Modeling Integration for Sustainable Design & Construction

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Sustainability
Manager

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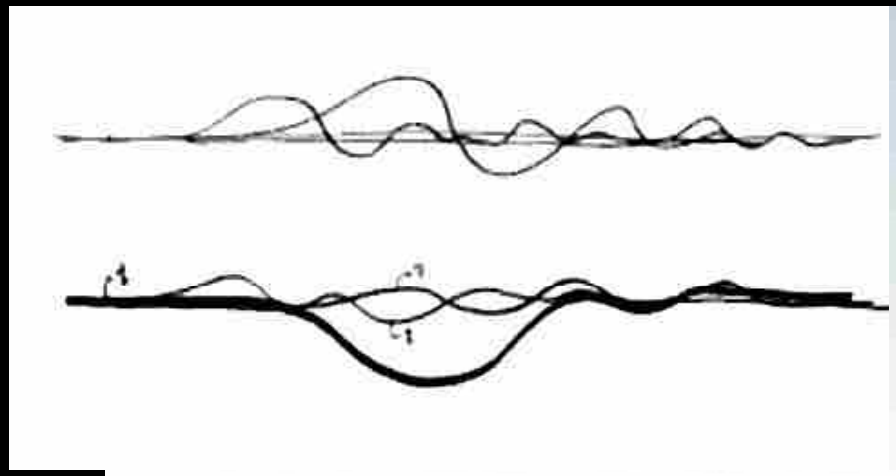
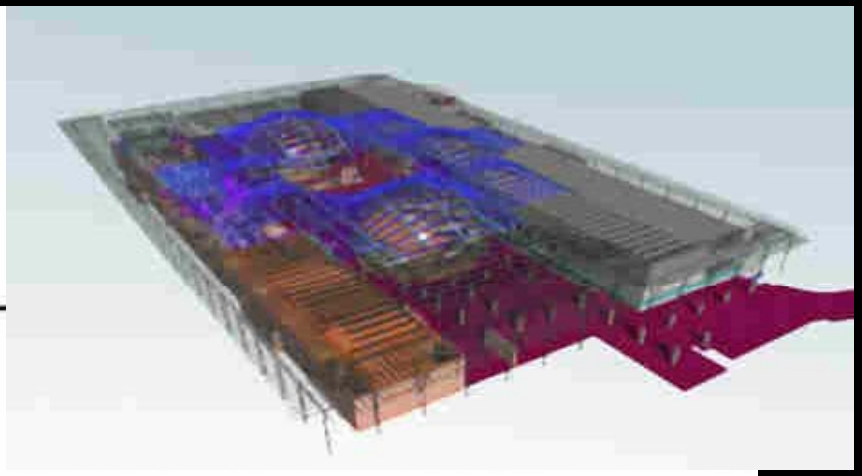
CONCEPT – DESIGN – SUSTAINABLE REALITY





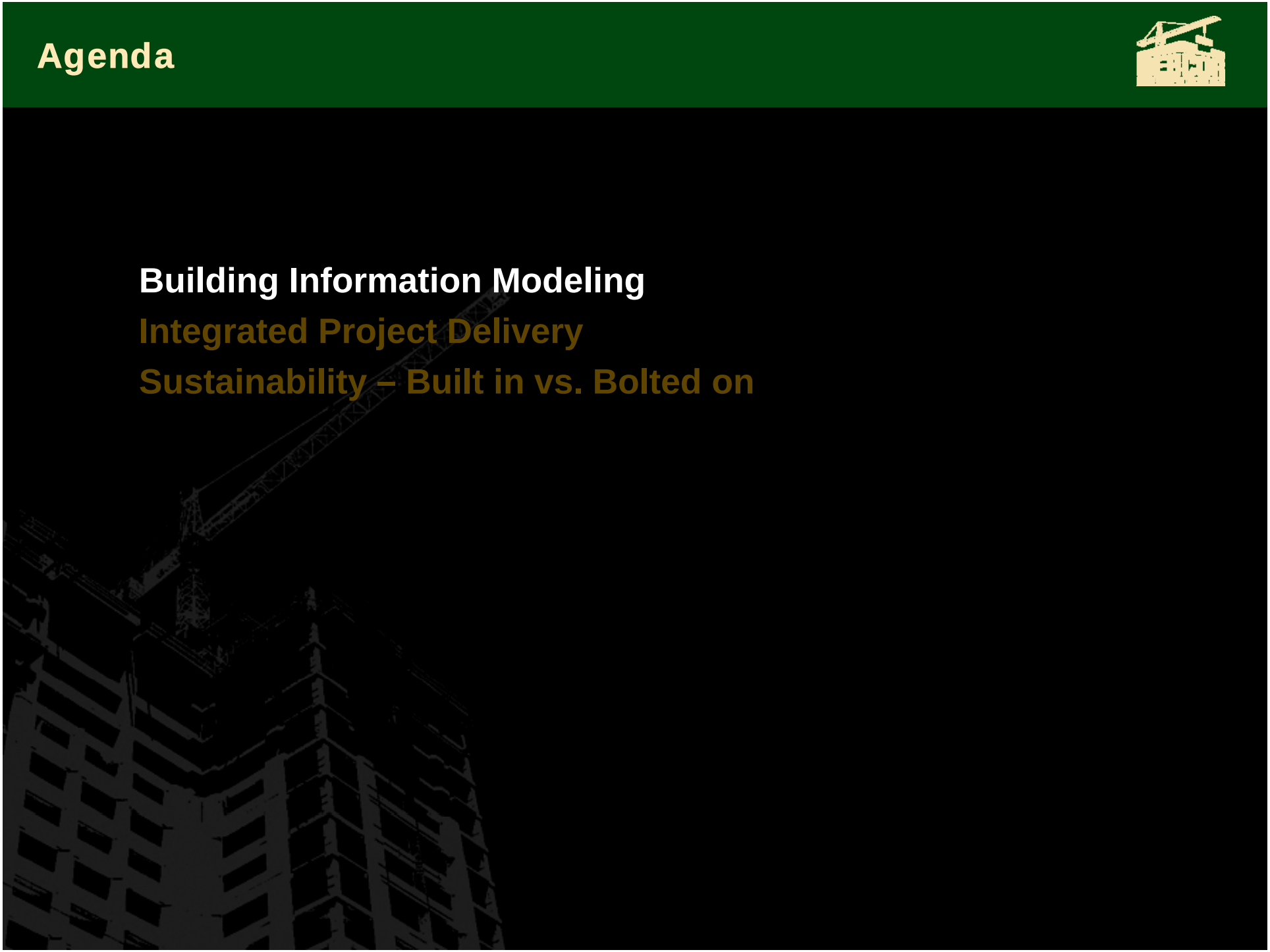
Agenda

Building Information Modeling

Integrated Project Delivery

Sustainability – Built in vs. Bolted on

Agenda

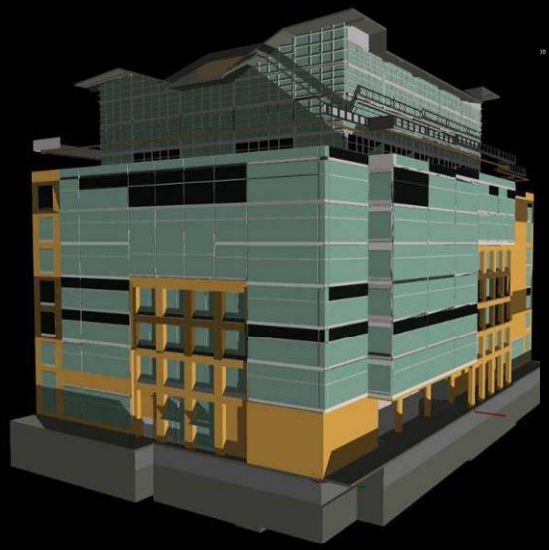


Building Information Modeling

Integrated Project Delivery

Sustainability – Built in vs. Bolted on

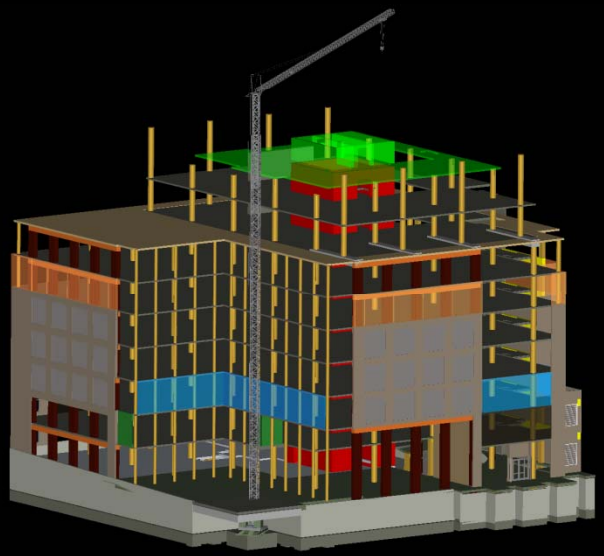
Multidimensional Building Information Modeling



Product Modeling

Static Geometry

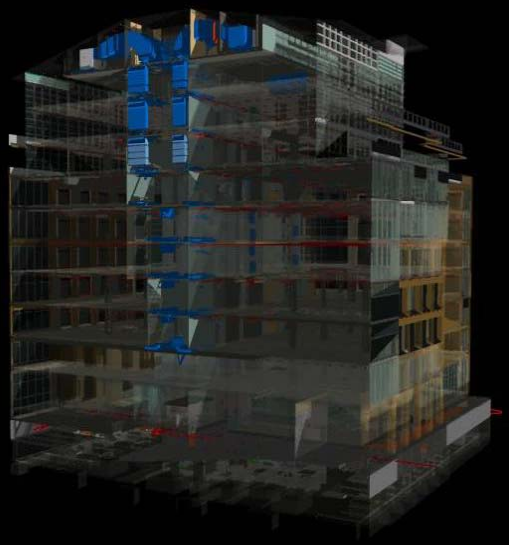
How the components and systems fit together



Process Modeling

Construction Sequence

How the building comes together

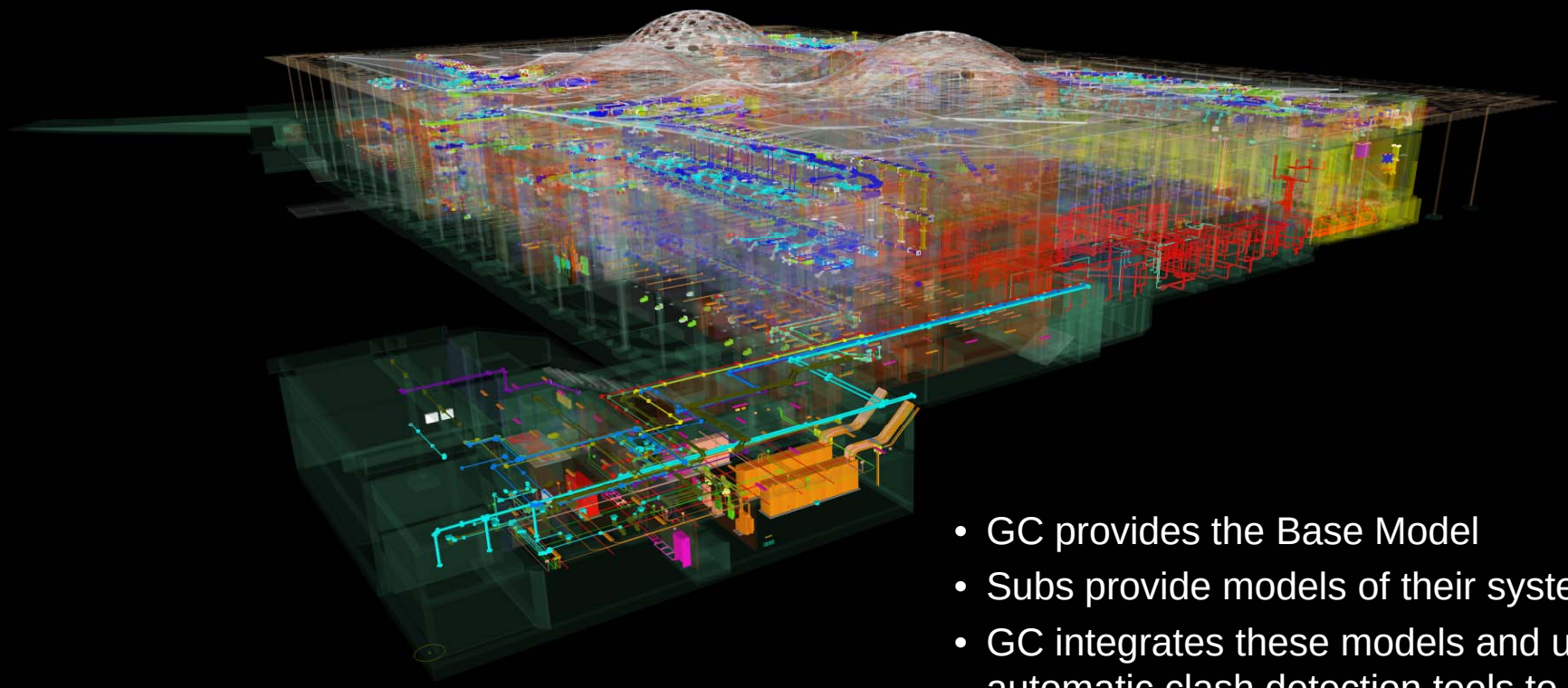


Analysis Modeling

Measurement and Simulation

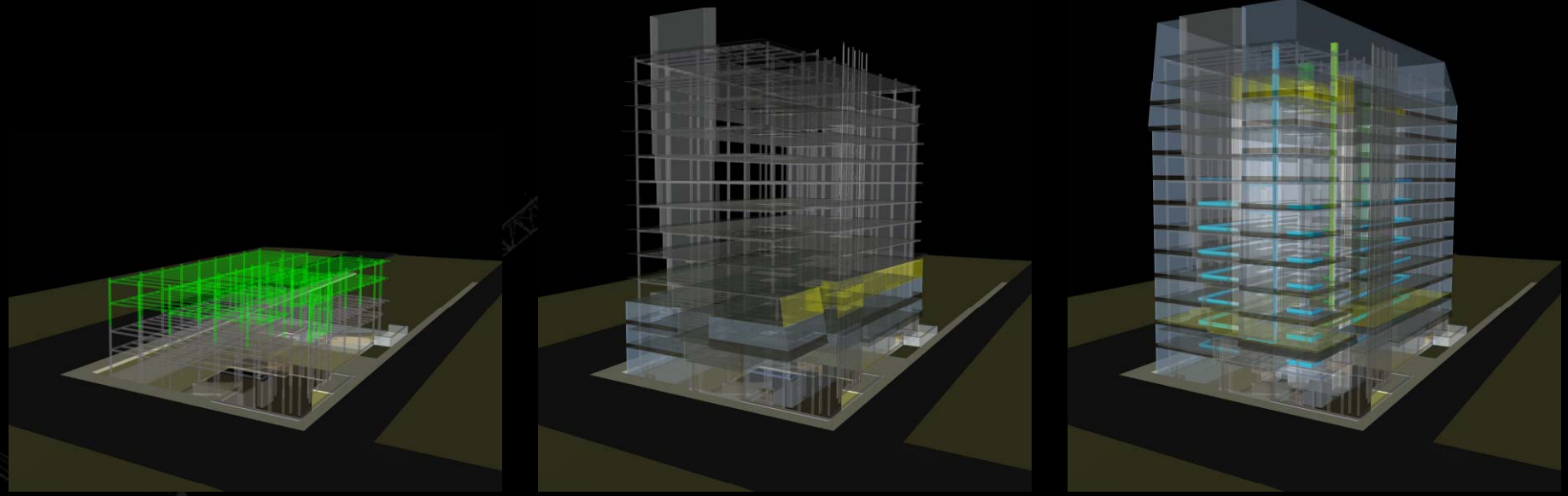
What the building costs and how it performs

Product Modeling



- GC provides the Base Model
- Subs provide models of their systems
- GC integrates these models and uses automatic clash detection tools to find the conflicts before fabrication is begun

Process Modeling



Location-based flow-line approach enables tighter scheduling and provides

- Better accuracy
- More reliable buy-in from Subcontractors
- Continuous workflow
- Effective tracking and control during construction
- Effective schedule conflict resolution

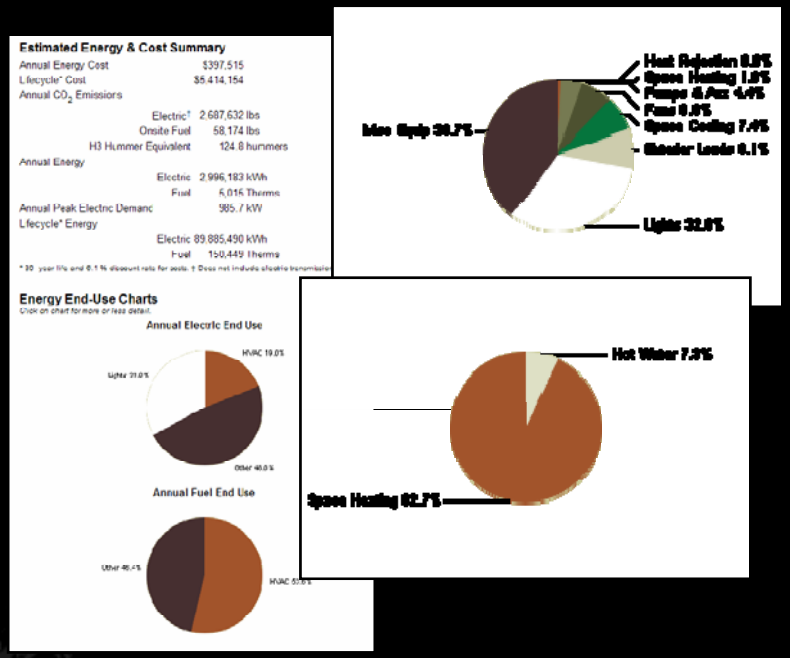
Analysis Modeling - Cost

21 RESIDENTIAL

Code	Specification	Quantity	Unit	Min.unitprice	Max.unitprice	Min.totalprice	Max.totalprice	Variance	Variance	Variance
01 01	GENERAL CONDITIONS	182,677	sf	13.35	13.35	2,438,738	2,438,738	0	27,402	27,402
02 02	BUILDING PAD, EARTHWORK, SITEWORK	182,677	sf	1.28	1.28	233,827	233,827	0	131,527	131,527
03 03	LANDSCAPE & IRRIGATION	182,677	sf	0.00	0.00	0	0	0	0	0
04 04	FOUNDATIONS	182,677	sf	4.02	4.02	734,362	734,362	0	144,315	144,315
05 05	BUILDING STRUCTURE	182,677	sf	50.63	50.63	9,248,937	9,248,937	0	69,417	502,362
06 06	EXTERIOR ENVELOPE (VERTICAL)	182,677	sf	39.17	39.17	7,155,458	7,155,458	0	168,063	350,740
07 07	WATERPROOFING, INSULATION, ROOFING	182,677	sf	5.32	5.32	971,842	971,842	0	27,402	45,669
08 08	INTERIOR CONSTRUCTION	182,677	sf	50.13	50.13	9,157,598	9,157,598	0	365,354	730,708
09 09	SPECIALTIES	182,677	sf	1.62	1.62	295,937	295,937	0	54,803	54,803
10 10	BUILDING EQUIPMENT	182,677	sf	5.95	5.95	1,086,920	1,086,920	0	54,803	54,803
11 11	FURNISHINGS	182,677	sf	0.00	0.00	0	0	0	0	0
12 12	SPECIAL CONSTRUCTION	182,677	sf	0.00	0.00	0	0	0	0	0
13 13	CONVEYING SYSTEMS	182,677	sf	4.43	4.43	809,259	809,259	0	74,898	74,898
14 14	FIRE PROTECTION	182,677	sf	2.96	2.96	540,724	540,724	0	36,535	36,535
15 15	PLUMBING	182,677	sf	20.05	20.05	3,662,674	3,662,674	0	23,748	376,315
16 16	HVAC	182,677	sf	19.55	19.55	3,571,335	3,571,335	0	124,220	188,157
17 17	ELECTRICAL	182,677	sf	24.84	24.84	4,537,697	4,537,697	0	126,047	752,629
18 18	MISCELLANEOUS EXPENSES	182,677	sf	3.25	3.25	593,700	593,700	0	91,339	91,339
19 19	CONTINGENCY	182,677	sf	4.78	4.78	873,196	873,196	0	91,339	91,339
20 20	JOB EQUIPMENT	182,677	sf	7.53	7.53	1,375,558	1,375,558	0	182,677	182,677
	TOTAL	182,677	sf	258.86	258.86	47,287,768	47,287,768	0	1,793,888	3,476,343

- Building the model takes no more time than 2D-based quantity take-off processes, yields more accurate and reliable quantities.
- Current tools accommodate a range of cost for each element, so the cost is accurately bounded. Precision increases as design progresses.
- Design team can see exactly where the cost can be affected by design changes.

