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ECONOMIC METHODS FOR RURAL ELECTRIFICATION

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Abstract— **This paper addresses the issue of economical rural electrification. The aim of this report is to propose optimal electrification system design for rural areas, taking in consideration conventional drawbacks in design of the systems due to connectivity of remote villages with main grid considering the scope of future expansion and then to reduce the cost for the same and increase the attractiveness of grid extension as a means of bringing the benefits of electrification to rural populations. The study presents a variety of options for reducing the cost of grid extension, including the various techniques as mentioned. This paper has considered technical aspects for the same as well as optimization of energy for reliable, economical considering various Government Schemes and efficient rural electricity.**

Index Terms—**Rural Electrification, Modification in Electrical Infrastructure, Optimization of energy, Government Schemes.**

I. INTRODUCTION

Electrical energy is an essential component in the developing process of any given location of the globe. Therefore, rural electrification remains an important issue in many countries. More often rural areas, which can also be seen as developing areas, are prone to several electrification problems. The diesel power supplies were previously used in rural areas for supplying power. However, diesel supplies are environmentally not friendly, less reliable and less efficient. Rural electrification will always be a challenging responsibility, due to reasons such as, the dispersal of the villages, the complications with grid extension alternatives relatively high electrification cost, especially for customers with low expected power demand, limitations of diesel power supplies as mentioned in the previous lines demand for electricity in rural areas worldwide has traditionally been met by extending the electricity distribution network out from the cities and towns.

II. IRURAL ELECTRIFICATION– IN VIEW OF ELECTRICITY ACT 2003

For the first time Electricity Act 2003 mentions rural electrification in a law. Section 5 further mandates the formulation of national policy on RE focusing specially on management of local distribution networks through local institutions. Giving a further boost to RE, the act in Section 4 also frees stand-alone generation and distribution networks from licensing requirements. Subsequently, the Government of India has released a draft paper on National Rural Electrification Policy.

Definition of Electrified Village according to the Union Government is –

"A village will be deemed to be electrified if electricity is used in the inhabited locality within the revenue boundary of the village for any purpose whatsoever"

The grid expansion in rural areas becomes very costly and uneconomical as compared to the electrification of the urban areas. The power consumed by these rural areas is also less and so the generated demand is also less and it is uneconomical. There is wastage of power in rural areas and to incur these costs from the residents become difficult. So we have to make appropriate design changes in the overall rural electrification system which would reduce the costs and provide us with better efficiency.

Two factors inflating the cost for grid extension into rural areas are:

A. The sub-optimal use of available materials and designs, such as the use of shorter spans than possible and the poor placement and sizing of transformers.

B. The adoption of designs used to serve urban loads that do not take into consideration the unique design implications of serving rural populations, including the widespread use of three-phase lines and over sizing of transformers and conductors.

III. WAYS OF REDUCING POWER LOSS AND OVERALL COSTS IN THE RURAL ELECTRIFICATION SYSTEM

The study presents a variety of options like:

III.1 Technical Aspect:
Using higher voltage and specific generators.

- Using higher quality poles to reducelife-cycle costs,
- Wider use of single -phase distribution,
- Considering the life-cycle costs of transformers rather than simply the initial capital cost. Properly sizing and placing transformers,
- Considering alternative pole designs,
- Using small transformers to serve small load centers adjacent to MV lines.

III.2 Adopting Renewable Energy Resources

- Solar Energy
- Wind Energy

III.3 Optimization of Resources

- Distributed Generation
- Demand Side Management
- Demand Response
- Smart Metering.

IV. TECHNICAL ASPECTS

IV.1 LINE DESIGN

It is necessary to reduce the cost of MV lines, and to ensure that the poles, conductor, and line hardware incorporated in existing designs are used optimally and that the lines are efficiently designed and constructed. Spans should be maximized to take advantage of the strength of conductors while ensuring a generally acceptable degree of safety. Conductors should not be oversized. Instead of ACSR Conductors, we can use AAC Conductors. Pole lengths should not exceed those necessary to meet ground clearance requirements and should be established using realistic safety factors. Finally, designs should be standardized to minimize the use of specialized engineering expertise, which adds to the time and cost of line design.

