DESIGNING A RENEWABLE ENERGY HARVESTING PARK AS AN ALTERNATIVE ENERGY SOURCE FOR THE AURORA PROVINCE, PHILIPPINES

TAN, JEFFREY STEVEN LA 200 B LANDSCAPE ARCHITECTURE THESIS

RATIONALE

Currently two-thirds of all the greenhouse gas emissions worldwide are produced by fossil fuel for energy production (Gielen et al., 2019). According to the International Energy Agency (2021) the global energy-related CO2 emissions is at 31.5GT (giga tonnes), which is still the highest ever annual concentration in the atmosphere, this is despite being in a pandemic. Due to the increasing carbon emissions, there is a risk of not being able to achieve the 2015 Paris Climate Agreement. The Paris Climate agreement implies that the world must limit temperature increases of 2 degrees Celsius.

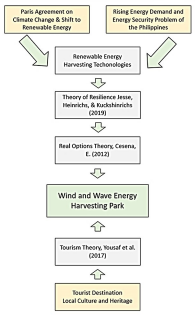
According to the United Nations (2021) the current global temperature has already increased by 1.1 degrees Celsius, which is near the 1.5-degree threshold. Not being able to achieve the Paris Agreement will result in an increased frequency of climate change disasters, bigger scales of heat waves and storms across the globe (United Nations Climate Change, 2019). Despite the continuous rise of renewable energy production, the transition is not happening fast enough. Moreover in the Philippines the use of renewable energy as energy supply is barely keeping up with the additional demand of electricity.

This research aims to create a renewable energy harvesting park in Aurora Province. The renewable energy sources would be from solar, wind and wave energy. This will be a pioneer in the Philippines as there is no wind and wave energy harvesting parks in the Philippines. Once implemented it could help provide energy security for of a lot of Filipinos and this would be a clean and safe energy harvesting method

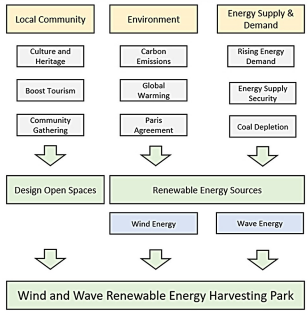
SCOPE & LIMITATIONS

01. The thesis will incorporate wind and wave as the main sources of energy for the energy harvesting park. Other forms of renewable energy will also be tackled and incorporated but will serve as secondary sources.
02. The data used for the proposed development will only look at the projected energy consumption of Aurora Baler for the next 10 years.
03. The study will be creating a renewable energy harvesting park design that will be power Aurora Baler.

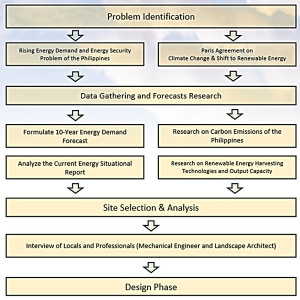
CONCEPTUAL FRAMEWORK



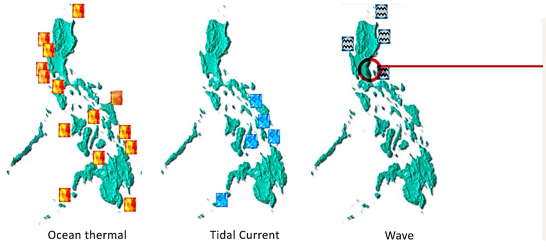
THEORETICAL FRAMEWORK



RESEARCH METHODOLOGY FRAMEWORK

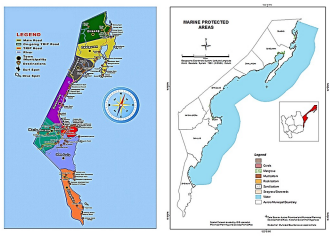


MACRO SITE-ANALYSIS

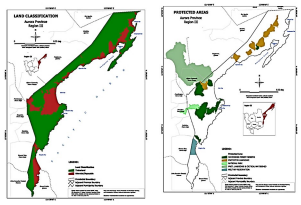


Tidal, Ocean Thermal and Wave Current Map of the Philippines
Source: Abundo, M (2011) Ocean/Marine Renewable Energy: An Emerging Option

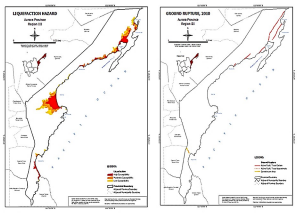
Aurora Province & Boundaries of the 8 Municipalities
Source: Aurora Gov



