HOW DO YOU INTEGRATE SUSTAINABLE DESIGN AND BIM INTO A MULTIDISCIPLINARY DESIGN-BUILD CURRICULUM?

Dr. Jeong Woo
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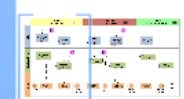
Dr. Matthew Trussoni, AIA, PE
Assistant Professor

MILWAUKEE SCHOOL OF ENGINEERING
ARCHITECTURAL ENGINEERING & CONSTRUCTION MANAGEMENT
BIM & SUSTAINABILITY CURRICULUM OUTLINE



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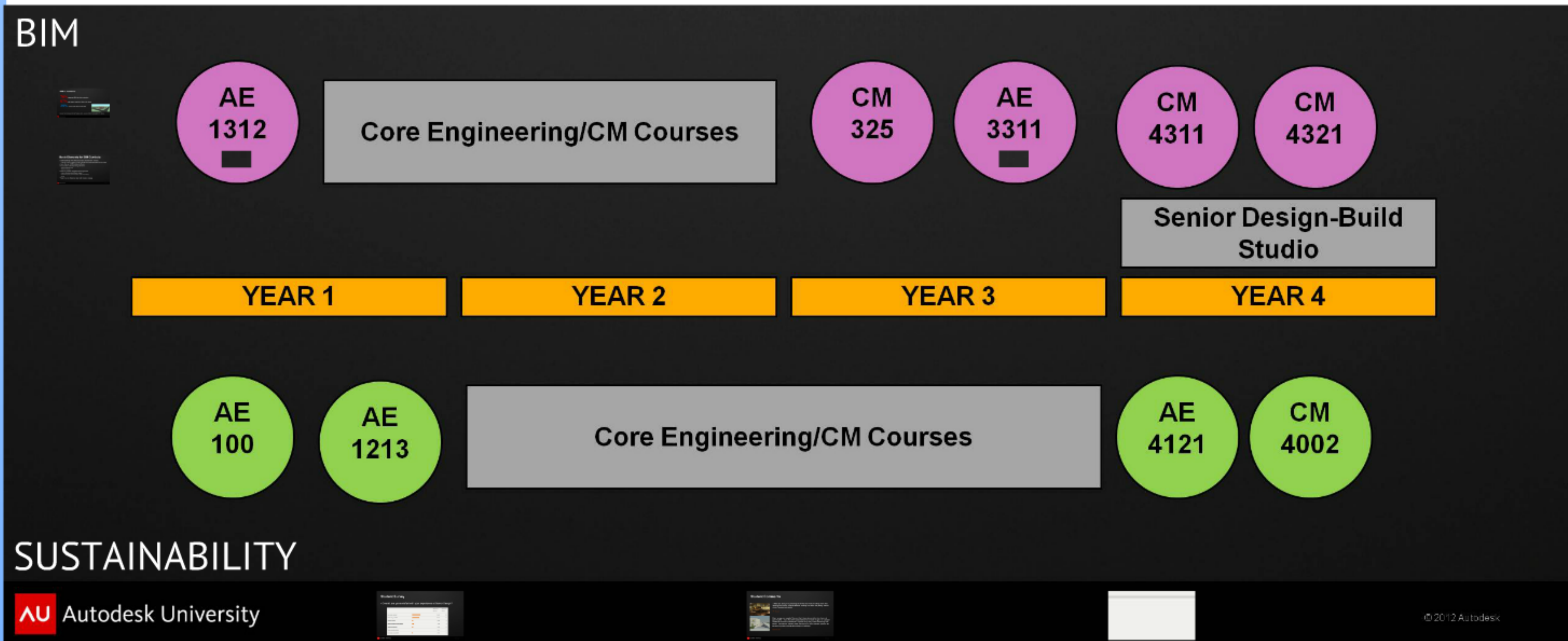


BIM in Academia

70% integrated BIM into their curriculum

97% will have an element of BIM in the future

35% teach model-based estimating

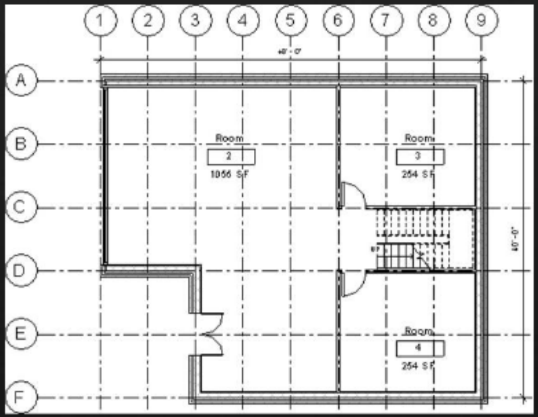
Source: Allan Chasey & Chris Pavelko, 2010, Journal of BIM, BuildingSMART Alliance

Basic Elements for BIM Curricula

- Understanding of the lifecycle project development process
  - The role of owner, designer, builder, users & other parties associated with the project
- Learn the use of BIM-related software
- Incorporate multidisciplinary elements
  - Within academic units
  - With the Industry
- Teach & practice integrated team approach
  - Team members relationships & respect
  - Teamwork (trust, communication, share information)
  - Ethics
- Teach how to effectively deal with industry change

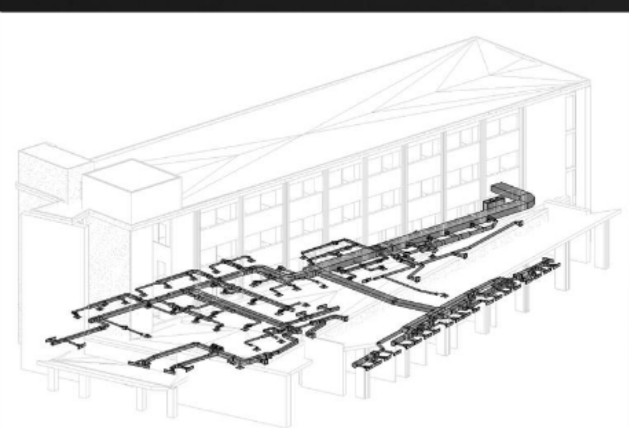
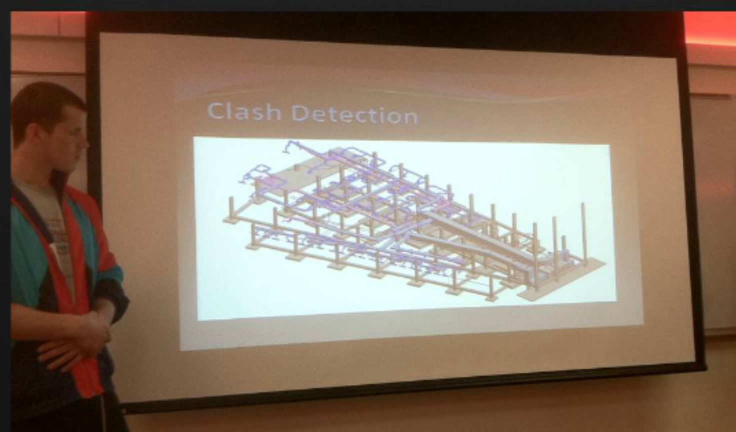
AE 1312 – Introduction to BIM

- Freshman course for both AutoCAD and Revit
- Learn model authoring skills with architectural components



AE 3311 – Introduction to BIM II

- Junior class for Revit Architecture, Structure, and MEP
- Focus on model integration

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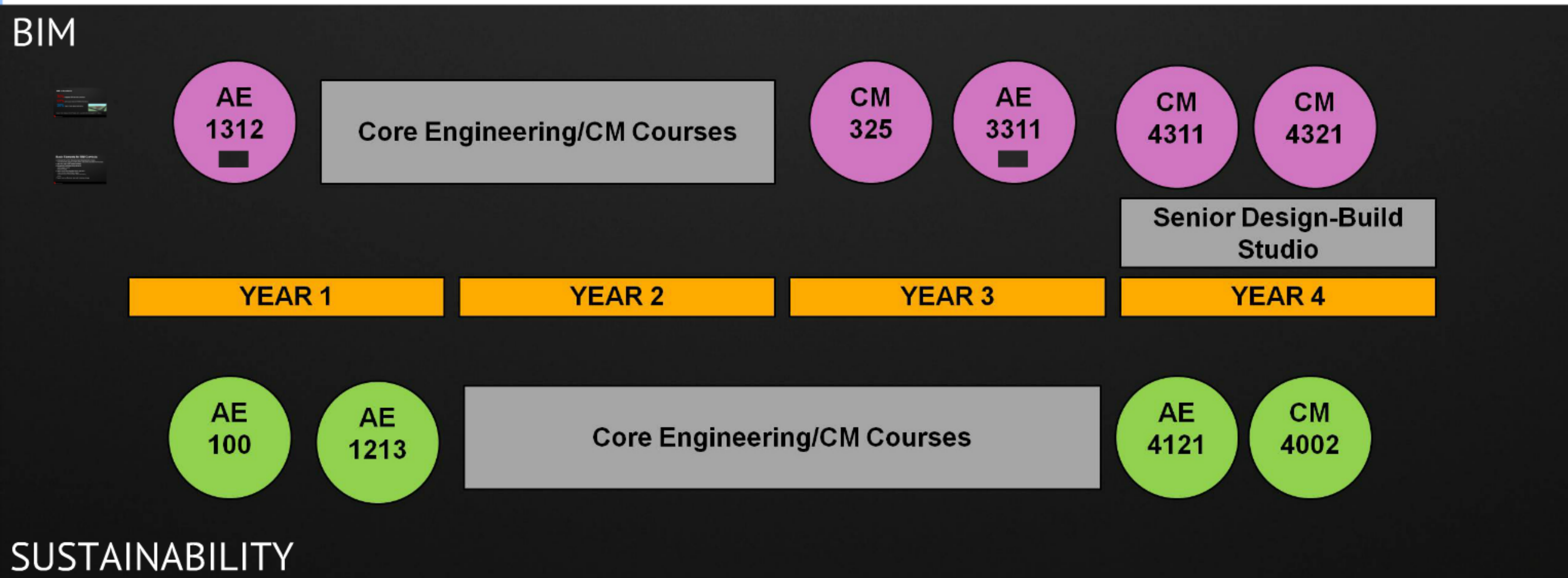
BIM & SUSTAINABILITY CURRICULUM OUTLINE



Student Survey

- Overall, are you satisfied with your experience at Senior Design?

	Response Percent	Response Count
Extremely satisfied	**42.1%**	**16**
Moderately satisfied	36.8%	14
Slightly satisfied	5.3%	2
Neither satisfied nor dissatisfied	7.9%	3
Slightly dissatisfied	5.3%	2
Moderately dissatisfied	0.0%	0
Extremely dissatisfied	2.6%	1

Student Comments

It did a very good job of preparing me for the real world, if nothing more than learning how to work under a deadline, working in a team, and getting used to things changing last minute.

CM Student

I have to say, I am proud of the work that I have done and the time I put in to accomplish it. I know that all the presentations have made me grow as a person and feel much more comfortable in aspects of my daily career and talking with clients. The research involved made me learn a lot about different systems and current and growing sustainable designs in buildings.

AE/CM Student

Student Survey

- Which of the following is the most helpful to learn the concepts of sustainability?

	Response Percent	Response Count
AE-4121 Environmental Science in Building Construction	**41.7%**	**15**
AE-4311 Architectural Design	2.8%	1
CM-4002 Sustainable Design and Construction	16.7%	6
AE-4712 Senior Design	38.9%	14
	Comments: Show Responses	9

AE 4712 allowed for creativity with sustainable design and gave us the opportunity not just to apply our understanding with drawings but through written deliverables as well. It provided a way to apply what we learned.

AE/CM Student

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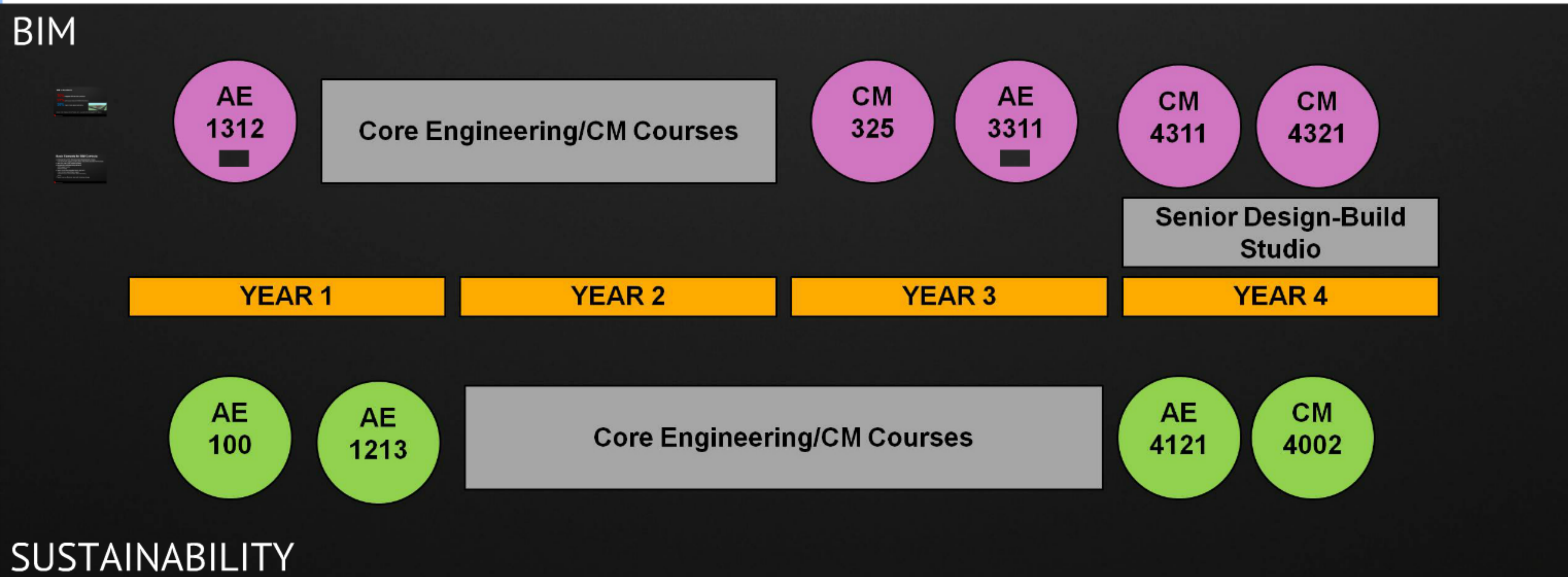
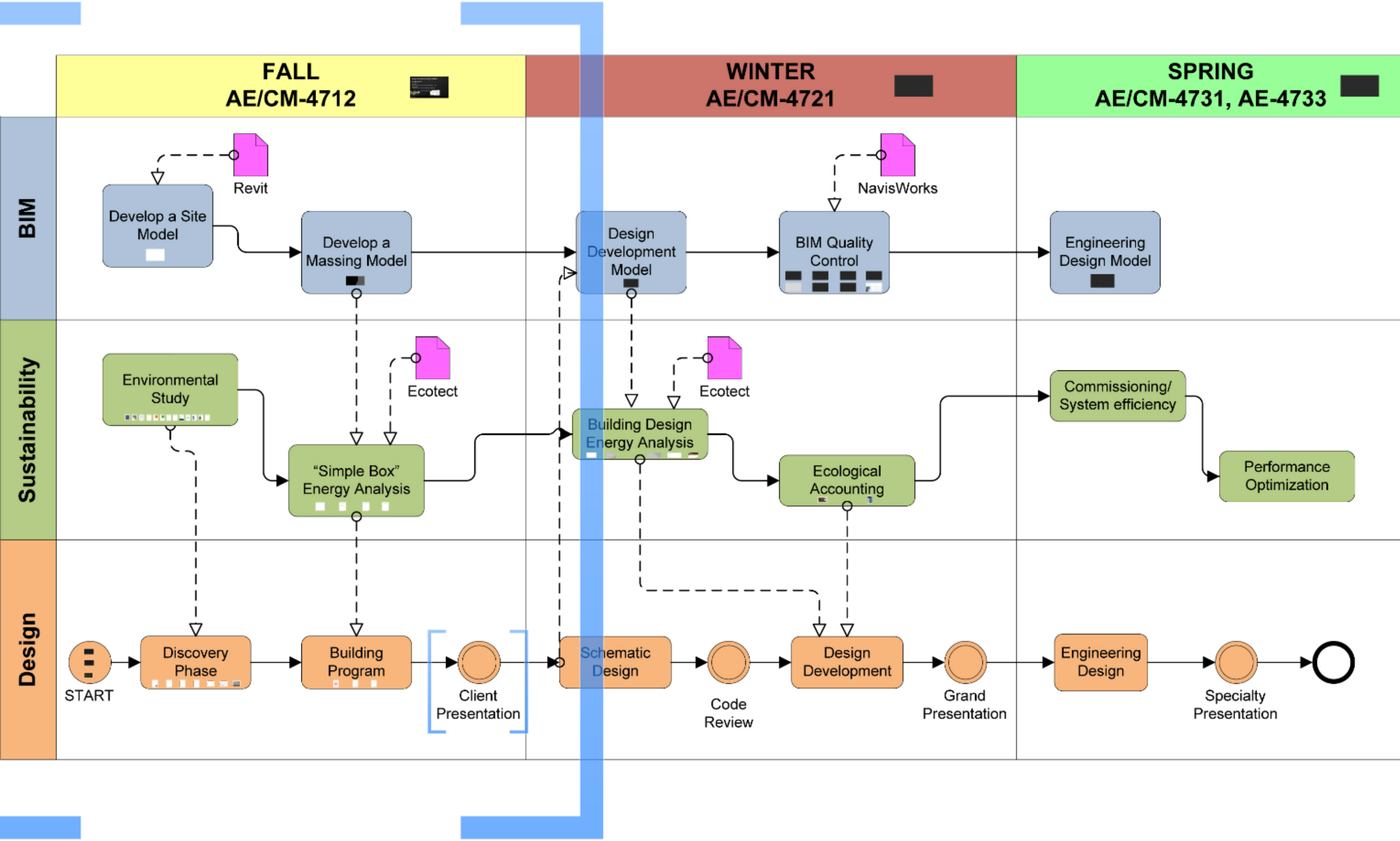
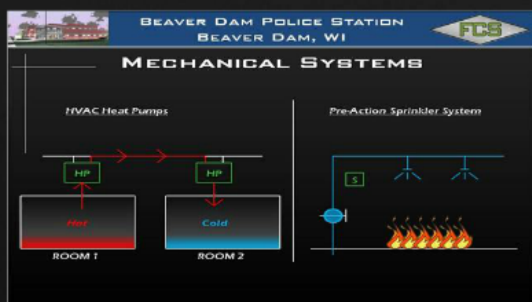
BIM & SUSTAINABILITY CURRICULUM OUTLINE

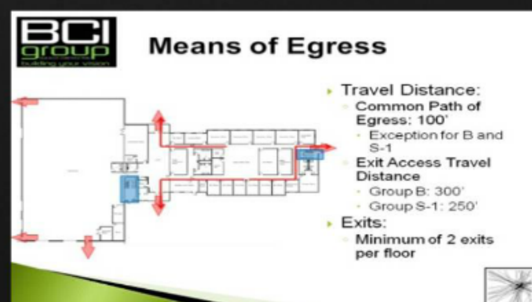



FALL
AE/CM-4712
WINTER
AE/CM-4721
SPRING
AE/CM-4731, AE-4733
BIM
Sustainability
Design
Revit
Develop a Site Model
Develop a Massing Model
Design Development Model
NavisWorks
BIM Quality Control
Engineering Design Model
Environmental Study
Ecotect
"Simple Box" Energy Analysis
Building Design Energy Analysis
Ecotect
Ecological Accounting
Commissioning/ System efficiency
Performance Optimization
START
Discovery Phase
Building Program
Client Presentation
Schematic Design
Code Review
Design Development
Grand Presentation
Engineering Design
Specialty Presentation

Design-Build Senior Design at MSOE

- Fall Quarter Activities
  - Client Meetings
  - Site Visits
  - Research (Building Codes, Zoning, Building types… etc.)
  - Deliverables
    - Building Program, Preliminary Budget and Schedule



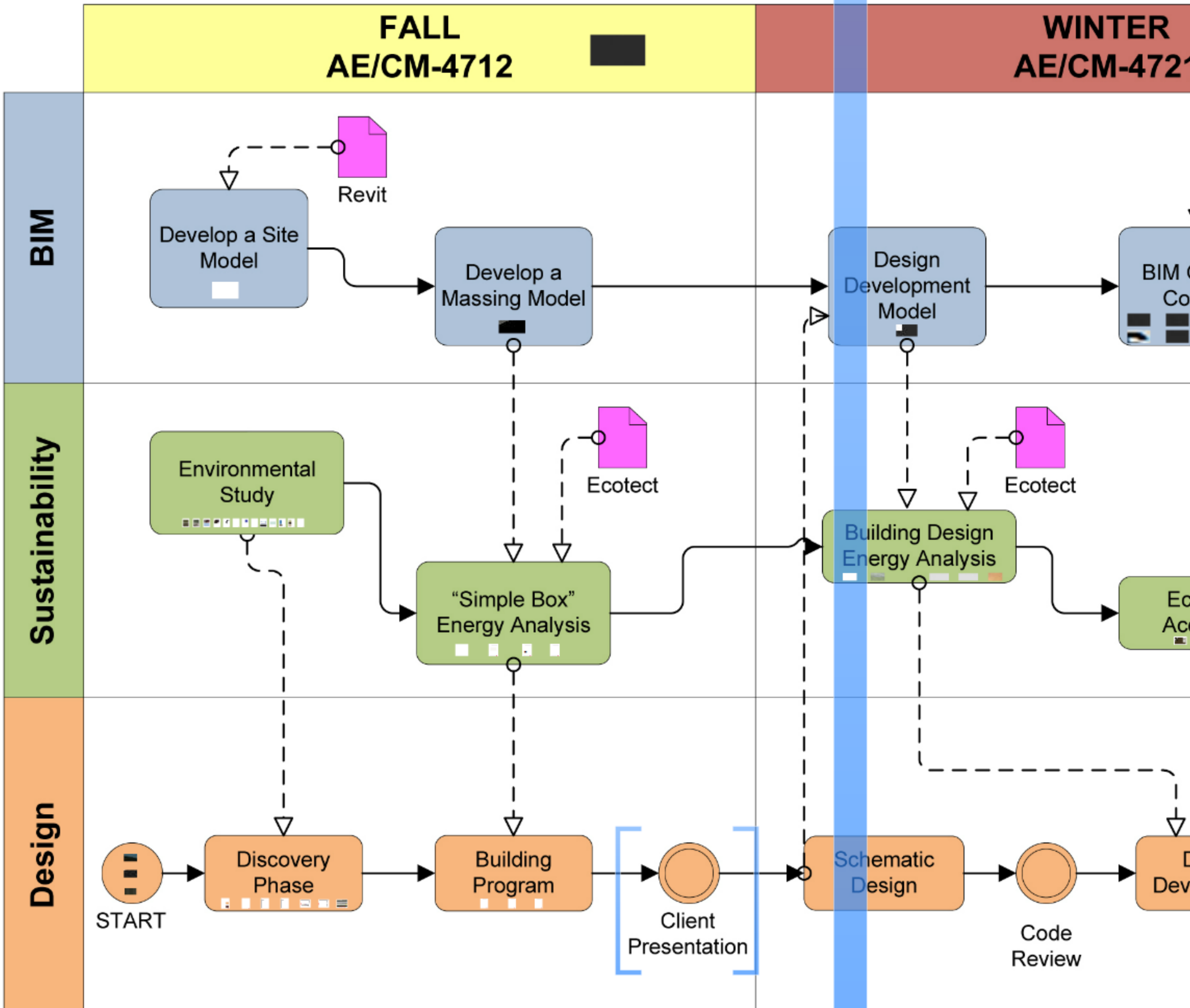


Design-Build Senior Design at MSOE

- Winter Quarter Activities
  - Architectural Schematic Design, Design Development, Final Architectural Design
  - Preliminary budget, milestone schedule, constructability
- Deliverables
  - Week 3 Preliminary Presentation to Client
  - Week 6 Design Development presentation to Plan Examiner
  - Week 9 Final Architectural Design Presentation to Jury of experts

