

MARINE RESEARCH CENTER FOR RENEWABLE ENERGY (WATER POWER)

Sarah Saud Al-jehani¹, Mohamed Shokry²

^{1,2}College of Architecture and Design, Effat University, Qasr Khuzam St., Kilo.2, Old Mecca Road. P.O.BOX 34689, Jeddah 21478, Saudi Arabia.

E-mail: saljehani@effatuniversity.edu.sa, mshokry@effatuniversity.edu.sa

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Abstract

Fossil fuels are non-renewable as they rely on finite resources that eventually diminish, becoming too expensive or harmful to recover from the environment. Renewable energy is thus considered as an alternative solution to combat this situation. The paper discusses the proposed marine research center development, which will be used as a center analysing and generating water based renewable energy. In this work, four case studies were referred for the development of the marine research center. Based on the case study analysis, the estimated gross-area for research center development was 26,400 m² for an estimated 800 users. The proposed research center comprised of several zone, which were research center, awareness center, residential unit, administration and logistic. For this work, there sites were compared, and Site 1 which is located at Khoralkara area in Rabigh, Saudi Arabia was chosen as the proposed site, as it attained the highest evaluation score of 81. The important element of this site is that it has a pure sea environment for catching a wave, and narrow channels for tidal power. The proposed research center was designed based on the concept of biomimicry, therefore Jellyfish design was proposed. This research center will serve as an alternative energy producer to the Saudi nation.

Keywords--Renewable energy, water power, research center, Saudi Arabia

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INTRODUCTION

The quick development of the human populace and mechanical advances have prompted increased interest in energy, which is expected to augment by half by 2030 [1]. However, the current rate of use of petroleum resources is reported to be very high, and this resource's sustainability is projected to decrease over time. In addition, the use of petroleum products is harmful to nature, which causes global warming and depletion of ozone [2]. Therefore, exploring 'clean' energy has turned out to be one of the most important tasks for research around the world. Thereafter, several substitute energy sources are being premeditated and instigated, including hydroelectric, wind, geothermal, solar, and biofuels [3]. Hydroelectric is seen as genuine methods of achieving the objective of supplanting petroleum derivatives in the present moment of these potential energy wellsprings [4]. The hydraulic power from water is an important source of power. Hence, there is an opportunity to develop a new generation of water energy from the ocean, sea and river. Additionally, water energy can provide an uninterrupted and mature source of electricity throughout the year. The constantly churning seawater provides an inexhaustible source of clean energy [5]. In addition, wave power is a form of marine energy obtained from the harnessing of kinetic energy. Tides is also a form of hydropower that converts the energy of the tides into useful forms of power [6].

Saudi Arabia is the fastest growing Middle East consumer of electricity. By the year 2032, the consumer rate is expected to exceed more than 120 gigawatts [7]. For this reason, Saudi Arabia should find alternative energy sources to meet electricity demand. Renewable energy is the optimum solution for generating power and preserving the Kingdom's oil and gas resources for the future. In addition, Saudi Arabia encourages the use of renewable energy to contribute to pollution reduction and change claims [8]. One of Saudi Arabia's considerations of renewable energy is hydroelectric power. As a result, the development of a research center provides a field for testing a technique and experiences related to the production of renewable energy from water. Thus, in this work, a proposal of

renewable energy research center is established, specializing in water power generation.

CASE STUDIES

For this work, four case studies, each studying different aspects of drawing, concept, site criteria and new trends is presented. The chosen case studies are :

- Lawrence Berkeley National Laboratory Molecular Foundry, Berkeley, California
- CSIRO Energy Centre Steel River, Newcastle, NSW ,Australia
- James H. Clark Center, Stanford University.
- NOAA Southwest Fisheries Science Center / Gould Evans

