# Review of Distributed Generation - An Approach towards Rural Electrification

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*Abstract*— Security of Energy and sustainable development are major issues now a day in developed as well as in developing countries. In present scenario the generation of electricity is of centralized process where in there are some cons of having this centralization process. to overcome that cons the Decentralized Renewable Energy generation is expected to become more important in the future electricity generation system. It showcases the alternatives including usage of Renewable energy towards Decentralized process and a scenario of action taken up for the use of Renewable Energy technologies. There are complex socio-economic issues that are hindering the growth of Renewable energy in India, especially in off-grid villages which are not connected by supply systems. Hence in this work the use of distributed generation for the process of rural electrification is discussed. Compared with urban industrial areas Rural environment present different electrification process. Those particulars imply rethinking electrification strategies taking into consideration economical, social and environmental aspects. In that view, distributed generation using renewable energy presents better features for remote areas. The paper presents the use of renewable energy generation and its environmental advantages with steps to be carried out in the process of designing a new distributed generation system using available renewable energy resources.

***Key words:*** Distributed Generation, Renewable Energy Sources, Charge Controller, Arduino Kit, Rural Electrification, Grid Connections

## I. INTRODUCTION

It is now proved that electric power is the important parameter for the economic growth and prosperity. In fact about 80% of the population lives in rural areas where the extension of utility grid is either complex or expensive in nature. The global electricity generation is projected to reach 30.36 trillion kWh in year 2030. At present the global electricity generation is around 21 trillion kWh. Globally the present electricity generation has been centralized one. Instead of centralization process the use of renewable energy in a decentralized manner has provided access to electricity to billions of people who are living in remote areas and the villages that are not connected to the grid. It does not have reliable electricity supply even though it is connected to the central grid. India has one of the fastest growing economies in worldwide consumer of energy. Traditional electricity generation technologies emit significant greenhouse gases into the atmosphere and hence they contribute to the global warming. Besides this the problems associated with fossil combustion technologies include acid rain, unequal distribution of resources and resource depletion. During this scenario the use of renewable electricity generation technologies provide satisfactory solution to the above-mentioned problems like lack of electrification in some regions and non-sustainability of fuel based generation. Increasing demand of electrical energy is one the major issue causing a large gap in generation and load demand. All the requirement of energy cannot be complete met with conventional grid supply so, for this purpose an alternative energy sources has to be recognized in order to meet Generation and demand supply management strategies. Hence it is necessary to explore the applications of decentralized energy sources which are helpful to meet the energy requirements of the consumers. With the process of rural electrification poverty alleviation and rural growth of a nation can be achieved.

### *A. Present scenario in Power Generation*

At present Centralized Generation (CG) process is in practice. "Centralized Generation" refers to the large scale generation of electricity by using the centralized facilities which are made available. Centralized Generation is usually placed in locations where the required primary energy sources (raw materials) are easily available for the generation according the type of plant which is erected and are generally far away from the load center. Consequently, large electricity transport, distribution lines and grids have to be installed. A centralized Generation facility includes fossil fuels plants, nuclear power plants, and hydroelectric plants, Wind farms, solar plants and many more. Since it is difficult to store electrical energy in large quantities, the electrical grids need to keep the balance between generation and load demand of the consumers. With this parameter the national grids holds complex central operation and control units in order to adapt the generation curve to the demand.

Centralized generation presents the disadvantages like despite of high quality and evolution of electricity transport technology, this transmission-system carries non-negligible leakages and reliability of grids depends strongly on the meshing degree of the network and this is usually lower in rural areas where the grid tends to be transmission mostly radial. Hence, in case of failures the transmission system turns to be a bottleneck and may affect large zones for considerable periods of time. Extending new branches of transportation systems lays out high resistance from the social and environmental point of view. In order to avoid above-mentioned bottleneck and taking into account of rural load characterization, distributed generation (DG) or embedded generation (grids with several and interconnected small generation points) is becoming more usual and is expected to experience a big increase in the coming years, contributing to the expansion of micro grids. Those grids do not need high voltage transportation systems, and hence avoid related losses, and present a higher meshing degree at low voltage. Generators connected to micro grids tend to be based on diverse primary energy sources (PV, wind and small-hydro).

