UMASS Dining Hall. A Path to Resiliency

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A Thesis Presented

By

LUKASZ CZARNIECKI

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Approved as to style and content by:

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Kathleen Lugosch, Chair

_____

Ajla Aksamija, Member

_____

Steve Schreiber, Department Chair
Department of Architecture

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ABSTRACT

UMASS DINING HALL A PATH TO RESILIENCY

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LUKASZ CZARNIECKI

B.F.A.A., UNIVERSITY OF MASSACHUSETTS AMHERST

M.Arch., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Kathleen Lugosch

This thesis investigates integration of University's Dining Hall and Emergency Shelter in terms of their inter-related sustainability factors; the ability to take advantage of the site to harvest, store, grow and learn about all aspects of food production, and to provide a safe place to stay during times of emergency. The program, in addition to being a dining hall, is concerned with teaching about food science and culinary studies, relating to the agrarian history of the University of Massachusetts and bringing that history into the current moment with the resurgence of localized food production and in support of the UMass award winning dining halls.

This program is designed for students to develop an understanding of food, water and environmental sustainable systems. Also in close relationship to the life essentials of food and water, this thesis addresses the need of the university to increase the existing shelter footprint on campus.

Based on recent climate experiences, we acknowledge there will be times of severe weather which can threaten our safety or even lives. During power outages and dangerous conditions resulting from severe storms, tornadoes, or earthquakes, the university is working to be able to provide shelter for people from our community and ensure them with a well-equipped and warm place to stay.

Lastly, the building is designed to have flexible spaces that can be programmed to house classes and events needed to provide learning and funding opportunities during summer time while the university is on break. All aspects of this design intertwine within each other creating an integrated system which is based on people, sun, and water circulation. The “systems” are designed to educate students as well as visitors; how to grow food, harvest green energy, and collect rain water for garden use. It gives a resource for food, energy and water on a daily basis while during emergency, crucial for survival.

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THESIS INTENT

1.1 Introduction

Sustainable Design is becoming more important each year. Architects are seeking certifications and their constructions are being designed to meet ever higher levels of environmental achievements. In addition, people are becoming aware of the importance of the healthy environment, not only for themselves, but for the future generations. Brand-new technology as well as modern innovations allow us to construct, research and test new methods for the problems that will come up in the future.

However the impact of Green Design on society is rather small when evaluated relative to the limited number of people who will experience private buildings. It relates only to people who live or work in those buildings. But what would happen if one designed a sustainable building on a university or college campus? Young people will be exposed to sustainable ways of living. They learn the habit of segregating waste. They learn about composting food. They learn how to grow their own food. They then will leave the campus bringing that culture with them.

The intent of this research is to design a place where students and visitors will learn not only how to grow or prepare healthy food, but at the same, time they would participate in and experience that environment. This thesis explores what systems should be used and what spaces would contribute to that idea of learning a sustainable life style.

When designing a building should we take into the consideration the resilience factor? Is the building ready for emergency response? Is there a division among the shelter spaces or all groups of people go to the same location? How do we combine Sustainable and Resilient design? How would one complement the other?

1.2 Objectives and Goals

The research is intended to respond to these questions. It is based on the literature review, precedent studies and implementation of findings in dining hall design. It is also a response to strategic planning of the location, and resources, in case of emergency response. The site, along with the structure, should be able to serve as both protection and for survival in case of longer disturbances. The research includes the newest sustainable approaches, as well as the knowledge and experience gathered throughout the past centuries. The thesis is also exploring the information, based on the University regulations, master planning, and advice from Emergency Management and Dining Departments. The research also evaluates existing dining halls and their impact in terms of energy and finances.

Based on that information, there should be a structure designed which will meet all requirements and become an attractive place to bring students interested in both sustainability and agricultural sciences as well as other students and visitors.

CHAPTER 2

LITERATURE REVIEW

2.1 How and Why Buildings Use Energy

In order start the conversation about how energy was used in the past and how it is used now, we need to understand how and why buildings use energy. It is crucial to realize how buildings use energy, what are the important factors of energy consumption, and obstacles to manage those factors. Buildings are the biggest energy users around the world, right after industry and transportation. Focusing on existing as well as new constructions, we can shape the environment, not only for us, but for future generations.

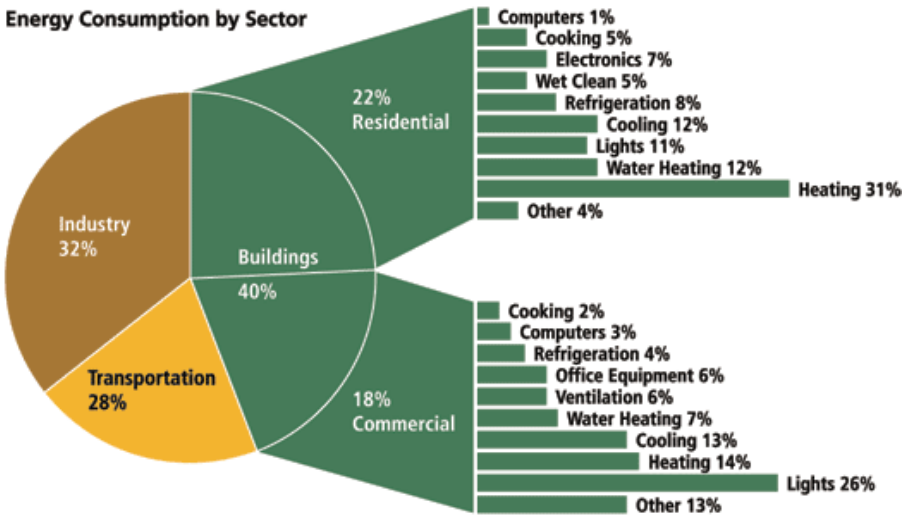

Figure 1: Energy Consumption by Section. (Image credit by the author)

As shown in Figure 1, the energy consumption based on the sector is divided into three categories: Industry, Transportation and Buildings. The last one is also broken down into two subcategories: commercial and residential where they account to about 18% and 22% accordingly.

In terms of energy consumption, we need to remember capacities of single devices, and how they are going to be used. Let's say we have the most efficient boilers, air conditioners, or other devices, but what happens if they run at the wrong times? What if they are used in an incorrect way? A good example of this can be light sensors. For instance, it is a great idea to use them at night, when somebody enters the office, but what if the same person is just passing the hallway, is there a need to light up entire floor for the next five minutes? It would be more efficient if the light devices were divided into smaller sections, or were operated by users instead of sensors. This way we can control the way our energy is used. According to Spielvogel "comparisons of buildings as the basis of installed capacities of HVAC, lighting, and other electrical equipment can be misleading, because the quantity of energy used is not necessarily related either to design load or to installed equipment capacity."[1]

Another important factor is the efficiency of how the devices operate at a given load, commonly only at 0 F and 100 F degrees. However, most of the time the energy is being used at the moderate load, while the extreme happens rarely.

Another illustration of how important it is to understand the way the equipment is being used is the utilization of the light bulbs. According to Spielvogel, "a 1,000-watt light bulb used 724 hours monthly gives a 100% load factor. However, in an office building, chances are that the light bulb will only be used 200 or 300 hours monthly, giving a load factor of 30% or 40%. When evaluating energy use, it is most beneficial to analyze those energies- consuming items that have the highest load factors."[2] Moreover, other components that can contribute to higher-energy consumption is the type of building, as well as the type of equipment, used in that space. For instance, computers in a

[1] Lawrence G. Spielvogel, *How and Why Buildings Use Energy* (USA, 1979), 53.
[2] Spielvogel, *How and Why Buildings Use Energy* ,55.

computer lab will require more energy to cool the space as well to cool each of the components. This is what it is crucial to plan the spaces in advance, rather than renovating existing condition after the structure was built. According to Spielvogel,: “most office-related energy systems are operated for 50 to 60 hours a week, while most computers are used for as much as 168 hours a week (24 hours a day). This means that it is necessary to provide lighting in the lobby, stairwells, corridors, lounges, and toilet rooms, as well as elevator services, vending machines, and so forth, for people working in these facilities."[3] The buildings EUI (Energy Usage Intensity) is different for specific types of buildings. So, for example; office use: 75,000 500,000 Btu/ft^2/year, food services: 300,000 to 500,000 Btu/ft^2/year, and research laboratories: 500,000 to 1,000,000 Btu/ft^2/year. There are six reasons that affect the energy use in the certain building types: the function the building is performing, type of control, energy distribution, hours of operation, ventilation rate, and finally thermal quality rate. As mentioned before, the building type is one of the biggest factors in terms of the energy consumption. It can affect what type of equipment is being used as well as the conditions which are needed to maintain them. In terms of the control factors, there are two main types: direct and indirect. The first one depends upon the needs of energy for the specific function. For instance, the sensors of the light in a room, which will turn on while someone is occupying it. The indirect one depends on larger factors and according to Lawrence: “indirect control includes such things as fixed cooling coil supply air temperature or outdoor temperature reset schedules. Many consider that to be a wonderful idea: the colder it gets outside, the hotter the water is. But what happened is that someone, the engineer or the control designer, has predicted the need for a specific amount of energy when it is a certain temperature outside."[4] So it is using more energy than it is needed at a given time to provide the service when it is required. Another example can be heating water for an entire day while the room is used only for a couple of hours during a day. Energy distribution is based on the equipment used to distribute the energy; for instance, the fans that move the heat

[3] Spielvogel, *How and Why Buildings Use Energy*, 56.
[4] Spielvogel, *How and Why Buildings Use Energy*, 59.

or cool air throughout entire building. So, not only producing the energy (boilers, AC Units), but the energy used to move the energy adds up in the final calculation. Operating hours, on the other hand, need a special attention and analysis. The building hours suggest when the heating or cooling should be used, but what if the room is unoccupied during the rest of a day? If we shut it down, we think we might save the energy but is it true? And here where you need the analysis and the researcher that should be done before the decisions are being made. Another question that should be asked before the design process is: how much energy does the boiler or AC Units need to bring the room temperatures back to the room level? It might be more energy intensive to bring the temperature up or down to the right level instead of keeping heated or cooled constantly. Finally, ventilation and thermal quality are based on the type and efficiency of a specific unit. The way the building is designed can make a huge difference and might be outweigh how efficient the equipment is. For example, we can take a water boiler, either it is placed at the center between two rooms, or separated in each of the rooms. It turns out that having a water boiler in one of the rooms separately is more efficient due to the energy loss while the water travels in the pipes and energy used to circulate the water adds to the final calculation. According to Lawrence: "selection of the proper design concept in terms of how energy is used can have a much greater impact on energy use than the efficiency of the equipment used. One of the key factors which can dominate the energy use of a building is providing the means by which it can be operated efficiently."[5]

2.2 Renewable Energy Sources

Energy might come from different sources. Some might be renewable and some not, which needs to be consider. We need to be aware what kind of energy are we using, for how long we can use it, and what is the total environmental cost of that energy. Among a different type of the energy sources we take into account: Hydro – which use a falling or moving water (through turbines or generators), Geothermal-

[5] Spielvogel, *How and Why Buildings Use Energy*, 67.

"The center of the earth is made up of rock so hot that it's melted. This heat sometimes makes underground water boil. When this hot water or steam comes up through a crack in the earth, we call it a geyser. When the steam is used to generate electricity, it's called geothermal energy"[6]. Others are: Solar- for instance PV Panels, use of sun's energy to heat the house, heat water or change a water into a steam to make electricity. Nuclear- "power plants run on uranium, an atomic fuel that when split gives off heat to boil water and make steam. The steam then turns turbines which make electricity"[7] and finally Fossil Fuels- such as oil, natural gas and coal, which are burned to produce electricity, and heat.

In order to keep the building sustainable both for the purpose of running the programs as well as displaying them to people we should start with passive energy.

Passive solar heating is one of the most efficient ways of saving the energy through natural resources. The solar gain can be done through windows, walls, skylights, or a roof.

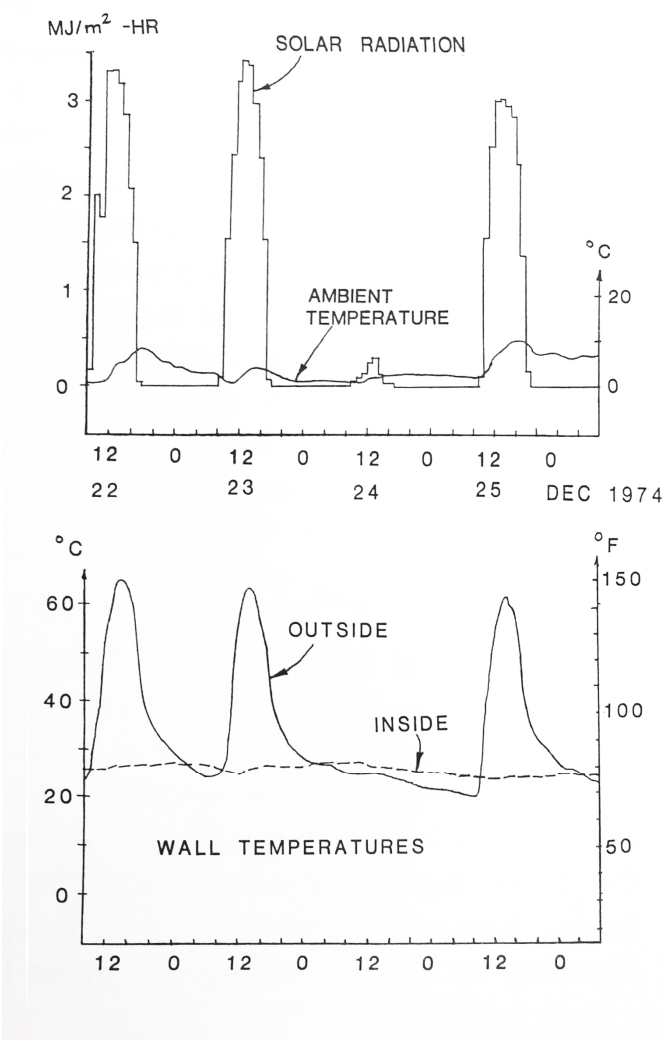

Figure 2: Wall Temperatures/ Solar, Ambient Temperature Charts. (Image credit by the author)

6 "Energy Sources Then and Now", http://www.energyquest.ca.gov/library/ben/ben3.html, (May 1, 2002).
7 "Energy Sources Then and Now", http://www.energyquest.ca.gov/library/ben/ben3.html, (May 1, 2002).

In this approach, the location and sun orientation are the most important aspects which help to gain additional heat during the winter season at no additional cost. There was a study done in Los Alamos at Scientific Laboratory to evaluate how much energy might be gained in different, yet controlled conditions. According to Balcomb: "test data for one year have been obtained on a pair of test rooms which utilize thermal storage- wall concepts, one with cylindrical water storage tubes and the other with a thick masonry wall, each located behind a vertical double glazed window, but with no additional provision against heat loss. The temperature histories were predicted by what proved to be an accurate simulation analysis technique developed at LASL: during the mid-winter months, each of their rooms have experiences an average inside temperature of 60F and 70F above the ambient temperature with no additional heating than that from the solar storage walls"[8]. This study proved that the solar heat gain can be calculated and predicted to work, not with a 100 percent precision, but we can predict what would be the best scenario in a given environment.

The passive solar systems can be divided into the following types: direct, thermal storage wall, solar greenhouse, roof pond, and natural convective loop. The direct type is achieved when the solar energy goes through the window with the best results if it is directed from the south. This system helps to gain a lot of sun during winter when the angle of the sun is low, while during summer the sun angle is high. The heat can be stored using a thermal mass, which can be concrete floor or wall. The second approach of a thermal storage wall is a glass wall which gains solar rays and returns them as heat to the room. Other types of storage walls can be a concrete wall, which in order to increase the heat gain can be painted black. According to Balcomb: "the temperature in the greenhouse does not require precise control as long as plants do not freeze. Solar energy could provide, typically, all the required heat for the greenhouse as well as a substantial portion of the building it serves"[9]. Another type of solar passive systems is the roof pond which brings the temperatures down in summer nights and keeps higher

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8 D. Balcomb, *Passive Solar Heating of Buildings,* (USA, 1979), *77*

9 D. Balcomb, *Passive Solar Heating of Buildings,* (USA, 1979), 79

temperatures during winter nights. Finally, the natural convective loop is a system where a solar collector is placed near a water heater, which helps to warm the water through the air.

2.3 Architectural Design Based on Climate and Energy

In order to prepare the best design, we need to focus on the local climate. We should take into account what is the weather like at the specific location, what should we expect from the weather to bring and finally consider at least fifty years of local weather history.

We should also know the energy sources that are available and where they come from.

To design a sustainable building that would serve both for occupants and for environment, we need to understand the laws of physics. One of the methods that can help us understand and visualize energy behavior is the psychometric chart. According to Milne: “the method permits an identification of 'least purchased energy' design strategies, first by utilizing the natural effects of sun, wind and nighttime cooling, and, only when these are insufficient, by selecting appropriate mechanical equipment. Rather, then the architect presenting the mechanical engineer with a design and the question, 'How much mechanical equipment do I need?', the approach implies that the architect, and engineers first ask, 'To what extent can a natural energy system be used; Can we achieve human comfort conditions with no mechanical equipment? and, 'If mechanical systems are required, how can they best be integrated within the building design to minimize purchased energy use?"[10]

Considering energy sources in the past and now, it is interesting to compare early 1980s and present to see how much the architecture has progressed, but at the same time how many design approaches are still true through today. The passive solar heating, passive ventilation, orientation, and material absorption are just examples of everlasting methods to architectural design. However, nowadays

[10] Murray Milne, *Architectural Design Based on Climate*, (USA, 1979), 97.

it is much easier to predict the material behavior, or energy use within the building before the building is finished.

According to Flavin "The heating, cooling, and lighting of buildings now consume nearly one-quarter of the world's annual energy supplies, and approximately two- thirds of this are derived directly or indirectly from oil and natural gas. The cost of providing fuel and power to this sector has escalated rapidly in recent years, and in many nations, buildings have been forced to the front lines in the fight to reduce petroleum use"[11].

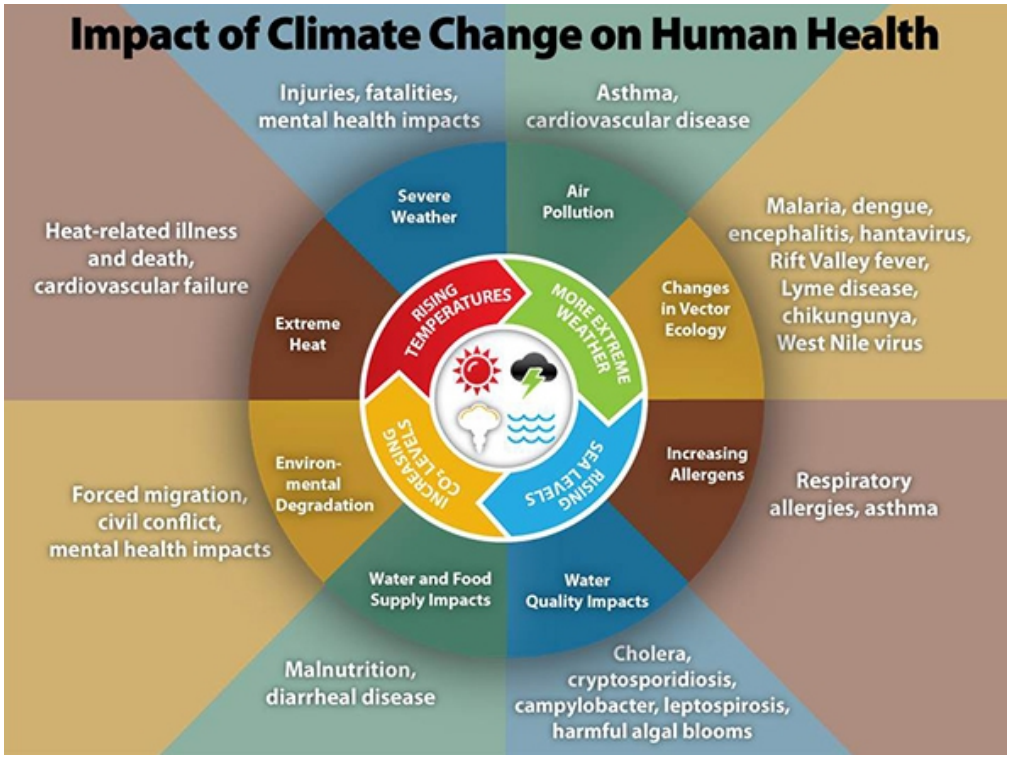

Figure 3: Impact of Climate Change on Human Health. (Image credit by the author)

[11] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 5

Before the air conditioning, electricity, and home devices were first available, people did not realize how the sustainable design could improve the quality of life as well as to saving money. After those innovations were presented for the first time, people started to understand that there is a huge area to improve. According to the economics from early 1950's and 1960's, the fuel prices were quite low, so the awareness of consumption was not as high as it is today. Furthermore, when fuel and electricity prices went up, architects understood that they must focus on sustainability. According to Flavin "major research efforts under way in more than a dozen countries are refining the state of the art, reducing costs, and starting to apply the new concepts to large commercial structures as well as private residences. Architects and engineers are reassessing the whole range of construction materials and techniques in their attempts to reduce the fuel requirements of buildings."[12]

How important it is to stay sustainable is shown in the Figure 5, which illustrate how damaging can be humans impact on environment, as well as on Figure 6, which illustrate the impact of human industry. In order to improve the existing conditions in the 1980s; architects started to use better insulation and storm windows, which brought the heating need down about 20%. It was exciting that, in those early days' architects noticed that the buildings built at $2 a barrel oil – will continue to stand even when the prices go up. And they were right, so the focus was not only on designing new sustainable constructions, but how to retrofit the existing buildings. According to Flavin "since 80 percent of the buildings in use today will still be around in the year 2000, it is essential that they be improved in response, to the altered world energy situation.

