# 1050 K STREET

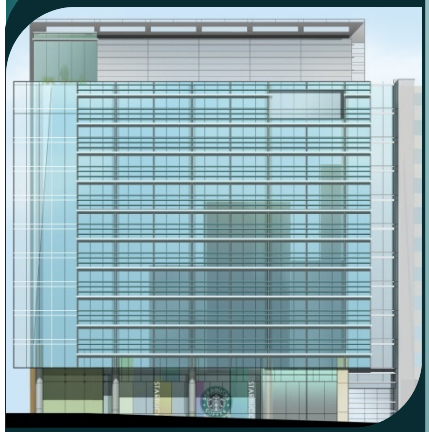
## Mechanical Systems Redesign

Malory J. Faust • Mechanical Option • Senior Thesis 2007

1050 K Street

# Topics of Discussion

- Building Introduction
- Chilled Beam Analysis
- Solar Shading Analysis
- Daylighting Analysis
- Conclusions



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Building Introduction

Chilled Beam Analysis

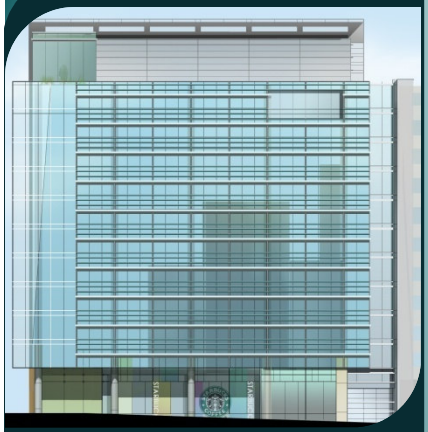
Solar Shading Analysis

Daylighting Analysis

Conclusions

# Project Team

- Owners: The Lenkin Company
  The Tower Companies
- Contractor: The Lenkin Company
- Architect: Hickok Cole Architects
- Structural Engineer: Tadjer Cohen Edelson Associates
- MEP Engineer: Vanderweil Engineers
- Civil Engineer: Timmons Group
- Curtain Wall Consultant: CDC



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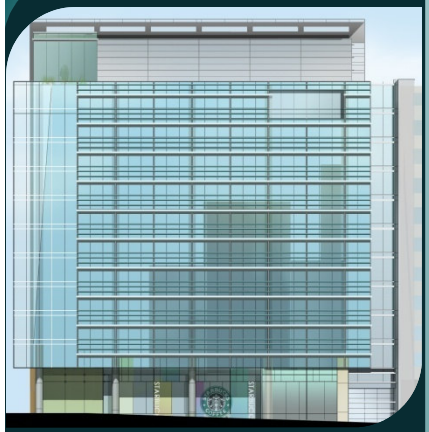
# Building Site

- Located on the corner of 11th & K Streets
- Streets on the North & West facades
- Alleys on East & South facades



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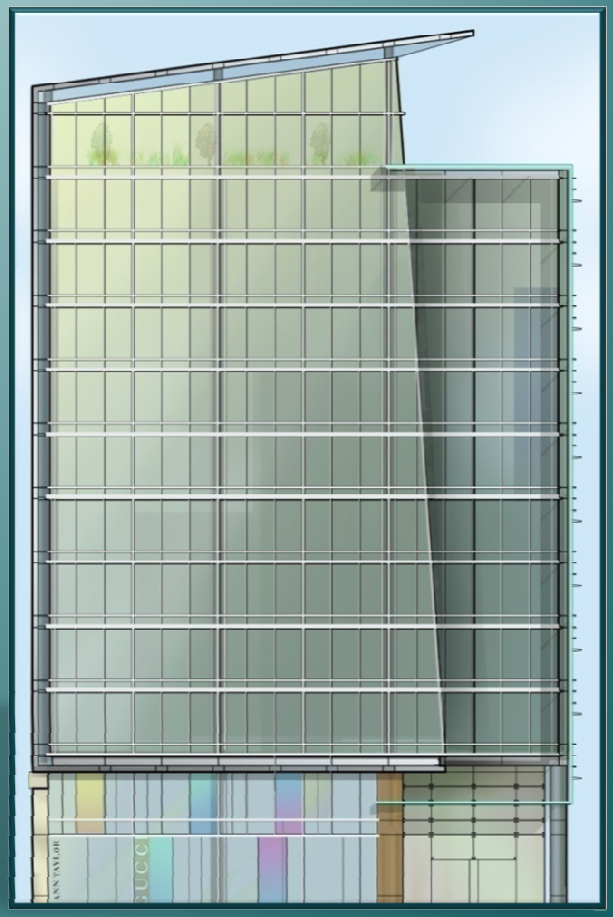
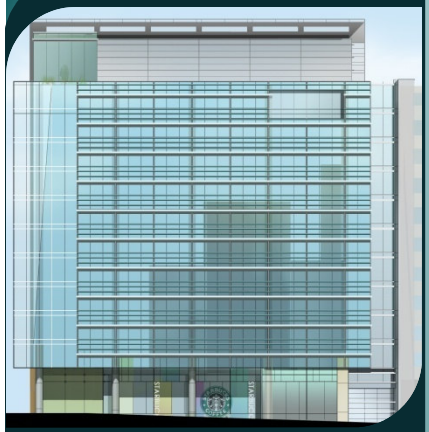
# Architectural Background