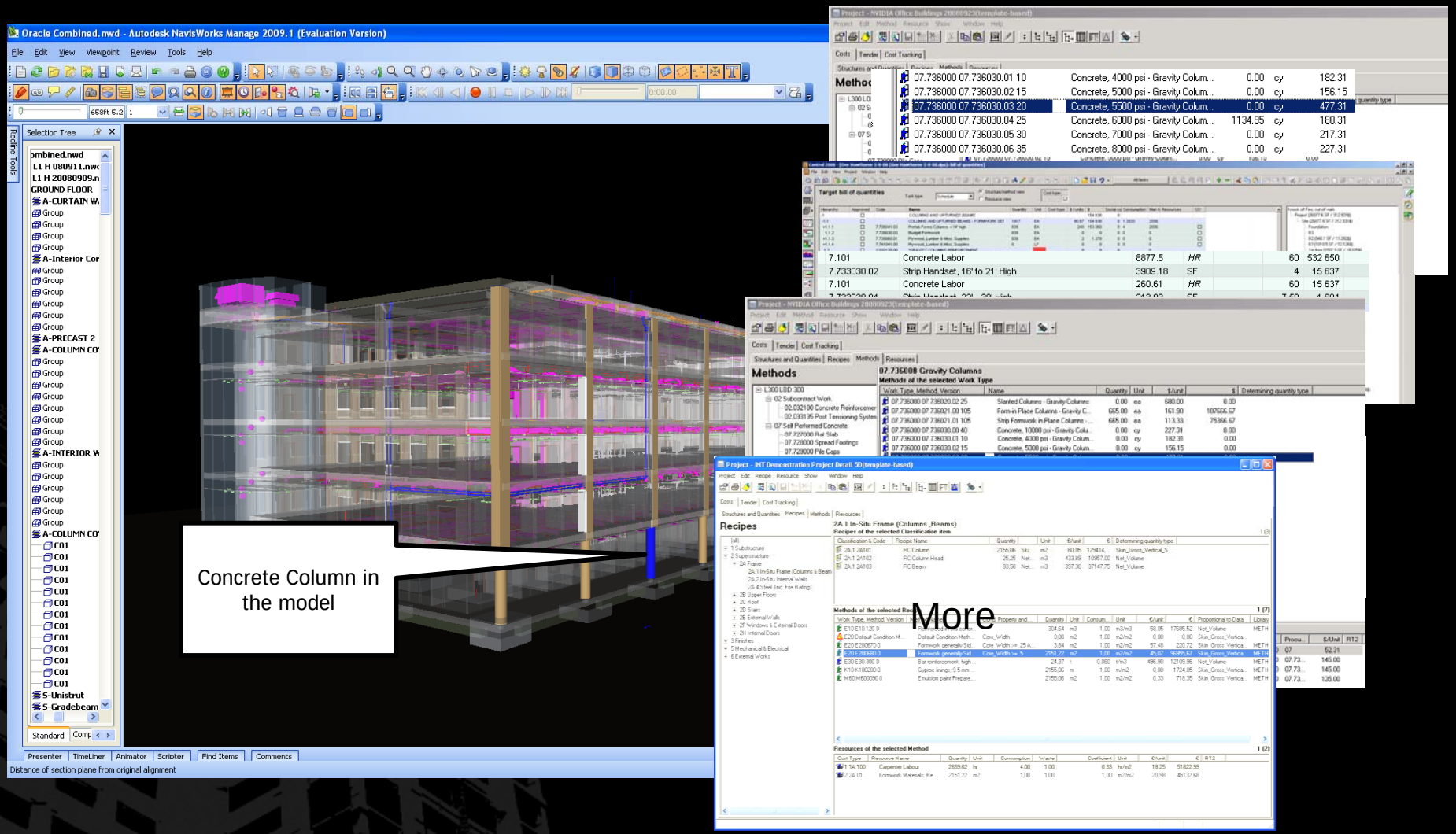
Analysis Modeling - Sustainability



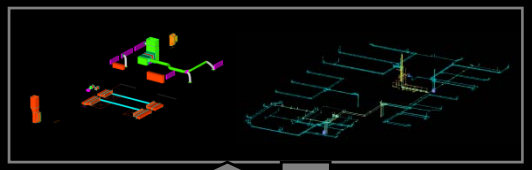
- Life Cycle Assessment
- Determining cost-effective sustainability strategy
- Detailed planning of specific sustainability approaches (LEED, Carbon Footprint, etc)
- Tracking and documentation of selected approaches

The Basic tool - Vico Constructor

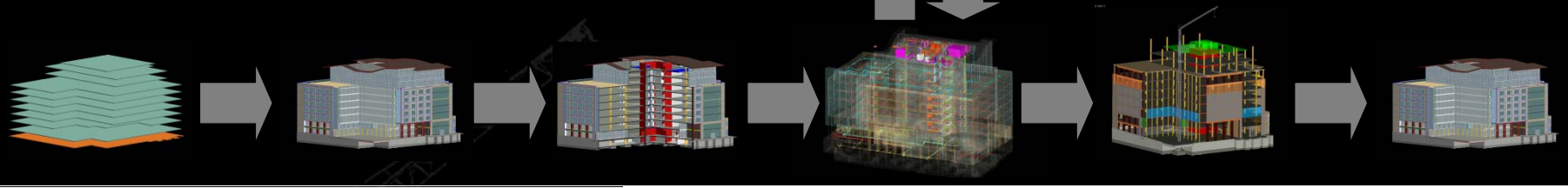
Multidimensional Database - Unlimited data capacity



Multidimensional Processes



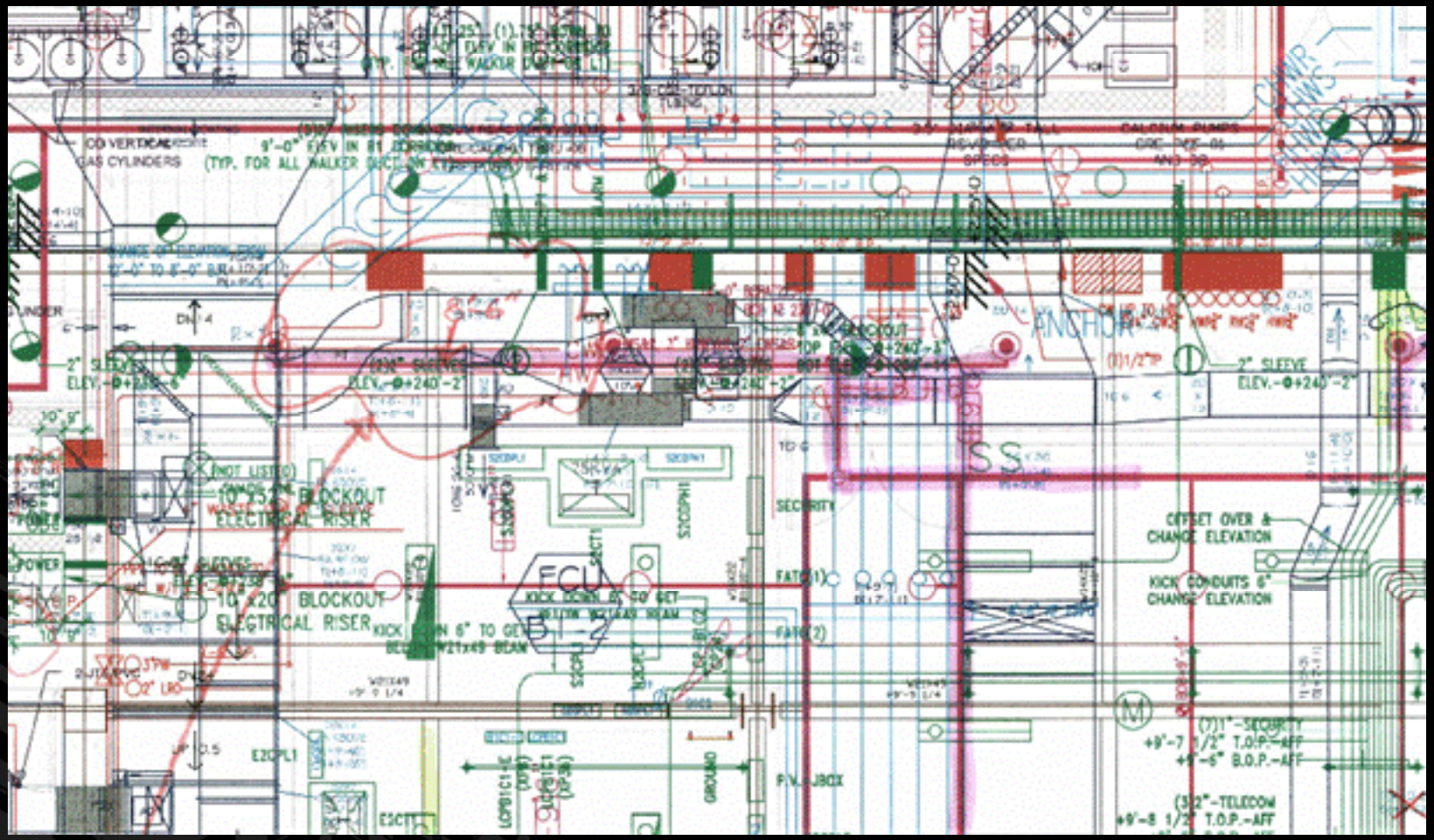
MEPS subcontractors create models of their systems.



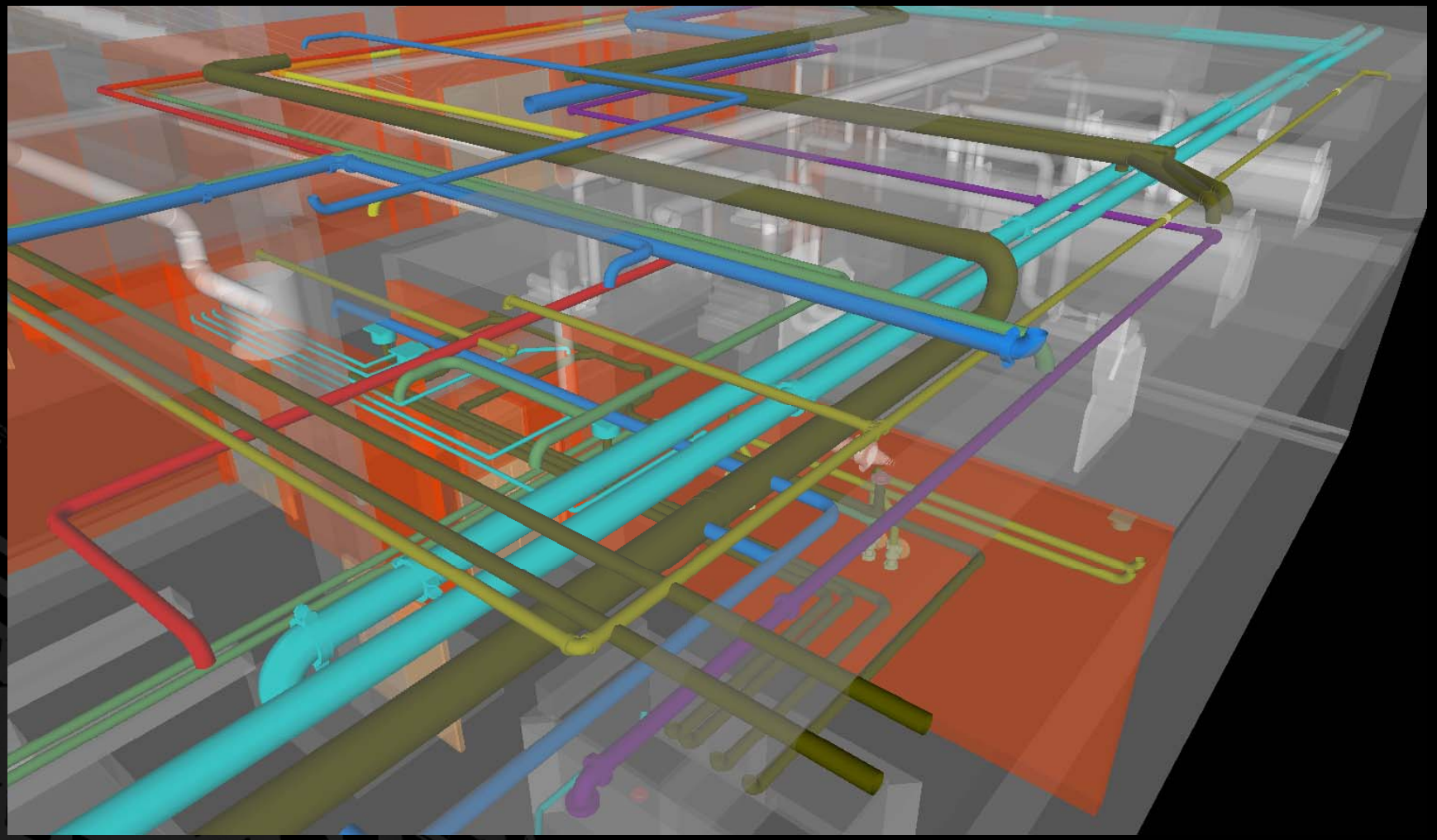
	Conceptual	Schematic	Design Development	Construction Documents	Field Management	Facilities Operation
Product	• Early massing studies	• Visualization and coordination begins	• Architectural/ Structural coordination issues resolved	• MEPS coordination finalized with much greater reliability - rework is eliminated	• Model resolves field questions	• As-built model can be delivered to owner for facility management and operations
Process	• Overall Schedule, project phasing	• 4D enables tighter construction schedule	• 4D enables early collaborative crew planning	• Collaborative 4D flow-line scheduling provides for trade commitment	• 4D flow-line provides more efficient trade coordination	
Analysis	• Conceptual Estimating	• Target Value Design allows resources to be focused on Owner's priorities	• Estimate precision increases	• Support for project buyout	• Changes are evaluated against baseline model	
	• Early sustainability options	• Early system selection, identification of LEED strategies	• Detailed cost/benefit analysis of sustainability strategies	• Planning for implementation of sustainability strategies	• LEED credit documentation	

Preconstruction → **Construction** → **Operation**

Product Modeling – System Coordination



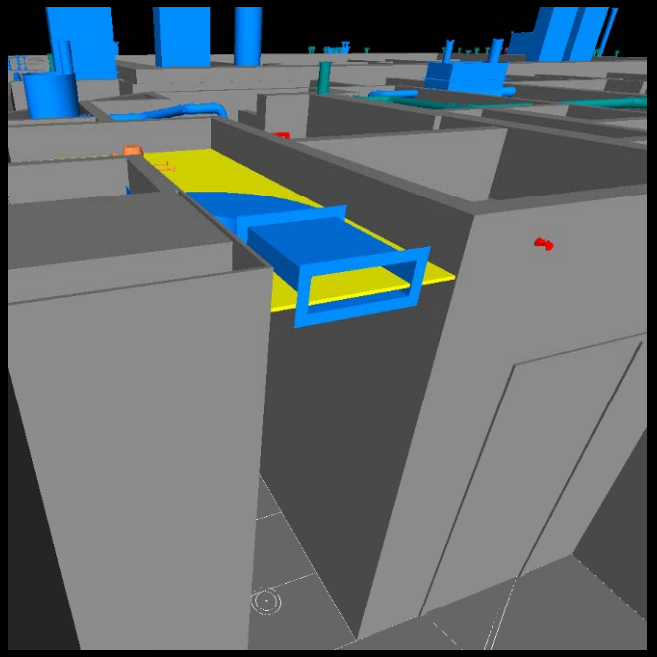
Product Modeling – System Coordination



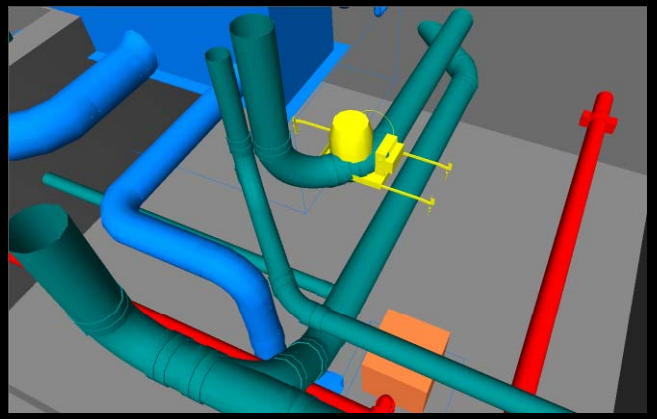
3D Product Modeling – System Coordination

After completion of 2D coordination we found an average of 11 conflicts per floor.

