mckinstry oregon headquarters portland or

alex wyczalkowski

mechanical option

senior thesis presentation

april 15 2009

OVERVIEW

- **INTRODUCTION**
- DESIGN OBJECTIVES
- EXISTING CONDITIONS
- MECHANICAL REDESIGN
- ENERGY & COST ANALYSIS
- LIGHTING REDESIGN
- CONCLUSIONS

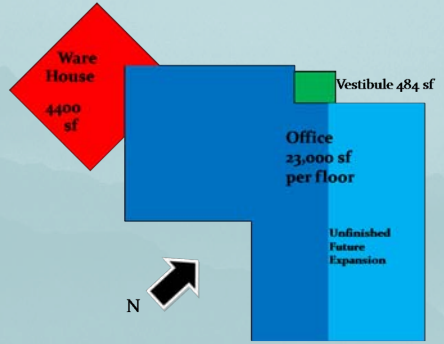
Design Objectives

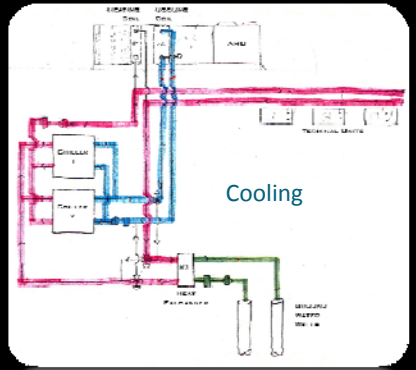
- Sustainability
- Comfort
- Economy

Building Overview

Stats

- Total SF: 50,590
- $11.1 million
  - $219.40/SF
- $1.39 million mechanical cost
  - $27.48/SF

