



Rural Electrification in India using Distributed Generation: Current Scenario, Government Initiatives, Regulatory & Technical Issues

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Abstract: This paper adopts a systematic approach to present the Government of India initiatives so far regarding rural electrification. It is proposed that a two pronged strategy of Grid extension and Distributed Generation (DG) should be adopted to meet the energy demands of India as a country if India targets to grow at annual rate of 8 % of its GDP. It also highlights the key issues regarding integration of DG in existing power system. It also infers that depending upon effective regulatory pricing & control; DG system can help to reduce transmission and distribution system losses.

Keywords: Distributed generation, electricity act 2003, reactive power valuation, rural electrification

I. Introduction

The earliest electrical power systems were Distributed generation (DG) systems designed to cater to the needs of small local areas. With the development of technology driven by economies of scale, the focus shifted to centralized generation by providing electricity to remote areas through grid extension. During the last decade, there has been a paradigm shift regarding centralized generation and DG has again emerged as a possible solution to tackle the ongoing energy crisis all of us are facing.

Rural electricity supply in India is suffering both in terms of availability for measured number of hours & penetration level. Out of the 27 Indian States, more than 24 States have more than 25% of their rural households yet to have an access to electricity [1]. A major bottleneck in the development of the power sector is the poor financial state of the State electricity boards (SEBs), which can be attributed to the lack of adequate revenues, state subsidies for supply to the rural subscribers & high T&D losses to the tune of over 25 %. Due to high T&D losses and low collection efficiency state utilities have very little incentive to provide electricity to rural areas, which in turn further add to already poor financial status of utilities giving rise to a 'vicious cycle'. This paper presents Government initiatives to supply electricity to rural areas through various schemes based on grid extension approach in Section II & Section III. It is further inferred that the policies of building large centralized generation and extended distribution networks are unlikely to solve the problems of rural electricity supply in the near future. DG close to the rural load centers using renewable sources appears to have the potential to address at least some of the problems of rural electrification. In Section IV it is discussed that to meet the projected electricity demand in India, DG seems to be a possible solution. Section V presents a rather general discussion of Distributed generation along with various technologies available for DG systems. Section VI and Section VII focuses on the major regulatory & technical issues raised in various literature available on DG along with some counter arguments to highlight the potential benefits of DG system.

II. Government Policies Regarding Rural Electrification

Rural electrification has been a key focus point of the policy makers for several decades. Sustained economic & social Development of India as a nation depends largely on the expansion of rural electrification & availability of reliable power supply to the rural community. Over the past four decades, Government of India has launched number of schemes for the purpose of rural electrification time to time. These include [1]:

- Minimum Needs Programme (MNP)
- Pradhan Mantri Gramodaya Yojna (PMGY)
- Kutir Jyoti yojna
- Accelerated Electrification of One lakh villages and one crore households

Due to the shortcomings in method of implementation, these schemes had a limited impact on the rural electrification scenario in the country. The primary reasons for their failures were [1]:

- The responsibility of implementing these schemes for village electrification was given to State Electricity Boards which were in bad financial health and hence were unable to provide sufficient funds.
- A substantial infrastructure became useless because state utilities which were given the responsibility of maintenance of rural electricity infrastructure did not have the necessary manpower in remote rural locations.

III. Recent efforts by the Government in providing Rural Electrification

Government of India amid growing global & domestic concerns about increasing divide between urban & rural electrification, enacted Electricity act 2003, which for the first time mentioned rural electrification in law [2]. Section 6 of the act mandates the hitherto implied Universal service Obligation by stating that the appropriate government shall endeavour to supply electricity to all areas including village & hamlets. Section 5 the act further mandates the formulation of national policy on electrification and local distribution in rural areas. It is proposed that local distribution in rural areas could be done through panchayat institutions, cooperative societies, non-governmental organisations or franchisees. Giving further boost to rural electrification Section 14 of the act exempts a person from licence requirement if the generation and distribution of power is restricted only for rural areas.

Subsequently, Government of India had released a draft paper on National rural electrification policy with following broad goals [3]:

- Accessibility-electricity to all households by 2012
- Availability-adequate supply to meet demand by 2012
- Reliability-ensure 24 hr supply by 2012
- Quality-100 % quality supply by 2012
- Affordability-pricing based on consumer ability to pay

In continuation with the reforms in power sector with special focus on Energy for All by 2012, Ministry of power launched Rajiv Gandhi Gramin Vidyutikaran Yojna (RGGVY) in March 2005 with the objective of electrifying over one lakh villages and to provide free electricity connections to 2.34 crore Below Poverty Line (BPL) households [4]. Under phase-I of RGGVY ministry of power has sanctioned 576 projects for 546 districts to electrify 1,10,886 villages and to provide free electricity connections to 2.29 crore BPL rural households [4]. As on 31st Dec 2012, works in 1,06,335 villages have been completed and 204.47 lakh free electricity connections have been released to BPL households [4].

