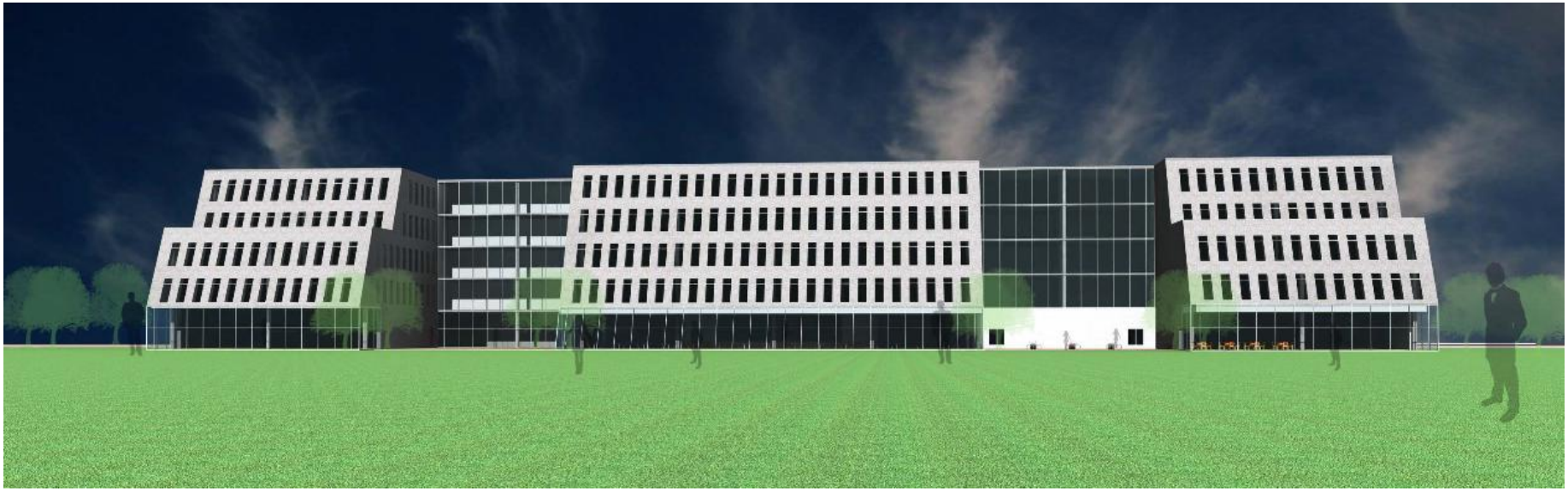
IPRO 335 Green Building Design Concepts and Integration



Problem Statement

Why is there a need for a green building?

How can green building design be achieved in a cold climate city like Chicago?

How can the occupants benefit from a well designed building?

What it means to Build Green

Reduce resource consumption of buildings

Reduce environmental impact

Create better living and working spaces

Agenda

- Integrate alternative sources of energy
- Design a better working space
- Reduce overall energy consumption
- Make building financially attractive through savings.
- Achieve LEED Platinum certification

Team Values

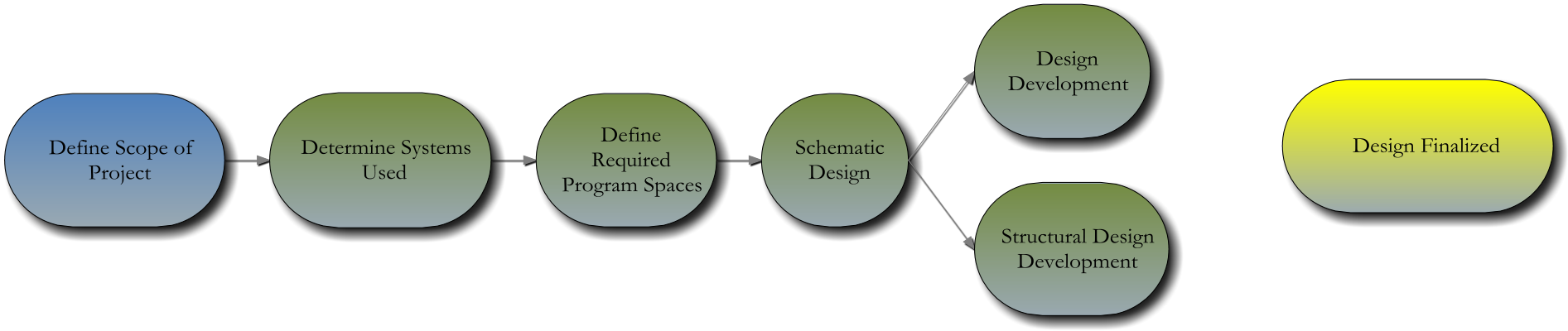
- Clear communication between disciplines
- Team cooperation
- Create an efficient and innovative design
- Gain experience in “Green” design concepts

Organization

Architects	Engineers
Eric Dexter	Aris Avanessian
Adrian Thovar Leon	Andrew Mey
Jacqueline Schaefer	Jonathon Okunaga
Justine Banda	Ali Razeq
Kibum Kim	Joshua Bergerson
Hye Um	
Jeffrey Burke	
Robert Christo	

Architectural Design

The Design Process



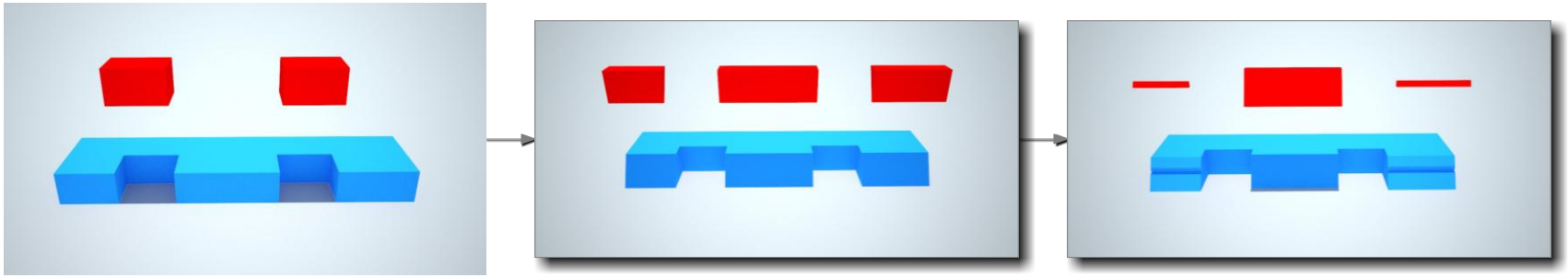
Concept- Design that is Based on the Needs of the Green Systems to be implemented

Site Selection- Vacant Lot At North and Grand

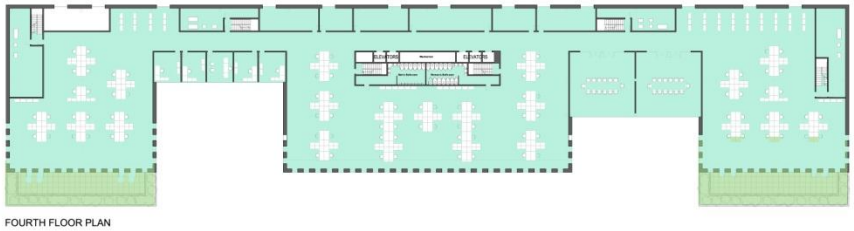
Structure Type- Precast Concrete System

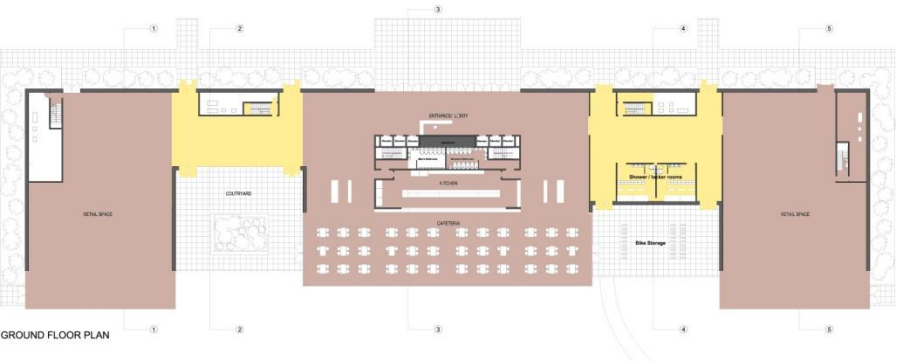
Program- Office Space 2nd- 5th and Retail on 1st Floor
Open Floor Plan For Flexibility

