Sustainability

Future Trends in Construction Series

The Architect's Role in Green Building

October 27, 2011

INTEGRATED PROJECT DELIVERY & BUILDING INFORMATION MODELING

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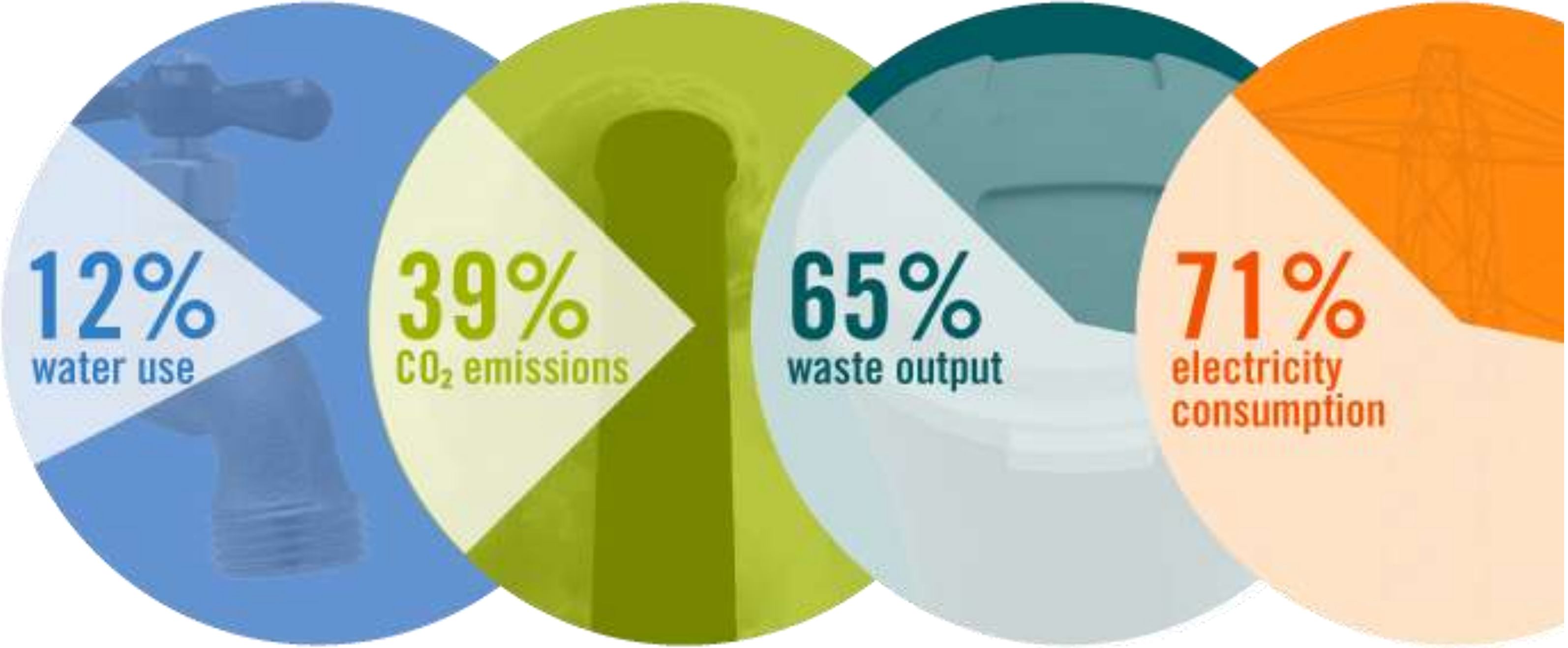
Impact of the Built Environment- U.S.



Impact of the Built Environment Worldwide

WORLDWIDE, BUILDINGS ACCOUNT FOR…

17% fresh water withdrawals

25% wood harvest

33% CO_2 emissions

40% material and energy use
45% in china

IPD & EARLY DESIGN

AIA Definition of IPD

"**Integrated Project Delivery** (IPD) is a project delivery approach that **integrates** people, systems, business structures and practices into a **process** that **collaboratively** harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction"

Working definition from AIA California Council

But, what's involved?

Critical Elements of IPD

1. Early Involvement
2. Shared Risk and Reward
3. Multi-Party Contract
4. Collaborative Decision Making
5. Liability Waivers
6. Goals developed jointly by
   - Owner
   - Architect
   - Contractor
   - Sub consultants
   - Sub contractors

Nice to have, but not absolutely required

1. BIM
2. Co-location of team members
3. Open financial books
4. Lean processes- design & construction
   "Six Sigma for Sustainability"
   by Thomas McCarty

Front Loading Design Decisions

Schematic Design

Entire project team is assembled & establishes design criteria.

Design Development

Team collaboration improves quality and minimizes risk.

Construction Documents

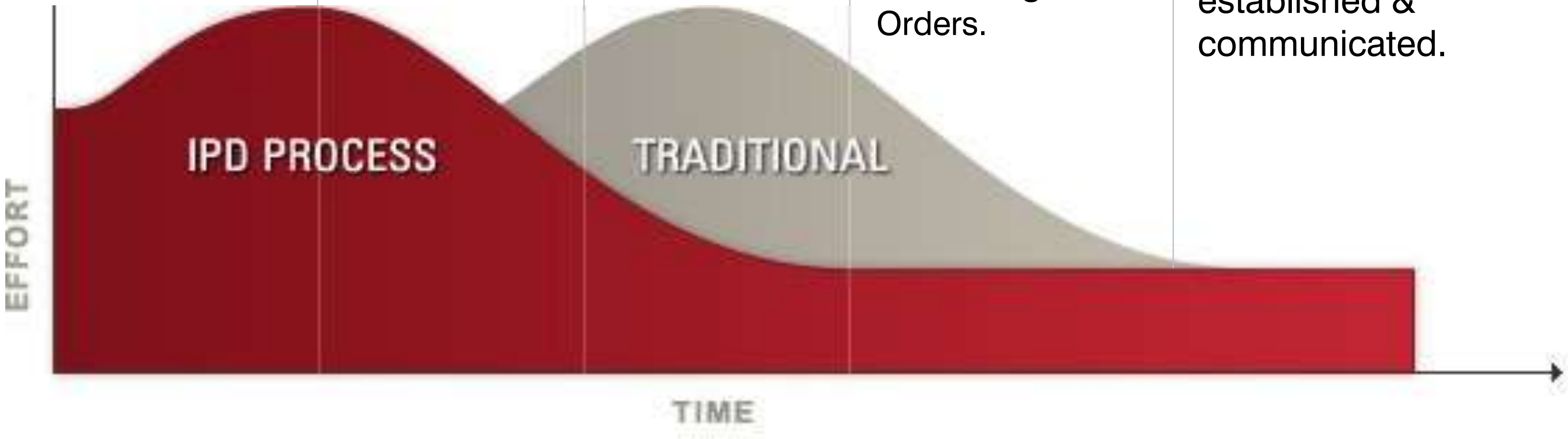
The formerly heavy design period is now the lightest design period.

Construction

Early planning pays off with reduced RFIs, schedule extensions, and Change Orders.

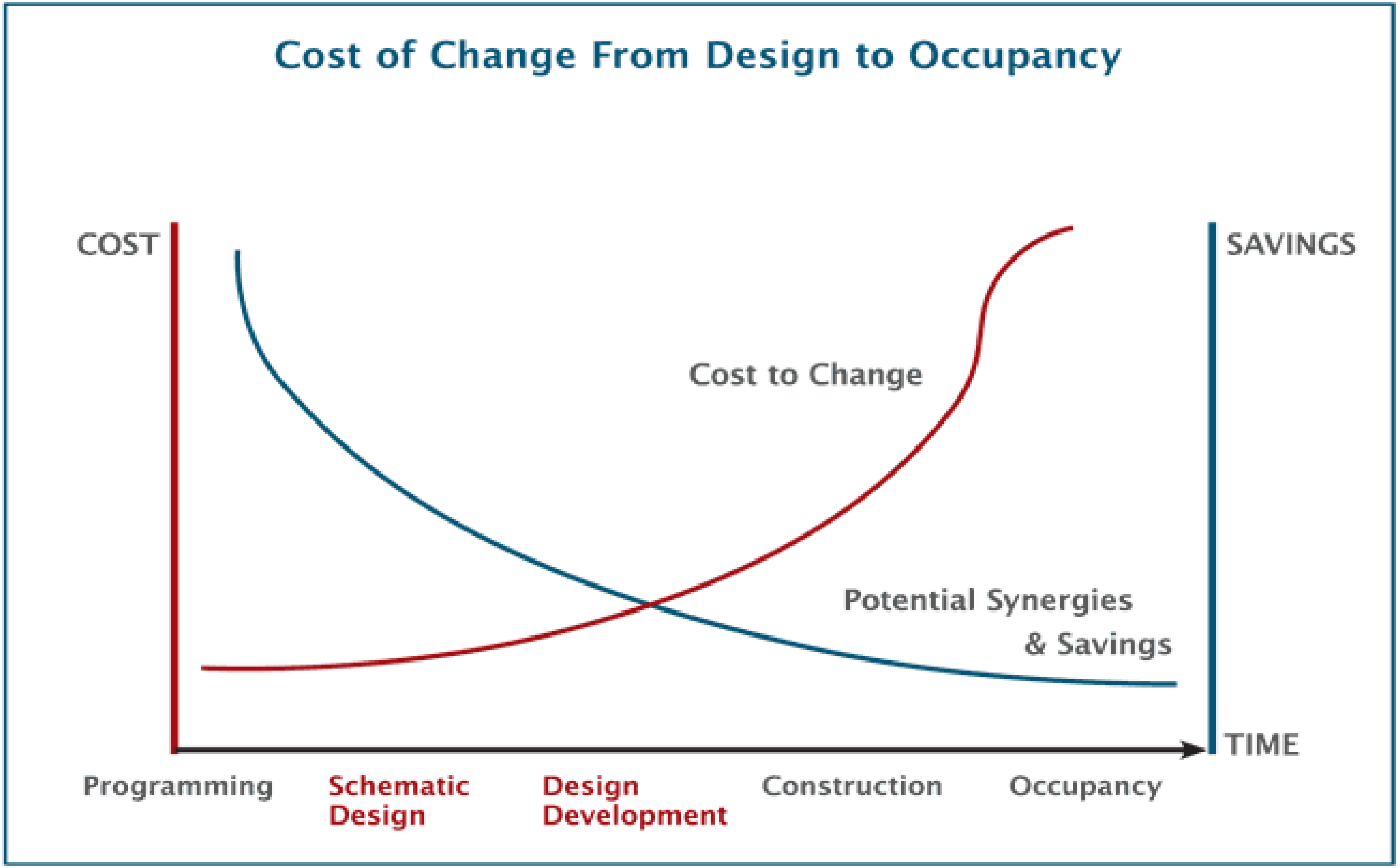
Transfer to Operations

Transfer is smoother as requirements for Closeout & Cx are well established & communicated.



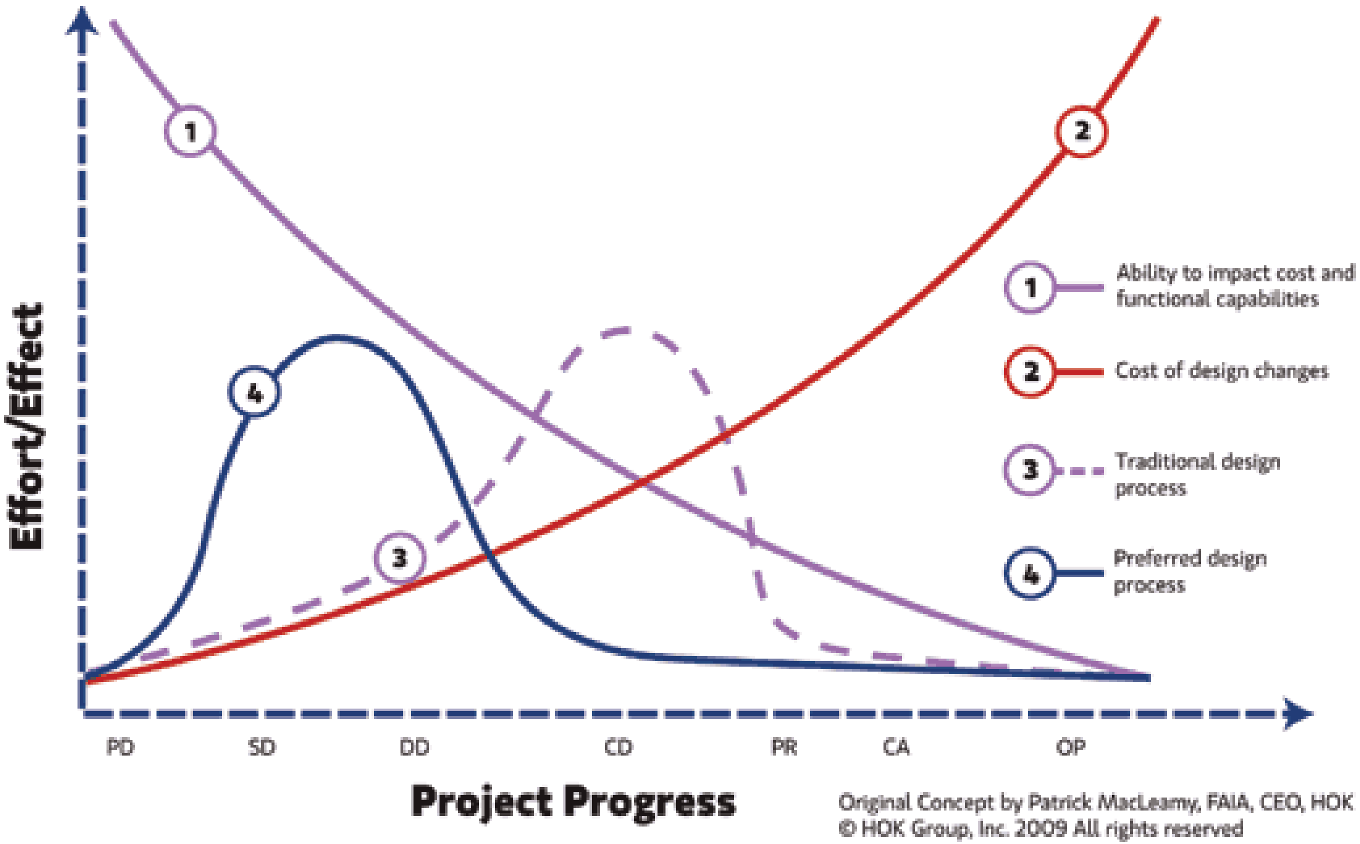
INTEGRATED PROJECT DELIVERY: EARLY EFFORT REDUCES COST & RISK

Cost Impact Curve



MacLeamy Curve

Project Effort and Impact



COMPARISON OF PROJECT DELIVERY METHODS

Traditional

Design

Owner hires Architect & design consultants

SD, DD, and CDs | Bid | VE- Redesign | In Budget | **Construction**

Design
Estimator establishes budget

Owner hires Contractor
Real Cost is established, then reestablished

RFIs clarify uncoordinated work
Owner changes increase costs

Design Build

Design

Owner hires Architect, design consultants & Contractor

Package 1 *Site & Foundation*

Package 2 Core and Shell

Package 3 *Interiors FF&E*

Construction

Separates into packages
GC prices packages

GC starts to build from packages as they're released
Pricing is locked in earlier keeping project in budget

IPD

Design | **Construction**

Owner hires Architect, design consultants & Contractor

Charrette | Design | Energy Modeling | Life Cycle Analysis

Design- with input from Owner, Facility Management, End Users, design consultants & CxA

Decisions are made across disciplines and approved by the leadership teams

Reduced RFIs and reduced Owner changes due to enhanced coordination and input from stakeholders

Cost estimating exercises conducted throughout design

COMPARISON OF PROJECT DELIVERY METHODS

	Organization	Contracts	Risk / Reward	Decisions	Design Method	Design Process	Cost Estimating
Traditional Delivery							
	Hierarchical	Built to minimize liability & protect individual parties	Risk & reward are assumed individually	Hierarchical	Core team meeting with decisions passed on to others not in attendance	Each discipline works in a silos	Cost estimate either per phase or after design is complete
	Sequential	Separate Contracts between parties					VE exercises are common
IPD-lite							
	Collaborative among design team members	Built to increase the sharing of information	May be an optional bonus for on time and under budget	Team decisions- with Owner approval	Charettes involving multiple disciplines and stakeholders	BIM & Charettes allow for "real time" decision making	GC participates during design to inform decisions
	Circular						May or may not need VE exercise
Full IPD							
	All on board from start	Team activity & joint decision making is expressed legally	Stronger contractual expression of team bonus	Decisions made by the team	"Design to design" / Design the Process	BIM models are shared across disciplines	Budget continually visited and used to inform design to prevent VE exercises
	Multi Party Agreement or Single Purpose Entity	Strictly limits the ability to sue each other			Evidence based decisions		LCA goals for each systems are established up front and visited throughout

Modern Work Environments enable Collaboration (Thankfully!)

Old work environments encouraged working in "silos", effectively preventing collaboration and impromptu brainstorming

Modern work environments maximize opportunities for "accidental encounters" encouraging free flow of ideas.

1

Design the Design Process

2

Create the Team

3

Conduct a Charrette

4

Publish the Goals

1

Design the Design Process

Contract Type and Communications

Contract Type

The Contract establishes the roles and responsibilities between disciplines, the manages risk, and establishes incentives.

Incentives can come in various forms. For example, additional fee for keeping the project on budget and on schedule- and for achieving a pre-determined level of energy savings.

Communications

Determine the channels of communication and how decisions will be reached and maintained.

For larger projects, consider co-locating design team members.

2

Create the Team

Representatives from Owner, Architect, and GC on each team

Senior Management Team

High

Highest level of authority, not involved in everyday design and construction decisions, but are the final word in conflict resolution

Project Management Team

Medium

Middle level of authority, involved in everyday design and construction decisions, resolves conflicts from Project Implementation Team

Project Implementation Team

Low

Lowest level of authority, but actively involved with implementation every day.

3

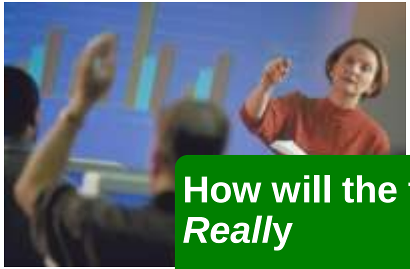
Conduct a Charrette

Who are the Team Members?

