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Feasibility Study of Offshore Wind and Solar Energy Technologies in United Arab Emirates

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***Abstract*— Renewable energy is an energy that can be available on the earth all the time in the domain of human life such as wind, solar, geothermal, wave's energies. The advantages of renewable energy are reducing the emissions that produced from burning coal and fuel resources and it is not limited like other resources. So this paper will focus in wind and solar energy and see if the power produced from solar and wind is applicable to refill the need to offshore oil and gas platforms. All data required for this paper will be collected for United Arab Emirates (UAE) offshore oil and gas platform. The selection of the wind turbine should be suitable for the region that have low wind speed and proper solar panels that give maximum power. The governing parameters include wind speed, air density, diameter and height of wind turbine, wind density and the design of the wind turbine blade. It mainly depends on the geography but finally the turbine choices are based on the energy demand of the area.**

***Index Terms*— Renewable energy, Wind energy, Solar energy, Offshore, Payback time**

I. INTRODUCTION

Most of the offshore platforms are using fossil fuel to operate and these will affect hugely the environment. There is a great effort from many countries to replace the fossil fuel energy for offshore platform to wind, solar and ocean energy to provide the necessary power for the platforms. This paper will focus in wind and solar energy and see their feasibility. Offshore wind turbine already established in many countries such as in China, Denmark, Germany, Japan, Sweden, USA and UK, as shown in Fig. 1 [1].

Wind and solar are likely auspicious as another form of alternative sources of energy. This feasibility eyes on the utilization of such energies and determine their capacity to meet consumption needs that other sources will not be capable of. With data collected focusing on these energies, it has been noted that wind and solar energies deliver a great output. Since electrical consumption of a power system ranges from 10 MW to 50 MW, the determined purpose of this study is to provide the same platforms with energy while focusing on reducing the emissions from burning coals and fuel energy resources. If wind and solar energies are fully utilized, the dependency on fossil fuels, which has adverse effects in our environment particularly with that of our ozone layer can be minimized [2]. With these results, they suggest that these two energy sources have turned the tables for energy consumption and energy saving which are earth friendly.

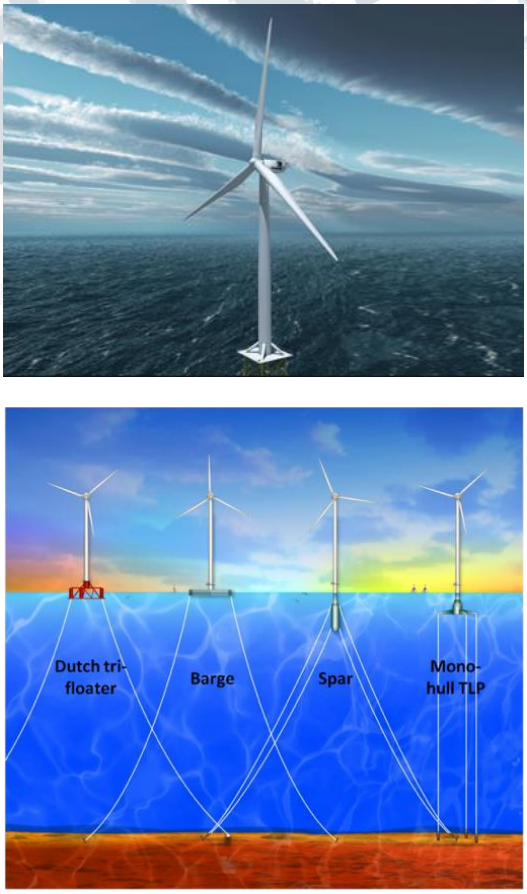

Fig. 1 Offshore wind turbine [1]

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Yet, there are some restrictions with the application of this type of alternative energy. For example, the cost of small-scale wind turbines could be high in terms of installation due to the expensive on a per kilowatt basis [3]. In addition to that, direction of the wind flow and the unsteady flow will effect on the effectiveness of the wind energy. These limitations could be overcoming by modifying the wind turbine blades in a way that producing more flow while operating at the same speeds [4-5]. In addition, running cost of the wind turbine is almost zero because no need for fuel requirement and the minimal requirement of the maintenance [6].

