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REVIEWS

Universal and Sustainable Access to Modern Energy Services in Rural India: An Overview of Policy-Programmatic Interventions and Implications for Sustainable Development

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Abstract | India's energy challenges are accentuated by the presence of large section of the population, especially in rural areas, lacking access to modern energy carriers. Lack of access to modern energy carrier-based services has implications for economic, social and environmental well-being of humanity. The implications are typically in the form of income poverty, primitive lifestyles, loss of dignity, physical hardship, health hazards, lack of employment and polluted environment. In 2007, for example in India, out of a population of about 1,125 million, 400 million were without access to electricity and 801 million were depending on solid fuels for cooking. This status indicates that the polices initiated, and the programmes implemented by the government of India as well as various state governments since the past several years have proved to be ineffective. Keeping these in mind, in this paper, an attempt has been made to provide deeper insights into the relationships between energy access status, policies and programmes and sustainable development by adopting a review methodology. In essence, the paper tries to analyse the linkage—current energy access status is an outcome of policy failure, and it has given rise to negative implications for sustainable development—through a synthesis of research papers and policy documents.

1 Introduction

In January this year, UN's general assembly designated 2012 as the International Year of Sustainable Energy for All.[1] This is in recognition of the significance of energy access to achieve sustainable development. Most important goal of this initiative is to achieve universal access to modern energy services by 2030. In this context, India's role as a country having significant share of modern energy deprived population is critical in achieving this goal. In 2007, out of a population of about 1,125 million, 400 million were without access to electricity and 801 million depending on solid fuels for cooking.[2–4] Three critical issues emerge out of this situation—(i) the above status is an outcome of the failure of the government policies and programs implemented over the past several years, (ii) the outcome of this serious energy deprivation has significant negative implications for sustainable development, and (iii) India needs radical and innovative approaches to bridge the energy access gaps. In this paper, an attempt has been made to provide deeper insights into the first two issues by adopting review methodology. In essence, the paper tries to analyse the linkages—current energy access status as depicted above is an outcome linked to ineffective policies of the past, and this outcome has given rise to strong negative implications for sustainable development. The methodology adopted for the study involves review of literature, data and policy documents.

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Expanding access to end-use services based on modern energy carrier is considered as an essential element to achieve the Millennium Development Goals (MDGs),[5,6] which represent the holistic goal of sustainable development. Strong action supported by political commitment is critical for tackling the challenge of energy poverty resulting from lack of modern energy access. Therefore effective policies and programmes are needed to encourage the integration of energy into development programmes and processes at the sub-national level.[7] One of the outcomes of lack of energy access is the continued dependence on traditional fuels like fuel wood and cattle dung. The inefficient procurement and use of traditional biomass based energy sources are posing serious economic, environmental, and health threats.[8,9] Developing countries like India are far behind in expanding access to modern energy, whether to meet nationally set energy access targets or facilitate achievement of the MDGs.[10] Sagar and Kartha (2007)[11] have explained the linkage between bioenergy and sustainable development from multiple perspectives based on extensive review of the literature. They observe that the use of bioenergy as a survival fuel by poor in the developing countries have largely contributed to unsustainable development with outcomes like gender discrimination, health hazards, sub-standard living conditions and emission of products of incomplete combustion (PICs) contributing to climate change. In 2007, India accounted for 27% and 23% of the world population respectively without access to electricity for basic lighting and modern fuels for cooking.[2,12] These sections of population are energy as well as income poor. The relationship between energy and poverty is obvious and goes both ways.[13] The linkage between expanding rural energy access and socio-economic development is well established.[14,15] In this paper, an attempt has been made to elaborate on this linkage and provide additional insights for a better understanding.

Modern energy access: Energy access is a term mostly used in the context of describing the energy use pattern of poor people in the world. It basically means the extent of access these poor people have to the energy end-use services delivered by the modern energy carriers like electricity, petroleum products, and modern bioenergy.