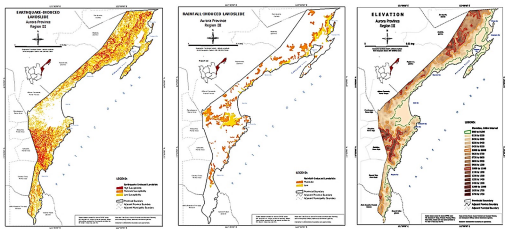
Dive, Surf & Marine Protected Areas
Source: Aurora Gov



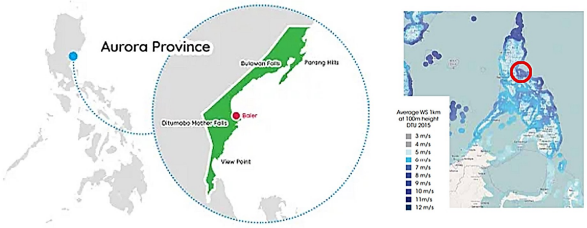
Land Classification & Protected Areas
Source: Aurora Gov



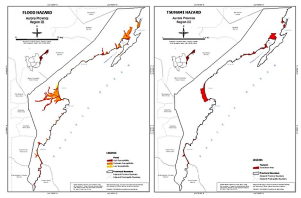
Liquefaction & Ground Rupture Hazard
Source: Aurora Gov



Earthquake & Rainfall Induced Landslide and Elevation
Source: Aurora Gov

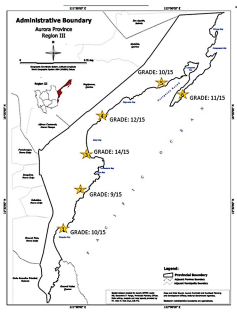


Aurora Province & Wind Energy Resource of the Philippines
Source: Aurora Gov



Flood Hazard & Tsunami Hazard
Source: Aurora Gov

SITE SELECTION CRITERIA



Grading System		Star Location					
Category	Criteria	1	2	3	4	5	6
Wind Speed	3-5m/2 Wind Speed	1	1	1	1	1	1
Temperature	18-22C ideally	1	1	1	1	1	1
Slope	0-3% ideally	1	0	1	1	1	1
Distance from town	500 – 1000 meters away	0	0	1	1	1	0
Distance from routes	Direct Access	0	0	1	0	0	0
Distance from airports	At least 2500 meters away	1	1	1	1	1	1
Distance from protected areas	At least 200 meters away	0	0	1	1	0	0
Land use	Should be classified as weak for pasture	0	0	1	0	1	1
Distance from ground water	At least 1000 meters away	1	1	1	1	1	1
Distance from surface water	At least 100 meters away	1	1	1	1	1	1
Distance from faults	2500 meters away	1	1	1	1	0	0
Landslide Risk	Low Risk	0	0	1	0	0	1
Flood Risk	Low Risk	1	1	0	1	1	1
Distance from Shore	Within 1000 meters away	1	1	1	1	1	1
Available wave energy	Present wave energy	1	1	1	1	0	1
	Total	10	9	14	12	10	11

ENERGY GENERATION CAPACITY OF WIND, WAVE AND SOLAR ENERGY

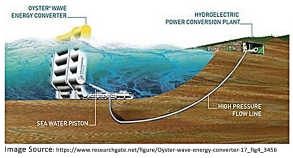


Image Source: https://www.researchgate.net/figure/Oyster-wave-energy-converter-17_fig1_3416

Oyster Wave Piston Technology
Flaps range from 18 to 26m in width and a power output of 250 to 450kw

Image Source: https://www.thoughtco.com/history-of-solar-cells-1992435

Solar Panels
One square meter (1sqm) of monocrystalline solar panels would yield around 1 kw of power each day

Image Source: https://www.euronews.com/green/2021/04/02/

Bladeless Wind Turbine
Vortex Atlantis/Grand that is 9 to 13 m tall and has a power output of approximately 1 kW. This model is ideal to be placed on residential and industrial areas that needs large power

