IPRO 323
Spring 2002

Sponsor: Skidmore Owings & Merrill LLP
Dr. Mahjoub Elnimeiri, Raymond Clark, Peter Ellis

Team 1: Office Zone

SAHAR ABBASZADEH FARD
MAGDY IBRAHIM
SANG MIN PARK
GORAN VESELINOVIC
MICHAEL GEROULIS

Team 2: Residential Zone

EMERALD CRUZ
RUSSELL KELLY
KELBY PHILLIPS
ERIKA LAU

Team 3: Residential Zone

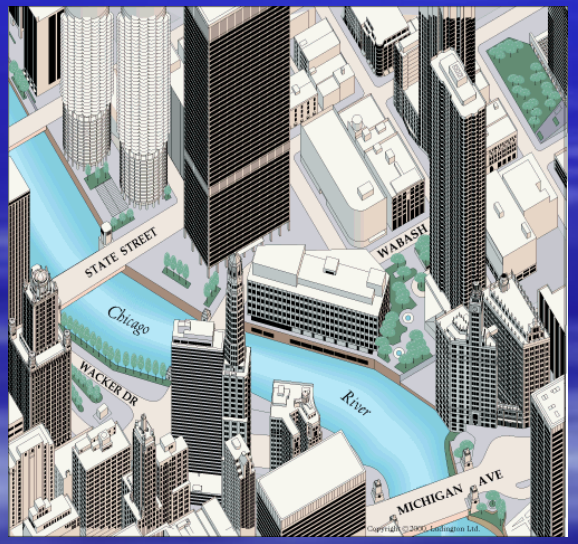
ALLAN CHUNG
ALICJA MORZYC
KATHERINE PANEK
RAFAL TROJNIAK

Team 4: Office Zone

CHING CHAN
MEGHAN PECAUT
LINDSEY PHILLIPS
SHANE STALEY

CHICAGO: Climatic Data and Related Building Design Considerations

°Latitude	**41°**
Shading Needed – Period	**June – August**
Shadow Angles – South Side	**65°**
Prevailing Winds – Winter	**SW – 12.0 MPH**
Prevailing Winds – Summer	**NE – 10.0 MPH**

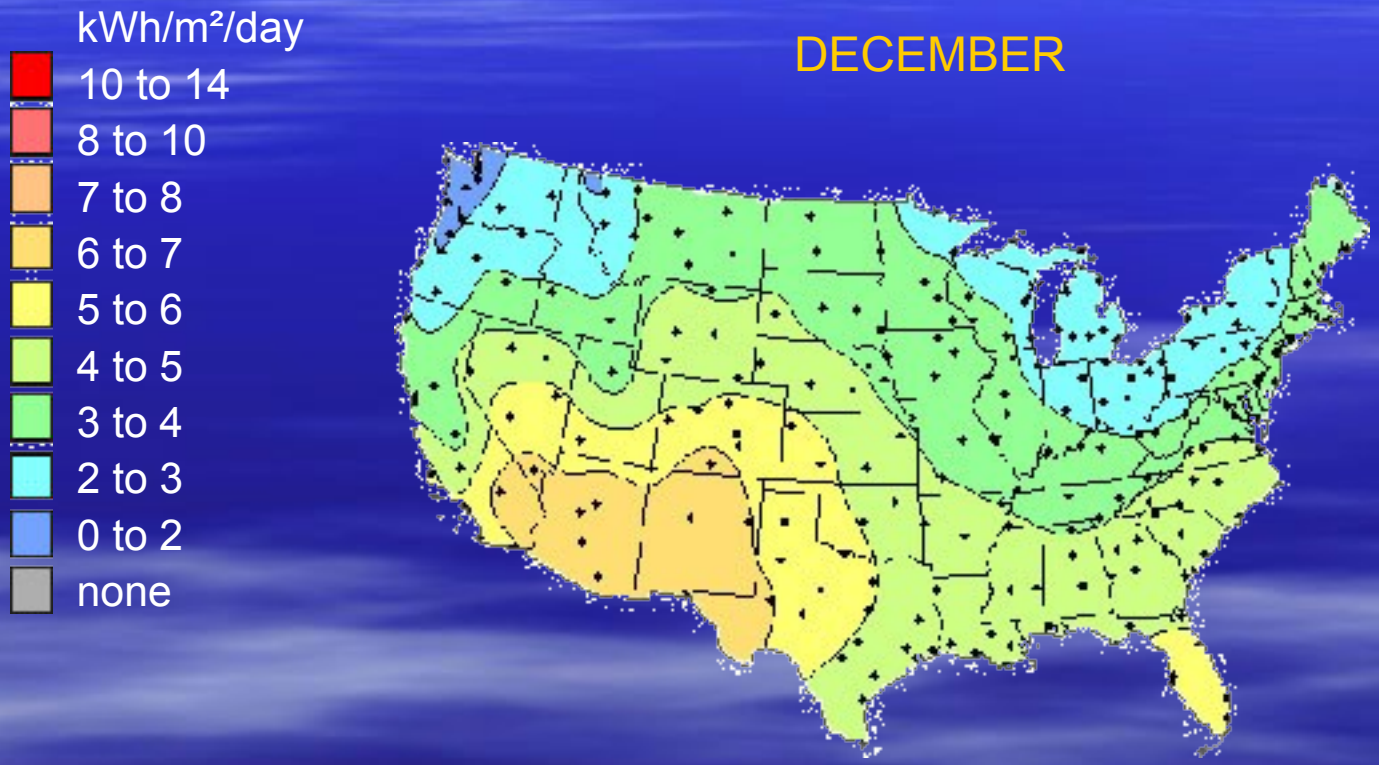


CHICAGO:

Climatic Data and Related Building Design Considerations

AVERAGE DAILY SOLAR RADIATION

DECEMBER

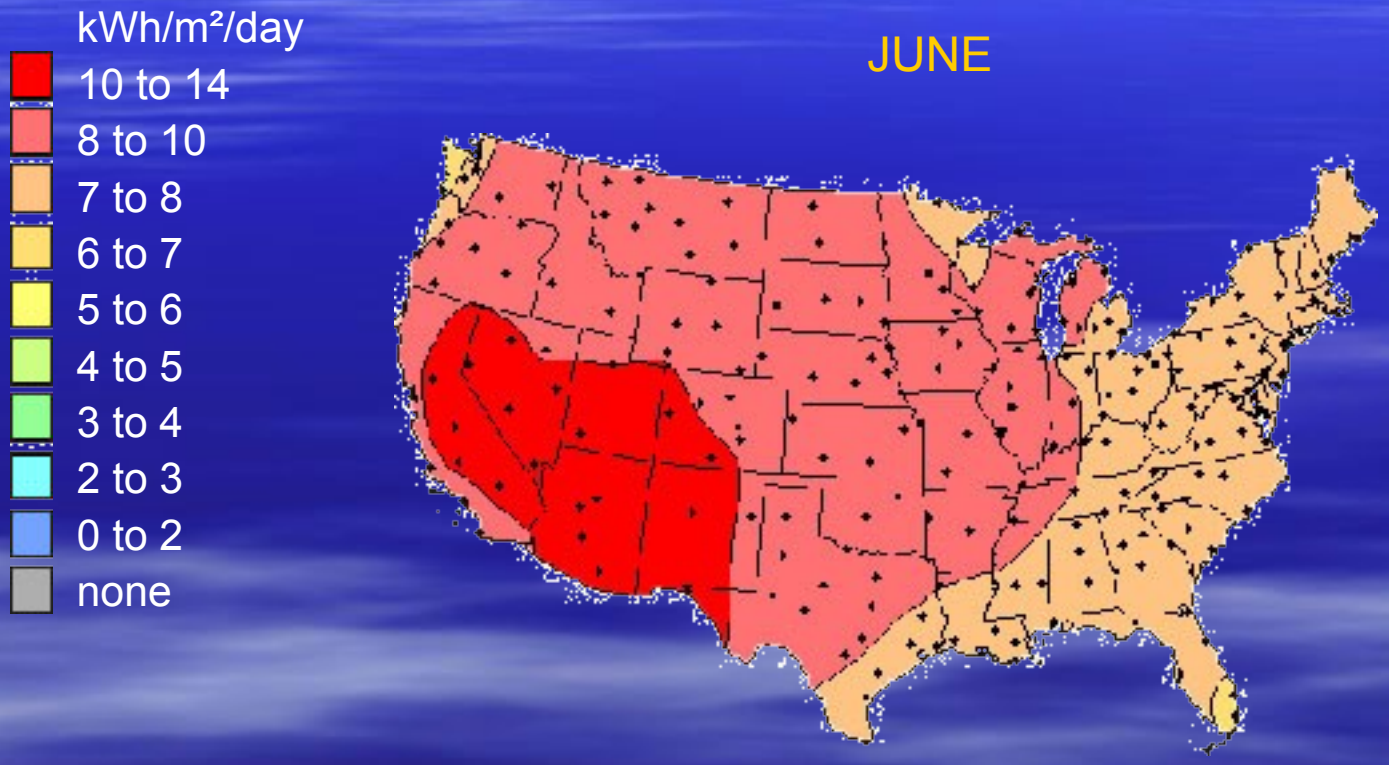


CHICAGO:

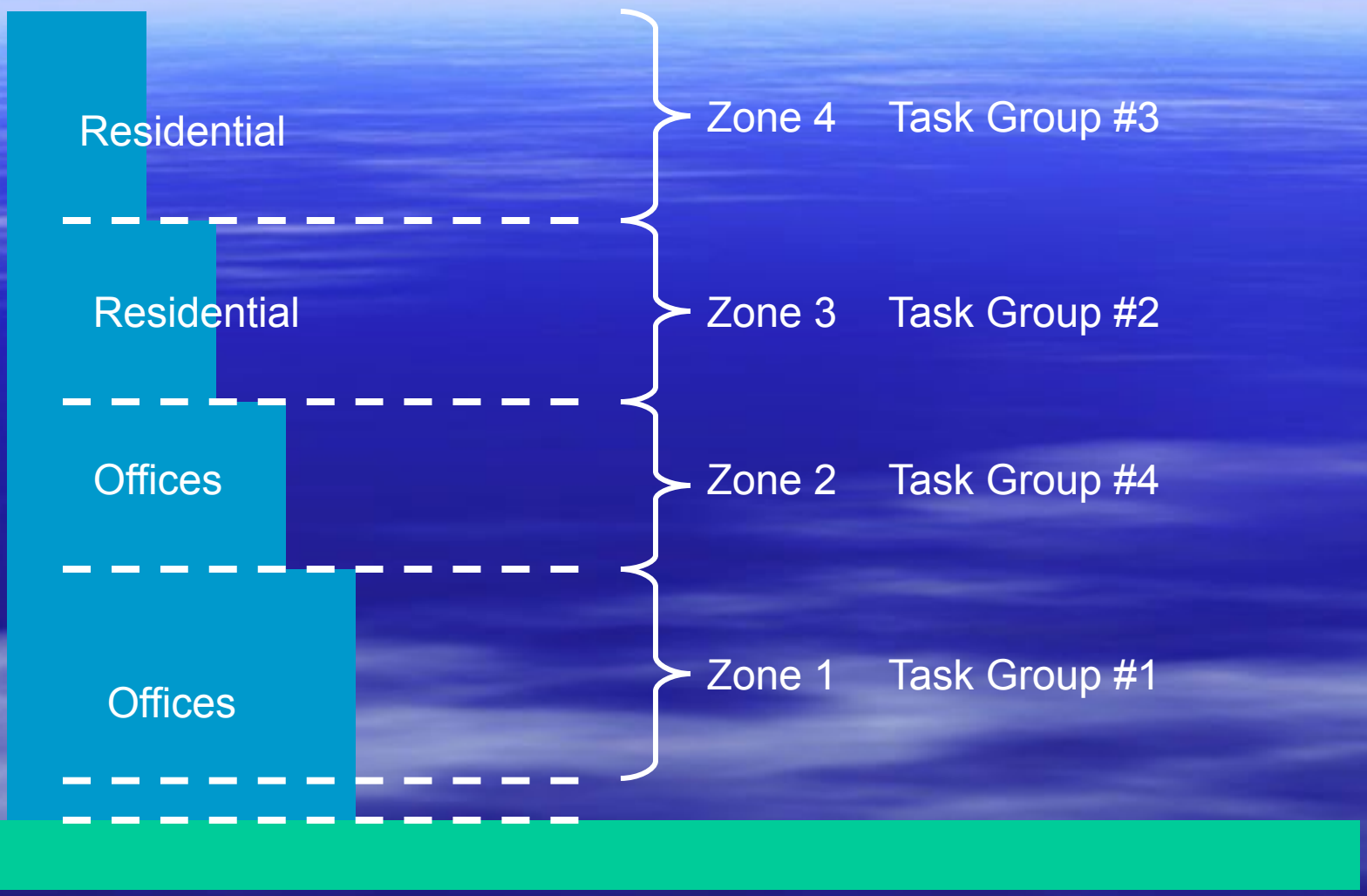
Climatic Data and Related Building Design Considerations

