A Movement Towards Self-Efficiency in Hawai‘i
Planning for the Future

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December 2010

Submitted towards the fulfillment of the requirements for the Doctor of Architecture Degree.

School of Architecture
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Doctorate Project Committee
Randy Akiona, Chairperson
Ted Garduque
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We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in fulfillment as a Doctorate Project for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.

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"We'll see green buildings long before 2020 – I think the movement is intensifying. Within the next 5-10 years we'll see a lot more green buildings being built. Not just buildings but green cities, green environment, green master plans, green products, green lifestyles, green transportation. I'm very optimistic." – Ken Yeang.[1]

[1] Ken Yeang, *Environmental innovation in architectural design*, Sustainable Lifestyle Magazine. http://www.sdstyle.org/article.php?id=102 (June 17, 2009).

CHAPTER 1

ABSTRACT

1.1 A Self-Efficient Hawai'i

1.2 Using more Renewable Resources in the Context of Hawai'i

1.3 Creating an Artificial Landmass

1.4 Goals of the Research

1.1 A Self-Efficient Hawai'i

I too am very optimistic that our future will be green and it can start here in Hawai'i. What better place to incorporate sustainability and to minimize transportation, as well as controlling air pollution in Hawai'i. We can utilize the sun, wind, and water more effectively by incorporating renewable energy. The purpose of this doctorate project is to research and design a self-efficient building in the context of Hawai'i while improving the quality of life. The process begins with the Natatorium War Memorial located on the island of O'ahu. The end result will be to revitalize this area with a mixed-use building that is self-powered that allows for multiple functions occurring in one central location, for instance: an interaction between living organisms, economic growth by providing kiosks to sell products and/or produces, sea life education, and future expansion.

There are many definitions of being *self-efficient*. One way will be using natural resources instead of importing coal, oil, and fossil fuels. This will lead to a better and cleaner environment to live and provide for the future. Another focus on being self-efficient will not only be on using natural resources, but being *self-sufficient*; providing the necessary resources that are needed to make a healthy community. Self-sufficiency and self-efficiency interconnects with each other, because in order to provide for one's self, one needs to be efficient to keep the resources alive and well.

In order for us to start living green we need to do the following, but not limited to:

- Provide power and energy through renewable resources
- Incorporate passive designs
- Design modularity – prevent airborne dust and other fragments while construction occurs
- Provide a lifestyle that reduces traveling, i.e. cultivating our own food, etc.
- Provide education – various sea life studies, etc.

Once this is all in order, we can start the process of living self-efficiently. Due to the circumstances of Hawai'i being islands, we are limited to what we can do; we need to create power to run our factories to produce clothes, products, and help cultivate farmlands. This will prevent us from importing elsewhere; it will allow Hawai'i to sustain the economic growth. This will inspire people to reconnect with the world by taking responsibility of how they use their natural resources respectively, and to reunite them with their mana (power) by spreading the aloha. Hawai'i will then be remembered as the pioneers of a greener future where together we'll wait patiently optimistically.

1.2 Using more Renewable Resources in the Context of Hawai'i

As a separate entity to the rest of the world, Hawai'i should start implementing systems or standards regarding the use of renewable resources. If successful this will inspire other cities and countries to follow Hawai'i's footsteps. One major obstacle - cost.

Budget and expenses are in the minds of all clients; who are trying to milk more services for less. What client's don't realize is that there are misleading facts about incorporating a sustainable design. They think it is expensive, but in actuality it is not expensive; further explanation will be in Chapter 4. Furthermore, the demand and cost for power and energy will only grow. For instance, we can already see gas prices rising and they are only continuing to rise.

As the demand and cost continue to rise for coal, oil, and fossil fuels, this should convince us to push for the use of renewable energy. While the supplies, listed above decreases and demand for energy increases it is causing the depletion of the earth's resources. At the same time, it is killing the environment; global warming, greenhouse effect, and carbon dioxide emissions. Furthermore, the population growth is rapidly increasing which is causing to expedite more use of coal, oil, and fossil fuels. If this continues it will eventually lead to the downfall of Hawai'i's economy; importing resources will eventually be too expensive. In order to prevent this disaster from happening sustainable developments should seriously be considered throughout Hawai'i. Further research will be needed to find areas that will be beneficial to use renewable resources efficiently.

All throughout the world have successfully implemented renewable resources. Why is Hawai'i one of the few to start using renewable resources up until now? We are always a step behind the other states, take the monorail for example. Only these recent years are we now planning on building one while other states and countries have implemented one. It is the perfect opportunity for Hawai'i to utilize the existing knowledge and make the necessary changes to best fit our context. Although Hawai'i is part of the United States, we are located in the middle of the Pacific Ocean where large amount of resources and land should not be used unwisely; land is scarce and limited so as architects and builders we need to utilize our lands more effectively and efficiently. By implementing renewable energy, we will be able to preserve our energy and utilize our natural resources.

1.3 Creating an Artificial Landmass for a Sustainable Design

The state of Hawai'i needs to find solutions and ideas to preserve land and resources more efficiently. When comparing Hawai'i to other states, such as: California, Texas, and other larger cities, Hawai'i is limited in land and resources. One method is to use brownfield lands – they are abandoned or underused industrial and commercial facilities available for re-use. Brownfield's are good ways to preserve land, however, in the State of Hawai'i they are mainly farmlands. Unlike larger cities where they have abandoned factories and so forth, we do not have many of those sites.

Another method to preserve land and resources is to create an artificial landmass, in this case the Natatorium War Memorial. An artificial landmass will help prevent urban sprawling onto green areas (farmlands) by having the necessary resources in one central location; creating an 'ohana (family) within the landmass. Also, it will redevelop an area that is no longer occupied by residence and visitors throughout the day. Furthermore, it will also provide an educational atmosphere: marine biology for elementary schools, high schools, and the university while learning about sustainable design.

A positive potential of having a landmass over the ocean will allow renewable energy to create power more effectively for the mixed-use building. If the mixed-use building is constructed on land, it will be surrounded by adjacent buildings or structures. These adjacent structures will prevent wind and sun from maximizing their natural resources into the renewable energy systems. If an artificial landmass was to be formed on the ocean where the building can be constructed, it will be able to get maximum wind and sun throughout the days, months, and years. These two renewable resources will be able to provide power and energy for the mixed-use building and making it self-efficient. Another feature is creating pure drinking water from the fresh air we breathe by using the

WaterMicron's Atmospheric Water Generators (AWG),[2] and possibly with further studies on seawater and technology with the collaboration of TeexMicron, also generating pure water from seawater.

In honesty, it will be expensive to create an artificial landmass. So, why not build on the existing structure of the Natatorium? However, with the help of the government investing in a project that will benefit Hawai'i and with other sponsors, it will create a positive impact towards becoming green. Not only relying on the government and sponsors for funding, creating a method that is cost efficient will also lower capital cost; design modularity. Also, there will be convincing facts on how this site location is worth constructing that will illustrate Hawai'i becoming green; this will be further explained in the research.

As mentioned earlier, future planning must be considered. Building an artificial landmass may be needed worldwide due to the overpopulation and polar icecaps melting. If we are forced to develop above seawater, this research will be the starting point of an idea or a reference of creating a self-efficient community on an artificial landmass. It is the importance of being self-sustain and rethinking of how we can use our resources more effectively and efficiently. The contribution here is the thought of being possible, making it into reality, and what elements are needed to become self-efficient. It is learning from our mistakes and not repeating them; humanity must survive.

1.4 Goals of the Research

Currently, sustainable design is being developed and seriously considered all over the world. The goal of this research is to find efficient methods for building construction while implementing renewable resources within the built environment to lower the demand for energy from the grid. Site selection and how to develop the site is the beginning process of sustainability. The next process is creating modular units and systems to minimize damage to the environment. In order to achieve self-efficiency in Hawai'i, a better understanding of the renewable energy systems is needed and how to improve them when applied; if there are other innovative ways. It will be the start of

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[2] TeexMicron, *Environmental Sustainable Projects*, http://www.teexmicron.com/ (Oct. 9, 2010).

more sustainable developments throughout Hawai'i. Also, the planet will be kept cleaner and healthier, as well as providing a better future for the generations ahead; taking care of our islands.

Once the first goal is accomplished, the research will move into the next goal which is the design of the mixed-use building while incorporating renewable resources with passive design systems. If successful, it will be the showcase of Hawai'i moving into its own architecture vernacular. As the research continues, the built environment will be based on how to provide energy without harming or minimizing damage to the earth's resources, and creating a destination of multiple activities. Extensive research will prove that using solar, wind, and hydrogen fuel cells as energy storage will support the building systems in order to become self-efficient to self-sufficient.

In order for the goals to be accomplished, background studies of what is destroying the earth's resources needs to be uncovered. As a designer, creating solutions or design ideas of how to be successful when designing renewable energy and passive design systems are wanted. Case studies of successful sustainable buildings will also help explain and prove the thesis. As stated earlier, the end product will be revitalizing the Natatorium War Memorial while being self-powered to become self-efficient. It will be an example of how we can move towards living green.

CHAPTER 2

CHANGE IS NEEDED

2.1 Shooting for a Sustainable Economy

2.2 The Shutting down of our Planet

2.3 The Consumption of Energy

2.31 Usage of Gas

2.32 Usage of Coal

2.4 Controlling the Outcome of Destruction

2.1 Shooting for a Sustainable Economy

Based on my twenty-four years of living in Hawai'i, solar (photovoltaic panels), wind, tidal, and wave renewable energy would best fit Hawai'i context. Extensive research on each method will be done to see which ones or even all would affect Hawai'i in a positive way. Throughout this research, explanations of why it is important that Hawai'i should have more renewable energy sources will be brought to attention. The research will be mentioning other countries and cities that are pushing for renewable resources because of the effects that greenhouse gases and carbon dioxide is having on the atmosphere. Hawai'i should start considering using more renewable energy, being more self-efficient so these problems that other countries and cities are having will not occur.

What is sustainability? According to David Gissen, sustainability is "A growing awareness of the environmental, social, and economic problems associated with contemporary architecture and the industry has led many business leaders and communities to adopt practices deemed to be more sustainable over the long term. Such strategies are usually aimed at keeping the engines of commerce humming and people employed, while reducing resource consumption, energy use, toxic emissions, and waste. The result is that the sustainability agenda tends to be a framework for the reform of the existing industrial system rather than a fundamental redesign, a way of being "less bad" by being more efficient."[3] Adding on to Gissen's point of view of sustainability, Dominique Gauzin-Muller states that, "Sustainable architecture is only really effective when set in an urban planning context which itself is based on sustainable principles."[4] Both points are agreeable; however there are other factors that make a sustainable design. For example, creating natural power is one, but also considering a multi-functional building. It is having the necessities that make up a community rather than sprawling outward.

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[3] David Gissen, *Big & Green: Toward Sustainability Architecture in the 21st Century* (New York and Washington D.C.: Princeton Architectural Press, 2002), page 8.
[4] Dominique Gauzin-Muller, *Sustainable: Architecture and Urbanism* (Switzerland: Birkhauser – Publishers for Architecture, 2002), page 9.

Having a sustainable design will not improve the earth's atmosphere right away; it does take a period of time. Looking back at history, experts predicted if we don't do anything now our future will be ruined. We will damage our ecosystem, our atmosphere, and our environment. They were ignored, and years later, we are striving to be more sustainable; fighting for a better future. But is it too late? We still can try and change the outcome by listening to people like Gauzin-Muller; it is in the urban planning of sustainable architecture that will make a difference, more the merrier. One building in the city will not make a difference, one building out of hundreds or thousands will not stop global warming. However, one building that generates its own power, creates an interaction between nature and organisms, and sustains life will be the beginning of moving towards a greener lifestyle. It all comes down to planning should have standards, schemes, and etc. in order to create a better living environment.

The statistics in deed shows that the average global temperatures has risen and will keep rising during the 21st century. Such changes may be minor for now but it will create a problem for the years to come; for example: over the last 1,000 years of climate record, it shows the 'medieval warm period' and the 'little ice age'.[5] The 'medieval warm period' was during the 1990s which was the warmest decade on record and in the last 30 years it shows a reduction in snow and ice cover in the Northern Hemisphere of about 10%. In the last 100 years, records show that a retreat of mountain glaciers in non-polar regions.[6] Other records show the average sea level rising and increasing rainfall over continental northern latitudes, but decreasing rainfalls in the sub-tropical regions. These currents changed during the second half of the last century; it got more drastic. There was a significant increase of heavy rainfall over the mid to high latitudes in the Northern Hemisphere. As for the Pacific region, where Hawai'i is located, during the El Niño phenomenon it caused more extreme climatic events and it intensified and persisted since 1970.[7]

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[5] Peter F. Smith, *Sustainability at the Cutting Edge* (Oxford: Elsevier, Ltd., 2006), page 1.
[6] Adrian Pitts, *Planning and Design Strategies for Sustainability and Profit* (Oxford: Architectural Press, 2004), page 13.
[7] Pitts, page 13.

We need to remember that these climatic changes do occur on its own through natural variability and natural events, but the United Nations Intergovernmental Panel and Climate Change (IPCC) has found out that human activity is to be blamed for the emissions of particular gases – global pollution – that is altering and will continue to alter the atmosphere. "Global pollution requires global solutions."[8] These altering climatic changes due to human activity are known as the greenhouse effect; figure 2.11 shows a generalized process of the greenhouse effect.

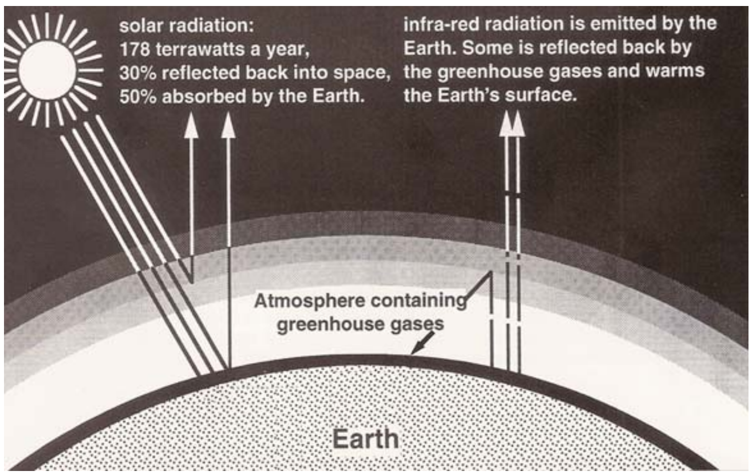

Figure 2.11 – Diagram of a greenhouse effect[9]

The importance of the greenhouse phenomenon is the earth's surface and atmosphere is about 91.4°F (33°C) warmer, and without this process it would be way too cold to sustain human life. The problem with the greenhouse effect is that the emission of gases into the atmosphere is increasing at an alarming rate over the last 250 years. This relates to human activity because of the industrialization and mankind's use and exploitation of fossil fuels coal, oil, and gas.[10]

Some questions did arise, is it inevitable to stop global climate change? Are we just slowing down the process of destruction? Incorporating sustainability, in other words, using renewable resources, will that change our future? Before we get into the future, we need to understand how the climate is changing and effecting the human race

[8] Smith, page 1.
[9] Pitts, page 14.
[10] Pitts, page 14.

to make the necessary changes. People should believe that enforcing sustainability, being self-efficient will help slow down the process of our destruction.

2.2 The Shutting Down of our Planet

Let's point out some issues why our planet is shutting down: the human population is rapidly increasing; the extravagant use of natural resources and fossil fuel reserves; decline in air, water, and soil quality; and the volume of just waste. Looking back at the 1900s, the human population was at 1.5 billion and now in the 2000s it's at 6 billion; a huge increase of people. This is troublesome because of the supply of food, shelter, and quality of life relies all on the planets well-being. According to Professor Jurgen Reichardt Essen, the business and industry is using up a third of our national economy energy, another third to heating purposes, and the other third for traffic and transportation.[11] As of now, the planet is shutting down; it is predicted that we will use up all of the oil reserves in 50 years, natural gas in 70 years, and coal in 190 years from now.[12] The years for coal may be sooner because it will be used more frequently when oil and gas is depleted or completely used up.

Adding onto the environmental damage, our climate is changing. In the past, the weather changes have done been interrelated with the use of energy sources. But now, it has interrelated because of the growth. There are more industries and factories that have been built that use fossil fuel, sending off carbon dioxide (CO_2) into the atmosphere. While CO_2, which is around 60% of the greenhouse effect, is being sent off into the atmosphere, that number has increased around 30% since 1750.[13] If this rate of emission keeps expanding during the twenty-first century, the carbon dioxide concentration will grow two to three times its preindustrial level.[14] "The burning of fossil fuels currently releases more than 21 billion tons of carbon dioxide into the atmosphere each year."[15] Gauzin-Miller states that, according to The Intergovernmental Panel on Climate Change

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[11] Lektorat Wylicil, *Efficient Buildings: Designing for Business Administration* (Singapore: Page One Publishing Private Limited, 2006), page 5.
[12] Gauzin-Muller, page 12.
[13] Gauzin-Muller, page 13.
[14] Smith, page 1.
[15] Gauzin-Muller, page 13.

(IPCC), during the 20th century the earth's temperature has warmed up between 32°F to 33°F (0.3°C to 0.6°C) and at the same time the sea level rose by an average of 6 to 10 inches (15 to 25 cm).[16] He continues on by saying that if we don't do anything now, temperatures will rise up to 36°F to 41°F (2°C to 5°C) and sea level will rise that may destroy certain cities.[17] For one, Hawai'i will no longer exist if the sea level rises because it will be under water. Zekai Sen further explains that if this trend continues on some areas of the world it will have extreme rainfalls and consequent floods, droughts may occur, and the imbalances of climatic behavior will cause the rise of either hot or cold temperatures.[18] Peter Smith explains that, "Its difference between the middle of an ice age and the warm periods in between is only about 5 or 6°C (9-10°F). So, associated with likely warming in the twenty-first century will be a rate of change of climate equivalent to, say, half an ice age in less than 100 years – a larger rate of change than for at least 10,000 years."[19]

When the temperature changes and fluctuates abnormally, our water resource gets affected. Our water resource gets affected when the world becomes warmer, more evaporation of water from the surface causing more water vapor in the atmosphere and more precipitation on average.[20] More importantly, it is the density of water vapor in the cloud formation that will lead to more latent heat being released. This will cause a problem because latent heat is the main source of energy that drives the atmosphere's circulation, the hydrological cycle will be more strenuous.[21] In other words, more frequent rainfalls will occur and also less rainfalls in some semi-arid areas. Statistics shows that floods and droughts are the most damaging to the world; this occurrence will not be good for human communities.

Smith also mentions another concern regarding to the water movements and affects regarding with the temperature changes. The other concern he mentions is the thermo-haline circulation (THC) – a circulation in the deep oceans, partially sourced

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[16] Gauzin-Muller, page 12.
[17] Gauzin-Muller, page 12.
[18]Zekai Sen, *Solar Energy Fundamentals Modeling Techniques* (London: Sprinker – Verlag London Limited, 2008), page 4.
[19] Smith, page 2.
[20] Smith, page 3.
[21] Smith, page 3.

from water that has moved in the Gulf Stream from the tropics to the region between Greenland and Scandinavia.[22] When there is evaporation occurring, the water is not only cold, but salty, causing a higher density than the surrounding body of water. This effect causes the thermo-haline circulation to sink and provides the source for a slow water circulation at low levels that connects to the rest of the ocean. Although this sinking assists in maintaining the Gulf Stream itself, in a globally warmed world, when fresh water is mixed in from melting ice it decreases the water's salinity.[23] Meaning, it will less likely to sink causing it to weaken and possibly cut off. If the circulation gets disrupted, large regional changes of climate will occur. This has been proven from paleoclimate history that such cut-off has occurred before at times in the past. What does this all mean? It refers to the movie *The Day After Tomorrow,* big tidal waves destroying all cities and humanity will eventually be in the ice age again.

2.3 The Consumption of Energy

Besides the climatic changes that are occurring, another problem humanity needs to worry about is the use of energy. As of now, the usage of oil, gas, and coal is depleting at a rapid rate. As stated earlier, estimates show that oil will be used up around 50 years, gas around 70 years, and coal around 190 years; this may change because more use on coal will occur when oil and gas is running low.

According to the International Energy Agency (IEA) *World Energy Outlook* 2004 report, developed countries will be at the mercy of the Organization of Petroleum Exporting Countries (OPEC).[24] This organization is predicted to supply half of the world's crude oil. Also in the report, it states 'As international trade [in oil] expands, risks will grow of a supply disruption at the critical chokepoints through which oil must flow'.[25] Over the next two decades humanity will still rely on the use of fossil fuels; IEA forecast that 85% of the increased energy usage will be met through the burning of oil,

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[22] Smith, page 4.
[23] Smith, page 5.
[24] Smith, page 164.
[25] Smith, page 164.

gas, or coal. The high demand of energy will result in more infrastructures which will cost about $16 trillion.[26]

Similar to the International Energy Agency, the World Energy Council is another forecaster to the consumption of energy being used. The World Energy Council growth projection is based on the Intergovernmental Panel Climate Change (IPCC) Business as Usual scenario which shows the energy growth to 2100. The graph shows the global consumption has grown 4.3% in 2004, which in fact is the highest annual increase in primary energy consumption. This large increase was not only due to the United States, most of the percentage is from China, an increase of 15.1% of energy consumption.[27] In 2005, China became the world's second largest oil importer.

We can see that the energy consumption level is high and it is only increasing. We also can make the assumption that we are going to run out of resources to provide energy, unless we start moving into the usage of natural resources. People argue that if the shift has moved into renewable resources, cost would be too high. But, as humanity start using up more fossil fuels; wouldn't one assume that cost would also rise because of the demand for energy when oil, gas, and coal are limited? Research has shown that we have reached the 'peak oil'– the rising demand for oil production that has reached a point where it is to high of a demand.[28] Some say that 'peak oil' will be met in 2010, other say otherwise. According to Colin J. Campbell of the Geneva-based Petroconsultants, a world-renowned expert on the subject says we have already reached that peak in 2005. In honesty, these years are irrelevant compared to the damages the marketplace will take once we have reached the peak point. Consumers have already seen the rise of oil and gas prices, we can confirm that the cheap years of oil and gas has gone and most likely not to return. It is predicted that a barrel of oil will pass the $100 mark in the near future; currently it is around $77.

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[26] Smith, page 164.
[27] Smith, page 164.
[28] Smith, page 165.

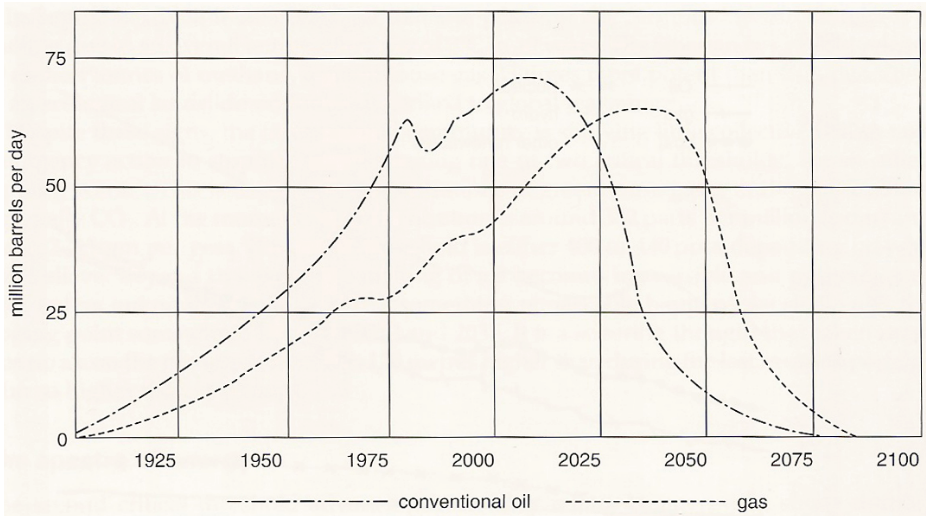

Figure 2.31 – Prediction on oil and gas resources until the year 2100[29]

It is inevitable to survive without food; it goes for the same with oil. As the price increases on food, it creates increasing population facing hunger, imagine what will happen when oil prices gets to that point. Also, while oil prices increase, it is said that the same rate for unemployment follows the same path.

The analyst Jeremy Rifkind of the US Foundation of Economic Trends mentions, "If production rates fall while demand continues to rise, oil prices are likely to spike or fluctuate wildly raising the prospect of economic chaos…and even war as countries fight over what little oil remains."[30] He continues on, "If we think oil is a problem now, just wait 20 years. It'll be a nightmare."[31]

2.31 Usage of Gas

The estimated average of gas on reserves is around 144 trillion m^3. The annual extraction rate of gas is around 2.3 trillion m^3; this is approximately 70 years of supply.[32] However, the number of years may come sooner than researchers predicted because of the usage of gas-fired power generation; if this continues, we may reach it in 2040. As the gas resources decline and the price increases, it may be better to become cost-

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[29] Smith, page 166.
[30] Smith, page 166.
[31] Smith, page 166.
[32] Smith, page 166.

effective by converting natural gas into hydrogen fuel cells. If no change is made, it is predicted that by 2035 our gas reserves may completely disappear; gas consumption has increased 3.3% in 2004.[33]

2.32 Usage of Coal

Coal provides 23% of its energy to the world, of that 23%, 69% is consumed through electricity. On the world scale, coal reserves are estimated to be around 560 billion tons[34]; equivalent to 190 years of coal supply at the current rate of consumption. According to the IEA, the current rate will go up from around 2.5 billion tons to around 3.95 billion tons by 2020. So, from having 190 years of coal supply remaining, it may be reduced to 123 years. However, researches have predicted that having 123 years of coal supply may be false because of the depletion of oil and gas. In other words, if we try to increase the longevity of oil and gas, we will be forced to start using more coal. As of now, it is predicted that we will be draining out the reserves by 2100. The rate of coal consumption has risen by 6.3% in 2004, but 75% has been due to China.[35]

Due to the high demand for electricity and energy, the US and Canada is planning on building 500 new-coal fired plants that will last for 30 years. As for China, they are planning on building 300 coal-fired power stations and expect to triple the capacity of their coal-fired plants by 2020. The difference with US and China, China's coal reserves has high sulfur content. This will be more CO_2 emissions over the next 25 years; it would be more pollution than the previous 250 years of burning coal.

By 2040, it is said that China will become the next power house and will eventually take over USA in economic strength. The scary part of this is that US will have to adjust and rely on China for energy: increase in price may occur. This is assuming that climate change will not create social and economic disasters.

In order to prevent catastrophic problems and relying on outside sources to provide energy demand, US need to start using renewable resources, especially for Hawai'i because importing resources will eventually be too expensive. Hawai'i needs to

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33 Smith, page 167.
34 Smith, page 167.
35 Smith, page 167.

find ways to become more self-efficient and take advantage of the location. In order for Hawai'i to do so, changes and improvements for a better quality of life need to be enforced. Standards, schemes, accreditation, certification, and so forth should be created. In Chapter 3, there will be some examples of other countries implementing their own systems; create ideas on how to prevent damages to our atmosphere and environment.

2.4 Controlling the Outcome of Destruction

Now is the time to make adjustments, control the emissions of CO_2 into the atmosphere. The best way to do this is through sustainability, in other words, relying on renewable resources. In order for this to be successful, all international and national groups must cooperate to come up with a standard or a system that is effective. "Renewable energy and especially solar radiation are effective energy technologies that are ready for global deployment today on a scale that can help tackle climate change problems. Increase in the use of renewable energy reduces CO_2 emissions, cuts local air pollution, creates high-value jobs, curbs growing dependence of one country on imports of fossil energy (which often come from politically unstable regions), and prevents society from being hostage to finite energy resources."[36] This thought has already been taken into effect, mainly in the European cities.

According to Gauzin-Miller, in the year 1992, the Rio Earth Summit was held. This summit included the head of states that committed their nations to explore new ways in order to answer the current needs without compromising the future generations to fulfill theirs. The concept of sustainability that was agreed on at the summit incorporated three principles: consideration of the "whole life cycle" of materials; development of use of natural raw materials and renewable energy sources; reduction in the materials and energy used in raw materials extraction, product use and destruction or recycling of waste.[37] When this is all said and done, the next question that needs to be answered is, how will renewable energy help the ecology and economy? Hawai'i should take this concept into consideration.

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[36] Sen, page 4.
[37] Gauzin-Muller, page 13.

"For most environmentalists, growth and profit became more acceptable with the emergence of the idea of sustainable development, linked as it is to a more equitable distribution of benefits and less damaging exploitation of natural resources."[38] This green movement lead up to a report called the "Factor Four"[39] that was produced by the Club of Rome. This report was created by the most advanced thinkers from the environmental perspective. The main goal of the report was to guide the future generations, it aimed to develop a system to have economic profits but at the same time protect the environment. In other words, using half the energy resource and improving the quality of life while making and/or saving a lot of money. They first started off thinking small scale, improving the existing technologies. The environmental thinkers wanted to improve production efficiency without increasing cost; limiting waste from transporting goods; trying to make the cars more fuel efficient, and have buildings more energy-efficient and comfortable to be in.[40] Sen also agrees that sustainable development needs to emerge for a better future. He states: "Continuance of economic growth and prosperity rely heavily on an adequate energy supply at reasonably low costs. On the other hand, energy is the main source of pollution in any country on its way to development" and he continues on saying: "As a whole electricity production based on fossil or nuclear fuels induces substantial social and environmental costs whereas it would appear that the use of renewable energy sources involves far less and lower costs."[41]

As green architecture improves through the years, we start seeing trends in environmental architecture. Even one of the top leading sustainable designers of architecture, Ken Yeang has realized this occurrence. He explains, "As the world approached the turn of the millennium, more and more architects began to realize that the old way of designing large buildings was straining the environment and, ultimately, directly and negatively affecting the way we live and work."[42] Adding onto this argument of how important sustainability is on our environment, David Gissen states:

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[38] Gauzin-Muller, page 14.
[39] Gauzin-Muller, page 14.
[40] Gauzin-Muller, page 14.
[41] Sen, page 12.
[42] http://www.sdstyle.org/article.php?id=102 .

"The consumption of fossil fuels is one of our biggest environmental problems. Drilling in ecologically sensitive areas, oil spills, air pollution, and the destruction of the atmosphere all result from the incredible demand for fossil fuels. We may think of cars and factories as the most obvious enemies of the environment, but buildings consume more than half the energy used worldwide. Mechanical systems that supply air-conditioning and heating, lighting systems, and other building technologies are now being redesigned to consume less energy-and, most important, alternate sources of energy are being developed. While building owners can purchase energy made from renewable or clean sources (solar, wind, or hydroelectric), many architects are now designing buildings that generate their own clean and renewable energy. If this trend continues, future architects may develop buildings that generate all their own power, with enough left over to contribute to the city's power supply."[43]

Architects/designers started to use natural resources, such as wood, grass, and even the earth itself. One such designer stands out, Paolo Soleri, a former follower of Frank Lloyd Wright, he created his own style or method which was called "arcology" or architecture consistent with ecology.[44] Soon later this method of bringing in natural elements, such as sky courts and roof gardens occurred in high-rise buildings, notable architects such as Norman Foster, Renzo Piano, Richard Rogers, and Ken Yeang had applied sustainable designs.

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[43] Gissen, page 19.
[44] Gauzin-Muller, page 16.