 

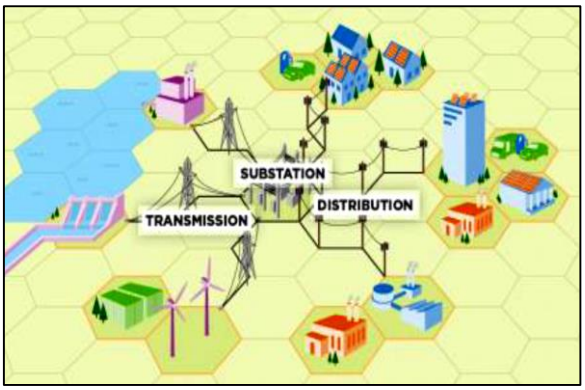


Fig. 1: Overview of Centralized generation

### *B. Environmental Impacts of Centralized Generation*

In general, the effects of centralized power plants can be highlighted as below:

- Air pollutant emissions
- Water use and discharge
- Waste generation
- Land use

In addition to these environmental impacts, much of primary energy of fossil fuels burned at power plants is wasted during generation and delivery to end users.

## II. DISTRIBUTED GENERATION

Decentralized electricity generation (DG) also distributed energy, onsite generation means generating power onsite rather than centrally eliminates the cost complexity interdependencies and inefficiencies associated with transmission and distribution. Here electric power source are connected directly to the distribution network or on the customer side of the meter. The size of the power plant may vary from Micro-DG, small DG, medium DG, and large DG. Under decentralized energy generation system, electricity needs of local people are met from a power station located in the villages, based on locally available raw materials like biomass, solar, wind or mini hydro.

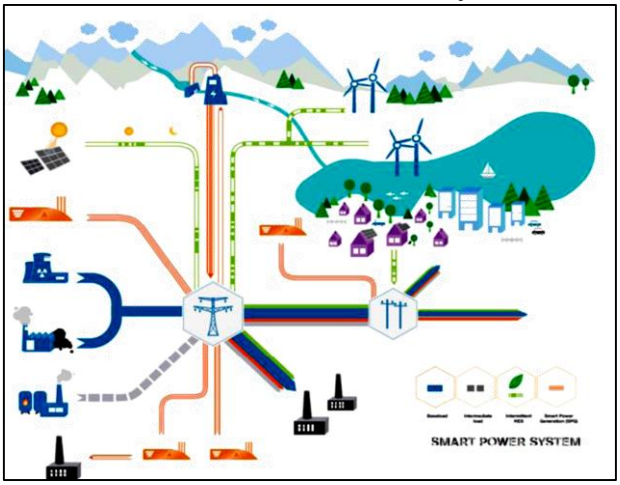


Fig. 2: Overview of Distributed Generation

| Energy Sources | Usage Options |
|---|---|
| Solar | Photovoltaic, Thermal power generation, Solar Home Systems, Solar water pumps Cookers, Dryers |
| Hydro Power | Power Generation |
| Tidal | Barrage, Tidal streams |
| Wind | Power generation, Wind generators, Wind mills, wind pumps |
| Geothermal | Power generation, Hydrothermal |

Table 1: Depicts different usage forms of renewable energy Sources.

### *A. Following are some options decentralized generation*

- Solar PV Rooftops– Top systems for abatement of diesel for power generation in urban areas.
- Biomass based heat and power projects and gasifiers for rural supply and industrial energy applications.
- Watermills/Mini/Micro hydel projects – for meeting electricity requirement of remote villages.
- Wind energy and Hybrid Systems – for mechanical and electrical applications, mainly where grid electricity is not available.

### *B. Activities to be taken up for carrying out the decentralization process*

This scheme can be executed through many processes as described below:

- Selection of village sites or location
- Survey of villages
- Preparation of Detailed Project Reports
- Constitution of Village Energy Committees
- Installation of approved distributed generation lighting systems in households, streets and for community uses.
- Capacity building and development of repair & maintenance infrastructure, etc.