[12] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 6

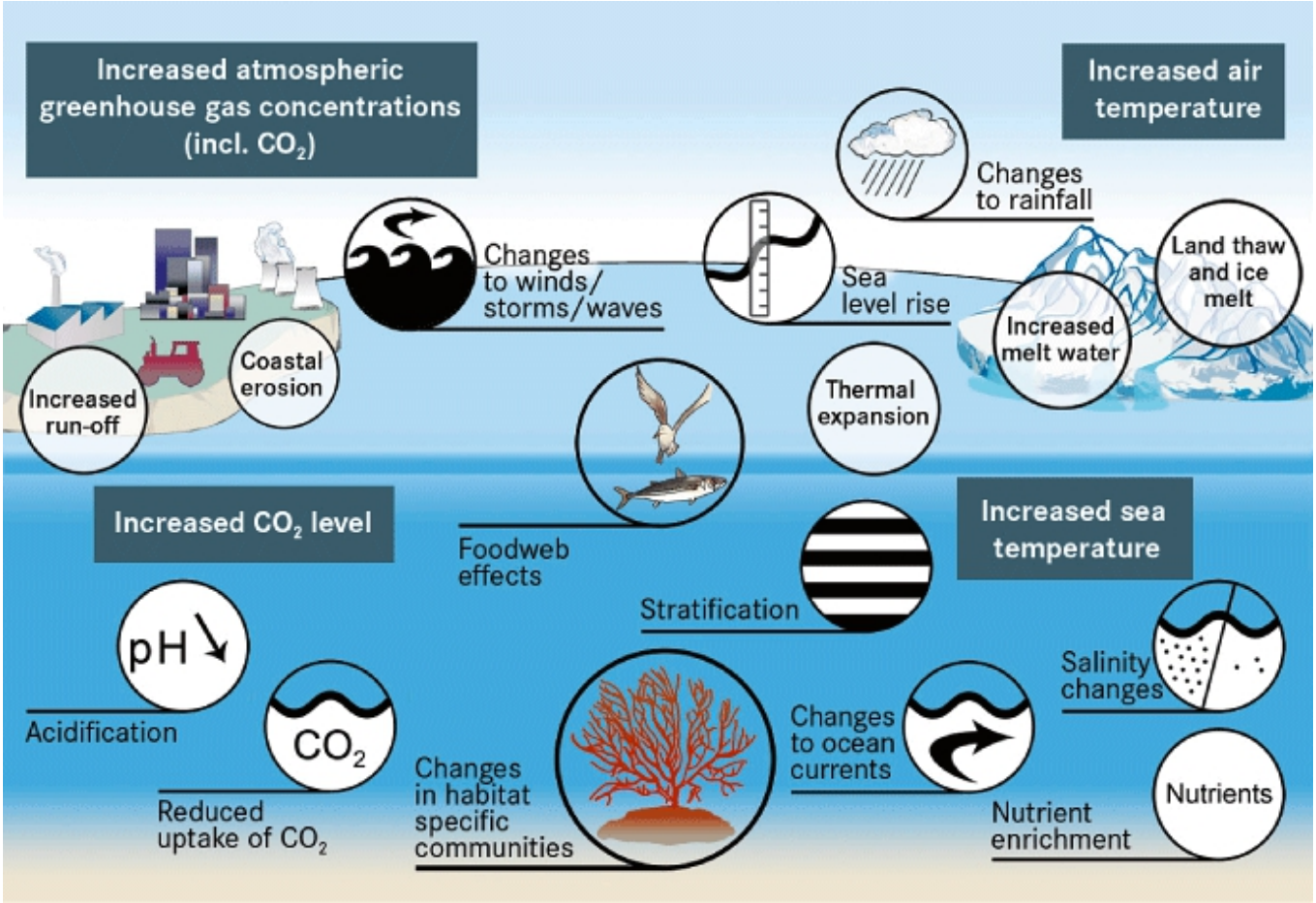

Figure 4: CO_2 impact on Climate. (Image credit by the author)

These changes will require substantial economic and institutional adjustments. However, in the long run, the benefits will unquestionably far outweigh the costs"[13].

The author is also evoking a knowledge of how design was used since ancient times. He mentions Socrates and his observations of the south-facing facades, and how it supposed to be used to our advantage. Some other interesting observations came from the Roman Empire, as Flavin mentioned, "Romans developed the first greenhouses as well as solar heated bathhouses; floor plans indicate residences were organized so that rooms would be comfortable at the time they were most often occupied; and access to the sun was actually made a legal right under the Justinian Code of Law adopted in the

[13] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 8

sixth century A.D."[14]. What is more interesting, similar design approaches can be found in China, Southwest America, and Africa.

Flavin focuses on two types of buildings: residential and commercial which are characterized by larger use of energy. "Together, the residential and commercial sectors account for between 20 and 40 percent of national energy use in most industrial countries. Of this, approximately four-fifths is used to heat, cool and light buildings and the rest runs appliances and water heaters. Residential energy consumption exceeds commercial energy use in most countries by 20 to 100 percent, though the rapid growth of the service sector has meant commercial buildings take up an ever-increasing share."[15]

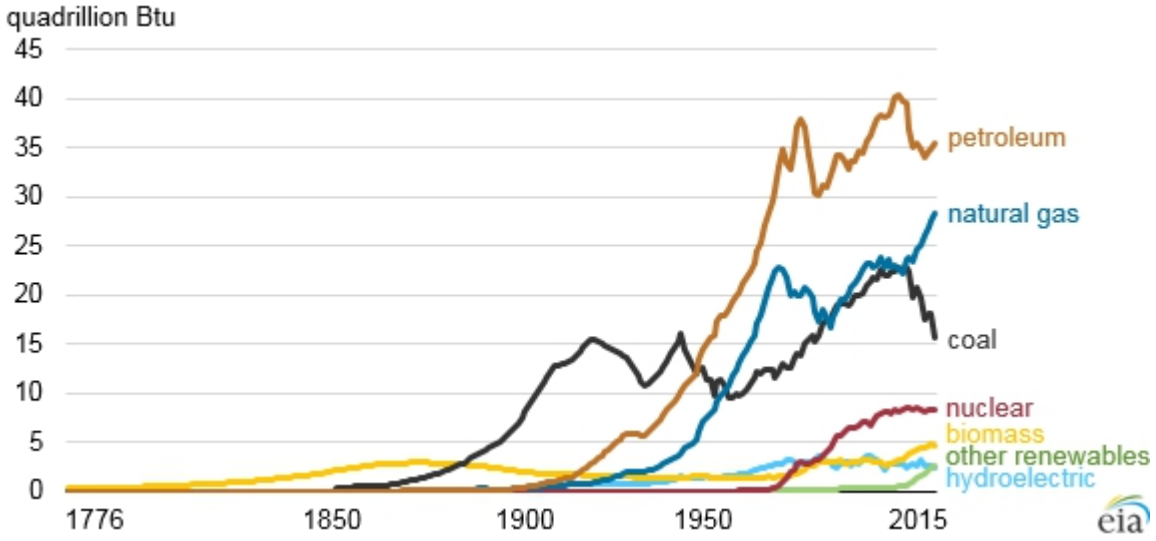

Figure 5: Energy Consumption in the United States (1776-2015). (Image credit by the author)

In Figure 5, we can see that the use of petroleum as well: natural gas, hydroelectric, nuclear, biomass, and other energy increased, while the use of coal is decreased. "Three fossil fuels—petroleum, natural gas, and coal—have provided more than 80% of total U.S. energy consumption for more than 100 years. In 2015, fossil fuels made up 81.5% of total U.S. energy consumption, the lowest fossil fuel share in the past

[14] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 9
[15] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 11

century. In EIA's *Annual Energy Outlook 2016* Reference case projections, which reflect current laws and policies, that percentage declines to 76.6% by 2040. Policy changes or technology breakthroughs that go beyond the trend improvements included in the Reference case could significantly change that projection".[16] Also, the renewable energies: wind turbines and PV panels in the past decade have increased significantly.

On the second chart, we can see that the use of natural gas is reaching the same level as petroleum, and use of the coal is drastically going down. "Some electric fuels, such as nuclear and hydroelectric, remain relatively flat in the Reference case, with little change in capacity or generation through 2040. Biomass, which includes wood as well as liquid bio fuels like ethanol and bio diesel, remain relatively flat, as wood use declines and bio fuel use increases slightly. In contrast, wind and solar are among the fastest-growing energy sources in the projection, ultimately surpassing biomass and nuclear, and nearly exceeding coal consumption in the Reference case projection by 2040".[17]

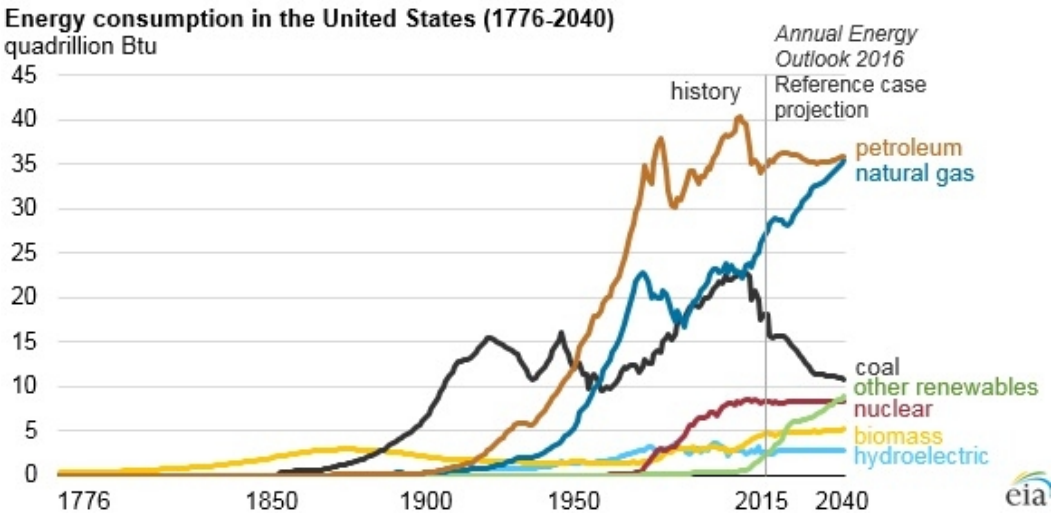

Figure 6: Energy Consumption in the United States (1776-2040). (Image credit by the author)

[16] "Fossil fuels still dominate U.S. energy consumption despite recent market share decline" https://www.eia.gov/todayinenergy/detail.php?id=26912 (July 1, 2015)

[17] "Fossil fuels still dominate U.S. energy consumption despite recent market share decline" https://www.eia.gov/todayinenergy/detail.php?id=26912 (July 1, 2015)

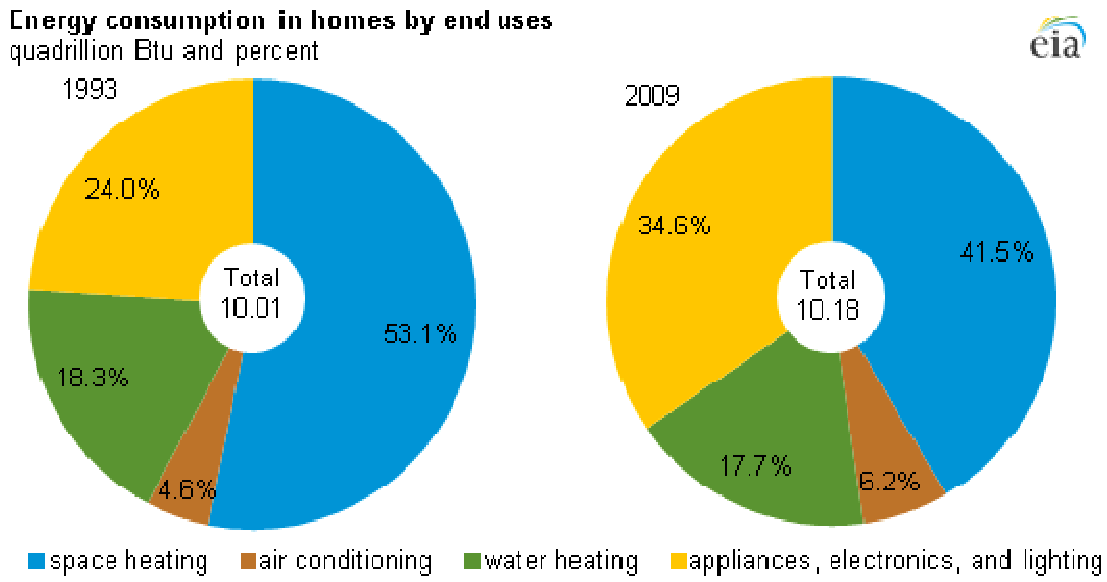

Figure 7: Energy Consumption in Homes by End Uses. (Image credit by the author)

On the third chart, we can see the energy in the homes is slowly increasing, and use of appliances, electronics and lighting is increasing, as well as air conditioning, while space heating and water heating are decreasing.

In 1973, after the OPEC oil embargo, can notice a significant improvement which was caused by smarter use of appliances "most of these improvements came from thermostats being set lower, adjustments of furnaces and air conditioners, and the addition of insulation to existing buildings."[18]

Some other way to achieve passive design is the use of a glass, this simple material which can transform a south part of the building into a greenhouse might be crucial if designed intentionally. The south facing facade keeps the heat during winter and creates a thermal barrier along with shading devices. Furthermore, it is important to remember to design "tight" in order to reduce small leaks that can be responsible for loosing or gaining heat based on the seasons. Another sustainable design approach might be a heat storage, which is achieved by thermal mass – concrete or stone flooring for instance, or water

[18] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 15

walls. According to Flavin "the wall, constructed of masonry or filled with water, is painted a dark color to absorb heat from the sun; heat collected during daylight hours is radiated to the rest of the house for many hours after sundown. This is known as a Trombe wall, named after Felix Trombe, who with Jacques Michael designed buildings using this technique at the French Solar Energy Laboratory in the late fifties and early sixties."[19] Another example is the green roof, which helps to reduce the thermal mass of the building, and adds the benefit of having a small park or place to be surrounded by nature in the busy and crowded city. It can be designed at different thicknesses, having different circulations, or even with diverse insulation amounts. A great example of that specific feature is in New Mexico and was built in 1972 by Steve Baer. Another illustration of thermal application is the Earth sheltered Building, according to Flavin: "Earthed- Sheltered buildings, whether they simply employ a sod roof or are constructed completely beneath the surface, use the earth as a natural insulator that dumps out temperature fluctuations in both winter and summer. By exposing such buildings to the vicissitudes of the weather only on the sunny side, the sun's heat can be effectively collected and stored. Earth-topped roofs have the additional advantage of providing natural evaporative cooling in the summer."[20] An example of solar houses is the house developed by Harold Hay in California, and by Lee Porter Butler also in California. However, it is important to keep in mind that some approaches are suitable for a specific climate zones which are called the ASHRE/ DOE Classification System. There are divided into five different climate zones named by capital letters from A to E.

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[19] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 20

[20] Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 21

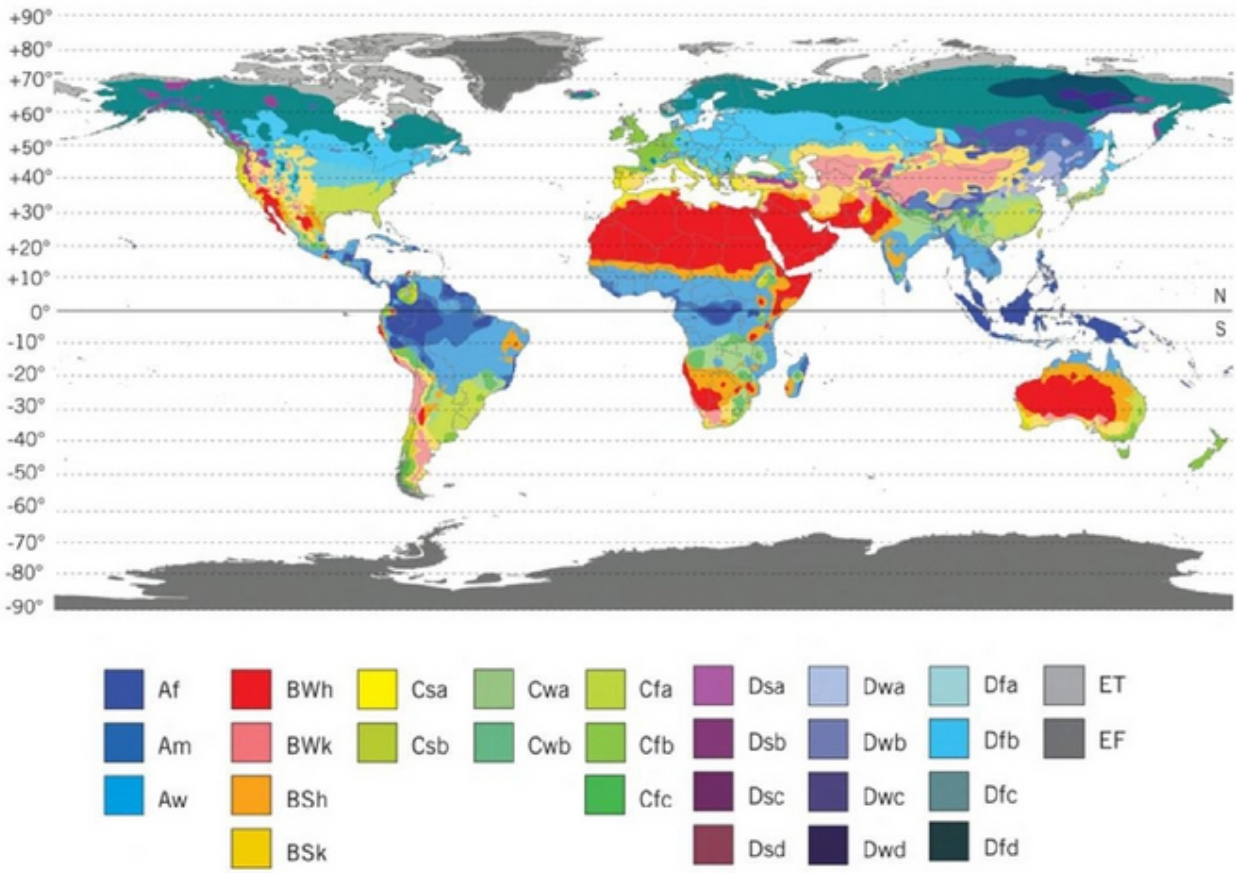

Figure 8: Koppen Climate Classification System. (Image credit by the author)

In smart sustainable design the following should be taken into consideration; energy resources, materials and specific customer's or commercial program needs. Flavin gives a great example of those principles, according to him: “Researchers in Canada and Northern Europe are taking quite a different tack. Since the sun is present for only a few hours a day at midwinter and for much of that time is hidden by clouds, relying on sunlight for a large portion of heating needs would be hopeless. Instead, architects are designing super- insulated, very tightly constructed structures. These buildings are wrapped in polyethylene plastic and special care is taken to seal all trouble spots, resulting in air infiltration that is

one-tenth that of a conventional house."[21] Talking about sustainable design, it is important to introduce sustainable approaches in the early stages of design. One of the interesting facts about passive systems is that the lighting and cooling of a larger building take more energy than heating. Here, the knowledge about the right position of Sun in order take advantage of the Sun for our and save energy becomes very crutial. Reported by Flavin "experts in the field are confident that designs that incorporate the use of daylight can make climate-sensitive architecture as cost-effective for large commercial buildings as it is for single-family dwellings."[22]

Harrison Fraker in his Medical Office in Princeton, New Jersey designed the atrium which introduced a large amount of light entering the building interior which was expected to lower the energy costs by about 30 percent. Along with the light also came heat which, dependent on the season, was a good idea. In summer the architecture was designed to evaporate from cooling using the sprinklers to bring the temperatures down. It is interesting that in 1980s technology was not as evolved as it is nowadays, yet those simple improvements contributed to energy cost savings.

In the 1970s, architects started becoming aware of that fact, so they could design sustainable buildings at the early stages instead of retrofitting them later. Nevertheless, the architectural schools started to train young architects the importance to the LEED design. At that time, the schools like Massachusetts Institute of Technology, Architectural Association in England, the University of Alberta in Canada, the University of Auckland in New Zealand, and the Technical University in Denmark started introducing "energy-conscious architecture" to the students. However, the teaching of young architects was only one side to the coin, along with design, a tremendous part was the dependent on industry. We need to remember about contractors, vendors, developers, or even people who work for the factories- producing a

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21 Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 22

22 Christopher Flavin, *Energy and Architecture: The Solar and Conservation Potential*, (November 1980), 33

new sustainable material. They had to be introduced to the market to be bought by architects or contractors.