What are the roles?

How do we define success?

What are operating hours? *Really*



How will the facility be used? *Really*

How is waste handled?

What are the water conservation goals? How do we achieve those goals?

PREDESIGN- OWNER'S PROJECT REQUIREMENTS

4

Publish Goals in the Owner's Project Requirements

1 Project Requirements
Project Schedule
Project Documentation
Owner's Directives
Restrictions and Limitations
Community
Codes and standards
Benchmarking
Energy Efficiency Goals
Environmental and Sustainability Goals

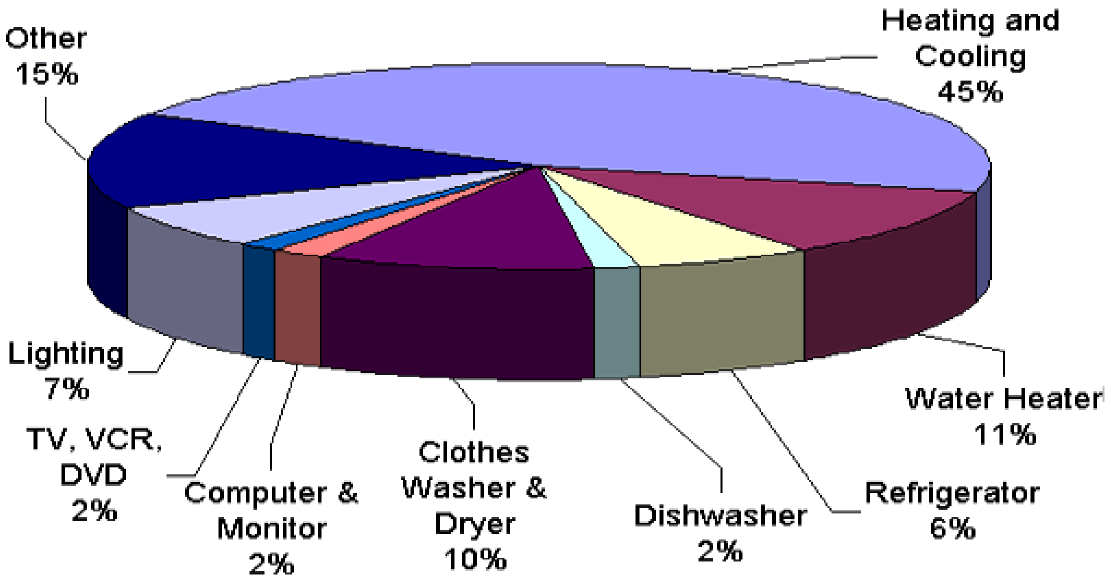
2 Usability Requirements
User requirements
Occupancy schedules
Health and Indoor Environmental Quality
Acoustical
Security and Audio Visual

3 Architectural
Quality of Materials / Construction
Adaptability
Vibration
Seismic
Accessibility
Aesthetic .
Communications / IT
Constructability

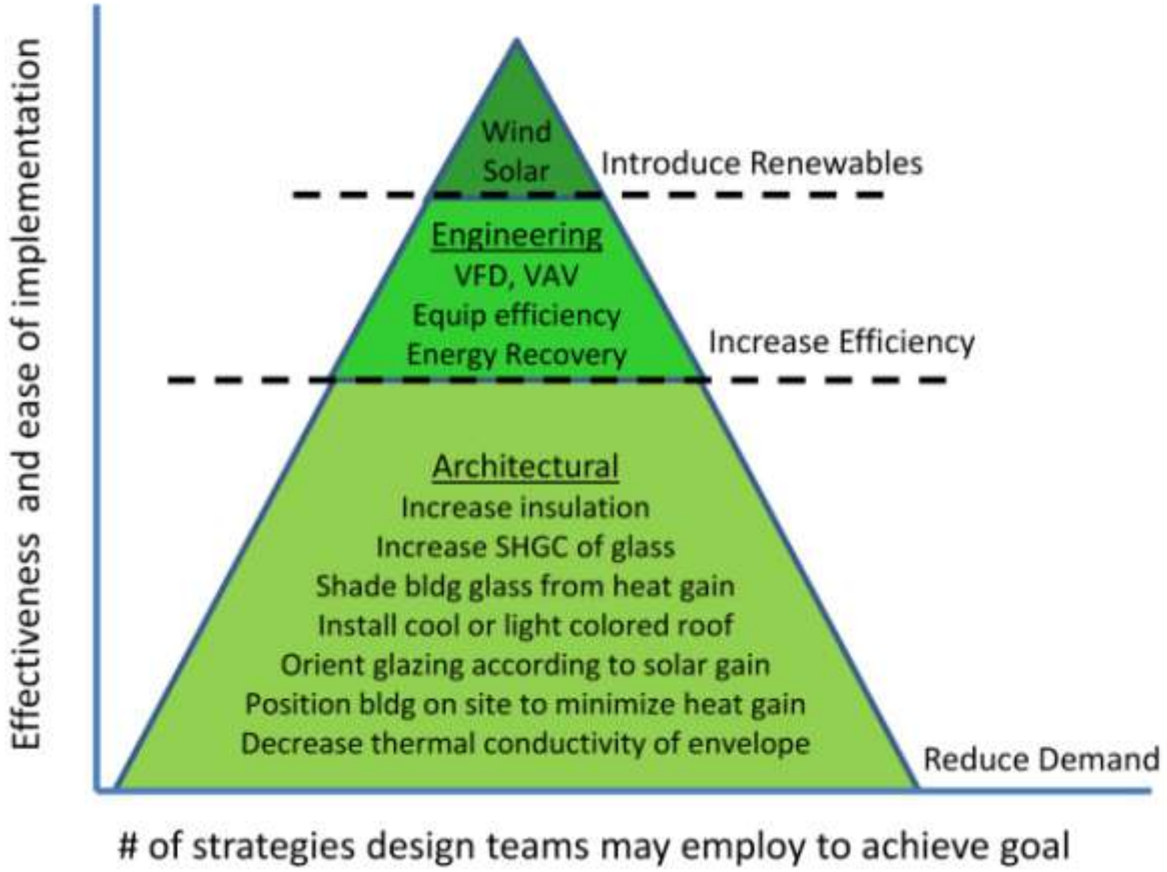
4 Mechanical, Electrical, Plumbing
Commissioning Process
Training
Warranty
Operations and Maintenance
HVAC Equipment
Allowable tolerances
Load Shedding
Submetering
Systems Integration

ENERGY EFFICIENCY

Early Design- Analyze Where the Energy is Concentrated



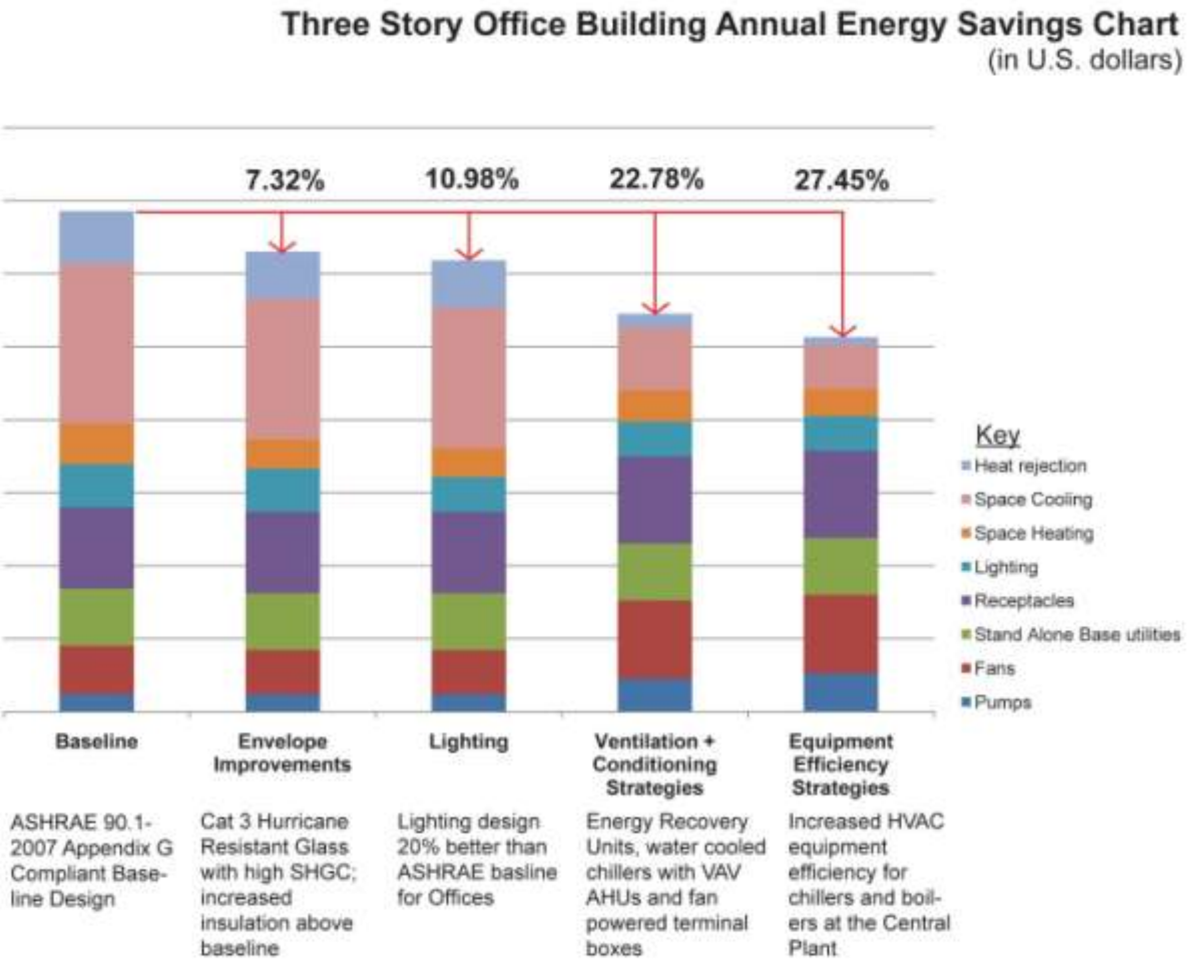
Early Design- The Energy Efficiency Triangle



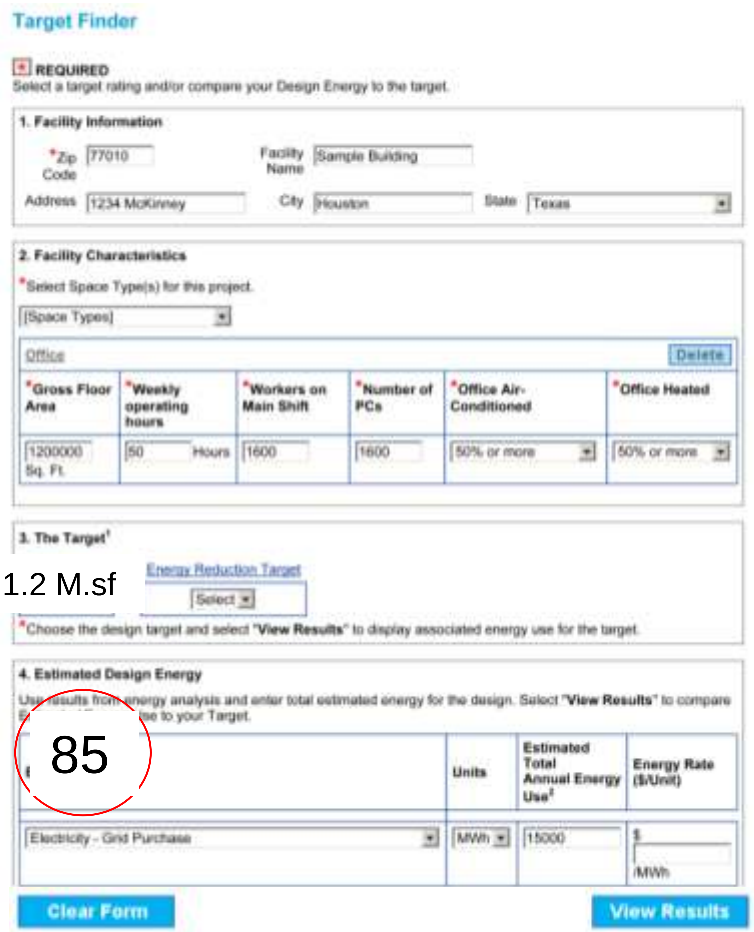
Early Design- Estimating Energy Savings in Schematics

	Alternative 1: Ribbon Windows	Alternative 2: PI Glazing	% savings due to glazing distribution
	Energy Consumption (BTU/sqft*yr)	Energy Consumption (BTU/sqft*yr)	
Longside Facing True North	34,323	31,652	8%
45 deg Rotation	35,161	32,511	8%
90 deg Rotation	35,515	33,303	6%
	% savings due to Building Orientation	% savings due to Building Orientation	
0 deg vs. 45 deg	2%	3%	
45 deg vs. 90 deg	1%	2%	
90 deg vs. 0 deg	3%	5%	11%

Sharing of Energy Analysis Information



TRACK ENERGY STAR SCORE THROUGHOUT DESIGN



Target Finder

REQUIRED
Select a target rating and/or compare your Design Energy to the target.

1. Facility Information

*Zip Code: 77010 — Facility Name: Sample Building
Address: 1234 McKinney — City: Houston — State: Texas

2. Facility Characteristics

*Select Space Type(s) for this project.
[Space Types]

Office — Delete

*Gross Floor Area	*Weekly operating hours	*Workers on Main Shift	*Number of PCs	*Office Air-Conditioned	*Office Heated
1200000 Sq. Ft.	50 Hours	1600	1600	50% or more	50% or more

3. The Target[1]

1.2 M.sf

Energy Reduction Target
Select

*Choose the design target and select "View Results" to display associated energy use for the target.

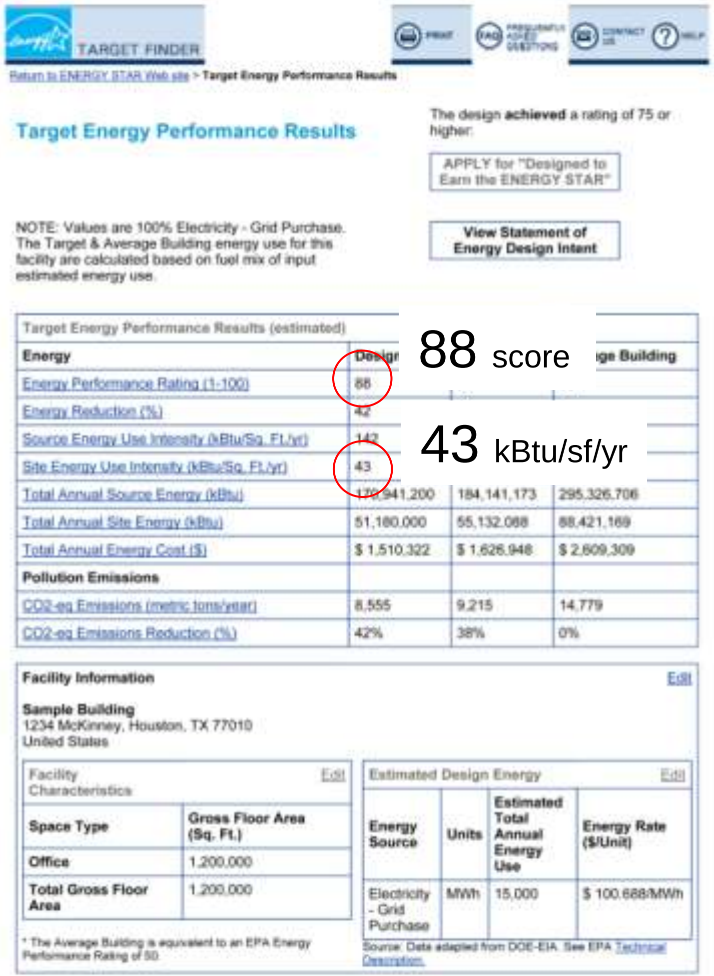
4. Estimated Design Energy

Use results from energy analysis and enter total estimated energy for the design. Select "View Results" to compare ... to your Target.

85

	Units	Estimated Total Annual Energy Use[2]	Energy Rate ($/Unit)
Electricity - Grid Purchase	MWh	15000	$ /MWh

Clear Form — View Results



TARGET FINDER

Return to ENERGY STAR Web site > Target Energy Performance Results

Target Energy Performance Results

The design **achieved** a rating of 75 or higher:

APPLY for "Designed to Earn the ENERGY STAR"

NOTE: Values are 100% Electricity - Grid Purchase. The Target & Average Building energy use for this facility are calculated based on fuel mix of input estimated energy use.

View Statement of Energy Design Intent

Target Energy Performance Results (estimated)

88 score

43 kBtu/sf/yr

Energy	Design		Average Building
Energy Performance Rating (1-100)	88		
Energy Reduction (%)	42		
Source Energy Use Intensity (kBtu/Sq. Ft./yr)	142		
Site Energy Use Intensity (kBtu/Sq. Ft./yr)	43		
Total Annual Source Energy (kBtu)	170,941,200	184,141,173	295,326,706
Total Annual Site Energy (kBtu)	51,180,000	55,132,068	88,421,169
Total Annual Energy Cost ($)	$ 1,510,322	$ 1,626,948	$ 2,609,309
Pollution Emissions			
CO2-eq Emissions (metric tons/year)	8,555	9,215	14,779
CO2-eq Emissions Reduction (%)	42%	38%	0%

Facility Information — Edit

Sample Building
1234 McKinney, Houston, TX 77010
United States

Facility Characteristics — Edit

Space Type	Gross Floor Area (Sq. Ft.)
Office	1,200,000
Total Gross Floor Area	1,200,000

Estimated Design Energy — Edit

Energy Source	Units	Estimated Total Annual Energy Use	Energy Rate ($/Unit)
Electricity - Grid Purchase	MWh	15,000	$ 100.688/MWh

* The Average Building is equivalent to an EPA Energy Performance Rating of 50.

Source: Data adapted from DOE-EIA. See EPA Technical Description.