- 11 story office building
- 4 levels below ground for parking
- Retail on the first level
- Curtain Wall – North & West facades
- Green Roof





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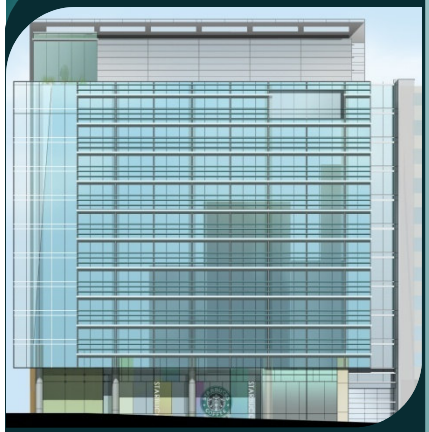
# System Summary

- Energy Recovery Unit (ERU)
  - 30,000 CFM Enthalpy Wheel
  - Cooling Coil
- AHU with cooling on each level
- VAV System with terminal reheat
- Chiller Plant
  - (3) 115 ton rotary screw chillers
  - (2) Cell, Induced draft open cell cooling tower
  - Waterside free cooling HX
- All heating done by enthalpy wheel and electric reheat



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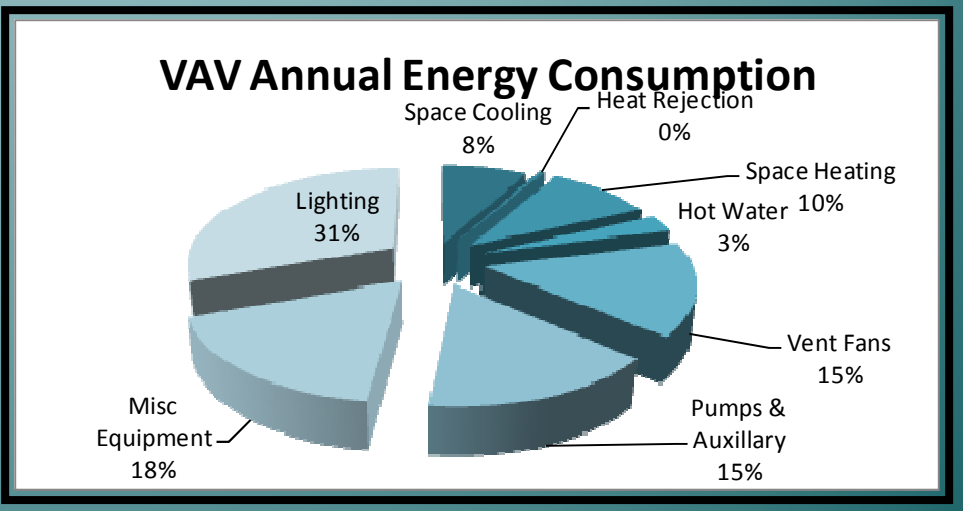
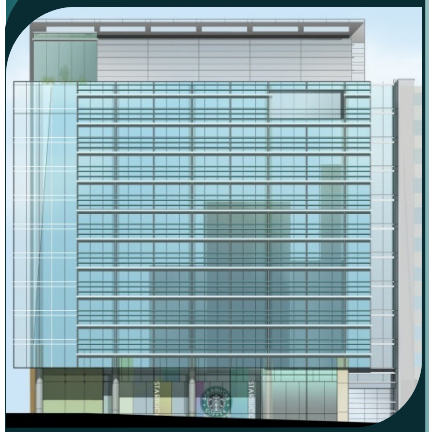
# System Summary

- Energy Consumption

| Energy Simulation Summaries | |
|---|---|
| **Enduse** | **KWh** |
| Space Cooling | 124400 |
| Heat Rejection | 7000 |
| Space Heating | 154200 |
| Hot Water | 44500 |
| Vent Fans | 242700 |
| Pumps & Auxillary | 243200 |
| Misc Equipment | 277700 |
| Lighting | 482700 |
| Total | 1576400 |





