A Study of Hybrid Wind - Tidal Power Design and Development of Offshore Renewable Energy Sources in Oman

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ABSTRACT

The goal of this project is to create a hybrid prototype system that uses wind turbines and tidal turbine to recover energy lost to the environment. Wind and Tidal power are two of the most widely used sources of renewable energy since they are both abundant and easy to convert to electrical energy. Although environmental factors limit the total quantity of wind and Tidal energy that may be used to power a hybrid system, they are still among the fastest-growing clean energy options. Since these hybrid systems will be installed in the offshore, they will be able to capture Tidal energy from the sea waves as well as wind energy flow from both sides of air stream. These hybrid systems can be installed together in one single pole for testing in the Oman offshore

Keywords: Investigation, design, wind, Tidal turbine, prototype

INTRODUCTION

Electricity can be produced in two ways: using either traditional energy sources or alternative energy sources. As the world's hunger for power grows, we'll need to find new sources of the stuff. Traditional energy sources such as coal, diesel, nuclear, etc., are currently used to create electricity. The most significant negative of these options is the high expense of waste management for byproducts such as coal ash and radioactive waste from nuclear power plants. It's bad for nature and bad for business. As with the environment, human health is severely compromised by nuclear waste. Traditional energy sources continue to deplete. The world's supply of it is rapidly depleting, therefore we need to find other sources of power before it disappears forever. The next generation facility must be cheap, reliable, and pollution-free. Energy from non-conventional sources should complement conventional sources well. There are advantages and disadvantages to each of the various non-conventional energy sources, such as wind, solar, tidal, and geothermal power, to name a few. The process of drawing heat from the planet, on the other hand, is laborious and requires a lot of heavy equipment. Both wind and tidal power are readily available. Often times, non-conventional energy sources, such as Tidal and wind, are excellent replacements for the conventional energy sources. Given the limitations of wind and tidal energy, which prevents it from generating power during not much speed in wind speed, we propose using a combination of energy sources to ensure that, should one fail, the other will continue to do so. And depending on the weather, we'll employ a combination of the two.

OBJECTIVE

Creating a wind turbine to harness wind energy for electrical generation is the focus of this project. In comparison to wind turbines, which need a lot of space because their blades have to spin so fast to be safe, this one may be installed in cities and other densely populated areas without sacrificing efficiency. Electricity keeps the world turning, and a country's progress is tied to its access to and efficient use of electricity. As mechanical engineers, our primary goal is to create devices that maximize energy utilization and productive output. To generate less reliance on fossil fuels and more electricity from readily available wind resources. Since we can collect more wind from passing automobiles, this setup is optimized for use on road medians. The implementation of hybrid technology was intended to increase the project's financial feasibility. Using this concept for a vertical axis turbine, we hoped to achieve a flexible and inexpensive means of harvesting wind energy. To do this, the turbine's power production had to be enhanced while the turbine's value was minimized. To determine whether or not this objective had been met, the design's power production and cost per wan were compared to those of wind turbines of a comparable size. In order to determine how this design may be scaled up to a larger size while maintaining the same level of performance, additional research was undertaken.

DESIGN OF HYBRID SYSTEM

The energy from the wind is transformed in a wind mill. The kinetic energy (K.E.) of the wind is transformed into shaft-transmitted energy via a turbine. Then, a generator takes that energy and makes electricity. This is something that must be remembered when developing the windmill's framework.

Therefore, the total wind energy is equal to

$P=0.5\rho AV^3$

ρ-density of air = $1.25 kg/m^3$

A= swept area (bh) = $0.45x0.75=0.35m^2$

V= velocity of air = 20m/s

$P=0.5x1.22x0.35x20^3=1725.544$watts

Design of Blade

speed ratio of Tip= λ

$\dot{\varphi}$= Rotational velocity (rad/s)

r= Radius of rotor

v=velocity of air (m/s)

$\lambda = \omega r/v$

λ = 8.3x0.76/5 =1.27

σ = N c / R rotor

Where N is blade number, c is blade chord [m] and R is rotor radius [m].