DESIGN STRATEGIES

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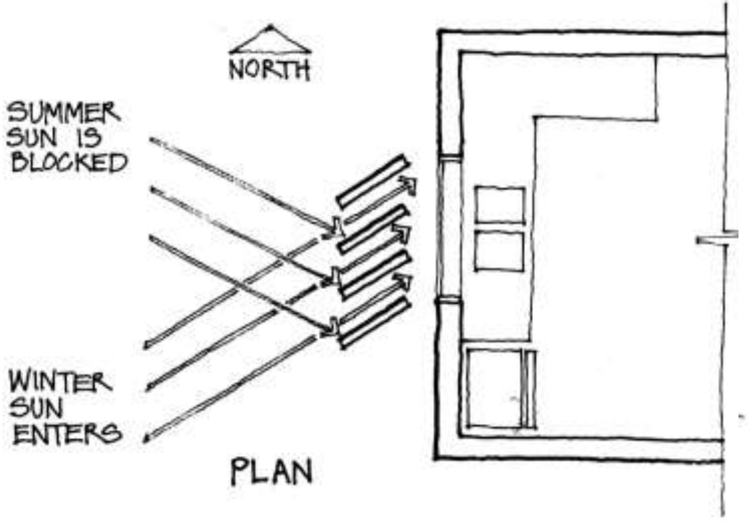
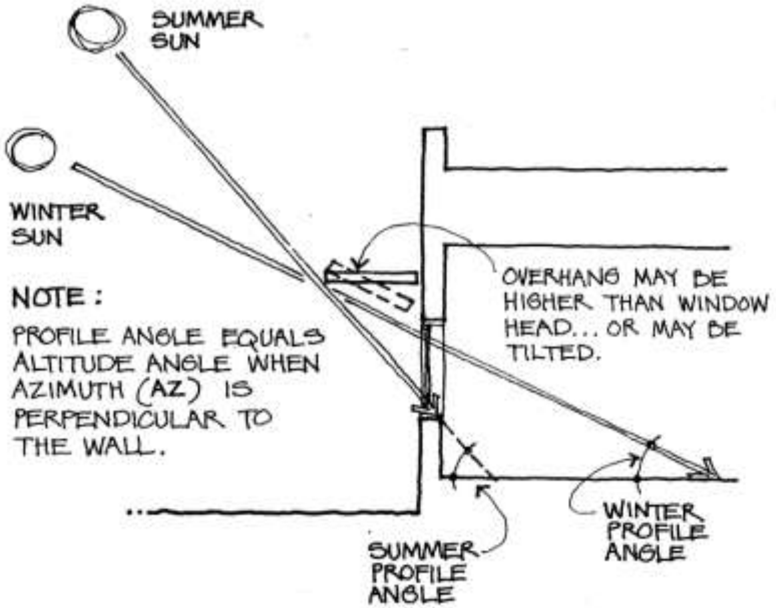
ARCHITECTURE INTERIORS CONSULTING ENGINEERING

Daylight Harvesting

Capturing Light while Minimizing Glare



VERTICAL FINS ON WEST FACADE



OVERHANG AND PROFILE ANGLE

Space Giving Technique

Day lighting strategy drives the design of the Interior Design and Space Planning.

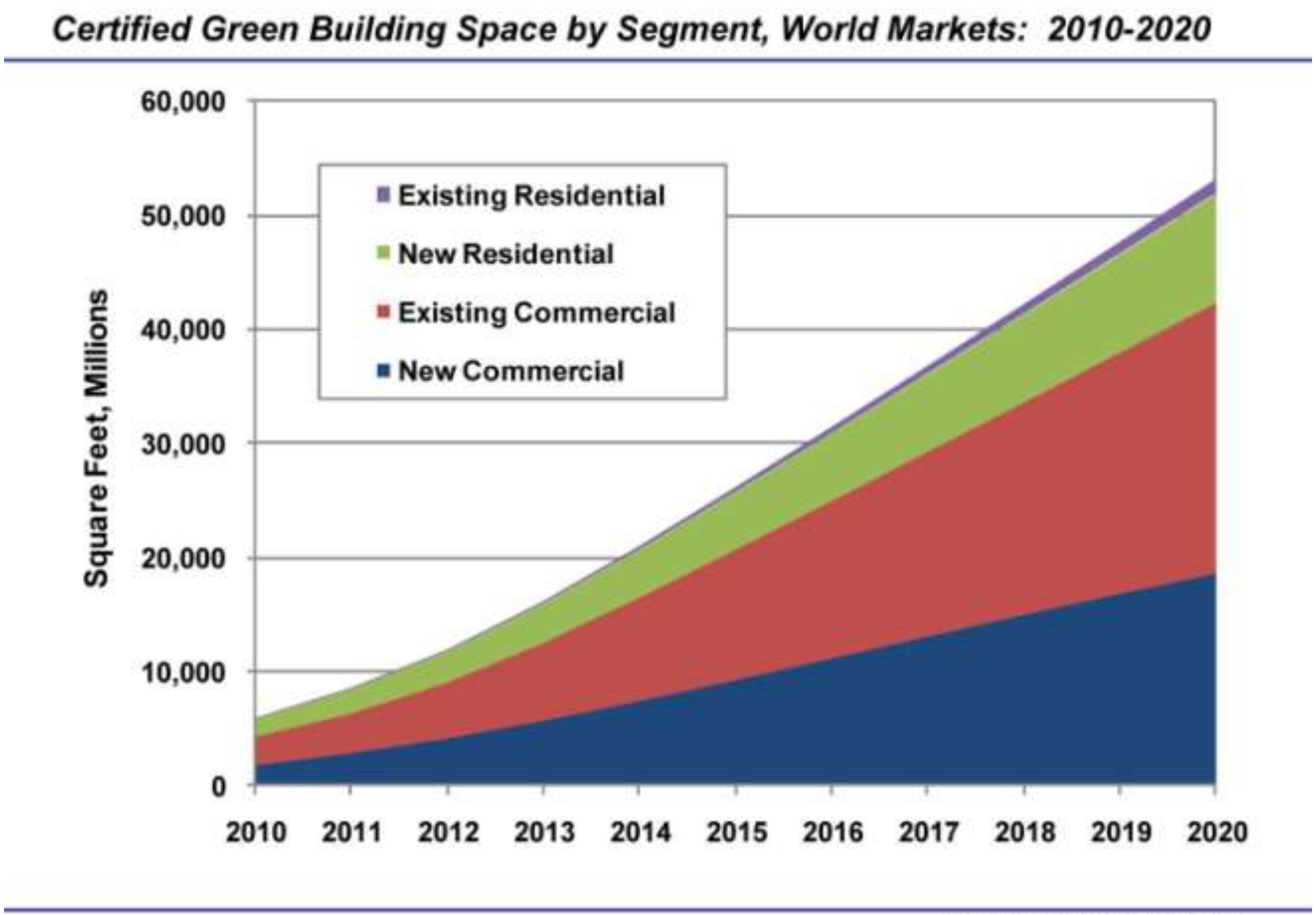
- High perimeter ceiling in reflective color
- Circulation along perimeter
- Shading devices on upper windows

Form Giving Technique

Day lighting strategy drives the design of the building envelope

IPD AND LEED

Future Trend of Green Building Certification



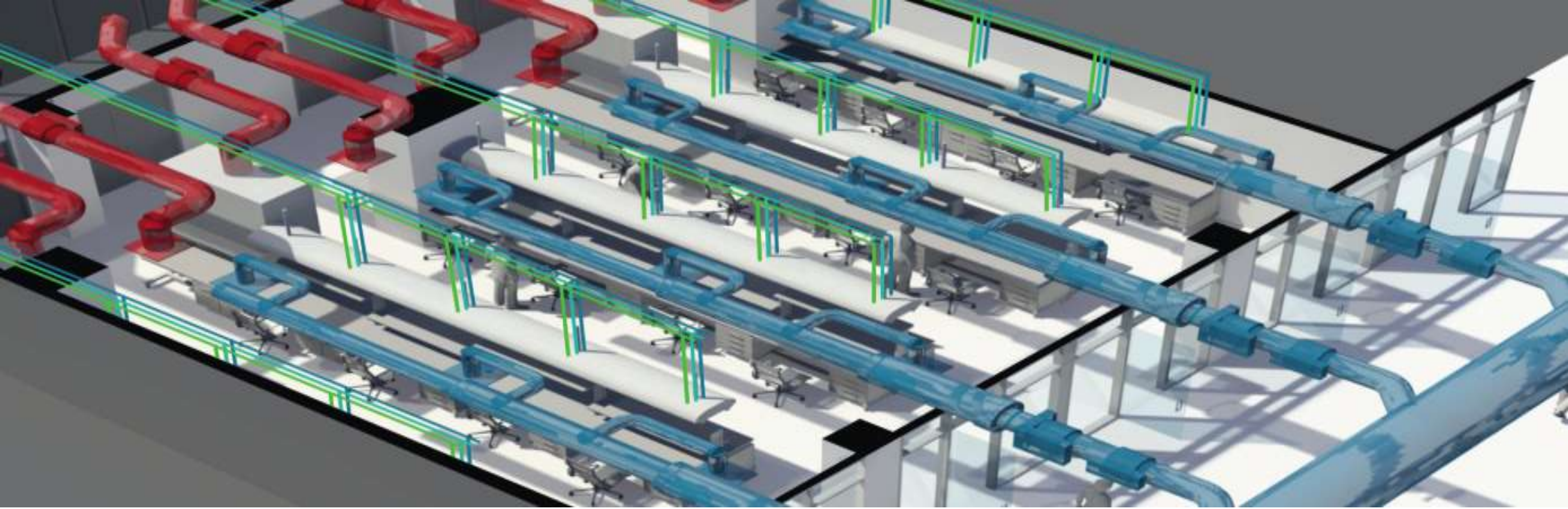
(Source: Pike Research)

LEED 2012 2nd Public Comments

Proposed LEED Credit: **Integrative Process-** Analyses to Support Integrative Process

Intent:
Encourage project teams to gather data, conduct analyses, and develop an understanding of key issues to be considered before decisions are made on design and building form to support integrative approaches aimed at achieving a high level of performance.

Site	Energy	Water
Analyze site characteristics: Topography, hydrology, microclimate, vegetation, soils Write narrative describing how discovery influenced design	Analyze energy loads: Massing and orientation Glazing, insulation, window to wall ratio, lighting power density, thermal comfort ranges, operational hours Select (5) parameters and run (2) scenario energy models against baseline	Analyze water usage for both interior and exterior water to determine burden on municipal supply and waste systems



PART II - BUILDING INFORMATION MODELING - INTRODUCTION

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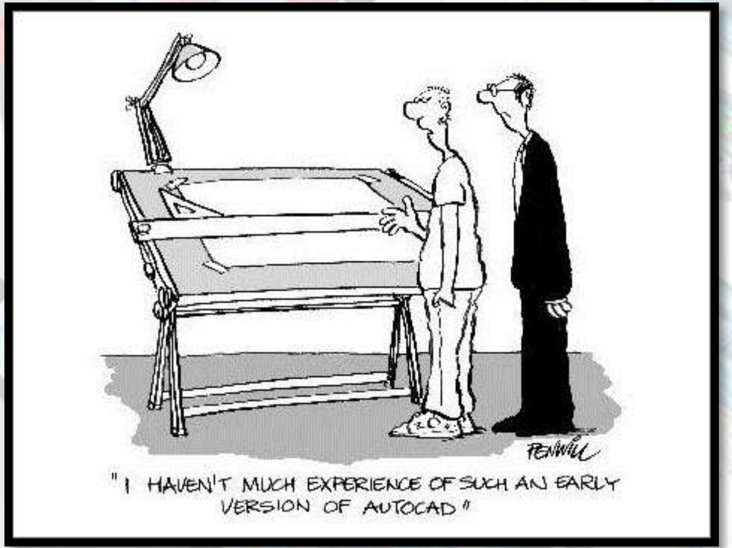
BIM in the Headlines

"BIM is an integrated, collaborative process that enables engineers, architects, contractors and clients to work from a single, digital project model and share reliable, coordinated information at every stage of a project lifecycle"

"Visualizations help all stakeholders understand the real scope, complexity and issues with a project, and allow the entire team to make more informed decisions earlier in the process."

Evolution from the Drafting Board to CAD(D)

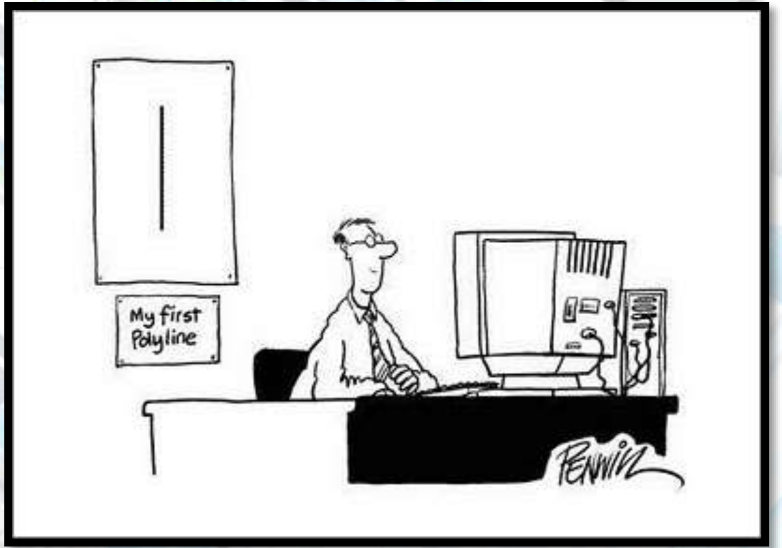
→ late 1980's (early 1990's)



http://bash-mohandis.blogspot.com/2007/07/cad-humor.html

Manual Drafting
"The Boards"

…mid 1990's →

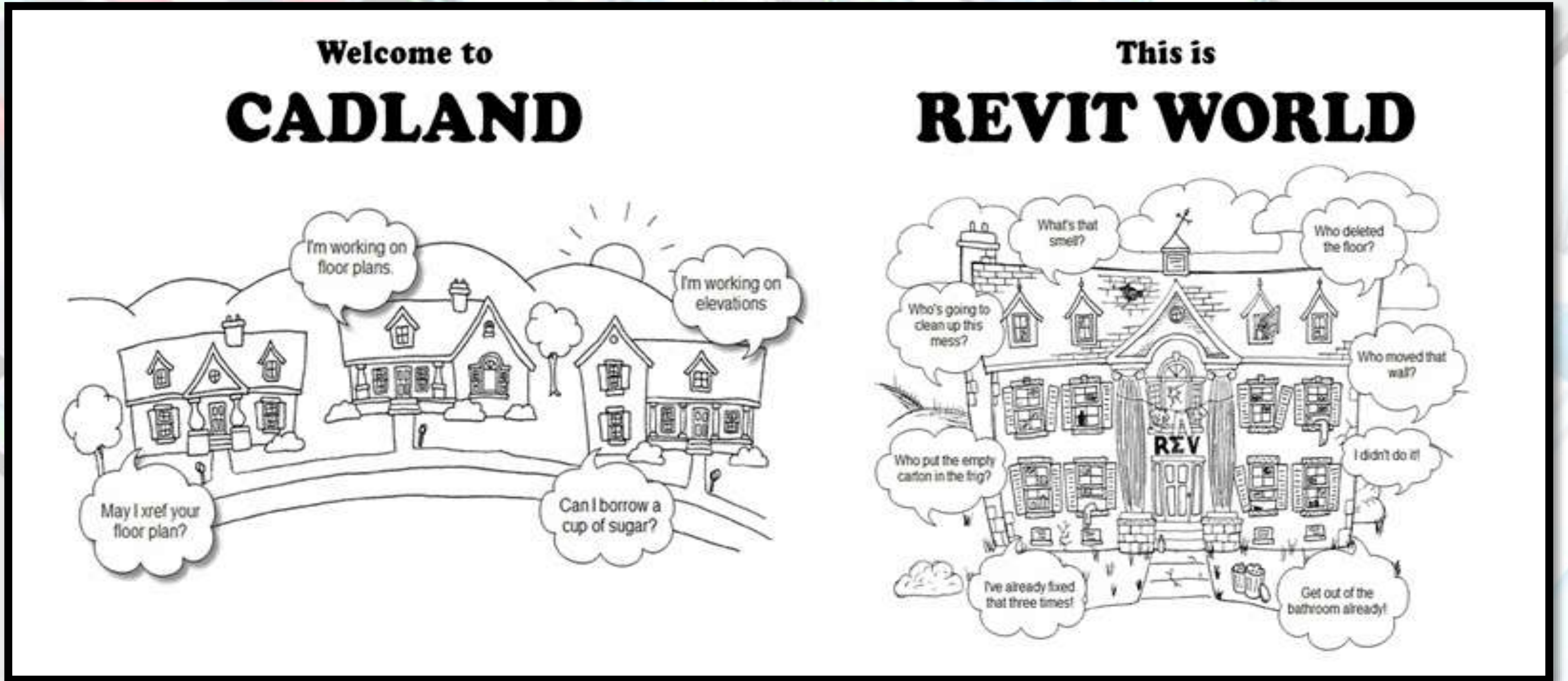


http://bash-mohandis.blogspot.com/2007/07/cad-humor.html

Computer Aided Drafting (and Design)
"CAD(D)"

Transition from CAD to BIM

→ mid 1990's | …early 2000's →



http://designerati.wordpress.com/2010/07/29/welcome-to-cadland-this-is-revit-world-pic/

Computer Aided Drafting (and Design)
"CAD(D)"

Building Information Modeling
"BIM"

BIM Defined

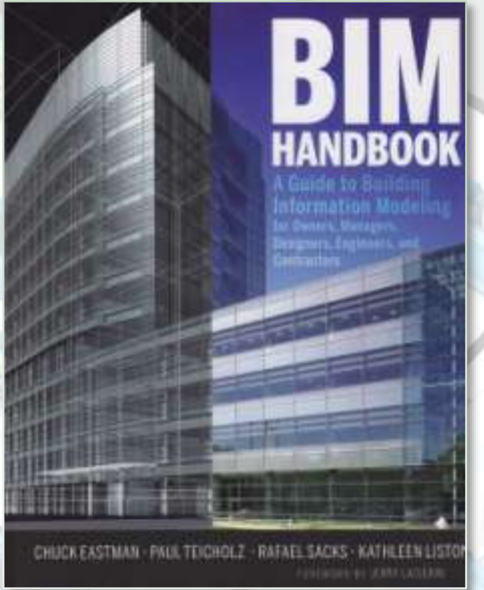
- **National Institute of Building Sciences:** *BIM "utilizes cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility."*