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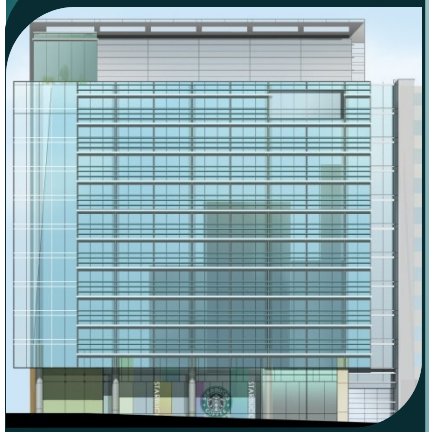
# System Summary

- Initial Cost

| VAV System Initial Cost Data | | | | |
|---|---|---|---|---|
| Component Description | Materials Cost | Unit | Total Units | Cost |
| VAV Box 300-600 CFM W/RH | $ 358.00 | Ea | 80 | $ 28,640.00 |
| VAV Box 500-1000 CFM W/RH | $ 368.00 | Ea | 11 | $ 4,048.00 |
| VAV Box 800-1600 CFM W/RH | $ 383.00 | Ea | 1 | $ 383.00 |
| VAV Box 500-1000 CFM W/o RH | $ 345.00 | Ea | 22 | $ 7,590.00 |
| Air Handling Unit 8000 CFM | $ 13,353.00 | Ea | 1 | $ 13,353.00 |
| Air Handling Unit 12500 CFM | $ 18,470.00 | Ea | 1 | $ 18,470.00 |
| Air Handling Unit 13500 | $ 19,850.00 | Ea | 9 | $ 178,650.00 |
| | | | | $ 251,134.00 |



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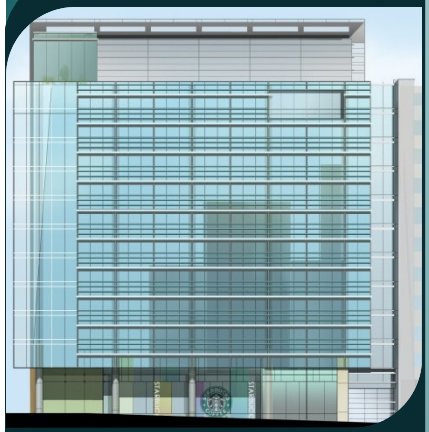
# Alternate Mechanical System

- Design Goals
  - Lessen annual energy consumption
  - Flexible system layouts & capacities
  - Aesthetically responsive



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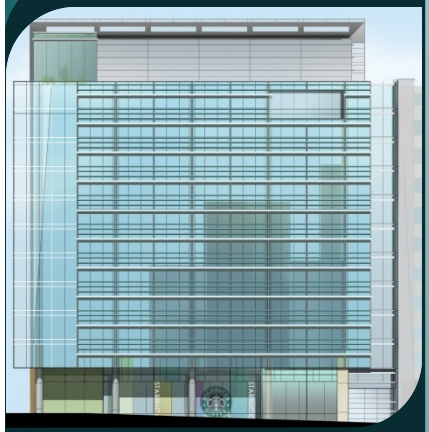
# Chilled Beam Background

- Air Conditioning system providing cooling & heating
- Uses principles of induction and free convection
- Can significantly reduce energy costs
- Aesthetic benefits



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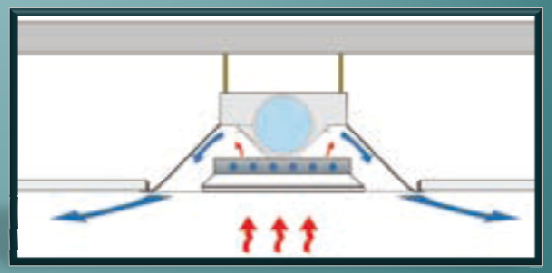
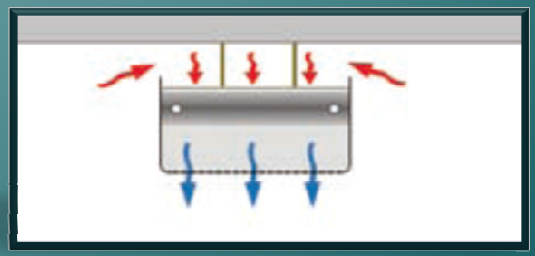
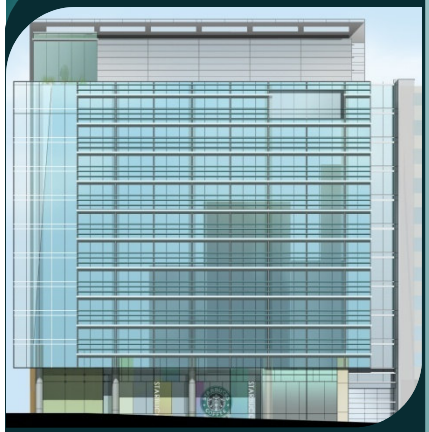
# Chilled Beam Background

