

Application Report

**Strategies for Sustainable Rural
Electrification in Indian Context**

India has varied geo-physical, agro-climatic and socio-economic conditions in the various regions, about 0.586 million villages spread over country offer various economic opportunities for judicious exploitation of local resources. Such optimal use of resources holds the key to sustainable development. Among the various factors for growth and development, energy is the crucial input for sustainable development of the rural areas. This paper brings out the various aspects of rural electrification, its importance, and problems. Different technical avenues and feasible strategies help the policy makers to take corrective actions for effective use of electrical energy.

Keywords: Environmental/Economic dispatch, DC-flow model, multi-objective optimization, evolutionary algorithms, neural networks.

1. INTRODUCTION

India is a country with numerically dominant rural population, where in it do about 600 thousand villages inhabit 72.2% of its human resource. About 40 % of the total energy is in rural areas, in which domestic sector constitutes major energy demand and its consumption accounts for 55-60 % of energy used. [1]. Following are some of the important aspects having direct and indirect bearings on energy supply, to rural –

- Both the traditional energy and commercial energy are in short supply and the demand supply gap is in increase.
- Pressure on traditional energy resources such as wood is continuously increasing due to growing population. Urbanization and the resulting deforestation are causing ecological problems.
- Heavy dependence on commercial fuels such as coal and oil as a short term measure for meeting increasing demand is alarming in view of depleting fossil fuels and leads to environmental pollution.
- Energy supply to far-off rural areas is associated with high transportation and transmission losses of about 22.4%.
- Increasing import of oil to meet the demand is mounting burden on foreign reserve of the country.

Thus emphasis should be laid on the auditing of the energy in such a way that ensures affordable, environment friendly and clean energy.

1.1 Impact of rural electrification

Recent studies of Rural Electrification (RE) indicate the following broad consensus concerning the impact of electrification on the rural areas of the India [2]:

- i. RE promotes agricultural development best when certain complementary inputs, such as electric pumps, financial services, etc are also available. However, subsidized power prices may conceal the reality that the economic cost of electric pumping often exceeds the cost of the alternative, especially in a period of falling oil prices.
- ii. RE appears to stimulate agro-industrial and commercial activity, will also exhibit rapid demand growth. There has been a systematic tendency to overestimate productivity gains in the industrial and commercial sectors during the economic appraisal of RE schemes.
- iii. Load growth and beneficial impacts are often hampered by not recognizing the dynamic nature of RE. Poor planning, inadequate maintenance and follow-up, overloading of systems and poor supply quality are some of the undesirable aspects.
- iv. Domestic consumers perceive a significant improvement in their living conditions, mainly due to the improved quality of lighting, for which they are willing to pay far more than their prior expenditures on kerosene might suggest. Access to entertainment via TV, tape and radio is also a contributory factor. However, electricity rarely replaces other fuels for cooking or heating, because of expense or convention.
- v. There is a marked tendency for the benefits of RE to accrue mainly to the better off and influential persons (wealthy landowners, politicians and local officials), unless the program is well designed and the, poorer beneficiaries carefully targeted. Thus, RE is generally not a good method for achieving income redistribution or social-equity oriented objectives. Furthermore care must be exercised to ensure that perverse effects do not occur, such as electricity revenues obtained from the urban poor being utilized to subsidize the rural rich.
- vi. Reading skills, literacy levels and educations are positively correlated with electrified households. Thus, more ambitious and motivated families may be the ones who would acquire an electricity connection first.
- vii. Farmers and households report greater security and order due to electric lighting, in relation to crime and theft, as well as protection from dangerous animals such as snakes etc.
- viii. There is little or no evidence for many other assumed benefits, like increased employment opportunities, reduced rural to urban migration, lower birth rates etc.