- **The GSA:** *"…'intelligent' and 'multifaceted ' computer software data model to not only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility"*

- **The Associated General Contractors of America:** *"the 'virtual construction' of structures through the development and use of intelligent computer software that helps simulate construction"*

Characteristics of a BIM Model

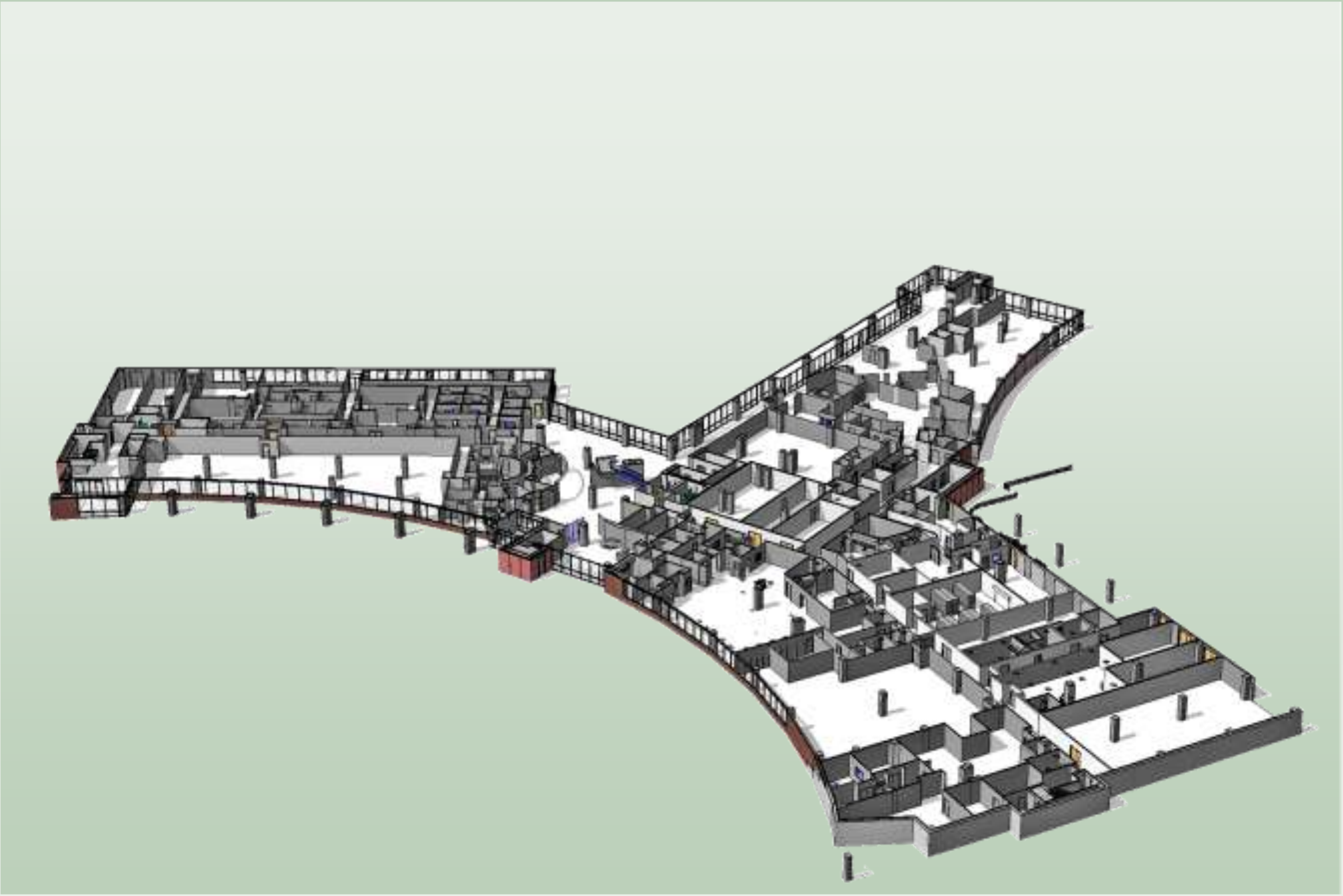
- Digital
- Volumetric (3D)
- Quantifiable
  - Dimensioning
  - Takeoffs
  - Queries
- Comprehensive
  - Visualization
  - Constructability
  - Performance
  - Sequencing
  - Financing
- Universally Accessible and Interoperable
- Durable and Usable throughout Building's Life-Cycle



http://www.ksiegarnia-artystyczna.com/galerie/b/bim-handbook-a-guide-to_17950.jpg

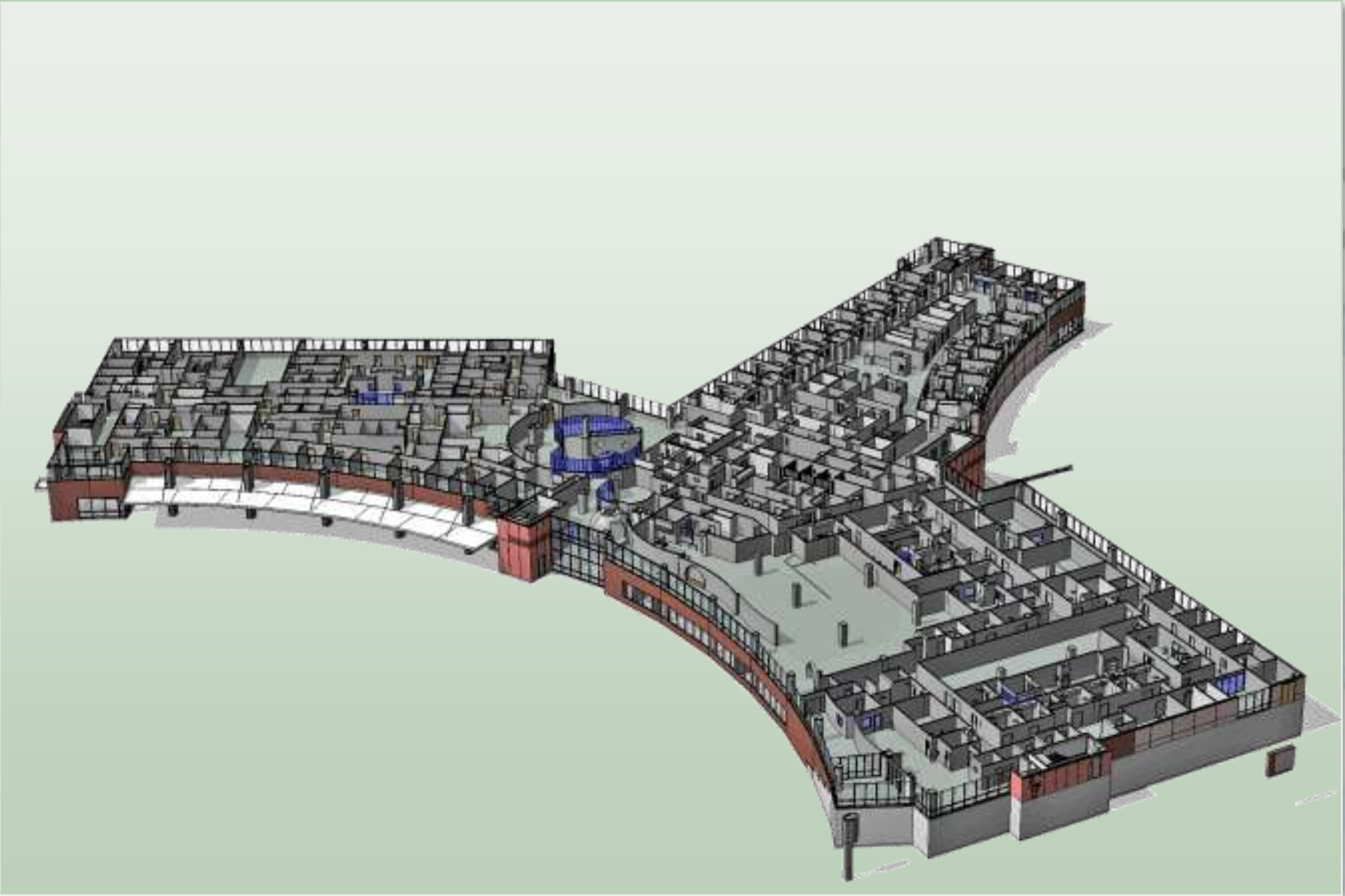
Eastman, Charles M., et al. Bim Handbook : A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors. Hoboken, N.J.: Wiley, 2008. 13.

Introduction



Building Information Modeling

Introduction



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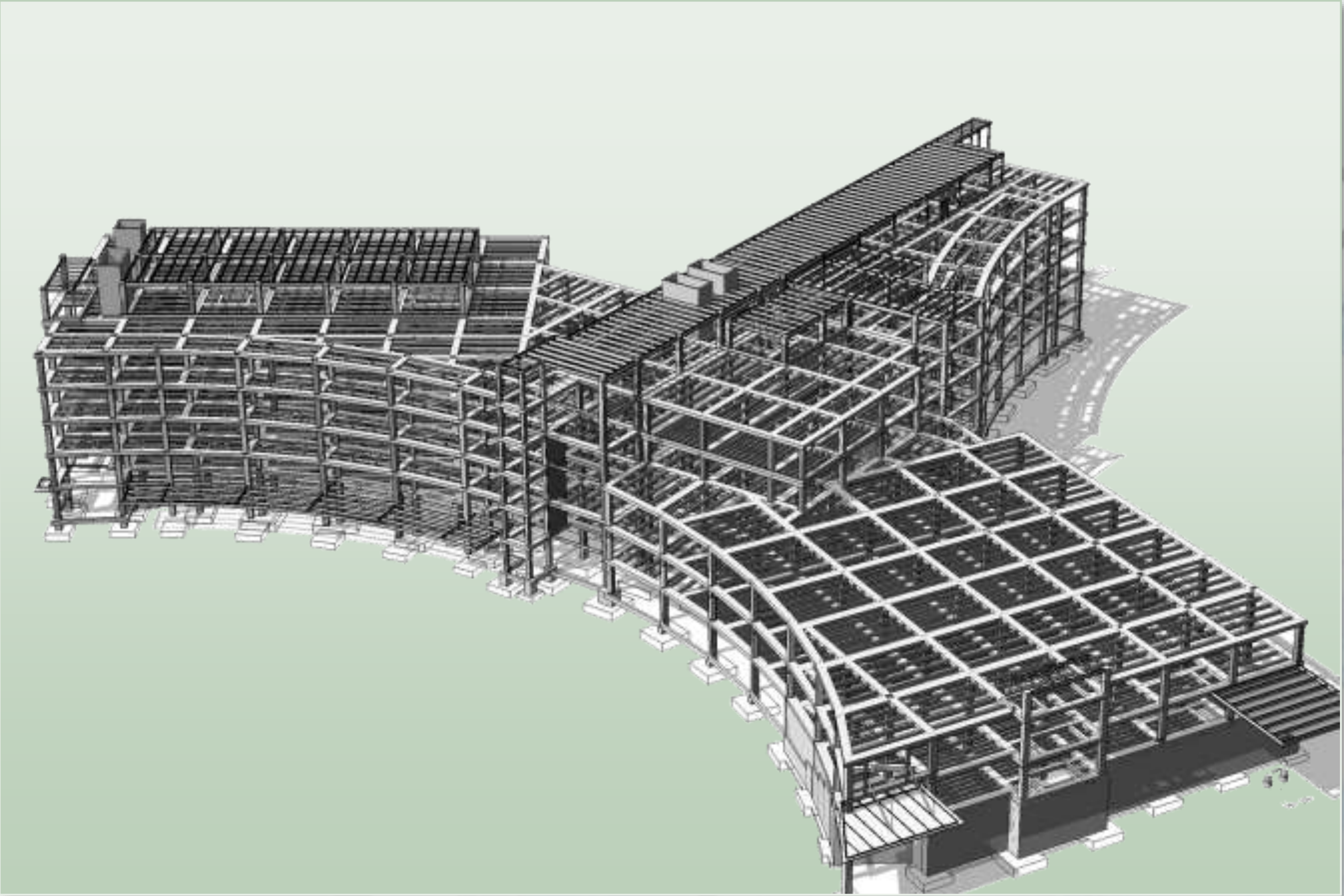
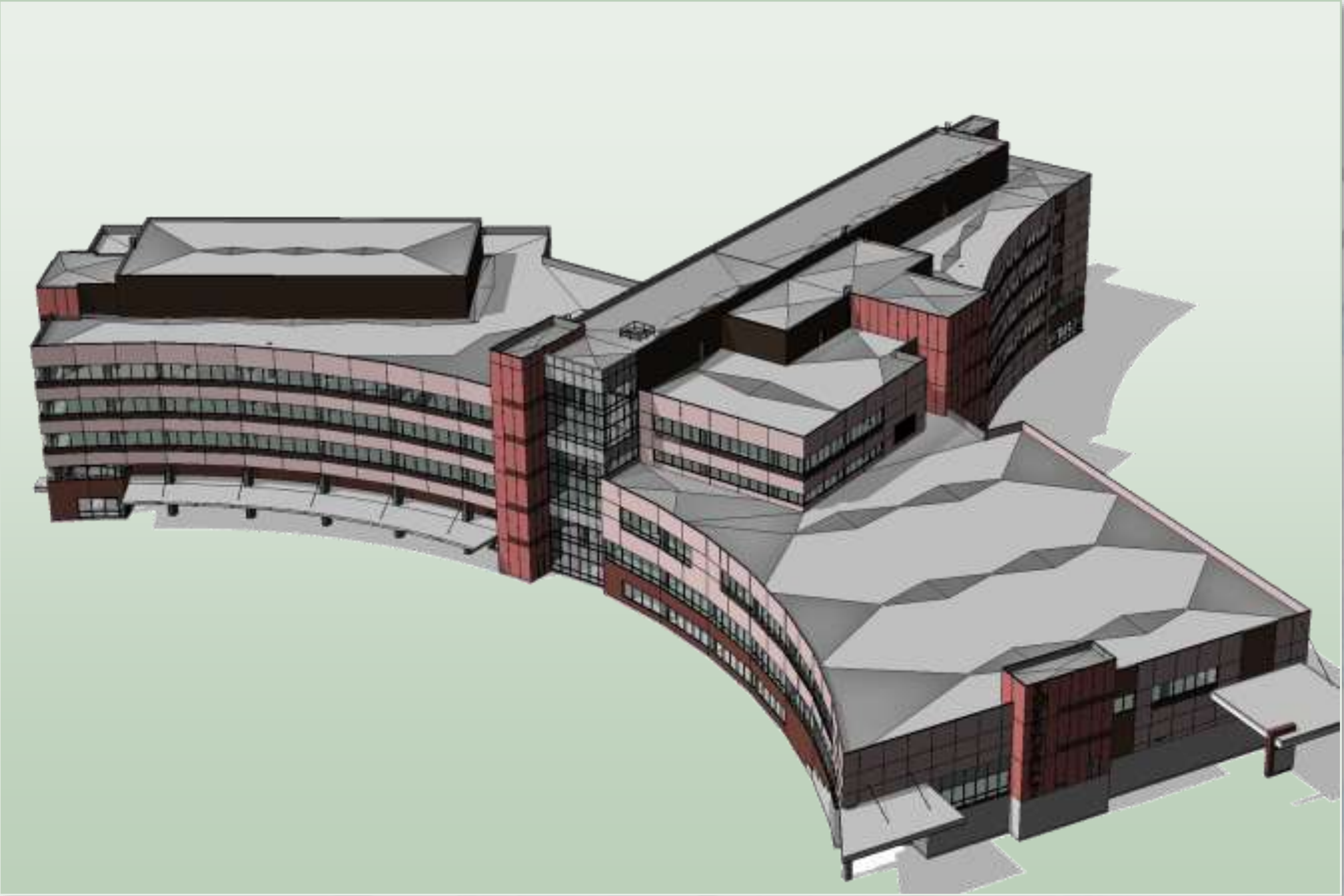


Introduction



Building Information Modeling

BIM – A Collaborative Workflow (Single Model Dynamics)

User 1 Local Copy

User 2 Local Copy

Central Model

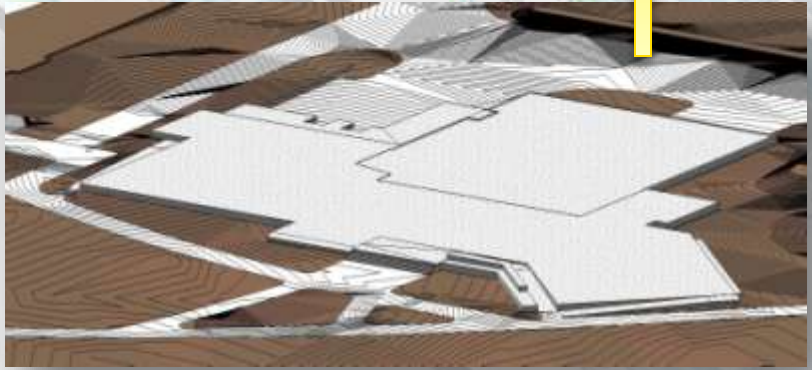
User 3 Local Copy

User 4 Local Copy

BIM – A Collaborative Workflow (Multiple Model Dynamics)