Technology	Specifications	Capacity	Wind Speed	24 Hour Energy Output	Capacity Factor		
					20%	41%	65%
Oyster Wave Piston Energy Harvesting Technology	25m Wide Flap	450kKw	n/a	10.8 MW	n/a	n/a	7.02MW
Vortex Bladeless Wind Turbine	10m Tall	1Kw	3-6m/s	.024 MW	n/a	.0096MW	n/a
Monocrystalline Solar Panels	Monocrystalline	5 kw/m^2/day	n/a	5 Kw	1 Kw	n/a	n/a

ELECTRICITY GENERATION PLAN

Generation Capacity of Renewable Energy Harvesting Technologies

Technology	QTY	Price	Total Cost of Technology	Annual Maintenance	Annual Generated Electricity
Oyster Wave Piston Energy Harvesting Technology	30 units (210.6MW)	51 million pesos per 1 MW	12 billion Pesos	225 million pesos	76,869MW
Vortex Bladeless Wind Turbine	350 units (3.36MW)	40,560 per unit	14.2 million Pesos	490,000 pesos	1,226MW
Monocrystalline Solar Panels	8000sqm (8MW)	51 pesos per 1 watt	408 million pesos	4.2 million pesos	2,920MW
Total			12.4 billion pesos	260 million pesos	81,015MW

INVESTMENT AND PROCUREMENT PLAN

Cost, Maintenance Cost & Annual Generated Electrical Energy of the Technologies

	Coal Powered Plants	Proposed Wind, Wave and Solar Energy Park
Equipment Cost	13 billion pesos	12.4 billion pesos
Annual Maintenance Cost	181 million pesos	260 million pesos
Operation Cost per KW		N/A
Total	13.18 billion pesos	12.66 billion pesos

COAL VS PROPOSED RENEWABLE ENERGY POWER PLANT

Technology	Annual Generated Electricity	Projected Sales Revenue (10peso/kwh) (Maintenance Cost – Gross Electrical Sales)	Years until ROI
Oyster Wave Piston Energy Harvesting Technology	76,869MW	543 million pesos	22 years
Vortex Bladeless Wind Turbine	1,226MW	11.7 million pesos	1.2 years
Monocrystalline Solar Panels	2,920MW	25 million pesos	16 years
Total	81,015MW	579.7 million pesos	21.4 years

RETURN OF INVESTMENT PLAN

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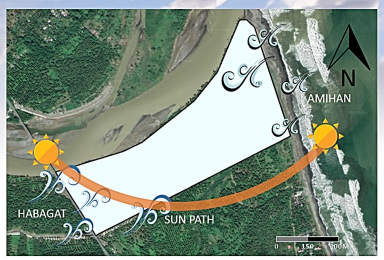
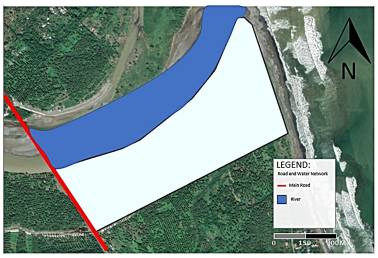


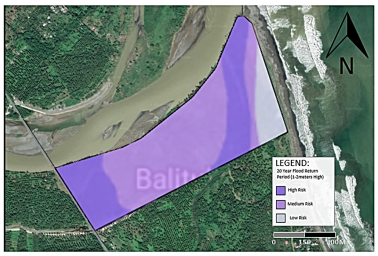
WIND AND SUN PATH

The site will have wind coming from both the north east and south west side. However the dominant wind direction and speed would be coming from the northeast as it is directly facing the pacific ocean.



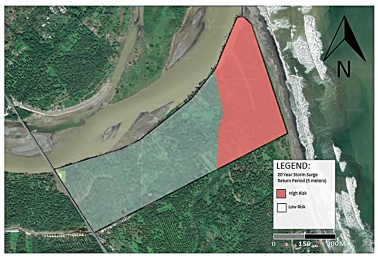
ROAD & WATER NETWORK MAP

The main road located at the west of the site is called Baler - Casiguran Road, while north of the site is Aguang River, and the east side of the site is the Sabang beach.



FLOOD HAZARD MAP

As observed in the given map the edge of the site towards the Aguang River is more vulnerable to the high risk of flooding, but there are ono going developments to reduce the risk.