2. FEATURES OF RURAL ELECTRIFICATION

Rural electrification is an important component of Integrated Rural Development. It has been given not so importance because, villages have few, small, decentralized loads, away from the near by grid, contributing to additional costs of transmission and distribution. Rural electricity distribution is costly due to dispersed distribution of loads in spread over areas. Domestic consumers inhabit remote rural locations with very little prospect for industrial and commercial growth causing negligence on the part of supply boards.

Majority of rural people have less per capita income and farmers cannot afford for energy derived from renewable energy sources, requiring higher capital investment during summer, their dependency increases on electrical supply. Rural domestic consumers are mainly peak time consumers and do not contribute to the improvement of the poor load factors (average demand/max. demand), which is about 0.2 to 0.3 [1]. Village electrification in neighboring countries is shown in fig 1.

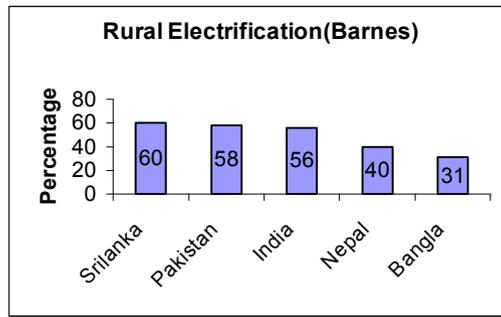


Fig. 1: Village electrification in neighboring countries

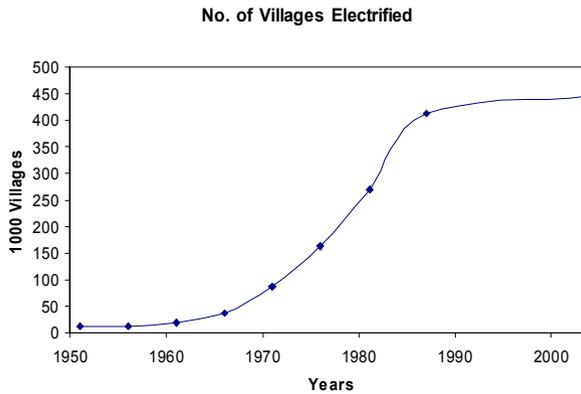


Fig 2: Electrification of villages in India [4]

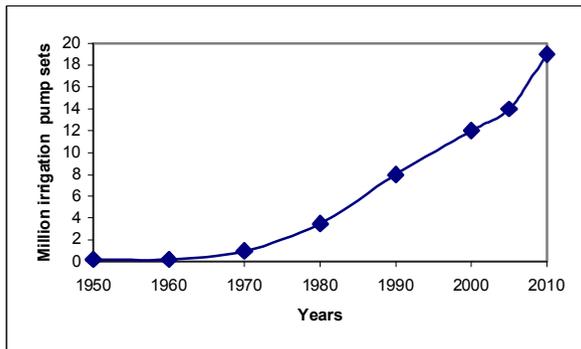


Fig 3: Irrigation of pump sets in India [4]

In view of all these points, Electrical power sector was recognized as a social sector in 1980s. The Five Year Plans of government of India, World Bank, International Monetary Fund, and other agencies have identified this socially relevant sector and initiated several steps like Electricity Act 2003, Public-Private-People partnerships, Electricity Regulatory Commission etc.

3. STEPS INITIATED BY GOVERNMENT OF INDIA

From the time of independence, Government of India and State Electricity Boards have given priority for rural electrification and the phenomenal growth is evident from fig2 and fig3 [4].

3.1 Status of Rural Electrification in India as on 12-12-2005

(Ref: Ministry of Power report)

Total Number of villages	- 5,87,258
Villages electrified	- 5,08,515
Villages to be electrified	- 78,743
Total number of households	- 13,82,71,559
Electrified households	- 6,42,63,719 -- 43.5%

Government of India has setup a technology mission on rural electricity namely, Rural Electric Supply Technology (REST) Mission, under ministry of power with representatives from other Ministries Rural Development, Non-Conventional Energy Resources, organizations like CSIR, BHEL, etc. The purpose of REST mission is to accelerate electrification to meet the goal of ‘**power for all by 2012**’. The mission is also to identify technologies that could be used in providing affordable and reliable power supply to rural areas and effect implementation through distributed generation schemes, wherever feasible. The purpose is to provide electrification of remaining ‘one lakh villages and one crore household’.

