduce energy consumption **Reduce** airflow



Depth 2

Breadth 1



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



Acknowledgements

Existing Mech. System

Depth 1

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

Depth 2

Breadth 1

Conclusion

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

Chilled Beam Summary

Model	Quantity
IQIC-4	85
IQIC-6	98
IQIC-8	68
Total	251

SEMCO IQID Series

Acknowledgements

Questions

Length	Total Cost				
4'	\$ 72,250.00				
6'	\$ 93,100.00				
8'	\$ 71,400.00				

\$ 236,750.00



Existing Mech. System

Depth 1

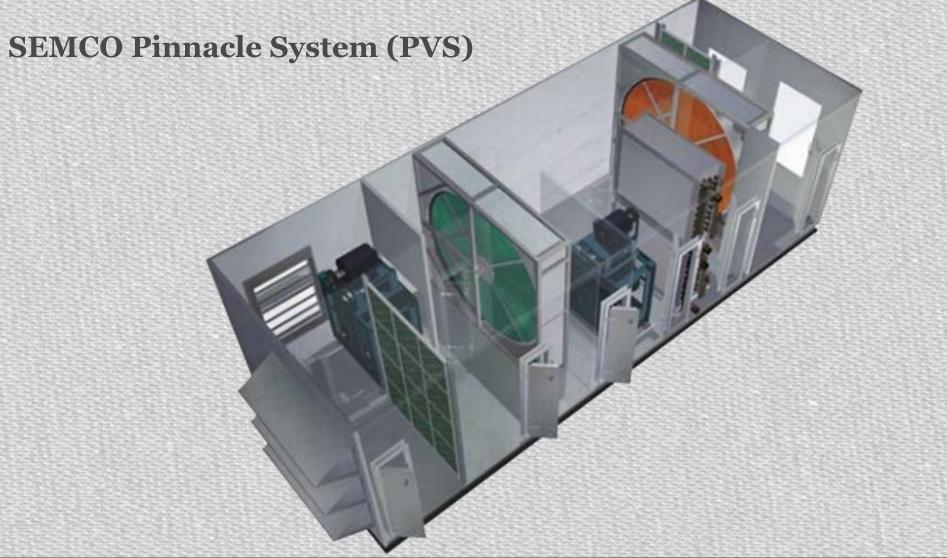
Depth 1 | DOAS with Chilled Beams

DOAS Unit Selection 40,000 CFM



Breadth 1

Conclusion



PVS Advantages

Delivers low dew points Provides high levels of OA and controls humidity Large latent load capacity



