Offshore Integrated Renewable Power System

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Abstract. This paper deals with integration of three energy sources for generating surplus amount of energy. As, India is a fast developing country though it needs millions of kilowatts of electricity per year for its industries. The increase in population, rapid industrialization and upgradation to E-vehicles needs ten times the electricity than we use today. Day by Day the amount of toxic substances released by non-renewable sources into the environment were tremendously increased. So, in order to overcome all this problem we have integrated the three renewable energy sources into a single system named as ‘Integrated Renewable Power System’ (IRPS) and trying to implement in offshore. The Oceans will produce constant energy with this system as wind is season based but placing this system in seashore and Delta regions it will constantly produce power and will result in solar efficiency and reduction in Tidal setup cost.

1. Introduction

India stands third in generating and consuming electricity. In comparison with other countries India consumes low per capita electricity with low electricity tariff. The main important policy of giving free electricity to Agriculture in India is appreciable one. Usage of electricity for Agriculture in India is about 17.58%. Renewable energy market will bloom continuously in the coming years and beyond. This paper deals with offshore integrated renewable power system consisting of solar, wind and tidal energies. The integrated system uses light to generate electricity when solar energy exists, uses wind power to produce power when wind energy exists, uses tidal for generating electricity when tidal energy exists. When wind energy and solar power are used together there will be an enhancement in energy service system. This means that energy service will be available even in the absence of one type of energy. Other advantages are the maintenance time is low; this contribute to reduction in downtime during repairs or routine maintenance. In addition, being primeval and free, the carbon emission is ultimately reduced by these renewable resources. To avoid pollution emission we have to shift from non-renewable to renewable resources. The non-conventional energy generation like nuclear will result in damage to human like boiler blast and health issues.

The government also aims to setup 50,000MW of new capacity through a hydro development plan by 2026 (roughly the end of the 14th Five-Year Plan), which is mostly concentrated in the southern part of the country[6]. Currently coal is satisfying 70% of the electricity production that is mostly utilized in the energy sector, and this type of energy production has proven to be the most economical form of power and electricity in India[7]. Comparing with global average of 2340KWh/yr, the per capita power consumption is nearly 733.54KWh/yr in India. Approximately 28.44% (2008-09) was the electricity losses during distribution and transmission in India. Due to several reasons power loss is common throughout the country and power cut has became common one in India. Due to improper funding over the previous years for system development works leading to unplanned distribution lines and losses in technology are high. By 2022, Wind Energy is estimated to...
contribute 60GW and solar energy to contribute 100GW and the total target also set to 175GW. Integrated power system is the combination of different non-conventional energy sources to supply electricity. In this proposed system wind, solar and tidal power systems are used for generating power. These three integrated system will have more advantages than other non-renewable energy sources.

Wind energy is extracted from the wind. This is the major renewable energy sources existing around the world. Electricity generation from wind mill depends on the speed of wind flowing in land surfaces. Comparing to speed of wind in land, there is much greater wind speed available in sea and delta regions[5]. The required amount of wind will be available every time in oceans. The rotational speed of wind turbines determines the charging of the battery which in turn depends on the wind speed[2]. Solar energy is an primary source of non-conventional energy and it is captured from radiant heat and light that come from the sun[3]. We can harness this free energy in different ways like photovoltaic cells, thermal solar technology and other available method of solar architectures. Undoubtedly, the sun is the strongest energy source and the solar energy has also proved this extreme beneficial source for environment. Tidal energy is an energy which converts ocean tides into electricity. Among the different form of renewable energy, tidal energy is the costliest one. This is derived from Earth-Moon system Motion[4]. These are the future of Energy production. Wind and Sun are less predictable than Tidal as tidal won’t depend on the weather condition. The electric grid system is the connection of power generating stations and sub-stations in a network of absolute voltage level transmission. This electric grid can reach enormous no. of customers than the normal generating station. It is assumed that the electricity delivered by the electric grid is available all the time but the substation rating is limited that relates the connection with the integrated power system[1].