- Active
  - Integrated with outdoor air supply
  - Utilizes air flow to induce room air
  - Can provide heating when requirements are low



- Passive
  - Typically used parallel to another system
  - Do not supply outdoor air
  - Rely on natural convection for cooling
  - May be provided in addition to active beams in high cooling spaces





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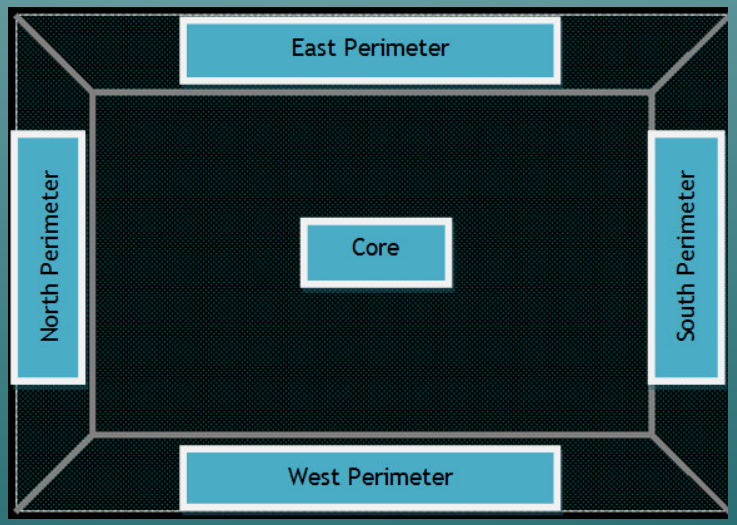
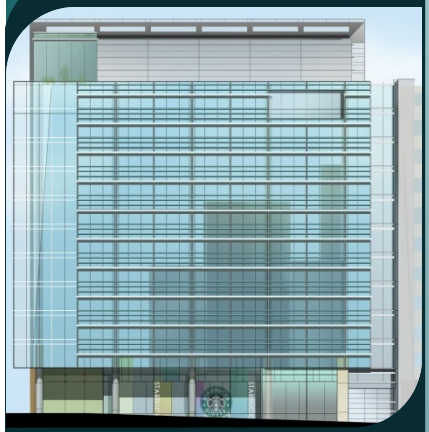
# Calculation Procedure

- eQuest
  - Core & Shell design did not require room by room analysis
  - Zoning
    - 4 perimeter zones (15')
    - 1 core zone





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# Calculation Procedure

- eQuest
  - Modeled as one large chilled beam per zone
  - Each beam modeled as a fan coil unit, removing the fan
  - Utilized “OA-From-System” command to provide ventilation to units
  - Attached all latent load to ERU dummy zone to decouple the space cooling loads

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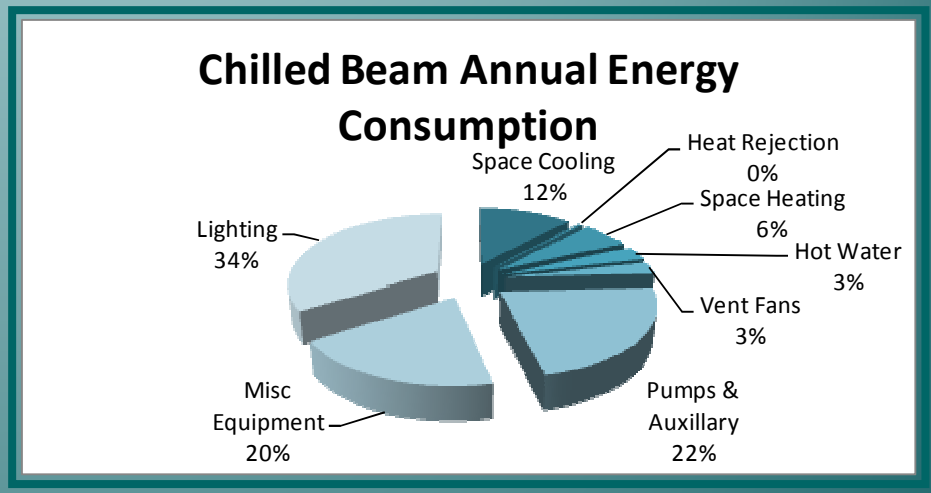
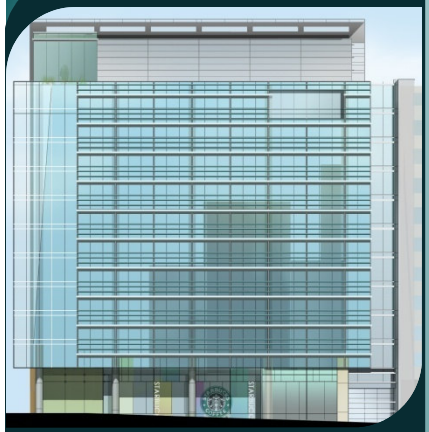
# Simulation Results