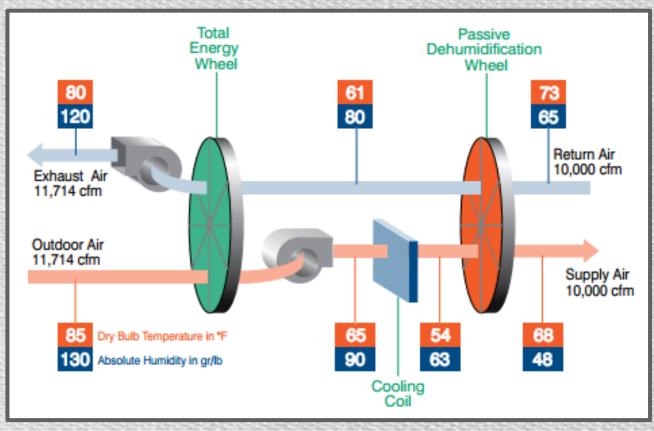
Questions

Total Energy Wheel & Passive Dehumidification Wheel

Existing Mech. System

Depth 1

Depth 1 | DOAS with Chilled Beams



PVS Cooling Mode

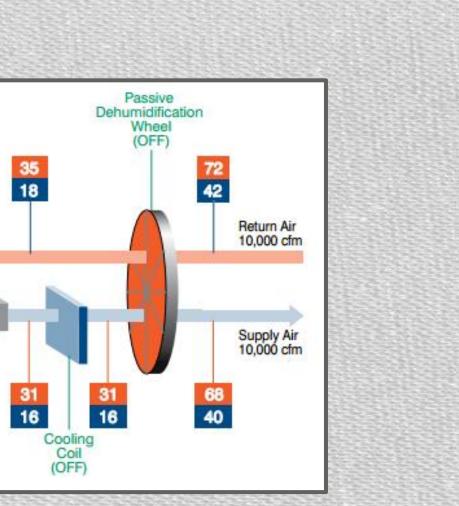


Conclusion Depth 2 Breadth 1 Total Energy Wheel (OFF) Passive Dehumidification Energy Wheel Wheel 75 45 61 60 8 Return Air 10,000 cfm Exhaust Air 11,714 cfm Outdoor Air 11,714 cfm Supply Air 10,000 cfm 15 Dry Bulb Temperature in "F 50 53 Dry Bulb Temperature in *F 6 Absolute Humidity in gr/lb 40 120 Absolute Humidity in gr/lb Cooling Coil **PVS Unoccupied Mode**

