# the Houston Museum of American Art

Chang Liu | Lighting + Electrical | Final Thesis Presentation| 4.26. 2013

## WELCOME TO THE HOUSTON MUSEUM OF AMERICAN ART

Since 1930, the Houston has championed groundbreaking American art. The museum's founder believed in supporting living artists, from celebrated pioneers to the latest innovators. We continue this tradition by presenting a mix of special exhibitions and installations of works from our collection.

We hope you enjoy your visit.

Design Scope

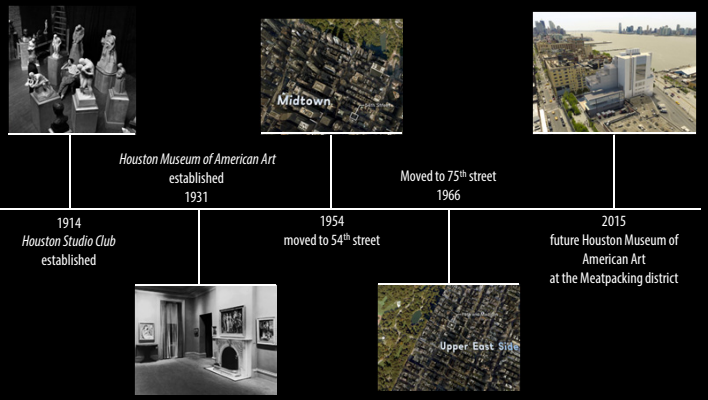
| | |
|---|---|
| LIGHTING DEPTH | Building façade |
| | Main lobby |
| | Theater |
| | 8th floor gallery |
| ELECTRICAL DEPTH | System type conversion study |
| | Wire upsizing |
| BREADTH STUDY | Daylighting |
| | Cogeneration feasibility study |
| | Acoustics assessment |
| | Social concepts |

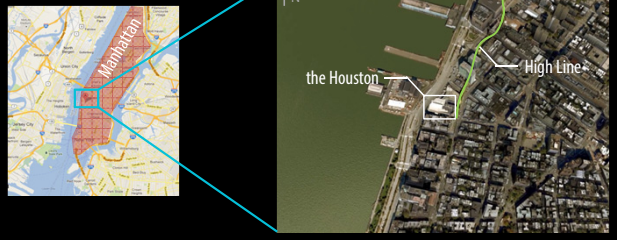
## Statistics

| | |
|---|---|
| Name: | the Houston Museum of American Art |
| Location: | New York, New York |
| Size: | 222,952 SF |
| Levels: | 9 stories above grade |

## Project Team

| | |
|---|---|
| Design Architect: | Renzo Piano Building Workshop |
| Executive Architect: | Cooper, Robertson & Partners |
| MEP Engineer: | Jaros, Baum & Bolles |
| Lighting Designer: | Ove Arup & Partners |
| Construction Manager: | Turner Construction, LLC |






"The museum will be a dynamic new presence downtown … as a vital resource that engages the neighborhood, enlivens the cultural dialogue, and welcomes the people of New York and beyond."

- Neil G. Bluhm, president of the Board of Trustees

The future Houston is designed to embrace and reciprocate the energy of the neighborhood and provide a stimulating and immersive space in which to experience art.

- Renzo Piano

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dynamic
enlivening
welcoming
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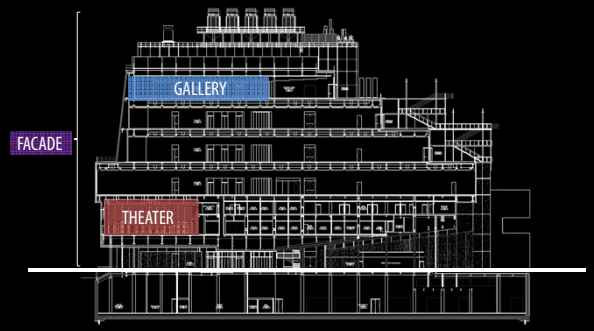
- Renzo Piano

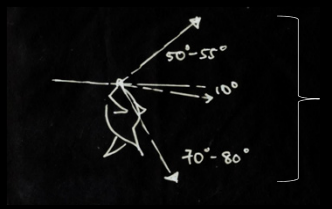
engaging Lighting Depth

Lighting Depth

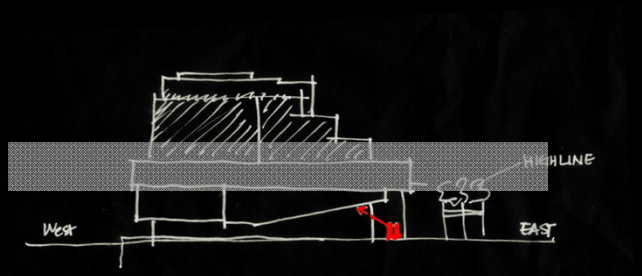


Building Facade

How much of a building do pedestrians experience when walking along streets?

