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A case study on Grid Integrated Micro Grid system

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ABSTRACT

With the evolution in the technological and industrial sector, there is an increase in the utilization of electrical energy. However, the rapid exhaustion of conventional fossil fuels which led to rapid development in the field of renewable energy for the production of electricity along with distributed energy resources. A micro grid can provide a better backup solution along with the main grid for providing continuous power. There are very niche awareness and knowledge about the Micro grid system. In this paper, efforts are made to create awareness and encourage people to adopt and implementation of Micro grid system for reliable, sustainable and environment-friendly power space. This paper involves a case study on the installation of a Micro grid system at Adas (18.7789°N, 76.2306° E), Dist-Beed, and Maharashtra. The main issue with location is that as this area comes under drought-prone area and receives the annual rainfall of just around 692mm, which results that nearby ParliVaijnath Thermal Plant is shut-off due to scarcity of water and faces the load shedding for an average of 6 hrs/day. The paper provides feasibility in terms of reliability, economics and sustainability using a Micro grid system. The analysis suggests that grid integrated Micro grid system is a more viable solution to such kind of areas where availability of conventional sources of energy is the main constraint. If grid integrated Micro grid systems are implemented in such rural areas, it would become a versatile option for energy through local power generation with the help of renewable energy sources. So, the whole study concludes that the implementation of Grid Integrated micro grid system will be more feasible to be implemented in the rural areas at village-level with most reliable, affordable expenses with zero fuel cost and small pay-back period for 24/7 power flow. Thus, the implementation of grid integrated Micro grid system provides a better option for local power generation and it also contributes substantially towards sustainability, reliability and environment.

Keywords— *Renewable Resources, Micro Grid, Local Power Generation, Payback Period, DERs*

1. INTRODUCTION

Electrical energy is the most important energy resource. The growth of the large generating plants is hardly able to keep pace with the increasing demand for electricity. Moreover, the cost of the upgrades required to enable today's power system to deliver the level of higher demand for electricity is far in excess of what society has so far been willing to bear. The excess of energy consumption is also a matter of concern. Taking into consideration the above concern this paper presents the solution to them.

A micro grid is an independent operating system consisting of a localized group of electricity sources and load that acts as a single controllable entity within electrical boundaries [2]. The Distributed Energy Resources consists of electricity generators, energy storage, load control, and power electronic interfaces between the distribution grid and the respective generators [8]. Hence, with studies, we selected Solar and Wind so as to form a hybrid system which will generate power and supply the village without any load interruption at least for the six hours of the day. We aren't using diesel so as to avoid any kind of pollution and to ensure safe, clean and reliable generation and distribution through the hybrid system.

I. SECTION A: DESIGN CONSIDERATIONS

(a) SITE SELECTION AND GEOGRAPHICAL ANALYSIS

The site selected in this paper is a village name as Adas, District Beed and state Maharashtra. The site location has co-ordinated as (18.7789°N, *76.2306° E).* The annual rainfall of the site was recorded around 692mm and thus the selected site has a dearth of rainfall since last two years and the flow of river water near the rural area is inadequate to establish a small scale hydro generation project. The selected site faces 6hours/day electricity shortage due to load shedding problem. The average temperature of the site is 45 degrees and the humidity of air is around 35%.

The selected site has sufficient solar irradiance of around 6.2 kWh/m^2 thus a solar PV system could be of a reliable to use. The average wind flow of the site is nearly around 7m/s which could be reliable to use for electricity generation.

(b) HYBRID SYSTEM

A Micro grid is termed as a small energy system or network at the distribution level that can operate in the stand-alone or grid-connected configuration. The primary elements of a Micro grid are energy sources, storage systems and loads[3]. The energy sources are categorized between renewable or non-renewable; Though, a strong tendency currently promotes the operation of renewable energy sources because of the positive environmental impression or effect that can be thus achieved. Photovoltaic (PV) arrays, wind turbines, biomass, and hydroelectric and diesel generators are the most habitual energy sources in Micro grids confirmed in the writings or literature. The optimization of other components (such as inverters, protection devices, controllers and all the necessary equipment to handle the Micro grid) rely on the type of energy source.