II. CASE STUDY AND METHODOLOGY

Offshore Platform

SHELL Malaysia Oil and Gas Sabah Water Platform will be our case study to be analysed [7]. The power consumption for this platform is approximately 10 MW. In this case SIEMENS SWT-4.0-120 wind turbine has been selcted and for the solar energy, the chosen photovoltaic panel used for this feasibility test is LG290 N1C-G3 MonoX, the power generated from the selected wind turbine SIEMENS SWT4.0-120 falls within 73.94 kW to 492.89 kW. Month of January is the highest month in terms of power output while Jun is the lowest power generation month.

The monthly average rated power output generated by solar panel LG290 NIC-G3 MonoX ranges between 12.87 kWh to 19.99 kWh. The lowest power value generated by the solar panels is 12.87 kWh which happens at the month of February while the highest month of solar irradiation happens in April with the power output generated 19.99 kWh. This case suggests the use of wind turbine and solar panel as a multiple unit to provide a sufficient power to accommodate the platform applications. This suggestion is to cover the limitation of the two types of energy due to the seasonal variant in weather conditions.

Wind Energy Data

In this research, wind speed data was provided by the weather network of Abu Dhabi. The data of wind speed in this report shall be calculated by the use of the following formula noted that v_2 is required wind speed at the hub height (h_2) and v_1 is the wind speed at specific height (h_1) and γ is the wind shear.

$$\frac{v_2}{v_1} = \left(\frac{h_2}{h_1}\right)^{\gamma} \quad (1)$$

As a result, values of v_1, h_2 and h_1 will be as the following; 5 m/s, 84 m and 10 m respectively based on the average values of the data in Fig. 2.

Applying the above formula (1) v_2 will be 6 m/s. The area, A will be calculated by knowing the blade diameter and using the below formula will be;

$$A = \pi * 41^2 = 5281\ m^2 \quad (2)$$

The power density, PD by the wind onto the wind turbine is given by the following equation;

$$PD = \frac{1}{2} * \rho * \left(\frac{v^3}{1000}\right) \quad (3)$$

$$PD = \frac{1}{2} * 1.225 * \left(\frac{6^3}{1000}\right) = 132.3\ kg/s^3$$

The output power, P for the chosen wind turbine will be determined as below;

$$P = A * PD * \eta = 5281 * 132.3 * 0.47 = 328.1\ \text{kW}$$

The efficiency of the wind turbine is given on 6 m/s wind speed and it is equal to 47%.

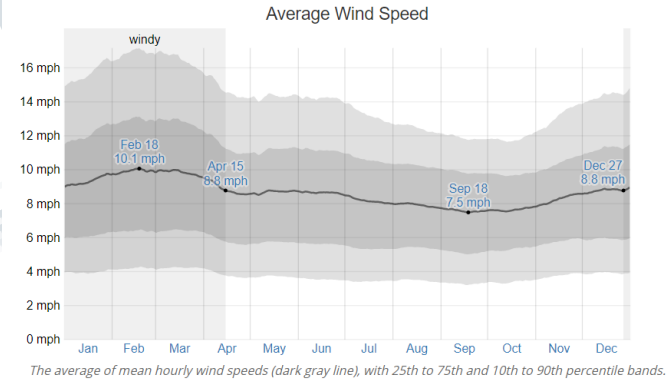

Fig. 2 Average wind speed in UAE [8]

Solar Energy Data

The solar irradiation will be known by the information from Masdar solar city which is located in Abu Dhabi to calculate the output power from the solar panels to provide the needful energy to the offshore platforms. The following graph (Fig. 3) provide the information of average monthly solar irradiation on the panels.

