TODD WILLIAM ROTTMANN

A PAVILION FOR THE UNITED STATES OF AMERICA
AT THE 1992 WORLD EXPOSITION
Educating the public about renewable energy resources
through experience and experimentation

MAY 1992
Pavilion for the United States of America at the 1992 World Exposition

Department of Architecture
College of Architecture and Planning
Ball State University

TODD WILLIAM ROTTMANN

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Bachelor of Architecture Degree Program
Thesis Design

Thesis Design Committee

A. E. Sonny Palmer  Professor of Architecture  Studio Critic

John McCreery  Associate Professor of Architecture  Thesis Critic

Jeff Culp  Center for Energy Research, Education, and Service  Thesis Critic

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Undergraduate Thesis  Todd William Rottmann  Credits
This work is dedicated to two special individuals.

Amy..... you have made my days,
you have made my nights,
make my tomorrows.

you are the greatest.

Jim....... here's to you,
here's to me,
best friends we'll ever be.

you taught me to be myself, how can I thank you.
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Origins, History, and Precedents of World’s Fairs

Even before the first official industrial exhibition in 1851, nations around the world had been involved in showing-off and trading their goods amongst each other. This idea of showing-off is the basic reason behind the origin of today’s World’s Fairs. Conceit is a natural human characteristic and demonstrations of it at work date back to the Old Testament days when kings would give a feast for visiting nobles and princes in order to display their wealth and prominence. Likewise, the Greeks would often halt feuds between city states temporarily so that they could trade and barter between one another during holiday feasts. These desires for trade and exhibition of material goods would serve as the foundation for future international cooperation.

From these beginnings, traveling salesmen and village markets became the tools used for interchange and display of goods. These activities were so popular that markets developed into social centers for many cities. Not only was the exchange of material possessions prevalent, there was the exchange of ideas and philosophical thought as well. Some of these markets eventually turned into fairs during medieval religious festivals—the only public holidays during that time of church dominance. In fact, the word ‘fair’ comes from the Latin word for holiday: ‘feriae’ (Allwood 7). The expansion and enlargement of these fairs occurred in congruence with improved technology and communication. As long as there were newer, better items to be shown and more people could be notified of an event, the fairs continued to grow. With the intermingling of theatrical performances that coincided with the religious holiday being celebrated, these fairs became an enchanting blend of trade and entertainment.

With the oncoming of the industrial revolution, fairs became showcases for new manufactured products while simultaneously enhancing industrial trade. Their organizers wanted to “forward the upward progress of industrial civilization” (Allwood 8). These gatherings allowed for the exhibition of goods from various countries under one roof for easy comparison. In order to attract more people, the fair organizers strived to make each exhibition bigger and better than the previous ones. What developed was the creation of the “world fair.”

Lawrence G. Zimmerman, a designer and World’s Fair memorabilia collector, divided the World’s Fairs of the past into seven different eras in order to systematically study their relevance. The first era was the Crystal Palace Era which started in 1851 with the “Great Exhibition of Industry of All Nations” in London conceived and sponsored by Prince Albert. There, the Crystal Palace was built with 300,00 49"X10" glass planes—the largest glass plane module ever. The entire building, which was 1851 feet long to correspond with the year, was constructed in six months, without scaffolding. Due to the unexpected financial success of this first World’s Fair, others immediately began all over the world. This era became a “catalog of the industrial revolution displayed for the first time” and is known for the invention of the elevator (New York, 1854), the ice cream soda (Paris, 1868), and suggested the idea of the department store (Zimmerman 65).

The second era, the Centennial Era, began in Philadelphia in 1876 with the 100th anniversary celebration of the Declaration of Independence. This was the first exhibition to follow a theme (honoring the anniversary of an event) and is remembered for the telephone, a monorail system, the first commemorative postage stamp, and the introduction of Japanese architecture (Zimmerman 66).
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In addition, this was the first time that individual countries paid for the erection of their own buildings, doing so to highlight their nation by separating themselves from the other exhibits. The use of eight buildings instead of one to house the exhibits created the multi-pavilion concept still used by fairs today. The era culminated in 1889 at the International Exposition in Paris where the Eiffel Tower was constructed.

The nobility of the eclectic forms of the Romans was the key element defining the third era, the Neoclassical Era. The main fair during this time was the World's Columbian Exposition held along the Lake Michigan waterfront in Chicago in 1893. This gathering commemorated the 400th anniversary of the landing of Columbus. Because of society's reverence for classical forms, this fair produced neoclassical structures that were "as impressive and impermanent as a set for a movie spectacular" (Zimmerman 68). The extensive use of neoclassicism continued throughout the private sector for decades following the fair's end. The only criticism of the World's Columbian Exposition was that it failed to produce a homogeneous exhibition that could have set the standards for city and community planning. This remark aids in the demonstration that fairs were starting to encounter other purposes besides merely promoting trade and goods, they were becoming more concerned with public relations and the display of varying lifestyles amongst the countries.

