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Sean Patrick Tharp

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Sean Patrick Tharp

April 2007

The world will not evolve past its current state of crisis by using the same thinking that created the situation.

- **Albert Einstein**

We do not seek to imitate nature, but rather find the principles she uses.

- **Buckminster Fuller**

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l n t r o



Defnltion of Sustainability



Fig1 / Fig2

A word that has become mainstream to members of the architectural community is **Sustainability**; but what does this word mean and why is it so popular? The root of this word is 'sustain,' which by definition means: to give support or relief to, to supply with sustenance, to support the weight of.¹ Still, what does this mean to the architectural community?

Sustainability is a word the architectural community uses to define an approach to the design of the built environment that considers environmental and social issues on more than just a superficial level. "Sustainability is fundamental to quality design, not just an optional niche market."² A precise definition for sustainability is almost impossible to outline, because every individual has their own interpretation of what quality design is and to what degree sustainable environmental and social issues are applied to the built environment.

One way which architects apply sustainability to the built environment is to do more with less. This means to reduce many of the harmful effects on the environment by current buildings, such as resource consumption, energy use, pollutions, and waste. This is similar to the David and Lucile Packard Foundation's definition of sustainability, "Any building that has significantly lower negative environmental impact then traditional buildings."³ This is a step in the right direction for sustainable design; it gets people thinking. But, it is not a solution to the environmental issues facing architecture; it only prolongs the destructions of our planet. This way of thinking continues to make building better for the environment by being less bad. But, being less bad isn't being good.

William McDonough is one of the architects that is doing more than being "less bad" to create a truly environmentally conscious ar-

chitecture. He has looked nature and its complex systems and uses nature as an example of how buildings and products can be designed using the concept of “waste equals food.”⁴ He once said, “I was tired of working hard at being less bad. I wanted to be involved in making buildings, even products, with completely positive intentions.”⁵ His concept requires buildings to take advantage of the sun and wind as sources of energy. Its materials and systems related to the buildings environment and culture. The waste from one of the building’s system becomes the nutrients for another or the environment, while still creating an aesthetically pleasing building.⁶ McDonough’s concept is a holistic approach to design of the built environment that begins to correct problems of past generations. It provides a vision of a sustaining architecture.



Fig.3

Sustainable architecture is not a new style or fad, it is an approach to the design of the built environment that addresses building's harmful effects on the environment. It creates a solution to the problems that our industrialized modern architecture and our ignorance to the consequences of this lifestyle have created. Albert Einstein once said, "the world will not evolve past its current state of crisis by using the same thinking that created the situation."⁷ For architecture to become part of the solution to current environmental issues facing our planet, architecture has to do more than just be "less bad." Architecture needs to stop using out of date ways of thinking and designing, if we are to create a truly sustaining architecture.

This thesis project will explore an alternative approach to design, in order to create an environmentally responsible high school, located in El Centro California. It will do more than just be "less bad." Like McDonough's approach to design, this thesis project will use nature as an example of how to design. Using strategies that allow this high school to function more like nature and strive to the ideal of a, "living building," a building that exists as if nature itself created it. These strategies will be as important to the design of this high school as other building components. They will create an outline from which the building will be designed.

Using environmentally friendly strategies, systems, and technologies as the form generator for this high school will allow the building to become part of a solution to environmental issues facing architecture today, not just prolonging its destruction. This high school will be at least 30 percent better than California's energy code. It will provide enough daylight so that every classroom will function without the need for electric lights during school hours, run completely on clean energy from renewable resources. As well as convert waste or byproducts from one system into resources for another. Testing, modeling, calculations, and computer analysis will be used to prove that the design of this high school meets these goals.



Fig.4

H i s t o r y

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Before the invention of the light bulb, air conditioner, and mechanical heating systems, architects and builders used their intuition and their understanding of nature to design and build buildings. This type of architecture is referred to as vernacular architecture. Vernacular architecture is one of the best insights into how to design buildings for a specific area with a certain climate.

Examples of vernacular architecture can be found throughout the United States and the world. Examples of this architecture can be found in the southern states, with its shotgun house and Creole cottage. In this hot, humid climate these buildings use deep porches and overhangs to cool the breezes before they enter the building. Many of the buildings are raised off the ground to allow air to circulate underneath to create a cooling effect around the entire structure. They also allow the inhabitant to take advantage of these shaded outdoor spaces. Another form of vernacular architecture would be the pueblos of the Southwestern States. This area has very hot summers and cool winters, so taking advantage of solar orientation and thick massive walls to keep cool during the summer and store heat during the winter is vital.⁸ These two examples of vernacular architecture are completely different from one another, as they should be. The environmental conditions and cultures that created them are completely different.

With the creation of the systems needed to overpower the environment there was also the creation of a universal solution to architecture that could be placed anywhere, no matter what the climate or culture of that area may be. As architecture conformed to a universal solution, many of the intuitive or “common sense” ideas of design were ignored like, human scale, the relationship of the building



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Fig.5



Fig.6

to place, and the appreciation of the organic form.⁹ It began to rely completely on internal systems and nonrenewable resources to create a comfortable interior, almost completely independent of its environment and its natural surroundings. This was made possible because of the systems that control the internal environment and cheap energy from nonrenewable resources. This trend of cheap nonrenewable energy is coming to an end as these resources are depleted and their harvesting and consumption techniques are damaging the environment.¹⁰

Today, the realization of the consequences of a universal solution to architecture has prompted a new approach to architecture, a sustainable or green architecture. It is more environmentally conscious. In many cases, it is a combination of vernacular strategies, and new technologies. This combination of vernacular strategies with technology makes buildings more efficient and as a result consume less energy to create a comfortable living environment. In some cases they can even supply their own clean energy from renewable resources like the sun and wind.

Theory

1. The theory of the firm is a framework for understanding the behavior of firms in a market.

2. It explains how firms make decisions about production, pricing, and investment.

3. The theory of the firm is based on the assumption that firms are profit-maximizing entities.

4. It also assumes that firms have access to all relevant information.

5. The theory of the firm is a key component of microeconomics.

6. It provides a foundation for understanding the behavior of firms in a market.

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20. It provides a foundation for understanding the behavior of firms in a market.

In the last few decades the majority of buildings have been designed as if nature around them didn't exist. These buildings used brute force over nature to control the interior environment.¹¹ They relied on electric lights to illuminate the interior, mechanical heating and cooling to create a comfortable living environment, and the grid infrastructure to supply buildings with energy from fossil fuels (non-renewable resources) and to also dispose of waste.

Sustainable design strives to counteract the detrimental environmental aspects of these buildings and create an environmentally conscious architecture. Sometimes in sustainable design today the sustainable features of the building come as afterthoughts, or some of the originally planned sustainable features are abandoned because of the design scheme, budget, or aesthetics. When this happens sustainable design becomes an option or superfluous element instead of an integral part of the design. The reality is that sustainable issues should have the same influence in the design as all other parts of the building.

Many of the strategies, systems, and technologies used in sustainable design can allow the building to function like nature instead of overpowering it. Buckminster Fuller said, "We do not seek to imitate nature, but rather to find the principles she uses."¹² Using technologies such as photovoltaics and wind turbines, allow buildings to become sources of energy. Incorporating passive strategies as integral components, such as daylighting, passive cooling, and heating within buildings take advantage of natural renewable resources and the local environmental conditions; to relate the building to the surrounding area. Including building systems like Living Machines allows buildings to filter their own waste water natu-



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2



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Fig.7

rally and convert waste back into a usable resource. These strategies, systems, and technologies also give buildings the opportunity to educate its occupants about sustainable and environmentally conscious design.

To create a building that functions like nature requires the formal aspects of the building to respond to the strategies, systems and technologies that are incorporated within the building. This way the environmentally conscious aspects of the building do not take a back seat to other design issues; they establish guidelines for how to design the building. The following strategies, systems and technologies are a few sustainable features that buildings can be incorporate to function like nature and achieve the ideal of a “living building.”

Passive strategies are age old and some of the best strategies to incorporate in order to make buildings that are better for the environment. These strategies are used to light, cool, and heat buildings by taking advantage of natural renewable resources like the sun and wind, to augment and even replace mechanical systems. Determining which passive strategies to use depends on the climate, location, and area of the building. Defining these techniques and strategies early is also essential because they have many effects on the design. If they are not considered throughout the entire design process, their positive effect will be greatly diminished. If these strategies and techniques are used properly they can greatly reduce the cost of operating buildings, reduce the size of other systems within the building, and the number of systems required within the building.¹³

Daylighting is a very effective passive strategy that can greatly reduce the need for electric lighting within the building by taking advantage of the sun to light the interior during the day. Daylight is also one of the most visually pleasing light sources, windows create a connection with the outdoors, the light is always changing and moving throughout the space to create interest, and it provides a continuous source of light.¹⁴ Windows alone can be effective sources of light for narrow spaces. But many times, spaces within a building can not be adequately lit by windows alone, so light shelves, window walls, clerestories, or skylights are incorporated to fill these spaces with natural light. Many of the strategies used for daylighting also play an important roll in passive heating and cooling.

Some **passive cooling strategies** take advantage of natural ventilation as a means to cool buildings. These strategies are very sensitive to the exterior climate. Passive strategies that