σ = 0.153 x 8 /0.2 = 5.3

Aspect ratio

Having defined the turbine's aspect ratio (AR) as the ratio between blade height and rotor radius

AR = H/R=0.76/0.2=3.3391

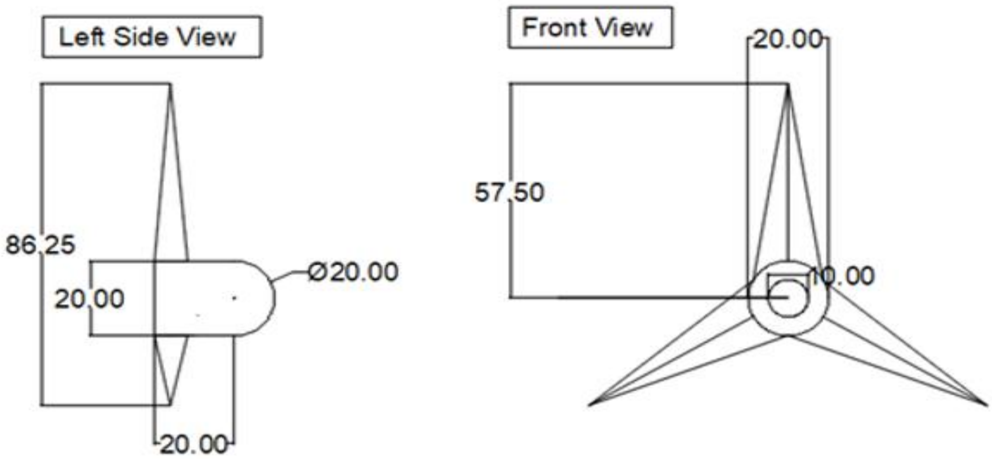

Fig 1: CAD model of wind turbine

Design of Shaft

P=2πNT/60 T=60P/2πN==60×1726.54/2π×80

T= 206 Nm T=206000N-mm

Tensile stress (σ)=401Mpa

r=σ =400/2 =201Mpa

Torsion equation T/I= σ/r

=16×206090.53/π × 201

d=17.4mm=20mm

Horizontal forces=F=T/R

T=torque, R=rotor radius F=45/0.2=195N

Vertical load=5kg (weight of turbine) =50N

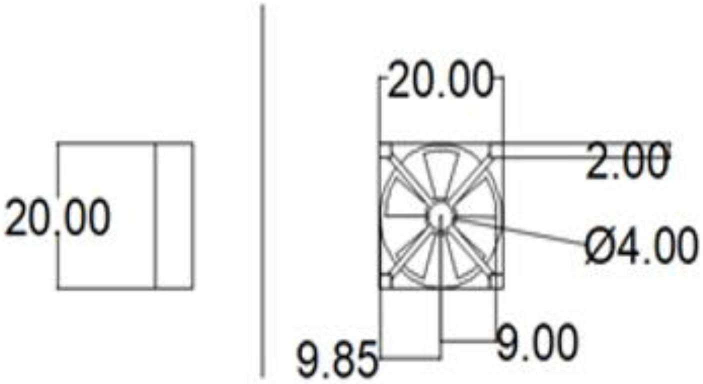

Fig 2: CAD Model of tidal turbine

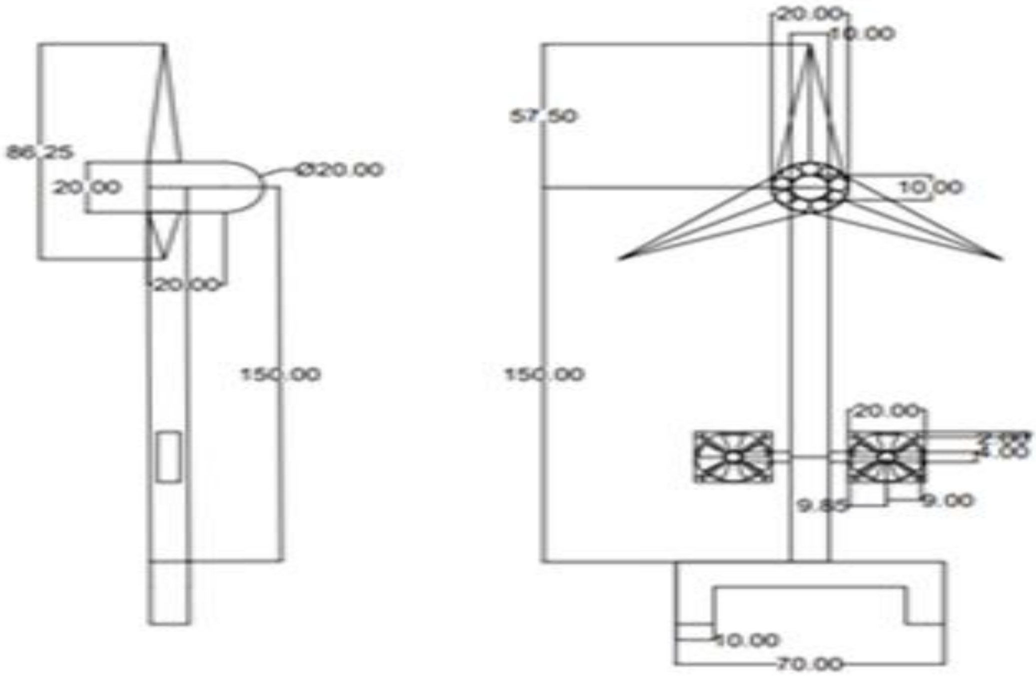

Fig 3: CAD Model of Hybrid wind and tidal turbine

Table: 1 List of parts and specifications

NO	Quantity	component	Material	Dimension	Unit	specification
1	1	Tower	Stainless steel	length 1500	mm	should sustain high vibration and load
2	1	Wind turbine	Carbon	Rotor diameter 1150 Blade length 550	mm	noise 40Bb power 40 W nominal voltage 12v/24v current 12v=35A 24v=18A
3	1	Deep-groove ball bearing	steel	Diameter 25	mm	SKF Lubrication system
4	1	Shaft	Mild steel	diameter 24	mm	N/A
5	2	Tidal turbine	Polybutylene Terephthalate	L.W.H 200x200x60mm	mm	N/A

RESULTS AND DISCUSSION

Kinetic Energy: K.E = $0.5mv^2$ (1)

K.E = kinetic Energy M = mass

V = velocity,

M is equal to its volume multiplied by its density (ρ) of air M =ρAV… (2)

Substituting eqn. (2) in eqn. (1) We get,

K. E= ρAV^3

K. E= ρAV^3watts

ρ=density of air (1.25 kg/m^3)

A =$0.25\pi D^2$ (sq.m)

D=diameter of the blade=0.25m

A=0.05sq.m

Available wind power P= $(\rho\pi D^2V^3)/4$

Power produced from wind turbine

Wind source; -

Power produced by wind at different velocities assume10m/s

P= $(\rho\pi D^2V^3)/4$

P= $(1.225 \times \pi \times 0.25^2 \times 10^3)/4$

P=30 W

Power from DC generator

P=VI

Where V=average voltage, I=average current

P=3.x3 P=9 watt

Efficiency for trail 1