Conservative estimate: $660,000 in rework, $600,000 in delay, or over $1.2 million total.



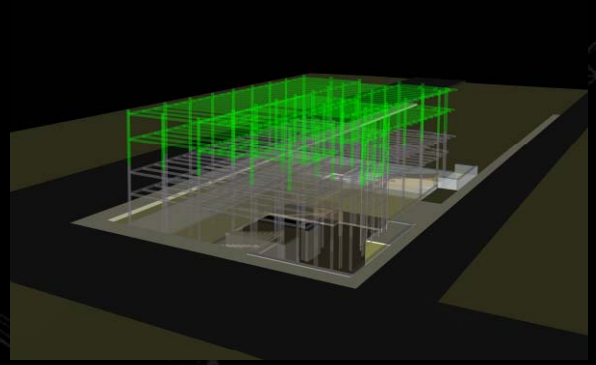
Would have required lowering of ceiling in breach of pre-sale agreements

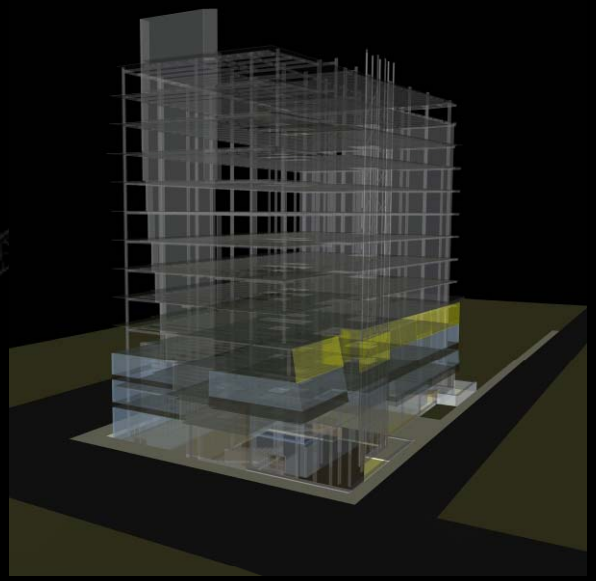


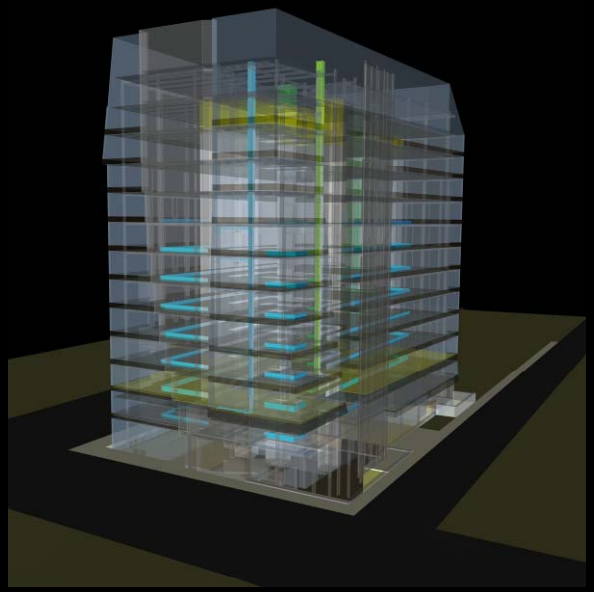
Would have required moving of light fixture with adverse effect on architecture.

- Mechanical
- Electrical
- Plumbing
- Sprinklers
- Clash

Process Modeling

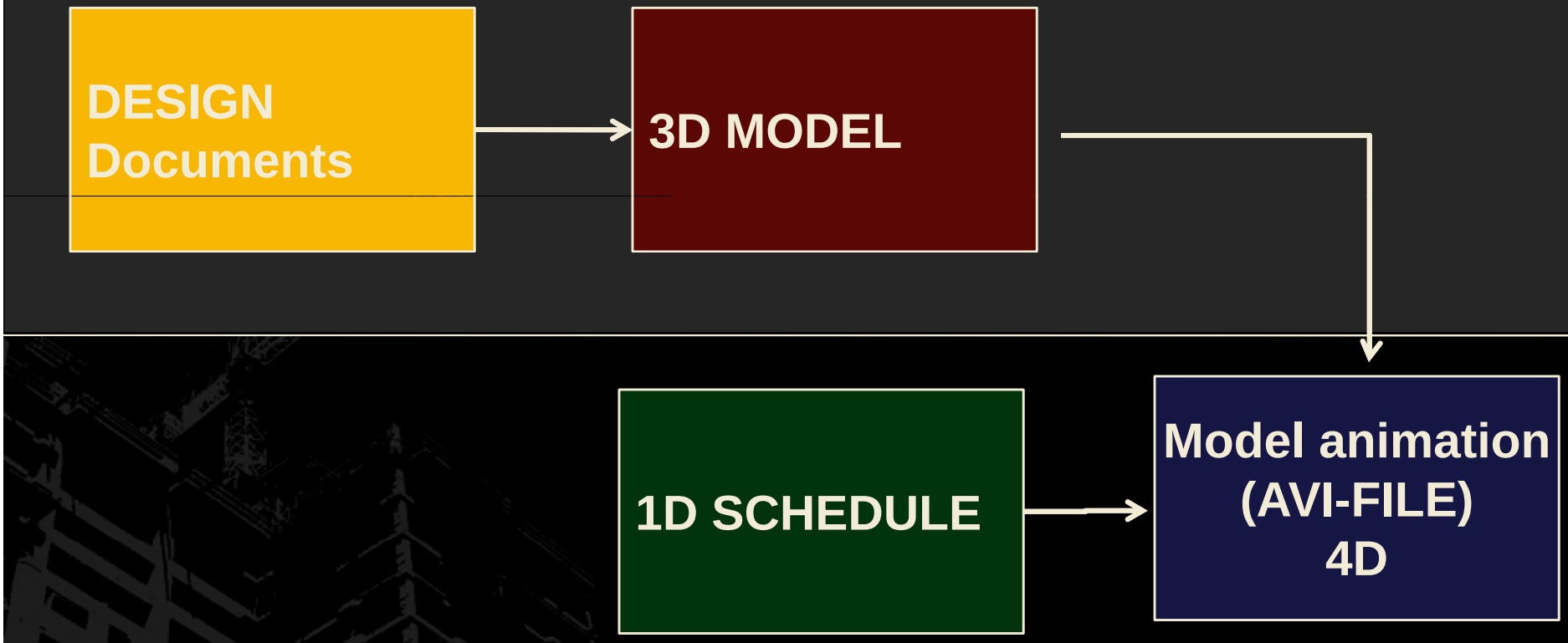






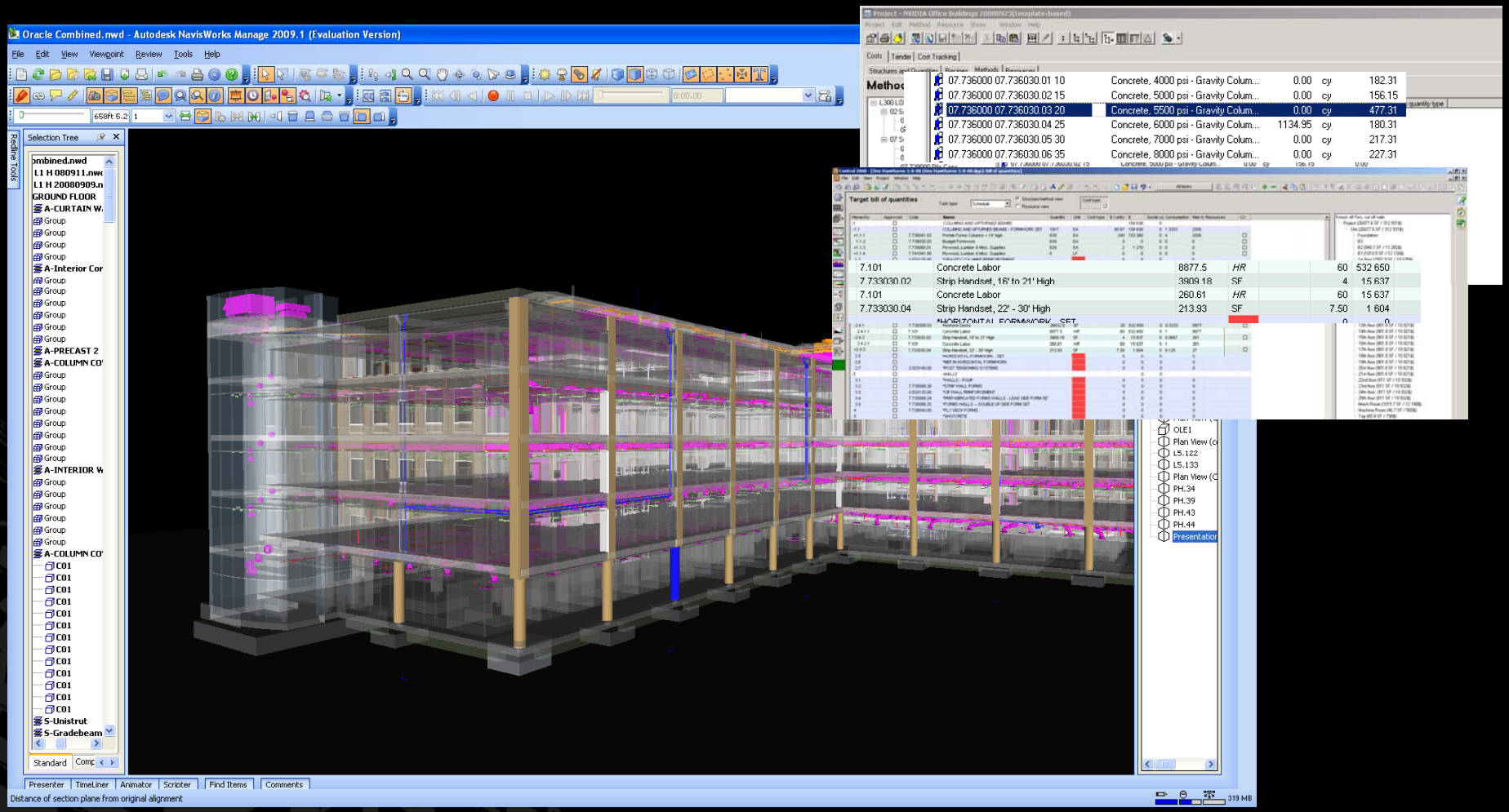
Process Modeling

Conventional 4D Technology



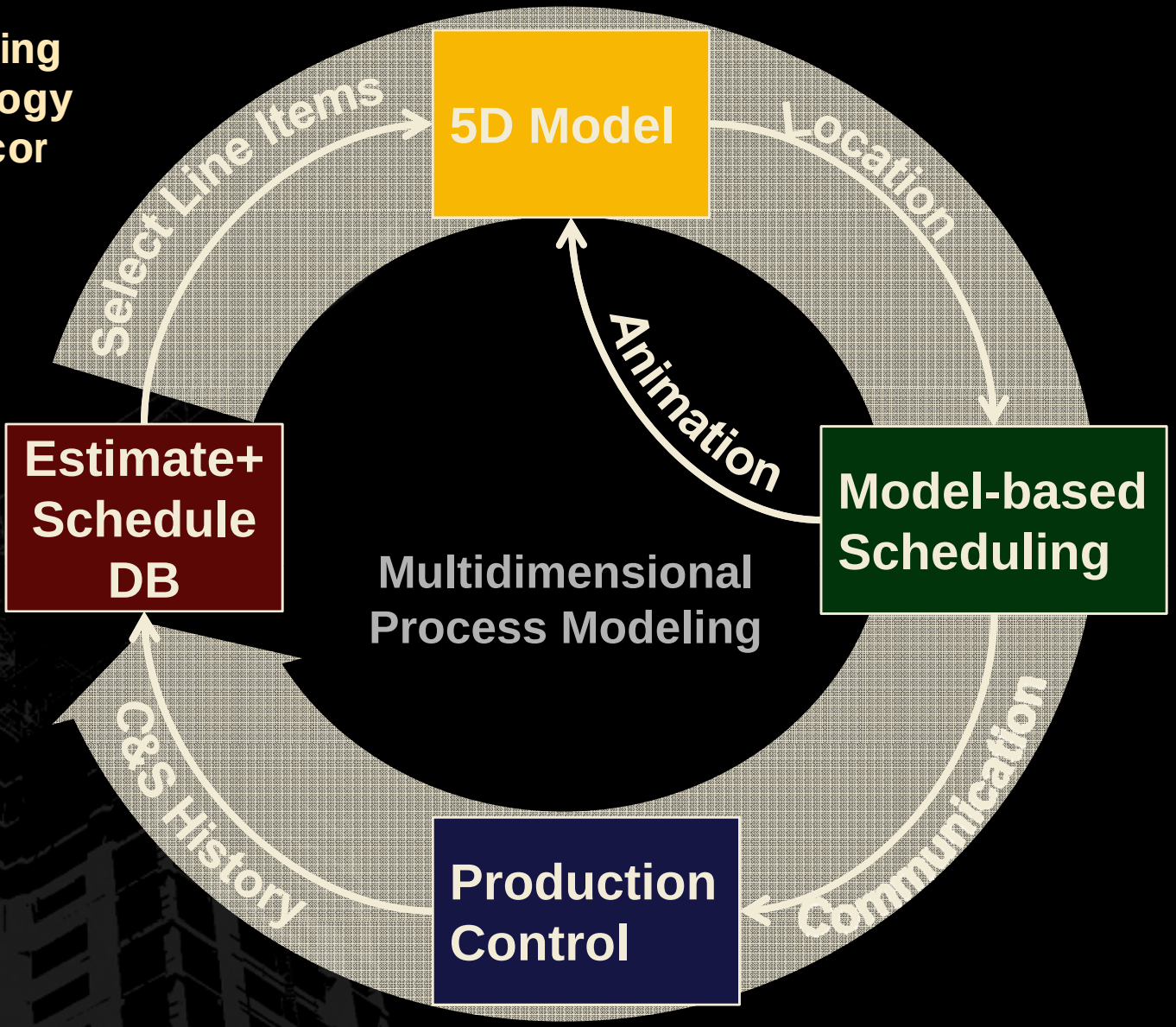
Process Modeling

Multidimensional Database



Process Modeling

Scheduling Technology at Webcor



Location-Based Line of Balance Scheduling

- Accuracy of task durations in schedule

- Buy in from Subcontractors
- Continuous workflow
- Clear and Simple communication
- Effective Conflict Resolution
- Reduced Rework
- Reduced Energy and Resource consumption

Analysis Modeling – Cost/Energy/Sustainability

21 RESIDENTIAL

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12 12	SPECIAL CONSTRUCTION	182,677	sf	0.00	0.00	0	0	0	0	0
13 13	CONVEYING SYSTEMS	182,677	sf	4.43	4.43	809,259	809,259	0	74,898	74,898
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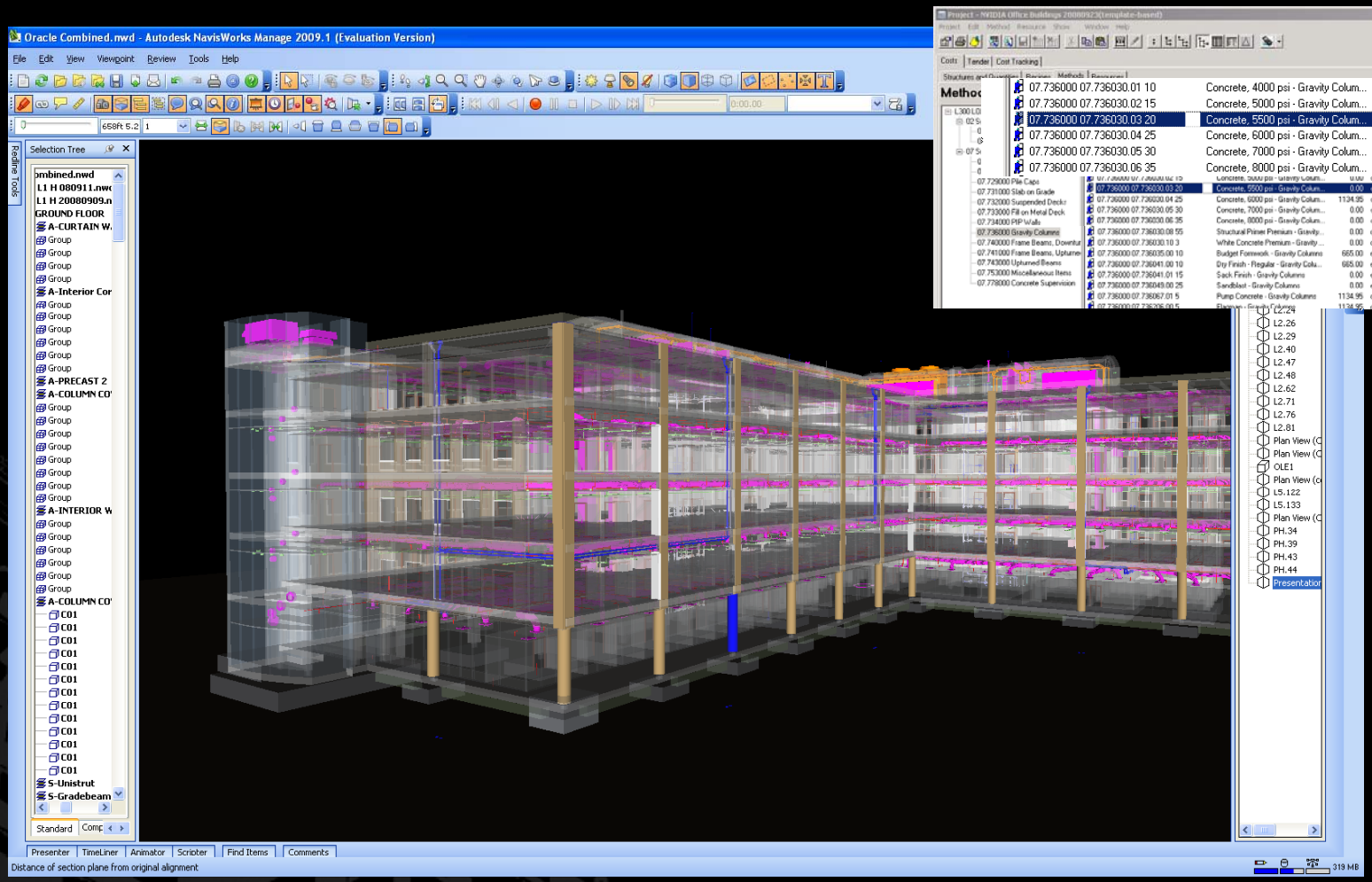
Analysis Modeling – Cost