CHAPTER 3

PLANNING AHEAD FOR OUR FUTURE

3.1 Examples of Standards and Schemes

Other parts of the world, such as European cities started to incorporate their own standards/schemes to consider while designing a building. While doing research there were two standards/schemes that stood out: France, the HQE scheme and the Switzerland, the Minergie standard. Gauzin-Muller explains the HQE as:

HQE: the 14 target areas[45]

EXTERNAL ENVIRONMENTAL IMPACT

ENVIRONMENTAL CONSTRUCTION

- **Relationship with immediate surroundings**
- **Integrated choice of construction materials and methods**
- **Low-nuisance construction processes**

ENVIRONMENTAL MANAGEMENT

- **Energy management**
- **Water management**
- **Waste management**
- **Maintenance policy**

SATISFACTORY INTERNAL ENVIRONMENT

COMFORT

- **Humidity**
- **Acoustics**
- **Visual**
- **Olfactory**

HEALTH

- **Sanitary treatment**
- **Air quality**
- **Water quality**

Even though this is not a certified scheme, this was a basic guideline to improve the environment. It was a trend to follow to improve on the quality of life. Another standard/scheme that was pushed for energy conservation and sustainability was the Switzerland Minergie standard, a trademark registered by the cantons of Zurich and

[45] Gauzin-Muller, page 22

Berne.[46] Its goal was to use energy rationally, incorporating renewable resources, improve on the quality of life, improve the economy and reduce pollution, and prevent environmental damage. The Minergie standard was first applied to small projects, and then it got promoted to larger state buildings in Switzerland.

Continuing on with the development of sustainability, a city or town cannot flourish based off of one building. Sustainability needs to adapt to a larger role, which should be included in the urban planning; but the main focus is not on urban planning. In order for sustainability within the urban planning to be successful, all walks of life must come together. There must be discussions, planning, ideas, recommendations, and so forth to help the development of sustainability. The things to consider when developing sustainability and urban planning are: land use and management, pollution and noise abatement, journey (circulation) management, energy management, environmental water management, green spaces, controlling waste, and social aspects.[47] "Future development of towns and cities must be conform to environmental, socially uniting principles, striking a sustainable balance between economic, social, environmental and cultural issues. This will be one of the major challenges which authorities will face in the decades to come."[48] But again, stated in the Abstract, the main focus will be on self-efficiency. These are ideas of how Hawai'i can be self-efficient and help start the process of a better sustainable environment.

There are notable environmental approaches, but in order to be successful, it all determines on the innovation approach to building issues. The team must formulate a system that answers the building issues, such as: project brief, design, construction and building management. While the team discusses these issues, there is one plan/goal in mind, and that is environmental protection. There are varieties of ways to incorporate sustainability in order to protect the environment; natural ventilation, natural lighting, glazing types, double-skin façade, roof gardens, green spaces, water catchment systems, and others. They are all good sustainable designs that contribute to the quality of life, but they do not answer how to create energy. What allows a building to create energy is

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[46] Gauzin-Muller, page 23.
[47] Gauzin-Muller, page 39.
[48] Gauzin-Muller, page 39.

through renewable resources. As what David Gissen said, these renewable resources may allow the building to be self sufficient and even power other adjacent buildings. Before we get ahead of ourselves, we should first explain some design considerations on how to plan for a better future with an ecological purpose.

3.2 An Ecological Approach to Architectural Design

As the shift moves from fossil fuels to green architecture, architects and designers should consider designing with nature and designing in an environmentally responsible way. If this idea is taken into consideration at the early stages of a project, it will help minimize the use of energy. Not only will it minimize energy, but it will effect the human society, also influence future generations to consider designing with an ecological way. As for the context of Hawai'i, this is the start of becoming self-efficient and not relying on outside resources. Also, this method of designing will prevent further environmental disasters and damages.

If we are to make an effort to consider an ecologically design in a responsible way, we need to figure out what is needed and what are the available resources for an efficient building. During the planning stage of design, architects should familiarize themselves to some of the basic concepts of ecology. Also, familiarize with the structure and function of the ecosystem. The purpose of this is to design a building that works with the environment, instead of fighting it. Currently, we can see most buildings do not work with the environment. It is due to the lack of knowledge and understanding how our ecosystem works. The lack of knowledge shows when designers don't know what is being affected and how is it being affected. According to Ken Yeang, "Designers tend to wrongly conceive the environment and its state as simply a physical and spatial zone (as a site and geographical location) on which the designed system is erected. They are not fully aware of (or some prefer to ignore) the existing ecological and biological systems inherent in their project sites."[49]

In order to design effectively towards an ecological way, we need to define what ecology is. Yeang defines ecology as, the study of the interactions of organisms,

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[49] Ken Yeang, *Designing with Nature,* (New York: McGraw-Hill, Inc., 1995), page 4.

populations, and biological species (including humans) with their living and nonliving environment; the composition change and stability of geographically localized groups of species, and the flow of energy and matter within such groups of species (ecosystem).[50] To summarize this definition, designers need to know how the building will affect the site and the surrounding environment.

Another crucial aspect of an ecological design is designers need to realize that there are limitations to human use of the earth's resources. Earlier in this document I mentioned how humanity is using up all of the earth's resources and how our planet is slowly dying. Once this argument is acknowledged, we can start moving into a sustainable world. But, in order to accomplish this feat, we need to start small. We need to start with one building and grow outward to the community.

The first step for any architects/designers is to think ecological when designing; they need to know that the boundary of the property is not only in that specific site. It doesn't matter whether there are walls, fences, and/or barriers around the site, the biosphere and ecosystems are not isolated in one particular area. As architects/designers, we need to know the biosphere and the ecosystems have an interlocking spatial property within the designed site. In other words, any change made to the site is going to affect everything in and around the site. Systems and methods are needed to control waste. For instance, there are methods of pollution control claiming to eliminate waste or to change one pollution form to another that is more expedient. As the one form changes to another, it actually doesn't eliminate waste; it just changes the form to some other contaminant that pollutes in a different environmental zone. Yeang defines environmental zones as "layers" – lithosphere, hydrosphere, biosphere, and atmosphere.[51] What this mean is, there are certain contaminants that affects different layers. We need to realize that these layers are not only interconnected within the site but beyond it. In order to prevent or slow down the process of contaminants affecting our atmosphere, we need to understand the interactions between components.

So, during the site planning for the built environment, the architect must acknowledge that any structure he/she designs for the site will inevitably affect not only

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[50] Yeang, page 6.
[51] Yeang, page 15.

the site but everything around it. No matter what the function is, because of the physical presence it will affect everything and everyone. For example, the mechanical systems that are needed to supply energy will give off air pollution in the atmosphere and be transferred elsewhere. The ideal solution is before any planning of the built environment, any influences of the structure should be taken into design considerations.

The next step for an ecological approach in architecture is formulating the framework. According to Yeang, "Ecological architecture is a designed system that seeks to minimize and at the same time is responsive to the negative impacts that it has on the earth's ecosystems and resources."[52] In other words, the framework for design needs to have a structure based on the interactions of the built environment to the earth's ecosystem and resources. The framework for design needs to show what the undesirable effects are and what needs to be minimized or altered through the design process. However, during the analysis process there is no limit to the number of variables that can be included or a descriptive explanation of the situation. The reason for this is because, climate change naturally occurs and also the built environment gradually changes. So, no matter how much input or output we have, it will never be as complete as possible. One way to go about this is, finding out the important variables within the built environment.

For this process to be easier on the architect there should be formulated principles in the form of an "open structure"[53] relating to the selected and relevant design constraints (e.g. environmental considerations) that can be organized. The open structure needs to be organized to relate to the design constraints so that it can facilitate their selection, consideration, and incorporation in the design process. For example, a matrix aligning what goes to what and what is needed and not needed. The open structure does not have to be descriptive with working with nature, because this allows the architect to decide which ecological considerations to incorporate throughout the design process. Another positive aspect when working with an open structure is, if any concerns arise towards the protection and conservation of the environment, they can be included.

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[52] Yeang, page 73.
[53] Yeang, page 80.

In summary to the framework of the design process, Ken Yeang states from his book, *Designing with Nature*[54]:

- A framework for ecological design should include the following components: the designed system, the environment of the designed system, and any interactions between the designed system and its environment.
- Any designed system has both a physical composition and form and its own set of operational functions, all of which interact with its environment spatially and systemically over time.
- Like a living system, the designed system requires continuous inputs of energy and materials, and makes outputs of energy and materials into its environment. A model which can structure the interactions between a designed system and the ecological environment in terms of these exchanges would therefore be advantageous because such a model would force us, first, to determine the internal activity that takes place within the system's dependence upon the ecological environment in terms of the energy and matter that are taken from it and returned to it as a result of the internal activity.
- We need also to examine the built environment within the spatial context of the ecosystems in which its activities take place, so that we can identify the accompanying consequences of these activities on the ecosystems.

Having a framework and organized principles of what is needed and not needed throughout the design phase would create a better environmental structure. The whole point of having these frameworks thought of in advance will lead to a better ecological design. It enables us designers to take into account the anticipated adverse effects that the building will have against the earth's ecosystems and resources. It will allow us to see what needs to be eliminated and minimized to prevent these unwanted effects. In relation to Hawai'i, we actually don't need to worry about pollution and other major waste compared to other cities as of now. But, the fear of it is, if we don't consider designing in an ecological way, we, sooner or later will reach to that point of no return.

[54] Yeang, page 86-87.

3.3 Controlling the Built Environment

The previous chapters talked about how we are destroying the earth's resources and planning with an ecological design. In this chapter, the discussion is going to be on the strategies and issues that should be considered when designing the built environment. In other words, I need to incorporate the necessary features for designing a self-efficient building.

Some of the issues that need to be focused on before designing a project while considering the ecological approaches are:

- Site location and orientation of the building
- Form and the design of the building
- Building relationship to and the effects of surrounding landscape and structure
- Interaction of the local ecosystems – climate, environment, and atmosphere
- A passive and active method in relation to the climate
- The use of materials and construction
- The use of building service systems

There are a number of aspects to consider throughout the building design in a strategic and managed manner. In order to incorporate a passive design with renewable energy that allows the building to be self-efficient, we need to look at other functions that are interconnected to the building design. For instance, *the specification of development*; *transportation systems*; *materials of construction*; *landscape features*; *sunlight and shade*; *air flow*; and *water and waste* are key elements to consider.

The building design should have *general specification and expectation* to be modified to take account for a better sustainability. The specification of development should start with locally based appraisal and the exchange of information. This will allow the production of development briefs within the community. Even though this is one building, there is still the need to consider working with the neighborhood board and with the community. Through the development briefs, it should be noted that potential enhancements or improvements will occur and be adjusted for. These potential enhancements or improvements may be either performance based or specification based. We as designers need to be flexible that changes can be made without disrupting the earth's resources.

New buildings have the potential to start the movement towards sustainability if designed well. The creation of a mixed-use building will have all of the features necessary for sustainability. This mixed-use building will be focusing on commercial, office, retail, and residential usage as well as a connection to the surrounding community facilities and amenities. By having all of these elements in one area, it supports an economic viability, but also, it benefits the environment by reducing the impact of transportation. Further research will be needed in order to design around transport hubs, which will allow closer commute to public transportation.

It is very important to prevent congestion and wasted time while commuting. There has been an increase of private vehicle transportation which causes traffic and carbon monoxide into the environment. Besides having renewable energy, a key element for a successful sustainable design is the movement and *transport systems*. This will not only reduce the congestion, pollution and energy use, but it will allow the community (mixed-use building) to have a sense of connection within.

Further information on transportation systems is not needed because that is not the main focus. The main focus is designing for self-efficiency within the mixed-use building. Full surveys and assessments on transportation will be conducted by civil engineers. In order for a project with this stature to move forward, architects will have to work with civil engineers for a thorough analysis.

The next component for controlling the built environment for a better sustainable design (self-efficiency) is the *materials of construction*. It is very important when choosing the building materials and the sourcing of them when relating to the environmental and energy impacts. Having appropriate strategies and controls for development will create better judgment when choosing materials. Also, having policies can influence the methods of manufacture and encourage prefabricated construction off-site as a means of improving efficiency, reducing waste, and increasing recycling through design for future disassembly.[55]

When developing policies, an assessment should be done of the environmental impact of techniques for extraction or production and minimizing the transportation of

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[55] Pitts, page 67.

materials and other resources.[56] A good example of this assessment is Leadership in Energy and Environmental Design (LEED), further explanation can be read in Chapter 4. Through this assessment, estimation should be made on the impact of the in-use energy consumption when choosing the materials, and also materials with toxic pollutants should be avoided. When assessing the impact of materials, environmental rating systems should be made. This will inform policy decisions and to encourage better design judgments.[57]

To continue on with better design judgments for sustainability, *landscaping techniques* around the mixed-use building is clearly as important. It is difficult to know how much energy will be conserved and what the benefits are throughout the building, but it is not difficult to design to optimize solar influences. Designing for the effects of shelter and windbreakers on air movement will help conserve the energy usages. As the design process of the mixed-use building begins, it is important to consider the spaces around the building to prevent unwanted air flow and direct sunlight.

The planting of trees, shrubs, and other flora will not only optimize solar benefits, it will also remove carbon dioxide from the air and generate oxygen. Positioning the landscape feature in the right spaces will give an aesthetic effect and enhance the environmental satisfaction with the mixed-use building. It will also go hand in hand with good energy and environmental policies.[58] Also, the purpose and positioning of landscaping should be focused on so there will be no wasted spaces.

Even though the main focus is providing energy and self-efficiency, there is still the need to consider the human comfort level within the landscape. For instance, it is for those people in the community (mixed-use building) that wants to enjoy the outdoors. So, planting should provide shading where necessary and cooling for the summer heat. Also, it will reduce excessive wind speeds. During the summer heat, trees will provide not only shade, but cooling throughout the day and warmer at night compared to the open surroundings. While designing the landscape, planting trees, shrubs, and other flora are not the only considerations; ponds and other water features will also help satisfy the

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[56] Pitts, page 67.
[57] Pitts, page 67.
[58] Pitts, page 74.

environmental needs. Water features will help with drainage systems and the use of passive water treatment systems such as reed beds.[59] This will help maximize the potential of sustainability towards water waste (which will be talked about further on in the paper). Ponds, fountains, and other water features will also modify local climate through evaporative cooling. The process is called 'adiabatic cooling' where the sensible heat removed from the air equals the latent heat absorbed by the water evaporated as the heat of vaporization.[60]

Another form of passive design is providing *daylighing and shading* throughout the building. When designing around solar radiation, it is important to take advantage of solar access that is available; solar heat gain can be determined. Which, in this case it will be because the building will be designed and built on an artificial landmass. In other words, it will be able to maximize the amount of solar access because there will be no adjacent structure blocking sunlight and natural ventilation. It is important when designing the interior spaces is not hit by direct sunlight; west and south side of the building needs to be shaded. If so, there is the need to design with overhangs or sun shading so that the inner space is comfortable to live, work, or be in; diffused lighting is preferable. Orientation of the building will be important for this matter. At the same time, thermal heat gain needs to be considered.

Natural ventilation and *air flow* are important features to consider for both the external and internal when designing for a passive design. When designing the mixed-use building, because it has a large dimension in size, it should avoid facing the stronger wind direction. Meaning, the long axis should be more parallel to the prevailing wind flow.[61] Flat vertical faces on tall buildings will generate substantial down-droughts and may be harmful to the pedestrian access. To solve this, it is better to have the façade either staggered or stepped back away from the strong winds and also incorporating canopies and podiums at the ground level. But, in this design, experimentation to create an innovative way to incorporate air flow to function as a cooling method will be

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[59] Pitts, page 75.
[60] Smith, page 33.
[61] Pitts, page 77.

conducted. Allowing natural ventilation into the building to keep the interior and exterior cool will help lower the energy usage for air conditioning.

The next focus on controlling the built environment with a passive design is the *water and waste* systems. There is the need to apply water storage and treatment either on site or within the building and have an active monitoring of consumption through metering. Low water consumption toilet flushes, spray taps, and other water-conserving appliances will help control the water usages throughout the building. Besides water waste, solid waste collection and disposal systems need to be appropriately stored and recycled. When applying these appliances, it is important to communicate these devices with the developer, client, and occupants so they can function properly.

The focus on this section is to control the built environment with a passive design that is climate sensitive. It is designed to reduce the impact on global climate and the earth's resources. It is appropriate to design building forms which includes location, size and type of openings in the building envelope to exploit advantageous solar heat gain. The thickness of insulation and thermal mass should also be incorporated to conserve the energy load. Internal spaces should be designed and adapted to the climate. The mixed-use building should be oriented properly so that the interior spaces with specific functions are located adjacent to the appropriate façade. Also designing buffer zones for the upper levels; roof gardens, balconies, atria, courtyards, verandas and arcades will enhance the passive design. This will help with noise, ventilation, unwanted sunlight, and cooling.

These are the necessary features to prevent unnecessary energy waste and at the same time provide a cleaner, green environment to live, work, and be active in. Understanding the links between operation and the degree of integration will help achieve the full benefits. The goal with controlling the built environment is to design effectively *autonomous* – the flows of energy and other resources are balanced and this building will be designed to make net resource contributions.[62] These design considerations will also help create a self-efficient building.

[62] Pitts, page 78.

3.4 Types of Renewable Resources

In this section, the discussion is about renewable energy being the source of a better quality of life and how they function. What does renewable energy exactly mean? Renewable energy is any system, method, or technology that heavily relies on an energy source that is regenerated over a short period of time that is from natural occurrences, i.e. sun, wind, water, etc. In other words, renewable energy is derived from resources that can never be used up or harmful to the environment. These renewable resources are solar (photovoltaic panels), wind, tidal, wave, biomass, geothermal, hydropower, and hydrogen fuel cells. There are specific ones that will be incorporated throughout the mixed-use building that will be designed, and they are: solar (photovoltaic panels), wind, wave and tidal, hydrothermal cooling, and hydrogen fuel cells.

The purpose of moving towards renewable energy is to take away or try to minimize the use of fossil-fuel-based energy use. Buildings consume about 40% to 50% of primary energy when creating acceptable and comfortable indoor environments. In order to maintain or even lower this rate down, planning and designing is important for the overall use. In the past, buildings were seen as energy and resource consumers, but now they are seen as an opportunity. An opportunity to create energy, an opportunity to make net contributions for resource, and most importantly an opportunity to design to reduce energy demand. There is a strong confidence that the renewable energies will be sufficient enough to provide energy for the self-efficient mixed-use building in the context of Hawai'i.

3.41 Solar Energy – Photovoltaic Systems

It is foreseeable that solar thermal will provide most of the renewable energy needed in the near future. In fact, solar radiation is by far the largest potential renewable resource compared to wind and water. For instance, if 1% of the earth's deserts were covered with solar thermal plants it would have provided energy for the world during the year 2000.[63]

[63] Smith, page 15.

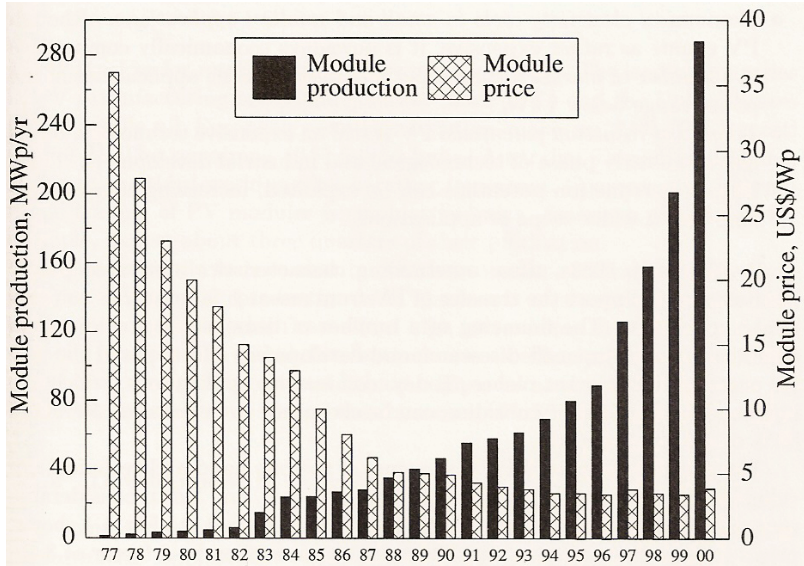

Figure 3.41.1 – Annual development of PV.[64]

Solar energy relies on the nuclear fusion of the sun. When sunlight hits the panels it is collected and converted in a few different ways. It either heats up water for domestic use or it can be converted to provide electricity (photovoltaic panels), as well as provide heating and cooling throughout a building. In this section, the primary focus will be on photovoltaic cells as a conductor of electricity for the mixed-use building that will be designed. This is one of the renewable energy that will provide power to the building in order to become self-efficient.

Photovoltaic modules have the ability to supply energy over a wide power range from mW for small appliances, such as: watches or calculators to kW systems for water pumps, and large central photovoltaic power stations in the MW range.[65] Generally speaking, a photovoltaic system is an expensive method of providing electricity. However, the market is growing for this kind of energy technology across the world because of the environmental concerns and the rise of fossil fuels; it's becoming economically viable.

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[64] Bubenzer, page 1.
[65] Achim Bubenzer, *Photovoltaics Guidebook for Decision-Makers,* (New York: Springer-Verlag Berlin Heidelberg, 2003), page 64.

Photovoltaic systems either supply energy directly to electrical equipment or provide energy into the public electricity grid. The different types of PV installations are[66]:

- Off-grid (stand alone) with battery storage.
- Grid-connected ground-mounted, i.e. solar farm.
- Grid-connected roof-mounted, lay-on technology.
- Grid-connected building-integrated.

Both the roof-mounted and building-integrated PV systems provide local, embedded generation. This means the PV systems are providing power to the building as oppose to central generation, which links large power stations through long, high-voltage transmission lines. So, there is a better efficiency rate for both the roof-mounted and building-integrated because there is no loss of power through transmission lines.

Here are some of the reasons why installing PV systems are beneficial[67]:

- Supplying a portion or all of the electrical requirements in the building reduces energy costs.
- The energy generation is within the built environment, this prevents the loss of electricity distribution compared to central generation; no transmission lines are needed.
- Utilizing the spaces on the roof and façade for energy generation.
- Renewable energy contributes to the environmental health.
- Users will be more aware of conserving energy; help reduce energy loads.

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[66] Nicolo Guariento, *Building Integrated Photovoltaics/ A Handbook,* (Switzerland: Birkhauser Verlag AG, 2009), page 10.
[67] Guariento, page 10.

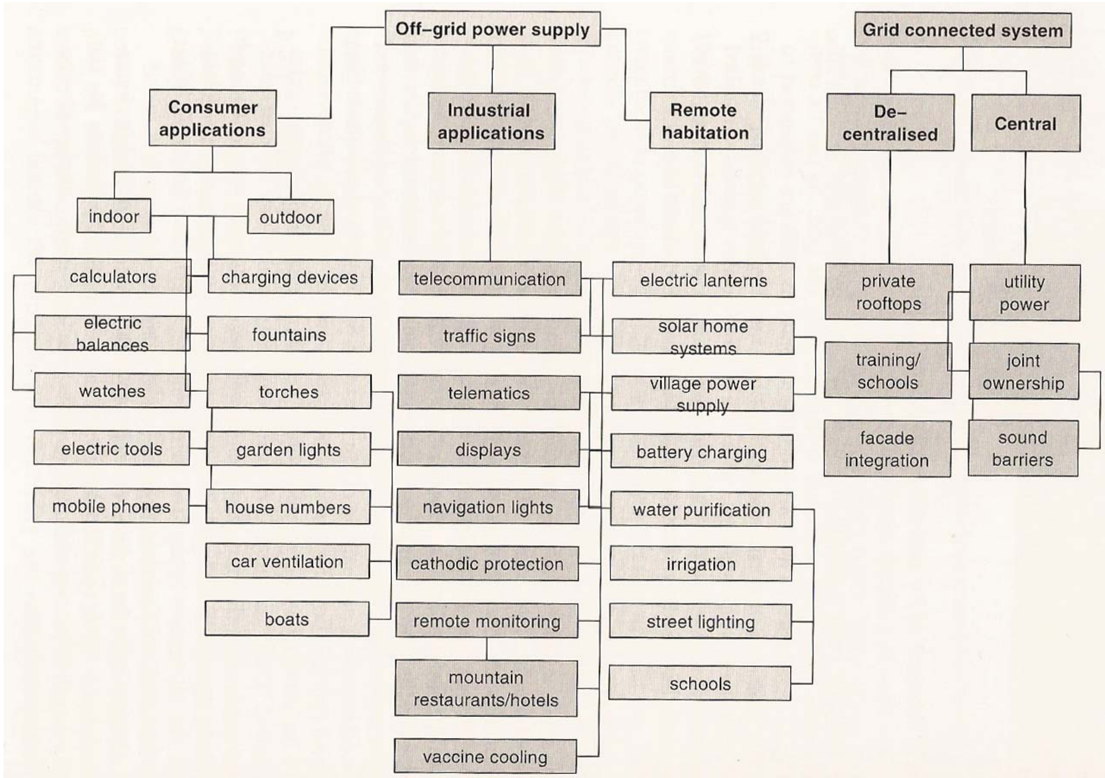

Figure 3.41.1 – Application areas of PV systems.[68]

By incorporating the roof-mounted and building-integrated PV (BIPV) systems, it will enhance the design and help create a self-efficient building. Currently, the BIPV has not hit the market compared to other PV systems. However, when the BIPV system is incorporated throughout the mixed-use building design, it will start a trend in Hawai'i to consider using this type of method when providing energy. When successful, Hawai'i will leave a stamp or create a trademark to other cities and countries that using BIPV is beneficial through providing energy and for its aesthetics.

Designing with BIPV systems will allow the designer to have an alternative to metal cladding or standard curtain walling. Not only will it provide energy, but also enhance the building image. For instance, the BIPV system can be used for shading, rainscreen, double-skin façade, curtain walls, and atria and canopies without disrupting

[68] Bubenzer, page 66.

the design of the building. Refer to Fig. 3.41.2. This will create a statement towards architectural innovation as well as engineering design.[69]

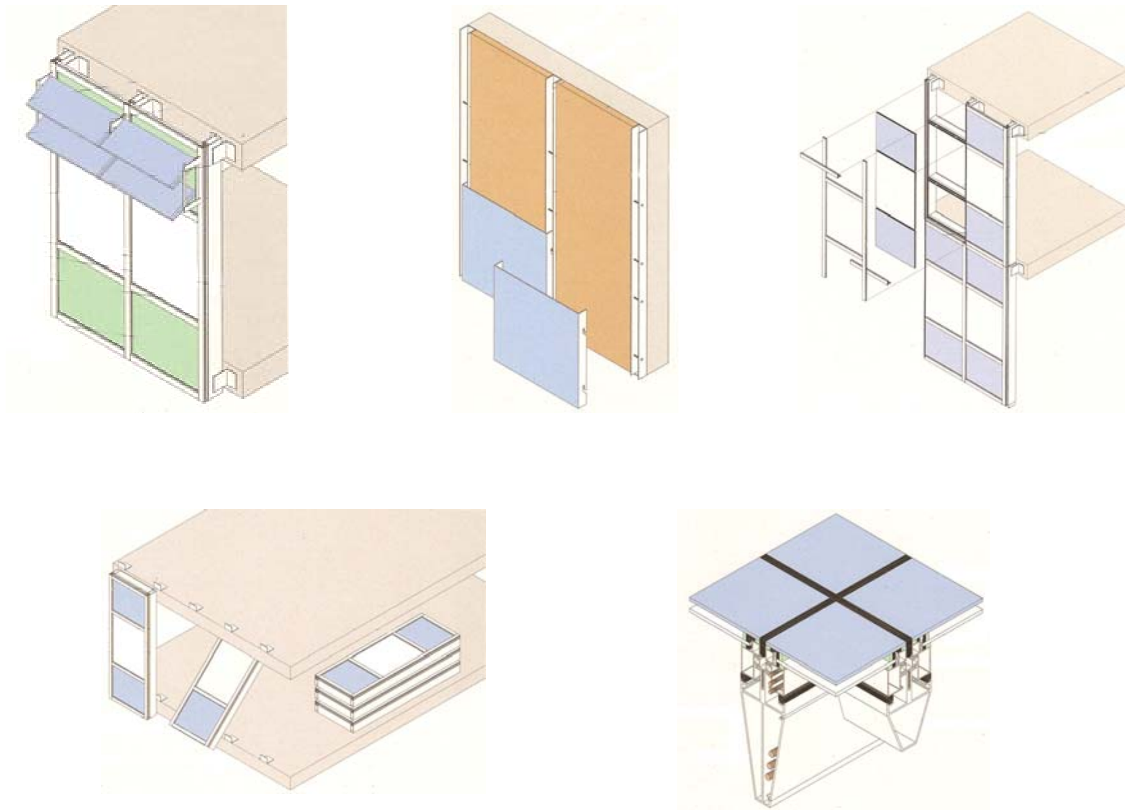

Figure 3.41.2 – Different BIPV systems in detail; also refer to Figure 3.41.3.[70]

When designing for a building-integrated PV system, there are requirements that need to be considered, they are[71]:

- Color, image, size
- Weather-tightness
- Wind loading
- Durability and maintenance
- Safety during construction and in use (fire, electrical, stability)
- Cost

[69] Guariento, page 11.
[70] Guariento, page 62, 70, 89, 100, 132.
[71] Guariento, page 44.

- Area of PV per square feet of occupied space – how much PV panels are needed to power the entire building.

In order to meet the high architectural quality for the BIPV, the Photovoltaic Power Systems Program for IEA defines it as: "Natural integration of PV systems, PV systems that are architecturally pleasing within the context of the building, good material and color composition, PV systems that adapt well to overall modularity, the visual aspect of the grid which is in harmony with the building and creates a satisfactory composition, PV systems that are appropriate to the context of the building and the integration of which is well designed, use of PV that has generated an innovative concept."[72]

The main goal of PV cells is to utilize the solar radiation efficiently. The design approach needs to be oriented towards the sun's path. However, in some cases there will have façades and surfaces that will not get as much solar radiation. The objective is to design with reflective materials so that the sunlight will hit these façades and surfaces and reflect onto the PV cells. If successful, all façades and surfaces will benefit from the solar radiation. Throughout the mixed-use building, there will be a combination of polycrystalline silicon PV cells and high-performance PV cells. The polycrystalline silicon PV cells will be on the façades that gets max sun light, as oppose to the high-performance PV cells that needs to be located on the roof.

Polycrystalline silicon is an alternative way of making silicon PV cells. In comparison to monocrystalline silicon it is less expensive but slightly less efficient. However, there is the trend for larger cells of 8 square inch (21cm x 21cm) for less cost and higher overall module efficiency.[73]

As the research and development continues to improve on the PV systems, the HIT PV cell is one that has a higher performance than the others. HIT PV stands for "heterojunction with intrinsic thin-layer," it is the combination of a crystalline and thin-film silicon cell.[74] What makes it significant is that, it is layered on the front and back sides with amorphous silicon coating. Meaning, there is two structurally different

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[72] Guariento, page 12.
[73] Guariento, page 19.
[74] Guariento, page 21.

semiconductors. It is able to absorb light on the back side just as the same as the front side. These modules are able to be effective on either side to generate at least 10 percent more electricity than the standard PV cells.[75] Refer to Chapter 7 Case Studies.

When this type of PV system is applied in the building application, in order for the back side to absorb ambient or reflected light it needs to have a reflective or white object behind it to achieve maximum gain. In comparison to monofacial cells, the bifacial cells (HIT) transmit more infrared so it benefits from a lower operating temperature.[76] Refer to Fig. 3.41.3; it's a chart of different types of PV cells showing their efficiency rate and the area to power output.