IV. Need for Distributed Generation

Despite several policy initiatives by the Government of India as outline above, including special focus on extending the national grid through RGGVY, 56% of rural households still do not have access to electricity [5]. As shown in table 1, currently India has grid connected total installed capacity of 212 GW for electricity generation [4] and it is

estimated that to rise at an average annual growth rate of 8 %, its installed electricity generation would reach up to 779 GW within two decades [6]. To meet this huge expected demand of energy, merely centralized generation & extension of grid will not be economically and technically viable option.

Distributed power generation, based on locally available energy resources and supply of this additional electricity into the rural electricity grid, can be an important part of the solution to supply reliable electricity supply to rural population [5]. In recent years, Electricity market liberalisation and increased environmental concerns has also driven DG to become a clean and efficient alternative to the traditional electric energy sources [7]. So with an eye on sustained GDP growth of 8 % and to achieve the targets of electricity generation in coming years as shown in table 1, Distributed generation seems a possible solution [6].

Table 1: Projected Electricity demand [6]

Year	Installed Capacity (GW) (For 8% GDP growth)
2011-12	220
2016-17	306
2021-22	425
2026-27	575
2031-32	779

V. Distributed Generation in India & Government Initiatives

DG is a new approach in the electricity industry and there is no generally accepted definition of distributed generation yet. As per Ackerman, Distributed generation is an electric power source connected directly to the distribution network or on the customer site of the meter [7]. DG can be from conventional or renewable sources such as biomass, bio-fuels, biogas, mini hydro, solar etc. for villages as shown in Table II. Conventional fuel based DG can be a viable option for energy production but setting up DG facility based on renewable energy can drastically reduce infrastructure investment and hence can lead to subsidizing renewable energy production [8]. The definition of distributed generation does not define the rating of the generation source, as the maximum rating depends on the local distribution network conditions, e.g. voltage level. It is, however, useful to introduce categories of different ratings of distributed generation. The following categories are suggested [7]:

Micro distributed generation: 1 Watt < 5 kW;

Small distributed generation: 5 kW < 5 MW;

Medium distributed generation: 5 MW < 50 MW;

Large distributed generation: 50 MW < 300 MW

These small scale projects generate electricity near the demand centres and thus avoid transmission losses & charges. Table 2 represents the various DG options in India [9].

Table 2: Summary of DG options in India [9]

DG Option	Type	Technology status	Capacity factor
Diesel	NR	C, I	N
Gas engine	NR	C	N
Micro turbine fuelled by natural gas	NR	D	N
Fuel cell fuelled by natural gas	NR	D	N
Wind turbines	R	C, I	13% Avg Max 30-38%
PV	R	C, I	Max 25%
Biomass gasifier	R	C	N
Gas Engine	R	Gasifier-I	-
Biomass Cogen.	R	C, I	50% Higher if aux. Fuel used

NR-Non Renewable; I-Indigenous, Renewable; D-Demonstration; C-Commercially available technology; N-Not constrained by the supply.

The Electricity Act 2003 has given impetus to rural electrification using DG by specifying distributed generation and supply through stand-alone conventional and renewable energy system as a mode for rural electrification in addition to Grid Extension. A key feature of the Electricity act 2003 is that it empowers the State electricity regulatory commission's (SERCs) to specify the terms and conditions for the determination of tariffs, and in doing so, they should be guided by *"the promotion of co-generation and generation of electricity from renewable sources of energy;"* (EA 2003, Section 61 (h)) and should *"promote co-generation and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licence;"* (EA 2003, Section 86 (1) (e)) [10].

The Rajiv Gandhi Gramin Vidyutikaran Yojna (RGGVY) has a financial outlay of 540 crores for implementation of DG projects in the places where grid connectivity is either not feasible or not cost effective [4]. Also, in compliance with sections 4 and 5 of the Electricity Act 2003, the Rural electrification policy in section 3.3 identifies decentralized distributed generation of electricity and proposes setting up of facilities together with local distribution network based on either conventional or non-conventional resources methods of generation. The National Electricity Policy notified on 12 February 2005 mentions under the Rural Electrification component, section 5.1.2 (a) that to provide a reliable rural electrification system, a Rural Electrification Distribution Backbone be established by extending the transmission lines. However, when the extension is not feasible, as in section 5.1.2 (d) of NEP, it directs that decentralized distributed generation facilities (using conventional or non-conventional sources of energy) together with local distribution network be provided [8]. The DG projects would be owned by State Government. Implementing agencies of the projects shall be either the State Renewable Energy Development Agencies (SREDAs) / departments promoting renewable energy or State Utilities or the identified CPSUs. The State Governments will decide the implementing agency for their respective states.