The Building



Massing Diagrams

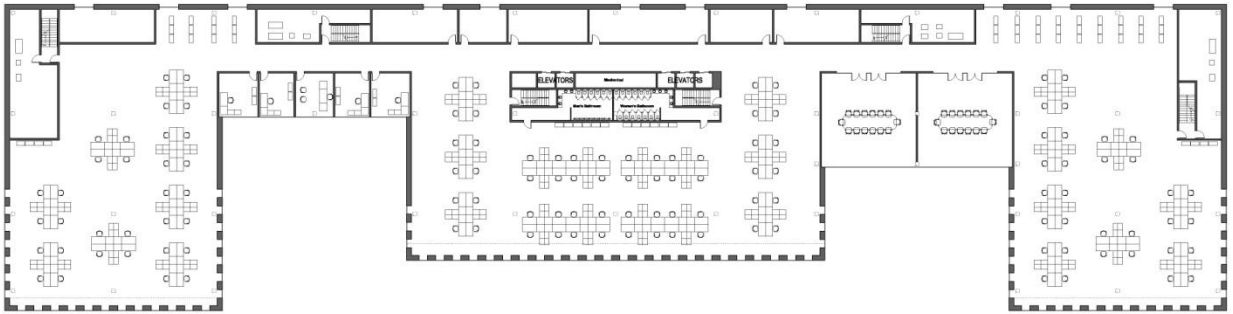




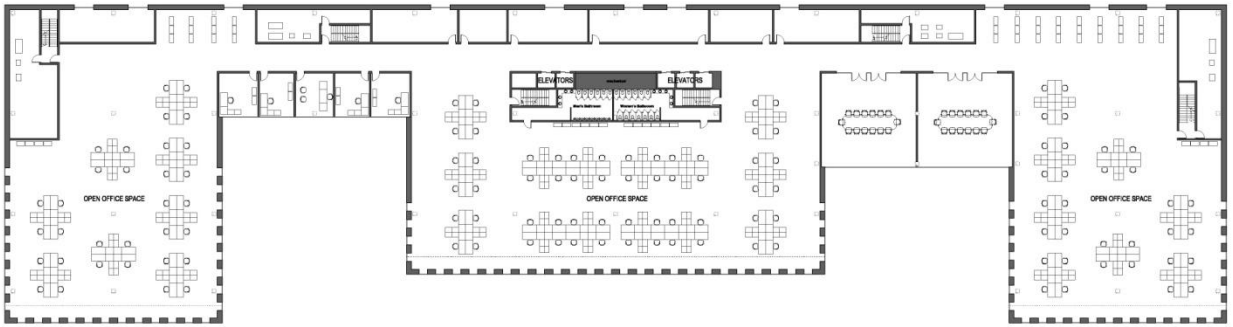
Floor Plans

2nd -5th floor office space
North side is storage
South Side is office To receive the most Daylight

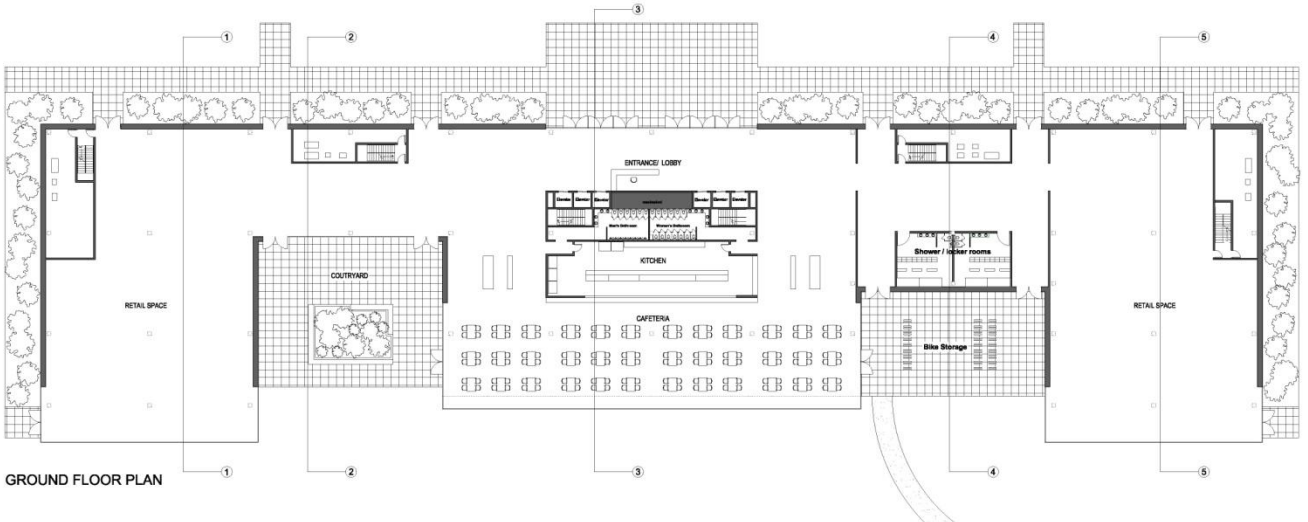
Ground Floor Retail and Food Court
Building Entry on North Side
Thick Walls that Act as A Thermal Mass



