

# *DuBois Regional Medical Center West Wing Addition*



Ben Ardary  
Final Presentation  
Thesis 2005

The Pennsylvania State University  
Architectural Engineering  
Lighting/Electrical Option

# Project Location

DuBois, Pennsylvania



# *Project Information*

- 120,000 sq. ft. new addition
- 50,000 sq. ft. of alterations to existing bldg.
- 6 stories (including basement)
- Total Cost = 22.8million

# Presentation Outline

## Topics Covered

### Lighting Depth

- Atrium Lighting Redesign

### Electrical Depth

- Market Shopping Possibilities

### Mechanical Breadth

- Thermal Energy Storage

### Construction Management

- TES Cost Analysis

## Topics Not Covered

### Lighting Depth Spaces

- Canopy
- Neonatal Intensive Care Unit
- Conference Room

### Electrical Depth

- Real-Time Pricing
- Redesign topics for Lighting and Mechanical work.
- Ground Fault Analysis

*DuBois Regional Medical Center  
West Wing Addition*



*Atrium Lighting Redesign*



# Atrium Lighting Redesign

## Design Goals

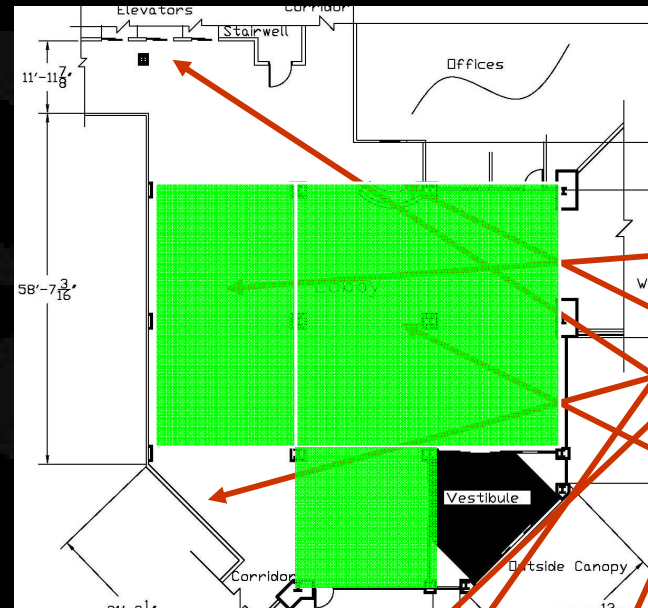
- Provide directionality
- Provide appropriate light levels
- Even distribution on floor
- Make space aesthetically pleasing



# Atrium Lighting Redesign

- Space Breakdown

- Reception Desk
- Circulatory Signage
- Elevator Doors
- Lounge Area
  - Paintings
- General Atrium Area

