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Katya Hristova
Michelle Ogrinc
Ananth Sampathkumar
Ranad Shqerat

Group 2
Kim Sagami
Mijeong Field
Yunseok Oscar Kang
Erika Lau
Velina Mirincheva
Abdul Muhammad

Group 3
Sophia Sebti
Rafael Enriquez
Michael Huang
Chuan-Fang Lin
Yehoshuah Yehudah

Professors: Mahjoub Elnimeiri & Hatice Sozer
Sponsor: Skidmore Owings & Merrill
+PROJECT: CONVENTION CENTER

+THE SITE:
The site, situated in downtown Phoenix, has the size of 2x4 regular city blocks. Washington street, on axis with the Phoenix city hall in the west, cuts the site in two parts. Next to the area are the Symphony Hall, Bank One Ballpark and the America West Arena.

+PROGRAM:
- exhibition space - 600,000sf
- ball room - 50,000sf
- meeting rooms 150,000sf
- lobby&concourses 10,000sf : 1 truck berth
- support space 200,000sf
- food service
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+CLIMATE:

+wind class 1 (up to 9.8 mph)

+precipitation:
  annual average 7 in.
  35 days

+relative humidity:
  27%
  clear days: 214

+temperature
  Annual average 70° F
  July 78° F - 105° F
  January 38° F - 65° F

Phoenix solar resource:
7500 Whr/sqm
(highest in the U.S.)

Phoenix
main wind
directions
PV TECHNOLOGY : ADVANTAGES
+ renewable & clean source of energy
+ decreases dependence on foreign oil supplies
+ delivers and stores electricity more efficiently
+ energy efficiency means using less energy to accomplish the same task
+ MONOCRYSTALLINE SILICON CELLS
  highest efficiency (24%) / most expensive

+ POLYCRYSTALLINE SILICON CELLS
  cheaper than monocrystalline/ slightly less efficient (19%)

+ THIN-FILM SILICON
  thin films of semi-conductive and conductive materials
  deposited on glass; least expensive/ least efficient (16%)
• The power yielded from a panel depends on its angle of inclination towards the sun. The optimum angle is dependant on the latitude of the site’s location. There are fixed panels as well as panels that track the sun’s movement.
• State of Arizona - Homeowners can claim a 25% tax credit on up to $4,000 of solar devices installed on a residence
• Arizona Public Service Co offers $2.00 per Watt rebate; maximum rebate is $10,000 per customer
• Solar devices are exempt from Arizona State Sales Tax
Efficiency Factors

• Temperature
• Relative Humidity
• Wind Loads
• Radiation
• Shading
• Orientation
• Lifetime
• Array Condition
**Comparison of Photovoltaics and Wind**

<table>
<thead>
<tr>
<th></th>
<th>PV</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>4 panels, 8 panels, 15 panels</td>
<td>1.5 m, 3 m, 7 m</td>
</tr>
<tr>
<td>Capacity (kW)</td>
<td>0.21, 0.42, 0.79</td>
<td>0.25, 1.5, 10</td>
</tr>
<tr>
<td>Output (kWh/yr)</td>
<td>387, 767, 1451</td>
<td>800, 3,000, 20,000</td>
</tr>
<tr>
<td>Storage Cost</td>
<td>$1,400, $1,400, $2,800</td>
<td>$1,400, $2,800, $14,000</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$4,200, $6,700, $11,600</td>
<td>$3,000, $10,000, $36,000</td>
</tr>
<tr>
<td>$/kWh</td>
<td>10.9, 8.7, 8.0</td>
<td>3.8, 3.3, 1.8</td>
</tr>
</tbody>
</table>

Assumes 6 m/s average wind speed at hub height and 5 sun hours per day.
Installation not included.
PV prices; Real Goods.
All systems use same quality battery; $1/amp-hour
Storage = 80% of rated capacity usable.

