Case-Study-Optimization and Modeling of Hybrid System for Tumnipada Village with Real Time Data

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ABSTRACT
Rural electrification with renewable sources implies rethinking on electrification strategies taking into consideration economic, social and environmental aspects. In that respect, renewable distributed generation linked with micro grids presents interesting features for remote or sparsely populated areas. This paper focuses the residential energy use with the help of micro grid concept for Tumnipada village, Sanjay Gandhi National Park, Borivali in Maharashtra. The uniqueness of this project is the use of the renewable energy resources which are easily available such as solar, wind, biogas or hydro, fuel cell for electricity generation. The paper also covers the main steps in the process of designing, surveying and modeling of a new micro grid system with the help of Matlab Simulink..

Keywords
Microgrid MATLAB Electrification

1. INTRODUCTION
The Electricity sector in India had an installed capacity of 225.133 GW as of May 2013, Worlds 5th largest. Captive power plants generate an additional 34.444 GW. This generated power constitutes 87.55% of Non-Renewable Power Plants and 12.45% of Renewable Power Plants.

Even after such a huge generation capacity there is still a huge shortage of power in India. This is due to ever increasing demand of electricity, drastic achievements in technology, increase in population and also wastage of electricity. Still more than 40% of rural areas are unelectrified.

Our approach is to electrify one rural area of the remaining 40% mentioned above to provide a small but beautiful home with the facilities where children can learn at night, farmers or workers can rest with fans on their head and a little bit of entertainment for children with education on computers. The aim is to power all 36 huts and a community classroom in Tumnipada, Sanjay Gandhi National Park. Borivali where currently there is no electric supply from state board.

The concept of Microgrid using renewable energy sources (Solar Energy) is to be implied for electrification of a total load of 500W. The use of solar is due to its efficiency, readily available and derived directly from sun i.e. free of cost. The other alternative for microgrid is fuel cell or biogas plant which can be easily installed in this situation.[8]

1.1 Rural Electrification
- One of the indicators for the socio-economic development of any country is the access to electricity. There are billions people in the world, especially in underdeveloped and developing countries that are excluded from using electrical energy.
- In today's emerging world our country lags behind as, there are places where electricity being the basic need not still been reached.
- So to help the country and those places by making them accessible to electricity, Rural Electrification is important.
- Total of 40% of backward areas in India are still waiting for electricity in their houses.
- This is our effort at grassroots level to contribute to the community by electrifying at least one small village.

1.2 MICROGRID
The term microgrid refers to a single electric power subsystem linked to a small number of distributed generators that can be powered by either renewable or conventional sources of energy, along with different load clusters.

- The key feature of microgrids is that they are able to operate independently of the central grid. This can help improve the power quality and reliability, as well as allow the local community to have more control over their power network
- The main criteria for distinguishing different kinds of microgrids are as follows

a) Whether it is connected to a central grid

b) What kinds of generation sources are connected to the microgrid.[8]

1.3 SOLAR ENERGY
- Sun is the never ending source of energy, will be able to generate electricity even after millions and trillions of years coming in future.
- Compared to windmill, solar energy is very much noise free and the installation cost for solar is lesser than that of windmill.
- Compared to other source of energy solar is the cheapest.
- There is no need for heavy electrical machines such generators or turbines to produce electricity from solar energy. This further reduces the cost of solar energy.
- It is easily scalable i.e it is easy to add solar panels to the existing system. Less intrusive than wind energy or tidal energy.[3]

Above discussed advantages of solar energy over other renewable sources easily qualifies solar as the best and reliable source of generating electricity and which would play a major role.