The Art Nouveau Era, the fourth era of World's Fairs, started in 1893 and is highlighted by the Paris Fair of 1900. Many of the fair's Art Nouveau structures remained after the fair and became a part of the city. One of the most notable accomplishments was the development of the first part of the Paris Metro subway system that included Guimard's sculpted cast iron entrances. It was now evident that fairs were also being used to revive failing economies and communities. Whether they provided monetary gain or pride, fairs were being organized to assist the host country. Both France and Britain used them on several occasions to bolster national faith after periods of war and turmoil. With people's attention focusing on those countries that displayed arms and armaments, an emphasis on nationalism arose during the Paris Fair of 1900 and continued at the Pan American Exposition in Buffalo the next year where, interestingly, President William McKinley was fatally shot in September while visiting. The St. Louis Exposition of 1904, the largest fair yet, is remembered for China's first entry at a World's Fair, the building of Washington University as an exhibit, the hosting of the Olympic Games, and especially the introduction of iced tea and ice cream.

Because of the rising cost of hand labor after World War I and the difficulty of forming Art Nouveau decorations on modern machinery, Zimmerman states that the "lleshness of the sensual form and the rich materials of Art Nouveau was replaced by an intellectual appreciation of geometric and cubist embellishments" (Zimmerman 70). Thus began the fifth era, the Modern Era, in 1925. During this period, an international organization (the Bureau International des Expositions) was founded to help regulate exhibitions. However, the propaganda value of fairs was too much for nations to forego so there were still as many fairs as the nations could produce. The purposes and quality of the fairs did not suffer though. For example, the 1939 New York World's Fair with its pure geometric symbols, the Trylon and Perisphere, addressed the beneficial spirit of World's Fairs by expressing an optimism for a better world. The exhibits showed how machines and goods could create an economically stable future in the city of tomorrow as opposed to dwelling on the unrest and unhappy past and present.

This spirit carried on into the sixth era of World's Fairs, the Atomic/Pop Art Era, which started in 1940. Fairs became symbols of peace between the nations—peace through understanding. People all over
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The world learned about different people, different cultures, and different countries. They learned about the past and looked into the future. Pop art and commercialism, where much is sold but few ideas are presented, were the only factors to cloud up the spirit of fairs during this time. The 1964 New York World's Fair is a prime example because it was almost entirely commercialism. Progressive Architecture called the fair "the most horrendous hodgepodge of jukebox architecture that has yet to be assembled" (Zimmerman 71). The main problem was that most foreign exhibitors decided to participate in Seattle's fair, so the organizers in New York had to rely on individual companies to fill the pavilion spaces. These industrial and commercial firms competed against each other for the visitors' attention, causing unavoidable and overwhelming publicity ploys and advertisements.

The seventh and final era that Zimmerman talks about is the Expo Era which spans from 1967-76. It began with the Canadian Centennial international celebration called Expo '67 that had the theme "Man and His World." This was the first break from the industrial exhibitions that were the norm. Focusing on the spirit of man rather than goods and products, this fair was less commercialized than those of the past. Commercialization and education were finally coming closer together in importance. They got even closer at San Antonio's HemisFair '68 where a revolutionary Francis Thompson film showed many of the problems of America. The spectacle of the movie was used to educate the public. The organizers of Expo '70 in Osaka, Japan, continued this technique with a film showing how our world depends on our behavior. At that exposition, the Festival Plaza designed by Kenzo Tange turned into a three-dimensional world where entertainment and education worked hand in hand in three different exhibit areas—the World of Mystery, the World of Harmony, and the World of Progress. They showed that together the people of the world could make a positive impact on the future. The visitors enjoyed themselves and hopefully retained some new knowledge and implemented it when they returned home. Expo '74 in Spokane, Washington carried the theme "Celebrating Tomorrow's Fresh New Environment." It too had an environmental goal in mind because its organizers wanted the fair to serve as a "springboard for deep public involvement in environmental problems," hopefully leading to community-based organizations and programs, maybe even the establishment of an environmental resource center in Spokane or another city (Meskowitz 29).

Eighteen years have passed since then and it is time for the World Exposition in Seville, Spain. The theme of Expo '92 is "The Age of Discovery" in which exhibits will show mankind's accomplishments in all fields of activity. One area of concern for many remains the protection of our environment. In fact, designing environmentally-aware pavilions has been the subject of several international competitions. Hopefully, these new pavilions will carry on the trend started in the Expo Era by educating and inspiring the public to lead environmentally conscious lifestyles in order to preserve our natural habitat and ultimately our existence.
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Bureau International des Expositions

The information contained in this essay was derived from The International Bureau of Exhibitions and Regulations Respecting International Exhibitions.

With the rapid growth and occurrence of international exhibitions around the turn of the century, it was inevitable that problems would arise. Among these complications, poor organization and conflicts of interest were the most prevalent. Not only did hosting countries encounter trouble, but the visitors and participants wanted certain guarantees. These issues led multiple nations to gather on several occasions in order to discuss the situation and develop solutions for the future. What resulted was thirty-one countries signing the International Convention of 1928 which "brought order to the world exhibitions situation by regulating their frequency and outlining the rights and obligations of the exhibitors and organizers" ("International" 2). Simultaneously, to carry out the provisions of the convention, the Bureau International des Expositions was formed to enforce it. This body is made up of representatives from each of the member nations to ensure that all nations comply with the regulations. The original convention was revised several times, the last time in 1965 which became the groundwork for the Protocol of 30 November 1972 that amended the original document and has governed ever since.