This information from many sources that provide monthly solar radiation in Abu Dhabi. The information give the average values, which include the maximum radiation will be that is during the month of June, which is also the longest day during the year. The maximum solar radiation equal 7 kWh/m^2 as the Masdar line illustrated. N310K VBHN310KA01 Black panels was selected for this

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feasibility and the area of the panels is 1.69 m^2 and the max power output is 310 W.
The performance ratio, PR of the solar panels will be 0.75. The formula of output power will be as the following;

$$P = A * r * H * PR \quad (4)$$

So A = 1.69 m^2 and r (solar panel yield) can be found by the following;

$$r(\%) = \frac{PR}{10A} = \frac{310}{10\text{x}1.69} = 18.34\%$$

H (average solar irradiation) is calculated using June data, which have the maximum radiation and it is equal to 7 kWh/m^2. So the output power will be equal to;

$$P = A * r * H * PR = 1.69 * 0.1834 * 7 * 0.75 = 1.63\ kWh$$

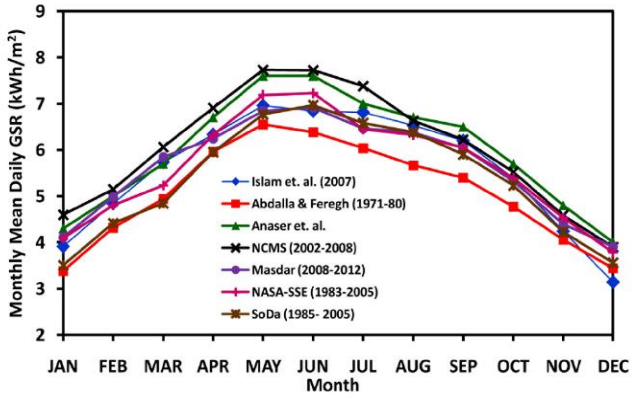

Fig. 3 Monthly solar radiation in Abu Dhabi [8]

Feasibility Study

The feasibility of any project can be studied by analyzing the cost input to the project and compare it with the expected profit [9-12]. This procedure will provide the amount of estimated savings by establishing this project. A consideration of the payback time from the project kick off will be taken.

The profit expected from the project will be considered as a saving. Input cost will include but not limited to the cost of the equipment, operation, maintenance and facility. The project profit will be obtained by calculating the total cost for running the facility without the renewable sources then subtract it from the total cost of running the facility depends on the renewable sources.

The payback time will be calculated by the use of the following equation;

$$\text{payback time} = \frac{\text{total cost}}{\text{saving cost per year}} \quad (5)$$

The total cost of the wind turbine and the solar panels installation depends on the quantity of energy demand for the platform usage. The platform consumed between 10 MW to 50 MW of energy so the total average energy is estimated to be 30 MW. To estimate the total cost of investment to install this platform with the wind and solar energy, the number of required wind turbines and solar panels has to be given.

According to the above results, wind turbine is providing a power equal to 328.1 kW and the power from solar panel is 310 W. The cost for the installation and maintenance per unit of solar panel and wind turbine is about AED 2000 and AED 13 mil, respectively.

Case 1
It was intended to provide 20 MW from wind turbine and 10 MW from solar panels and calculate the payback time so the price will be as the following (Table 1);

TABLE I Cost Analysis for Case 1

	Solar panels	Wind turbines
Quantity	32259	61
Total cost (AED)	61.4 mil	817.4 mil

The payback time using (5) is 45 years.

Case 2
It was now intended to provide 10 MW from wind turbine and 20 MW from solar panels and calculate the payback time so the price will be as the following (Table 2);

TABLE II Cost Analysis for Case 2

	Solar panels	Wind turbines
Quantity	64517	31
Total cost (AED)	122.8 mil	415.4 mil

The payback time using (5) is now reduced to 28 years.

Case 3
Now only wind turbines are considered and compared to the other cases (Table 3);

TABLE III Cost Analysis for Case 3

	Wind turbines
Quantity	92
Total cost (AED)	1232.8 mil

The payback time using (5) is 63 years.

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Case 4
Now only solar panels are considered and compared to the other cases (Table 4);

TABLE IV Cost Analysis for Case 4

	Solar panels
Quantity	96775
Total cost (AED)	184.2 mil

The payback time using (5) is about 10 years.

III. RESULTS AND DISCUSSIONS

The calculated power for each month depends on the selected wind turbine for wind energy application could be presented in the Fig. 4. As presented in the figure the monthly output of the ENERCONE-82 E4 wind turbine is located between 328 kW to 120 kW. It was notice from the graph that month of February was the highest month in terms of the power output. On the other hand, months of September & October were the lowest power output.