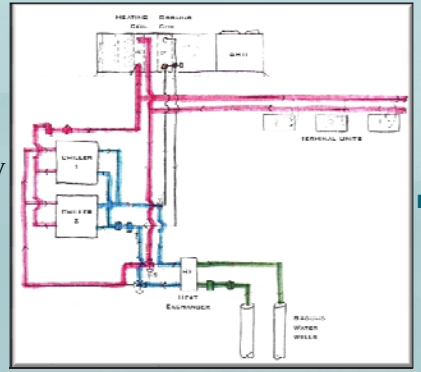




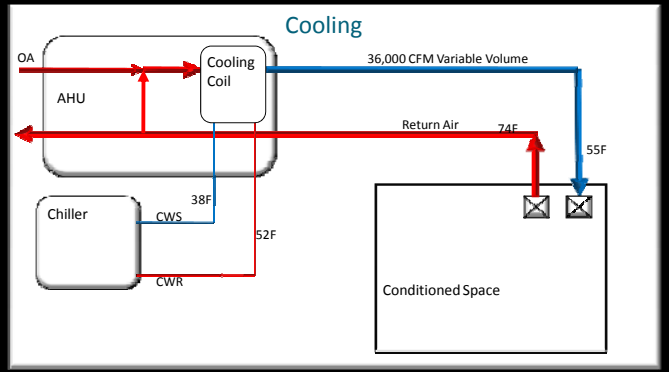
Waterside Mechanical

Heating

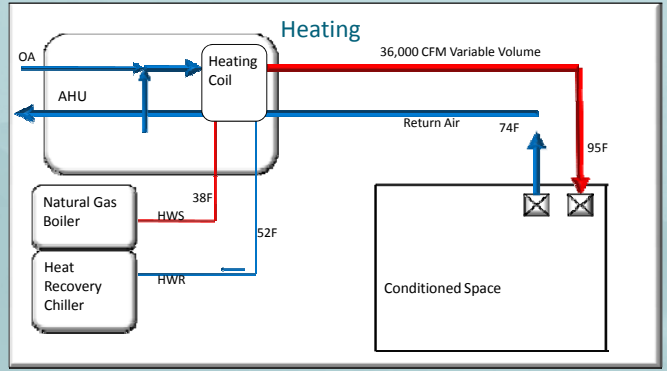
- Heat Recovery Chiller
- Boiler Added



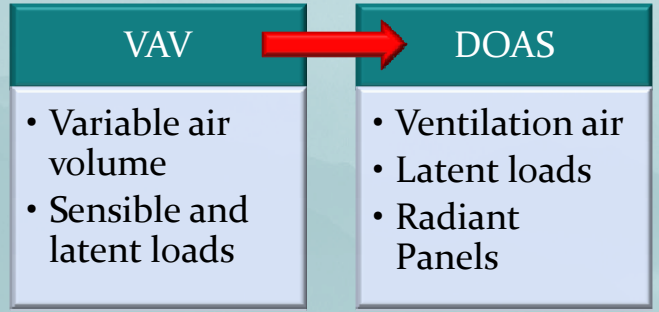
- VAV System
- Open Loop Ground Water Heat Transfer