IV.2 POLES

The poles are often the costliest single component required for grid extension. And are the obvious areas in which to focus in attempting to reduce cost. Several options are possible for pole cost, including the use of:

- Underground cabling to eliminate the needs for poles altogether,
- Shorter poles to reduce cost of materials,
- Longer spans to reduce the number of poles,
- and Alternative pole designs.

IV.3 LONGER SPAN

In addition to using shorter poles for a given span to reduce cost, the cost of poles can be further decreased by reducing their number per kilometer of line through the use of longer spans. To maintain adequate line-to-ground clearance, longer poles would be required because longer spans imply larger sag if conductor strength is not to be exceeded. So although fewer poles would be needed per kilometer, each pole would be costlier because of both its increased length and diameter. (Refer fig.1) Using shorter spans results in less sag, and shorter poles can be used to maintain the minimum ground clearance requirements. Shorter poles are less costly, but their increased number per kilometer results in a net increase in cost.

IV.4 DISTRIBUTION TRANSFORMER

The cost of distribution transformers is a small part of the construction cost of most lines serving rural areas. In this case, the capital cost of each transformer is usually borne by the much smaller number of consumers it serves. Moreover, given that transformers consume power 24 hours per day independent of imposed load, recurring costs incurred in operating transformers can even be more significant. Therefore, in considering the cost of transformers, their life-cycle cost—in this case, the sum of both their initial capital cost and their operating cost—must be considered. Only after these components are understood can approaches to reducing cost be better designed. Instead of one large rating transformer, we can go for two small rating transformers, so that one of the transformers as per load can operate at higher efficiencies. Also depending upon the load area, we can have single phase transformers also. Considering future power system design, we can go for GIS Transformers or Superconducting Transformers whose efficiency is 99%.

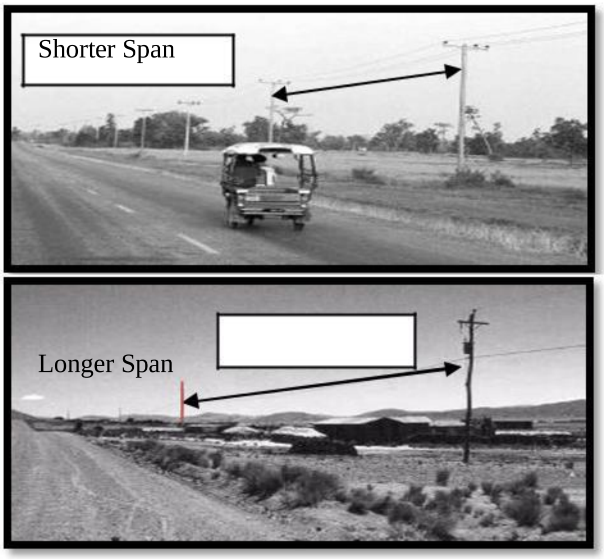

Fig 1: Lines in Bolivia have significantly longer span than in Laos with a similar type of terrain as shown in the figure.

IV.5. SINGLE PHASING

If a single-phase line is constructed, and if an eventual increase in load beyond the capacity of that line is envisioned, adding another length or two of conductor to the existing line at some later time would increase its capacity. A single length of conductor can be added to a single –phase (phase-phase) line designed after the European configuration to convert it from single - to three-phase. There are still at least two advantages to adopting this approach:

Accurately predicting future load is frequently a difficult task that is subject to a variety of factors and it is best to delay a commitment to three-phase distribution until it is clearly needed.

Any delay in covering the cost of increasing line capacity reduces the life-cycle cost of the investment by decreasing its present value. The neutral conductor replaced by a return current loop entirely through the ground would reduce the cost. In this case, only a single conductor is used and, by using high-tensile-strength steel conductor, spans of considerable length are possible.