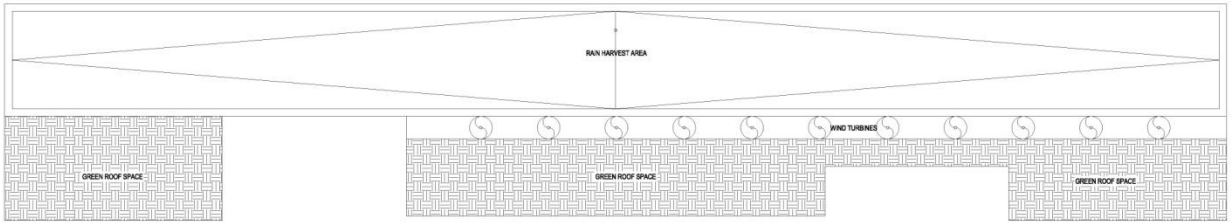
THIRD FLOOR PLAN

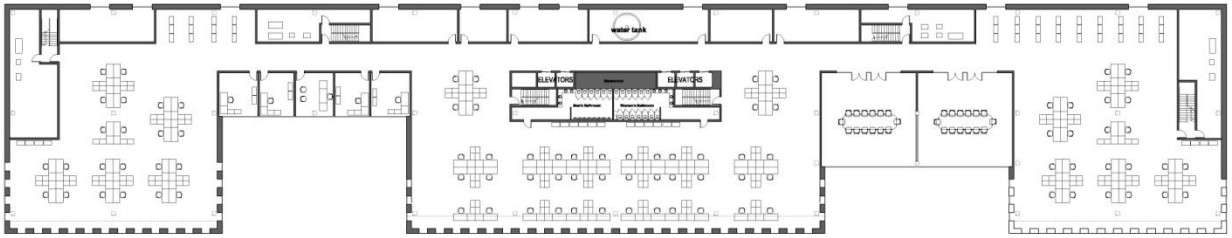


SECOND FLOOR PLAN

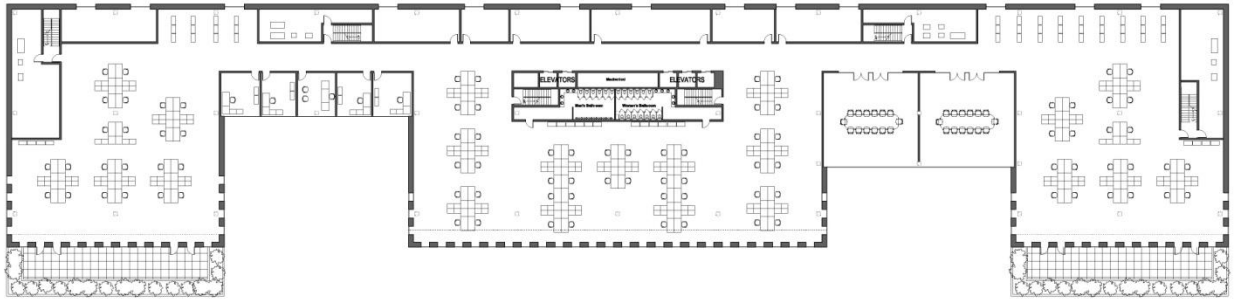


GROUND FLOOR PLAN

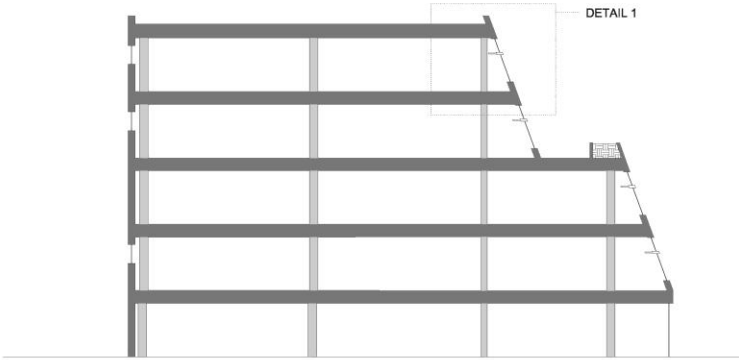




FIFTH FLOOR PLAN



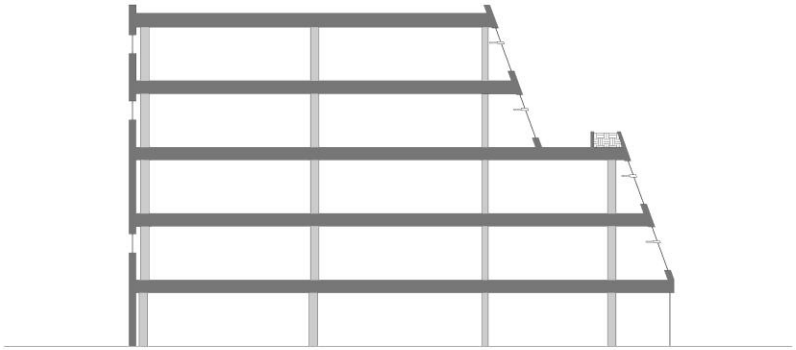
FOURTH FLOOR PLAN



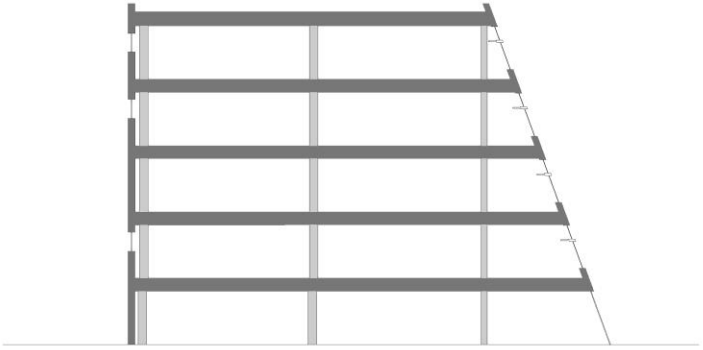
CROSS SECTION 5

CROSS SECTION 2

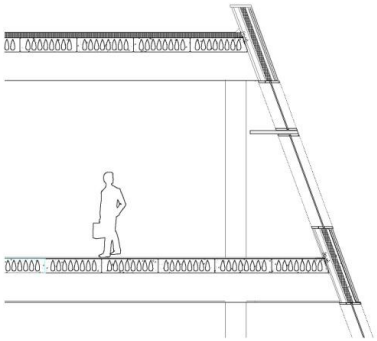
CROSS SECTION 4



CROSS SECTION 1



CROSS SECTION 3

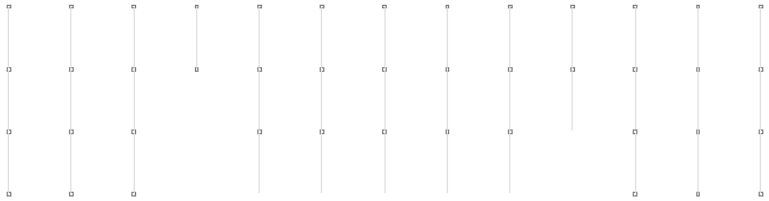


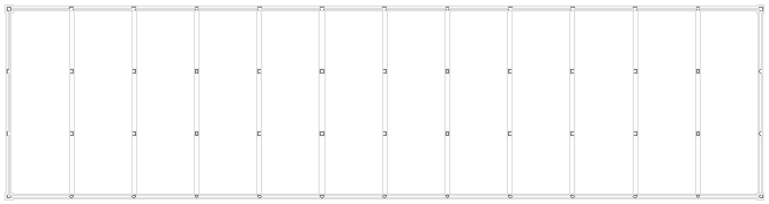
WALL SECTION DETAIL

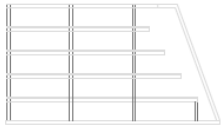
Structural Design

Structural Overview

- All members precast by Spancrete
- Frame: 40’ bays w/ Beams in N/S Direction
- 1-Way Floor System

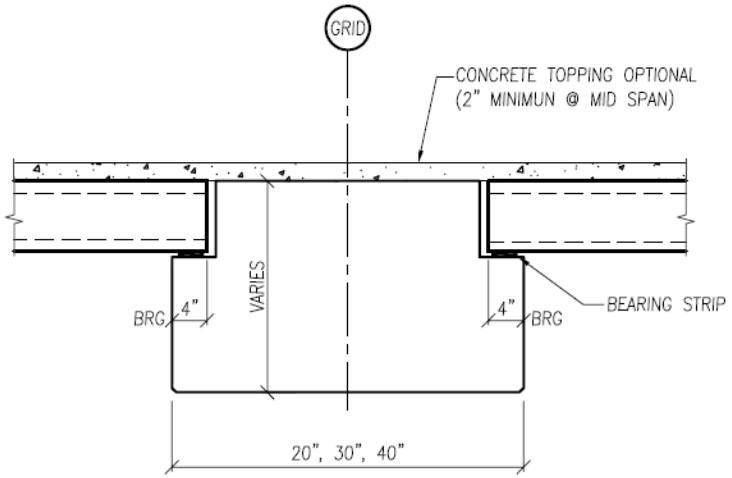






Structural Members

- Columns: 2’ x 2’ Reinforced
- Beams: Inverted Double Tees
- Floor Slabs: 12” Hollowcore
- Load-Bearing Walls on E/W edges



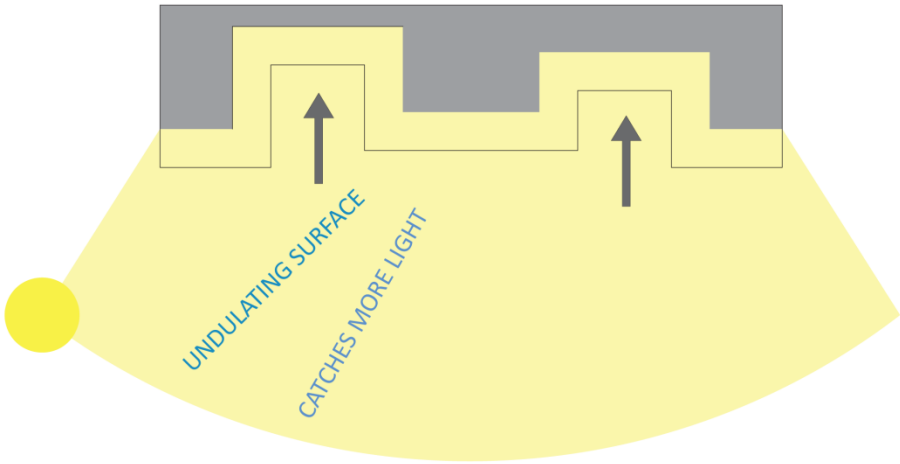
Why Precast???

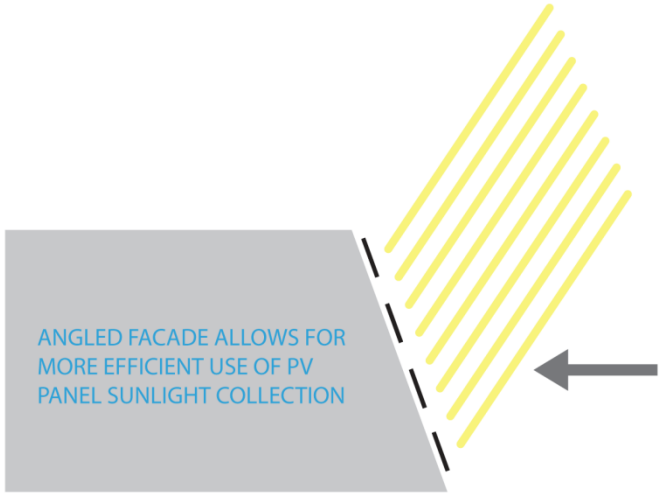
Shorter Construction Time
Easier Construction
Simplified, Flexible Design
More Efficient Use of Materials

Total Cost of Structure: $5,091,000

Day Lighting
&
Photovoltaic Panel Design

Passive Day Lighting and Photovoltaic Panel Design



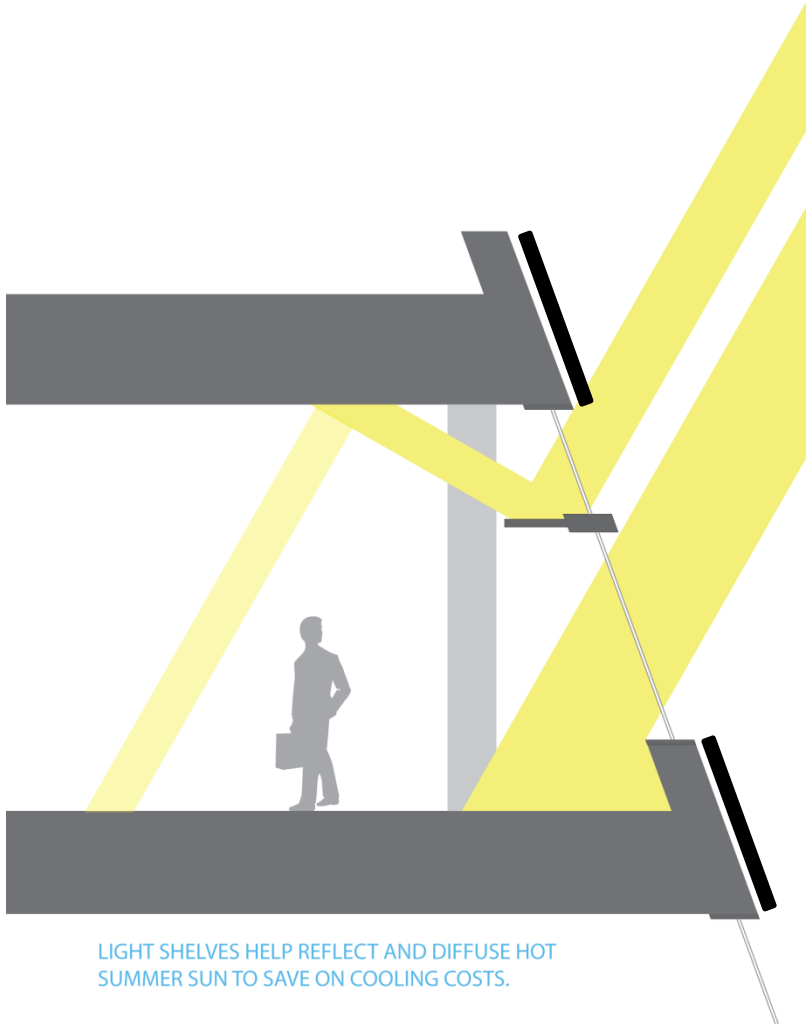


The passive solar strategies implemented in the building include an exterior envelope which maximizes the area of sunlight received, and an angled south façade which positions the photovoltaic panels which cover it at a more efficient angle to capture sunlight.

Natural Daylighting

LEED day lighting factor criteria:
Minimum daylight factor if 2% for 75% of normally occupied spaces.
To determine required area of aperture for windows
(ex. West open office section on third floor):

A = (DF target)(Floor Area) / Aperture Effectiveness factor
A = (.025)(7707 sq. ft) / .2
A = 966.4 sq. ft.
Our windows are 40” wide by 10’-10” tall. There are 31 in this area of the building.
3.33’ x 10.83’ x 31 = **1117.9 sq. ft > 966.4 sq. ft.**
Natural light exceeds the requirements by the LEED day lighting guidelines.