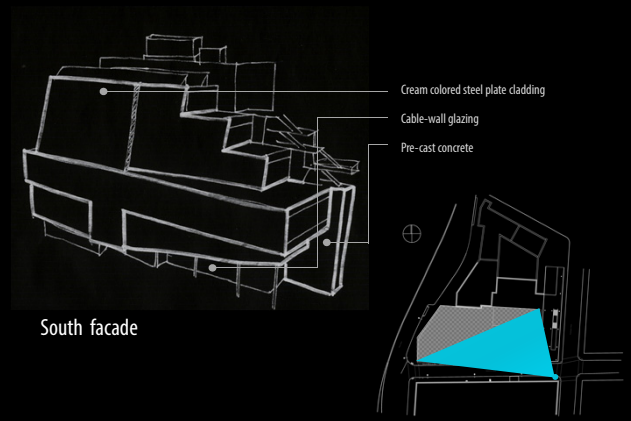



Comfortable view range

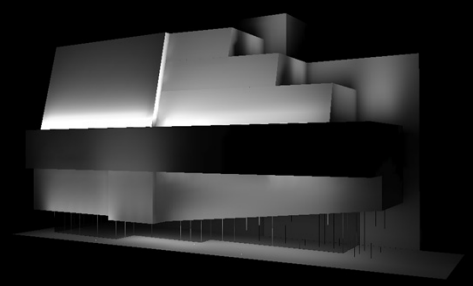


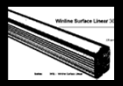

South elevation

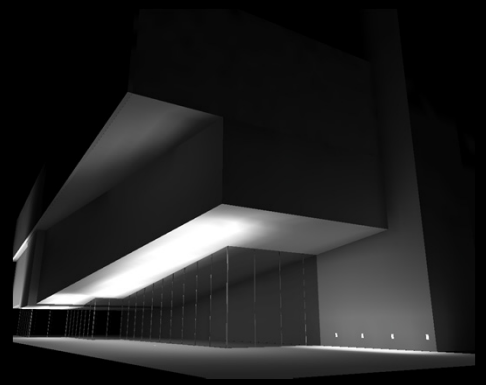
The upper floors of buildings can only be seen at a distance and never close-up in the city scape