- Energy Consumption

| Energy Simulation Summaries | |
|---|---|
| **Enduse** | **KWh** |
| Space Cooling | 166400 |
| Heat Rejection | 7500 |
| Space Heating | 84600 |
| Hot Water | 44500 |
| Vent Fans | 39400 |
| Pumps & Auxillary | 316400 |
| Misc Equipment | 277700 |
| Lighting | 482700 |
| Total | 1419200 |




- 10 % reduction in energy consumption
- Overall savings of 157200 KWh/year



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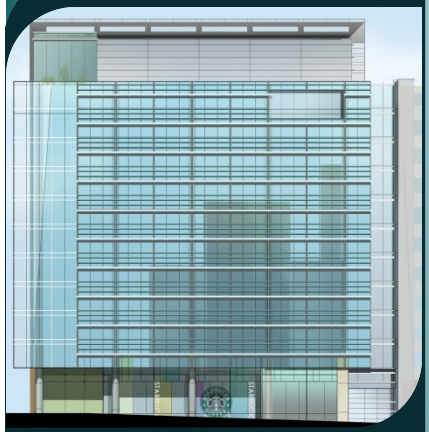
# System Design Summary

- Chilled Beam Sizing
  - Used Halton Hit Design Program
  - Maintained ventilation requirements
  - Uphold aesthetic appeal of office spaces



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# System Design Summary

Halton HIT Design - Unit selection design data

DESIGN DATA

| | | |
|---|---|---|
| Total air flow rate: | 180 | l/s |
| AQ opening: | - | |
| Nozzle airflow rate: | 180 | l/s |
| AQ diffuser airflow rate: | - | l/s |
| Supply air temperature: | 18.0 | °C |
| Inlet water temperature: | 14.0 | °C |
| (•) Outlet water temperature: | | |
| ( ) Water mass flow rate: | 15.5 | °C |

Room...

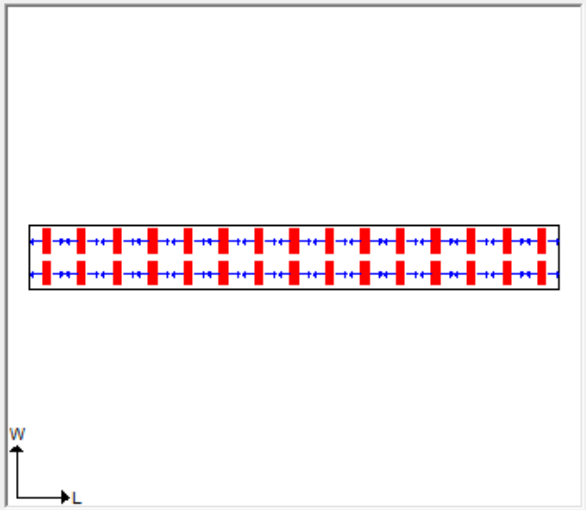
SPACE RESULTS

| | | |
|---|---|---|
| Air flow: | 180 | l/s |
| Room temperature: | 22.0 | °C |
| Supply air temperature: | 18.0 | °C |
| Inlet water temperature: | 14.0 | °C |
| Heat gain: | 0 | W |
| Primary air capacity: | 866 | W |
| Coil capacity: | 6786 | W |
| Total capacity: | 7652 | W |
| Water mass flow rate: | 1.080 | kg/s |

UNIT PERFORMANCE

| | | |
|---|---|---|
| Air flow: | 6 | l/s |
| Primary air capacity: | 29 | W |
| Coil capacity: | 226 | W |
| Total capacity: | 255 | W |
| Total pressure drop: | 111 | Pa |
| Water pressure drop: | 0.6 | kPa |
| Water mass flow rate: | 0.036 | kg/s |
| Sound pressure level: | 14 | LpA |