Photovoltaic Panels

SolarWorld SW 230, 230 Watt Monocrystalline Solar Panel

20,265 SF of Solar panel area on the south facade
230 Wp per panel at STC
Each panel is 18 SF
20,265 / 18 = 1125 panels
4.5 kWh/m2/day from PV solar radiation graph
Insolation Percent: 18.75%
kWh/panel = (230Wp x .1875 x 87600h)/1000 = 377.78 kWh/panel
1125 panels x 377.78 kWh/panel = 425,000 kWh
$793 per panel
$892,125 total

Provides 18% of the entire building's energy.

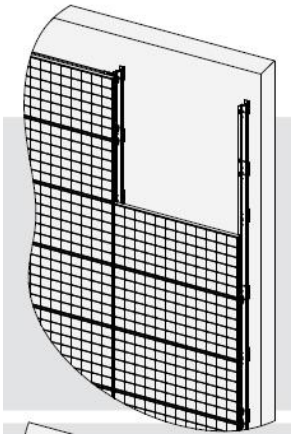
Sunmodule
SW 220/230 mono

Performance under standard test conditions

		SW 220	SW 230
Maximum power	P_{max}	220 Wp	230 Wp
Open circuit voltage	V_{oc}	36.6 V	36.9 V
Maximum power point voltage	V_{mpp}	29.3 V	29.6 V
Short circuit current	I_{sc}	8.18 A	8.42 A
Maximum power point current	I_{mpp}	7.51 A	7.76 A

Performance at 800 W/m², NOCT, AM 1.5

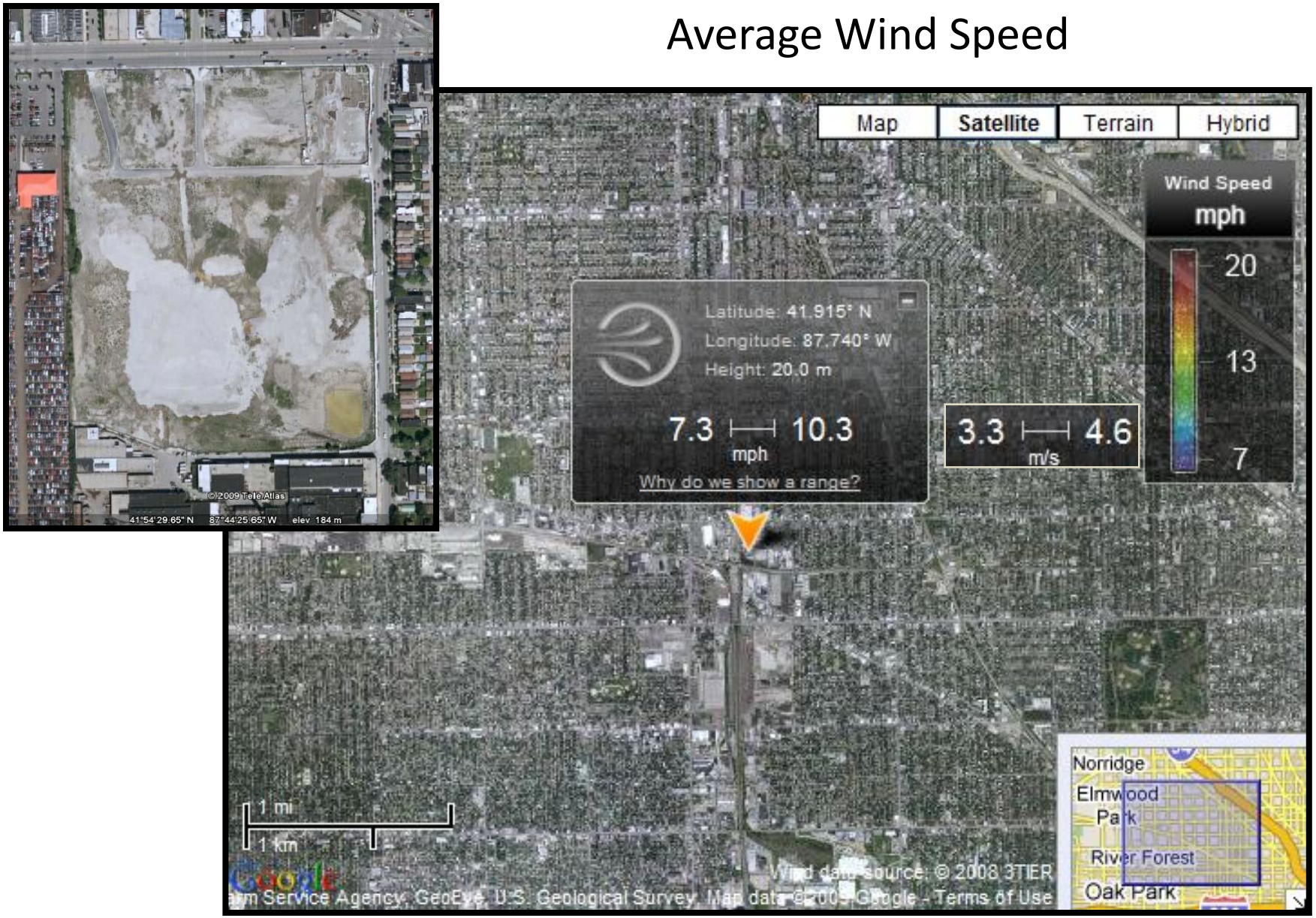
		SW 220	SW 230
Maximum power	P_{max}	157 Wp	164 Wp
Open circuit voltage	V_{oc}	33.1 V	33.4 V
Maximum power point voltage	V_{mpp}	26.3 V	26.6 V
Short circuit current	I_{sc}	6.76 A	6.96 A
Maximum power point current	I_{mpp}	5.98 A	6.18 A



Used as a rain screen cladding on South façade.

Wind Turbine Design

Average Wind Speed



Data from: http://firstlook.3tier.com/

Annual Wind Energy Production

- Assuming 34000 sq ft of 1st floor retail space
- Based on 12900 BTU/sq ft=3.78 kWh/sq ft for energy efficient lighting.
- Energy demand for lighting 1st floor retail space=128520 kWh/year
- Goal is to provide 1/3 of energy demand for lighting retail space.
- This amount would also be approximately 1% of the total energy use (LEED points).
- Required production to meet goal = 42840 kWh

Turbine Used

- Urban Green Energy 4Kw 2nd Gen
  - Cost: $21920 ea
  - Average Annual Energy Production: 4000kWh/turbine
  - Specs: 9’ x 11’,

    770 lbs
  - Need: 11
  - Break even point: 18 years.
  - 44,000 kWh annually

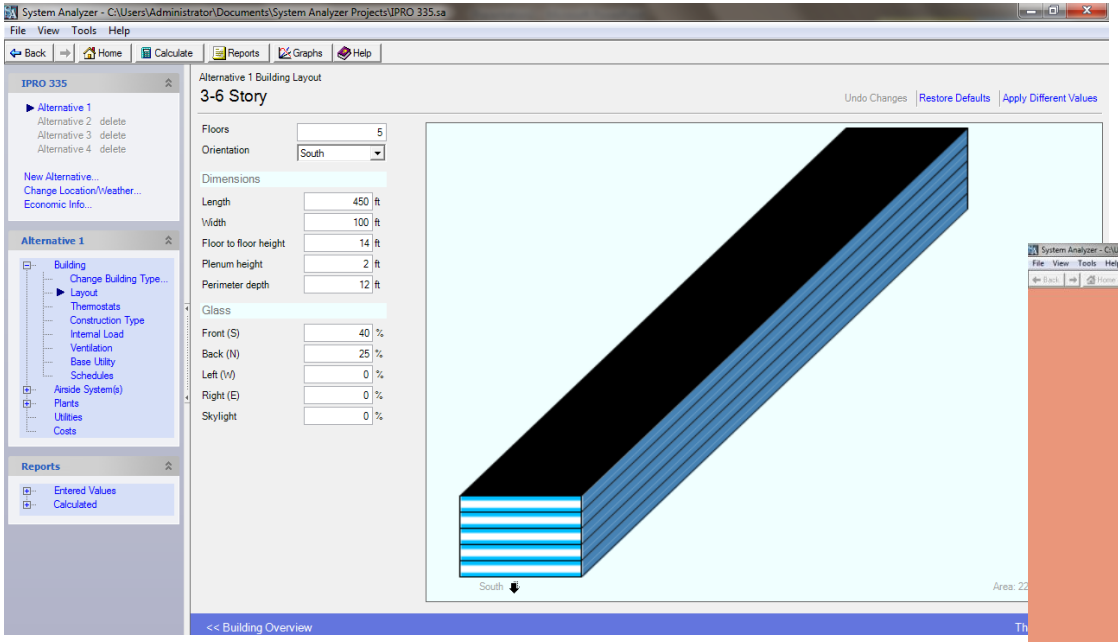
Geothermal System

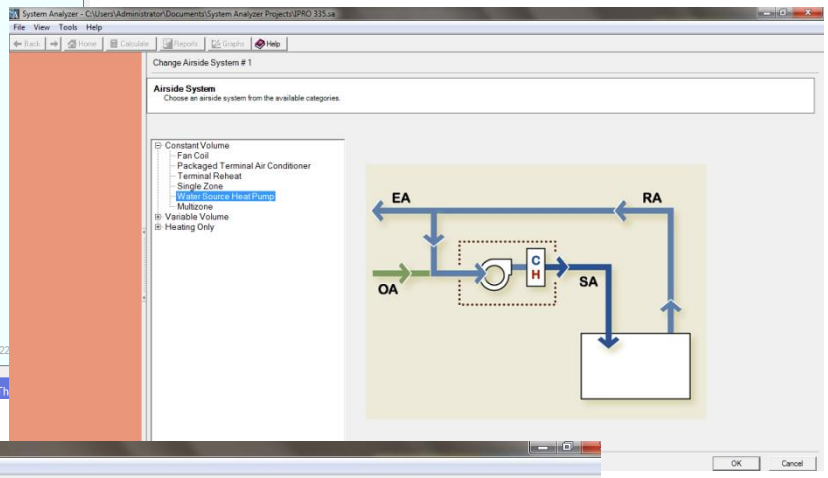
Background Information

- Location: Chicago
  - Average High Temperature: 83.7˚F in July*
  - Average Low Temperature: 12.9˚F in January*
  - Annual Heating Degree Days: 6536*
  - Annual Cooling Degree days: 752*
  - Average Ground Temperature: 51.1˚F (Average Depth of 250-300 ft.)
- System
  - Vertical Closed Loop
  - Decentralized
  - Liquid to Air
    - Duct system with multiple heat pumps throughout