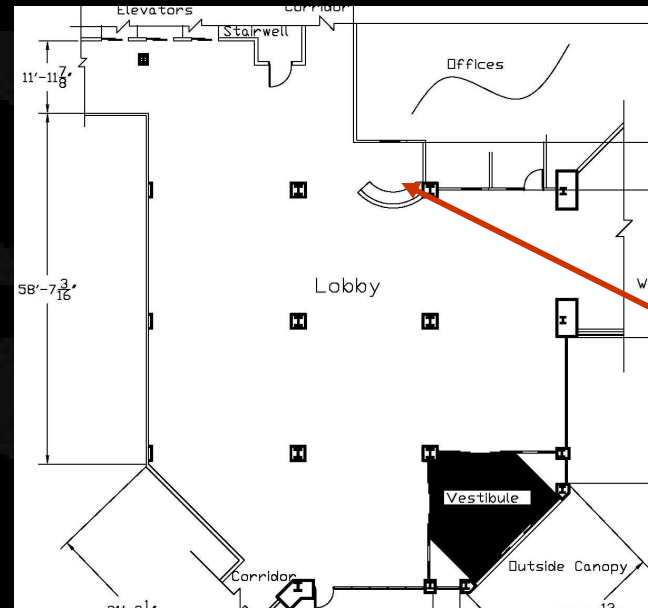


- Lounge Area
- Reception Desk
- Circulatory Sign
- Elevators
- General Area

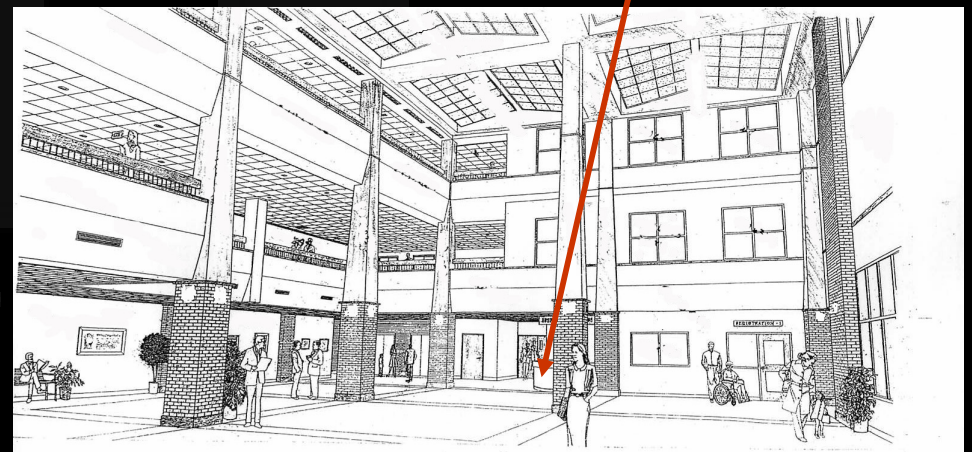


# Atrium Lighting Redesign

- Space Breakdown
  - Reception Desk
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Reception Desk

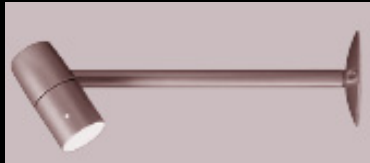
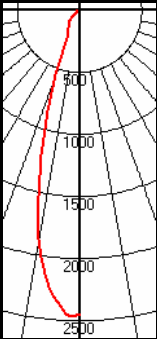




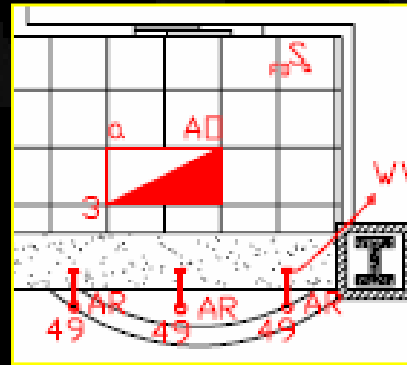
# Atrium Lighting Redesign

## Reception Desk Lighting

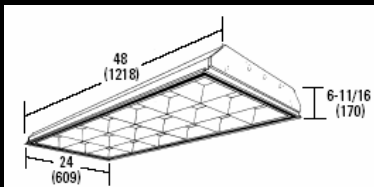
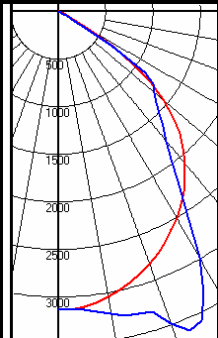
- Luminaire AR



## Luminaire Layout



- Luminaire AO



## AGI 32 Calculation Summary

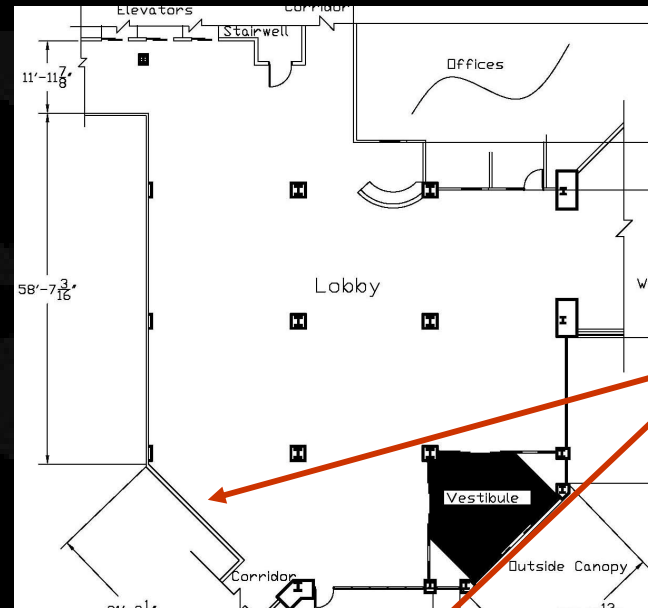
- Desktop Average Illuminance = 35 fc > 30 fc
- Visitors Desktop Ave. Illuminance = 54 fc > 30 fc

# *Atrium Lighting Redesign*



# Atrium Lighting Redesign

- Points of Interest
  - Reception Desk
  - **Circulatory Signage**
  - Elevator Doors
  - Lounge Area
    - Paintings
  - General Atrium Area