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Acknowledgements

Questions



PVS Heating Mode

Depth 1 | DOAS with Chilled Beams

Systems

Overview

Existing

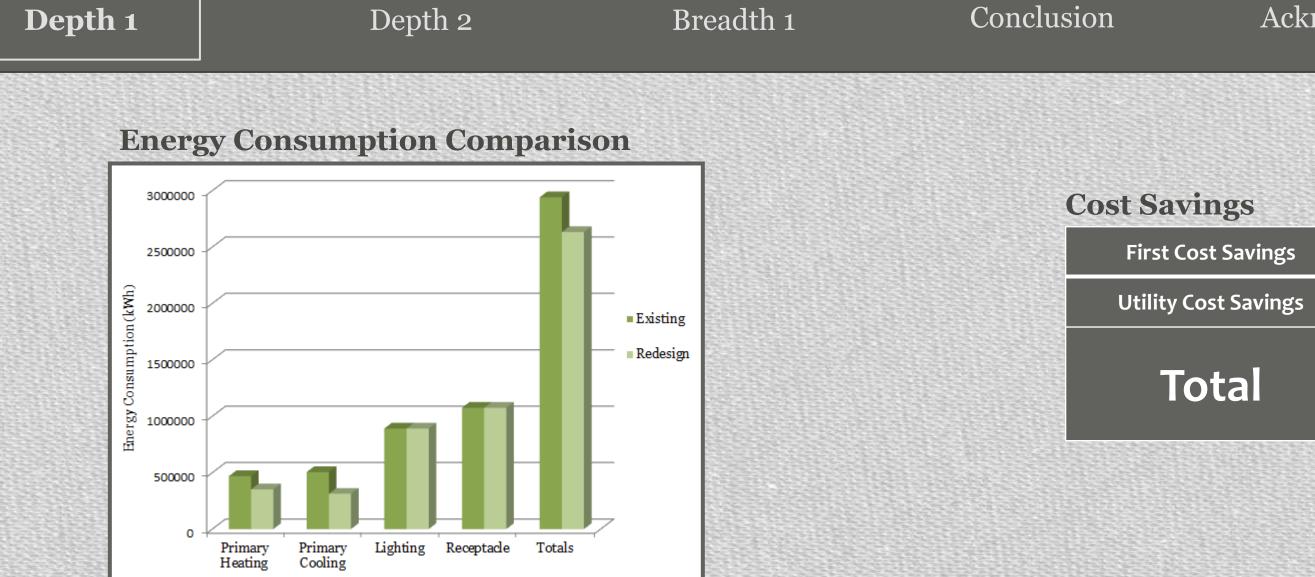
Mech. System

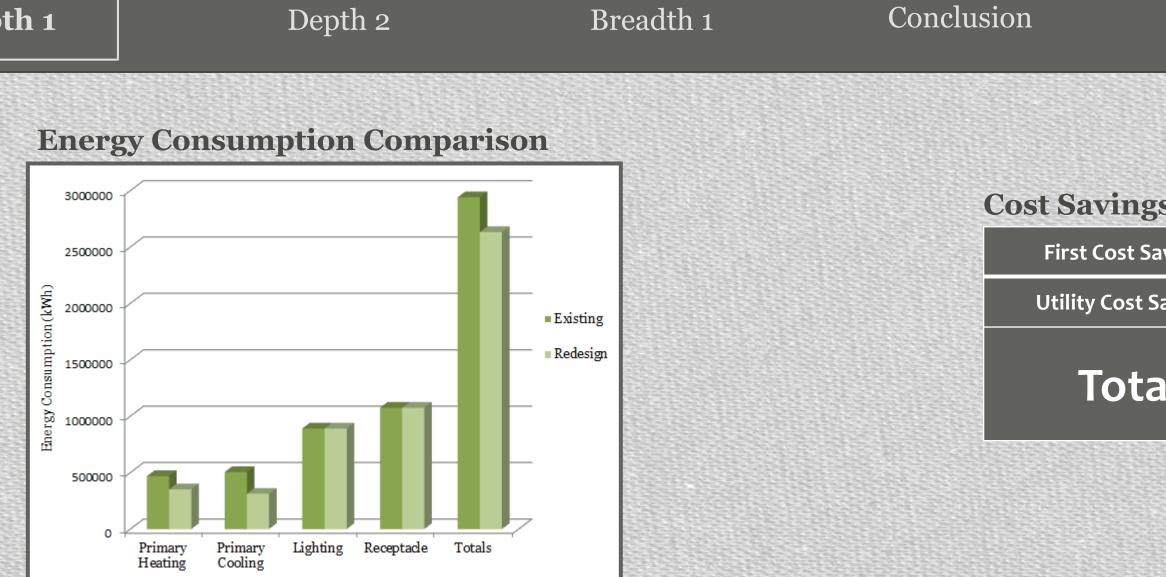
First Cost Comparison

Project

Overview

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			
	Re	designed System	ו				
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			