The Convention defines exhibitions as "a display which, whatever its title, has as its principle purpose the education of the public: it may exhibit the means at man's disposal for meeting the needs of civilization, or demonstrate the progress achieved in one or more branches of human endeavor, or show prospects for the future. An exhibition is international when more than one state is invited to take part in it" ("International" 3). Trade fairs and exhibitions are often confused with one another; but the purpose for a trade fair is to promote trade, not educate the public. While exhibitions do display goods, they do so to show the value of such items, not to sell them.

The Convention distinguishes between two main types of international exhibitions: universal exhibitions and specialized exhibitions. Universal exhibitions have large, general themes that encompass all aspects of human development and progress. At these gatherings, the participating countries are responsible for designing and building their own pavilions but are not charged rent for the site. On the other hand, at specialized exhibitions, the host government builds the display spaces and then charges rent to the participating countries who fill it. Another difference between the two types of exhibitions is that specialized ones center around a narrow theme, one that usually only focuses on a single aspect of human venture. The Bureau International des Expositions determines which type an exhibition is upon completion of the application by the host country.

Whether the government of the host country organizes the exposition or just supports it, that government appoints a Commissioner General "who is responsible for representing the state and guaranteed the fulfillment of commitments made with respect to the Bureau International des Expositions and the other countries" ("International" 5). Those commitments entail compliance with the basic premise for the Convention: to determine the duration and frequency of exhibitions and to protect the exhibitors. The maximum duration for exhibitions was set at six months and the frequency
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The chart below details the interval which must elapse between two exhibitions in the same or different countries:

<table>
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<th>Type of exhibition</th>
<th>Interval which must elapse</th>
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<td></td>
<td>In the same country</td>
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<tr>
<td>Universal exhibitions</td>
<td>20 years</td>
</tr>
<tr>
<td>Specialized exhibitions of the same nature</td>
<td>10 years</td>
</tr>
<tr>
<td>Specialized exhibitions of different nature</td>
<td>5 years</td>
</tr>
<tr>
<td>Universal and specialized exhibitions</td>
<td>5 years</td>
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</tbody>
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The Bureau International des Expositions is made up of the following people:
- General Assembly (1 to 3 representatives from all member nations)
- President
- Four Vice Presidents
- Executive Committee
- Specialized Committees
- Secretariat General

In essence, the General Assembly is the governing body of the Bureau. They meet at least twice a year. When 2/3 of the members are present, quorum is reached and the representatives vote on issues pertaining to the Convention. Even if a nation has three members on the General Assembly, each nation only gets one vote. Another function of the General Assembly is to approve and register proposed exhibitions.

As for the other offices mentioned above, the President is in charge of calling the meetings and serves a two-year term. The Vice Presidents are in charge of the committees and their terms are decided by the General Assembly. The Executive Committee is made up of twelve representatives designated by the General Assembly and their main task is to review all exhibition registration requests and give their advice for approval or not to the General Assembly. There are three Specialized Committees which are in charge of regulations, budgets, and other information. Finally, the Secretary General is appointed by the General Assembly to administer to business of the Bureau.

Any government of a state may become a member of the Bureau International des Expositions by agreeing to the terms of the 1928 Convention and the Protocol of 1972 and by paying a modest membership fee. By becoming a member, a nation will have a say in the organization of exhibitions in which they are hosting or planning to participate in. Their input will aid the development of each exhibition and set precedents in policies and principles for future ones. The greater the number of countries that are involved, the greater the influence the organization will have.
Exhibitions are an ideal medium for influencing the public. Unfortunately, many fail due to the conflict between showmanship and purpose. Herein lies a problem, how do commercialism and education in exhibitions combine? Since nations and organizations that participate in World's Fairs usually do so to show off what they know or what they can do, to remove the element of propaganda would bring an end to participation by these exhibitors. No one would get involved if they were to receive no new recognition or status. Besides, these exhibitions are meters of cultural and economic standards and humans take interest in what the latest trends and peak achievements are around the world. Modern society wants to know what is available to them and what direction they can or could follow with their lifestyles. What they learn at a fair will eventually "be re-embodied as active fators in everyday life after the manner of chain reactions" (Lohse 12). Although the idea of educating the public is a noble one, nations could not afford to spend millions of dollars on a pavilion that could foster little economic gain or national pride. In addition, the attendance would be low since people want to be entertained and amazed as well as educated when they go to see a World's Fair. The prospect of only being educated is a dry one and would not inspire many citizens of the world to spend their money traveling thousands of miles. Learning is an important part of a World's Fair pavilion since people are inquisitive by nature and are always in search of new knowledge, yet, learning should be complemented by humor, hands-on activities, and spectacle to stir up the audiences emotions and provide for a diversity of experiences. We live in a spectacle world where the limitless bounds of reality within movies translate into greater expectations towards every form of entertainment. Since World's Fairs are basically entertainment, their designers need to find the fine line that allows educational material to be interesting and exciting without turning it into a phony, exaggerated commercialization. One person's idea of how much is too much varies from another's, especially with the diversity of cultures present at a World's Fair, so finding that fine line is not an easy task. But, once found, the result would be multitudes of entertained fair-goers experiencing an educational and economically successful World's Fair.