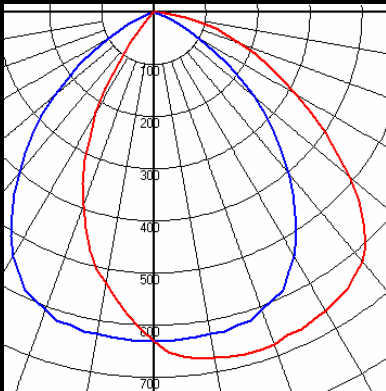
Circulatory Sign



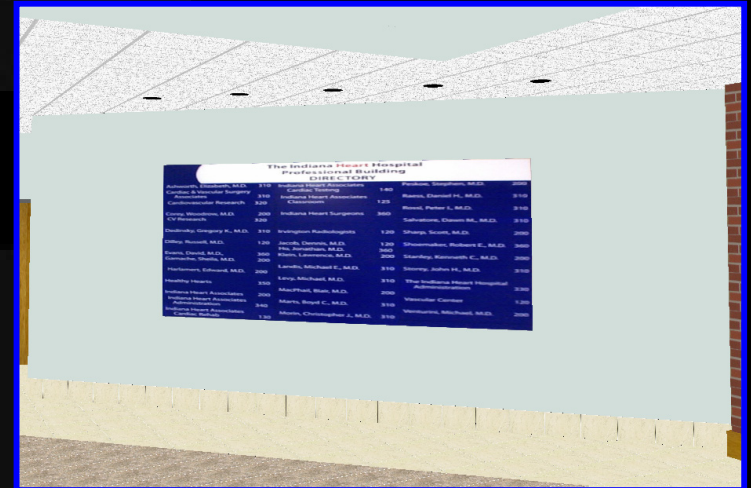
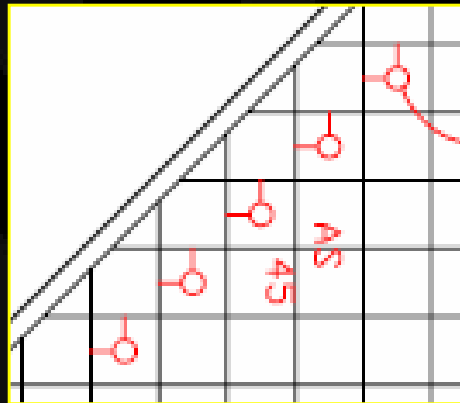
# Atrium Lighting Redesign

## Circulatory Signage

- Luminaire As



## Luminaire Layout



## AGI 32 Calculation Summary

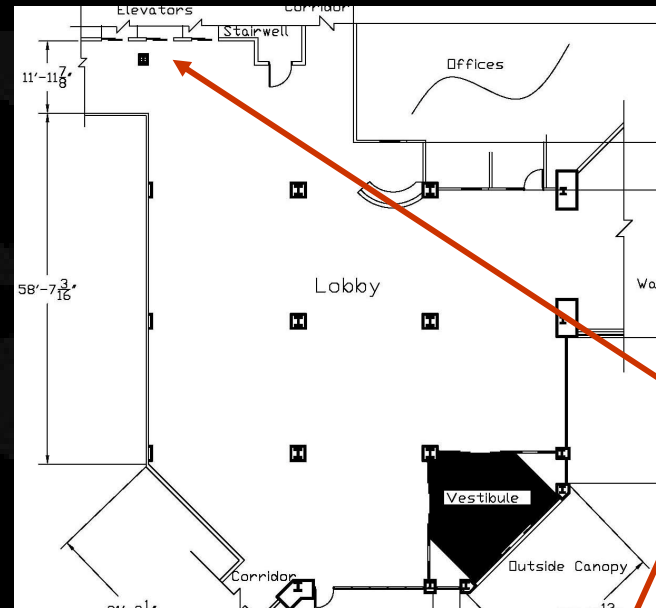
- Signage Average Illuminance = 33 fc > 30 fc

# Atrium Lighting Redesign



# Atrium Lighting Redesign

- Points of Interest
  - Reception Desk
  - Circulatory Signage
  - Elevator Doors
  - Lounge Area
    - Paintings
  - General Atrium Area



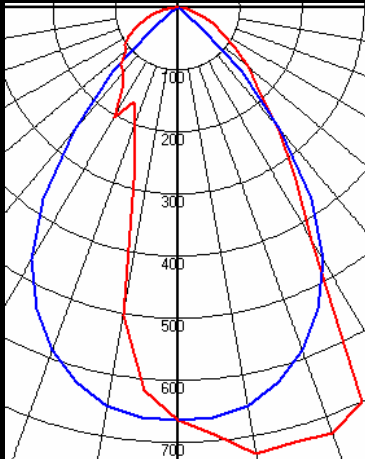
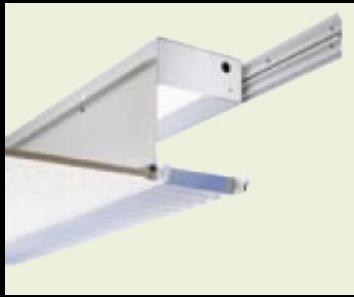
Elevators



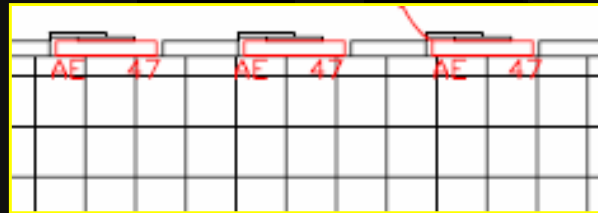
# Atrium Lighting Redesign

## Elevator Doors

- Luminaire AE



## Luminaire Layout



## AGI 32 Calculation Summary

- Elevator Door Average Illuminance = 21 fc
- Maximum Door Illuminance = 89 fc
- Minimum Door Illuminance = 7 fc