LOCATION




Installation height: 2.60 m Columns: 15

Location: 2 Rows: 2

VELOCITY CONTROL

Side: 3 Middle: 3

VIEW

(•) 3D ( ) Side vlim: 0.20 m/s

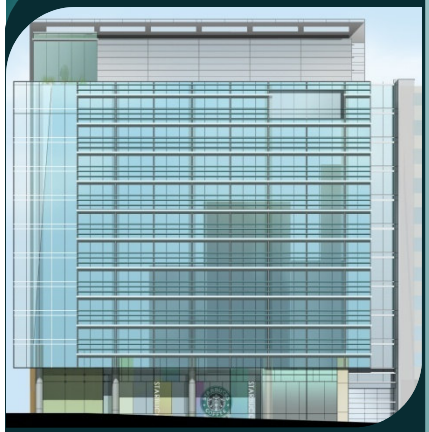
DESIGN STATUS

*OK*

Perforated ceiling... Optimise...

Update results

Ok Cancel



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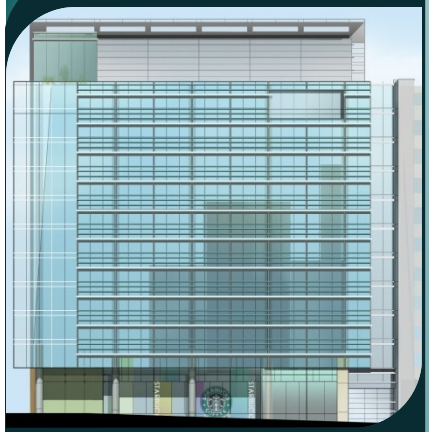
# System Design Summary

- Chilled Beam Layout
  - Perimeter zones
    - East & West – (2) rows of 15
    - South & North – (2) rows of 9
    - All additional cooling by passive
  - Internal
    - 11 rows to line up with perimeter active beams



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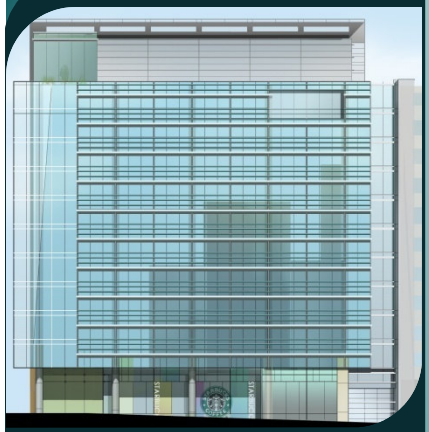
# System Design Summary

- Chilled Beam System Cost
  - Cost of Beams: $200/ LF
  - 1985 Beams total
  - 735 MBH Electric Boiler

| Chilled Beam Initial Cost | | | | |
|---|---|---|---|---|
| Component Description | Materials Cost | Unit | Total Units | Cost |
| Chilled Beam | $ 200.00 | LF | 7940 | $ 1,588,000.00 |
| Boiler | $ 10,300.00 | Ea | 1 | $ 10,300.00 |
| | | | | $ 1,598,300.00 |



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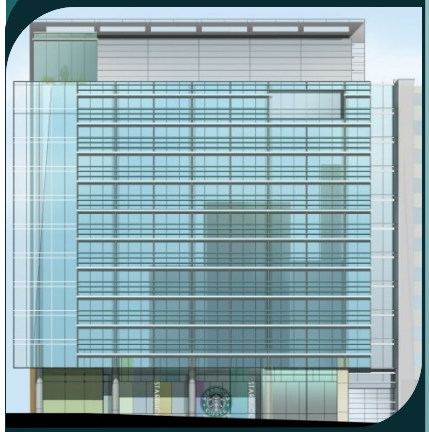
# Solar Shading Background

- Blocks 75% of incoming radiation
- Absorbs up to 15 % of incoming radiation
- Prevents 25% of internal heat from escaping in heating conditions
- Transparent
- Reduces glare



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Building Introduction

Chilled Beam Analysis

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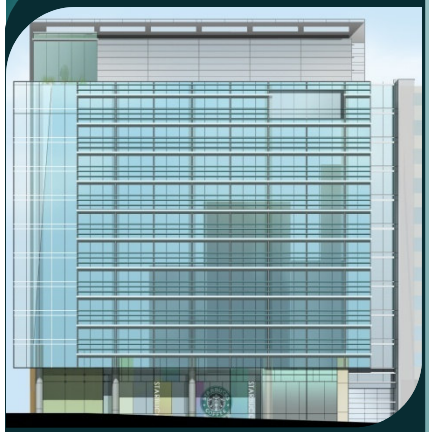
Daylighting Analysis