AVERAGE DAILY SOLAR RADIATION

JUNE

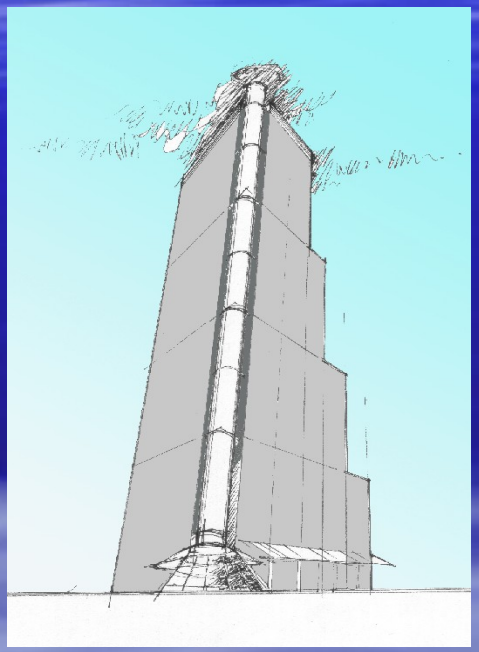


Basic Area of Concern

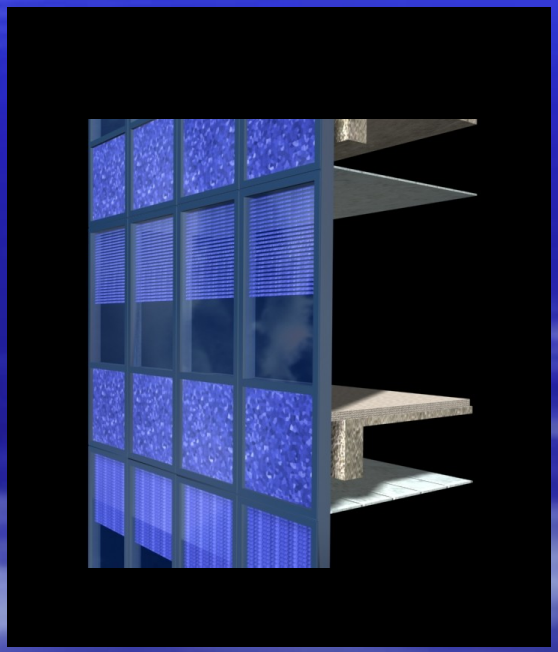


Trump Tower Project,
Chicago, IL

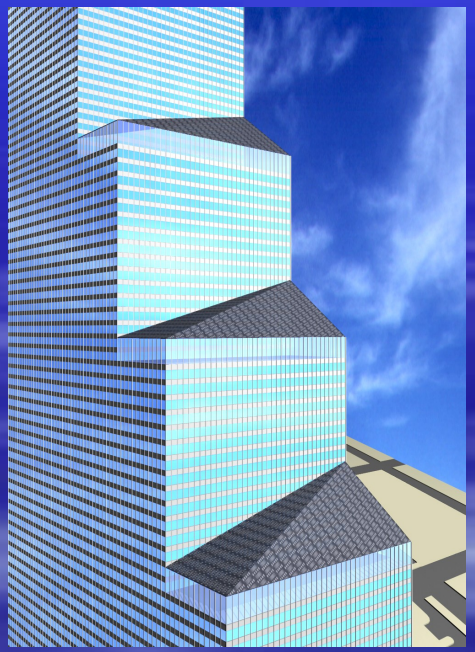
Group 1 Proposals



Solar Chimney

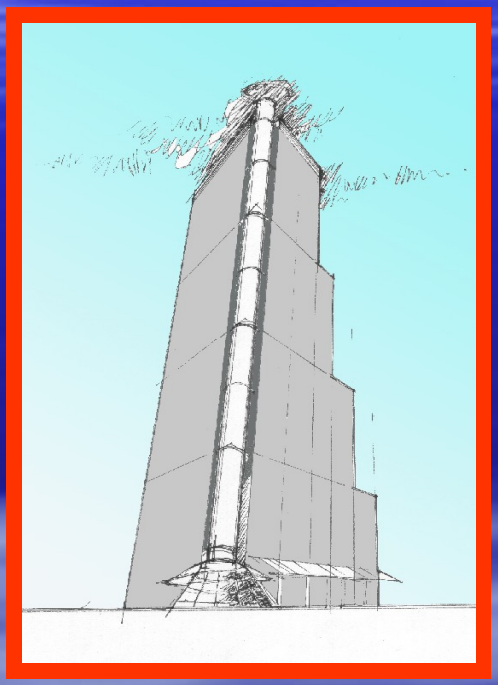


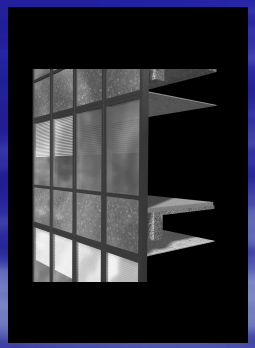
Modular window-wall systems with PV



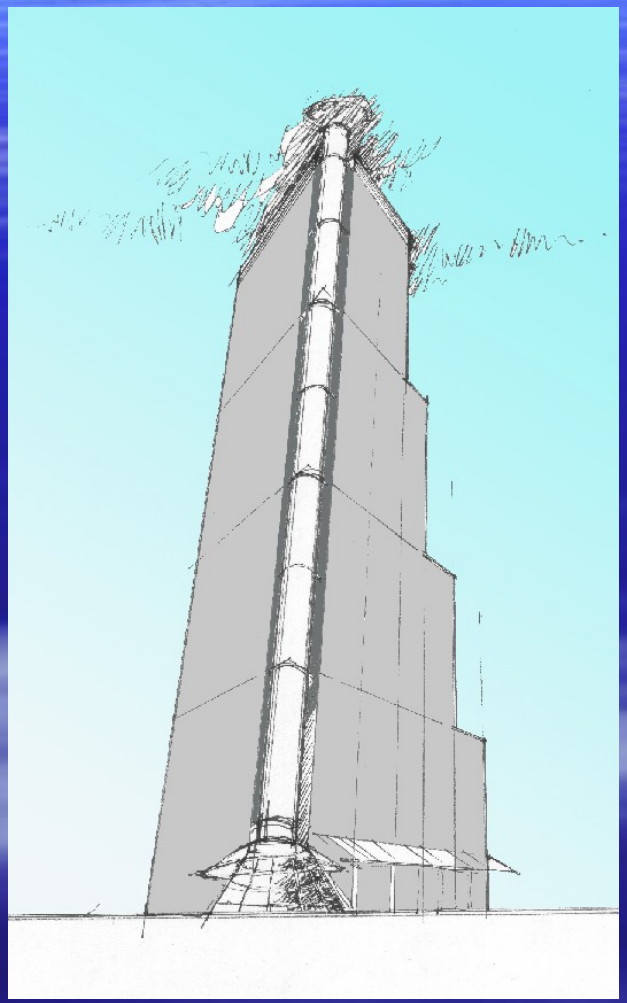
Sky Garden

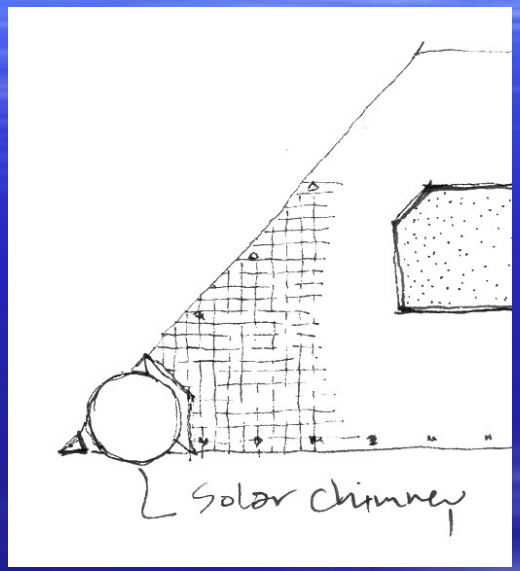
First Concept: SOLAR CHIMNEY





First Concept: SOLAR CHIMNEY



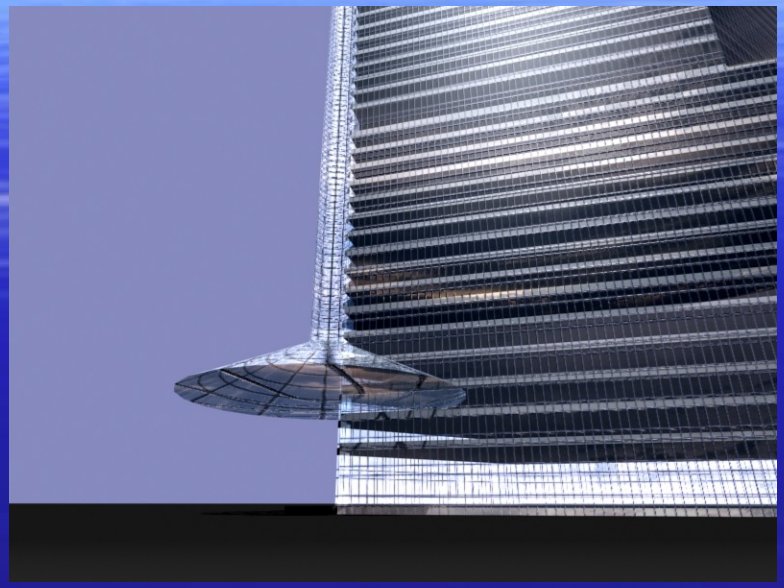


Location: South-East impractical acute-angled corner.

This chimney will funnel air from ground level through a wind turbine located at the very top.

Materials: Includes a steel structure, supported from floor slabs at each level, and a glass or plastic tube-like chimney.

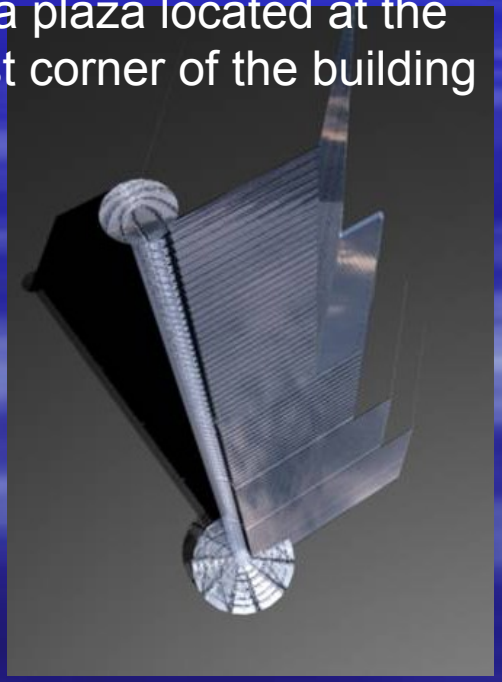
First Concept: SOLAR CHIMNEY



At the base of this construction would be a giant umbrella-type structure:

i) scoop fresh air up into the chimney

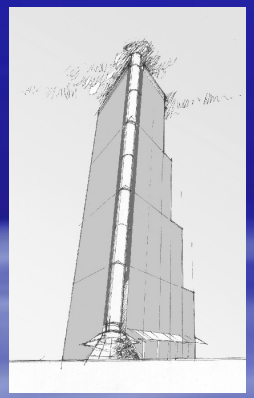
ii) to shield a plaza located at the southwest corner of the building

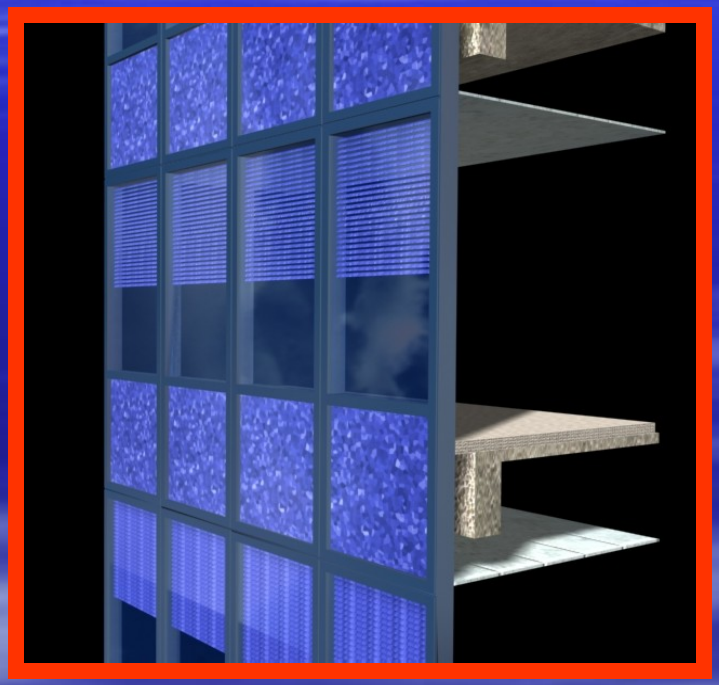


At the top, a turbine would be installed, to convert this wind into a form of energy.

Some sort of shielding device would have to be constructed here as well, to protect the turbine from particles and debris.