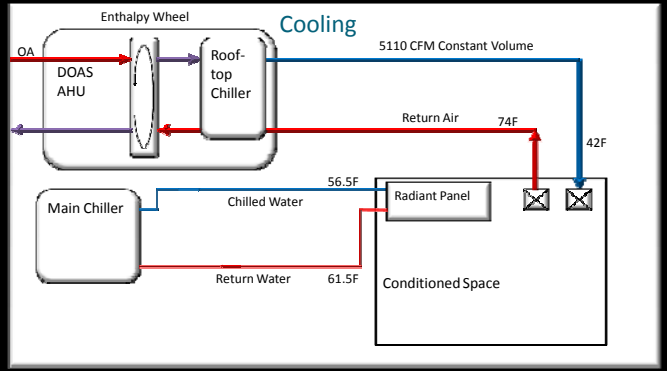


Variable Air Volume

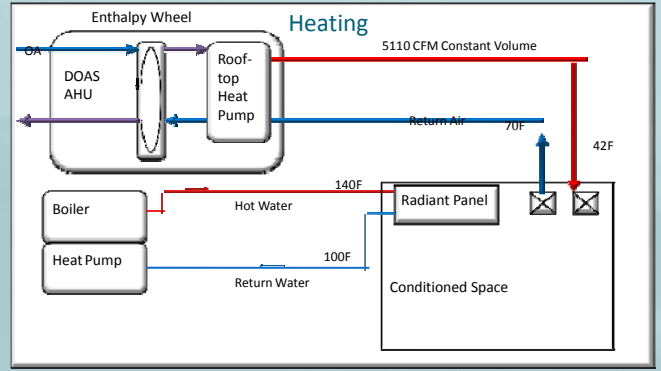


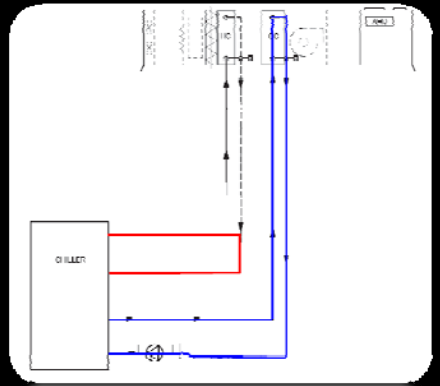
Mechanical Redesign





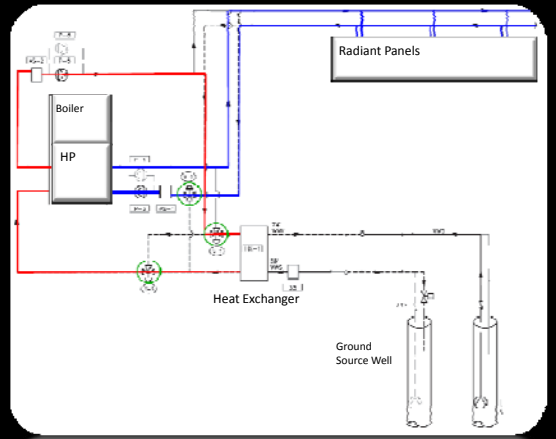
Dedicated Outdoor Air System





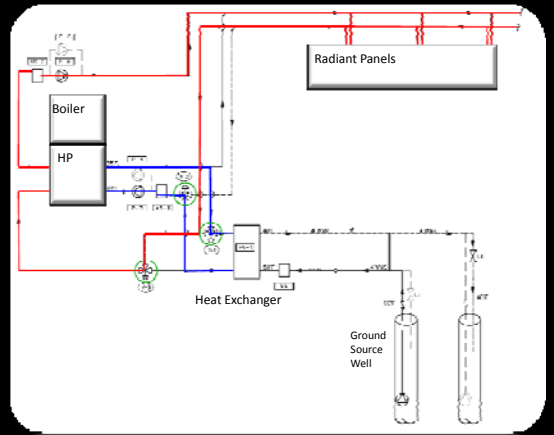
Central Plant Considerations

- System Split
  - Ventilation Air
    - 42F



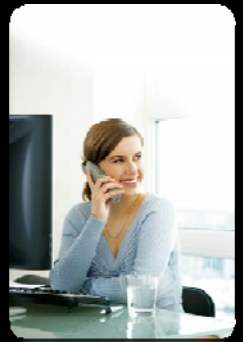
Central Plant Considerations

- System Split
  - Ventilation Air
    - 42F
  - Radiant Panels
    - 56.5F



Central Plant Considerations

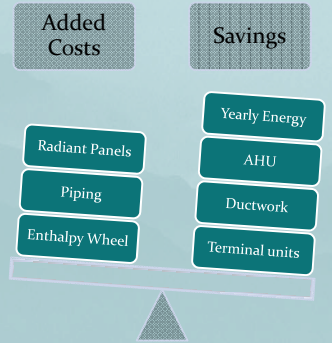
- System Split
  - Ventilation Air
    - 42F
  - Radiant Panels
    - 56.5F
- Hot Water Temperature
  - Efficiency vs. thermal stratification
  - Raise ΔT

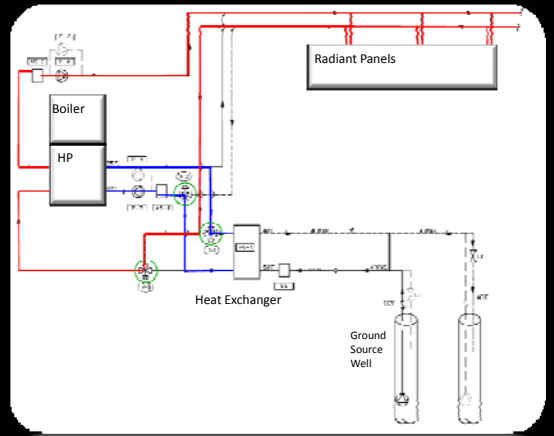


DOAS - Comfort

- Proper Ventilation
  - No mixed air
- Humidity Control
  - Latent and Sensible Loads Decoupled

DOAS - Costs

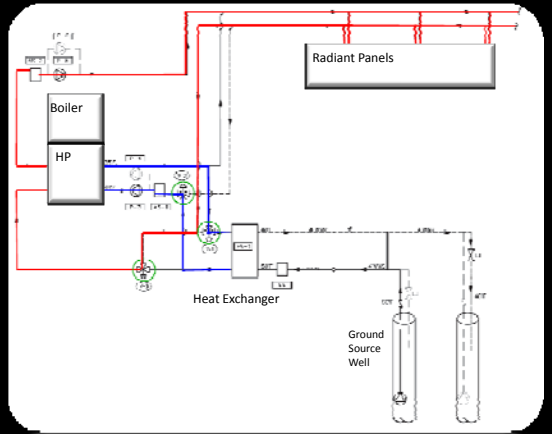




Piping

- Hot Water
  - 45 GPM
  - Piping from original design adequate
- Chilled Water
  - 225 GPM