Type	Typical module efficiency	Area requirement
high-performance hybrid silicon (HIT)	17–18%	6–7 m^2/kW_P
monocrystalline silicon	12–15%	7–9 m^2/kW_P
polycrystalline silicon	11–14%	7–10 m^2/kW_P
thin-film CIS	9–11%	9–11 m^2/kW_P
thin-film CdTe	6–8%	12–17 m^2/kW_P
thin-film amorphous silicon	5–7%	14–20 m^2/kW_P

Figure 3.41.3 – PV cell technologies efficiencies.[77]

There are various PV integration opportunities towards various façade systems, and they are[78]:

- Shading
- Rainscreen
- Stick system – lightweight curtain wall
- Unitized curtain walling that is factory-made, preferred for high-rise buildings
- Double-skin façade
- Atria and canopies

[75] Guariento, page 21.
[76] Guariento, page 21.
[77] Guariento, page 21.
[78] Guariento, page 45.

- Glazing systems

Further design research and experimentation is going to be conducted to see which PV integration will be the most effective to achieve self-efficiency of power. Below is an illustration of the different types of PV integration.

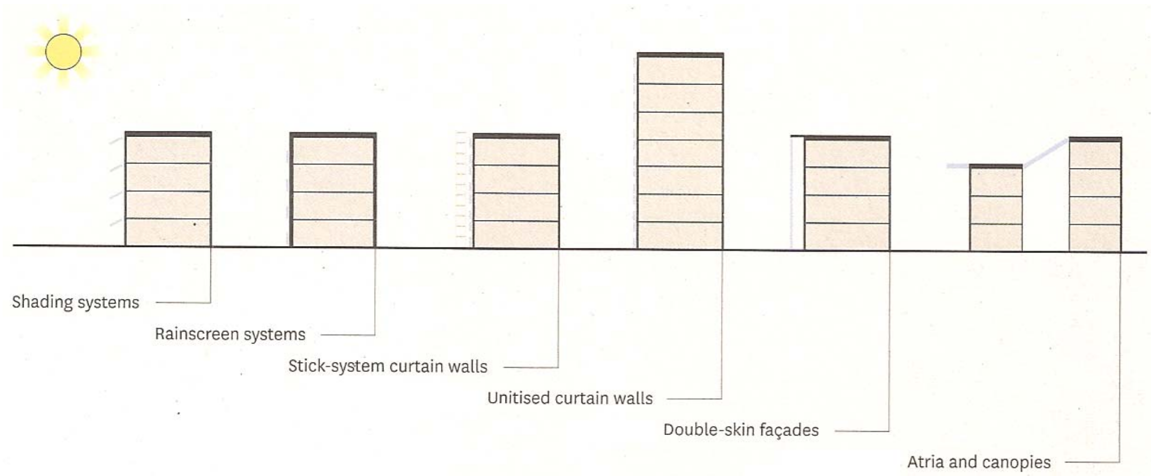

Figure 3.41.3 – PV integration options.[79]

As the designer designs for the best possible photovoltaic system for the building, they also need to consider electrical storage and a control system. This will add to the cost for a complete photovoltaic system. However, using hydrogen fuel cells as the primary energy storage will be beneficial throughout the years (see section 3.45 for further information on hydrogen fuel cells). There is also the cost for the conventional PV applications. These are considered the non-hardware cost and they consist of the system components or balance of system (BOS) components[80]:

- Inverters
- DC wiring and connections
- Controller and operating units
- Mounting structures
- Safety components

[79] Guariento, page 45.
[80] Bubenzer, page 140.

Based on the information above, PV systems are costly to incorporate. However, there are ways to reduce the cost. There is a need to strategies for cheaper power electronics[81]:

- Increase in mass production
- Optimization of generator concept
- Optimization of production (integration)
- Innovative inverter concepts
- Improved operational function and comfort
- Increase of inverter size

As PV systems grow in the global market, Hawai'i should start implementing these renewable systems before they become obsolete. New technologies for the pursuit of higher performance PV's will always be researched and developed. Hawai'i will benefit by keeping ahead of the market. For instance, if Hawai'i creates their own innovative way to incorporate PV systems to gain max efficiency from the sun, soon enough there will be natural energy to further research and develop. Cost of fossil fuels, coal, and oil will no longer be the case. Instead, cost will go to the innovative approaches to incorporate PV systems creating a patent for Hawai'i. These innovative approaches will be experimented and incorporated throughout the mixed-use building.

3.42 Wind Turbines

Imagine a state that can provide 30% of electric energy without damaging the earth. Imagine providing 30% of electric energy for only a one time payment. Believe it or not it already happened in the northern German state, Shleswig-Holstein, also Denmark produced about 20% by using wind power.[82]

Wind turbines have the same function as PV systems; they provide low cost of electricity (COE) and high project net value (NPV). The best part of this is fuel (wind energy) is free as oppose to fossil fuel, coal, or oil. By having the fuel for free the COE dominates the ratio of costs per unit energy, rather than a combination of capital costs,

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[81] Bubenzer, page 145.
[82] Myer Kutz, *Environmentally Conscious Alternative Energy Production,* (New Jersey: John Wiley & Sons, Inc., 2007), page 119.

fuel cost, and thermal efficiency.[83] It is the ability to trade the initial and future cost for the building for energy improvements from new technologies; this is how we move into an efficient technology development and market success. Here is a predicament, pay less upfront but pay more through the buildings life cycle or pay more upfront for no later payments for energy.

When trying to maximize energy production while minimizing cost, it is important in choosing a balanced generator to rotor size. During high-wind speeds operation, larger generator relative to rotor size turbines should be used. As oppose to during low-wind speeds operation, larger rotor for a given generator size turbines should be used. This type of configuration has been proven through economic and design analysis.

Furthermore, the wind turbines need to be designed for the maximum gain within the built environment. However, this is no easy tasks because wind patterns are complex as the air passes over, around, and between buildings. When integrating wind turbines within the built environment it is important to know that it must be able to handle high turbulence caused by buildings. In this case, it would be best to use vertical-axis configuration instead of horizontal-axis. Vertical-axis can operate at a lower wind speed and they are less stressed from building turbulence, as oppose to horizontal-axis that transmit vibrations to the building structure.[84] This is caused by the bending moment by the tower under wind load. Using the vertical-axis wind turbines may be more beneficial because they can be sited on roofs or walls.

The vertical-axis wind turbines are well balanced that it transmits a minimum vibration and bending stress to walls or roofs.[85] Also, it has a high output power-to-weight ratio. Another advantage is it can be located within the envelope of the building because of the location of the electricity generator is located beneath the rotors. Meaning, the loss of energy through transmission lines is reduced.

When designing for self-efficiency for energy, it is always smart to have both wind turbines and PV systems. During the night hours when the PV systems are no

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[83] Kutz, page 119.
[84] Smith, page 53.
[85] Smith, page 53.

longer functioning, the wind turbines continue to generate power. The building/s will have a consist flow for producing energy.

So far it has only been the positive view on wind turbines. There are negative features of having wind turbines integrated within the building[86]:

- the necessity of a high mast
- if mounted on buildings, they require substantial foundation support
- noise problems (vertical-axis turbines are discrete and silent)
- they can be visually intrusive

The design process needs to include experimentations of wind turbines with PV systems in order to create various methods of how to integrate both systems in the building for an innovative way. At the same time, the design needs to solve the negative features of the wind turbines. An innovative approach is to design the wind turbines in a helicopter position so it will be integrated with the floor plates. Another approach is to have the wind turbines designed with the parking lot structure. This way it will save additional use of space, the noise will not affect the building users, and it can have the foundation support. Further investigation is needed when designing with wind turbines to achieve a self-efficient building. If successful, this will lead to a better understanding of how wind turbines and PV systems can function effectively and efficiently together in the context of Hawai'i.

3.43 Wave and Tidal Turbines

Wave power is another form of solar energy because heat from solar radiation creates wind and wind generates wave. Waves have the ability to create solar energy with an energy density of 100kW per meter length of wave crest.[87] According to the World Energy Council, wave power could meet 10% of the world's electricity demand. If, at its full potential, it has the capability of achieving 25% or about 12GW of peak demand; note, this is based off of the UK demand.[88] However, looking at reasonable

[86] Smith, page 55.
[87] Smith, page 114.
[88] Smith, page 114.

estimations, with a load factor of 50% for wave power it still has the ability to output about 6GW.

The sea is a huge mass-spring that has a steady movement of water. During high seas, an average wave length is about 120m which carries roughly 100kW/m of energy that can be captured through various technologies. The advantage of water power is the fact that the ocean will always be there.

The favored water power system is the horizontal-axis underwater turbines for offshore tidal currents. The underwater turbines function the same way as wind turbines but the density of water is four times greater than air, meaning if the rotor is 10m in diameter it will generate as much power as a wind turbine of 40m in diameter.[89] These underwater turbines operate at a minimum tidal velocity of about 2m/second. Since the tidal flow is relatively constant, less force is needed to rotate as oppose to wind turbines.

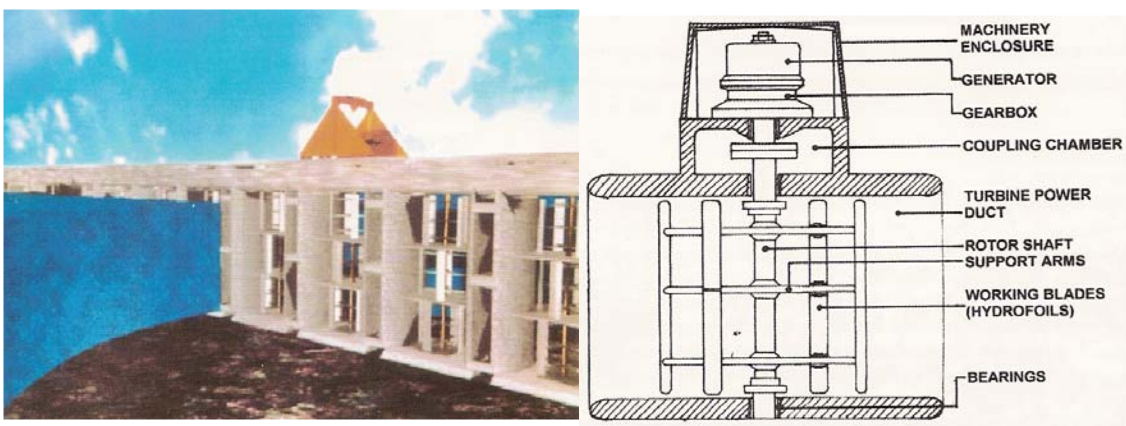

Figure 3.43.1 – Tidal fence under water vertical axis turbines[90]

The fact that tidal energy produces large burst of energy at regular intermittent intervals creates a problem towards the grid and for the generator if peak output coincides below the market prices. Denmark had faced this problem where there was no demand for the excess power, so it had to export to Norway and Sweden below the market price. However, with technology advancing there is a solution for this.

[89] Smith, page 122-123.
[90] Smith, page 123.

One way is to use hydrogen and the other is the Redox Flow Battery. Through the process of electrolysis of water, it turns the hydrogen into fuel cell stack, which then can deliver energy at the peak of the price curve (refer to Section 3.44 Hydrogen Fuel Cells for more information). As for the battery method, it has the capability to store multi-megawatt hours of electricity. There are twin cisterns containing electrolyte, one collects electricity as the other releases on demand.[91] Currently, these methods are economically unreasonable, but as they become more efficient and more demanded the prices will decline.

This form of renewable generator will not be incorporated into the mixed-use building because of some restrictions; sea level depth of the site is not efficient enough to incorporate this system. However, it is important to mention this because it can be used for future purposes. There is always room for future expansion and technology when needed.

3.44 Hydrogen and Fuel Cells

Imagine a world that has an unlimited supply of energy with no pollutants. This is what hydrogen can provide. Hydrogen can be produced from water or from any hydrocarbon fuel. Similar to electricity, it carriers energy that is produced from other sources and delivers it in the form of power and heat. The only difference between the two is that, hydrogen is a lot easier to store than electricity. "Hydrogen is a good alternative to fossil fuels for the production, distribution, and storage of energy."[92] If hydrogen technology continues to advance, it will be able to provide our energy needs through renewable resources like wind power and solar energy.

The shift towards a hydrogen economy has already begun. Looking in the past, we can see a trend of movements, from wood fuel to coal, then to oil, and now to natural gas. This movement is shifting for a carbon free environment, and the best solution for it is hydrogen. In order for hydrogen to be successful, automotive industry, oil companies, and utilities as well as government funding needs to play a significant roll.

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[91] Smith, page 125.
[92] Kutz, page 165.

The great aspect of hydrogen is that it can be produced from any source, especially from renewable resources. Vijay Vaitheeswaran states: "The beauty of the hydrogen model is that it is not wedded to any specific primary energy source or technology."[93] Hydrogen is also able to be phased into the existing energy systems with little or no disruption to any particular locale or economy.[94] For example: in a sunny desert, hydrogen can be produced from solar energy, while in areas that are coal based, hydrogen can be produced from gasified coal.

As stated earlier, hydrogen and electricity complements each other, in other words, they work well together. Electricity can produce hydrogen as well as hydrogen can produce electricity. So, in a world of hydrogen and electricity, if one needs to be substituted for any reason, the other can easily fill in that roll for providing energy. However, the more efficient way of using them is, when electricity is generated from any of the renewable energy, hydrogen would store and deliver it.

There are different storage technologies for hydrogen[95]:

- High-pressure tanks
- Cryogenic storage
- Metal hydrides
- Chemical hydrides
- High surface absorbents, such as nanostructured carbon-based materials.

Hydrogen will not only serve as a storage feature, but as a backup to the grid. The power that is generated from wind turbines and photovoltaic cells can be used to make hydrogen. As a backup, hydrogen can also be reconverted into electricity and sold to the grid if the grid has reached its maximum capacity and needs more power. Hydrogen is flexible in many ways, it would also serve to smooth out the daily and seasonal fluctuations of solar and wind power.[96]

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[93] Vijay Vaitheeswaran, *Power to the People: How the Coming Energy Revolution Will Transform an Industry, Change Our Lives, and Maybe Even Save the Planet* (New York: Farrar, Straus and Giroux, 2003), page 4.
[94] Rebecca L. Busby, *Hydrogen and FUEL CELLS: A Comprehensive Guide* (Oklahoma: PennWell Corporation, 2005), page 4.
[95] Kutz, page 174.
[96] Busby, page 8.

As technology advances, soon hydrogen will be utilized to fuel vehicles and aircrafts, and be the main source to provide power to homes and offices. Hydrogen has the potential to power vehicles, running turbines or fuel cells to produce electricity, and co-generating heat and electricity for buildings.[97]

Fuel cells could play a critical role for providing energy on demand. Fuel cells act as batteries that produce electricity. In order for the fuel cells to function properly or at all, it needs to have fuel (hydrogen) and oxygen.

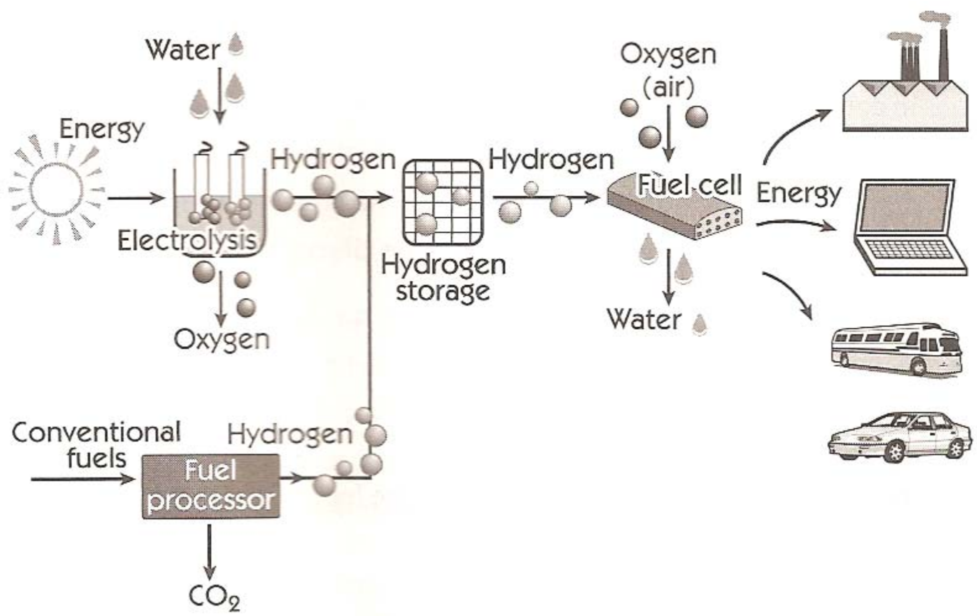

Figure 3.44.1 – Hydrogen economy diagram.[98]

Fuel cells are now gaining a great deal of attention as clean energy converters for producing electricity to consumers and providing energy for electronic vehicles. The reason why it is receiving a great deal of attention is because of the potential for high fuel-to-electricity conversion efficiencies and fuel cells are fueled with hydrogen that only emits water and waste heat.[99] Other beneficial advantages that fuel cells have are the potential for low maintenance, high reliability, and low noise levels. Another

[97] Kutz, page 191.
[98] Busby, page 11.
[99] Kutz, page 193.

advantage is fuel cells are modularly designed; they are able to connect with other fuel cells easily if needed.

The different types of fuel cells are:

- Polymer electrolyte membrane (or proton exchange membrane
- Phosphoric acid
- Solid oxide
- Alkaline
- Molten carbonate

Below is a summary of each fuel type.

Fuel cell type	Temp. range	Efficiency*	Electrolyte	Capacities	Primary application	Notes
Polymer electrolyte or proton exchange membrane	<100°C (<212°F)	50–60%	Polymer membrane (thin plastic film)	100 W to 250 kW per cell	Transportation, stationary	Fast startup, high power density, rapid response to power demand, relatively rugged
Phosphoric acid	160°–220°C (320–430°F)	37–55%; up to 72–80% with heat recovery	Concentrated phosphoric acid	25–250 kW per cell	Stationary	Fuel of choice is natural gas
Solid oxide	800°–1,000°C (1,500–1,800°F)	45–65%; up to 70–85% with heat recovery	Solid nonporous ceramic materials	200 W per cell; 300 kW to 3 MW per module	Stationary, utility	Typically applied in stacks of hundreds; a plant might produce up to 10 MW
Alkaline	23°–250°C (70–482°F)	50–60%	Potassium hydroxide solution (35–50% KOH)	2.2 kW	Spacecraft	Being developed for other applications
Molten carbonate	650°–660°C (1,200°F)	45–60%; 70–85% with heat recovery	Melted carbonate salt mixture	250 kW to >1 MW	Stationary, utility	Corrosive electrolyte limits durability

*Without recovery of cogenerated heat, unless otherwise noted.

Figure 3.44.2 – A chart of fuel cell technologies[100]

Electrolysis is the link between renewable energy and useable fuels. Energy from the sun, wind, and other renewable sources needs to be converted into chemical energy for providing energy to vehicles and stationary use. In order for hydrogen to use and

[100] Busby, page 102.

store the generated energy from the renewable resources, it must go through the process of electrolysis, water splitting – electrolytes are liquids or solids that channel charged particles inside the cell.[101]

According to Myer Kutz in *Environmentally Conscious: Alternative Energy Production*, he states when working with hydrogen, there are certain precautions to take:[102]

- Hydrogen should not be mixed with air.
- Contact of hydrogen with potential ignition sources should be prevented.
- Purging hydrogen systems should be performed with an inert gas such as nitrogen
- Venting hydrogen should be done according to standards and regulation.
- Due to the hydrogen flame being invisible, special flame detectors are required.

As of now, distribution cost and hydrogen production costs are not feasible prices. Currently, scientist and researchers are finding ways to produce hydrogen in a cost-effective way. Once this is solved, the future will be more of a hydrogen economy. Hydrogen and fuel cells will become more involved with providing and storing energy from the renewable energy systems.

[101] Busby, page 13.
[102] Kutz, page 198.

CHAPTER 4

BENEFITS OF BEING SELF-EFFICIENT ECONOMICALLY

4.1 Economic Benefits

4.2 Social Benefits

This chapter is about how to profit from being sustainable and self-efficient. We know that this world is based on generating money and figuring out the methods of saving money. There are other ways to benefit from being self-efficient whether it's generating energy, which is the most expensive aspect of a building, to the comfort level throughout the building, and how it fits to social and cultural issues. However, it is the economic and financial case that is the most convincing for a client to incorporate renewable energy. Of course, economic issues can be made possible with the help of the government. The government needs to aid the advance of sustainable design and development. Besides the governmental aid, there is also performance and encouragement that is needed from the general public to design for sustainability.

When incorporating renewable resources, it is important to note that payback (profits) should be considered over a medium to long timescale. Profitable sustainability will not start occurring over some period of time. *How long?* It depends on certain factors, for example: the market prices on renewable energy can and may fluctuate. Importantly, in order to reveal the full benefits of sustainability, the information and actions at different scales and different levels of responsibility should be integrated to give a full idea.[103] Nevertheless, designing for sustainability has benefits.

4.1 Economic Benefits

We can assume when talking about sustainability, client's have the false impression that cost will be high. For instance, designing for sustainability cost significantly more to design and construct, and the only savings are reductions in energy consumption; in actuality current prices are a small fraction of total running costs.[104] It can be contradicted that design and construction with their associated infrastructure does not necessarily cost more and it may reduce cost options when designing for sustainability. Also, not only will a sustainable design lower energy costs but even lower the running costs across many facets of operations; this may account for a better profit.[105]

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[103] Pitts, page 100.
[104] Pitts, page 100.
[105] Pitts, page 100.

According to Adrian Pitts in his book, *Planning and Design Strategies for Sustainability and Profit*[106], he states several ways in which lower running costs result when designing for sustainability:

- They are more energy efficient and have lower energy costs.
- The size and types of building services systems installed are usually smaller and less complex, resulting in lower capital and maintenance costs.
- The design of the building in a sustainable way, with more focus on structure and fabric, leads to a building that can be more robust in operation and flexible in use, offering more efficient utilization.
- Well-designed building has higher standards of construction and generally the fabric requires less maintenance and refurbishment.
- There are many hidden long-term benefits in terms of the improvements in the built environment that are not often included in analysis.

The reason why cost seems to be high when incorporating renewable energy is because the initial or capital costs of development is compared with longer-term running costs, and these are taken into account by those in the building development.[107] While doing the cost analysis, it is often seen that sustainability must compete with other cost decisions based on future impacts, and in such a way the cost, the interest, and the discount rates are taken into effect. However, these assumptions can be argued when investing in sustainability. Prediction on future energy and environmental costs cannot be accurately analyzed and it goes the same for the length of sustainability issues and activities. It must be thoroughly analyzed through time. Although, capital cost savings can be done through more efficient use of resources. For example: lower purchase costs and lower costs of waste disposal.

Initiatives have already been taken into action; the UK government along with the Building Research Establishment is researching the business benefits of sustainable construction.[108] They have found through numerous case studies that improvements in

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[106] Pitts, page 100-101.
[107] Pitts, page 101.
[108] Pitts, page 101.

performance through energy efficiency shows there are no significant additional cost. In order for this to happen, action and decision must be at the early stages.

Another group that is taking initiative with its Sustainable Economy Program is the Forum for the Future. They have gathered enough facts that resulted in a positive outcome when actions have been taken and also in environmental, social, and economic benefits. One building project had a savings of around $298,000 in environmental costs because of the materials reuse minimized waste management to reducing landfill taxes.[109] Other projects and companies started to implement waste management to avoid the confrontation of future environmental issues; such as, focusing more on waste streams and better judgments when choosing suppliers. Another method was to incorporate better management process in other areas and reduce wasted time; working hours are more efficiently done. Now, financial institutions are seriously considering environmental issues.

When talking about materials and waste management, one example is the City of Melbourne. In 1999, the city enacted an Environmental Local Law which incorporated the city's Environmental Management Plan (EMP) to set out requirements for properties in the city, and their owners and occupiers to consider waste disposal and environmental practices. The goal was to provide safer and cleaner environment through land efficiency and disposing waste appropriately. A checklist was formulated as a guideline for the private and public use to ensure they will comply with the plan and also it explained the importance of the environmental policies.

Besides benefiting from materials and waste management, sustainability accounting should be considered throughout the construction sector in order to gain benefits. It is used as a tool to identify, evaluate, and manage environmental and social risks. In detail, it acknowledges resource efficiency and cost savings to improve social and environmental issues with financial opportunities. The process also incorporates performance assessment and benchmarking for best practice. An example of this process was done through a hospital project in Swindon; the construction company generated in savings over $2.6 million through the use of energy-efficient design features. The design

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[109] Pitts, page 101.

features consisted of an efficient use of wall and floor construction resources. The financial assessment for the hospital project considered a payback over a long timescale, 27 years to be exact, and not just the initial construction costs. Stated earlier in this section, pay back of benefits needs to be considered over a period of time.

Mainly focusing on the commercial aspect, it is highly important that while designing for sustainability, the work-force needs to be efficient. Besides the benefits of money saved and money generated from design and construction, companies also consider their greatest asset and their greatest cost to be their employees. It is proven when a well designed sustainable building is built, productivity increased and the absence of employees decreased. The ING Bank is a good example of this dramatic change. It had a 15% decrease of absent employees when it was moved to a different building in Amsterdam. The new building incorporated both sustainable and high environmental qualities.

Not only will sustainable design offer monetary benefits, but it also offers other advantages. In the commercial aspect, it offers employee satisfaction. However, this does not only relate to the commercial side, but all aspects. The impact of comfort level between guests, employees, and user needs to be all considered. This is important because the end product is a mixed-use building which will incorporate retail, commercial, and residential usages. If the indoor environment is satisfactory, it creates a marketability aspect. Selling spaces will be much easier; this leads into the next beneficial aspect of designing for sustainability.

It is more often seen that clients want to achieve LEED certification on their projects. The Leadership in Energy and Environmental Design (LEED) rating system is in conjunction with the Green Building Council. It was originally designed for commercial buildings; the aim was to provide a US national standard for what a green building should be. The intention of LEED is to provide design guidelines in combination with a third-party certification procedure.[110] In November 2002, the 2.1 version was released that included an assessment for commercial renovation projects, high-rise residential buildings, and standards for new commercial designs. Since then, it

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[110] Pitts, page 89.

has been updated. The adjustments were made to include office buildings, government buildings, recreational facilities, and manufacturing plants and laboratories.

LEED is based on a point's award system; the maximum achievable points are 69. All but one category is awarded as a single credit, meaning each category is worth a single point. The only category that allows more than a single credit is under the energy and atmosphere. In addition to the awardable points for each category, there are some that have prerequisites that needs to be satisfied. The points are awarded under six categories:

1. Sustainable Sites (14 possible points)
2. Water Efficiency (5 possible points)
3. Energy and Atmosphere (17 possible points)
4. Materials and Resources (13 possible points)
5. Indoor Environmental Quality (15 possible points)
6. Innovation and Design Process (5 possible points)

The awards are set as: certified, 26-32 points; silver, 33-38 points, gold, 39-51; and platinum, 52-69 points.

The question becomes how this benefits the client. It benefits the client in many ways, but here is one example of how it benefits. The Green Building Division of the Council develops green building policies for city facilities and city-funded projects. Furthermore, it provides awards, incentives and grants, design and construction advice, workshops and resource information for both residential and commercial sectors.[111] In 1999, the City Council's in Portland adopted the Green Building Initiative; the *G/Rated* (green rated) building.

A Commercial Incentive Program that is under the G/Rated banner encouraged design and construction of green buildings. The main purpose was to support and provide funding for additional costs of professional consultancy and advice services that would create a better built environment that would respond to environmental qualities. Portland took advantage of the incentives. There are two schemes in operation: the

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[111] Pitts, page 168.

Portland LEED Track and the Innovation Track.[112] The eligible groups were: owners and developers of commercial, institutional, and mixed-use projects in Portland. The monetary benefits/awards for the Portland LEED Track were broken down to $15,000 for meeting the Portland LEED *certified* rating and up to $20,000 for those projects achieving *silver* rating.[113] As for the Innovation Track, there main focus was on the use of emerging and transferable green technologies and up to $5,000 can be awarded.[114] After this scheme was created, many projects benefitted from it.

Another way that LEED can benefit the client is through public publishing and getting recognized. Nowadays the building trend is shifting over to green buildings, so being LEED certified will allow the client's building spaces be more marketable. For example, take an old rustic car and add a high quality stereo system; the value of the car has just gone up. The same goes for having a LEED certification on the building. An example of being recognized for good environmental quality design is the Jean Vollum Natural Capital Center in Portland. The project is a $12 million redevelopment of an 1895 warehouse building. In the 2.0 version of LEED certification, it was awarded the gold standard; 41 points out of 69. Besides being successful in the assessment grades, it was also known to revitalize its role and as a piece of architecture. The President of the US Green Building Council describes it as a 'landmark of national significance'.[115]

The problem is there are too many impatient and misguided clients. They want the turnaround of renewable energy to be quick instead of a long period of time. This is the reason for our earth's resource depletion. I have stated and gave case studies of how beneficial it is to design for sustainability. Private organizations need the help of the government, extra funding or incentives should be offered to push for sustainability. Especially for Hawai'i, we are small in size and mainly rely on tourism for income. Referring back to the focus on self-efficiency, there are beneficial impacts out there that would allow the project to be interesting to the public and have a positive impact. Having a mixed-use building that is self-efficient is economically beneficial.

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[112] Pitts, page 169.
[113] Pitts, page 169.
[114] Pitts, page 169.
[115] Pitts, page 170.

On a positive note, Hawai'i has already started with commercial tax credits. If a business in Hawai'i incorporates a solar system, 86% of the cost is offset by tax credits and incentives, and also the return of the investments is as quick as 3 years.[116] According to the business Rising Sun Solar + Electric, the financial incentives for a business in Hawai'i that goes to Solar Electric are[117]:

- 30% Federal Business Energy Tax Credit.
- 35% State of Hawai'i Energy Conservation Tax Credit.
- Federal and State Accelerated Depreciation.
- Energy Savings.

4.2 Social Benefits

By having the mixed-use building self-efficient does not only mean providing energy. The concept of a mixed-use building is gathering specific features into one central location; meaning, less traffic congestion means less carbon monoxide emissions into the atmosphere. This allows for cleaner, safer, and more pleasant environment to be in. Mixed-use building also prevents from increasing the development cost and urban sprawl, expanding into the countryside, in the case of Hawai'i, preventing from building over green areas. It is the necessary resources that a community of living organism's needs to function properly. The mixed-use building is socially beneficial by having sleeping quarters, offices, stores, restaurants, and luxury amenities in one area where traveling will not take up most of the day. It allows an interrelationship between the guests (visiting professors, workers from other cities, and etc.) to the working class to tourist.

The last area that benefits may occur is the image of the mixed-use building. Buildings itself create symbols of attitudes and attributes amongst the occupants, and the image of the environmental design is strong. This leads to creating a strong perception of design quality and interest in sustainability. Which will eventually change the future of more positively viewed public and other organizations when choices are made about

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[116] Rising Sun Solar + Electric, *Commercial Tax Credits,* http://www.risingsunsolar.com/commercial.php (Nov. 14, 2009).

[117] http://www.risingsunsolar.com/commercial.php.

spending, investing, and other activities. In shorter terms, a good sustainable design has the ability to create a more desirable marketability that is worth pursuing.

Sustainable design has the potential of being profitable if the correct measures are taken into account. Having a sustainable design will not only profit the client, employees, and users, it will develop a cleaner and safer environment to be in. All of us are profiting environmentally and financially. In honesty, it is easy and cheap to design for sustainability, but why not see what other successful projects that was sustainable and use that approach as a guide to improve on. There are projects that employed new technologies, tried and tested design and construction approaches. It is a start to start implementing cleaner and a better built environment. It is a fact that self-efficient will benefit everyone and now is the time to start creating innovative ways to show the public.