Second Concept: **Modular window-wall systems with PV**

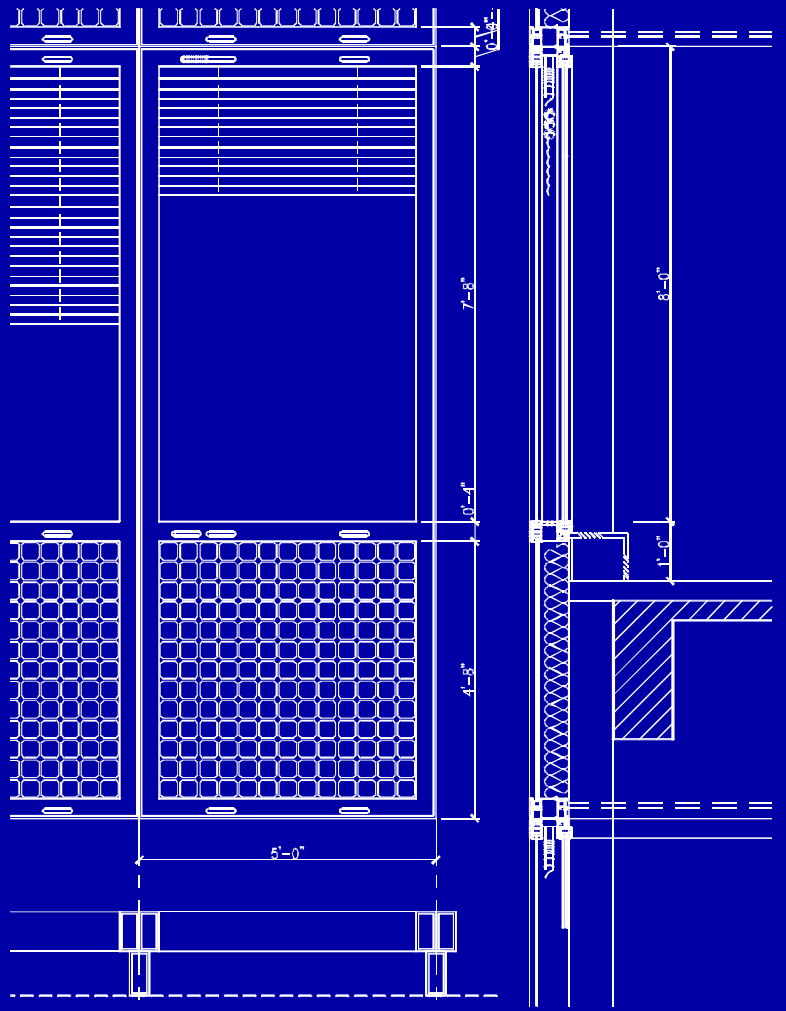




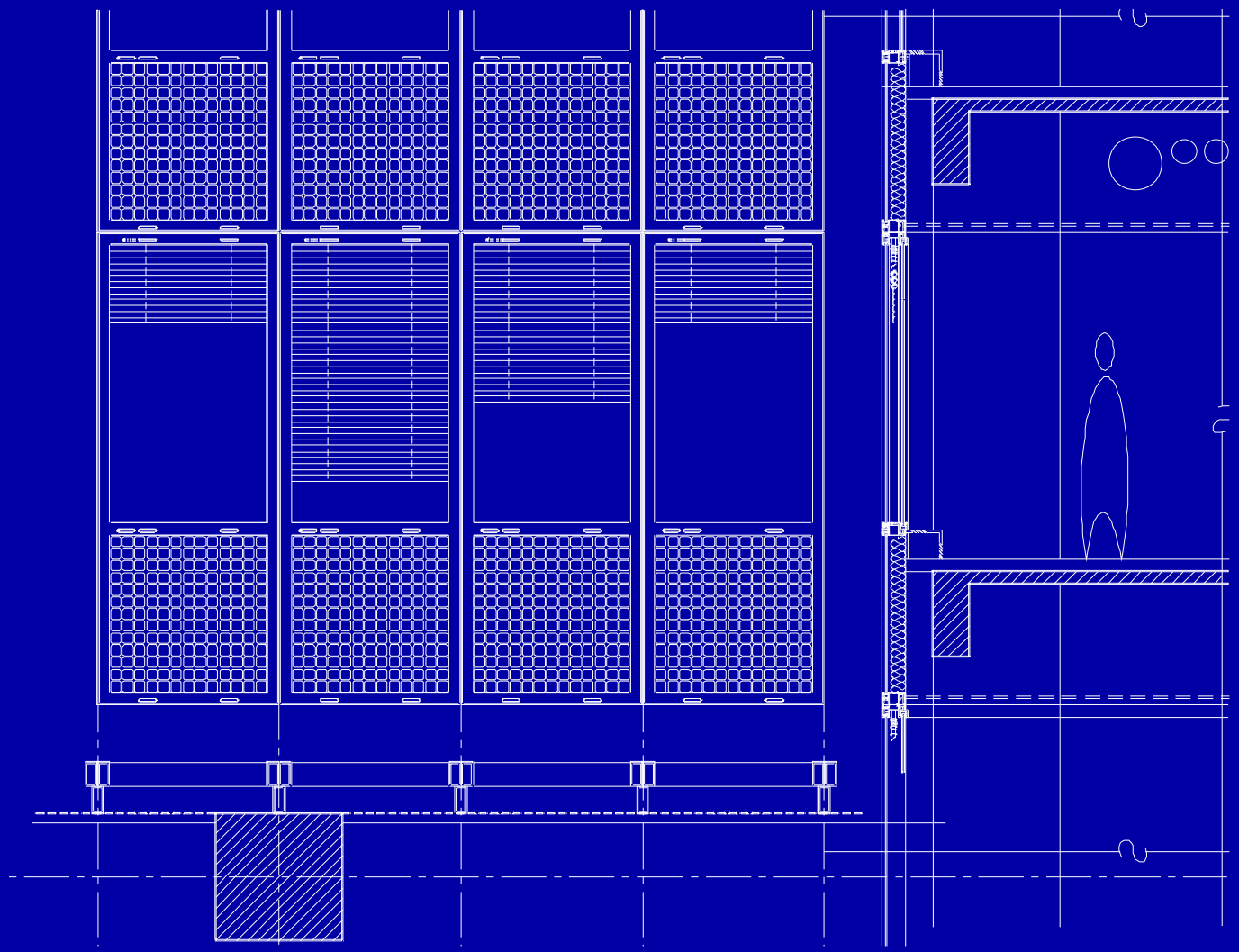
Second Concept: Modular window-wall systems with PV

The panel is designed as a one modular piece with everything installed: the blinds have the PV on the outer surface before the inner skin which consists of double low-E clear glass.

The chamber between two skins insures that PV cells do not get hot by means of natural ventilation



Second Concept: **Modular window-wall systems with PV**

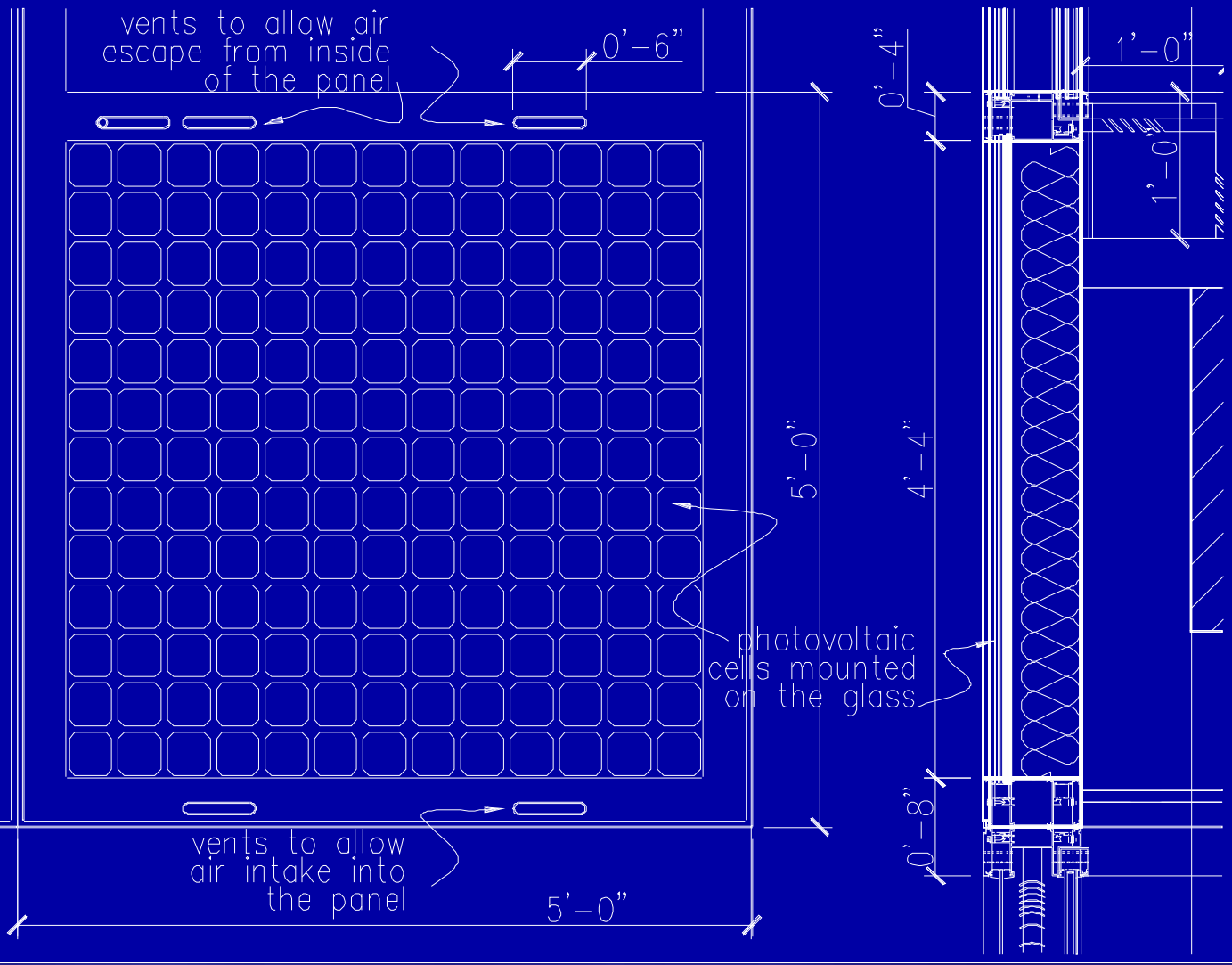


Second Concept: **Modular window-wall systems with PV**

Questions and Concerns

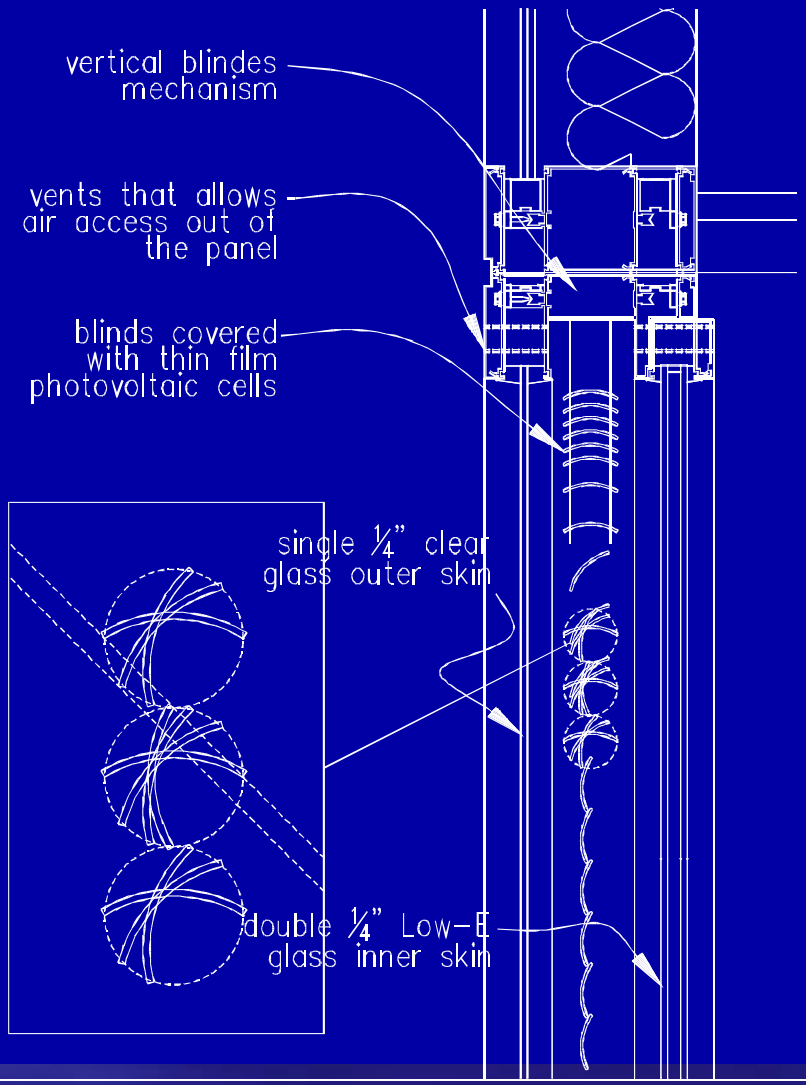
- How do we ventilate the Panels?
- How do we clean the interior of the module?
- What is the best angle of the blinds?
- How do the modules connect with each other?
- How the blinds work?

Second Concept: Modular window-wall systems with PV

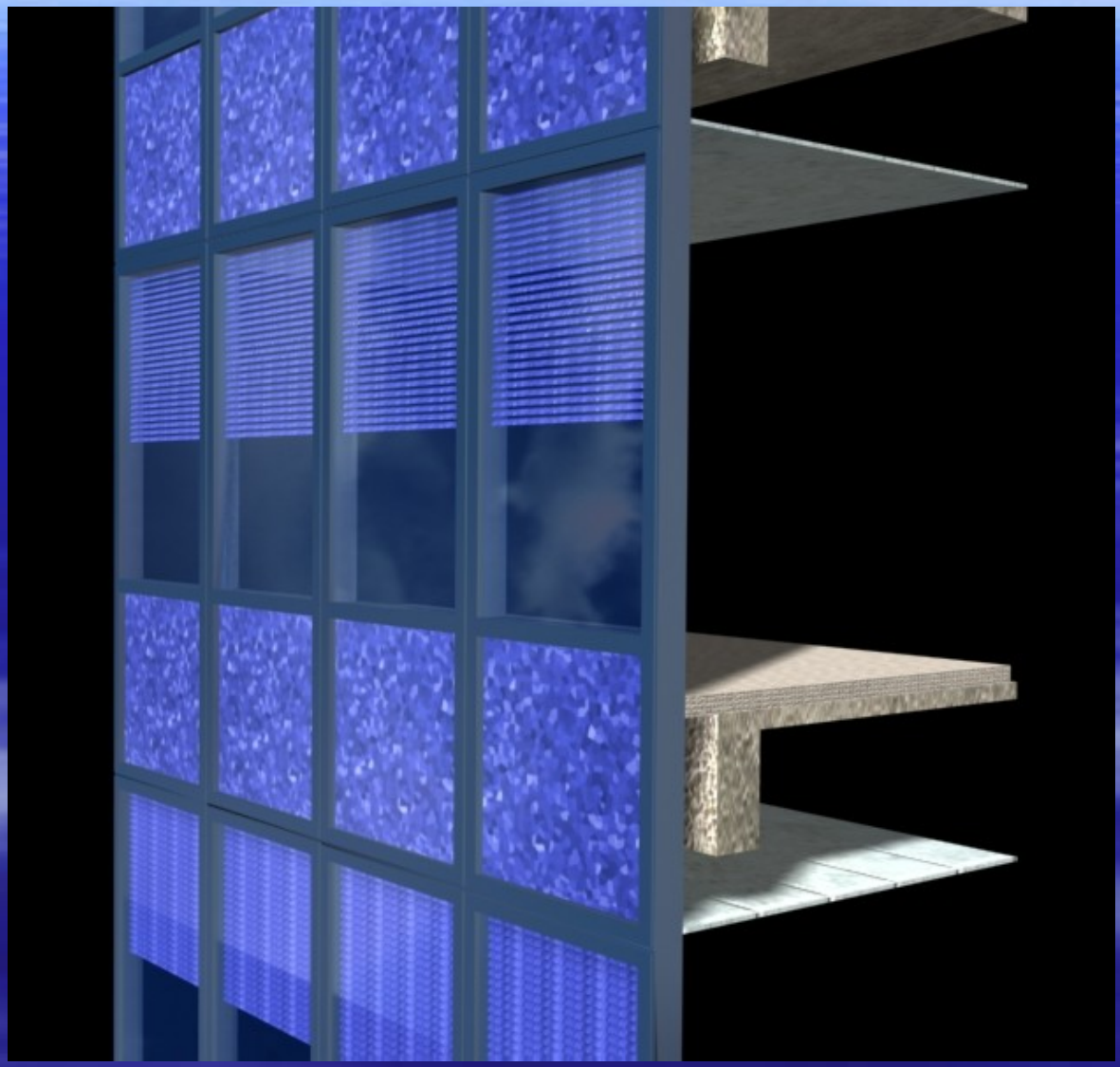


Second Concept: Modular window-wall systems with PV

Detail showing the double skin window module

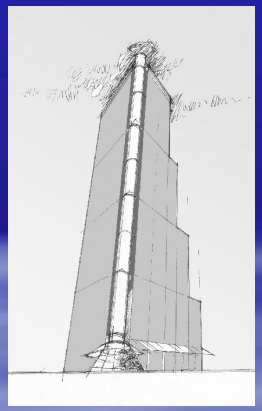


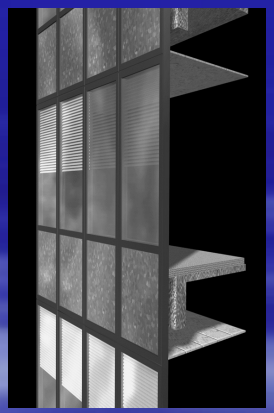
Second Concept: **Modular window-wall systems with PV**