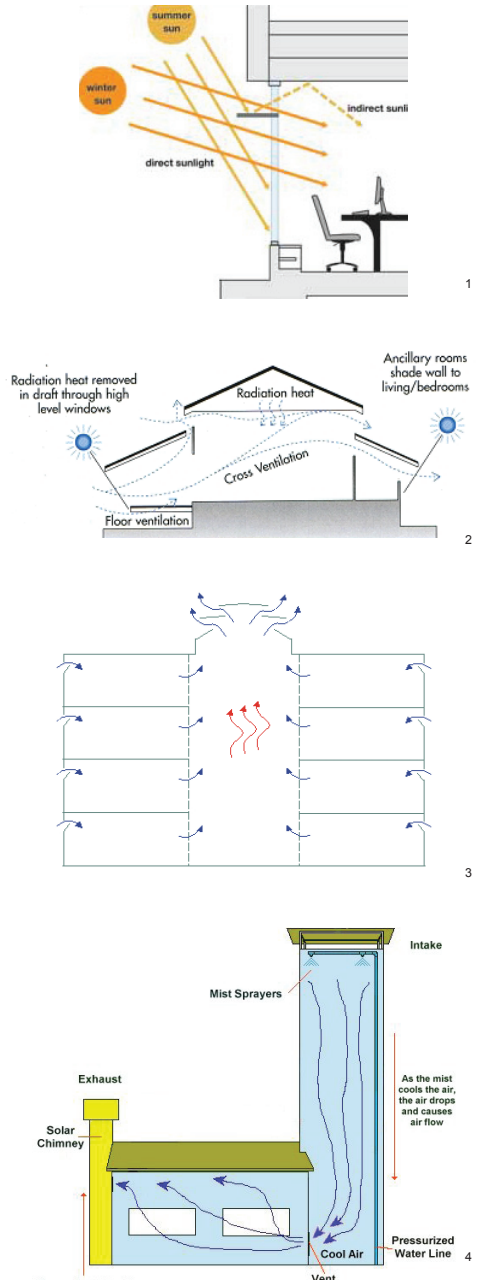


Fig.8

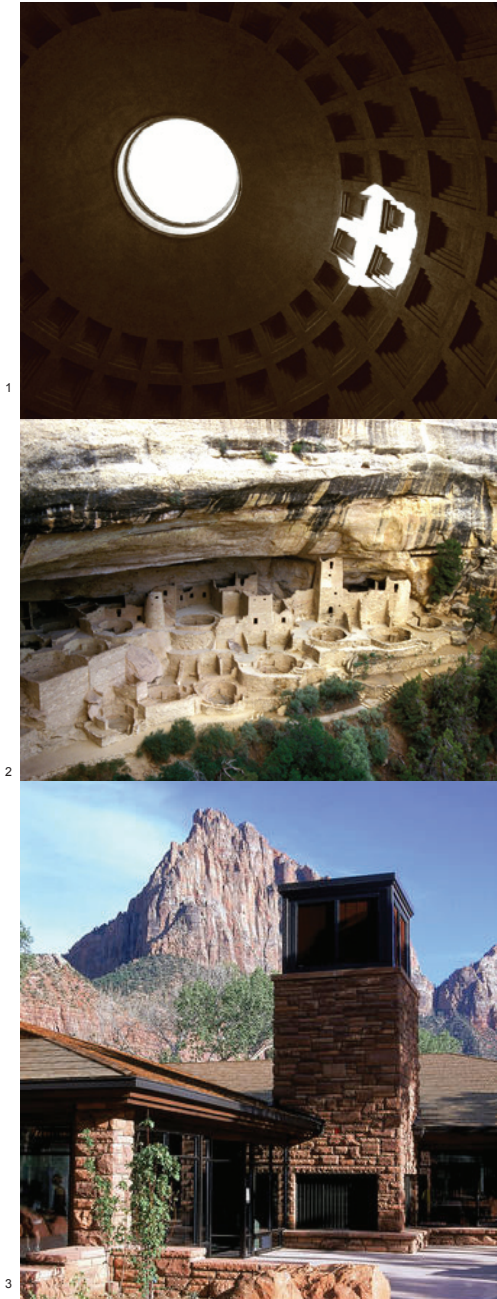


Fig.9

work in a hot arid climate may not work for a hot humid climate so choosing passive cooling strategies should be considered carefully based directly on a climate analysis.¹⁵ The windows that provide daylight also provide inlets and outlets for passive cooling strategies like cross ventilation, stack ventilation, and nighttime flushing. Cooltowers are also an effective passive cooling strategy. They allow air to pass through a moistened mat, that cools the air, which drops to the bottom of the tower and then into the building.¹⁶ In some milder climates these techniques can be used to cool buildings without the need for any mechanical cooling, but in harsh, hot, or humid climates these strategies cannot meet all the cooling needs so they are used to augment mechanical systems.

Passive heating strategies take advantage of the sun as a source of heat for buildings to reduce the need for mechanical heating systems. Direct-gain, indirect gain, and sun spaces are three of the strategies that can be used to heat buildings. All of these strategies may incorporate a thermal mass. During the day the thermal mass is heated by the sun and during the night it radiates heat throughout the building.¹⁷ The thermal mass also helps to stabilize the interior temperature.

The sun and wind are natural renewable resources that are very effective when taken advantage of through the use of passive strategies, but when these natural resources are combined with technologies like photovoltaics and wind turbines they become clean and efficient sources of energy for buildings. These technologies convert the sun and wind into electricity for powering building systems and appliances. Therefore, these technologies can reduce a building's reliance on or make it completely independent from traditional production of energy, which are harmful to the environment and relies on nonrenewable resources.

Photovoltaic cells or PVs take advantage of the most abundant, reliable, clean, and under utilized natural resource; the sun. PVs convert the sun's energy or light into electricity. This conversion of light to electricity through the use of PVs is internal and has no moving parts, which requires very little maintenance and is a simple application for buildings.

PVs are not a new technology. They have been around for quite some time. One of PVs first applications was to provide electricity in space for NASA space missions.¹⁸ It wasn't until the early 1990s that the up-front costs and efficiency of PVs were applicable for use in buildings.¹⁹ Today there are a multitude of photovoltaic cells that can be used in building applications ranging from the standard PV panels to PV glazing systems, PV shingles, and PV laminates that can be applied to any smooth surface.²⁰

Wind turbines are another way of converting a natural renewable resource into electricity through a very visually dynamic process. They transform the wind's kinetic energy into a spinning propeller that generates electricity that can be used in buildings. This pro-



cess is not as reliable as the sun because in most areas the wind doesn't blow constantly. But when it does, wind turbines can produce large amounts of electricity. In most building applications, because of wind turbines' inconsistency, they are combined with photovoltaic arrays to create a wind/solar hybrid.²¹

The incorporation of photovoltaic arrays and wind turbines allows buildings to become a clean source of energy, reducing the building's environmental impact. Both of these energy creating technologies have a visual impact on the building. This fact can be exploited and used in the design of the building to make these features aesthetically pleasing as well as educational for its occupants and visitors.

Fig.10

Living Machines created by John Todd, co founder of Living Technologies Inc., are small complex miniature ecosystems that are used to filter waste water and sewage from a building naturally. The living machine consists of a series of ponds that use plants, fish, algae, and bacteria to clean and break down waste water and sewage. As the water moves down through the series of ponds it becomes cleaner and cleaner until it reaches the final marsh and is then ready to be recycled for non-potable uses within the building.²² This is powered chiefly through solar energy (photosynthesis) and gravity.

Quantum Dots are a new nanotechnology that could potentially double the efficiency of traditional photovoltaics.²³ These quantum dots come in different sizes ranging from 2 to 10 nanometers. The different sized quantum dots absorb different spectrums of sunlight, therefore expanding the bandwidth of sunlight that can be absorbed. These dots even allow for the absorption of the invisible infrared part of the spectrum.²⁴ In tests quantum dots have also been proven to release more than one electron at a time, compared to current PV technology that only release one electron. In photovoltaic application the different sized quantum dots are layered within the panel. This allows a single panel to absorb a larger portion of the light spectrum, increasing the panel's efficiency, supposedly to 60 percent or more.²⁵ Another advantage to quantum dots is that there is really no restriction to shape, size or material that they are incorporated in. These quantum dots could be the breakthrough to making solar electric cost effective and easier for the public to use.

Solar Ink is a new liquid silicon nanomaterial that is being developed by Innovalight. This technology is similar to thin film photovoltaics, it captures the sun's light and converts it into electricity. This nanomaterial is anticipated to have some distinct advantages over traditional solar cells. Solar Ink will be more cost effective because it uses less silicon, and has a more efficient manufacturing process,

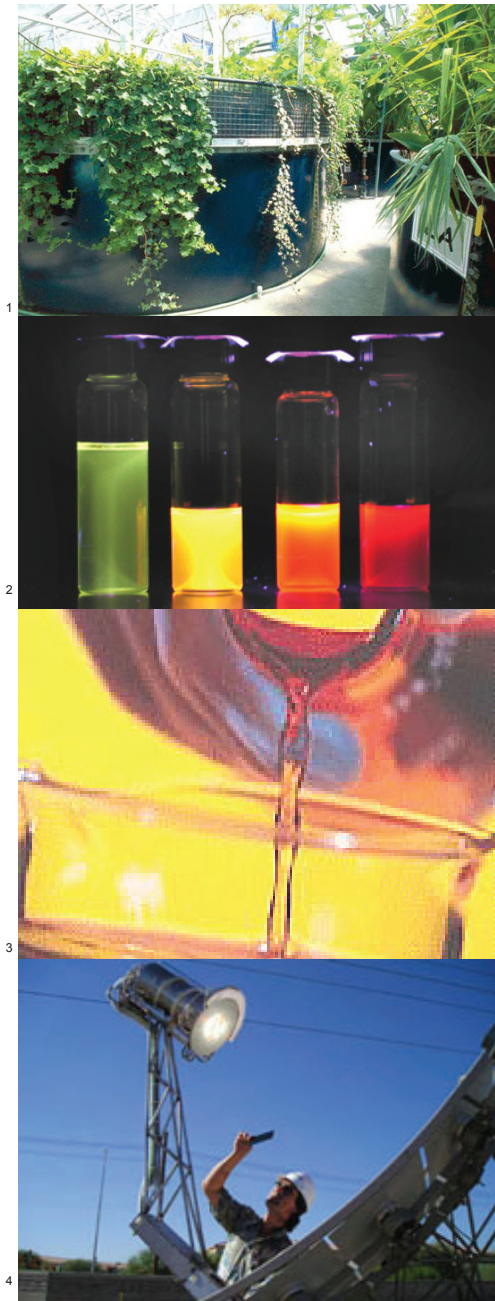


Fig.11

roll-to-roll printing commonly used for printing paper or film.²⁶ This nanomaterial takes advantage of quantum dots, so it will have the ability to absorb more of the sun's energy making it more efficient than traditional PVs. Its' roll to roll manufacturing process not only allows it to be produced cheaper but allows it to be printed into flexible applications such as cloth and plastic.²⁷ There are also other liquid based nanomaterial that are applied in a paint or spray form being developed.

Solar hydrogen production is another emerging process, SHEC labs has designed a system for this process. This process uses mirrors to concentrate sunlight onto to thermo-catalytic reactors to convert methane, carbon dioxide, and water into hydrogen.²⁸ This system, unlike traditional means of producing hydrogen, is effective at a small scale and doesn't rely on fossil fuels to produce hydrogen. SHEC system and process uses, the sun, a clean renewable energy source to create hydrogen. Their process also uses waste such as land field gases, biogas for municipal waste, and methane from carbon Dioxide, therefore using waste product that are polluting our environment and transforming them into a useable source of energy.²⁹ In buildings this system could allow for the fueling of hydrogen powered cars on site and the recharging of fuel cells to power the building that is free and produced by the building itself.

These are just a few of the new emerging technologies and systems that are being developed for the future application in buildings. Some of the technologies and systems above are not yet available but when they are they have the ability to make building technologies and systems better or more efficient. Being aware of what systems and technologies are out there that can help to make building more environmentally conscious, is an important to design.

P r e c e d e n t s

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"Perhaps the most important goal of the MSU EPICenter project was to change the way in which buildings are designed built, operated and maintained. The design team realized that to achieve this goal it had to begin by re-examining the design process itself."³⁰

The EPICenter, Educational Performance and Innovation Center was a proposal for a very ambitious sustainable building for Montana State University. It would have housed classrooms, laboratories, student study spaces, and become the new home for the chemistry department. The combinations of these components brought the total square footage of the building to over 250,000. This proposal created a vision of an architecture for the future.

If built, this proposed building would have been a living building, that takes the knowledge from living systems found in nature, like the flower, and follows its examples.