CHAPTER 5

DESCRIPTION OF THE SITE

5.1 Climatic Data of Hawai'i

5.2 Coastal Data of the Site

5.3 Purpose of the Site Location

5.4 Site Analysis in an Ecological Approach

5.5 Alternative Sites (Matrix): 'Brownfields'

5.6 Artificial Landmass

5.1 Climatic Data of Hawai'i

The climate of Hawai'i moderately changes throughout the year. The temperature change in Hawai'i only occurs during the summer season to the winter season. The reason for this is due to the year-round warm sea surface temperatures. It also keeps the overlaying atmosphere warm as well. As stated above, Hawai'i only experiences two seasons: summer and winter. The summer season is from May to October and the winter season is from November to April. The average daytime summer temperature at sea level is 78°F, during the nighttime at sea level it falls around 10°F.[118] Hawai'i also consists of different weather patterns that create different climate zones at various elevations because of the volcanic mountains.

In Honolulu, during the summer season the daytime high temperature ranges from 85 to 87°F (29.4 to 30.6°C).[119] During the winter season, daytime high temperature ranges from 70 to 74°F (21.1 to 23.3°C), and at nighttime lows from 65 to 69°F (18.3 to 20.6°C).[120]

Average Temperatures – O'ahu: (Salmon, *Architectural Design for Tropical Regions)*[121]

	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
(C)	**22.7**	**22.7**	**23.3**	**24.1**	**25.0**	**26.1**	**26.6**	**27.7**	**29.4**	**26.0**	**24.9**	**23.3**
(F)	**73.0**	**73.0**	**74.0**	**75.5**	**77.0**	**79.0**	**80.0**	**82.0**	**85.0**	**79.0**	**77.0**	**74.0**

Honolulu, Hawai'i has a 50 to 60% daily humidity factor, which is much less than Hong Kong and Havana who all shares the Tropic of Cancer.[122]

Hawai'i's temperature stays moderate because of the trade winds throughout the year. These breezes that are prevailing from the northeastern side of the island of O'ahu are referred to windward. Hawai'i in general is affected primarily by high-pressure zones in the North Pacific that pump relatively cool, moist trade winds down onto the islands'

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[118] Cleveland Salmon, *Architectural Design for Tropical Regions* (New York: John Wiley & Sons, Inc., 1999), page 51.
[119] Salmon, page 53.
[120] Salmon, page 53.
[121] Salmon, page 53.
[122] Salmon, page 54.

northeastern slopes.[123] Due to the mountain slopes, these winds are forced upward where their moisture condenses into clouds that produce rain.

The other type of wind that Hawai'i experience once or twice a year is called Kona winds. This type of wind brings in stormy or hot, sticky weather. A Kona storm develops west of the Hawaiian Islands, and as they move east they draw winds up from the south. When these winds occur, they damage crops and real estate. Kona winds are unpredictable; they may last for a day, few days, weeks, or sometimes they do not arrive.

Average Rainfall – O'ahu: (Salmon, *Architectural Design for Tropical Regions)*[124]

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
(mm)	86.4	66.0	71.1	33.0	25.4	4.1	15.2	15.2	17.8	50.8	66.0	88.9
(in)	3.4	2.6	2.8	1.3	1.0	0.4	0.6	0.6	0.7	2.0	2.6	3.5

5.2 Coastal Data of the Site

Tides and Currents:

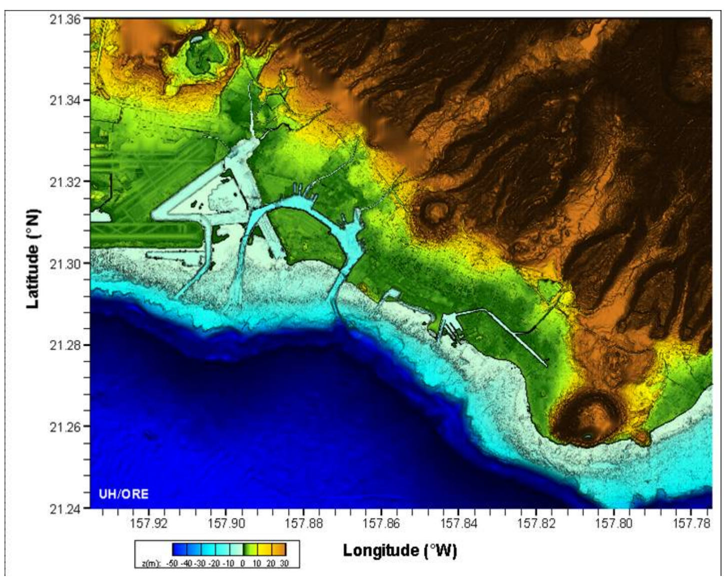

Figure 5.22 – Bathymetry Image of Honolulu[125]

[123] Salmon, page 54.
[124] Salmon, page 55.

Average Seasonal Cycle for Honolulu

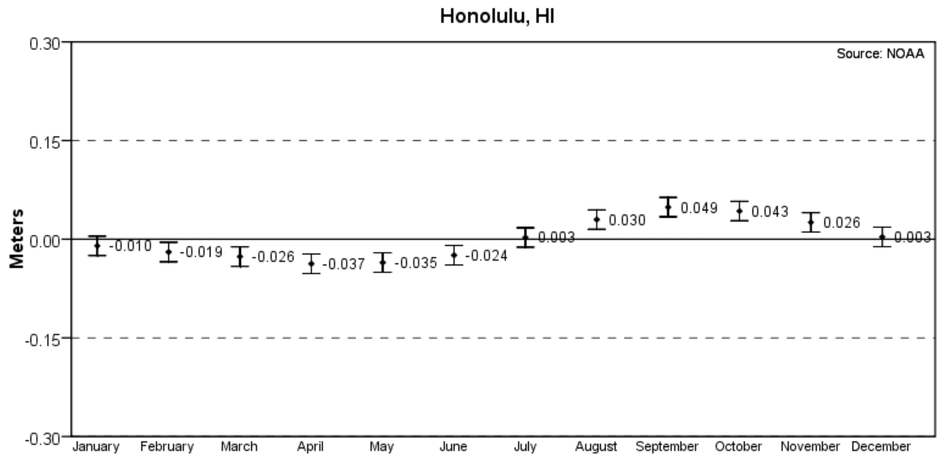

Figure 5.23 – Average Sea Level in meters[126]

Mean Lower Low Water (MLLW)

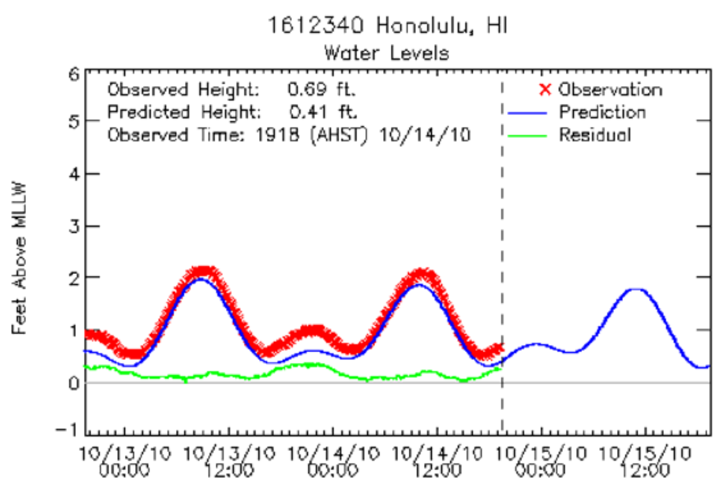

Figure 5.24 – Water Levels between Oct. 13 – Oct. 15, 2010[127]

According to the National Oceanic and Atmospheric Administration for Honolulu:[128] Monthly Average Mean Tide Level: 0.80 feet – the arithmetic of mean high water and mean low water.

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[125] Cheung, Fai Kwok Prof. Ocean and Resource Engineering Department
[126] National Ocean Service, *Tides and Currents*, http://www.oceanservice.noaa.gov (Aug. 14, 2010).
[127] Ibid.
[128] Ibid.

Monthly Average Mean Range of Tide: 1.28 feet – the difference in height between mean high water and mean low water.

Spring Range of Tide: 1.64 feet – spring tides.

Wind Currents:

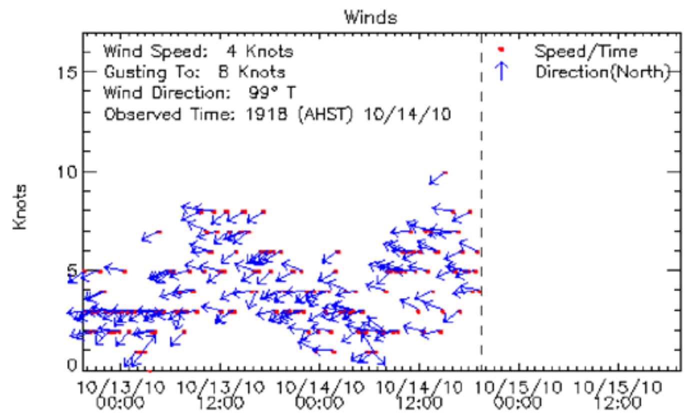

Figure 5.26 – Wind Speed between Oct. 13 – Oct. 15, 2010[129]

Weather – wind velocities:

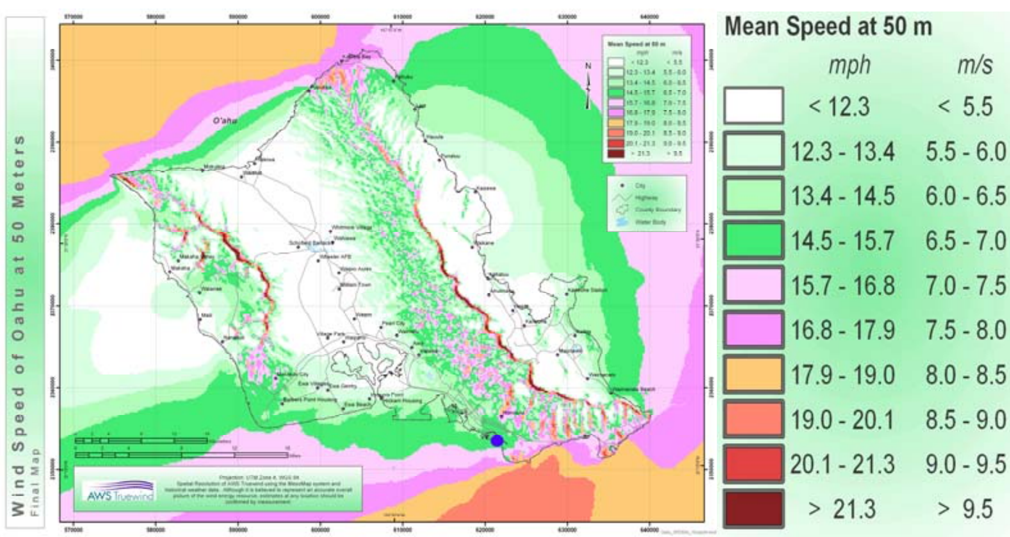

Figure 5.25 – Wind Speed throughout O'ahu with site location[130]

Average Wind Speeds: 14.5 mph – 15.7 mph at Kapiolani Park area.[131]

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[129] http://www.oceanservice.noaa.gov

[130] HECO, *Wind Resource Maps*, http://www.heco.com (Sept. 13, 2010).

[131] Ibid.

5.3 Purpose of the Site Location

Adjacent Destinations

- Waikiki activities
    - Retail/Restaurants
    - Hotel
    - Offices
    - Beach access
    - Pedestrian and vehicular traffic
    - Recreational activities: zoo, aquarium, and Kapiolani Park
    - Harbor
    - Street parking
- Mānoa Valley
    - University and other schools
    - Residential District
    - Recreational facilities – a park and a gymnasium
    - Churches
    - Stores
    - Supermarket
    - Street parking
- Downtown
    - Residential Apartments
    - Offices/Banks
    - Stores
    - Pedestrian and vehicular traffic
    - Restaurants/Bars
    - Harbor
    - Parking structures

Proposed Building

- Mixed-Use
    - Power generator: PV panels and wind turbines
    - Residential High-rise

- Offices
- Retail – kiosks
- Multi-functional area
- Agricultural pods
- Portable food carts
- Beach access
- Educational facility
- Recreational facilities – sky courts and pedestrian walkways
- Harbor – boat transportation
- Bicycles are provided to get around the city
- Revitalizing a historical monument
- Visual aesthetics

Each destination has its own identity. Take Waikiki, it's an attraction for tourism as oppose to downtown which is a business district; Mānoa can be seen as a residential and educational district. The proposed building will incorporate all of these multiple functions so that visitors will get the best of all worlds within a community. We shouldn't forget about the Natatorium, which is a war memorial monument. At the same time it will be harmless to the environment with a sustainable design.

5.4 Site Analysis in an Ecological Approach

Before a designer gets into the designing of the building, a site analysis needs to be complete, but in an ecological approach. The architect needs to determine the direct ecological spatial impacts of any activity, the designed structure, and/or the intended change to an ecosystem; an ecological description of the site must be done.[132] In the description, it needs to consist of the spatial and systematic explanation – the changes over a period of time. It is best to remember and consider that the interactions between organic and inorganic components need to work together as a whole in the ecosystems. In order for the architect to go about identifying the environmental components and the human activities, it would be easier if they classified the range of ecosystem factors into

[132] Yeang, page 91.

features that can be studied separately; for example: elevation, soils, drainage, microclimate, aspects of vegetation, and so on.[133] At the same time, consider time and space for each factor; each one will be affected through time differently.

The mapping for each factor (components and process of the site's ecosystems) should be broken down into a matrix; a horizontal "layer-cake"[134] model. This model breaks down the ecology of the site as layers of components including their own complexities, organizations, and interactions. These components are broken down into climate, bedrock and near the surface of the earth, physical geography and land forms, ground- and surface-water hydrology, soils, flora, fauna, and man-made elements.[135] These layers can be easier seen in Figure 5.21.

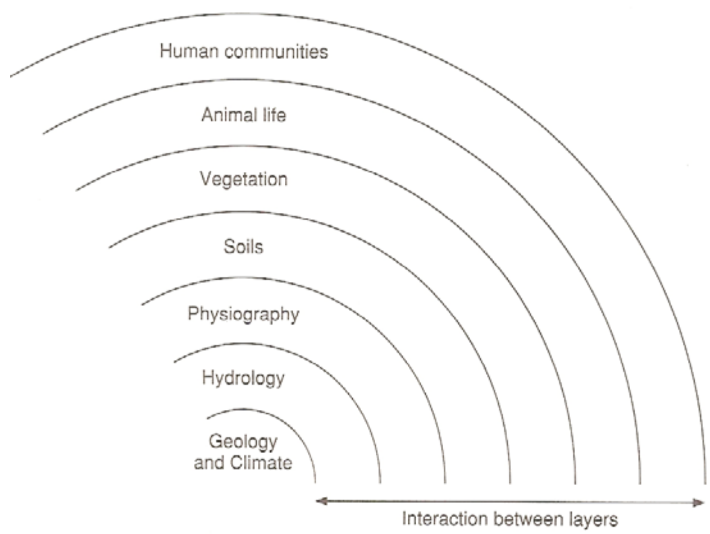

Figure 5.41 – A structural "layer-cake" model of the ecosystem.[136]

As the site analysis is conducted for the designed structure, all factors need to be taken into consideration. Also, there is the need to understand that all of the levels are in chronological order of ecological development as well as a functional relationship. In other words, each layer forms the next layer through interaction and evolution. It should be noted that some man-made structure excavates until the bedrock. In this case, because

[133] Yeang, page 91.
[134] Yeang, page 92.
[135] Yeang, page 93.
[136] Yeang, page 92.

the building is going to be constructed onto an artificial landmass, minimal damage to the sand bed and/or reef bed will occur. This is possible because the foundation of the building will not be dug into the ground, it will be hovering over the sea level.

Further detail with the layers of interactions is not needed for this research because soil analysis should be worked on with the geotechnical engineers. Just as a start up, it was needed to briefly state the ideas and considerations when designing for an ecological approach for the built environment. The site analysis should involve the study of the site ecosystems and also the surrounding ecosystems that will be affected by the designed structure. We need to remember that whatever gets built on the site, it will have a negative impact to the earth's resources. The idea here is to minimize the negative impact of the designed structure and find ways to utilize the natural resources efficiently within the built environment – a passive design. Also, designers need to analyze the prevailing winds, sun path, and other significant features on site.

5.5 Alternative Sites (Matrix): 'Brownfields'

(Refer to the chart on the next page)

Site Options	City	District	2.5 Mile Radius Population	Current Use	Potential Use	Flood Zone	Land Value	Site Area	Wind Avg.	Access: Airport	Access: Nearest Harbor	Avg. Income of Household	Neighborhood Amenities	Miles to a Univ./College	Miles to Waikiki
East Kapolei	Kapolei	Urban	39,055	Agriculture	Residential, Commercial, and Recreational Area	Undetermined	$10,914,900	0.634 Acres	13.4 - 14.5 mph	15 Miles	6.5 Miles	$39,867	Parks, Golf Courses, and Schools	13.3 Miles	18.4 Miles
Keehi Lagoon Park	Moanalua	Urban	121,390	None	Park/Rec. Area	100 yr/500 yr	$9,901,400	13 Acres	13.4 - 14.5 mph	2 Miles	2.5 Miles	$35,621	Parks, Beach Access, Harbor, and Industrial Area	5.5 Miles	6.7 Miles
Keehi Industrial Lots	Kalihi	Urban	121,231	Island Recycling Inc.	None	No	$1,175,300	1.6 Acres	13.4 - 14.5 mph	2 Miles	2.5 Miles	$36,041	Parks, Beach Access, Harbor, and Industrial Area	5.5 Miles	6.7 Miles
Wilikina Drive	Wahiawa	Urban	38,370	None	Residential/ Government	Undetermined	$948,500	2.344 Acres	< 12.3 mph	18 Miles	21.5 Miles	$30,545	Parks, Lake Wilson, Pub and Military Facilities	15.5 Miles	22.2 Miles
Sand Island Reuse Facility	Iwilei	Urban	121,231	Baseyard Hawaii	A Non-Profit Agency	100 yr	$491,000	1.3 Acres	13.4 - 14.5 mph	3 Miles	2.5 Miles	$36,041	Recreational Area, Harbor, and Beach Acces	3.9 Miles	4.9 Miles
Proposed Site	Honolulu	Urban	126,009	Natatorium War Memorial	Mixed-Use Building	Yes	Negotiable	2 Acres	14.5 - 15.7 mph	9 Miles	11.5 Miles	$73,915	Kapiolani Park, Hotels, Aquarium, Zoo, Beach Access, and Diamond Head	2.5 Miles	0 Miles

Figure 5.51 - Site Comparison Chart

Site Options	East Kapolei	Keehi Lagoon Park	Keehi Industrial Lots	Wilikina Drive	Sand Island Reuse Facility	Proposed Site
Pros.	1. Housing redevelopment	1. Recreational area	1. Recreational area	1. Cheapest land value of the five Brownfields	1. Recreational area	1. Pedestrian friendly
	2. Agricultural area	2. Easy access to the airport	2. Easy access to the airport	2. Near Lake Wilson	2. Beach access	2. Aquarium, Zoo, Beach, Hotel, and Park accessibility
	3. Pedestrian friendly	3. Near downtown district	3. Near downtown district	3. Agricultural area	3. Utilities - electrical, water, wastewater, etc. are on-site	3. Med - High average wind speeds
Cons.	1. High risk level of pesticides	1. Industrial Area - pollution	1. Industrial area - pollution	1. Far traveling distance from Waikiki	1. Currently in use	1. High cost of living
	2. Ambient noise from vehicular traffic	2. Near the freeway - noise	2. Near the freeway - noise	2. Undeveloped area	2. Industrial area - pollution	2. Homeless population
	3. Occasional noise from flight aircrafts	3. Near the harbor - water contamination	3. Near the harbor - water contamination	3. Low average of wind/year	3. Not residential friendly	3. Ocean disruption

Figure 5.52 - Site: Pros and Cons Chart

The two charts above gives a brief description and a comparison and contrast of the current brownfields located in O'ahu against the proposed building. This is to justify why the proposed building should be able to be constructed on the current structure of the Natatorium; slightly off-shore. The reason why the land value for the proposed building is negotiable is because the City of Honolulu owns the land. The mixed-use building, if the land is given, will house some of the City of Honolulu functions; spaces and areas will be provided for them. This way the cost for the land, if built on one of the other brownfields will be saved. Also, the proposed site location of the mixed-use building will fulfill some of the LEED requirements under Sustainable Site (refer to the next section).

Below images are the Brownfields located across the island of O'ahu:

Figure 5.51 – East Kapolei: Agricultural Land.[137]

Figure 5.52 – Keehi Lagoon Park.[138]

[137] Hawai'i Brownfields Assessment Program, *Brownfields*, http://hawaii.gov/dbedt/gis/brownfields/ (Oct. 13, 2010).
[138] Ibid

Figure 5.53 – Keehi Industrial Lots.[139]

Figure 5.54 – Wilikini Drive in Wahiawa.[140]

Figure 5.55 – Sand Island Reuse Facility: A Non-Profit Agency.[141]

[139] Ibid.
[140] Ibid.
[141] Ibid.

LEED – Sustainable Site: (information provided by Randy Akiona)[142]

Prerequisite 1: Construction Activity Pollution Prevention

Intent - Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.

Proposal - Modular units built in a factory and erected on-site

Credit 2: Development Density & Community Connectivity

Intent - Channel development to urban areas with existing infrastructure; protect greenfields and preserve habitat and natural resources.

Requirements:

(Option 1) - Construct building on previously developed site and in a community with density of 60,000 SF per acre net.

(Option 2) - Construct building on previously developed site: within half mile of residential zone with average density of 10 units per acre net, within half mile of 10+ Basic Services (listed below), and with pedestrian access between the building and the services.

Proposal: Constructing a mixed-use building on the current structure of the Natatorium.

Basic Services: bank, *place of worship*, *convenience grocery*, *day care*, *cleaners*, *fire station*, *beauty*, hardware, *laundry*, *library*, medical/dental, senior care facility, *park*, pharmacy, post office, *restaurant*, *school*, supermarket, theater, community center, *fitness center*, and museum.

Credit 4.1: Alternative Transportation

Intent - Reduce pollution and land development impacts from automobile use.

Requirement - The project is within a quarter mile of two or more public or campus bus lines usable by building occupants.

Proposal - according to Dr. David Suzuki, one way Canada is cutting down CO_2 emissions, they are expanding bicycle lanes as oppose to expanding freeways; also prevents vehicular traffic and congestions. The proposal is to provide bicycles for use and, optional – electrical vehicles with power station; this will also satisfy Credit 4.3: Alternative Transportation Low-Emission & Fuel-Efficient Vehicles.

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[142] Akiona, Randy Prof. Civil Engineering Department.

<u>*Credit 5.2:*</u> Site Development Maximize Open Space

Intent - Provide a high ration of open space to development footprint to promote biodiversity.

Requirement - Reduce the development footprint (defined as entire building footprint, hardscape, access roads and parking) to exceed the local zoning's open space requirements for the site by 25%.

Proposal - eliminating parking (residence are not allowed to own a car), providing roof gardens, and having an open retail space (no walls).

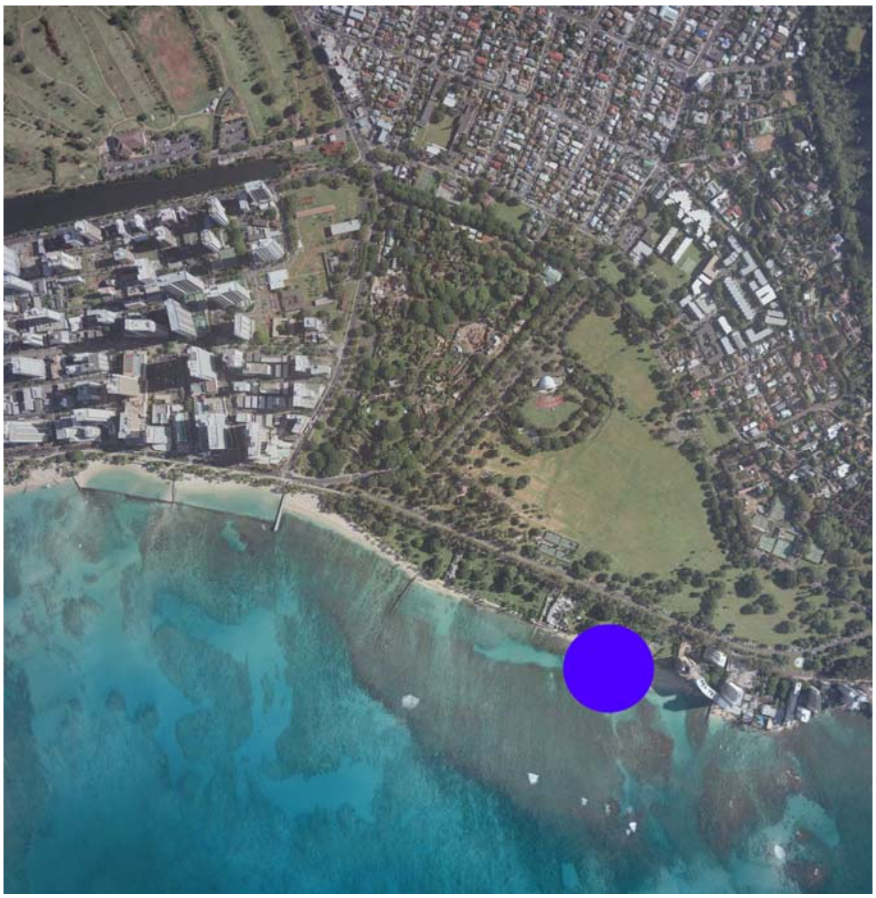

Figure 5.53 – Aerial View of Kapiolani Park with Site Location[143]

[143] SOEST, *Coastal Geology Group*, http://www.soest.hawaii.edu/coasts (Sept. 13, 2010).

5.6 Artificial Landmass

The location of the artificial landmass will connect to the main tourist attraction area – Waikiki. This is the best location for the mixed-use building because it is within the main tourist area which will generate income, education, attraction, living quarters, and so on. The landmass will be a destination for visitors, a sense of place. Let's take Dubai for an example, specifically 'The World'. It consists of residential, resort, commercial, marinas for commercial and transportation, all which produces income. People like to get away from the business life-style and go somewhere serene, peaceful, and even having some excitement. However, at the same time it is disrupting the sea life; destroying reefs and sand bars. Environmentalists have complained about building over the ocean. As for the proposed design, new strategies and methods will be learned through the mistakes of Dubai; environmental damages will be prevented.

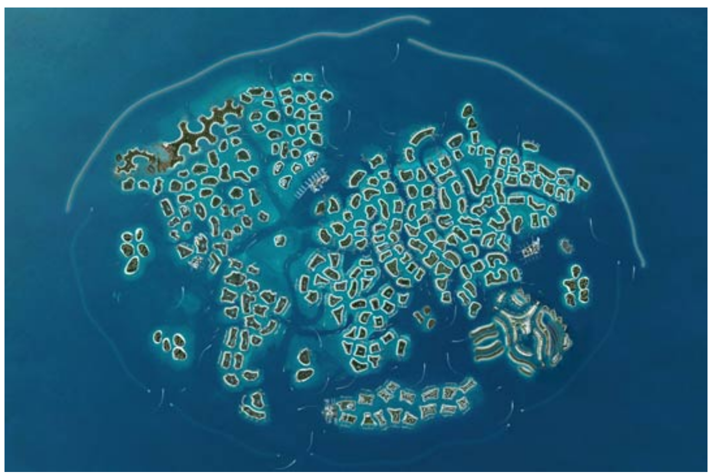

Figure 5.61 – 'The World' in Dubai[144]

There are a few ways to build an artificial landmass. One way is to use landfill to create the structure and then form the landmass - terraforming. Another way is dumping rocks and sand into the ocean floor. The other way is using columns/framing systems to support the weight of the structure, like oil rigs out in the ocean. Lastly, an innovative way could be using a floatation device; this way the structure will not be affected by sea level rise, however we need to know that the ocean is in a constant movement.

The way the artificial landmass is going to be constructed is a structure similar to the oil rigs as it will help stabilize the current structure of the Natatorium. This method

[144] The World, *Overview*, http://www.theworld.ae/ (Nov. 28, 2009).

would prevent damage to the ocean floor. There will be only a pedestrian access that connects and reusing the existing Natatorium War Memorial ramp. As stated before, most environmentalists would go against an artificial landmass over the ocean which is why this mixed-use building will house a laboratory below sea level to do field study. Marine biologist will have the opportunity to study the ocean floor and recreate life to put back what was destroyed. However, if this idea is not feasible to the city, then it will be constructed over the existing structure of the Natatorium with a trade off with the City of Honolulu.

The point here is Hawai'i needs to from an identity, creating something rare, innovative, moving forward with technology, and life-style. At the same time, why not incorporate renewable resources where it will provide energy effectively. This leads back to the main focus, being self-efficient. Having the necessary resources to support a community, in this case the mixed-use building community. Boat and pedestrian transportation, energy, living quarters, shopping areas, work spaces, education, and green spaces will allow this mixed-use building to become self-efficient; having everything in one area so there is no need to import or travel using vehicles.

CHAPTER 6

DESIGN DEVELOPMENT

6.1 Approaching the Building Design

6.2 The Proposed Building

6.3 Building Systems

6.4 Energy Consumption and Generator

6.5 Conceptual Sketches of Scheme 1

6.6 Spatial Arrangements for Scheme 1

6.7 Conceptual Sketches of Scheme 2

6.8 Spatial Arrangements for Scheme 2

6.9 Scheme 3 – Developing the Design

6.1 Approaching the Building Design

"Around here, however, we don't look backwards for very long. We keep moving forward, opening new doors and doing new things…and curiosity keeps leading us down new paths." – Walt Disney.[145]

Till this day Walt Disney is still moving forward through his work, his ideas, his creations, and his ability to turn art into design. He is an artist at heart who pioneered creativity into reality. Walt Disney had the vision to foresee the future, letting his intuition as a dreamer to set foundations for future artists and designers. He opened the doors for others to start creating their own styles, symbols, icons, and personality. He had changed the way we design.

As the research continues to move forward, enhancing certain abilities and knowledge is the key to stay ahead with innovation. Hawai'i needs to apply more innovative approaches to develop a foundation to be an icon to the rest of the world when it comes to designing with sustainability. Creating design guidelines for Hawai'i that improves the quality of life in any environment will represent a trademark that may potentially influence designers to envision what the aspect of good design is. It is in my power to continue the growth and the movement of Hawai'i for a better future.

Furthermore, it is the spatial design within the built environment that needs to be well thought of in order for the building to be successful. By successful, it doesn't only mean functioning properly, but as in the perspective of an artist, designer, and creator it has to be a symbol of what can be instead of what was. Everything that a designer must do is to envision what lies ahead, what are the potentials, what is the next big idea. If this is successfully thought of, it will open the doors for Hawai'i to be marketable. For instance, Walt Disney's artistry influenced others to create their own art work. It is the expansion of ideas that will help turn unsuccessful buildings into successful ones. Researching and experimenting a certain style of spatial designs that can become a standard for living, working, and experiencing needs to be done.

As time never stops there is no telling what or when an innovative product will hit the market. As of now, designers, clients, and developers can see that renewable energies

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[145] Meet the Robinsons. Dir. Stephen J. Anderson. Writ. Jon Bernstein and Michelle Bochner. Perf. Angela Bassett. Disney, 2007.

are the forward movement from coal, oil, and fossil fuels. As what Walt Disney said, it is the curiosity that drives us into new paths. The advancement of technology and how to improve on them is the key to innovatively apply renewable resources into a building that allows it to become self-efficient. Disney also said we don't look backwards for very long. However, we must refer to the past and see what was successful and unsuccessful in order to make the necessary changes. It will be beneficial to compare the facts from the past to the present and develop a prediction to what the future on the potential applications of renewable resources are.