The most promising approach to organizing World's Fairs lies in the concentration on a central idea that ties together cultural and social issues. This agreed upon idea needs to be one that interests the public—something that they would like to learn more about by experiencing it first-hand, thereby attracting crowds to the fair. By following a common theme, individual pavilion designers could express their nation's or organization's individuality through a built form while still tying into the others via a homogeneous thought. This thematical patterning provides for the comprehensible organization and display of exhibits that could demonstrate their sponsors' knowledge, achievements, status, etc. while still teaching the audience something beneficial.
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1992 World Exposition

The 1992 World Exposition in Seville, Spain, occurring from 20 April to 12 October, is the first universal exposition since the one in Osaka, Japan in 1970, with over 60 countries expected to participate and an estimated 17 million visitors. The theme is "The Age of Discoveries" since Spain is hosting the fair to celebrate the 500th anniversary of the discovery of the Americas by Christopher Columbus. Emphasis is not only on the lands involved in the 15th and 16th centuries, but on all scientific and technical discoveries that have moulded the history of man. With over 100 exhibits, there will be a wide variety of aspects of that topic covered.

The fair will occur on the Island of Cartuja, a 450 hectare piece of land between two branches of the Guadalquivir River opposite of Seville’s historic district. The fair site itself will cover only 215 hectares of the island, much of that being devoted to natural amenities like lakes, canals, and fountains (16 hectares) and parks and gardens (50 hectares). Only 40 percent of the site is to be built on. In addition, to enhance the natural beauty of the area, 1/2 million trees are being planted. As for preservation on the site, the existing 15th Century Carthusian monastery of Santa Maria de las Cuevas and five truncated cone-shaped kilns of the tile-making works built at the beginning of the century are being rehabilitated and have become symbols of the fair.

Connection between the Island of Cartuja and Seville is achieved by vehicular and pedestrian bridges. Another way to reach the island is by traveling the Guadalquivir River since there will be several boat docks along the edge of the site. Within the fair complex, pedestrian circulation is aided by a panoramic railway (monorail) that circles the area and a cableway that cuts through the middle of the site. Another transportation system dealing with the Exposition is a high-speed train railway, being created using some existing tracks, to connect Seville and Madrid. Estimated time of travel between the two cities would be reduced to merely three hours.

In addition to using the fair to boost local economic and employment situations, the City Council of Seville, the Autonomous Community of Andalusia, and the national Spanish government are using the 1992 Exposition to promote the modern image of today’s Spain for tourism purposes. The fair will have other future benefits as well. After the fair is over, most of the pavilions are scheduled to remain as permanent structures. The fair site and its buildings will become a large park, a cultural center, and the beginnings of Seville University.

In a time of increasing world conflict and upheaval, the importance of the role of the 1992 World Exposition as a peaceful gathering and exchanging of ideas amongst the nations is heightened. The fair becomes a symbol of world peace and the good that can be accomplished through work with a common purpose. One can only hope that this fair will reach these goals and, at least temporarily, unite the peoples of the world.

All facts and figures contained within this essay were taken from the various sources listed in the Bibliography section of this document.

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Climate of Seville, Spain

Temperature

All temperatures in degrees Celsius with Fahrenheit equivalent in parenthesis

Mean annual temperature of 19 degrees (66)
Hottest month: July, average of 27.9 degrees (82)
Coldest month: January, average of 10.5 degrees (51)
Highest temperature ever recorded: 47 degrees (116)
Mean daily temperature range in winter (December): 9.1 degrees (16.5)
Mean daily temperature range in summer (July): 16.2 degrees (29)

Sunshine

Clear sky: 132 days of the year
Cloudy: 165
Overcast: 68

Sunshine: 2878 hours per year (average 7.88 hours a day)
Radiation: average of 375 ly per day
154 ly per day minimum average in winter (December)
567 ly per day maximum average in summer (June)

Insolated region. Very clear air so radiation levels are always high. Among the highest levels in the world.

Water

Precipitation: 57 days of the year
Fog: 60
Snow: 00
Frost: 05

Precipitation per year: 534.9 millimeters
Maximum average per month: 84.0 (December)
Minimum average per month: 1.0 (July)
Evaporation potential per year: 940

Rainfall percent per year
27 — Spring
03 — Summer
36 — Autumn
34 — Winter

Cyclones [rotation of air (counter clockwise in northern hemisphere)] around a low pressure center] contribute the most rainfall. Many come from the Atlantic Ocean and some come from the Mediterranean Sea. The mountains of Spain and Portugal help to weaken the cyclones by
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breaking them up. Average duration of a cyclone is 8 days but they can last up to 19 days.

Rivers are irregular in flow because they are chiefly fed by runoff water from rains, especially in the mountain regions which receive the most rain. The rivers reach their maximum in the spring and autumn and their minimum in the summer. Flooding of Guadalquivir is sporadic ranging from 10 to 120 years with the average being around 20 to 30 years. Seville has built flood walls and rerouted parts of the Guadalquivir to prevent flooding of specific areas.