"Flowers are marvels of adaptation, growing in various shapes, sizes, and forms. Some lie dormant through the harshest of winter only to emerge each spring once the ground has thawed. Other stay rooted all year round, opening and closing as necessary to respond to changing conditions in the environment such as the availability of sunlight. Like buildings, flowers are literally and figuratively rooted to place, able to draw resources only from the square inches of earth and sky that they inhabit, the flower must receive all of its energy from the sun, all of its water needs from the sky, and all of its nutrients from the soil. Flowers are also ecosystems, supporting and sheltering microorganisms and insects just as our buildings support and shelter us. Equally important, flowers are beautiful and can provide the inspiration needed for architecture to truly be successful."³¹

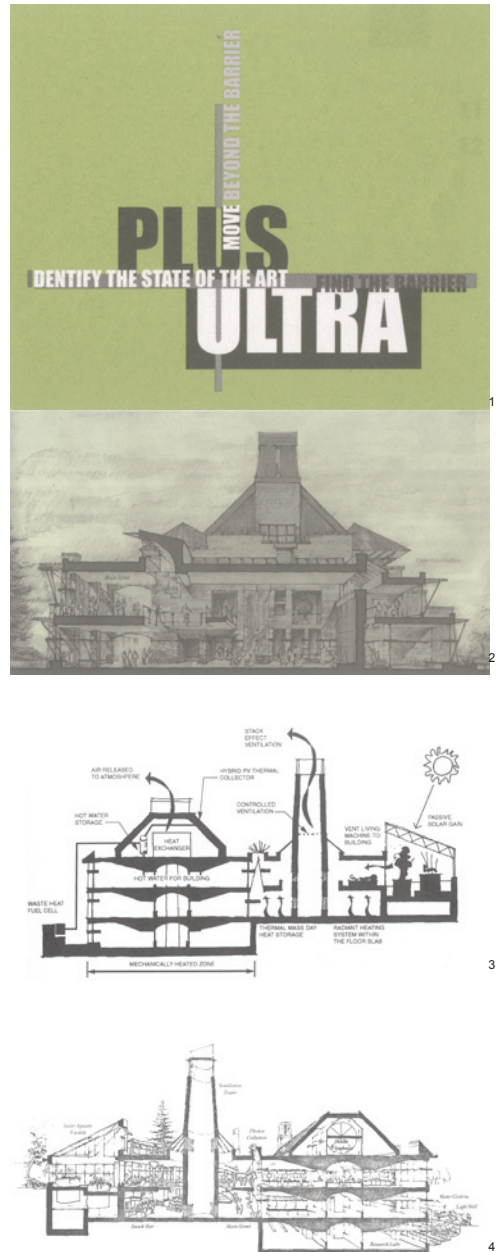


Fig.12

By taking this example to heart the technologies and strategies incorporated into the EPI-Center would have allowed it to have no more environmental impact than if nature itself had created it. It was a new and revolutionary approach to the built environment.

For the EPICenter to accomplish all of its goals it needed a new design process and this started with the makeup of the design team. The design team for this project was far different from the norms of traditional practice. It had architects, engineers, and consultants like the typical design team, but it also had artists, historians, scientists, educators, and students.³² All members of the design team were involved in the design process from the beginning and were included and informed on all components and aspects of the building. This was done to change the way professions think about the design process rather than each one doing their own part and not considering how it affects others. They adapted their parts to help and improve the others, making the final solution a more cohesive whole.

Changing the makeup of the design team was just the start of creating a new design process; it also involved creating new ways of thinking about the design process. One of these methods was coined by the term **PLUS ULTRA** which in Latin means “more,

beyond.”³³ To the design team this meant redefining the state of art. This method started by “identifying the state of art in any field, system, or technology, then identifying the barriers to moving beyond that state of art and then removing those barriers and redefining that state of art.”³⁴ Another method used for changing the way in which people think about the design process was thinking holistically about the project, Making sure that if one system, strategy, or component was changed, its effect on the related systems and the whole was considered.

This approach to the design of the EPICenter allowed for the integration of many different technologies, prototypes, and strategies to work together as one large system that worked like nature. It is also understood that the size of the design team and the time put into the development of prototypes and research is highly unlikely to happen in most projects. It was possible on this project because there were grants and money specifically for research and development. Even though this project was never built, its successes lie in its new design process, methods of thinking, and the awareness that it created for sustainability. It proved conceptually that a building of this scale and goals of becoming a living building were not just a fantasy but a reality that could be accomplished, if people are willing to change the way they think.

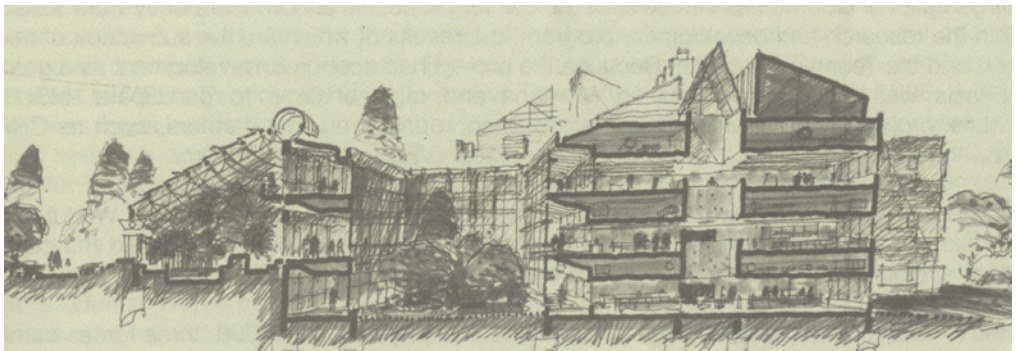


Fig.13

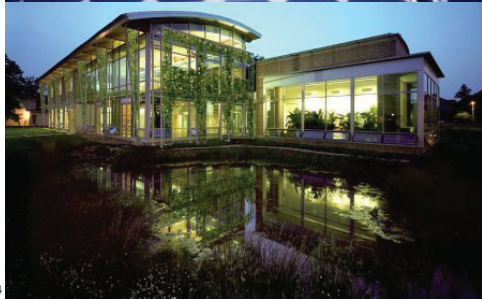
“We intended to create not just a place for classes but rather a building that would help to redefine the relationship between humankind and the environment – one that would expand our sense of ecological possibilities”³⁵

The Adam Joseph Lewis Center for Environmental Studies is a steeping stone for the development of ecological and sustainable design, located on the Oberlin College campus in Ohio. This building houses classrooms, office spaces, environmental studies library, and a resource center. These components brought the total square footage of the building to 13,600.

Many different classes are held within this building, some are even environmental studies courses, but for the students, visitors, and faculty in this building the learning and knowledge gained doesn't just take place in the classroom. The building itself is a teacher and informs students through its technologies and systems.³⁶ As the students and faculty learn from, monitor, and understand the building, it evolves and is modified to adapt to its environment and to new more efficient technologies.

One of the systems that allows the AJLC to move toward a smaller ecological footprint or environmental impact was the inclusion of the living machine. The living machine treats waste water from the building by filtering it through a biological system. The water is then reused for non-potable uses within the building and for landscape irrigation. This system not only filters all water from the building naturally, but is powered by the sun.³⁷

Another important feature that lessens the AJLC environmental impact is the use of a photovoltaic array. The photovoltaic array



allows the building to supply its own energy during the day and return energy to the grid when energy production is in excess of what the building consumes. During the night the building uses energy from the grid to run the building. This is one of the features of the building that may evolve in the future, with the inclusion of fuel cells so that excess energy can be stored during the day to run the building during the night hours. This way the building becomes less dependent on the grid.

The AJLC is an example of boldness and modesty all in one. It shows that a sustainable and ecological building of this type is possible today, through the use of its advanced technologies and strategies. But, it also realizes that a building of this type is an evolving process and allows the building to adapt. Now that the building is operating, it is monitored and analyzed to quantify data that compared with preliminary design calculations highlights the buildings strengths and weaknesses.

Fig.14

"Not so many years ago, gazing out the window of your high school could get you in trouble for not paying attention. That was before designers of school realized that natural light from the sun could actually make one a better student."³⁸

The North Clackamas High School is a model for sustainable school design located in Clackamas, Oregon. This project was designed for over 1,800 students plus faculty members and has a total square footage of 265,355. This is a large scale sustainable project that is a model for energy efficiency.

Clackamas High School's outstanding energy efficiency was made possible in large part due to its integration of passive systems with its active systems. This building was orientated to take maximum advantage of daylighting, ventilation, and solar strategies. Courtyards, narrow bays, window walls, clerestories and light shelves were used to maximize daylighting which cut back on the need and use of electric lighting. The inclusions of mechanically controlled damper louvers and air stacks supply natural ventilation throughout the building, which allowed for a downsized HVAC. Thermal masses were incorporated in the walls and floors to help maintain internal temperatures. There were also occupancy, CO₂, and light sensors installed throughout the building to ensure that light, heat, or air conditioning is only supplied to areas where it is needed.³⁹ These energy efficient strategies incorporated within this building are estimated to save the Clackamas school district over \$69,000 a year.⁴⁰

Clackamas High School's design also dealt with many of the typical program issues that arise when designing a high school. First, the school was laid out in a way to insure security of the grounds by keeping eyes on the site.



Fig.15

The design also addressed safety issues on the exterior by separating service zones, vehicle access, and pedestrian areas.⁴¹

Designing a sustainable school like Clackamas High School is not only energy efficient and better for the environment, but schools like it have been proven to make better students. Studies have been done that show that naturally lighting, natural ventilation, operable windows, and views to the exterior increase test scores, attendance, and productivity, all of which are intergral components of sustainable design.⁴²

Site Analysis

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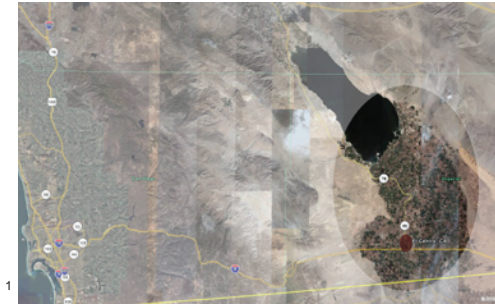
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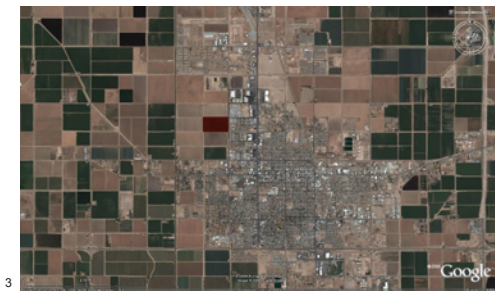
S i t e S e l e c t i o n



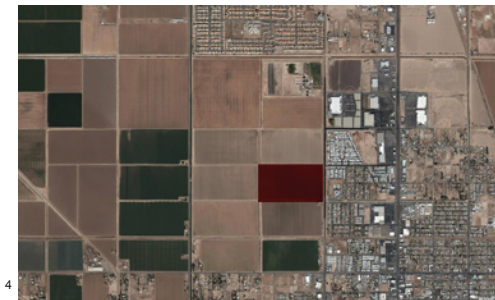
The site for this thesis project is located in the Imperial Valley of California, more specifically within the City of El Centro. El Centro is the largest city in the Imperial Valley and is located in extreme southern California. It is 117 miles east of San Diego and 15 miles from the Mexican boarder.



The exact site within the city was a difficult choice. One of the sites that was considered was old industrial land that would have been classified as brown field, which would be a logical choice for a sustainable project. This thesis project would have been able to transform land that is now unusable into useable land again, but its proximity to railroad tracks and location on the outer edge of town were not desirable traits.