Three-phase distribution can result in increased motor costs. Although main three-phase feeders may be adequately built and maintained, experience in a number of countries has shown that this is often not the case with LV circuits. Subsequent occurrences of temporary fault conditions cause the opening of commonly used single -phase protection devices along three-phase lines. This results in single-phasing and eventual burning out of three-phase motors. So for small-motor customers, selecting single-phase over three-phase motors, even if a three-phase supply is available, may result in life-cycle financial benefits even if the initial cost per motor is higher.

V. ADOPTING RENEWABLE SOURCES

V.1 SOLAR ENERGY

These renewable energy products include Solar and Wind energy generated and utilizing equipments. Solar energy which is freely available could be used for lighting the Solar Lamps, Solar Home Lighting Systems, Solar Street Lights, Solar Fans, Solar Dryers, etc. A subsidy of about 70% can be received in Solar Energy Sector for rural areas.

Fig: Solar Home Lighting Systems

Fig: Solar Street Lighting Systems.

V.2 WIND ENERGY

A Wind turbine of about 1KW or upto 3KW can be installed in rural areas by taking the help from Government Subsidies.

Fig: Wind turbine for rural areas.

VI. OPTIMIZATION OF RESOURCES AND ENERGY CONSERVATION TECHNIQUES FOR POWER SYSTEM

VI.1 DISTRIBUTED GENERATION (DG)

Distributed power generation is a small scale power generation technology that provides electric power at a site closer to customers than the central generating stations. The buses which are having less voltage profile are chosen for the location of distributed generation. Its aim is to provide electricity to the consumer at a reduced cost and more efficiently with reduced losses than traditional plants. Another benefit offered by installation of (DG) is reduction in line losses due to reduction of current flowing in the main line.

VI.2 DEMAND SIDE MANAGEMENT (DSM)

DSM is implementation of those measures that help the customers to use the electricity more efficiently and in doing so reduce the utility cost for the customers. Some of the steps that utilities in India have taken to implement an effective program in end use energy efficiency and DSM are as follows:

1) Installation of Energy Efficient Bulbs like CFL.
2) Installation of Shunt Capacitors in all DTs.
3) TOD Metering and different Tariff for peak and off peak hours (for Indl. Consumers).
4) Strengthening of Sub-Transmission and Sub-Distribution network.
5) Energy Audit and Awareness in Energy Conservation.

VI.3 DEMAND RESPONSE

Demand Response is defined as “Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in price of electricity over time or to incentive payments designed to induce lower electricity use at times of high wholesale prices. In Maharashtra on similar basis MSEDCL, Tata Power have introduced in distribution sector, offerings like CFL, LED bulbs, etc. to residential consumers for paying bills on time.

VI.4 SMART METERING

Revenue collection is one of the key challenges perceived by the business community seeking to address the rural electrification market through micro-grids. Tampering of meters is a common phenomenon in rural India and significant research has gone into identifying some solutions on this front. Smart meters are electronic boxes having the capability of 2-way wireless communication with a database which tracks the energy usage of each customer connected to the micro-grid. The meters can either be pre-paid or post-paid depending on the community's willingness to pay the appropriate tariff set to offset the business set-up and operational costs. These meters help in streamlining revenue collection, enhancement of service and operational efficiencies and minimization of power loss and theft.

VII. ROLE OF GOVERNMENT ORGANIZATIONS

Some of Rural Electrification Schemes run by GOI are discussed below:

VII.1 RAJIV GANDHI GRAMIN VIDHYUTIKARAN YOJANA

The RGGVY is the latest national RE scheme launched by the Ministry of Power to execute the vision for rural electrification. The plan was instated in April of 2005 with the following objectives:

• 100% electrification of all villages and habitations in the country
• Electricity access to all households.

For achieving the said objectives, the RGGVY envisions creating a:

• Rural Electricity Distribution Backbone (REDB) with at least one 33/11 KV (or 66/11 KV) substation in each block.
• Village Electrification Infrastructure (VEI) with at least one distribution transformer in each village/habitation.
• Decentralized Distributed Generation (DDG) systems where the grid is not cost-effective or feasible.