There are basically two types of storage systems that is ultracapacitors and energy storage systems (batteries). The former are electrochemical capacitors have the ability to store significant amounts of energy to be generated in short intervals of time. The latter are electrochemical devices composed of two electrodes distinguished by an electrolyte that work credits for the electrochemical reaction; the most common types are lead-acid and lithium-ion batteries. Two basic stages are compulsory to design and plan a Micro grid. Initially, the load is characterized and the requirements for the power supply are specified, e.g. voltage, current and consumption profiles. The second stage is sizing the energy storage sources (Batteries) and the related devices; the location of the Micro grid is considered for this purpose since it will give a clear idea of the possible energy sources.

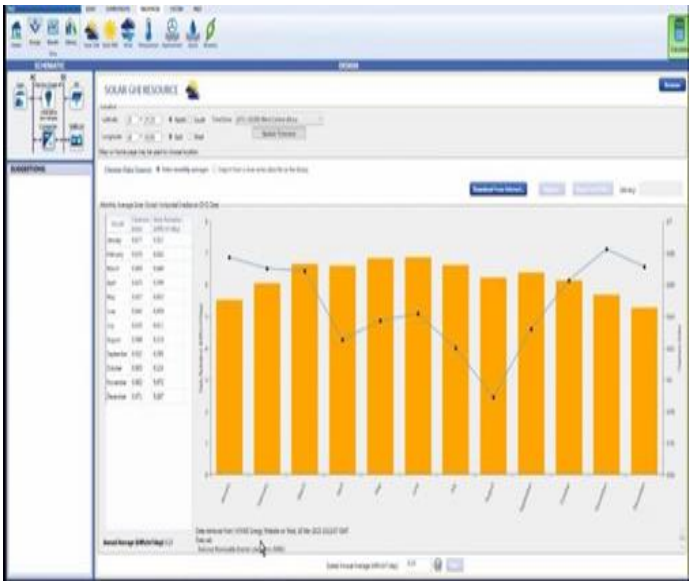

Fig. 1: Graph representing solar radiation

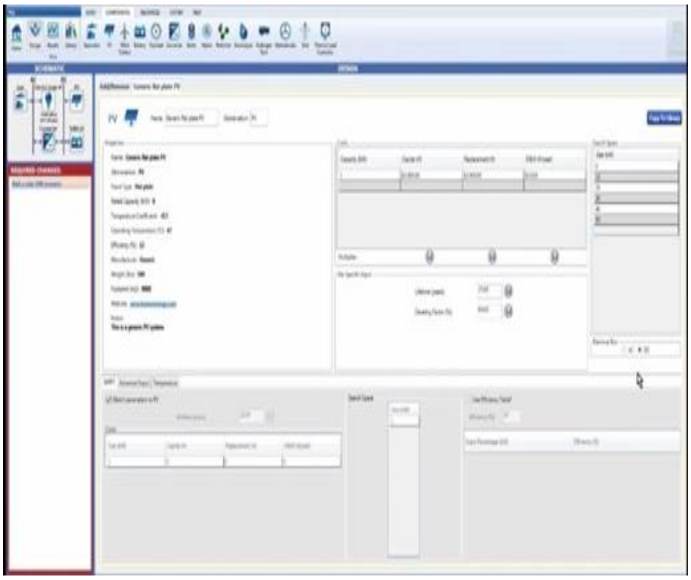

Fig. 2: Solar PV system specification

(c) SOLAR PV SYSTEM

Solar energy generation is one of the emerging, fastest growing and most promising renewable energy sources of power generation worldwide. Nowadays, electrical energy becomes one of the basic needs in our day to day life, which makes increasing demand for it. As a significant source of electrical power generation, fossil fuels are on a verge of extinction day by day and also its consumption raises serious environmental concerns. These reasons urge for research or development of new energy sources which are renewable and ecologically harmless.

The renewable energy sources include wind, solar, water, biomass and geothermal energy sources. Out of which, solar energy has the greatest potential in the long term and is predicted to play a major role in the coming years [7]. It is the cheapest method of generating electricity compared with other energy sources. Solar power is the conversion of sun radiation into electricity through the use of solar photovoltaic cells. This conversion takes place in the solar cell by the photovoltaic effect. As said by many experts that the amount of solar energy reaching the earth is more than 10000 times the current energy consumption by man. There are several applications that use solar power, here is the information on the generation of electricity through PV cells. The solar power generation is the most efficient route for power generation because it takes a minimum number of steps (for producing electricity) than that of other generation methods Solar energy is available freely and conveniently in nature and it needs no mains supply. .Solar generation plant can be installed in a few months while the conventional power plants take several years to build an electricity generation plant. Solar power is clean energy as it produces no air or water pollution. Also, there are no moving parts to create noise pollution. Unlike fossil fuels, no toxic emissions are released into the atmosphere during solar energy power generation. Solar power has less running cost that means once the capital investment is made, there is no need for continues purchase of fossil fuels as the solar energy is effectively free in nature.

