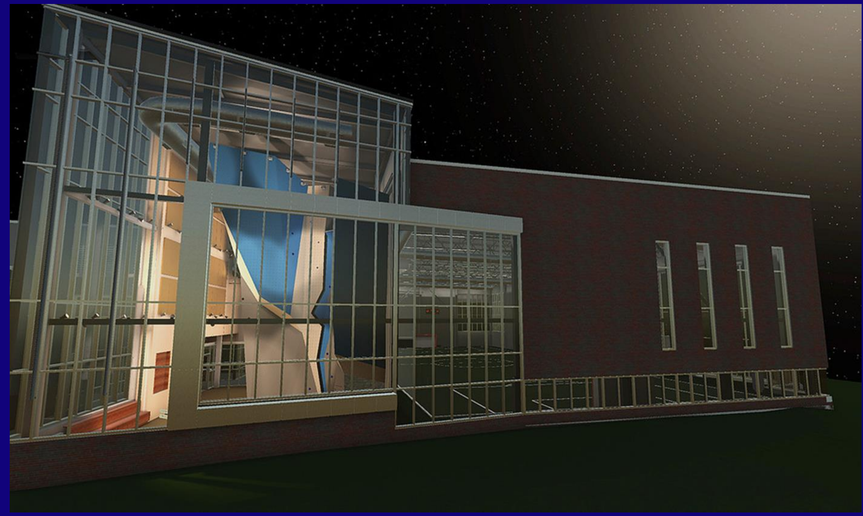
# Penn State University Intramural Building: Phase 3

Issac Colson
Construction Option
Advisor: Dr. Robert Leicht



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# Project General Information

Building Name: IM Addition and Renovation Phase 3

Size: 61,297 SF

Location: University Park Campus

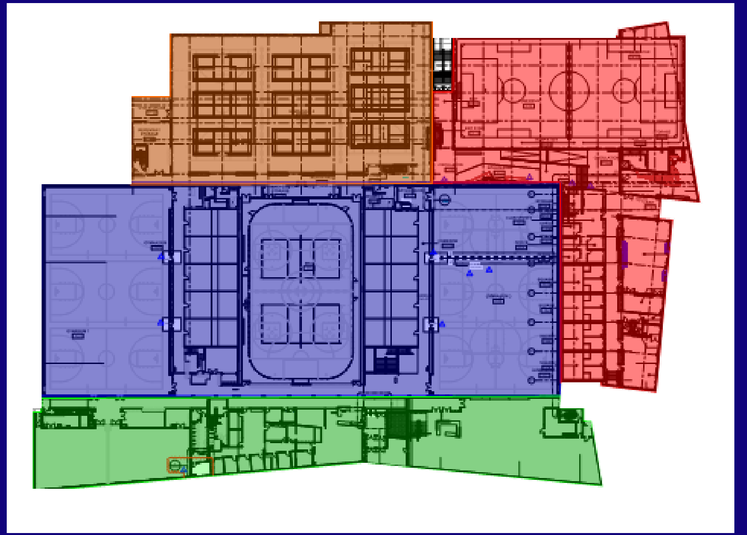
Occupancy Type: Athletic Facility / Mixed Use