2 Rural Energy Access Status in India: A Synthesis

The rural energy access situation in India, in terms of both lack of access to cooking and lighting, is discussed extensively in the literature. The focus is predominantly on assessing the current status and discussing earlier efforts in expanding rural electrification through policy initiatives and programmes as well as recommending strategies for mainstreaming energy access.[6,16–20] The rural households in India predominantly depend on non-commercial fuels for their cooking needs and there is a serious lack of any policies and programmes for expanding cooking energy access.[18,19] On many occasions the problems were accentuated by fuel insufficiency, over exploitation of biomass resources and poor reliability and quality of energy services available; however these continued despite numerous initiatives by the government.[21] Other issues related to rural energy are difficulties in accessing finance for poor households for expanding energy access for lighting and cooking fuels.[19]

Figures 1 and 2 show an attempt to capture dynamic changes in rural cooking energy and electricity access that have occurred over a time period of 23 years, across various income classes and regions represented by different states in India using the latest National Sample Survey results.[22,23] In the graphs (Figures 1 and 2), the y-axis indicates the energy access levels (%) whereas the x-axis indicates various points in the range given by the 12 yearly data points for which data are available during 1984 to 2007, 12 income classes represented by per capita monthly expenditure (PCME) classes in 2005 as a proxy, and 13 states (or regions) representing various access levels in the order of highest to lowest. Figure 1 indicates the undesirable trends in cooking energy access. The temporal trends should have had the highest slope indicating spectacular growth in cooking energy access levels. However, this is not the case, the access level has increased from 1% to just 10% in about 23 years. On the other hand the slopes are very high for both the graphs showing changes in access levels with respect to income and regions in that order. This suggests that the pro-poor energy access policies of the government have failed to achieve the desired results. Similarly, some states have miserably failed in providing energy access to the rural population.

Compared to cooking energy access, the lighting access situation appears far better (Figure 2). Unlike cooking energy access, the governments both at the national and state level have initiated many programmes for expanding rural electricity access. There is a significant increase in percentage access to electricity with the rise in income levels. Similar increase also can be seen with respect to regions indicating serious imbalance in electricity access levels across states.

3 Socio-Economic and Environmental Implications of Lack of Energy Access in India

3.1 *Implications for sustainable development*

Affordable and reliable access to electricity end-use services results in increased productivity in agriculture and labor, improvement in the

Sustainable development: Sustainable development defined as the development that is economically feasible, socially acceptable and environmentally friendly, and that contributes to maximization of human welfare.

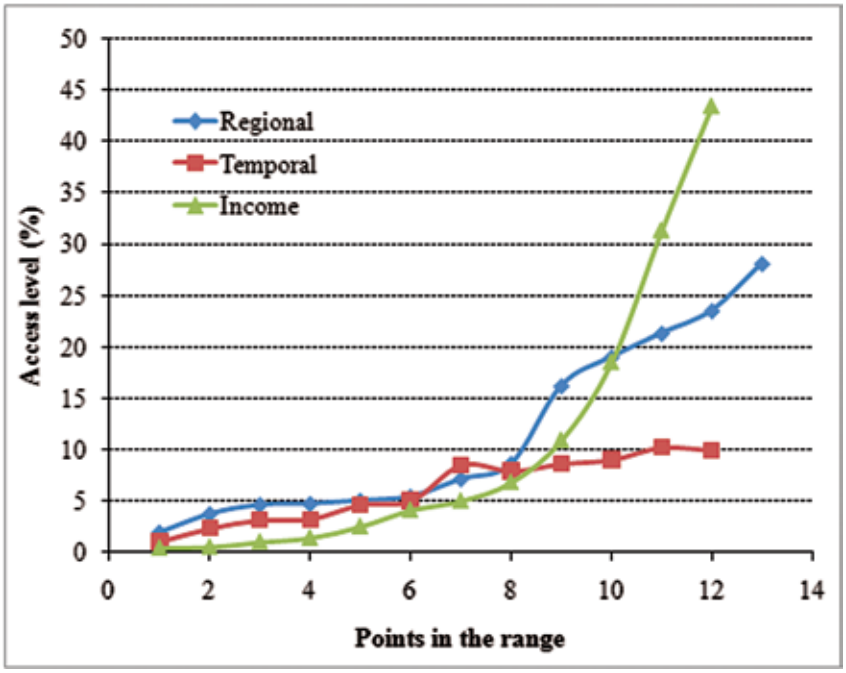

Figure 1: Dynamic changes in rural cooking energy access.