Multidimensional Database



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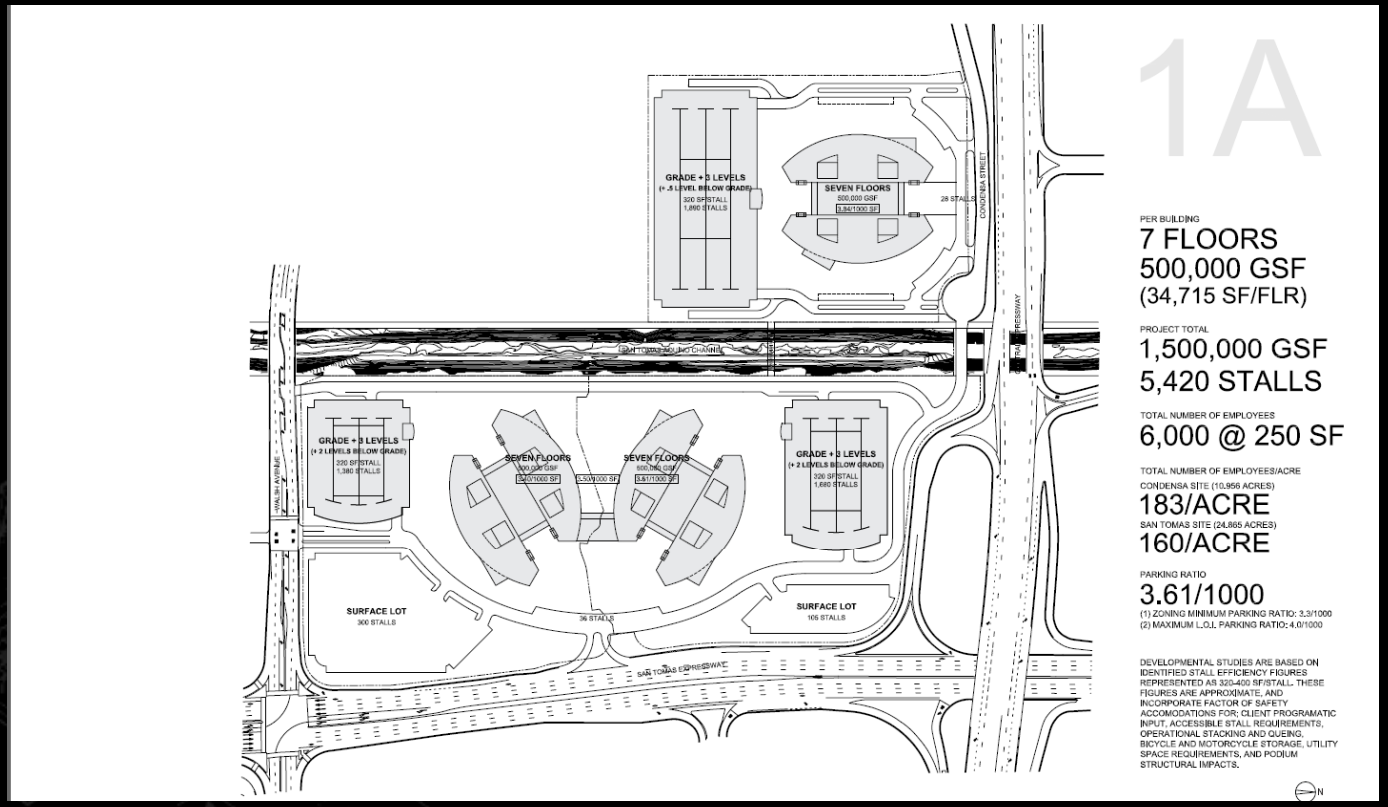
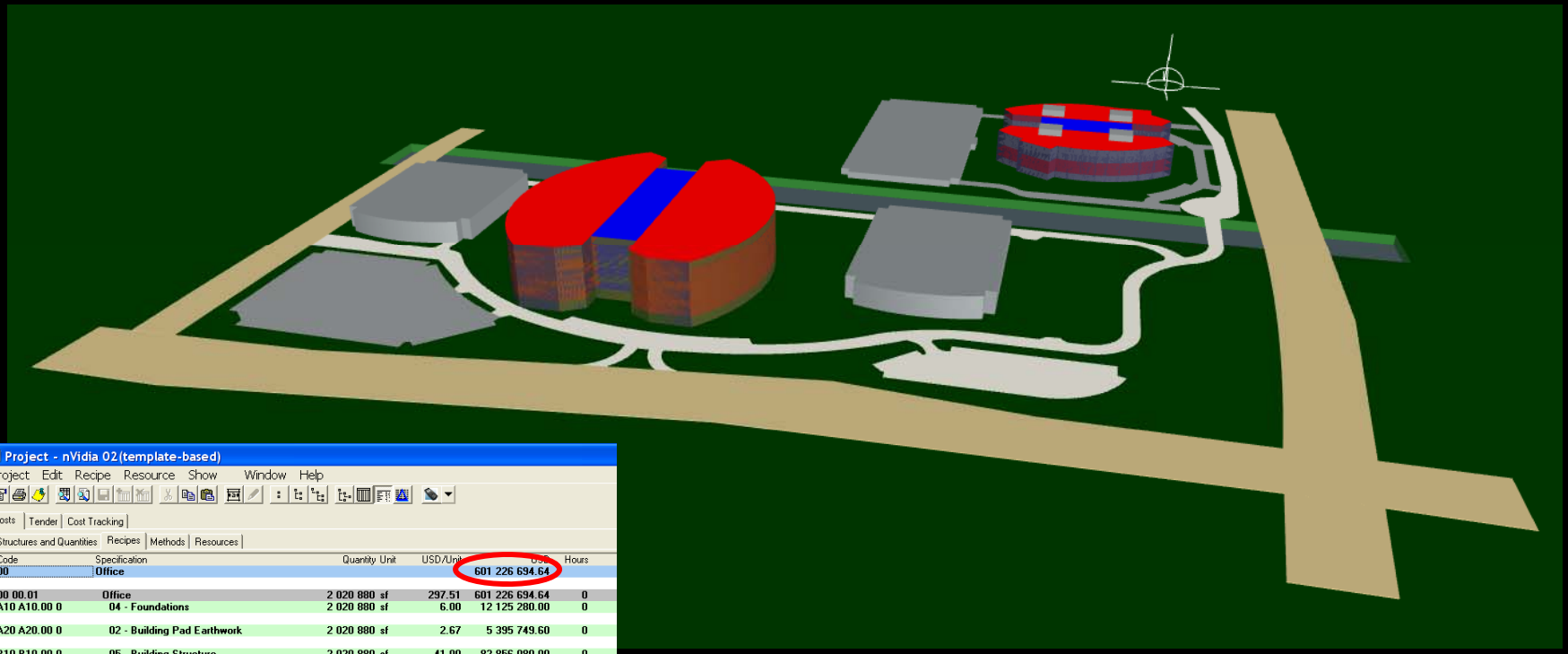


- Conceptual model can be created with minimal information.
- Site plan, building and garage floor plan given.
- Interior program – i.e., clean room, cafeteria, conference rooms are not determined.
- Costs are $/system/sf of floor plate size and exterior skin area.

Analysis Modeling – Cost

Conceptual



Project - nVidia 02(template-based)

Project Edit Recipe Resource Show Window Help

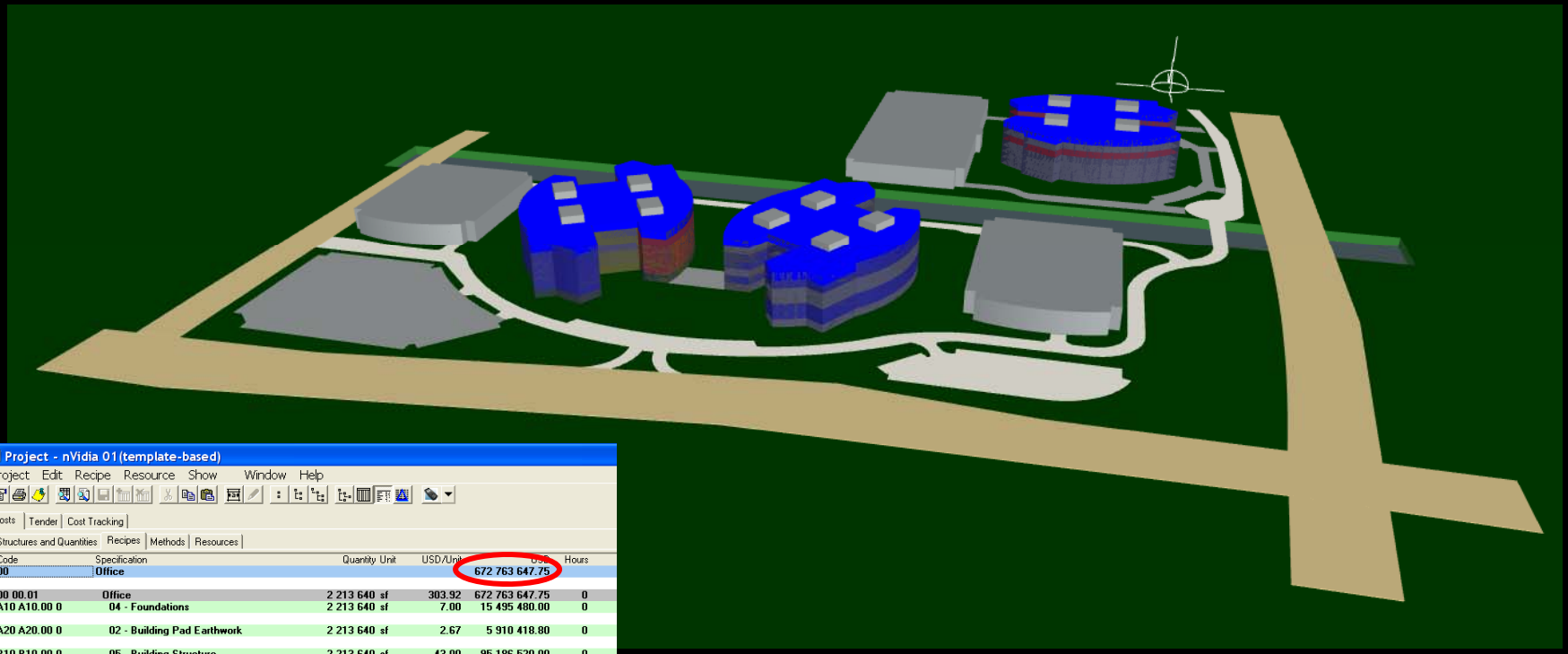
Costs | Tender | Cost Tracking |

Structures and Quantities | Recipes | Methods | Resources |

Code	Specification	Quantity	Unit	USD/Unit	USD	Hours
00	Office				601 226 694.64	
00 00.01	Office	2 020 880	sf	297.51	601 226 694.64	0
A10 A10.00 0	04 - Foundations	2 020 880	sf	6.00	12 125 280.00	0
A20 A20.00 0	02 - Building Pad Earthwork	2 020 880	sf	2.67	5 395 749.60	0
B10 B10.00 0	05 - Building Structure	2 020 880	sf	41.00	82 856 080.00	0
B20 B20.00 0	06 - Exterior Envelope	2 020 880	sf	38.00	76 793 440.00	0
B30 B30.00 0	07 - Waterproofing, insulation, & roofing	2 020 880	sf	5.00	10 104 400.00	0
C10 C10.00 0	08 - C&S interior construction	2 020 880	sf	16.00	32 334 080.00	0
D10 D10.00 0	14 - Elevators	2 020 880	sf	3.96	8 002 684.80	0
D20 D20.00 0	16 - Plumbing	2 020 880	sf	3.51	7 093 288.80	0
D30 D30.00 0	17 - HVAC	2 020 880	sf	11.00	22 229 680.00	0
D40 D40.00 0	15 - Fire sprinklers	2 020 880	sf	2.41	4 870 320.80	0
D50 D50.00 0	18 - Electrical	2 020 880	sf	11.57	23 381 581.60	0
E10 E10.00 0	11 - Equipment	2 020 880	sf	0.45	909 396.00	0
E20 E20.00 0	12 - Furnishings	2 020 880	sf	0.00	0.00	0
F10 F10.00 0	13 - Special construction	2 020 880	sf	0.25	505 220.00	0

Analysis Modeling – Cost

Conceptual



Project - nVidia 01 (template-based)

Project Edit Recipe Resource Show Window Help

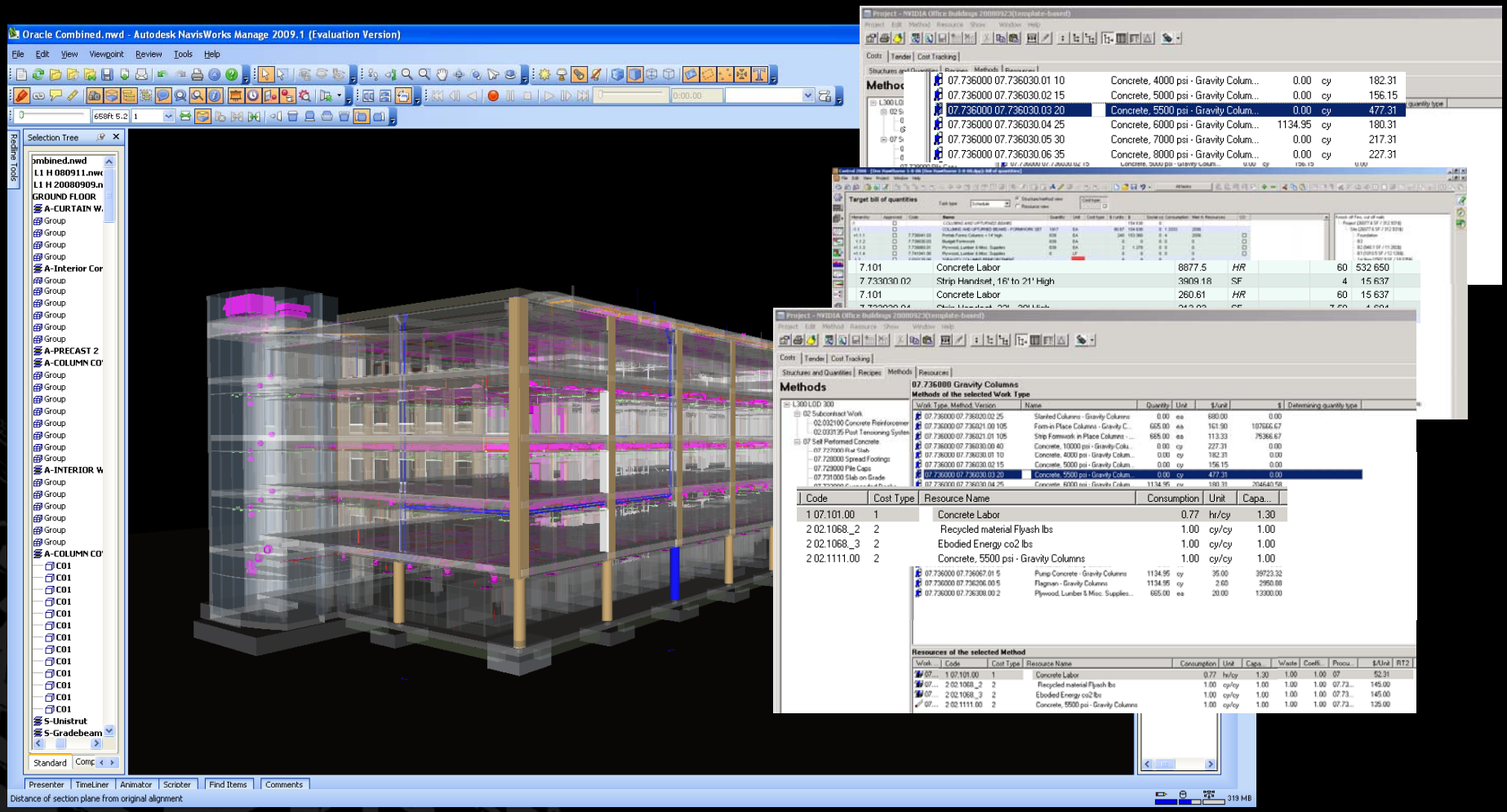
Costs | Tender | Cost Tracking

Structures and Quantities | Recipes | Methods | Resources

Code	Specification	Quantity	Unit	USD/Unit	USD	Hours
00	Office				672 763 647.75	
00 00.01	Office	2 213 640	sf	303.92	672 763 647.75	0
A10 A10.00 0	04 - Foundations	2 213 640	sf	7.00	15 495 480.00	0
A20 A20.00 0	02 - Building Pad Earthwork	2 213 640	sf	2.67	5 910 418.80	0
B10 B10.00 0	05 - Building Structure	2 213 640	sf	43.00	95 186 520.00	0
B20 B20.00 0	06 - Exterior Envelope	2 213 640	sf	40.41	89 453 192.40	0
B30 B30.00 0	07 - Waterproofing, insulation, & roofing	2 213 640	sf	5.00	11 068 200.00	0
C10 C10.00 0	08 - C&S interior construction	2 213 640	sf	16.00	35 418 240.00	0
D10 D10.00 0	14 - Elevators	2 213 640	sf	3.96	8 766 014.40	0
D20 D20.00 0	16 - Plumbing	2 213 640	sf	3.51	7 769 876.40	0
D30 D30.00 0	17 - HVAC	2 213 640	sf	12.00	26 563 680.00	0
D40 D40.00 0	15 - Fire sprinklers	2 213 640	sf	2.41	5 334 872.40	0
D50 D50.00 0	18 - Electrical	2 213 640	sf	11.57	25 611 814.80	0
E10 E10.00 0	11 - Equipment	2 213 640	sf	0.45	996 138.00	0
E20 E20.00 0	12 - Furnishings	2 213 640	sf	0.00	0.00	0
F10 F10.00 0	13 - Special construction	2 213 640	sf	0.25	553 410.00	0

Analysis Modeling – Cost/Energy/Sustainability

Multidimensional Database



Analysis Modeling – Cost/Energy/Sustainability

Schematic

Structures and Quantities | Recipes | Methods | Resources | Method groups

Code	Specification	Quantity	Unit	USD/Unit	USD	Hours
01	Office				18 706 329.02	
00-B	Shell				18 706 329.02	
00-B 02	Curtain Wall Panels	83 667	sf	85.00	7 112 041.20	0
00-B 02_1	Window Wall	1 919	sf	64.99	124 741.82	0
00-B 02_2	Precast	82 959	sf	50.00	4 147 585.20	0

Autodesk® GREEN BUILDING STUDIO

Estimated Energy & Cost Summary

Annual Energy Cost	$1,245,765
Lifecycle* Cost	$16,967,313
Annual CO_2 Emissions	
Electric†	4,162.5 tons
Onsite Fuel	217.9 tons