Construction Dates: May 2016 – August 2017

Approximate Construction Cost: $17 Million

Delivery Method: Design/Bid/Build, CM at Risk

Existing Building ----------Phase 1----------Phase 2----------Phase 3



# Presentation Overview




## Project Team

Owner: Penn State University

CM: Mortenson Construction

Architect: Moody Nolan

Civil Engineer: Sweetland Engineering

And many more…

# Presentation Overview



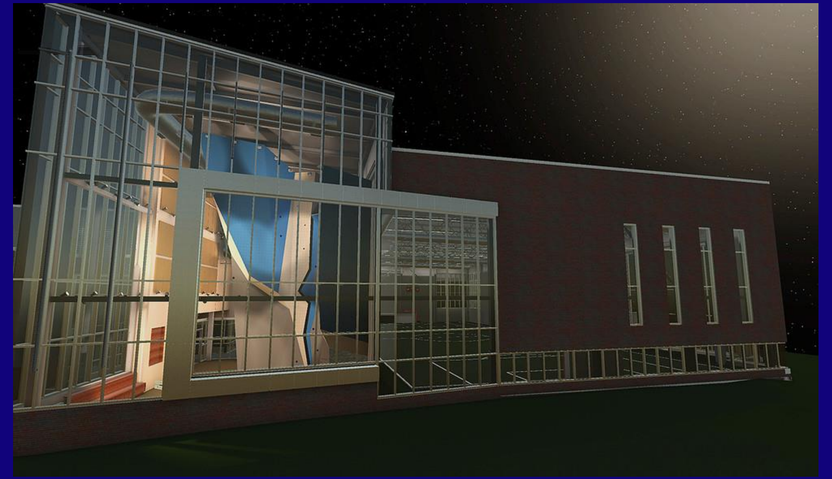
## Notable Features

1.) Rock Climbing Wall

2.) Bouldering Wall

3.) Indoor Turf Field

4.) Table Tennis Area



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# Analysis Overview

## Analysis 1: Alternate Roofing System Analysis

## Structural Breadth

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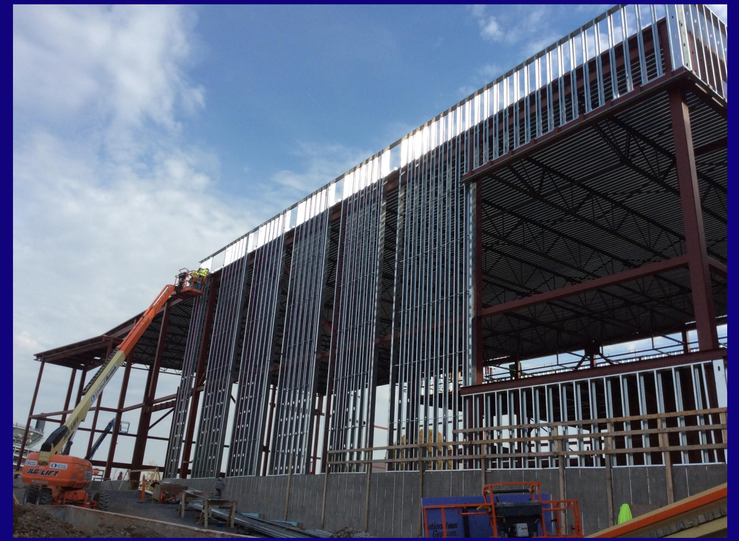
Analysis 2: Modularized Exterior Wall Analysis



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## Analysis Overview

Analysis 3: Alternate Mechanical System Analysis

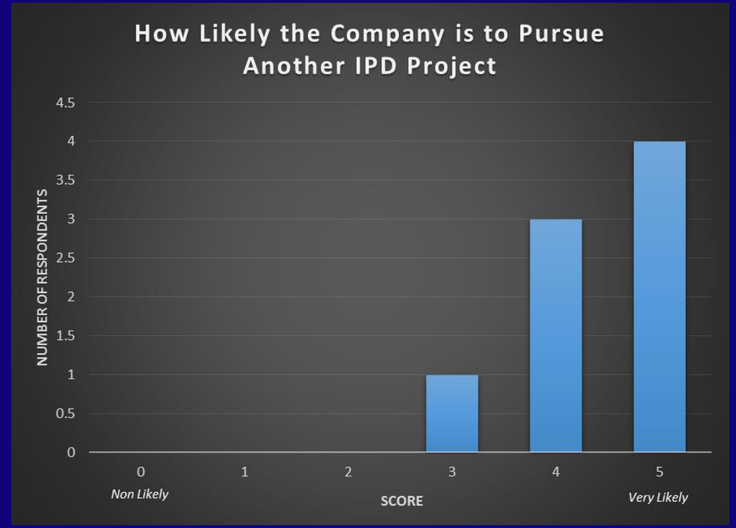
Mechanical Breadth

# Presentation Overview



# Analysis Overview

## Analysis 4: Sub Contractors and IPD Projects



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# Analysis 1: Alternate Roofing System Analysis

## Current System: Modified Bitumen Roofing

Summary of System:

-Middle of the road install time

-Middle of the road life span

-Reliant on roofer experience for installation

-Easy to repair

# Presentation Overview



# Analysis 1: Alternate Roofing System Analysis

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## Options

1. TPO

2. EDPM

3. BUR

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# Option Descriptions

TPO ( Thermoplastic olefin)
Benefits: Cheap, Fast Installation, Durable
Negatives: Seam Durability, Debris Protection

EDPM (ethylene propylene diene monomer)
Benefits: Cost, Ease of Installation, Low Weight
Negatives: Color, Debris Protection

Built Up Roof (hot asphalt and gravel)
Benefits: Life Span, roof durability, flashing durability
Negatives: Weight, Cost, Installation Time, Safety

# Options

1. TPO

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# Options

1. TPO

2. EDPM

3. BUR

# Presentation Overview



# Cost Evaluation

**PSU IM Phase III Roof Cost Comparison**

| Roof Type | Cost | Difference | Percentage |
|---|---|---|---|
| Modified Bitumen | $ 263,098.17 | 0 | 0% |
| EDPM | $ 166,413.14 | $96,685.03 | -37% |
| TPO | $ 177,327.56 | $85,770.61 | -33% |
| Built-Up Roofing | $ 304,001.90 | -$40,903.73 | 16% |

# Cost Summary

EDPM roofing saves a total of $96,000 (37% savings)

TPO roofing saves a total of $85,000 (33% savings)

Built Up roofing did not save any money

Both TPO and EDPM are potential roofing systems that will have monetary savings

# Presentation Overview



# Schedule Evaluation

| PSU IM Phase III Roof Schedule Comparison | | | |
|---|---|---|---|
| Roof Type | Duration | Difference | Percentage |
| Modified Bitumen | 43 | 0 | 0% |
| EDPM | 40 | 3 | -7% |
| TPO | 22 | 21 | -49% |
| Built-Up Roofing | 51 | -8 | 19% |

# Schedule Summary

EDPM roofing saves a total of 3 days (7%)

TPO roofing saves a total of 21 days (44%)

Built Up roofing did not save accelerate the schedule

Both TPO and EDPM are potential roofing systems that will have monetary savings

# Presentation Overview



# Final Conclusions

TPO saves the most time and money upfront and has the most benefits.