Lawrence Berkeley National Laboratory Molecular Foundry, Berkeley, California

National Laboratory (LBNL) is a research laboratory for nanoscale materials (Figure 1). In addition, the facility is one of five U.S. Department of Energy Nanoscale Research Centers and the only one on the west coast. The design would incorporate green building strategies with the goal of achieving the U.S. Green Building Council's Gold Leadership in Energy and Environmental Design (LEED). The design's mission is to build a building that is consistent with the proposed research and implement practices that reduce reliance on fossil fuels during its construction and operation. Some of the design features proposed include separating laboratories from non-laboratory functions for heating, ventilation and air conditioning (HVAC) energy efficiency, orienting the building for solar exposure, and the provision of natural daylight in laboratories. The building is a simple rectangular form with the long axis oriented from the east to west, which is optimal for day lighting. The primary mass of the building emerges from a slopping hillside between two adjacent buildings for staking advantage of views of San Francisco Bay. The building program includes three main functional components: laboratories, offices, and space for interaction and collaboration. Laboratories and offices are connected to facilitate interactions, accommodate visitors, and create a working environment that stimulates the Nano sciences' intellectual advancement. For this reason, there is space of interactions in each floor. Because of the requirements of the

Building Code H8, each floor is divided into two fire safety areas by two-hour-rated walls. Two vertical shafts per area provide space for exhaust routing and supply ductwork. A dedicated air handler and two dedicated exhaust fans serve each area. The utility building is located next to the Molecular Foundry, so pipes run between the two buildings. There are main air handlers and exhaust fans on the roof. The air handler for the clean room is on the loading dock area of level 1.

CSIRO Energy Centre Steel River, Newcastle, NSW ,Australia

The CSIRO Energy Centre provides state of the art scientific research facilities for CSIRO's Division of Energy Technology at Steel River, a 5-hectare Eco-industrial Park site in Newcastle (Figure 2). In addition, the Centre is being developed in stages. The building comprises a total floor area of approximately 9800m², accommodating laboratories, process bays and office/support facilities. The Buildings consisting of three principal functional areas: Laboratories, Bay and Support Facilities, and Office/Support Facilities. These main functional spaces have been arranged as three separate wings, the energy center (solar panels) is central circulation spine element, which will form the main circulation link for the complex. The spine is the main plant areas for the centre, as well as renewable energy plants and equipment such as photovoltaic, wind turbines and other future energy research elements such as fuel cells and battery systems. Each of the laboratories and offices will be housed in a separate east wing that characterizes 40 percent of the site. The connection between the laboratories is done by bridges. The process bays and associated facilities will be housed off the western side of the spine on the flat part of the site. The building conserves energy by using passive design.

James H. Clark Center, Stanford University.

The James H Clark Center is a remarkable building that includes a multidisciplinary teaching and research facility centrally located on the campus of Stanford University (Figure 3). It was finished in October 2003. Forty-five research groups from biology, engineering, physics, chemistry, mathematics, and medicine work together in a unique environment. The architecture reflects its design approach to encourage communication and the exchange of ideas and thoughts. The three-story building takes the form of three wings of laboratories centered on an open courtyard overlooked by balconies. The divided into east and west wings accommodate wet bench research, and the south wing contains computational spaces, classrooms, a coffee café and a restaurant to encourage wide campus interaction. A partial basement houses extremely vibration-sensitive laboratories for lasers and imaging equipment as well as other specialized core facilities. The fixed building core zone is located on the outer edges of the building and includes building core elements such as elevators, toilets, stairs and duct shafts. This zone is located outside the building so that they do not interfere with the interior spaces' openness and adaptability. The enclosed laboratory support zone includes spaces requiring enclosure for reasons including noise control, temperature control, light control, cleanliness and safety.

The open wet laboratory zone is clustered around the sinks, adjacent to the enclosed laboratory support zone. There is support zone allowing for a variety of room sizes to support individual needs of the researcher. The Connections are established via external walkways covered by a protruding canopy. This structure unifies the complex that strengthens the organic shape of the interior courtyard and its spatial privacy.