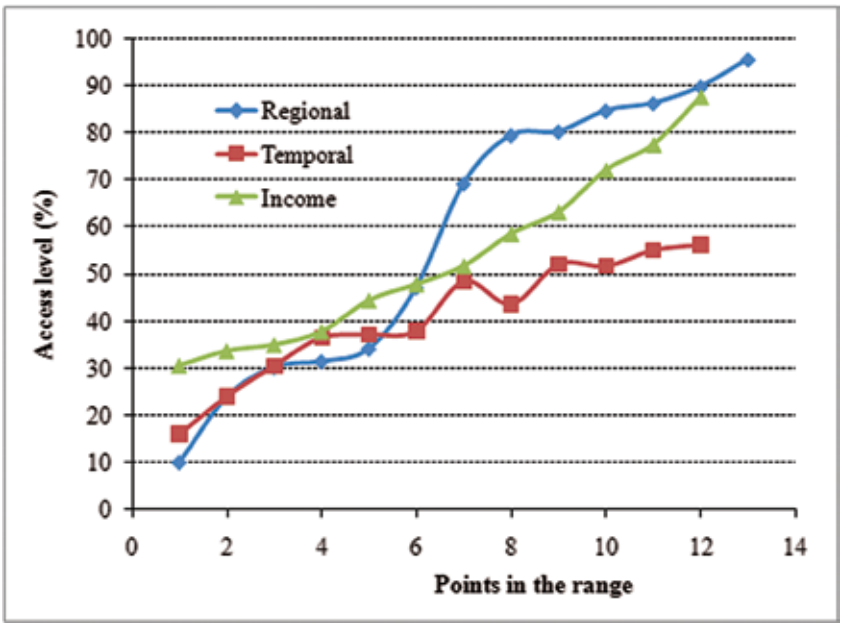

Figure 2: Dynamic changes in rural electricity access.

delivery of health and education, access to communications, improved lighting, enabling productive end-uses through grain mills, motors, and pumps, and increasing public safety through outdoor lighting.[24] Similarly, lack of access to modern energy carriers has implications for economic, social and environmental well-being of humanity. The implications could be in the form of income poverty, primitive lifestyles, loss of dignity, physical hardship, health hazards, lack of employment and polluted environment. By expanding access most of these negative impacts could be overcome. Further, the positive implications of universalizing access to modern energy carriers span the sphere of economic, human, social and environmental developments (Table 1).

Table 1: Expanding Energy Access: Implications for Economic, Human, Social and Environmental Developments.[27–29]

Development	Implications	Remarks
Economic Development	Employment Income generation Micro-enterprises Productive Livelihoods	• Employment due to new economic activities. • Source of light for economic activities in evenings. • Economic activities such as tailoring, hair salons, phone services, radio and television repair, and refrigeration. • Enabling enterprise development, utilizing locally available resources, and creating jobs. • Electricity for motive power for different end-uses and to enhance productivity. • Refrigeration for vaccines and food staples. • Reducing post-harvest losses through better preservation. • Distributed energy production supply chain. • Transportation and communications to increase market access. • Reducing energy expenditure.
Human Development	Education	• Educated professionals, such as doctors, nurses, and teachers, are more willing to remain in villages. • Lighting allows children to study outside of daylight hours. • Due to time saved on fuel collection and ill health, children will have more time for education. • Enabling access to media and communications that increase educational opportunities.
	Health	• Lighting in health clinics to extend hours of operation. • Healthier conditions for domestic work and study. • Illness reduces earning capacities and leads to additional expenses for health care. • Reducing exposure to indoor pollution will reduce child morbidity and mortality. • Kitchen fires and kerosene wick lamps are a major cause of burns for infants and toddlers. • Cutting down indoor air pollution will contribute to better respiratory health among women. • Reduce physical burdens and associated health risks. • Providing access to better medical facilities for maternal care. • Allowing for medicine refrigeration, equipment sterilization, and safe disposal by incineration. • Providing access to health education media. • Enabling access to the latest medicines/expertise through renewable-energy based telemedicine systems.
	Information & knowledge empowerment	• Television, radio, information/internet kiosk creates access to relevant information. • Information related to markets for inputs and outputs. • Informed decisions, enhanced awareness. • Knowledge about rights and duties.
	Gender empowerment	• Physical Drudgery reduction by lessening women's workload in collecting fuel. • Time saving due to avoided wood collection and reduced cooking time through more efficient devices will allow for productive endeavours, adult education and child care. • Eliminating the dependency on fuel collection far from home will reduce the risk of assault and injury for women and girls. • Involving women in household energy decisions contributes to promoting gender equality and empowering women. • Owning a less-polluting stove raises a woman's prestige—both as a sign of wealth and, indirectly, through a soot-free kitchen environment. • Freeing women's time from survival activities, allowing opportunities for income generation. • Reducing exposure to indoor air pollution and improving health. • Lighting streets to improve women's safety.
Social Development	Safety and Security Community Participation Clean environment	• Increased security in public spaces and walkways. • Empowerment enables social participation and collective decision making. • Enhanced status by moving up the energy ladder and ownership modern devices. • Clean local environment enables local recreation. • Enhanced incomes and economic activities facilitates community initiatives, social gatherings and religious functions.