2.1 Energy Resources Patterns in Rural Area

Energy survey of households is conducted in a village Nuggikeri, of Karnataka state, is shown in fig 4, 5, 6 and daily electrical load pattern in fig7 [1].

2.2 Observations of the Survey

- 1) Majority of the villagers use firewood for water heating and cooking. Dependency on firewood has lead to deforestation, effect on ecology, and soil erosion over the years. Only 27% of the forest is remaining in India.
- 2) Previously wood was available at ‘zero cost’ in nearby villages; women and children used to collect it. But now the picture has changed and villagers are purchasing wood or slowly adapting to ‘switching fuel’.
- 3) The amount of crop waste available in rural village has been rapidly decreasing every year.
- 4) Dependency on kerosene is due to subsidized rates in public distribution systems.
- 5) For the villages already electrified, penetration of electrical energy utilities is very less.

Rural people are having intermittent power supply of 12 hours during summer and partly winter season. Power shutdown lead to the potential crop loss of about 3.1% to 13.3% of agricultural Gross Domestic Product (TERI 2001).

The demand for energy is increasing and local resources cannot meet this demand. Hence, the energy resource pattern has been shifting to electrical energy in the coming

years and energy resource auditing of every village plays an important role in sustainable development.

3 STRATEGIES PROPOSED

The total nationwide survey of the energy sources available has to be carried out priority wise and dividing the whole work into sequential tasks and prioritization of these tasks to achieve the national objectives. The whole work of electrification can be divided as per the following priorities [3].