Design-Build Senior Design at MSOE

- Spring Quarter Activities
  - AE Students – Working Drawings and Engineering Calculations
  - CM Students – Estimates, Schedules, Mobilization plans, Safety Plans, VE, and BIM QC
- Final Deliverables
  - Specialty Presentations in front of industry experts



FALL
AE/CM-4712
WINTER
BIM
Sustainability
Design
Revit
Develop a Site Model
Develop a Massing Model
Design Development Model
Environmental Study
Ecotect
"Simple Box" Energy Analysis
Ecotect
Building Design Energy Analysis
START
Discovery Phase
Building Program
Client Presentation
Schematic Design
Code Review

Design-Build Studio at MSOE

- 4 sections of Senior Design
  - approx.25 students each section
  - Each section divided into (3) teams
  - (8-10) students per team
- Project spans entire year
- Real Projects for Real Clients

Design-Build Faculty Members

- Typical Faculty Team
  - Architect
  - Construction Manager
  - Structural
  - Plumbing
  - HVAC
  - Fire Protection
  - Electrical

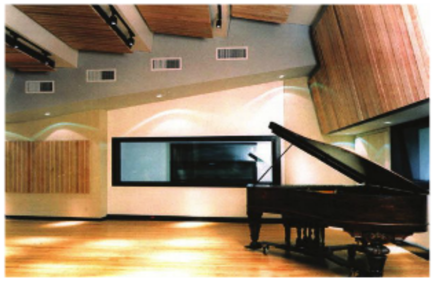
Design-Build Senior Design at MSOE

- Typical Student Team
  - (2) Construction Management
  - (2-3) Structural
  - (2) Mechanical (Plumbing/Fire Protection/HVAC)
  - (1-2) Electrical

In order to prepare for the design of the WMSE Media Center, The Frontier Design Team researched radio stations, media centers and green buildings. The following are some motifs were discovered in the assessment of all the buildings:

- A lot of power will be required for the radio station which will make energy conservation difficult.
- There will be very specific spatial requirements demanding large and oddly shaped rooms
- The WMSE Media Center will be a high profile building with a lot of public attention and use.
- Because of the location the WMSE Media Center, we should encourage public transportation and walking, especially because of live concerts and multiple public uses.

RADIO STATIONS: From radio rtations, we learned about how radio stations have been constructed in the past and the spatial arrangements required within them.



Interlochen Center for the Arts
Interlochen, Michigan

- 9,800 SF
- 5 studios and control rooms and 8 offices
- Piano recording studio
- Radio towers offsite

89.3 KPCC
Pasadena, California

106.3 Mix FM
São Paulo, Brasil

MEDIA CENTERS: From Media Centers, we learned about what defines the modern "Media Lab" building and the spatial requirements associated with them.

EMPAC Center at Rensselaer Polytechnic Institute
Troy, New York

- Acoustic separation prevents conduction of noisy vibrations. Some parts of the building even sit on springs embedded in the foundation
- Concert hall, theater, studios and lobby
- Fiber optic and copper cable for digital transmission
- Light dimmers and projection screens
- 2,164 custom designed acoustic panel: 1,280 diffusive; 884 absorptive

Books:

Architectural Acoustics - William Cavanaugh

This book includes important information for architects, engineers, and all other who focus on unwanted sound throughout a building. The main topics in this book are the basic principles of architectural acoustics, various types of acoustical materials and methods, and building noise control application. This will be helpful when trying to control the sound in the auditorium and studios.

ASHRAE Green Guide, 3rd Edition

This manual is created to provide help to HVAC&R system designers in designing a green building. It contains need-to-know information on every aspect of the building process from planning to operation and maintenance of the facility. This will be useful on the WMSE project because of the intrinsic green nature of the project, and will help facilitate better results.

Green Buildings Pay - Brian Edwards

This guide examines, through case studies how different approaches to green design can produce more sustainable patterns of development. The studies are described by their designers and often also by the client, thereby ensuring that the buildings are seen in the context of market realities.

Energy Efficient Buildings: Architecture, Engineering, and Environment - Wayne Forster

An examination of how energy efficiency can be enhanced by integrating advances in architecture and engineering. Critical studies of outstanding recent building projects around the world reveal the many innovative ways designers can integrate architecture and engineering to produce buildings that are both attractive and energy efficient.

Solar Power in Building Design: The Engineer's Complete Design Resource - Peter Gevorkian

Solar Power in Building Design is a complete guide to designing, implementing, and auditing energy-efficient, cost-effective solar power systems for residential, commercial, and industrial buildings. From basic theory through project planning, cost estimating, and manufacturing methods, this vital resource offers you everything needed for solar power design success.

Optimizing the Performance of a Photovoltaic Array by Evaluating Site-Specific Parameters - Adam McMillen

Master's thesis covering performance maximization measures for a variety of cases. Because the site is limited and PV will likely be an important aspect the Media Center project, this book will help optimize performance and get the most out of the PV space available.

Zoning and Code

Current use: Surface Parking

Size: 0.70 acres

Approximately 84% of the site can be developed (about 0.60 acres) and there are no landscaping requirements for the site.

Zoning: RED (redevelopment), currently being rezoned by the City of Milwaukee and the owner

- Permitted, limited, special, conditional, and prohibited uses for property in a redevelopment districtshall be as indicated in the redevelopment plan for that district (attached)

Environmental Conditions: prior use included fuel and coal business and gas station.

Maximum Height: 12 stories

Minimum Height: 4 stories

Allowable form combination: Slab and Core.

Several streets within the district have significantly higher levels of pedestrian activity, these streets include Water street, Edison street, and portions of Knapp, Juneau, and Cherry. With these higher levels of activity the code requires that there must be 50-75% glazing on the ground floor.

Setbacks:

- 15' from dock line (west)
- 6' from property line (North)
- 0' from the property line (east)
- 0' easement from the property line (south)

AVALON

AVALON ASSOCIATES

Zoning and Code

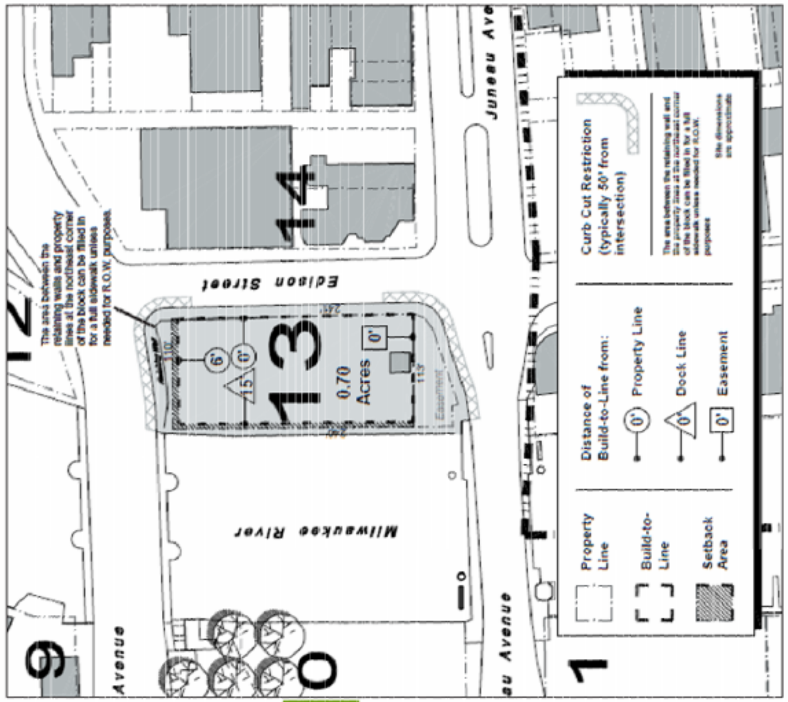
International Building Code

- Classification: Assembly A-1 (television and radio studios admitting an audience)
- Allowed for mixed occupancy
- All exit doors must shall discharge directly to the exterior of the building.
- Interior Finishes: Class B materials (corridors & exit enclosures), Class C (rooms and enclosed spaces)
- Fire Sprinkler system Required if fire area exceeds 12,000 SF or occupational load of 300 or more.
- Light transmitting panels should not be used as wall panels on exterior walls.
- 2 hour or greater fire-resistance rating, smoke detectors in HVAC system, and also fire alarm system, standpipes also required.
- Dead ends of 70 feet in sprinklered buildings.
- Mandatory safety scores: Fire Safety=16, Means of Egress = 27, General Safety = 27.

VALON

AVALON ASSOCIATES

Zoning and Code



Parcel	Block 13
Allowable Building Form Combinations (I: Slab and Core; II: Types in I + Large Venue; III: Types in I + Rowhouse	I
Approximate Acreage	0.70 acres
Current Use	Surface parking
Allowed Use	See Use Table on page 82
Existing Zoning	C9B(A)
Recommended Zoning	C9B(A)
Known Utilities	There are new street retaining walls on the north edge of the parcel.
Known Environmental Conditions	Prior use of parcels within the block include fuel and coal business and gas station.

Note: Park East zoning was changed to RED in 2005.

AVALON
AVALON ASSOCIATES

Zoning and Code

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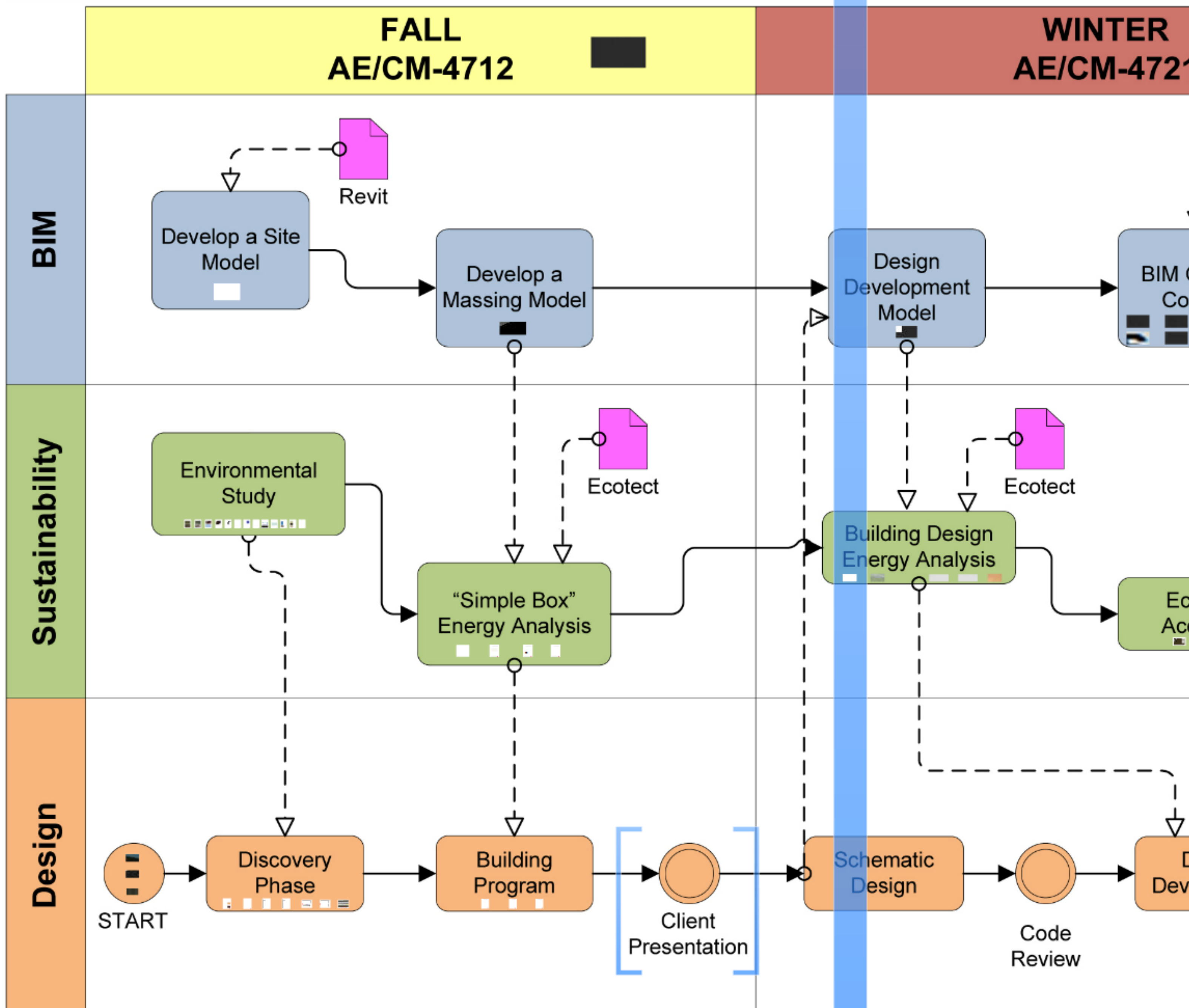
1201 N Edison St, Milwaukee, WI 53202
E Knapp St
SITE ANALYSIS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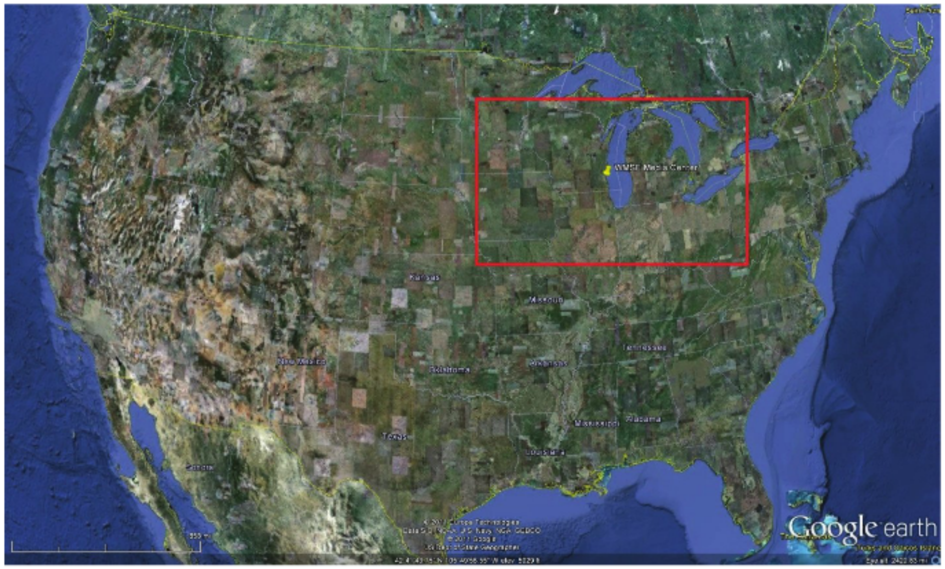
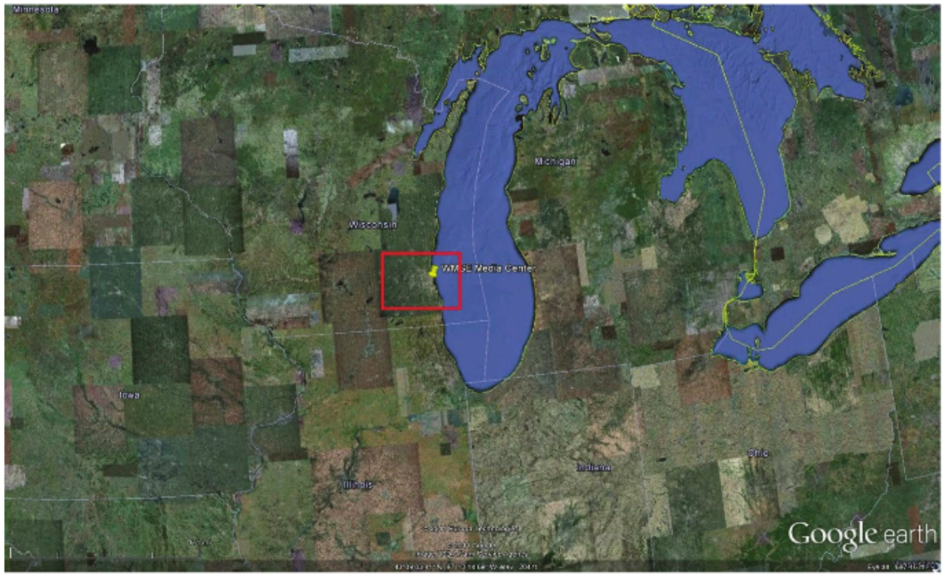
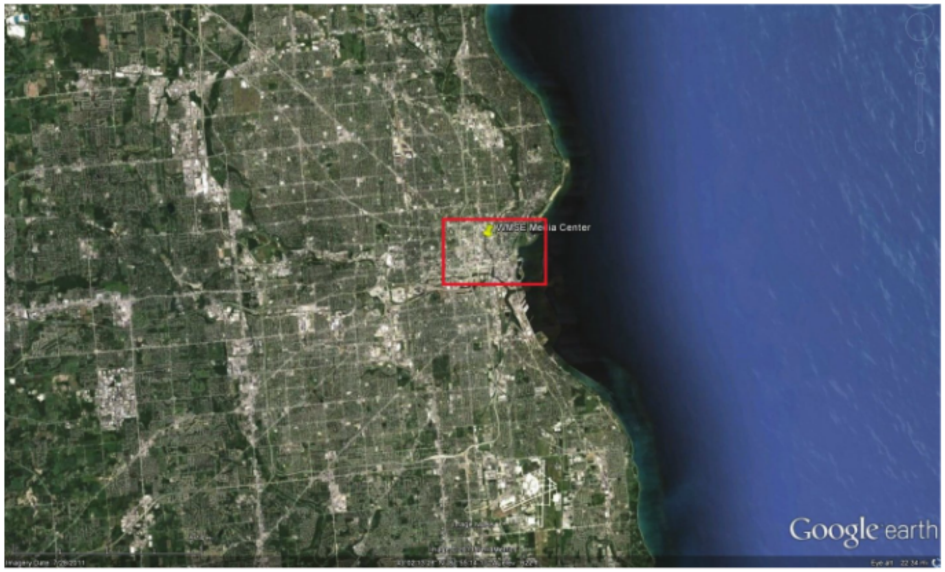

Google earth

USA


Michigan
Wisconsin
WMSE Media Center
Iowa
Illinois
Indiana
Ohio
Google earth

Midwest

SITE LOCATION

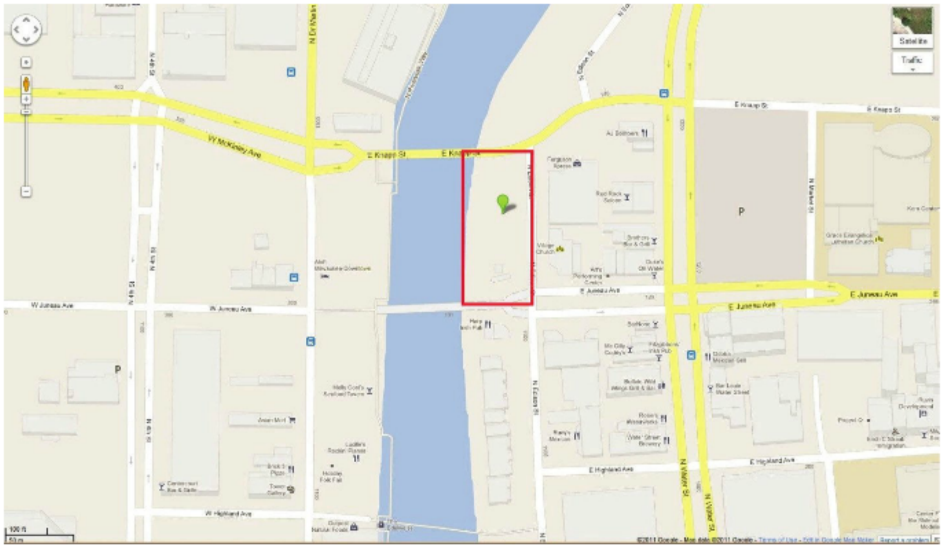


Milwaukee

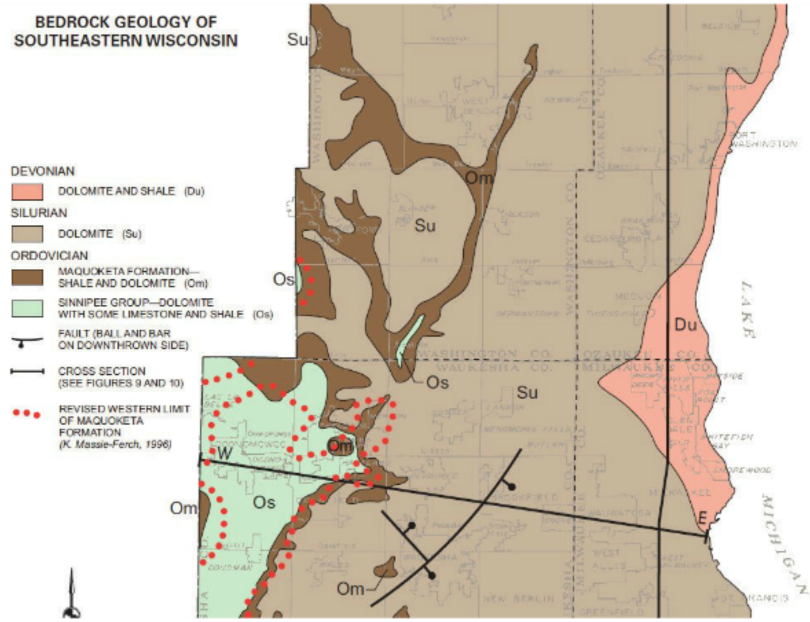
Downtown

SITE LOCATION

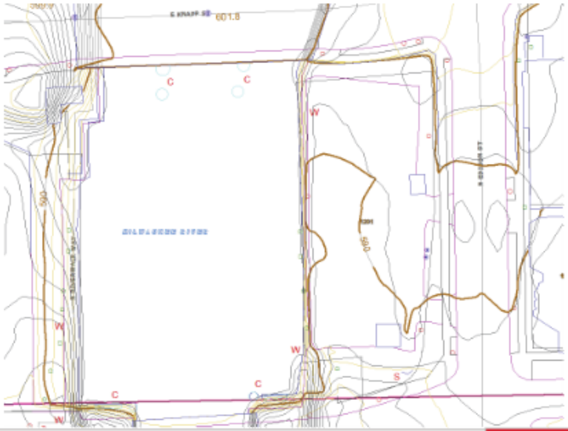
Park East



1201 N. Edison St.

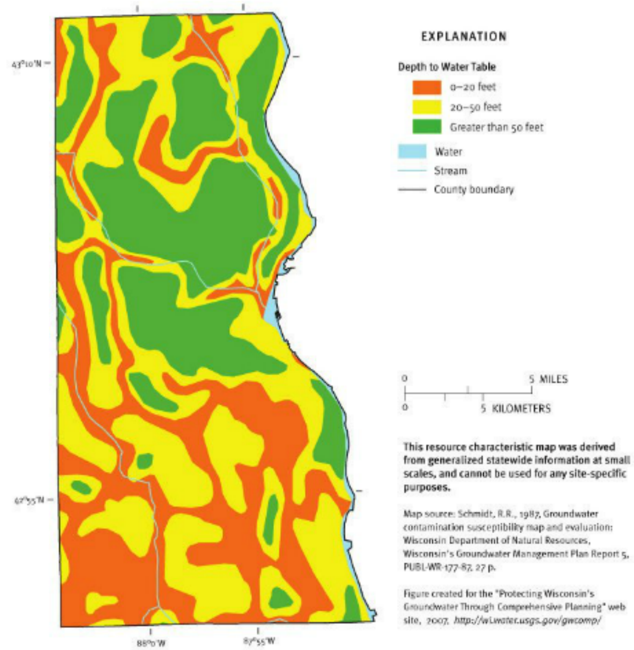


The Silurian section in Southeastern Wisconsin consists of up to 600 feet of dolomite, subdivided into five formations. These are, from the top, the Waubakee Formation, the Racine Formation, the Waukesha Formation, the Brandon Bridge beds, and the undifferentiated "lower Silurian beds". The Waubakee Formation consists of dense, laminated to thin-bedded, slightly shaly, gray dolomite and is present only in Ozaukee and eastern Milwaukee County. It varies from 60 to 100 feet in thickness, and is unconformably overlain by the Devonian Thiensville Formation. Locally, reefs developed in the underlying Racine Formation project through the Waubakee Formation and are overlain directly by the Thiensville Formation.