Other important issues arise. Referring to power and providing energy through renewable resources, will it be enough to allow a building to become self-efficient - how much energy will Hawai'i gain from the sustainable design? *Will it make a difference?* How will it make a difference? Overall, will Hawai'i benefit or lose amounts of energy and money? Further research is needed to understand weather patterns, climate issues, economic development, high and low peaks of tourism, and methods of reducing construction waste.

As for the next part of this research documentation, design of the mixed-use building with the integration of renewable energy and passive design systems will be further developed. Investigation will be needed, such as: calculations, programming, functions, spatial qualities, improving the quality of life, and the building design itself. As for the design of the building it will integrate these renewable energies within the structure. For instance, having the wind turbines built within the structure of the mixed-use building. Another would be partnering up with some of the hotels in Waikiki on hydrothermal – deep sea cooling. This will help with the air conditioning energy load. Creating a modular system where rooms, mechanical systems, and waste systems are prefabricated off-site and erected on-site. Construction management and efficient methods will provide an idea of cost and how cost can be reduced.

As an artist, designer, and creator, the design of the building will be of significant value. In order to establish a foundation for other cities and countries, the design of the mixed-use building has to contribute to their benefits. Applying renewable resources for a self-efficient building while being monumental will impact on how designers think today and for the future. The challenge that needs to be over come is, keep designing ahead of the time frame. Moving forward and thinking outside of the box, out of the norms, and out of the ordinary, as well as moving forward with or even ahead of technology, design strategies, and innovation. It is the continuous growth of knowledge and taking advantage of what is out there to promote more self-efficient buildings.

6.2 The Proposed Building

Program:

Underwater Laboratory – sea life studies; education

Kids Area

Open Retail Space

Office space

150+ Residential Units (29 Residential Floors)

Multi-functional area

Agricultural pods/areas

No vehicles allowed, however alternative transportation will be provided (i.e. bicycles)

Sky courts and gardens

Pedestrian and vehicular circulation (service vehicles only)

Successfully incorporating renewable energy – PV and wind turbines

Sustainability

- Passive design solutions
- A/C and lighting sensors
- Water catchment system
- Low flushing toilets and urinals

As mentioned throughout the paper, the purpose of the proposed mixed-use building is to house multiple functions so visitors and the locals can experience them in one central location while providing its own energy. This proposition is for future developments when land is no longer available, but at the same time working with natural elements such as: sun, wind, marine species, and the ecosystems. Larger cities have the ability to build on brownfields; the island of O'ahu doesn't have much choice because there are a select few. Most are farmlands, one is a restricted preservation, and the others are in areas that are not developed. This leads to the uniqueness of the building and how the building will be constructed. Instead of terraforming and disrupting the marine species and coral reef, it will be placed on an oil rig framing structure which will minimize the damages as oppose to what is happening in Dubai. As mentioned above, it may be built on the existing structure of the Natatorium if negotiations with the City of Honolulu permit.

The proposed building will help satisfy the AIA 2030 Challenge which is to reduce energy dependence for new construction. This mixed-use building is a movement towards educating the general public about sustainable design and providing ways or methods of implementing them throughout the building. The targeted goals by the year 2030 are:[146]

- Net-zero energy for new construction: That means a new building will operate by efficiently using energy and creating renewable energy such that it requires no more net energy than it produces. Renewable sources (i.e. wind, solar, etc.) can be generated on-site or acquired from more centralized sources.
- 50% better than the International Energy Code requires for energy performance for existing building.

The 2030 Challenge will:[147]

- Significantly reduce energy intensity
- Demonstrate how to reduce energy use and save money
- Provide information for funding, tax credits and other incentives
- Encourage research and development for innovative renewable energy
- Design, construct and operate net-zero energy buildings by 2030
- 50% better than the International Energy Code requires for energy performance for existing building.

[146] AIA/DC, *2030 Challenge Committe*, http://www.aiadc.com/01-7%202030energycomittee.asp (Oct. 27, 2009).
[147] Ibid.

6.3 Building Systems

Water Supply – WaterMicron's Atmospheric Water Generators[148]

This system is purely based on the humidity and temperature of the region in order to create water from air. The machines produce various amounts of water based on the size and application. They range and produce from 250 up to 5,000 liters of water in a single day. Ideally, humidity levels should be about 35% to allow the machines to maximize water manufacturing performances. In other words, higher the humidity level is in the region, the more pure water is produced in a day. Honolulu, where the proposed building location is, has an average level of 64% humidity and average temperatures of 70° Fahrenheit – 85° Fahrenheit.

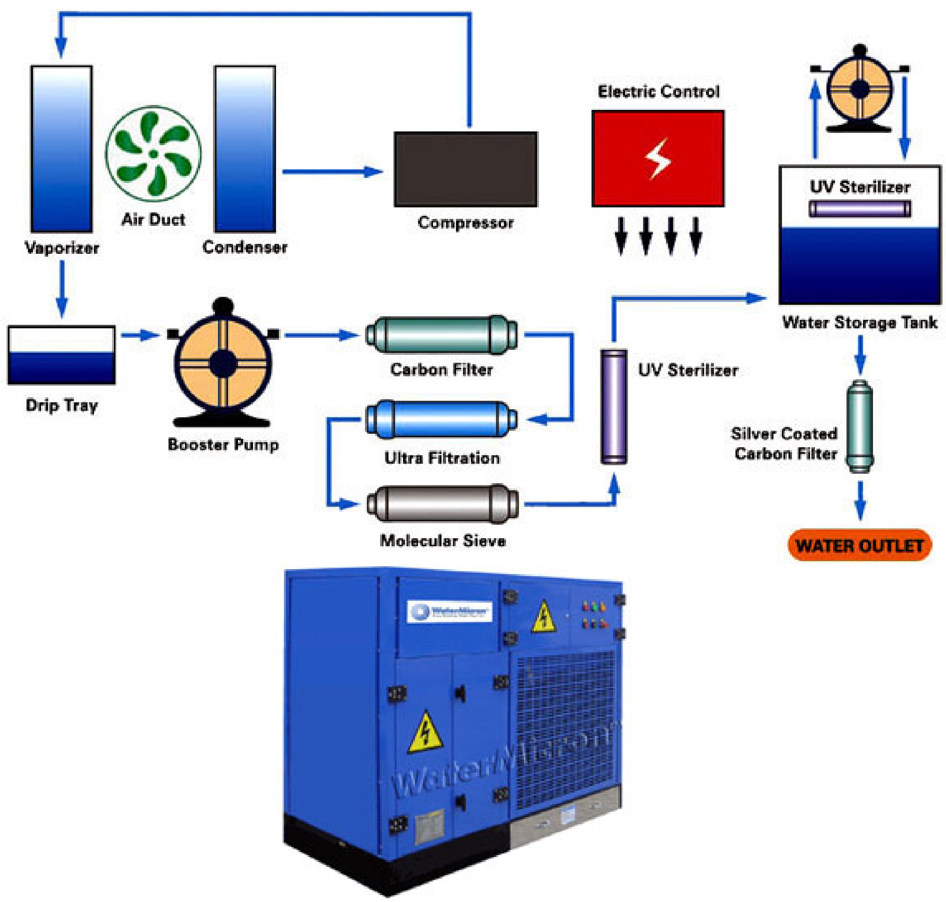

Figure 6.32 – WaterMicron AWG Machine Commercial Unit Diagram.[149]

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[148] WaterMicron, *Technology*, http://www.watermicron.com/ (Oct. 13, 2010).
[149] Ibid.

WaterMicron AWG – C5000L:[150]

Power Supply:	380V/50Hz (3 phases)
Input Power:	115kW
Production Capacity:	5000 liters (80.6°F 65%)
Working Conditions:	68°F – 100.4°F (40%RH – 95%RH)
Noise Level:	<79dB
Size:	18'- 4" x 6'- 10" x 5'- 11"
Net Weight:	9,900 lbs

Waste Management – Waste to Energy

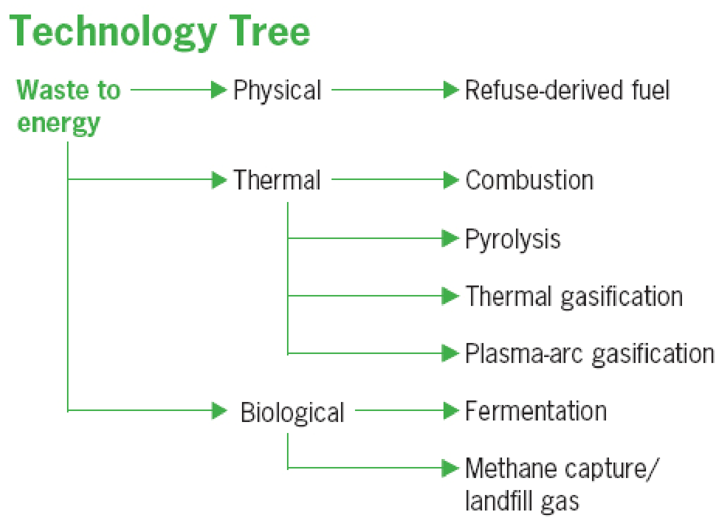

Figure 6.33 – Waste to Energy Technologies.[151]

Advancing technology will allow us to generate energy from our waste more effectively and efficiently. The Army is making a movement towards turning trash into energy in Iraq. Dr. James Valdes, scientific advisor of biotechnology with the U.S. Army Research, Development and Engineering Command explained how they developed two

[150] Ibid.
[151] Lux Research, *The Cleantech Report*, http://www.luxresearchinc.com/ (Oct. 28,2010).

prototypes of "Tactical Garbage to Energy Refinery,"[152] also known as TGER system. Dr. Valdes and his staff saw an opportunity to create energy to power the generators and stoves at most operating bases.

TGER system is small enough that fits in a CONEX container (20' long x 8' high x 8' wide) and able to power a standard 60-kilowatt generator. Dr. Valdes explains the system: "TGER turns solid trash into fuel pellets which are fed into a down-draft gasifier. The gasifier then heats the pellets, and breaks down into a synthetic gas composed of simple hydrocarbons that resembles low-grade propane. TGER processes the liquid and food waste into a hydrous ethanol which is blended with the syngas to create usable energy."[153] Another term is called refuse-derived fuel (RDF) or solid recovered fuel (SRF) which can be sold as solid fuel. The one flaw of this system being used in the mixed-use building is that, according Dr. Valdes, "It takes six hours to fully power up, during which time the amount of diesel fed into the machine slowly drops, until the generator is powered by less than one gallon of fuel per hour, as compared to five per hour without TGER."

Still, this system will need improvements because the waste stream that goes into TGER is a mixed waste stream of papers, plastics, and food-slop garbage, it cannot process glass, metals or hazardous waste streams such as medical wastes. However, this is the right step in getting rid of waste within the mixed-use building safely in an environmental way. The price of this system is currently unknown so the problem is, whether this system is viable and/or feasible.

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[152] U.S. Army, *Army Turning Trash into Energy in Iraq*, http://www.army.mil/-news/2008/06/19/10194-army-turning-trash-into-energy-in-iraq/ (Oct. 28, 2010).
[153] Ibid.

Figure 6.34 – TGER at Camp Victoria, Iraq.[154]

Another method to convert waste into energy is through *pyrolytic gasification*. The name speaks for itself; pyrolytic – a chemical change brought about by heat, and gasification – the chemical reaction and molecular breakdown or degradation of materials in order to make it into a gas. The pyrolysis technique burns the waste through high heat without any oxygen and the end result is grey ash, which can be reused to form lightweight blocks for building internal walls. Also, with enough waste in a building or throughout the community feeding into the system it can generate 'green' energy as a by-product. Pyrolysis produces an 80 percent heat output, meaning if 100 kilowatts of energy is put into the process, the return will be 80 kilowatts of heat energy. This heat can be used to power a steam turbine to generate electricity and put back into the grid or used effectively throughout a building. Even better, it has the *potential* to be self-driven, in other words, once the process begins there is no need for energy if waste is continuously fed into the system. On naval ships, it can handle up to 2.8 tons of waste per day. However, land systems can convert more than 150 tons of mixed solid waste per day into over six megawatts per hour of electricity. Below are the diagrams of each process options.

[154] Ibid.

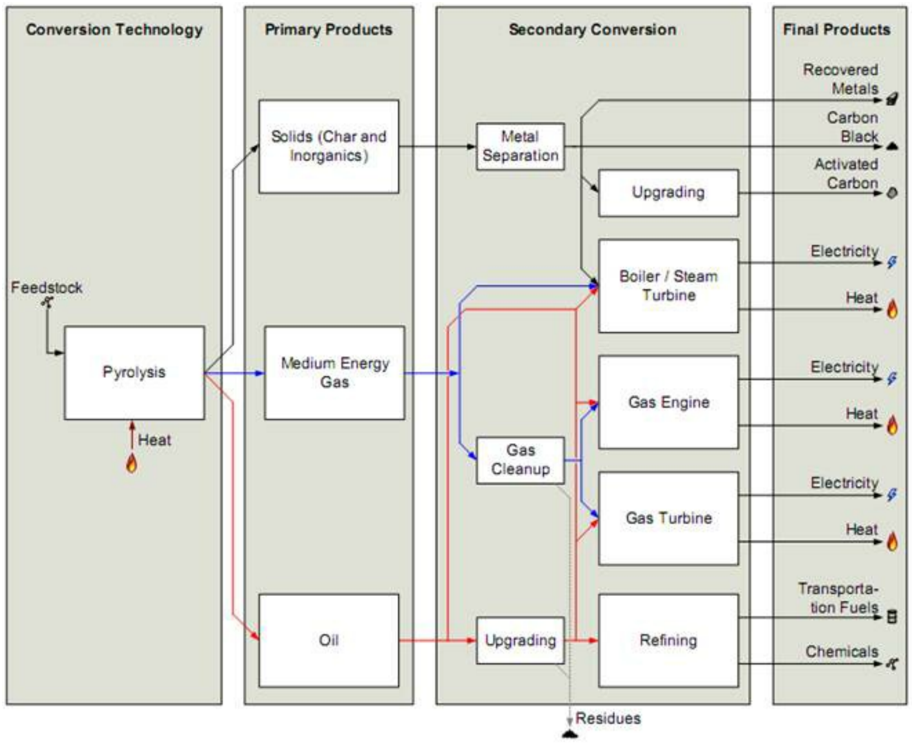

Figure 6.35 – Pyrolysis Process Flow Options Diagram.[155]

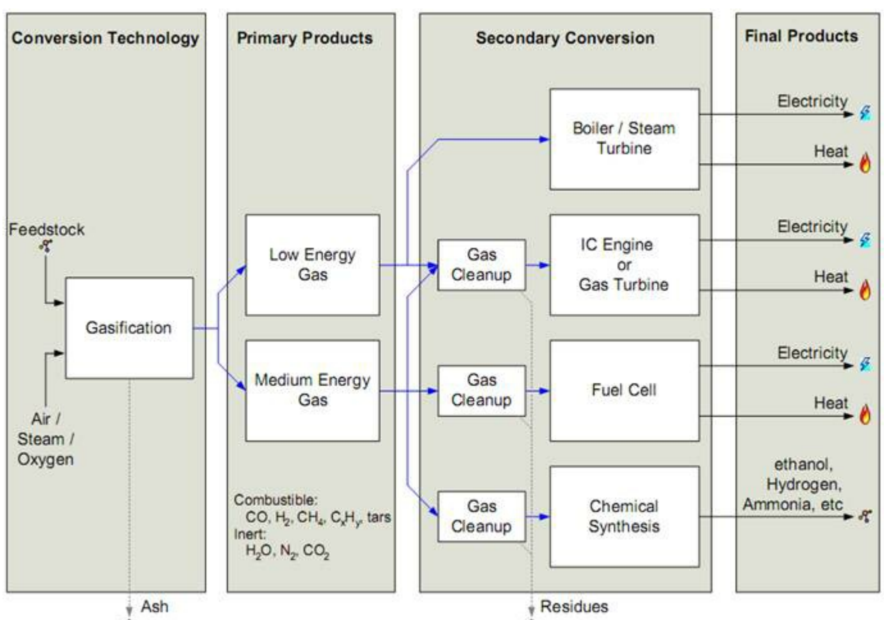

Figure 6.36 – Gasification Process Flow Options Diagram.[156]

[155] Costello, *Gasification and Pyrolysis*, http://www.rccostello.com/gasification.html (Oct. 28, 2010).

A biological method from converting waste to energy can be done through *anaerobic digestion* – "To produce biogas can occur either naturally (as in landfill gas), or in a biogas plant."[157] First, waste and various types of bacteria are placed into an airtight container, which is called a digester. It will produce a biogas of pure methane content higher than 95%, and then it can be either burned directly in boilers or cleaned and supplied as natural gas. After the process is complete, electrical energy can be transferred either back to the utility grid or generate power for use throughout the building, i.e. lighting, processing plants, ethanol plants, and greenhouses. Biogas plants have been served in India, Israel, Australia, and elsewhere.

These systems or methods may sound good, however, there are challenges that may cause them to fail or never be established. The challenges are: lack of versatility – not being able to dispose or convert all waste into energy; in the case of pyrolysis and gasification, it must be cleaned of tars and particulates in order to produce clean and efficient fuel gas.[158] The most challenging is the high capital costs. Despite the reduction of waste and the generation of energy, waste to energy technologies is very expensive to install. Especially for new technologies that are not established in the market. Further research and development will be needed to see if one of these methods is feasible to use in the proposed mixed-use building. As of now, it is an open option of whether incorporating a system or connecting back into the piping of Kapiolani Park.

6.4 Energy Consumption and Generator

<u>Averages based off of HECO:</u>

Residential Unit = 650kW x 150 units = 97,500kW/month

97,500kW/mo. x 12 mo. = 1,170,000 kWh/yr.

1,170,000 divide by 365 days = 3,205kWh/day

3,205kWh/day divide by 6.04 peak sun hours x 1000 = 530,709W system needed

Office Unit = 2,171kW x 6 offices = 13,026kWh/mo.

13,205kWh x 12 mo. = 156,312kWh/yr.

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[156] Ibid.
[157] http://www.luxresearchinc.com/
[158] Ibid.

156,312kWh/yr divide by 365 days = 428kWh/day

428kWh/day divide by 6.04 peak sun hours x 1000 = 70,861W system needed

Retail (only lighting) = assuming

18W compact fluorescent light bulb x 75 = 1,350W

.05 LED night lighting x 25 1.25W

1,350W + 1.25W = 1,351.25W system needed

Total Energy needed = 602,921.25W system needed

Generator:

PV Panels only

602,921.25W divide by 318W PV system = 1,896 PV panels needed.

However, one Magnetic Levitation Wind Turbine has an output of 250kW (11 feet high x 12 feet wide). All of the wind turbines and PV panels will be exposed to allow the general public and residence the opportunity to learn about the systems.

250,000W x 6 magnetic levitation wind turbines = 1,500,000 watt system.

Figure 6.41 – One example of a Maglev Windmill[159]

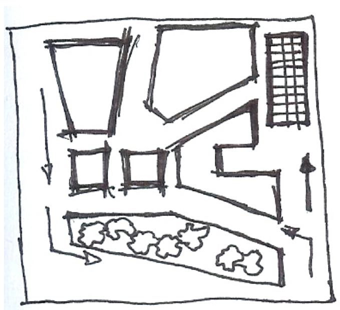
The reason why the magnetic levitation wind turbines generate a great deal of power is because it is suspended in the air there is no need for ball bearings, it uses full-

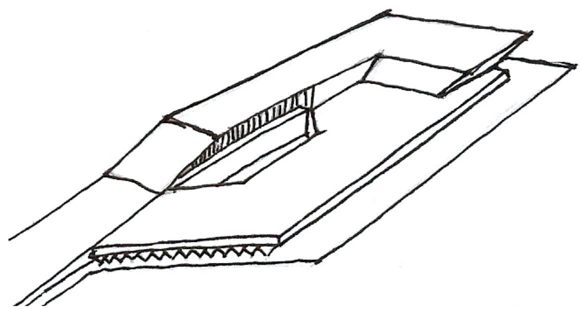
[159] Green Energy Solutions, *250kW Vertical Axis Wind Turbine*, http://masteringgreen.com/ (Sept. 21, 2010).

permanent magnets and not electromagnets (no electricity required); which results to no energy loss through friction. The best part of this system is it reduces maintenance cost.

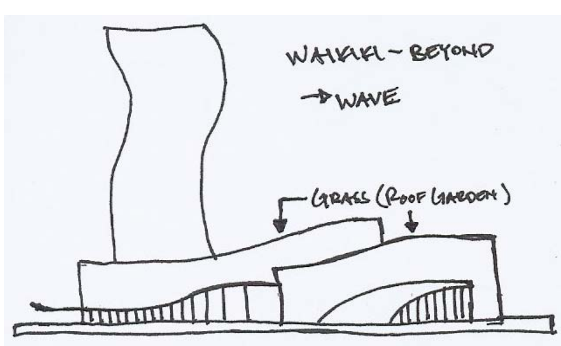
The remaining energy will be stored into the hydrogen fuel cells that can be transported back into the grid to supply the rest of Honolulu with energy. Also, the remaining energy will be reused elsewhere throughout the building.

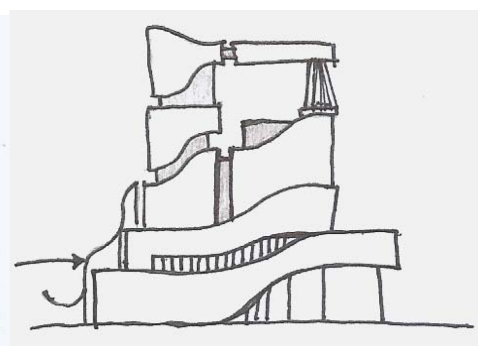
6.5 Conceptual Sketches of Scheme 1

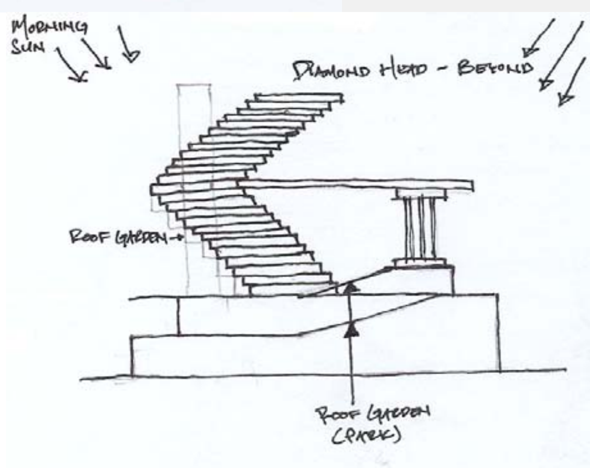




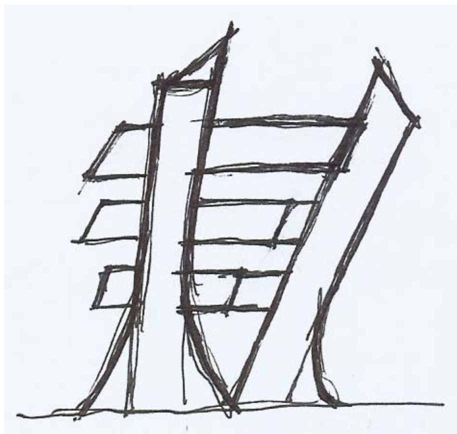
These are conceptual sketches of the retail area; trying to maximize open space and allow daylighting and natural ventilation in to minimize the use of electrical lighting.

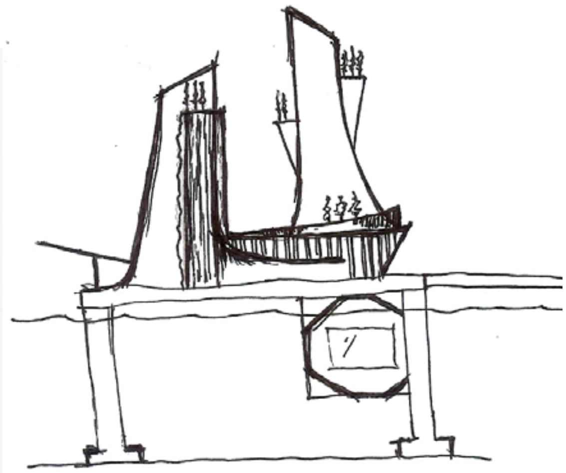




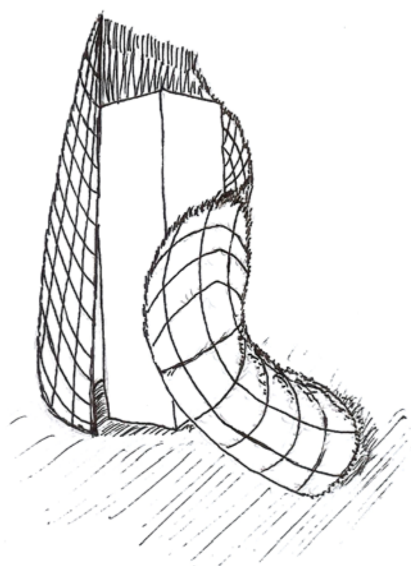


Conceptual images (previous page) of what the total building would like look. The features that are represented in these illustrations are trying to represent the ocean and at the same time an attractive visual. These are also trying to incorporate sustainability: roof gardens, daylighting, etc.

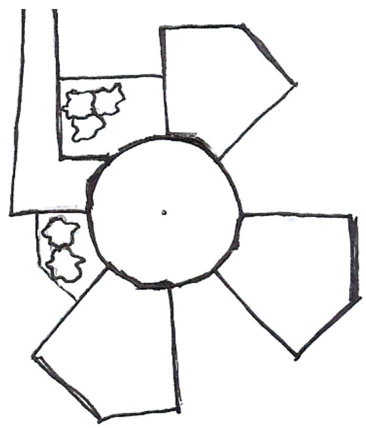
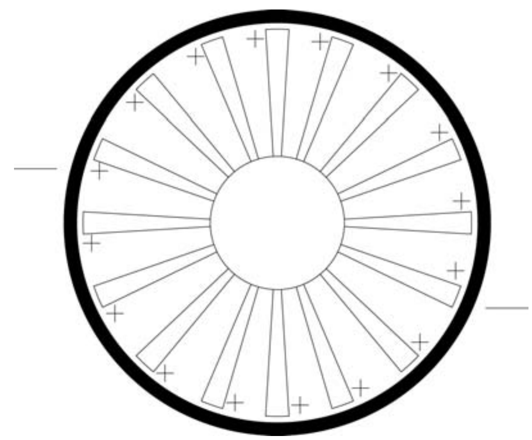




These illustrations are representing green towers. The right side is the start of the laboratory space that is underwater.



Designing the outer skin using a mesh (Ethylene tetrafluoroethylene, EFTE) – a fabric that helps control the building climate within.

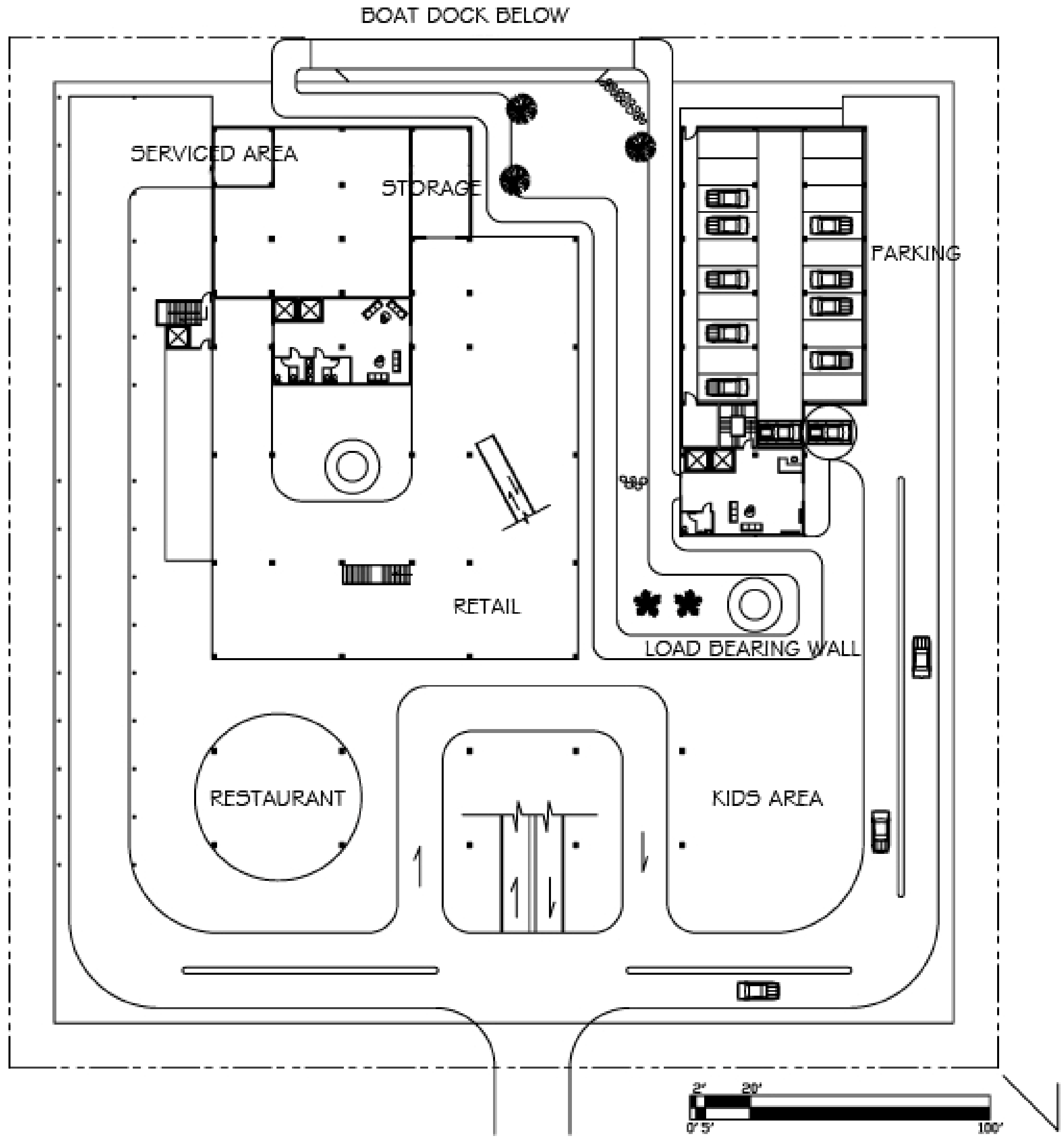
Left side image is a conceptual residential floor plan allowing natural ventilation.

Right side image is an innovative way to design these wind turbines: a magnetic strip with a negative and positive charge that allows the blades to keep rotating with a controlled speed.