South facade

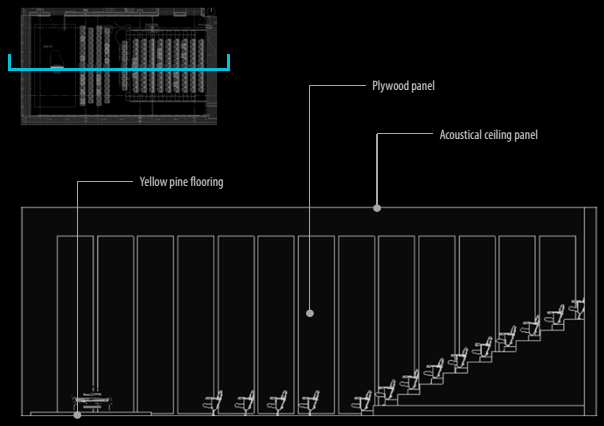


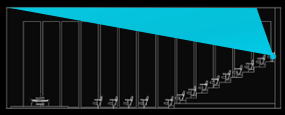


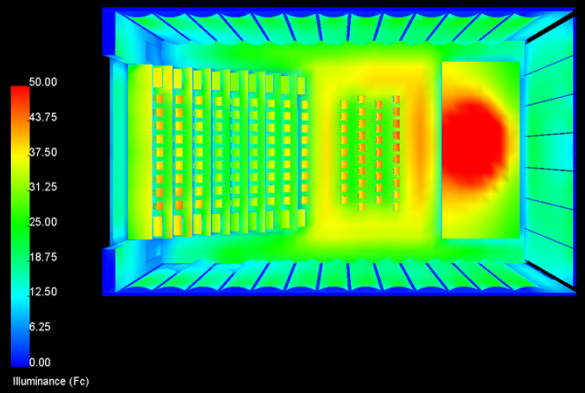


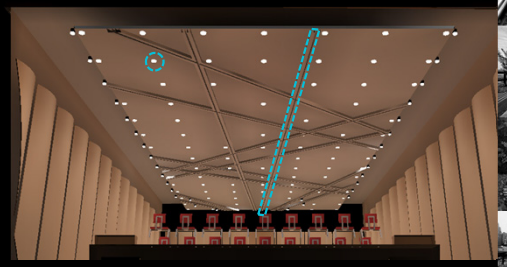
Theater

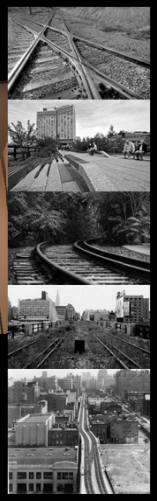
multi-media presentations motion picture films lectures podium discussions
rentable for outside parties performances screening of new artwork