PV modules will account for 1/3 to ½ of the initial cost
TYPES OF TURBINES:

Horizontal axis wind turbines

[Images of various types of wind turbines]
LOCATION & ORIENTATION

Factors influencing location:

Wind conditions
Topological features
Grid connection and reinforcement
Surrounding built environment

Factors influencing Orientation:

5 - 9 rotor diameters in the prevailing wind direction
3 - 5 rotor diameters in perpendicular direction
EFFICIENCY:

Betz law:

only 59% energy transformation possible

The energy output depends on:

- the wind speed - varies with the cube of the wind speed
- the density of the air (height of the location)
- the rotor area - increases with the square of the rotor diameter.
COST CONSIDERATIONS:

factors influencing cost:
Energy output
Scale of the project
Installation cost
Operation and maintenance cost
INTEGRATION INTO THE BUILT ENVIRONMENT

1. Stand-alone structures
2. Retro-fitting existing buildings
3. Full integration into the built form
4. Partial integration into the built form
PROPOSED INTERVENTION

INTEGRATION OF

1. PHOTOVOLTAIC CELLS ON ROOF SURFACE AND SOUTH FAÇADE TO GENERATE ELECTRICITY AND SERVE AS AN EFFECTIVE SHADING DEVICE

2. WIND TURBINE TECHNOLOGY ON WEST FAÇADE

3. 700,000 sq. ft. OF GREEN AREA ON ROOF SURFACE PROVIDING THE CITY WITH AN URBAN PARK.

4. 2 SETS OF COURTYARDS THAT SERVE AS LARGE LIGHT WELLS INTRODUCING NATURAL LIGHT INTO THE CENTRAL SECTION OF THE BUILDING.

5. PASSIVE COOLING TECHNOLOGY IN THE COURTYARDS THAT DEFLECT LIGHT INTO THE BUILDING AND COOL HOT HUMID AIR WHICH THEN GETS RECIRCULATED.

6. RETRACTABLE MEMBRANES THAT PREVENT SOLAR GAIN ON THE WEST FAÇADE DURING THE LATTER HALF OF THE DAY.
EXPLODED VIEW

4’x4’ monocrystalline modules

5’ wide support panels aligned at optimum tilt angle for maximum efficiency

20’x20’x15’ Space Truss integrating roof garden and PV panels

700,000 sft. elevated Urban Park

WS-4A (~20A) horizontal axis Helical Wind Turbine situated along the west facade to maximize use of prevalent wind direction
SOUTH-WEST BIRD’S EYE VIEW
DAMP MEMBRANES ALTERNATING WITH GLAZED PANELS SERVE TO DEFLECT LIGHT INSIDE AND COOL INCOMING WARM AIR
SECTION THROUGH WEST FACADE
Louvers shading interior corridor
Pool of water cooling interior corridor
Rooftop PV panels
Thermal mass wall
ENERGY COST CALCULATIONS

Initail Cost of PV
$6.39 \times 9 \text{cells} \times 384,896 \text{sq.ft} = $22,135,368.96

Money Saved Per Year
$416,586.08 \ (5,355,891.84 \text{kWh})

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
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<tbody>
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<td>Space Cool</td>
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<td>0.39</td>
<td>0.72</td>
<td>0.81</td>
<td>0.88</td>
<td>0.94</td>
<td>1.04</td>
<td>1.03</td>
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<td>0.86</td>
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<td>0.68</td>
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<td>7.86</td>
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<tr>
<td>Pumps &amp; Aux.</td>
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<td>Misc. Equip.</td>
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<td>2.18</td>
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<td>2.12</td>
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<tr>
<td>Area Lights</td>
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<td>0.85</td>
<td>0.83</td>
<td>0.84</td>
<td>0.86</td>
<td>0.81</td>
<td>0.87</td>
<td>0.81</td>
<td>0.84</td>
<td>9.96</td>
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<tr>
<td>Total</td>
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<td>3.82</td>
<td>4.66</td>
<td>4.63</td>
<td>4.72</td>
<td>4.76</td>
<td>4.92</td>
<td>5.01</td>
<td>4.65</td>
<td>4.81</td>
<td>4.32</td>
<td>4.17</td>
<td>54.53</td>
</tr>
</tbody>
</table>
Cross Section

Roof Structure Plan

Roof Drainage Section

Longitudinal Section
WEST ELEVATION

INTERIOR CORRIDOR

WEST ENTRANCE
East Elevation

Longitudinal Section

West Elevation
Perspective of Pedestrian Roof Space

Perspective of Pedestrian Roof Space
With a 54,000,000 kW/per year consumption, and the tilted roof design producing 242,922 kW/per year.

We chose to use the MonoCrystalline PV Cells from the company Airtherm at $6.39 per cell. With a surface area of 200,000 sq ft covered with pv cells, the cost of installation will be $11,502,000 USD.

Therefore the payback period will be approximately 48 years, as opposed to a flat roof which would be 59 years.

Total Energy Consumed:
54,000,000 kW/per year

Total Energy Produced:
215,155 kW/per year

242,922 kW/per year