Hydraulics are a major source of energy since Spain does not possess large quantities of mineral fuels.

Advection (cold air going over warm land) causes occasional thunderstorms. Only convective precipitation in summer.

Wind

Generally out of the Southwest
Average speed: 1.7 meters per second
Maximum average per month: 2.0 (March)
Minimum average per month: 1.4 (Autumn and Winter months)

Very little wind in the Guadalquivir River valley.

Almost no wind in summer because of diminished air currents in lower atmosphere above the Iberian Peninsula. Similar to sub-tropical dry weather.
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Introduction
Niagara Falls flows five billion gallons of water per hour. Imagine that it flows gasoline at that same rate for 200 million years. If that gasoline could be collected and burned, the resulting energy would be the same amount that the sun gives off in an hour. If those quantities are too large to comprehend, envision a coal train that is ten times as long as the distance between the earth and the moon. If all the coal in the train was burned, the product would be equal to the amount of the sun's energy that reaches the Earth's upper atmosphere every hour (Angrist 471). With growing global concern over environmental hardships, now is the time to take affirmative action to ensure a sustainable and productive future for all people. Just like solar energy, there are many renewable energy sources — including geothermal, wind power, and water power — that are readily available for our usage. Even though the technology to utilize these energy sources exists, it is not implemented often enough to create noticeable impact on the environment. Why, then, are these powers not used? My belief is that people's notions about renewable energy sources and energy-efficiency possess negative connotations. Due to lack of knowledge and poor previous examples, people believe that these mechanisms are always ugly, expensive, and difficult to operate. Ignorance on this subject occurs in designers as well as their clients. The fact is that these notions, although fairly well founded, do not have to be true. My goal is to integrate renewable energy sources and energy-efficient technologies within the design process in order to create a highly functional and aesthetically-pleasing architecture. Through the public's experimentation and experiences within these architectural works, I intend to educate them about the uses and possibilities for renewable energy resources. My knowledge as of now comes from the classes I have taken at this university. My first concern for the depleting condition of the Earth's energy sources came from a natural resources class. Within the architecture department, I have had studios and classes dealing with the needs and availability of different environmental systems and the issue of a sustainable architecture.
Special thanks go to those individuals and organizations who helped me by providing needed counseling, guidance, information, and services.

Marie-Helene Defrene, Secretary General of the Bureau International des Expositions
Karen Eldridge of the Association of Collegiate Schools of Architecture
A. E. Sonny Palmer
John McCreery
Jeff Culp
Doug Knecht
Becky Amato

and, of course...Mom and Dad
Description
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Through my thesis project, I want to educate the public about the possibilities of a sustainable architecture. This sustainability can be reached by proper manipulation and utilization of available renewable energy resources and site characteristics. I need to reach large numbers of people because it takes more than a handful to successfully sway the tide of wasteful living. I need to reach the largest corporations as well as the smallest individual. Since World's Fairs appeal to people worldwide, I have chosen to design a pavilion for the United States of America at the 1992 World Exposition. An estimated 17 million people will visit the pavilion at 250,000 per day. Countries and their designers have historically used World's Fairs to expose, influence, and impress the public with futurist visions. Visitors to this pavilion must be inspired to remember and utilize what they have experienced.

I intend for visitors on this site to participate with the architecture by allowing them to manipulate it to create their own spaces. These manipulations will leave behind traces of previous activity and be symbolic of those who have been there. In addition, since these activities will involve natural elements such as the sun, wind, water, and earth, the visitors will be engaging renewable energy resources. By dealing with these elements directly, the visitors will be able to remember better what they did and how it affected their comfort, surroundings, feelings, etc.

Another aspect of the visitors' experience will be the ability to control various mechanical and energy-producing functions and witness what effect their actions have. These mechanisms include wind generators, water power generators, photochromic glazing panels, solar panels, and passive cooling systems. These activities are described in further detail in the design solution section of this document.

Since I want the people to be truly involved in what they are doing and what is going on around them, designed experiences are to stimulate as many of the senses as possible. The greater the effect on the person, the greater their memory will be of that event. I want the visitors to feel, hear, see, smell, and possibly even taste their environment. All areas will attempt to arouse each of these senses in an effort to create a total sensory experience.
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The site for Expo '92 is located in Spain on 215 hectares of the Island of Cartuja which is located between two branches of the Guadalquivir River opposite the historic district of Seville. More information on the fair and its site can be found in the 1992 World Exposition essay in this document. The particular site I chose for my project is located between the man-made lake and the sculpture garden near the center of the fair area. This space serves as a link between the two above-mentioned items and as a connection between the curved pathway around the lake and a main axis for the pavilion grouping (see Exposition Site Plan in design solution section).

The configurations and massing of the surrounding buildings are not known. It is assumed for the purpose of this thesis that the plots as outlined on the site plan will be utilized and built-up to their maximum potential. My pavilion must respond to the natural elements, land characteristics, pedestrian circulation routes running to it and by it, views from all sides (especially from across the lake), current land usage in the area, and post-fair usage goals. Utilizing the area's natural resources (soil, wind, rain, sun, etc.) for the good of the users and the site is the most important concern. Since this concern is so site-specific, what I design will be tied to this site only. However, the ideas that are gained by the visitors can be integrated into any climate and site type.