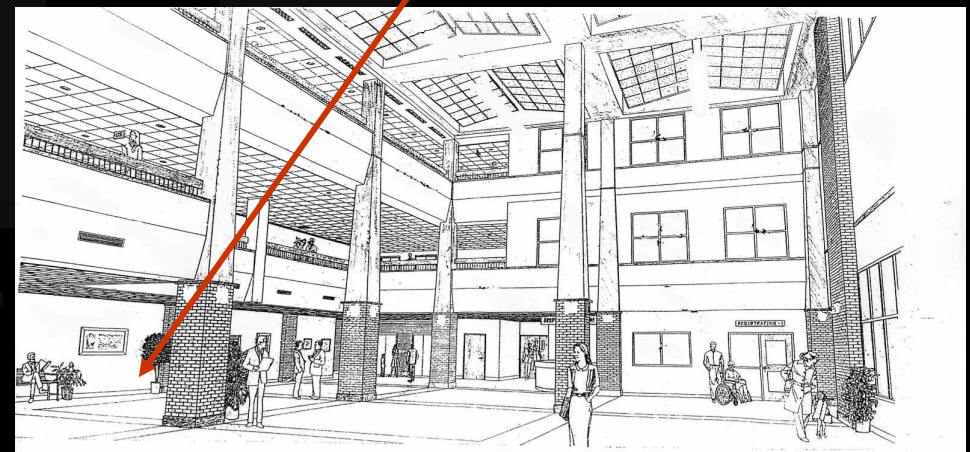
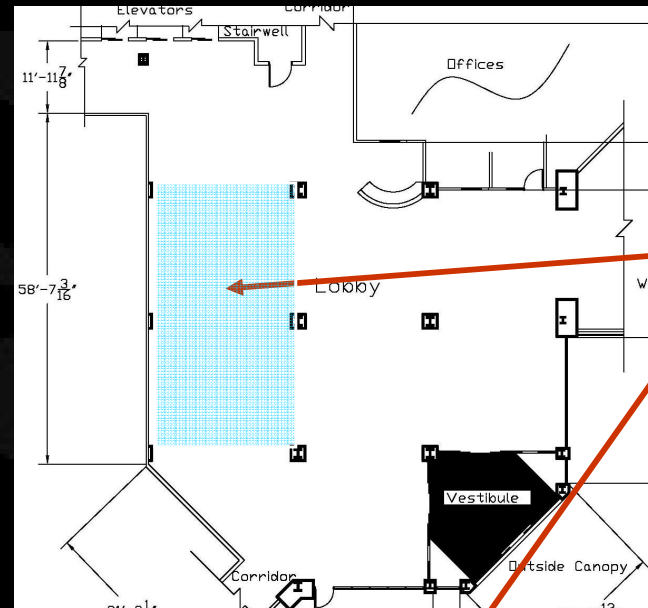
# *Atrium Lighting Redesign*





# Atrium Lighting Redesign

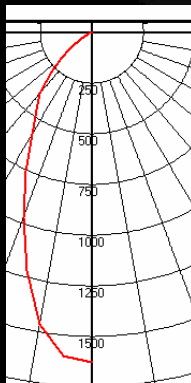
- Points of Interest
  - Reception Desk
  - Circulatory Signage
  - Elevator Doors
  - Lounge Area
    - Paintings
  - General Atrium Area