2. RURAL LITERATURE

The rural electrification typically focuses on economic & physical aspects of development and also on needs of the local communities. The rural electrification would be called a successful one based on its value, as perceived by the user from a personal perspective, inclusive of the needs and priorities at the end user is seen as the key factor in the design of infrastructure of the project. The aim of the project is to identify properties that are important for shaping the rural place and fulfilling the energy needs. The current energy source in project site is heavily reliant on burning of biomass. The use of traditional fuels as the main source of energy by rural households, which is the area of concern. The survey of the rural area (project site) concludes that it has an abundance of potential renewable energy sources that, if pursued could significantly alter the nature's energy and can cause a shift away from the combustion of biomass. In additional, small scale hydropower can also be raised for meeting the load demand. In short term period a micro grid will be set up for supplying the required load demand to the rural area. There are few problems and challenges faced which are listed below:

- High capital cost
- Dependence of donor
- Lack of policy and legal construction[4]

2.1 Site Survey

The proposed site is located in SANJAY GANDHI NATIONAL PARK at Borivali in Maharashtra state. The geographical coordinates of location is Latitude: 19°14′05″ Longitude: 72°51′35″ Elevation above sea level: 22 m. The site is located in midst of Sanjay Gandhi National Park, about 9.5 km away from the main entrance named as TUMNIPADA. TUMNIPADA is a small locality, now presently consisting of total 36 houses and a student study room (powered by NGO), total inhabitants are around 150. A decade ago, the population there was only 50 but recently it has increased to 150, so the requirement of electricity has also increased. So, it is important to make some changes and bring about Rural Electrification.

TUMNIPADA is isolated from electricity supply due to the Forest Act and their protest against the rehabilitation. So, still there is no source of electricity. The inhabitants there in are still classified as backward class and use the old methods for lighting their houses (like kerosene lamp). The houses are made of cow dung and mud. Only natural cooling is used.

The demand of electricity is depend upon the mindset of the villagers, there is some basic need of villagers e.g. lamp, fan, mobile charging etc.

1.4 Village Statistics

Table 1: Village Summarization

Rural Energy Needs	**Primary sources of Energy**				
	Kerosene/ Candles	Dry cell Battery	Bio-Mass	Human Energy	Not Used
Household					
Lighting	✓				
Cooking					
Water Heating					
Fan					
Community Enhancement					
School/ community Room	✓	✓			
Street Lighting					

2. PROPOSED METHODOLOGY

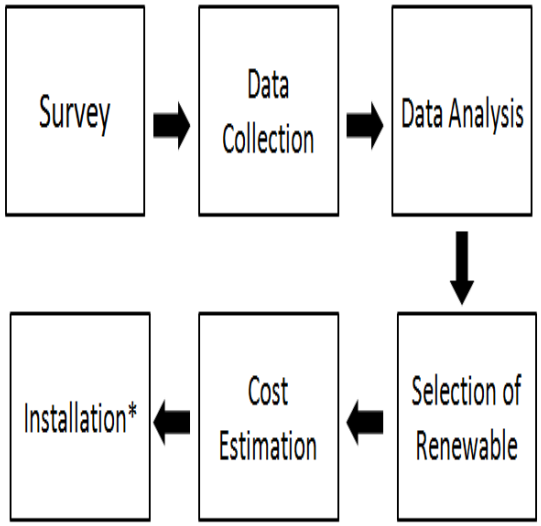

Figure 1: Flow chart

- **SURVEY:** The complete analysis of the site with survey of area of site, population, standard of living, type of land and geographical conditions along with present state of electricity supply.
- **DATA COLLECTION:** This includes the load collection, lux analysis, wind speed, biomass availability and hydro-scope analysis.