Structures and Quantities | Recipes | Methods | Resources | Method groups

Code	Specification	Quantity	Unit	USD/Unit	USD	Hours
01	Office				20 419 045.00	
00-B	Shell				20 419 045.00	
00-B 02	Curtain Wall Panels	130 616	sf	85.00	11 102 360.00	0
00-B 02_1	Window Wall	8 516	sf	64.99	553 540.00	0
00-B 02_2	Precast	37 332	sf	50.00	1 866 600.00	0
00-B 02_3	Curtain Wall Glass	79 101	sf	85.00	6 723 585.00	0

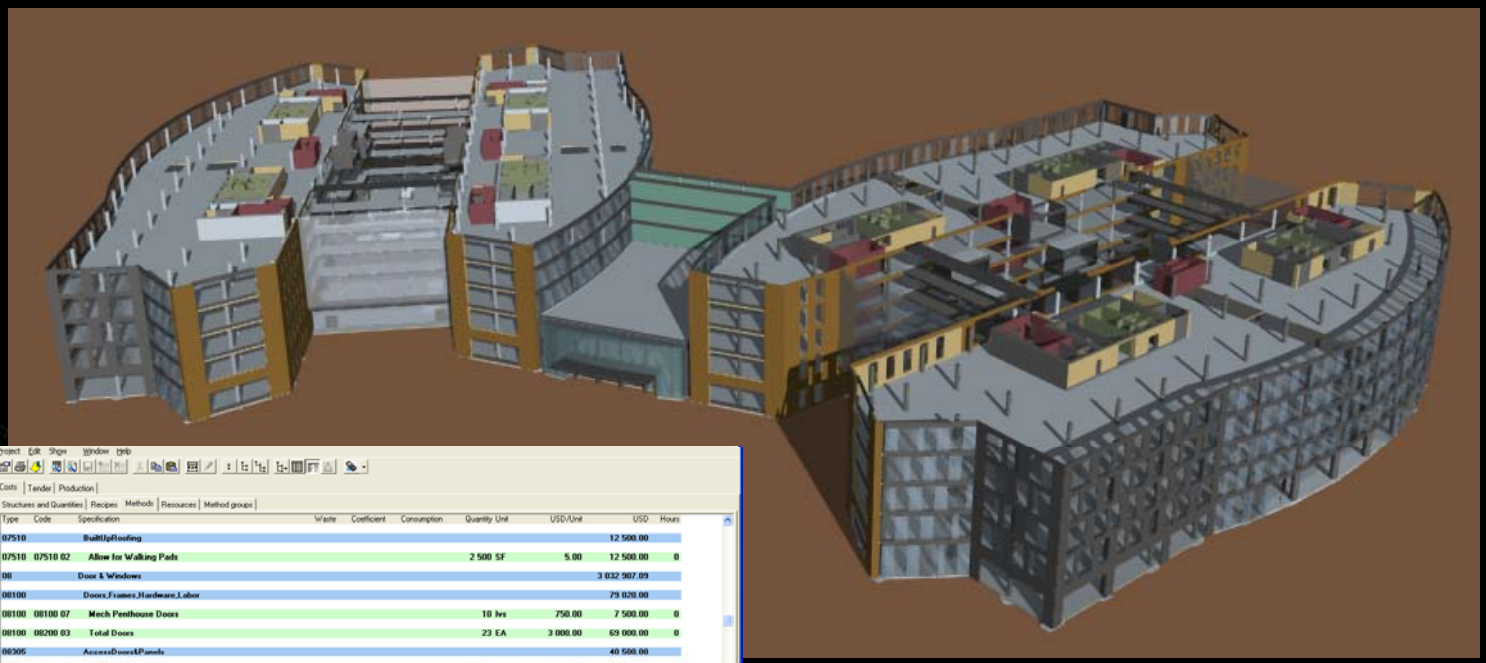
Autodesk® GREEN BUILDING STUDIO

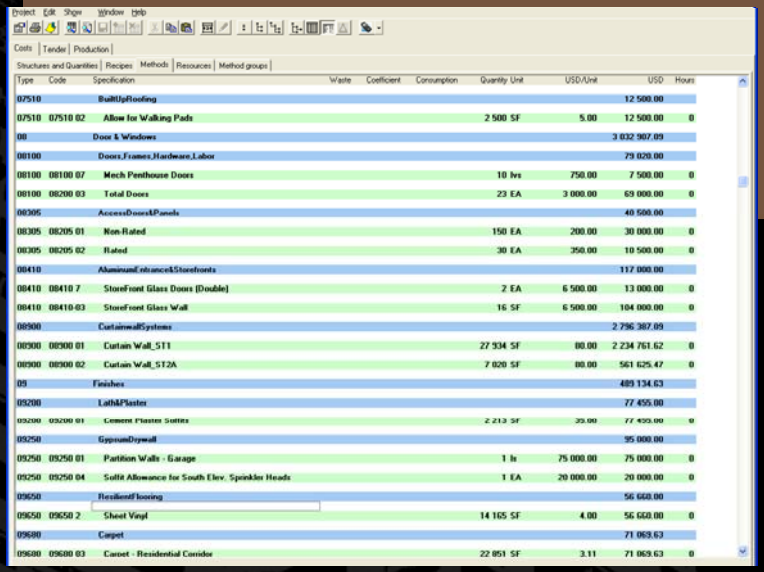
Estimated Energy & Cost Summary

Annual Energy Cost	$1,142,352
Lifecycle* Cost	$15,558,833
Annual CO_2 Emissions	
Electric†	3,569.4 tons
Onsite Fuel	230.1 tons

Analysis Modeling – Cost/Energy/Sustainability

DD - CD





Type	Code	Specification	Waste	Coefficient	Consumption	Quantity Unit	USD/Unit	USD	Hours
07510		BuiltUpRoofing						12 500.00	
07510	07510 02	Allow for Walking Pads				2 500 SF	5.00	12 500.00	0
08		Door & Windows						3 032 907.09	
08100		Doors_Frames_Hardware_Labor						79 020.00	
08100	08100 07	Mech Penthouse Doors				10 hrs	750.00	7 500.00	0
08100	08200 03	Total Doors				23 EA	3 000.00	69 000.00	0
08305		AccessDoors&Panels						40 500.00	
08305	08205 01	Non-Rated				150 EA	200.00	30 000.00	0
08305	08205 02	Rated				30 EA	350.00	10 500.00	0
08410		AluminumEntrances&Storefronts						117 000.00	
08410	08410 7	StoreFront Glass Doors (Double)				2 EA	6 500.00	13 000.00	0
08410	08410 03	StoreFront Glass Wall				16 SF	6 500.00	104 000.00	0
08900		CurtainwallSystems						2 796 387.09	
08900	08900 01	Curtain Wall_ST1				27 934 SF	80.00	2 234 761.62	0
08900	08900 02	Curtain Wall_ST2A				7 020 SF	80.00	561 625.47	0
09		Finishes						489 134.63	
09200		Lath&Plaster						77 455.00	
09200	09200 01	Cement Plaster Soffits				2 213 SF	35.00	77 455.00	0
09250		GypsumDrywall						95 000.00	
09250	09250 01	Partition Walls - Garage				1 ls	75 000.00	75 000.00	0
09250	09250 04	Soffit Allowance for South Elev. Sprinkler Heads				1 EA	20 000.00	20 000.00	0
09650		ResilientFlooring						56 660.00	
09650	09650 2	Sheet Vinyl				14 165 SF	4.00	56 660.00	0
09680		Carpet						71 069.63	
09680	09680 03	Carpet - Residential Corridor				22 851 SF	3.11	71 069.63	0

- Quantities used to verify subcontractors pricing and quantities.
- Interiors modeled and ready for 3D Coordination.
- Sustainability metrics ready for tracking.
- Flow line schedule generated by model.

Agenda

Building Information Modeling

Integrated Project Delivery

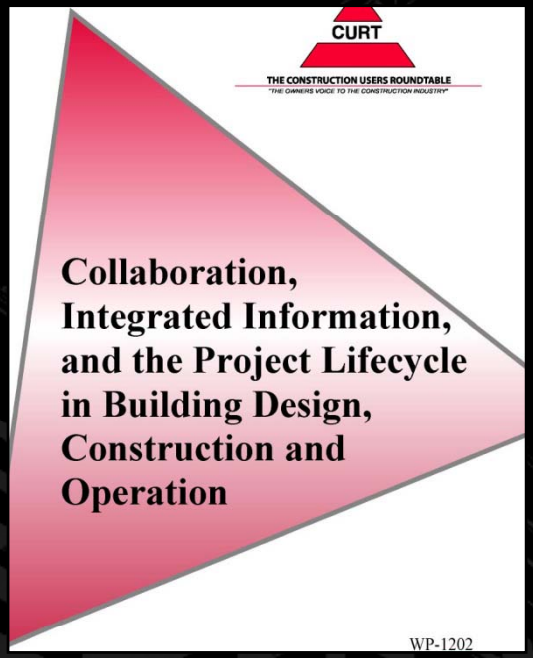
Sustainability – Built in vs. Bolted on

Integrated Project Delivery - Origins

Construction Users Roundtable (CURT)

Organization of large facility owners (Boeing, Cisco, IBM, Intel, GSA, etc)

White Paper 1202 (“The CURT Report”) published August 2004



“Owners regularly experience cost and schedule overruns and must demand collaboration, open information sharing and appropriate technology”

- Owner Leadership
- Integrated Project Structure
- Open Information Sharing
- Virtual Building Information Models

Integrated Project Delivery - Origins

AIA Response

February 2005 – Integrated Practice Strategy Working Group (IPSWG) formed

December 2005 – AIA adopts Integrated Practice, Sustainability, and Diversity as their three Strategic Initiatives

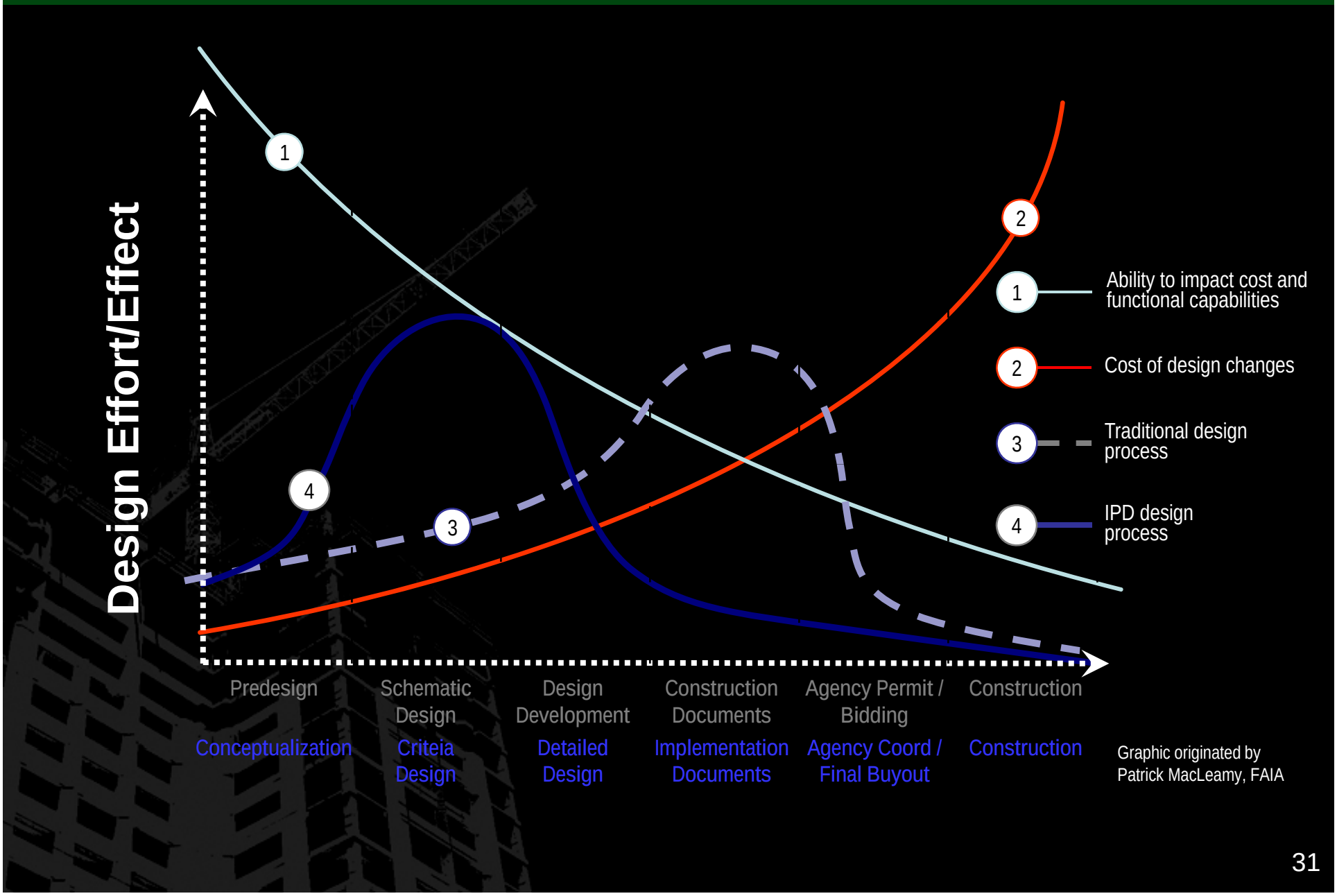
2007 – AIACC publishes two editions of *Integrated Project Delivery: a Working Definition*
http://ipd-ca.net

November 2007 – AIA Contract Documents Committee and AIACC publish *Integrated Project Delivery: a Guide*
http://aia.org/ipdg

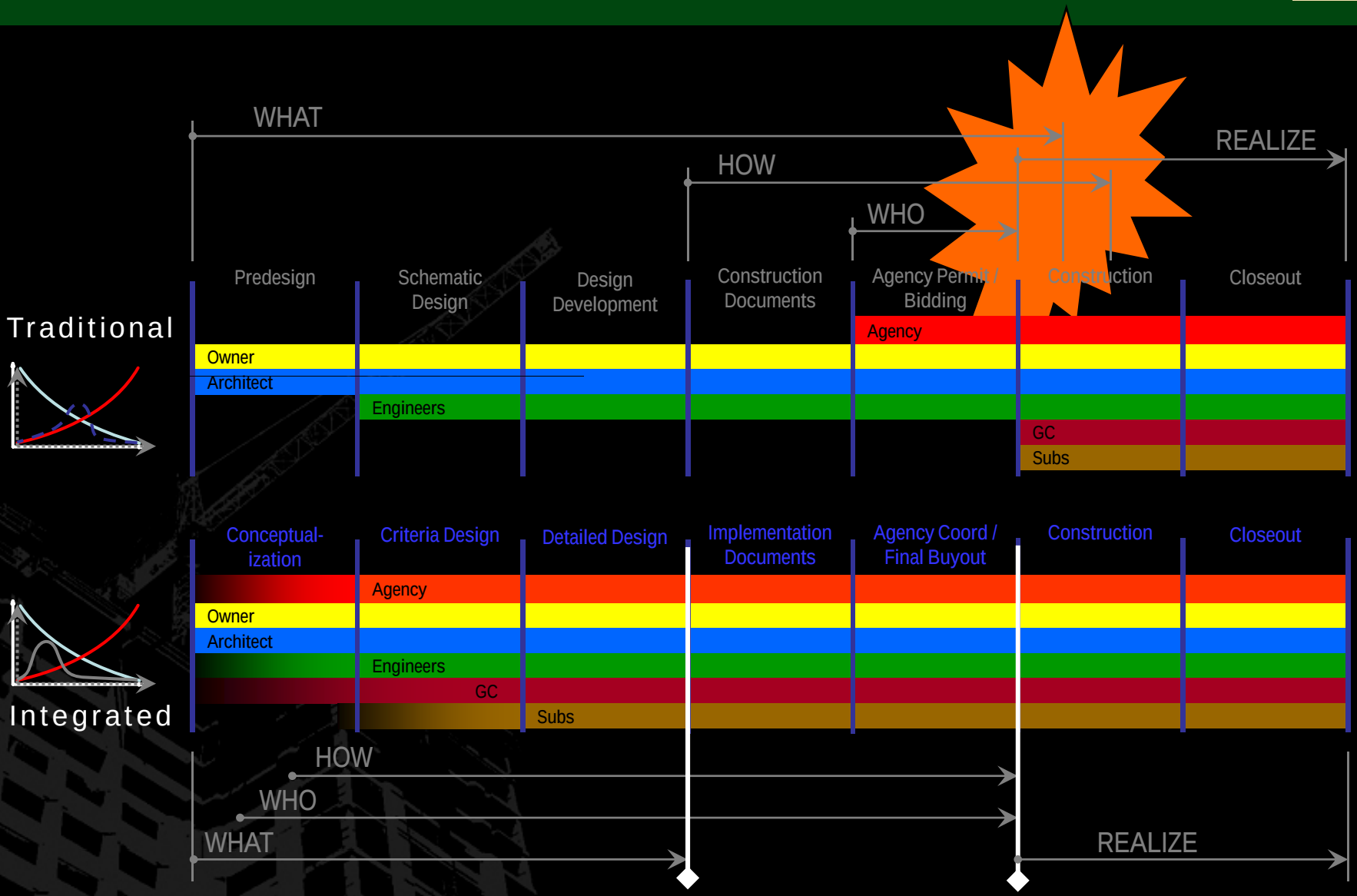
November 2007 – ConsensusDocs publishes *ConsensusDocs 300*
http://www.consensusdocs.org

May 2008 - AIA Publishes *A195/B195/B295* transitional
C195 SPE contracts
http://aia.org/docs

Project Effort and Impact



Delivery Process



Agenda

Building Information Modeling

Integrated Project Delivery

Sustainability – Built in vs. Bolted on

SUSTAINABILITY – "BUILT IN vs. BOLTED ON"

1. Early Sustainable Design collaboration:
   - Building orientation
   - HVAC
   - Lighting
   - Photovoltaic
   - Water
   - Envelope
   - Energy
   - Daylighting
   - Wind
   - Carbon

2. Innovative Product Solutions

3. Carbon Footprint & Embodied Energy

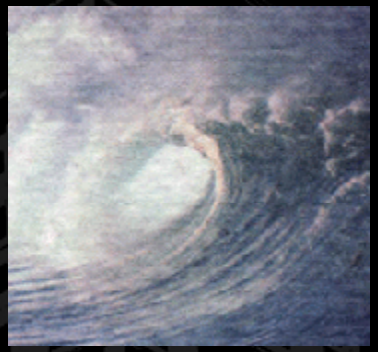
4. LEED Credit Frequency Matrix Analysis