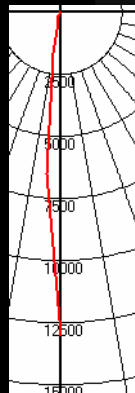
# Atrium Lighting Redesign

## Lounge Area

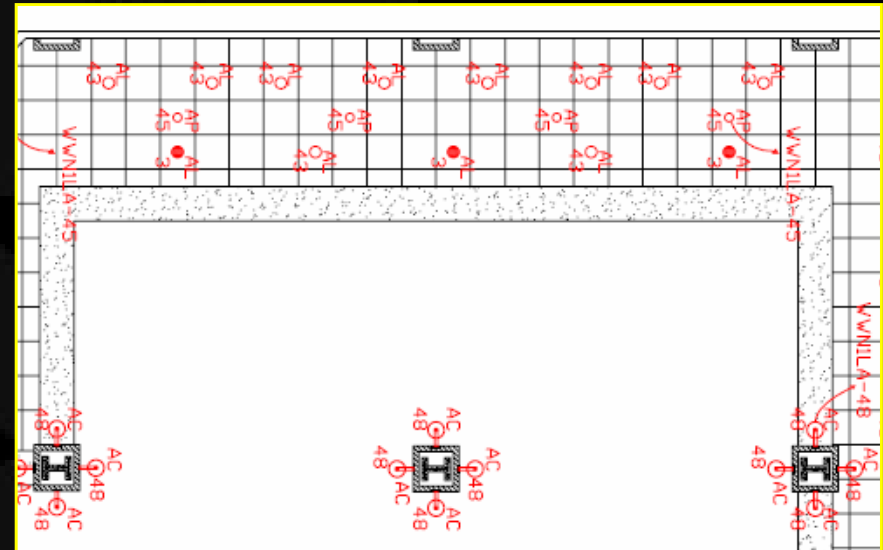
- Luminaire AC



- Luminaire AP



## Luminaire Layout



# Atrium Lighting Redesign

## AGI 32 Calculation Summary

- Under Third Floor Balcony  
Chair Reading Avg. Illuminance = 44 fc > 30 fc



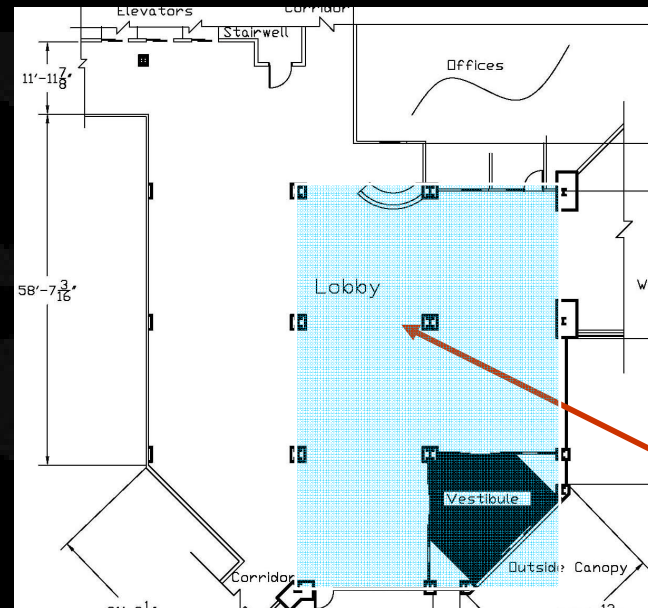
## AGI 32 Calculation Summary

- Under Second Floor Balcony  
Couch Reading Avg. Illuminance = 33fc > 30fc  
Chair Reading Avg. Illuminance = 31 fc > 30 fc



# Atrium Lighting Redesign

- Points of Interest
  - Reception Desk
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  - General Atrium Area



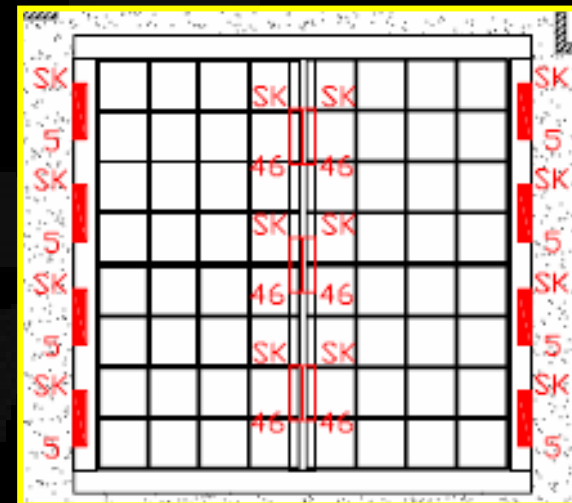
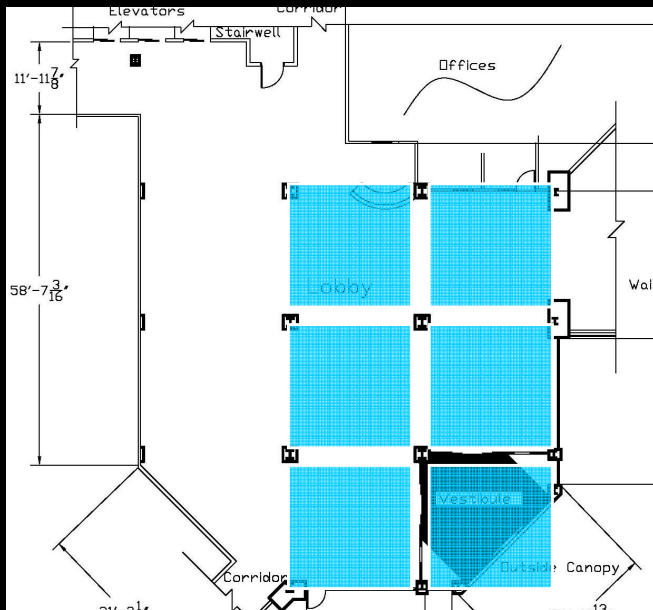
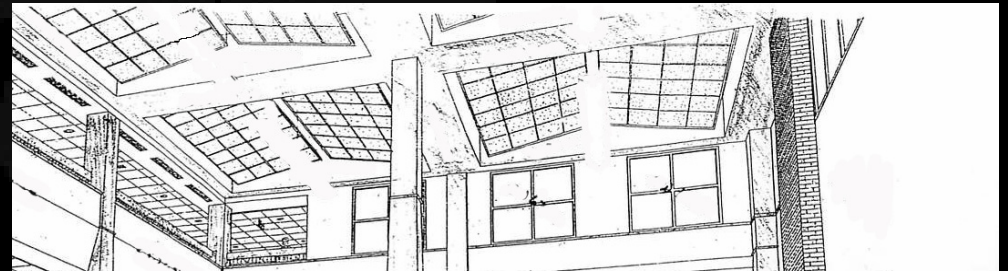
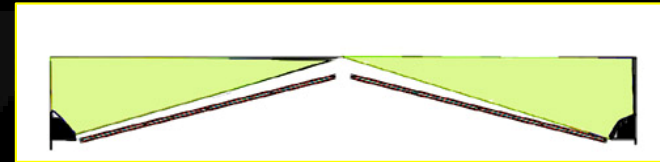
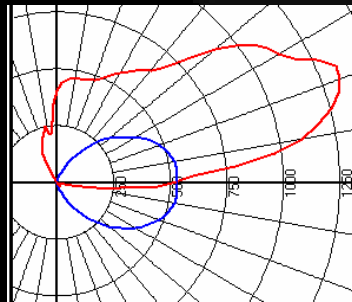
General Area