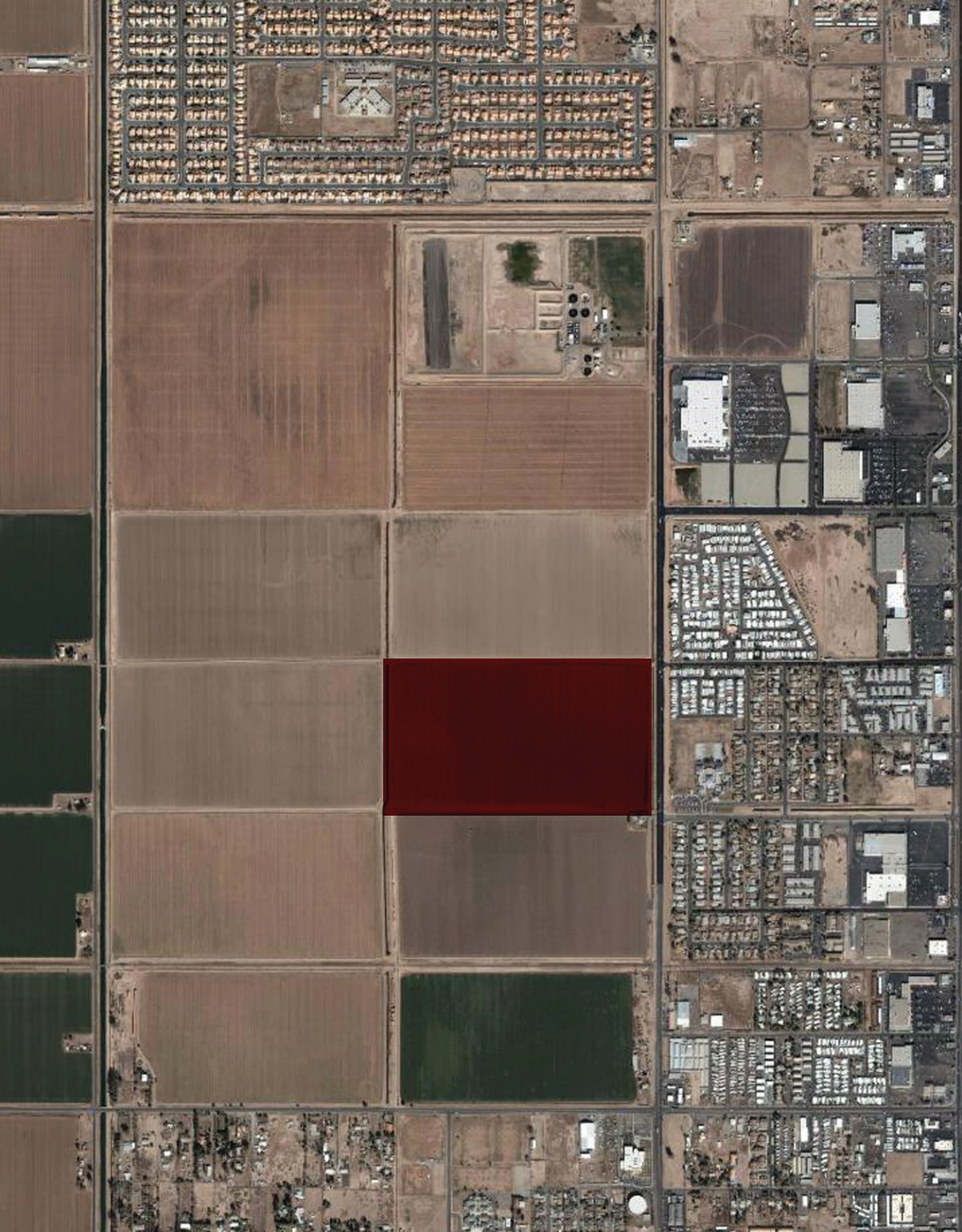
The specific site within the city of El Centro is located between Lincoln Avenue to the North, Villa Avenue to the south, and just west of La Brucherie Avenue. This piece of land was once an agricultural field that produced many different crops. For the last two years this land has been idle and is now scheduled to become part of a large residential development of fast track homes. Using a virgin site isn't the most sustainable thing for this thesis project, but this thesis project will be better suited and environmentally friendly for the site than a large number of fast track homes.



This site has many attributes that will be beneficial to this thesis project. First of these was its location within the city. It is situated within walking distance to many different residential communities. This will cut back on the distance students have to travel to attend school. The site also fronts one of the main arteries of the city running north and south that has stop lights on both corners of the site, which will accommodate vehicular access to and from the site. The site's size, the size of nearby

Fig.16/Fig.17

buildings, and adjacent land planning will allow this thesis project to take full advantage of wind and sun in its design. This also ensures that the views of Mount Signal to the southwest and the In Ko Pah Mountains to the south will be preserved.



The Imperial Valley was once known as the Colorado Desert and was classified as uninhabitable and worthless land until the introduction of water from the Colorado River in 1901. This new resource allowed the pioneers of this area to begin farming and growing crops. This sparked a rapid population increase in the area, and created a need to transport goods to and from the Imperial Valley. As a result, a branch line from the Southern Pacific railway was constructed. Until the introduction of water and the construction of a railroad, Imperial was the only city located in this area. Soon after, the cities of El Centro, Brawley, Calexico, and Holtville were founded.⁴³

In the early years of these towns the population growth was very explosive. This was due to the intense competition between the cities for the county seat which El Centro won. The irrigated land and farming grew just as fast as the population, with the construction of new canals and laterals to supply more water to the Valley. Today, there are more than 500,000 acres of land in production and hundreds of miles of canals and laterals. Agriculture remains one of the Valley's major industries, but El Centro has also emerged as the Valley's administrative and commercial center.

1



2



3



Fig.19



Site Observations



Looking North



Looking East



Looking South



Looking West

Fig.20/Fig.21



Fig.22/23



Site



Views



Drainage



Noise



In-Ko-Fan Mountains

mount Signal

Lincoln Ave

Villa Ave

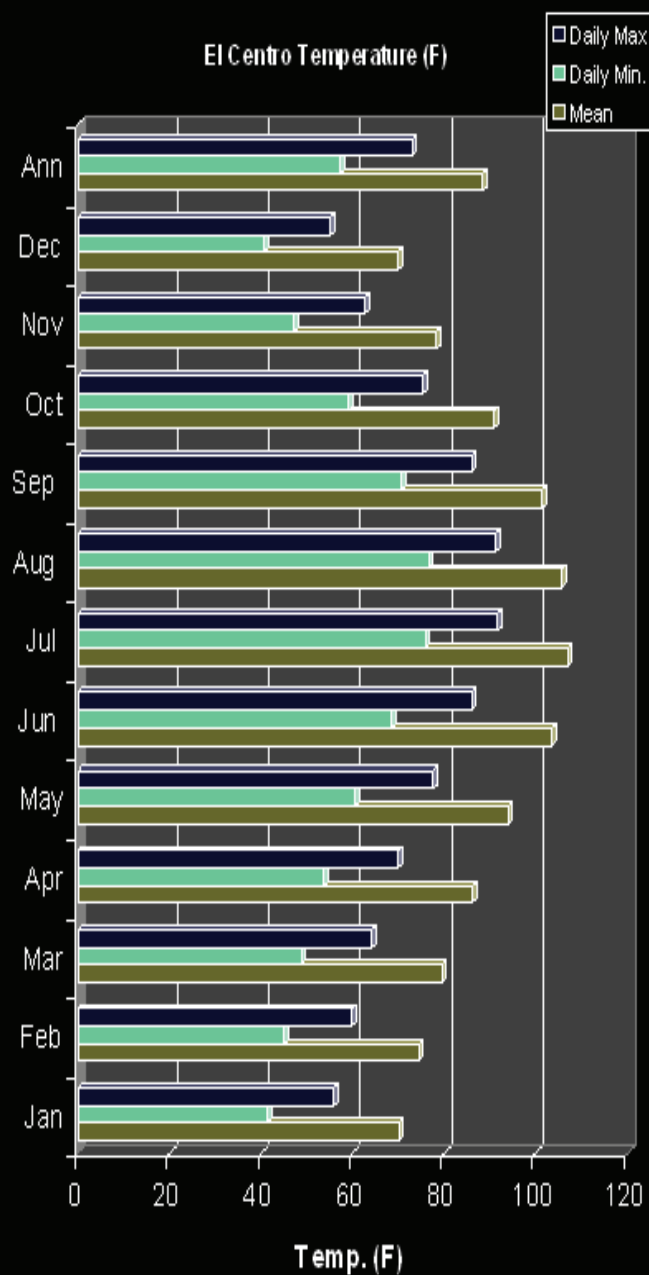
The climate of the El Centro is a typical low desert. It has very hot dry summers and warm winters. During the winter, the temperatures average 57 degrees and 107 degrees during the summer.⁴⁴ On average El Centro receives a total of 3 inches of rain a year.

One of the first things to consider in this climate are the extreme summer temperatures. Therefore, the design of this thesis project will have to consider ways to counteract these extreme temperatures. Thermal masses, cool towers, and window shading strategies can be useful tools to aid in counteracting hot temperatures.

The lack of rainfall in this area is also another important climate feature that this thesis project will need to address. As said before, El Centro, as well as the entire Imperial Valley receives all of its water from the Colorado River. Harvesting any amount of rainfall will be helpful to lessen the amount of water the building needs to draw, just like desert plants do. Incorporating systems like living machines to recycle the building waste water will also be helpful.

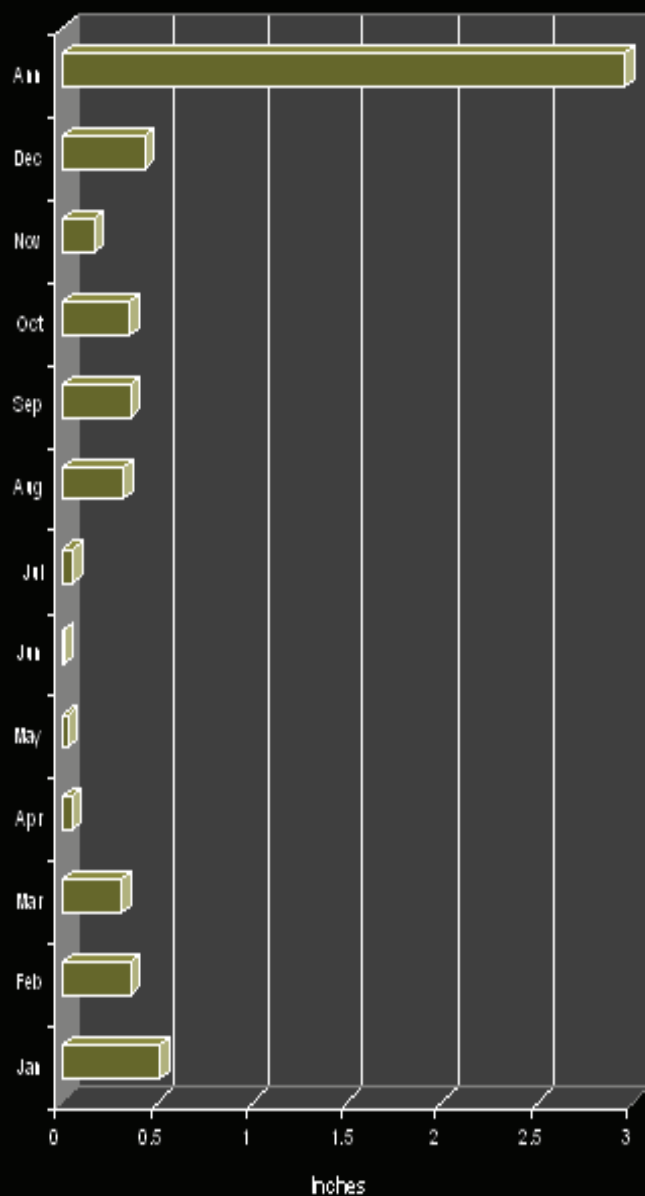
The amount of sunshine that this area receives has its advantages and its disadvantages. The more sunny days there are, the more electricity can be produced by photovoltaics. The large amount of sunshine also means a large amount of solar heat gain. This project's design will have to pay close attention to solar heat gain issues.