The central government announced that all villages in India got electrified. Survey says this is a great winning for Asia’s largest economy after China and Japan. Even India stands third in production of electricity and consumption. But in India nearly 200 million people lack proper approach to electricity due to remote areas and power distribution challenges, says World Bank. Even if minimum 10% of household and public buildings including dispensaries, village councils, community centres, schools and health centres in a village got electrified the government will consider the village as electrified. But as per records and obtained data’s only six states in India (i.e.-) Kerala, Punjab, Goa, Andhra Pradesh and Tamil Nadu had completely accessed to electricity. Government of India is also preparing a policy for promotion of electric vehicles. All Indian’s should adopt electric vehicles in all modes -bike, car, trucks, buses, etc.. to reduce Carbon emissions. They planned to shift one third of petrol and diesel vehicles to electric fleet by 2030. The power ministry also planned to set up charging base station network in big cities and in major highways for implementing e-vehicles and for gaining momentum in electric vehicle sales. Both new and traditional car manufacturers of Indian automobile industry planned to release electric vehicles in coming years. Even some of the vehicles have specs and tech features that exceed most gas-powered cars. To satisfy all this needs our current generation of electricity won’t be sufficient enough.

2. Materials and methods
In order to beat all this problem’s we've integrated the three renewable energy sources into one system named as ‘Integrated Renewable Power System’. To meet our future energy requirement with renewable energy with an Integrated Renewable Power system. The IRPS tower top consists of wind turbines, the middle portion will contain solar panel and the tidal system will be placed in the rock bottom. The major disadvantages of using independent renewable energy resources are that there won’t be sufficient wind, sunshine all the time. So that any one source of power fails other two will take care of the generation. In this proposed system we can use three energy sources combine. Another way is that we can use any one source and keep other source as a stand by unit. This will lead’s to continuity of generation. This will make system reliable.

2.1. Design of Integrated Renewable Power system (IRPS)
For this integration system we need to find the required data
2.1.1. **Required Information for solar energy:**
1. Total mean daily duration of Sunbeam in hours
2. Solar Radiation per day horizontal (KWH/m2/day)

2.1.2. **Required information for Wind energy:**
1. Total mean in hour for a year(m/sec)
2. Wind energy generated from the turbine.

2.1.3. **Required information for Tidal energy:**
1. Density of ocean tide water and it’s tidal range vertical
2. Barrage basin’s Horizontal area.

Figure 1 represents the block diagram of Integrated Renewable Power System using Wind, Solar and Tidal Power. This block contains

1. PV arrays,
2. Wind Turbines,
3. Tidal Turbines,
4. Batteries,
5. Rectifiers,
6. Invertors AND
7. Electric Grid.

The ocean has Tera Watt amount of energy with the mixture of wind, solar, Tidal power. Higher wind speeds are available offshore compared to ashore, so offshore wind power’s electricity generation is higher per amount of capacity installed. The Tidal Energy is the only renewable energy which costs greater than any other non-conventional energy sources for its construction. But when tidal energy got integrated over solar and wind, the total cost for foundation of three sources will get ultimately reduced.
Offshore wind speeds tend to be faster than ashore. There will be greater difference in power generation than in land even a small amount of wind speed is increased it would result in large energy production. Alternative as compared to normal solar plants. Most of the lands which were occupied by solar plants are getting to be saved. Some other advantages of offshore installation is lesser transmission costs and even it is an integrated system so it’s maintenance cost and work will be made easy. To support this super structure, we are using Monopile foundation. Also, there arises a problem called ‘Gyroscopic effect’. What it means is when wind turbine rotates in clockwise direction and if the tidal wave tends the tidal turbine to rotate in anti-clockwise direction, due to opposite forces attracting on each other it produces gyroscopic effect. Due to this effect there will be a chance of collapsing the entire Monopile foundation. To avoid this problem, we added an additional Tripod Foundation to Tidal turbine and also it gets attached to Monopile to prevent the system from breaking.

2.2. Selection of Location

Nearly 7600 km coastline area in India is suitable for installing offshore wind farms and it generates energy of about 127 GW power and also planned for offshore solar energy production for about 10000TWh per day, says survey. The central government identified coastal areas of Tamil Nadu, Maharashtra and Gujarat as possible places for Offshore projects in our country. But the central government chosen for floating type of Solar Panel, when Panels are installed in floating type there will be a chance of collapsing and break in panels as Indian oceans are rough sometimes. So, we planned for mounting panels over Monopile.