EDPM also saves time and money but not as much as TPO. Has several other benefits.

BUR is too costly to the budget and schedule. Does not provide enough benefits to be substituted.

# Presentation Overview



# Final Conclusions

TPO saves the most time and money upfront and has the most benefits.

EDPM also saves time and money but not as much as TPO. Has several other benefits.

BUR is too costly to the budget and schedule. Does not provide enough benefits to be substituted.

# Recommended Option

TPO

# Presentation Overview



# Structural Breadth

## Future Reroofing Option Structural Analysis

-Often less expensive then complete replacement
-Protects valuable building assets by not exposing building
-No delay to day to day operations
-Less future problems

# Things to Consider

-Weight of new system on existing structure

-Current status of existing roof

-Cost Considerations

-Surrounding Area

# Presentation Overview



# Structural Breadth

## Future Reroofing Option Structural Analysis

| System Total Weights | | | |
|---|---|---|---|
| Name | Pounds / SF | SF | Total Weight (Pounds) |
| Modified Bitumen roofing | 6.98 | 35436 | 247343 |
| TPO Roofing | 5.824 | 35436 | 206379 |
| EDPM | 4.382 | 35436 | 155281 |
| Built Up roofing | 8.725 | 35436 | 309179 |

# Presentation Overview



# Structural Breadth

## Future Reroofing Option Structural Analysis

| System Total Weights | | | |
|---|---|---|---|
| Name | Pounds / SF | SF | Total Weight (Pounds) |
| Modified Bitumen roofing | 6.98 | 35436 | 247343 |
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| Built Up roofing | 8.725 | 35436 | 309179 |

| Reroof Dead Load Analysis | | | | | | |
|---|---|---|---|---|---|---|
| Original Roofing System | | | | | | |
| System | System Weight (PSF) | Secondary System | Secondary Weight (PSF) | Total (PSF) | Design Dead Load (PSF) | Exceed? |
| Modified Bitumen | 6.980 | Modified Bitumen | 6.980 | 13.960 | 12 | YES |
| | | TPO | 5.824 | 12.804 | | YES |
| | | EDPM | 4.382 | 11.362 | | NO |
| | | BUR | 8.725 | 15.705 | | YES |
| Prescribed Roofing System | | | | | | |
| System | System Weight (PSF) | Secondary System | Secondary Weight (PSF) | Total (PSF) | Design Dead Load (PSF) | Exceed? |
| TPO | 5.824 | Modified Bitumen | 6.980 | 12.804 | 12 | YES |
| | | TPO | 5.824 | 11.648 | | NO |
| | | EDPM | 4.382 | 10.206 | | NO |
| | | BUR | 8.725 | 14.549 | | YES |

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# Final Conclusions

The original system only allows for a TPO reroofing option

The proposed TPO option allows for a TPO and EDPM reroofing option

TPO presents the best opportunity for future roofing options while still being under the roof design load

# Presentation Overview



# Analysis 2: Modular Exterior Wall Analysis

Current System: Stick Built Exterior Walls

Summary of System:

-Classic stick built wall construction

-Phases construction by installing steel studs, followed by sheathing, brick and other wall components

-Typical construction method but has room to be improved

## Presentation Overview



# Analysis 2: Modular Exterior Wall Analysis

Current System: Stick Built Exterior Walls

Summary of System:

-Classic stick built wall construction

-Phases construction by installing steel studs, followed by sheathing, brick and other wall components

-Typical construction method but has room to be improved

# Option

Modularized Wall Panels

Advantages:

-Saves time on site
-Lower material cost
-Safer working conditions
-Higher quality product

Disadvantage:

-Longer design and lead time

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# Cost Evaluation

| Wall Cost Comparison | | | | |
|---|---|---|---|---|
| Simplified Cost Model | | | | |
| Name | Cost | Shipping Cost | Total | Difference |
| Stick Built Exterior | $888,923.79 | $0.00 | $888,923.79 | NA |
| Modular Wall Panels | $843,264.14 | $4,250.00 | $847,514.14 | 4.7% |

# Cost Summary

Modular walls have a lower cost for materials and labor

Modular walls have an additional shipping cost

Modular walls still present a lower cost option for IM Phase 3

Savings of $41,409.65 (4% of original cost)