Temperature



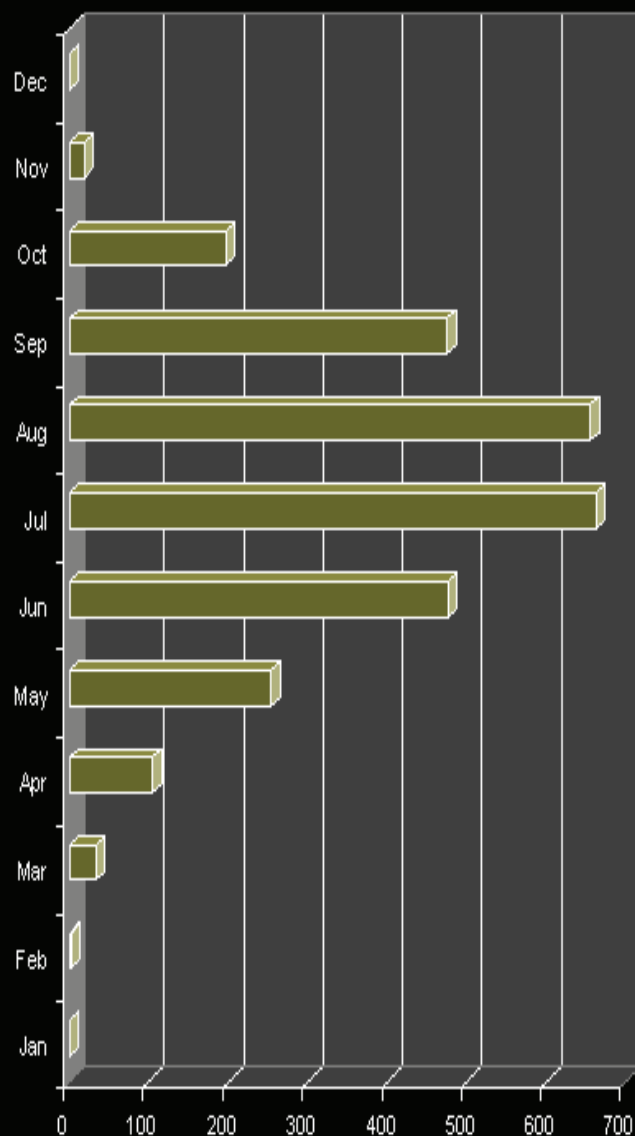
P r e c i p i t a t i o n

B Centro Precipitation

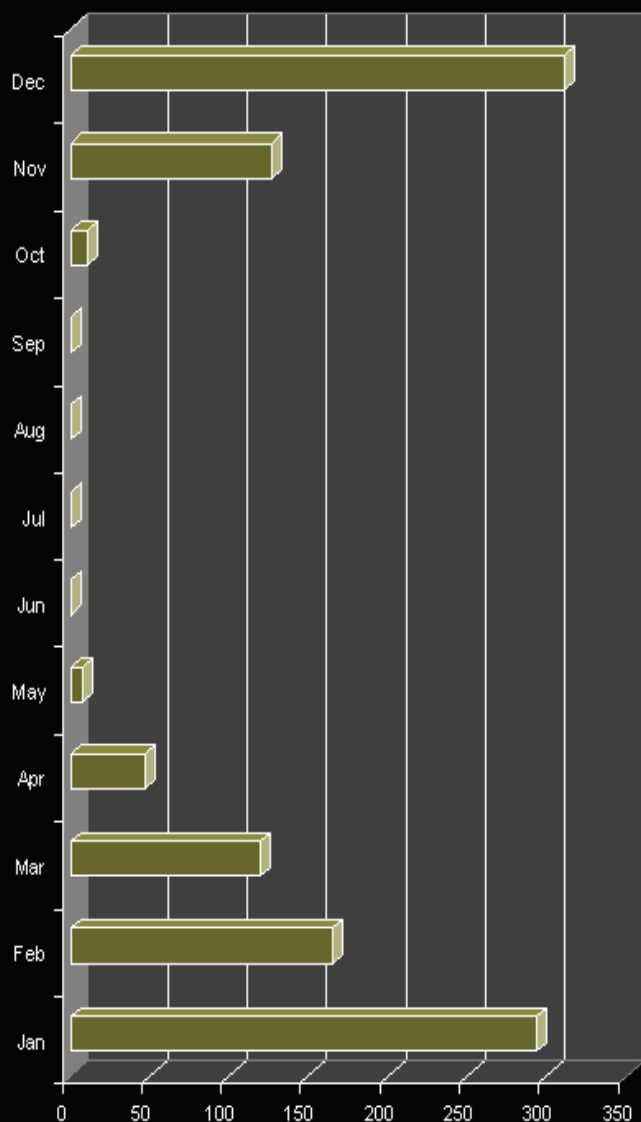


Cooling Degree Days(70)

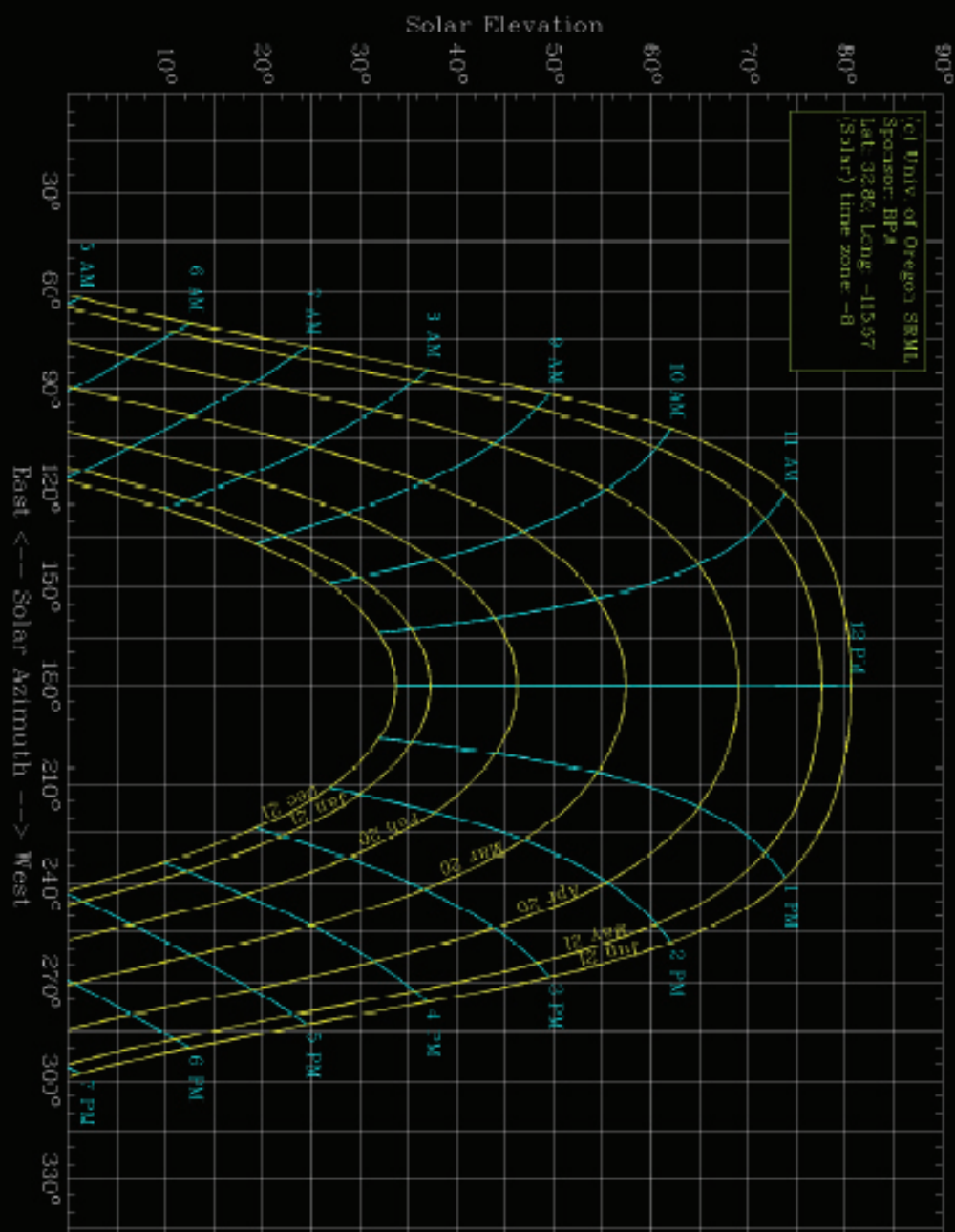
Cooling Degree Days Base (70)



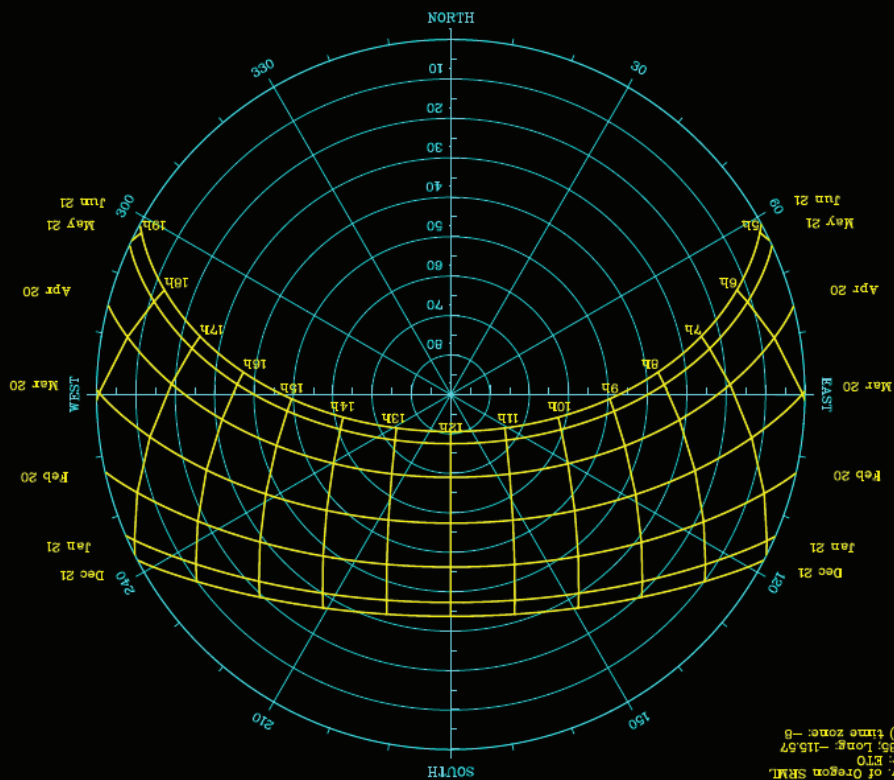
Heating Degree Days Base (65)