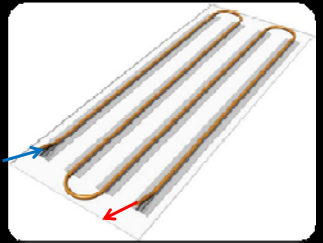
Copper piping → PEX / Steel



Piping

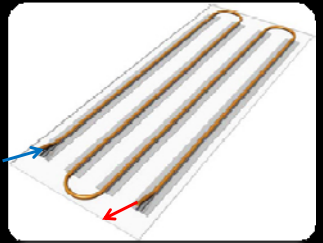
- Hot Water
  - **$9,060 savings**
- Chilled Water
  - ($50,070) added

Copper piping → PEX
Steel



Radiant Panels

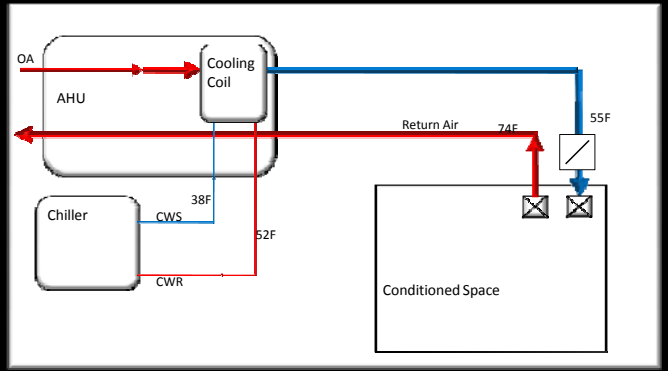
- Sensible Loads
- Cooling
  - Interior and Perimeter
  - 42% of ceiling
  - 5°F ΔT
- Heating
  - Perimeter only
  - 40°F ΔT



Radiant Panels

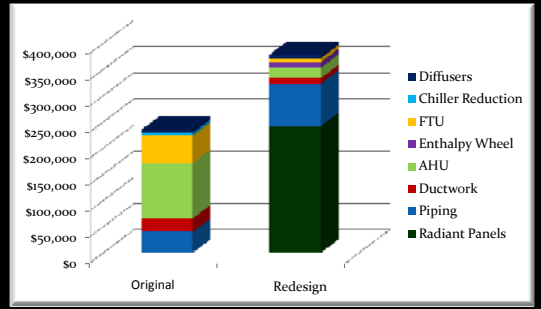
- Cooling
  - 17615 SF
  - $13/SF
- Heating
  - 6,316 SF
  - $2/SF additional

- ($241,620)



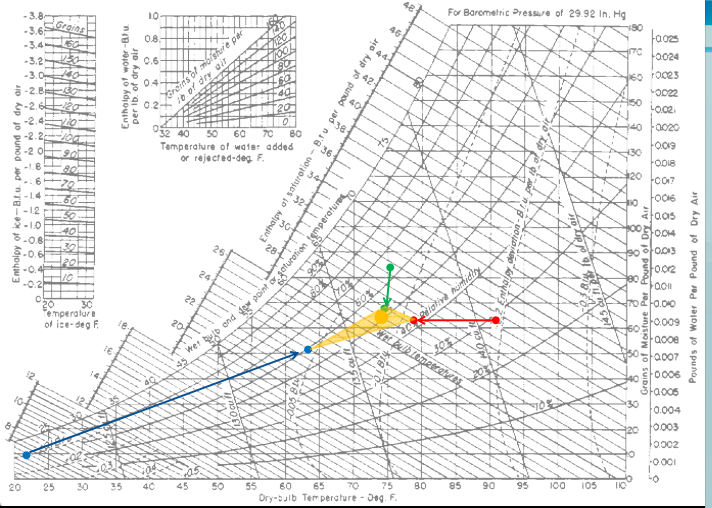
Air Side System

• 5110 CFM AHU	**$85,000**
• 15% of original	
• Constant Volume	
• Enthalpy Wheel	($10,600)
• 80% efficient	
• Smaller Ductwork	**$15,600**
• Terminal Unit Dampers	**$44,900**
• High Induction Diffusers	($1,500)