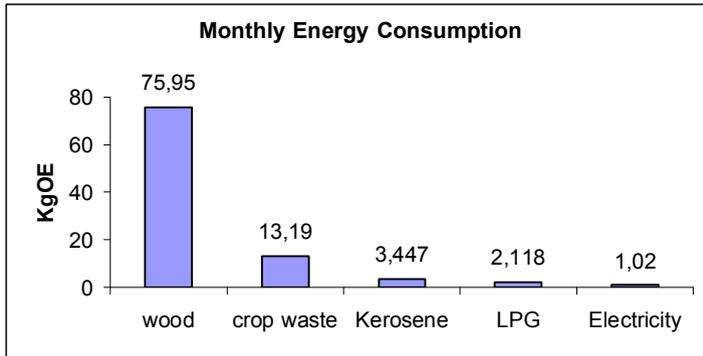


Fig 4: Monthly energy consumption in [KgOE] the village per family

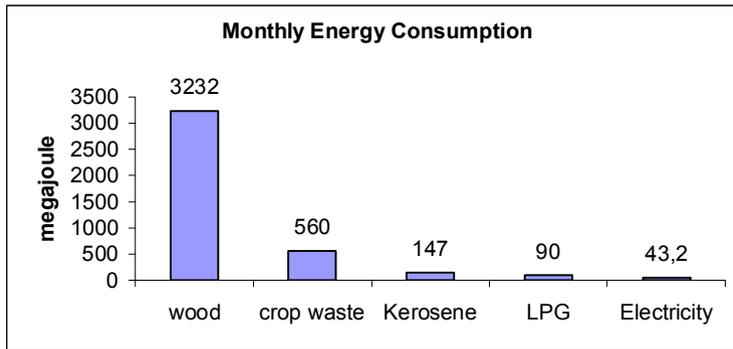


Fig 5: Monthly energy consumption in [MJ] the village per family

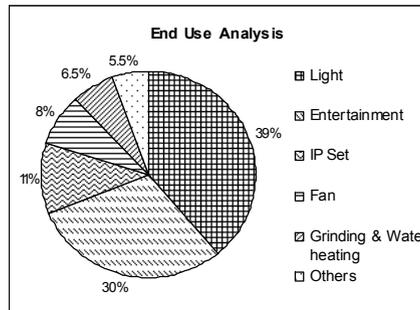


Fig 6: End use of electrical appliances with irrigation pump

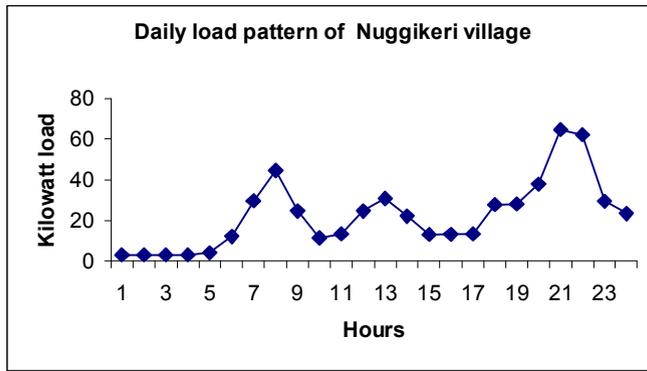


Fig 7: Daily electrical load pattern of village

3.1 Quick survey of remote villages 78743 remote villages

These are remote villages with difficult access and need to be covered initially to provide electricity through decentralized generation. For this survey of all the available resources locally are to be identified and the least cost option worked out to ensure that minimum needs of the villages are met immediately. Normally, options available are

- Small /Mini / Micro hydel generation
- Bio gas / bio mass generation
- Solar photo voltaic powered / stand alone systems
- Diesel generation.

Other sources like wind etc. are not easily predictable and reliable in these left out areas. However, small wind and diesel sets can be utilized along with SPV in hybrid mode. The combination of these systems depend upon financial resources and affordability of these systems from the point of view running and maintenance expenditure which is generally very poor in these villages 1,40000. It has to be thought of as a social necessity.

3.2 Detailed survey of balance 508015 villages

In this program village wise survey of various resources locally available and the cost estimation thereof can be made. This could include the future growth potential in the area, development of rural industrialization etc. The exercise so made can be compared with the cost of grid extension and the final least cost option adopted. However, due to the overall shortage of power, the power can be generated from local resources and surplus power evacuated through the grid after meeting the local needs.

3.3 All villages' survey

This will need a nationwide program on a detailed scale so that all aspects of exploitation of local resources, consumer preferences, local tariffs etc to be covered. This stage will help in preparation of a detailed master plan about availability and economical preferences of all the sources of energy. This stage can bring a clearer picture about the status of resource base for its economical exploitation for meeting the energy needs of the country.

3.4 Action plan for implementation of survey program

1. For the purpose of speedy implementation of the program, simultaneously work has to be taken up in several regions. We may divide the whole country into say, six regions for the purpose viz. Northern, Southern, Eastern, Western, Northeastern, central region.
2. Select six major agencies along with survey teams for a detailed village wise survey of the potential covering customer need, panchayats, NGOs, affordability, load potential etc.
3. Before undertaking the field survey, a quick review of detailed surveys already carried out by various agencies has to be done. Some of the following survey reports based on primary and secondary sources on energy and related aspects are already available which cover some useful data at the village/district/state level.
 - a) Economic Survey-District wise Town and Village Directory by Census Department
 - b) Household surveys by National Sample Survey/Central Statistical Organization
 - c) State wise Techno-Economic Survey Reports by National Council For Applied Economic Research
 - d) All India Census-Small Scale Industrial Units by Small Scale Industries, Ministries of Industries.
 - e) Survey Reports of Hydro Potential by Alternate Hydro Energy Center.
 - f) Central Review and other Survey Reports by Central Electricity Authority.
 - g) Annual Economic Survey Report by Ministry of Finance.
 - h) Basic Rural statistics by Ministry of Rural Development.
 - i) The data, which is not available, has only to be included in the survey so that considerable time is saved. A detailed questionnaire can be prepared and handed over to the survey agencies to include in their programmes for their next survey. While undertaking village wise survey and working out details, following requirements also need to be looked into viz. requirements of households in village, of a cluster of village, of a block and a district as a whole.
4. Similarly, the load requirements have to be projected based on basic needs, additional community development and industrialization.
5. Time limit for survey has to be fixed.
6. Cost estimation of survey per village has to be worked out.
7. Hydrological data collection, wind resources assessment, solar insolation and light intensity, cattle population, dung availability, wasteland for biomass cultivation, etc are to be recorded regularly in the village as well as in the vicinity for possible exploitation of suitable resources.