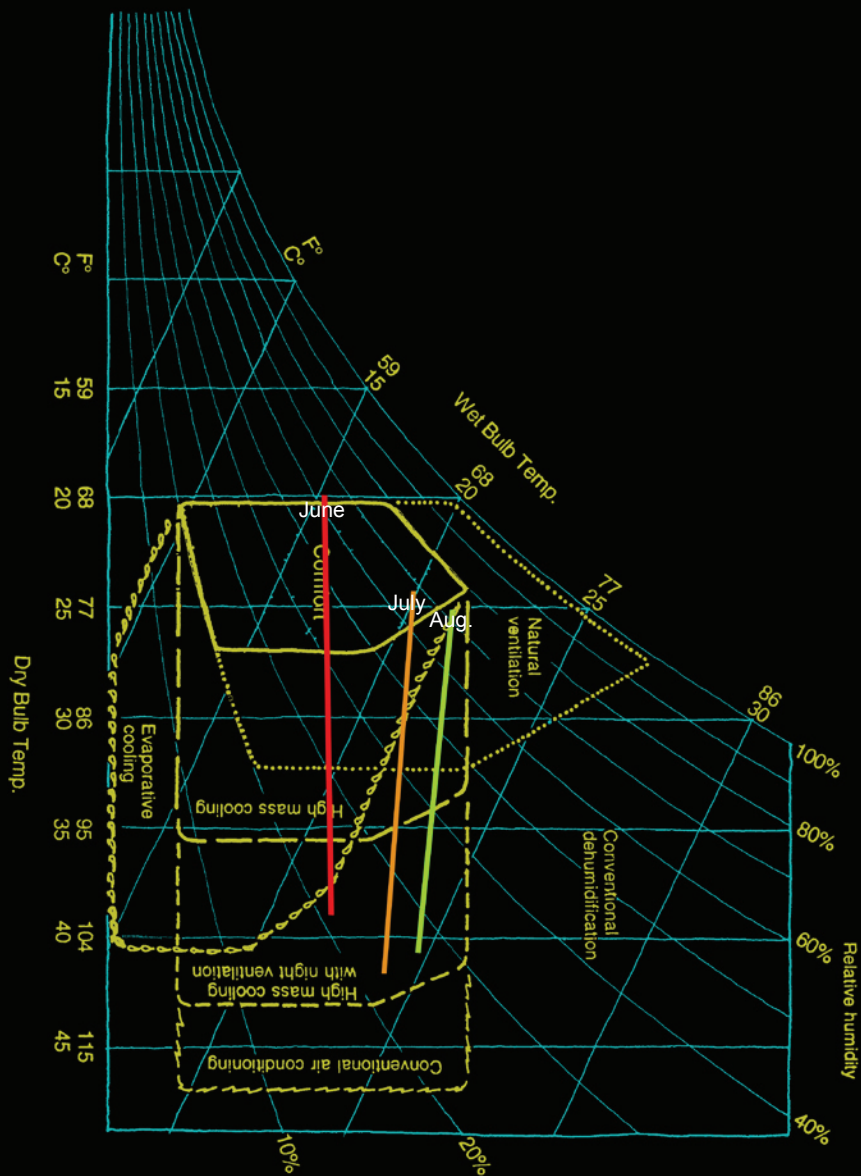
Solar Elevation



S u n P a t h



Bioclimatic Chart



P r o g r a m

1. Introduction to the Program

2. Overview of the Program

3. Program Objectives

4. Program Structure

5. Program Content

6. Program Evaluation

7. Program Conclusion

8. Program Appendix

9. Program Bibliography

10. Program Index

11. Program Glossary

12. Program Acknowledgments

13. Program Credits

14. Program Contact Information

15. Program Disclaimer

16. Program Copyright

17. Program Privacy Policy

18. Program Terms and Conditions

19. Program License Agreement

20. Program End User License Agreement

Designing a sustainable building takes thought and consideration. It is important to decide what sustainable strategies, systems, and technologies will be most effective for the climate and location of the building. Once these are determined, they become the driving force behind the design. They are incorporated holistically to work towards creating a living building.

When designing a living building there are seven basic principles that the building must follow. Living buildings must:

“Harvest all energy and water needs on site.

Be adapted specifically to site and climate and evolve as conditions change

Operate pollution-free and generate no waste that aren’t useful for some other process in the building or immediate environment

Promote the health and well-being of all inhabitants as a healthy ecosystems does

Be comprised of integrated systems that maximize efficiency and comfort

Improve the health and diversity of the local ecosystem rather than degrade it

Be beautiful and inspire us to dream.”⁴⁵

One of the problems that this high school will encounter in becoming a living building is acquiring its own water from the site itself. It is located in the desert and the only source of water comes from the Colorado River, but water issues will still be addressed in how much water the building consumes and how the waste water can be treated to become a resource for the surrounding irrigation.

Another goal of the design of this high school is to create spaces that encourage learning, not just a traditional school curriculum, but also learning through architecture. The intention is to educate the students, faculty, and visitors about sustainability through the architecture and the design of the building.

Quantitative Program

64	Classrooms	1,000sqft	64,000sqft
11	Lab / Studios	1,300-2,000sqft	23,100sqft

Administration			10,500sqft
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12	Offices	100-150sqft
1	Guidance center	1,000sqft
1	Entry / Reception	2,000sqft
1	Nurses Office / Sick Room	500sqft
2	Conference / Meeting Room	500sqft
1	Teachers Lounge	2000sqft

45,500sqft

Gymnasium

4	Locker Rooms	2,500-3,000sqft
1	Weight Room	3,000sqft
1	Wrestling Room	4,500sqft
2	Gyms	9,000-18,000sqft

2,500sqft

Field House

10,600sqft

Library / Information Technology

1	Library	9,200sqft
1	Office	150sqft
1	Computer Center	1,250sqft

12,600sqft

Multi-Purpose Room

1	Food Preparation	2,000sqft
1	Dinning / flexible space	10,000sqft

16,000sqft

Performing Arts

2	Offices	100-150sqft
1	Auditorium	5,500sqft
2	Band / Choir	1,500-2000sqft
1	Dance Studio	1,300sqft
3	Practice Rooms	75-150sqft
4	Storage Rooms	250-400sqft

12,000sqft

Industrial Technology

2	Shops	2,000sqft
2	Storage Rooms	625sqft
3	Labs	1,300sqft

187,700sqft

358,800sqft
48,000sqft
129,600sqft
225,000sqft
77,000sqft
144,000sqft
7,000sqft

Exterior Space

3 Baseball / Softball Fields	260' x 460'
4 Tennis Courts	100' x 120'
1 Baseball / Softball Fields	360' x 360'
1 Football / Track Stadium	300' x 700'
7 Basketball / Volleyball	100' x 110'
2 Soccer Field	200' x 360'
7 Apparatus Areas	1,000sqft

916,400sqft

C o d e A n a l y s i s

Code Analysis

Code Analysis

Code Analysis

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Code Analysis

305.1 Educational Group E.

Educational Group E occupancy includes, among others, the use of a building or structure, or a portion thereof, by six or more persons at any one time for educational purposes through the 12th grade. Religious educational rooms and religious auditoriums, which are accessory to churches in accordance with section 302.2 and have occupant loads of less than 100, shall be classified as A-3 occupancies.

Table 302.1.1 Incidental Use Areas

Laboratories and vocational shops, not classified as Group H, located in Group E or I-2 occupancies. 1 hour or provide automatic fire-extinguishing

303.1 Assembly Group A

A – 1 Assembly uses, usually with fixed seating, intended for production and viewing of the performing arts or motions pictures including , but not limited to:

- Motion picture theaters
- Symphony and concert halls
- Television and radio studios admitting an audience
- Theaters

A – 4 Assembly uses intended for participation in or viewing outdoor activities including, but not limited to:

- Arenas
- Skating rinks
- Swimming pools
- Tennis courts

A – 5 Assembly uses intended for participation in or viewing outdoor activities including, but no limited to:

- Amusement park structures
- Bleachers
- Grandstands
- Stadiums

Table 302.3.2 Required Separation of Occupancies (Hours)

Between Occupancy Groups A-1, A-4, A-5, and E requires 2 hour separation

Table 503

Height and square footage limitation for construction types.

506.3 Automatic sprinkler system increase.

Where a building is equipped throughout with an approved automatic sprinkler system in accordance with Section 903.3.1.1, the area limitation in table 503 is permitted to be increased by an additional 200 percent (Is = 200 percent) for multistory buildings and an additional 300 percent (Is = 300 percent) for single-story buildings. These increases are permitted in addition to height and story increases in accordance with Section 504.2.

Table 601

Fire-resistance rating requirements for building elements.

1003.2 Ceiling Height

The means of egress shall have a ceiling height of not less than 7 feet

1003.3 Protruding objects

Protruding objects shall comply with requirements of sections 1003.3.1 through 1003.3.4.

1004.7 Fixed seating.

For areas having fixed seats and aisles, the occupant load shall be determined by the number of fixed seats installed therein.

For areas having fixed seating without dividing arms, the occupants load shall not be less

than the number of seats based on one person for each 18 inches (457mm) of seating length.

1005.1 Minimum required egress width.

The means of egress width shall not be less than required by this section. The total width of means of egress in inches (mm) shall not be less than the total occupants load served by the means of egress multiplied by the factors in Table 1005.1 and not less than specified elsewhere in this code. Multiple means of egress shall be sized such that the loss of any one means of egress shall not reduce the available capacity to less than 50 percent of the required capacity. The maximum capacity required from any story of a building shall be maintained to the termination of the means of egress.

1020.2 Width

The width of exit passageways shall be determined as specified in Section 1005.1 but such width shall not be less than 44 inches (1118mm), except that exit passageways serving an occupant load of less than 50 shall not be less than 36 inches (914mm)

1006.1 Illumination required.

the means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied.

1013.3 Common path of egress travel.

In occupancies other than Groups H-1, H-2, and H-3, the common path of egress travel shall not exceed 75 feet (22860mm).

1014.1 Exit or exit access doorways required.

Two exits or exit access doorways from any space shall be provided where one of the following conditions exists:

- 1.The occupant load of the space exceeds the values in Table 1014.1
- 2.The common path of egress travel exceeds the limitations of section 1013.3
- 3.Where required by Sections 1014.3, 1014.4, and 1014.5

1014.1.1 Three or more exits.

Access to three or more exits shall be provided from a floor area where required by Section 1018.1.

1014.2 Exit or exit access doorway arrangement.

Required exits shall be located in a manner that makes their availability obvious. Exits shall be unobstructed at all times. Exit and exit access doorways shall be arranged in accordance with sections 1014.2.1 and 1014.2.2.

1024.1 General.

Occupancies in Group A which contain seats, tables, displays, equipment or other material shall comply with this sections.

Table 2902.1 Minimum Number of Required Plumbing Fixtures

A – 1. Water closets, Male 1 per 125: Female 1 per 65: Lavatories, Male and female 1 per 200: Drinking fountains 1 per 500

A – 4. Water closets, Male 1 per 75 for the first 1,500 and 1 per 120 for the remainder exceeding 1,500: Female 1 per 40 for the first 1,500 and 1 per 60 for the remainder exceeding 1,500: Lavatories, Male 1 per 200: Female 1 per 150: Drinking fountains 1 per 1,100.