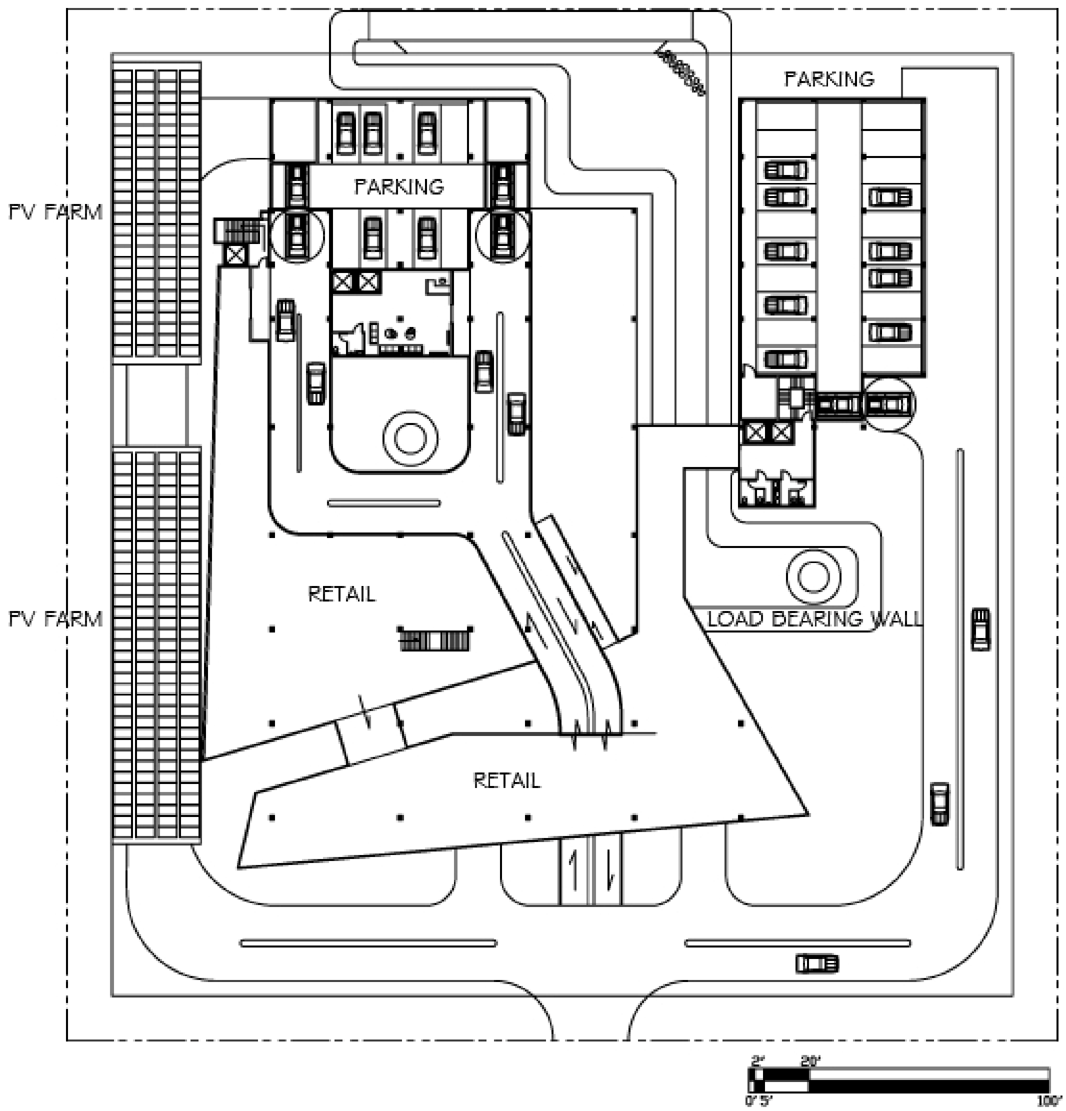
6.6 Spatial Arrangements for Scheme 1

The next phase is turning the conceptual sketches into spatial arrangements within the buildings envelope. The plan is to create a living environment that provides open air and open spaces for interaction between the living organisms. As the building expands upward from the platform it creates a propeller effect that imitates the inner wind turbines that are incorporated within the structure. Also, there is a horizontal slight break of the mass form of the building to provide green roofs for the upper levels. This represents the harmony between manmade structure and nature.

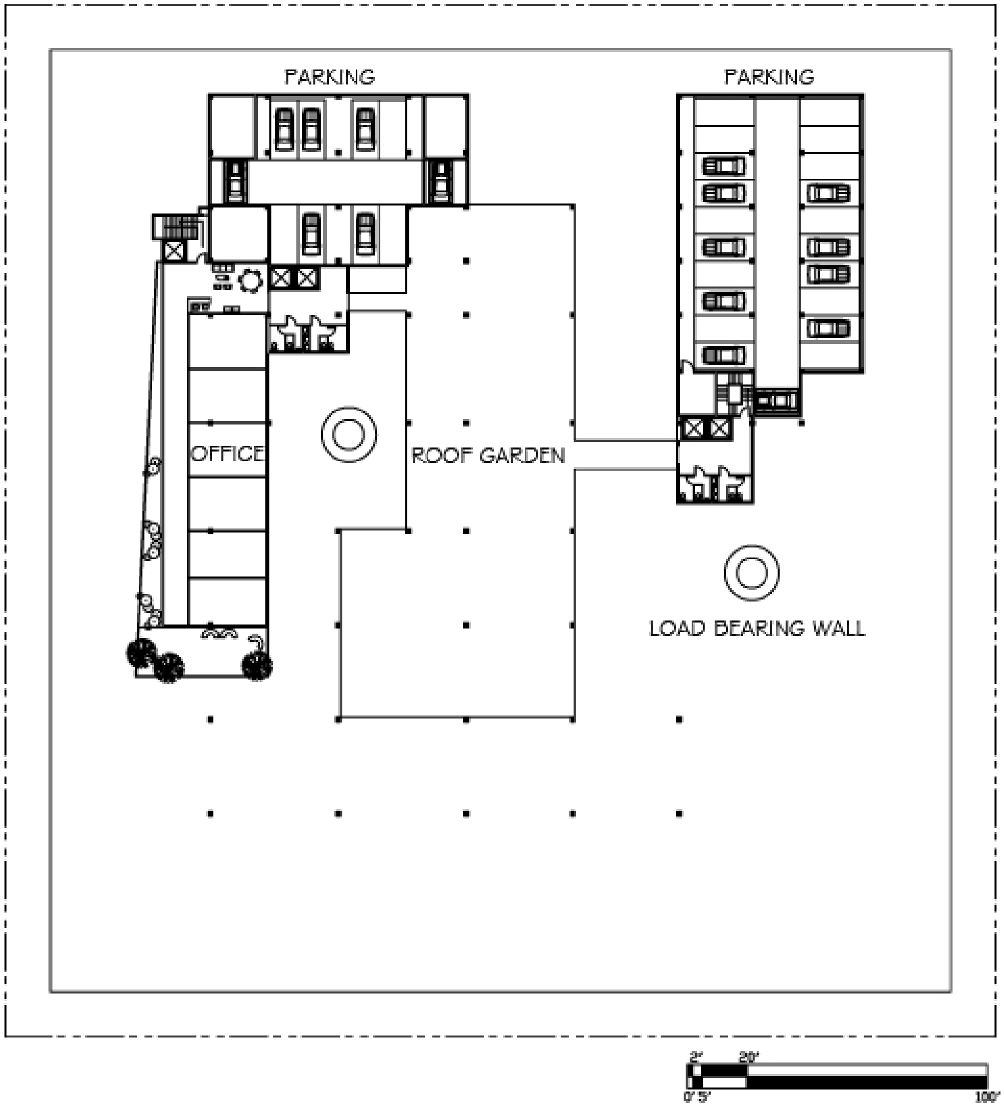
As noted earlier, designers need to find ways to construct the building without harming the environment. The idea here is to design based of modularity. Spaces will be construction in a factory and lifted on-site. This will minimize construction on the site and also prevent any toxic pollution into the atmosphere.



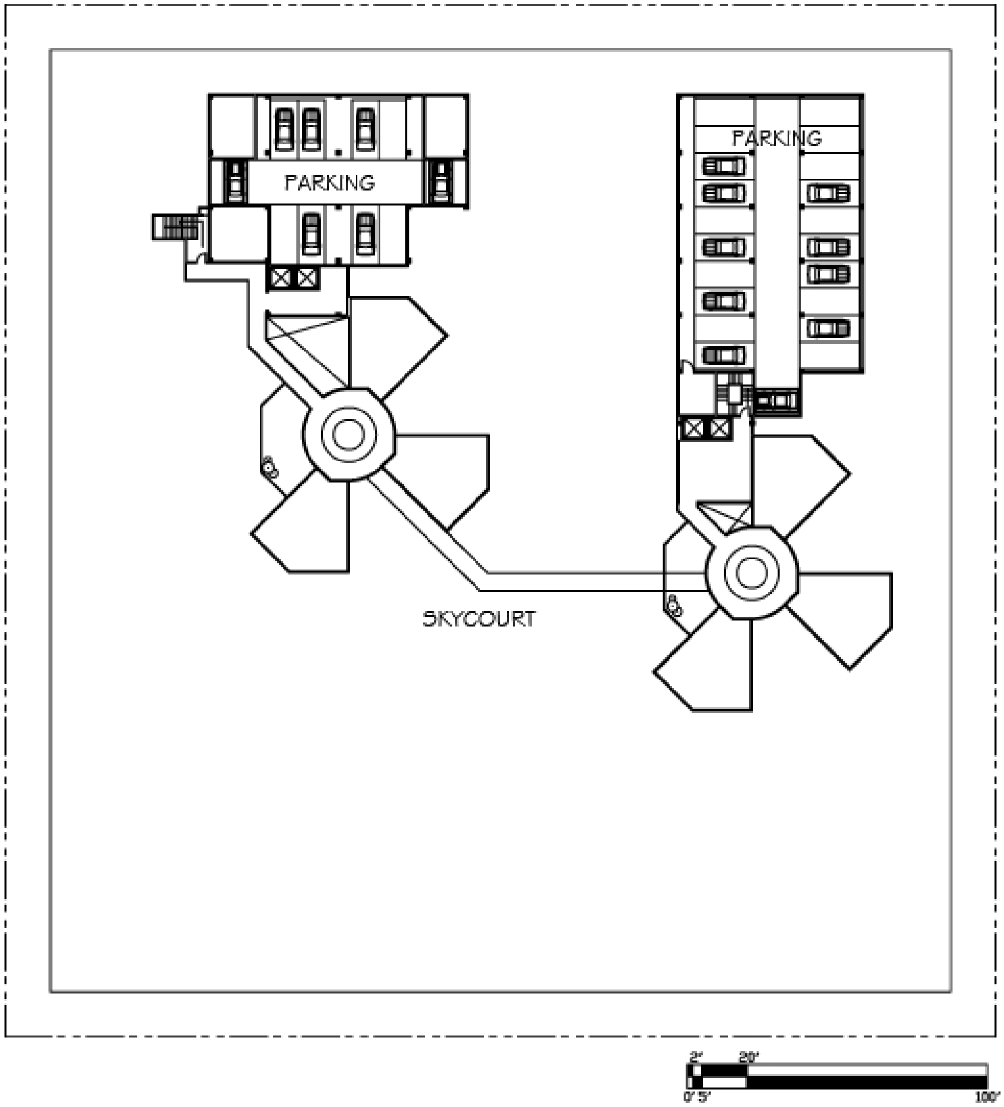
Ground Floor – Open retail spaces, restaurant (learning center below), kid's area, and parking



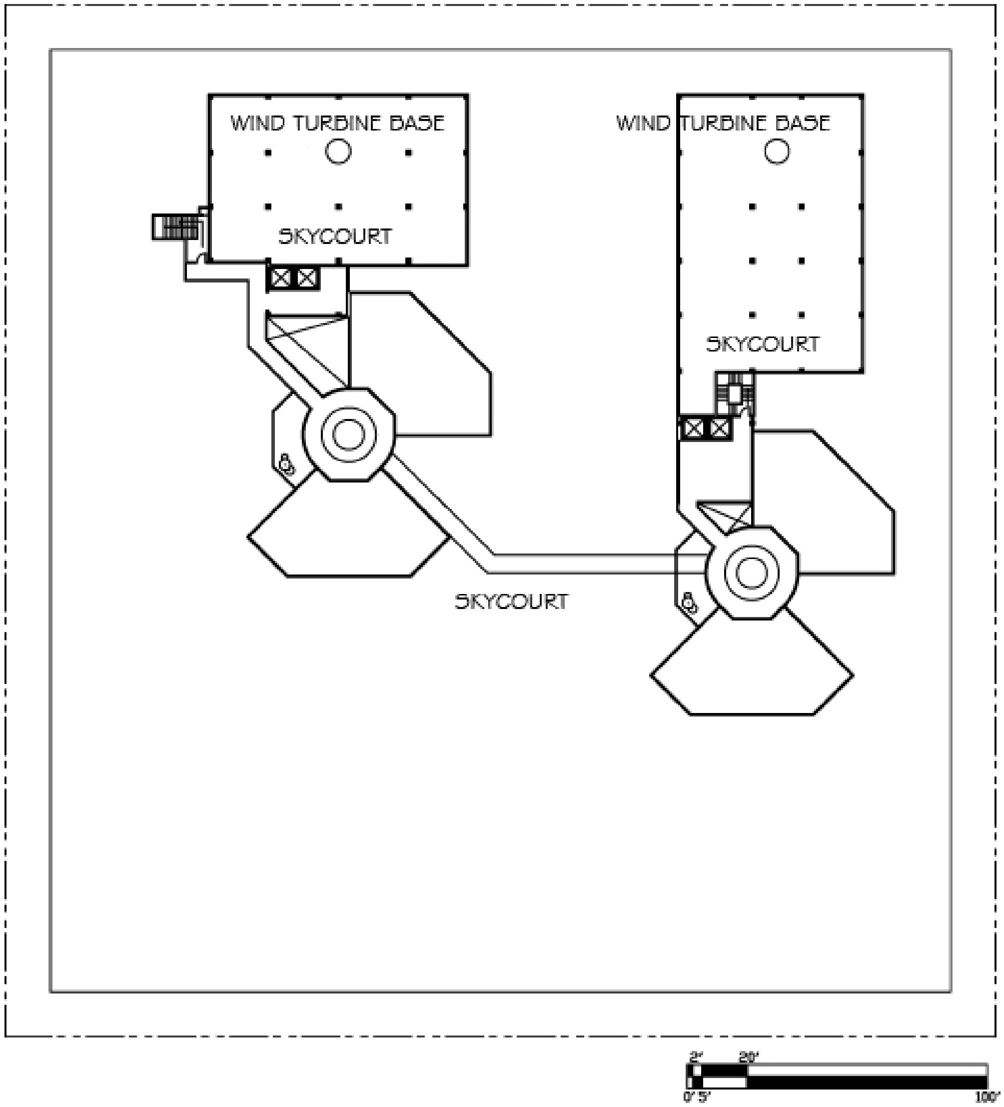
Second Floor Plan – open retail space, PV farm, and parking



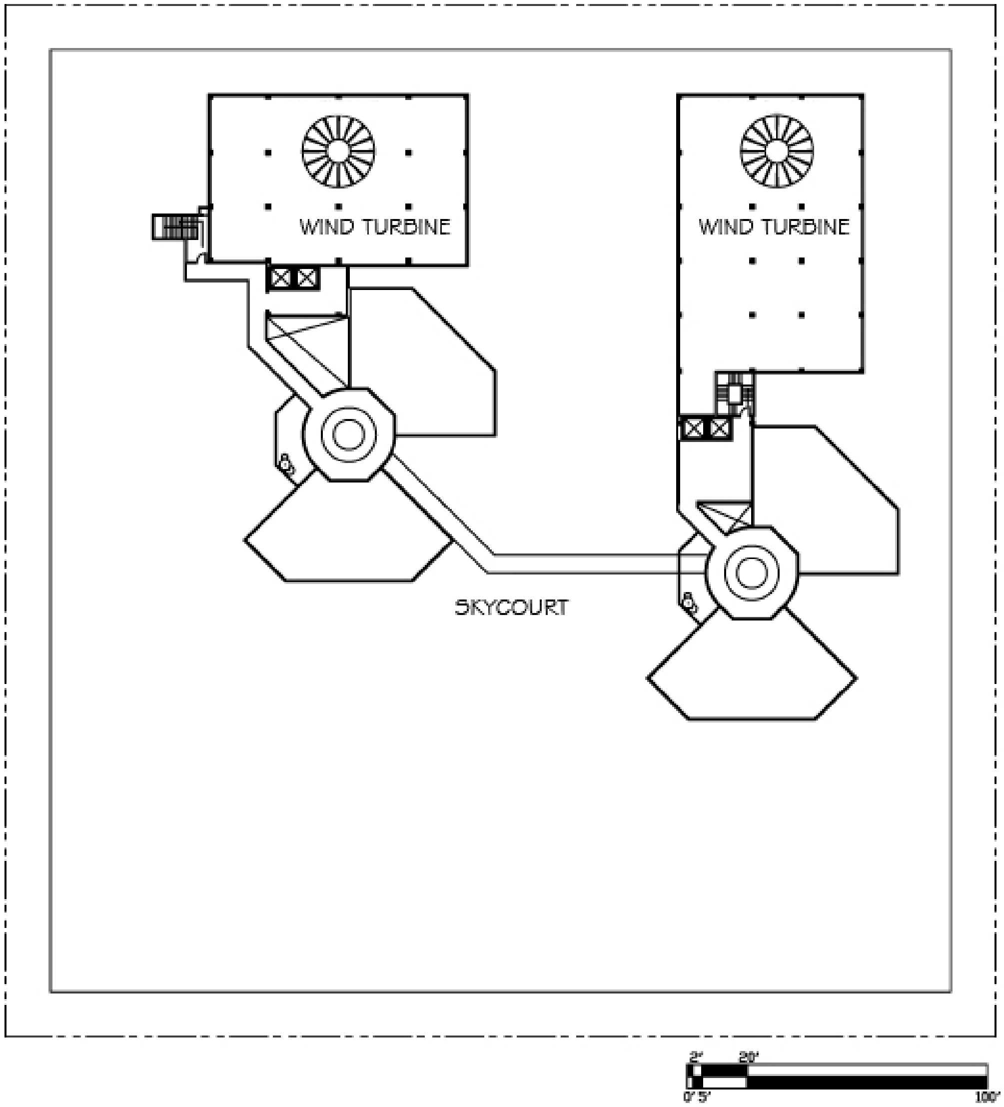
Third Floor Plan – office space, roof garden, and parking



Typical One Bedroom – 4 – 8 Floors and 14^{th} – 26^{th} Floors



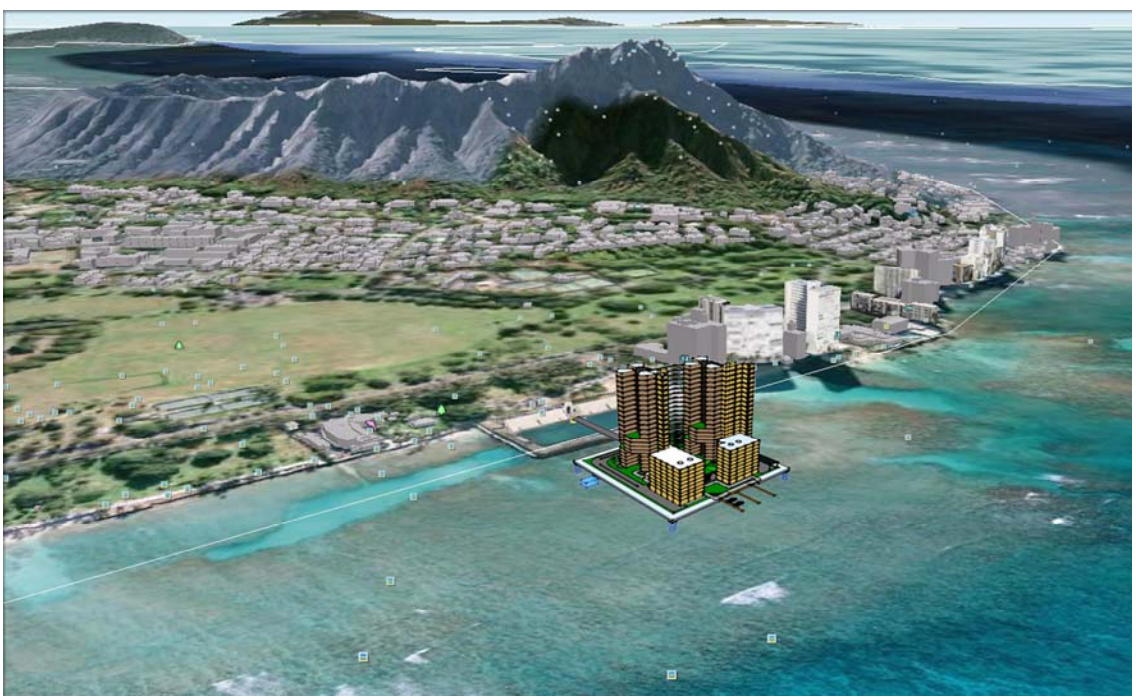
Typical Two Bedrooms – 9th and 12th Floors



Typical Three Bedrooms – 10th and 11th Floors

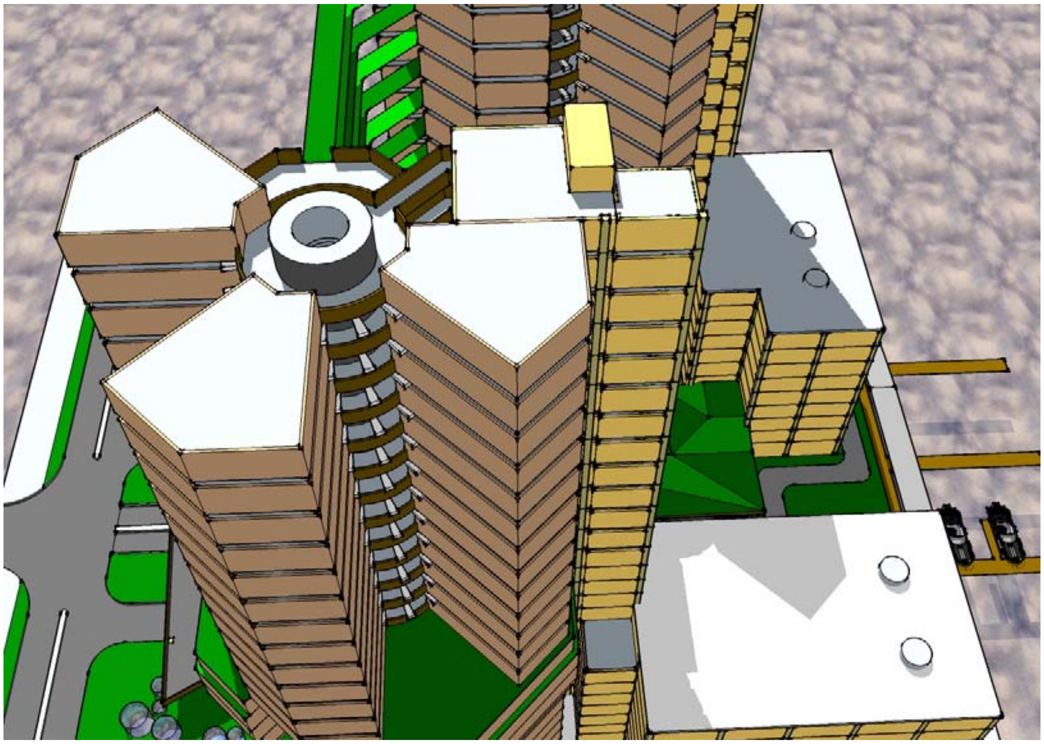
Aerial Perspectives:

Perspective View of Waikiki with Proposed Building

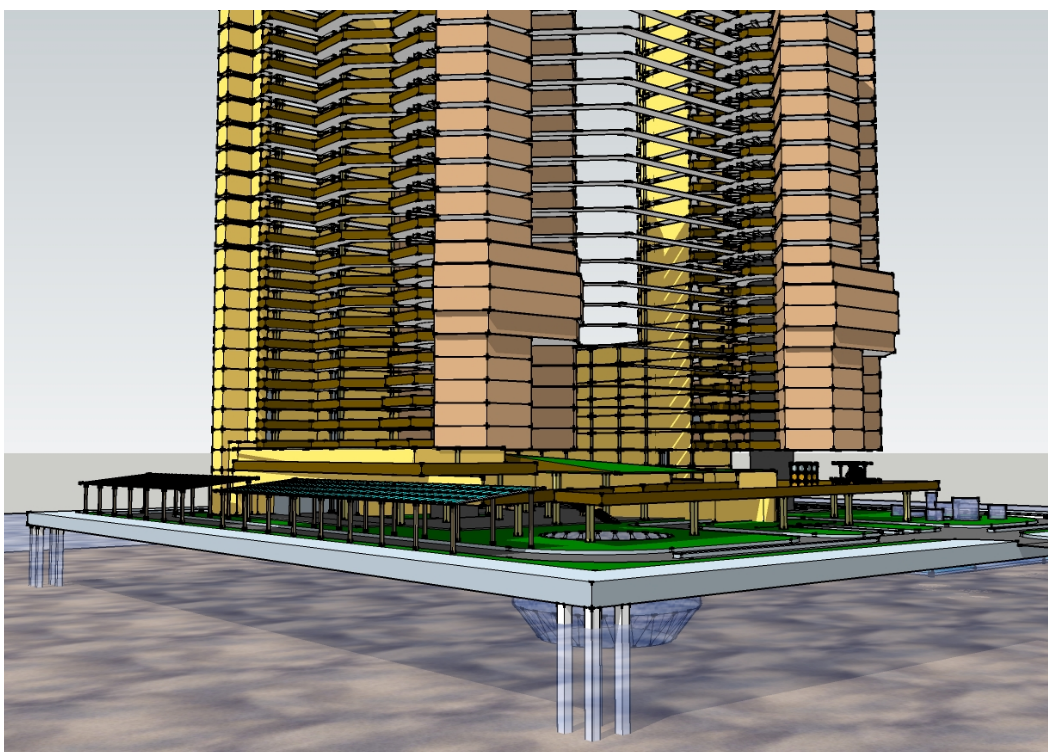


Perspective View of Diamond Head with Proposed Building

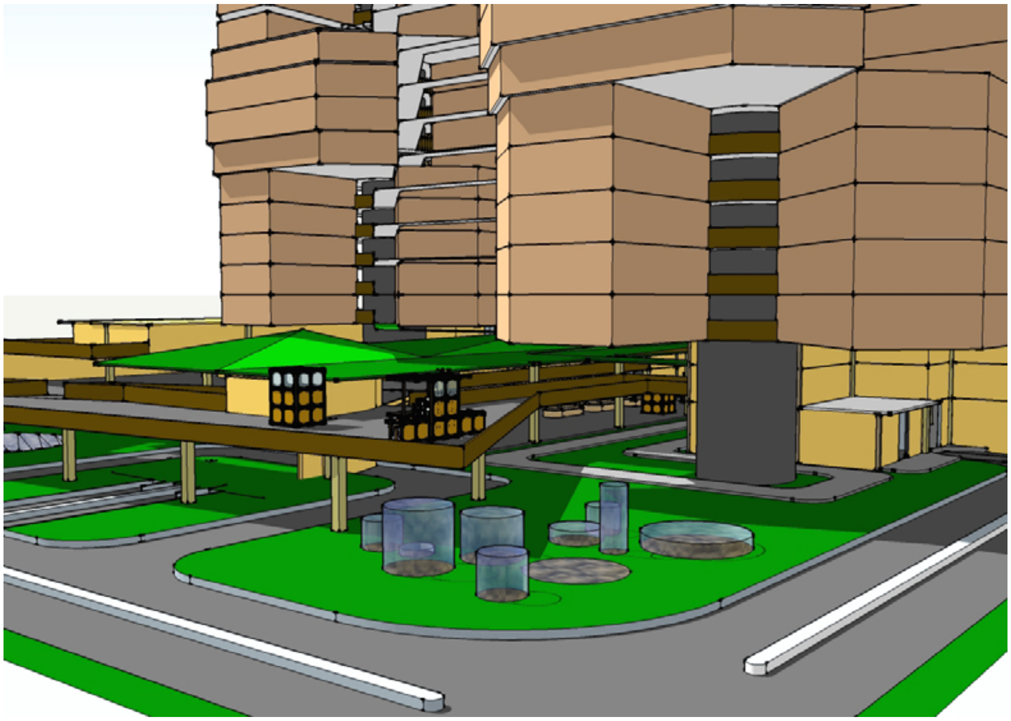
Perspectives:



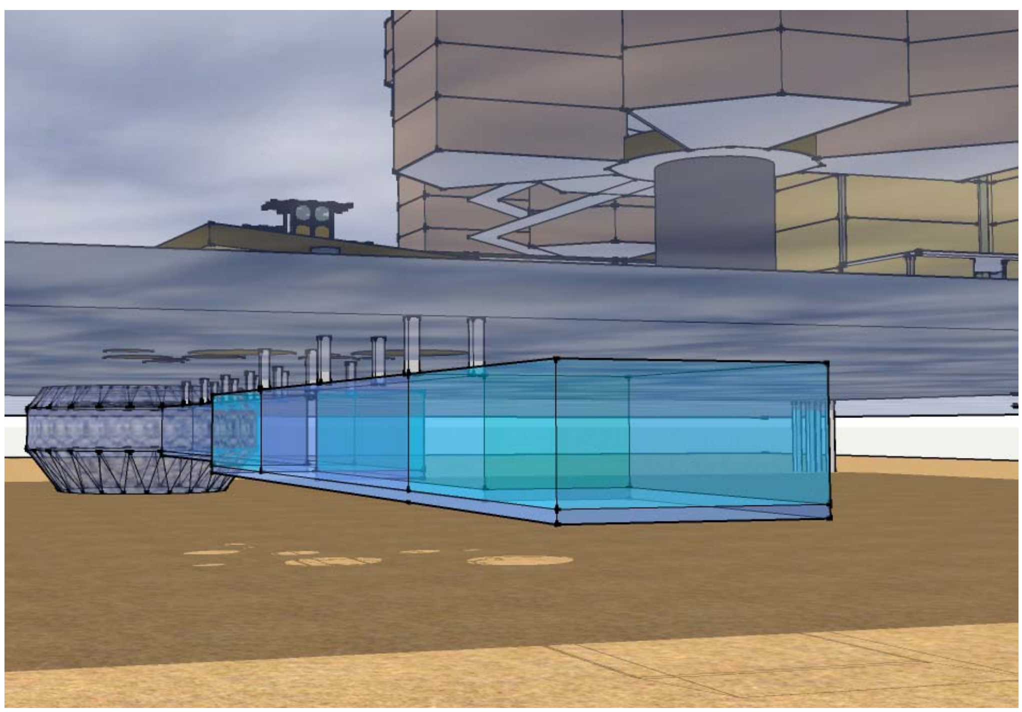
View of the wind turbines incorporated within the structure and above the parking



View of the PV Farms, Restaurant, and Retail



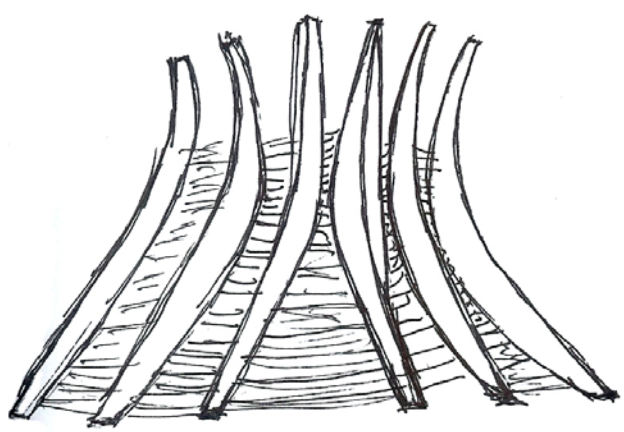
View of the Kid's Area and Retail

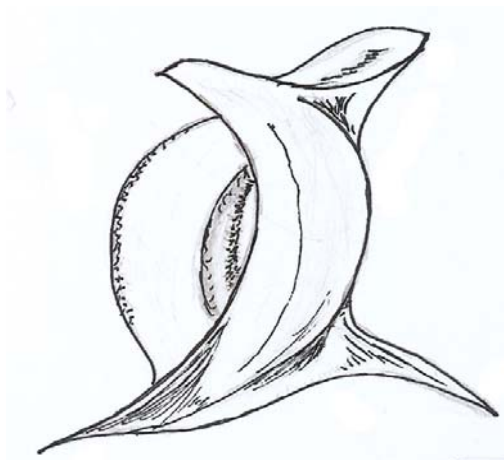


Learning Center with Restaurant in the background

6.7 Conceptual Sketches of Scheme 2

The Waves are conceptual urban image of sustainability designed for the State of Hawai'i which will reduce vehicular traffic congestions and prevent the problems of sprawling outwards onto green spaces either through building or traveling long distances. In order to prevent building over undeveloped green spaces, the Waves has been designed vertically and over an existing site to revitalize the area; Natatorium War Memorial. As noted earlier, the two towers will house and produce energy through photovoltaic and wind turbines. Not only will it produce energy, but it will have the capability and the spaces to grow plants and vegetables for the residence to be self-efficient from food. The Waves will be an educational facility along with apartments, offices, and open retail areas for residence and/or guests.