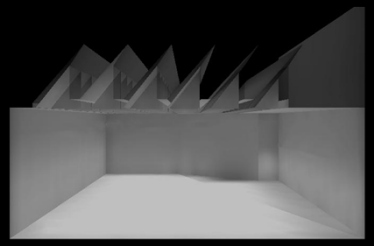


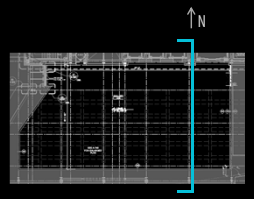


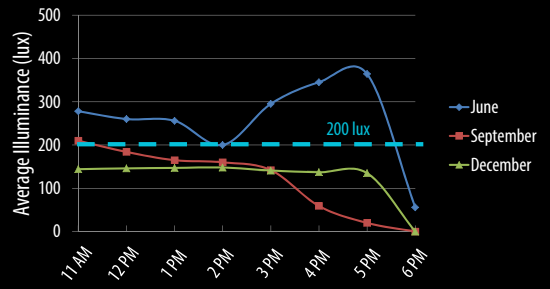



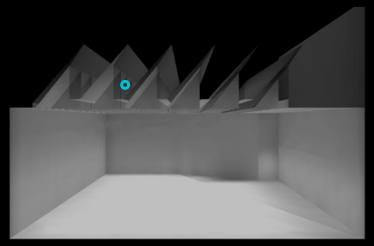


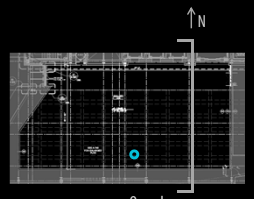
8th floor gallery



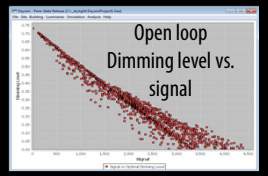


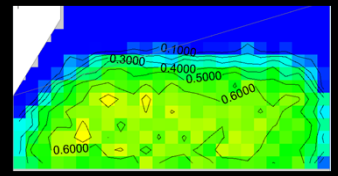





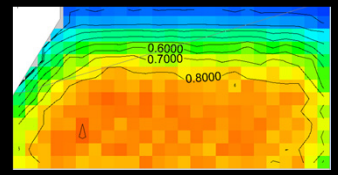



Open loop sensor

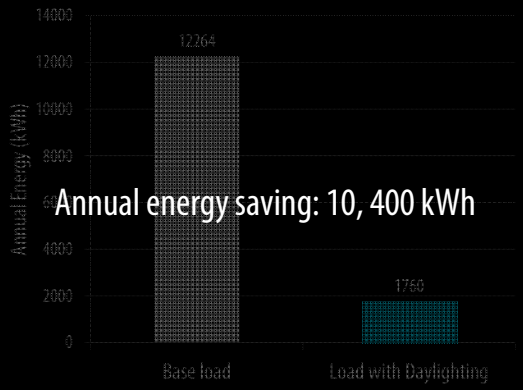


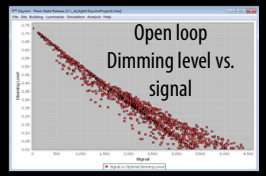

Daylight autonomy 200 lux

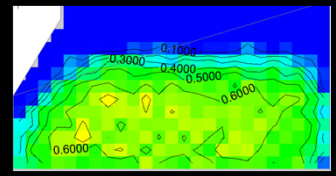



Continuous daylight autonomy 200 lux

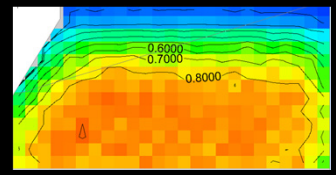



Annual energy saving: 10, 400 kWh




Daylight autonomy 200 lux




Continuous daylight autonomy 200 lux

| | | | |
|---|---|---|---|
| *Annual Electricity Use* | | | |
| Annual Purchased Power, kWh | 3,797,626 | 1,186,142 | (2,611,484) |
| Annual CHP Power Generation, kWh | 0 | 2,611,484 | 2,611,484 |
| Total Annual Electricity Use, kWh | 3,797,626 | 3,797,626 | 0 |
| *Annual Thermal Energy Use* | | | |
| Non-CHP Thermal Use*, MMBtu/yr | 11,838 | 701 | (11,227) |
| CHP Thermal Used, MMBtu/yr | 0 | 11,227 | 11,227 |
| Total Thermal Energy Use, MMBtu/yr | 11,838 | 11,838 | 0 |
| *Annual Fuel Use* | | | |
| Non-CHP Thermal Fuel Use*, MMBtu/yr | 14,772 | 739 | (14,033) |
| CHP Fuel Use, MMBtu/yr | 0 | 25,488 | 25,488 |
| Annual Total Fuel Use, MMBtu | 14,772 | 26,227 | 11,455 |
| | | | |
| Operating Costs | | | |
| Purchased Electricity | $729,144 | $277,880 | ($347,022) |
| Purchased Fuel | $103,995 | $151,607 | $48,109 |
| Incremental O&M | $0 | $41,784 | $41,784 |
| Annual Operating Costs | $833,147 | $671,270 | ($257,957) |

Annual operating savings: $ 257,957

## NY policies & Incentives

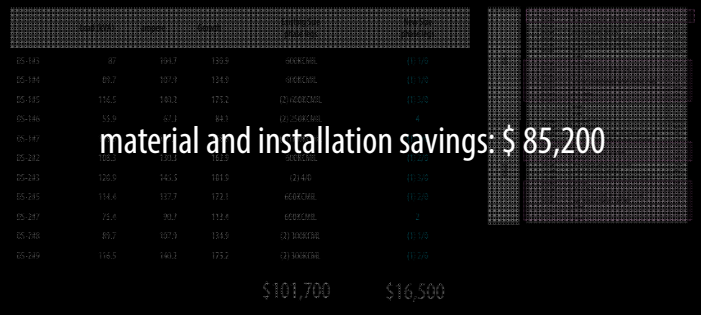
| Existing Electricity Incentives | Policy/Incentive Type |
|---|---|
| Agricultural Energy Efficiency Program | Rebate |
| CHP Acceleration Program | Grant |
| Carrier Anderson Commercial and Industrial Rebate Program | Rebate |
| Energy Smart New Construction Program | Production Incentive |
| Existing Facilities Program | Production Incentive |
| FlexTech Program | Grant |
| Industrial and Process Efficiency Performance Incentives | Production Incentive |
| Listed Design Program (LDP) | Loan |
| Local Option - Solar, Wind & Biomass Energy Systems Exemption | Tax |
| Manufacturing Assistance Program (MAP) | Grant |
| National Grid Gas - Commercial Energy Efficiency Rebate Programs (Rates MC) | Rebate |
| National Grid Gas - Commercial Energy Efficiency Rebate Programs (Upstate NY) | Rebate |
| New York Natural Gas Rates | Utility Rate |
| Tax-Exempt Equipment Leasing Program (TELP) | Tax |

## Measure 1

- ☑ Do you pay more than $.07/ kilowatt-hours on average for electricity (including generation, transmission, and distribution)?
- ☑ Are you concerned about the impact of current or future energy costs on your business?
- ☑ Is your facility located in a deregulated electricity market?
- ☑ Are you concerned about power reliability? Is there a substantial financial impact to your business if the power is not available for 1 hour? For 5 minutes?
- ☐ Does your facility operate for more than 5,000 hours/year?
- ☐ Do you have thermal loads throughout the year (including steam, hot water, chilled water, heating)?
- ☐ Does your facility have an existing central plant?
- ☐ Do you expect to replace, upgrade, or retrofit central plant equipment within the next 5-10 years?
- ☐ Do you anticipate a facility expansion or new construction project within the next 5-10 years?
- ☑ Have you already implemented energy efficiency measures and still have high energy costs?
- ☑ Are you interested in reducing your facility's impact on the environment?