2.4 Environmental Aesthetic

In order to attract students into certain buildings – they have to be functional as well as appealing. Furthermore, architects must combine functionality; if it's a dining hall, what else is happening there? Are there the additional spaces like shops, a bakery or even a private space for students to take a break? At the same time, it must be eye catching to get their attention and make them want to approach such a facility. According to Kieran beauty in design is crucial "if it isn't beautiful, then it isn't sustainable. The aim here is to speculate on the notion of an aesthetics derived from an integral world. Nothing of beauty has ever been made by addition or by counting points."[23] Another point to consider is early innovations in architecture which tended to focus on energy and horsepower, while now the main focus is on low energy use, sewage, thermal control, and harvesting energy from PV Panels. Le Corbusier's Cite de Refuge is an example of the original house that used air conditioning.

According to Kieran, there is a visible separation between nature and human. Still, architects have been trying to bring people as close to nature as possible. As an example, Stephen is using The Farnsworth House where Mies van der Rohe situated it right in the middle of woods. At the first glance, we can find that he was successful. The materials he used worked well, especially glass, which makes an impression of being a part of nature while being and looking from inside out. On the other hand, the building does not remind us anything that exists in nature. Its regular shapes make the structure exposed and visible which is not really integrated with nature. Of course, the house is surrounded by nature, but glass creates separation from it. Moreover, it is important to design structures that are "organic" and

[23] Stephen Kieran, *Evolving an Environmental Aesthetic, (*August 2011), 244

closer to organic forms, and as Kieran mentioned; aesthetics can be more attractive than any other force. As an opposite example, Kieran describes the Hut building as integrated and engaged with nature.

Another view of aesthetics is “the skin." According to Stephen “skin acts as a filter, not an envelope, which selectively admits and rejects the environment based upon the needs within the body across time. It sweats to provide evaporative cooling from the heat and forms goose bumps to close its pores to the cold”. Skin mirrors our body, which protects organs, but at the same time is beautiful. And according to Kieran it should be noticeably attractive to be successful. As he states: “the integral skin at Sitwell parallels biological skin in its functional layers. Two outer layers are wood, with the outermost layer organized to shield solar gain."[24]

Lastly, in his article Kieran talks about the “natural circle of life." As humans are born, they grow up, get old and die. The same thing happens with buildings. I find it crucial to focus on beginning, as well as the end buildings "life." Designers and contractors focus on how to build the structure, but not always how to disassemble it. So, Kieran touches an important aspect of architecture, which is: how to assemble, but also how to disassemble. As an example, he brings the Loblolly House which natural shape comes from biophilic exploration. As he states, “Loblolluy House confronts not only the question of how we assemble our architecture but how we disassemble it, how we manage not only the beginning of life but its end."[25] According to Kierans belief that there is an “aesthetic potential for deep biophilic connections to natural form by accepting and representing, in short, rendering aesthetic not only the manner of assembly but the disassemble, reuse or recycle of all the components of our buildings."[26]

In the Biophilic Architectural Space, Grant Hildebrand distinguishes five survival advantages of architectural characteristics: complex order, prospect and refuge, enticement, peril and case study.

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24 Stephen Kieran, *Evolving an Environmental Aesthetic, (*August 2011), 247
25 Stephen Kieran, *Evolving an Environmental Aesthetic, (*August 2011), 249
26 Stephen Kieran, *Evolving an Environmental Aesthetic, (*August 2011), 249

Talking about the prospect, Hildebrand highlights the feeling of shelter, a place where we can feel safe. There have been made some studies that prove that being surrounded by nature can help bring the blood pressure down as well as make us feel more relaxed and less stressed out. According to Hildebrand "we need a place to hunt and forage, offering open views over long distances, ideally brightly lit to illuminate resources and dangers, and conditionally lit to cast information- laden shadows- our fondness for sunlight may derive from its usefulness for this purpose."[27] As an example, he talks about the Edwin Cheney house in Oak Park, Illinois -describing the interior to prove his point. He also quotes Kaplan's thought that "a scene high in mystery is one in which one could learn more if one were to proceed farther into the scene... What it evokes is not a blank state of mind but a mind focused on a variety of possibilities, of a hypothesis of what might be coming next. It may be the very opportunity to anticipate several possible alternatives that makes mystery so fascinating and profound."[28]

Finally, Hildebrand talks about the fifth advantage which is the case study: retirement home – which include all mentioned advantage characteristics in that one specific structure which comes all together at the end. According to him "buildings might offer meaningful surrogates of those appealing characteristics of nature that once, long ago, gave us better odds for survival, and although no longer useful for that purpose, may still bring us pleasure. If buildings can do that, it may be of real importance that they do so."[29]

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[27] Grant Hildebrand, *Biophilic Architectural Space, (*August 2011), 244
[28] Grant Hildebrand, *Biophilic Architectural Space, (*August 2011), 267
[29] Grant Hildebrand, *Biophilic Architectural Space, (*August 2011), 275

2.5 Building for the Purpose

Looking at buildings over a time, we can notice that some of them might not be occupied anymore. What might be the cause of that? Which, out of many factors that together create a unique system, failed? It is crucial to take into consideration the buildings function- which might be very influential on what will happen with the building in the future. Losing the function, which once was determined puts in risk the buildings outlast. That's why it is important to calculate, predict and create spaces so in case the program will change their function, we can still reuse the space. As an example, we can use the office building, while the facility stops to function as an office building, it is highly difficult to reorganize the internal spaces into for example conference room or open dining hall.

In "How buildings learn what happens after they're built" Stewart Brand focuses on "flow"- which is presented in detail throughout the book. He notices that every building is designed for its specific function, but at the same time, those functions might change according to time and place. For example, the school building might change its function after the "newer" building is being built. An illustration that comes to mind is the UMass Fine Arts Center – originally designed for "Arts" become a home to architecture students and soon, it will go back to its beginning. In this case its interesting, how one function becomes something else to- in the end go back to the original intention. Another example might be a building that is not performing well, or if a weather disaster occurs, that building might stay vacant or adopt a new function.

According to Brand, buildings do not adapt well to their functions "Almost no buildings adapt well. They're designed not to adapt, also budgeted and financed not to, constructed not to, administrated not to, maintained not to, regulated not to, and taxed not to, even remodeled not to.

But buildings adapt anyway, however poorly, because the usage in and around them are changing constantly."[30] One aspect of why it happens might be that architecture is permanent, there are some decisions made that basically in some cases are impossible to implement into something else than what it was designed for. Here, it is important to remember that "we shape our buildings, and afterwards our buildings shape us".[31] Another way of the highlighting the "flow" can be its connection to the materials. For instance, as Brand perceived, some materials that in the past were recognized as a good or safe – today are bad, and in some cases, very harmful to our health. According to Brand" asbestos went from being very good for you to very bad for you". What is interesting is that there is more money spent on buildings that are being renovated then building a new one. Stated that way, it brings more attention and at the same time- value of the "flow" effect. How important is the function of the building? How important is it to do research on what it will be or what it might become in the future. All of that can improve not only the (environment by saving energy or pollution) but at the same time our own time and money.

As Brand noticed, there are three forces that shape function, technology, money, and fashion. Technology offers, say, new double-pane insulated windows with sun-reflective membrane-expensive, but they will save enormously on energy costs for the building, and you get political points for installing them. By the time their defects become intolerable, even newer windows will beckon. He distinguishes the "flow" effect among different types of the buildings. For instance, commercial buildings must adopt very fast to different circumstance with a pressure of working properly - "if they grow, they move, if they fail, they are gone".[32]juh, the most stable buildings are the domestic ones- homes. The buildings "mold" with occupants throughout the ages. Lastly the institutional buildings behave as they were often not designed to be changed. However, an interesting finding is that buildings

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30 Stewart Brand, *How Buildings Learn: What Happens after they're built,* (Viking: 1994), 2
31 Stewart Brand, *How Buildings Learn: What Happens after they're built,* (Viking: 1994), 3
32 Stewart Brand, *How Buildings Learn: What Happens after they're built,* (Viking: 1994), 7

which their purpose is to "make money" for instance the offices are more likely to change their function then the domestic ones. For instance, if the business fails, the same space might be adopted by an art gallery or dance room, while in case of a home, the living room will in most cases stay a living room. So, they do change differently based on their type, material or purpose. According to Brand the value of the history is very important to American people. This is the time where many old buildings are being preserved from any renovations. In this case, the "flow" is impeded. The value of the historic buildings is so high that it is forbidden to do any renovations even to a domestic house. At times, even the owner does not have a right to change its "functions". According to Brand, "age is so valued that in America it is far more often fake than real. In a pub-style bar and restaurant you find British antique oak wall paneling- perfectly replicated in high-density polyurethane. On the roof are fiber- cement shingles molded and colored to look like worn natural slate."[33]uhu. The similar thing can be spotted in Europe especially with a picturesque style buildings. People constantly changing their surroundings to keep it updated and better than it was before.

One of the very little things in today's world that is not changing is Levi's invention- jeans. It is interesting that Stewart noticed that jeans are the same since the first 501's, they only have a minor changes or improvements. After learning that fact Brand asked the question "are there any blue-jeans buildings among us?" I think it was quite an interesting question, which makes me start realizing how not only "things", but also our surrounding is constantly changing, and how do we know that it's changing for better? When asbestos was new -people thought that it was quite an invention, or for instance a playground in bad locations, how many crimes happened there? We need to rethink our plans, there are many "unknown" factors that must be taken into consideration.

Brand also talk about "Shearing Layers" and its importance in architecture. He distinguishes four layers: Shell, Services, Scenery, and Set. Shell is structure, which lasts the lifetime of the building (fifty

[33] Stewart Brand, *How Buildings Learn: What Happens after they're built,* (Viking: 1994), 10

years in Britain, closer to thirty-five in North-America). Services are the cabling, plumbing, air conditioning and elevators("lifts"), which must be replaced every fifteen years or so. Scenery is the layout of partitions, dropped ceilings, etc. which changes every five to seven years. Set is the shifting of furniture by the occupants, often a matter of months or weeks. Which bring us to the assumption that Layers can affect occupants. Another interesting fact is that the site as the most outer layer and can affect entire cities.

Downtown New York City, which has very narrow long blocks, is uniquely dense and uniquely flexible. The layers with a connection to the flow cause the interiors to constantly change while the exteriors stay mostly the same.

Furthermore, Brand talks about "The scenario-buffered building" and explains it with a diagram. The diagram states the usual new building and a scenario-buffered building where the only difference is "scenario planning" and a "scenario for the occupancy" which gives more options, while it doesn't exist in the usual building. According to Brand "the great vice of programming is that it over responds to the immediate needs of the immediate users, leaving future users out of the picture, making the building all too optimal to the present and maladaptive for the future."[34]It was a quite interesting assumption that whatever the client says will happen, it will not. It is not easy to control or even more predict what the future will bring, and how the new changes should adopt. These are the forces that have a huge influence on our buildings future. It was fascinating to look at a different view at design process, how those small details can affect future owners or occupants.

[34] Stewart Brand, *How Buildings Learn: What Happens after they're built,* (Viking: 1994), 181

2.6 Sustainable Design

Sustainable design is becoming more and more popular in today's architecture not only leading the way but also taking a risk, especially in designing a new technology, the ones that might be beneficial today, but need to be tested for years.

In "What Does Sustainability Look Like?"- Matthias Sauerbruch and Louisa Hutton talk about sustainable architecture, problems related to sustainable design, as well as methods and materials. They start with pointing out big issues like climate conditions and they end up on specific details like how to design high efficiency building with respect to nature.

One of the big issues we are facing right now are: climate change, especially excessive use of Earth's resources and expanding global population and their needs. Furthermore, excessive consumption, which causes ecological damage to the Earth is enormous. According to Sauerbruch and Hutton "generally speaking, the two options that bring us forward in the campaign to reduce our oversize ecological footprint are a reduction in the demand and technological innovation. Only with considerable innovation in the technologies of energy production and/ or carbon capture will we be able to meet demands in a sustainable way: thus, highly developed countries have to research the efficient use of(renewable) energies at every level and they have to reduce energy consumption at the same time."[35] So, as they mentioned, there is a huge need for the renewable energy, technological innovations and reduction of energy use.

To solve those problems, we need to first understand how buildings operate, what are available systems, and how to use our knowledge to design friendly and efficient environments. In terms of materials, it is important to use environmental friendly materials that do not damage our environment. In designing a building, we need to keep in mind not only the materials, but also the way they were

[35] Matthias Sauerbruch and Louisa Hutton, *What Does Sustainability Looks Like?,*(Rottherdam 2011), 41

produced matters. Having that knowledge, we can easily calculate that sometimes materials like concrete – which is commonly used throughout the entire world also produces CO2 which is harmful to the environment. According to Sauerbruch and Hutton: "construction as a field obviously has to contribute to this change and hence the most pressing question for architects right now is how they can help, and how this activity may affect their thinking, professional habits and conventions. Again, the same two directions seem worth considering: the passive reduction of unnecessary energy consumption through intelligent design and the active application of energy- saving or energy production technology."[36] Nonetheless, it is also important to remember how much energy is being used to produce certain materials and the cost of transportation (if it is a long distance, air pollution must be accounted for). It is crucial to use local materials – the best option would be to use renewable materials like wood. In this case, the wood is not only organic, and can be local, but is friendly for occupants. Some studies point out that one of the health effects of using wood in construction can be lowering the blood pressure in an occupant's body. So, careful choice of materials can not only lower the amount of waste, damage the environment but can also be beneficial to our health.

Another important point to consider is not only how to design and build a structure, but how to maintain it and help it last for many years. As reported by Sauerbruch and Hutton "we must see buildings as things that ought to last at least fifty years or longer, and one of the questions that we therefore must ask ourselves is what may guarantee this longevity? Solidity seems the obvious answer and, indeed, well-chosen immateriality and appropriate detailing help in this respect."[37] Also, new technology comes in handy for "predicting" the building behavior that might boost the efficiency of used systems. We can evaluate many options, conditions, and propose the best approach in order to maximize our design efficiency. The computer programs are becoming more and more sophisticated and more accurate than they were even a few years ago.

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36 Matthias Sauerbruch and Louisa Hutton, *What Does Sustainability Looks Like?,*(Rotterdam 2011), 41

37 Matthias Sauerbruch and Louisa Hutton, *What Does Sustainability Looks Like?,*(Rotterdam 2011), 42

Another important aspect is to have knowledge about how to control our buildings. Using sophisticated tools such as ArcGIS, we can calculate distances between occupants and print rooms, distances between buildings and bus stops, between buildings and parking lots. That goes further beyond the design of a single building, yet we can organize the parking spaces according to occupants, their location, and to maximize efficiency in traffic, but also minimize the use of fuel.

Architecture as a society modeling tool, is another aspect of sustainability with roots in social and cultural background is as a society modeling tool. It is interesting that designing a space can affect how people will move from point A to point B. We can place stores and offices on their way to maximize the number of potential customers. According to Sauerbruch and Hutton, "architecture is present everywhere; it is more suitable than any other discipline to act as a medium to express a change in the anathematic relationship between nature and civilization in a visually comprehensible way. Architecture could become an agent of a changed attitude and practice in dealing with nature and it resources."[38] Thus, buildings become an image of history. They represent their own times, social movements (for example concrete buildings in a communist times) and they illustrate the changes- between each century.

Buildings are like living organisms, they "live" and they have their own purpose in society. I posit that we should not only consider how to design a sustainable building, maintained to maximize its life expectancy, but also how to deconstruct it when its life is close to an end.

In "The Architecture of the Passively Tempered Environment" Keith Bothwell talks about passive design. He states that the key to success is the connection between; knowledge, understanding, intention, and achievement in the process of design. In order to achieve it we need to possess the knowledge – first about our climate, environment and scale it down into as specific building and its needs. According to Victor Olgyay – who is mentioned by Bothwell "to meet the problem of climate

[38] Matthias Sauerbruch and Louisa Hutton, *What Does Sustainability Looks Like?,*(Rotterdam 2011), 43

control in an orderly and systematic way requires a pooling of effort by several sciences. The first step is to define the measure and aim of requirements for comfort. For this the answer lies in biology. The next is to review the existing climatic conditions, and this depends on the science of meteorology. Finally, for the attainment of a rational solution, the engineering sciences must be drawn upon. With such help, the results may then be synthesized and adapted to architectural expression."[39] Bothwell also talks about good functional performance and subconscious intentions which stand in opposition to the first one. He places the early sustainable approaches in the Renaissance, however the foundation for sustainable design can be found in ancient ages. Ancient structures and the way they were built assures us that those people had tremendous knowledge for that time. Examples can be a tall tower built of stone and the use of passive ventilations). However, the main point is to regenerate the resources used by building. A great example can be a rain water collection system which helps to reuse rain water as gray water, to water plants, or in some sophisticated cases after filtering water, to wash hands. Passive design is the most efficient, effective and expressive way to boost the building's efficiency and lower the cost to operate. As Bothwell stated: "the area of passive environmental design is widely acknowledged to be the foundation of genuinely sustainable buildings. Passive environmental control relates to the way in which the orientation, section, materials and envelope of a building – the form and fabric of the building itself- create comfortable conditions inside, without mechanical devices such as air conditioning or heat pumps. For example, a building in a temperature climate can be kept cool during a hot summer if it has good day lighting to prevent the need for heat generating lamps, shades or guards against solar penetration, an interior lined with high thermal mass materials and a tall section with both low and high openings to flush the building with cold air at night."[40] It is very useful to list all the sustainable approaches: orientation, section, materials, envelope of a building, comfortable conditions inside without mechanical devices, green roofs, technology, renewable energy, PV panels,

[39] Keith Bothwell, *The Architecture of the Passively Tempered Envirioment,?,*(Rotterdam 2011), 66
[40] Keith Bothwell, *The Architecture of the Passively Tempered Envirioment,?,*(Rotterdam 2011), 67

wind turbines, heat pumps, large south facing windows, high level of insulation, plenty of daylight, natural ventilation, free cooling, free solar heating, and minimize the use of materials and energy grounded in climate and culture.

In hot humid climates, lightweight perforated walls allow cooling breezes to pass through, and overhanging roofs prevent sunlight from entering", or "we have seen that according to Herzog, Fordham and others, it is far more effective to reduce carbon emissions and conserve energy by employing passive design principles first to light, heat and cooling buildings. Only secondly should we employ renewable energy technologies to meet any shortfalls in energy requirements."[41] Bothwell also emphasizes the minimal use of materials and energy- the theory is important, but it is very nice to see the actual examples in life. Also, as mentioned in a previous article he points out the social and cultural aesthetics of the sustainable design "we share some aesthetics preferences in common with all other human beings, each culture and subgroups has its own particular conception of beauty. Further down the scale, as individuals, we all have our personal, unique, aesthetic responses based on our own particular experiences."[42]

2.7 Resilience in Architecture

Jill Fehrenbacher who wrote an article about: "Resilient Design: Is Resilience the New Sustainability? "asks a very important and interesting question. Recent history proves that our climate is constantly changing, forcing us to a re-think the way we perceive architecture. What happens if the building passes all LEED points, but eventuality will fail in a natural disaster? According to Fehrenbacher **"**While the term "sustainability" in today's lexicon often conjures up an image of CFLs,

41 Keith Bothwell, *The Architecture of the Passively Tempered Enviriment,?,*(Rotterdam 2011), 70

42 Keith Bothwell, *The Architecture of the Passively Tempered Enviriment,?,*(Rotterdam 2011), 71

Priuses and low carbon emissions, “sustainability” literally means “to endure." Any so-called “green” products and buildings that don’t stand the test of time are not truly sustainable. As climate change turns our attention to the possibility of increasingly likely disaster scenarios, resilient design serves to remind us to design for durability over time.”[43] So, in terms of the resilience architects should always keep in mind the surrounding environment as an important starting point. As an example, Fehrenbacher illustrates the New York climate, where “the most common and likely natural disaster scenarios involve water: hurricanes, flooding, storm surges, and blizzards.”[44]

In addition, there is also a seismic activity and fire danger which should be taken for the consideration during planning. In the example given by Fehrenbacher “if the Con Edison power plant that exploded on 14th Street in lower Manhattan during Hurricane Sandy had had higher flood barrier walls — and had generally been better designed to withstand flooding — all of lower Manhattan would not have lost power for the 4 days that followed Hurricane Sandy, leading to widespread evacuations, hospital evacuations, and public transportation failure.”[45] That gives us an idea of where architecture should strive to be responsive. In order to start planning the site, it is important to know the technical details of what materials should be used and how they are assembled. There are two crucial techniques that should be considered while planning for resilience; base isolation - which is a separation of the base portion with the rest of the building, and expansion joint application.