Conclusions

# Design Summary

- Apply shades to 100% of curtain wall
- North and West facades
- 8'-9" floor to ceiling height
- 235 LF of shades
- (517) 5x8.75 shades

| Chilled Beam Initial Cost | | | | |
|---|---|---|---|---|
| Component Description | Materials Cost | Unit | Total Units | Cost |
| Chilled Beam | $ 200.00 | LF | 7160 | $ 1,432,000.00 |
| Solar Shades | $164 | 43.75 SF | 514.8 | $ 84,427.20 |
| Boiler | $ 10,300.00 | Ea | 1 | $ 10,300.00 |
| | | | | $ 1,526,727.20 |



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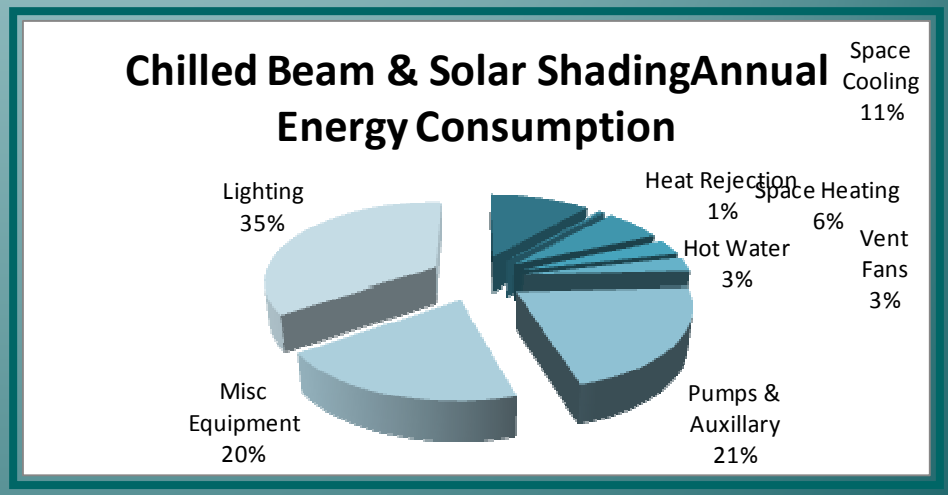
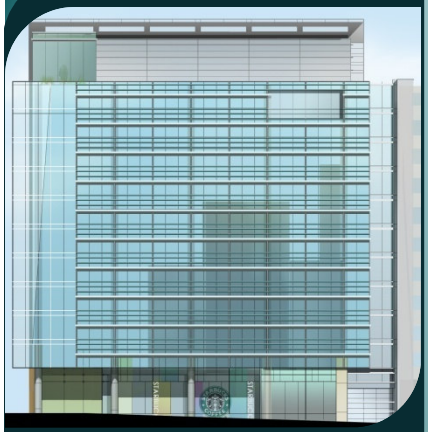
# Design Summary

- Energy Consumption

| Energy Simulation Summaries | |
|---|---|
| **Enduse** | **KWh** |
| Space Cooling | 157400 |
| Heat Rejection | 7100 |
| Space Heating | 89800 |
| Hot Water | 44500 |
| Vent Fans | 39300 |
| Pumps & Auxillary | 294800 |
| Misc Equipment | 277700 |
| Lighting | 482700 |
| Total | 1393300 |




- 6% reduction in cooling energy
- 7% reduction in pump energy



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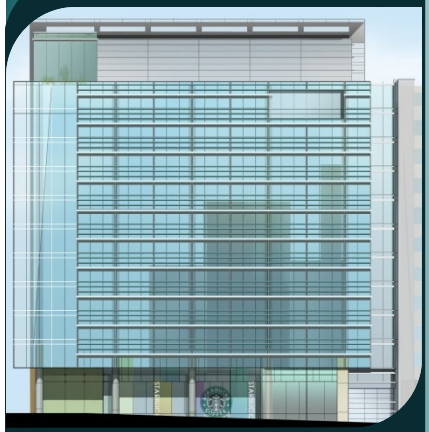
# Daylighting Background

- Daylight sensors installed in perimeter zones
- Utilize sunlight when sufficient
- Decrease lighting energy consumption
- Sophisticated, dynamic controls
- Require calibration