NOAA Southwest Fisheries Science Center / Gould Evans

NOAA Southwest Fisheries Science Center (Figure 4) is an international research facility which help talented scientists and support ongoing research for the protection and management of the region's living marine resources. The building has different techniques to preserve the energy that are narrow floor plates

that allow daylight to permeate the spaces, fan-assisted natural ventilation, and high-efficiency equipment and lighting. A variety of native species, including coastal chaparral and sage, have been planted on the green roof. Solar shading on the west and south facing windows helps to reduce the building's cooling loads to 69 percent. A large photovoltaic array on the roof offsets 7% of the building's energy needs. The architect works with ocean topography and applied to a building that creates outdoor gathering spaces, rooftop terraces and courtyards that reinterpret the culture of the courtyard. The building space is 124,000 square feet in the edge of the contour to preserve ocean views. The building has a complex program of offices, laboratories, conference rooms, parking, library and the world's largest 528,000 gallon ocean technology development tank. It has five story but it never seems taller than three stories, also there is green spaces and terraces for gathering.



Figure 1. Lawrence Berkeley National Laboratory Molecular Foundry, Berkeley, California



Figure 2. CSIRO Energy Centre Steel River, Newcastle, NSW ,Australia



Figure 3. James H. Clark Center, Stanford University.



Figure 4. NOAA Southwest Fisheries Science Center / Gould Evans

PROGRAM ASSUMPTION AND SPACE DETAILS

Based on Table 1, the computed ratio is 33m²/ user and the average of cross area is 26,400 m² for 800 user. The types of user will comprise of students, researchers, staff and public. The building type will be academic and governmental.

Table 1. Case Study comparison

Elements	Case Study 1	Case Study 2	Case Study 3
Gross floor area	8,779 m ²	9800 m ²	16,900 m ²
Capacity	216 user	352 user	650 user
Ratio	40 m ² /user	28 m ² /user	32 m ² /user

Table 2 shows the details of the proposed research center. Based on Table 2, the zone of the proposed research center is divided into 5 parts, which are research center, awareness center, residential unit, and administration and logistic/services. The percentage of division is as follows, 47% will comprise of research center, 30% will comprise of awareness center, 13% will comprise of residential unit, 5% will comprise of administration, and 5% will comprise of logistic/service. The other details of gross floor area, net area, number of floors and foot prints for each zone is presented in Table 2.

Table 2. Overall Research Center Details

Zone	Percent ages (%)	Gross Floor Area (m ²)	Net Area (m ²)	Floors	Footprint (m ²)
Research center	47	12408	9306	4	3102
Awareness Center	30	7920	5940	2	3960
Residential Unit	13	3432	2574	1	3423
Administration	5	1320	1056	2	660
Logistic/Services	5	1320	1056	-	1320
Total	100	26400	20235	-	12474

Table 3 shows the detailed division of research center zone. Based on Table 3, the research center zone will comprise 60 % of laboratories, 20% of offices, 10% of library, 3% of lobby, 2% of clinic health unit and 5% of seminar room. The details of area is shown in Table 3.

Table 3. Research center zone division

Content	Percentages (%)	Area (m ²)
Laboratories	60	5584
Office	20	1861
Library	10	930
Lobby	3	279
Clinic Health Unit	2	186
Seminar Room	5	465
Total	100	9306

SITE SELECTION

Proposal site: Site 1

The first site is located in the Khoralkara area in Rabigh (Figure 5). The estimated area of the site is 30,000 m². The important thing of the site is it has pure sea environment for catching a wave, there is also a bay with narrow channels for tide power. It is also located in the future importer city and near Saudi Arabia's two valuable economic, educational and development cities, Jeddah and Yanbu.

Proposal site: Site 2

The second site is located in Jazan, near Jazan University (Figure 6). The estimated area of the site is 30,000 m². The site's

importance is that it has strong current power because it integrates the pure marine environment between the Arab Sea and the Red Sea.

Proposal site: Site 3

The third site is located in the Jazan region of Farasan Island (Figure 7). The estimated area of the site is 30,000 m². The important of site is it has strong current power because integrate between Arabian Sea and Red Sea, tides and pure environment of sea. The important thing about the site is that it has strong current power because it integrates tides and pure sea environment between the Arab Sea and the Red Sea.