Acknowledgements

Questions

\$ 181,495.00

\$ 24,727.03

\$ 206,222.03

Systems Overview

Existing Mech. System

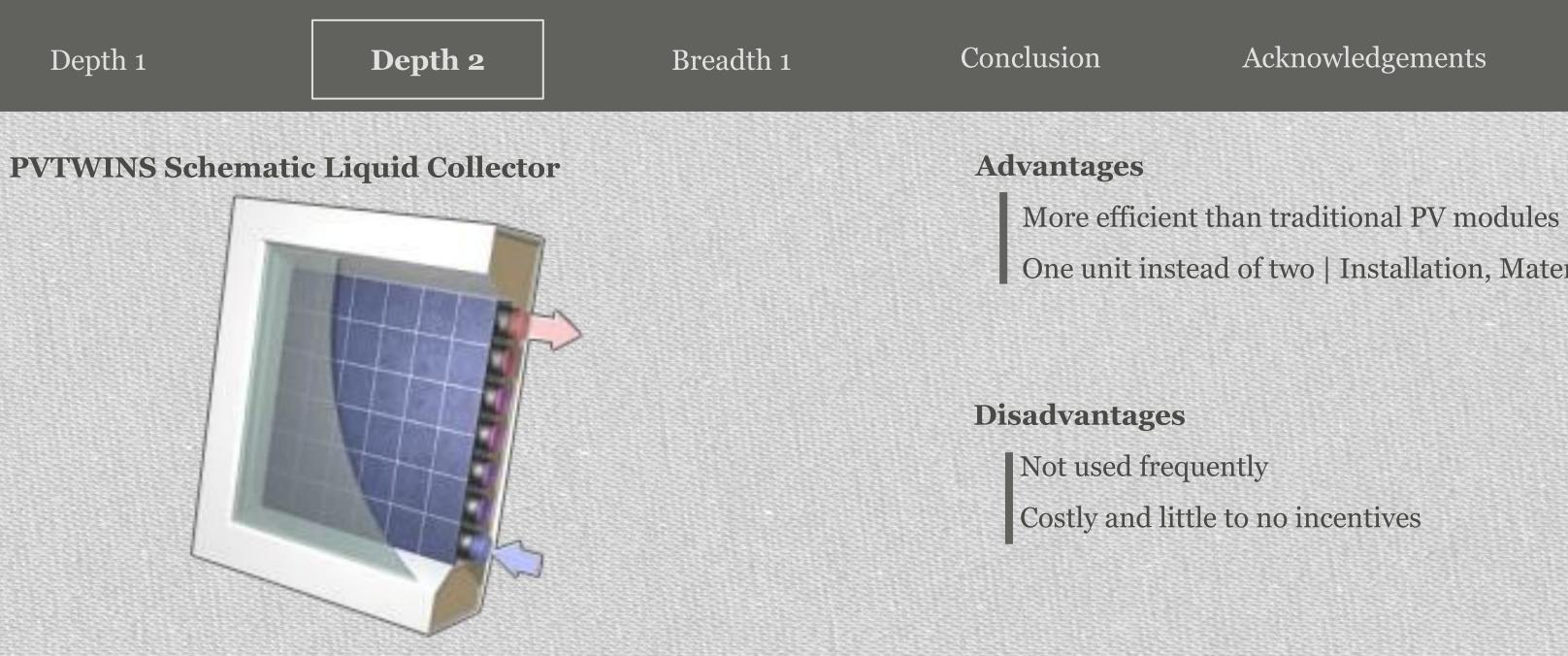
Depth 1

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



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Questions

One unit instead of two | Installation, Materials, Energy



Systems Overview

Existing Mech. System

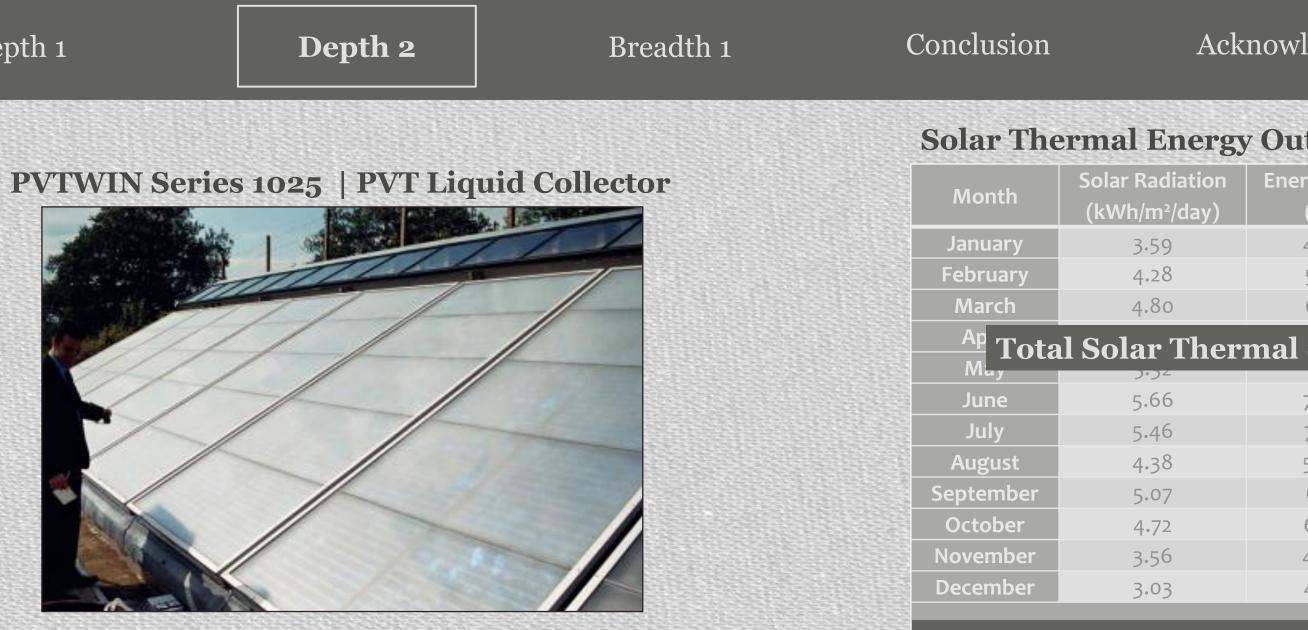
Depth 1

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

Design Information

of Collectors | 10 Collectors Area | 6.4 m² each collector **Tilt** | 40°





Acknowledgements

tput			
rgy Output (kWh)	Therms		Cost
4825.0	164.6	\$	189.33
5752.3	196.3	\$	225.72
6451.2	220.1	\$	253.14