Ƞ =9/30=0.3

Ƞ = 30%

Table: 2 Tidal Power

ρ (kg/m^3)	V (knots)	V (m/s)	P/A_0 (W/m^2)
1,025	0.5	0.26	9
1,025	1.0	0.51	70
1,025	1.5	0.77	235
1,025	2.0	1.03	558
1,025	2.5	1.29	1,090
1,025	3.0	1.54	1,884
1,025	3.5	1.80	2,992
1,025	4.0	2.06	4,466
1,025	5.0	2.57	8,722
1,025	6.0	3.09	15,071
1,025	7.0	3.60	23,933
1,025	8.0	4.12	35,725

Tidal Power at Turbine

$P = 1/2*\rho*A*V^3* Cp$

Where:ρ= sea water density= 1025kg/m³

A= swept area=314.16 m^2

Cp=power coefficient= 0.4

V=for maximum flow velocity=3 m/s

$P=1/2\times 1025 \times 314.16 \times (3)^3 \times 0.4=1739$kW

Since we have 2 tidal turbines, we multiply by 2

P=1739*2=3478 KW

Torque available on turbine shaft N=100 r.p.m

$P=2 \times\pi \times N \times T/60$

T=2.1350N-m

Figure 4: Prototype model of project

CONCLUSION

Hybrid wind and tidal turbine, to sum up. Even while a single turbine might not generate enough electricity for a settlement, a cluster of turbines along a large offshore area might generate enough energy to power public facilities like lighting and even generate a profit by selling any extra power back to the grid. Our project's primary focus is the Design and Fabrication of a Wind/Tidal Hybrid Renewable Energy System (HRES). Hybrid Renewable Energy Systems (HRES) that combine Wind and Tidal energy are more effective and environmentally friendlier than other Renewable Energy Systems, and hence have greater potential to improve human and environmental well-being. The hybrid Renewable Energy System has a more contemporary appearance and design, and requires less maintenance. Combining it with a wind energy generating unit will increase the output and make for more consistent electrical power because the energy generated is so sensitive to wave fluctuations. If you're in a position of leadership, prominence, or disadvantage, a hybrid system is where you want to be.

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