5. LEED Documentation Management

THE WAY WE BUILD IS CHANGING

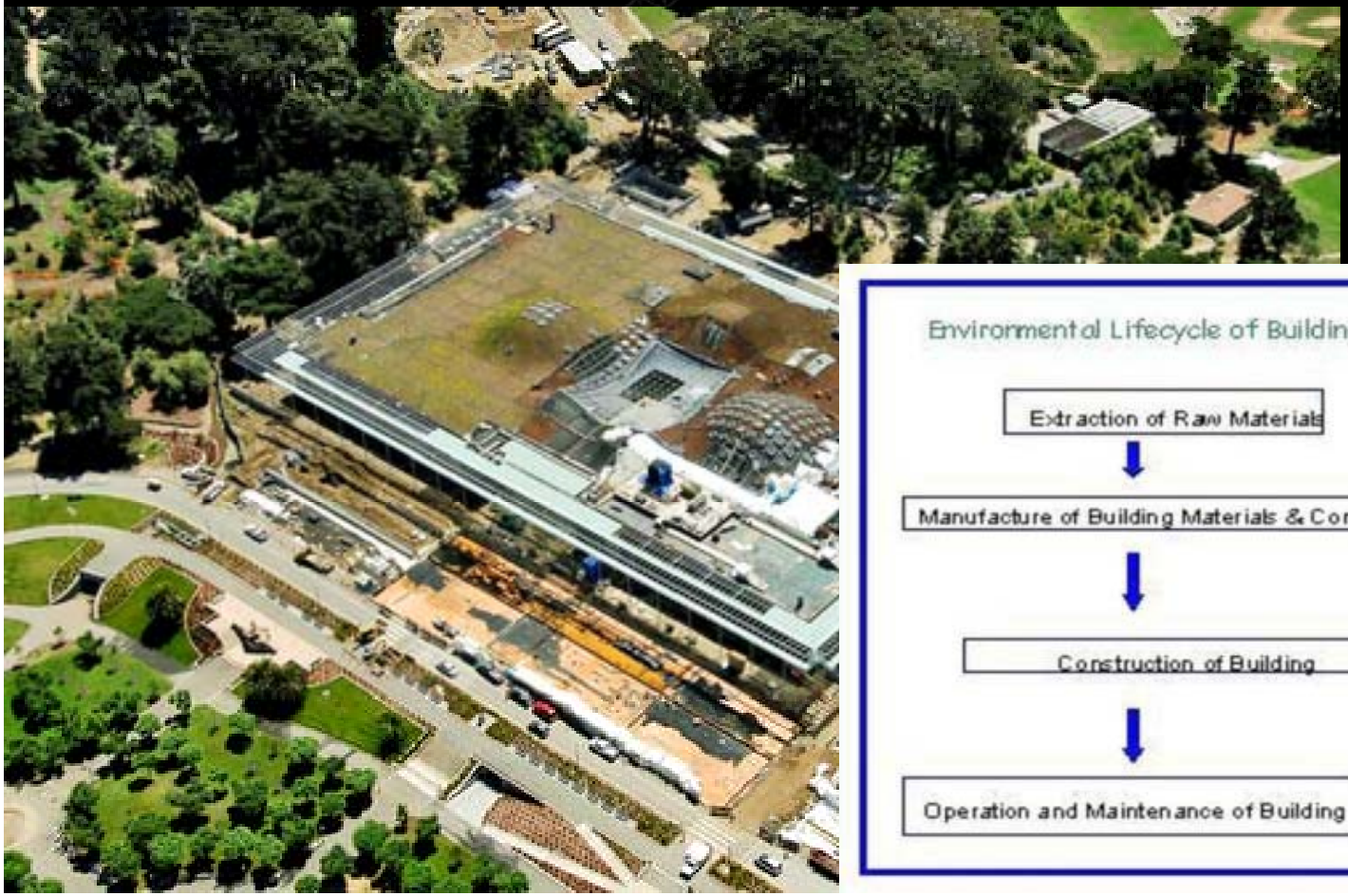
Why are we here today?

- Recognize we have an environmental responsibility to improve the way we build
- Manage finite resources of our planet in a sustainable way:
  - Energy (consumption and embodied)
  - Water
  - Air quality
  - Others…


RESPONSIBLE RESOURCE MANAGEMENT

- Over the Lifespan of a Building
- Life-Cycle Energy Assessment (LCA)
- Carbon Footprint Measurement



HOW IS SUSTAINABILITY MEASURED?

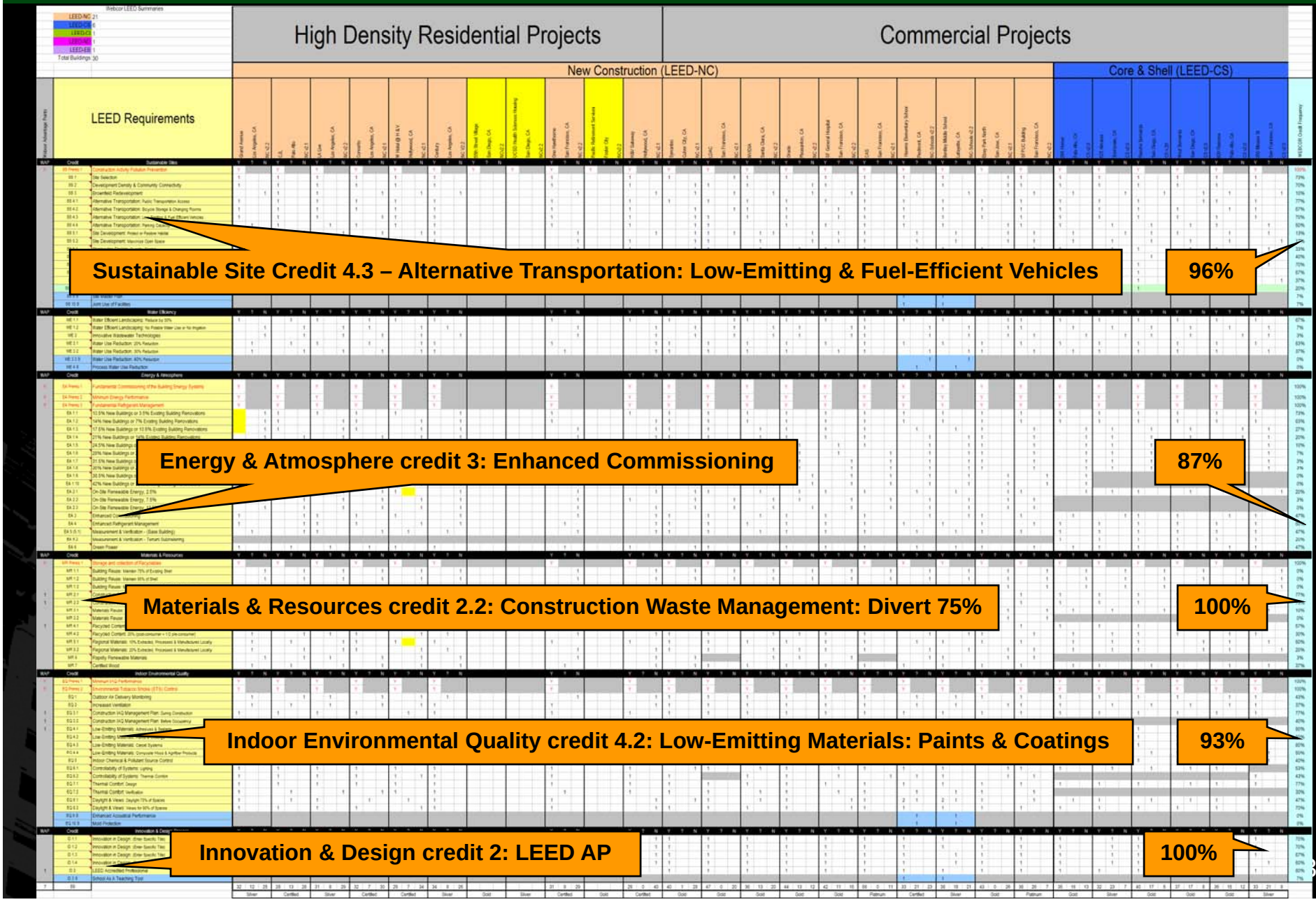
Rating systems help address sustainable impact of energy consumption of the building:

- LEED
- GPR
- Green Globes

Green Globes

GreenPointRATED
A PROGRAM OF BUILD IT GREEN

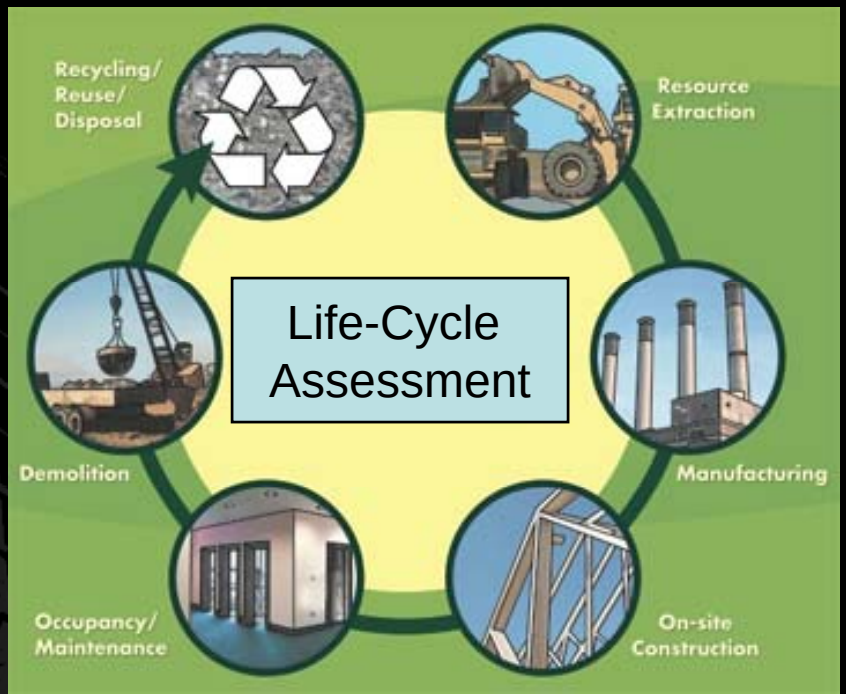
UNDERSTANDING WHAT WORKS & WHERE
LEED CREDIT FREQUENCY MATRIX



WHAT IS LIFE-CYCLE ASSESSMENT?

Managing Life-Cycle Assessment (LCA)

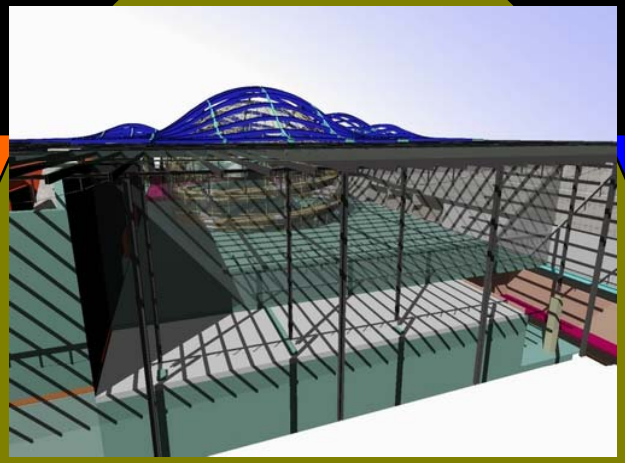
- Cradle-to-Cradle vs. Cradle-to-Grave vs. simple pay back
- First Cost & First Carbon vs. Future Cost & Future Carbon
- Multi-dimensional perspective (subcontractors, consultants, team members, owners, etc)
- Modeling the Built-Environment



LIFE-CYCLE ASSESSMENT DIAGRAM

INPUT

- Fuel
- Energy
- Raw Materials
- Water



Design + Construction Activities

OUTPUT

- Usable Products
- Water Emissions
- Greenhouse Gas
- Solid Waste

LIFE-CYCLE ASSESSMENT CALCULATION

What is the TOTAL LCA that a building will use over the life of the building?

(Embodied energy/carbon of materials/project/construction)

+

(Building energy/carbon generation) X (Life-cycle duration of building)

=

(Total energy/carbon generation over life time of building)

MEASURABLE RESOURCES

- Energy reduction
- Energy modeling
- Fuel consumption
- Building envelope efficiency
- Water usage
- On-site power generation
- Lighting needs
- Building materials
- Material extraction
- Material fabrication
- Material transportation
- Installation process

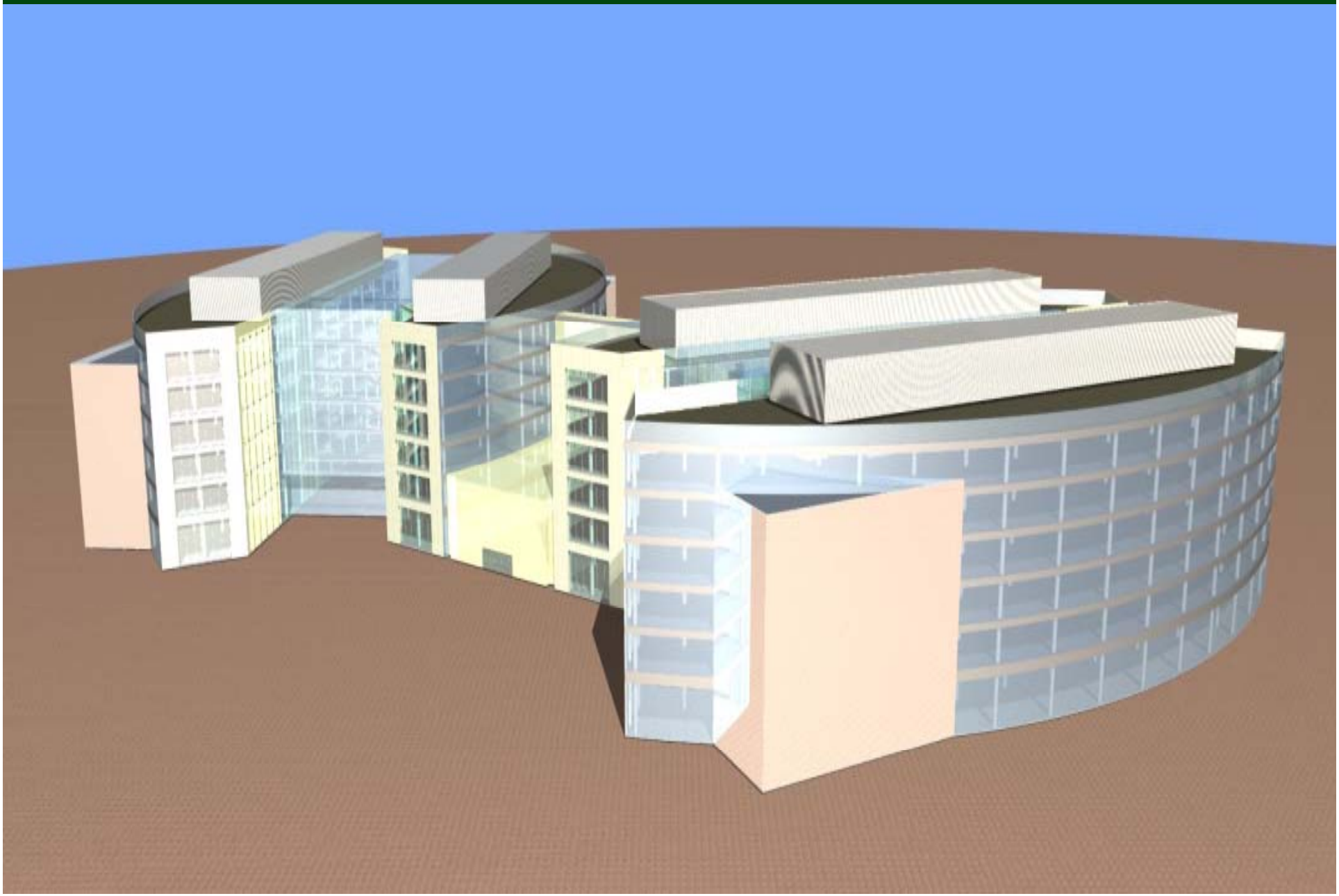
= <u>Carbon Footprint Analysis</u>

EMBODIED ENERGY: WHAT IS IT, HOW IS IT MEASURED?

- Embodied Energy – who is measuring it?
- How do Virtual Building tools address energy consumption analysis?
- What's in the project?
- How is it designed?
- How is it build in?

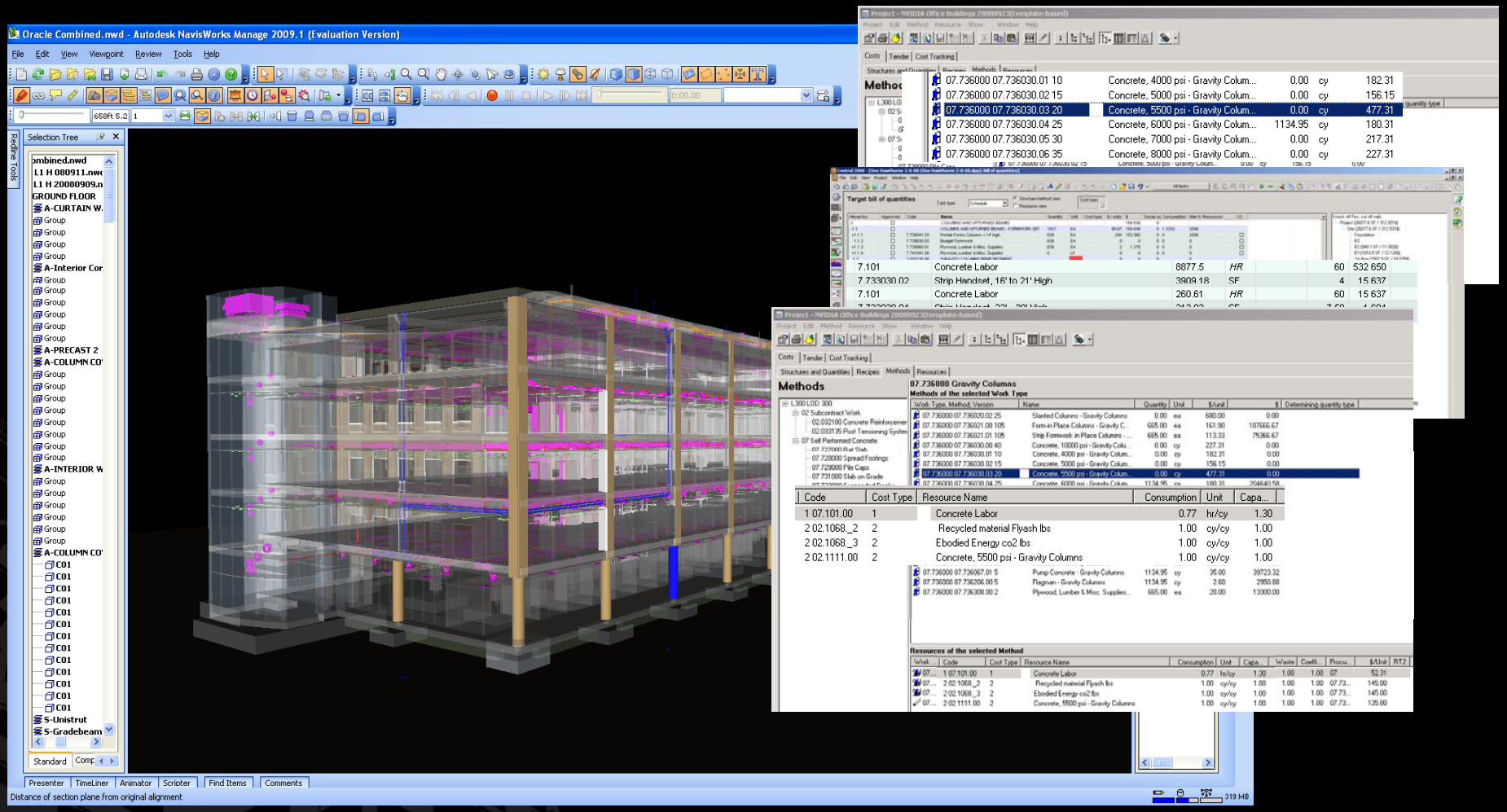
- How is it maintained and operated?
- What is the overall sustainability impact of the building?