Savings	\$2,911.		52 200.57
7607.0	259.6	ې \$	298.50
7338.2	250.4	\$	287.95
5886.7	200.9	\$	230.99
6814.1	232.5	\$	267.38
6343.7	216.5	\$	248.92
4784.6	163.3	\$	187.75
4072.3	139.0	\$	159.80
Tota	l Savings	\$ 2	,911.66

Systems Overview

Existing Mech. System

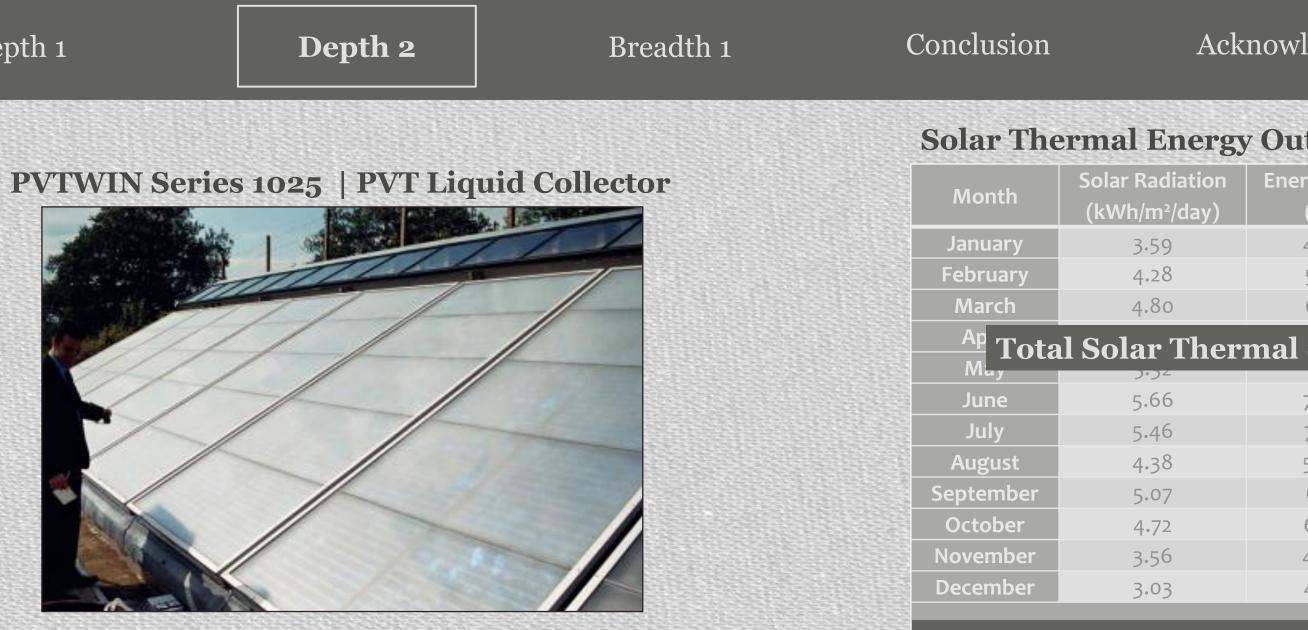
Depth 1

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

Cost Summary

Total Collector Cost | \$98,350 **Total PVT Savings** | \$7,544 Simple Payback | 13 Years





Acknowledgements

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rgy Output (kWh)	Therms		Cost
4825.0	164.6	\$	189.33
5752.3	196.3	\$	225.72
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Tota	l Savings	\$ 2	,911.66