Since the World Exposition is a multi-cultural affair, the pavilion will not be geared towards any single culture. This building must represent the United States as well as respect its context because I intend for this pavilion to remain after the fair is over. Because it would maintain its basic function as an experiential playground incorporating the natural environment, there would be few changes needed for the site to continue to teach visitors after Expo '92.
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The short term goal for my thesis is to gain the public's acceptance of the use of renewable energy sources and energy-efficient technologies in architecture. The long term goal is to create buildings that are near self-sufficiency, both old and new constructions. By showing the positive aspects and possible applications of these ideas, I hope to move viewers from a position of agreement to a position of action. Only through doing can we improve the way we treat our environment.

My desire is that people learn from my learning by means of visual (project) and oral (discussion) communication. As a culmination of my knowledge to date, my thesis project should open new doors of thought on how a building's systems can work with and benefit its users and surroundings. This issue is critical for everyone, not just designers, since they will not design something that the users do not want. My learning through research, discussion, and design will eventually lead to my own practice of environmentally-conscious architecture, and hopefully it will influence the work of others as well.

This learning process is not an end, it is a beginning. I and others can take it further, personalize it, and practice it. My design occurred intuitively and I went where it took me. The final product for my thesis, this document, is a representation/presentation of that journey.
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In order to encompass all of the activities I desired to design and provide each one with their own identity, I chose not to design a single pavilion, but rather a series of them. These events would then be connected together via common circulation routes which allow the visitor several options on where they want to go. The pathways also provide variety in the elevation that the visitor experiences the site—some are elevated, some are on the ground plain, and some sink down into the earth or water.

By separating the various exhibits, they can each maintain their significance and relate better to their contents or purpose. For example, some events want to occur underground while some want to occur up in the air. While it is possible to combine these and put one on top of the other, with the multitudes of people that will be visiting the site at one time and the hurried pace they might be following, I felt it would be best to separate each piece so that all of the people there could be engaged in a common event and that event would be evident from various positions along the pathways so that the visitors could see them and then choose if they wanted to get closer or possibly participate directly. That choice would allow the people to see each place but only engage the ones they wanted.

All of the spaces are tied together and unified by several different means. One of them is the pathway system, as mentioned earlier, which provides a physical connection. Another link is the grid system they are laid out on which will be described later. A third similarity between the pieces is their overall simple geometric forms which provides easy identity and ease of orientation while inside. A fourth aspect providing unity is the use of concrete and masonry units as primary building materials since these act as good insulators and latent heat distributors. Furthermore, all elements are permanent in character due to their continued use after the fair is over.

The paths and the buildings are laid out on two different angles. The first is parallel to the rectilinear arrangement of the fair, thereby continuing that grid through the site. This continuation helps link my site with the general fair. The second responds to true North which is 12 degrees to the Northwest of the fair grid. This orientation to the South is important for maximizing solar potential in some of the exhibits. These two grids meet at a common point along the edge of the main circulation path cutting through the site and then radiate from each other. The two circular elements in plan on the North and South edges of the site symbolize this rotation.
Design Solution
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The following section of this document describes the design solution for my thesis. The description will start with the site as a whole and then move into the various buildings and mechanisms in further detail. All presentation drawings and model photographs are on the pages immediately after this written description.

To the north of my site is a lake and to the south is a sculpture garden. My site is to serve as a link between these two elements. This connection is important since this portion of the greater fair site I assume to be turned into a park when the fair is over. The water from the lake enters along the northern edge of my site, penetrating into the inner portion. This creates a continuation of the lake and a distinct line of where my site stops and the lake begins can not be drawn. The water continues throughout the site but at a different elevation and in a different manner (it creates a soft grid in one area and provides nutritional support for a hydroponics garden in another).

In order to relate to the garden to the south of my site, I created a submerged hydroponics shade garden along the southern edge and continuing up both sides of my site. This green space is a visual tie with the green space of the sculpture garden. Tree-shaded seating areas penetrate the rigid edge of the garden, not only providing places to sit for those walking by the site, but also continuing the lines of trees in the shade garden out onto the pathway, making a link to the trees bordering the garden on the other side of the path.

Primary entry to the site is gained on the West and East sides on the points where the two present circulation routes for the context connect with my site. At the points of entry, circular porticos with horizontal slatted roofs greet the visitors with shade from the hot summer sun. The slats are angled to block light during the summer when the sun is high in the sky and admit it during the winter when the sun is lower. Between these two entries is the main circulation path through the site. The orientation of the pathway not only directly connects the two entries, but also responds to the angle of true North mentioned in the programme section of this document. A straight connection allows visitors the opportunity to just pass through if they desire. My hope is that as they walk through, they will see something that interests them and stop for awhile or penetrate deeper into the site to participate physically with the objects there.