GROUNDWATER RESOURCES

The south eastern-most part of Wisconsin is on the border of the Lake Michigan water basin. This means that any water used in the area is returned to Lake Michigan. The area inside that border is not wide and excludes most of Waukesha, and parts of the New Berlin and Brookfield suburbs of Milwaukee. The Great Lakes Commission is currently collaborating to limit the about of water taken from Lake Michigan to supply areas outside of the Great Lakes Basin. Measures are expected to be passed in the next three years to protect the amount and quality of the world's greatest source of freshwater.



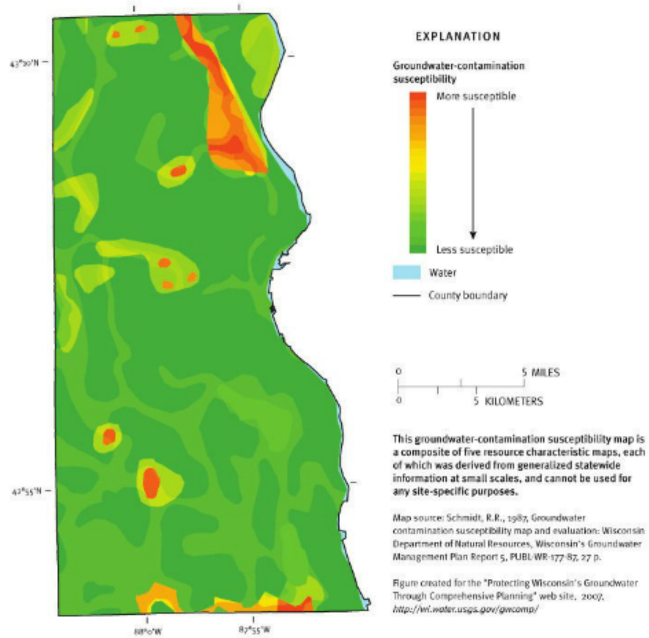
The depth of the water table is between 0' and 50' deep for most of Milwaukee. At the WMSE site the water table height is at the high water mark of the river next to it.

HUMAN ACTIVITIES THAT MAY CREATE GROUNDWATER QUALITY PROBLEMS IN SOUTHEASTERN WISCONSIN

Originating On the Land	Originating Below Land Surface
Above-ground storage tanks (bulk fuel storage)	Above Water Table
Accidental spills	Animal waste storage facilities
Agricultural activities:	**Landfills**
Animal feedlots	Leakage:
Fertilizer and pesticide storage, mixing, and loading	**Underground storage tanks**
Fertilizer and pesticide application	Underground pipelines
Irrigation return flow	Sewers
Silage and crop residue piles	**On-site sewage disposal systems**
Dumps	Surface wastewater impoundments
Highway de-icing, including material **storage sites**	Sumps, dry wells
Waste spreading or spraying (sewage, **sludge**, septage, whey)	Waste disposal in dry excavations
Stockpiles (chemicals and waste)	Below Water Table
Infiltration of contaminated surface water or precipitation	Ground water development:
Salvage yards	**Improperly abandoned wells and holes**
Application of fertilizers and pesticides to urban lawns and gardens	Improper well construction
Urban runoff	Overpumping
	Drainage or disposal wells
	Waste disposal in wet excavations

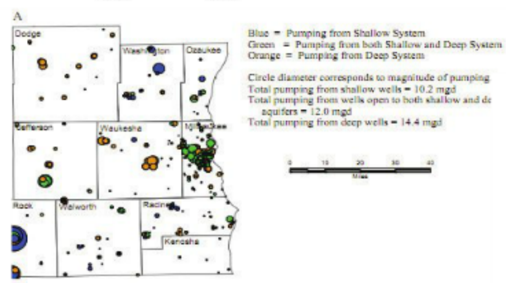
GROUNDWATER RESOURCES

Milwaukee ground water was tested in 30 different private wells. 100% of the samples met the health-based drinking water limit for nitrate-nitrogen. In 2002 a study was conducted that showed 21% of private drinking water wells in the region contained a detectable level of an herbicide. The city spent over $213 million on cleaning up the ground water from petroleum that was caused from leaking underground storage tanks. The chart below illustrates that there is very little contamination to the ground water in the area.

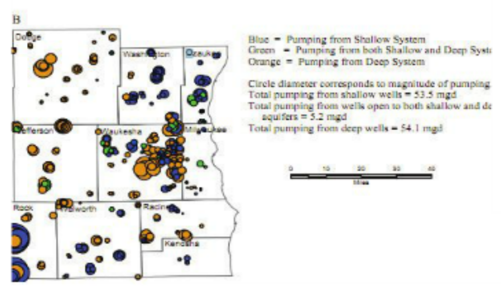


The maps to the right identify the public wells in Milwaukee. It illustrates the following about the pumping volume of wells:

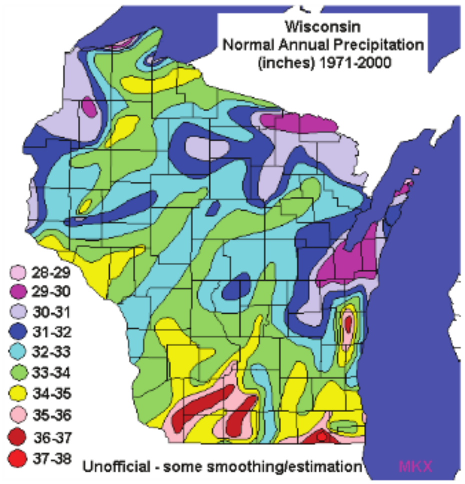
<u>Image A</u>
Shallow wells = 10.2 mgd
Wells open to shallow and deep aquifers = 12.0 mgd
Deep wells = 14.4 mgd.

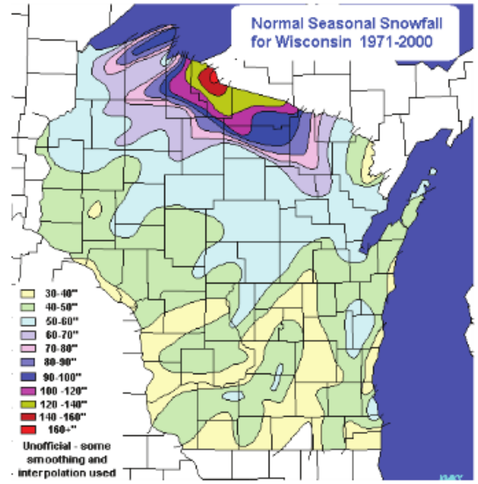


<u>Image B</u>
Shallow wells = 53.5 mgd
Wells open to shallow and Deep aquifers = 5.2 mgd
Deep wells = 54.1 mgd.

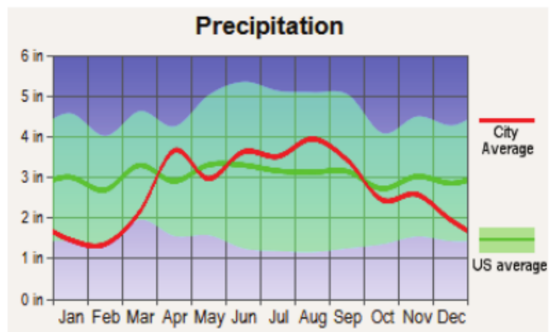


MILWAUKEE CLIMATE DATA

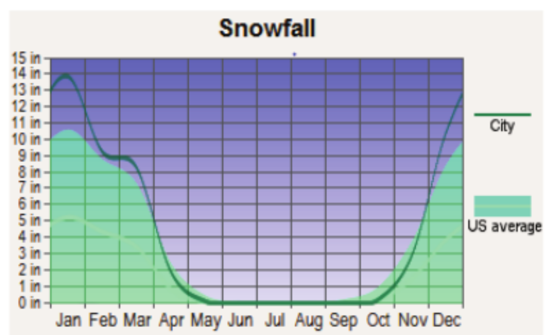




Month	Rainfall
January	1.85in
February	1.65 in
March	2.59 in
April	3.78 in
May	3.06 in
June	3.56 in.
July	3.58 in
August	4.03 in
September	3.30 in
October	2.49 in
November	2.70 in
December	2.22 in



Month	Snowfall
January	14 in
February	12 in
March	9 in
April	5 in
May	0.75 in
June	0 in
July	0 in
August	0 in
September	0 in
October	1 in
November	6 in
December	13 in



CLIMATE DATA

Milwaukee Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temperature	18.9	23.0	33.3	44.4	54.6	65.0	70.9	69.3	61.7	50.3	37.7	24.4	46.1
Avg. Max Temperature	26.1	30.1	40.4	52.9	64.3	74.9	79.9	77.8	70.6	58.7	44.7	31.2	54.3
Avg. Min Temperature	11.6	15.9	26.2	35.8	44.8	55.0	62.0	60.8	52.8	41.8	30.7	17.5	37.9
Days with Max Temp of 90 F or Higher	0.0	0.0	0.0	< 0.5	< 0.5	2.0	4.0	2.0	1.0	0.0	0.0	0.0	9.0
Days with Min Temp Below Freezing	29.0	26.0	23.0	9.0	1.0	0.0	0.0	0.0	< 0.5	4.0	18.0	27.0	137

Milwaukee Heating and Cooling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Heating Degree Days	1429	1176	983	618	338	82.0	14.0	27.0	123	456	819	1259	7324
Cooling Degree Days	0.0	0.0	0.0	0.0	16.0	82.0	197	160	24.0	0.0	0.0	0.0	479

Milwaukee Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (inches)	1.6	1.4	2.7	3.5	2.8	3.2	3.5	3.5	3.4	2.4	2.5	2.3	32.9
Days with Precipitation 0.01 inch or More	11.0	10.0	12.0	12.0	12.0	11.0	10.0	9.0	9.0	9.0	10.0	11.0	125
Monthly Snowfall (inches)	13.7	9.6	8.3	1.8	0.1	< 0.05	< 0.05	< 0.05	< 0.05	0.2	3.2	10.2	47.1

Other Milwaukee Weather Indicators	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Wind Speed	12.6	12.3	12.8	12.8	11.5	10.4	9.7	9.5	10.4	11.4	12.5	12.2	11.5
Clear Days	7.0	6.0	6.0	6.0	7.0	8.0	10.0	10.0	9.0	9.0	5.0	6.0	90.0
Partly Cloudy Days	6.0	6.0	8.0	8.0	10.0	10.0	11.0	11.0	9.0	8.0	6.0	6.0	100.0
Cloudy Days	18.0	15.0	17.0	16.0	14.0	12.0	10.0	10.0	12.0	13.0	18.0	19.0	175
Percent of Possible Sunshine	44.0	47.0	50.0	53.0	60.0	65.0	69.0	66.0	59.0	54.0	39.0	38.0	54.0
Avg. Relative Humidity	57.0	73.0	73.0	71.5	69.5	69.5	71.5	74.0	75.0	72.5	71.5	73.5	75.5

Summary of Wisconsin's Climate Trends from 1950 to 2006

- Wisconsin statewide average temperature increased 1.5 F°.
- The greatest amount of warming is occurring in winter and spring, especially in northwest Wisconsin.
- Nighttime lows are warming faster than daytime highs, especially in summer.
- There has been a decline in extremely cold winter nights, especially in northwest Wisconsin.
- Date of last spring freeze in Wisconsin is occurring 6 to 20 days earlier.
- Date of first fall freeze in Wisconsin is occurring 3 to 18 days later.
- The growing season in Wisconsin has increased up to 4 weeks.
- Statewide, annual average precipitation has increased 15% although parts of the north became drier.

Summary of Wisconsin's Future Climate Projections

- Scientists project Wisconsin will warm by 4 to 9 °F by mid-21st Century.
- Warming will likely be most pronounced in the winter.
- Projections show there will be fewer extremely cold winter nights and more hot summer days.
- The probability of greater than 3-inch rainstorms will increase during spring and fall.

EXPECTED ENERGY USE

Below, the estimated energy use for the WMSE Media Center is tabulated. It is based on similar existing buildings and the owner's expectations of higher efficiency and lower usage than typical buildings. The buildings compared are assumed to be like those described in the Building Type Research (p. 7) These examples include media labs, radio stations and green buildings such as the Interlochen Center for the Arts, the EMPAC Center at the Rensselaer Polytechnic Institute and the Center for Urban Waters in Tacoma, Washington.

Energy	**Design**	**Target**	**Average Building**
Energy Performance Rating (1-100)	N/A	93	50
Energy Reduction (%)	N/A	60	0
Source Energy Use Intensity (kBtu/Sq. Ft./yr)	N/A	58	120
Site Energy Use Intensity (kBtu/Sq. Ft./yr)	N/A	29	55
Total Annual Source Energy (kBtu)	N/A	13,600,000	24,000,000
Total Annual Site Energy (kBtu)	N/A	5,800,000	11,000,000
Total Annual Energy Cost ($)	N/A	$ 118,965	$ 225,625
Pollution Emissions			
CO2-eq Emissions (metric tons/year)	N/A	19	37
CO2-eq Emissions Reduction (%)	N/A	50%	0%
WMSE Media Lab/Radio Station 1296 N Edison St, Milwaukee, WI 53202 United States			

Ratios of Energy Use:

2010 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)

	Natural Gas	Fuel Oil (1)	LPG	Other Fuel(2)	Renw. En.(3)	Site Electric	Site Total	Site Percent	Primary Electric (4)	Primary Total	Primary Percent
Lighting						1.02	1.02	12.00%	3.2	3.2	17.40%
Space Heating	1.61	0.18		0.06	0.11	0.18	2.14	25.10%	0.55	2.52	13.70%
Space Cooling	0.04					0.58	0.62	7.30%	1.82	1.86	10.10%
Ventilation						0.51	0.51	6.00%	1.6	1.6	8.70%
Refrigeration						0.39	0.39	4.60%	1.23	1.23	6.70%
Electronics						0.26	0.26	3.10%	0.82	0.82	4.50%
Water Heating	0.46	0.02			0.03	0.09	0.59	6.90%	0.29	0.79	4.30%
Computers						0.21	0.21	2.50%	0.66	0.66	3.60%
Cooking	0.18					0.02	0.2	2.40%	0.07	0.25	1.40%
Other (5)	0.3	0.01	0.15	0.04	0	0.65	1.15	13.50%	2.03	2.53	13.80%
Adjust to SEDS (6)	0.58	0.15				0.69	1.42	16.70%	2.15	2.89	15.70%
Total	**3.11**	**0.36**	**0.15**	**0.11**	**0.14**	**4.6**	**8.54**	**100%**	**14.42**	**18.35**	**100%**

WATER TREATMENT

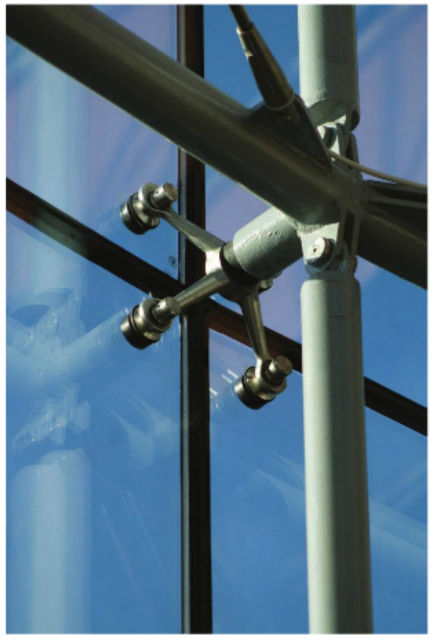
Milwaukee uses Lake Michigan to supply its potable water. This water is treated at two plants, passing the water through multiple treatment process barriers that keep illness-causing microorganisms from our drinking water. The primary form of disinfection in the city plants is ozone gas which is bubbled through the lake water after it enters the treatment plants. This highly reactive gas destroys illness-causing microorganisms, controls taste and odor, and reduces chlorinated disinfection byproducts. Following inactivation of microorganisms, the processes of coagulation, settling, and biological filtration remove additional particles.

This site's waters will be treated at Jones Island Wastewater Treatment about three miles away. Other options to treat water for the site compost toilets, wetland purification or bioswales.

Substance	Ideal Goals (MCLG)	Highest Level Allowed (MCL)	Median Value	Highest Level Detected	Source(s) of Contaminant
Aluminum	0.2 mg/L	NR	0.045 mg/L	0.309 mg/L	Water treatment additive; Natural deposits
Barium	2 mg/L	2 mg/L	0.021 mg/L	0.021 mg/L	Natural deposits
Bromate	10 µg/L	10 µg/L (RAA)	4 µg/L (RAA)	NR	Byproduct of drinking water disinfection
Chlorine, total	4 mg/L	4 mg/L	1.40 mg/L	1.95 mg/L	Residual of drinking water disinfection
Chromium	100 µg/L	100 µg/L	< 2 µg/L	2 µg/L	Natural deposits
Copper (2008)	1.3 mg/L	1.3 mg/L (AL)	0.056 mg/L (AL)	NR	Corrosion of household plumbing systems
Fluoride	4 mg/L	4 mg/L	0.77 mg/L	2.06 mg/L	Water treatment additive; Natural deposits
Haloacetic Acids, total	NA	60 µg/L	1.2 µg/L	9.4 µg/L	Byproduct of drinking water disinfection
Lead (2008)	Zero	15 µg/L (AL)	5.3 µg/L (AL)	NR	Corrosion of household plumbing systems
Organic Carbon, total	TT	TT	1.3 mg/L	2.6 mg/L	Natural deposits
Potassium	NR	NR	1.4 mg/L	1.6 mg/L	Natural deposits
Radium, combined (2008)	Zero	5 pCi/L	0.99 pCi/L	1.1 pCi/L	Natural deposits
Sodium	NR	NR	9.3 mg/L	17.3 mg/L	Natural deposits
Sulfate	500 mg/L	NR	28 mg/L	32 mg/L	Natural deposits
Trihalomethanes, total	NA	80 µg/L	3.6 µg/L	10.4 µg/L	Byproduct of drinking water disinfection
Turbidity	NA	<0.3 NTU 95% of the time	0.04 NTU 95% of the time	0.08 NTU 1-day max	Natural deposits
Uranium, total (2008)	Zero	20 pCi/L	0.14 pCi/L	0.18 pCi/L	Natural deposits

Milwaukee is globally recognized as a leader in Water Treatment and Quality Monitoring. The Jones Island Water Reclamation Facility is at the front of the industry when it comes to quality and efficiency. The Milwaukee Metropolitan Sewage District provides research and water treatment developments to many national and worldwide organizations, companies and governments. The Jones Island Water Reclamation Facility is approximately two miles from the WMSE Media Center site.

One aspect of sustainable design is the use of local, recycled and renewable materials. To this end, there are several materials that stand out for reasons of location, style and performance.



Glass Cladding:
Technology improvements have made glass performance incredible in regards to thermal resistance, light control and strength.

Glulam Beams:
A versatile material that allows many different design and engineering options, glulam beams can be manufactured using different woods. Glulam can be made in many different styles and is looked on by the public more favorable than more structural materials.

Cream City Brick:
A local material, cream city brick defined Milwaukee's history. There are a number of recycled brick suppliers in the area. Cream City Brick is aesthetically attractive and performance proven.

Limestone:
Milwaukee and the surrounding area have rich deposits of limestone. Tons of it was removed during the deep tunnel project and because of its strength and pleasing look, it is an appealing material in this project.

Green Roof Systems:
The Urban Environment is taking huge steps forward in regard to ecology. Living roof systems increase thermal capacity of roof assemblies, provide oxygen recycling and support human quality of life opportunities.

In addition to specific materials, Frontier Design & Construction has identified a number of local suppliers of materials pertinent to this project. The following list includes suppliers that have sustainable design materials and practices, are within a 500 mile radius of Milwaukee and have a reputation of quality.

