International Journal of Engineering & Technology, 7 (4.41) (2018) 116-119

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



Feasibility Analysis of Captive Power Generation using Renewable Resources in Mangalore

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Abstract

Smart cities are considered to build a strong and intelligent infrastructure with sustainable environment. It would be impossible to build an efficient Infrastructure without reliable energy source. Under the mandate of the smart cities, 10 per cent of the total energy consumption of the cities must be met by renewables. However, India's challenges with harnessing solar energy are unique. For example, accumulation of dust on solar panels and high per unit cost of energy are some of the challenges the renewable energy industry in India faces. Thus, there is a need for supporting solar energy with other sources of renewable energy considering its limitations. Hence, the proposed study is aimed at understanding the feasibility of utilizing renewable energy resources to produce power which can be coupled with proposed solar energy to be produced to provide uninterrupted electric power requirements of Mangalore City which otherwise, draws its power requirements largely from State owned Mangalore Electric Supply Company (MESCO). As far as production of electric energy using renewable ener.gy resources by Mangalore Corporation is concerned it can generate power on Biogas, Wind and Tidal. Garbage which they collect from citizens, commercial establishments and industrial units

Keywords: *feasibility analysis, captive generation, renewable energy, solar, wind, bio-mass*

1. Introduction

As renewable generation grows it will ultimately overwhelm the ability of compensate conventional resources to renewable energy resources, and require the capture of electricity generated by wind, solar and other renewables for later use. And also there are different energy storage systems for eg: Transmission level energy storage options include pumped hydroelectric, compressed air electric storage, and flywheels. Distribution level options include: conventional batteries, electrochemical flow batteries, and superconducting magnetic energy storage (SMES). Batteries also might be integrated with individual or small clusters of wind turbines and solar panels in generation farms to mitigate fluctuations and power quality issues. Although grid storage requires high capacity and long lifetimes, it often allows a stationary location and housing in a controlled environment, very different from the conditions for portable or automotive storage. Further, the power-electronic technology plays an important role in distributed generation in the integration of energy sources into the expanding in these applications become more integrated with the grid based systems.

Smart Grid: Now in the immediate future, renewable energy sources cannot support the entire grid by themselves. So they have to be connected to the main grid acting as auxiliary power sources thus reducing the overall burden on the primary power generation units. They could also be employed to serve load units totally isolated from the main grid. A power system having wind powered turbines, micro generators, fuel cell based system and PV systems augmenting the main power lines will constitute a distributed power generation (DG) system. In a DG system end users need not only be passive consumers, but they can be active suppliers to the grid. Distributed generation (DG) is an alternative which is not only gathering momentum but can also playing an important role in meeting the ever increasing power demands by using an alternative source of energy such as photovoltaic, wind, fuel cells, etc.. The need of integrating the renewable energy into power system is to minimize the environmental impact on conventional plant. Smart grid plays a major role here

The basic objective of smart grid is to promote active customer participation and decision making as well as to create the operation environment in which both utilities and consumers can interact with each other. In smart grids, users can influence utilities by providing DG sources such as photovoltaic modules or energy storage devices at the point of use, and reacting pricing signals. Additionally, utilities can improve reliability through the demand response programs, adding DG or energy storage at substations, and providing control automation to the grid.

Smart grid has different aspects and can be characterized as follows:

- Interactive with users and markets
- Adaptive and scalable to varying situations
- Optimized to make the best use of resources and equipment
- Pro-active instead of reactive to prevent emergencies
- Self-healing grids with advanced automation • Integrated, merging monitoring, control, protection,
- maintenance, EMS, DMS, AMI, etc.
- Having plug-and-play features for network equipment
- ICT solutions

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- Secure and reliable
- Cost efficient
- Provides real time data and monitoring

2. Renewable Energy sources

The four main Renewable resources i.e., Biomass, Wind, Solar and Tidal are present in the smart city Mangalore which can be used for harnessing energy to provide uninterrupted supply of energy for basic utilities services