A – 5. Water closets, Male 1 per 75 for the first 1,500 and 1 per 120 for the remainder exceeding 1,500: Female 1 per 40 for the first 1,500 and 1 per 60 for the remainder exceeding 1,500: Lavatories, Male 1 per 200, Female 1 per 150: Drinking fountains 1 per 1,000.

E. Water closets, Male and female 1 per 50: Lavatories, Male and Female 1 per 50: Drinking fountains 1 per 100.

P r o j e c t

U n d e r t a k i n g

W o r k i n g

W o r k i n g

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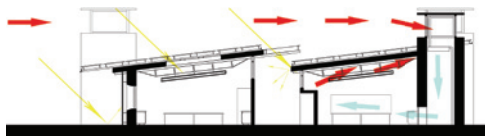
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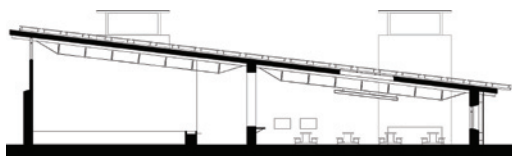
P l a n s / S e c t i o n s



Classroom Section

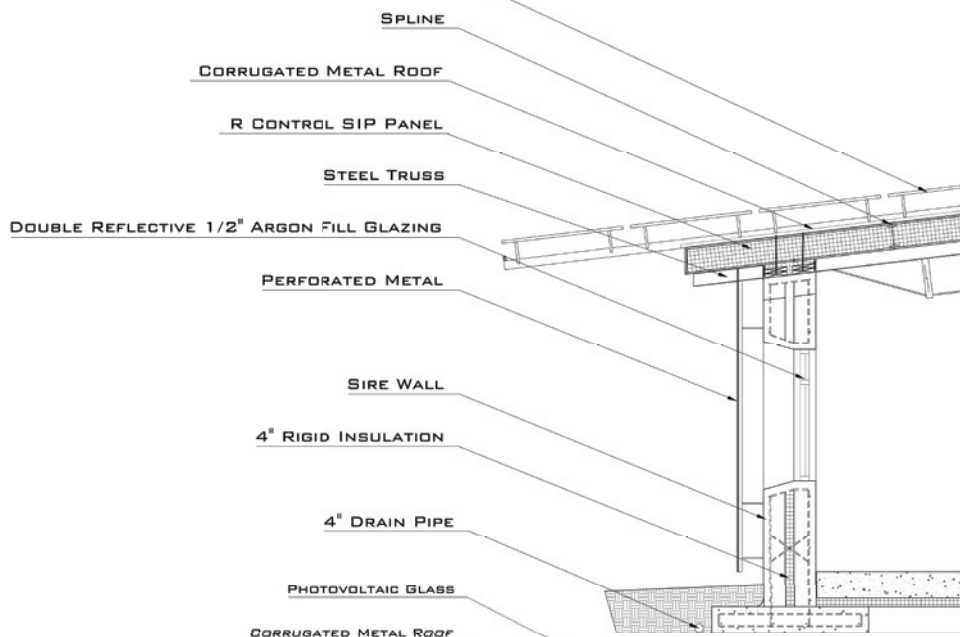


Library Section

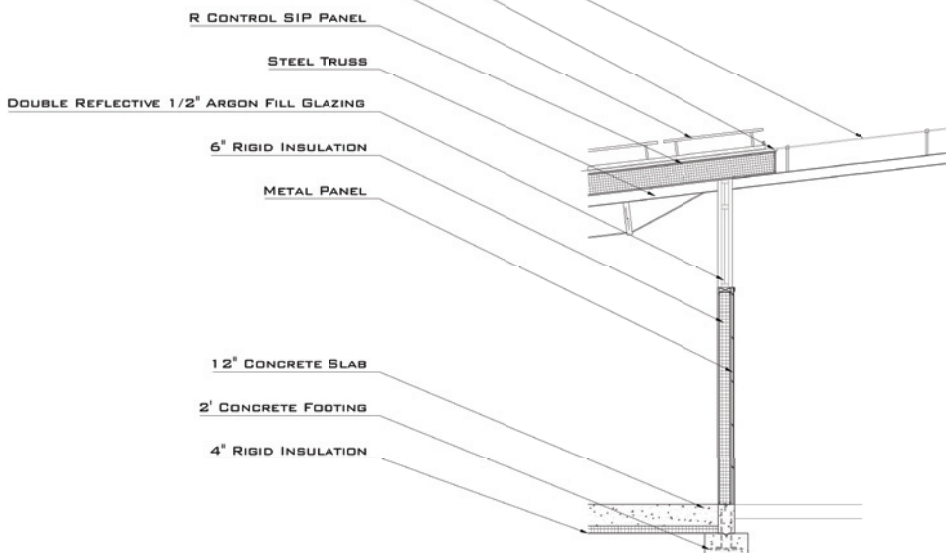


Cafeteria Section

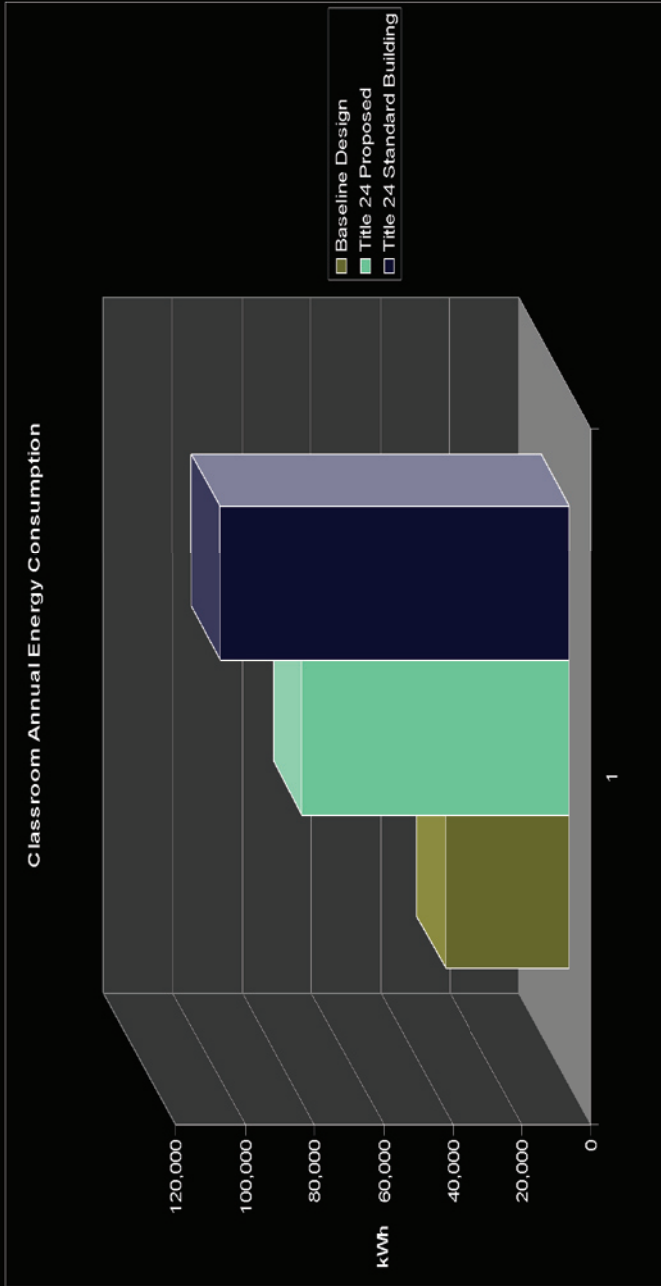
200 WATT SINGLE AXIS TILT PHOTOVOLTAIC PANNEL