LIFE-CYCLE INVENTORY DATA

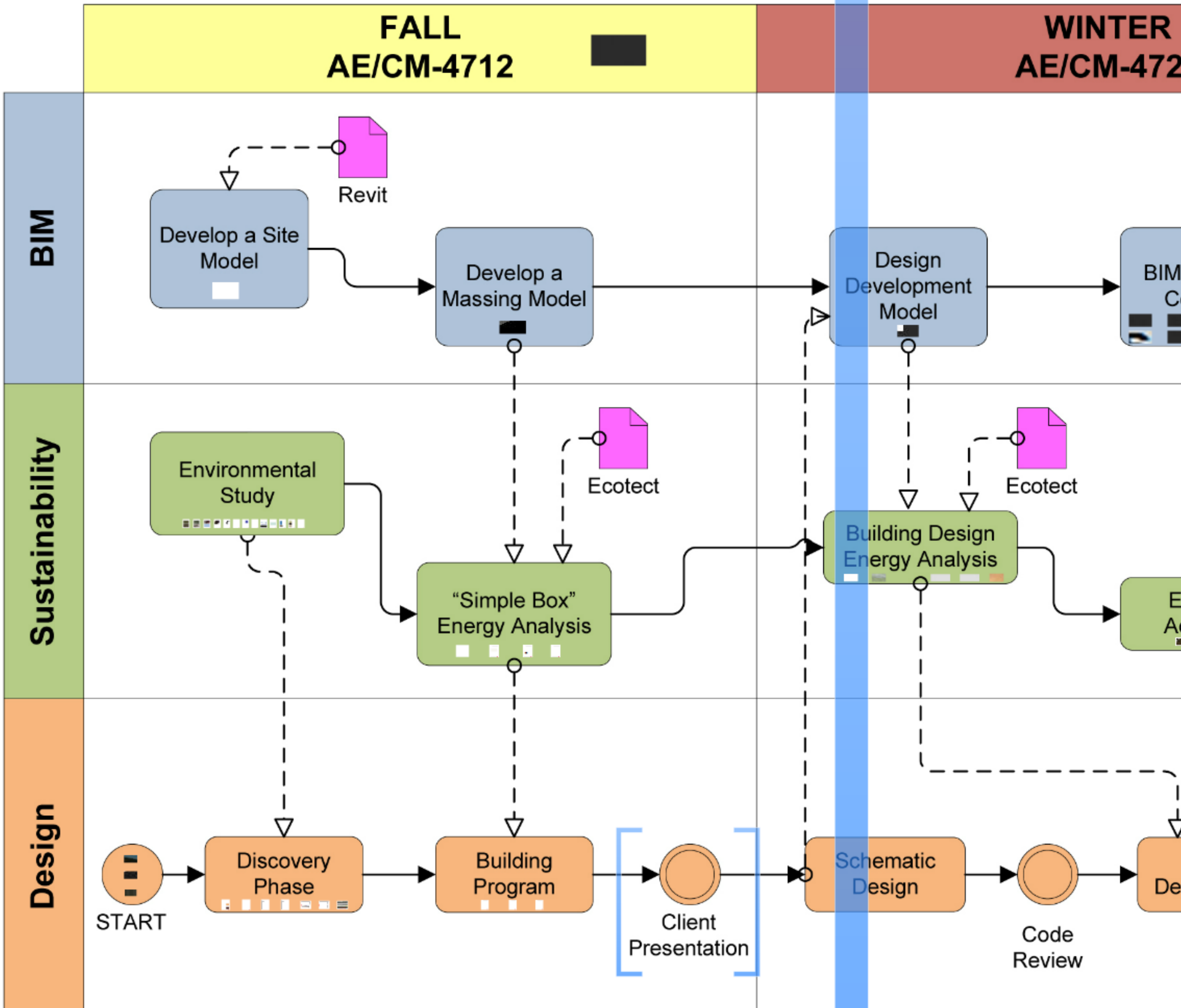
- National Renewable Energy Laboratory – Need to register to have access to the database, Free to use: *http://www.nrel.gov/lci/*
- Building Ecology Life Cycle Assessment Software, Tools and Databases – Extensive listing of resources for doing research on life-cycle assessments: *http://www.buildingecology.com/sustainability/life-cycle-assessment/life-cycle-assessment-software*

ALTERNATIVE BUILDING MATERIALS / TECHNIQUES:

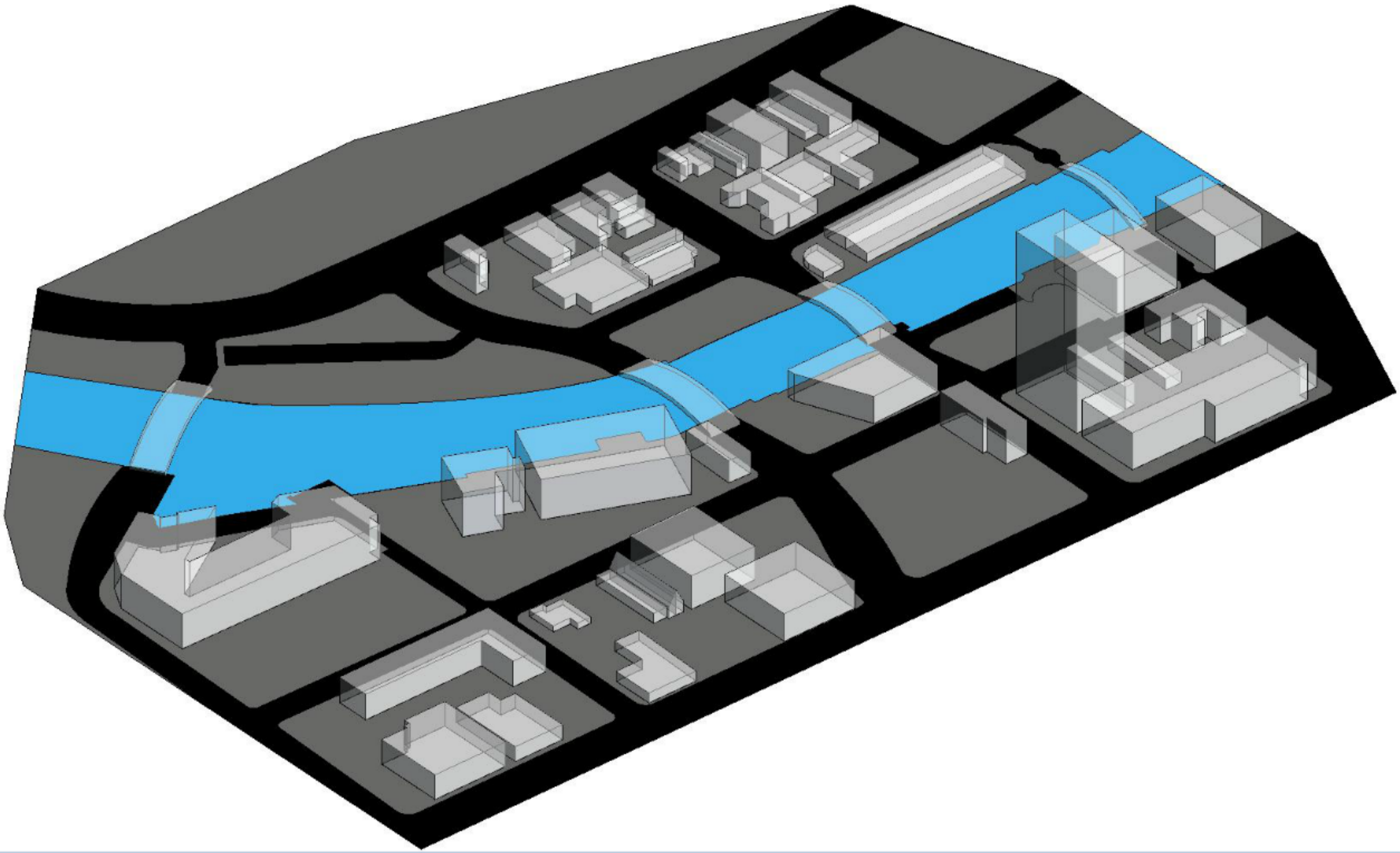
- Cream City Brick – Traditional building material found in historic Milwaukee buildings
- High Density Resin Panels – Found on Discovery World at Pier Wisconsin, High recycled content, consistent look, minimal maintenance, good examples: *http://www.3-form.com/solutions.php* & *http://www.3-form.com/materials.php*
- 3-Form Material Solutions – Recycled glass and plastic /resin material supplier: *http://www.3-form.com/*
- Architectural Systems, Inc – *http://www.archsystems.com/*
- Johnson Controls – A leading provider of equipment, controls and services for heating, ventilating, air-conditioning, refrigeration and security systems that increase energy efficiency and lower operating costs in buildings: *http://www.johnsoncontrols.com*
- Green Roofs – Helps decrease heat island effects and manage water on the building: *http://greenroofs.com*
- Orion Energy Systems – A leading innovator in power technology, specializing in high-efficiency lighting, headquartered in Manitowoc, WI.: *http://www.oesx.com*

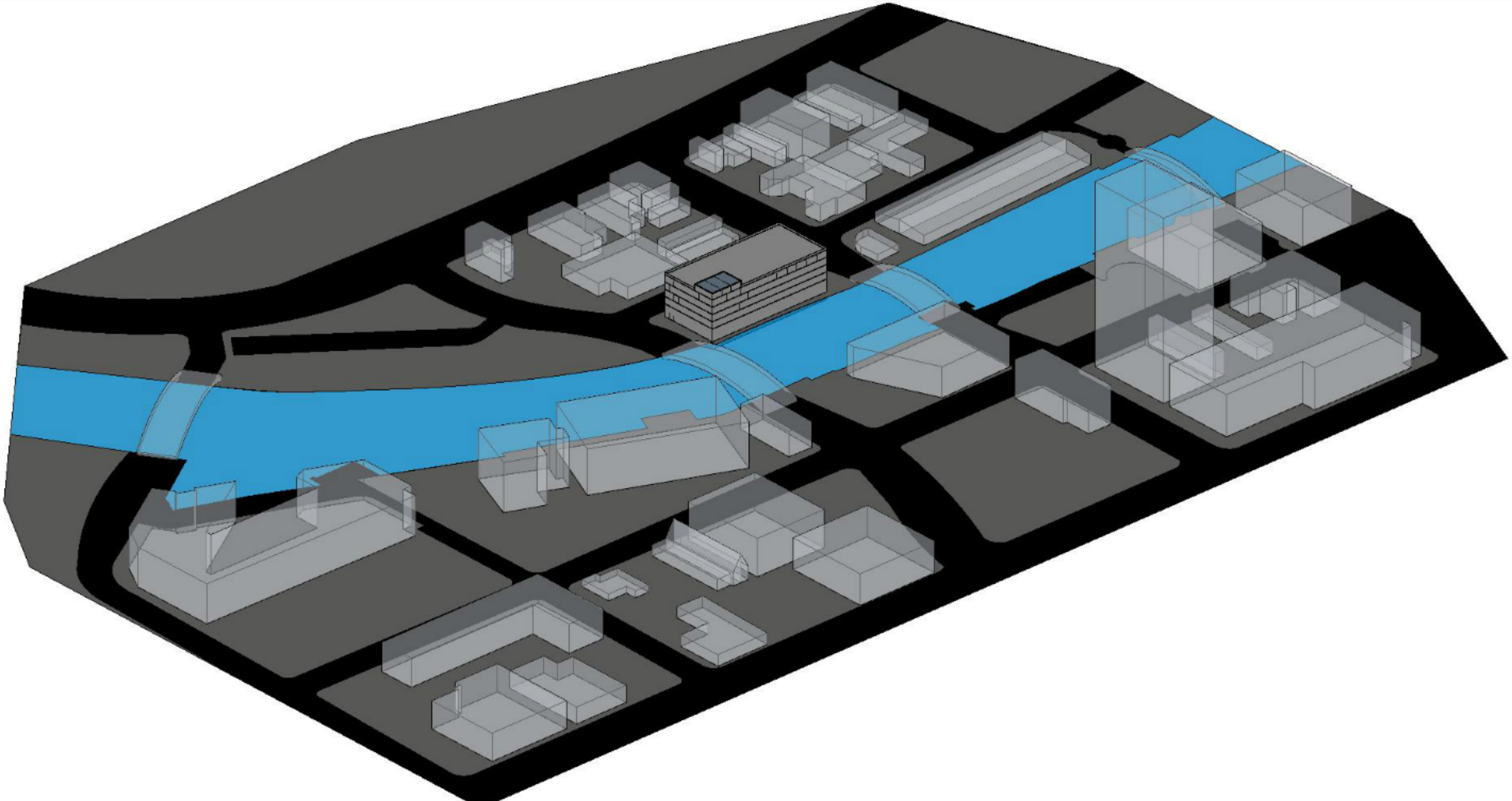
C&D RECYCLING:

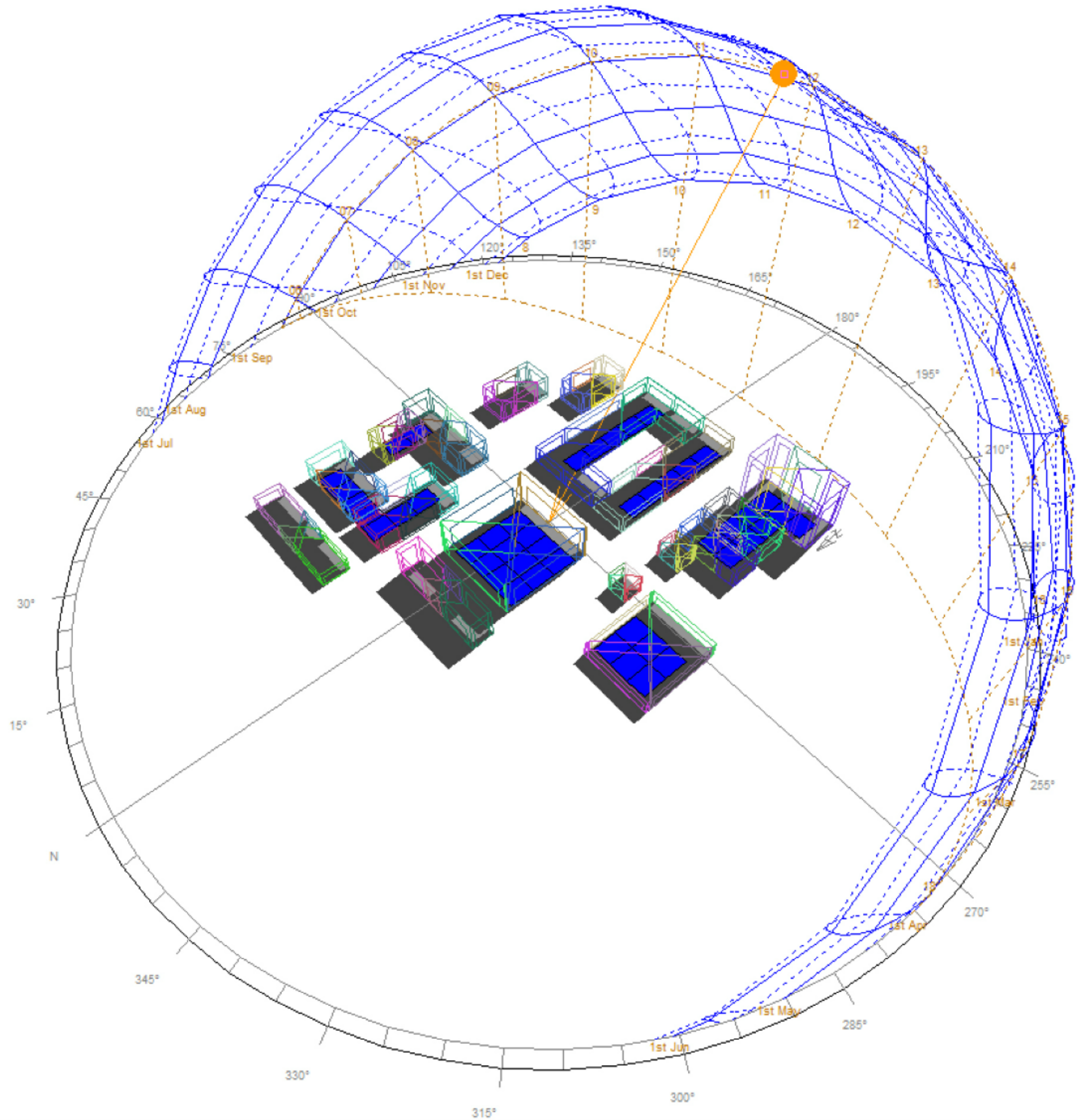
- WasteCap Resource Solutions, Inc. – WasteCap Resource Solutions, Inc. is a nonprofit, industry supported 501(c)(3) organization that provides waste reduction and recycling assistance to businesses. WasteCap assists and encourages companies to effectively drive costs out of their operations through improved solid waste management practices: *www.wastecap.org*
- Veolia Environmental Services – Veolia Environmental Services (VES) provides a complete range of industrial, regulated waste and waste-to-energy services for our customers. They will handle collection, transportation, disposal, and recycling of waste and industrial materials: *http://veoliaes-sw.com*



FALL
AE/CM-4712
WINTER
BIM
Sustainability
Design
Revit
Develop a Site Model
Develop a Massing Model
Design Development Model
Environmental Study
Ecotect
"Simple Box" Energy Analysis
Ecotect
Building Design Energy Analysis
START
Discovery Phase
Building Program
Client Presentation
Schematic Design
Code Review







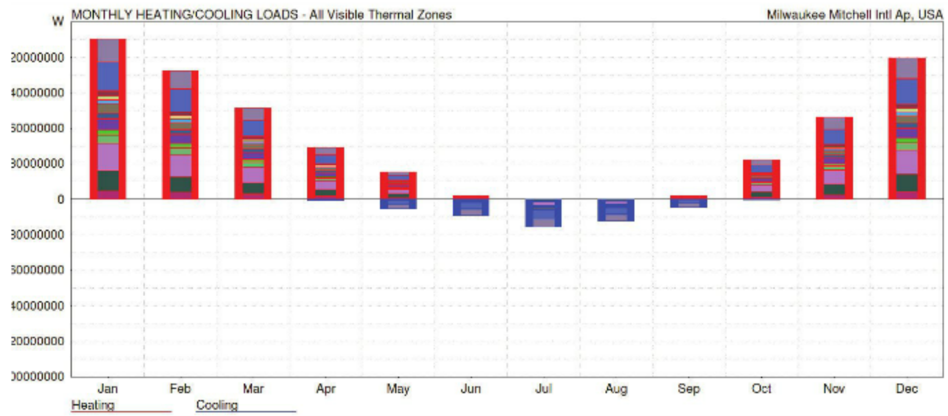
1st Jul
1st Aug
1st Sep
1st Oct
1st Nov
1st Dec
1st Jan
1st Feb
1st Mar
1st Apr
1st May
1st Jun
N
15°
30°
45°
60°
75°
90°
105°
120°
135°
150°
165°
180°
195°
210°
255°
270°
285°
300°
315°
330°
345°

A Solar Ecotect Analysis is able to take assumptions such as location, size, orientation and building usage to compile energy usage predictions. The following figures illustrate some of those findings.

Predicted monthly heating and cooling loads

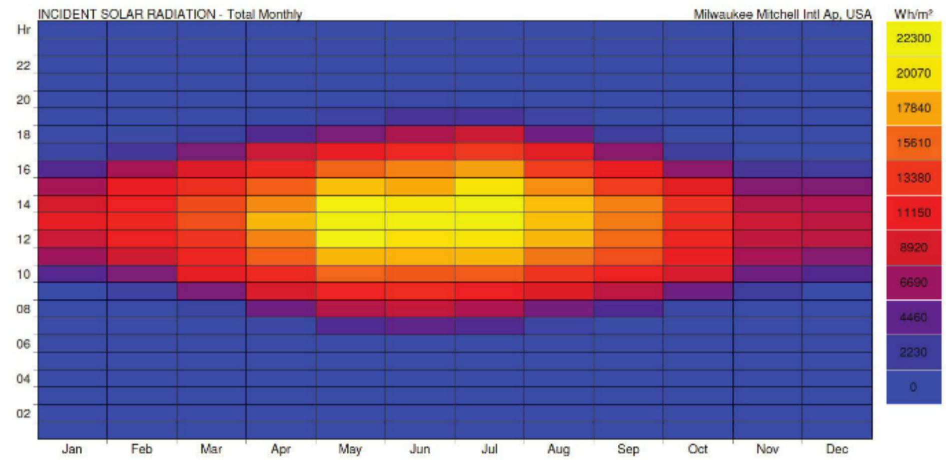
Month	Heating (Btu)	Cooling (Btu)	Total (Btu)
January	2,780,079,872	-	2,780,079,872
February	2,226,612,992	-	2,226,612,992
March	1,577,648,896	962,844	1,578,611,712
April	892,334,272	23,941,346	916,275,648
May	475,820,800	163,824,640	639,645,440
June	63,462,240	284,753,152	348,215,424
July	-	484,044,384	484,044,384
August	4,801,223	374,559,840	379,361,056
September	66,151,648	140,385,408	206,537,056
October	690,808,704	8,653,201	699,461,888
November	1,419,175,552	-	1,419,175,552
December	2,441,618,944	-	2,441,618,944
Total	12,638,514,176	1,481,124,864	14,119,639,040
per square meter	1,051,371	123,212	1,174,583
per square foot	11,316,863	1,326,243	12,643,106

All Visible Thermal Zones Max Heating: 6894514.5 Btu/hr at 05:00 on 5th January
Comfort: Zonal Bands Max Cooling: 4176363.0 Btu/hr at 13:00 on 7th July



SOLAR POTENTIAL

The solar potential for the site has a yearly total availability of 18,90,642 Wh/m^2. The total incident yearly radiation to the site is 1,322,520 Wh/m^2. The total amount of absorbed solar Wh by the mass model of the proposed building is 4,075,434. This number is due to the lack of reflective material on the building's mass model.