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solar radiation is the input for the given system. Solar radiation falls on the arrays of PV cells as the input. PV Array circuit combiner combines the PV cells with the circuit. There is a need of protection from the ground fault which is achieved by the Ground Fault Protector. The ground fault protector is connected to an Inverter via a DC Fused Switch. Inverter converts dc power to ac power. Inverter is further connected to Main Service Panel via AC Fused Switch and Utility switch.
The Main Service Panel provides the required power to basic utilities of the city like water supply etc.,

i. *Financial Overview:* Financial overview includes the analysis of costs of type of solar panels used i.e., German or China tech., Central Inverters, Combiner and Junction boxes, Protective gears arrangement, SCADA and Data logger system, Land bank, Erection of project and then finally calculating the total project cost.

ii. *Income:* In this section, using data collected regarding the availability of daily sun hours, maximum solar Intensity available on the site, total sunny days in Mangalore, daily units generated and the cost paid by the government per unit, the net income over the year is calculated.

iii. *Determining number of panels:* No. of solar panels required is calculated using the total capacity of the plant, number of sunny hours per day and solar insolation

i. Considering the configuration details obtained from the corporation number of panels per string is calculated.

The total payback period is calculated using the investment and net income.

i.

ii. *iv. Summary:* The project involves collection of data consisting of costs of various parts of solar power plant including maintenance cost, evaluation of the net income considering government subsidiaries and hence determining the number of solar panels required for the successful setting up and running of the plant. Using the calculated values of net income and investment, Payback period is determined. Collecting the installation, maintenance cost, the power generated and the cost per unit of electricity generation from a biomass plant and hence, calculating the net income over a year. Using the above values payback period is calculated.

2.2. Biomass

There is already a biogas plant near Urwa Market in the Residential zone in Mangalore. The plant is called as Nisargruna Biogas Plant which can process 2 tonnes of almost all biodegradable waste daily. As the plant is located at market and residential zone, transportation cost is reduced.

i. *Financial Overview:* Financial Overview includes the analysis of cost of two types of maintenance required in Nisargruna Biogas plant. The maintenance cost includes HR and Site maintenance costs. So, the total maintenance cost of the biogas plant was considered for further calculations regarding payback period.

ii. *Maintenance Cost:* Maintenance cost includes analysis of various costs involved include HR maintenance and site maintenance.

iii. *Income:* The units generated per day is collected from the Mangalore city Corporation. From the cost per unit and units generated per day, total income per year is calculated and then the net income is determined by deducting the total maintenance cost from the total income.

iv. *Summary:* From the analysis of various costs and calculation of the net income per year, Payback period is calculated.

2.3. Wind

i. Breakup of per MW Cost: The per MW cost of the various turbines and accessories, civil and electrical work, Grid integration and installation is collected from the Mangalore municipal corporation. Using these Data, the total investment for the setting up of the 10 MW capacity plant is calculated.
ii.Operation and Maintenance Cost: The operation and maintenance cost per kwh for one day is collected. From this data the total cost for one year was calculated.
iii.Net Income: From the daily unit's generation the total yearly units are calculated. The total income is calculated using the price that the government pays per unit. The operation and maintenance cost are subtracted from the total income to obtain the net income over the year.
iv.Summary: Collecting the range of the capacity of turbines, number of turbines required was determined. Dividing the total investment by net income, payback period was obtained.

2 4. Tidal.

i. Technical/Economical Potential Analysis: Tidal streams are caused by the rise and fall of the tides, which occur twice a day around the coast. As water flows in and out of estuaries, it carries energy.

The extractable power depends on the area of the basin and the tidal range. The mean spring peak velocity is the primary indicator of how energetic a tidal stream site is.

ii. *Stakeholders and Possible Incentives for Promotion of Tidal Energy:* An assessment of various stakeholders involving research and private institute developers was done. Incentives for this sector and their suitability analysis for wind energy was done.

iii. *Summary:* From the total investment and the net income which was calculated from the sale cost of tidal energy per unit, total return per annum was determined. So, the net income was obtained by deducting the operation and maintenance cost from the total return and hence, payback period was calculated by using investment and net income.

3. Methodology

Data collection from Mangalore Municipal Corporation and analysing the data collected.

- Phase 1: Collecting garbage data which they collect from citizens, commercial establishments and industrial units and it's analysis to determine the payback period.
- Phase 2: Collection of Solar radiation data from Mangalore City Corporation, installation cost and calculation of payback period.