Now for this site we opted for the flat roof-mounted solar panel the positive side of this choice is that we have various alternatives available that is Flush mounted, Tilt-up mounted, Self-ballasted mounted easily for installation around 3-6 months rather than settling for power station which costs more and consumes more time.

The temperature of your solar panel has a direct effect on its ability to generate electricity. This has to do with the laws of thermodynamics and how heat limits any electronics ability to produce power. For solar panels, this impact is reflected through the temperature coefficient, which is expressed as the percentage decrease in output for every 1-degree Celsius (°C) increase in temperature from 27°C (room temperature). Solar panels are tested for their efficiency at 27°C, and that is why this is used as the reference point. Solar radiations of the selected site are shown in figure (1). A solar plant which we specified is -0.5°C such that the solar radiation we received from the data over the years, that gives an estimation of 47°C; the efficiency of solar panels is the amount of electrical output it can give for the amount of solar radiation falling on it per meter square. Considering the specifications in our case solar panel is of efficiency 13% and if we take area 1.5 m2. If the amount of solar radiation falling on this panel is 1000W/m2, then this panel is capable of producing 1000*14%*1.5 = 210W. If this energy falls for 5 hours, then this panel will produce 210*5= 1050 Wh or 1.05kWh in a day, such that the efficiency through these factors is of 13% as the panel is polycrystalline the efficiency is of that range and keeping cost factor in mind, it is lesser than monocrystalline also such that we received total power rating of the system is 0-50 kW