Systems Overview

Existing Mech. System

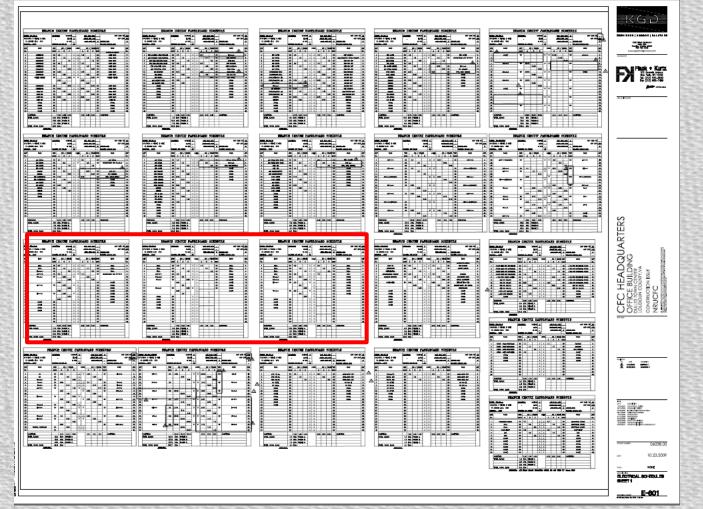
Depth 1

Breadth 1 | Electrical

Redesign Goals

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

Condense Panel Boards



Depth 2

Breadth 1

Conclusion

Acknowledgements

New Feeder Size

(4) #4 + (1) #8 G. in 1-1/2

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11	DP-1-2	~	2.80	<u> </u>	2.80	2	2	⊢	2.60	2.80	<u>~</u>	l
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HP-2-2	14 15 13 1	
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JBTOTALS		= 75 <i>Amps</i>

Systems Overview

Existing Mech. System

Breadth 1 | Electrical

Redesign Goals

Condense Panel Boards | Remove FPBs Electrical Production of PVT Collectors

PVT Colle

Depth 1

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lector	Electric Energy	y Output				
า	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value (\$)		PV Schematic	
у́У	3.59	4,164	\$ 333.12			
ry	4.28	4,370	\$ 349.60			
ו	4.80	5,278	\$ 422.24			
	5.34	5,457	\$ 436.56			
	5.32	5,328	\$ 426.24			
	5.66	5,495	\$ 439.60			
	5.46	5,354	\$ 428.32			
t	4.38	5,369	\$ 429.52			AC Isolator
oer	5.07	5,004	\$ 400.32			Ge
er	4.72	4,967	\$ 397.36		DC Isolator	
					-	