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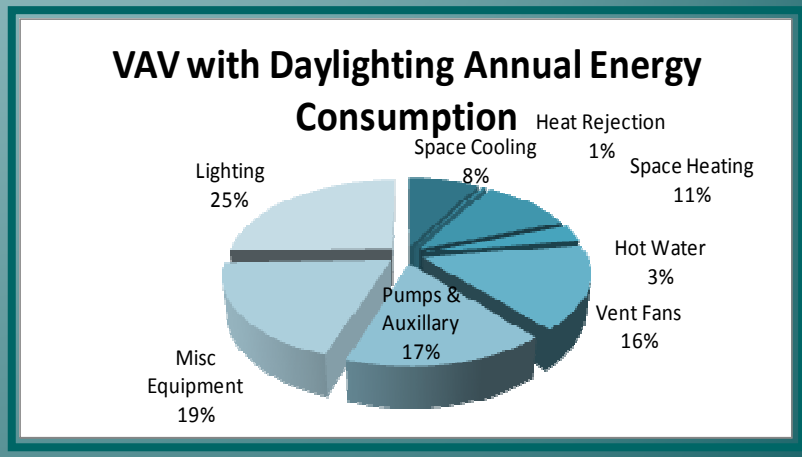
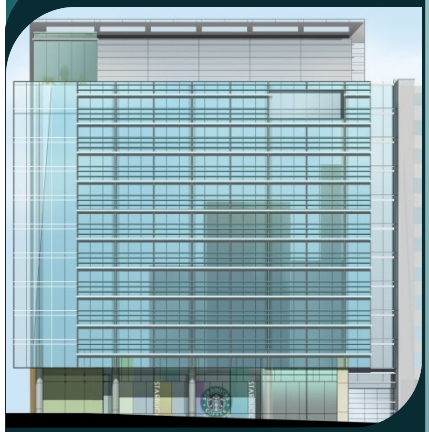
# Design Summary

- Energy Consumption

| Energy Simulation Summaries | | |
|---|---|---|
| **Enduse** | **VAV** | **Daylighting** |
| Space Cooling | 124400 | 116100 |
| Heat Rejection | 7000 | 6500 |
| Space Heating | 154200 | 155900 |
| Hot Water | 44500 | 44500 |
| Vent Fans | 242700 | 230500 |
| Pumps & Auxillary | 243200 | 236200 |
| Misc Equipment | 277700 | 277700 |
| Lighting | 482700 | 364200 |
| Total | 1576400 | 1431600 |




- 25% reduction in lighting energy consumption



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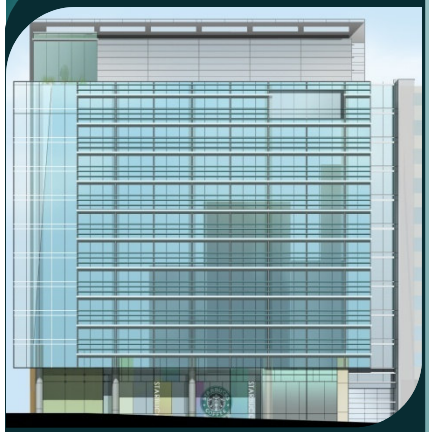
# Conclusions

| Simple Payback Summary | | | | |
|---|---|---|---|---|
| | VAV | Chilled Beam | Shading | Daylighting |
| Initial Cost | $ 251,134.00 | $ 1,598,300.00 | $ 1,526,727.00 | n/a |
| Annual Energy Cost | $ 189,010.36 | $ 170,174.07 | $ 167,056.67 | $ 171,648.84 |
| Annual Savings | $ - | $ 18,836.29 | $ 21,953.69 | $ 17,361.52 |
| Simple Payback | 0 | 71.5 | 58.1 | n/a |

- Regardless of energy savings the chilled beam system is not more economical solution than the VAV system due to drastic initial cost differences



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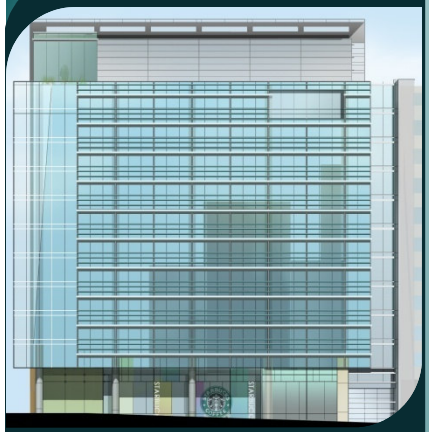
# Thank You

- All AE Faculty and Staff
- My classmates, especially Erin & Patrick
- My family and friends
- Professionals at Vanderweil Engineers, especially Brandon Harwick and Sam Bohsali



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# Questions