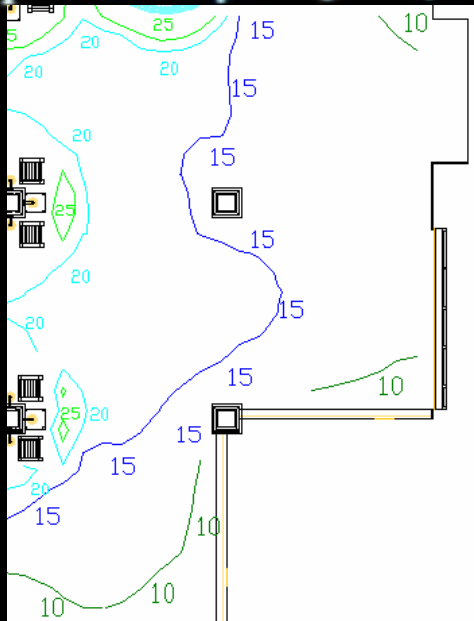
# Atrium Lighting Redesign

## General Area

- Luminaire SK

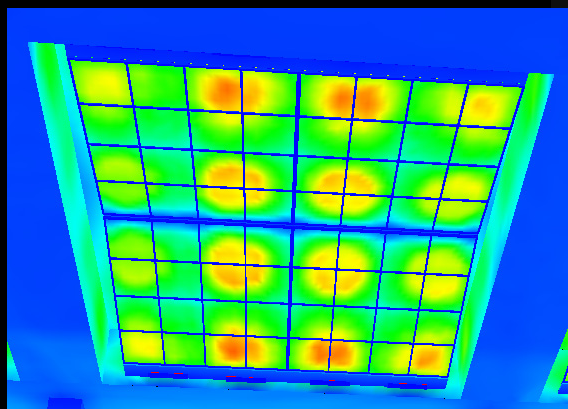
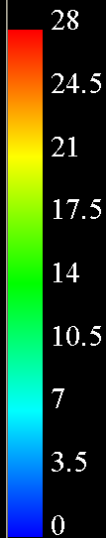


# Atrium Lighting Redesign



## AGI 32 Calculation Summary

- Three Story High Atrium Area
  - Floor Average Illuminance = 17 fc > 10 fc



Pseudo Luminance Rendering



# Atrium Lighting Redesign

## Conclusions

- Lighting redesign provides great directionality.
- All workplanes meet desired lighting levels.
- Distracting highlights on floors were avoided.
- Artificial Skylights added visual interest within the space.
  - Artificial Skylights proved difficult to illuminate without getting hot spots.
- Power Density =  $0.79 \text{ W/ft}^2$

Left Side View



Right Side View



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*Market Shopping for Electricity*



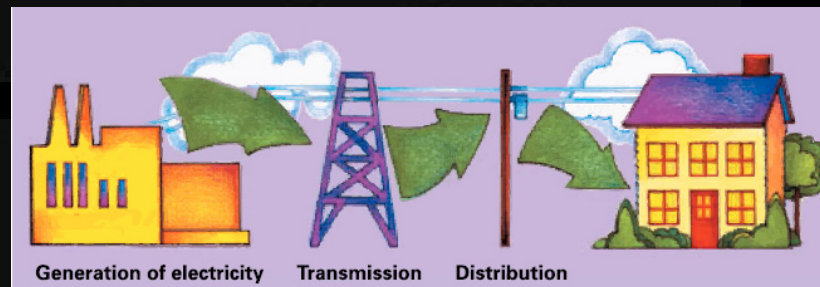
# Market Shopping

## Background

- Electricity Generation Customer Choice and Competition Act passed in 1996
  - Act called for Electricity Generation Competition for all customers by the year 2000
  - Allowed for competition between different utility suppliers to drive down prices.