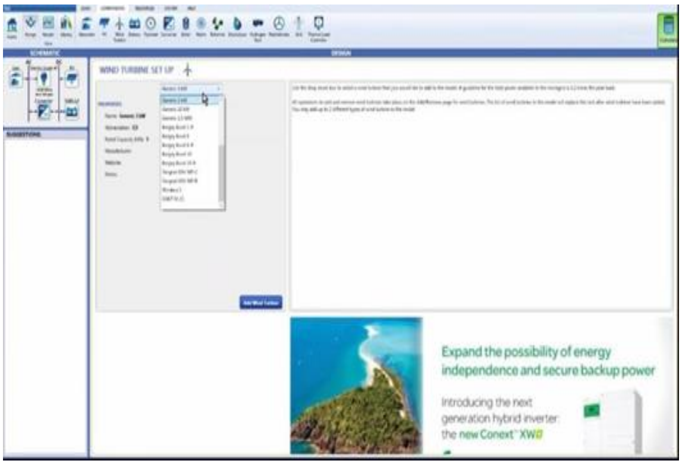

Fig. 3: Wind resource set up

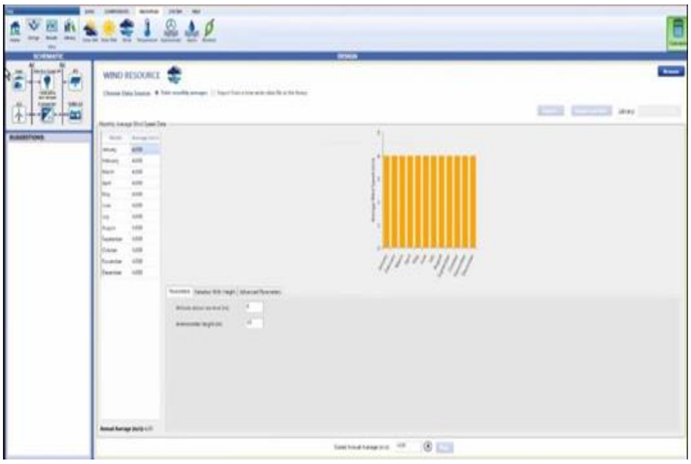

Fig. 4: Wind speed data

(d) WIND ENERGY GENERATION

A form of solar energy is wind energy. The uneven heating of the atmosphere by the sun and the irregularities of the earth's surface cause wind. Wind energy is a renewable energy resource that is clean, reliable and available in plenty for free. It does not pollute the surroundings as it does not include the emission of harmful gases that may cause acid rain or greenhouses gases. The wind turbine converts the kinetic energy into wind power. The output of which can be given to a generator to convert it into electrical energy. The rotor is connected to the main shaft, which spins the generator to create electricity. The wind turbines have two basic groups; the horizontal-axis variety and the vertical-axis design. A variety of sizes are available for the wind turbine and therefore the power ratings.Wind energy cannot be stored even if wind-generated electricity can be stored if we make use of batteries and all winds cannot be harnessed to meet the timing of electricity demands. Good wind sites are often located in remote locations far from areas of electric power demand. The set up selected for the wind turbine is shown in figure (3). The wind speed graph shown in figure (4) gives the idea of calculating the cut in speed required of wind generator specification.

II. SECTION B: DATA ANALYSIS

(a) OVERALL SYSTEM ANALYSIS

As the load of the site selected varies per month thus the average load for a period of the year of a sample house is taken for entered in the software. For the consideration of the calculation and evaluation and design of micro grid, the load is taken to be 10 kW. As the micro grid support the main grid to supply power for the load shedding period which taken to be 6hr/day. A designed micro grid consists of a distributed energy resource as a solar plant, a small scale wing generation and a battery which serves a purpose of the energy management system. The life of the project is taken for 20 years. The solar generation unit of micro grid consists of a panel of nearly 310-Watt and of polycrystalline nature. Even though the efficiency of the polycrystalline panels are moderate but the cost consideration of the project has to be taken into account and thus the selection is done. Solar radiation of the site is given in figure(1). This data is entered into the software. The maintenance and operation of the solar plant are taken to be negligible. The inverter cost and a protection system cost is taken around 20 % of the whole solar generating unit. The wind generating unit consists of Wing turbine of 3kW. The power output is depending upon wind speed. The power output is ranging a maximum value of 5 kW.

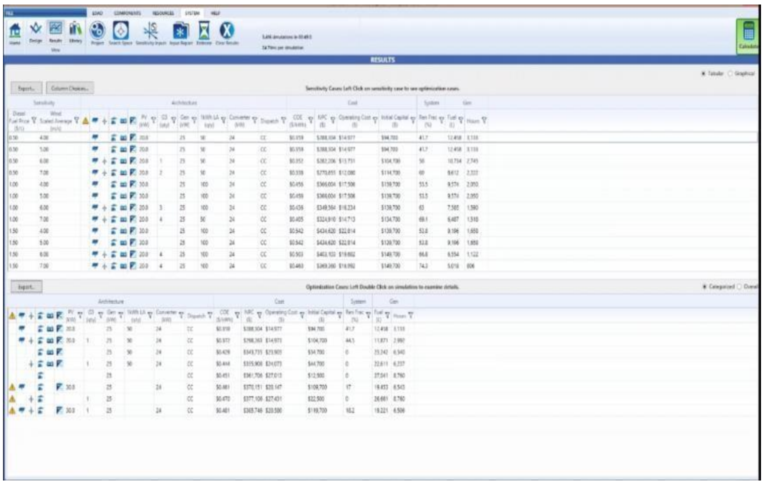

Fig.5: Optimized system results in Homer software

(b) RESULT OF SIMULATION

After giving input values to each and every sectional requirement of the software, the optimized result is obtained at the end of the process shown in figure (5). Every division of the software has the constraints of data in which a compromise has to be made. The best efficient hybrid system is obtained at the top of the result. The alternative options are also shown in a relative manner. For the site selected, almost 256 solar panels, 6 inverters along with 2 sets of wind turbines are needed. As batteries are selected as an energy storing device, a battery bank of 56 is required to store the electricity and for peak shifting. Since the selected site has a rural background, therefore, the financial status has to be taken into account. Homer software also calculates the amount of energy produced by micro grid and the energy given to the grid. In the grid-connected mode, the micro grid support almost 65 % of the load the rest 35% is supported by the main utility grid. In the total power produced by the micro grid, 83 % of the power is produced by the solar system and the wind energy acts as a supporting agent of it. The energy produced by the PV system in the summer month of the site is obtained as 136 150 kWh for a year. The amount of wind energy produced is less than 1 kW for the site selected. The cash flow and economic survey are obtained in the last section of the simulation.