VII.2 NATIONAL SOLAR MISSION

The objective of the Nationl Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible. The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. The first phase (up to 2013) will focus on capturing of the low hanging options in solar thermal; on promoting off-grid systems to serve populations without access to commercial energy and modest capacity addition in grid-based systems. In the second phase, after taking into

account the experience of the initial years, capacity will be aggressively ramped up to create conditions for up scaled and competitive solar energy penetration in the country.

VII.3 DEENDAYAL UPADHYAYA GRAM JYOTI YOJANA

Government of India has launched the scheme "Deendayal Upadhyaya Gram Jyoti Yojana" for rural electrification.

The DDUGJY scheme was launched in July 2015 with the aim of electrifying 18,452 villages by May 1, 2018 – within 1,000 days. The plan for electrification is that the implementation mode will be 12 months and the process will be divided into 12 stages, with timelines for each stage. According to reports, 5,279 villages have been electrified so far. Of the remaining 13,173 villages, 9,228 are to be electrified through grid and 3,398 off-grid, while 547 villages are to be electrified by state governments.

A total of 253 villages across the country were electrified under the Deen Dayal Upadhyaya Gram Jyoti Yojna (DDUGJY), between February 8, 2016 and February 14, 2016. Of these villages, 111 are in Odisha, 81 in Assam, 40 in Jharkhand, 13 in Rajasthan, 4 in Bihar, 3 in Madhya Pradesh, and 1 in Uttar Pradesh.

VII.4 UJWAL DISCOM ASSURANCE YOJANA (UDAY)

SCHEME

The Distribution Utilities of the country are reeling under heavy debt burden. As on 30th September, 2015, the outstanding debt of the DISCOMs stood at Rs.4.3 lakh crore. In order to bring relief to these Utilities from the burden of debt, and to improve their overall performance, Government of India launched the Scheme UDAY on 20th November, 2015, after a series of discussions with all the stakeholders, namely the State Governments, DISCOMs, lenders etc. UDAY is an aim to ensure a permanent solution to the debt-ridden Distribution utilities to achieve financial stability and to improve their operational efficiencies, for sustained growth. Rajasthan, Uttar Pradesh, Chhattisgarh and Jharkhand have already signed the MoU under UDAY for operational and financial turnaround of DISCOMs. With the signing of MoU with Bihar, approximately 33% of the DISCOM debt, ie. around Rs.1.40 lakh crore, would be restructured. Gujarat has also signed the MoU for operational turnaround, considering the healthy financial position of the DISCOMs of the State.

. The reduction in AT&C losses and transmission losses to 15% and 4% respectively is likely to bring additional revenue of around Rs.6650 cr. during the period of turnaround.

While efforts will be made by the State Government and the DISCOMs to improve the operational efficiency of the DISCOMs, and thereby reduce the cost of supply of power, the Central government would also provide incentives to the DISCOMs and the State Government for improving Power infrastructure in the State and for further lowering the cost of power. Higher demand for power from DISCOMs would mean higher PLF of Generating units and therefore, lesser cost per unit of electricity thereby benefitting consumers. The

DISCOMs would also increase power supply in areas with reduced AT&C losses. The scheme would allow speedy availability of power to around 1152 villages. UDAY is an effort to make the DISCOMs financially independent and operationally healthy, to be able to supply adequate power at affordable rates, through 100% Village electrification and 24X7 Power For All. Mr. Piyush Goyal, our Power Minister has said, "Because of UDAY Scheme, every DISCOM would make profit by 2019".