Architectural Model

MEP Model



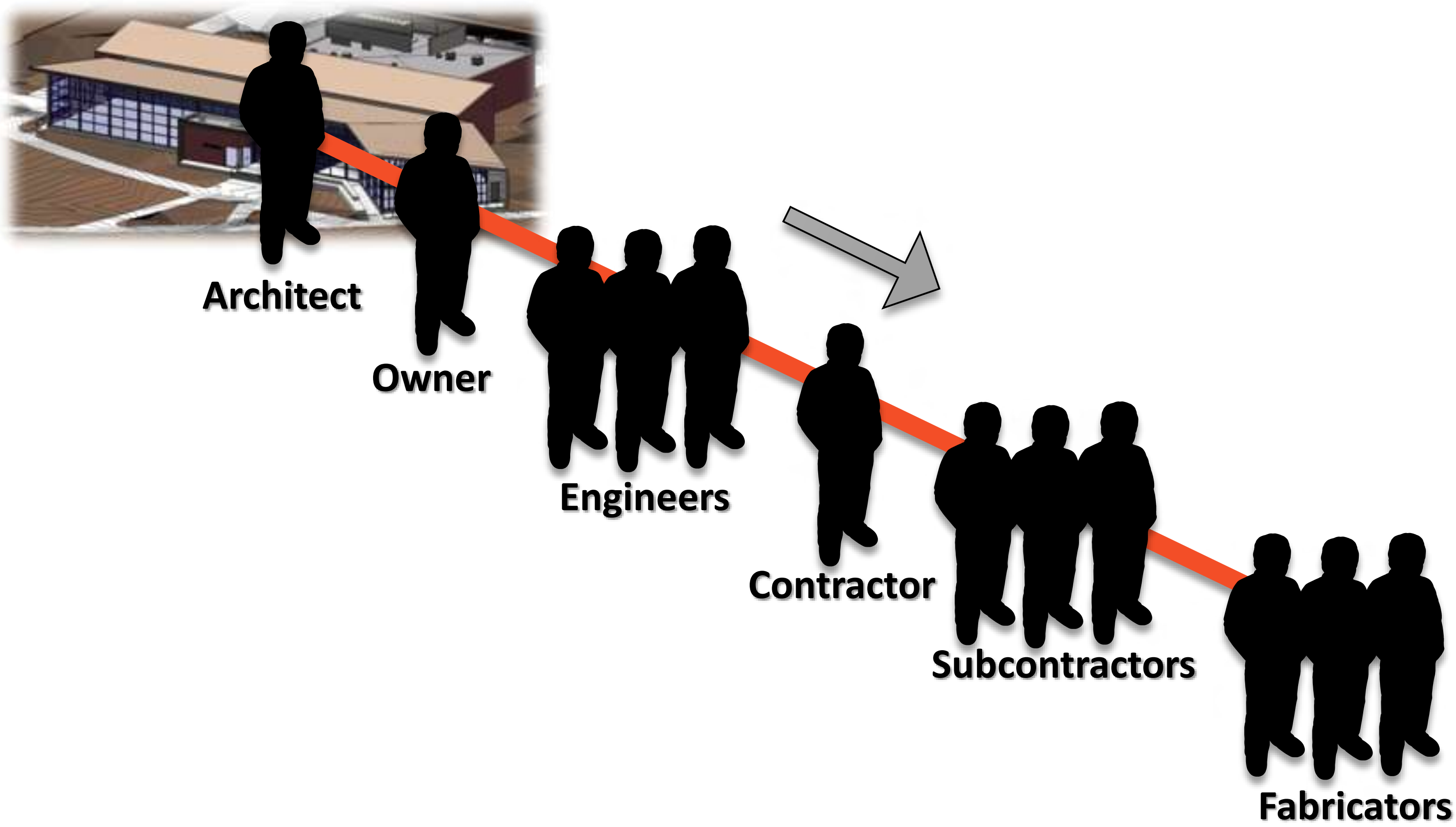
Civil/Site Model

Structural Model

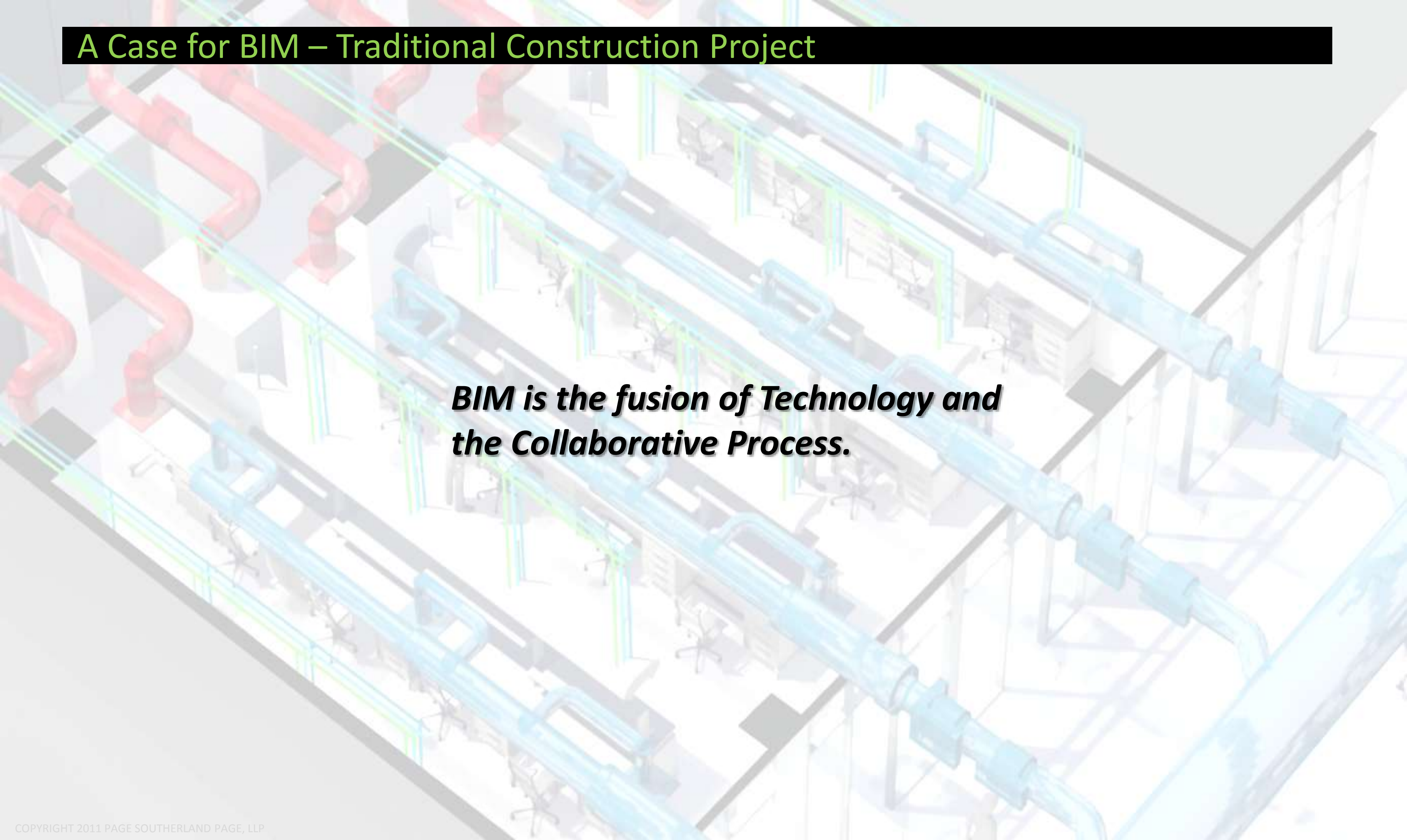
A Case for BIM - Conventional Project Dynamics

- **Owners Vision of final deliverable is unclear**
- **Plans and Specifications are inaccurate or incomplete**
- **Contracts awarded to lowest bidder (not the necessarily most competent bidder)**
- **Low-bid contractors and subs need to make money by issuing change orders ($$$)**
- **Information sharing limited due to potential Liability**
- **Risk is most often deferred to others rather than shared collectively**
- **Selfishness - Each only concerned for themselves**
- **Adherence to Schedule is often lacking**

A Case for BIM – Traditional Construction Project

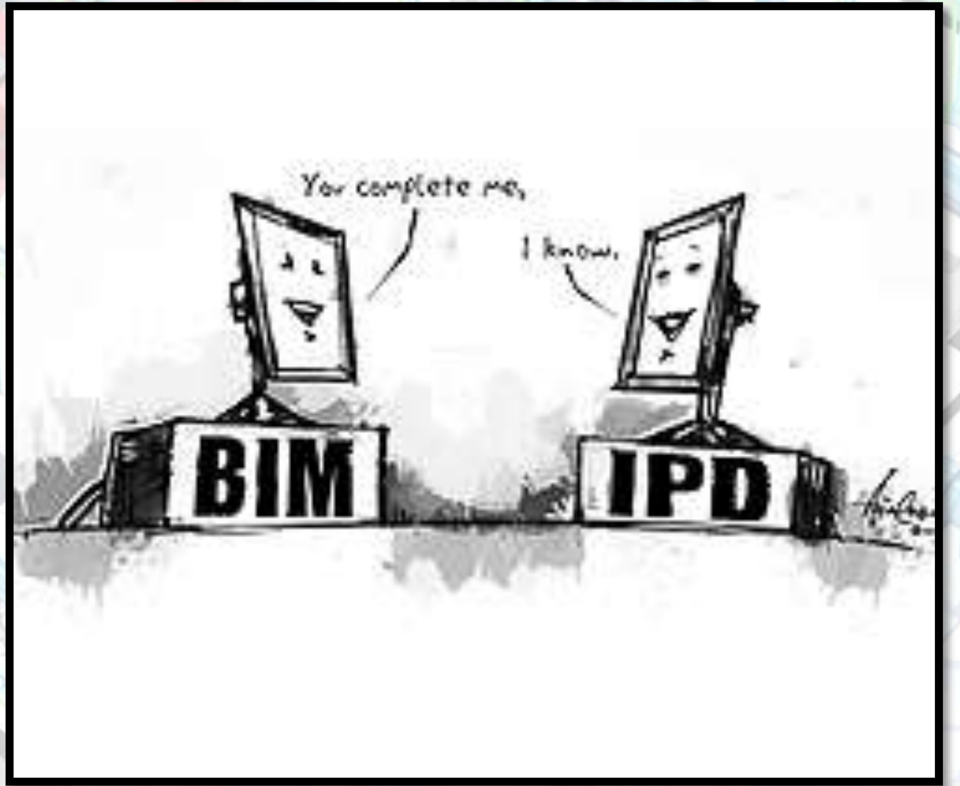


A Case for BIM – Traditional Construction Project



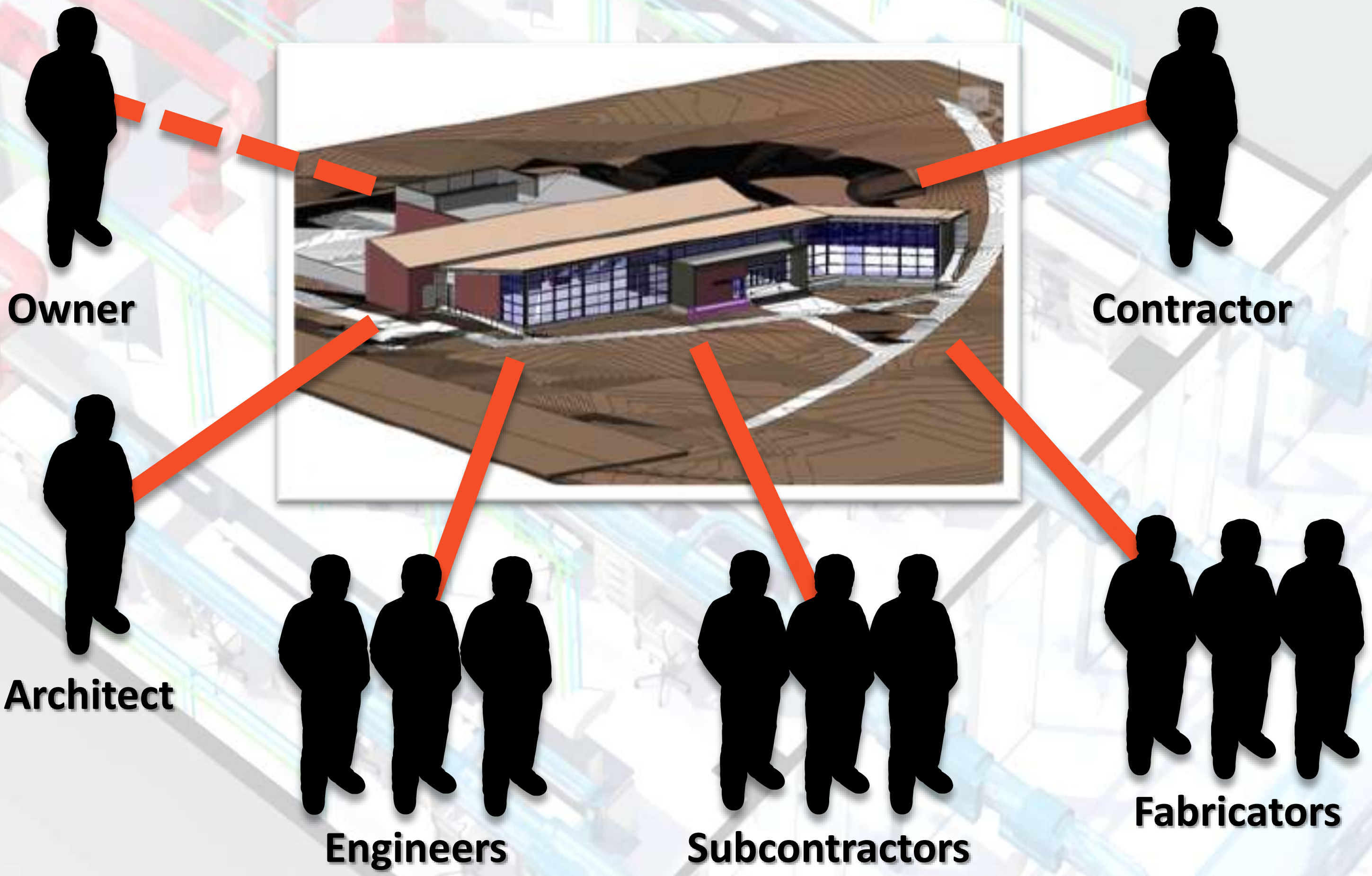
BIM is the fusion of Technology and the Collaborative Process.