TOTAL MONTHLY SOLAR EXPOSURE									
Milwaukee Mitchell Intl Ap, USA									
	AVAIL.	AVG	REFLECT	INCIDENT	ABSORBED	TRANSMITTED			
MONTH	Wh/m2	SHADE	Wh/m2	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh
-------	--------	------	--------	--------	--------	--------	--------	-------	-------
Jan	104362	0%	0	51986	160200	51986	160200	0	0
Feb	113895	0%	0	70657	217734	70657	217734	0	0
Mar	150446	0%	0	100398	309384	100398	309384	0	0
Apr	187480	0%	0	138058	425434	138058	425434	0	0
May	219545	0%	0	171217	527616	171217	527616	0	0
Jun	221878	0%	0	176066	542560	176066	542560	0	0
Jul	233582	0%	0	183137	564350	183137	564350	0	0
Aug	195702	0%	0	147348	454063	147348	454063	0	0
Sep	177903	0%	0	118001	363628	118001	363628	0	0
Oct	128172	0%	0	79645	245430	79645	245430	0	0
Nov	80969	0%	0	45764	141026	45764	141026	0	0
Dec	76708	0%	0	40242	124008	40242	124008	0	0
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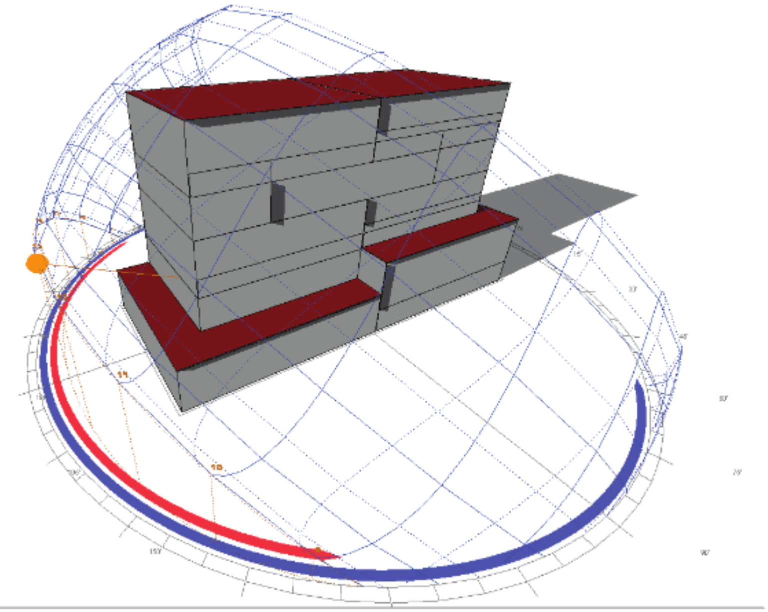
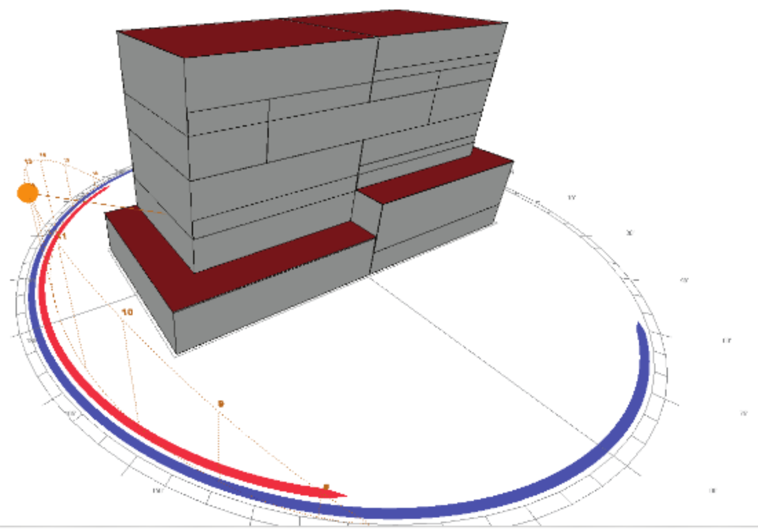
TOTALS	1890642		0	1322520	4075434	1322520	4075434	0	0

DAYLIGHT EVALUATION





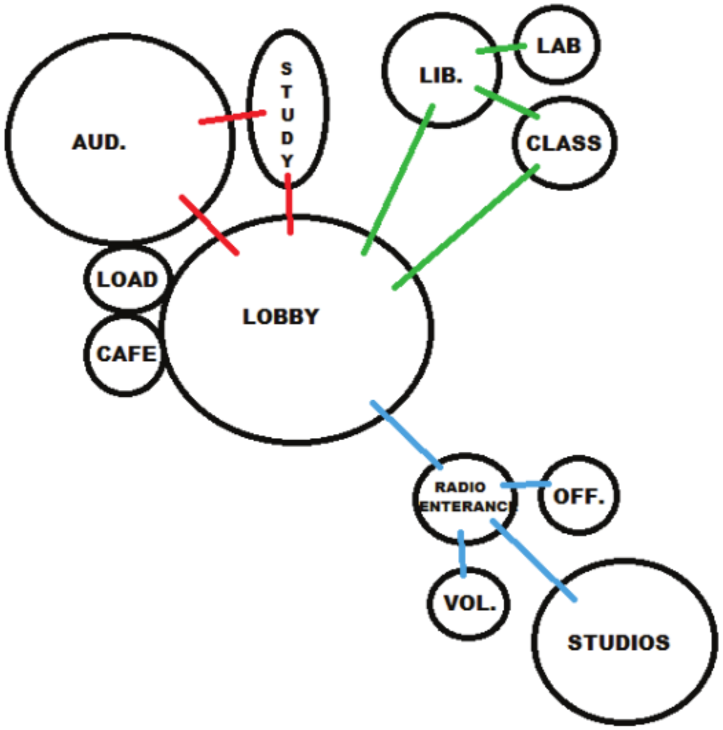
MATRIX OF SPACE RELATIONSHIPS

This matrix illustrates the importance of spaces' proximity to other spaces. For example, the Study Area has a close relationship to the Classrooms and Library but should not need to be near the Equipment Room, Auditorium or Gift Shop.

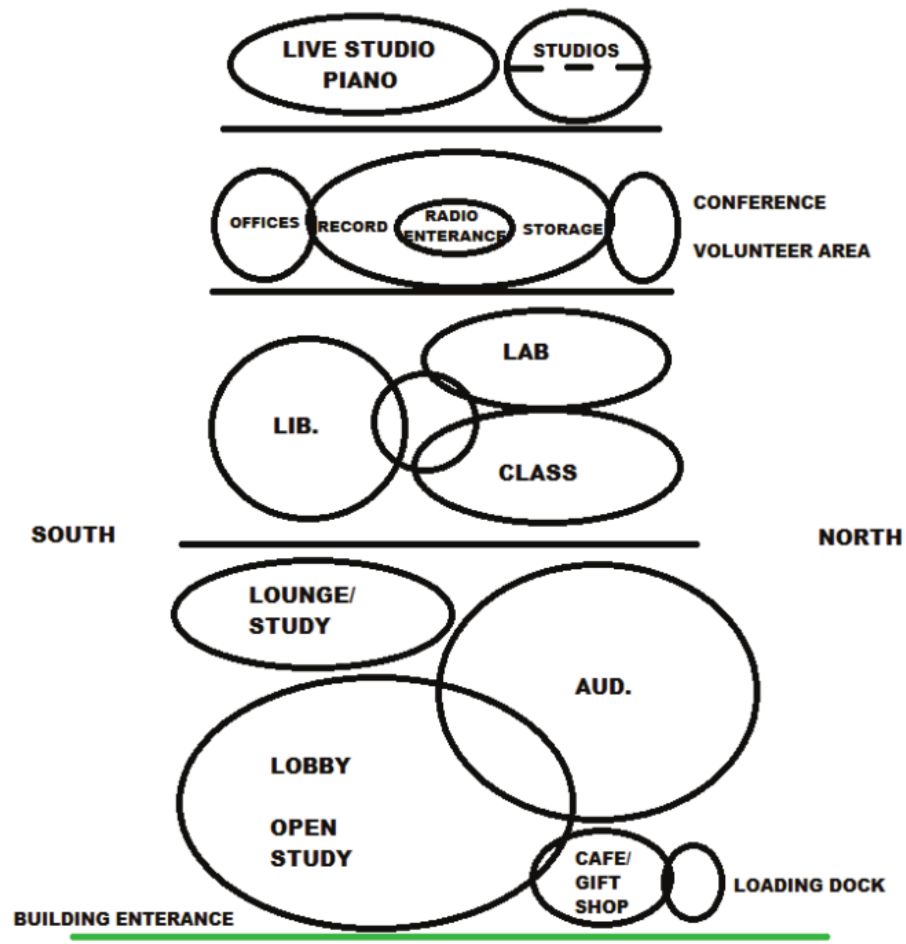
Room	Lobby	Classrooms	Auditorium	Men's Restroom	Women's Restroom	Loading Dock	Equipment Room	Labs	Library	Studios	Voiceover/interview	Offices	Study Area	Public Access Studio	Recording Studio	Broadcast Studio	Production Studio	Conference Room	Storage Closets	Break Room	Gift shop	Kitchenette	Locker Rooms	Restaurant
Lobby	x																							
Classrooms	3	x																						
Auditorium	1	3	x																					
Men's Restroom	1	1	1	x																				
Women's Restroom	1	1	1	1	x																			
Loading Dock	2	3	1	3	3	x																		
Equipment Room	3	3	1	3	3	1	x																	
Labs	3	1	3	1	1	3	2	x																
Library	3	1	3	1	1	3	3	1	x															
Studios	3	3	3	1	1	3	1	3	3	x														
Voiceover/Interview	3	3	3	3	3	3	2	3	3	1	x													
Offices	3	3	3	1	1	3	3	3	3	1	1	x												
Study Area	2	1	3	1	1	3	3	2	1	3	3	3	x											
Public Access Studio	2	3	3	2	2	3	3	3	3	3	3	2	3	x										
Recording Studio	3	3	3	3	3	3	2	3	3	1	1	2	3	3	x									
Broadcast Studio	3	3	3	3	3	3	2	3	3	1	1	2	3	3	1	x								
Production Studio	3	3	3	3	3	3	2	3	3	1	1	2	3	3	1	1	x							
Conference Room	3	3	3	2	2	3	3	3	3	2	2	1	3	3	2	3	2	x						
Storage Closets	3	2	1	3	3	1	3	2	3	1	3	1	3	2	3	3	3	2	x					
Break Room	3	3	3	3	3	3	3	2	2	1	1	1	2	3	1	1	1	1	3	x				
Gift Shop	1	3	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	x			
Kitchenette	3	2	3	3	3	3	3	3	2	2	2	1	1	3	2	2	2	2	3	1	3	x		
Locker Rooms	3	3	1	1	1	2	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	x	
Restaurant	1	3	1	1	1	3	3	3	2	3	3	3	1	3	3	3	3	3	3	3	1	3	3	x

1	Primary Relationship
2	Secondary Relationship
3	No Relationship
x	No Comparison/Same Roc

This is a further illustration of the matrix above.

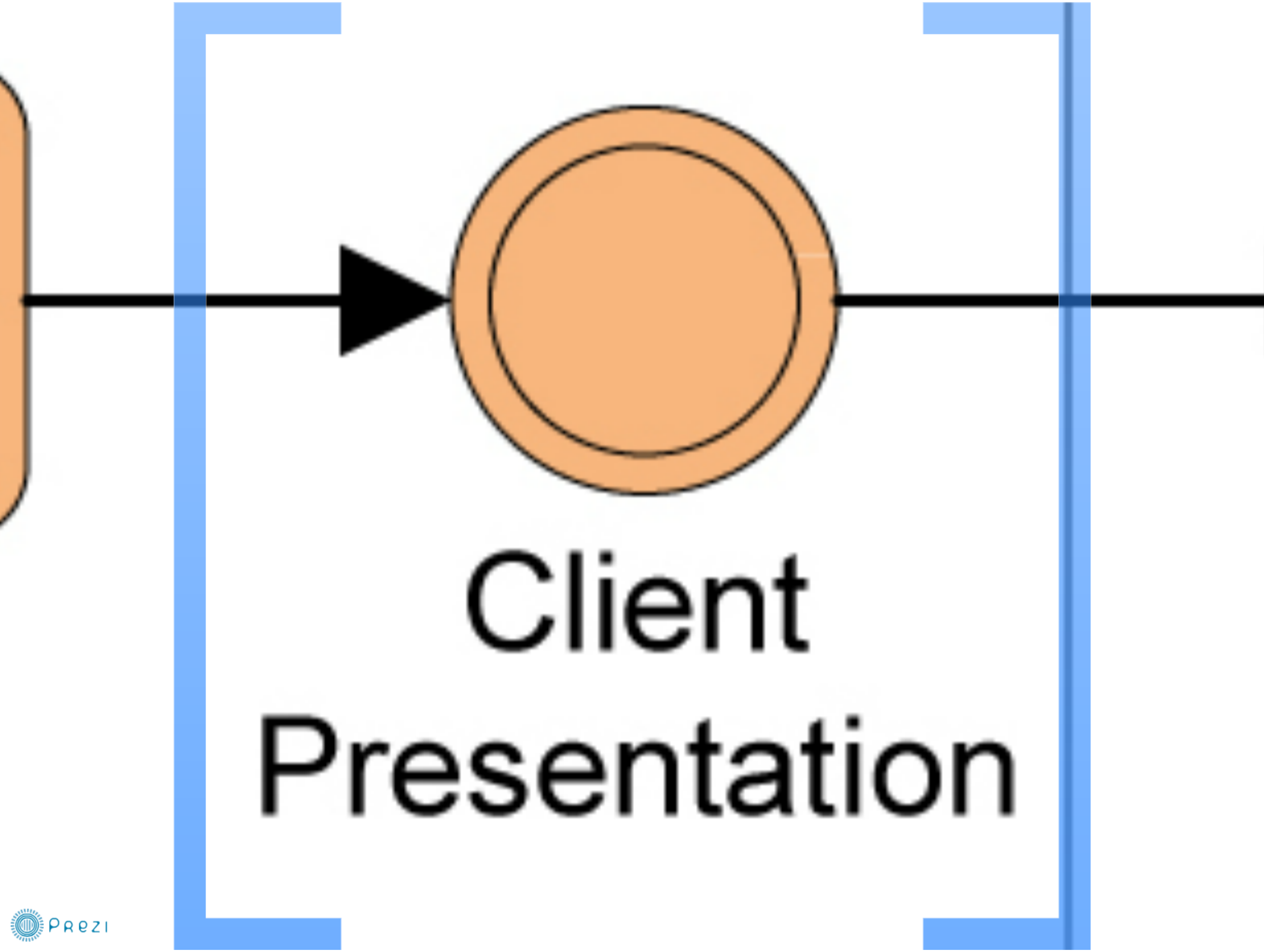


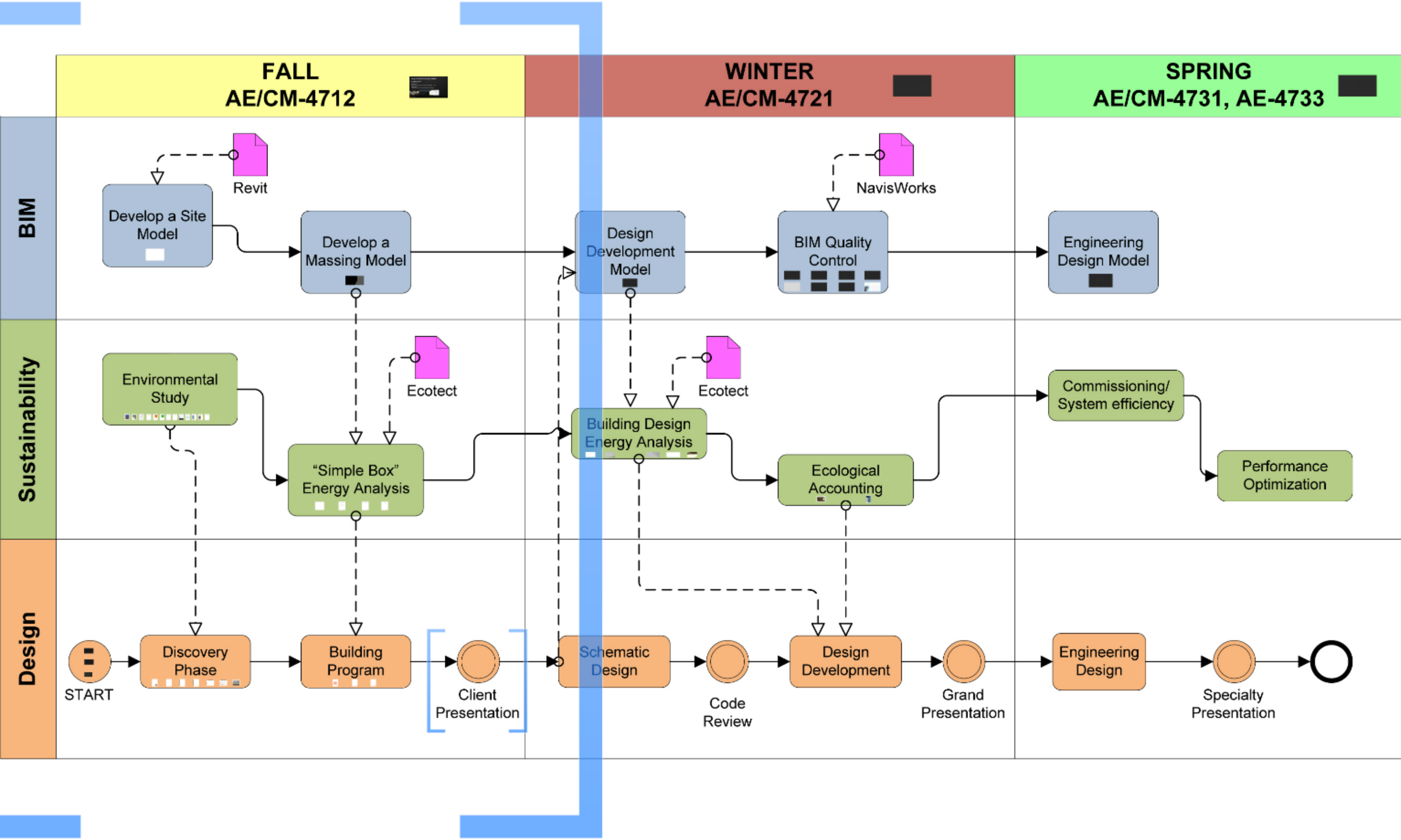
GRAPHIC SPACE DIAGRAMS

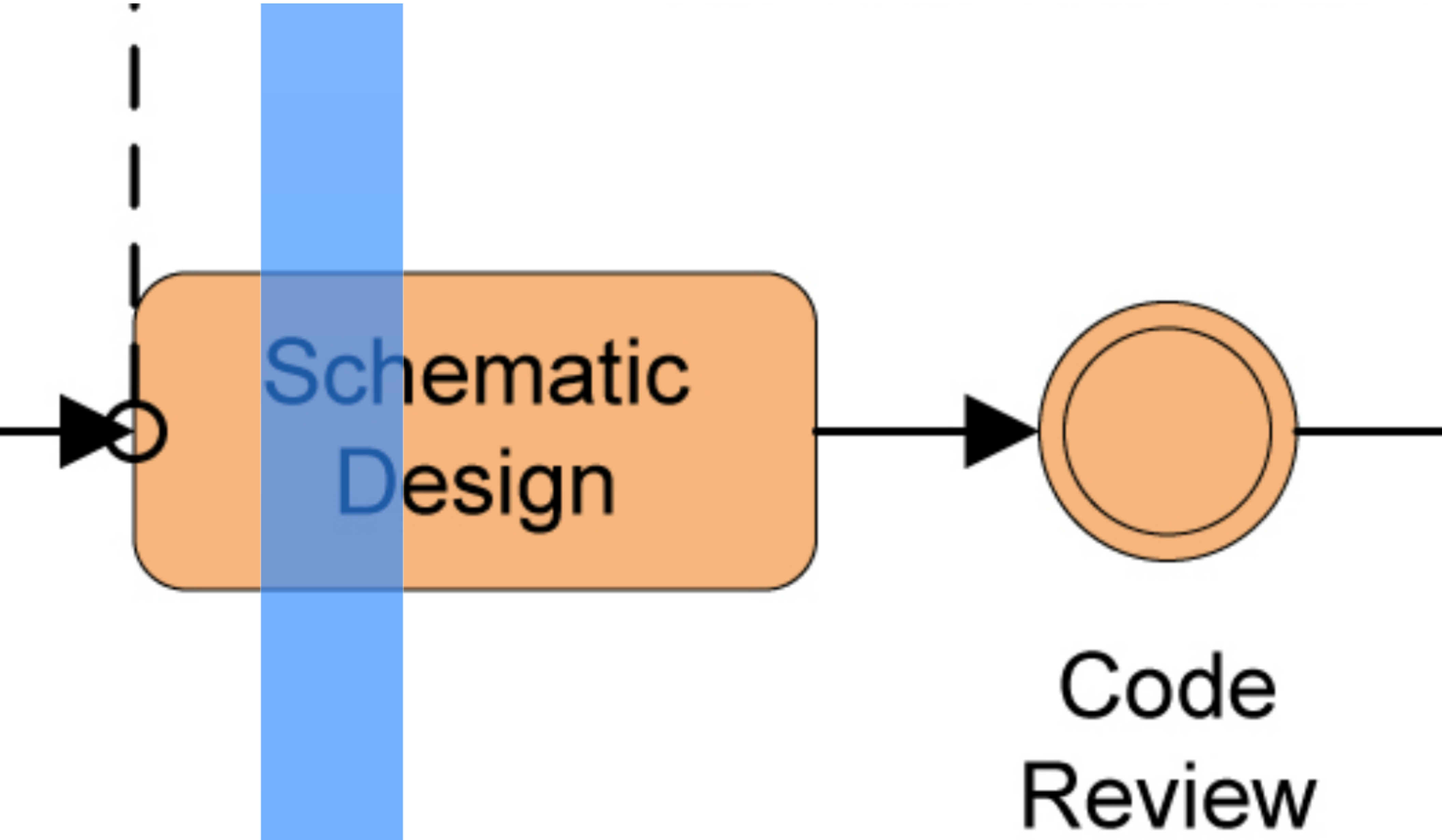


Pedestrian
Entrance

Vehicular
Entrance


Client
Presentation

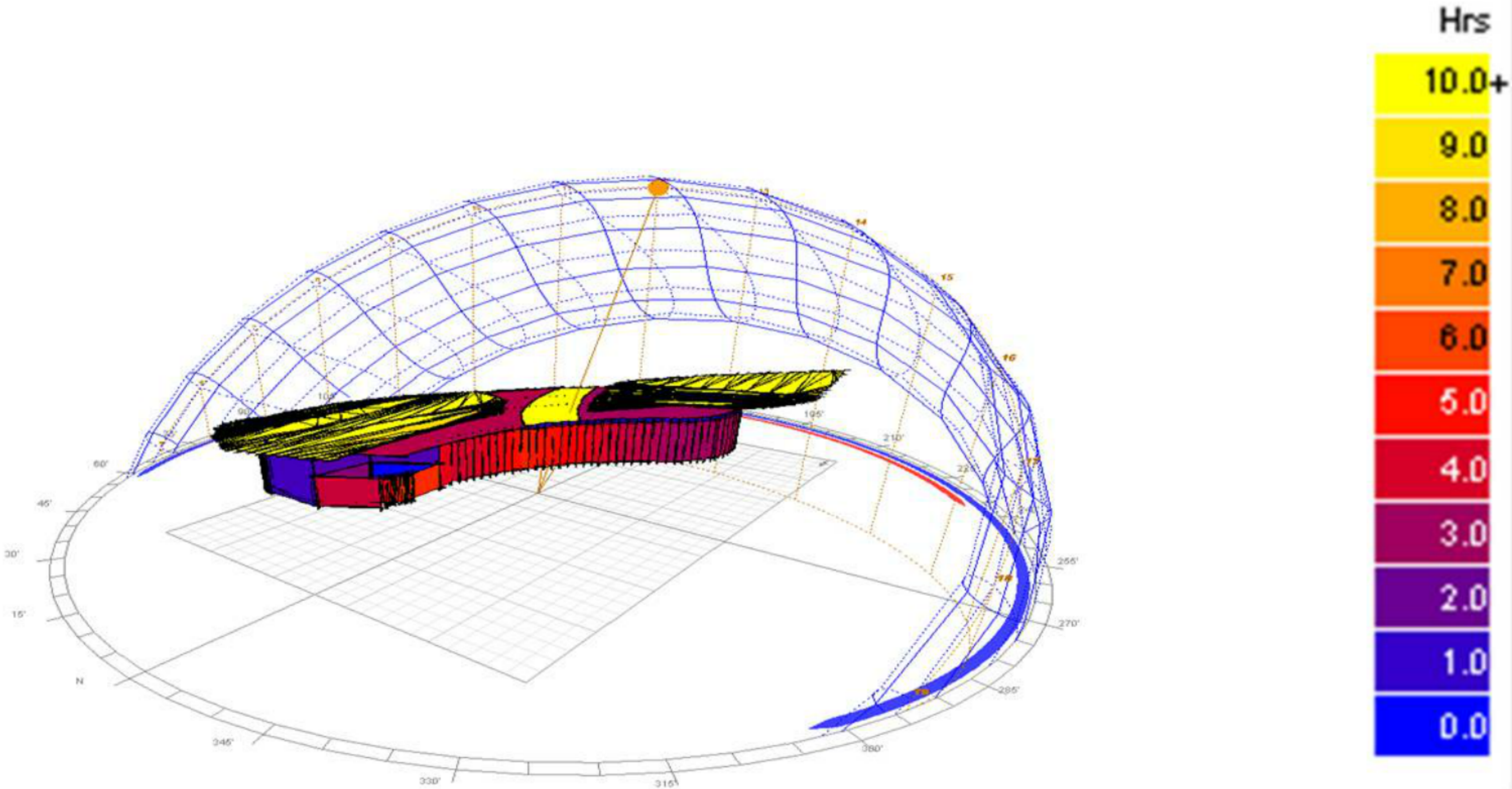

FALL
AE/CM-4712
WINTER
AE/CM-4721
SPRING
AE/CM-4731, AE-4733
BIM
Sustainability
Design
Revit
Develop a Site Model
Develop a Massing Model
Design Development Model
NavisWorks
BIM Quality Control
Engineering Design Model
Environmental Study
Ecotect
"Simple Box" Energy Analysis
Building Design Energy Analysis
Ecotect
Ecological Accounting
Commissioning/ System efficiency
Performance Optimization
START
Discovery Phase
Building Program
Client Presentation
Schematic Design
Code Review
Design Development
Grand Presentation
Engineering Design
Specialty Presentation