For maintaining sustainable development, it is important to reduce down the carbon footprints scale. Homer software has always become a second priority to study carbon emission amount. Generally, a PVsyst software is used for detailed study of Solar PV system design and CO2 emission studies [5]. The total production of greenhouse gases is termed as carbon footprints. The main reason for carbon footprints is the support of the application in industrial use. The use of solar PV system reduces the number of carbon footprints which naturally leads to the enhancement of sustainable development. The simulation result of PVsyst software shown in figure (6) shows the carbon emission in the next 10 years.

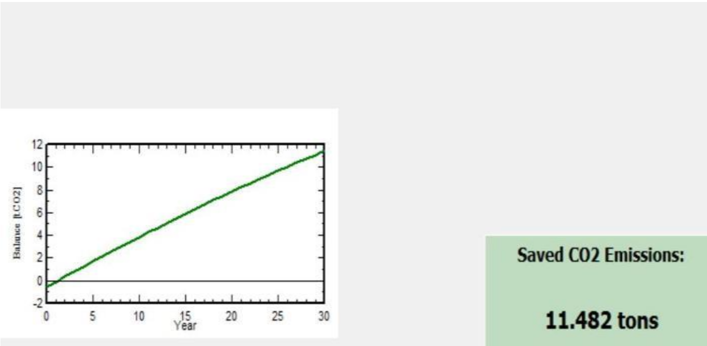

Fig. 6: Result of PVsyst software for carbon footprints

III. SECTION C: BENEFITS OF USAGE OF RENEWABLE RESOURCES

Government has initiated a subsidy scheme to help individuals and organizations procure these Solar Energy Systems at reduced capital costs. The scheme is being implemented by IREDA (Indian Renewable Energy Development Agency Ltd.) through NABARD (National Bank for Agriculture and Rural Development). The scheme that was last modified on 15th March 2012 provides 40% subsidy on capital costs of Solar PV Systems for units located in both urban and rural areas in India.

As a first step, it is important to choose the right manufacturer/supplier from whom you purchase the Solar PV system. The manufacturer/supplier should be an MNRE (Ministry of New and Renewable Energy) approved manufacturer/supplier. To get a list of approved suppliers in your area, you can check the link: http://www.mnre.gov.in/information/manufacturesindustriesarchitectsconsulting-organisation/

Only the models approved by MNRE are eligible to be covered under the scheme. The list below gives models approved by MNRE: (Source: NABARD)

The benchmark cost of a solar PV system as per a NABARD document (link) is Rs 270 per Wp. But the unit costs are revised from

Technical and Financial parameters of pre-approved Models to be financed

Model	Photovoltaic modules/ panels (Wp)	Battery capacity	Maximum recommended load and duty cycle	Benchmark Cost (₹.)	Max. capital subsidy eligible * (₹.)
I	10	12 V, 7 AH (SMF)	5-7 watt load for 3 to 4 hrs (20 watt hrs/day)	2700	1080
II	18-20	12 V, 20 AH (Tubular L.M./Gel VRLA)	10 watt load for 4 hrs (40 watt hrs/day)	4860-5400	2160
III	37-40	12 V, 40 AH (Tubular L.M./Gel VRLA)	20 watt load for 4 hrs (80 watt hrs/day)	9990-10800	4320
IV	50	12 V, 60 AH (Tubular L.M./Gel VRLA)	30 watt load for 4 hrs (120 watt hrs/day)	13500	5400
V	70-80	12 V, 80 AH (Tubular L.M./Gel VRLA)	45 watt load for 4 hrs (180 watt hrs/day)	18900-21600	8640
VI	100	12 V, 120 AH (Tubular L.M./Gel VRLA)	60 watt load for 4 hrs (240 watt hrs/day)	27000	10800
VII	125	12 V, 150 AH (Tubular L.M./Gel VRLA)	75 watt load for 4 hrs (300 watt hrs/day)	33750	13500
VIII	150-160	24 V,75/80 AH (Tubular L.M./Gel VRLA)	90 watt load for 4 hrs (360 watt hrs/day)	40500-43200	17280
IX	200-210	24 V, 100/120 AH (Tubular L.M./Gel VRLA)	120 watt load for 4 hrs (480 watt hrs/day)	54000-56700	22680

* @ ₹ 108 per watt of module capacity

time to time and your manufacturer/supplier should be able to guide you properly on the same.