(*Continued*)

Table 1: (Continued).

Development	Implications	Remarks
Environmental Development	GHG emissions Black carbon Mitigation options Climate adaptation & resilience	• Reducing deforestation for traditional fuels, reducing erosion and desertification. • Reducing greenhouse gas emissions by using renewable energy. • Moving up the energy ladder and using energy efficient devices decrease greenhouse gas emissions. • Reducing pressure on forests, particularly in areas where biomass is scarce. • Reducing emissions of products of incomplete combustion including methane, black carbon, etc. • Energy-efficient devices based on renewable sources. • Building climate change adaptation capabilities and thereby climate resilience through empowerment.

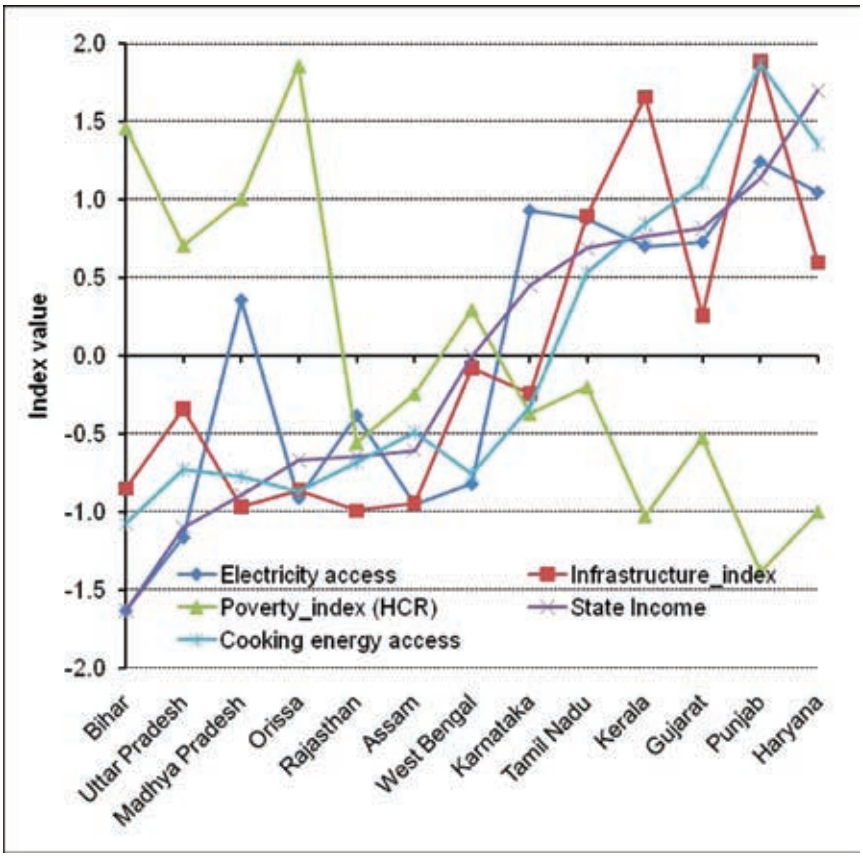

Figure 3: Rural household energy access and development (2005).

The strong relationship between energy access and economic development is a proven fact. Here, an attempt is made to validate this hypothesis in the Indian context. Two rural household energy access indicators, access to modern fuel for cooking and electricity for lighting, are compared with indicators like per capita income (state domestic product), head count ratio of poverty (HCR) and index of infrastructure. The per capita state income is in terms of per capita net state domestic product at factor cost (at current prices).[25] The incidence of poverty is measured in terms of HCR, and the index of infrastructure is developed using economic, social, and administrative infrastructure indicators.[26] Since indicator values use different scales and vary with huge margins, a normalization procedure is followed. The five indicators with normalized values for the chosen states are plotted (Figure 3). Except for HCR, all other indicators show higher values which indicate a better performance by the state. In the case of HCR, higher values indicate higher incidence of poverty.