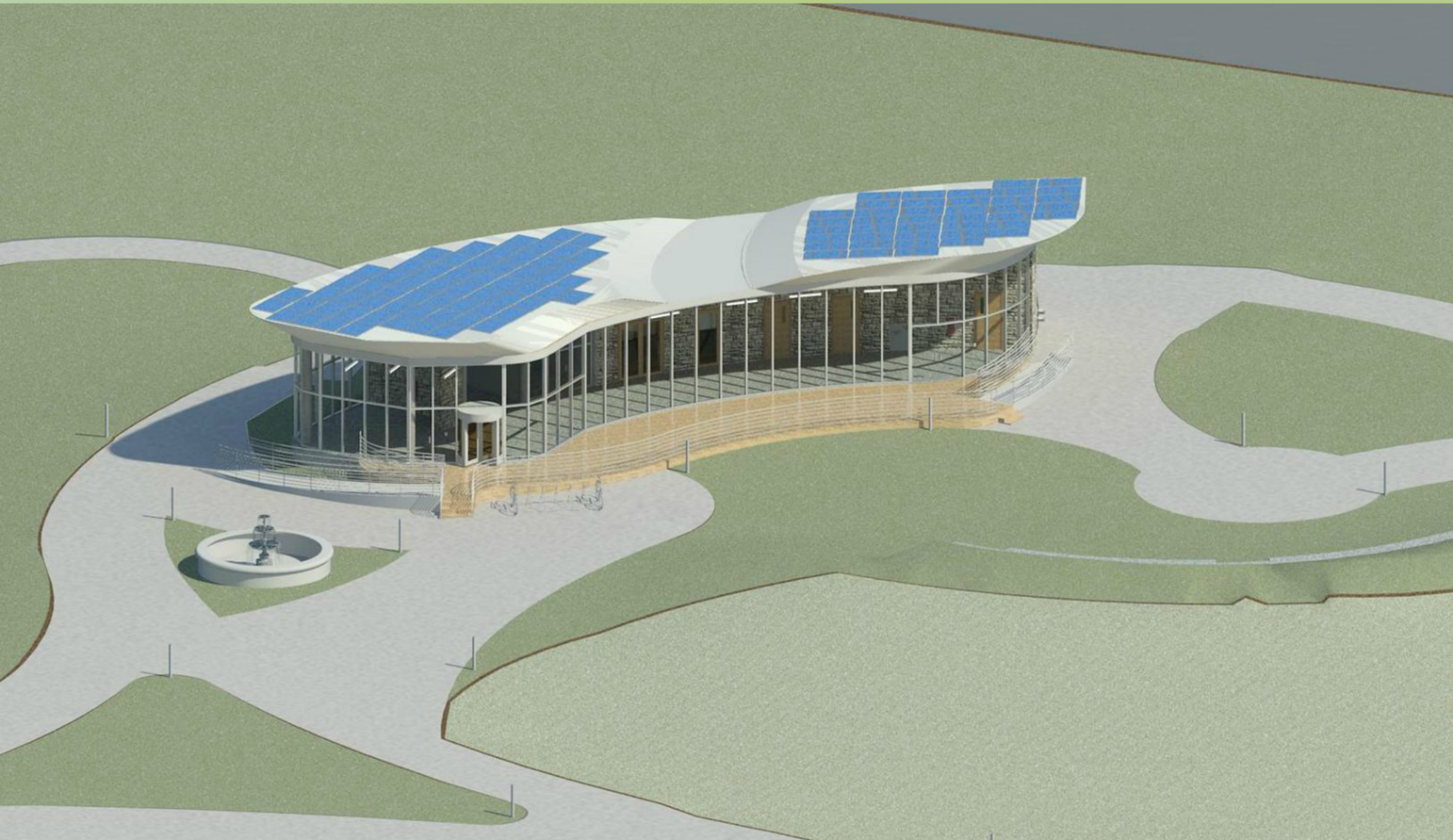


Prezi

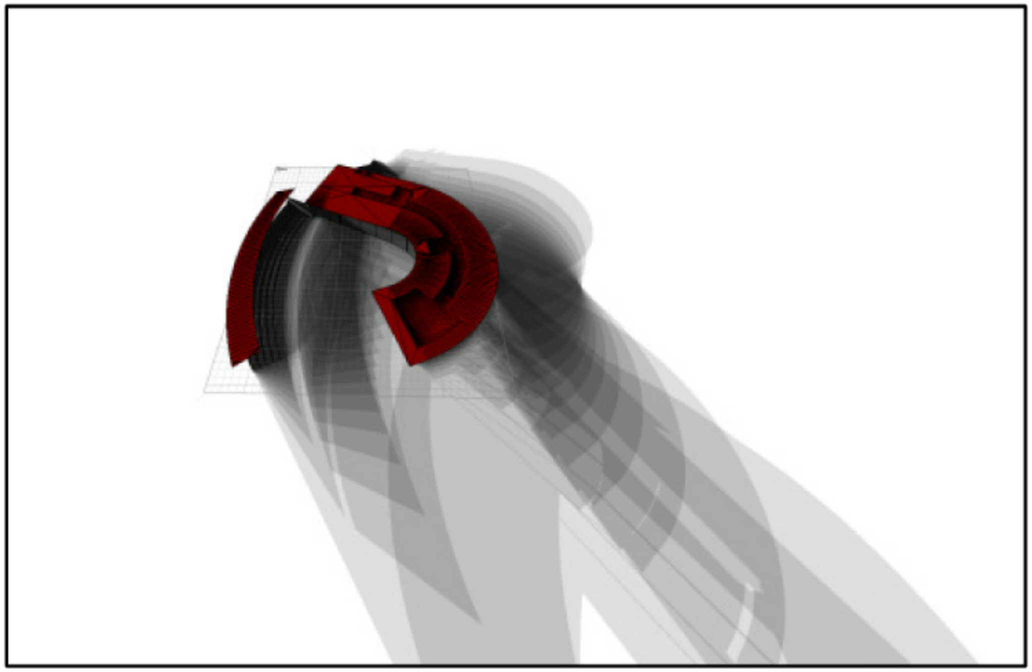
Design Development Model

- Virtual building models including architectural components
- Use Central File approach for collaborative design processes