Moreover, the next step should consider the testing of specific materials with specific conditions. The test can be executed by building's components, three-dimensional computer models, and one to one scale real building sections. According to Fehrenbacher “A common way to test the seismic resilience of a design is

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[43] Jill Fehrenbacher, “*Resilient Building Design: Is Resilience the New Sustainability?*”, http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

[44] Jill Fehrenbacher, *“Resilient Building Design: Is Resilience the New Sustainability?”,* http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

[45] Jill Fehrenbacher, *“Resilient Building Design: Is Resilience the New Sustainability?”,* http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

to use a "Shake Table". This is a rectangular platform which is coupled to hydraulic motion actuators to shake the platform in different ways and therefore, test structural models or building components with a wide range of simulated ground motions, including reproductions of recorded earthquakes time-histories."[46]

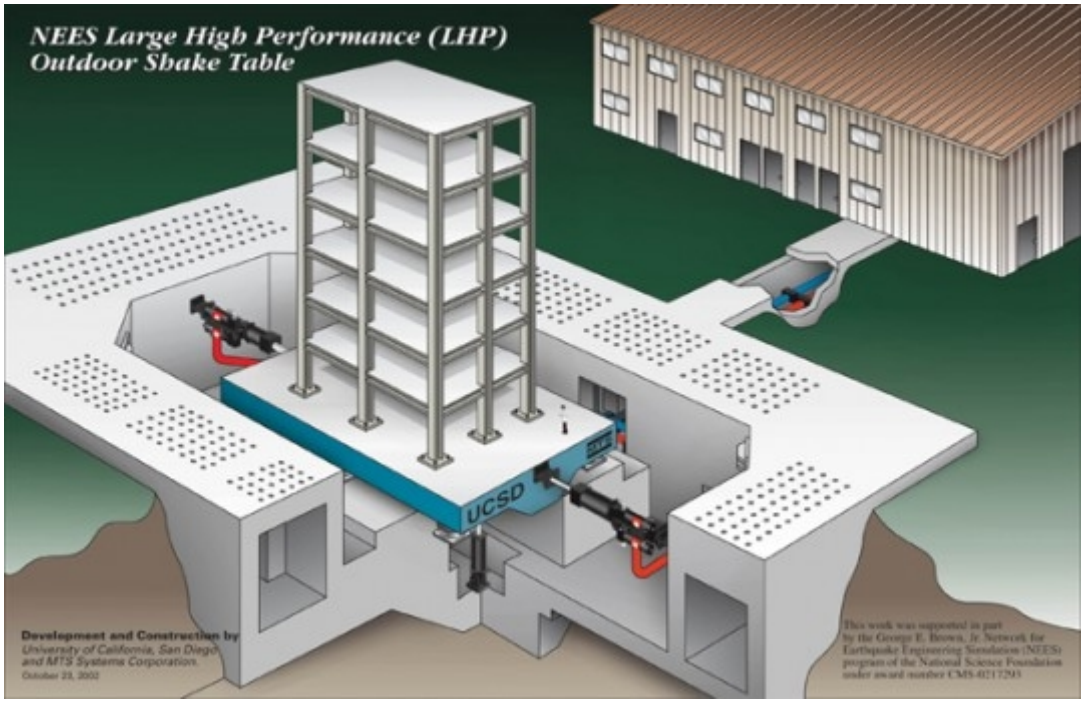

Figure 9: NEES Large High Performance (LHP). (Image credit by the author)

We should also mention other disasters: Storms, Hurricanes, Flooding, Extreme Heat & Cold, Fire Resistance, Infrastructure Failure & Power Outages, Everyday Resiliency & Normal Wear and Tear and finally Interior Finishes.

Starting with storms, hurricanes, and flooding, the buildings needs to be able to withstand wind, precipitation and ground flooding which might destroy the building's foundations. According to Fehrenbacher "Buildings in hurricane prone areas need to be very well-sealed, as well as have adequate

[46] Jill Fehrenbacher, "*Resilient Building Design: Is Resilience the New Sustainability?",* http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

drainage solutions for roofs, terraces, basements, and any other areas which may collect water. For mechanical rooms, where adequate ventilation and outside air-intake is important, storm-resistant louvers are a good choice for maximizing air intake while blocking wind and driving rain. They're designed specifically to let air in and keep wind and driven-rain out."[47]

Likewise, what also might be highly effective are flood barrier walls, and even better placing the "emergency backup generators" on the upper levels of the building. One of the great examples is the Spaulding Rehabilitation Hospital designed by the Perkins + Will located in Boston. It is a great, yet simple practice to improve building resistance, which might prevent the building from losing power while the patients can remain inside.

Figure 10: Spaulding Rehabilitation Hospital. (Image credit by the author)

According to the hot and cold-weather circumstances, it is important to remember and keep in mind what might happen if the power outages happen. If the building does not have any operable windows, passive ventilation and cooling cannot happen. The building becomes dangerous for the occupants and unhealthy.

[47] Jill Fehrenbacher, *"Resilient Building Design: Is Resilience the New Sustainability?",* http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

So, it is a good approach to consider passive cooling and ventilation in large commercial buildings, where you can create stack ventilation. According to Fehrenbacher "if electricity is knocked out due to a flood or earthquake, or even if there is just a common 'blackout," an all-glass office building can quickly become like an oven on a hot summer day, potentially risking the health and lives of occupants inside. Proper insulation, natural ventilation with operable windows, solar shading devices, and employing stack ventilation can help buildings remain comfortable for inhabitants even when there is no mechanical heating and cooling available."[48] However, a simple device such as shadings can dramatically change the building's inner atmosphere increasing the occupants comfort and lowering the cooling costs.

In terms of fire resistance, it does not only relate to the fire itself, but the fire caused by the earthquake, tornado, or other natural disaster. Again, based on the local weather climate, there are different to consider threads. For instance, the west side of the United Stated will struggle with wild fires, while the south-east part faces tornado's and floods. According to Fehrenbacher: "In addition to urban fire hazards, wildfires are a growing threat in the Western United States, and steps that can be taken to protect commercial buildings against wildfire include fire-resistant landscaping, brush-clearing, and barrier zones in wildfire prone areas."[49]

In terms of Infrastructure Failure & Power Outages; it relates to the previous statements where to prevent the power outages, architects should place the generators on the upper floors.

Besides a natural disaster, we should also remember about an everyday use of the building materials and what comes after when the materials might wear out too soon. For instance, people walking everyday into the building, they step on the tiles, wood floor, and carpets, which speed their aging and lead to material failure and finally to its replacement. According to Fehrenbacher: "On average, a commercial building

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[48] Jill Fehrenbacher, *"Resilient Building Design: Is Resilience the New Sustainability?",* http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

[49] Jill Fehrenbacher, *"Resilient Building Design: Is Resilience the New Sustainability?*", http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

has a lifespan of 73 years (Source: 2010 Buildings Energy Data Book, US DOE), meaning over almost a century, many commercial structures will see millions of human feet trudging through its spaces."[50] That reads to the building envelope and how important it is to design it well in order to avoid its failures. The weak points are the windows, doors, roofs, floor connections, moisture protection and flashing and drainage. However, there are also systems that help prevent disasters inside the building like, for example, pressure relief vents that lower the pressure of the building. Finally, the interior finishes are also an important aspect in terms of resilience and sustainability. That also relates to the previous examples and is based on the door, floor and wall materials. The better the materials are, the longer the resilience is.

In conclusion, resilience is an important factor in today's architecture, which is a part of sustainability. Without resilience, sustainability might fail. There are many natural or manmade factors that influence the way we should design buildings, as well as the need to remember that each case is different due to the climate, location, building type and material.

2.8 Resilient Design Round Table, Marcy Marro

In the Resilient Design Round table- Marcy Marro interviews architects asking them about the resilience factor in architecture. First, the explanation of resilience architecture comes from Alex Wilson where he states that: "Resilient design is a process of creating buildings and communities that will not only be safer in a world of increasing risks and vulnerabilities, but also better adapted to what are likely to be changing conditions with the advent of climate change."[51] Resilience design is a part of the sustainable way of designing buildings; it is a direct response to the exact location, climate and building

[50] Jill Fehrenbacher, *"Resilient Building Design: Is Resilience the New Sustainability?"*, http://inhabitat.com/resilient-design-is-resilience-the-new-sustainability, (2013)

[51] Marcy Marro, *"Resilient Design Roundtable"*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

type. According to Greg Malla vice president at SmithGroupJJR in Washington: “Resiliency is a companion to sustainability. While sustainability seeks to maintain our balance with the environment, resiliency seeks to maintain the durability and integrity of our communities by designing with consideration to the changing landscape that results from climate change. This concept is significant because we want to create enduring architecture.”[52] And finally, according to Jefferey Dugan principal at Dattner Architects in New Youk: “Resilient design really became a high priority for all architects and engineers here in New York City post-super storm Sandy. While other parts of the country and places around the globe have experienced similar storms and the accumulative effects of climate change, Hurricane Irene and the subsequent Super storm Sandy one year later really opened our eyes to the impact of climate change in New York and the northeast Seaboard."[53]

It is important to keep in mind that our decisions will influence a buildings future, their: “durability, flexibility, adaptability and redundancy," and what comes after is also the impact on materials, and site that surrounds the buildings. The key point is not just to prepare, or in other words, to respond to the last disaster that occurred in the area, but to be able to predict what else might happened and foresee it. According to Mella: “Another important consideration is the concept of being self-sustaining if a project's infrastructure is disrupted. In this regard, resiliency pairs well with net-zero energy and water buildings. If municipally provided power and water is lost, the Brock Center can still function, relying on natural day lighting for illumination and natural ventilation for cooling. Its super-insulated envelope allows it to maintain thermal conditions for an extended period. Its collected rainwater can continue to meet the occupants' potable water needs. Its two wind turbines and 38 kW photovoltaic array can still generate power, powering emergency lighting and ventilation. If additional batteries were provided to take the

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[52] Marcy Marro, *“Resilient Design Roundtable”*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

[53] Marcy Marro, *“Resilient Design Roundtable”*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

center "off-the-grid," the center could function very much like it does on a typical day in the face of most disruptions, thus weathering the storms we anticipate in the future." [54]

It terms of the resilience, there is one material that seems most appropriate to this kind of design; metal. Metals are recyclable and capable of managing both heat gain or loss, it can support the building envelope during strong winds, and finally can protect a building from flood. A great example is the Brook Environmental Center in Virginia Beach and according to Mella: "The Brock Center sits within a hurricane zone, and its design anticipates many "doomsday scenarios" like crashing waves at its foundation, high-winds twisting the building's structure, and large and small wind-borne debris crashing into the building's windows and skin. Steel structural components and reinforcing provided a means to efficiently resist these forces, armoring the design."[55] Metals can also prevent erosion from a harsh salt ocean water. In addition, the aluminum cladding on the windows improves their durability and metal roofs helps to drain the water preventing the algae. Metals also improve the thermal bridging in the building's envelope which might be of benefit in a decreased level of lost heat. Finally, metals are highly customized, which is quite effective and productive at the same time.

Furthermore, according to Wilson: "Metal roofing and siding sheds rain and snow extremely well, minimizing risk of moisture damage and decay. Metal framing cannot rot, so if it gets wet it can dry out without lasting damage and without harboring mold or other decaying organisms. Metal roofs provide the best option for harvesting rainwater-which can be an important resilience measure, particularly in areas prone to drought. Metal siding and roofing protects buildings from wildfire."[56]

Another important aspect in resilient design is the difference between varied building types. For instance, a residential building will have different expectations then commercial. According to Mall:

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[54] Marcy Marro, *"Resilient Design Roundtable"*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

[55] Marcy Marro, *"Resilient Design Roundtable"*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

[56] Marcy Marro, *"Resilient Design Roundtable"*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

"Resilient residential buildings can be designed to be self-sustaining to weather the storm, providing safety and comfort for its occupants. Essentially, a residential building will maintain its function during disruptions. A commercial building can be tasked with doing more. An office building may not need to function like an office building during a catastrophic event, instead it might provide shelter for its local community. Commercial buildings may be more dynamic, acting as community centers, providing for those in less-resilient environments during disruptive events."[57]

Another way to prevent catastrophic impacts is to perform computer studies and analysis as well as the use of infrastructure prepared by the federal government which are developing guidance documents like the Climate Resilience Toolkit. According to Wilson: "There are some very good resources today for assessing flood risk, with the Federal Energy Management Agency (FEMA) taking the lead. The IBHS offers excellent guidance on certain aspects of resilience through its Fortified Home and Fortified Business programs."[58]

Finally, along with the climate changes, there comes constant updates in building laws.

2.9 Resilient Design- Shelter Requirements

One of the building's program includes the transformation of existing spaces into emergency shelter. Those spaces become 1% of use while the other 99% remain the same daily throughout the year. During emergency, a building becomes a shelter to serve two types of group of people. First one, consist of a large area used daily as a dining hall with islands located at the atrium on three different levels. The

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[57] Marcy Marro, *"Resilient Design Roundtable"*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

[58] Marcy Marro, *"Resilient Design Roundtable"*, http://www.metalarchitecture.com/articles/magazine-features/resilient-design-roundtable.aspx, (February 2015)

second one is reusing classrooms and conference rooms which are located on the opposite side of the building. People would be divided into two groups; those who need a special care and those who doesn't. However, another reason to split those two spaces is the appearance of service dogs, and according to Red Cross Standards, animals cannot be located at the dining area. Figure 19 show organizational chart, while Figure 20 an emergency response diagram.

At the same time, we need to remember about every day needs; food, water and energy. The Building's program is designed in order to fulfill those requirements. Another aspect that become crucial is the universities' rich agriculture history. Designing this kind of building, not only increase campus attractiveness, but respect and contributes to its history. According to Stockbridge, school of agriculture: "The Stockbridge School of Agriculture grew out of the very beginnings of the Massachusetts Agricultural College, now the University of Massachusetts. Massachusetts' Land Grant College formed in 1863, hiring its first professor of agriculture, Levi Stockbridge, and enrolling its first students in 1867. Twenty-seven individuals graduated in 1871 as the first class of agriculture students from Mass Aggie."[59] So, the continuation of that tradition enriches the buildings purpose and design.

The middle part of the structure contains large atrium, or so called "Green Wall Atrium" which during the 99% time is used as an agricultural exhibition and kitchen supplement. During emergency time that symbolic amount of food should provide temporary a source of food. Likewise, the energy- that can be powered by the sun devices and water that is collected from the roofs can also add to resiliency. The water would be used to water plants located at Green Walls, Green House and Roof Gardens. However, mentioning a two types of shelter spaces, there is also one common space that would gather all people during a life-threatening event such as tornado and earthquake. That space would be located underground shifted deep into the or hillside. those documents are a Red Cross Standards which provides an amount of information required submit.

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[59] Stockbridge School of Agriculture, *"History"*, https://stockbridge.cns.umass.edu/history

TOOL A

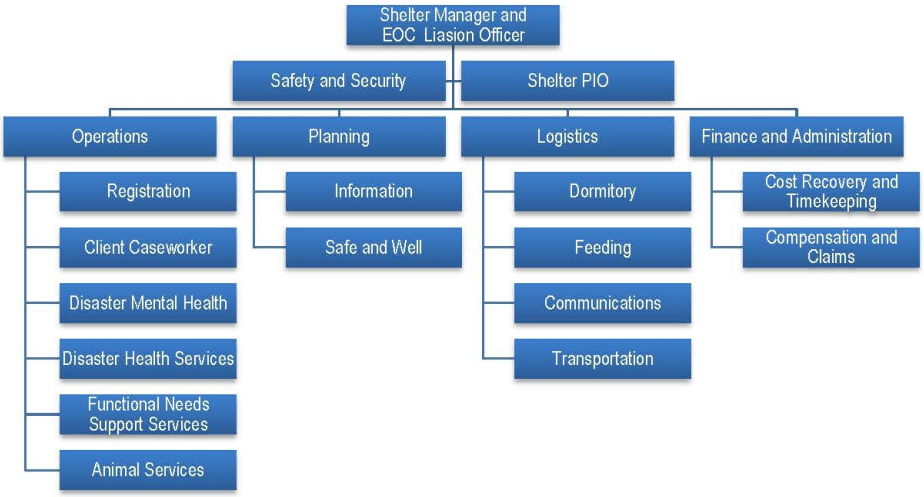
Shelter Organization Chart

[This structure follows the ARC model.]

The following positions are not part of the standard ARC model but should be added

Shelter Organization Chart Option 2

[This structure more closely aligns with the NIMS and ICS model.]



Support Entities within the Local Jurisdiction

The following table outlines the roles and responsibilities of each entity that has a supporting role in the coordination and execution of the shelter plan.

Figure 11: Shelter Organization Chart. (Image credit by the author)

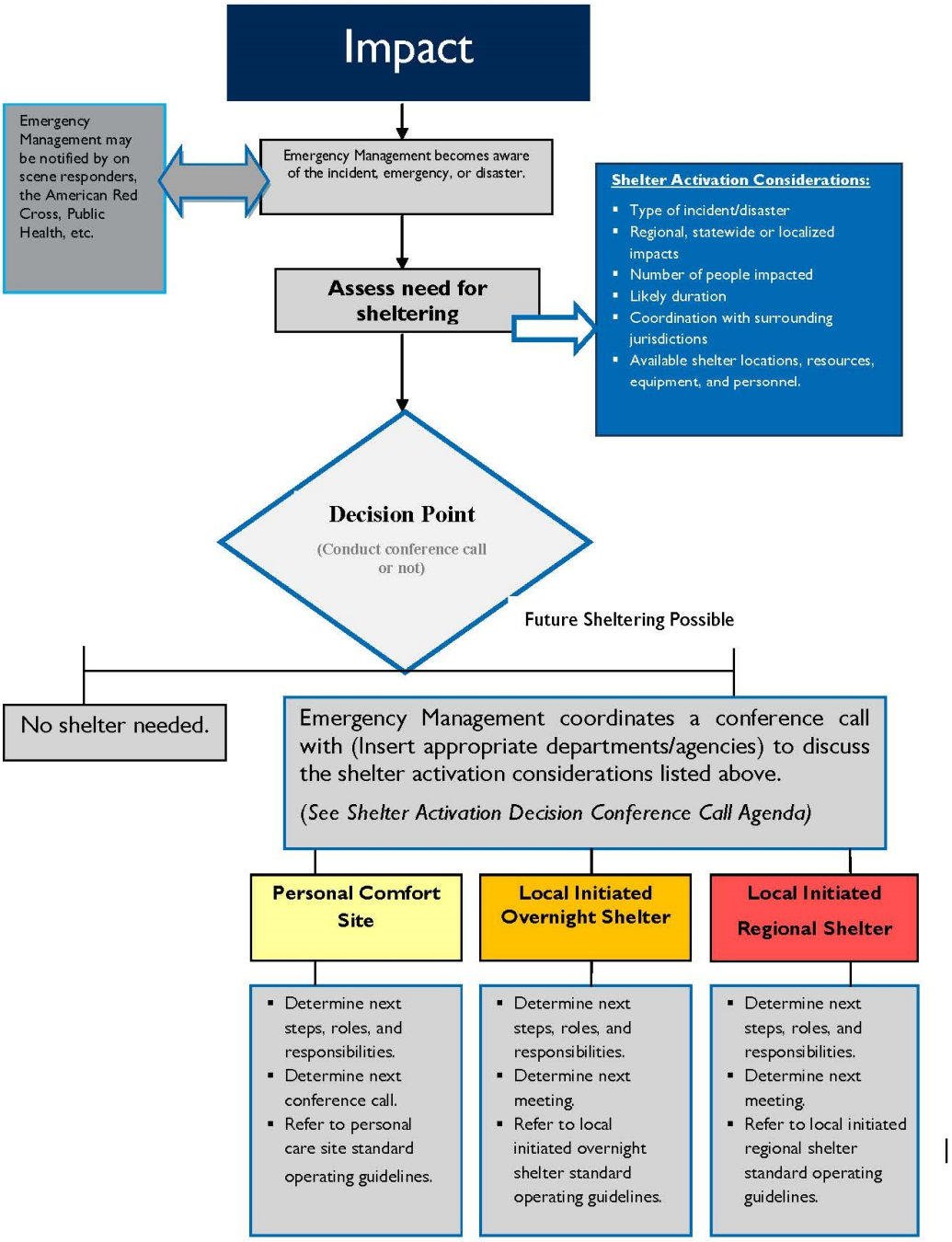


Figure 12: Shelter Operations Plan. (Image credit by the author)

CHAPTER 3

ARCHITECTURAL PRECEDENTS

3.1 Omega Center for Sustainable Living

The Omega Center for Sustainable Living is in the Omega Institute for Holistic Studies designed by BNIM Architects in Rhinebeck, New York in 2009. The construction project of the is a mix use with an area of 6,200 square feet and cost of $2,800,000.00. According to AIA "The primary goal for this project was to overhaul the organization's current wastewater disposal system by using alternative methods of treatment. As part of a larger effort to educate the client's visitors, staff, and local community on innovative wastewater strategies, they decided to showcase the system in a building that houses both the primary treatment cells and a classroom and laboratory."[60] Moreover, the structure uses systems like gray water or treated water for garden irrigation as a tool to teach their students.

It is quite interesting and I think happens more often now, that institutions or architects not only design a system, but display it for others to educate them about the importance of sustainability in our lives. In this structure, it's been designed as a method to clean the water and bring it back to the system. In order to do that they hired specialists and used earth, plants and sunlight. The whole system is net zero energy and to achieve it they had to "be free of waste (volume, material, energy), organized, and carefully tuned to harvest solar energy for passive heating and lighting, using the entire mass for thermal comfort. The resultant design's simplicity and elegance suits its purpose well". The systems that were used are: "passive daylight, passive solar heating, natural ventilation, geothermal, fans and electric lighting

[60] "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

systems. It was also important to design the interior to be able to provide a light for the plants growing in the interior lagoons."[61]

The focus for the project was to solve water issues. At the same time, they wanted to emphasize the importance of fresh water. To deal with the obstacles of agricultural runoff, landscaping chemicals, septic systems or urban water issues, they designed a sustainable living building. For my thesis presentation, I designed a Dining Building on UMASS Campus that embodies and educates about the sustainable systems.