Figure 3 suggests a strong relationship between energy access and overall development. With zero being the mid-point for the range of normalized values for the index on state income, the performances of states on different indices are compared. West Bengal is on the mid-point having obtained zero value for the index state income. Therefore West Bengal and the states ordered before it can be classified as low income states whereas the states after West Bengal as high income states. The states with low average per capita income have invariably obtained values lesser than zero for the three indicators, namely, on infrastructure, electricity and cooking energy access, and above zero for HCR with a few exceptions. Similar is the case with high income states obtaining below zero value for HCR and above zero for the remaining three indicators, again with a few exceptions. Madhya Pradesh is ineffective in providing cooking energy access to the rural households whereas it has done well with respect to electricity access. Karnataka, though a high income state, is ineffective in terms of providing cooking energy access and fares badly with respect to infrastructure index. Rajasthan and Orissa, though categorized as low income states, have done fairly well in reducing the poverty levels. They have below zero HCR levels. The trickledown effect appears to be strong in these two states. However, similar good performance is not visible with respect to energy access and infrastructure index. Overall it could be stated that the states with better rural infrastructure and energy access levels have lower incidence of poverty and higher per capita income levels.

3.2 *Implications for human health*

Lack of energy access for cooking has resulted in increased dependency on conventional biomass based fuels. It is also imposing huge burden on rural poor, especially women. The considerable effort spent on gathering biomass and cattle dung, and then preparing them for use is not priced into the cost of such energy. These fuels produce smoke and indoor air pollution, are inconvenient to use, and adversely affect the health of people, particularly women and children. Reliance on biomass often results in regular exposure to harmful emissions of carbon monoxide, hydrocarbons and particulate matter.

Exposure to the above emissions is an important cause of disease and mortality in developing countries. Conservative estimates of global mortality show that in 2000 between 1.5 and 2 million deaths were attributed to this risk factor. This accounts for approximately 3% to 4% of total mortality worldwide. Approximately one million of these deaths were due to childhood acute (lower) respiratory infections (ALRI), with the remaining due to chronic obstructive pulmonary disease (COPD) and lung cancer among adult women.[30] According to the estimates of the World Health Organization (WHO) about 1.5 million premature deaths occur each year due to indoor air pollution. In addition, it is estimated that indoor air pollution causes about 36% of lower respiratory infections and 22% of chronic respiratory disease.[31] The recent estimates confirm these findings. According to a study by UNDP and WHO, globally almost two million deaths occur annually from pneumonia, chronic lung disease, and lung cancer are associated with exposure to indoor air pollution resulting from cooking with biomass and coal, and 99% of them occur in developing countries.[10] Women and children, especially the girl children, suffer most from indoor air pollution, because traditionally they are responsible for household chores. Also women and children are typically responsible for biomass collection, an exhausting task that can result in long-term physical damage.[32]

Even in the Indian context studies have revealed the serious implications of indoor pollution. A World Bank study reports that the respirable particles are strongly associated with acute respiratory infections (ARI) among children accounting for the largest number of child deaths in India.[33] Same study points out that the disease burden due to indoor air pollution is disproportionate and women and young children in rural areas are most affected, with more than 400,000 dying every year in India. Of these deaths, almost 90 per cent accounts for children under the age of five. Rural households have been linked to an additional 450 million cases of acute or chronic illnesses due to the use of biomass fuels. The disease burden decreases productivity and livelihoods of the poor and reduces the time children spend in school, thus contributing to the vicious cycle of poverty and ill health.[33]

3.3 *Implications for climate change*

Dependency on traditional fuels has implications for both local and global pollution. Emissions from burning solid fuels in open fires and traditional stoves also have significant global warming effects, due to incomplete combustion of fuel carbon.[10,34] In reality, however, household energy consumption has never been the focus for climate change mitigation related interventions. This is because most solid fuels are considered renewable with zero net addition of CO_2 to the atmosphere. The underlying assumption is that most of energy

consumed is for cooking or heating and this is mostly derived from renewably harvested fuel wood or agricultural waste, which are considered carbon neutral. This reliance by the rural households on the so-called 'climate-friendly' biomass energy sources, combined with their low levels of energy use have resulted in a lack of motivation for policy-makers and NGOs to focus on rural household energy use in the context of climate change.[9] However, if the wood burned is not replaced with new plant growth, then a net addition of CO_2 to the atmosphere does occur.[9,35] Earlier studies have reported that on an average, in India, 40% of the fuel wood is typically obtained from unsustainable means in the sense that it is not from renewable biomass source.[36]