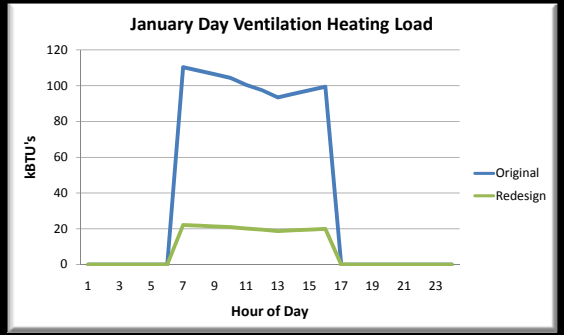
First Cost Analysis

	Total Mechanical Cost	Cost/SF	Redesign Savings	Savings/SF
Original	$1,394,511	$27.56		
Redesign	$1,537,814	$30.40	**($143,303)**	**($2.83)**



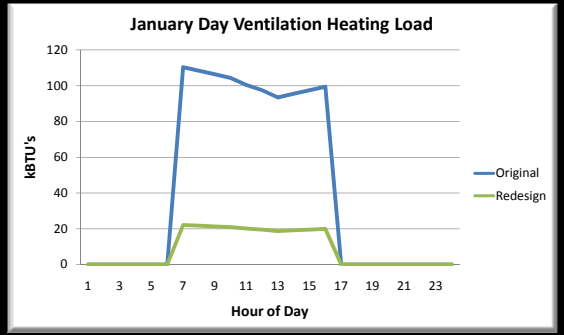
Ventilation Load Energy Savings

- Enthalpy Wheel
- Reduced load on AHU Chiller



Ventilation Load Energy Savings

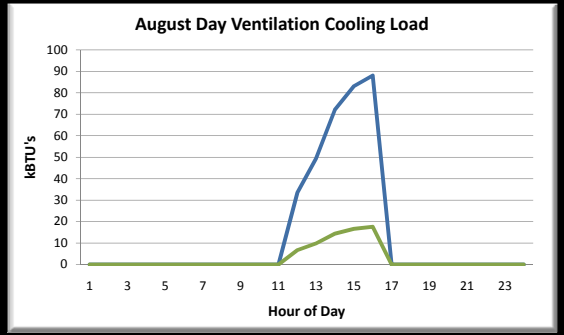
- Enthalpy Wheel
- Reduced load on AHU Chiller
  - Yearly Heating: 202,000 kBTU
  - Yearly Cooling: 8,900 kBTU



Ventilation Load Energy Savings

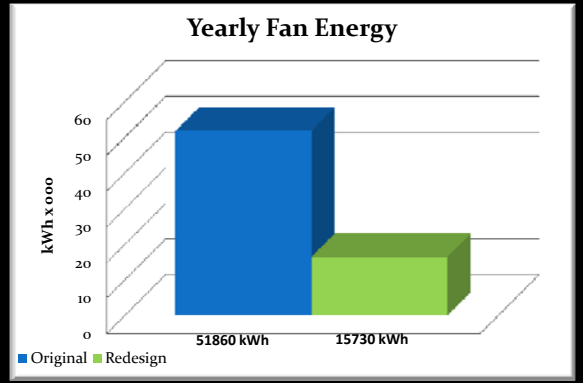
Yearly Savings

- **15,100 kWh**
- **$1,208**



Ventilation Load Energy Savings

- Cooling Load Peak Reduction
  - 70,640 BTU/hr
- Reduces Chiller Size
  - **5.9 Tons**
  - **$5,900**



Fan Energy

- Reduced Ventilation Air
  - 36,000 CFM → 5,110 CFM
- Yearly Savings
  - **36, 130 kWh**
  - **$2,890**