Dining buildings use a lot of power, and are used throughout entire day -every day there is a need for high efficiency structure that would help save campus money. This example is quite sophisticated and provides a good source of information – especially concerning the sustainable systems. According to AIA "Omega envisioned the OCSL project as a means of thinking globally and acting locally. This began with the decision to clean up and build on the former dump to ensure that leaching or other threats to the aquifer would cease.

The innovative natural systems approach of reclaiming water and returning it clean to the local watershed represents a direct approach of reducing the water footprint of every individual who visits the campus; of improving the aquifer and Long Lake locally, and having similarly positive impacts on regional and global water supplies beyond."[62] I think it would be interesting to learn from this project not only how, or what type of systems to use, but how to expose them to the public while keeping an aesthetically pleasing design at the same time.

The location of the site is at the lower Hudson River Valley watershed basin. The site was also reversed from its previous stage- once damaged now has been restored to a healthy system. According to AIA the design used is "regenerative of native site ecology, didactic in form, holistic in function, and above all,

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61 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

62 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

provides inspiring landscapes that reflect the ecological and cultural context of the campus."[63] The site is also divided into four wetland cells that slope down into the buildings southern area. The site is placed on an east-west axis – which is the best location for the sun daylight control and solar heat gain. As I mention before the building section was designed in the way to maximize the amount of sunlight in order to provide light for the plants which help to enrich the indoor environment with oxygen. According to the AIA "Recognizing that the plants would reach a light saturation point at around 30,000 luces, the team made a design goal to flatten the amount of light falling on the plants surfaces during the summer months to this level in order to minimize the heat taken on by the space. (Conversely, during colder months, the amount of light will be maximized and warm the space). Solar tracking skylights were installed to aid in this effort. Future sunshades along the southern face will bounce sunlight onto the ceiling of the greenhouse, allowing for an even distribution of light and shading the lower portion of glass during the summer months."[64] There is also a green roof which includes vegetation and recycled metal. All the systems work together to provide a healthy atmosphere for the occupants.

In terms of a water management, water is provided from groundwater wells that goes through the system and returns a high-quality water. According to AIA "The new engineered biological waste water treatment system now returns a higher quality of water back to the earth using natural systems that see our waste as food. Aerated lagoons, one component of the system, are on display for all to see, carrying gray water through the reclamation process. At the end, the water may be used to support the needs of the building."[65] In addition, the rain water is collected to provide gray water for the toilets. Moreover, in order to design a net zero energy building, along with passive heating, cooling breezes and thermal mass, provided PV panels in order to generate power. This was done not only to reduce or eliminate waste, but the generation of power was important to designers. According to AIA "The shape

63 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109
64 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109
65 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

of the building is designed to harvest sunlight via windows, skylights, and shading devices to produce appropriate, comfortable lighting without adversely affecting air temperatures. Electric lighting systems are extremely efficient and controlled to be used only when conditions mandate supplemental light."[66] What is interesting, the energy -generated from PV panels provides more power than is used and that makes it sustainable.

In terms of materials and design, the architect wanted to highlight the textures and colors of the surrounding region. The building was constructed out of reused materials like dimensional lumber, plywood, or beech wood paneling; "(Materials came from warehouses, schools, office buildings, and other projects). All installed wood is either from an FSC-certified forest or a reclaimed source, including the plywood roof and wall sheathing, which was salvaged from the 2009 presidential inaugural stage. Materials were also sourced to avoid "Red List" materials from the Living Building Challenge Guidelines."[67] Almost all materials used in construction were reused or recycled.

66 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

67 "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

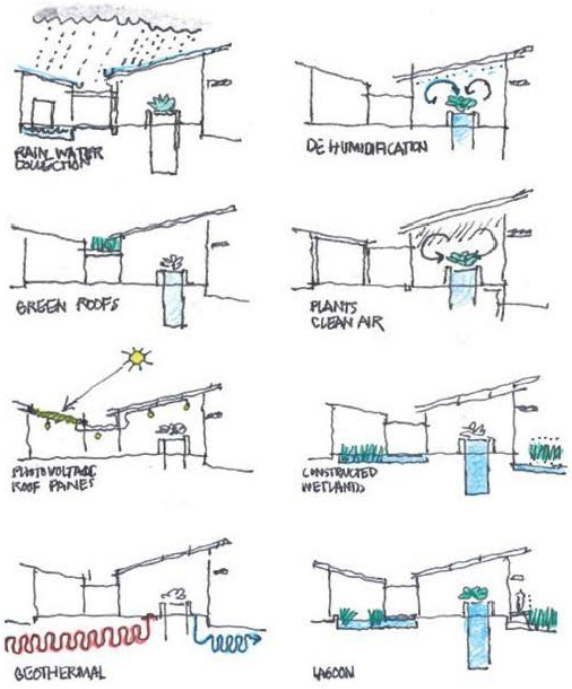

Figure 13: Layers of Design. (Image credit by the author)

Finally, the main purpose for this building was not only to build a sustainable structure, but at the same time create a learning environment where students or visitors can see how those systems work in a real environment. It is great to see live examples and witnesses that they work. It can be inspirational for the young architect and engineers, to pursue sustainable design. According to the AIA "Our approach was an intuitive, scientific, and experiential process. Concepts were modeled using scientific tools to measure comfort, energy, day lighting and other metrics. The team collaborated and relied upon the findings of the modeling to develop an integrated, high-performance design for the building and site. One example was using water as a tempering element to improve comfort and reduce mechanical system capacity."[68] The website also provides great pictures and diagrams (also many other projects) that can be used as a source for my thesis research project.

[68] "Omega Center for Sustainable Living", *The American Institute of Architects,* http://www.aiatopten.org/node/109

Figure 14: Section Perspective and Internal View. (Image credit by the author)

3.2 The Surry Hills Library and Community Center

The Surry Hills Library and Community Center / FJMT was designed by Francis Jones Morehen Thorp in 2009 and is located at 405 Crown St, Surry Hills in Sydney. The Building area is 8,192 sqft. The site itself measures 82 by 91 feet surrounded by roads: Crown Street, and the main street of Surry Hills. The Surry Hills building is placed in the interesting and busy area where the residential apartments are located along with: terrace housing, shops and commercial/industrial buildings where the architectural style is mostly Victorian. More over according to Archdaily website "The project's brief was developed in close consultation with the very active local community. The key approach that emerged from these discussions was that the community wanted a facility that everyone could share. Rather than only a library or a community center or childcare center, it became clear that it was important to have these facilities together in one building, in one place. In this way, the building became a truly shared place where the whole community could meet and use it in different ways. Important, too, was for the building to represent and reflect the community's values."[69]

In addition, according to the architect and entire planning team "In response we developed what for Sydney is a new type of public building. It is not a singular typology, for which there are many precedents, but a hybrid public building that is many things in one: a library/resource center, community center and childcare center all integrated into one modest building and accessible by all."[70] The building shall be quite appealing, on one side the structure is light, transparent and reflective, on the other is opaque and heavy. All of that creates an interesting interaction within the materials (glass, wood and steel). According to architect: "from our early studies, four integrated formal elements emerged: a new simple open space and platform, a prismatic glass environmental atrium, a suspended

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69 "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

70 "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

'U' shaped timber form and a transitional foyer space. On the southern edge, the Collins Street road closure was converted to a modest public park with a raised grass platform. This new space extended the function of the building and reasserted itself as a public place."[71] The building looks modern and simple, yet elegant and welcoming. The program is mixed use – which can maintain existing purposes of the occupants as well as transform into other- for example lecture hall or even a shelter in case of an emergency.

In terms of the façade, the building is equipped with vertical and movable shading devices- which can rotate according to the suns path or based on the program needs, for instance if the space needs lighter the shades can "open" and let more sun come inside. According to Francis:" The tapered glass atrium evolved in response to the ambitious sustainability objectives of the project, and equally to the sense of layered transparency and the project's inspirational quality. The series of glass prisms creates an open, transparent facade, akin to an open dolls house, and addresses the new open space so that all the different activities of the center are visible and displayed, encouraging participation."[72] At the entrance of the building there is a prismatic environmental atrium which is facing the small park that is situated right up front at the entrance /facing the south side of the structure. The white concrete of the interior is balancing the surrounding glass walls and wood structures which are lifted above the ground in order to open up the first floor and brings the light inside.

According to the program reported to Archdaily: "The library on the ground and lower-ground levels contains a diverse borrowing collection of approximately 30,000 items, local history collections, some reference material and public access computers. The community center on level one comprises a function facility for 125 people and adjoining veranda, meeting rooms, commercial teaching kitchen, Neighborhood Center administration offices and amenities. On level two, the

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[71] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

[72] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

childcare center provides accommodation for 26 children in two groups (1–2 and 2–5 years) and includes an outdoor landscaped play space with automatic shade roof."[73]

In terms of the sustainable design the building contains a Green Roof, "which provides increased thermal mass and reduces heat gains to the building"[74], Outside Air Intake which is a source of the clean air that goes into the building, Double Skin Facade, Bio Filters which contains a plants and biomass in order to release 02 and absorb CO2, "Experimental use of plants to bio-filter pollutants is integrated in the gardens of specially selected plants within these glass enclosures."[75] Underground in the building there are Geothermal Heat Exchangers for "passive tempering of incoming outside air to the "Bio- Filter" by transferring energy from the earth to the building."[76] The opposite side the roof is equipped with Photovoltaic Panels which also provide shade for the roof. Another feature which the building is equipped with are the Fan Coil Units which "trims fresh air to satisfy heating and cooling needs of the building", Relief Air – which transfers air outside, Low VOC finishes, Low Formaldehyde furniture, Labyrinth- "the array of environmental initiatives intrinsic to the design also include a thermal labyrinth for passive filtering and tempering of the air, solar-tracking timber Louvre systems, automated fabric shading, mixed mode ventilation, extensive photovoltaic array, geothermal cooling bores, green roof, rainwater collection and recycling, and sustainable material selection"[77], and finally the Rainwater Storage Tank which supplies wc's and landscape irrigation.

Sustainability was very important to the architect and as he stated: "A key project objective was to establish a new Australian standard of excellence for environmentally sustainable design in civic

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[73] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

[74] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

[75] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

[76] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

[77] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

buildings. The building incorporates many sustainable design innovations and seeks to integrate these into the architecture and explore the expressive potential of such systems. This is most evident in the environmental atrium."[78]

The building is also managed by the BMS control system which automatically monitor and control the internal conditions of the building. Based on the different factors like temperature or light, the system is able to adjust the light and shade, ventilation and is also able to track the electrical and hydraulic systems to maximize the buildings efficiency.

According to Archdailypreview.com "The Surry Hills Library and Community Centre was also recently awarded the 2009 Winner of Environmental Excellence by Urban Development Institute Australia NSW, 2009 Winner for Excellence in Construction Award – Public Buildings ($10-$25 million) by Master Builders Association NSW and 2009 Finalist for the International UN World Environment Day Award."[79]

[78] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

[79] "Surry Hills Library and Community Centre/ FJMT", http://www.archdaily.com/57339/surry-hills-library-and-community-centre-fjmt, (April 2010)

Figure 15: The Surry Hills Perspectives. (Image credit by the author)

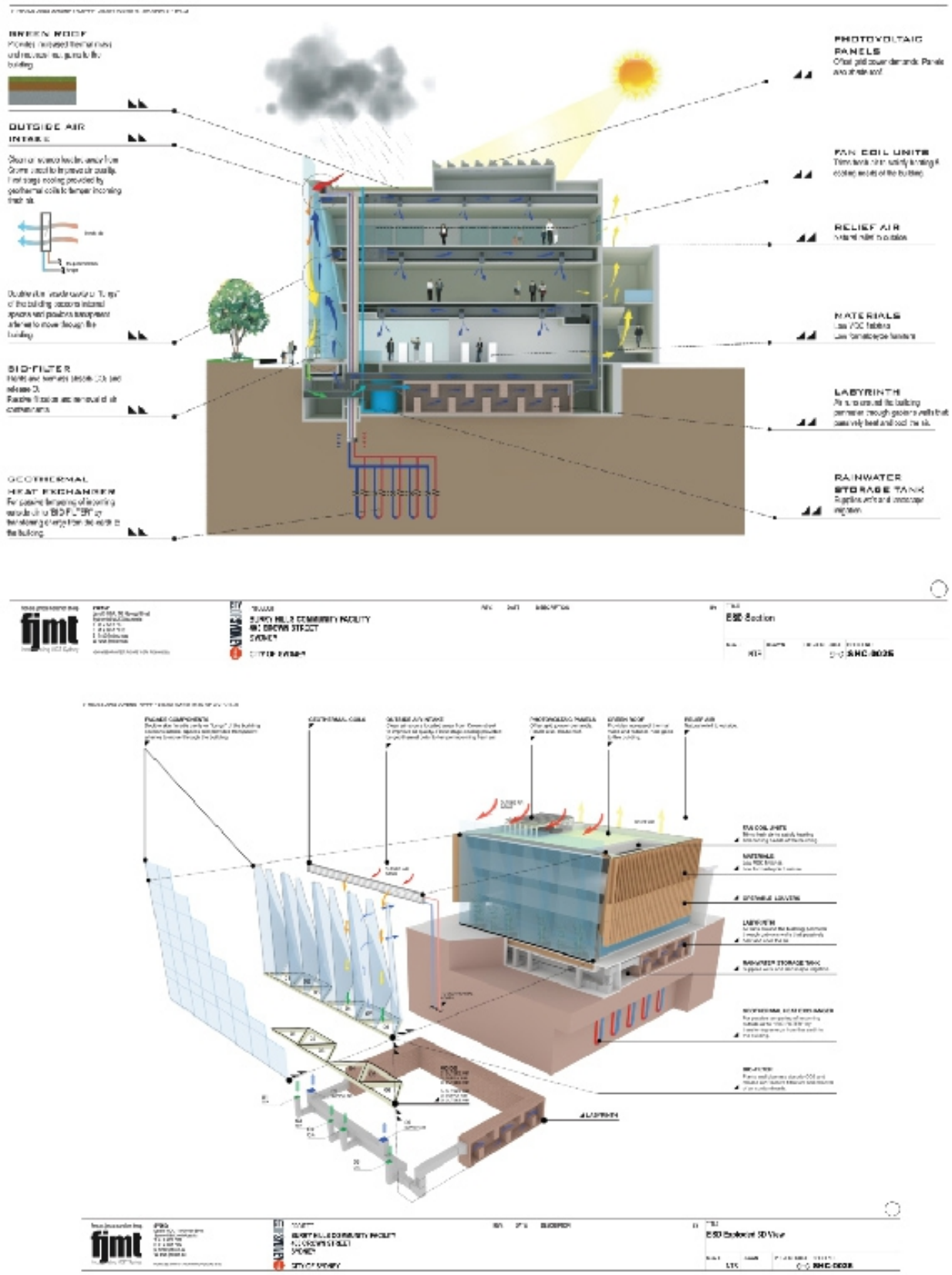

Figure 16: Building's Systems. (Image credit by the author)

3.3 Feeding a Campus Mission Indiana University Bloomington

Indiana University was founded in 1820. With an area of 2,000 acres, it hosts 32,500 undergraduates along with, 10, 000 graduate and professional students. The University planning group came up with a Master Plan which took about twelve months of hard work which included Working Group and Steering Committee meetings, topical workshops, focus group sessions, technical meetings, personal interviews and public open house presentations. They come up with key themes: promote Bloomington's unique natural features, preserve and reinvigorate the core, embrace the Jordan River, commit to a walkable campus, and finally, create a diverse campus neighborhood."[80] One of the issues identified during the meetings was the lack of students in the East Jordan area while they step out for lunch, to study or to socialize. The area varies in height, but there are also places where there is vast open space. So, one of the proposals included making this place more vibrant, denser. A place where students can hang out, during classes and finally to "create new student life resources, retail amenities, and dining venues to maximize convenience and foster community."[81] The phase 1 study proposed a New Dormitory with an area of 147,000 GSF, four levels and 188 units with 450 beds. In addition, there would also be new Apartments which would be a replacement of the existing University West Apartment building totaling 84,000 GSF, four levels, and 106 units with 122 beds. In the Second Phase the committee proposed two new Apartments counting 120,000 GSF. Another idea was to build a new Parking Structure with four levels and 680 spaces in order to provide parking for the students and guests. Planning assumptions and observations include the following:

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[80] *Feeding* a. *Campus Mission*. SCUP 2012 North Central Regional Conference, www.gundpartnership.com/pdf/GUND_SCUP_IUDining2.pdf, (2012)

[81] *Feeding* a. *Campus Mission*. SCUP 2012 North Central Regional Conference, www.gundpartnership.com/pdf/GUND_SCUP_IUDining2.pdf, (2012)

"• It will be an active, dynamic building housing spaces and amenities that are of ongoing interest and relevance to students. The program should foster the creation of a social neighborhood community that attracts students to the site.

• It is important that this facility become a destination for dining and non-meal period socialization.

• This site should differentiate itself from the balance of the campus food services. The desire is to create appealing and somewhat unique choices for students while maintaining a balance with the food service experiences and options offered at other parts of campus.

• Students are interested in connecting with other students, especially during meals.

• The planning emphasizes variety in seating by creating strategic adjacencies between dining and service environments.

• Guests using this building will enjoy ease of circulation and straightforward dining locations. Signage, traffic flow and sight lines will be considered in the development of the plans."[82]

[82] *Feeding* a. *Campus Mission*. SCUP 2012 North Central Regional Conference, www.gundpartnership.com/pdf/GUND_SCUP_IUDining2.pdf, (2012)

Ground Level Plan

Figure 17: Ground Leven Plan. (Image credit by the author)

Figure 18: Buildings View. (Image credit by the author)

Trends in student dining according to Indiana University include the following:

"• Variety and increased choice

- Individualized micro restaurant markets that offer students a visual connection with food preparation and ingredients
- Increased interaction between food service staff and students
- Staff supported by equipment within the server that is designed to prepare, store and display finished and raw products
- Centralized production kitchen and loading dock serving the micro restaurants
- Intimate seating areas with distinct characters, rather than a single, large dining room
- Online ordering and non-traditional meal hour service and pick up
- Dining Hall as a social magnate to transform an under-utilized campus district."[83]

3.4 Kent Denver Dining Hall / Semple Brown Design

The Kent Denver Dining Hall was designed by Semple Brown Design which includes: Bryan Schmidt, AIA, LEED AP, Dru Schwyhart, LEED AP, Sarah Semple Brown, AIA, Tom Gallagher, Architect, LEED AP, Mary Kay Sunset, ASID, LEED AP and landscape architect Christopher Hoy Design Group. The building was completed in 2011 in Englewood, CO, USA with the area of 20,000 sqft. According to Semple Brown: "The new dining hall is in a 210-acre campus that hosts a mix of environments including sports fields, native grasslands, lakes, wetlands and a variety of wildlife. The original 8,000 square foot structure was built in 1968 and with subsequent enrollment increases it had become inadequate for the required 750 meals per day the school serves. The new facility had to address

[83] "Kent Denver Dining Hall/ Semple Brown Design", http://www.archdaily.com/175179/kent-denver-dining-hall-semple-brown-design, (October 2011)

this hindrance as well as reveal the cycle of food culture – catalyst for a more holistic dining and food education experience."[84] The structure has been renovated with additional space added of 12,000 sqft. The architects took advantage of the projects location, which is facing a beautiful wall of mountains, and because of that, designers used a large window on the west facade. The building is located near the fruit orchard and flower garden which only adds to the building's attractiveness as much as the function. According to Archdaily "An orchard with a variety of fruit trees spans the range of native seed mixes. Two bee hives in the orchard facilitate cross-pollination. This will provide a supply of locally grown fruit which will be incorporated into meals served over the course of the school year". The surrounding pathways near the building are used for the classes, where professors can teach students about the integrity of the building and surrounding nature. It is another example of a wonderful connection between the structure and sustainable systems, which not only display the connection, but prove that it provides benefits both for us and nature. Moreover, the system includes: "16 square foot, interior 'green' wall is a featured aspect of the design with over 576 plants including herbs that will also be freshly harvested and utilized in cooking on a day to day basis."[85] One of the interesting aspects is that the building is open to the local community, and the spaces were designed to accommodate up to 250 people.

In terms of the sustainable design, besides the materials used, the building's roof is tilted in 3 places providing water to the surrounding wetlands. The toilets on the other hand contain water-less urinals, which helps to save the water. Sustainability was introduced in the early stages of construction, according to Archdaily:" Extraordinary efforts by the contractor resulted in eighty-five percent less

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[84] "Kent Denver Dining Hall/ Semple Brown Design", http://www.archdaily.com/175179/kent-denver-dining-hall-semple-brown-design, (October 2011)

[85] "Kent Denver Dining Hall/ Semple Brown Design", http://www.archdaily.com/175179/kent-denver-dining-hall-semple-brown-design, (October 2011)

construction waste. Operationally, after feeding 700 lunches the building generates less than one trash bag of waste per day that isn't composted or recycled."[86]

Moreover, the roof contains PV Panels which aggregate over fifty percent of total building energy, and the designed contributed to energy savings by taking advantage of natural daylight.