## Measure 2

| | |
|---|---|
| **Facility Energy Use*** | |
| Facility Average Electric Demand, kW | 1,826 |
| Facility Average Heating, MMBtu/hour | 1.7 |
| **CHP System Information** | |
| CHP System Type | Recip Engine |
| CHP System Capacity, kW | 1,222 |
| CHP Electric Efficiency | 33.0% |
| CHP Thermal Output, Btu/kWh | 4,299 |
| CHP Thermal Output, MMBtu/hour | 5.7 |
| CHP System Fuel Cost (Natural Gas), $/MMBtu | 5.62 |
| CHP Installed Cost, $/kW | $2,300 |
| CHP O&M Cost, cents/kWh | $0.0140 |
| **CHP Cost to Generate Power** | |
| Operating Cost Conversion | |
| CHP Fuel Cost, $/kWh | $0.0410 |
| Thermal Credit, $/kWh | ($0.0256) |
| Incremental O&M, $/kWh | $0.0094 |
| ***Operating Costs to Generate Power, $/kWh*** | $0.1209 |
| Capital Charge, $/kWh | $0.1350 |
| ***Total Costs to Generate Power, $/kWh*** | $0.1480 |
| Current Average Electricity Price, $/kWh | |
| **Spark Spread, $/kWh** ** | ($0.0870) |



material and installation savings: $ 85,200

$101,700 $16,500

## Summary

Lighting redesign approached from social, functional, and aesthetics aspects and successfully achieve the overall concept of "engaging".

Daylighting analysis proved that daylight integration of the space helps to reduce the energy cost as well as to reinforce the positive psychological impacts of daylighting, and at the same time provide different lighting variations for artworks viewing

Cogeneration feasibility analysis set the first step to establish a successful combined heat and power system and to install a reliable energy source for the project. Electrical system type conversion based on the CHP implementation will greatly reduce the cost associated.

## Acknowledgements

I would like to thank the many individuals who made this thesis possible.

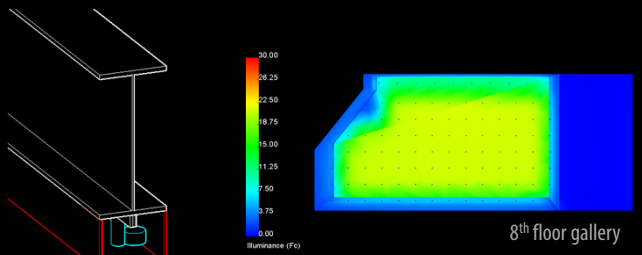
| | |
|---|---|
| Ben Gordon | Engineer, Turner Construction |
| Jean Sundin | Principal, OVI |
| Enrique Peiniger | Principal, OVI |
| Shawn Good | Lighting Department Head, Brinjac Engineering |
| Sandra Stashik | Marketing Manager, Acuity Brands Lighting |
| Dr. Richard Mistrick | Honors Advisor, AE Lighting Associate Professor, Penn State |
| Dr. Kevin Houser | Thesis Advisor, AE Lighting Professor, Penn State |
| Leslie Beahm | Electrical Advisor, Reese Engineering |

Family and friends for their support

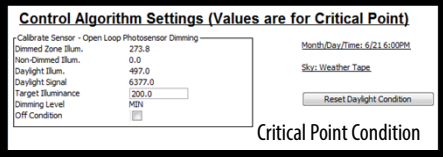
We hope you enjoyed your visit.
Question and Answer

## Appendix

L.F. Raceway * no. of conductor)x 1.1/100 = C.F.L.