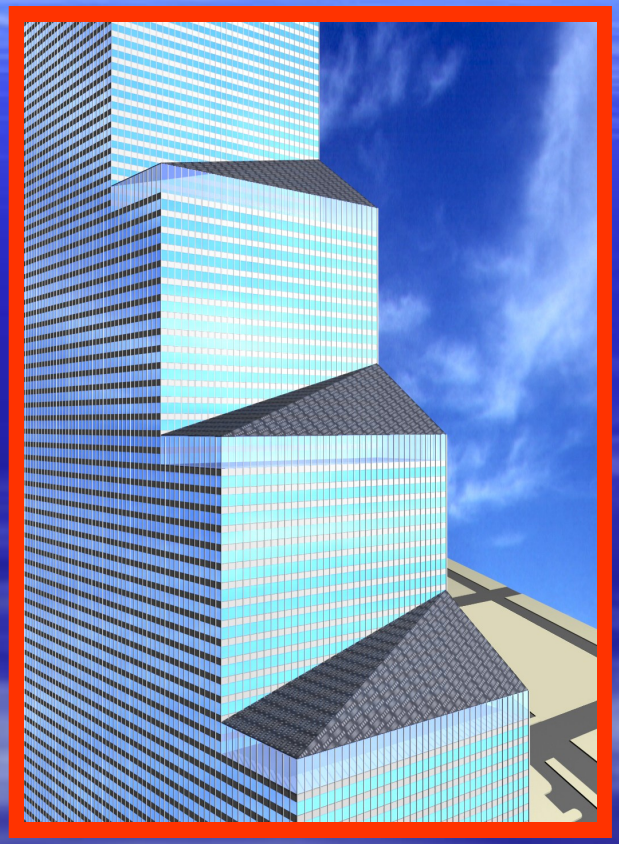


Window-wall system incorporating PV modules

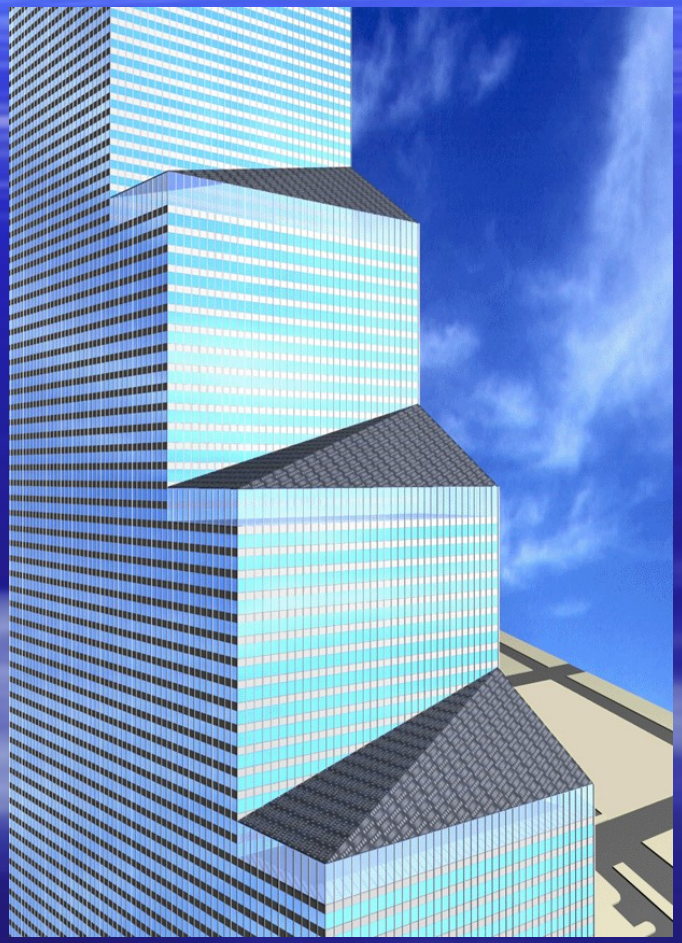
Third Concept: **Sky Garden**





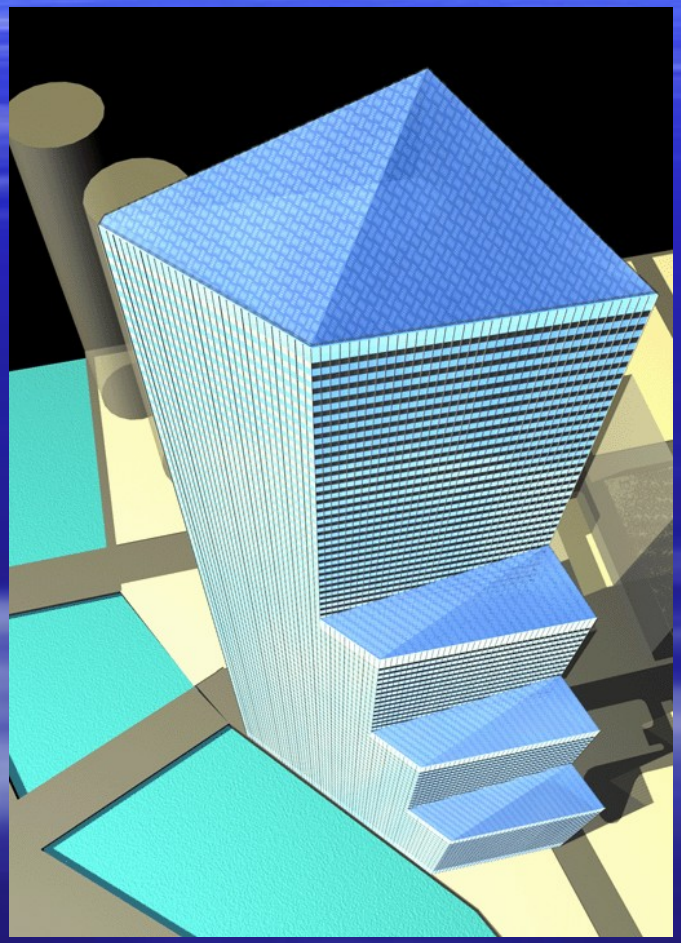


Third Concept: Sky Garden



- Two general possibilities for installing photovoltaic cells in high-rise building are building facades and roof. In this project, the sky garden with PV roof is another possibility as an architectural element of the building or the system.
- Rest and refugee area with green.
- Dynamic overall shape.

Third Concept: **Sky Garden**

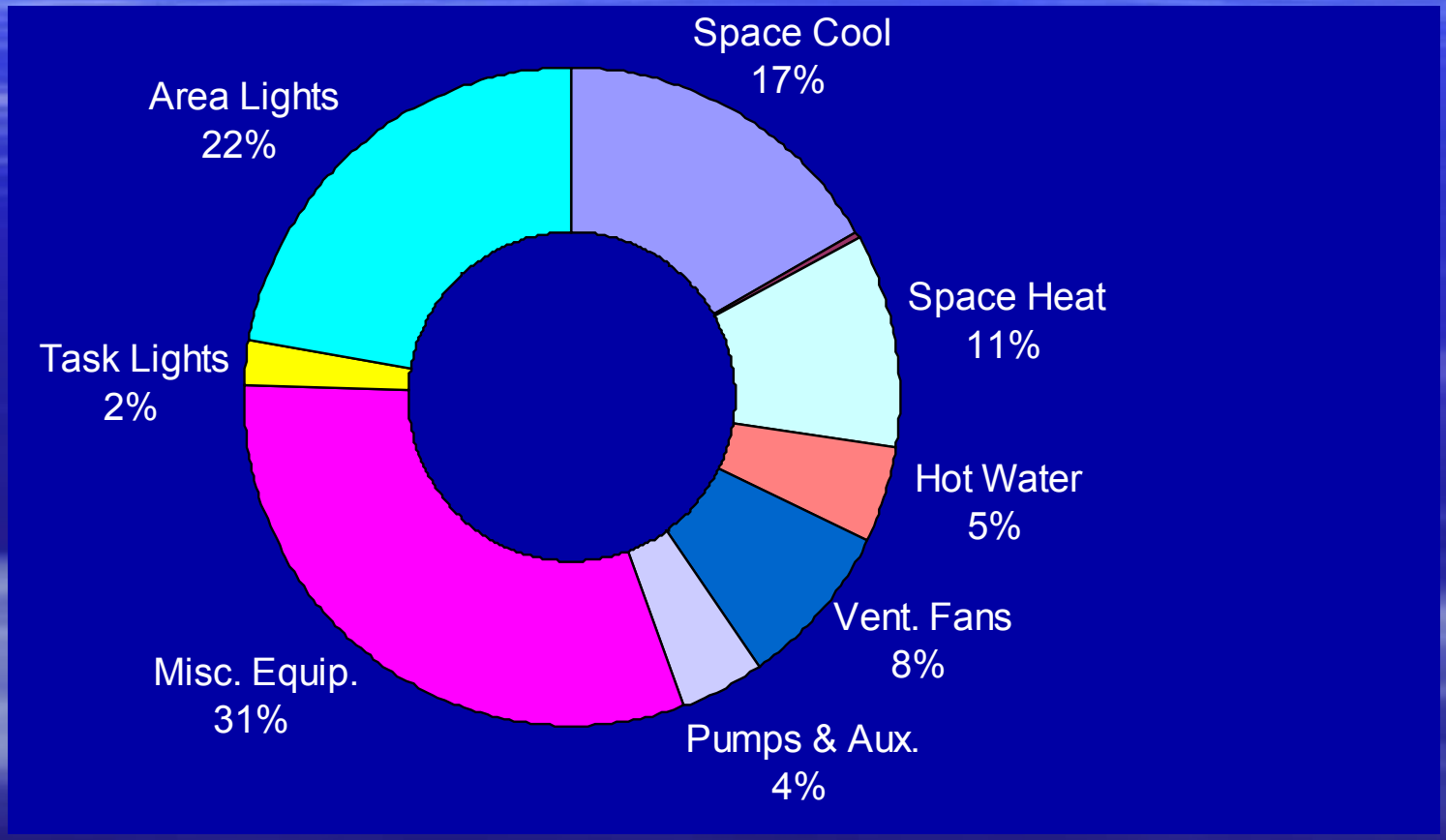


Total Energy Consumption

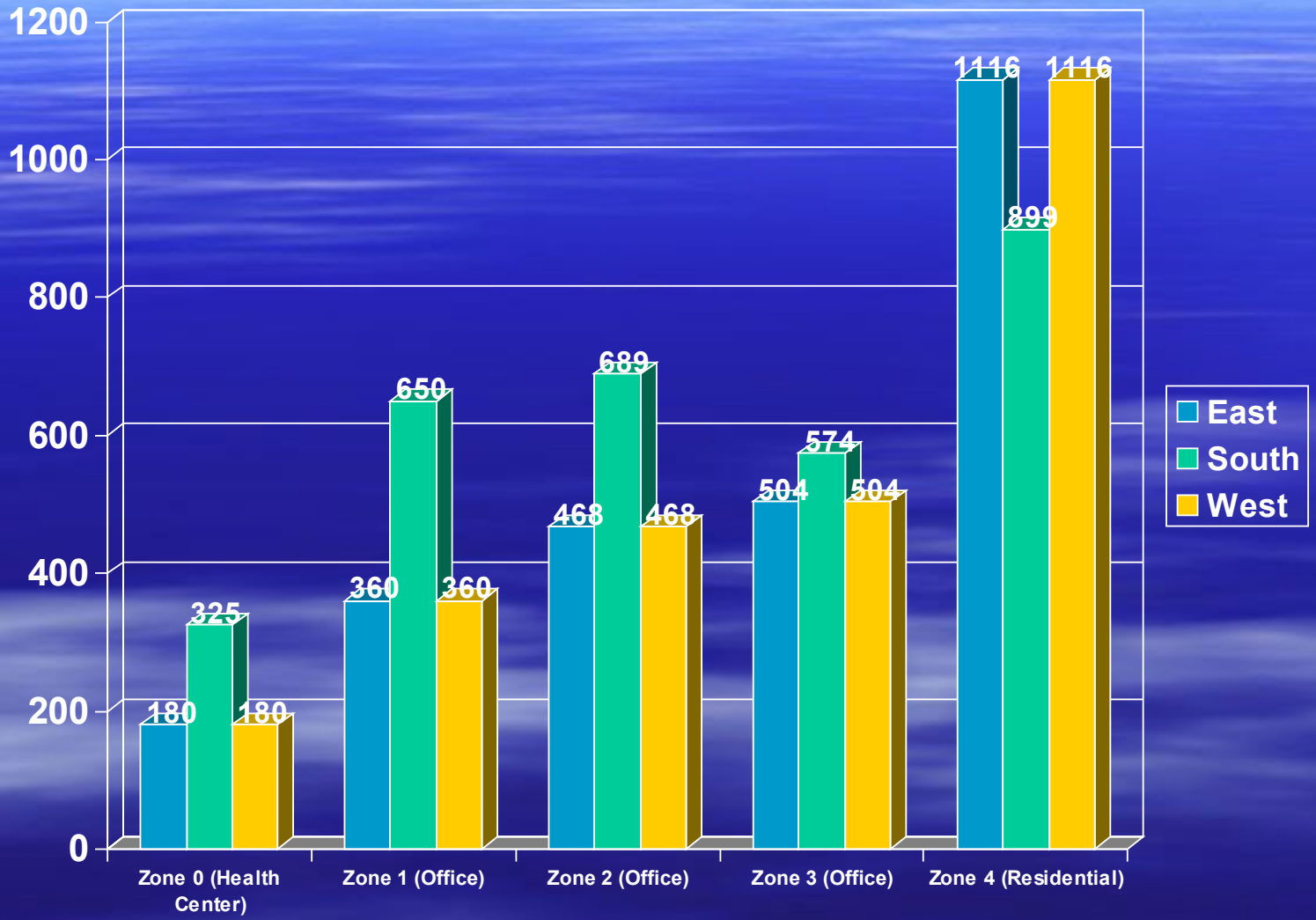
Using E-Quest for calculating Electric Consumption (kWh x000)

	Zone 1	Zone 2	Zone 3	Zone 4	Total
Space Cool	1,083.20	785.80	668.10	1,800.00	4,337.10
Heat Reject.	28.00	20.50	17.50	-	66.00
Refrigeration	-	-	-	-	
Space Heat	674.30	519.50	489.40	1,050.00	2,733.20
HP Supp.	-	-	-	810.00	
Hot Water	277.20	198.60	165.70	620.00	1,261.50
Vent. Fans	581.00	422.00	360.00	750.00	2,113.00
Pumps & Aux.	457.50	330.30	277.90	-	1,065.70
Ext. Usage	-	-	-	-	
Misc. Equip.	2,670.30	1,916.90	1,597.90	1,920.00	8,105.10
Task Lights	235.20	168.50	140.60	-	544.30
Area Lights	1,471.30	1,025.70	818.90	2,480.00	5,795.90
Total	7,478.00	5,387.90	4,535.90	9,430.00	26,831.80

Annual Energy Consumption by End-use.