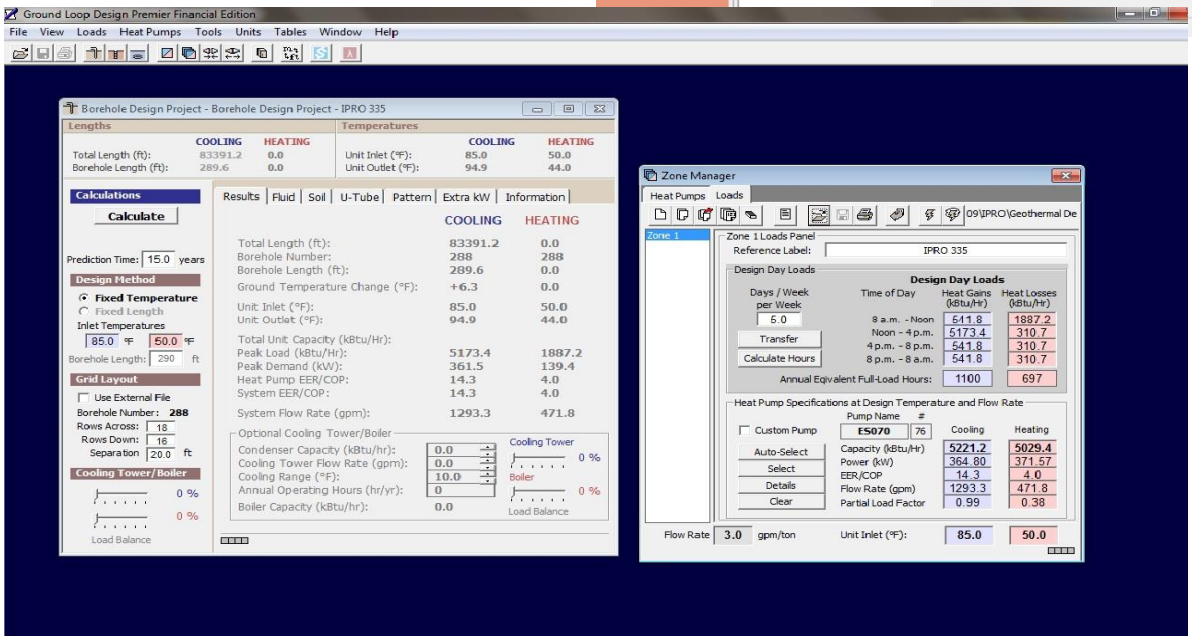
*Source: http://www.climate-zone.com/climate/united-states/illinois/chicago/

Trane System Analyzer





Ground Loop Design 2009



Heating – Cooling Loads
Gains & Losses

Time of Day	Heat Gains [kbtu/hr]	Heat Losses [kbtu/hr]
8 A.M. – Noon	541.8	1887.2
Noon – 4 P.M.	5173.4	310.7
4 P.M. – 8 P.M	541.8	310.7
8 P.M. – 8 A.M.	541.8	310.7

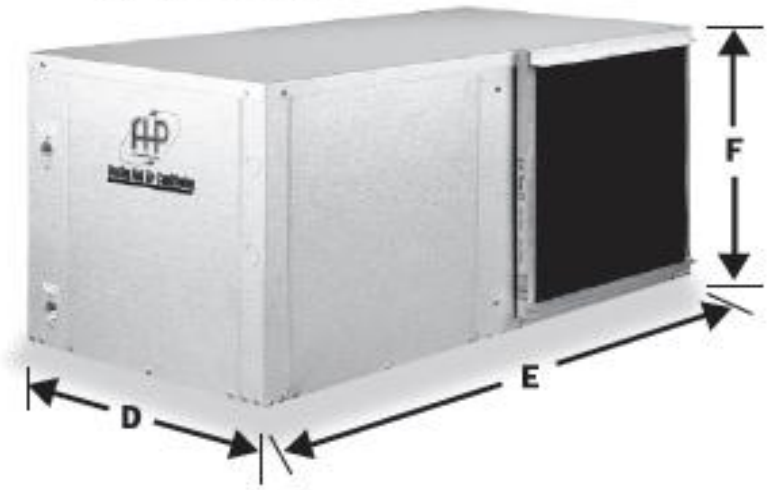
- Days Occupied Per Week: 5
- Annual Equivalent Full Load Hours
  - Heating: 697
  - Cooling: 1100

Heat Pump

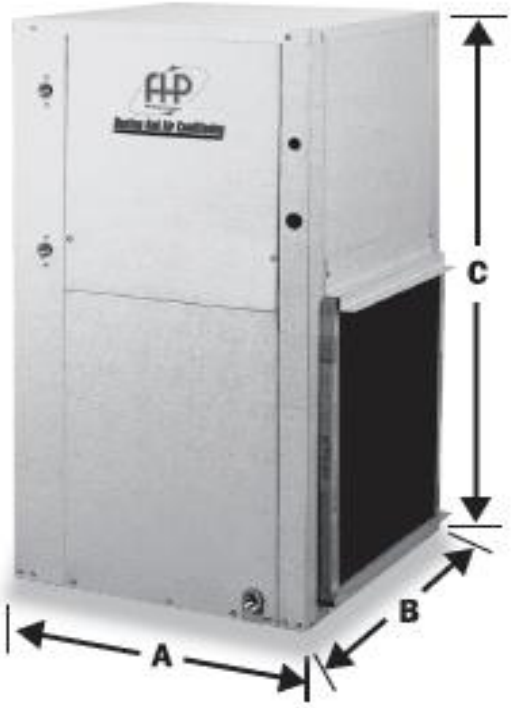
- Pump Manufacturer: Florida Heat Pump
- Pump Series: ES Series R-410 A
- Pump Type: Water to Air
- Pump Name: ES 070
- Capacity:
  - Cooling: 5221.2 kBtu/hr
  - Heating: 5029.4 kBtu/hr
- Power:
  - Cooling: 364.80 kW
  - Heating: 371.57 kW
- Number of Units: 76
  - Horizontal, Vertical, Ceiling Mounted

VERTICAL

HORIZONTAL



COUNTERFLOW



DIMENSIONS						
MODEL	VERTICAL/C. FLOW			HORIZONTAL		
	WIDTH	DEPTH	HEIGHT	WIDTH	LENGTH	HEIGHT
	A	B	C	D	E	F
ES018	21.50	21.50	40.25	25.50	43.00	21.75
ES024	21.50	21.50	40.25	25.50	43.00	21.75
ES030	21.50	26.00	47.25	26.00	54.50	21.75
ES036	21.50	26.00	47.25	26.00	54.50	21.75
ES042	24.00	32.75	47.25	30.00	68.00	21.75
ES048	24.00	32.75	47.25	30.00	68.00	21.75
ES060	26.00	33.25	51.25	30.00	68.00	21.75
ES070	26.00	33.25	58.25	30.00	78.00	21.75

All ratings & specifications are subject to change without notice.

Ground Loops

- Cooling Mode Dominant
  - Total Length: 83,391.2 Feet
  - Borehole Number: 288
    - 289.6 Feet per Borehole
    - 18 X 16 Grid Arrangement
    - 20 Foot Separation
    - 1.25 Inch Polyethylene Piping
    - Parallel Circuits with one borehole per circuit
  - Approximately 430 Ton Capacity (1516 kW)