The first building the visitor will encounter is the geothermal/daylighting pavilion. This pavilion is separated from the pathway by a 10 foot high wall of compacted earth. After going around the wall, the visitor chooses to either walk out onto the roof of the sunken building or enter it. If they choose to go onto the roof, they will get a view looking over the shade garden and a portion of the daylighting experimental area. If they choose to enter, they will walk down a ramp that runs parallel to the earthen wall. This slow decent represents their submergence into the ground. The area will get cooler, the natural lighting will get darker, there will be the smell of damp soil, and the sound of water trickling will be heard from beyond. The people enter through a doorway into a tunnel that has a bright light at the end. Upon reaching the end, they have the choice of walking out onto an open-air terrace or continuing on their journey below the ground.
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The terrace is a semicircular slice of flooring running around the perimeter of the building and with the shade garden running along the other edge. This terrace serves as the daylighting experimentation area. Here, people are given building blocks, in standardized units that connect into holes in the floor and ceiling that covers a portion of the area, that they can use to create their own spaces (walls, openings, shading devices). Maybe they will create a space similar to what they have back home. Maybe they will create their dream space. Maybe they will create a space they have seen before. Some spaces will be large and built by many people while some will be small and built by an individual. The existence of the many spaces represents the character and thoughts of those who were there. The notion of different people working together to achieve a common goal despite language and cultural barriers is symbolic of the peaceful unification purpose of world’s fairs. The flexibility provided by the open area allows for the constructing to take place anywhere at any time. This way, people can respond to the position of the sun as it changes throughout the day and throughout the year. Play, response to the environment, and cooperation synthesize as the people of the world gather in the daylighting experimentation area.

If the people choose to continue their journey into the ground, they will walk down another set of ramps. These ramps curve around and open up into a large space. On the opposite wall, running the entire length of the space, is the compacted earth wall first seen along the pathway above ground. A 2 1/2 foot wide opening in the wall brings in a light wash of natural light. Within the semicircular space is a grid of water with earthen stepping stones. The ceiling plane is a mirror of this grid with lighting elements running continuous through it in the same location where the water is on the ground plane. Water runs down the back wall feeding the gridded stream. The visitors within this space feel as if they are in an underground aquafer as water runs into the space, flows through it, and then exits. People can feel the coolness of the water and the earth, thereby gaining an understanding of how a geothermal heat transfer system can work. The people exchange their heat for the coolness just like the elements do in the system.

By crossing the water grid or exiting out the sides of the space, the visitors enter into the hydroponics shade garden. Here, plants are grown in 2-foot-wide planters that run in strips overhead from the back wall to the front wall, raising higher off of the ground as they go. The roots of these plants then hang down through the space and into the flowing pool of water that makes up the ground plane for the space. As the roots of each plant grow longer, they are rotated up the planter, until they reach the top, at which point they are transferred out to another site where they can be utilized as plant material or as food. The visitors walk along pathways running amidst the roots. Being within the roots adds to the feeling of being underground. Also along these paths are rows of trees that are grown, rotated forward, and then transferred similar to the other plants. This area aids the understanding of how hydroponics works and how different elements of our environment function together since the synthesis between sun, vegetation, earth, and water can be seen.

From the main circulation path, if the visitor chooses not to enter the geothermal/daylighting pavilion, the site can be entered by two paths. The first one is accessed by walking up a ramp similar to the
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ramp that descends into the pavilion, but this one is located on the other side of the earthen wall. At the top of the ramp is the elevated pathway that traverses the site and reaches out over the lake on the other side. Along the way, the path circles around the central water feature of the site (to be detailed later) and passes through the office/exhibit building.

The second walk starts at ground elevation but descends along its way, cutting a groove down into the water that fills the site. As the visitor slowly lowers below water level on his journey, he finds a waterfall feeding into a semicircular pool along one of the walls. This waterfall comes from the water on the site and is accented by the site's central water feature, a two-storey-tall fountain. This spray of water rises up between two levels of walks, with its misty air cooling those who pass by.

Continuing walking, the visitor reaches the water power pavilion. This building is basically a rectangular box with no lid that is lowered into the water until its sides barely remain above the water height. The front wall of the pavilion is all glass so that visitors can look out into the lake and see the organisms, creatures, vegetation, and submerged earth that make up such an environment. Within the building, are two water power exhibits, one on each side of the path. One is a tidal lift translator. The visitors walk down a flight of stairs to get to a level below the pavilion floor. With the water on the South side of the pavilion kept lower than the water of lake by a series of operative gates that run along the northern edge of the site that separate the waters and allow the water level within the site to lower due to evaporation and water usage for site functions, water runs under the water power pavilion to level out the two water bodies. As it does so, it lifts foils on a continuous revolving belt much like air flow over an airplane wing lifts the plane off of the ground. This belt, like a vertical conveyor belt, turns a generator inside the pavilion, creating energy.

The second water exhibit is an evaporative hydroelectric system. In this case, the water runs through troughs built along the ceiling plane in order to balance the levels of the two bodies of water. As the water runs through them, it turns small hydroturbines that feed into a generator similar to the tidal lift translator. The troughs are transparent so the visitors can see the water and the turbines moving.

Upon leaving the water power pavilion, the visitor ascends up a ramp back to water level. At this point, the visitor is on a semicircular path along the lake that the person can wander along and look out over the lake at the other pavilions. This path also provides access into the office/exhibit building via stairs or elevators at several locations.