Number of PV Panels



Energy Saving Calculation for the proposed scheme

Calculation of Savings for the Designed module & Sky Garden

IPRO 323- Spring 2002

Task Group I

Façade

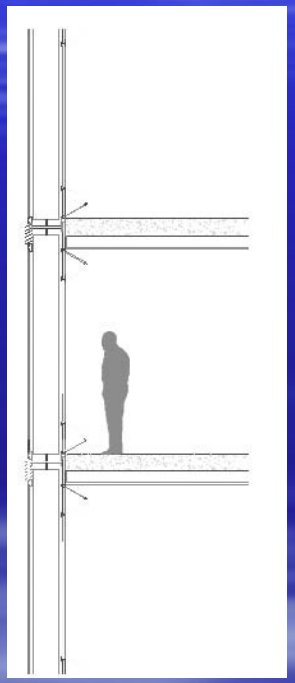
				East		South		West	
Zone 0	Nomber of modules			36		65		36	
Health Center			5	180		325		180	
5 floors @ 16' fl2fl									
	Area of PV at 41' (Blind area)		46.2		8316		15015		8316
	Area of PV at 90' (Spandrel area)		18.7		3366		6077.5		3366
Zone 1	Nomber of modules			36		65		36	
Office			10	360		650		360	
10 floors @ 13' fl2fl									
	Area of PV at 41' (Blind area)		33.2		11952		21580		11952
	Area of PV at 90' (Spandrel area)		18.7		6732		12155		6732
Zone 2	Nomber of modules			36		53		36	
Office			13	468		689		468	
13 floors @ 13' fl2fl									
	Area of PV at 41' (Blind area)		33.2		15537.6		22874.8		15538
	Area of PV at 90' (Spandrel area)		18.7		8751.6		12884.3		8751.6
Zone 3	Nomber of modules			36		41		36	
Office			14	504		574		504	
14 floors @ 13' fl2fl									
	Area of PV at 41' (Blind area)		33.2		16732.8		19056.8		16733
	Area of PV at 90' (Spandrel area)		18.7		9424.8		10733.8		9424.8
Zone 4	Nomber of modules			36		29		36	
Residential			31	1116		899		1116	
31 floors @ 11' fl2fl									
	Area of PV at 41' (Blind area)		24.5		27342		22025.5		27342
	Area of PV at 90' (Spandrel area)		18.7		20869.2		16811.3		20869
	Total Area of PV at 41'	100%		79880.4		100552		79880	
	Total Area of PV at 90'	70%	49144		58661.9		49143.6		
				34400.5		41063		34401	
	Total PV Area with tilt factor			114281	sqft	141615	sqft	114281	sqft
			75%		100%		80%		
	Total PV Area with tilt & Orientation fact			85710.7		141615		91425	
	Total PV Area with orientation factor and tilt factor on the façade								318751

Sky Gardens

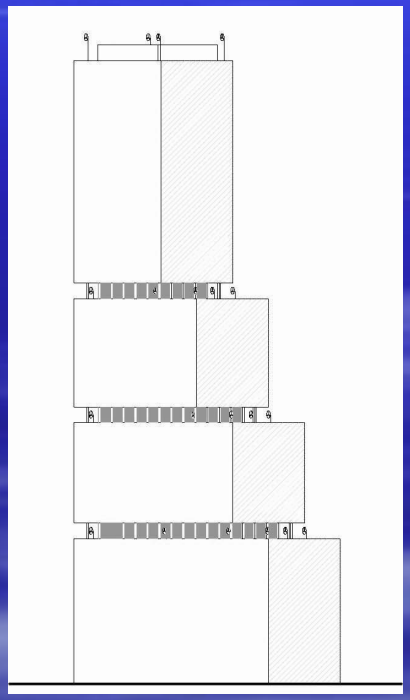
Roof 1							
	Area of PV at 45' (80%)			7204			
			80%	5763.2			
	Area of PV at 30' (~100%)					4511	
			100%	4511			
	The ratio of PV to vision glass		70%	10274.2			
					7191.94		
Roof 2							
	Area of PV at 45' (80%)			7204			
			80%	5763.2			
	Area of PV at 30' (~100%)					4511	
			100%	4511			
	The ratio of PV to vision glass		70%	10274.2			
					7191.94		
Roof 3							
	Area of PV at 45' (80%)			7204			
			80%	5763.2			
	Area of PV at 30' (~100%)					4511	
			100%	4511			
	The ratio of PV to vision glass		70%	10274.2			
					7191.94		
Rooftop							
	Area at 30' (90%)			12139			
			90%	10925.1			
	Area at 30' (~100%)					11530	
			100%	11530			
	The ratio of PV to vision glass		100%	22455.1			
					22455.1		

Total PV Area with Orientation factor & Tilt factor on the roofgard		44030.92	sqft
	44031sqft + 310838.2sqft=		
Total PV- Crystaline Area on façade & roof gardens		362781.8	sqft
Net output of Crystaline Panels at 100% (41') = 15 kwh/sqft/yr		15	
Reduction Factor = 90%	90%		
Shading Factor = 95%	95%		
Total output		4652676	kwh/yr
Annual Energy Consumption from EQuest		26831800	kwh/yr
Percentage of Energy savings per year			17.34