Figure 19: Building's Perspectives. (Image credit by the author)

[86] "Kent Denver Dining Hall/ Semple Brown Design", http://www.archdaily.com/175179/kent-denver-dining-hall-semple-brown-design, (October 2011)

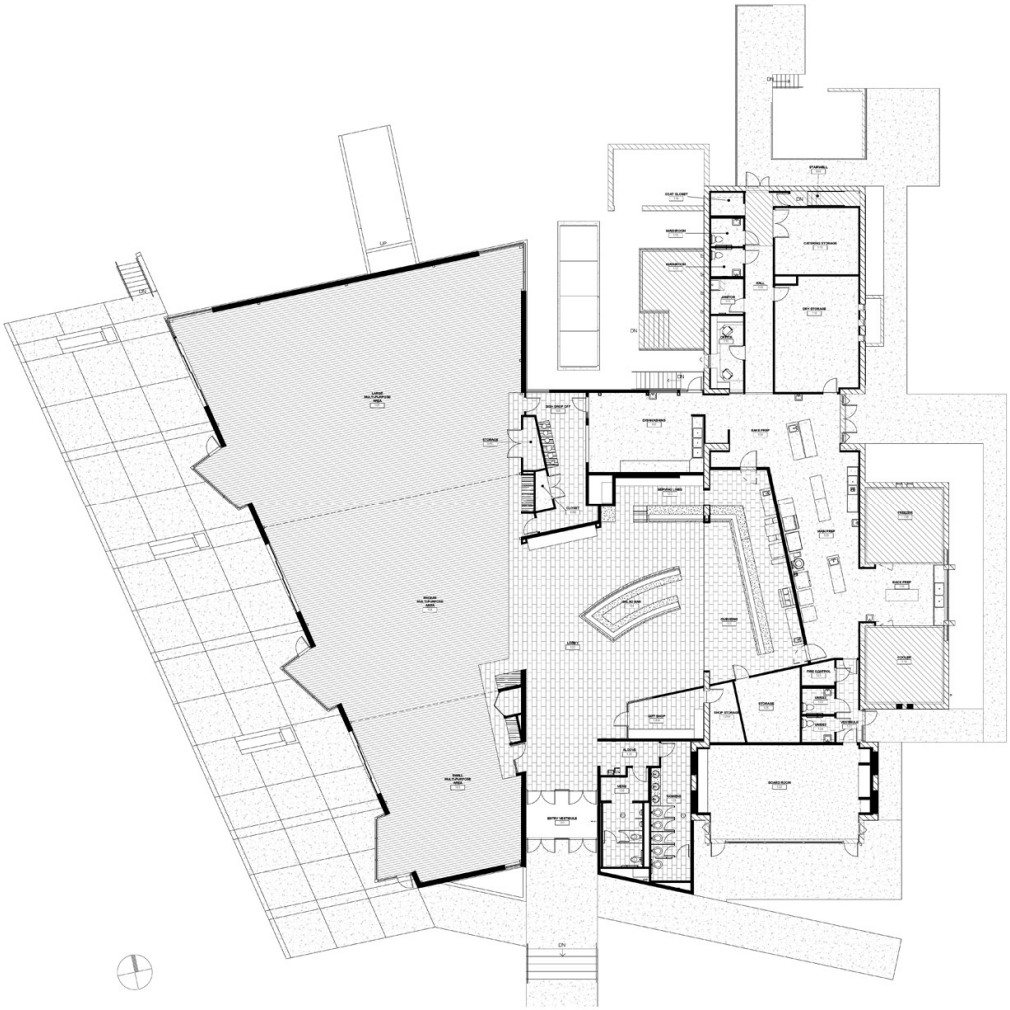


Figure 20: First Floor Plan. (Image credit by the author)

3.5 The Pavilion at Laurel Village

The Pavilion at Laurel Village is located at the Colorado State University. The building is certified with LEED Platinum. It was designed by 4240 Architecture and finished in 2014 serving students from the College of Natural Sciences Learning Community and Eco Leader Program as "student gallery, mail room, campus "Eco-leaders" office space, study spaces with seating and hammocks, an

entertainment nook complete with a pool table, a living wall and finally classroom space and student- led bike repair shop. The whole structure is a two-story building with 11,500 square foot area."[87]

In addition to serving program needs, the building employs visible, environmentally aware strategies and structures. Exposed cross-laminated timber structure, reclaimed materials and a sloped green roof highlight the material palette. Passive heating and cooling elements, such as the plant-covered "living wall," significantly cut down on emissions and create a comfortable physical environment. These and other green strategies and designs also allow the building to function, appropriately, as a teaching tool—giving students a deeper awareness and appreciation for conscious decisions." Moreover, the building was constructed out of sustainable, renewable and reclaimed materials. The interior spaces are flexible, regardless of their low footprint area. "While the Pavilion is a fully enclosed structure, it incorporates the Natural Sciences' connection to the outdoors. This is in part due to the amphitheater, slate projection wall and sod hill that create a flow from campus to the upper story study lounge."[88]

Figure 21: Buildings' Perspectives. (Image credit by the author)

[87] "Top 10 States 2015: The Pavilionat Laurel Village, CSU", http://www.usgbc.org/articles/top-10-states-2015-pavilion-laurel-village-csu, (March 2016)

[88] "Top 10 States 2015: The Pavilionat Laurel Village, CSU", http://www.usgbc.org/articles/top-10-states-2015-pavilion-laurel-village-csu, (March 2016)

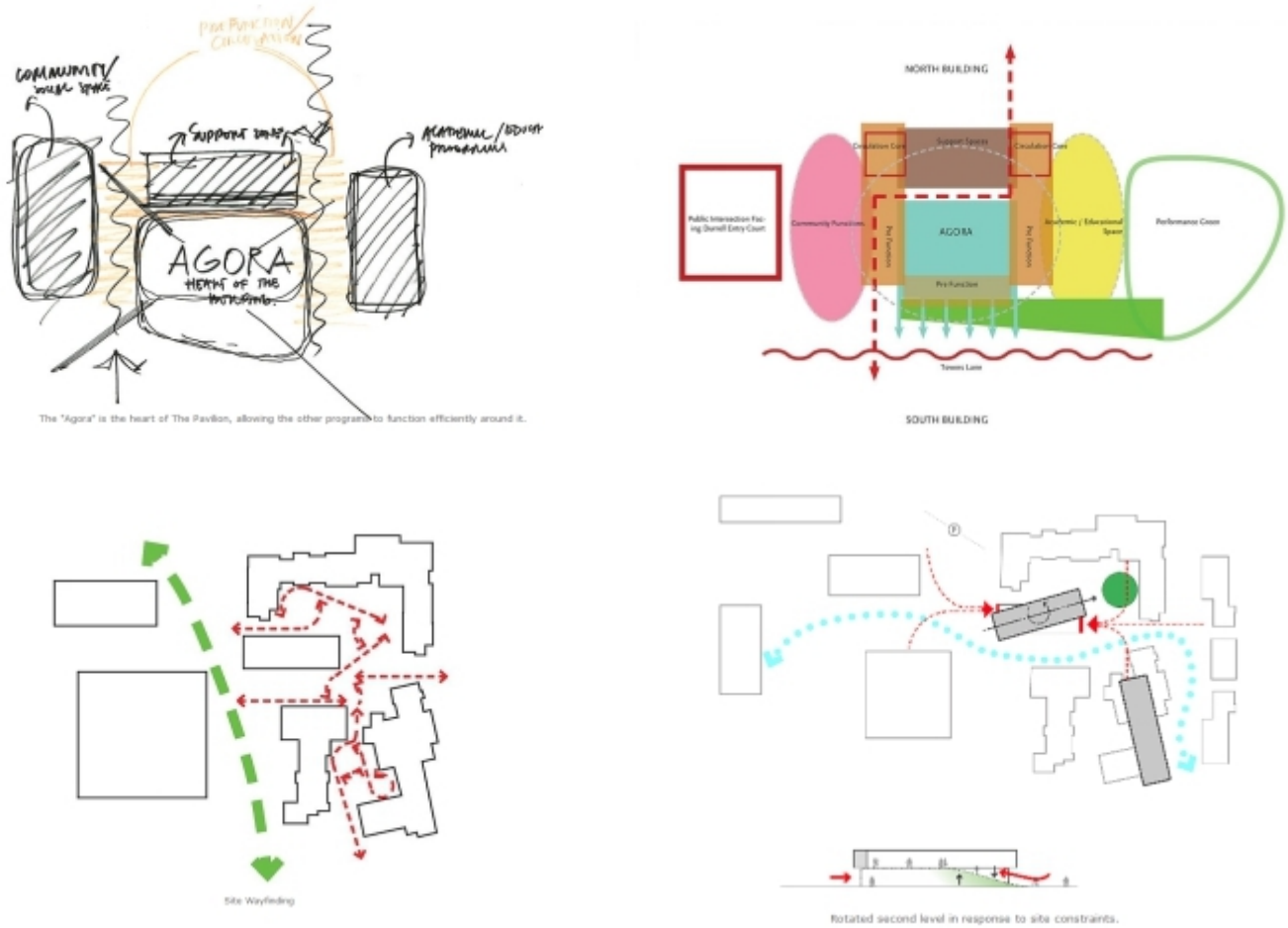


Figure 22: Design Process. (Image credit by the author)

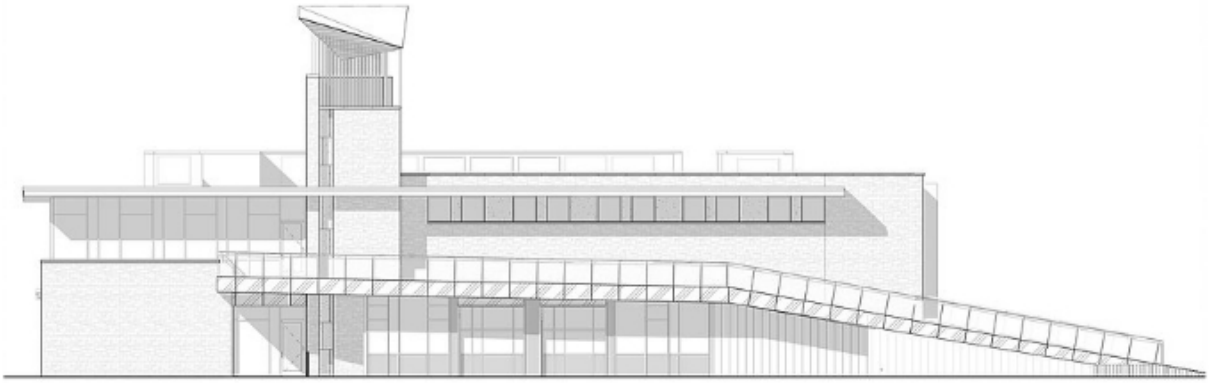


Figure 23: South Elevation. (Image credit by the author)

Figure 24: West Elevation. (Image credit by the author)

Air Flow Diagrams - Computational Fluid Dynamics (CFD) helped assist in the analysis of the aerodynamics as well as the aesthetic value it brings to the project.

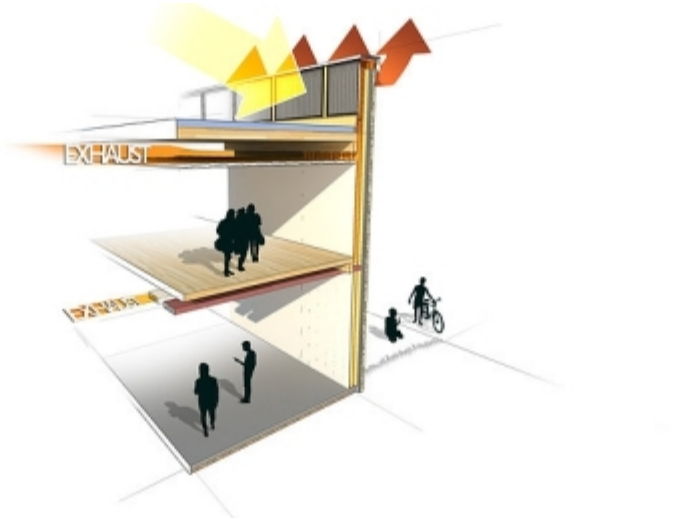


Figure 25: Trombe Parapet Diagram. (Image credit by the author)

Figure 26: Cooling Summer Air Diagram. (Image credit by the author)

Figure 27: Heating Winter Air. (Image credit by the author)

Figure 28: Green Roof. (Image credit by the author)

Figure 29: Garage Doors. (Image credit by the author)

Figure 30: Interior Green Wall. (Image credit by the author)

3.6 SRDP-IWMC Office / H&P Architects

The SRDP- IWMC Office was designed by H&P Architects in Ha Tinh Province, Vietnam, in 2014. The building is three stories high with an East- West direction and14,068 sq.ft. According to the Archdailyt: "Located at the heart of Ha Tinh city and on a street with many governmental offices, the Coordination Committee SRDP-IWMC Ha Tinh Office is the headquarter of the SRDP project (IFAD organization) and IWMC project (ODA funded by Belgian government). On the two upper floors are the Verical Fields, a structure to hold plants and crops. The crops are supplied by the irrigation system which is placed between the "block joints" preventing the building from noise and air pollution, overheating and typhoons."[89]

[89] "SRDP-IWMC Office/ H&P Architects", http://www.archdaily.com/585141/srdp-iwmc-office-h-and-p-architects, (January 2015)

Figure 31: Building's Perspective. (Image credit by the author)

Figure 32: Exterior Facade. (Image credit by the author)

Figure 33: Interior Views. (Image credit by the author)

Figure 34: Interior Spaces. (Image credit by the author)

Figure 35: 1st Floor Plan. (Image credit by the author)

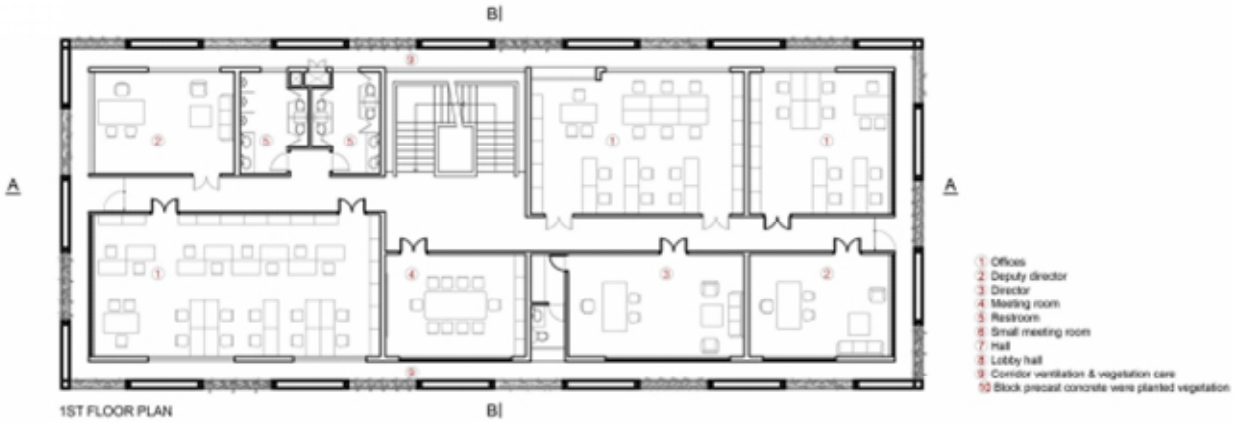


Figure 36: Building's Section. (Image credit by the author)

Figure 37: Building's Elevation. (Image credit by the author)

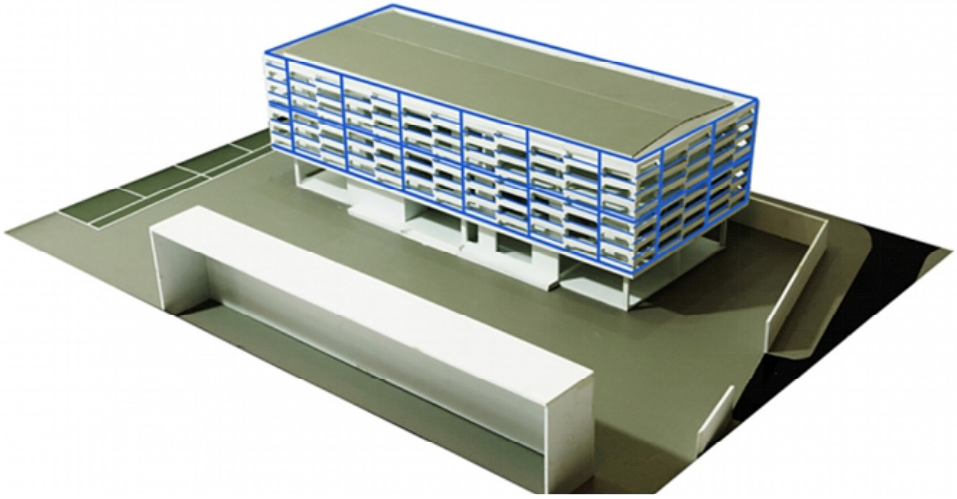


Figure 38: 3D Model. (Image credit by the author)

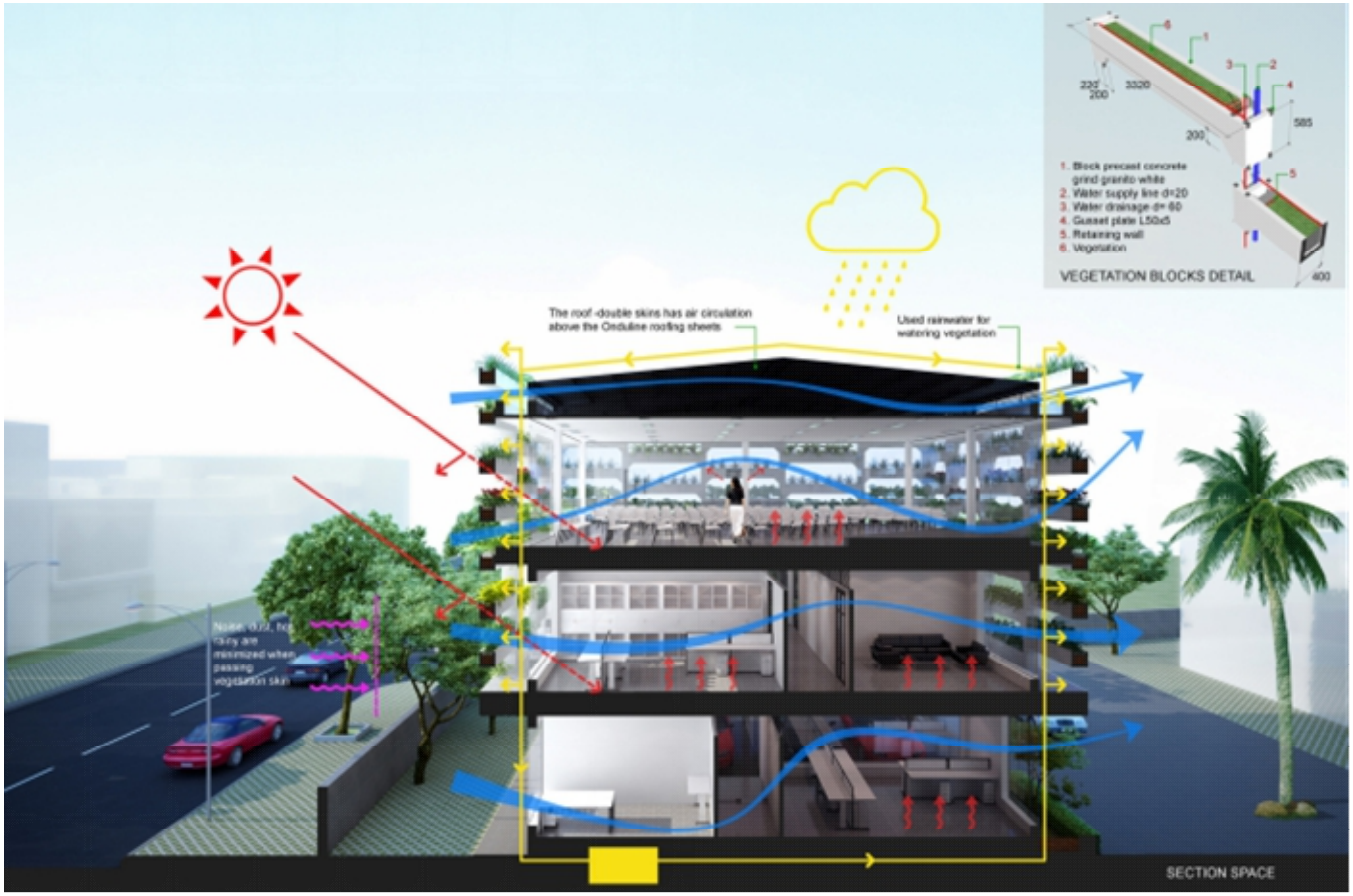


Figure 39: Sustainable Systems. (Image credit by the author)