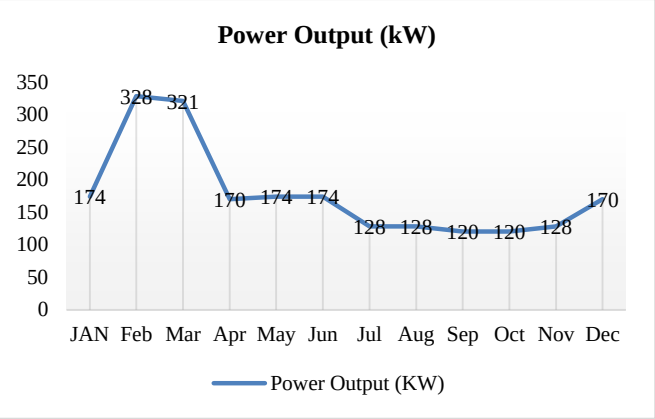

Fig. 4 Power output monthly for wind energy

As presented in Fig. 5 the monthly output of the N310K VBHN310KA01 solar panel is located between 11.3 kWh to 6.42 kWh. The least month in terms of power output is December with a power output of 6.42 kWh; however, Jun is the highest month in terms of power generation with a value of 11.3 kWh. In general, it can be said that the most times of the day it was recorded the highest power generation will be between 12 PM to 3 PM. This is due to the availability of the sun.

Depending on the presented results on the previous sections, multiple units of wind turbine and solar panel could be installed in order to supply a sufficient power to the offshore platform. The power generation will be seasonal. For example, at the summer season power generated from the solar panel will be the largest.

In addition to that, from the data presented at the cases it is noticed that in case 1 if the wind turbine units are increased and compared to the solar panels more power generated could be obtained because of the working hours; yet, more area will be needed for such choice and the payback time will be long due to the high investment on a such unit.

Case 2 shows the reverse way by using more solar panels than wind turbine units. It could be said that the payback time will be shorter due to the low investment cost. The disadvantage of this choice will be at the working hours of this type of choice because of the sun lights. In addition, storage unit for the energy collected from the sun lights will be needed.

Case 3 is the worst choice using only wind turbine units. It will have long payback time and high investment cost. Finally, the last case 4 shows that using solar panel units only will be the best choice due to the shortest payback time and the low investment costs.

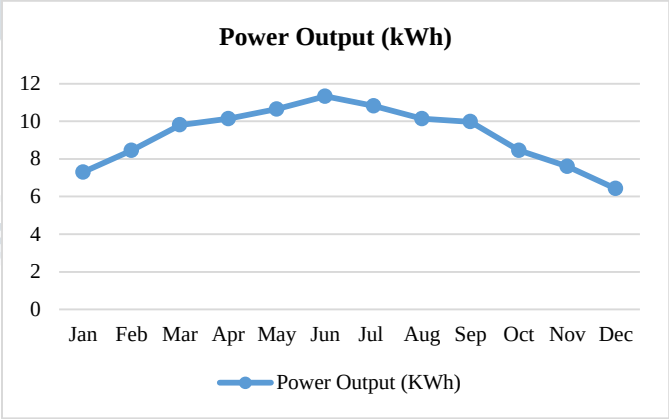

Fig. 5 Monthly power output for solar panel

IV. CONCLUSION

In conclusion, wind and solar energy could be the best solution for the demands of power generation for the offshore applications. As per the presented information at this paper, the highest power output generated by the wind energy is 328 kW, on the other hand 11.3 kWh is the power supplied to offshore platforms generated from solar energy.

In the matter of fact, installation of these types of energy (wind or solar) will not provide a sufficient amount of power required for the platform applications unless the operator installed them as multiple units. Also, having multiple unit will integrate the features of each units and

their power generation capabilities based on the surrounded weather and climate and the changes among them.

In addition, it is clear now that the use of solar panel unit is the most feasible choice for the offshore platforms in UAE due to the cost is one of the main reasons as well as the power output. On the other hand, wind turbine is not a preferred choice because of the high investment cost and longer payback time.

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