## Who does the local utility compete with?

- Electric Generation Supplier (EGS)
  - EGSs are responsible for the generation and transmission of your electricity



# Market Shopping

## Procedure

- Obtain available list of EGS companies for your local utility.
- Acquire the price to compare from utilities being considered.
  - Price to Compare = Generation + Transmission
- Compare prices to local utilities price to compare.
- If an EGS's price to compare is lower than the local utilities then savings can be found.
  - Savings =  $[(\text{EGS} - \text{Local Utility}) \times (\text{average monthly kWh})] / 100 = \$/\text{month}$

# Market Shopping

## Findings

- Current utilities price to compare
  - Generation Charge = 4.273 cents/kWh
  - Transmission Charge = 0.92 cents/kWh
  - Price to Compare = 5.173 cents/kWh
- EGSs prices to compare
  - Lowest EGS price to compare = 5.8 cents/kWh

## Conclusion

- Market shopping for electric generation is currently uneconomical

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*Thermal Energy Storage*



# Thermal Storage



## Thermal Energy Storage

Reduces energy costs by allowing energy-intensive cooling equipment to be operated during off-peak hours when electricity rates are low.

### Design Goal

- Maintain original plant size
- Shift On-peak ton-hours to off-peak rates
- Produce payback period and overall savings

### General Information

- Existing chiller plant of 742 Tons
- Req. off-peak cooling demand of 600 Tons
- 8904 on-peak ton-hours
- 12 hrs on and off-peak

# Thermal Storage

## Design Procedure

- Minimum available charge tonnage =  $742\text{tons} - 600\text{tons} = 142\text{ tons}$
- De-rate for ice making =  $142 - 142(.3) = 103.2\text{ Tons}$
- Minimum ton-hours charged =  $(103.2\text{ Tons}) * (12\text{ hours}) = 1238.4\text{ Ton-hours}$
- % Shift =  $1238.4\text{ Ton-Hrs} / 8904\text{Ton-Hrs} = .14$  or 14% (worst case)