Long Term Financial Analysis

NPV Lifecycle Costs ($) - 15 years

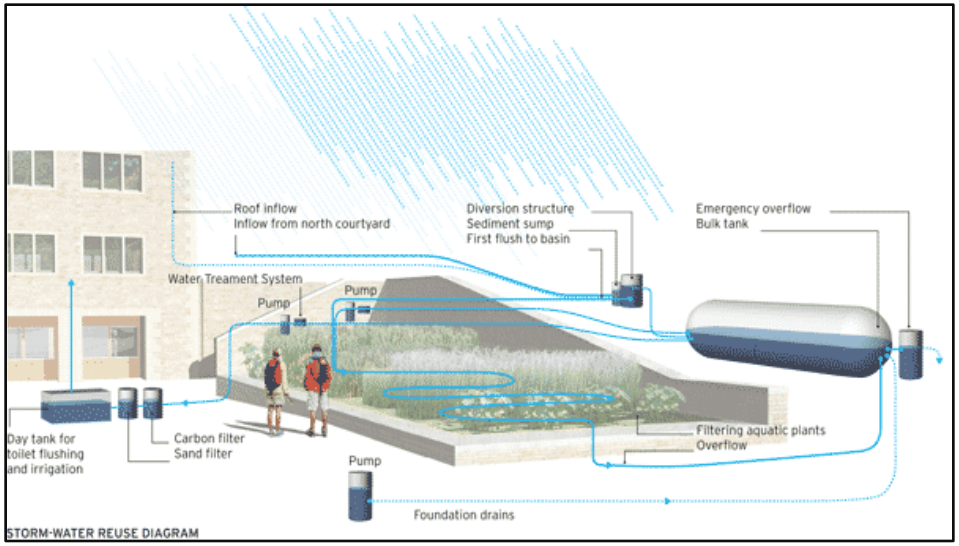
	Geothermal	Air-cooled Chiller / Boiler	Savings
Total Power:	630,454.70	967,354.56	336,899.86
CO2 Emissions:	74,111.17	89,038.31	14,927.14
CO2 (tons):	*4,453.1*	*5,350.0*	*896.9*
Water:	0.00	0.00	0.00
Water (Gallons):	*0.0*	*0.0*	*0.0*
Maintenance:	269,677.08	2,022,578.07	1,752,900.99
Mechanical Room Lease:	12,734.75	8,989.24	-3,745.51
Installation:	1,373,500.00	1,221,000.00	(152,500.00)
Tax Incentives:	(137,350.00)	0.00	137,350.00
Salvage:	(6,496.59)	(20,789.10)	(14,292.51)
TOTAL:	**2,216,631.11**	**4,288,171.07**	**2,071,539.96**

Simple Payback is approximately 1 year.

Rainwater Harvesting System

Rainwater Harvesting System

-**Rainwater harvesting** in urban areas and cities can have diverse benefits.
Providing supplemental water for the city′s requirements, increasing soil moisture levels for urban greenery, increasing the ground water table through artificial recharge, mitigating urban flooding and improving the quality of groundwater are a few of the many benefits.
Our idea is to reuse the collected rainwater for flushing toilets throughout the building.
By addopting the rainwater harvesting system our building saves **430800 gallons of rainwater every year which is saving 11.82% of flushing water.**



Rainwater Harvesting System

-Size Calculations

	Light duty ferrocement	
Tank volume	3000.00	gallons
Height	6.00	feet
Wall thickness (av)	1.00	inches
Roof thickness	1.00	inches
Floor thickness	3.00	inches
Roof rise/tank diameter	0.10	ratio
Floor beyond walls	1.00	inches
Density of material	100.00	lbs/ft3
Hoop spacing	6.00	inches
Major reinforcing diameter	0.13	inches
Diameter	9.23	feet
Diameter/ height	**1.54**	**ratio**
Volume	401.02	Cubic feet
Volume under roof	31.24	Cubic feet
Volume under roof	233.72	Gallons
Total volume	**432.26**	**Cubic feet**
Radius	4.61	Feet
Roof rise	0.92	
Circumference	28.98	Feet
Roof area	66.84	Square feet
Wall area	173.87	Square feet
Total stucco area	240.70	Square feet
Floor area	69.27	Square feet
Total area	**309.98**	

-Cost Calculations

Material	**Unit cost**		**3000 gal**
3/8” rebar (20’ pieces)	$3.11	30	$93.30
1/2” rebar (20’ pieces)	$4.98		$0.00
Lath (27”x8’ pieces)	$5.36	27	$144.72
6x6x10x10 Welded Wire Mesh (7’x200’ rolls)	$138.00	1	$138.00
1/2” Hardware cloth (4’x100’ rolls)	$39.94	1	$39.94
Tie wire (big looped bundles)	$2.60	2	$5.20
Cement (94 lb bags)	$5.65	18	$101.70
Plaster sand (yd3)	$29.50	4	$118.00
Water (gal)	$0.01	500	$5.00
Thoroseal/Bonsal Sure Coat (50 lb bags)	$19.20	7	$134.40
Color (lbs)	$2.88	5	$14.40
Hog rings (25 lb boxes)37	$38.40		$0.00
Hog ring staples (boxes of 10,000)	$10.00	1	$10.00
Dobies	$0.50	30	$15.00
Poles	$16.50	6	$99.00
Concrete (yd3)	$91.50	2	$183.00
Approx. cost ($)			**1,102**

Rainwater Harvesting System

- Energy Performance

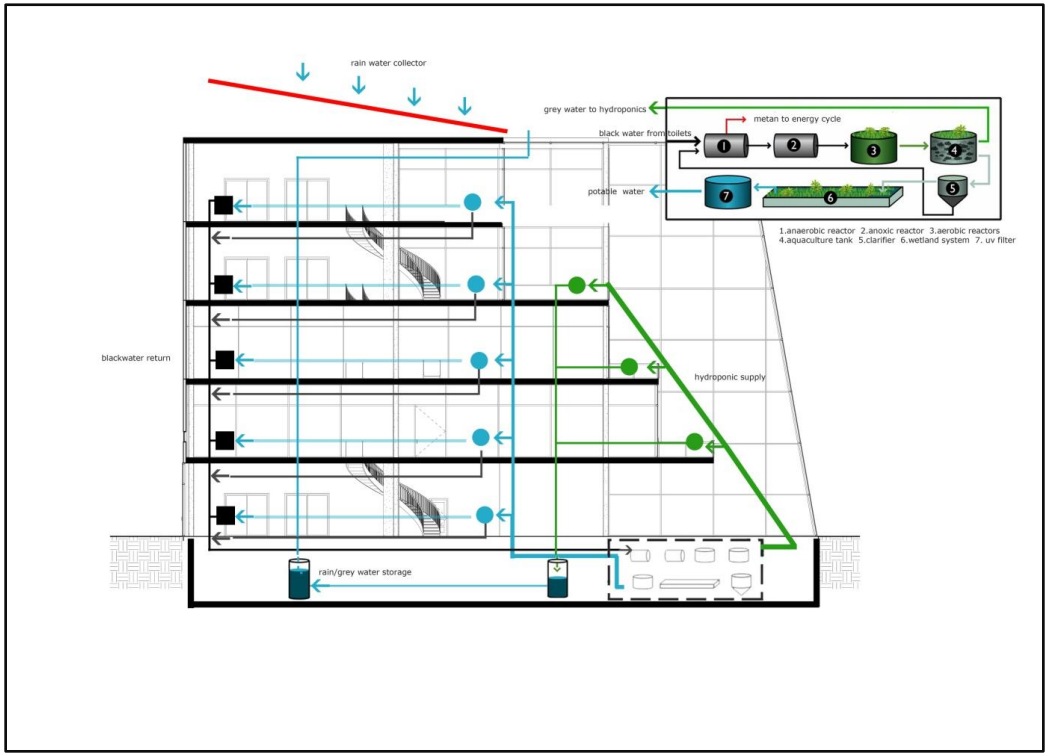
- Total building area: **221000 sf**
- Roof area**: 37000 sf**
- Rain water harvesting area**: 18700 sf**

Chicago average precipitation: **38.01 in/year**
: (3.2 in/month)

Rainwater calculator A = (catchment area of building)
R = (inches of rain)
G = (total amount of collected rainwater)
(A) x (R) x (600 gallons) / 1000 = (G)

Total amount of collected rainwater: **35900 gal/month**
Saving 430800 gallons of rainwater every year

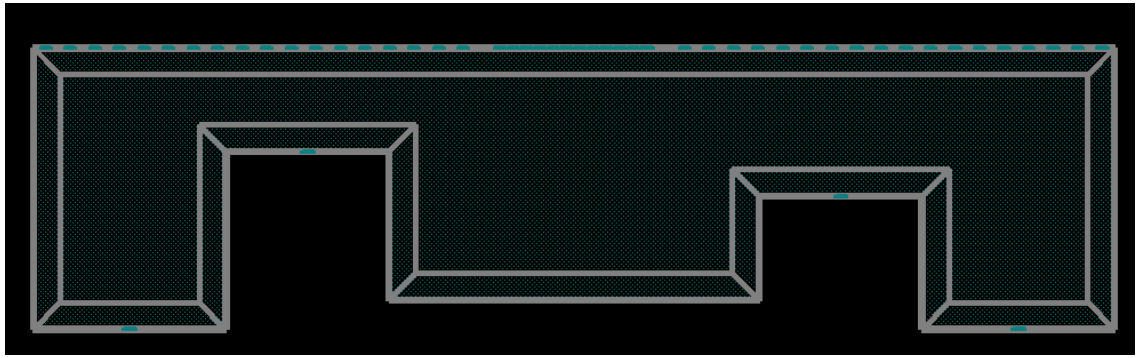
Total occupation of the building: **2750 people**
Average person uses **4.2 gal for flushing a day**
Total use of flushing water: **10150/day**
Saving 11.82% of flushing water