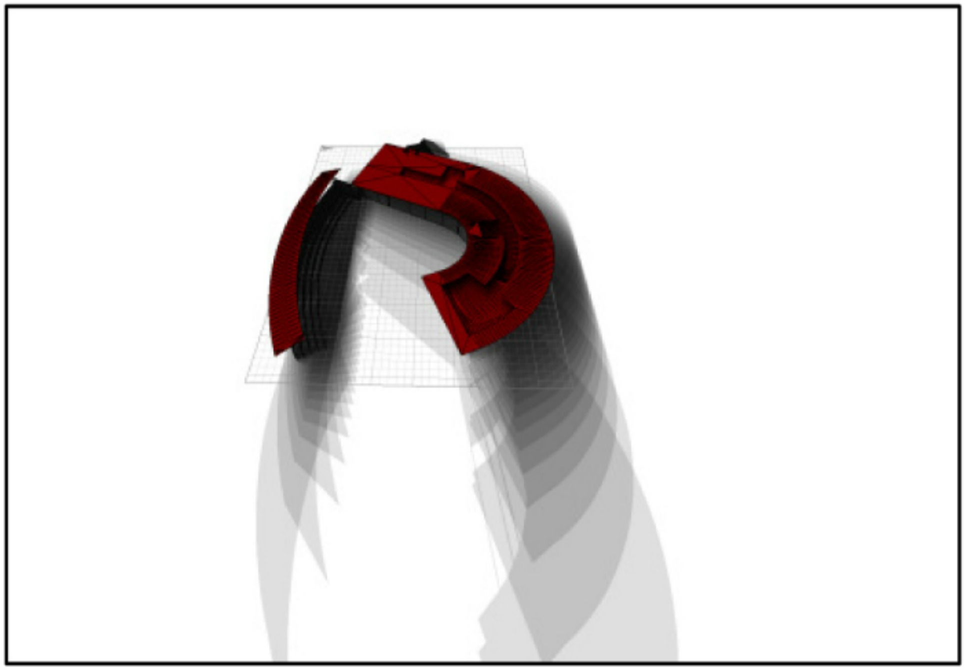

Hrs
10.0+
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0



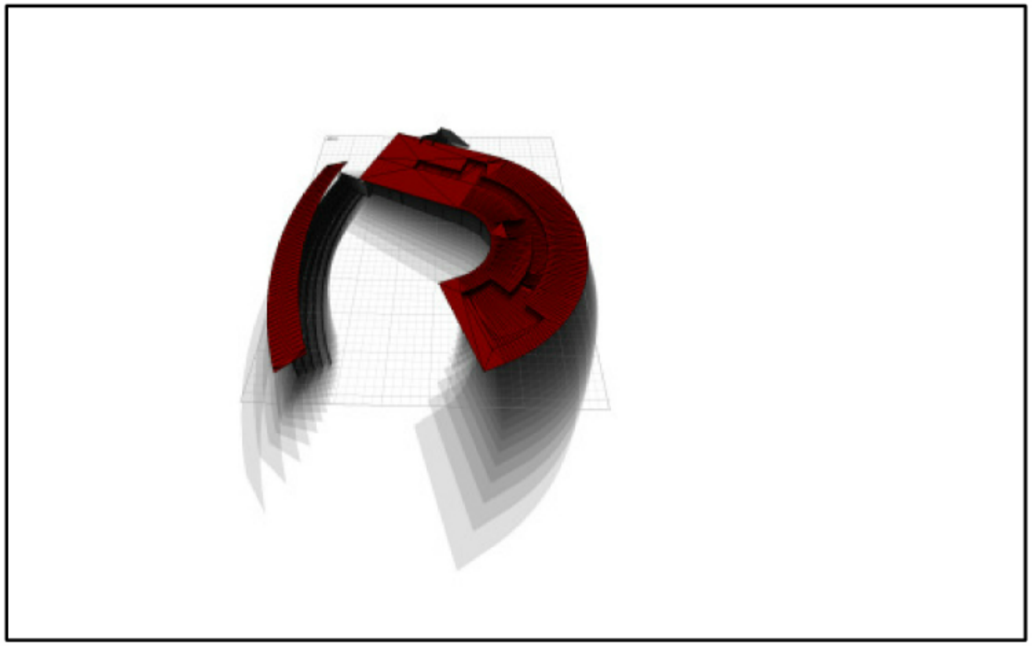
Winter Solstice



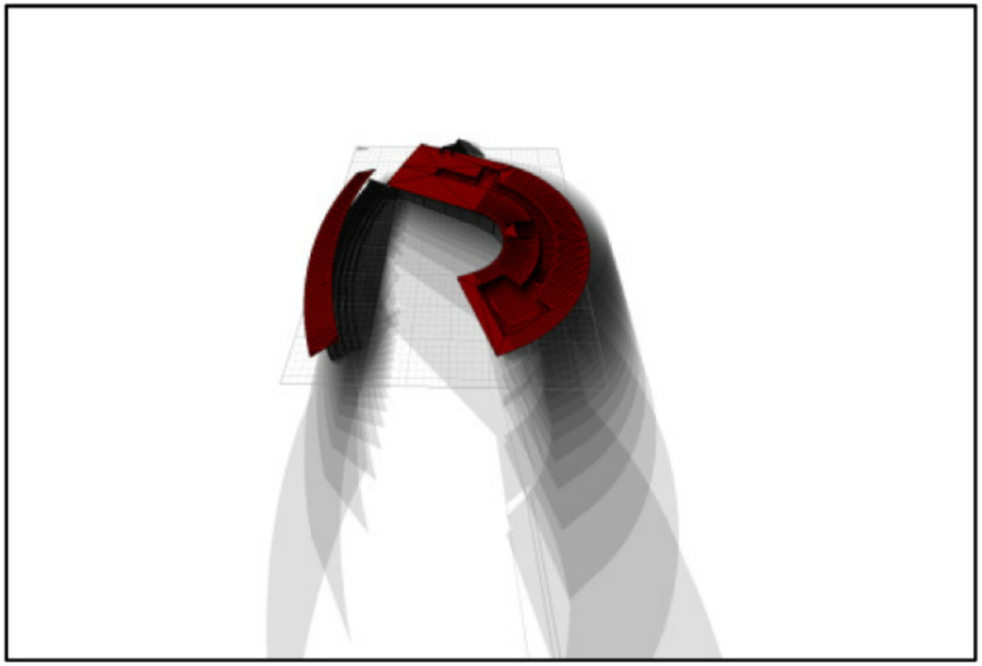
Spring Equinox

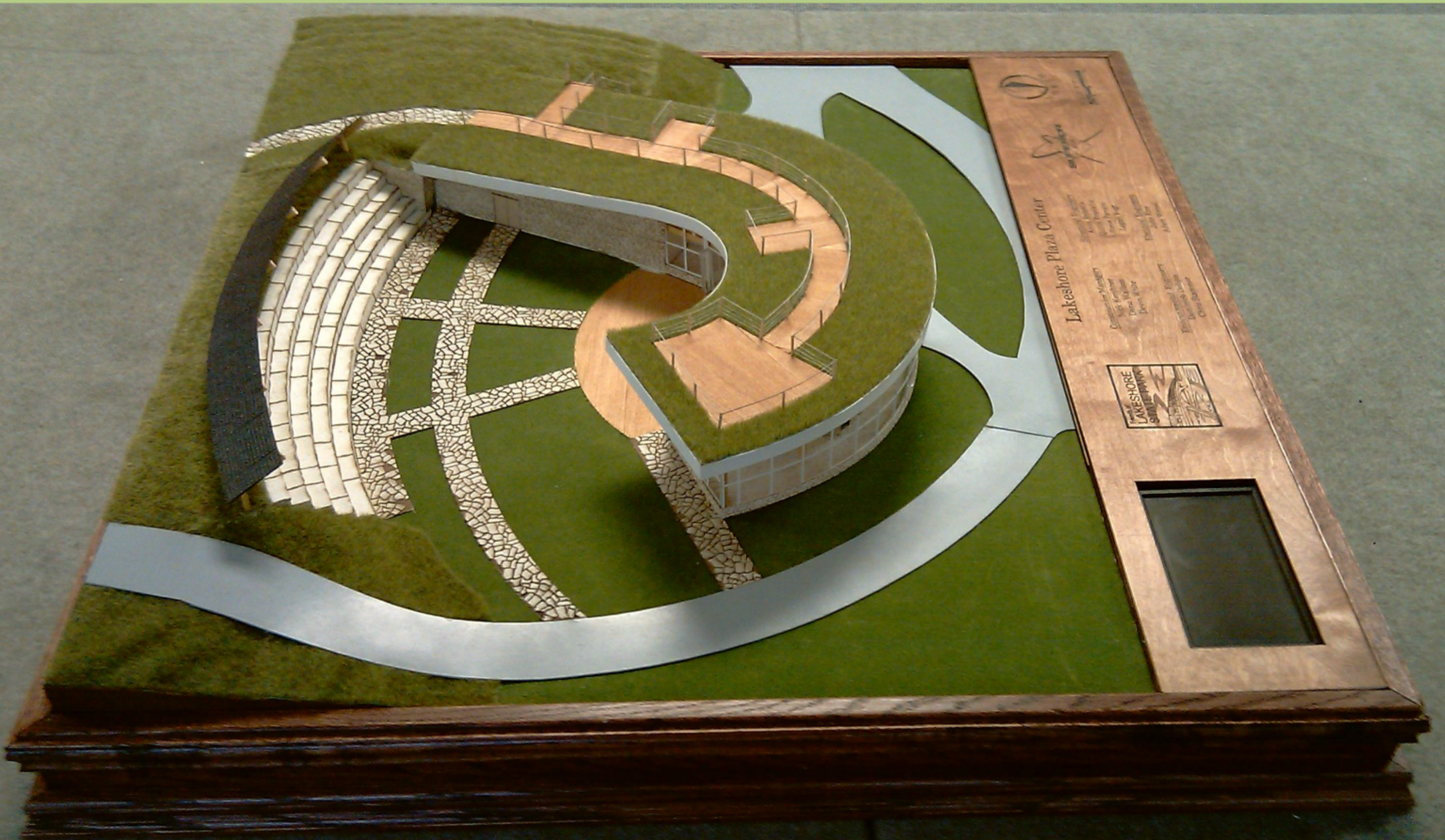


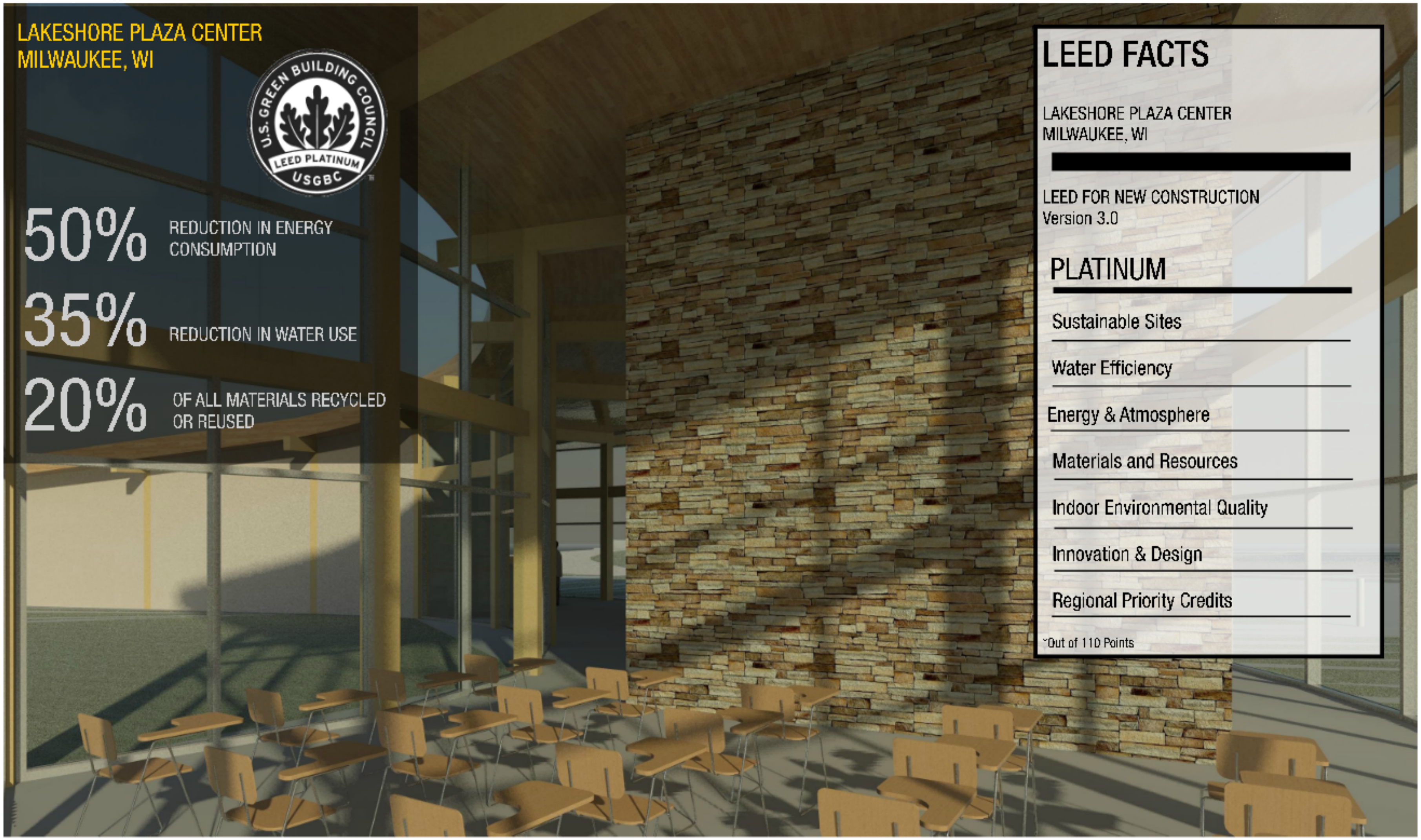
Summer Solstice

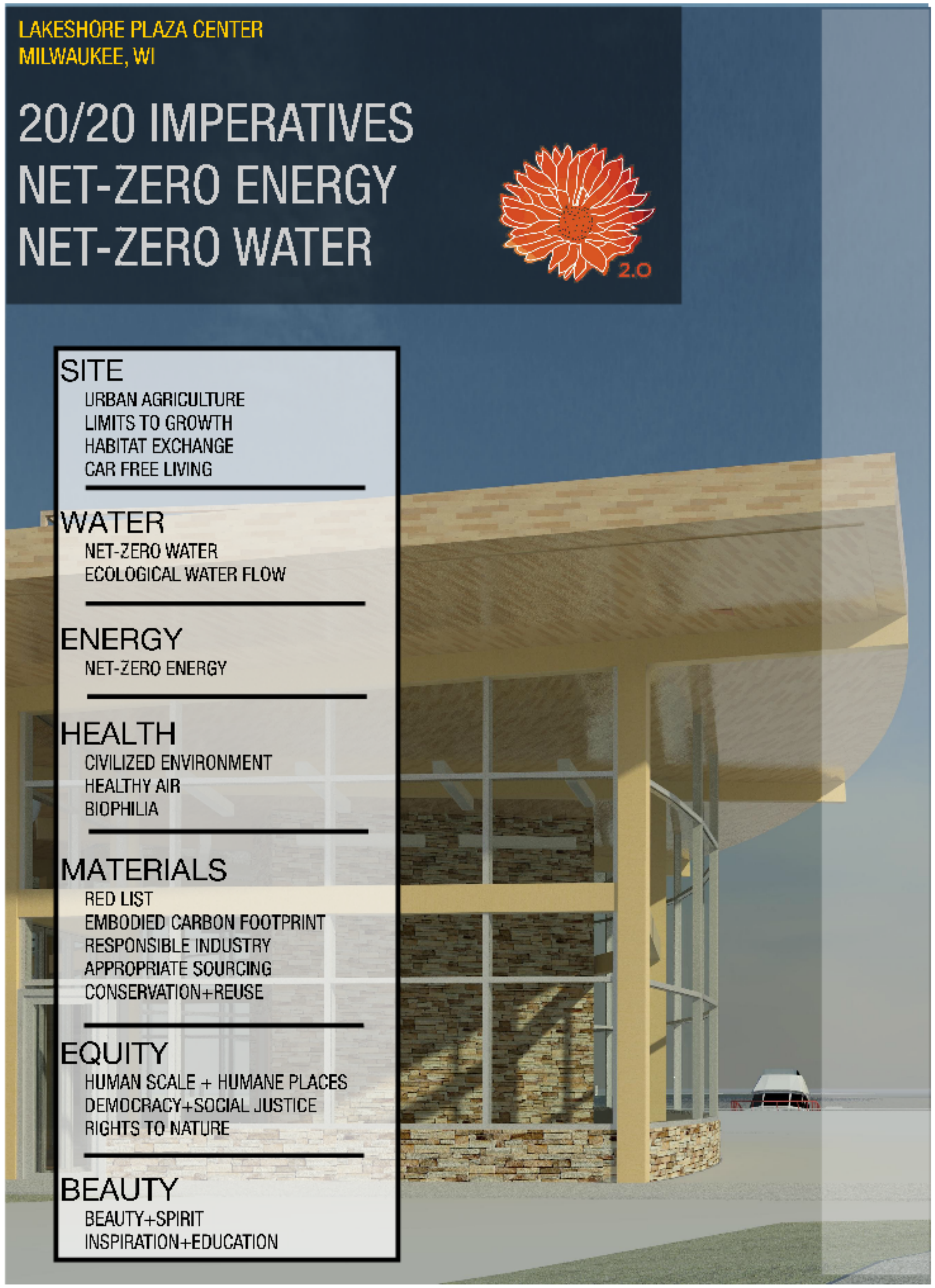


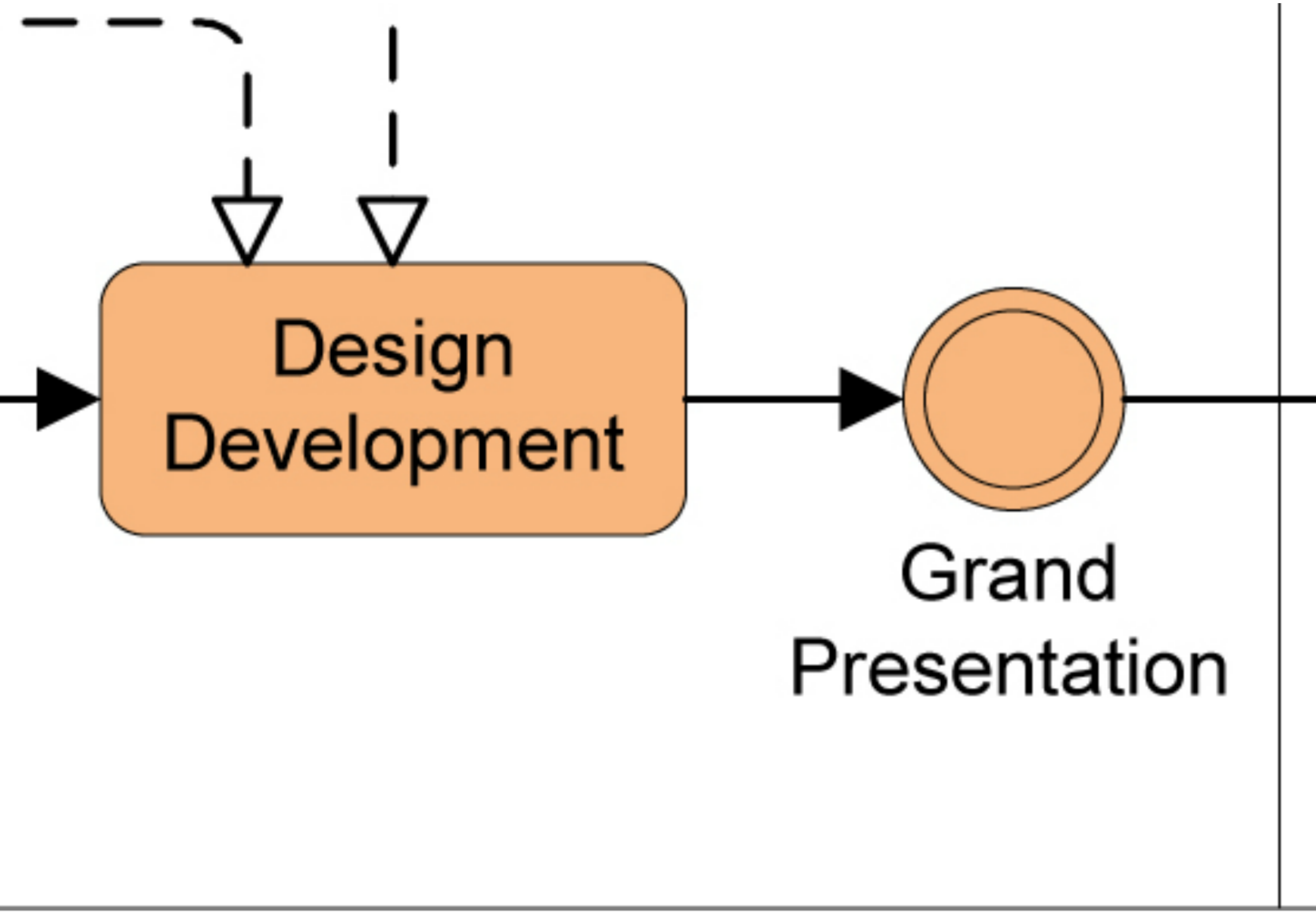
Fall Equinox



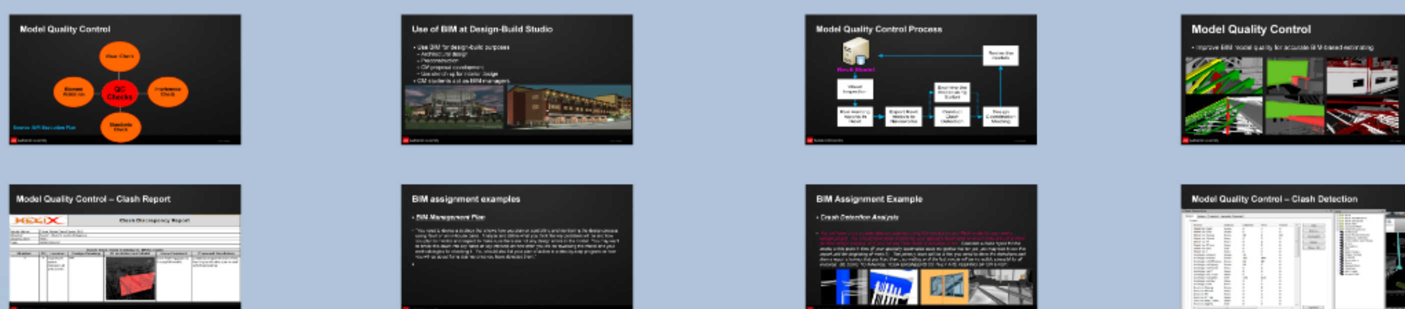

Lakeshore Plaza Center
LAKESHORE


LAKESHORE PLAZA CENTER
MILWAUKEE, WI
U.S. GREEN BUILDING COUNCIL
LEED PLATINUM
USGBC
50% REDUCTION IN ENERGY CONSUMPTION
35% REDUCTION IN WATER USE
20% OF ALL MATERIALS RECYCLED OR REUSED
LEED FACTS
LAKESHORE PLAZA CENTER
MILWAUKEE, WI
LEED FOR NEW CONSTRUCTION
Version 3.0
PLATINUM
Sustainable Sites
Water Efficiency
Energy & Atmosphere
Materials and Resources
Indoor Environmental Quality
Innovation & Design
Regional Priority Credits
*Out of 110 Points

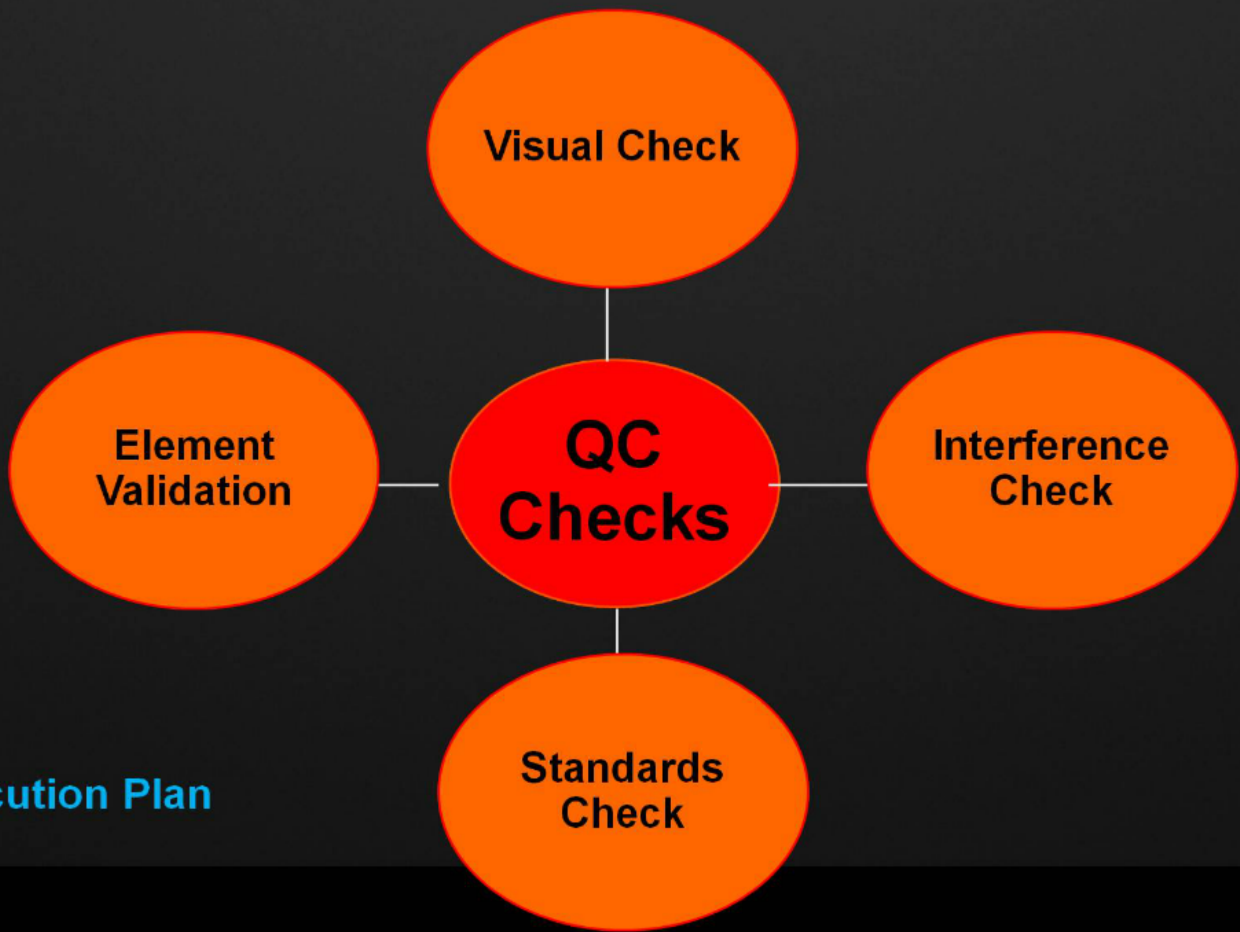

LAKESHORE PLAZA CENTER
MILWAUKEE, WI
20/20 IMPERATIVES
NET-ZERO ENERGY
NET-ZERO WATER
2.0
SITE
URBAN AGRICULTURE
LIMITS TO GROWTH
HABITAT EXCHANGE
CAR FREE LIVING
WATER
NET-ZERO WATER
ECOLOGICAL WATER FLOW
ENERGY
NET-ZERO ENERGY
HEALTH
CIVILIZED ENVIRONMENT
HEALTHY AIR
BIOPHILIA
MATERIALS
RED LIST
EMBODIED CARBON FOOTPRINT
RESPONSIBLE INDUSTRY
APPROPRIATE SOURCING
CONSERVATION+REUSE
EQUITY
HUMAN SCALE + HUMANE PLACES
DEMOCRACY+SOCIAL JUSTICE
RIGHTS TO NATURE
BEAUTY
BEAUTY+SPIRIT
INSPIRATION+EDUCATION


Design
Development
Grand
Presentation

BIM Quality Control



Model Quality Control

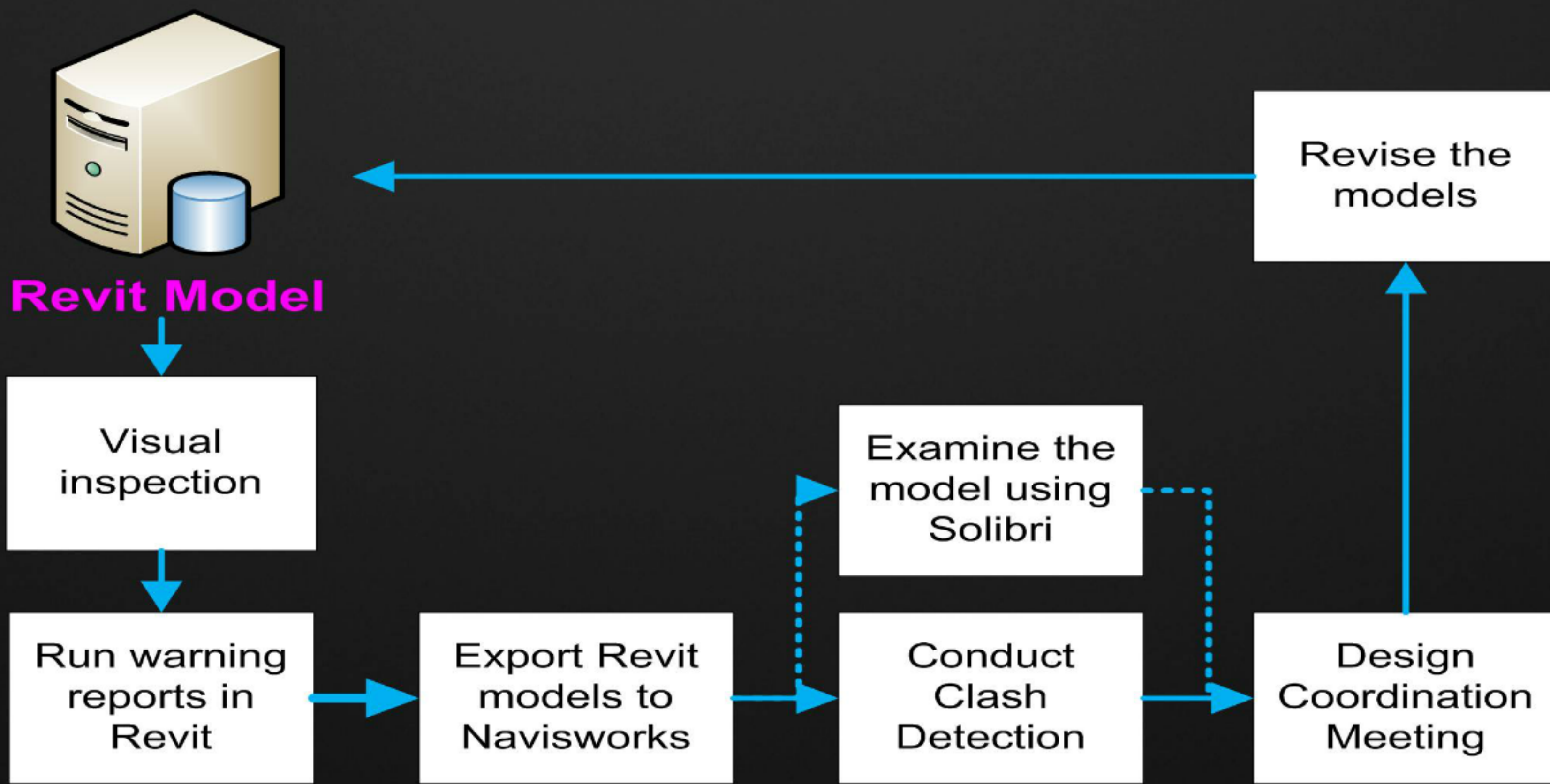


Source: BIM Execution Plan

Use of BIM at Design-Build Studio

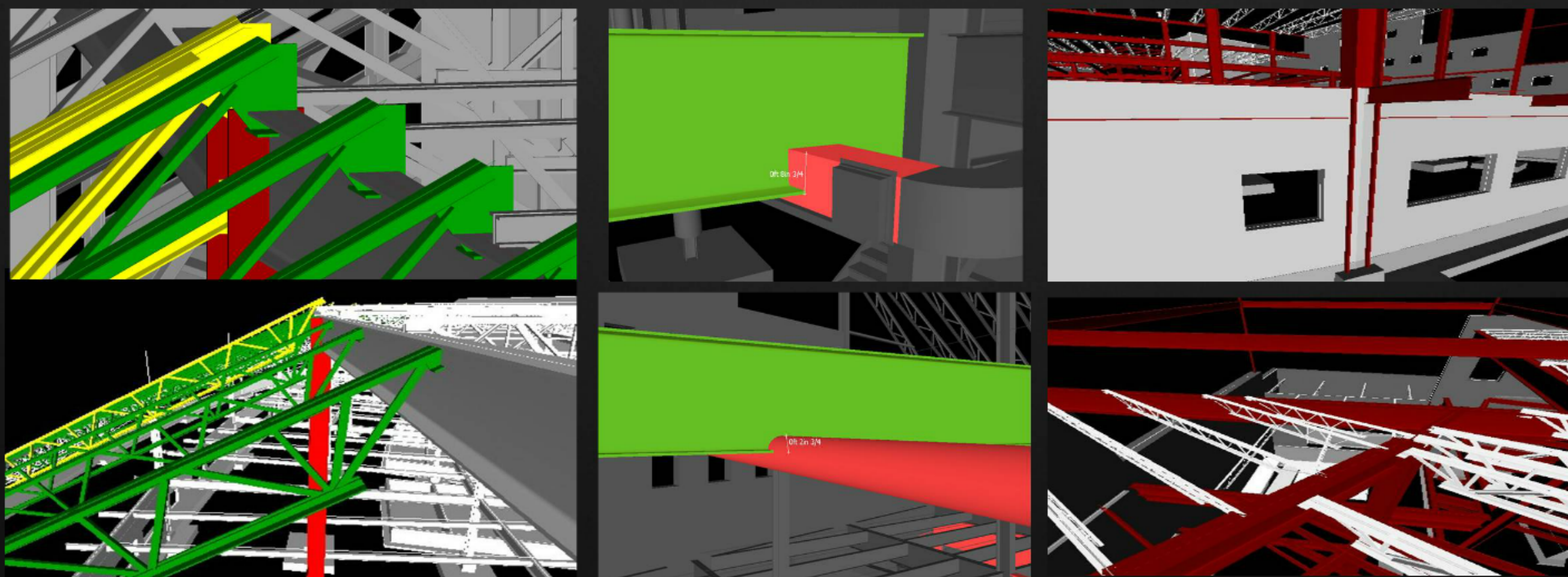
- Use BIM for design-build purposes
  - Architectural design
  - Preconstruction
  - CM proposal development
  - Use sketch-up for interior design
- CM students act as BIM managers

Model Quality Control Process



Model Quality Control

- Improve BIM model quality for accurate BIM-based estimating

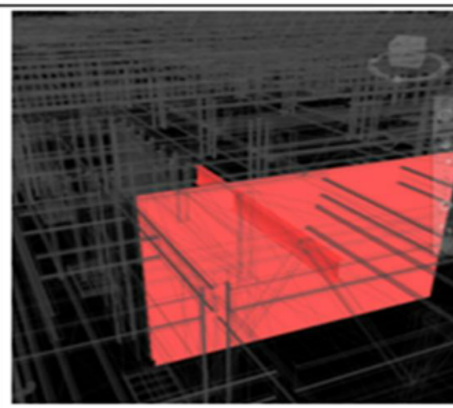


Model Quality Control – Clash Report

Clash Discrepancy Report

Model Name	Canal Street Data Center 2011
Checker	Austin Meier & Justin Cosgrove
Organization	Helix
Date	10/28/2011 8:57

Batch Type: Floor Framing vs. HVAC Ducts

Number	ID	Location	Design Drawing	3D Architectural Model	Issue Comment	Proposed Resolution
4	4	In plenum space between all data suites	N/A		Steel framing passes through firewalls.	Create beam penetrations from framing and make sure to seal with fireproofing.