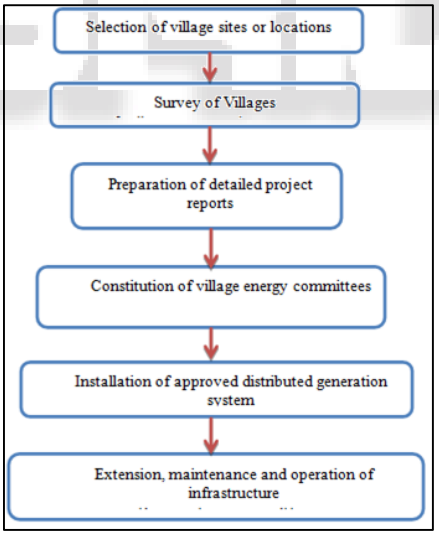


Fig. 3: Flow chart for execution of distributed generation process

### *C. Need for Distributed Generation*

- Distributed generation offers a number of technological advantages over current system.
- It is clean, reliable and affordable.
- It supplies additional electricity to the rural electricity grid.
- Flexibility.
- Upgradability.
- Economy of scale.
- Efficiency.

 

## III. RURAL ELECTRIFICATION AND TECHNOLOGIES USED

Rural Electrification is the process of bringing electrical power to rural or the remote areas where the supply of the electricity from the grid is difficult to provide. Electricity is not only used for lighting and household purposes, but it also allows for mechanization of many farming operations and in many agricultural uses. In areas where there is a labor shortages, this allows for greater productivity at reduced cost and with independent supply.

### *A. Rural Electrification – Indian Perspective*

A vital programme for socio-economic development of rural areas. To ensure rapid economic development by providing electricity as an input for productive uses in agriculture, rural industries, etc. To improve the quality of life of the rural people by supplying electricity for lighting of rural homes, agriculture purpose, shops, and community centers, public places etc.

### *B. Selection of Technology*

This describes the most common alternatives in electricity generation attending to the primary source, particular characteristics of load profiles in rural areas and the grid topologies that suit to renewable rural micro-grids. Finally, evidences of the maturity level of the presented technologies are given. the below study shows the Primary energy sources and characteristics Electricity generation consists in transforming energy from nature into electrical energy.

| Primary Sources | Technology Used | AC/DC |
|---|---|---|
| Sun | Photovoltaic | DC |
| Oil<br>Gas<br>Coal<br>Biomass | Combustion | AC |
| Water | Hydraulics | AC |
| Wind | Wind farms/Mills | AC |
| Heat From Earth Crust | Geothermal | AC |
| Tides | Tidal energy | AC |

Table 2: Depicts the most common technologies available at the moment: their primary energy source, their renewability.

Unfortunately, renewable energies are, in most cases are the intermittent sources (solar irradiation, wind speed, waves, etc.) which is their main disadvantage. For that reason renewable energies are generally highly dependent on energy storage systems or backed by continuous generation technologies.

### *C. Technology choices for DG*

- Small / Mini Hydro
- Diesels generating sets powered by bio-fuels, (non-edible vegetable oils such as Jatropha, Pongamia, etc)
- Biogas
- Solar Photo Voltaic
- Wind / diesel / hybrid / new technology etc.

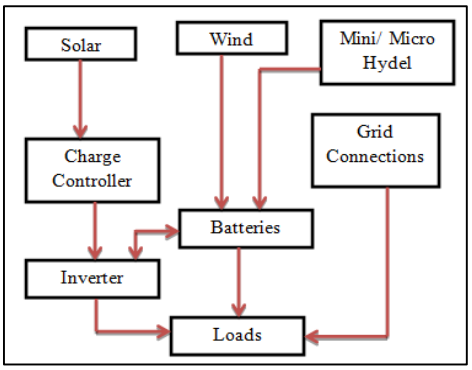


Fig. 4: Model of Proposed distributed generation system

### *D. Main Resources and Controllers*

#### *1) Solar Energy*

This is a one form of the energy available from sun which can be obtained from sun and converted into electrical energy. Solar panels are used to collect the solar energy from sun cited energy is converted into electrical energy by suitable arrangement.

#### *2) Wind Energy*

This is also one form of energy which is available in the form of wind and can be converted into electrical energy by wind energy conversion system .In the conversion of wind energy to electrical energy we use wind turbine and generator .generators are used to convert mechanical energy to electrical energy.

#### *3) Mini Hydro*

Mini hydro is the development of hydroelectric power on a scale serving a small community or rural areas .Its generating capacity of 1-20 MW which is aligns the concept of distributed generation.

#### *4) Charge Controller*

A charge controller also named as charge regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents over charging and may protect against over voltage, which can reduce battery performance or lifespan and may pose a safety risk.