Group 2 Proposals



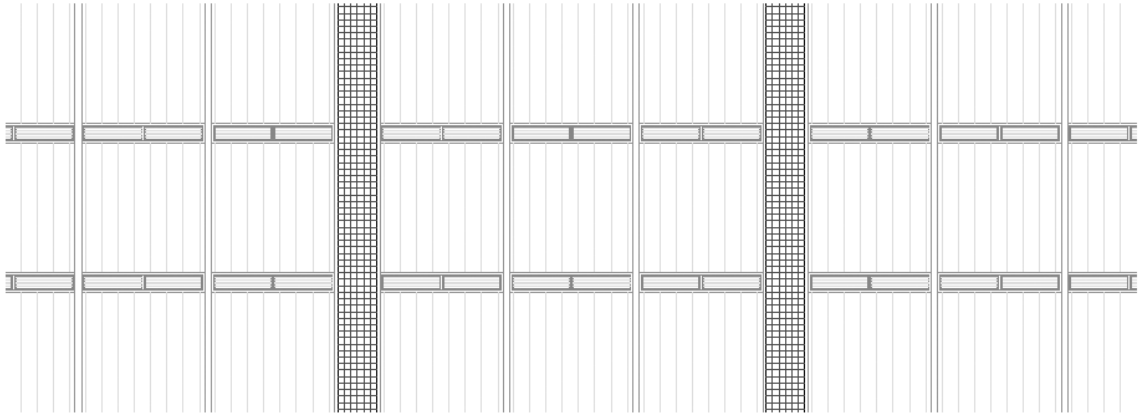
Double window-wall with PV



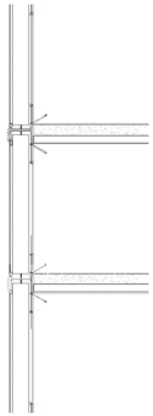
Wind Turbines

First Concept: **DOUBLE WINDOW-WALL WITH PV**

Plan view of the curtain wall

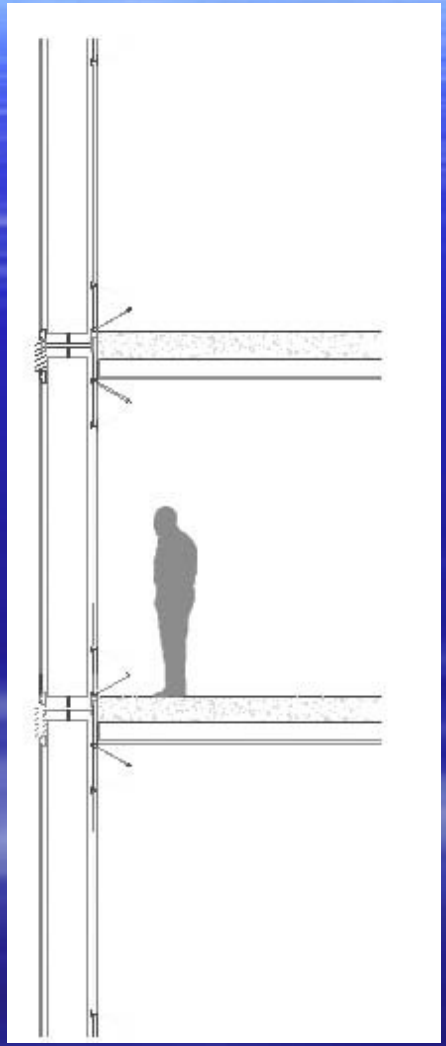


Elevation



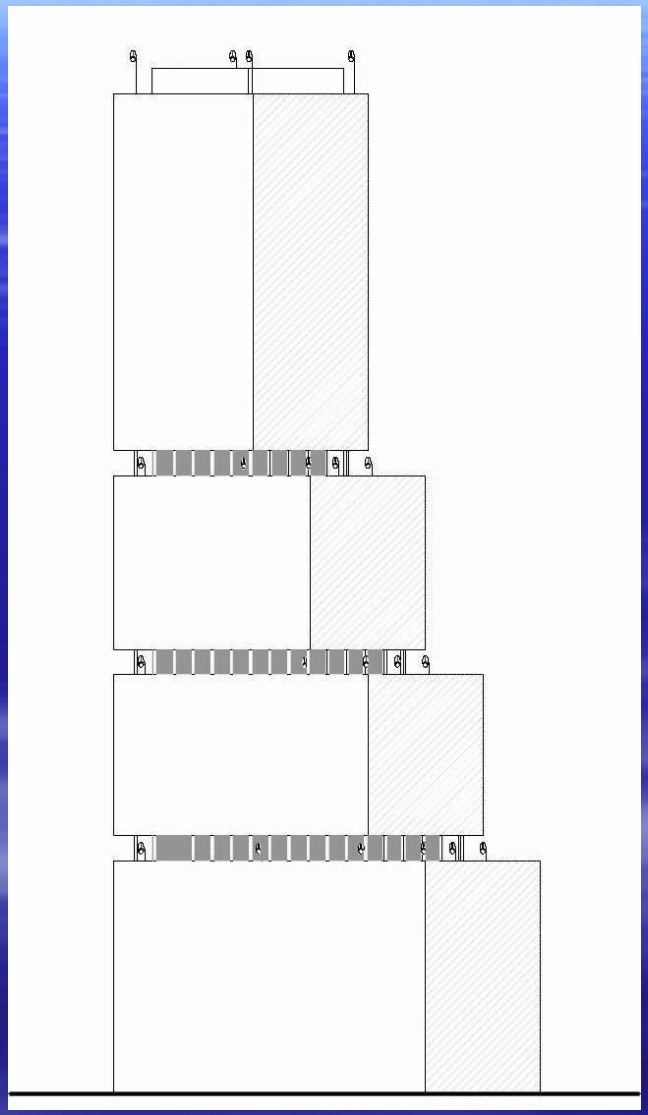
Section

First Concept: DOUBLE WINDOW-WALL WITH PV



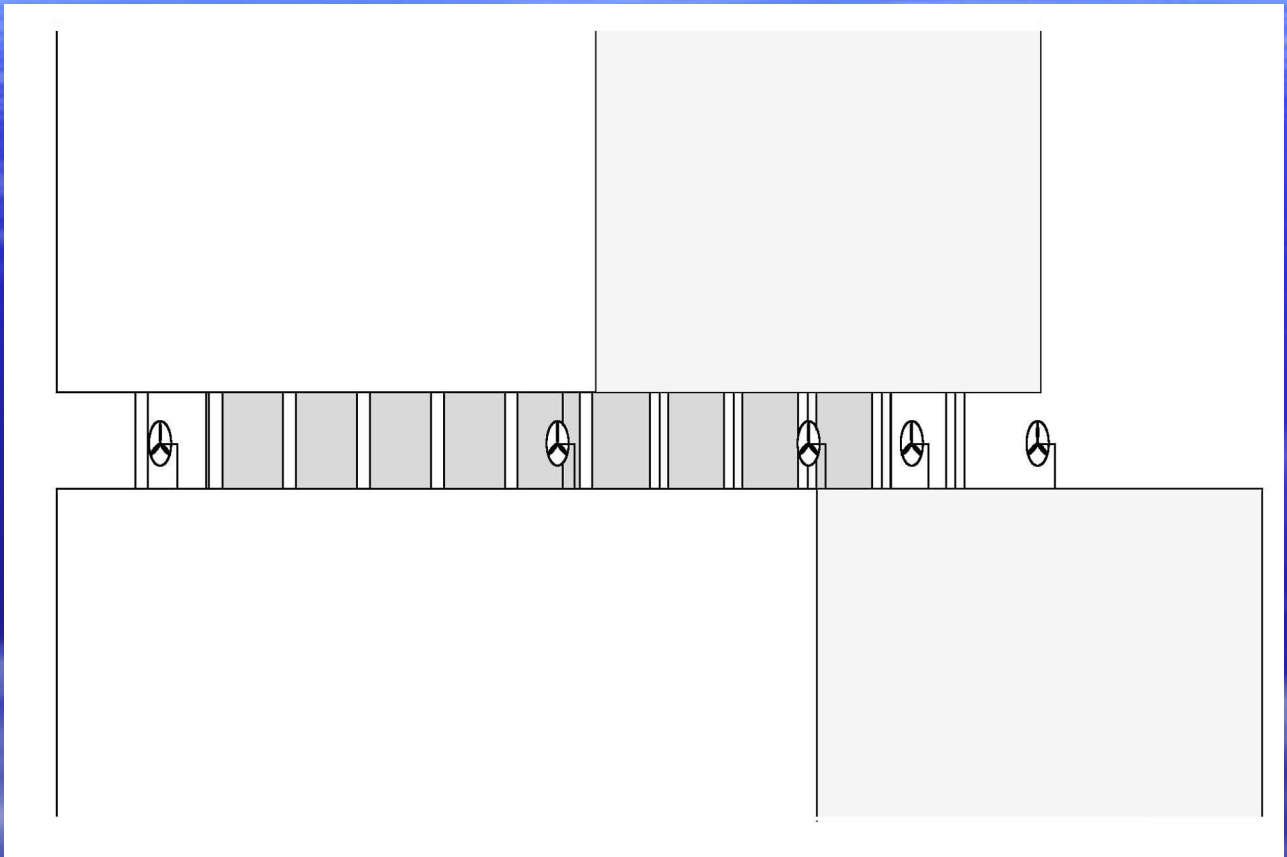
Detail of the
Enclosure System

Second Concept: **WIND TURBINES**



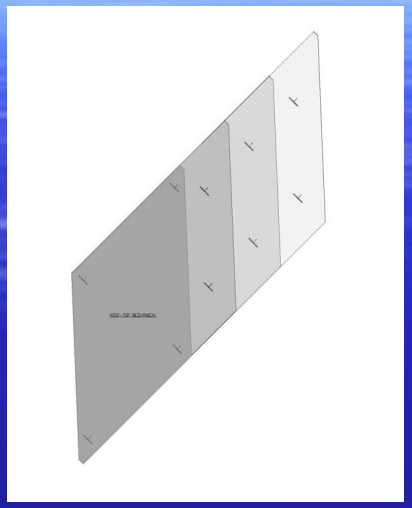
Elevation of the tower with incorporation of wind turbines located on various mechanical floors

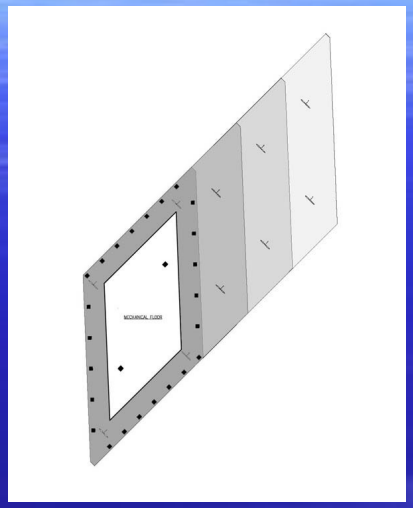
Second Concept: **WIND TURBINES**

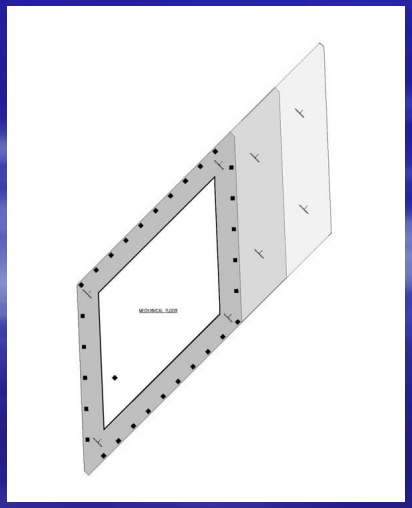


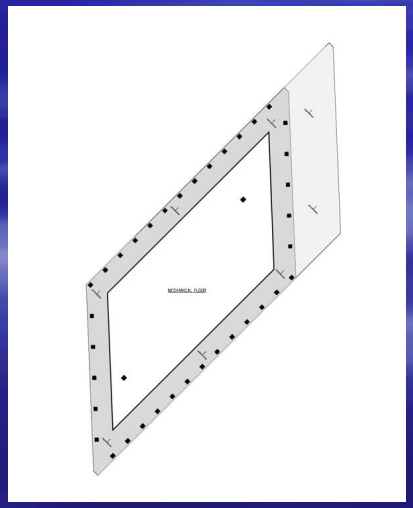
Detailed Elevation

Second Concept: **WIND TURBINES**







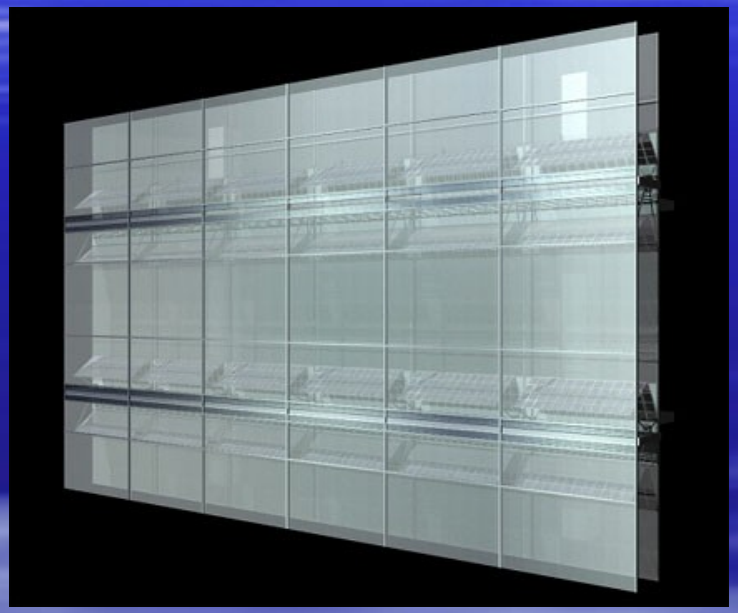


Location of wind turbines in plan

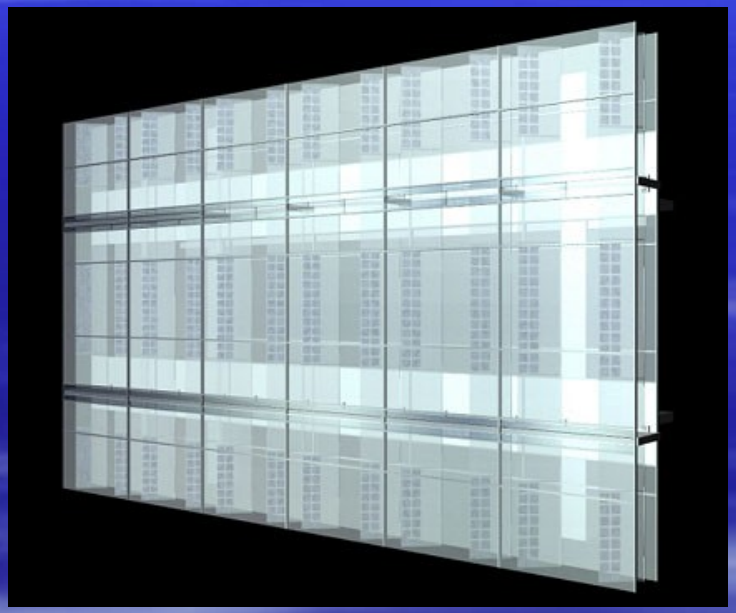
Second Concept: **WIND TURBINES**

Level	Height	Wind Speed	Power/ Turbine Area	Turbine Area	Total Power	Façade Area lost	Power/ Façade Area
Roof	330 m	27 m/s	2,362 W/m^2	42 m^2	99,204 Watts	None	N/A
3	201 m	16 m/s	492 W/m^2	63 m^2	30,996 Watts	1,525 m^2	20.3 W/m^2
2	137 m	11 m/s	160 W/m^2	63 m^2	10,080 Watts	1,870 m^2	5.4 W/m^2
1	78 m	6 m/s	26 W/m^2	84 m^2	2,184 Watts	2,175 m^2	1.0 W/m^2

Group 3 Proposals



(South Side)



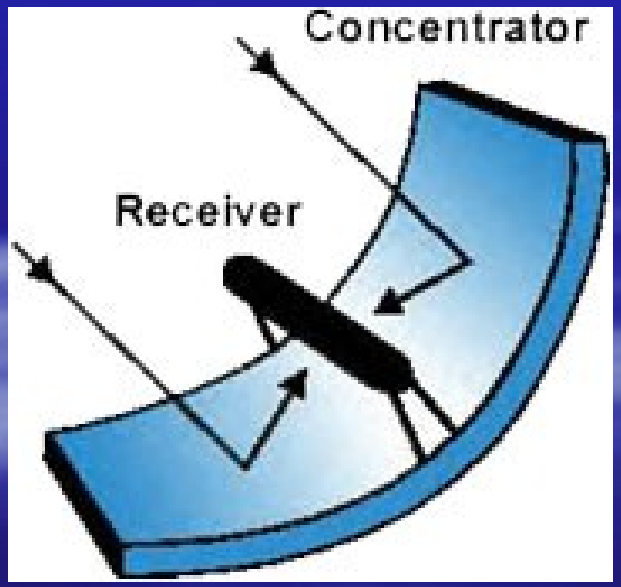
(West Side)

Curtain wall system

First Concept: Parabolic Trough Collectors

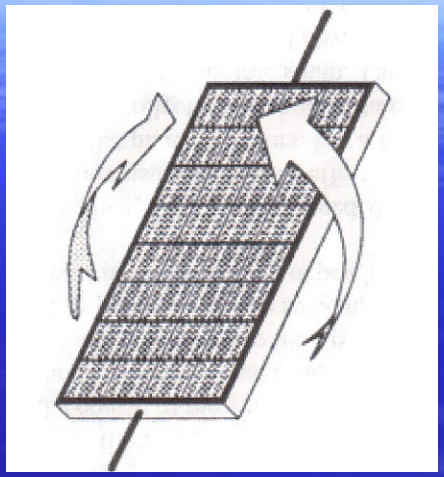
Flat Panel vs. Concentrators

Parabolic Trough Concentrators are the simplest parabolic concentrating systems.

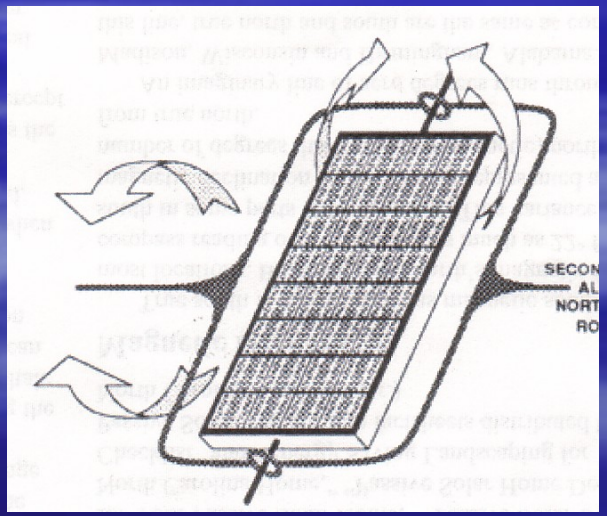


Second Concept: Sun Motor Tracking System

One-axis vs. Two-axis Tracking systems.

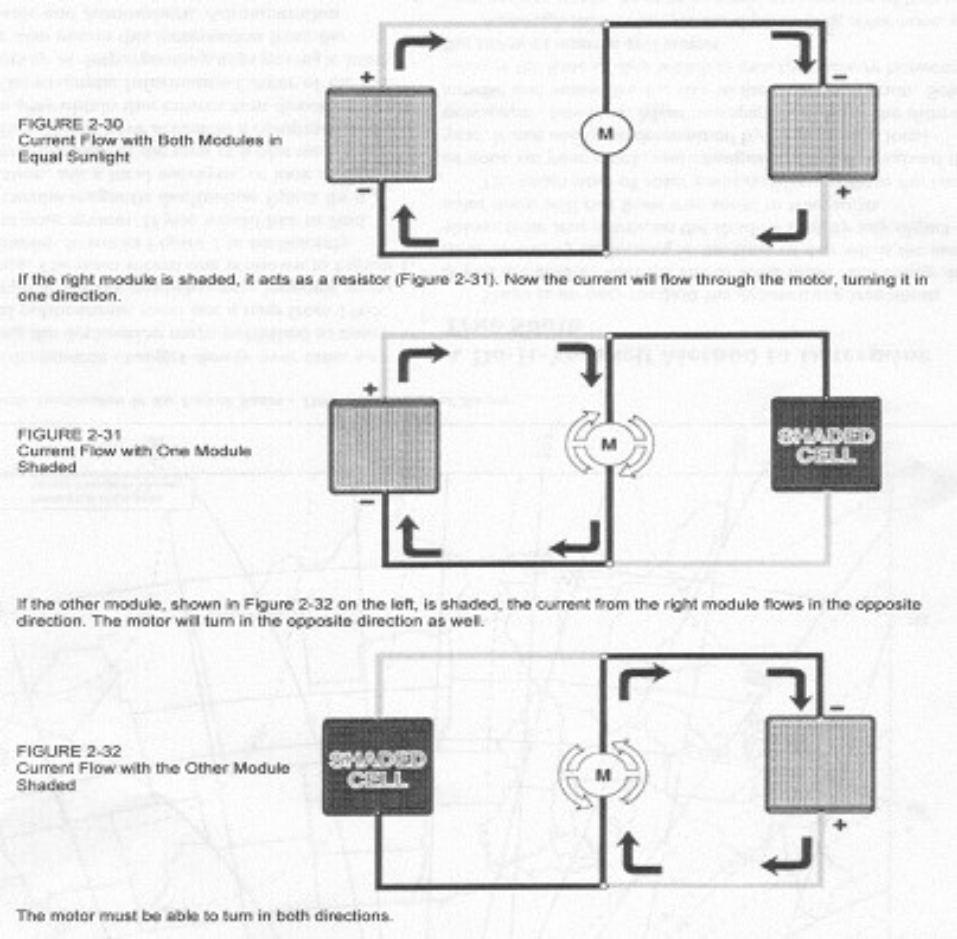


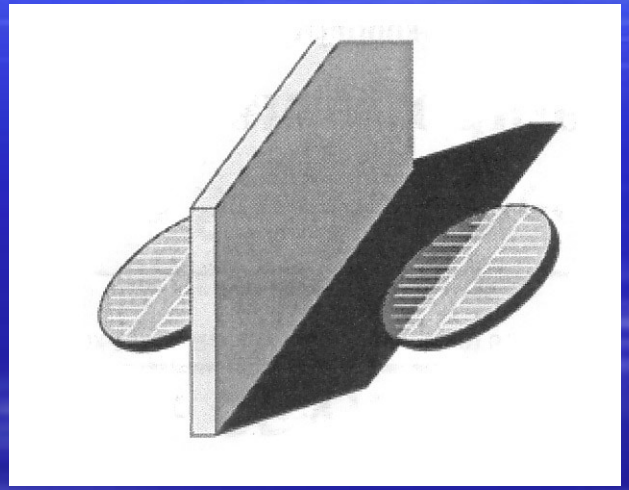
One-axis tracking



Two-axis tracking

Second Concept: Sun Motor Tracking System





This is how a sensored panel works

AC Energy and Cost Savings

Station Identification

City	Chicago
State:	IL
Latitude:	41.78 ° N
Longitude:	87.75 ° W
Elevation:	190 m

PV System Specifications

AC Rating:	4.0 kW
Array Type:	1-Axis Tracking
Array Tilt :	41.8 °
Array Azimuth:	180.0 °