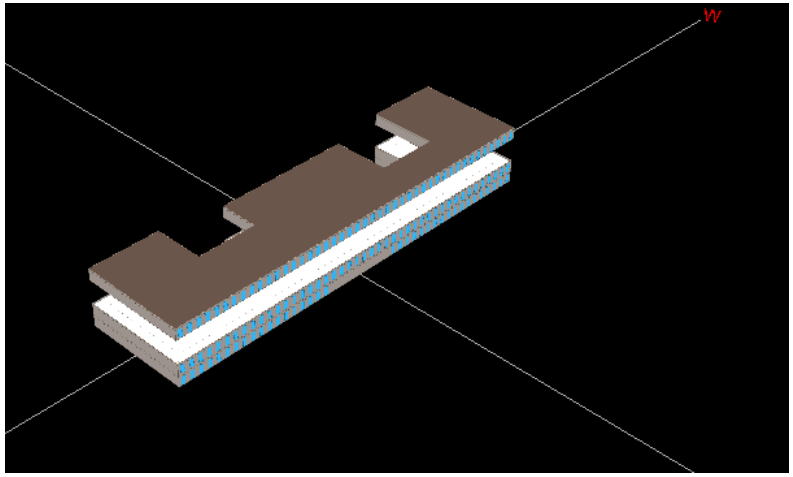
Applied system diagram

Energy Model

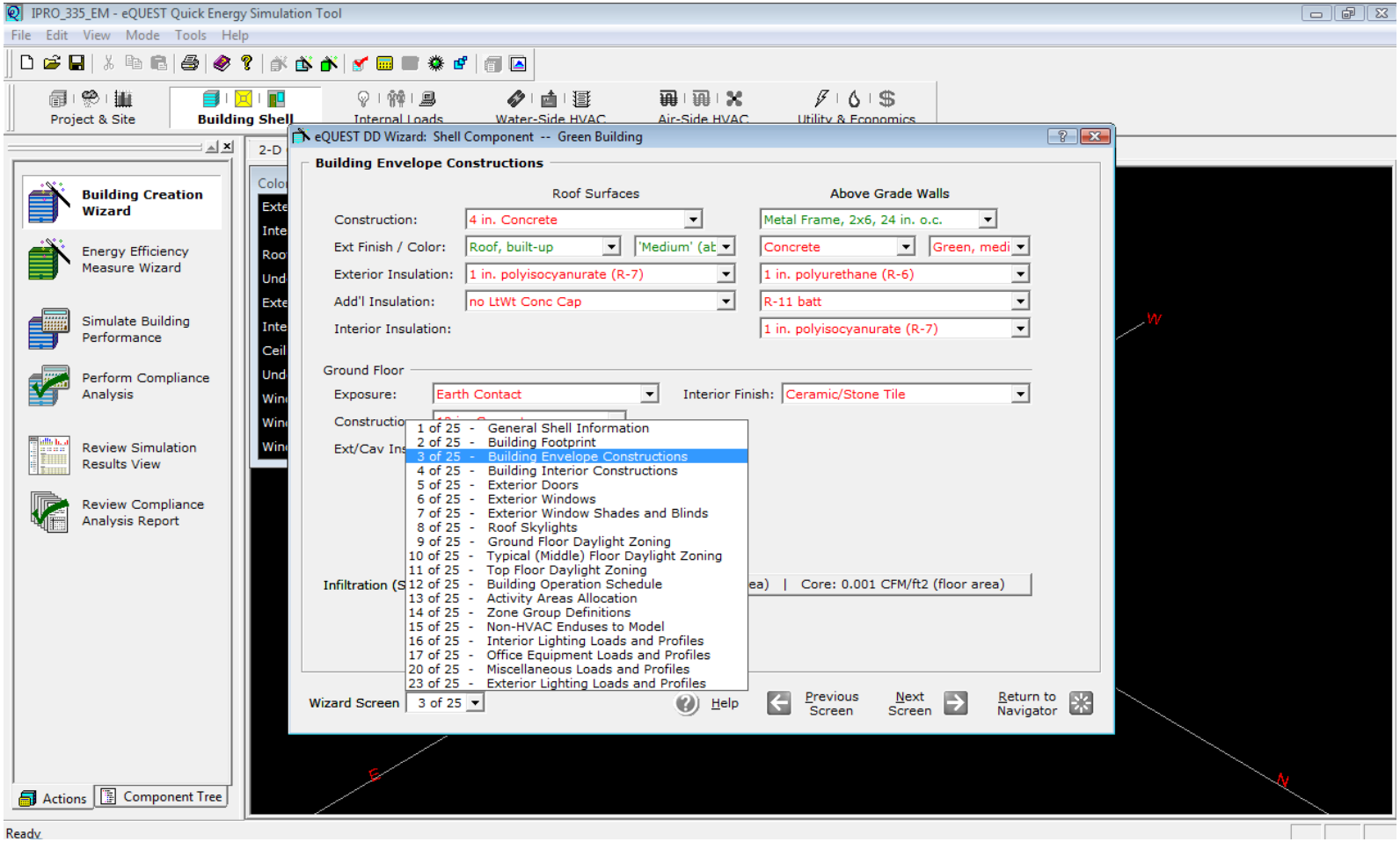
- eQuest v.3.63 used
- Imported footprint for more accurate model



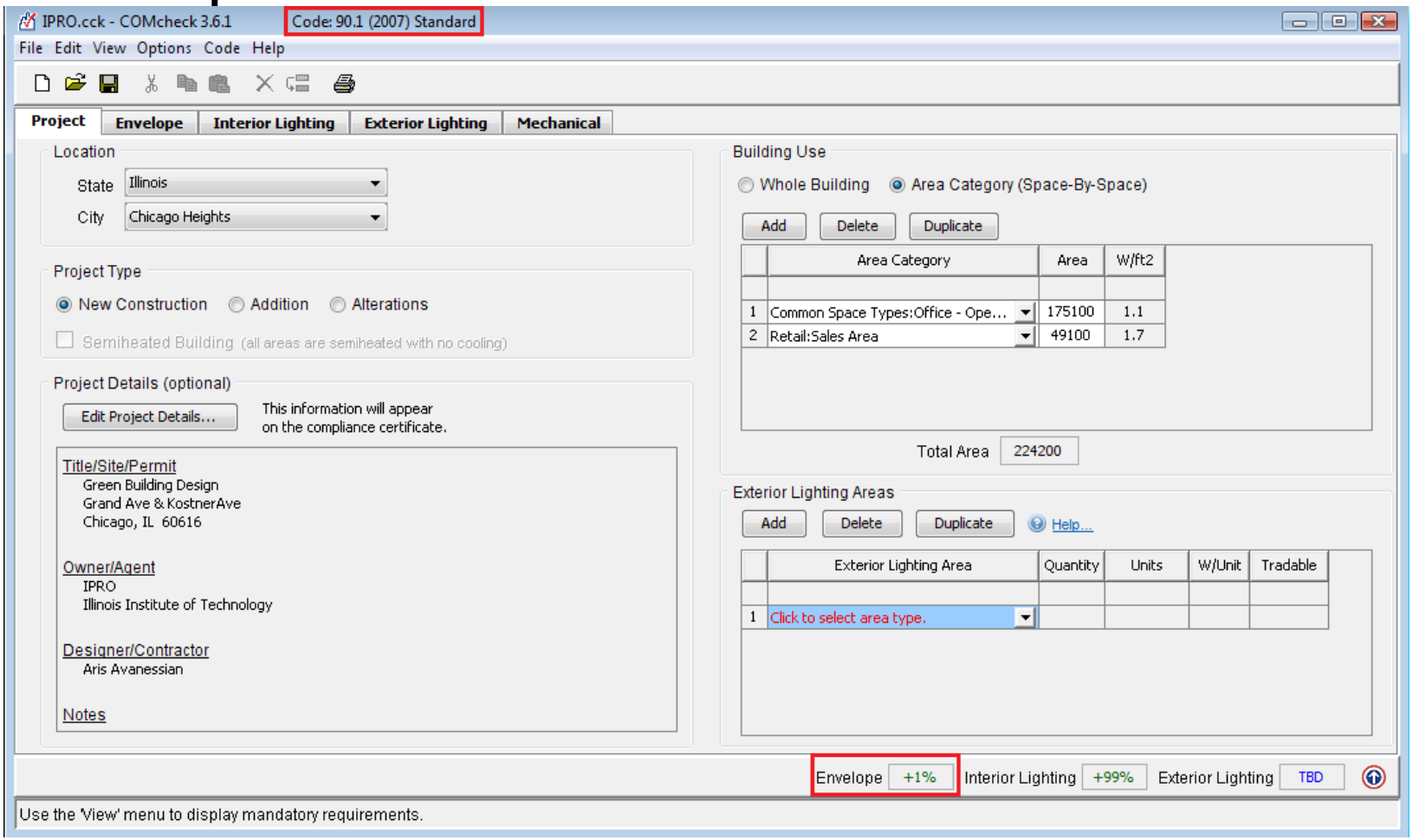
- Useful visualization tool
- Comparison charts