On cross axis to the pathway just described, running at water level, is another path that runs across the site from East to West. The West end of this path terminates with a wind farm. The farm is a series of twelve wind generators rising out of the water on a grid with pathways running between them. Atop the device is a three-bladed upwind generator with a swiveling head to allow it to turn and face the direction of the wind. At eye level, on the shaft, is a savonius/darrieus combination generator that creates interesting visual patterns when the visitor looks through it at the objects in the background. Four of the generators have a solid pad around them so that the visitors can walk up to them. Each of these devices has a crank so that the visitor can raise the height of the generator and a ratchet to
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change the direction the generator is facing. The visitor can see how the changes in these factors affect how much the generator turns and how much energy is being produced. The wind generators are located in the water so that they can produce hydrogen through electrolysis. The hydrogen then can be used as a fuel for site functions or used to produce electricity in a fuel cell.

The wind generator in the Southwest corner of the farm is different from all of the others. Instead of having a vertical shaft, it has a horizontal one that reaches out over the water. Its generator is suspended from a line. At the end of the line is a metallic needle which breaks the water's surface. As the generator spins in the wind, it sways the line causing the needle to create patterns in the water. The idea behind this is to turn the wind, something that can not be seen directly, into a visual element.

On the East end of the cross-axial path are the shading pads. These are six 15-foot-square pads that can each be reached by walks extending off of the pathway. On these pads are one of two shading devices that can be manipulated by the user to shade an area of the pad. The first device is similar to the geometry of a crane. It has a curved photovoltaic solar panel that turns the sun's light into energy at the same time it shades the users. This panel is connected to an arm on a pin joint. The arm can be raised or lowered by a pulley system that the user operates with a crank. The entire device is on a swivel base so that it can be turned to face the sun throughout the day.

The second shading device operates more automatically. As more electricity is generated during the day on a photovoltaic panel similar to the one mentioned above, the heating element in a freon piston at the base of the device gets hotter. As the temperature in the piston rises, the freon expands up to 40 times its original volume. This expansion pushes the piston holding the solar panel up towards the sky. Therefore, as the sun rises throughout the day, so does the solar panel. A crank at the base allows the user to adjust the angle of the panel according to the sun's position. In addition, the device is on a swivel which permits it to be turned to face the sun as it crosses the sky. Both of these shading devices, with their interactive nature, provide the visitor with a greater understanding of the sun's position at different times of the year and the day.

On the Northern edge of the site, raised on stilts to permit views to the lake underneath it, is the five storey office/exhibit building. The interior is a single-loaded corridor with offices along the South side. The North curvy wall is constructed out of five-foot-square photochromic glazing panels. From the inside, this wall provides unlimited viewing out across the lake from all levels. On the outside, it becomes a huge drawing board with a control panel located on the other side of the lake. There, people can control the tint of each glazing panel by pressing on the square that represents that panel on a large control board. This way, the wall becomes a continuously changing array of patterns and
The North wall is a cavity wall with the interior portion being a thick masonry wall acting as a tromb wall and the exterior portion being a glass curtain. As air within the several-foot-wide space is heated, it rises and flows out of a vent at the top. The flowing air turns a generator which creates electricity. Also, the turning generator helps to pull still more air through the space. The pull on this air due to the stack effect creates a continuous circulation of air through the building up from the adiabatically cooled air along the ground plane of the site. Controllable louvres are placed within the air space to prevent too much sun from reaching the tromb wall during the summer months since overheating would be a problem.

The upper storey of the building is a solar collector area. The sun's rays are utilized to heat water, create steam power, and create electricity through photovoltaics. Visitors will be able to walk amongst these devices and see how they operate first-hand. These active systems serve as a counterpart to the passive cooling system of the building.
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ENTRY

GEOThERMal AREA

SECTION OF GEOThERMAL AREA

SECTION OF HYDROPONIC SHADE GARDEN

EXPERIMENTAL DAYLIGHTING AREA

EXPERIMENTAL DAYLIGHTING UNITS

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This section lists the critique issues brought up in my final thesis jury and how they could be resolved or where I see them leading me.

I am approaching the technologies but I do not reach that extensive of a level, they are not fully developed. Hopefully, that level could be reached with more specific research in the next stage.

A stronger case for using renewable energy resources could be made if I had charts or graphs to show the savings. Now that the technologies being used are decided, figures can be drawn up as to the costs.

The zigzag path in the hydroponics shade garden does not reach its full potential in that natural area. I agree, but I was not sure on how to travel through the roots without disturbing them. This problem requires much more design thought.

Circulation paths are not wide enough. True in some places. My hopes were that there were enough pathway options that the visitors would be disbursed enough to avoid overcrowding.

Vegetation stops and does not fully mix with the water on the site. True. After the geothermal/daylighting pavilion, the site becomes very mechanical and the natural elements, except water, seem to be left out. More plantings and gardens are needed. Trees could have been used as several of the shading pad devices as a balance to the other mechanisms used.

The entries need to be more symbolic of the United States of America. There could possibly be a flag or map detailed in the pavers.
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