Figure 5. Site 1



Figure 6. Site 2



Figure 7. Site 3

SITE EVALUATION CRITERIA

The selection of the site considers the multi-criteria. Depending on the value called weighting factor (WF), each criteria should be followed. The weight factor is deduced as follow.

Weighting Factors

- 1 = not very important
- 2 = somewhat important
- 3 = important

In addition, the site with the highest sector will be selected for the project.

Site Capacity (WF= 3)

The usable area of the land should be less than the total site area. Also should be consider the following space, which is parking and drop-off area, truck parking for services, land scape and outdoor facility

Shape/proportional (WF= 2)

The proper site is rectangular, so it easiest for planning. Also it's close to the project functions.

Topography (WF=2)

Ideally, the site's counter line will be gentle and sloping towards the sea.

Access (WF=3)

Clear access from main road and sub road.

Noise levels (WF=3)

The side should be far enough from the traffic and commercial facility (Malls- Culture Citers-Recreational Parks).

Utilities (WF=2)

The presence of electrical, water, gas, sewer, and other services should be in place. Connection to an existing, reliable water supply system and sewage waste disposal system with adequate capacity is preferred in particular.

Security and Safety (WF=2)

The site should be convenient for a fire station and police station. Providing adequate site lighting to discourage vandalism. The site should be away from industrial and manufacturing areas to avoid bad air quality problems such as odor, dust, noise, etc.

Views (WF=1)

The views from inside the site into the immediate surroundings.

Site Evaluation

Table 4 shows the evaluation of the site for all three sites. The sites were evaluated in terms of site capacity, shape, topography, access, noise levels, utilities, security and safety, and views. Based on Table 4, Site 1 showed the highest score of 81 for the evaluated criteria compared to Site 2 with 68 and Site 3 with 64. Thus, Site 1, which is located in the Khoralkara area in Rabigh was selected as the proposed site.

Table 4. Site evaluation

Site Criteria	Site 1	Site 2	Site 3
Capacity, (WF=3)	15	15	15
Shape/proportional, (WF=2)	13	13	10
Topography, (WF=2)	10	5	7
Access (WF=3)	8	10	3
Noise levels, (WF=3)	15	4	10
Utilities, (WF=2)	3	7	3
Security and Safety, (WF=2)	4	8	5
Views, (WF=1)	13	6	11
Total	81	68	64

SITE ANALYSIS

The site is located in North side of Rabigh, in khoralkara area. In this location, the warm season lasts from May to October with an average daily high temperature above 37°C. The cold season lasts from December to February with an average daily high temperature below 29°C. The relative humidity typically ranges from 24% (dry) to 84% (humid) over the course of the year, rarely dropping below 11% (very dry) and reaching as high as 100% (very humid). The air is driest around May, at which time the relative humidity drops below 31%. Furthermore, it is most humid around July, exceeding 78% (humid). Over the course of the year typical wind speeds vary from 0 m/s to 10 m/s (calm to fresh breeze), rarely exceeding 13 m/s (strong breeze). The highest average wind speed of 5 m/s (gentle breeze) occurs around June, at which time the average daily maximum wind speed is 10 m/s (fresh breeze). The lowest average wind speed of 3 m/s (light breeze) occurs around December, at which time the average daily maximum wind speed is 6 m/s (moderate breeze) as shown in Figure 8. As far as topography is concerned, the contour line is gradually moving from height to depth. In terms of

accessibility, two main roads, one highway and one secondary road access the site. A subway should be created to reach the site. In terms of energy types, the location consist of wave energy and tide energy from sea. Thus, it will an ideal location to construct the marine research center for renewable energy.