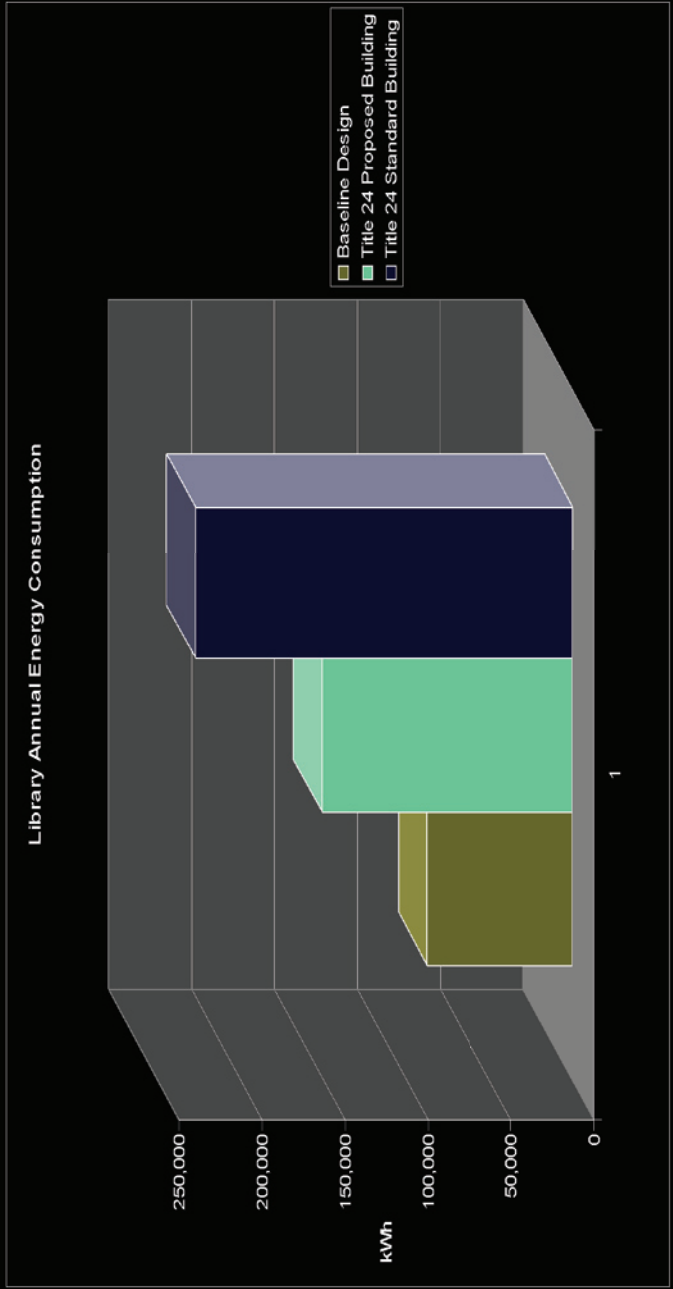


200 WATT SINGLE AXIS TILT PHOTOVOLTAIC PANEL

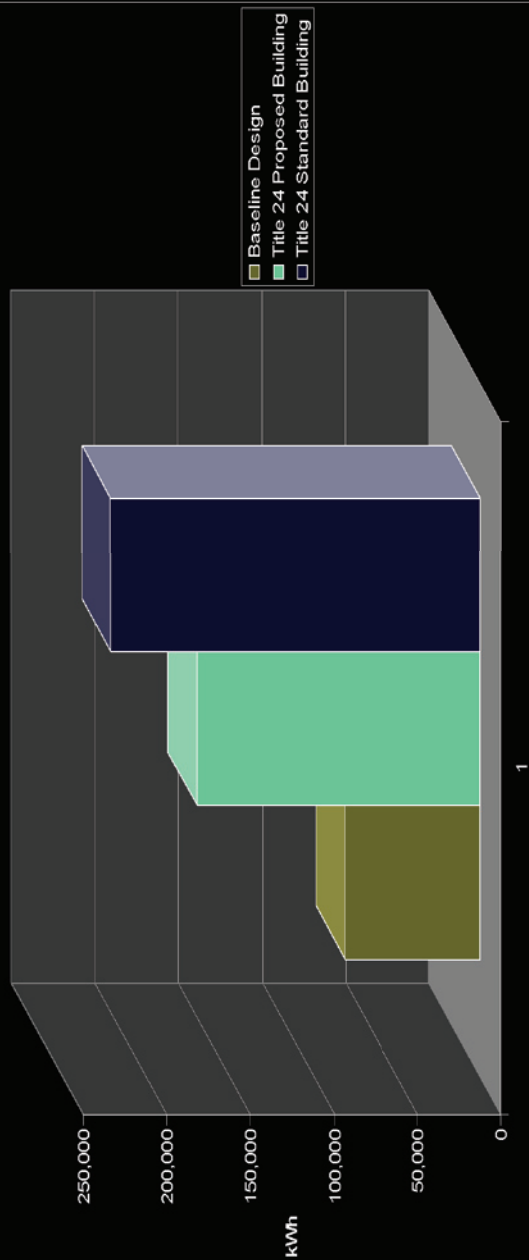


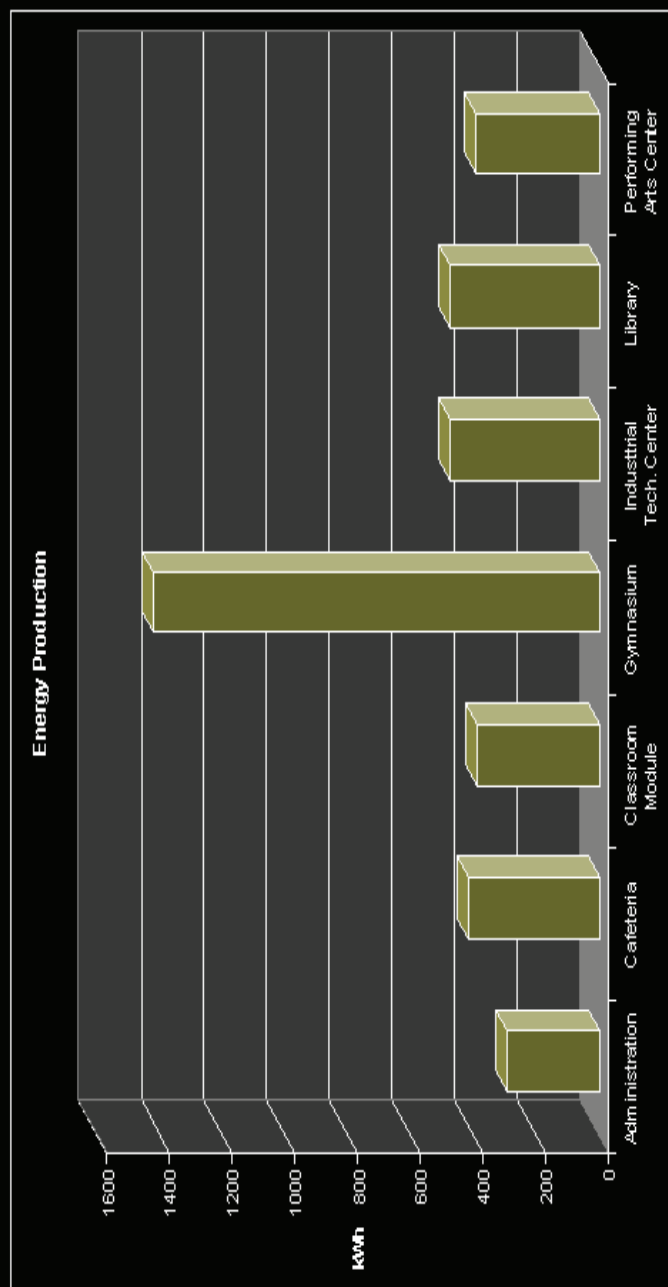


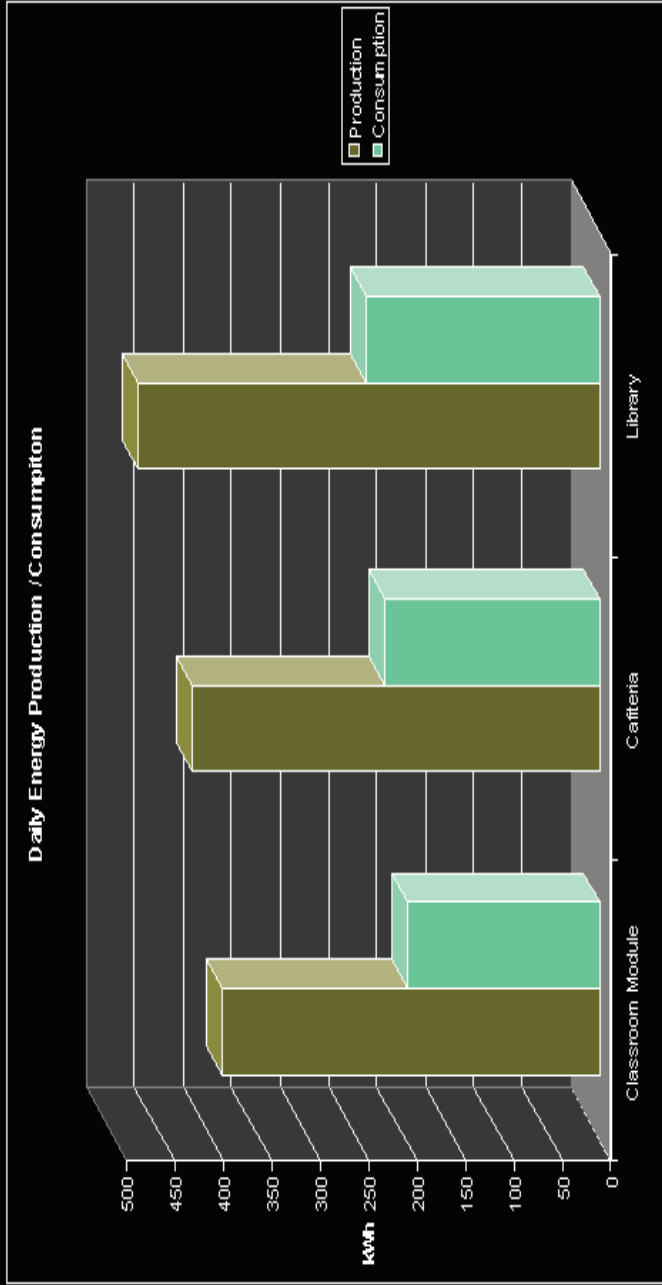


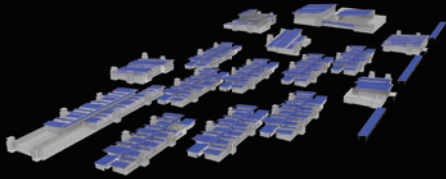


Cafeteria Annual Energy Consumption

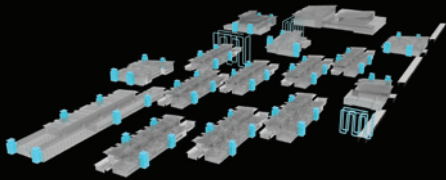




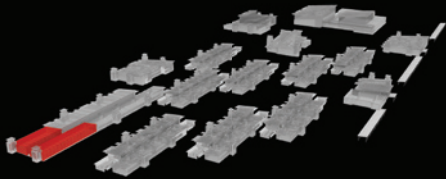




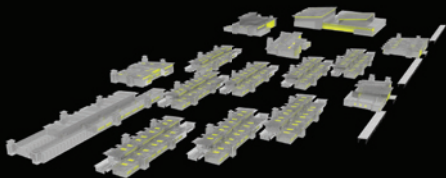
Electricity Diagram



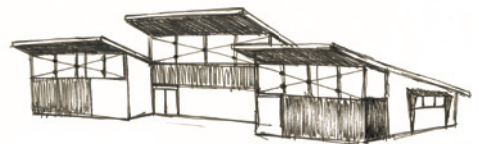
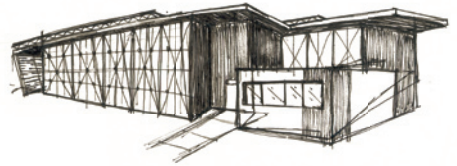
Cooling Diagram



Living Machine Diagram



Daylighting Diagram





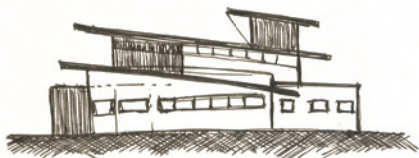
Administration Building



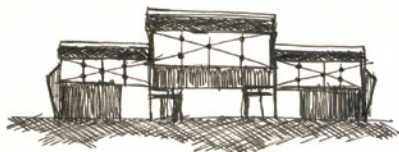
Gymnasium



Library



Performing Arts Center



Industrial Tech. Center

P e r s p e c t i v e s

Entry Perspective



Courtyard Perspective



Quad Perspective



Quad Perspective

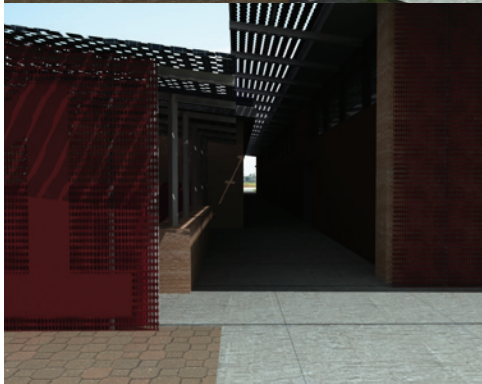




Center Mall Perspective



Locker Kiosk Perspective



Classroom Hallway Perspective



Photovoltaic / Interior Classroom Perspective

Throughout this past year I have gained a vast knowledge of many different sustainable design techniques, both passive and active, and the impact that they have on design. By incorporating these techniques into the design of my high school as a primary concern, they became integral parts of the design. Thereby creating a school that runs completely on clean renewable energy, recycles its own byproducts and uses less energy than traditional buildings. Displaying how sustainable design can be taken to the next level, to design a building that has almost no impact on the environment.

By making the sustainable aspects of my project the primary concern, I struggled bringing the project back to dealing with the human scale. Once I had put all of my focus on the sustainable aspects of the project it was hard to branch away and make sure the project functioned as a school. This along with the sheer scale of the project were the two things that I struggled with the most.

This thesis project has only increased my passion and hope to help implement the ideas behind this thesis project in the professional field. It would be nice to work on a project that has similar goals in the real world, now that I know it can be done hypothetically.

I would also like to thank my thesis Advisors, Tom Wood, Chris Livingston, and Jack Smith greatly. Without them I would have never been able to finish this project.

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