In case the cost of the unit is less than the benchmark cost than the full 40% subsidy can be claimed. But if unit cost is more than the benchmark cost then the capital subsidy will be limited to the maximum capital subsidy ceiling as indicated in the table above. Only individuals, group of individuals, Self Help Groups (SHGs), JLGs (Joint Liability Groups), Non-Government Organizations

(NGOs) and Farmer’s club are eligible for a subsidy through NABARD. Private/Public Limited
Companies are not eligible for this subsidy. To avail the subsidy, you need to have an account with a scheduled commercial bank or a regional rural bank. Most public nationalized banks can be approached for this. 40% of the cost is subsidized and the rest 60% of the cost is eligible for a soft loan. However, the margin to be paid by the beneficiary (out of the 60%) is decided as per RBI norms. The repayment period of the loan is 5 years. The interest rates are also as per RBI norms. To obtain the loan one has to submit the quotation and the documents available from the vendor. A vendor should provide the MNRE approval form, TIN number, project proposal, etc. which needs to be submitted to the bank.

After processing the loan and verifying all the documents, the banks provide loan and the documents are sent to NABARD for release of subsidy. The EMIs start as soon as the loan is processed; however, the release of subsidy through NABARD takes some time. As per MNRE, the interest on the loan should not be for the subsidy part. The banks have the right to recall the subsidy in case they observe that the subsidy is misused.

According to the Ministry of New and Renewable Energy, the Central Government pays 30% of the benchmarked installation cost for rooftop PV systems. This subsidy is applicable in states that are in the general category. However, a subsidy of up to 70% of the benchmarked installation cost is offered in some states that lie in the special category -- North MNRE PV Rooftop Cell. These include states such as Uttarakhand, Sikkim, Himachal Pradesh, Jammu & Kashmir and Lakshadweep. In addition to this, State Nodal Agencies also offer subsidies in various states. This subsidy scheme is applicable for institutional, residential and social sectors. However, it is not applicable to the commercial sector, industrial sector and public sector undertakings. PSUs are eligible to avail incentives on the basis of energy generation.
Whereas the system we planted and on the basis of analysis from cost calculations and energy generations the system is able to achieve around 24% of government subsidy.

The major advantage is also that solar panel installations reduce the carbon footprint, a carbon footprint measures the total greenhouse gas emissions caused directly and indirectly by a person, organisation, event or product. A carbon footprint is measured in tonnes of carbon dioxide equivalent (tCO_2e). The carbon dioxide equivalent (CO_2e) allows the different greenhouse gases to be compared on a like-for-like basis relative to one unit of CO_2. CO_2e is calculated by multiplying the emissions of each of the six greenhouse gases by its 100-year global warming potential (GWP).

A carbon footprint considers all six of the Kyoto Protocol greenhouse gases: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6).

TYPES OF CARBON FOOTPRINTING
The main types of the carbon footprint for organisations are:

(a) Organisational
Emissions from all the activities across an organisation, including buildings' energy use, industrial processes and company vehicles.

(b) Value chain
Includes emissions which are outside an organisation's own operations (also known as Scope 3 emissions). This represents emissions from both suppliers and consumers, including all use and end of life emissions.

(c) Product
Emissions over the whole life of a product or service, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal.

(d) Supply chain
Emissions from the raw materials and services that are purchased by an organisation in order to deliver its services and/or products.
(Source: carbonemissions.org)

The system we installed after analysis we received the carbon footprint around 11482 tons, this data can be also estimated through online software or PVsyst just by updating the data of generation of energy and emissions whereas in our case we used solar panels which has one of the least carbon footprints compared to conventional resources.

2. CONCLUSION
In this paper, a case study on the design and installation of Micro grid system is done on the simulation software for a rural area in Maharashtra where it is difficult to provide electricity for complete 24 hours and major focus is given on the distributed energy resources for keeping a sustainable balance in nature. The use of a diesel generator and the use of gas emitting methods is strictly avoided for giving the electricity supply. The use of local generation of energy is promoted by the use of distributive resources for energy-efficient use. Efforts are made to spread awareness amongst the people for the use of sustainable development method. The zero carbon emission is achieved in the case study which leads to a reduction in flue gases in the environment. The payback period of the project is obtained in the cost analysis of the software section. The reduction in the number of carbon footprints mainly focuses on the enhancement of sustainable growth of the environment.

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