\$ 301.36

\$ 268.32

\$ 4,632.56

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Total

3,767

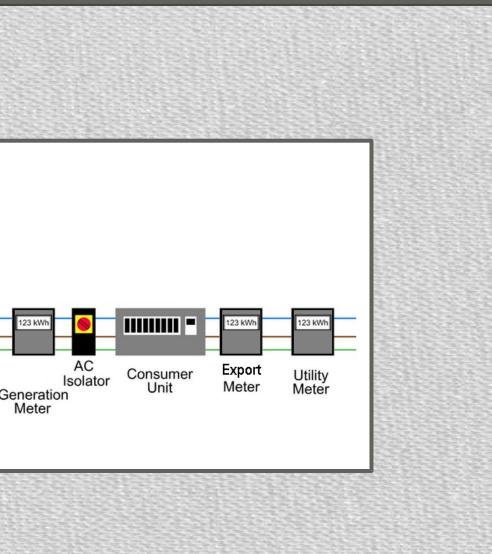
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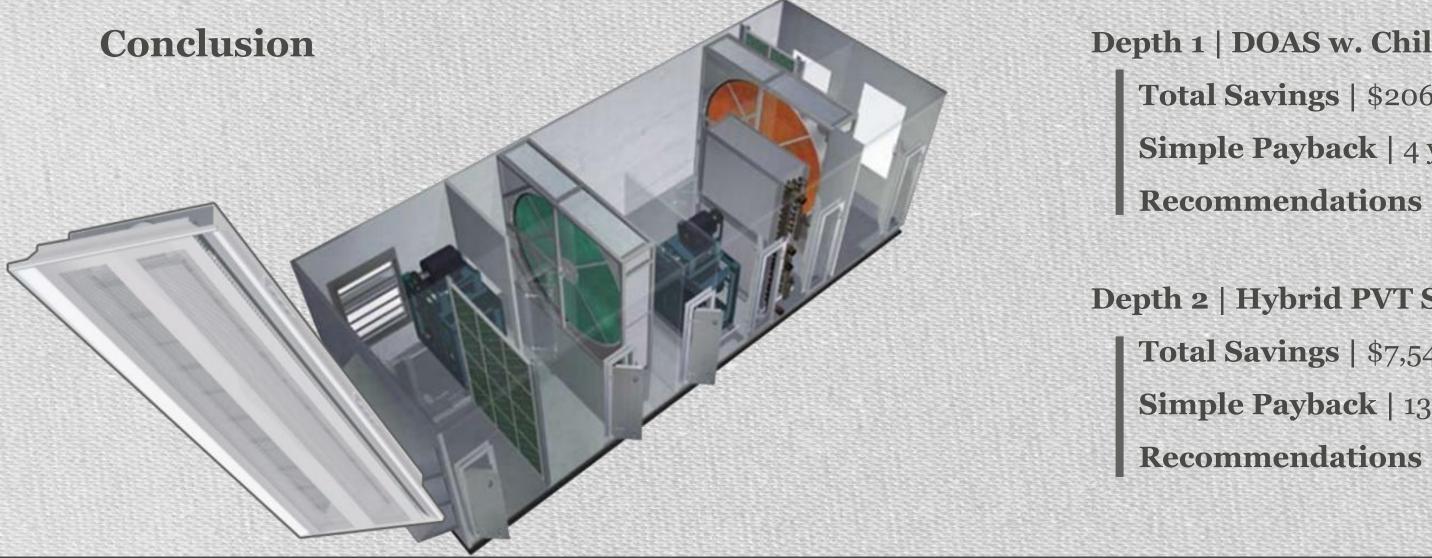
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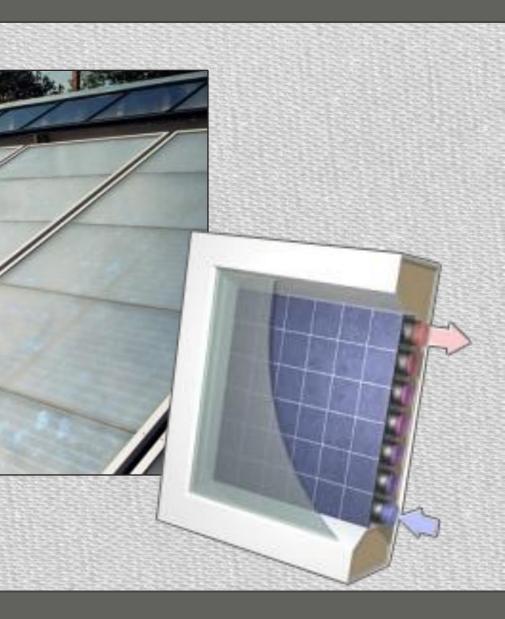
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th 2 Hybr	id PVT Solar System			
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Project	
Overview	

Existing Mech. System

Depth 1

Penn State University Architectural Engineering Faculty

Dr. Stephen Treado | Thesis Advisor Robert Holland | Course Coordinators M. Kevin Parfitt | Course Coordinators

Industry Professionals

Depth 2	Breadth 1	Co

onclusion

Acknowledgements

- **National Rural Utilities Cooperative Finance Corporation**
 - John L. Moone CPM, CFM

- Darren Bruce, PE, LEED AP BD+C | Sebesta Blomberg
- Trevor Boz, LEED AP | WSP Flack+Kurtz
- Alexandra Parris | KGD Architecture

Penn State AE Class of 2012 **Friends & Family**

Acknowledgements

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Systems Overview

Existing Mech. System

Depth 1



Depth 2

Breadth 1

Conclusion

Thank you!

Questions?



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Acknowledgements