VII.5 DOMESTIC EFFICIENT LIGHTING PROGRAM

The initiative is part of the Government's efforts to spread the message of energy efficiency in the country. LED bulbs have a very long life, almost 50 times more than ordinary bulbs, and 8-10 times that of CFLs, and therefore provide both energy and cost savings in the medium term. LED bulbs have be distributed in a phased manner from March 2015 onwards. The entire project of installing LED bulbs for domestic and street-lighting in 100 cities is targeted for completion by March 2016. For encouraging the citizens, 7 Watt LED bulb is provided at Rs. 100/= as compared to the market MRP of Rs. 400/= for the same which is manufactured by Energy Efficieny Services Limited (EESL). This facility would also be suitable for rural electrification as the rural power demand would still be lowered thereby enabling simpler generation-distribution techniques. Uptil now Govt. has sold 700,96,975 LED bulbs, thereby saving 2,47,72,271 KWH ie. Avoiding 2088MW of peak demand as on 1st March, 2016.

VIII. GOALS FOR UTILITY

VIII.1 Phase 1: It will focus on challenges which will need urgent attention and if reduced will give vital benefits. Utilities will go for technologies which can be implemented in short time like one or two years. Eg. Metering at each level.

VIII.2 Phase 2: It will be achievable in the medium term. It will be designed to bring operational efficiency and customer service excellence. The system should be designed such as it will be compatible and scalable to accommodate future needs and technology. We know that SCADA deals at HT automation and LT deals at Substation level automation. At this level, utility should be able to monitor and control all feeders, receiving station remotely.

To start with, small pilot project can be implemented. At this stage, process will begin towards implementation of Smart Grid.

VIII.3 Phase 3: It will focus on the projects which will take comparatively longer time and higher investments like Smart Grid, Mini/Micro grids or Distributed Generation or Energy Storage devices, etc. But after implementation, Utility will be

able to monitor and control every KWH flowing through the grid.

IX. CONCLUSION

The electrification of rural areas require a boost which has to be completed within 2020. The Government has set a target of 7,000 village electrification by the end of March, 2016. The Government today as per the budget on 29/02/2016 has promised 100% village electrification by 1st MAY, 2018. The whole of India should be free from the hassle of the power cuts, load-sheddings, etc. As the urban load shedding can be fulfilled by diverting the power from rural areas to the urban which was done till today should be eradicated. We can adopt simple Solar-Wind Hybrid systems for rural areas, as per the load demand on Public-Private partnership. By Distributed Generation or by Captive Power Plants, the local demand can be met. With the help of interconnected grid system associated with the national grid, new power lines should be made using efficient methods for rural electrification. Optimization would play an important role in reducing the cost of unit generated. Exhibitions, lectures should be held in the rural areas for the people to develop the habit of energy conservation and by using renewable systems. The Central schemes such as DDUGJY, IPDS, Power Sector Development Fund or such other schemes of MOP and MNRE are already providing funds for improving Power Infrastructure in the State. Having good incentive based tariff structure for renewable sources associated with subsidies, this problem can be solved.

REFERENCES

[1] Sandeep S. Gaikwad, "Optimization of Distributed Generation Capacity for Line Loss Reduction and Voltage Profile Improvement Using N-R Method and PSO" in Future Power Systems for Green and Clean World, 2011.

[2] Nisha V. Vader and M.M.Dixit, "Latest techniques in Energy Conservation for Power System" in Future Power Systems for Green and Clean World, 2011.

[3] Sushil V. Pawaskar, "Transformers for future power systems" in Future Power Systems for Green and Clean World, 2011.

[4] A.R.Sihag, Neha Mishra and Vivek Sharma, TERI, India

"Impact of Power Sector Reform on Poor" – a case study of South and South East Asia.

[5] Vijay Modi "Improving Electricity Services in Rural India"

Centre on Globalization and sustainable development, The Earth Institute at Columbia University.

[6] Transfer of MSEB's rural electrification scheme & rural electricity distribution to panchayats. (unknown author)

[7] http://www.mnre.com for idea on National Solar Mission.

[8] http://powermin.nic.in/Rural-Electrification for information on Government Schemes for rural electrification.

[9] http://www.sustainabilityoutlook.in/content/smart-micro-grids-rural-electrification.