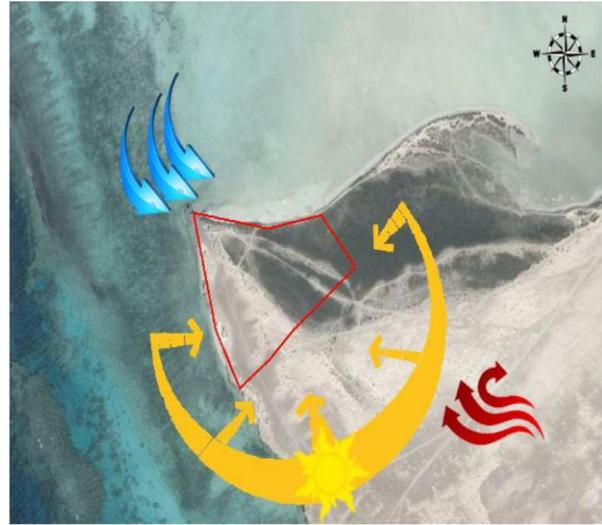


Figure 8. Site 1 analysis

Figure 9 shows the site plan proposed design of the marine research center. This site was designed based on the concept of biomimicry. This site was design based on Jellyfish, as it comprises of a big head and bristles. Thus, based on Figure 9, it is observed that the head will comprise the research center, and the bristles will comprise of residential unit, awareness center and building administration. Figure 10 shows the cross section of the research center. Based on Figure 10, it is observed that the structure consist of wind catcher, green roof and double glass. The research center structure consists of space truss and cast in place. Space truss is a lightweight, rigid structure built from interlocking struts in a geometric pattern and used in the research center frame. On the other hand, cast in place concrete has the advantages associated with all concrete, such as thermal mass, durability and resilience to disaster. Additionally, cast in place concrete is an excellent solution for free forming concrete into a variety of shapes, span and form. Thus, this material was incorporated for the marine research center. Figure 10 shows the overall perspective view of the proposed research center.

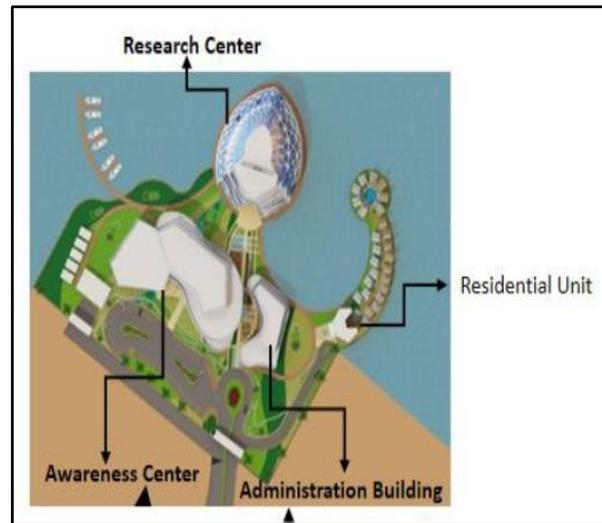


Figure 9. Site plan.

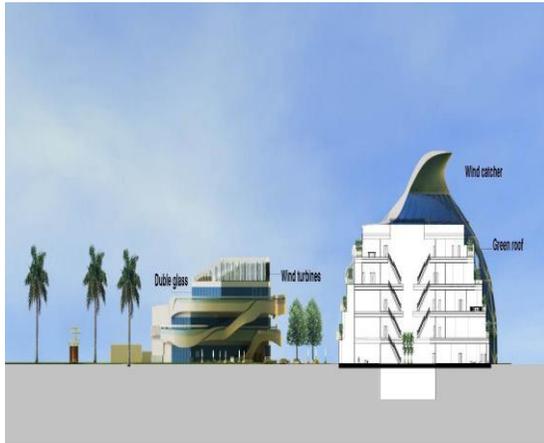


Figure 10. Site plan.



Figure 11. Perspective view of marine research center

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CONCLUSION

This work has proposed a design plan for a water-based marine research center to generate renewable energy. The proposed site is located in the Khoralkara area of Rabigh, Saudi Arabia. This site has a pure sea environment for catching a wave, and there is also a bay with narrow channels for tidal power. The research center component package is comprised of research center, awareness center, residential unit, administration, and logistics. The gross area of the proposed research center is 26400 m². The research center was design using biomimicry concept based on Jellyfish structure. This proposed research center will be able to use its surrounding environment to create renewable energy. It will be beneficial for the Saudi government as it will serve as an alternative energy for the oil producing nation.

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