BIM + IPD

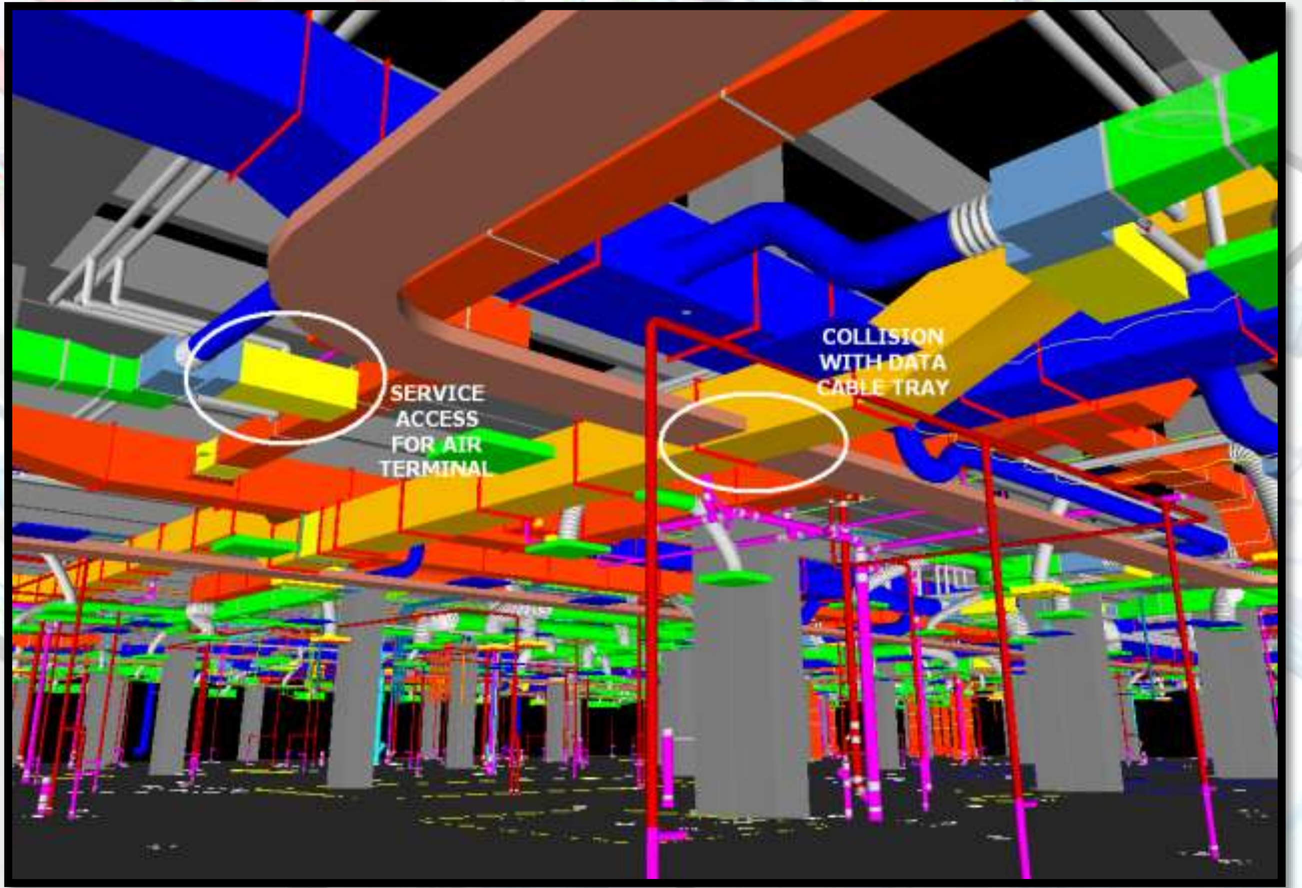


http://www.di.net/assets/cartoons/cartoon_bim_ipd.gif

A Case for BIM – Collaboration and Coordination

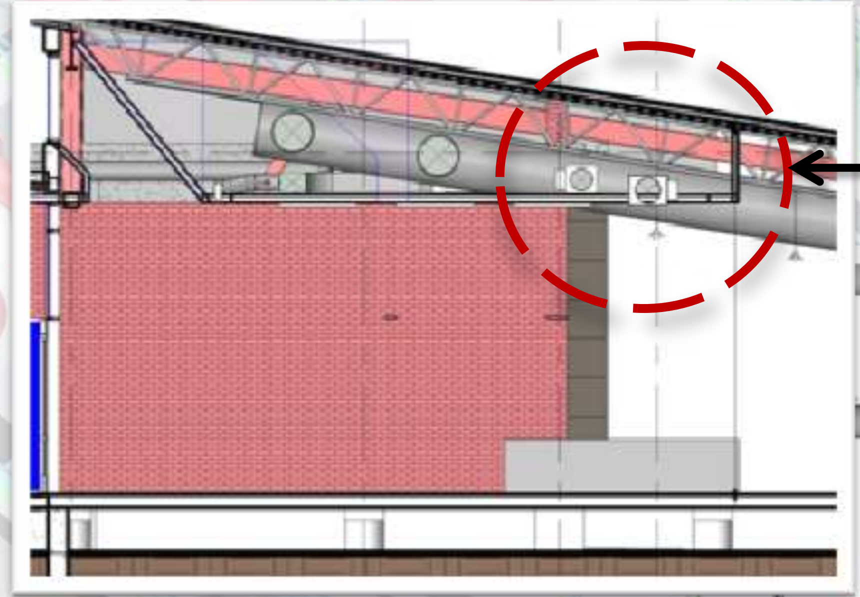


Clash Detection

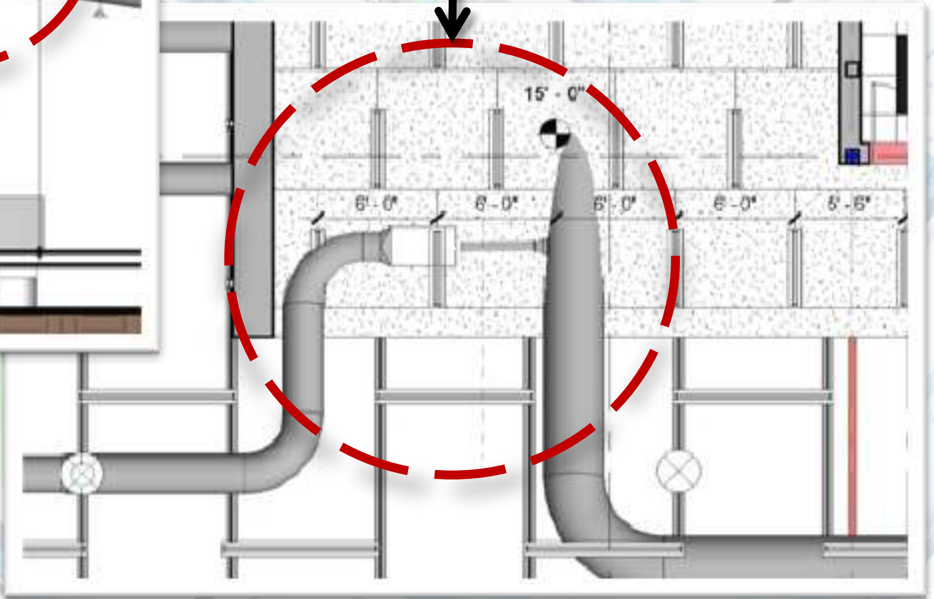


Building Information Modeling

Clash Detection

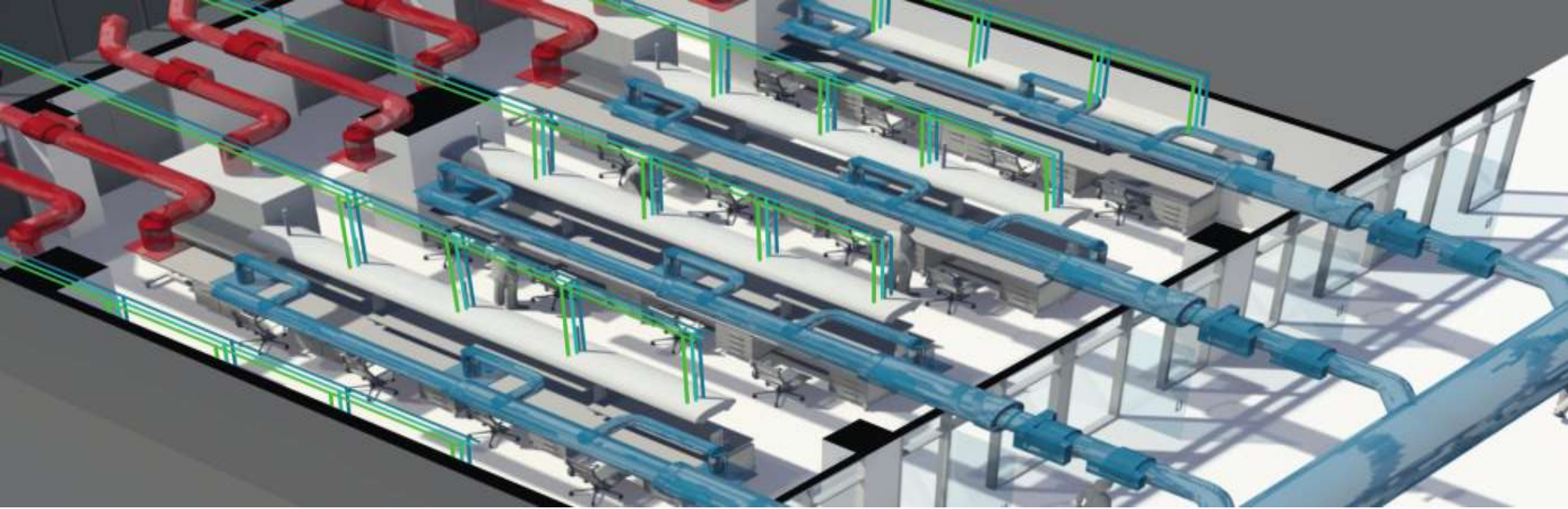


SECTION VIEW



REFLECTED CEILING VIEW

Building Information Modeling



PART III - BUILDING INFORMATION MODELING - SUSTAINABILITY

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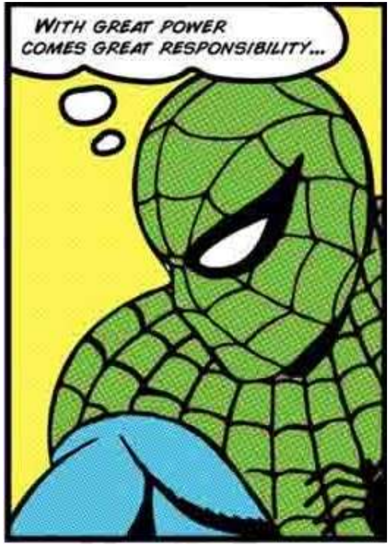
BIM Facilitates the Exploration of Sustainable Design Integration

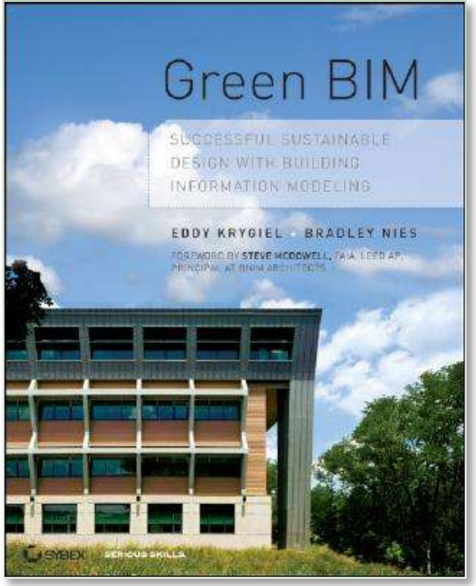
BIM in and of itself does not imply sustainable design strategies and goals, but does facilitate the achievement of 'green' objectives when leveraged properly.



Building Information Modeling

Sustainable Design Strategies

- Building Orientation
- Building Massing
- Optimize Daylighting
- Water Harvesting
- Energy Modeling and Analysis
- Renewable Energy Source Utilization
- Use of Sustainable Building Materials

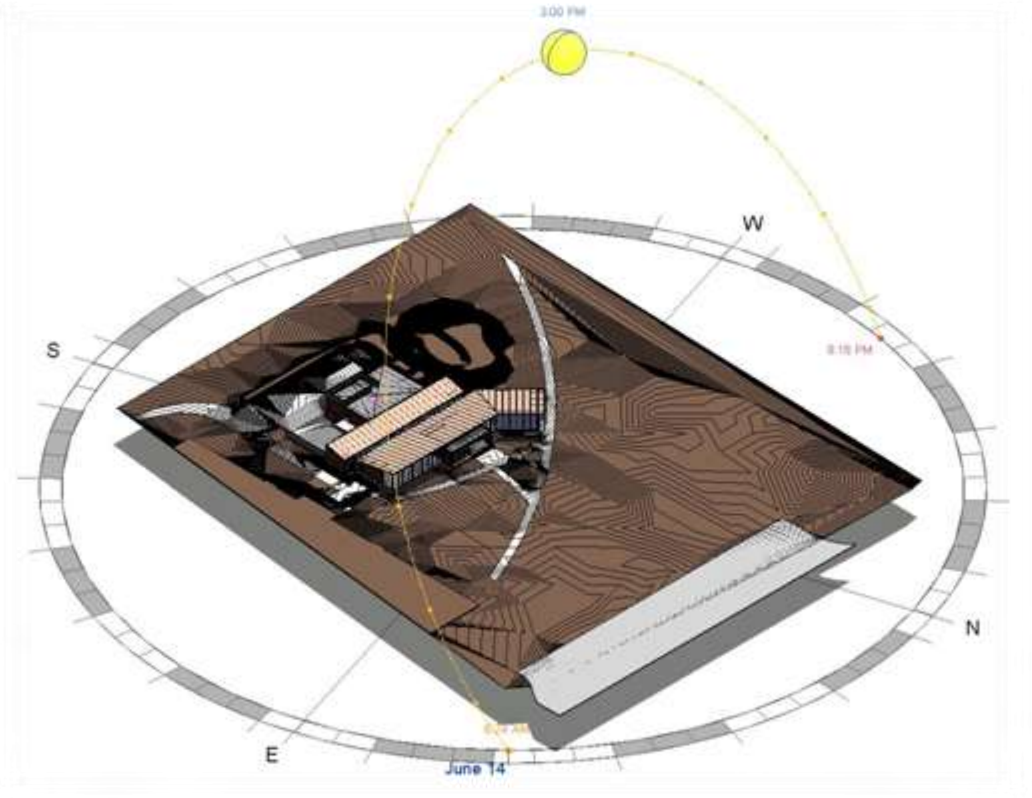


http://www.amazon.com/Green-BIM-Successful-Sustainable-Information/dp/0470239603#_

Sustainable Design Strategy #1 - Building Orientation

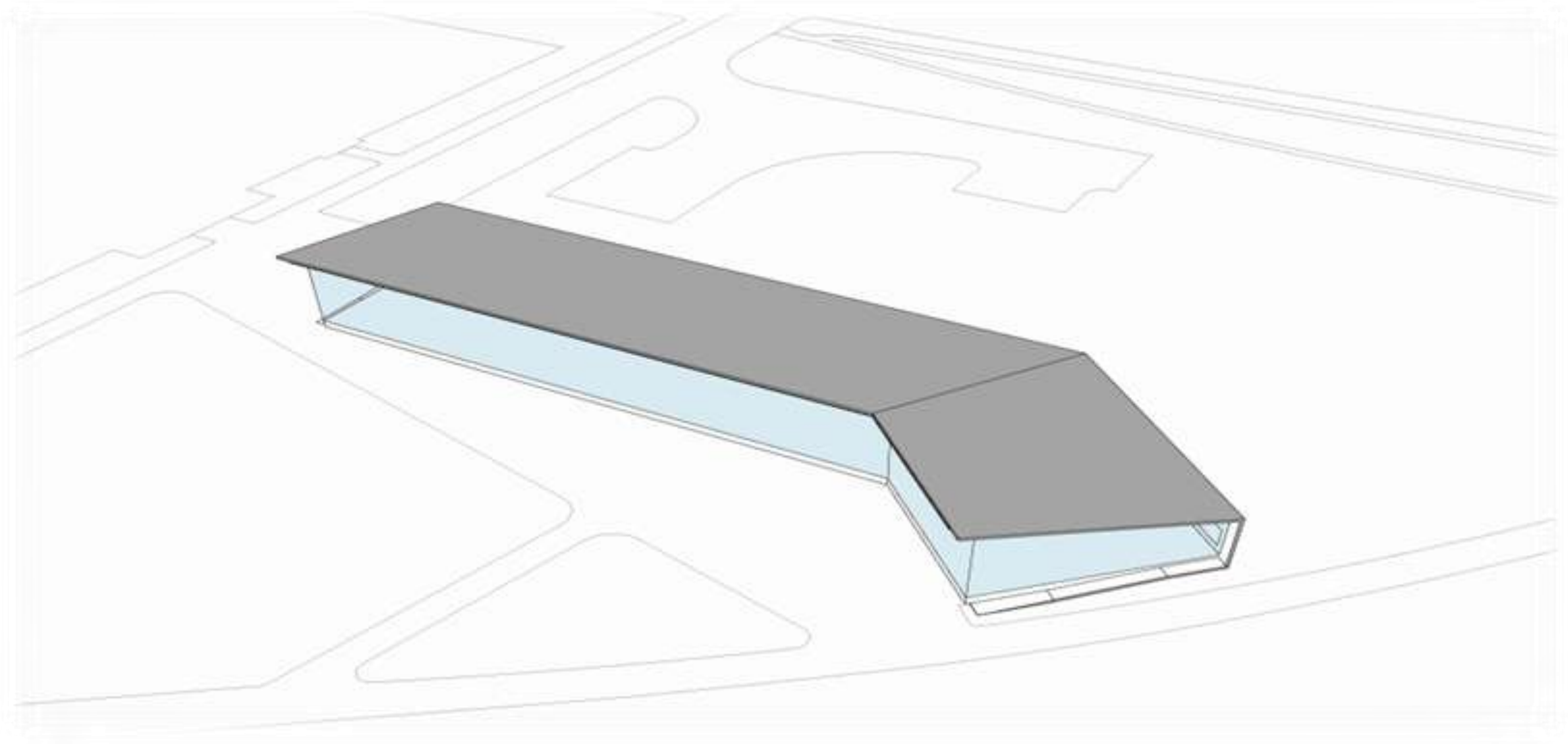
BIM Building Orientation Analysis Tool:

- ❖ Revit
- ❖ Ecotect Analysis
- ❖ Green Building Studio

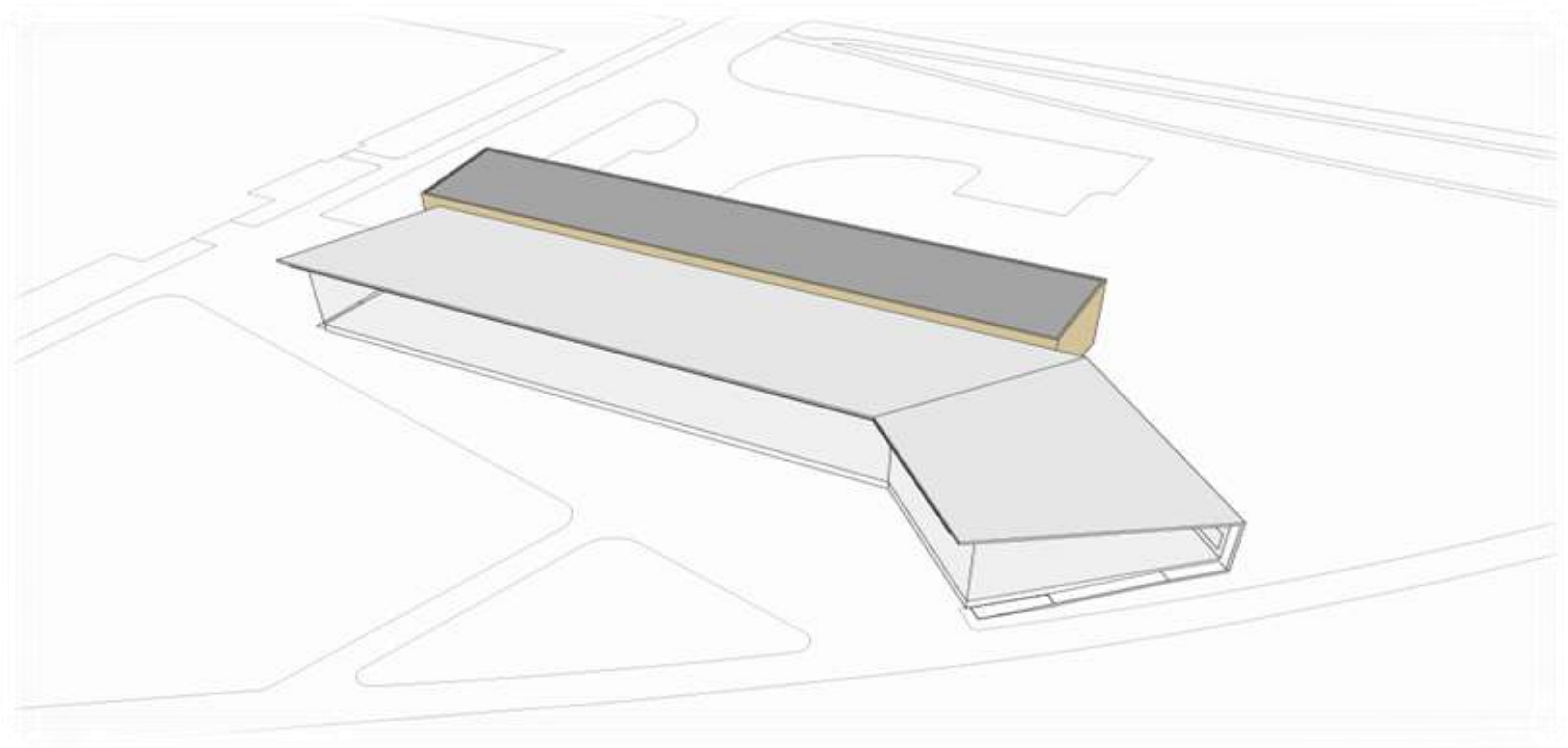


Optimization strategies work best if performed iteratively. BIM facilitates such iterative analysis.