# Presentation Overview



# Schedule Evaluation

| Wall Duration Compariosn | | |
|---|---|---|
| Simplfied Schedule Model | | |
| Name | Days | Difference |
| Stick Built Exterior | 84 | NA |
| Modular Wall Panles | 53 | 37% |
| | | |
| *Total Saved* | 31 | |

# Schedule Summary

Original system had a duration of 84 days on site

Installation of modular panels is only 53 days on site

Total savings of 31 days of on site work (37% of original duration)

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# Final Conclusions

The modular walls present a minimal cost saving, while also accelerating the schedule by a significant amount

Added safety and quality of materials is an added benefit of modular walls

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# Final Conclusions

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Added safety and quality of materials is an added benefit of modular walls

# Recommended Option

Modular Walls

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# Analysis 3: Alternate Mechanical System Analysis

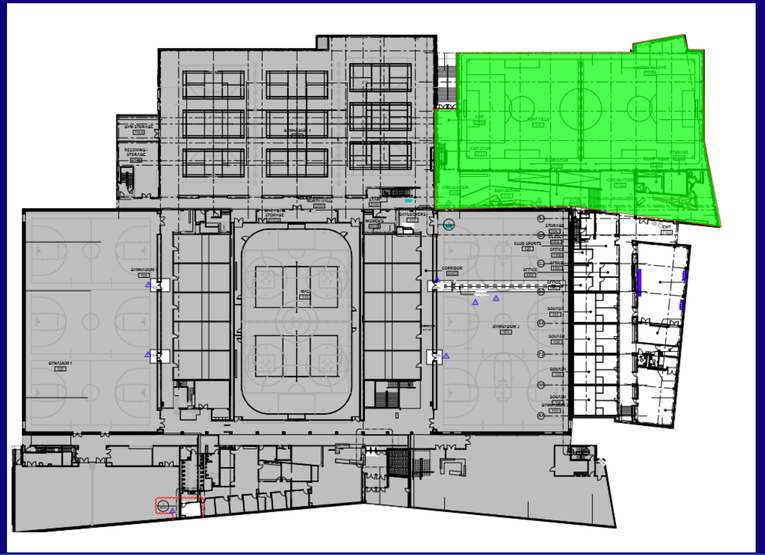
Current System: Hybrid Ventilation System

Summary of System:

-When temperature and humidity levels are met system opens all windows in addition and utilizes only ceiling fans

-Is only active in the bouldering wall area, rock climbing wall, and turf field area shown in green

-Is very energy efficient



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-Is only active in the bouldering wall area, rock climbing wall, and turf field area shown in green

-Is very energy efficient

## Option

Economizer System

Advantages:

-Very similar to existing system

-Brings in outside air using ducts rather than relying on natural ventilation

Disadvantage:

Uses significantly more power during operational periods

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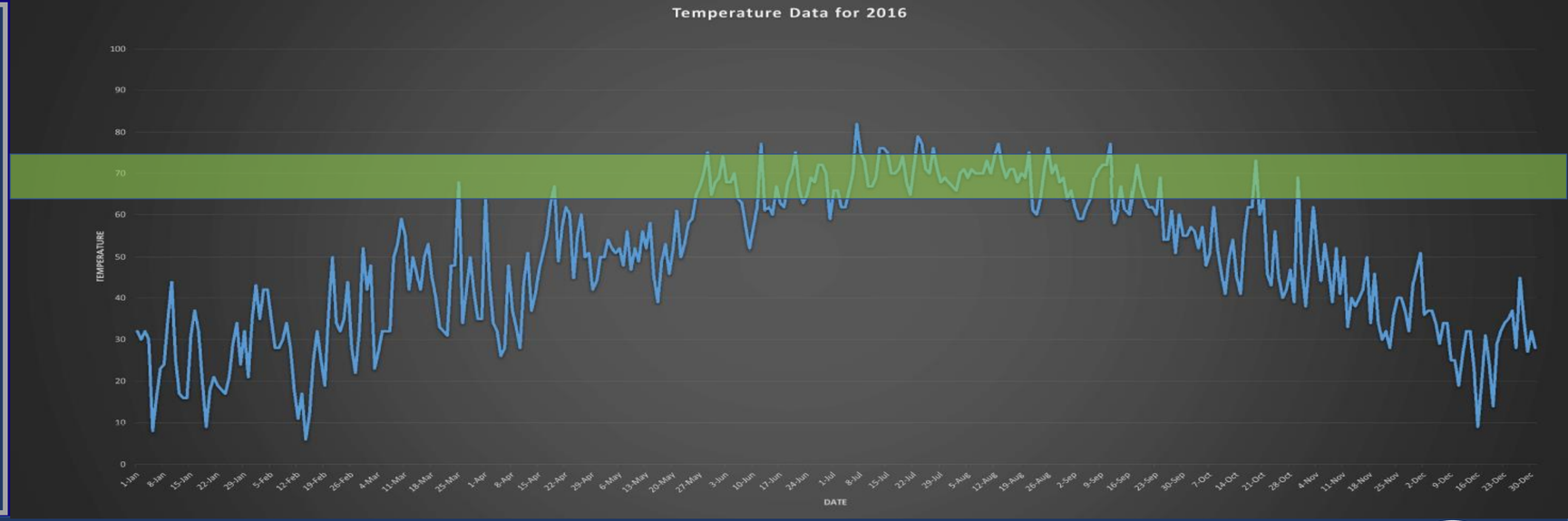