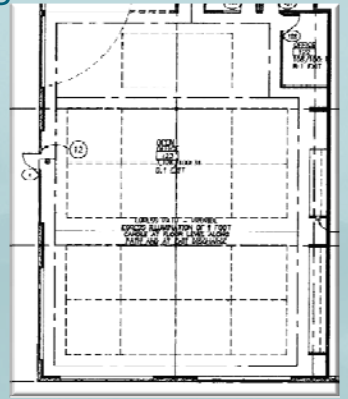
Total Yearly Savings

- **$4,100 ($0.08/SF)**
  - $143,300 added cost ($2.83/SF)
  - 35 year payback

Lighting Redesign

Original

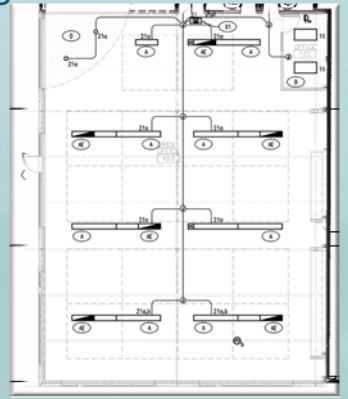
- Open Office Spaces

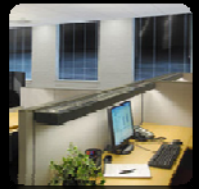


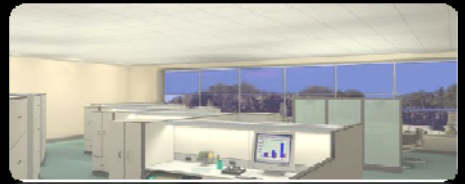
Lighting Redesign

Original

- Open Office Spaces
- Suspended Pendants
  - 1.02 W/SF

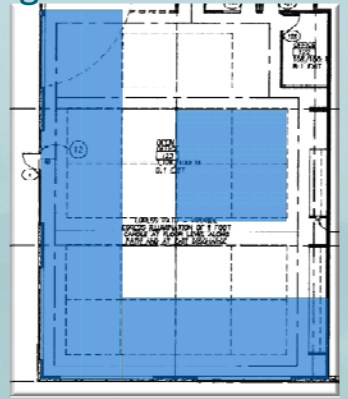


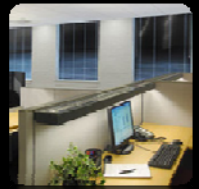


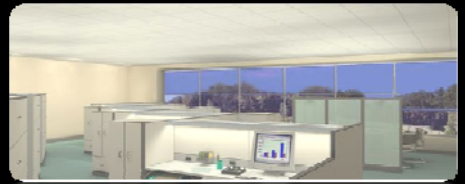


Tambient Lighting

- Illumination from cubicle
  - Task Lighting
  - Space and Floor

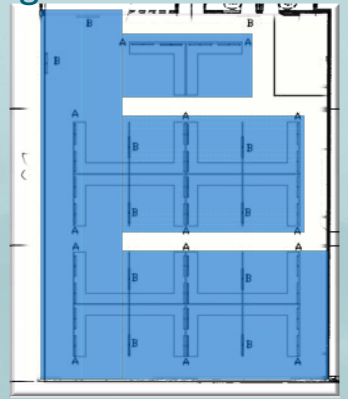


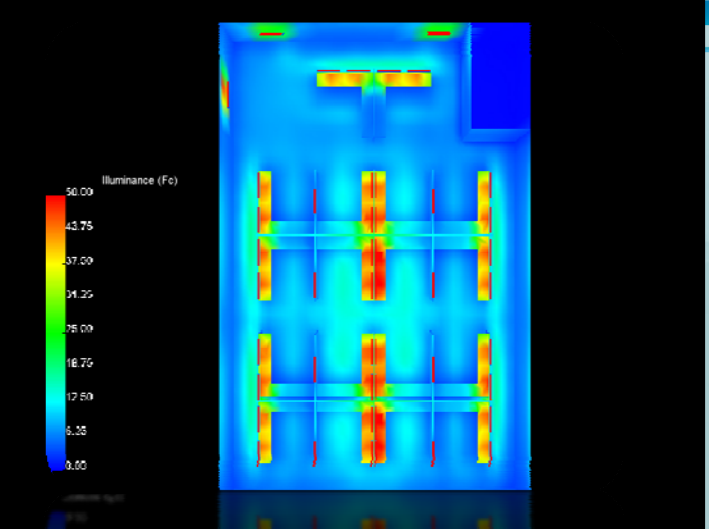




Tambient Lighting

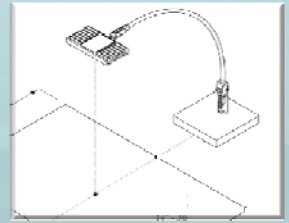
- Illumination from cubicle
  - Task Lighting
  - Space and Floor
- Task and Uplights
- Uplights