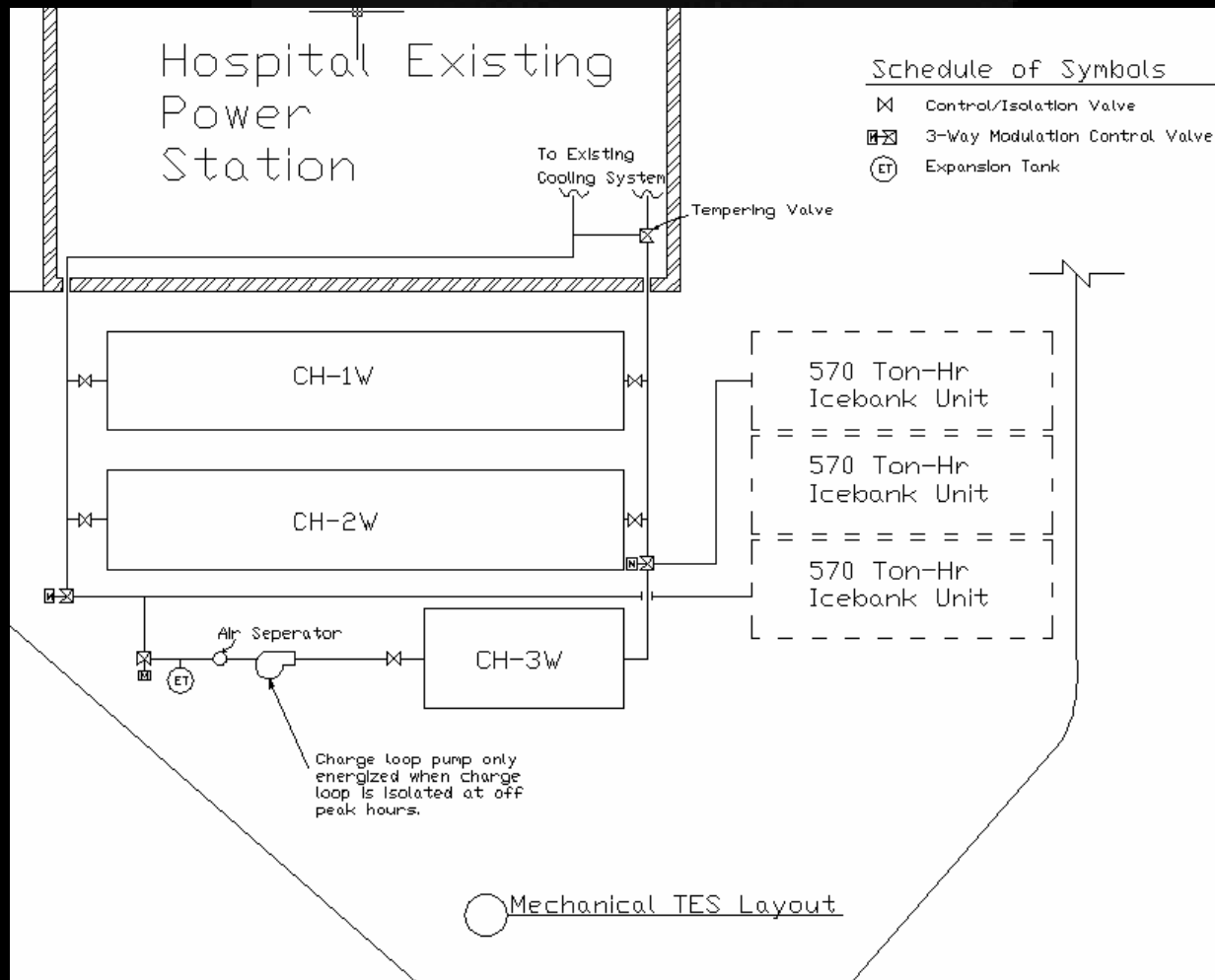
## Cooling Plant Configuration

Given a required 742 Tons on-peak, a plant consisting of two 300Ton chillers along with a 155 Ton chiller is recommended. The 155 Ton unit will be dedicated to ice making and de-energized on-peak.

- Revised Charge Tonnage:  $155 - 155(.3) = 108.5\text{ tons}$
- Minimum Ton-hours =  $108.5\text{ Tons} * 12\text{ hrs} = 1302$
- % shift =  $1302\text{ Ton-Hrs} / 8904\text{Ton-Hrs} = .15$  or 15%

# Thermal Storage

## Equipment Layout



# Thermal Storage

## Design Conclusions and Comments

- Revised Plant Size = 755Tons
- % Increase =  $(755\text{Ton}-742\text{Ton})/742\text{Ton} = 2\%$  Increase (negligible)
- Minimum Ice Tank Capacity = 1302 Ton-Hours
- Chiller Priority Control

The actually available charged ton-hours will be greater than what was calculated. This is due to the fact that the space will not require design tonnage at all hours. A chiller profile was not available, therefore this was the closed estimate we could make.



# Thermal Storage

## Energy Analysis

- Chiller Power Requirements

  - 300 Ton Chillers = 251.86 kW

  - 155 Ton Chiller = 133.92 kW

- Charge Hours

  - Off-peak hours Monday thru Friday 8 PM to 8 AM and Saturday & Sunday

    - Off-Peak = 3,421,510 kWh/year

    - On-Peak = 1,571,610 kWh/year

- Total with TES system = 4993120 kWh/year

- Total without TES system = 5,578,080 kWh/year

- % Reduction = 10.5 %

# Thermal Storage

## Savings from Reduction in kWh/year

- Existing Utility Rate Structure
  - On kWh Charge = \$0.004108/kWh
  - Off kWh Charge = \$0.00335/kWh
  - Distribution Charge = \$0.00011/kWh
- Without TES System = \$200,609/year
- With TES System = \$178,192/year
- Savings = \$22,417/year

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*Thermal Storage Cost Analysis*



# Cost Analysis

## Initial Mechanical Redesign Cost

- 300 Ton Chillers = \$150,725
- 155 Ton Chiller = \$86,665
- Charge Loop Pump = \$7900
- Icebanks = \$171,000
- Total Cost = \$576,015
  
- Cost Difference for TES system = \$178,900
- Savings/year = \$22,417

# Cost Analysis

## Mechanical Payback Period

- Assumed 6% interest rate.

- Equation used:  $S(1) = S(F/P)_1 + S(F/P)_2 + \dots + S(F/P)_n = I_c$

S = savings    F/P = Future given Present Value Multiplier     $I_c$  = Initial Cost

n	F/P	Savings	Compounded Savings
yr		\$	\$
0.00	1	22417.00	22417.00
1	1.06	23762.02	46179.02
2	1.1236	25187.74	71366.7612
3	1.191	26698.65	98065.4082
4	1.2625	28301.46	126366.8707
5	1.3382	29998.43	156365.3001
6	1.4185	31798.51	188163.8146

System will pay for itself between 5 and 6 years.

# Conclusions

## Atrium Lighting Redesign

- Meet required goals and criteria

## Market Shopping for Electricity

- No current opportunities.

## Thermal Energy Storage (TES)

- Produced a savings of \$22,417

## TES Payback Period

- System should pay itself off in five or six years.

# Acknowledgments



## Companies

- DuBois Regional Medical Center
- Turner Construction Company
- CALMAC Manufacturing Corp.
- First Energy

## Peers

- Emad Hasan
- Joseph Lookup
- Josh Lutton
- Benjamin Mitten
- Kyle Pepperman
- Mike Regan
- Christopher Rush
- Kelly Sadusky
- Ryan Wanko

## Faculty

- Kenneth Davidson
- Professor Parfitt
- Dr. Mistrick
- Dr. Moeck
- Jonathan Dougherty

**Family and Friends!**

*DuBois Regional Medical Center  
West Wing Addition*



*Thank You for Your Time!*

*Questions?*

**DRMC**