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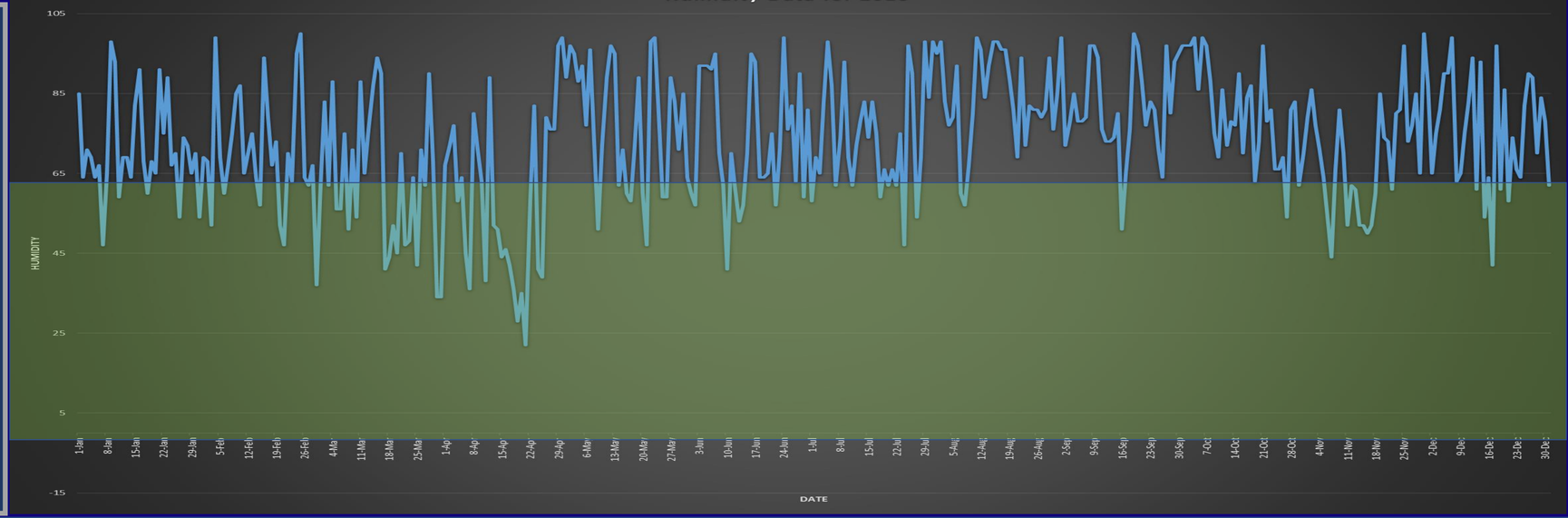

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**Zone Temperature Comparisons for Ventilation System**

| Month | Highest Temp. | Lowest Temp. | Total Hours | Zone 1 | |
|---|---|---|---|---|---|
| | | | | Hours Active | Percent |
| January | 59 | 17 | 744 | 0 | 0% |
| February | 64 | 17 | 696 | 0 | 0% |
| March | 77 | 32 | 744 | 31 | 4% |
| April | 78 | 19 | 720 | 88 | 12% |
| May | 86 | 35 | 744 | 60 | 8% |
| June | 86 | 42 | 720 | 162 | 23% |
| July | 95 | 53 | 744 | 80 | 11% |
| August | 91 | 51 | 744 | 46 | 6% |
| September | 87 | 42 | 720 | 122 | 17% |
| October | 80 | 28 | 744 | 52 | 7% |
| November | 71 | 24 | 720 | 8 | 1% |
| December | 51 | 4 | 744 | 0 | 0% |
| *Total* | | | 8784 | 649 | 7% |

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**Energy Costs per Year**

**Hybrid Ventilation System**

| Year | KWH | Cost / KWH | Total |
|---|---|---|---|
| 2017 | 623 | 13.2 | $ 82.24 |
| 2027 | 623 | 14.3 | $ 89.09 |
| 2037 | 623 | 15.31 | $ 95.38 |
| 2047 | 623 | 16.4 | $ 102.17 |
| | | *Total* | $ 2,856.42 |

**Economizer System**

| Year | KWH | Cost / KWH | Total |
|---|---|---|---|
| 2017 | 23364 | 13.2 | $ 3,084.05 |
| 2027 | 23364 | 14.3 | $ 3,341.05 |
| 2037 | 23364 | 15.31 | $ 3,577.03 |
| 2047 | 23364 | 16.4 | $ 3,831.70 |
| | | *Total* | $ 107,460.38 |