3.7 Bann Huay San Yaw- Post Disaster School

Bann Huay San Yaw- Post Disaster School / Vin Varavarn Architects

The Bann Huay San Yaw- Post Disaster School was designed by Vin Varavarn Architects in 2015 in Chiang Rai, Thailand. The building (one of nine) is a response to the earthquake that happened on May 5th, 2014 with a 6.3 Richter scale rating which destroyed 73 schools. Architects chose the engineering teams as a support and started a project with D4D which is a nonprofit network "Design for Disasters." The main concepts of the project were: to construct an earthquake resistant structure, easy to assemble,

and low in cost. To save on the square footage architects combined three classes into one, according to the Archi: "For the layout, we had proposed to combine three classrooms into one building to minimize the land use. Each classroom is punctuated by small foyers, which will be used for placing student shoes and to help reducing the noise between classrooms."[90] In addition, the building is raised above the ground creating additional space underneath. The building itself is constructed out of the lightweight steel frame, and surrounded by bamboo shelves; which provide a base for the plant pods making the cold steel more welcoming. According to architect: "The flower pots represent our message to remind the children that in spite of the harsh and cruel realities of caused by natural disasters, nature can also bring them beauty and joy to every day of their lives."[91]

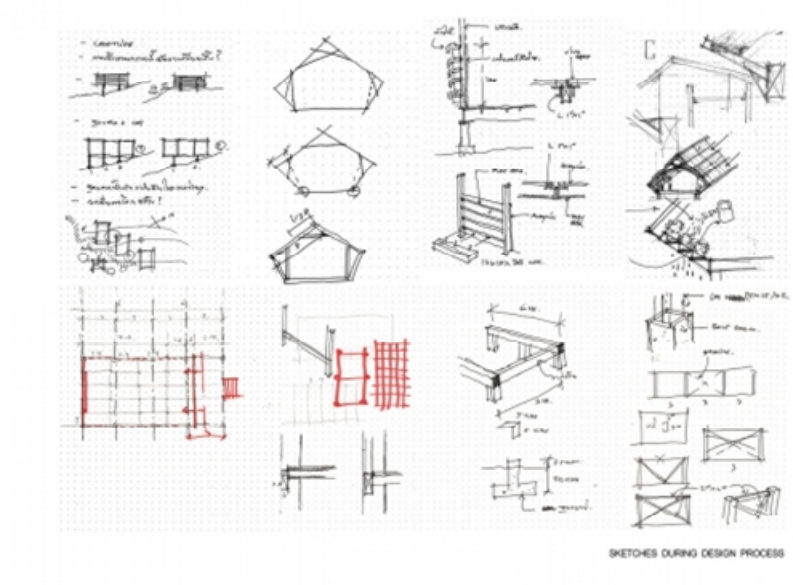


Figure 40: Design Sketches. (Image credit by the author)

[90] "Bann Huay San Yaw- Post Disaster School/ Vin Varavarn Architects", http://www.archdaily.com/776325/bann-huay-san-yaw-post-disaster-school-vin-varavarn-architects, (November 2015)

[91] "Bann Huay San Yaw- Post Disaster School/ Vin Varavarn Architects", http://www.archdaily.com/776325/bann-huay-san-yaw-post-disaster-school-vin-varavarn-architects, (November 2015)

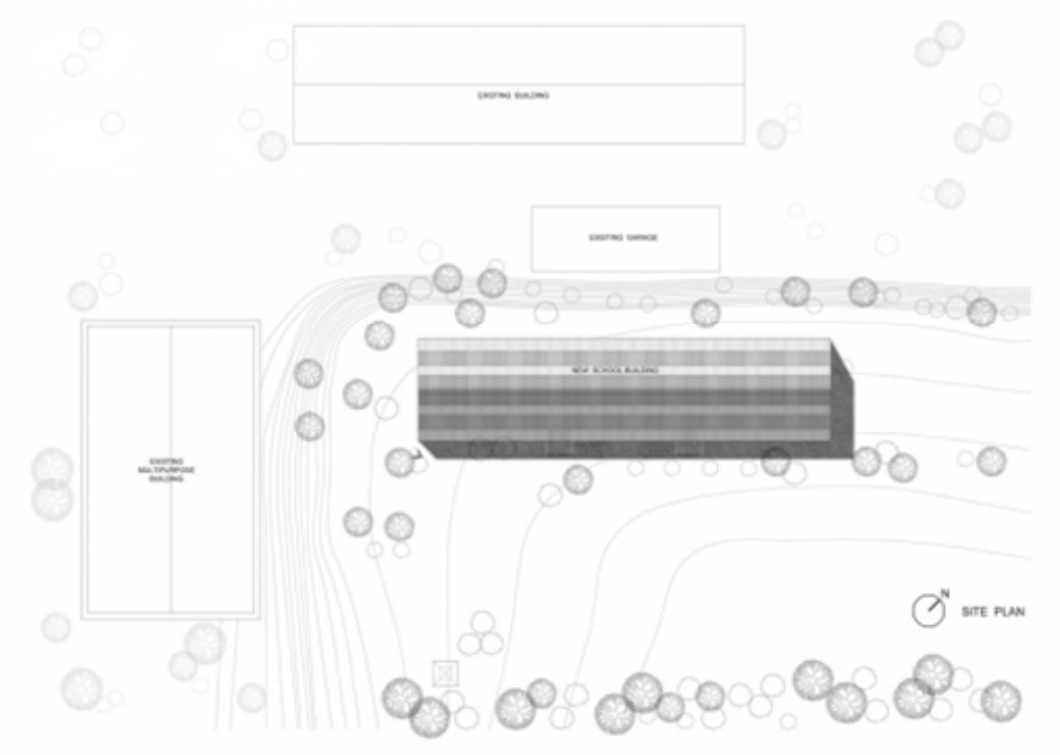


Figure 41: Site Plan. (Image credit by the author)

Figure 42: Building's Perspectives. (Image credit by the author)

Figure 43: Building's Perspectives. (Image credit by the author)

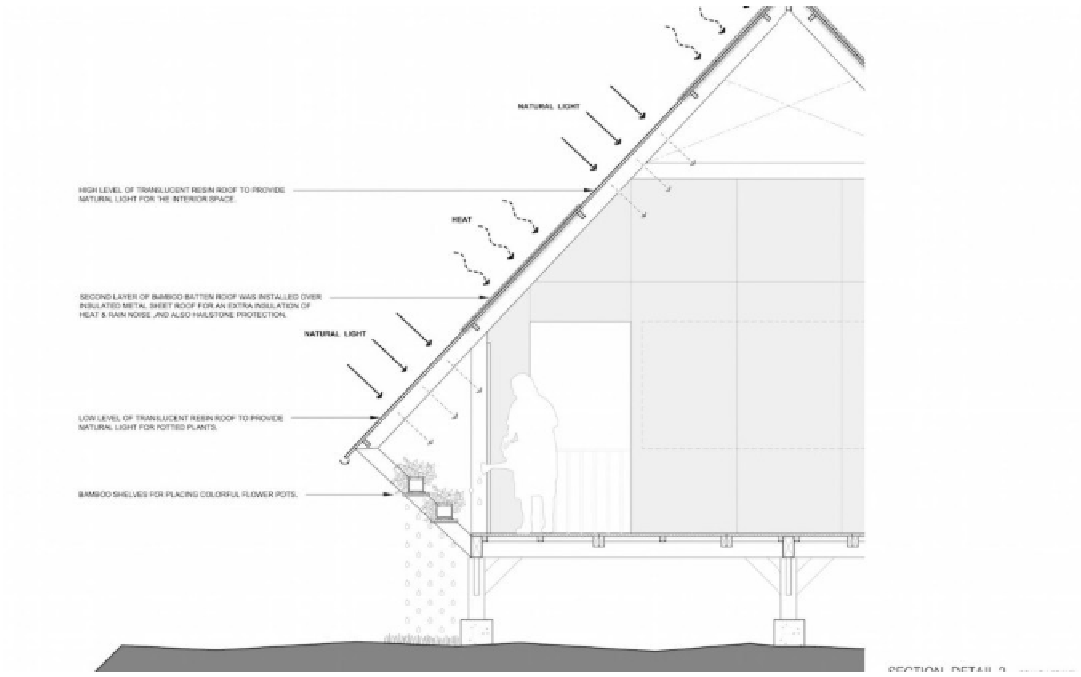


Figure 44: Building's Section. (Image credit by the author)

CHAPTER 4

SITE AND CONTEXT

4.1 Projects Site and Analysis

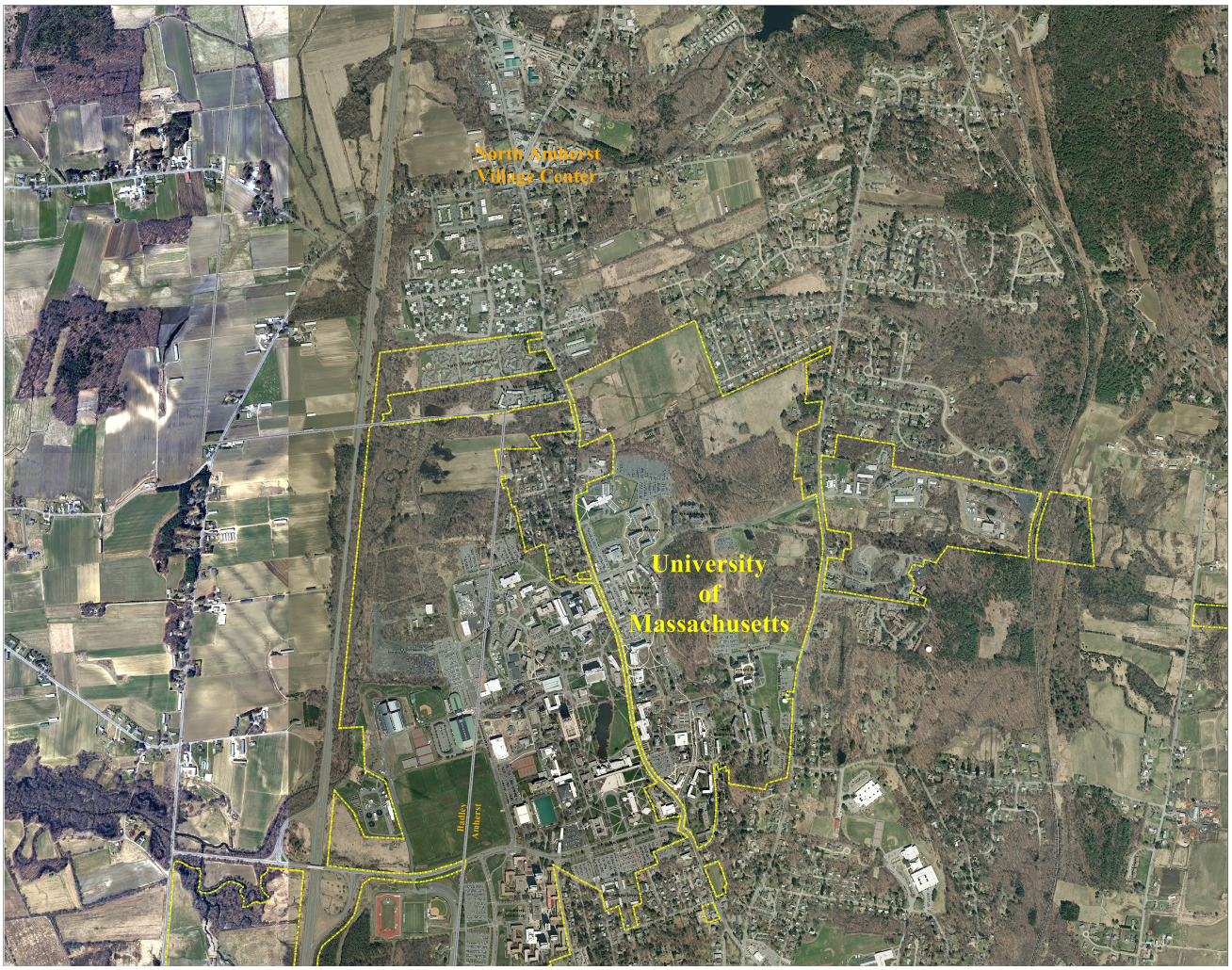


Figure 45: University of Massachusetts Borders. (Image credit by the author)

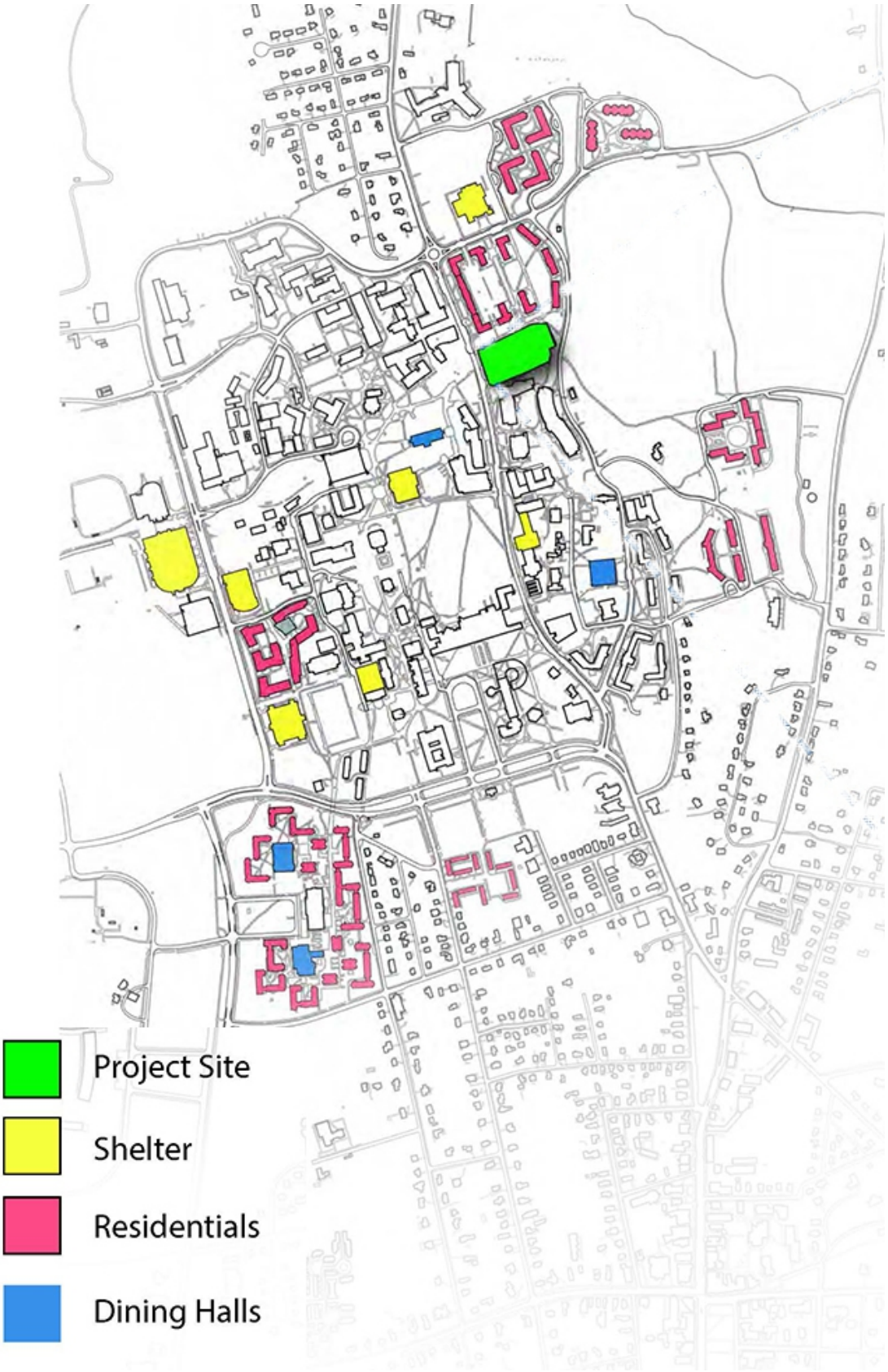


Figure 46: Campus Map.

CHAPTER 5

PROGRAM

5.1 Building's Program

Row Labels	Sum of Room: Area
1st Floor	
Atrium	
18197	18,197
Atrium Total	18,197
Atrium Entrance	
191	191
193	193
Atrium Entrance Total	384
Circulation	
443	443
Circulation Total	443
Dining Hall	
27961	27,961
Dining Hall Total	27,961
Dish Return	
574	574
Dish Return Total	574
Kitchen	
1232	1,232
Kitchen Total	1,232
Women Restroom	
299	299
Women Restroom Total	299
Men Room	
343	343
Men Room Total	343
1st Floor Total	49433
2nd Floor	
Circulation	
886	886
1508	1,508
2017	2,017
5626	5,626
Circulation Total	10,037
Classroom	
1953	1,953
3467	3,467
Classroom Total	5,420
Conference Room	
482	482
1029	1,029
Conference Room Total	1,511
Dining Hall	
23048	23,048
Dining Hall Total	23,048
Green Lab	
1646	1,646

Shelter 40sqft per Person	Dining Hall	699
	Total	699

Shelter 40sqft per Person	Classroom	136
	Conference Room	38
	Green Lab	138
	Dining Hall	576
	Total	887

Figure 47: Building's Report

1670	1,670
2203	2,203
Green Lab Total	**5,519**
Men Restroom	
203	203
344	344
Men Restroom Total	**547**
Women Restroom	
258	258
303	303
Women Restroom Total	**561**
2nd Floor Total	**46643**
3rd Floor	
Circulation	
1472	1,472
8957	8,957
Circulation Total	**10,429**
Conference Room	
988	988
Conference Room Total	**988**
Food Production	
13547	13,547
Food Production Total	**13,547**
Office	
219	219
276	276
324	324
336	336
338	338
343	343
354	354
364	364
375	375
395	395
435	435
Office Total	**3,759**
Men Restroom	
197	197
344	344
Men Restroom Total	**541**
Women Restroom	
258	258
304	304
Women Restroom Total	**562**
3rd Floor Total	**29826**
Basement	
Circulation	
602	602
8622	8,622
Circulation Total	**9,224**

Shelter 40sqft per Person	**Conference Room**	25
	Office	94
	Total	119

Figure 48: Building's Report

Freezer				
829	829			
1014	1,014			
1267	1,267			
1410	1,410			
1443	1,443			
1536	1,536			
1892	1,892			
Freezer Total	**9,391**			
Kitchen				
1974	1,974			
2231	2,231			
2427	2,427			
Kitchen Total	**6,632**			
Mechanical Room				
16910	16,910			
Mechanical Room Total	**16,910**			
Storage				
2319	2,319			
2568	2,568			
Storage Total	**4,887**			
Waste Management				
2354	2,354			
Waste Management Total	**2,354**			
Basement Total	**49,398**			
(blank)				
Grand Total	**175,300**	Shelter Spaces	430	ADA
			1,275	All
			1,705	

Figure 49: Building's Report

5.2 Concept Proposal

The project investigates the integration of Dining Hall and Emergency Shelter. The spaces promote a healthy lifestyle, teaching students not only to select healthy food, but also how to grow and compost it. Such a facility would be an integration to existing majors as: Food Science and Biology and Agriculture- which happen to be the first programs in USA. Along with an increasing number of new students such a facility would help make a good decision.

The students enrolment chart is shown in Figure 48.

The building is divided into three components: A dining hall- located on the west, learning facility on the east and atrium located in the middle which connects those two structures.

Besides the building program contains shelter structure it was not designed to withstand a tornado, but simply to increase shelter footprint on the campus. It is especially important since Massachusetts was already affected by tornado in June 2011 as well as snowstorm in October 2011. Especially the last one left many people without electricity and running water for few weeks. The shelter would serve both students and local community, especially a people with special need, and families with young children. The map of shelters is shown in figure (#).

Since, the building is divided into three sections it gives the opportunity to separate spaces into two categories: people who need special care, and those include people with service dogs, and the rest. The report based on the building's program includes square footage of the spaces along with shelter capacity, both are shown in the fig(#). In order to use such transformation, the green labs and classrooms would provide private spaces, while dining hall along with atrium serve for the rest people.