#### *5) Nano Aurdino Kit*

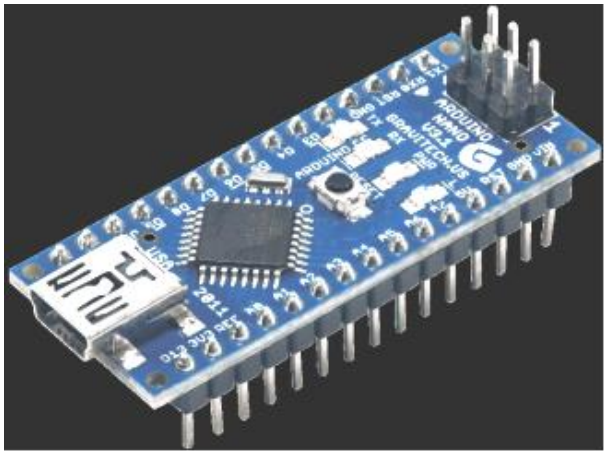

Fig. 5: Nano Arduino Kit

Aurdino is a software device which is user community that designs and manufactures computer open source hardware, open-source software, and microcontroller based kits for building digital devices and interactive objects that can sense and control physical devices. Here in this paper design of charge controller is based upon the Arduino programming interface and control.

## IV. WORKING PRINCIPLE OF DISTRIBUTED GENERATION

The electric power generated by each main resource that is solar, wind, mini-hydal are integrated and are fed to the charge controller. The charge controller limits the rate at which the electric current is added or drawn from electric batteries. It also helps to prevent overcharging and may protect against over voltage, which can reduce battery performance or life span. The power from charge controller is stored in batteries. Commonly rechargeable battery lead-acid batteries are used. Now the battery is connected to the inverter where it converts direct current to alternating current and it is discharged to the loads. Whenever there are insufficient resources or there are any unfavorable conditions of Decentralized generation, the village can be electrified by taking tapings from the grid connected transmission lines which are passing through that village. The three phase AC power from grid are fed to the changeover switch which also shows the electrical parameters such as voltage, current, power factor. Once selected a population or a rural area to electrify, a consumption assessment must be done in terms of peak power and amount of energy needed in a yearly basis. In parallel, an assessment of local renewable energy resources must be done for the selected area in terms of PV, wind, biomass and micro-hydro. Depending on the interests of users, the energy control and storage strategy has to be defined.

### *A. Benefits*

- Cost saving and increased productivity
- Industrial and commercial uses of electricity
- Household uses of electricity: Lighting, cooking
- Agricultural uses of electricity: Water pumping
- Quality of life, community services and participation
- Income distribution and social equity
- Employment creations

### *B. Government Initiatives for Rural Electrification*

The village electrification program mandates that rural households receive electricity not only for domestic lighting, but also for productive applications such as water pumping for irrigation, community applications, and health care. Accordingly, MNRE proposes to deploy decentralized electricity generation technologies including biomass gasification, small hydro, and wind and SPV power plants

- Rural electrification under Minimum Needs Program (MNP, 5th five year plan)
- Pradhan Mantri Gramodayan Yojana (PMGY, 2000 - 2001)
- Kutir Jyoti Scheme (KJC, 1988 - 1989)
- Accelerated Rural Electrification Program (AREP, 2003 - 2004)
- Accelerated Electrification of one hundred villages and 10 million households (2004 – 2005)
- Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY, April 2005)

## V. CONCLUSION

Distributed generation for rural electrification is one of the best methods to improve agricultural productivity, industrial and commercial use of electricity for many rural activities. It works best when it is complemented by social and economic infrastructure development. By having continuous assessment in cost reduction and also in research and development it can become the most potential energy source. DG helps the customers to sell excess generation back onto the grid with more pricing than that of normal tariff. Renewable energy is more efficient and self- reliant. The distributed generation process for rural electrification reduces the Transmission &Distribution losses and also helps in sustainable development by providing continuous electricity in rural areas. Distributed generation systems can also be implemented in urban areas if sufficient funds are provided by the authority apart from implementing in rural areas, distributed generation projects, if widely spread can reduce the burden on both electricity supply shortfalls and reduce the urgency of costly grid extension. Renewable will have a vital role to play in satisfying the rural electrification targets in the country if we see future energy options.

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