MODELING FUNCTIONALITY – SUSTAINABILITY & BIM



Analysis Modeling - Sustainability

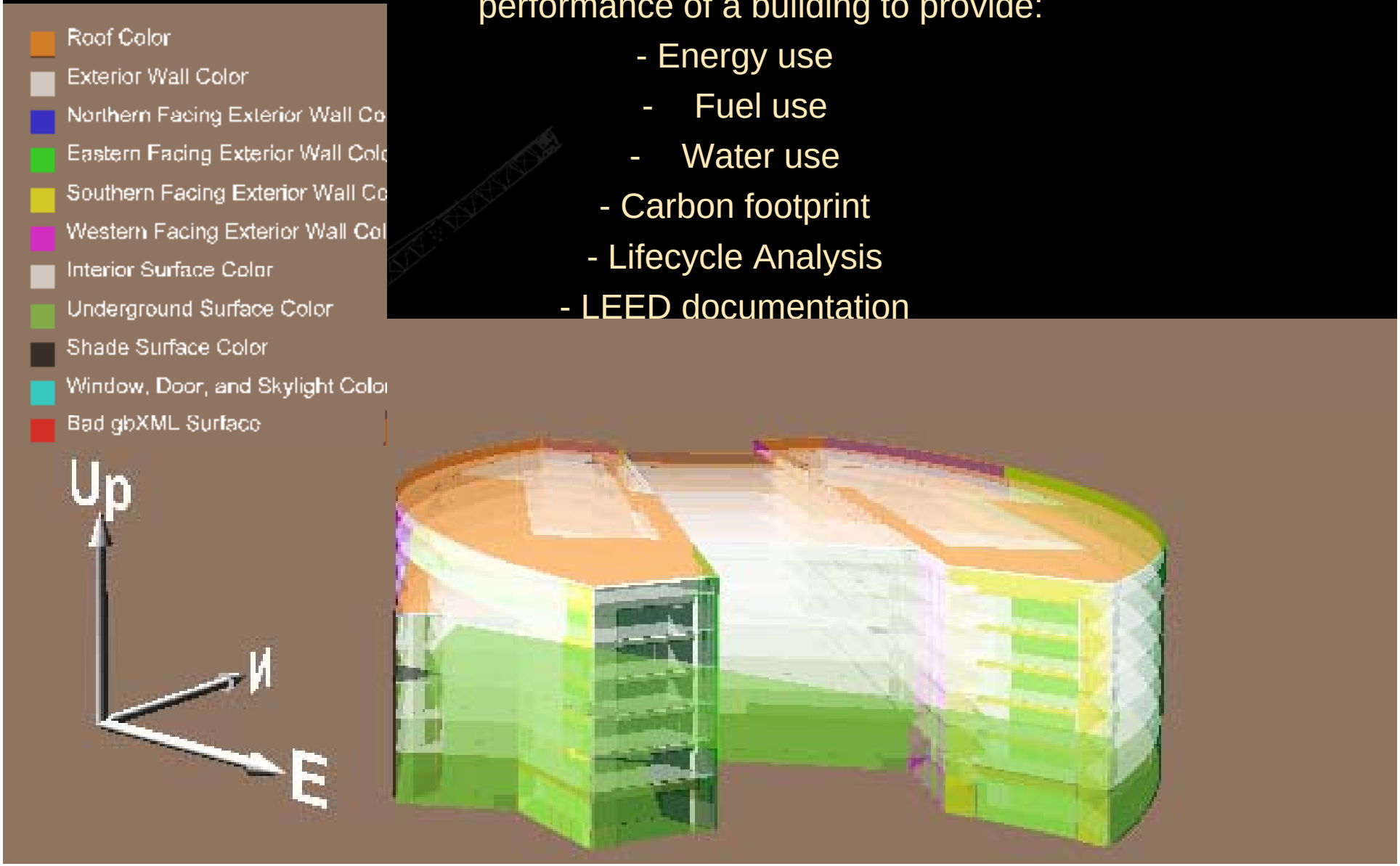
Multidimensional Database



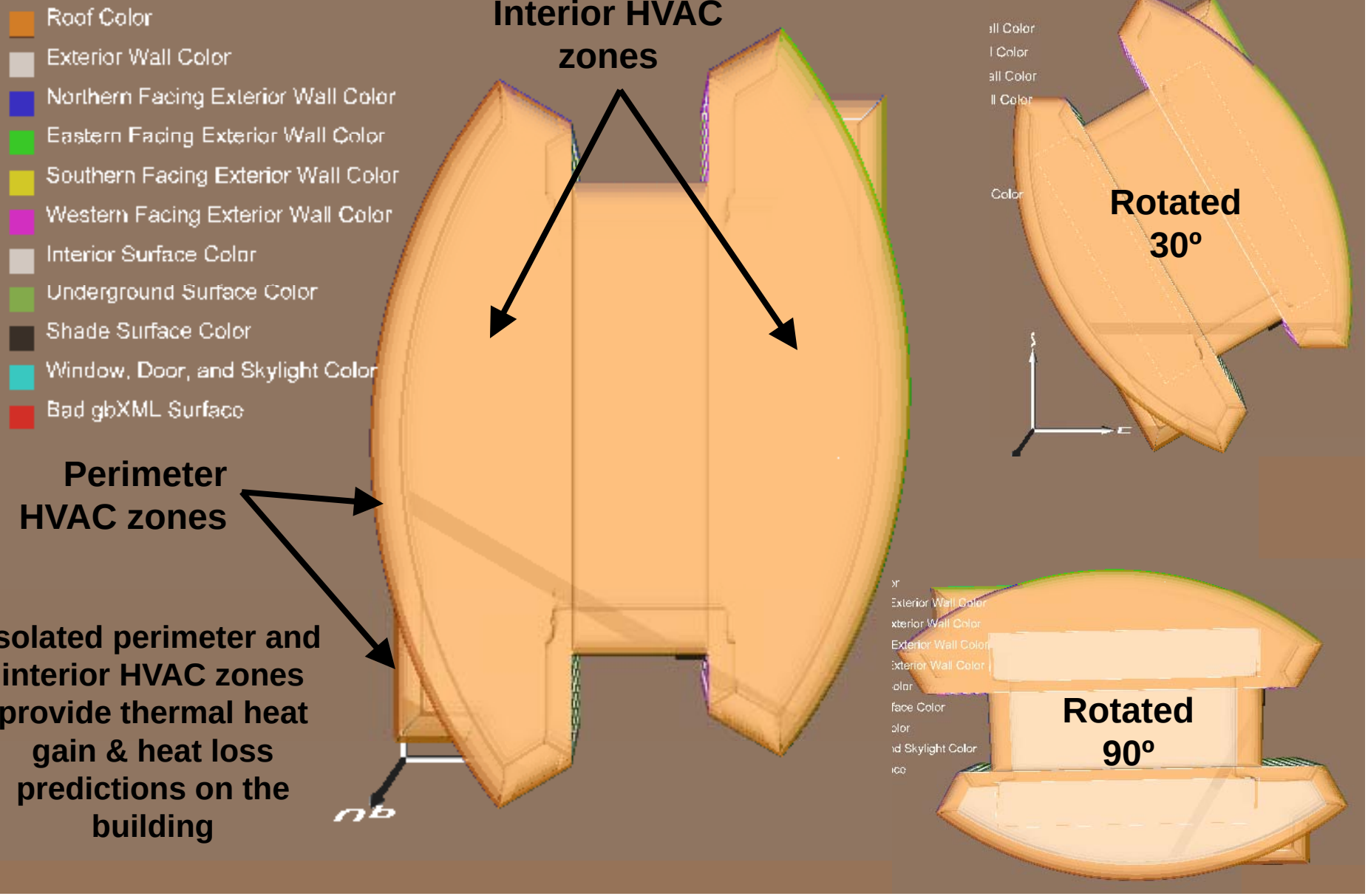
MULTI-DIMENSIONAL MODELING FUNCTIONALITY

Multi-Dimensional Design & Construction modeling simulates and analyzes the performance of a building to provide:

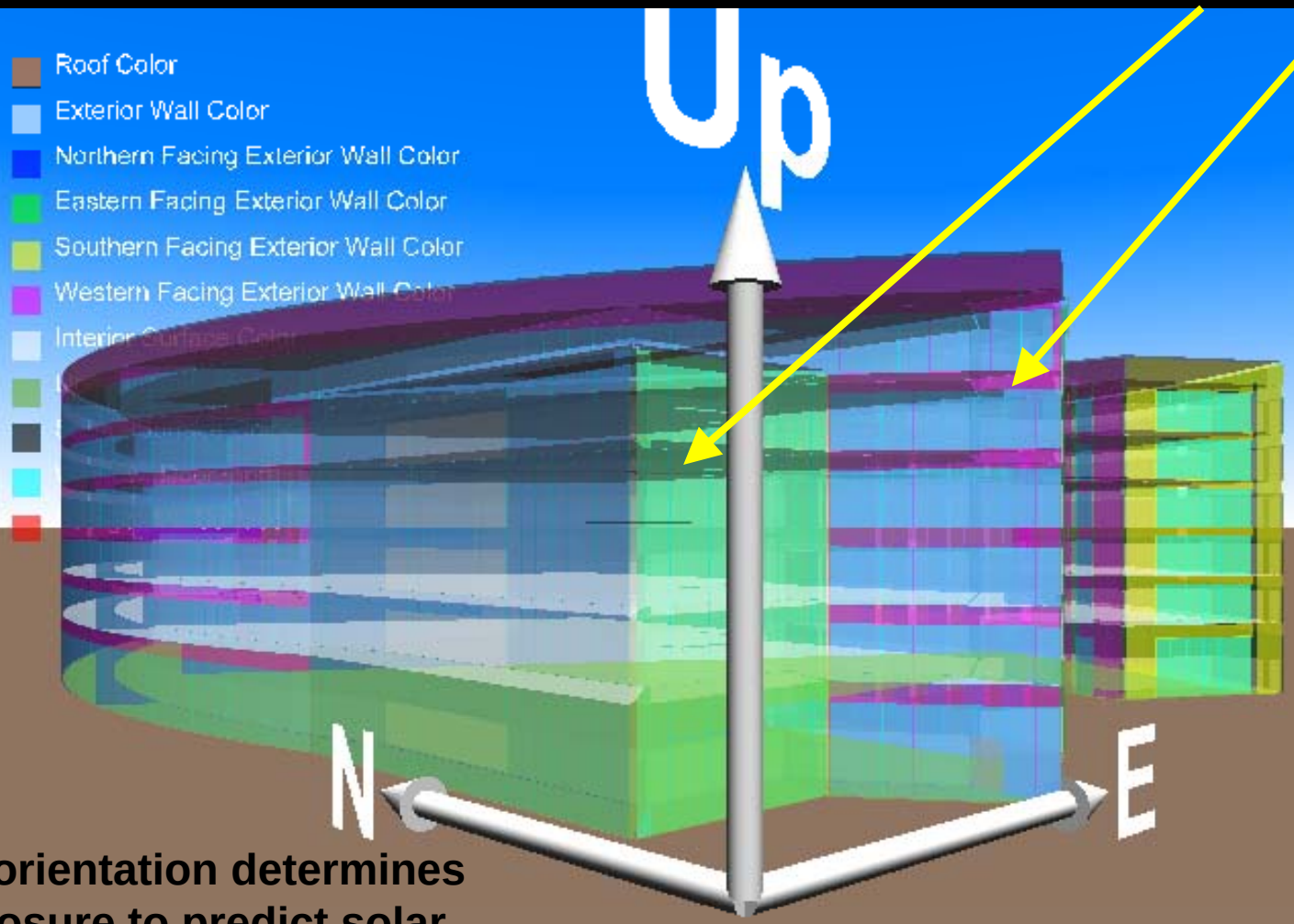
- Energy use
- Fuel use
- Water use
- Carbon footprint
- Lifecycle Analysis
- LEED documentation



MODELING THE BUILT ENVIRONMENT

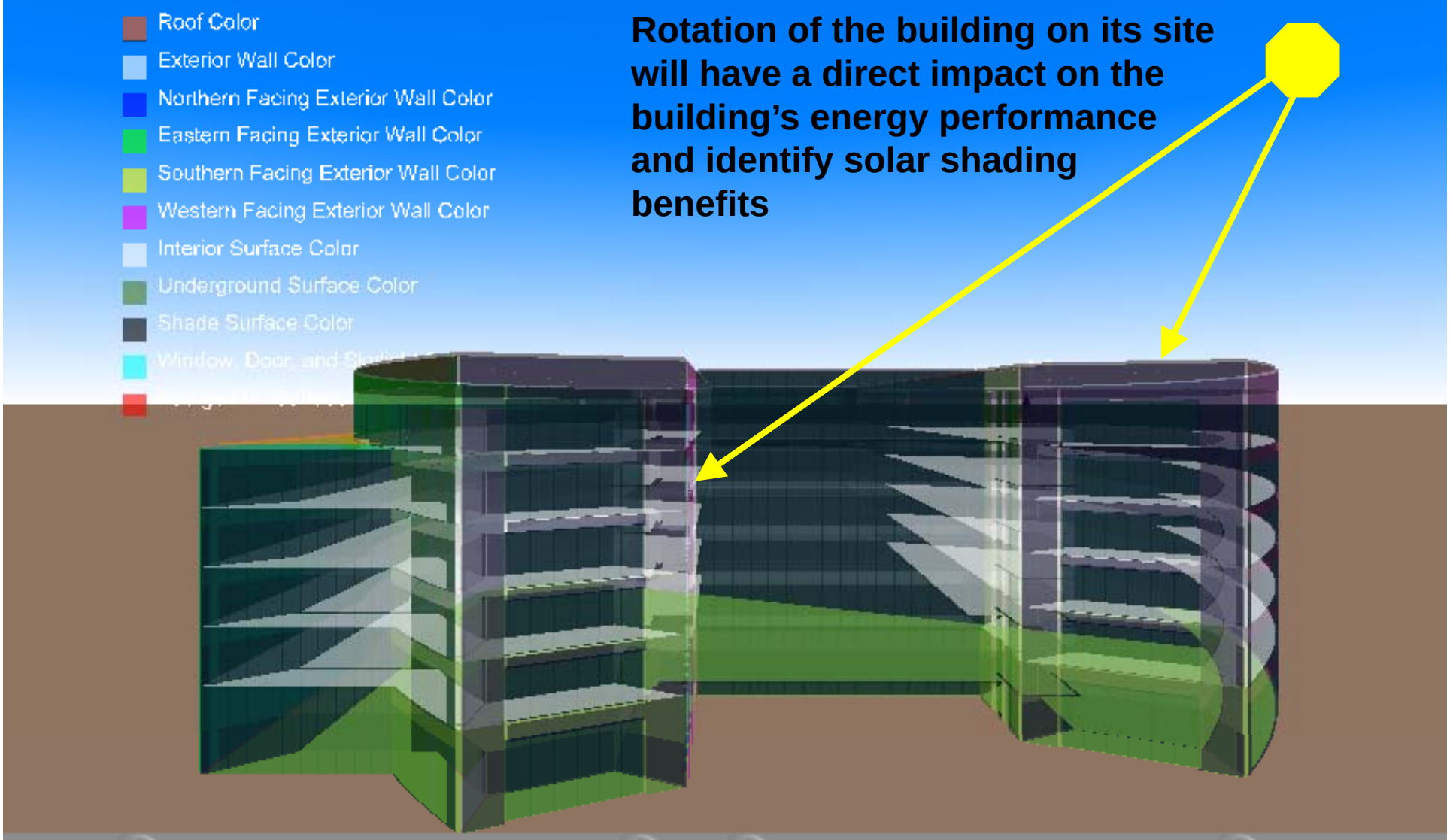


MODELING THE BUILT ENVIRONMENT



Building orientation determines solar exposure to predict solar heat gain

MODELING THE BUILT ENVIRONMENT



Rotation of the building on its site will have a direct impact on the building's energy performance and identify solar shading benefits

MOVING TOWARDS CARBON NEUTRAL DESIGN STRATEGIES

Performance based modeling provides energy calculations for both annual and lifecycle costs and the building's resulting CO2 emissions

General Information

Project Title: NVIDIA

Run Title: test nVidia GBS.xml

Building Type: Office

Floor Area: 533,361 ft²

Estimated Energy & Cost Summary

Annual Energy Cost		$1,227,889
Lifecycle* Cost		$16,723,847
Annual CO_2 Emissions		
	Electric†	4,096.0 tons
	Onsite Fuel	182.8 tons
	Large SUV Equivalent	389.0 Large SUV's
Annual Energy		
	Electric	9,132,586 kWh
	Fuel	31,520 Therms
Annual Peak Electric Demand		2,608.4 kW
Lifecycle* Energy		
	Electric	273,977,580 kWh
	Fuel	945,604 Therms

* 30 -year life and 6.1 % discount rate for costs. † Does not include electric transmission losses or the renewable and natural ventilation potential.

MOVING TOWARDS CARBON NEUTRAL DESIGN STRATEGIES

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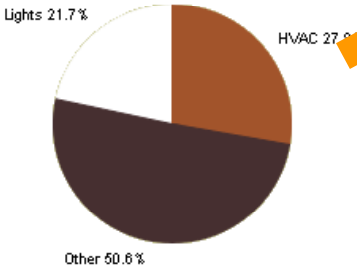
	Electric	273,977,580 kWh
	Fuel	945,604 Therms

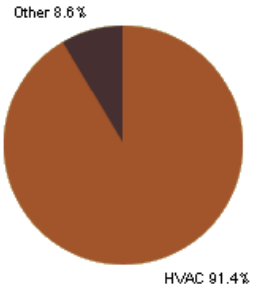
Energy End-Use Charts

Click on chart for more or less detail.