Make provisions for funds, International co-operation from aid agencies can be expected in this regard that will help them assess the realistic demands for their products in the Indian markets.

The State Electricity Boards, Power Departments because of their large network in the respective states, MNES, IREDA, REC, TERI, NGOs, due to their interest in the penetration of energy saving electrical appliances and promotion of renewable energy can play a significant role in helping at successful national survey. After this stage, strategies for actual implementation can be taken up, requirement of funds are clearer and budgetary

provisions can be made more realistically. This would also enable the manufacturers and others to plan their own strategies for the available demand.

4. CONCLUSION

Electric power is a vital engine for growth; not only in the urban-industrial context, but also in rural areas-through its more widespread use in productive activities, and its potential to improve living conditions. Thus, rural electrification could play an important role in the development process, and be most effectively used to help numerous and disadvantaged rural masses of the India move away from their subsistence type of existence, and significantly improve their quality of life in the coming years. Nevertheless, the high relative costs of RE and the lack of funds in developing countries pose formidable problems and underline the importance of efficient use of scarce resources. Many of the fundamental structural changes that are transforming the societies, such as the shift from the industrial to the post-industrial economy, cannot be ignored by the country if they are to take their place as equals in the global environment and compete successfully in international markets. In the long run, this modernization must reach and affect the rural areas of the developing countries, and electrification is an essential prerequisite in this process. At a very general level, there are several salient points that have emerged through the analysis of past experience.

- Rural electrification is a tool for national socio-economic development, and should be treated like any other policy instrument. In particular, it should be subject to the same rational analysis, and closely co-ordinate with the other policy tools available to the government of a developing country, to meet national objectives and goals.
- Rural electrification alone is unlikely to automatically entail development, and may in fact be costly and ineffective. However, a set of infrastructure services would be much more likely to result in greater benefits and welfare improvements through synergistic effects. Such a comprehensive package would include not only electricity supply, but also some or all of the following-
 1. agricultural extension services and inputs
 2. rural and agricultural credits
 3. irrigation
 4. incentives for small business, agro-industries, and cottage industries
 5. roads and transport
 6. schools and educational facilities
 7. hospitals and healthcare facilities
 8. rural markets
 9. communications facilities
 10. electricity support services
- Rural electrification issues cannot be separated from the overall context in which they are embedded. Thus RE must be analyzed within an integrated framework that includes rural energy, the broader power and energy scene, and the overall macro economy. At the same time, rural electrification and rural development are inextricably intertwined, and rural development itself is only one aspect of overall national development [2].

Recognition of the dynamic nature of RE is an important key to successful implementation. The institutional framework, load forecasting, design and planning of networks, operation and maintenance practices, methods of financing, assessment of socio economic benefits and costs, and other aspects must be tailored to the often rapid evolution and growth of rural loads and the grid that serves them. Focusing on the accelerated step-up phase of a new rural electrification scheme and initial investment is only the first step. Continued attention must be paid to financing and maintaining the level of services to electricity consumers in the scheme area over a long period of time, as load growth continues.

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