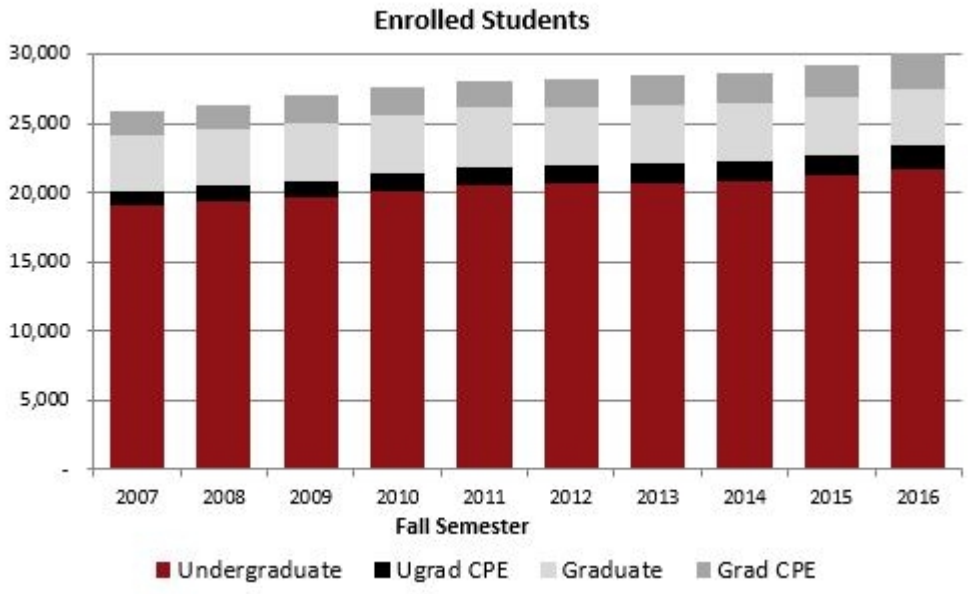
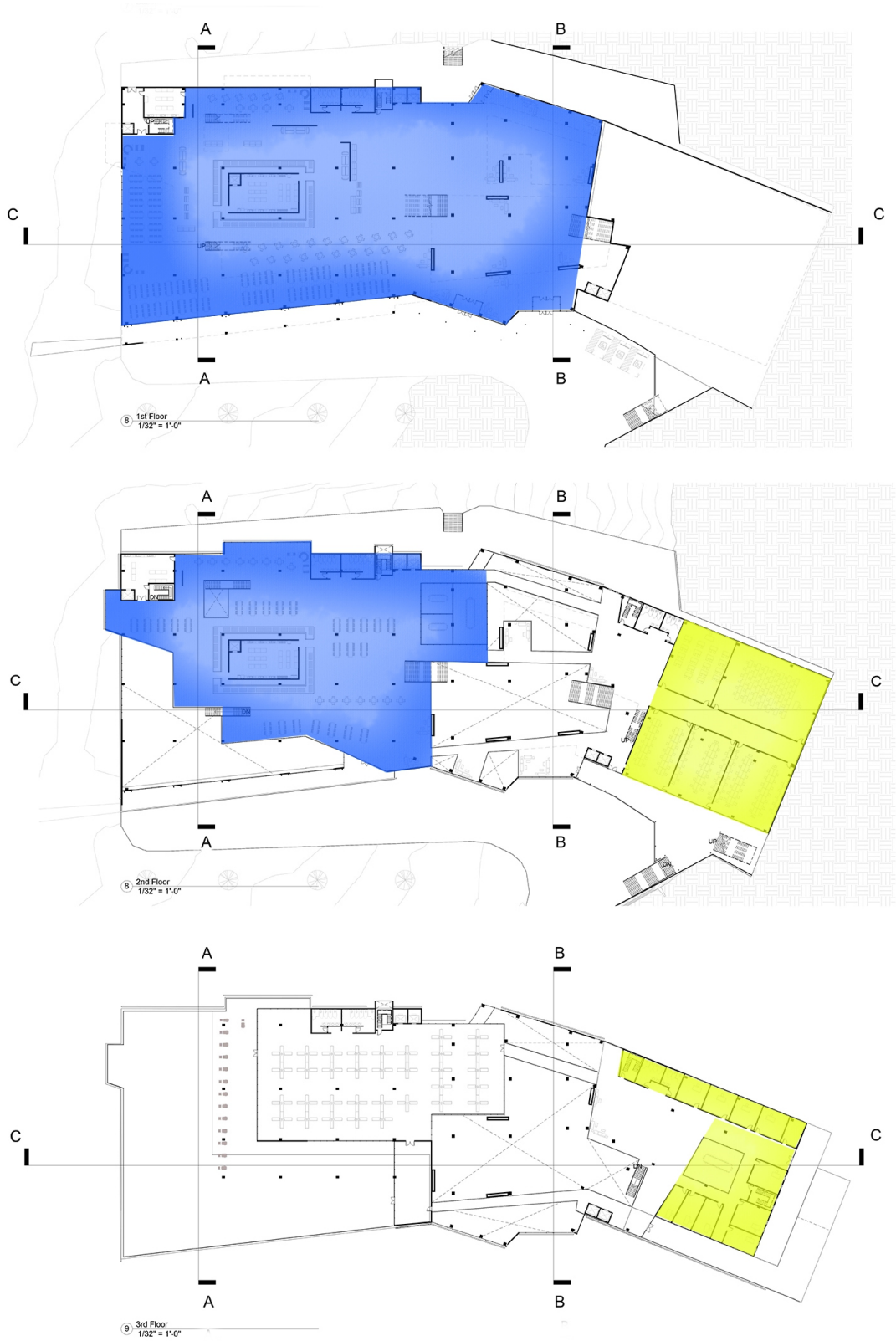


Figure 50: Enrolled Students.



Space Distribution

People with Special Needs and Disabilities

People without Special Needs and Disabilities

Figure 51 Building's Floor Plans

The building is located along east- west orientation, with main PV-glass façade facing south. The main point to situate atrium in the middle is to “force” the circulation between dining hall and learning facility. The east side of the building is mounted into hill and floors begin with the second floor with entrance facing the mountain. The structure was designed to replace existing Worcester Dining Hall increasing the footprint by about 100,000 sqft. The number of dining seats would stay about the same; around 800 seats.

Since the building would generate about 90% payback between September and May, it is crucial to keep the facility going through the summer. In order to fulfill that expectations there are conference rooms on the second floor as an addition to dinning. These conference rooms might serve business meeting as well as other occasions, for example family meeting or weddings.

The third floor provides dining hall with food production, which grow symbolic amount of food, yet would still provide a food in case of emergency.

Along with food production, the building collects rain water and store it underground. The filters clean the water, so it is used not only to water the greens, but would provide drinking water. In addition to food and water, there is a biomass furnace located in the basement. It burns the compost- providing building with free energy assisted by PV-glass atrium. It is especially important in case of emergency providing a free energy for people charging their devices.

The top of the east and west sides of the building contains roof gardens bringing down the thermal mass, but also providing a recreation for students and guests. It would be especially crucial in the process of bringing not only students but potential customers.

Finally, the main spaces which are two dining located on the first and second floors are designed in the circular way, which help lowering the lines saving both time and seating spaces.

CHAPTER 6

DESIGN

6.1 Building Design

Figure 52: Building's Perspectives

Figure 53: Building's Entrance

Figure 54: Building's Second Entrance

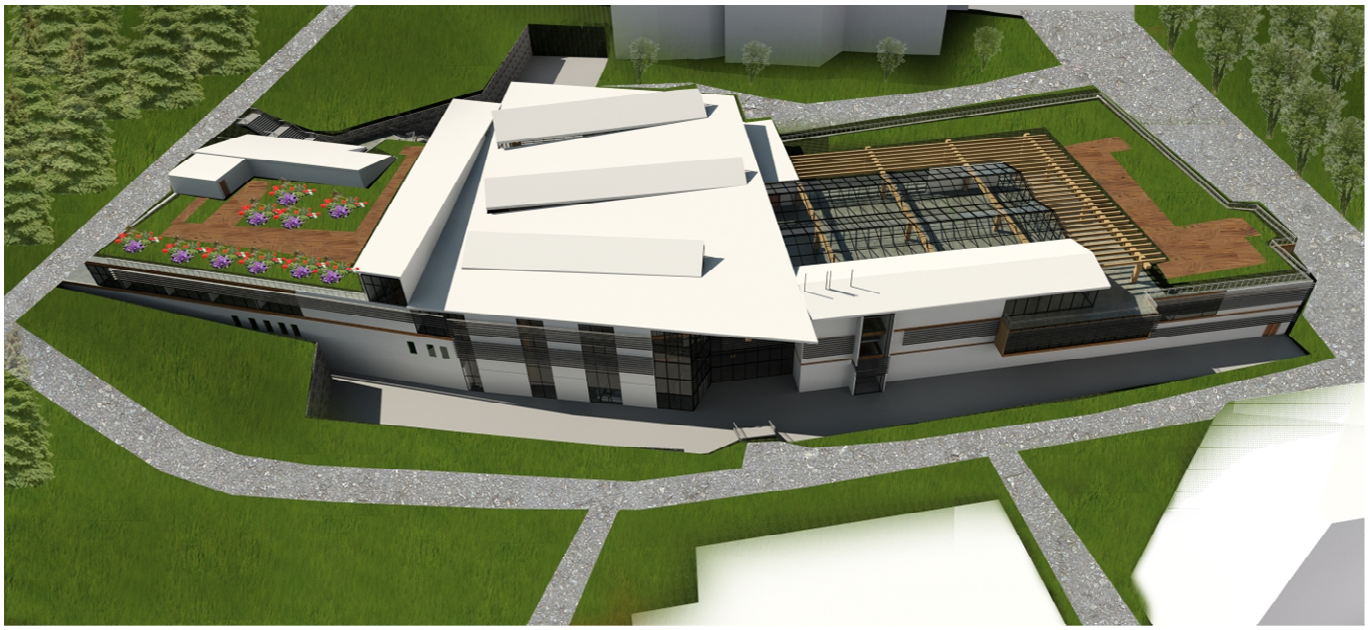


Figure 55: Roof Gardens.

Figure 56: Night View

Figure 57: Atrium.

Figure 58: Dining Hall

Figure 59: Internal Bridges

Figure 60: Roof Garden

Figure 61: Building's Floor Plans

CHAPTER 7

FINAL REVIEW BOARDS

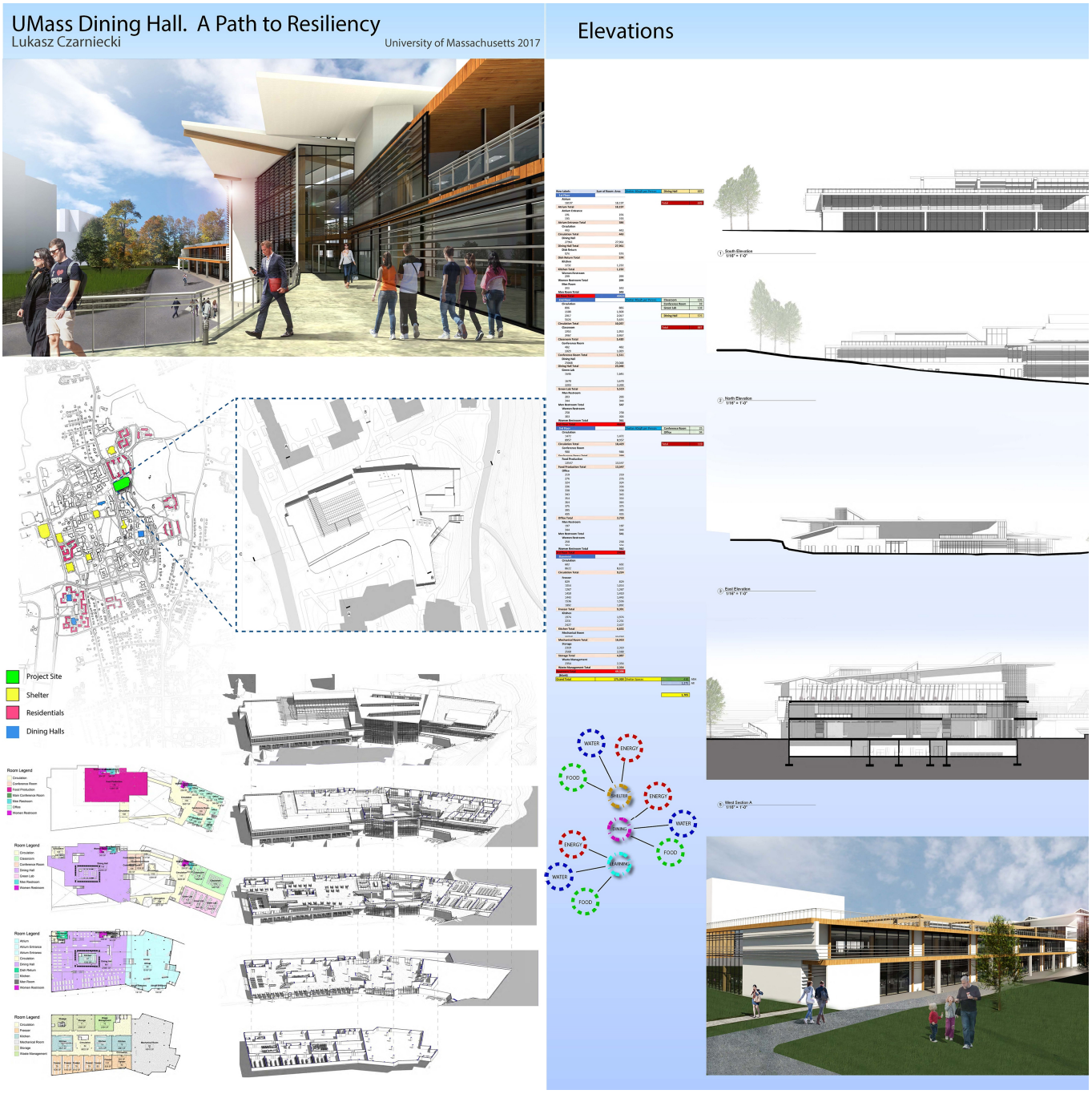


Figure 62: Board 1 and 2

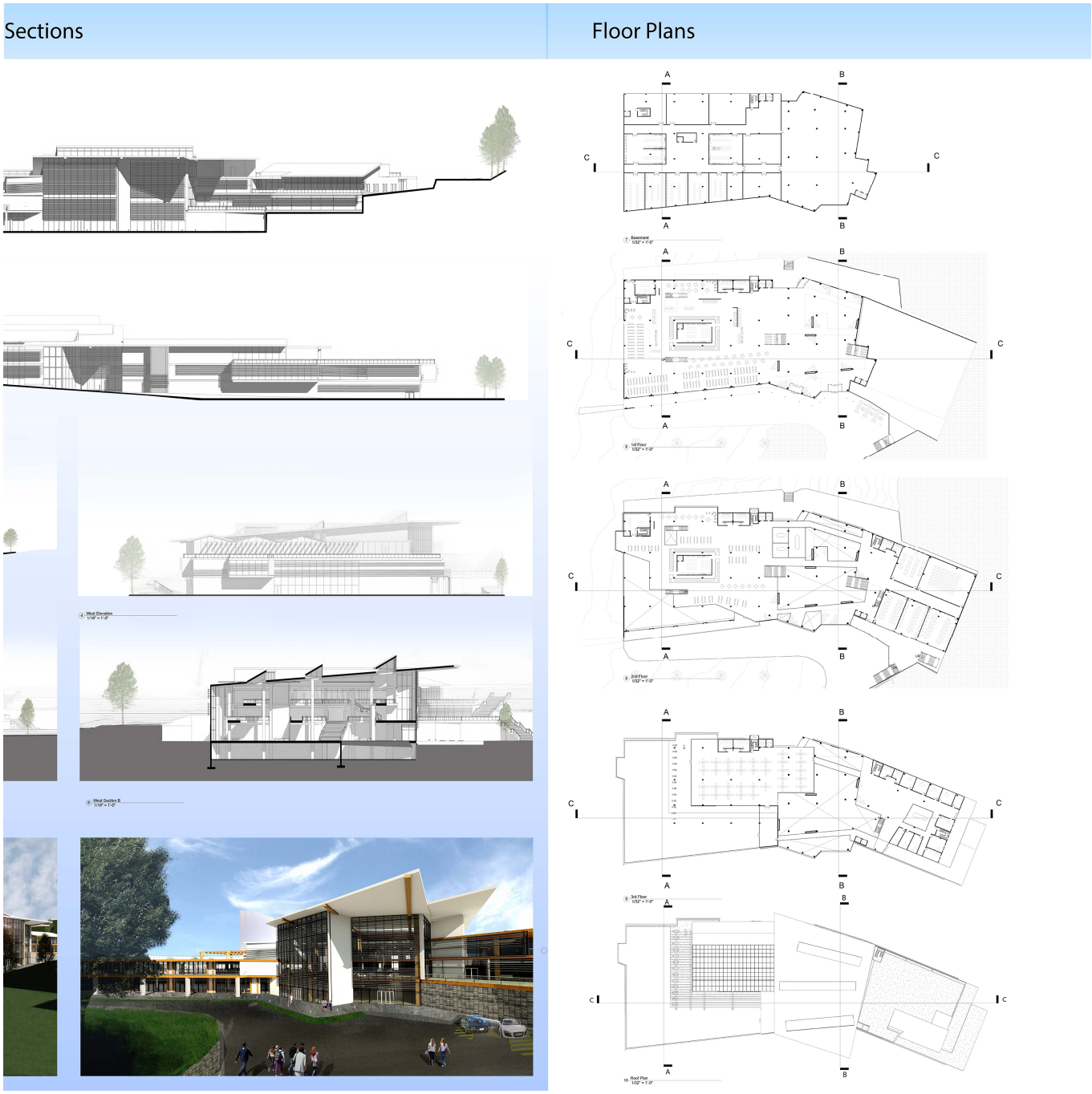


Figure 63: Board 3 and 4

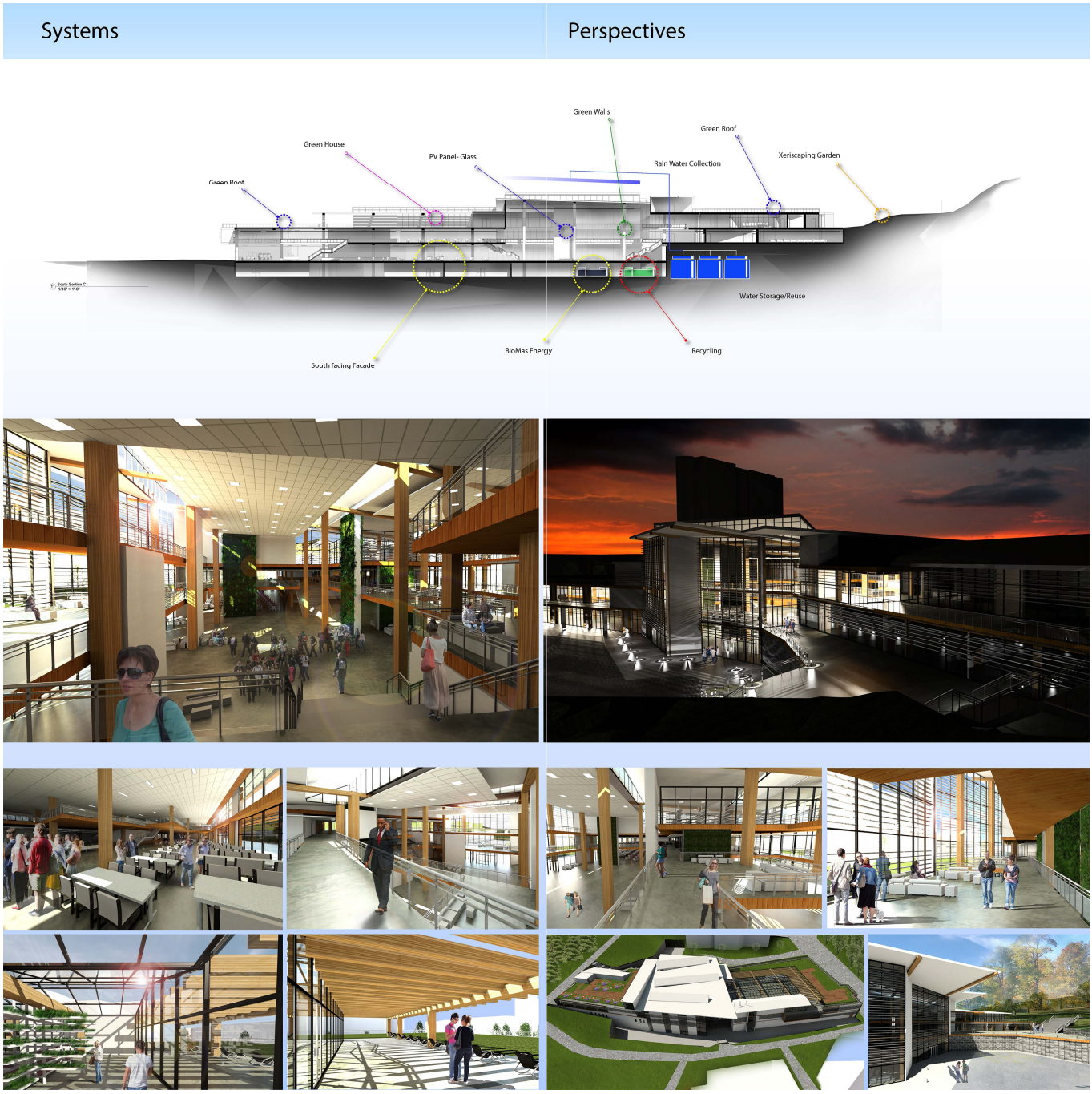


Figure 64: Board 5 and 6

CHAPTER 8

CONCLUSION

The Dining Hall was designed to meet the universities' standards and fulfill student's expectations to live healthy. Such a facility would contribute to the already growing number of new students, as well as generate money, and support itself throughout the year.

All the crucial program decisions were made based on two interviews; with a Director of University Emergency Management and Business Continuity, the Executive Director of Auxiliary Enterprises and Garett Distefano, the Director of Residential Dining. All the information gathered during those interviews become a fundamental basis for the building's design.

Based on conversations with critics, as the design progressed, I was better able to communicate the essence of the design, to create a facility that teaches about food, water, and environmental sustainability, and more wholly integrates with nature. The new ideas become a part of my final design fulfilling the students and visitor's expectations such as opening kitchen to expose the process of preparing food, integrating outside gardens or reusing the atrium space to increase the shelter footprint. Such a facility would be able to flexibly reconfigure to adjust to different circumstances and help to meet the university's need for resilient shelters in times of emergency.

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