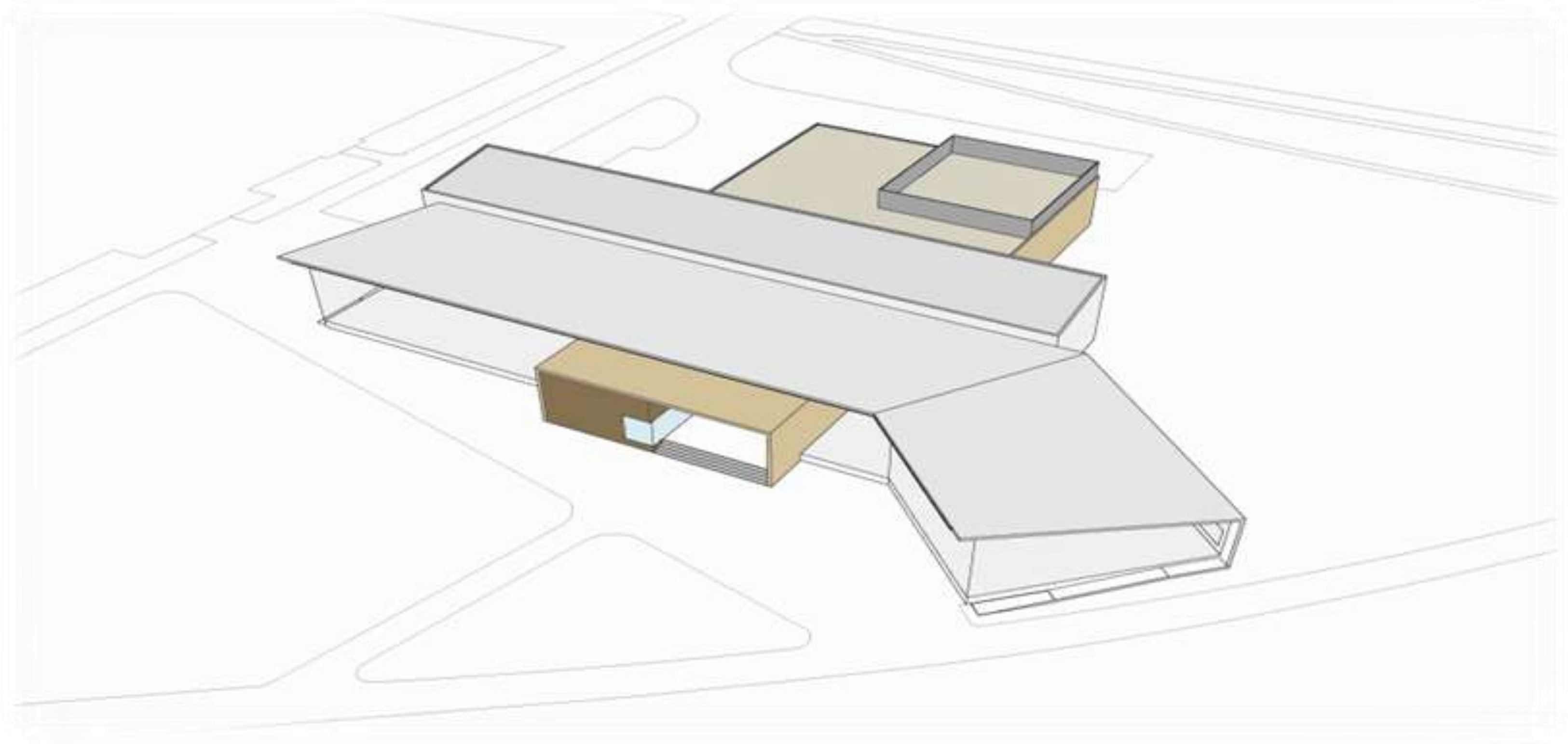
Sustainable Design Strategy #2 - Building Massing



Sustainable Design Strategy #2 - Building Massing



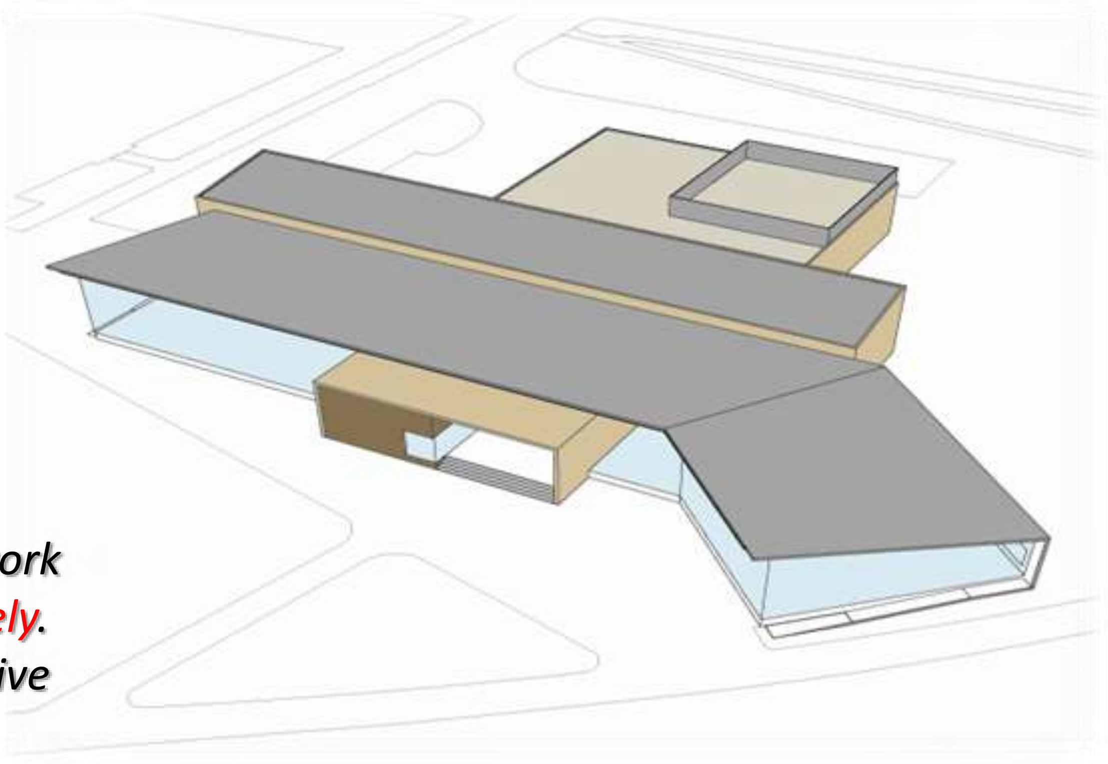
Sustainable Design Strategy #2 - Building Massing



Sustainable Design Strategy #2 - Building Massing

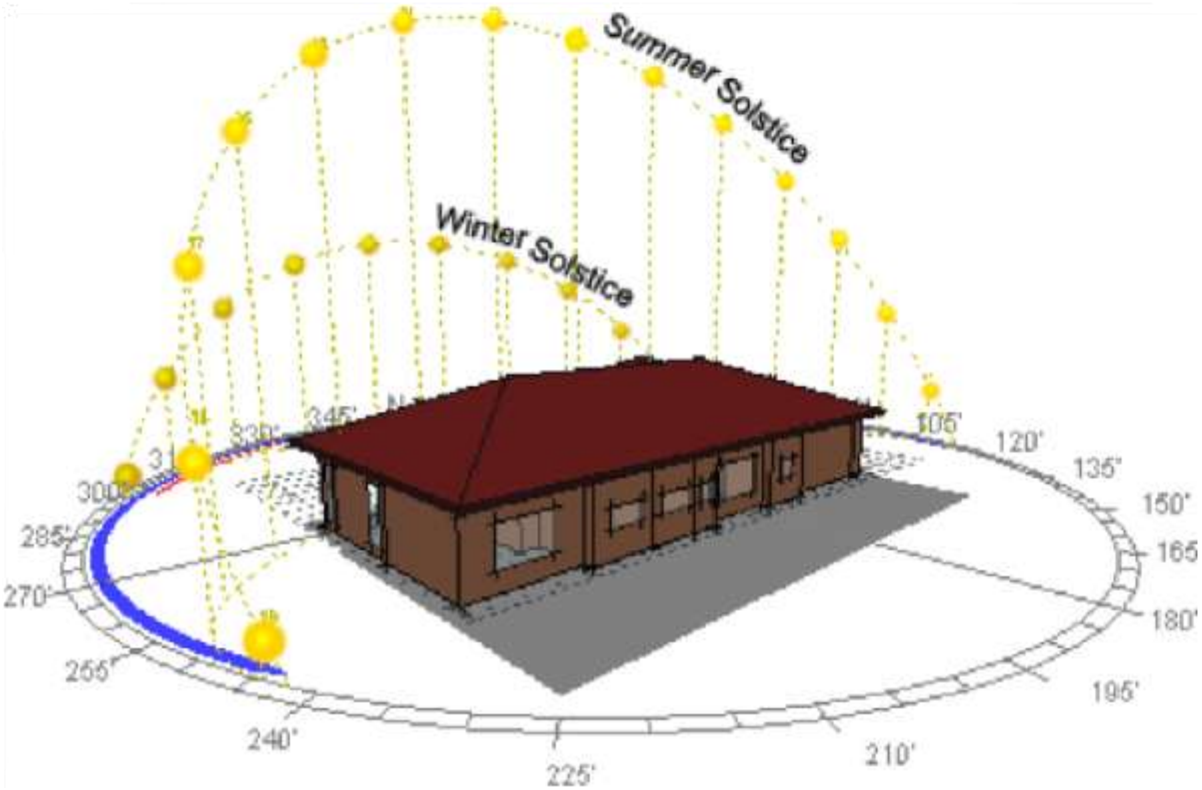
BIM Building Massing Analysis Tools:

- Revit
- Ecotect Analysis
- Green Building Studio

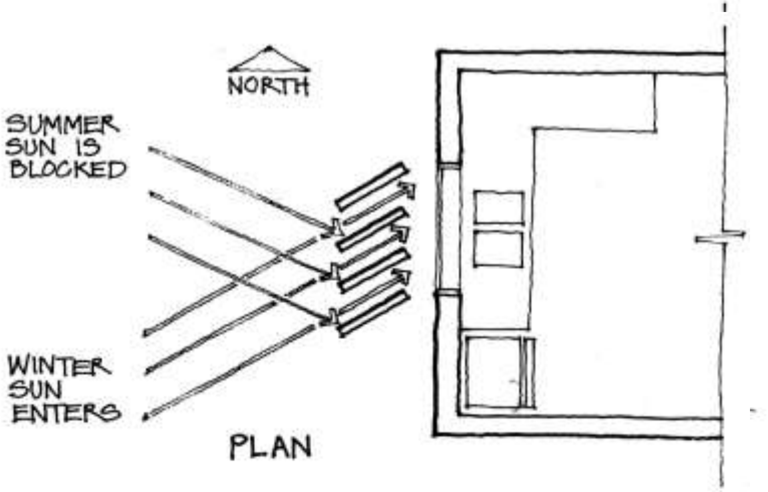


Optimization strategies work best if performed iteratively. BIM facilitates such iterative analysis.

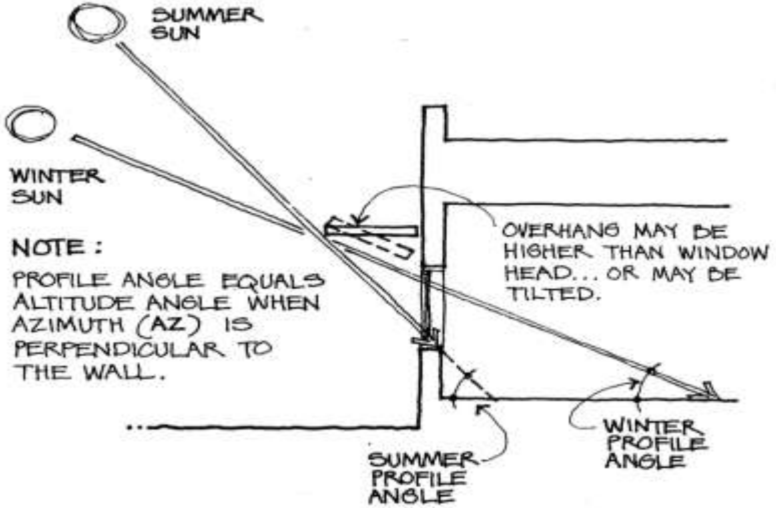
Sustainable Design Strategy #3 – Optimize Daylighting



Sustainable Design Strategy #3 – Optimize Daylighting

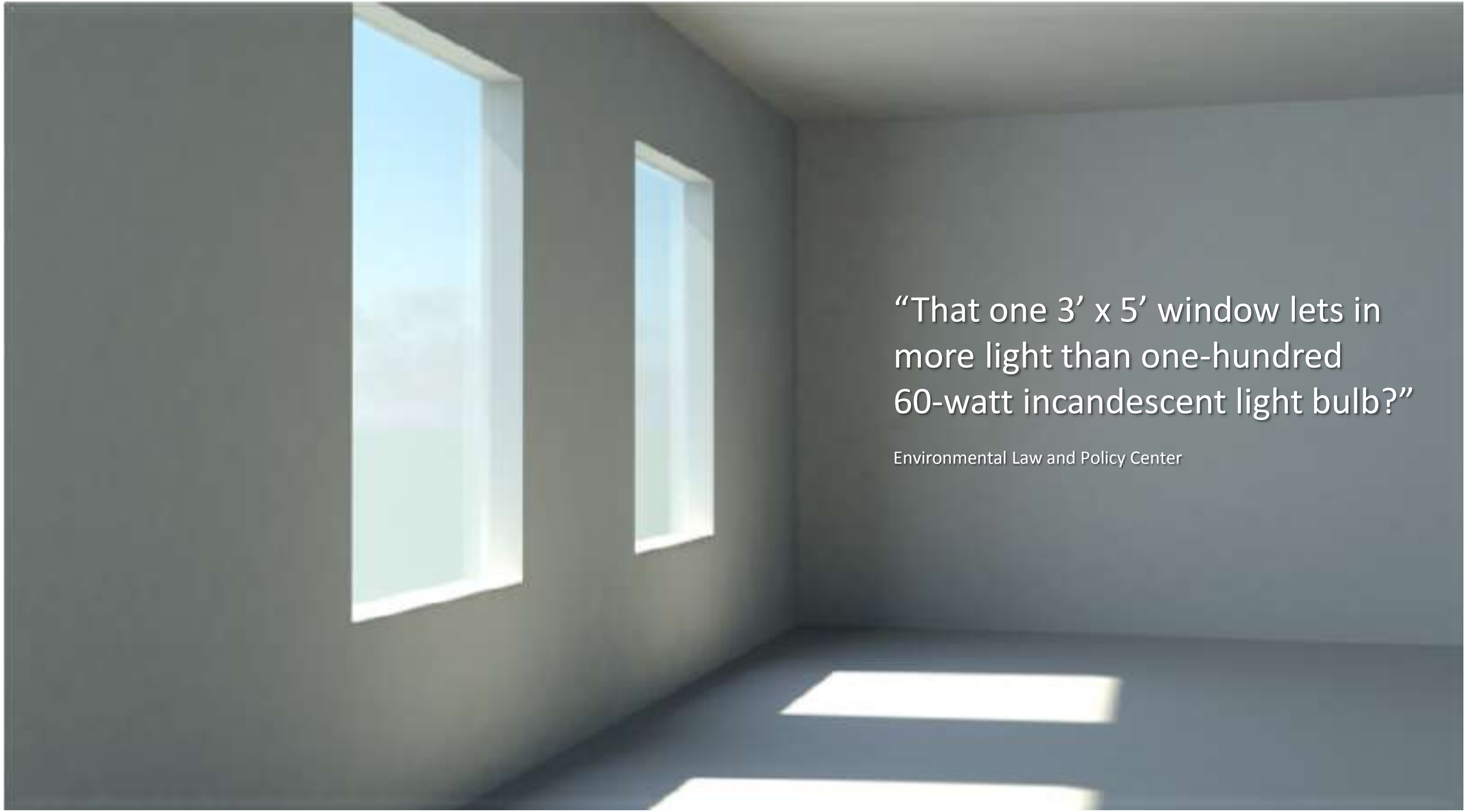


VERTICAL FINS ON WEST FACADE



OVERHANG AND PROFILE ANGLE

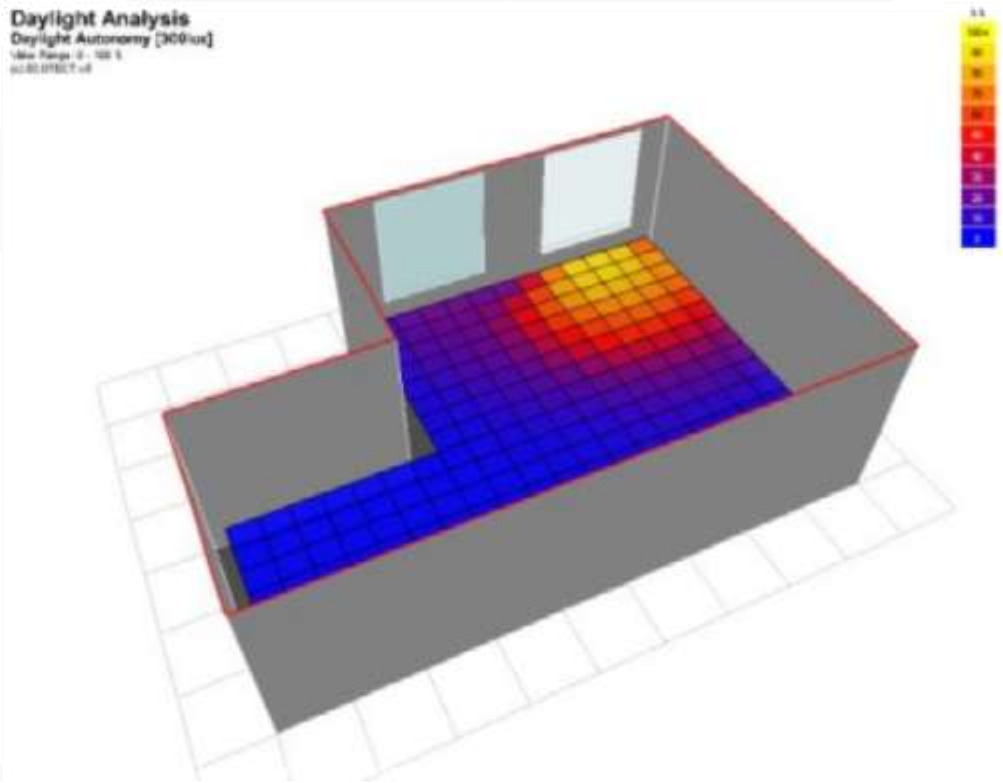
Sustainable Design Strategy #3 – Optimize Daylighting



Sustainable Design Strategy #3 – Optimize Daylighting

BIM Daylight Analysis Tool:

- IES <VE>
- DAYSIM
- **Su2ds**
- 3ds Max



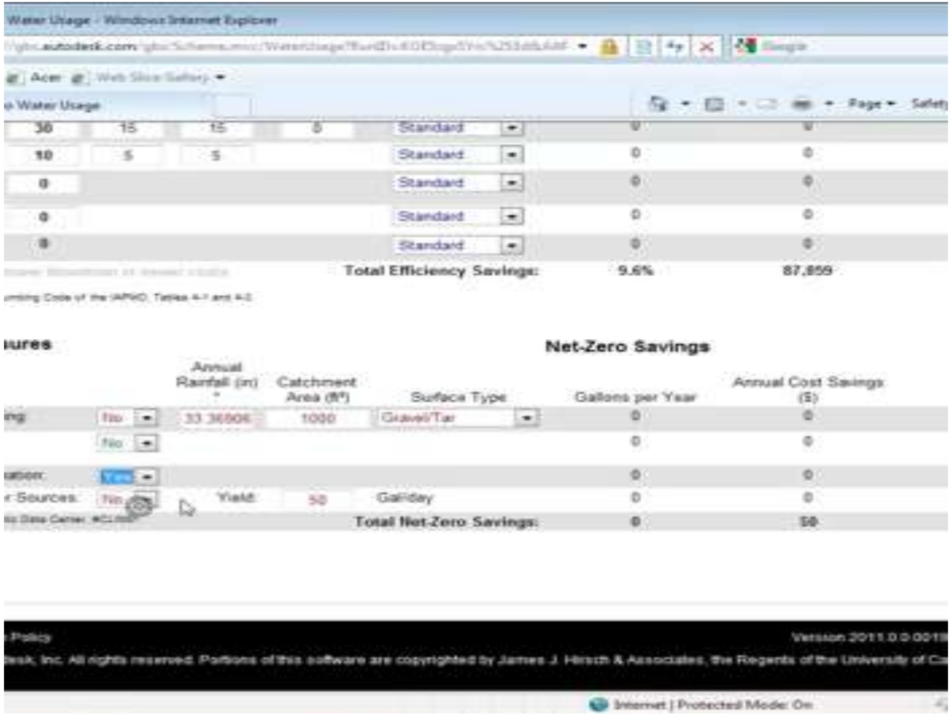
http://internal.gsd.harvard.edu/people/faculty/reinhart/images/software/daysimlarge.jpg

Optimization strategies work best if performed iteratively. BIM facilitates such iterative analysis.