- Phase 3: Collection of Wind details in Mangalore like the average speed of the wind data, various cost involved in wind plant and calculation of the payback period.
- Phase 4: Collection of Tidal details in Mangalore like tidal range, speed and Area of the basin, calculation of average power that can be generated, analysis of cost of various components of the plant and hence, determination of pay-back period.

- Studies have found that offshore and coastal wind power is one of the fastest growing industries in many areas, especially those with shallow coastal regions due to the preferable generation conditions available in the regions (Jennifer C. Wilson, et al. 2010). The average hourly wind speed in Mangalore experiences significant seasonal variation over the course of the year. The windier part of the year lasts for 3.7 months, from May 21 to September 13, with average wind speeds of more than 7.9 miles per hour. The windiest day of the year is July 1, with an average hourly wind speed of 11.1 miles per hour. The calmer time of year lasts for 8.3 months,

- from September 13 to May 21. The calmest day of the year is November 18, with an average hourly wind speed of 4.8 miles per hour. As water flows in and out of estuaries, it carries energy. The extractable power depends on the area of the basin and the tidal range. The mean spring peak velocity is the primary indicator of how energetic a tidal stream site is.

4. Results and Analysis

4.1. Power generation using available biomass in and around the Mangalore city already installed.

Tables 1, 2 and 3, gives the details of the plant, installation cost, maintenance cost and total power generated. From the details given in the table, Payback period is calculated (Investment/Net Income) it is about 5.91 years.

Table.1: Investment in Biomass

Installation Cost	30Lakhs

Table.2: Operation and maintenance cost of biomass

HR Maintenance	Rs 29700/month
Site Maintenance	Rs 42300/month
Total Maintenance	Rs 72000/month

Table.3: Income from biomass

Units per day	230 units
Cost/unit(Rs)	7
Total Income/year(Rs)	230x7x30x12 = 579600
Net Income(Rs)	507600

4.2. Solar

Tables 4, 5 and 6 gives the details of panel, total investment, and irradiation details of Mangalore city and also the estimation cost to generate 10 MW power from solar. Payback Period is calculated as (Total Investment/Net income) i.e., 7.58(Cr)/2.06(Cr) it is about 3.67 years. Hence, the Payback period will be around 4 years.
From the Table 7, it is calculated the total no. of solar PV panels to be used 4531. Total 4531 panels are considered to generate the required energy-7MW

Table.4: Investment in Solar

Solar Panels(China Tech.)	4.1Cr.
Solar Panels(German Tech.)	5.93Cr.
Central Inverters(4)	1Cr.
Combiner + Junction Boxes	30 lacs
Protective gears arrangement	10 lacs
SCADA and Data logger system	10 lacs
Land bank	5 lacs(approx)
Erection of project	10 lacs
Total project cost(China Tech.)	5.75 Cr.
Total project cost(German Tech.)	7.58Cr.

Table 5: Operation & Maintenance of Solar

Human resource	20 lacs/year
PV maintenance	1 lacs/year
Site maintenance	1 lacs/year
Total maintenance cost	22 lacs/year

Table.6: Income from Solar

Daily Units Generated	5000 units
Yearly units generated	5000x365 = 1825000 units
Govt. pays per unit	Rs12.5/unit
Total income over the year	Rs2.28Cr.
Net income over the year	2.28-0.22=2.06Cr.

Table.7: Require number of Panels

Total capacity of the plant	1MW
Average Sun hrs/day	7
Total power/day	7MW
Total watt-hrs/day	7x1000x1000W-h/day
Maximum Solar insolation at the site	6.18 KW-h/m/day
Divide total watt-hrs/day by solar insolation	1132686.08
Multiply it by 1.2(cover system inefficiency)	1359223.3
No. of solar panel	4531(Wp of chosen solar panel

Table.8: Investment in Wind

Turbines and Accessories	Rs3.68Cr
Civil work	Rs0.58Cr.
Electrical work	Rs0.47Cr.
Grid integration	Rs0.37Cr.
Installation	Rs0.11Cr
Others	Rs0.62Cr.
Total	Rs5.84Cr.

Table.9: Income from Wind

Daily Units generation	10000units
Yearly units generated	10000x365 i.e., 3,650,000units
Govt. pays per unit	Rs12.5/unit
Total income over the year	3,650,000x12.5 i.e., Rs4.56Cr.
Net income over the year	4.56-0.18 i.e., Rs4.38Cr.