- **DATA ANALYSIS:** According to the survey, load is to be calculated and the complete calculations of solar panels, batteries and inverter selection.
- **SELECTION OF RENEWABLES:** As per the geographical conditions, solar is the best fit for the renewable energy source as wind speed in inadequate and no scope of hydro power generation.
- **COST ESTIMATION:** According to the load calculations, site survey and solar calculations, the cost estimation is done. 1kW of power generation costs upto 1 lakh rupees. But the increment is not linear in case of solar, so the estimation is to be precisely done. Costing includes prices of PV panels, batteries, inverter, panel mounting, fuses, MCBs, wiring, sockets and switches, CFLs, fan and battery housing.
- **INSTALLATION:** This is to be done if funds are provided by NGOs or any other sources. If not so, the community classroom only will be powered. Efforts are made to receive funds from NGO already working in the same village already.
- **PV CELLS & OTHER RENEWABLES:** The first block indicating what renewable source of energy is to be used. According to the condition of the village, use of solar energy is the best fit. So PV panels are used. Is accordance, other sources can be used in the microgrid such as fuel cells, biogas, etc.
- **BATTERY:** This is the power storing element for the PV cells. Since solar energy is not available for 24 hours, battery is to used to provide energy during non-sunshine hours. The battery connection depends upon the voltage level which is required by the user.
- **INVERTER:** Most of the user load consists of AC appliances, but power generated by renewable sources is of DC nature. So, use of Inverter is must in this situation. Ratings of inverter to be used also depend upon load calculations.
- **CONTROL CIRCUIT:** Recent trends have developed inverters with built in control circuits which can be easily programmed due to use of microprocessors.
- **PROTECTION CIRCUIT:** Due to load fluctuations, protection is necessary for inverter, battery as well as PV panels as they are of very high costs. Protection devices used are fuses for dc side circuit and MCBs for AC side circuit.[6]

3. CALCULATION

Table 2: Load Details for 36 huts

Sr. no.	Appliance	No. of Appliance	Watt Rating of Appliance
1	CFL	72	25
2	Ceiling Fan	36	40

- Total load:

1. 1800W x 5hr = 9000Wh = 9kWh
2. 2.1440 x 6hr = 8640Wh = 8.6kWh

So, Total load = 17.5kWh

- Battery Bank Sizing
- Assuming System Voltage =120V
- Total load =17.5KWh
- $Wh = \frac{17500 \cdot V \cdot I \cdot h}{120\ V}$

  = 145 A-hr

  Considering the inverter efficiency = 85% & DoD = 80%
- A-hr = 145A-hr/(0.85*0.8)= 213.23 A-hr
- So we need a battery of rating 12V, 120 A-hr, 20 batteries
- Autonomy = 1 day
- A-hr = X + nX
- = 213.34 + (1*213.34)
- ≈ 418 A-hr
- For 1 day = 20 batteries
- For 2days = 40 batteries

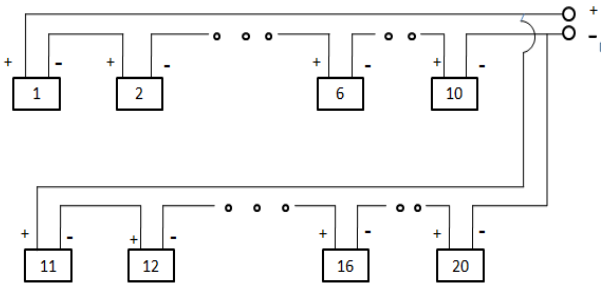

Figure 2: Connection Of Batteries

- Calculations for Solar Panel:
- Efficiency of Batteries = 85%
- Energy supplied by PV panels at the input of inverter= input of inverter/efficiency of battery

= (17500/0.95)/0.85

=20588.2356/ 0.85

= 24211.45 W-hr

- Total A-hr generated by PV panels = W-hr/System voltage
- = 24211.45/ 24
- ≈ 1000 A-h
- Total sunshine hours = 7 hrs
- Total current generated by PV panels

  = 1000A-hr/7hr

  = 142.85 A
- Assuming PV panel of 250W_p (24V,10A)
- Number of PV panels needed = 142.85/10 ≈ 14
- So we will have to use a total of 28 panels of 250W_p. [4][6]

4. CONCLUSION

Depending upon the load profile of a typically located village in National Park, a Micro-grid system based on locally generated renewable energy sources is to be implemented. Based on the qualitative and quantitative analysis of geographical conditions of the site and availability of different sources, a solution is presented. The ability of MG to island generation and loads together has a potential to provide a higher local reliability than that provided by the power system. To sum up, rural electrification based on renewable energies in developing countries promises a cleaner, cheaper and more democratic way of the quality standard of an important section of the world's population.

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