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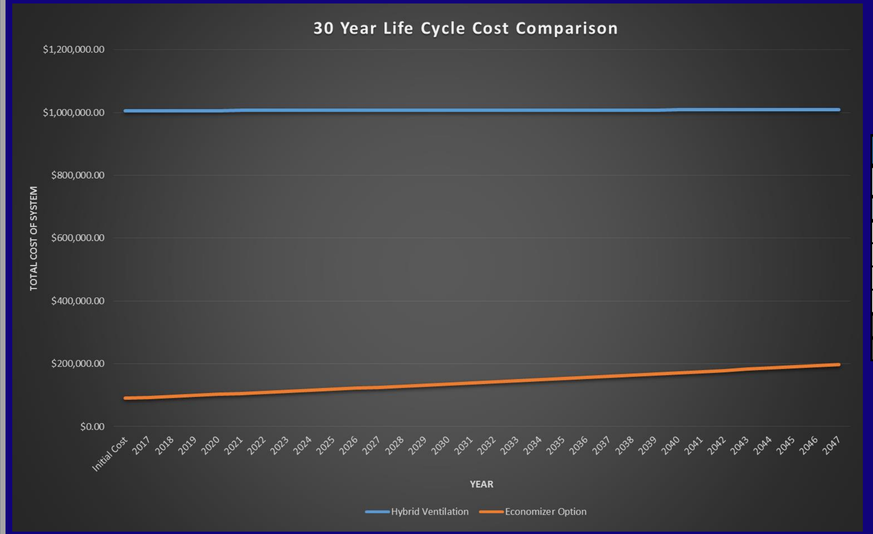


**Energy Costs per Year**

| Hybrid Ventilation System | | | | Economizer System | | | |
|---|---|---|---|---|---|---|---|
| Year | KWH | Cost / KWH | Total | Year | KWH | Cost / KWH | Total |
| 2017 | 623 | 13.2 | $ 82.24 | 2017 | 23364 | 13.2 | $ 3,084.05 |
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# Cost Evaluation

| Mechanical System Cost Summary | | | | | |
|---|---|---|---|---|---|
| Life Cycle Cost | | | | | |
| System | Initial Construction Cost | Cost Year 1 | Cost Year 10 | Cost Year 20 | Cost Year 30 |
| Hybrid Ventialtion Systm | $1,005,889.05 | $1,005,971.29 | $1,006,828.97 | $1,007,767.33 | $1,008,754.48 |
| Economizer System | $90,114.31 | $93,198.36 | $125,363.58 | $160,554.44 | $197,574.69 |
| | | | | | |
| *Total Difference* | $915,774.74 | $912,772.93 | $881,465.39 | $847,212.90 | $811,179.78 |
| *Pecentage* | 91% | 91% | 88% | 84% | 80% |

# Cost Summary

Life cycle cost took into affect power usage over of each system over the period of running

Also compares initial upfront costs

The comparison lasted for 30 years with estimated power prices

Economizer system was significantly less expensive after 30 years

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# Schedule Evaluation

| Mechanical System Schedule Summary | | | | | |
|---|---|---|---|---|---|
| System Durations | | | | | |
| System | Start Date | End Date | Duration | Difference | Percentage |
| Hybrid Ventilation System | 28-Nov-16 | 26-Dec-16 | 21 | N/A | N/A |
| Economizer System | 28-Nov-16 | 12-Dec-16 | 11 | 10 | 48% |

# Schedule Summary

Hybrid ventilation system would have a duration of 21 days

The economizer edition would save 10 days (48% of the construction time)

The economizer would be the better option in terms of schedule savings

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# Final Conclusions

The economizer system present the best option in terms of upfront cost and schedule reduction

The hybrid ventilation system outperforms the economizer system in terms of energy savings

Over 30 year period economizer is still the preferred option

Adjustments made to acceptable temperatures and humidifies may change final conclusions

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# Recommended Option

Economizer System

# Presentation Overview



## Analysis 4: Subcontractors and IPD Project

Surveys were given to several subcontractors working at Penn State

The surveys gauged subcontractor experience with IPD projects

Also asked them to rank and compare several notable benefits know to come from IPD Projects

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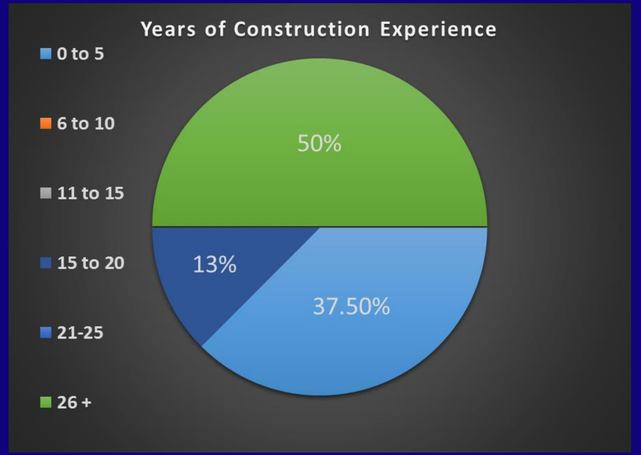
# Survey Results