Energy Specifications

Cost of Electricity:	8.0 ¢/kWh

Energy Production

Month	Energy (kWh)	Energy Value ($)
1	440	35.20
2	494	39.52
3	642	51.36
4	751	60.08
5	861	68.88
6	847	67.76
7	871	69.68
8	757	60.56
9	675	54.00
10	599	47.92
11	377	30.16
12	312	24.96
Year	7625	610.00

Design: Curtain Wall

-A flat panel system will be used over a concentrator. The concentrator is an efficient way of gathering sun, but due to overheating and an expensive cooling and tracking system, it is not economical.

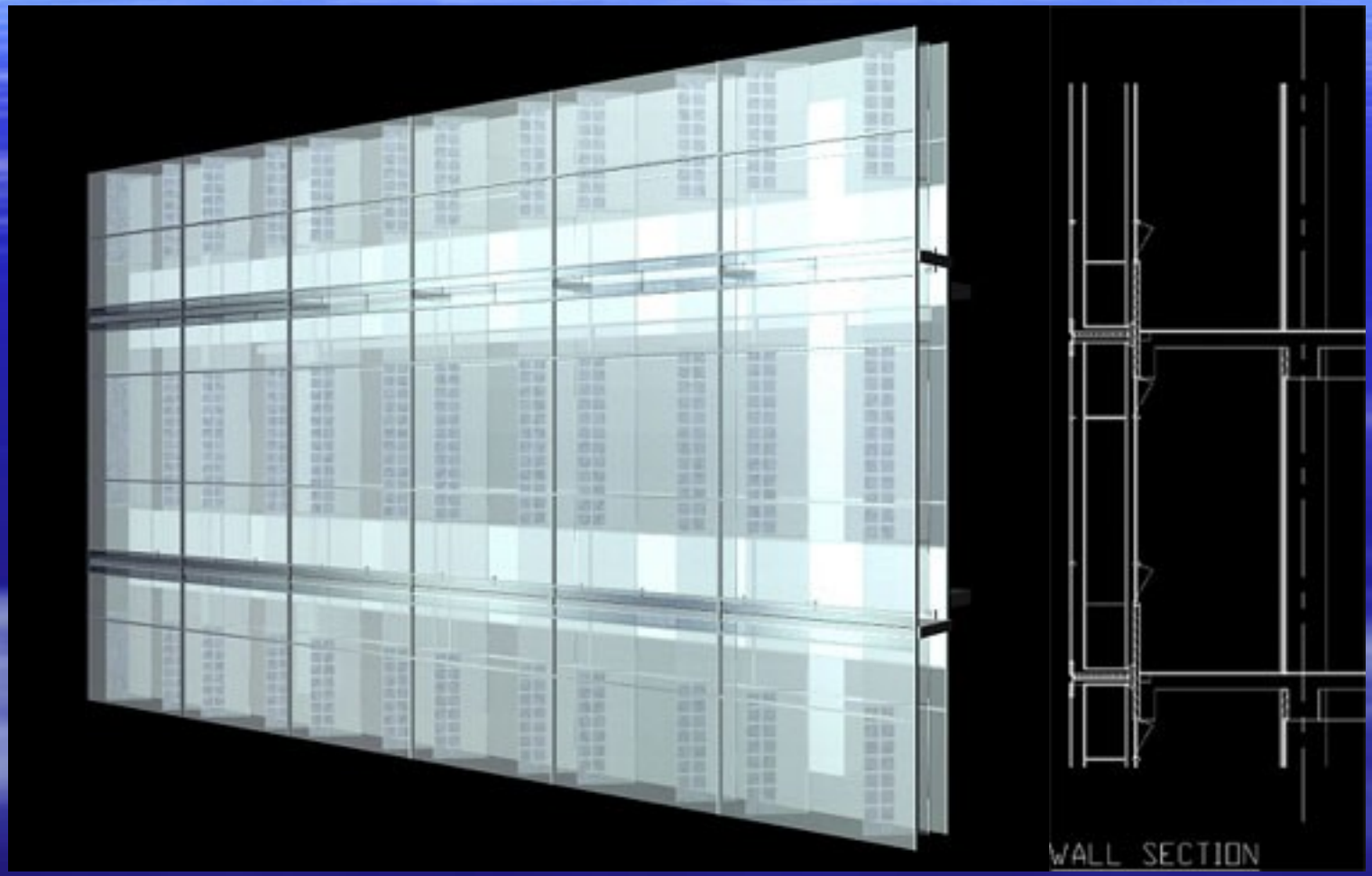
-To protect the PV panels from the strong turbulence of Chicago winds, a double wall façade is used. The panels still remain effective and will be able to operate longer due to less stress being placed on the fragile panels. In addition, vents in the wall will allow for natural cooling and the use of the double wall gives residents access to a balcony year round.

-A tracking system will be used to make efficient use of the panels. The panels will be able to track the sun's path through the sky during the solar window.

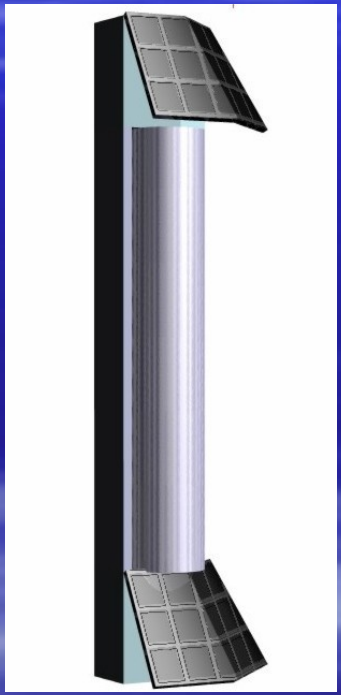
-As a result an effective design is created that allows the building to function with the use of PV panels.

South Side Curtain Wall

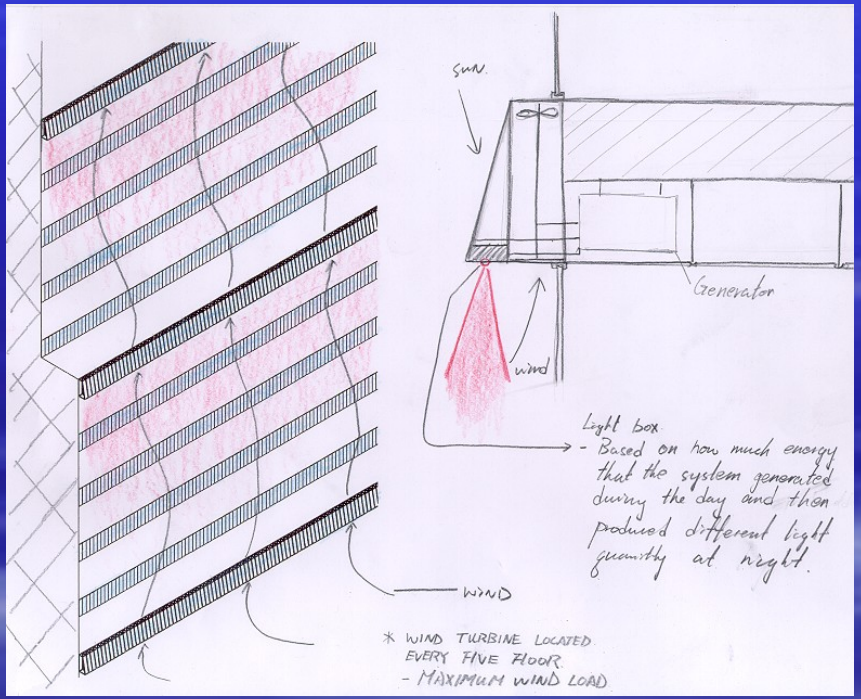
West Side Curtain Wall



Group 4 Proposals

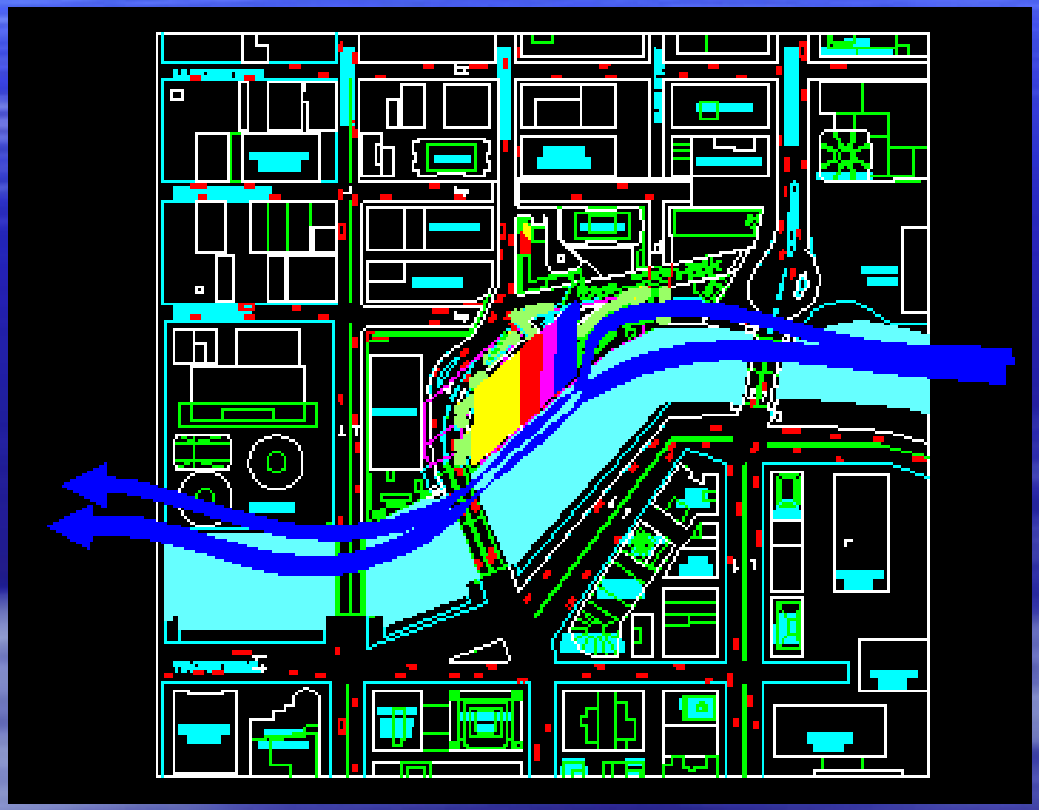


Corners with Prefabricated Units



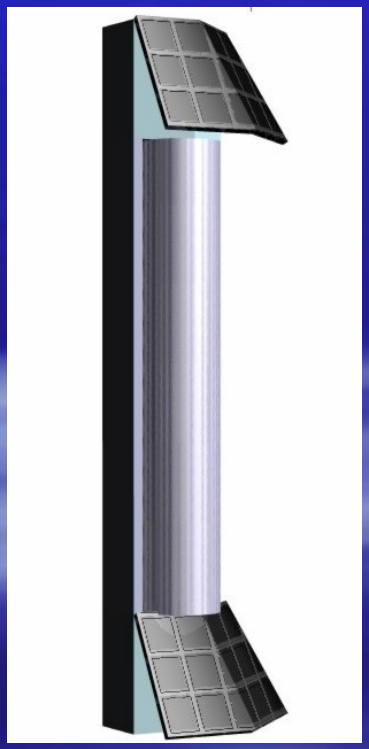
Prefabricated Units Applied to Facade

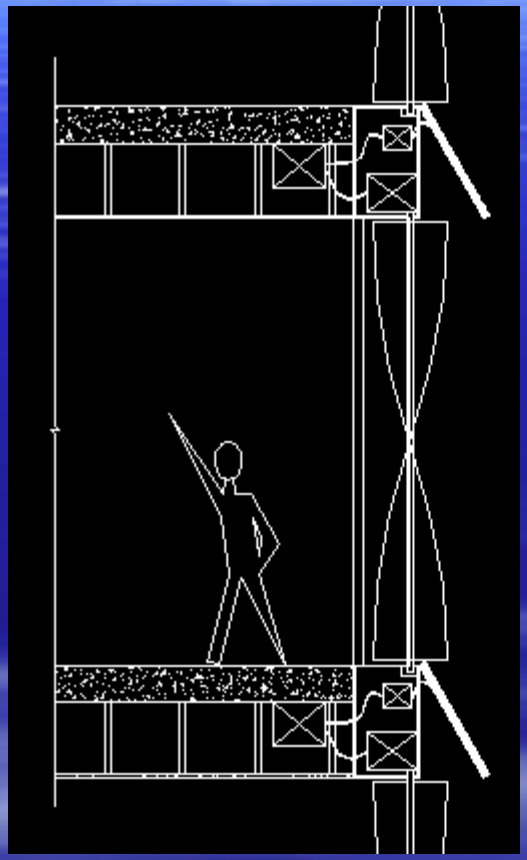
First Concept: Corners with Prefabricated Units