BIM assignment examples

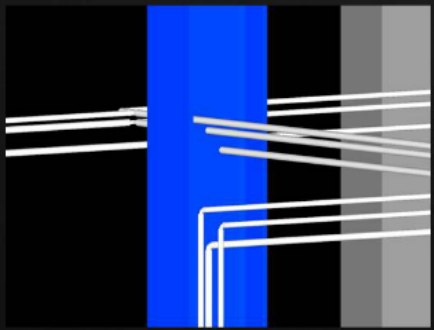
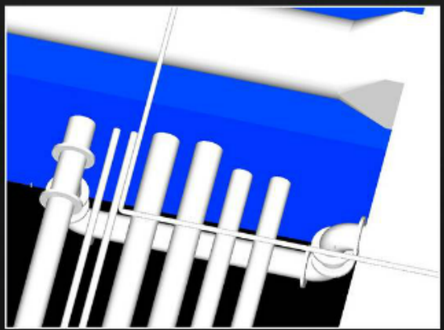
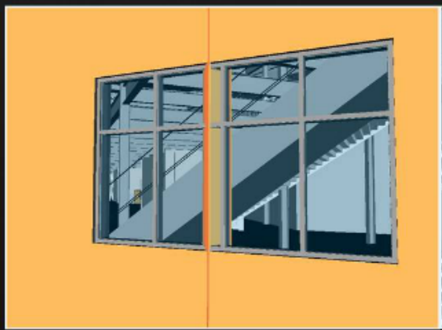
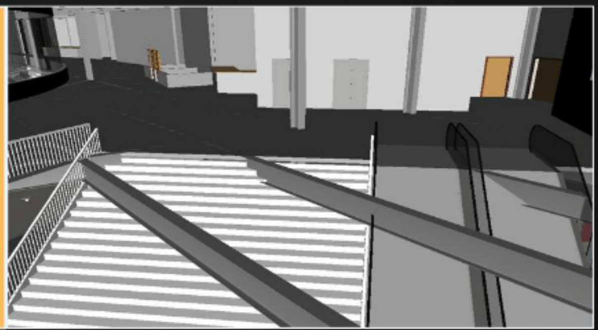
- ***BIM Management Plan***

- "You need to devise a strategy that shows how you plan on controlling and monitoring the design process using Revit on an in-house basis. Analyze and define what you think the key problems will be and how you plan to monitor and inspect to make sure there are not any design errors in the model. You may want to break this down into key dates or key intervals on how often you will be reviewing the model and your methodologies for checking it. You should also list your plan of action in a step-by-step program on how you will go about fixing clashes once you have detected them."

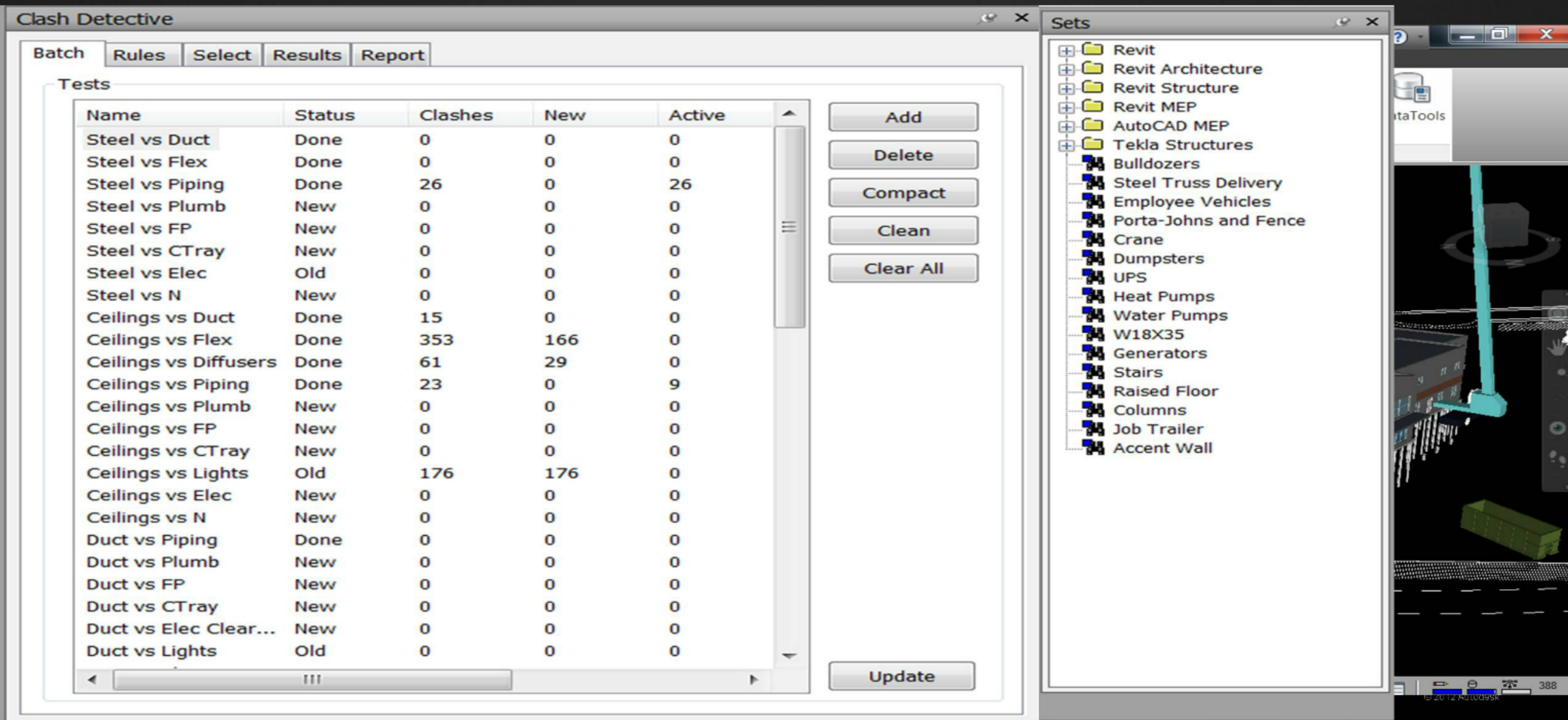
BIM Assignment Example

- ***Crash Detection Analysis***

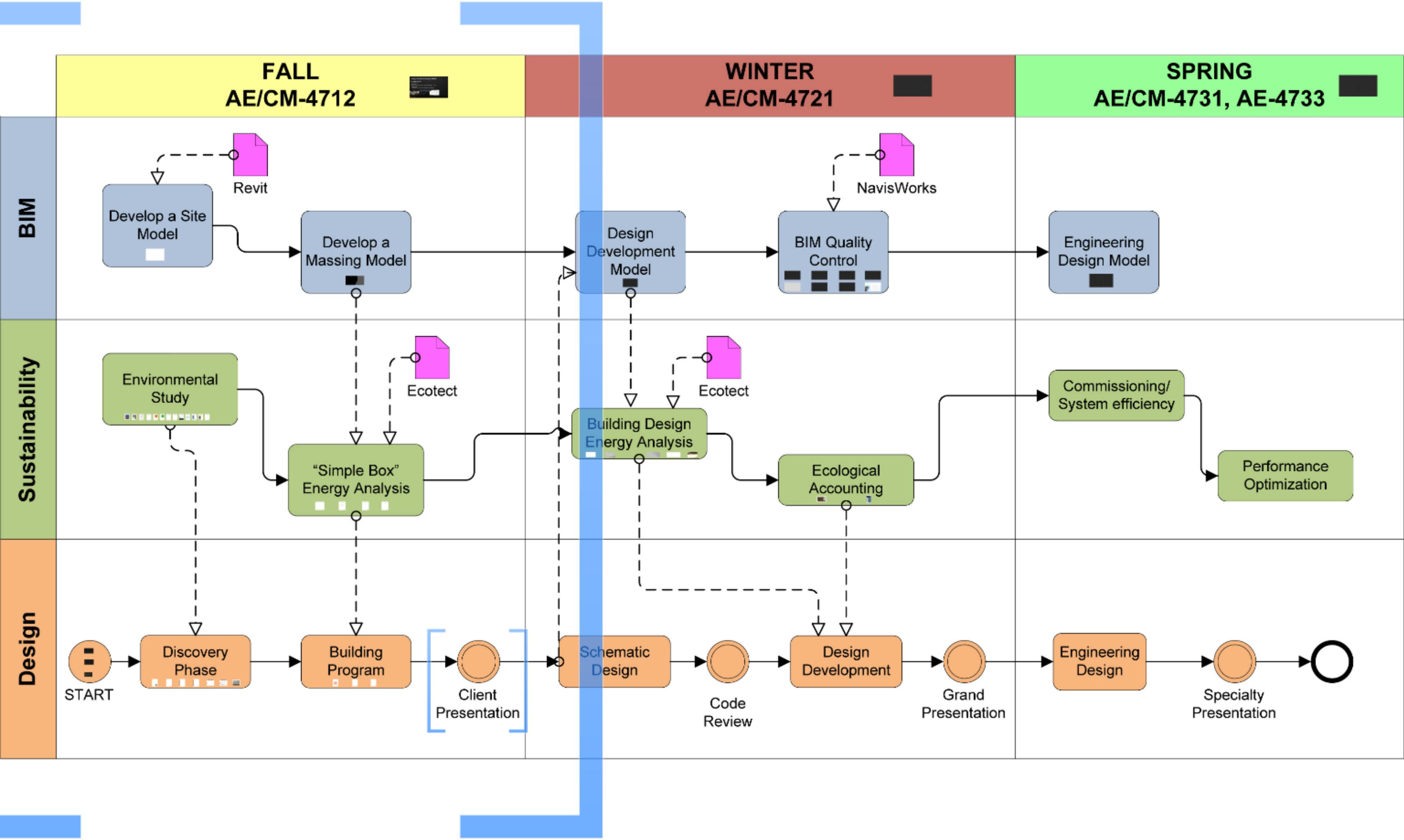
- *You will have to run a clash detection analysis using Navisworks on your Revit model for your senior design project. You should have been monitoring your specialty teammates to ensure they are using Revit for their design process, now you will see if the model is accurate or not. Generate a clash report for the model at this point in time (if your specialty teammates have not gotten that far yet, you may wait to run this report until the beginning of week 9). The primary issue will be is that you need to show the detections and then a report showing that you fixed them, so waiting until the last minute will be incredibly stressful for all involved. BE SURE TO MANAGE YOUR ENGINEERS SO THEY ARE KEEPING UP ON THIS!!!!*

Model Quality Control – Clash Detection

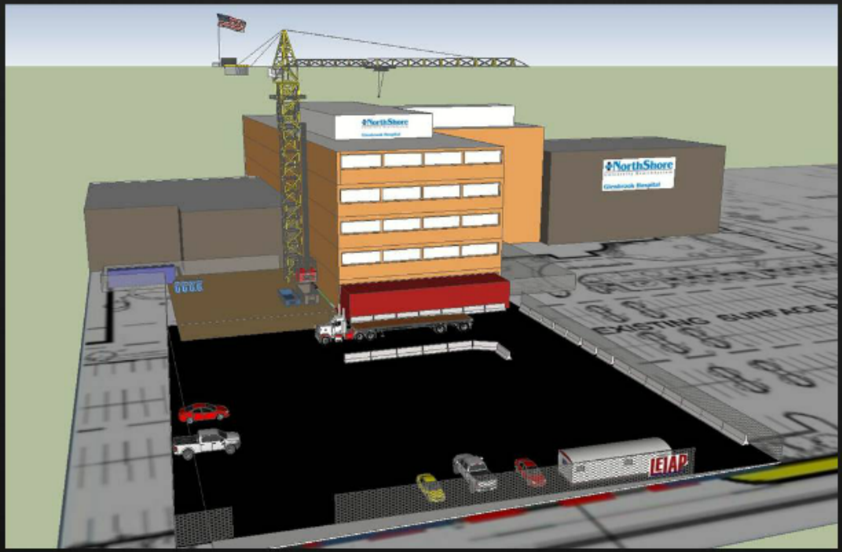


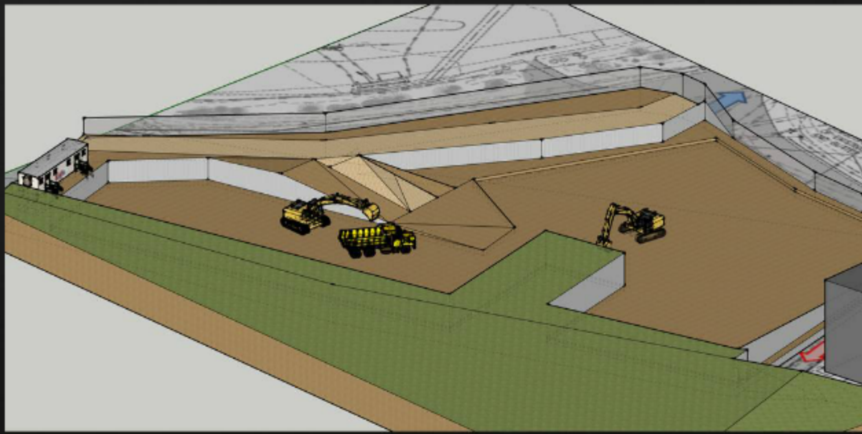
Name	Status	Clashes	New	Active
Steel vs Duct	Done	0	0	0
Steel vs Flex	Done	0	0	0
Steel vs Piping	Done	26	0	26
Steel vs Plumb	New	0	0	0
Steel vs FP	New	0	0	0
Steel vs CTray	New	0	0	0
Steel vs Elec	Old	0	0	0
Steel vs N	New	0	0	0
Ceilings vs Duct	Done	15	0	0
Ceilings vs Flex	Done	353	166	0
Ceilings vs Diffusers	Done	61	29	0
Ceilings vs Piping	Done	23	0	9
Ceilings vs Plumb	New	0	0	0
Ceilings vs FP	New	0	0	0
Ceilings vs CTray	New	0	0	0
Ceilings vs Lights	Old	176	176	0
Ceilings vs Elec	New	0	0	0
Ceilings vs N	New	0	0	0
Duct vs Piping	Done	0	0	0
Duct vs Plumb	New	0	0	0
Duct vs FP	New	0	0	0
Duct vs CTray	New	0	0	0
Duct vs Elec Clear...	New	0	0	0
Duct vs Lights	Old	0	0	0


FALL
AE/CM-4712
WINTER
AE/CM-4721
SPRING
AE/CM-4731, AE-4733
BIM
Sustainability
Design
Revit
Develop a Site Model
Develop a Massing Model
Design Development Model
NavisWorks
BIM Quality Control
Engineering Design Model
Environmental Study
Ecotect
"Simple Box" Energy Analysis
Ecotect
Building Design Energy Analysis
Ecological Accounting
Commissioning/ System efficiency
Performance Optimization
START
Discovery Phase
Building Program
Client Presentation
Schematic Design
Code Review
Design Development
Grand Presentation
Engineering Design
Specialty Presentation

Develop Site Logistics Plans

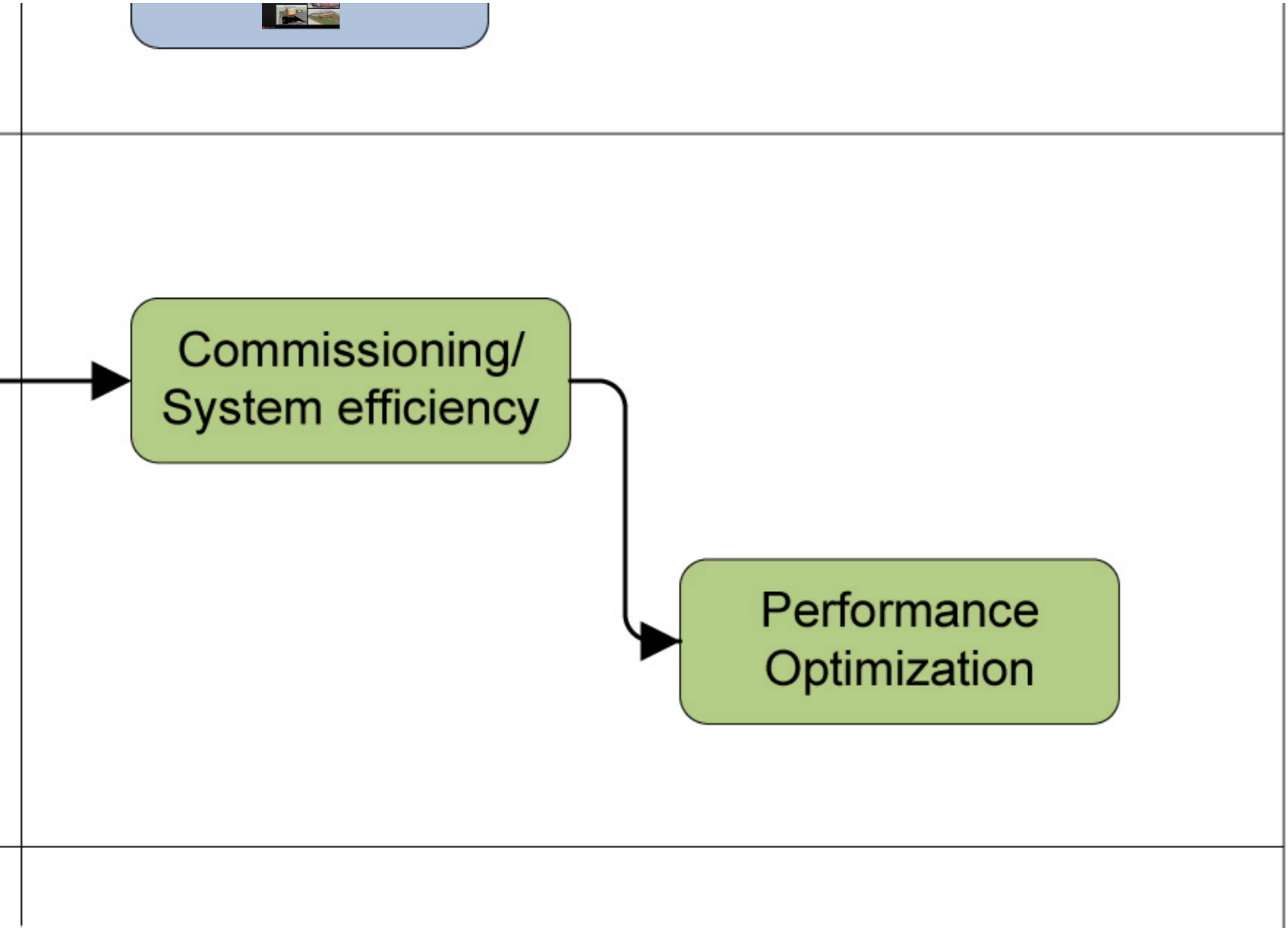
- Analyze construction processes
- Use SketchUp and Revit models

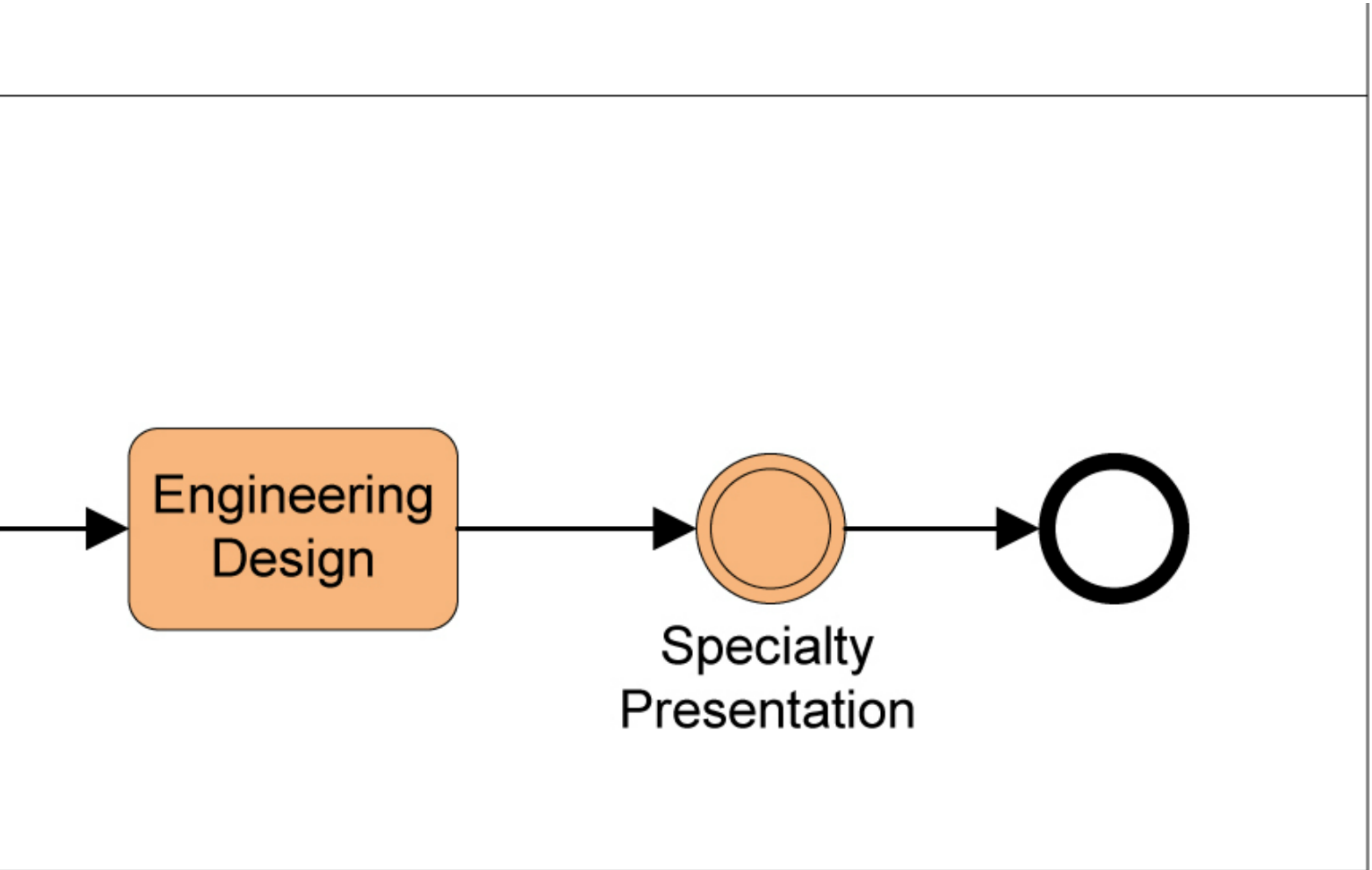




Autodesk University

Prezi


Commissioning/
System efficiency
Performance
Optimization


Engineering Design
Specialty Presentation

HOW DO YOU INTEGRATE SUSTAINABLE DESIGN AND BIM INTO A MULTIDISCIPLINARY DESIGN-BUILD CURRICULUM?

Dr. Jeong Woo
Associate Professor

Dr. Matthew Trussoni, AIA, PE
Assistant Professor