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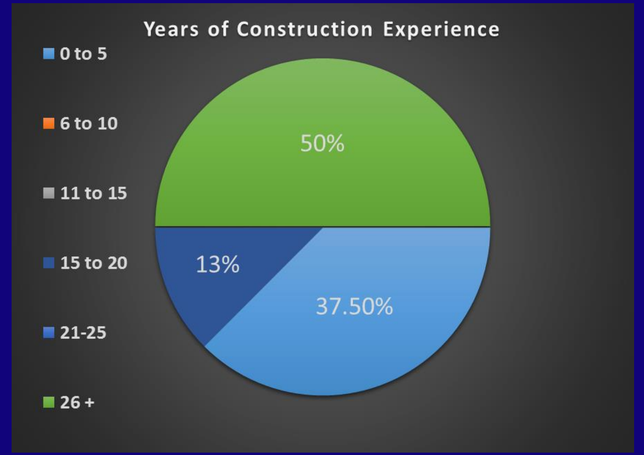


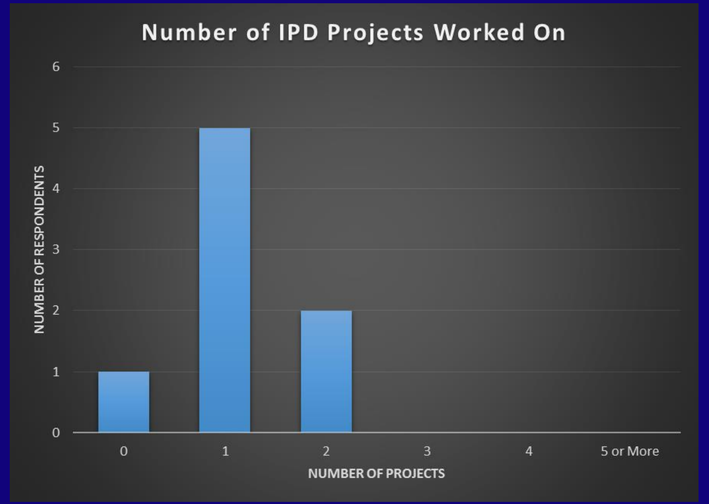

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Structural Breadth

Analysis 2: Modularized Exterior Wall Analysis

Analysis 3: Alternate Mechanical System Analysis

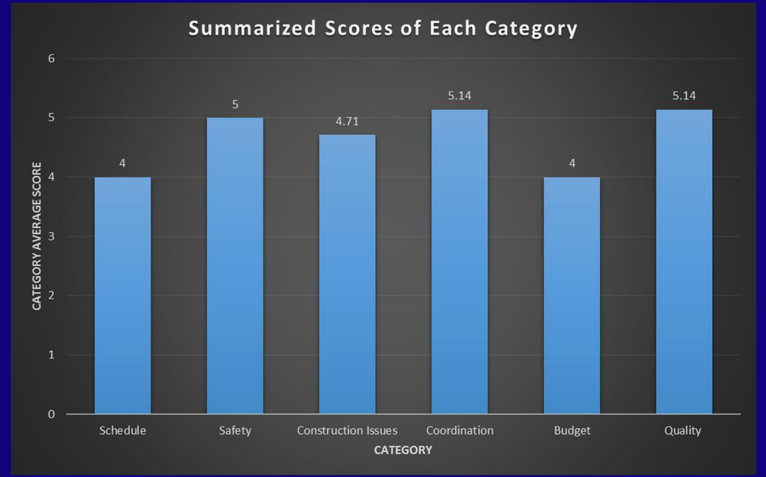
Mechanical Breadth

Analysis 4: Sub Contractors and IPD Projects

Final Recommendations

Acknowledgements

# Survey Results



# Presentation Overview

Project Overview
Analysis Overview
Analysis 1: Alternate Roofing System Analysis
Structural Breadth
Analysis 2: Modularized Exterior Wall Analysis
Analysis 3: Alternate Mechanical System Analysis
Mechanical Breadth
Analysis 4: Sub Contractors and IPD Projects
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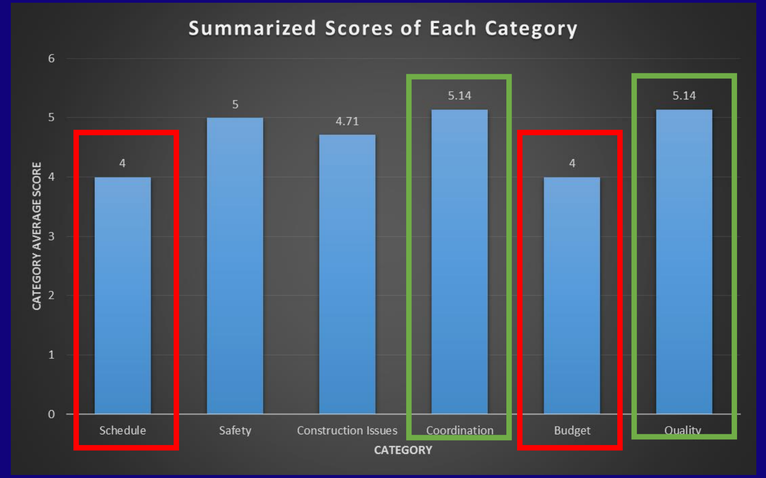
# Survey Results