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|}
\hline
S.no & Systems & Onshore & Offshore \\
\hline
1. & Wind & 2.8-2.9 per unit & 7-9 per unit \\
\hline
2. & Solar & - & 12.5\% greater than onshore \\
\hline
3. & Tidal & - & 80\% efficient than other sources \\
\hline
\end{tabular}
\caption{Efficiency over onshore installation}
\end{table}

2.3. Calculation of Power Generation
The total power generated from three system can be calculated by sum of power generated by Wind turbine, tidal turbine and PV arrays.

\begin{equation}
TP = \left( NT \times PW \right) + \left( NP \times PS \right) + \left( PE \times NTT \right)
\end{equation}

Where,
\begin{align*}
TP & - \text{Total power generated} \\
NT & - \text{No. of wind Turbines} \\
PW & - \text{Power generated from Wind turbines} \\
NP & - \text{No. of panels} \\
PS & - \text{Power generated from Solar panels}
\end{align*}
PE - Potential Energy generated from Tidal
NTT - No. of Tidal Turbines

2.3.1. Power calculation for Wind energy:
The power generated by wind energy is calculated by,

\[ PW = \frac{\rho \times A \times (V)^3}{2} \]  

Where,
- PW - Power generated by wind
- \( \rho \) - density of air (kg/m³)
- A - swept area of turbine (m²)
- V - velocity of wind (m/s)

2.3.2. Power calculation for Solar energy:
The power generated by solar panel is calculated by,

\[ PS = (SPW \times T \times 75\%) \]

Where,
- PS - Power generated by panel
- SPW - Solar panel watts
- T - Average hours of sunlight per day

2.3.3. Power calculation for Tidal energy:
The power generated by Tidal energy is calculated by,

\[ PE = \frac{A \times \rho \times g \times (h)^2}{2} \]

Where,
- A - horizontal area of barrage basin
- \( \rho \) - density of water (kg/m³)
- g - acceleration due to gravity (m/s)
- h - vertical tide range (m)

3. Results and discussion
The first offshore wind energy was established in Denmark in 1991 and it is about two decades old history. But this has increased to a total installation of about 28.308 GW in 17 different countries around the globe. The important countries in the installations list are UK (9946 MW), Belgium (1556 MW), China (5930 MW), Germany (7507 MW), Denmark (1701 MW). FOWIND is the project launched in 2013 in India to support offshore wind energy development and to contribute use of clean technologies in India.

![Figure 3. Output comparison between onshore and offshore](image-url)
When wind energy is placed independently on land it can produce power of 3 MW but when the same wind turbine is placed in offshore the efficiency will increase to 3.6 MW and if the solar panels are installed in offshore, the output will be 12.5% greater in comparison with onshore. Offshore wind speed will be steadier than on land which result in more production. Ocean will act as the game changer for solar panel manufacturers and the whole industry. Offshore solar farms need to be utilised properly as there is many problem at the moment.

![Figure 4. Constructed Sample Project Prototype](image)

Above picture represents the sample view of Integrated renewable power system (IRPS). This was constructed and tested in river. The test was carried out to check the stability and for practical understanding. The observation says that offshore wind energy production will produce 5-10 MW extra per turbine in place of 2-3 MW. Offshore solar energy system will produce 8245-10157 TWh per day for 20km². Indian tides can able to produce energy of about 8300MW of Tidal Power generation.

| S.no | Power system     | Output |
|------|------------------|--------|
| 1.   | Wind Turbine     | 28V    |
| 2.   | Solar panels     | 80V    |
| 3.   | Tidal Turbine    | 15V    |
|      | **Total**        | **123V** |

The wind Turbine present in our sample project model produced 28V and a single solar panel can produce 20V (20*4= 80V). So, solar panels in the system can produces an average of 80V. We used brushless motors for tidal turbines and it produced up to 15V of electricity. This small prototype can able to produce nearly 123V in total, consider the real time application of Integrating these three renewable sources that may result in huge success.
The offshore wind energy market is the major developing and increasing investment option in the present and future days. United Kingdom being the top country among other countries for more no. of investment over offshore energy production and installation. In the first half of 2020 overall investment in renewable energy capacity was $132.4 billion. Comparing with 2015 the no. of job offers and investment over offshore renewable energy were tremendously increased by 2020. Job offer all over the world in 2020 for renewable energy is 436 million.

4. Conclusions
Our study focused on minimising foundation setup costs and to generate efficient amount of energy all the time as the ocean provides constant wind, solar and tidal energy. After the tests were carried out, a complete relationship between three energy systems were found. As this IRPS system is reliable and more efficient over conventional energy sources for power generation. The countries across the world is trying to reduce the usage of fossil fuel and investing more to encourage the improvement of non-conventional energy sources. In order to solve the distribution challenges faced by our government we can replace Hydroelectric plant in place of tidal energy and can be usable in river. It can be usable in remote areas to avoid distributing electricity problems by government to remote places.

5. References
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Acknowledgements
We would like to express our sincere gratitude to our project mentor Assistant Prof. Dr. K Deepan Durai for providing an opportunity to expose our ideas and providing a valuable guidance throughout this project.