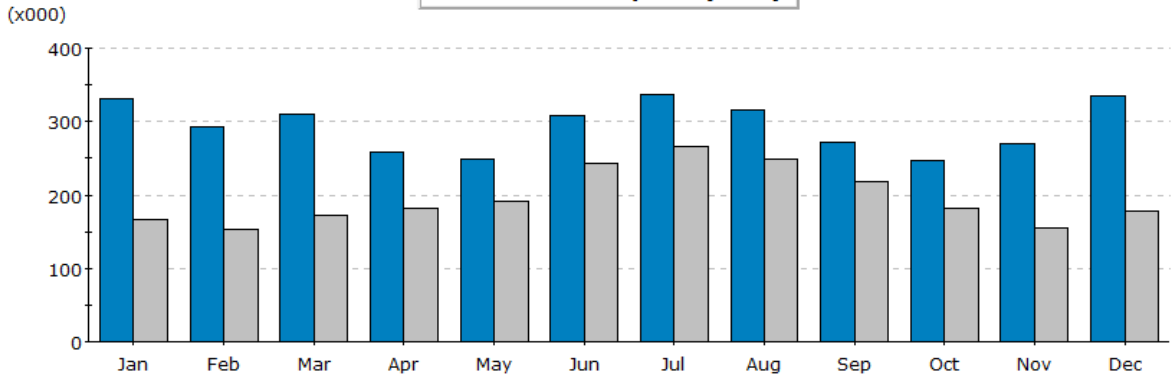
eQuest


IPRO_335_EM - eQUEST Quick Energy Simulation Tool
File Edit View Mode Tools Help
Project & Site
Building Shell
Internal Loads
Water-Side HVAC
Air-Side HVAC
Utility & Economics
Building Creation Wizard
Energy Efficiency Measure Wizard
Simulate Building Performance
Perform Compliance Analysis
Review Simulation Results View
Review Compliance Analysis Report
Actions
Component Tree
eQUEST DD Wizard: Shell Component -- Green Building
Building Envelope Constructions
Roof Surfaces
Above Grade Walls
Construction:
4 in. Concrete
Metal Frame, 2x6, 24 in. o.c.
Ext Finish / Color:
Roof, built-up
Concrete
Exterior Insulation:
1 in. polyisocyanurate (R-7)
1 in. polyurethane (R-6)
Add'l Insulation:
no LtWt Conc Cap
R-11 batt
Interior Insulation:
1 in. polyisocyanurate (R-7)
Ground Floor
Exposure:
Earth Contact
Interior Finish:
Ceramic/Stone Tile
1 of 25 - General Shell Information
2 of 25 - Building Footprint
3 of 25 - Building Envelope Constructions
4 of 25 - Building Interior Constructions
5 of 25 - Exterior Doors
6 of 25 - Exterior Windows
7 of 25 - Exterior Window Shades and Blinds
8 of 25 - Roof Skylights
9 of 25 - Ground Floor Daylight Zoning
10 of 25 - Typical (Middle) Floor Daylight Zoning
11 of 25 - Top Floor Daylight Zoning
12 of 25 - Building Operation Schedule
13 of 25 - Activity Areas Allocation
14 of 25 - Zone Group Definitions
15 of 25 - Non-HVAC Enduses to Model
16 of 25 - Interior Lighting Loads and Profiles
17 of 25 - Office Equipment Loads and Profiles
20 of 25 - Miscellaneous Loads and Profiles
23 of 25 - Exterior Lighting Loads and Profiles
Core: 0.001 CFM/ft2 (floor area)
Wizard Screen
3 of 25
Help
Previous Screen
Next Screen
Return to Navigator
Ready

- ComCheck used to ensure ASHRAE 90.1 baseline standards were met in order to gain LEED points.



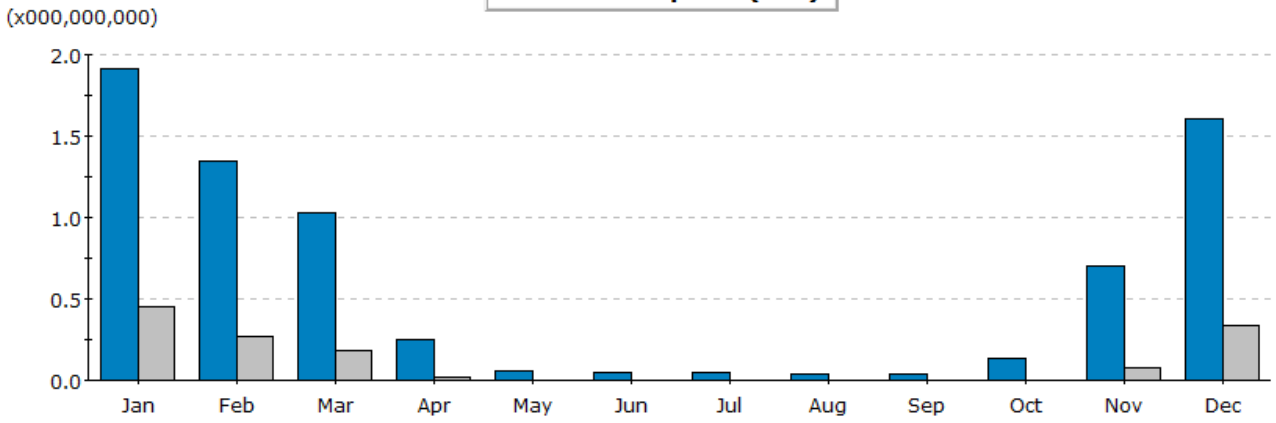
Electric Consumption (kWh)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Run 1.	330.3	292.1	310.9	257.7	248.1	307.7	337.5	316.5	272.1	247.0	270.2	335.6	3,525.7
Run 2.	165.9	152.4	172.3	181.0	191.8	242.9	266.5	249.5	218.4	182.7	154.8	177.7	2,355.8
Run 3.													
Run 4.													
Run 5.													

1. IPRO_335_Standard - Standard (11/23/09 @ 19:02)
2. IPRO_335_EM - Energy Efficient (11/23/09 @ 18:24)

Gas Consumption (Btu)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Run 1.	1.92	1.34	1.03	0.25	0.06	0.05	0.04	0.04	0.04	0.13	0.70	1.60	7.20
Run 2.	0.46	0.27	0.19	0.02	-	-	-	-	-	0.00	0.08	0.34	1.35

Total Annual Energy consumption

Annual Energy USE (kWh)		Ambient Lights	Task Lights	Misc Equip	Space Heating	Space Cooling	Heat Reject	Pumps & Aux	Vent Fans	Total
0	Base Design	--	--	--	--	--	--	--	--	--
1	0+Standard	1,064,919	39,645	1,193,629	0	561,606	47,928	401,289	216,727	3,525,743

Annual Energy USE (kWh)		Ambient Lights	Task Lights	Misc Equip	Space Heating	Space Cooling	Heat Reject	Pumps & Aux	Vent Fans	Total
0	Base Design	--	--	--	--	--	--	--	--	--
1	0+Energy Efficient	827,970	16,996	925,324	45,820	369,712	39,307	85,626	45,089	2,355,839

33% Energy saved not including energy produced from PV panels and Wind Turbines

LEED Certification

Yes	?	No		
21			SUSTAINABLE SITES	26 Points
6			WATER EFFICIENCY	10 Points
32			ENERGY & ATMOSPHERE	35 Points
5			MATERIALS & RESOURCES	14 Points
15			INDOOR ENVIRONMENTAL QUALITY	15 Points
1			INNOVATION IN DESIGN	6 Points
			REGIONAL PRIORITY	4 Points
82			PROJECT TOTALS (Certification Estimates)	110 Points

Certified: 40-49 points Silver: 50-59 points Gold: 60-79 points Platinum: 80+ points

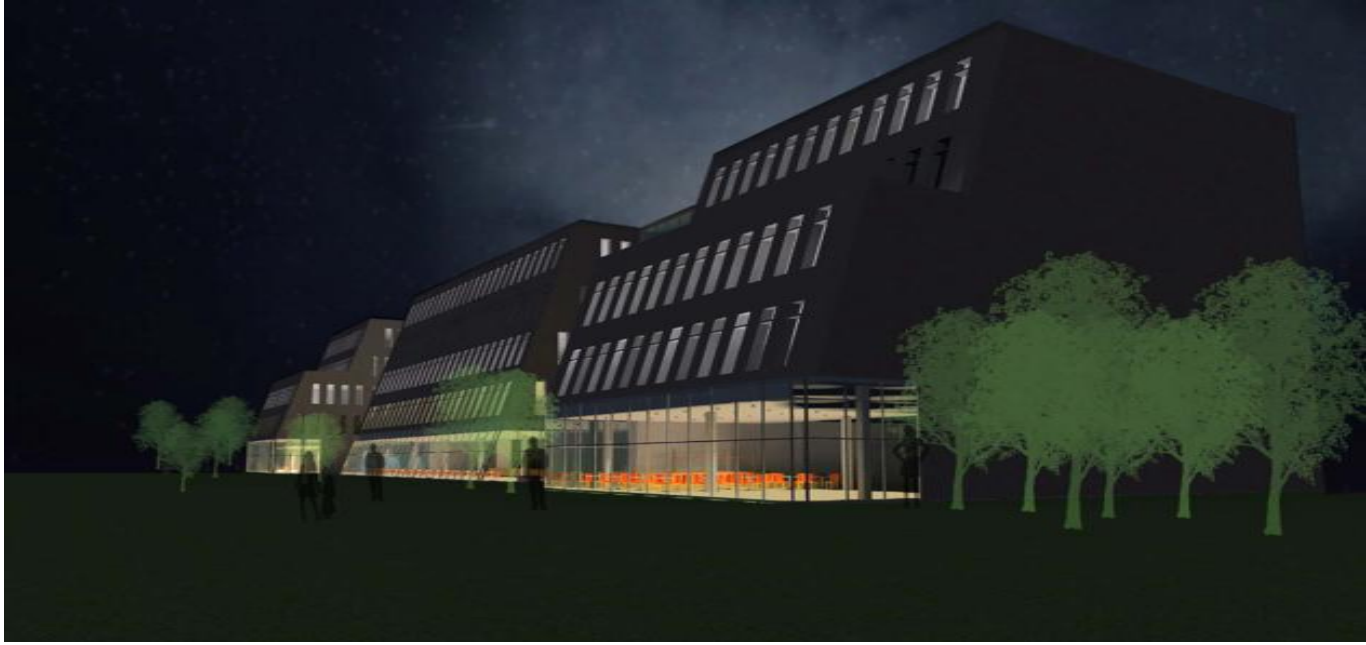
- Achieved LEED Platinum through smart design and energy reductions

Conclusion

- 424,997 kWh produced from PV
- 44,000 kWh produced from Wind Turbines
- Minimal natural gas consumption due to heat pumps
- Saving 11.82% of flushing water
- Construction utilizes local resources
- Increases day lighting while maintaining a well insulated envelope

Total power used reduced from3,525,743 to1,886,842 kWh annually

Total energy saved becomes 47%!



Questions?