AGI analysis

- 5 footcandles on floor
- 30 footcandles on work plane
  - Add 3W task lights



AGI analysis

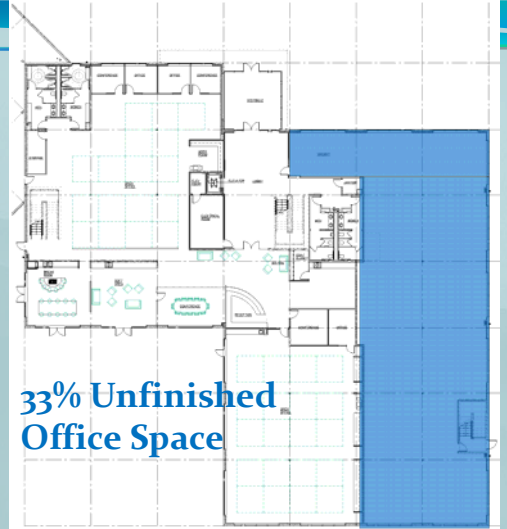
- **.50 W/SF**
  - Half original load
- Good Ceiling Distribution

Multiple Energy Savings

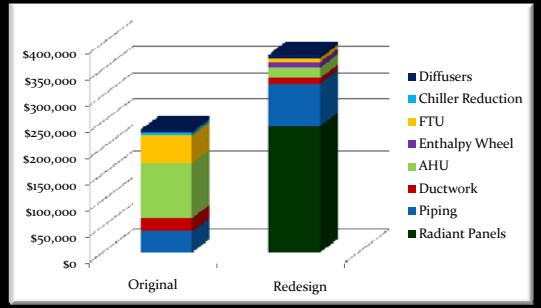
- Lighting Electricity
  - **$3,109/yr**
- Cooling Load
  - **$506/yr**
- Reduced Chiller Size
  - **$3400**

Adjusted Payback

- 35 years → **18.1 years**

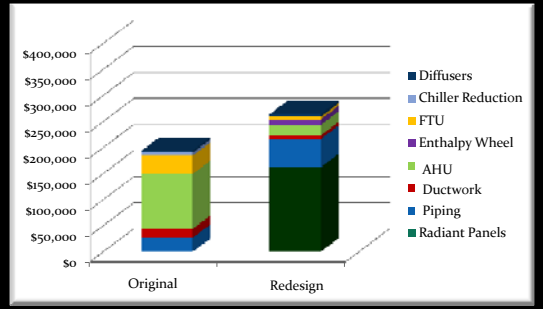


33% Unfinished Office Space



Construction Phasing

- Large Costs Reduce
  - Radiant Panels
  - Piping
- Savings Upfront
  - AHU
  - Chiller



Construction Phasing

- Greatly Reduced First Cost
  - $139,900 → $66,100 ($1.31/SF)
- Slightly Reduced Savings
  - $7,715 → $5,170 ($0.10/SF)

- Payback
  - **12.8 years**

Conclusions

- Sustainability
  - Reduced Energy Usage: **1.91 kWh/SF/yr**

- Comfort
  - Better Ventilation
  - Better Humidity Control

- Economy
  - Reasonable Payback: **12.8 years**

Acknowledgements

- Thanks to:
  - Sponsor: McKinstry
    - Jon, Tom, Aaron, Erik, Phil, Bev
  - Penn State Faculty
    - Professor Srebric and Freihaut
  - Friends and Family
    - Brad Sisenwain, Kanis Glaewketgarn – Lighting
    - Halina, Wojtek, Matt, Chris

QUESTIONS?