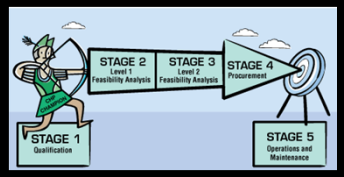



8th floor gallery




Critical Point Condition

## Appendix




| | Load (kVA) | ampere | Growth | Existing Size | New Size | L.F. Raceway | Original Cost | New cost | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | phase legs | phase legs | | | | |
| DS-1#3 | 87 | 104.7 | 130.9 | 600KCMIL | (1) 1/0 | 230 | 5,123.25 | 1,189.10 | |
| DS-1#4 | 89.7 | 107.9 | 134.9 | 600KCMIL | (1) 1/0 | 244 | 5,435.10 | 1,261.48 | |
| DS-1#5 | 116.5 | 140.2 | 175.2 | (2) 600KCMIL | (1) 3/0 | 290 | 12,919.50 | 2,217.05 | |
| DS-1#6 | 55.9 | 67.3 | 84.1 | (2) 250KCMIL | 4 | 328 | 7,071.68 | 840.66 | |
| DS-1#7 | 105.6 | 127.1 | 158.8 | (5) 600KCMIL | (1) 2/0 | 328 | 36,531.00 | 2,056.56 | |
| DS-2#2 | 108.3 | 130.3 | 162.9 | 600KCMIL | (1) 2/0 | 244 | 5,435.10 | 1,529.88 | |
| DS-2#3 | 120.9 | 145.5 | 181.9 | (2) 4/0 | (1) 3/0 | 244 | 4,509.12 | 1,865.38 | |
| DS-2#5 | 114.4 | 137.7 | 172.1 | 600KCMIL | (1) 2/0 | 313 | 6,972.08 | 1,962.51 | |
| DS-2#7 | 75.4 | 90.7 | 113.4 | 600KCMIL | 2 | 201 | 4,477.28 | 515.16 | |
| DS-2#8 | 89.7 | 107.9 | 134.9 | (2) 300KCML | (1) 1/0 | 244 | 6,039.00 | 1,261.48 | |
| DS-2#9 | 116.5 | 140.2 | 175.2 | (2) 300KCML | (1) 2/0 | 291 | 7,202.25 | 1,824.57 | |
| | | | | | | | 101,715.35 | 16,523.84 | 85,191.51 |

# Appendix

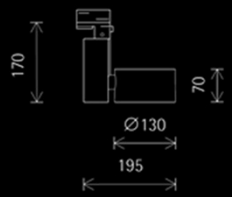

| Space Type | $E_v$ |
|---|---|
| Building Façade | Lighter-toned façade materials (Reflectance ≥0.5), 200 lux ; Darker-toned façade materials (Reflectance <0.5), 400 lux |

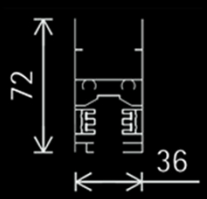
| Space Type | Power Density (W/sqf) | Note |
|---|---|---|
| Building Façade | 0.2 W/ft² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length | Tradable |
| Building Grounds | 1.0 W/linear foot for walkways less than 10 ft wide. 0.2 W/ft² for walkway 10 ft wide or greater, plaza areas, and special feature areas | Nontradable |
| Canopies | 1.25 W/ft² | Tradable |

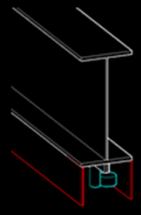
| Space Type | $E_h$ | $E_v$ | Avg:Min |
|---|---|---|---|
| Audience Seating - During production | 2 lux @ floor | 1 lux @ 5ft AFF | 2 : 1 |
| Audience Seating - pre/post production and during intermissions | 100 lux @ floor | 30 lux @ 5ft AFF | 2 : 1 |
| Circulation - During production | 2 lux @ floor | 4 lux @ 5ft AFF | 5 : 1 |
| Circulation - pre/post production and during intermissions | 100 lux @ floor | 30 lux @ 5ft AFF | 2 : 1 |

| Space Type | Power Density (W/sqf) |
|---|---|
| Audience/Seating Area for Performing Arts Theater | 2.6 W/ft² |

# Appendix



| Space Type | $E_h$ | $E_v$ | Avg:Min |
|---|---|---|---|
| Object with low sensitivity to light | 200 lux @ floor | 200lux @ 5ft AFF | 2:1 |
| Circulation/general | Avg=0.2 times object Eh but with min>10lx | Avg of 0.2 times object Ev | 4:1 |

| Space Type | Power Density (W/sqf) |
|---|---|
| Gallery | 1.02 W/ft² |