***Highest Rated:***
Quality
Coordination

***Lowest Rated:***
Budget
Schedule

# Presentation Overview

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# Conclusion

Subcontractors have a different view of IPD projects than GCs and CMs

More education should be provided to contractors to help them understand the benefits of IPD

Educating subcontractors enables them to create better project

Can help to increase the quality of construction across the board

# Presentation Overview



## Final Recommendations

## Option Suggested

| | |
|---|---|
| Analysis 1 | TPO Roofing |
| Analysis 2 | Modular Exterior Walls |
| Analysis 3 | Economizer System |

# Presentation Overview



## Final Recommendations

## Option Suggested

Analysis 1 — TPO Roofing

Analysis 2 → Modular Exterior Walls

Analysis 3 — Economizer System

# Presentation Overview



## Final Recommendations

## Option Suggested

Analysis 1 — TPO Roofing

Analysis 2 — Modular Exterior Walls

Analysis 3 → Economizer System

# Presentation Overview



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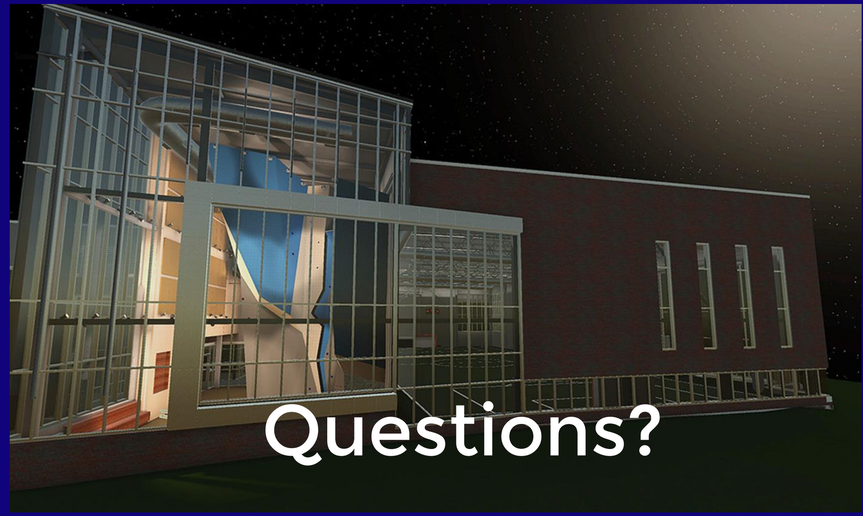
Dr. Robert Leicht
Professor Paul Bowers
And all of the Penn State AE Faculty and staff

***Special Thanks***
Friends
Family
Fellow AEs


# Thank You !

Issac Colson
Construction Option
Advisor: Dr. Robert Leicht



# Picture Credits

- Slide 1: Mortenson Construction Renderings
- Slide 2-4: Mortenson Floor Plan
- Slide 5: Each Logo Comes From the Companies Official Websites
- Slide 6-9: Mortenson Construction Renderings
- Slide 10-12: Mortenson Weekly Updates Photos taken On Site
- Slide 14: Roofing Pictures
  - http://guyroofing.com/commercial/roofing-types/modified-bitumen-roofing\
  - http://www.superiortyler.com/modified-bitumen.html
  - http://www.durablecoolroofs.com/services/app-sbs-bitumen
- Slide 15: Pictures Repeated from Slide 14 and adding
  - http://www.gaf.com/roofing/commercial/products/single_ply_roofing/everguard_tpo_single_ply_membranes
  - http://www.georoofingaz.com/tpo-roofing-phoenix/
  - http://www.epdmroofs.org/what-is-epdm
  - http://coroofcraft.com/types-of-roofs/built-up-roof-bur-membranes/
  - https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwjf3KC0xYnTAhVL1hoKHYQ0AdUQjxwIAw&url=http%3A%2F%2Fwww.boonebrothers.com%2Findex.php%2Froofing-systems%2Fbuilt-up-roofing%2F&bvm=bv.151325232,d.ZGg&psig=AFQjCNFXNafgXB1Lgk9UyMbN-yZMvno59g&ust=1491351951426422
- Slide 17-19: Same Pictures Used as slide 15
- Slide 26: https://www.decorconstruction.com/tpo/
- Slide 27: Mortenson Construction Photo
- Slide 33: Mortenson Construction Drawing