4.3. Wind

Tables 8 and 9, gives the details of wind intensity & cost of power generation details and also the payback period.
Operation and Maintenance cost is very low, approx. Rs 0.5 per kWh. Thus, Operation and Maintenance cost for one year is 0.5*10000*30*12 i.e., 0.18Cr

Payback period is calculated as (Total Investment/Net Income) 58.4/4.38 i.e., 3.33. Hence, the payback period is around 13 years.

4.4. Tidal

Table 10, gives the details of estimation of tidal energy system in Mangalore city.

Total Investment is 154665.12*8.255 is Rs 1276760.566. hours of operation per day is 4. Sale cost of tidal energy is Rs 7/unit.
Therefore, total return per annum will be 10x4x7x30x12 i.e., Rs 100800. From the table Operation and Maintenance cost per unit is Rs 2097.52 Net income per year is 100800-(2097.52*10) i.e., Rs 79824.8. So, the payback period is Total Investment/Income per annum i.e, 1276760.566/79824.8 i.e, 14.9 years. Hence, the payback period is about 15 years.

Table.10: Commercial Plant capital cost breakdown for Tidal

	Rs/MW
Power conversion system	58145.76
Structural steel elemnts	32910.24
Subsea Cable cost	1300.8
Turbine installation	38568.72
Subsea Cable installation	20357.52
Onshore electric grid interconnection	3252
Total installed cost	154665.12
Operation and maintenance cost	2097.52

5. Proposed Solution:

15 kV biogas plant with capacity of 2 tonnes which generates 230 units per day is set up in and round Mangalore for producing power through Biogas. The suitable location is Near Urwa Market, Residential zone. As the plant is located at market and residential zone, transportation cost is reduced. The payback period is close to 6 years which is slightly more than solar and much lesser than wind and tidal energy. The Installation cost of the plant was Rs 30 lacs.
1 MW Solar plant can be set up in Kuloor, Gandhi Nagar which could generate 5000 units daily. The site is chosen because daily sun hours is 7 hrs/day and Maximum Solar intensity on the site is 6.18 KW-h/m/day. The required number of panels is 4531 and the payback period is the least for solar which is 4 years.
Setting up of a 10 MW capacity Wind plant at Marvanthe where the wind speed is 28km/hr and space needed is 5km. Using the best possible turbines and accessories, we can provide uninterrupted supply of power in Mangalore city using smart grid integration. The payback period is obtained as 13 years which is lesser than tidal.
A 10 MW capacity tidal plant can be set up at Marvanthe with an area of 500x500 square meters of each basin. We chose Maravanthe because it can be developed into a restricted area, the speed of the waves here is good and we can also control sea erosion. The plant will not cause any problem to fishermen and marine movement too will not be affected. There is no violation of the Coastal Regulatory Zone norms and it does not come in the Naval path. The project is eco-friendly. A total of 5 basins is required to produce the desired power output, using either Tidal Barrages or Stream turbines which are the two main forms of harvesting methodologies. The payback period is the maximum i.e., 15 years.

6. Conclusion

To provide the power from renewable sources to Mangalore city as a part of smart city. solar, biomass, wind and tidal power generation has been analysed. which also helped in various calculations like payback periods and determination of solar panels required for producing desired amount of electrical power. After collecting the data about various plants in Mangalore, we came across some useful results of power generation using the various forms of renewable energy in Mangalore city. The strength of the project is that it has not only shows the important calculations, but also gives an estimated payback period for both biomass, solar, wind and tidal power generation and also plenty of opportunity to generate the power from renewables.

Acknowledgement

We successfully completed our project a part of VIII Semester BE. Thankful to our guide Dr. Srinivas Rao Potty, Associate Professor Senior Scale in the department of Humanities and Management for his guidance. We would also like to thank Dr. Vittaleswar for providing us the necessary motivation to work on the project. A special word of thanks to Dr R. Shivarudraswamy, Associate professor in the Department of Electrical and Electronics Engineering, for being a constant source of help. Last but not the least, we are thankful to the Department of Electrical and Electronics Engineering, and also the Director of MIT Manipal, for providing us the platform to work on such enriching project.

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