The shape of the towers came from the inspiration of coral life. They are most decorated and attractive. People all over the world come to Hawai'i to swim and snorkel to see these marine species come to life and grow. The growth of this marine species depends on the human elements. The public needs to be educated more about coral life and about sustainability in order for coral to survive. In order to be successful the Waves must be designed to be ecologically friendly and push towards an ecological city.

6.8 Spatial Arrangements for Scheme 2

The architectural process for Scheme 2 took a different approach from Scheme 1. Rather than floor by floor upward designing with no site boundaries (artificial landmass), the Waves were designed through looking at the exterior perspective while ensuring the social diversity of the public; home to office and laboratories to educational to recreational activities while on the existing structure. It will recreate the old function of the seawater swimming pool. Also, it is promoting pedestrian circulation for a healthier life-style.

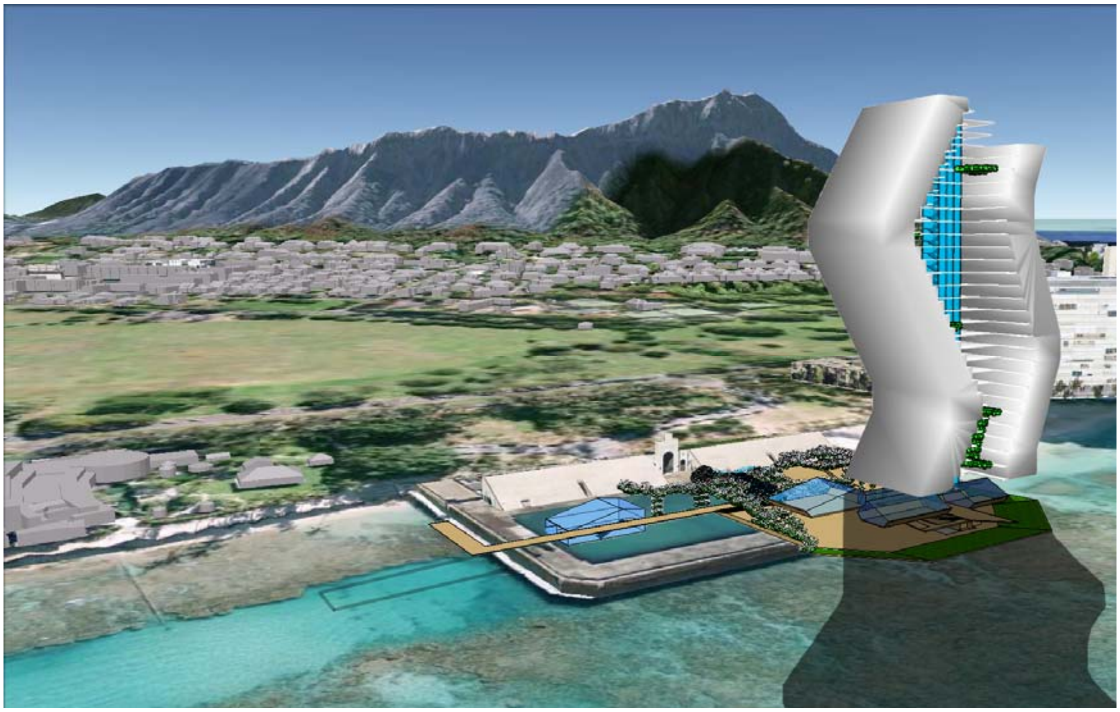
Three different styles of the Waves were designed to represent the building concept to meet the architectural functions and to revitalize the area. However there are similar features as in Scheme 1, such as modular systems (30'x 28' rooms) and a roof garden that interacts with the retail and learning center. The void in between the two buildings will act as an atrium to provide day light into the lower areas.

<u>Scheme 2.1:</u>

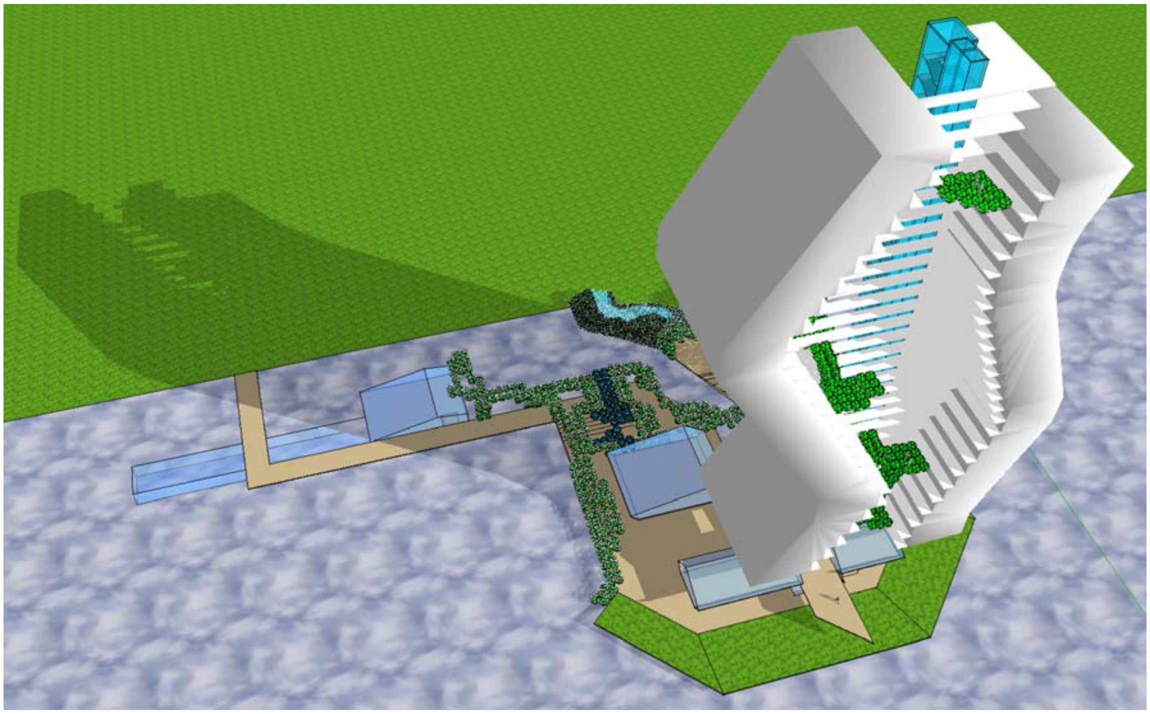
Plan View

The idea for this design is working with the building as a whole. Curving the exterior walls to imitate coral growing out of the water to acknowledge they also live with the human population. Functionally, the Waves will maximize the use of its footprint to preserve space for the island of O'ahu. The design is also a representation of working with nature, as the garden/park is pulled upwards into the residential towers; it's creating sky courts for the residence. At the same time it is molded around the modular bedroom system (30' x 28' – 1 bedroom layout). When two of these rooms are put together it becomes a two bedroom, same goes for the three bedrooms, if three rooms are put together it becomes a three bedroom layout.

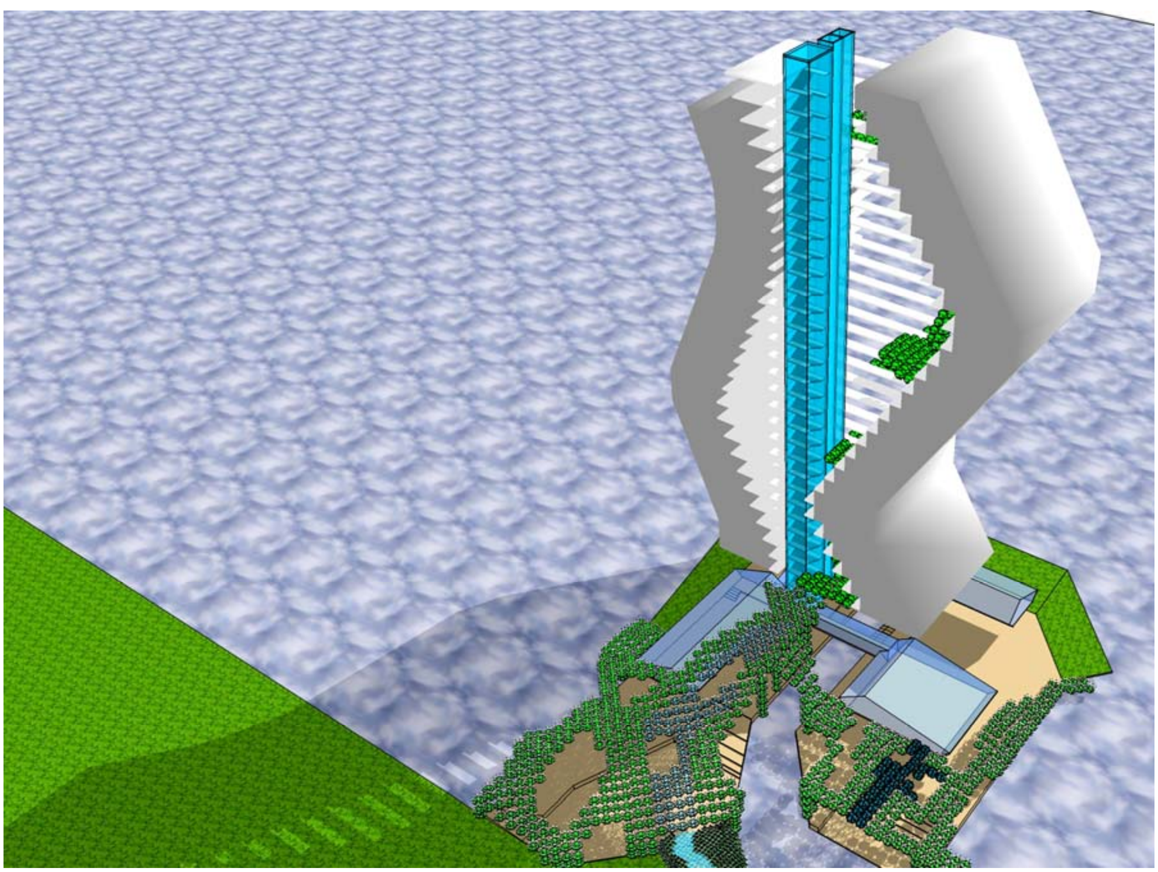
Waikiki View

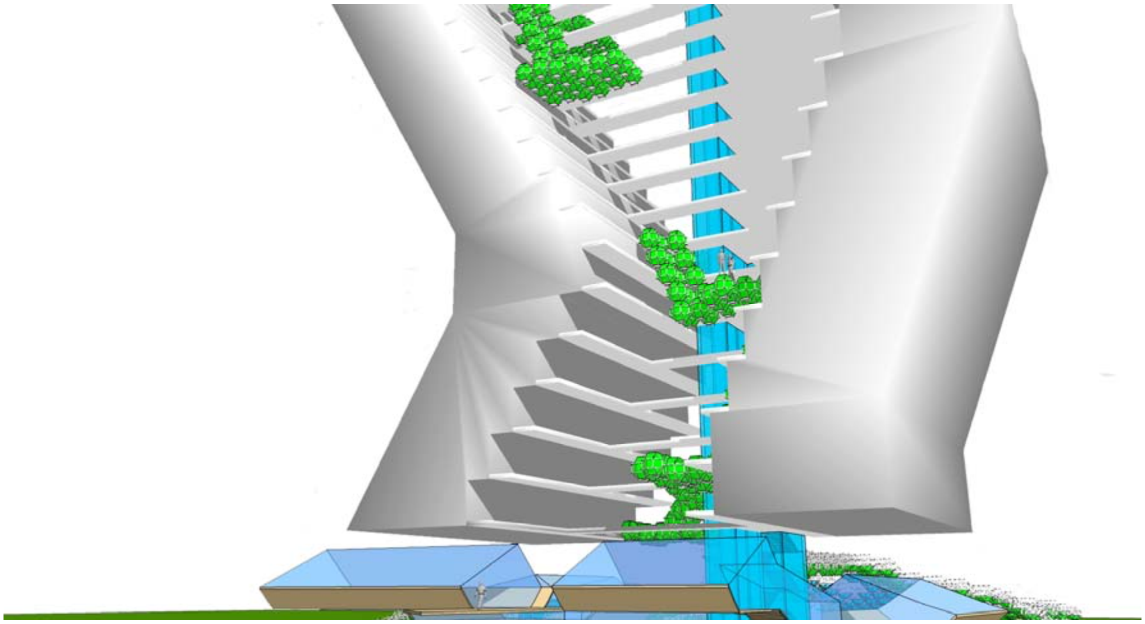

Diamond Head View

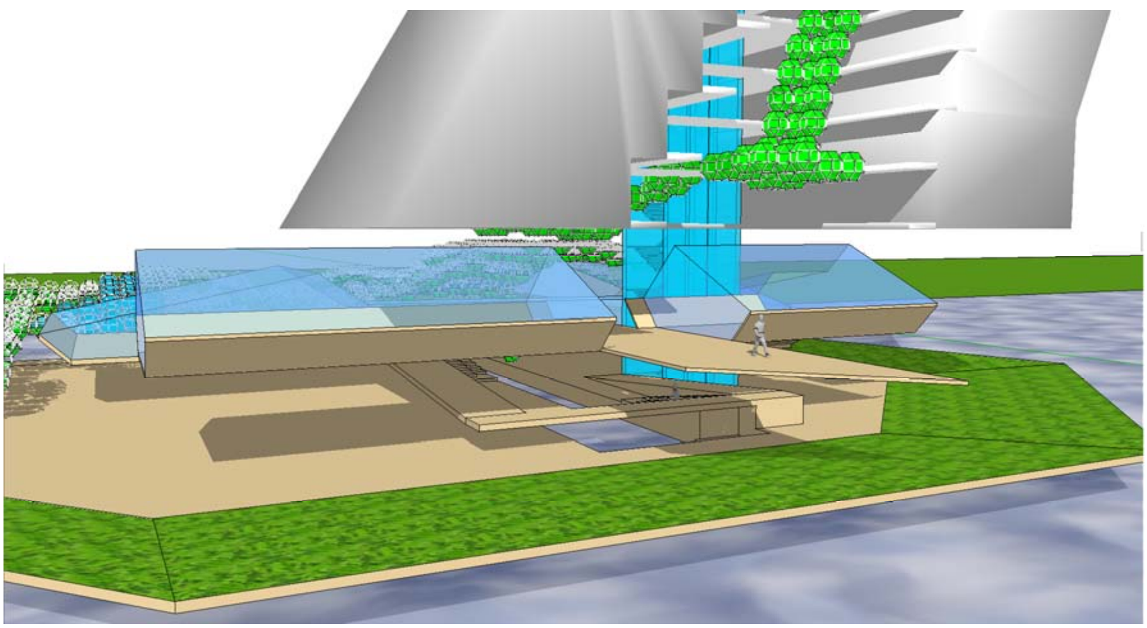

Ocean View with the existing structure: Natatorium War Memorial



A view from above looking down at the sky courts





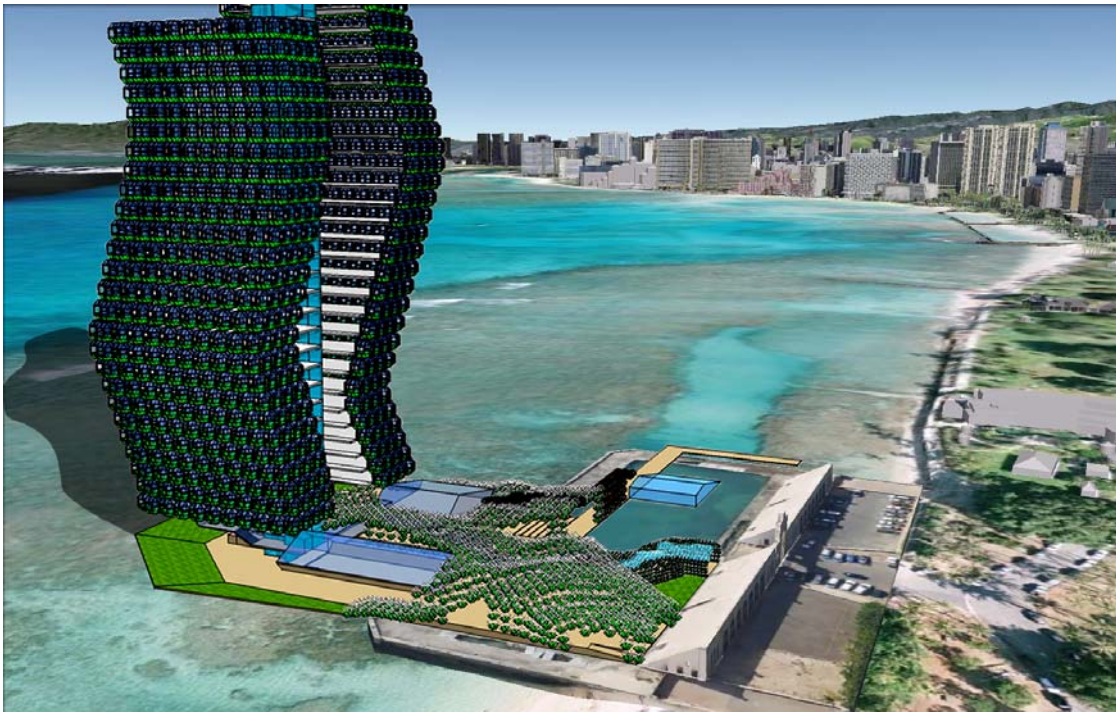


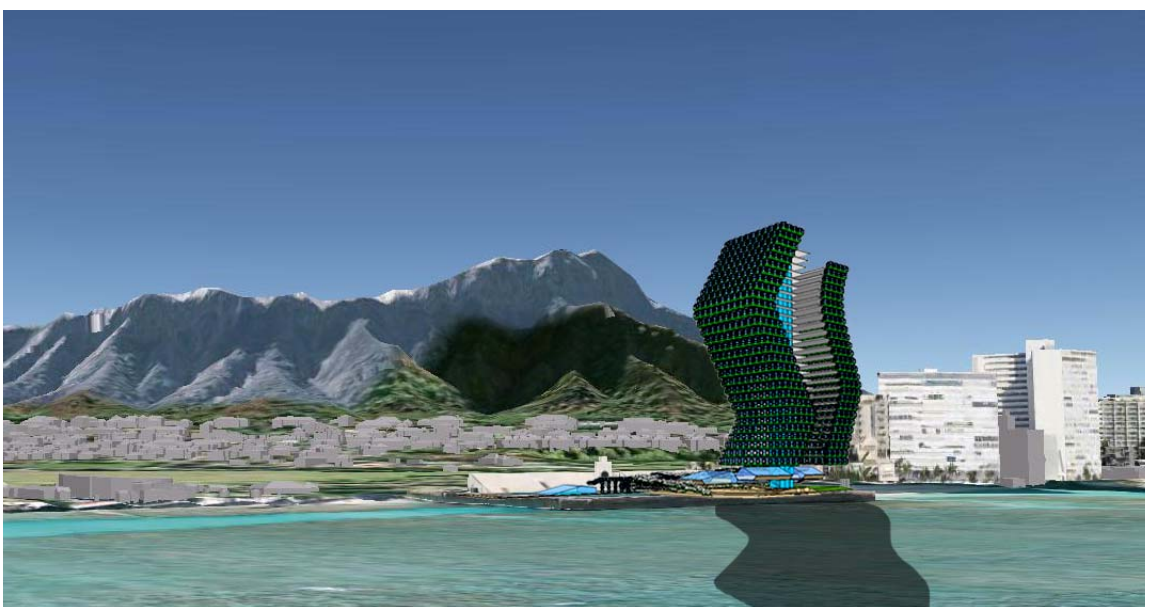
Multifunctional Spaces as well as Offices

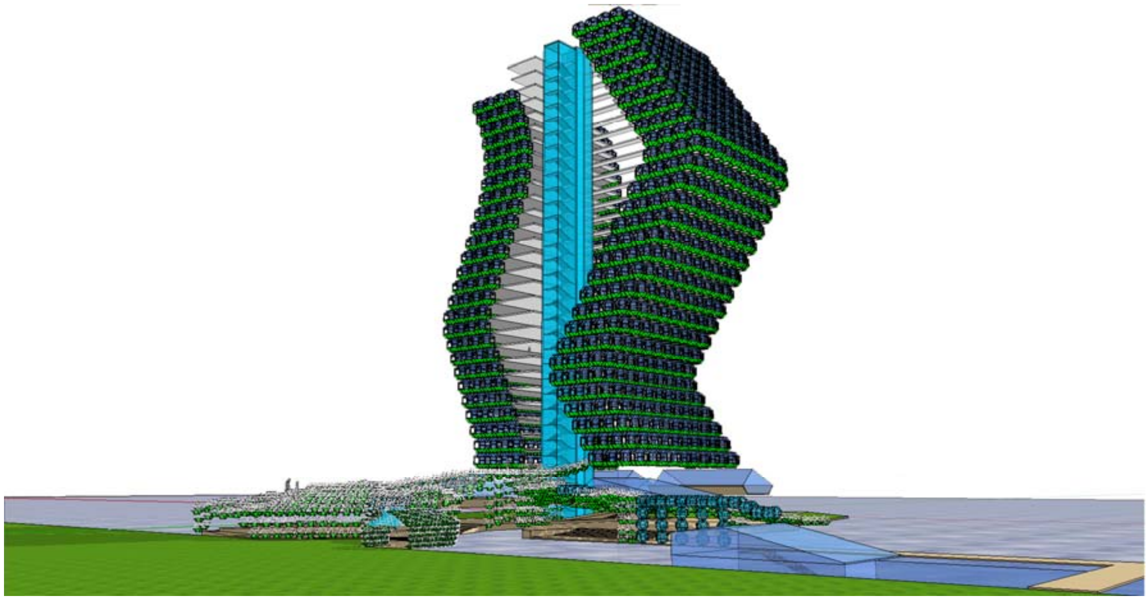
Scheme 2.2:

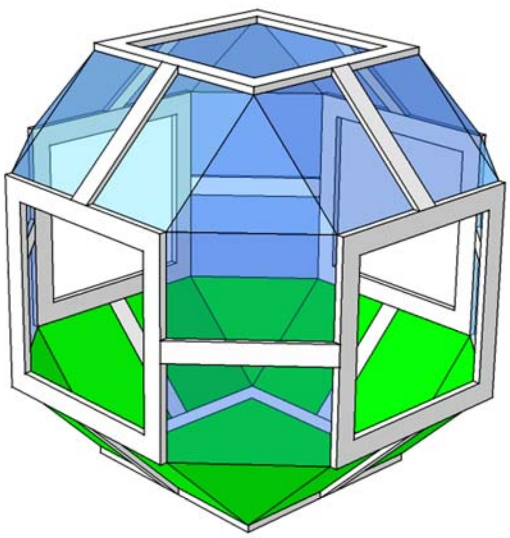
Plan View

This design is working with a framing system on the exterior of the building acting as a double skin façade as well as a structural function: housing a roof garden for the residence; imitating a yard and also for passive design control. It will help satisfy the need to become more self-efficient to self-sufficient by not only looking at creating energy but cultivating food at the same time.

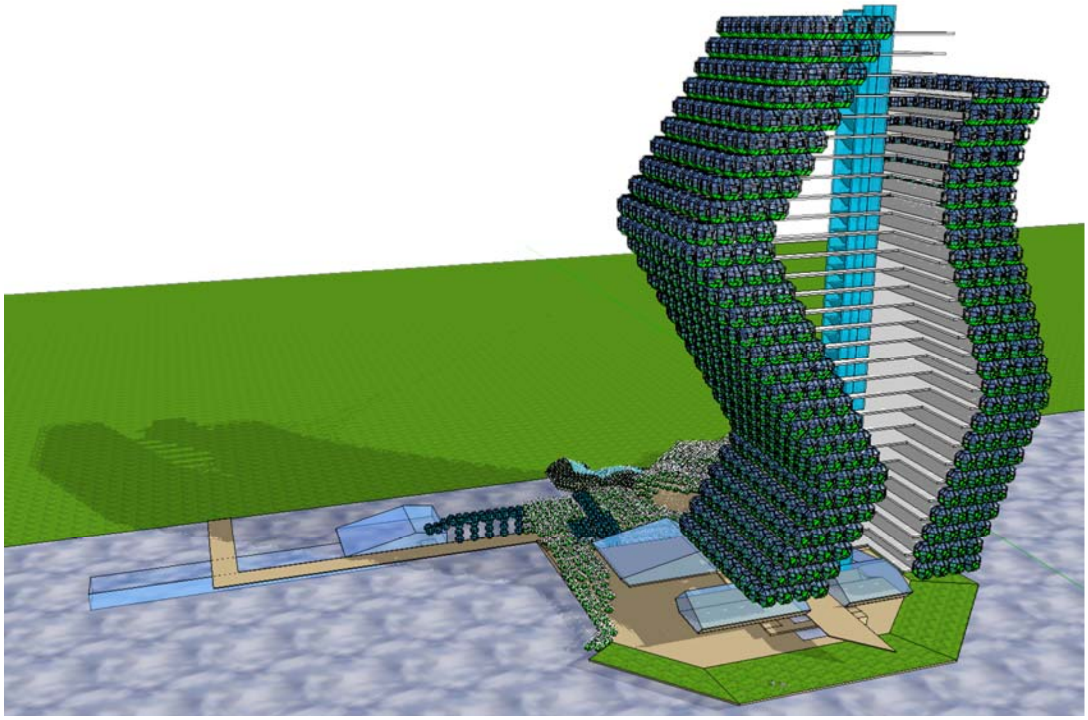

Waikiki View with the Roof Garden interacting with the Retail Area.

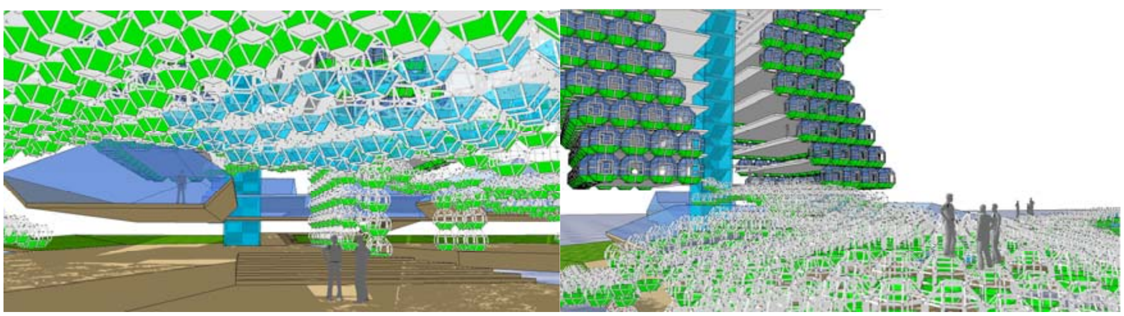

Diamond Head View



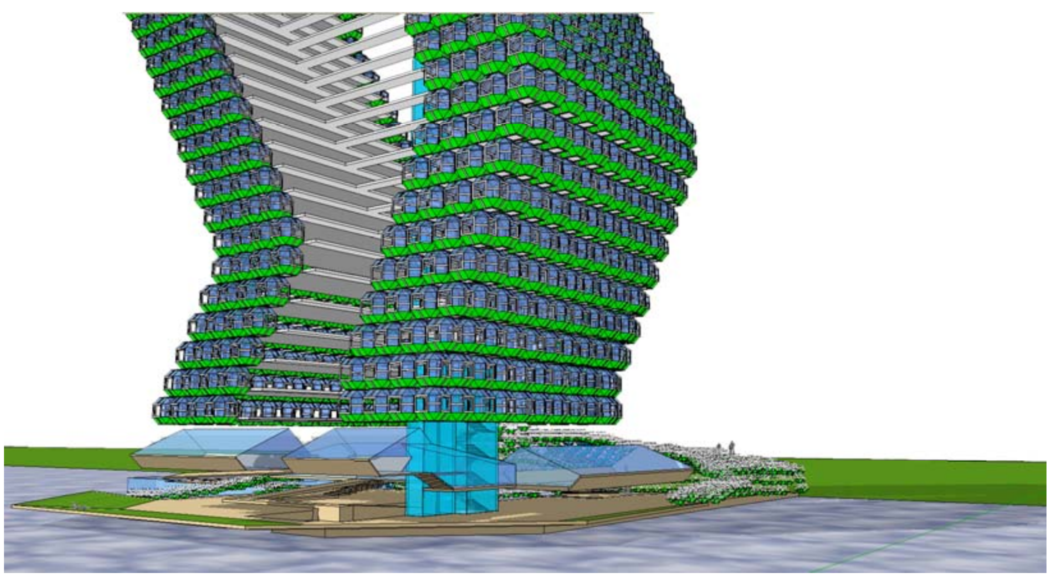


As stated earlier, the idea for this design is to house agricultural pods. These pods are able to sustain plants, vegetables, and other agricultural goods. At the same time it functions as a passive design for cooling and heating while acting as a sun shade for the interior. Also they act as noise barriers from the outside.