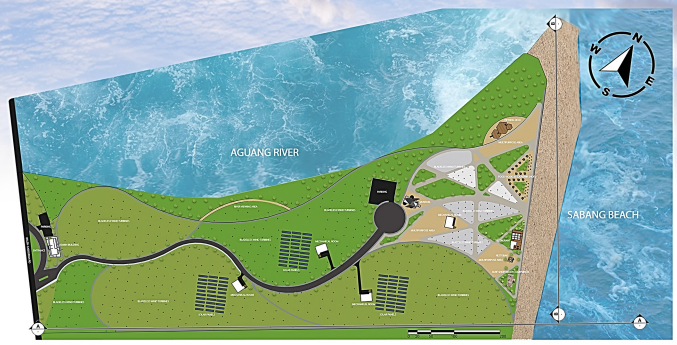


STORM SURGE HAZARD MAP

The edge of the site exposed to the Sabang Beach is the most vulnearble part in terms of storm surge, but there are on going improvements on the boardwalk to reduce strom surge risk.

BUBBLE DIAGRAM

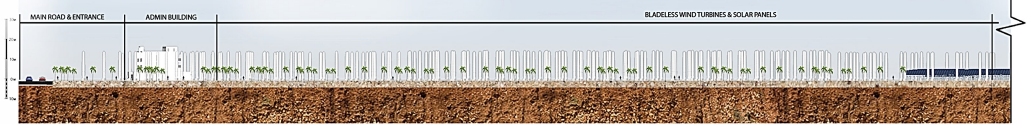
Spaces like restaurant & surf shop are positioned at the edge of the site near the beach to get the serene views. Whereas the core portion of the site is dedicated to the bladeless wind turbine & solar panels. There are also allocated parking for tourists as there is a lack of parking spaces in the area.



SITE DEVELOPMENT PLAN

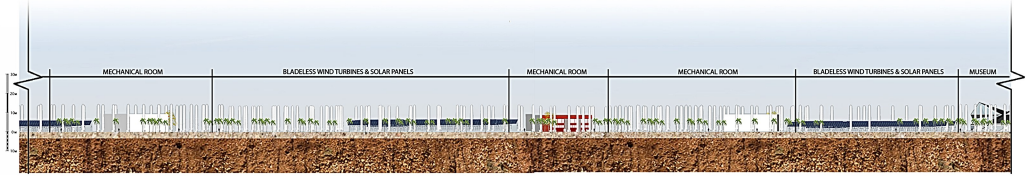
Baler-Casiguran road acts as the primary access for the site from the city centre. A certain amount of vehicular traffic is allowed inside the site and parking is provided. All the commercial spaces are positioned at the beach front to capture views and to provide easy access to tourists along the beach. The site also contains a musuem that showcases wind and wave energy harvesting procedure to provide insights for tourists and locals. The design also provided a viewing deck on the north portion of the site for an overlooking view of the area. The Aguang River is also highlighted by providing a viewing area for tourists to enjoy.

The concept of the site took inspiration from the famous waves of Aurora Baler and surf boards to create the curvilinear and triangular fin like form of the site.



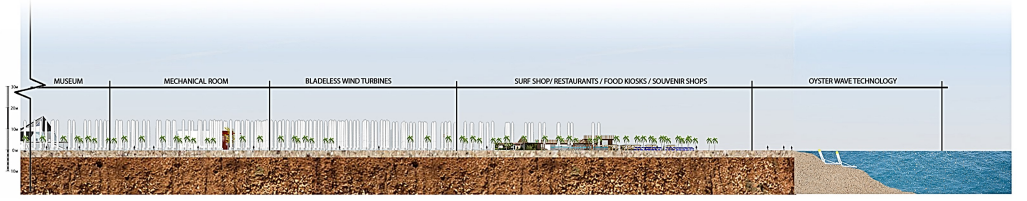
SIDE ELEVATION 01

0 20 50 100 200M



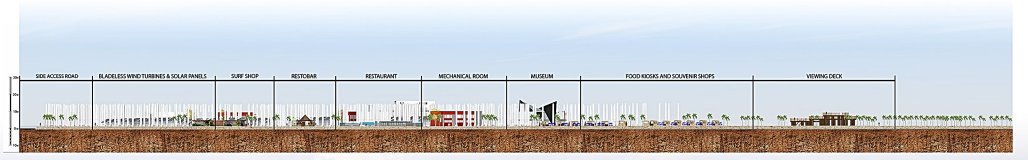
SIDE ELEVATION 02

0 20 50 100 200M



SIDE ELEVATION 03

0 20 50 100 200M



FRONT ELEVATION

0 20 50 100 200M

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