VI. Regulatory Issues in Implementing Distributed Generation

1) *Competition regarding power pricing:* The per unit cost of power generated from DG system is higher than that generated from the grid [12]. The cost of generation of grid power from the coal fired power plants is in the range of Rs. 2.5 per KWh to maximum of Rs. 5 per KWh [13] which is comparatively cheaper. This limitation of high initial

cost of DG systems is partially offset because DG saves on huge transmission infrastructure as generation set up & consumers are situated in close vicinity. Also, DG system are usually community owned which ensures sustainable use of energy and promotes efficiency and energy conservation practices which are generally absent in centralized set up with no people's ownership or partnership.

2) *DG's competition with large power producers*: The efficient integration of DG in the electricity market depends upon market structure, market operation and pricing [11]. Post liberalization of electricity markets, DG system has been provided the opportunity to sell power to a wide range of customers in open market. On the other side, already there is a presence of bulk power producers who have a large share of total production and thus larger market share. So the effective regulatory measures have to be put into place to make DG system economically viable.

Connection of DG system in the distribution network wherein DG system is eligible to export power to the grid, requires the distribution system to be upgraded because traditionally distribution systems are designed to deliver power from transmission system to the end user customer [12]. Now if the cost incurred in the up gradation of the local grid is to be paid by DG owner, the competitiveness of DG compared to large power producers will be affected. To cope with these problems effective policies should be designed.

VII. Technical Issues in Implementing Distributed Generation

1) *Voltage profile*: The relation between DG and power quality is an ambiguous one [14]. On the one hand many authors stress the potential positive effects of DG for voltage support & power factor corrections [14] others stress the negative implications of DG whose presence characterized by rise in the voltage level of radial distribution network. This rise in voltage help in maintaining a nearly flat voltage profile in distribution system under heavy load conditions but causes a major concern when the grid is operating under lightly loaded conditions.

Driesen et al. in their study on 14 MVA, 70/10 kV and four cable feeders found that the difference between the voltage dip in base case without DG compared to the system with DG was only 1% [14]. So it was concluded that connecting DG in the distribution system does not affect dynamic voltage stability significantly [14]. It was also concluded that DG strongly support the voltage at near by nodes and had less impact on distant ones [14].

2) *Reactive power valuation*: Most rural buses are characterized by low power factor because of the presence of large number of irrigation pumps which absorbs reactive power from the system and thus leads to dip in voltage and high distribution losses in the feeder [15]. Due to poor financial health of the state utilities, progress of installing capacitor banks or Static voltage compensators (SVCs) for reactive power compensation in the grid is rather slow. In such a scenario, synchronous generator installed DG system can locally supply reactive power and thus avoid the capital cost of capacitors or SVCs. Since generator installed in the DG system is to be operated at lower power factor to supply reactive power to the load, real power generation of the generator is to be reduced according to generator capability curve [15]. But this decrease in real power generation from DG gets more than offset by providing the local reactive power support.

The present buy back tariff policy of utilities does not give any incentive to the DG system owner to supply reactive power. The solution of the optimization problem involving several constraints like specified bus voltages, power transactions between buses and generation limits determines the cost of real & reactive power supplied by DG system [15]. Looking into the Indian scenario, this approach of reactive power pricing will not be applicable because of intermittent nature of supply & lack of readily available data such as the real and reactive power load at each bus. A much simpler method could be to consider triangular relation between active, reactive and apparent power for a particular power factor as per the generator capability curve [15]. So DG system can help the utilities in improving voltage profiles and reduce distribution losses if proper reactive price mechanism could be developed.

VIII. Conclusion

In this paper we examined the efforts of Government of India in providing electricity to rural areas in last four decades which were mainly focussed on extension of grid to remote unelectrified areas. Having recognized the limitations of centralized energy supply systems, it was inferred that DG close to the rural load centers has the potential of addressing the energy crisis that the rural India is facing. The sustenance and growth of an economy will strongly hinge upon the extent of use of DG in the future, with centralized energy systems serving as the backbone. The increasing penetration of DG brings various technical and economical challenges in integrating the distributed generations in to existing power systems, which are critically examined. It is finally concluded that to make DG system viable in open markets electricity market regulatory authorities and government policy makers should modify market structure & reactive power pricing mechanism.

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