L: Under the Roof Garden, Retail Area   R: Roof Garden



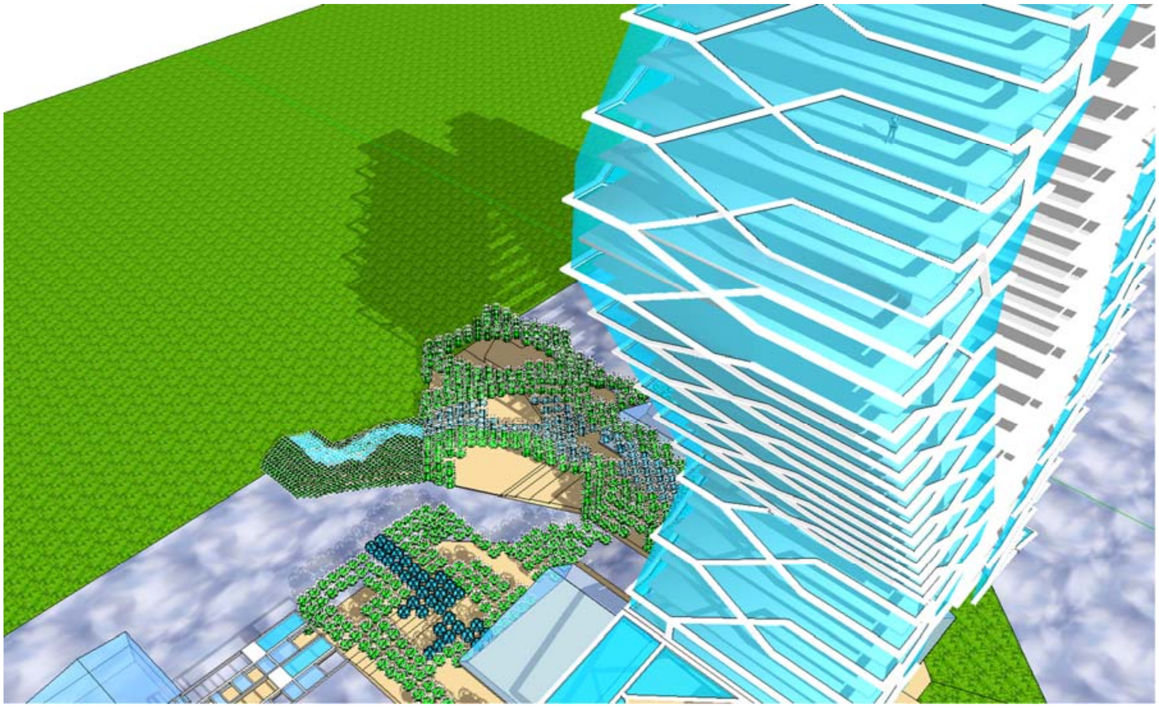
Scheme 2.3:

Plan View

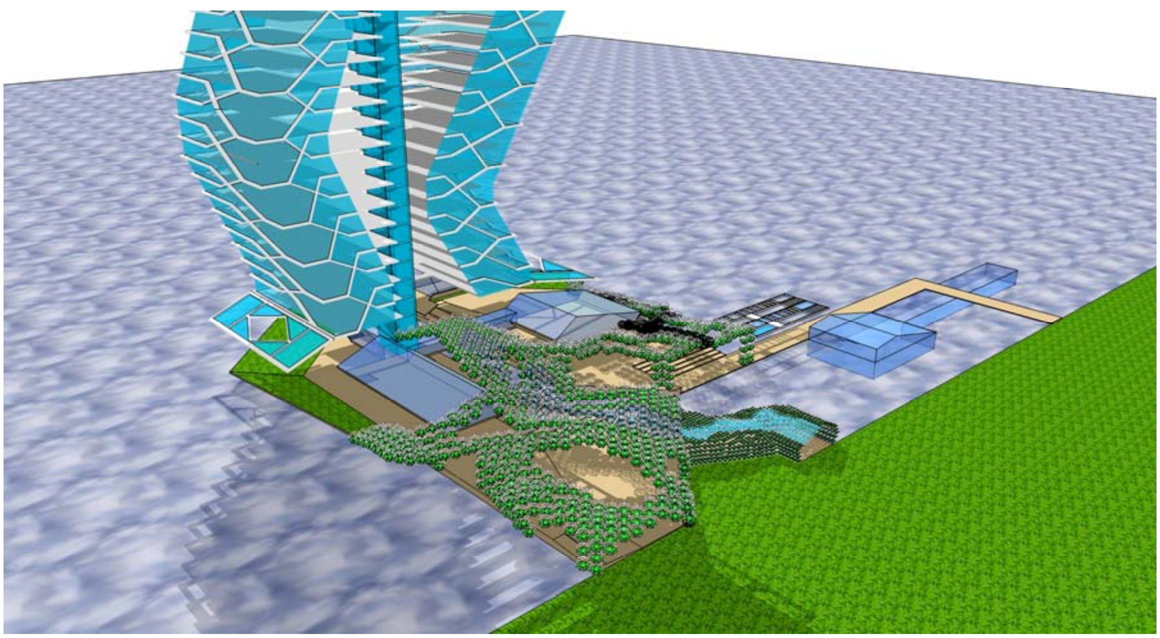
The idea of using a double skin façade for passive design solutions to satisfy sustainability can be best seen in this design. The double skin façade acts as an air circulation cavity for the main residential tower structure while being a sun shade. At the same time it provides views towards Waikiki and to Diamond Head. Not only will it be a passive design solution for cooling and heating, it will also house photovoltaic panels to generate energy for the building while allowing day light into the residential units. Visually speaking, the Waves Towers represents the building concept of replicating how coral reef lives. They search for different areas to live and grow depending on the conditions of the water. The framing system imitates the coral reef spawning out to different locations while the glazing acts as the ocean. The residence inside and visitors are the marine species living with one another; interaction amongst all forms of life.

Waikiki and Kapiolani Park View

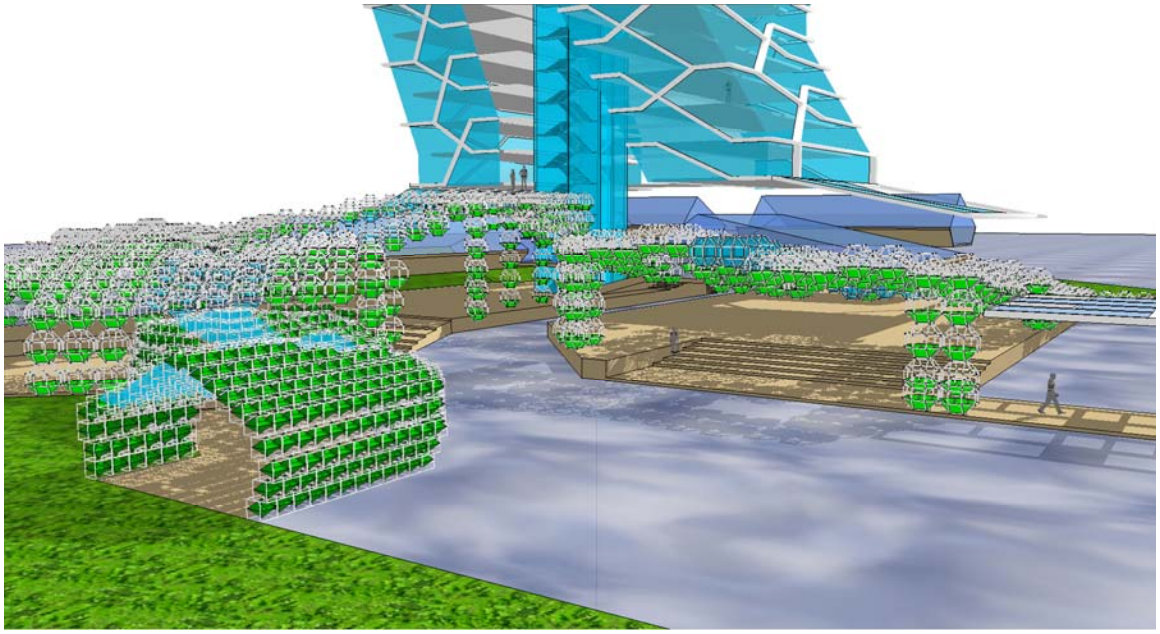
Diamond Head View



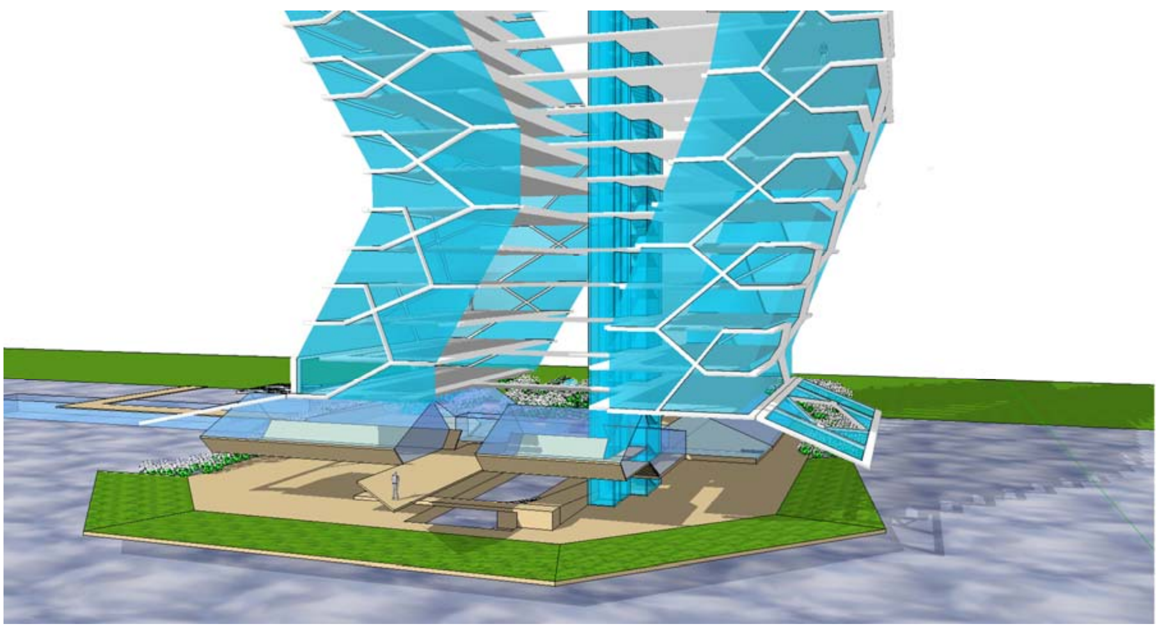
Double Skin Façade



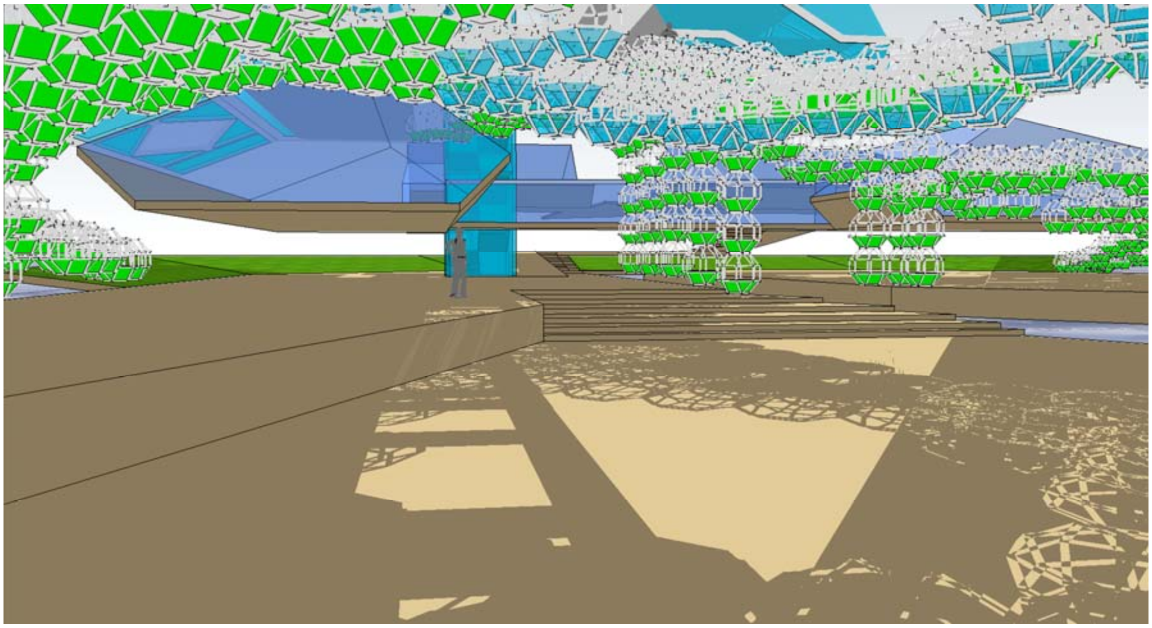
View to the Park



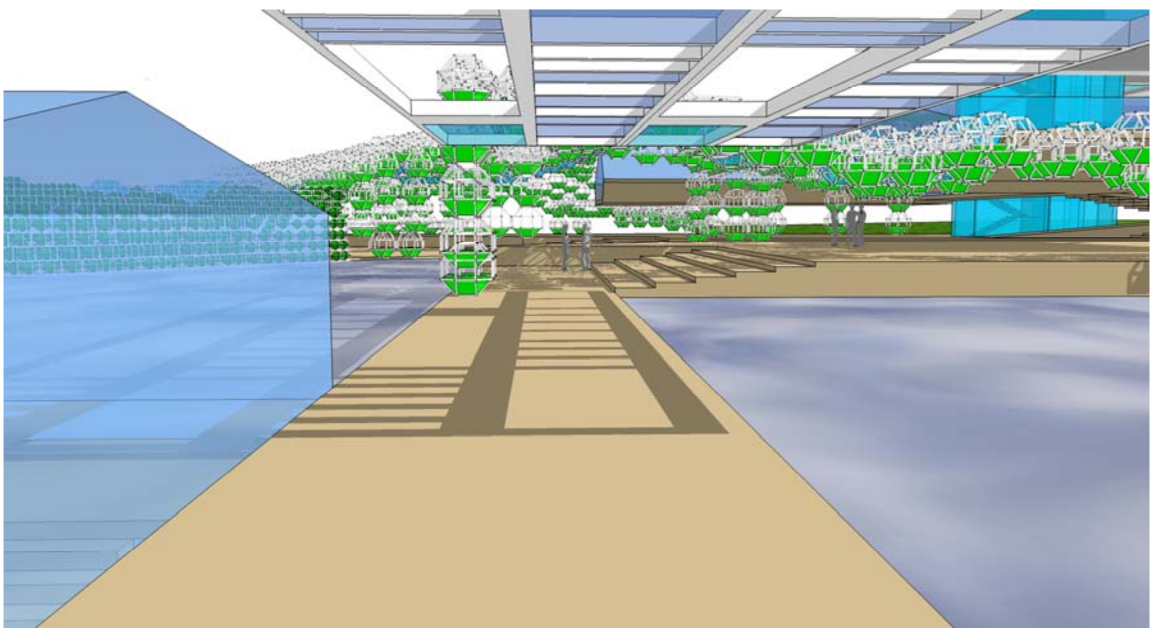
Entry View



Multi-functional Spaces and Offices



Open Retail Spaces below the Park



View from the Learning Center

6.9 Scheme 3 – Developing the Design

Plan View

The vision here is to eradicate the existing landscape into the building; integrating nature and manmade development while co-existing with the current structure. The building consists of green zones for visitors, residence and office workers to restore the connection between human and the earth. The mixed-use building will bring about a new way of designing and how we plan for the future for the State of Hawai'i. However, there are some restrictions that were taken into consideration that shaped this design.

The *Waikiki Marine Life Conservation District* is a State Law that protects the beach front, coral reef, aquatic life, and water quality along Waikiki and into Diamond Head. The solution was to use the existing Natatorium swimming pool as the site constraint; not allowing the building to be built into the ocean floor. This also allows the adjacent beach to have access of the sun throughout the day.

Walk Score[160]:

2777 Kalakaua Avenue, Honolulu, HI 96815

According to *Walk Score*, this site is 55 out of a 100 (Avg. for Honolulu is 64), which is somewhat walkable. However, I can argue that, throughout the day there are many residence and visitors that walk around Kapiolani Park which is in front of this location to exercise and do other recreational activities. The Waves will promote a healthier life-style by enforcing residence and visitors to walk because of the elimination of vehicles. Also, it enforces them to use the public transportation, which is 63 (good transit) as oppose to driving their own cars that causes vehicular traffic and CO_2 emissions. This may be a new beginning of a walkable standard for the State of Hawai'i.

Nearest:

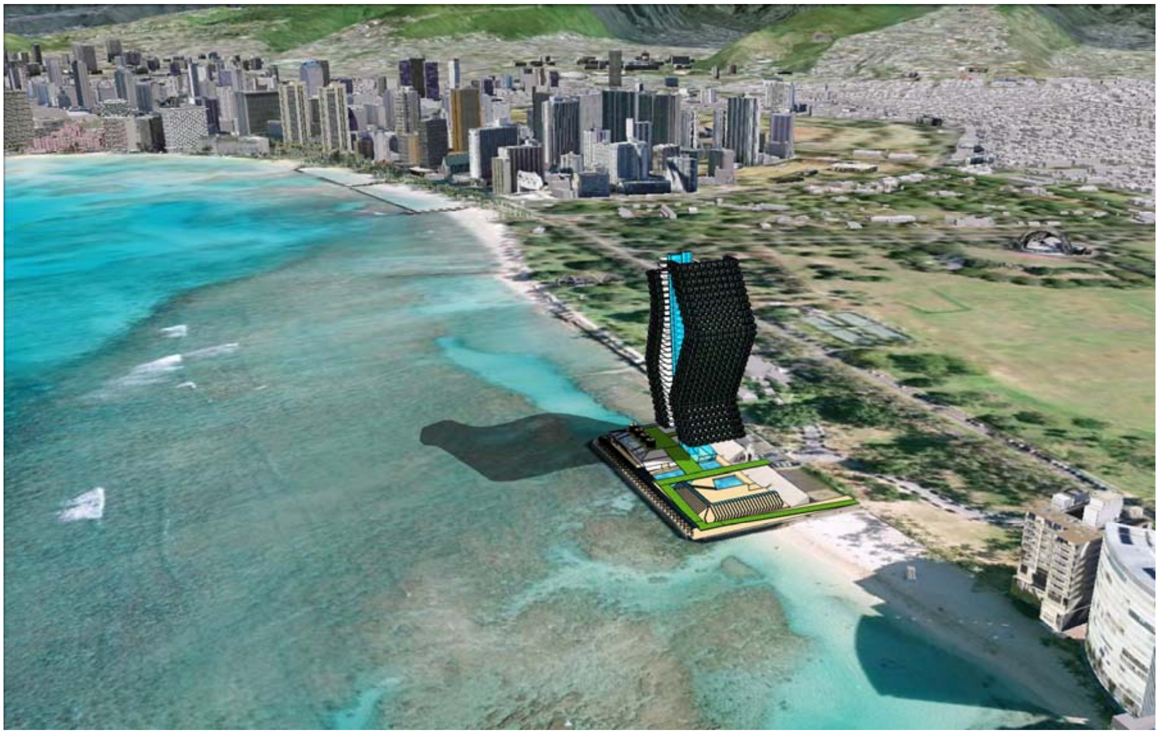
Restaurant	0.15 mi
Coffee	0.43 mi
Groceries	0.63 mi
Shopping	0.09 mi
Schools	0.49 mi (Elementary)
Books	0.49 mi
Bars	0.42 mi
Entertainment	1.77 mi
Post Offices	0.93 mi

Bus Lines:

2 and 15	0.05 mi
42, 98, 201, and 202	0.29 mi

One can argue that why not be a theater or a theatrical performance area? To answer this, theater is only occupied during working hours. A residential tower/s with other functions will be occupied all day and all night. Not only will this site be used efficiently and effectively, the Natatorium War Memorial will be revitalized.

[160] Walk Score, *Find a Walkable Place to Live*, www.walkscore.com (Nov. 22, 2010).



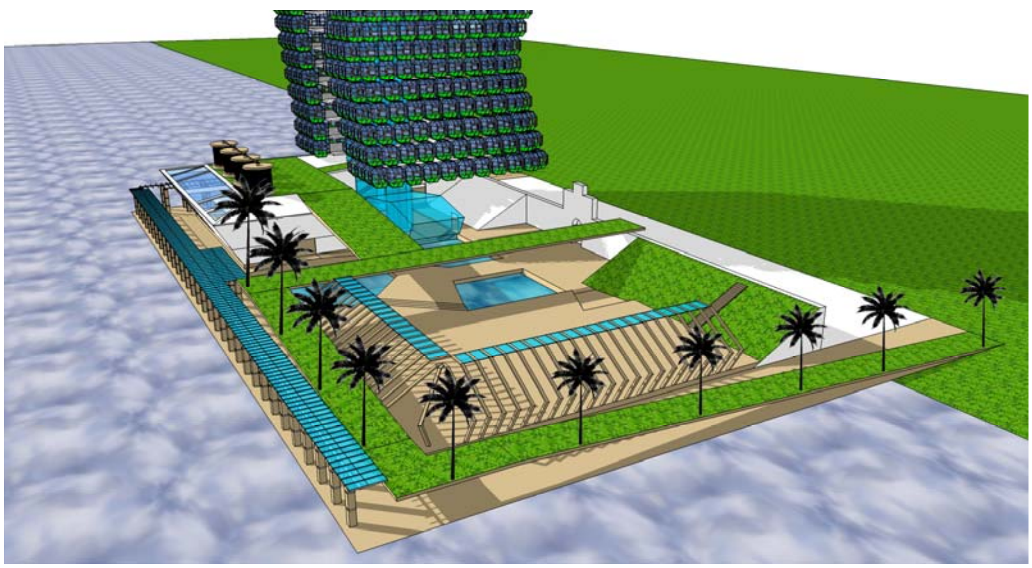
Waikiki and Kapiolani Park View

Front Entry Elevation

- The idea here is to use the current space of the Natatorium for the Hydrogen and Fuel Cells storage, also housing the mechanical systems.
- WaterMicron Generators are on the top level so less pumping is needed.

Boardwalk, Learning Center (underwater – into the reef channel) and Office Spaces

- As the mixed-use building is a Learning Center, the wind turbines and PV panels will be accessible to the general public for their education. As for the other two wind turbines, they will be located higher up the building (near the WaterMicron generators) as they will get higher wind speeds. The reason why they are not shown in these images is because they will depend on finances and structural configuration; they will be integrated with the buildings structure.
- Battery packs will be connected to the PV panels to power the night lights.



Green Zone and Multi-functional Area

- The Multi-functional area will house retail kiosks, performances, conferences, and/or other activities.
- The agriculture pods (stated earlier in Scheme 2.2) will not only act as farming or yard pods, but as noise barriers when there are activities in the Multi-functional occurring.

CHAPTER 7

CASE STUDIES

7.1 Artificial Landmass – Dubai, ‘The World’

7.2 Hawai’i ‘Brownfields’

7.3 Approaches to a Sustainable Building

7.4 Approaches to a Passive Design

7.1 Landmass

Location: Dubai, 'The World'

Overview:

The artificial landmasses are planned out to have a mixture of aesthetic beauty and seamless functionality. Strategically placed transportation hubs and marinas to commercial centers give a sense of order. The development is to provide the visitors and residents an experience that will never be forgotten and the yearning for more so they will come back again.

Flaws:

The clear water is now becoming cloudy with silt. The construction is causing damage to the coral reefs and threatening local marine species.

Terraforming:

Terraforming opens the door for development. The islands are able to be sculptured in a way that creates different experiences, densities, and a greater return investment.

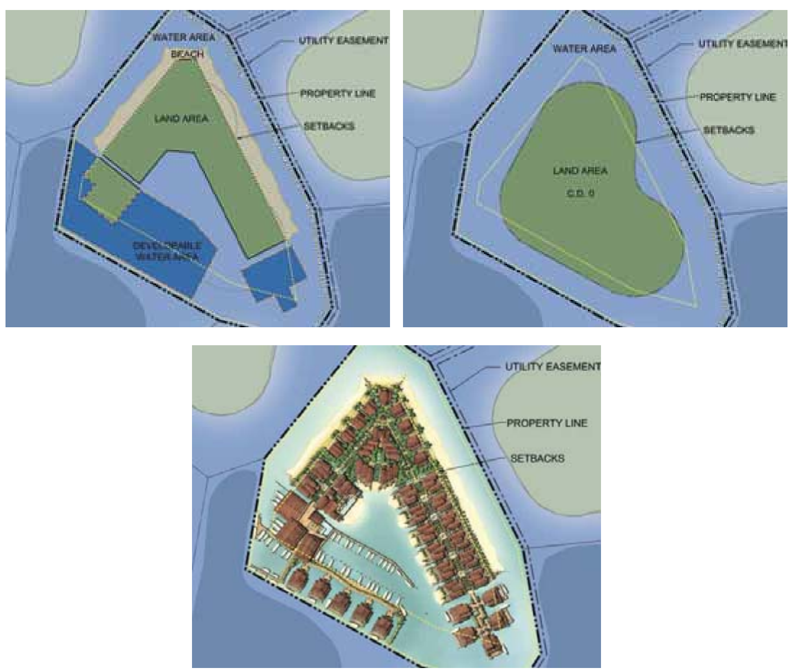


Figure 7.1 – Terraforming process.[161]

[161] The World, *Overview*, http://www.theworld.ae/ (Nov. 28, 2009).

7.2 Hawai'i 'Brownfields'

Project Name: Hawai'i Children's Discovery Center

Owner: Private Nonprofit Corporation

Project Description:

Before the Center was opened, the State of Hawai'i Community Development Authority completed site assessment, site cleanup, and structural renovations. The Hawai'i Children's Discovery Center opened to the public in 1998; it was once an abandoned city incinerator. The new Center design incorporates the old building structure and the exhaust stack. The Center is nearly 38,000 square feet and it houses an interactive exhibit for the children and their families to explore and discover the world.

The project was to help redevelop the neighborhood in becoming a recreational use. Adjacent to the Center is a new-30 acre waterfront park.

Figure 7.21 – Hawai'i Children's Discovery Center.[162]

Figure 7.22 – Old Incinerator.[163]

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[162] Brownfields, *Hawai'i Children's Discovery Center*, http://hawaii.gov/dbedt/gis/brownfields (Feb. 13, 2010).

[163] Ibid.

7.3 Approaches to a Sustainable Building

Project Name: DIFC Lighthouse Tower

Architect: Atkins

Project Description:

The DIFC Lighthouse Tower is 400 meters tall and is located at the Dubai International Financial Center. The design of the project is presumably achieving LEED platinum rated for a low-carbon commercial building. It will reduce its total energy consumption by 50% and water consumption by up to 40%.

Sustainable Approaches:

The design is a passive solar architecture with low energy, low water engineering solutions, energy and water recovery, as well as renewable resources and photovoltaic panels constructed in the façade. For example[164]:

- A digital lighting system is proposed with daylight and movement sensors to reduce energy consumption.
- Grey water recycling to service the irrigation needs of the landscaped areas.
- Flow restrictors on taps and showers as well as low flushing toilets along with waterless urinals
- 150 solar water collectors to meet the hot water requirements for the whole building.

Figure 7.3 – DIFC Lighthouse Tower.[165]

[164] Atkins, *Projects,* http://www.atkins-me.com/home.aspx (Nov. 30, 2009).

7.4 Approaches to a Passive Design

Project Name: Plaza Atrium

Architect: Ken Yeang

Project Description:

The 24-storey Plaza Atrium is located in the commercial area of Kuala Lumpur. This project was Yeang's first opportunity to incorporate his ideas on climatically appropriate forms for a high-rise building type. The challenge was to design a building in a hot-humid tropical climate.

Passive Approaches:

The roof is a Z-section concrete louver to filter the rain, permits accumulated hot air to disperse and diffuses sunlight.[166] The offices within the atrium space are stepped back for terraces and had the intent to be landscaped, but never was. The building was able to control the entry and emissions of heat, glare, breeze, ventilation, and rain.

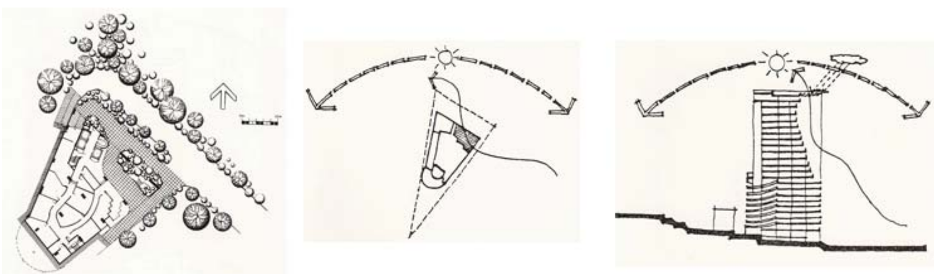

Figure 7.41 – Site of the Building with Sun Path.[167]

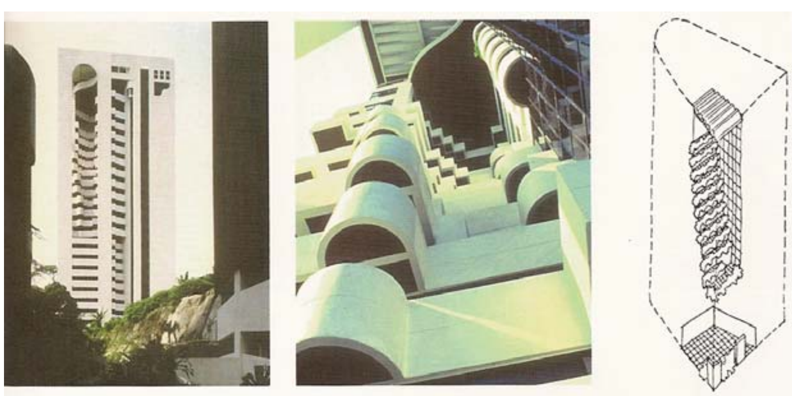

Figure 7.42 – Plaza Atrium with a Conceptual Sketch.[168]

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[165] http://www.atkins-me.com/home.aspx

[166] Robert Powell, *Rethinking the Skyscrapper, The Complete Architecture of Ken Yeang* (New York: Watson-Guptill Publications, 1999), page 16.

[167] Powell, page 19-20.

[168] Powel, page 17.

CHAPTER 8

CLOSING STATEMENTS

8.1 Architectural Contributions

8.2 Acknowledgements

8.1 Architectural Contributions

There will be a lot of questions about this research paper, such as: Why build here, why can't others build there, and most important question of all is, what are the contributions that will be made to the society and the State of Hawai'i? To answer these questions, it is not why this proposed building has the privilege of building here, it is how the proposed mixed-use will function and provide for the people on the island of O'ahu and visitors that travel here to push for an ecological contribution.

To sum up the paper, we all know the earth's resources are dissipating and causing global warming. One of the intent is to educate the general public of how they can make the necessary changes to become more environmentally friendly; sustainable. Take Dr. David Suzuki, he points out important facts and considerations of becoming sustainable in our daily lives. For example: to the general public they should eat more sustainably. Eat more sardines rather than tuna because sardines are a lot easier to catch preventing less traveling around on boats, meaning less oil into the ocean. Another is building more bicycle routes rather than expanding roads. This will prevent carbon dioxide emissions and vehicular congestions. Be a community leader to help protect nature and our quality of life.

How does this relate to the proposed building? It relates by providing the necessary amenities to cut down traveling, provide natural ventilation, allow wanted sunlight and prevent unwanted sunlight to reduce energy, generate its own energy through renewable resources to become self-powered, and to build over existing structure or places that are no longer used – reducing the carbon footprint in an architectural stand point.

To answer why this building will be allowed to be built at this location and other developers or architects may not have the opportunity, and not to say they don't, is because it is giving back to the City of Honolulu – providing offices or functional spaces, and at the same time to the people. One of the goals is to revitalize the Natatorium War Memorial - bringing people back to utilize this area more efficiently throughout the entire day. As of now it is only used during sun hours, at night fall it is a dark place with little security. Also, it is an opportunity to take advantage of the site features; one of the highest average of winds throughout O'ahu, utilizing the sun efficiently throughout the day, promoting a healthier life-style by enforcing people to walk or use more of the public transportation, to banks, supermarkets, shops, the beach, and so forth – possibly a new standard of planning. Furthermore, it will not only be a residential building, a retail place, or a business area, it will be a learning facility to educate the general public about sustainability: how to effectively and efficiently use natural resources and how to protect our marine species. If not, here are the consequences to the human population and to the other living organisms on earth.

In fairness to all, it is a building that is open for public use. Even though it may be a high-end residential quarters, there is no one specific status of income that can reside here. It will be welcoming and inviting to learn innovation. The main contribution is to improve the quality of life and allow our future generations to live in harmony with nature.

8.2 Acknowledgements

This research paper was written with the encouragement and support of my Chair and Committee Members. I would like to thank them for taking their time away from their busy schedules to help guide me through my architectural education. If it wasn't for them, I wouldn't have gotten to where I am.

I hope and wish this research paper will benefit the State of Hawai'i in the future. I believe we will make the necessary changes so that we will not reach the point of disaster to the human population and the marine species. However, if it comes to that point, this paper will be an image to what Hawai'i can be. Most of all, special thanks to the State of Hawai'i where I grew up and inspired me to write this research paper.

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Theodore Garduque – Committee Member (Garduque Architects - President)
Aaron Hyland – Committee Member (Architectural Resources Group, Inc. – Principal)

CHAPTER 9

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9.2 Additional Resources

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