Sustainable Design Strategy #4 – Water Harvesting

BIM Water Harvesting Analysis Tools:

- Green Building Studio
- Revit



http://bimcurriculum.autodesk.com/sites/default/files/styles/video_img/public/Unit3_Lesson3_Tutorial2_Badge.png

Optimization strategies work best if performed iteratively. BIM facilitates such iterative analysis.

Sustainable Design Strategy #5 – Energy Modeling and Analysis

BIM Energy Analysis Tools:

- ❖ Trane Trace
- ❖ Ecotect
- ❖ Green Building Studio
- ❖ eQuest
- ❖ EnergyPlus
- ❖ IES <VE>

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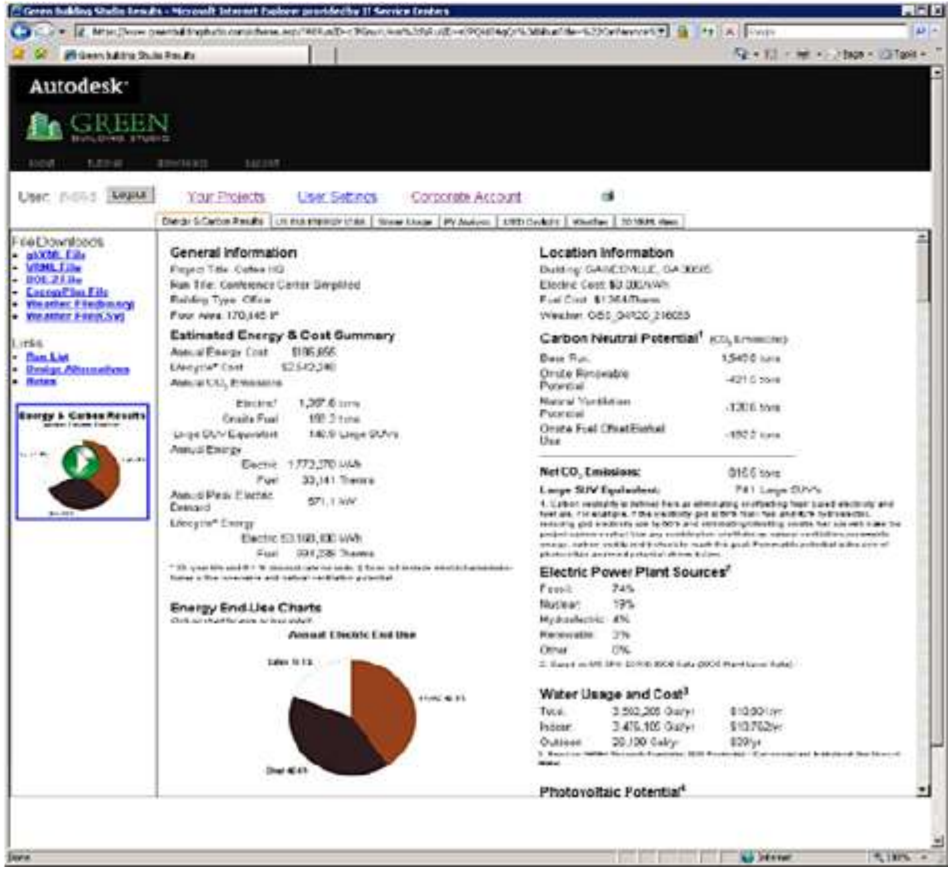
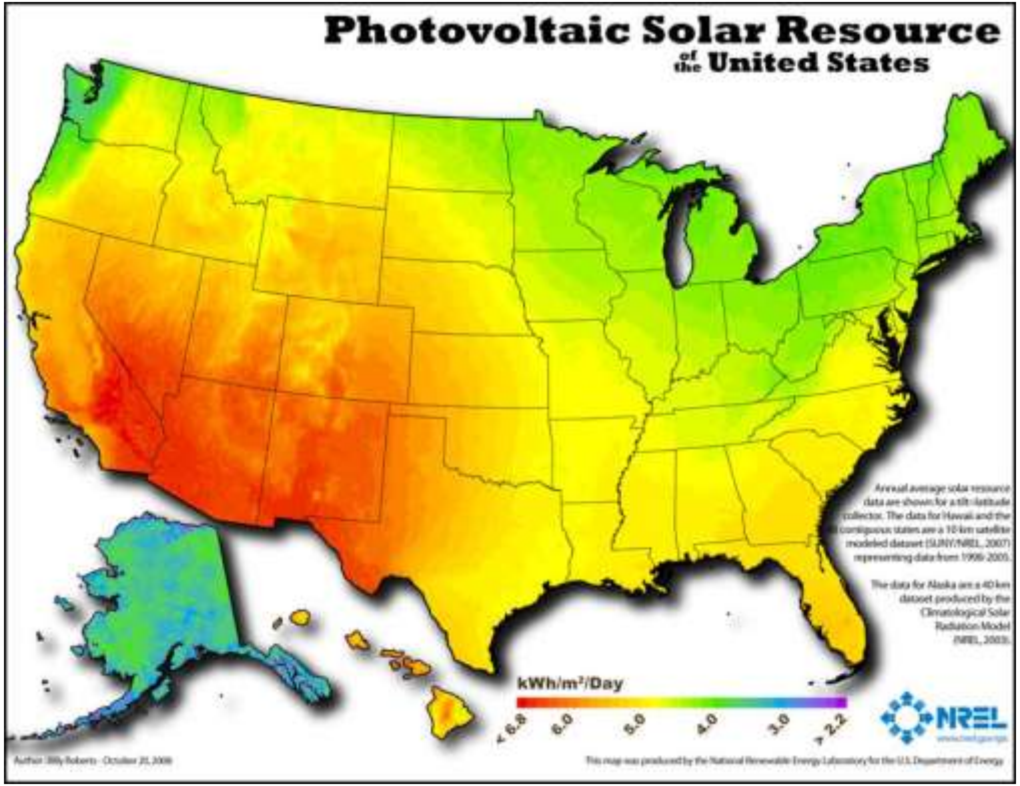


http://bldgsim.files.wordpress.com/2009/06/gbs.jpg

BIM Renewable Energy Analysis Tools:

- PVWATTS
- Green Building Studio



http://www.nrel.gov/gis/images/map_pv_national_lo-res.jpg

Optimization strategies work best if performed iteratively. BIM facilitates such iterative analysis.

Sustainable Design Strategy #7 – Use of Sustainable Building Materials

BIM Sustainable Building Materials Usage Analysis Tool:

- Revit

Wall Material Takeoff			
Family and Type	Material: Name	Material: Area	Material: Volume
Basic Wall: Foundation - 1' 5" Concrete	Concrete - Cast-in-Place Concrete	11353 SF	15673.94 CF
Basic Wall: Foundation - 3' 0" Footing	Concrete - Cast-in-Place Concrete	1177 SF	3118.74 CF
		12530 SF	18792.68 CF
Basic Wall: Exterior - Brick on CMU	Concrete - Precast Concrete	3754 SF	1084.31 CF
Basic Wall: Exterior - Brick on CMU - Entrance	Concrete - Precast Concrete	44 SF	13.14 CF
		3798 SF	1097.44 CF
Penthouse Screen Wall: Penthouse Screen Wall	Finishes - Exterior - Metal Panel	13166 SF	11520.28 CF
		13166 SF	11520.28 CF

http://docs.autodesk.com/REVIT/2011/ENU/images/AEC/Revit/2011/UsersGuide/PNG/materialtakeoffschedule_short.png

Optimization strategies work best if performed iteratively. BIM facilitates such iterative analysis.

Building Information Modeling

Design Options – Furniture Layouts

Design Options – Furniture Layouts

Building Information Modeling

Design Options – Materials Study

Design Options – Materials Study

Design Options – Materials Study

Case Study: University of Houston – West Dining Hall – Schematic Design

Building Information Modeling

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Building Information Modeling

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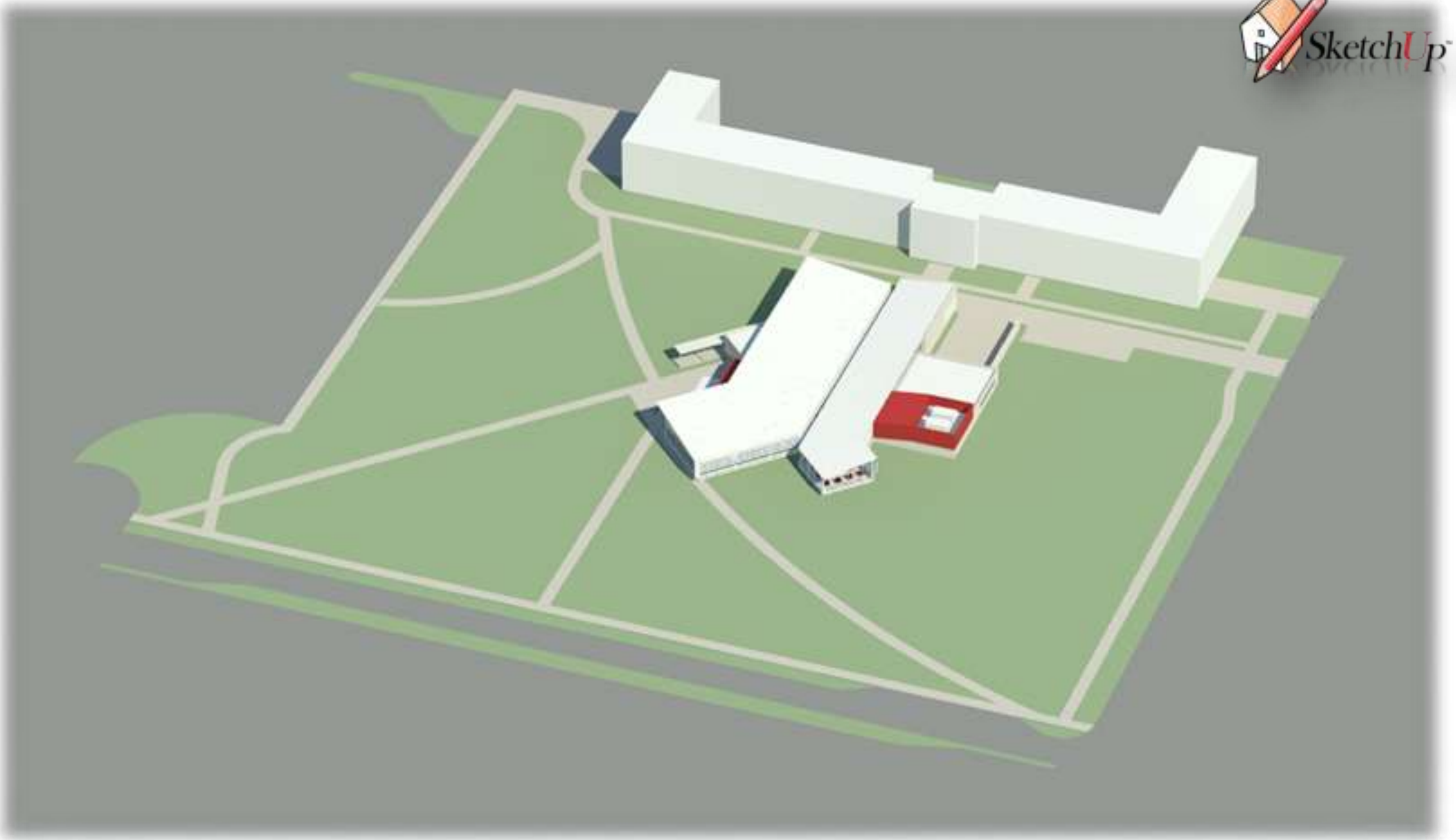

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Building Information Modeling

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Building Information Modeling

Case Study: University of Houston – West Dining Hall – Design Development

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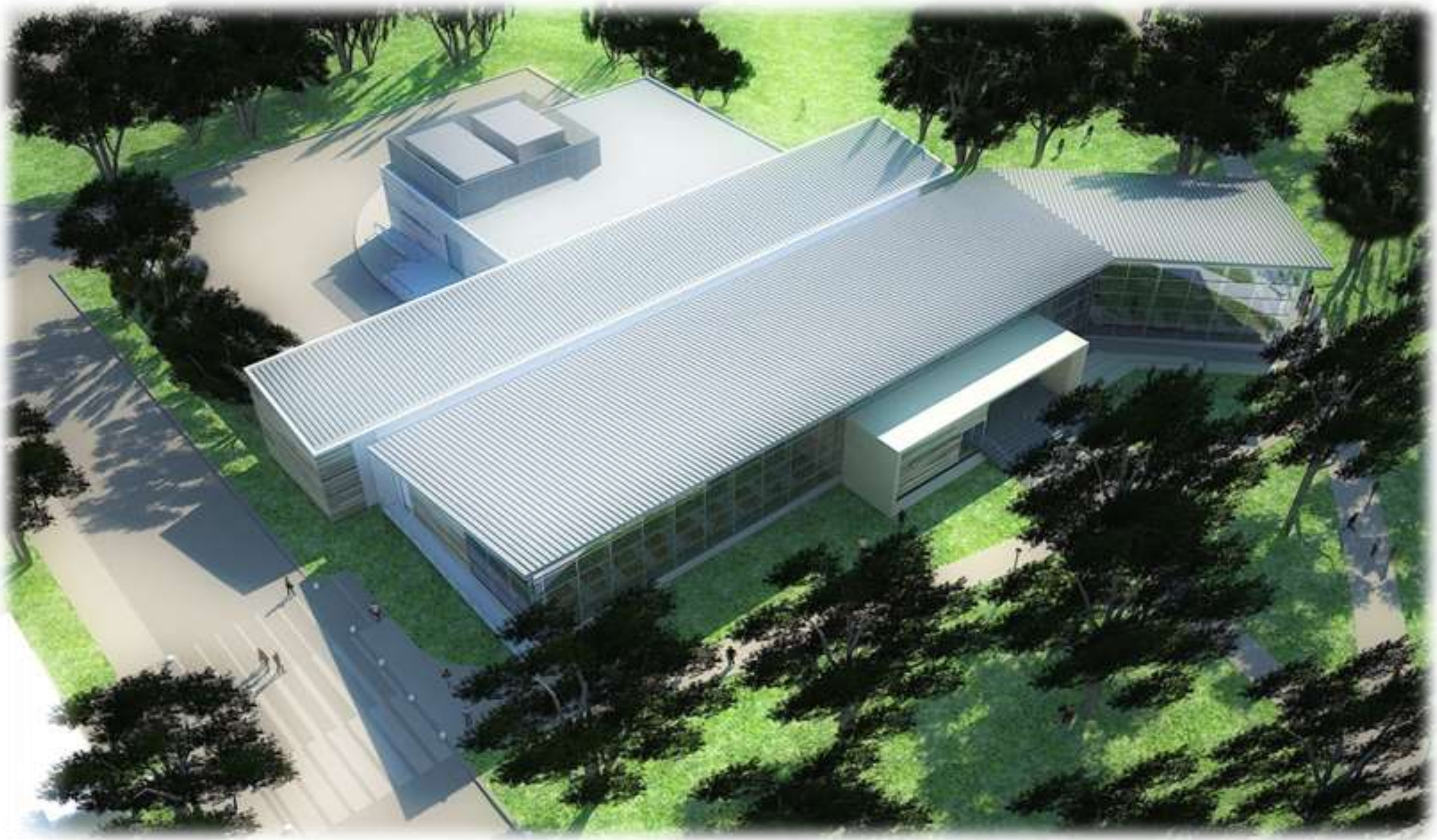

Case Study: University of Houston – West Dining Hall – Design Development

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Building Information Modeling

THANK YOU

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