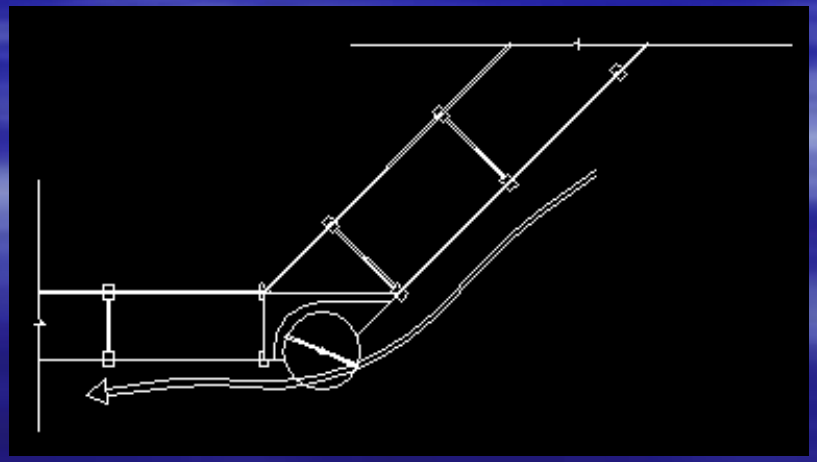
Utilizing South facade for maximum sun and wind power

First Concept: **Corners with Prefabricated Units**

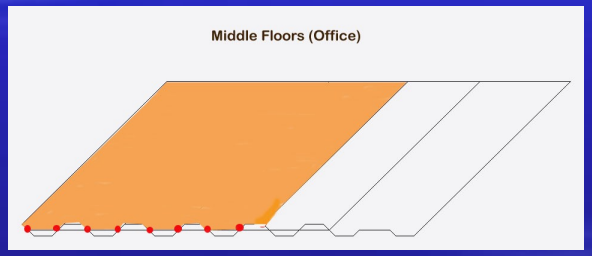




PV & Turbine Unit

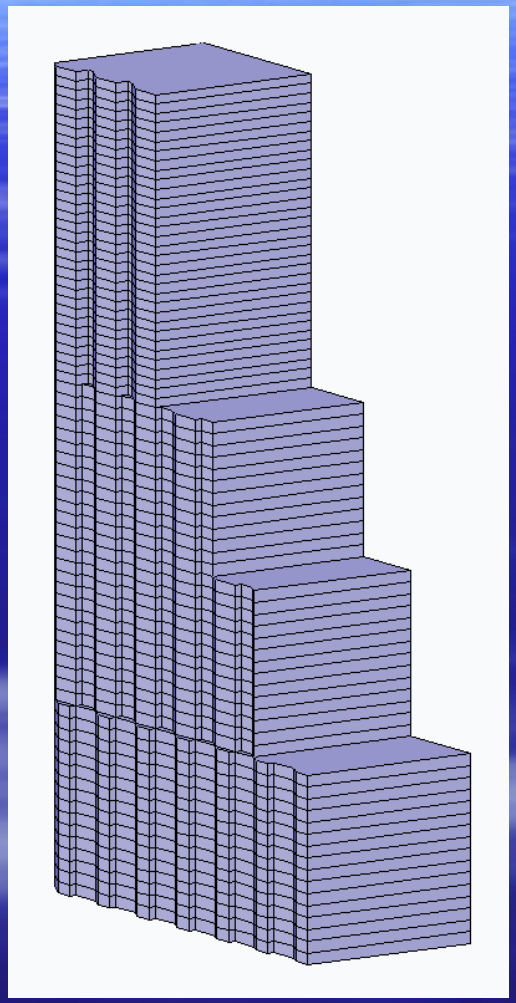


First Concept: Corners with Prefabricated Units

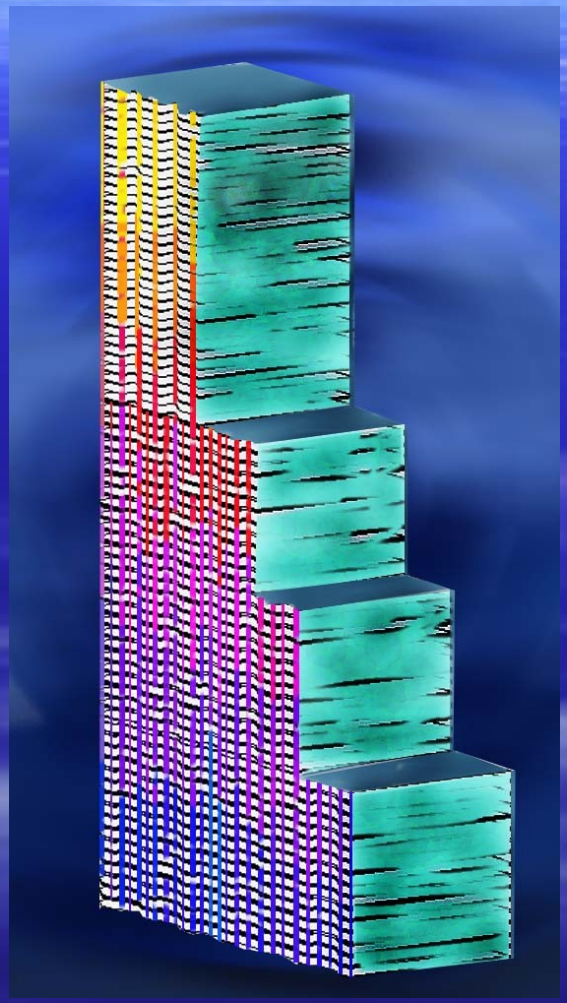


Floor Plans with Turbine Location

First Concept: Corners with Prefabricated Units

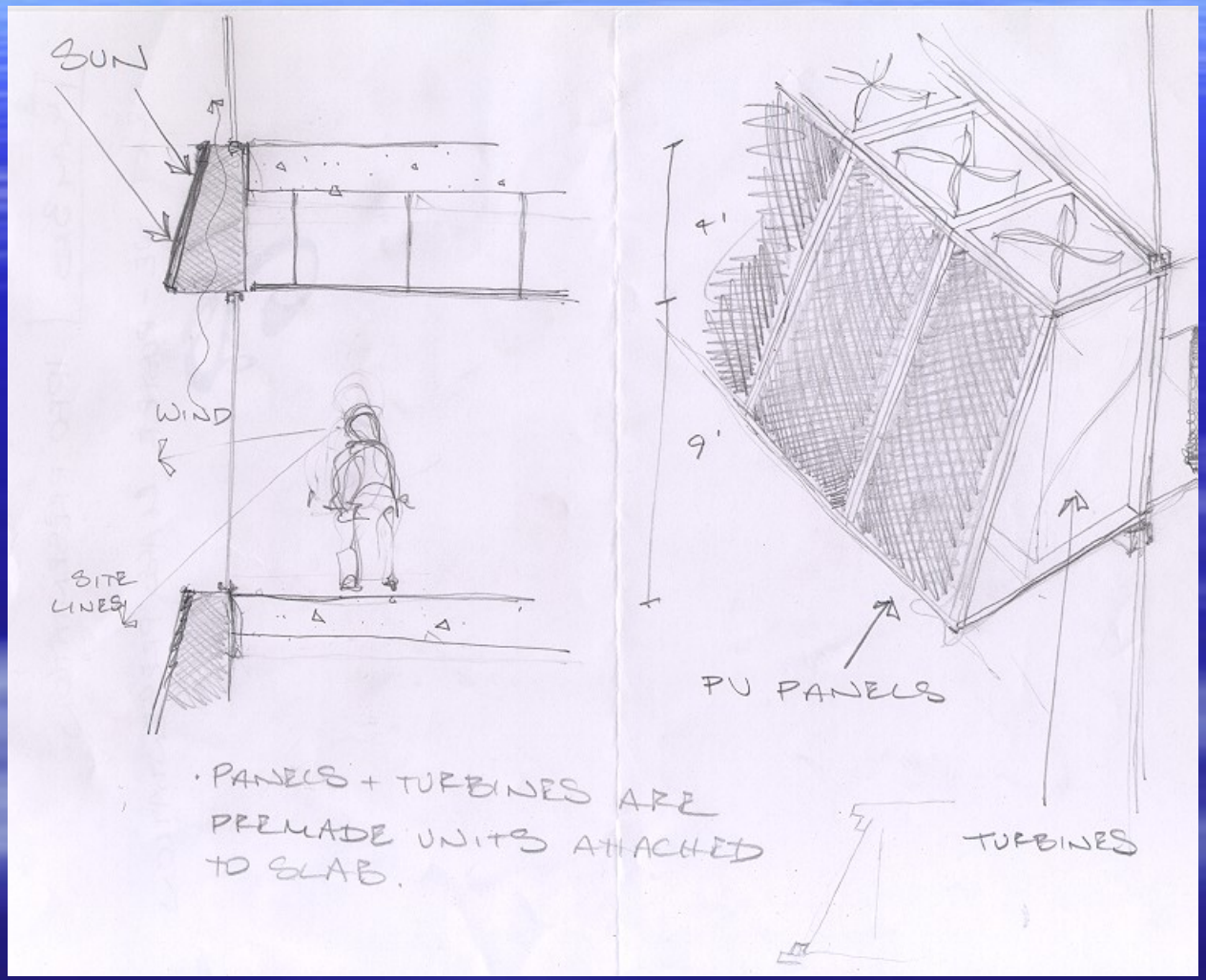


Proposed Form



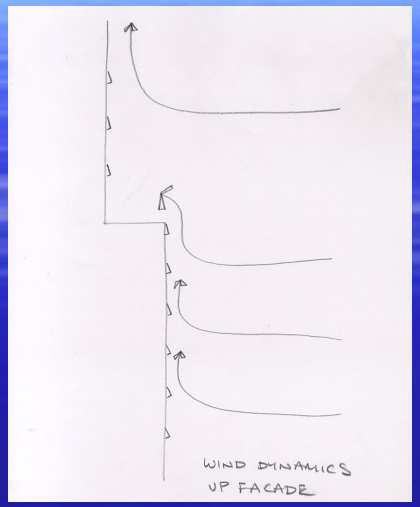
Proposed Lighting Scheme

Second Concept: **Prefabricated Units Applied to Facade**

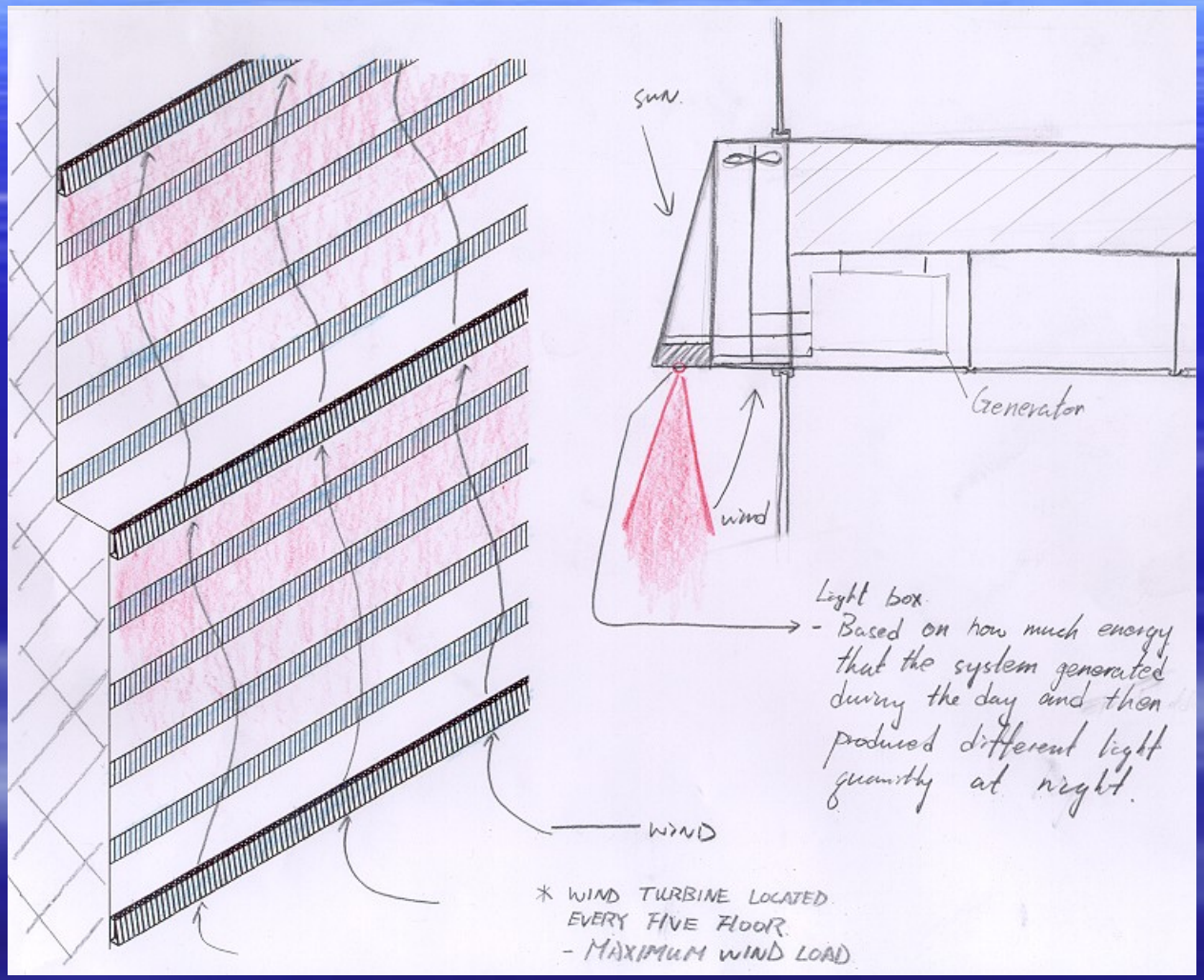


Units attached to slab, generator in spandrel

Second Concept: **Prefabricated Units Applied to Facade**



Wind direction



Conclusion

Prefabricated units allow for ease of installation, as well as maintenance

Shaping the building can control and increase the energy produced by wind as well as create dynamic interior spaces

During the day, the PV panels visually mark where the energy is being produced

Using the units to power exterior lighting is a visual portrayal that the building is utilizing renewable energy and changing in response to fluctuating environmental conditions