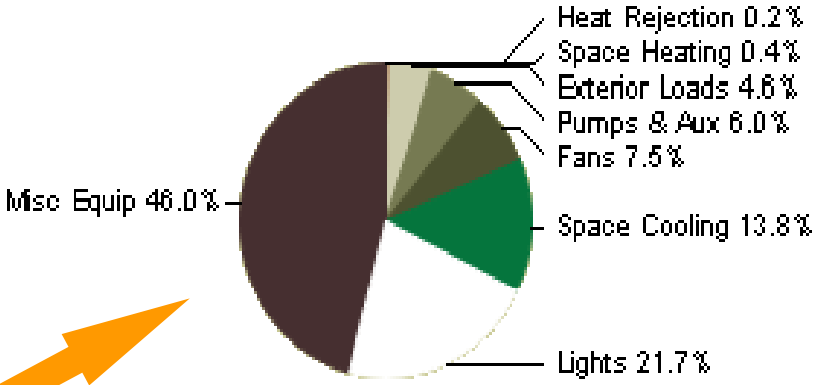
Annual Electric End Use



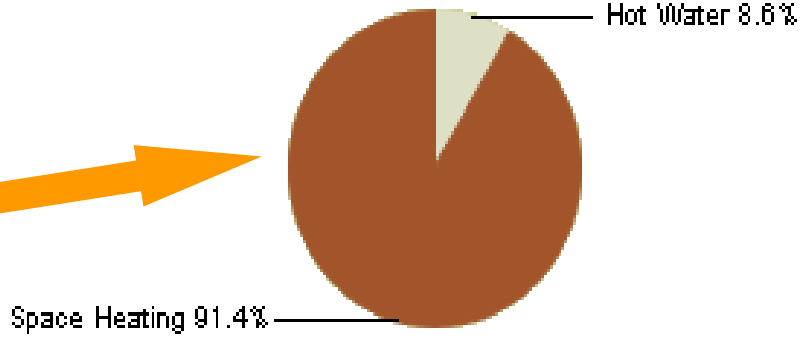
Annual Fuel End Use



Annual Electric End Use



Annual Fuel End Use



MOVING TOWARDS CARBON NEUTRAL DESIGN STRATEGIES

Water, Photovoltaic potential and daylighting calculations are assessed for the model

Water Usage and Cost[3]

Total:	14,914,598 Gal/yr	$48,556/yr
Indoor:	14,888,498 Gal/yr	$48,517/yr
Outdoor:	26,100 Gal/yr	$39/yr

3. Based on AWWA Research Foundation 2000 Residential / Commercial and Institutional End Uses of Water.

Photovoltaic Potential[4]

Annual Energy Savings:	1,531,186 kWh
Total Installed Panel Cost:	$11,042,928
Nominal Rated Power:	1380 kW
Total Panel Area:	107362 ft^2
Maximum Payback Period:	37 yrs @ $0.13 / kWh

4. Results based on all exterior surfaces being analyzed. Escalation rate of 0% applied to electric rate. Payback calculation does not include federal or state incentives, loan information, or tax breaks.

LEED Daylight[5]

Area w/ Glazing Factor > 2%:	16.1% - No LEED Credit

5. Glazing Factor is the ratio of exterior illumination to interior illumination and is calculated using floor area, window geometry (area and height) and visible transmittance of the glass. The project qualifies if glazing factor is > 2% in a minimum of 75% of all regularly occupied areas.

Wind Energy Potential[6]

Annual Electric Generation:	847 kWh

6. A single 15 ft diameter turbine, with cut-in and cut-out winds of 6 mph and 45 mph respectively, and located at the coordinates of the weather data.

MOVING TOWARDS CARBON NEUTRAL DESIGN STRATEGIES

Performance based modeling produces estimated Carbon Footprint based on the net CO2 emissions expected from the building's current design. Building design modifications can potentially reduce CO2 footprint

Location Information

Building: SANTA CLARA, CA 95052

Electric Cost: $0.131/kWh

Fuel Cost: $1.000/Therm

Weather: GBS_04R20_046110

Carbon Neutral Potential[1] (CO_2 Emissions)

Base Run:	4,278.9 tons
This Run:	3,799.5 tons
Onsite Renewable Potential:	-1,417.7 tons
Natural Ventilation Potential:	-1,108.7 tons
Onsite Fuel Offset/Biofuel Use:	-230.1 tons
Net CO_2 Emissions:	1,043.1 tons
Large SUV Equivalent:	94.8 Large SUV's

DEVELOPING MATERIAL CARBON FOOTPRINT TOOLS

What are the project goals and what do they include?

- Minimize construction waste
- Lower the embodied energy
- Minimize raw material usage
- Reduce resource consumption

EARLY INVOLVEMENT OF A WELL-EDUCATED TEAM!

CURRENT CARBON RECIPES ARE NOT GOOD ENOUGH

- BIM model provides quantities volume
- Various external public Carbon footprint calculators identify materials' embodied energy as systems and GWP (Global Warming Potential)
- Is this accurate enough?

Assembly Type	Structure Type	Details	GWP per SF (lbs)	Material Used (sf)
Columns & Beams	(Column)	(Beam)		
	Concrete	Concrete	20.17	44,700.00
	Concrete	Wide-flange steel	11.42	44,700.00
	Concrete	Glulam	6.26	44,700.00
	Concrete	Structural Composite Lumber	5.56	44,700.00
	Hollow Structural Steel	Wide-flange steel	6.72	44,700.00
	Hollow Structural Steel	Glulam	1.68	44,700.00
	Hollow Structural Steel	Structural Composite Lumber	2.38	44,700.00
	Glulam	Wide-flange steel	8.02	44,700.00
	Glulam	Glulam	2.64	44,700.00
	Glulam	Structural Composite Lumber	1.92	44,700.00
	Structural Composite Lumbar	Wide-flange steel	7.92	44,700.00
	Structural Composite Lumbar	Glulam	2.53	44,700.00
	Structural Composite Lumbar	Structural Composite Lumber	1.82	44,700.00
	Wide-Flange Steel	Wide-flange steel	8.19	44,700.00
	Wide-Flange Steel	Glulam	2.34	44,700.00
	Wide-Flange Steel	Structural Composite Lumber	1.64	44,700.00

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	Hollow Structural Steel	Wide-flange steel	6.72	44,700.00
	Hollow Structural Steel	Glulam	1.68	44,700.00
	Hollow Structural Steel	Structural Composite Lumber	2.38	44,700.00
	Glulam	Wide-flange steel	8.02	44,700.00
	Glulam	Glulam	2.64	44,700.00
	Glulam	Structural Composite Lumber	1.92	44,700.00
	Structural Composite Lumbar	Wide-flange steel	7.92	44,700.00
	Structural Composite Lumbar	Glulam	2.53	44,700.00
	Structural Composite Lumbar	Structural Composite Lumber	1.82	44,700.00
	Wide-Flange Steel	Wide-flange steel	8.19	44,700.00
	Wide-Flange Steel	Glulam	2.34	44,700.00
	Wide-Flange Steel	Structural Composite Lumber	1.64	44,700.00

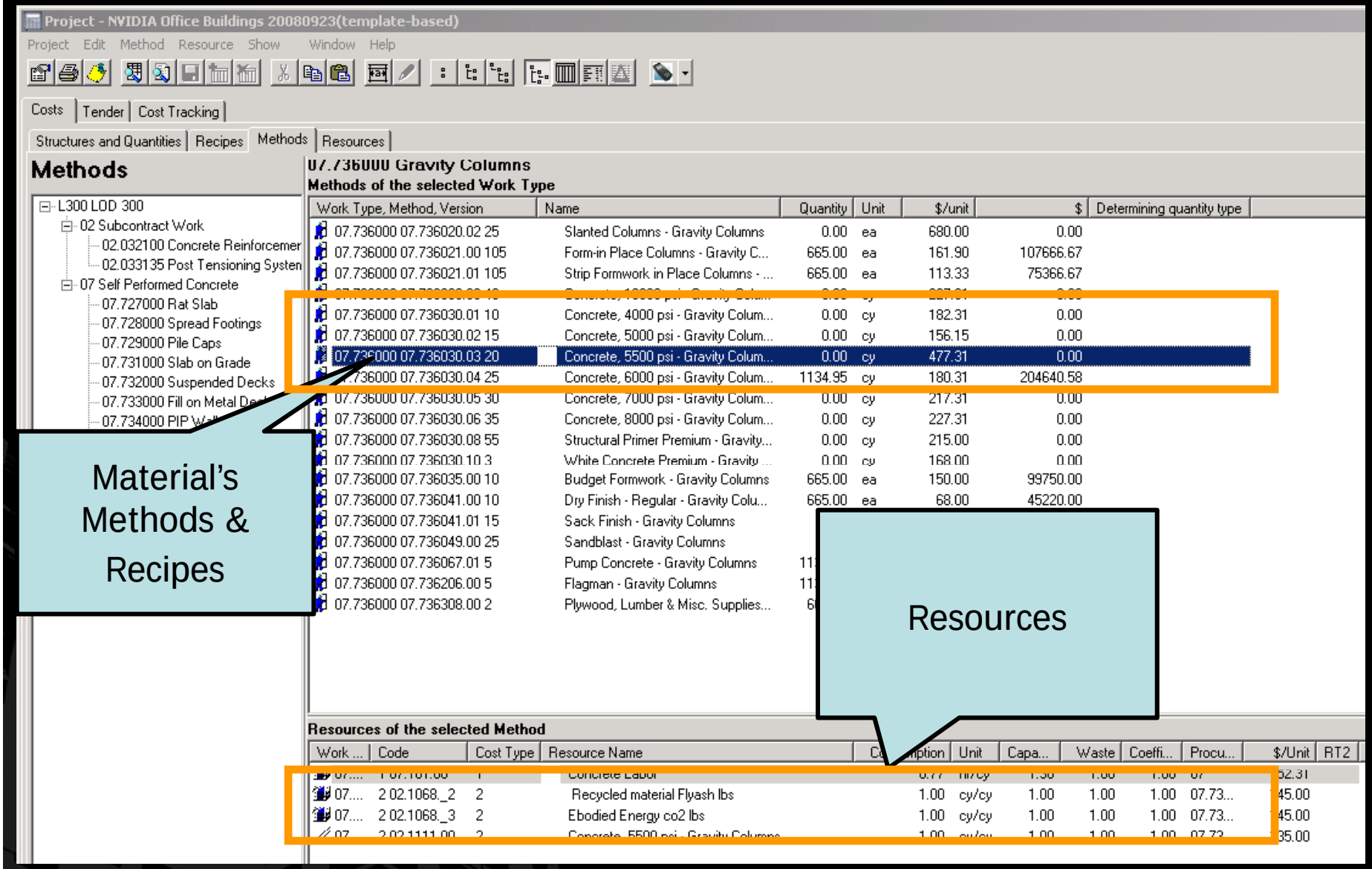
CREATING ACCURATE CARBON FOOTPRINT CALCULATORS

Webcor's internal Carbon calculator allows us to build systems by component to gain the most accurate Carbon numbers and GWP figures

Slab On Grade	0	0	0	0	0	0
Bees I.D.	**Item Name**	**Unit measure**	**GWP (g carbon)**	**Embodied Energy (MJ)**	**Smog (g)**	**Water Use (L)**
A1030A	Generic 100 % Portland Cement	ft^3	12910.53806	167.1	45.9	17.55
A1030B	Generic 15 % Fly Ash Cement	ft^3	11899.44863	161.7	43.2	16.77
A1030C	Generic 20 % Fly Ash Cement	ft^3	11561.94862	159.9	42.3	16.5
A1030D	Generic 20 % Slag Cement	ft^3	11691.03802	161.7	42.6	16.5
A1030E	Generic 35 % Slag Cement	ft^3	10806.78799	157.8	40.2	15.69
A1030F	Generic 50 % Slag Cement	ft^3	9892.537959	153.9	37.8	14.88
A1030G	Generic 5 % Limestone Cement	ft^3	12573.03805	165.3	45	17.28
A1030H	Generic 10 % Limestone Cement	ft^3	12573.78805	165.3	45.3	17.49
A1030I	Generic 20 % Limestone Cement	ft^3	12604.71686	165.6	45.6	18.03
A1030J	Lafarge Silica Fume Cement	ft^3	18530.55636	204.6	45.6	16.02
A1030K	Anonymous IP Cement Product	ft^3	10160.27298	157.8	38.7	15.18
A1030L	Lafarge NewCem Slag Cement (20 %)	ft^3	11754.03802	162.9	42.9	41.4
A1030M	Lafarge NewCem Slag Cement (35 %)	ft^3	10902.12739	159.3	40.5	59.4
A1030N	Lafarge NewCem Slag Cement (50 %)	ft^3	10050.12737	156	38.1	77.4
A1030O	Generic 35 % Fly Ash Cement	ft^3	10520.85919	154.2	39.6	15.69

Roofing Insulation						
Bees I.D.	**Item Name**	**Unit measure**	**GWP (g carbon)**	**Embodied Energy (MJ)**	**Smog (g)**	**Water Use (L)**
B3012A	Generic Blown Cellulose R-38	ft^2	190.702374	2.577123747	2.0775899	4.2742624
B3012B	Generic Fiberglass Batt R-38	ft^2	189.1872193	3.57348972	2.3542638	0.002557598
B3012C	Generic Blown Mineral Wool R-38	ft^2	409.3684368	8.681	4.37	0.217
B3012D	Generic Blown Fiberglass R-38	ft^2	179.489787	2.322494385	2.2940163	0
B3012E	Anonymous R-38 Product	ft^2	507.7677008	13.118	8.56	2.01

MATERIAL RECIPES TO ACCURATE CARBON CALCULATION



CUSTOMIZED CARBON FOOTPRINTING ANALYSIS

Proposed Buildings		
Total Building GWP (lbs)	Lowrise 02-W-01	Highrise 21-0-04
Base Case	3679087	23761933
Green Case	1543913	17944946
Super Green		
% of GWP Saved (base-green)	58.04%	
% of GWP Saved (base-super green)	59.83%	

GWP per Unit (lbs)	Lowrise 02-W-01	Highrise 21-0-04
Base Case	66892	214071
Green Case	28071	161666
Super Green	26871	138547
% of GWP Saved (base-green)	58.04%	24.48%
% of GWP Saved (base-super green)	59.83%	35.28%

Total Building	Base Case	Green Case
midrise A	2227998	1278826
midrise B	8320228	5067196
midrise total	10548225	6346021

GWP per Unit	Base Case	Green Case
midrise A	69625	39963
midrise B	141021	85885
midrise total	210646	125848

Lowrise 02-W-01	Base Case	Green Case
Collumns & Beams	133440	113980
Exterior Walls	1047286	173408
Interior Walls	78479	60975
Intermediate Floors	445495	275220
Windows	979291	739436
Roofing	995096	114872
Total Building	3679087	1477890

Midrise A 08-E-01	Base Case	Green Case
Collumns & Beams	85824	73308
Exterior Walls	823914	136422
Interior Walls	123188	201850
Intermediate Floors	286527	177012
Windows	770422	581724
Roofing	138123	108509
Total Building	2227998	1278826

Midrise B 08-E-01	Base Case	Green Case
Collumns & Beams	1698314	
Exterior Walls	498479	
Interior Walls	337055	304401
Intermediate Floors		978404
Windows		2736345
Roofing	444892	158191
Total Building	8320228	5067196

Highrise 21-0-04	Base Case	Green Case
Collumns & Beams	5322863	3013738
Exterior Walls	1167427	849583
Interior Walls	1901330	1717156
Intermediate Floors	8165066	3066518
Windows	6408457	6408457
Roofing	796790	323278
Total Building	23761933	15378729

Proposed Buildings		Global Warming	Potential (GWP)
Total Building GWP (lbs)	Lowrise 02-W-01	Midrise 08-E-01	Highrise 21-0-04
Base Case	3679087	10548225	23761933
Green Case	1543913	6997159	17944946
Super Green	1477890	6346021	15378729
% of GWP Saved (base-green)	58.04%	33.67%	24.48%
% of GWP Saved (base-super green)	59.83%	39.84%	35.28%

Highrise 21-0-04	Base Case	Green Case	Green Case
Collumns & Beams	5322863	5322863	3013738
Exterior Walls	1167427	1047486	849583
Interior Walls	1901330	1717156	1717156
Intermediate Floors	8165066	3066518	3066518
Windows	6408457	6408457	6408457
Roofing	796790	382467	323278
Total Building	23761933	17944946	15378729

Webcor's Carbon calculator compares building systems resulting in the most accurate Carbon figures

INNOVATION: ALTERNATIVE MATERIALS

- Improved Drywall Options – Eco-Rock, Carbon-Neutral drywall product
- Integrity Block – CMU block alternative made with 50% pre-recycled content and requires 40% less energy to manufacture
- Vertical “PT” solutions
- Sudaglass – non-ferrous concrete reinforcement, basalt-based fiber technology
- Serious Materials – advanced eco-friendly ***materials*** for sustainable development

INNOVATION: NEW PRODUCT SOLUTIONS

- Sustainable Form Inclusion Systems reducing which reduce cement volume in concrete mix designs and utilize slab alternatives such as Bubble Deck, styrofoam, recycled plastics, rubber tires, wax cardboard, etc…options
- iCrete Products – mix design identifies appropriate aggregate distribution to reduce cement use up to 30%
- Strategic relationship with Venture Capital firms: Navitas Capital

NAVITAS CAPITAL™

INNOVATION: NEW STRUCTURAL SYSTEMS

Greater structural efficiency and longevity focused on reducing the CARBON FOOTPRINT and increasing livability of buildings

- Vertical “PT” solutions – reducing steel rebar in structural concrete by 45%
- High strength concrete (5,000 psi vs. 15,000 psi)
- Reduced material (sand aggregate and steel)
- Reduced cement (CO2)
- SFIS (Sustainable form inclusion systems) utilizing “waste stream”….Styrofoam, recycled plastics, rubber tires, etc…options… to displace concrete

INNOVATION: ADVANCING TECHNOLOGIES

- Adura Wireless Lighting Controls
- Wireless HVAC controls
- GE Zenon Water Products – onsite gray, black and rain water filtration systems
- Skywater products – dehumidifier condenser unit creates potable water
- Valence Energy – lithium phosphate energy storage solutions
- Finelite – high-performance, energy efficient illumination
- Control4 – innovative home automation solutions

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Control 4
Everyday Easy™

SIMPLIFIED & MORE ACCURATE LEED DOCUMENTION

Database vs. Paperwork

CONCEPT – DESIGN – SUSTAINABLE REALITY