It has also been shown that inefficient combustion of traditional biomass fuels in cookstoves yield significant gaseous products of incomplete combustion (PICs) that are GHGs.[34] This incomplete combustion results in emission of black carbon, which is a potent GHG. Residential sector in India is considered as one of the major contributors of black carbon (BC). It has been estimated that the global warming effect of black carbon is equal to 20 to 50% of the effect of CO_2.[37] According to the authors, limiting their presence in the atmosphere is an easier, cheaper, and more politically feasible proposition than the most popular proposals for slowing climate change. Thus, black carbon from biomass combustion and access to modern energy services have implications for climate change mitigation and adaptation respectively.[38] In other words, it is in general agreed that about 10–20% of the gross warming is due to black carbon[39] compared to about 40% by CO_2. The residential sector is contributing approximately 18% to 25% of the black carbon in the world.[39,40] In the Indian context, the total BC emissions range between a high of 600 Gg/year to a low of 416 Gg/year.[41] Even the BC contributions of the biofuel used by the household sector in India too show similar variations ranging from 167–420 Gg/year. The recent estimate for the year 2000 pegs the household biofuel use contribution to BC at about 174 Gg/year.[41] In addition to all these, the biomass combustion emits other GHGs like CH_4 and N_2O.

In India, cattle dung is first converted into cakes (mixing the wet dung and loose biomass) and dried sufficiently before being used in conventional stoves for cooking. This open exposure of cattle dung results in the release of CH_4 to the atmosphere. Experiments reveal that from one tonne of dung about 26% of gas potential is released when it is stored untreated in pits for a week to 10 days. Thus, out of the gas potential of 45 m^3/tonne dung, 25.73% = 11.58 m^3 of biogas with 60% methane (6.95 m^3 or 4.96 kg of CH_4) is released to the atmosphere. This is equal to about 104 kg CO_2 equivalent per tonne of cattle dung.[42]

In addition to biomass, the rural households in India also use LPG, kerosene and coal for meeting their cooking and heating needs. Similarly, these households use electricity and kerosene for lighting purposes. Thus, household cooking and lighting, the most critical basic end-uses together were responsible for around 170 Tg of GHG emissions in 2005. This is equivalent to per capita (for the rural population) emissions of 210 kg CO_2e per year. If we add the emissions due to electricity consumed for other end-uses, then the total would be about 191 Tg CO_2e and the rural per capita household emissions will be about 236 kg CO_2e per year.

4 Initiatives in Expanding Rural Energy Access in India: An Assessment of Policies and Programmes

4.1 *Initiatives for expanding rural cooking energy access*

The critical issue of rural energy access was always on the agenda of the government and efforts have been made to address the shortcomings. The first concentrated efforts began in the 1970s in response to the oil crisis. The major thrust of these early efforts was on fuel substitution by supplying kerosene through the Public Distribution System (PDS) and power through rural electrification. Various government committees, such as the Fuel Policy Committee (1974), Working Group on Energy Policy (1979), Advisory Board on Energy (1985), and Energy Demand Screening Group (1986) were set up to reflect on energy issues and the best possible ways to meet the growing energy needs of the rural population.[21]

Rural energy access: Rural energy access basically means providing physical as well as affordable access to electricity and modern fuels like LPG, biogas for the rural households to perform basic energy related activities.

Historically, the policy towards rural energy was to encourage the use of non-commercial energy, especially for cooking, and discourage shift to commercial fuels like kerosene and LPG. However, the proposal was to use better conversion technologies like biogas plants and improved cook-stoves to promote energy efficiency.[43,44] The Government of India, in tune with such a policy has, for the past 30 years, taken steps to improve the supply of biofuels and introduce new and renewable sources of energy as alternative fuels to meet the cooking energy demands of the rural population.[21] The dismal current state of rural household access to modern cooking fuels reflect the governmental thinking and lack of any targeted policies towards improving access to modern fuels. Unlike targeted

policies and programmes for expanding access to electricity, especially for lighting, nothing was created for expanding cooking energy access. Only in the recent past, the Integrated Energy Policy (IEP), the expert committee report submitted to the planning commission mentions this aspect in the context of household energy security. It emphasizes the criticality of the issues related to rural energy by stating that some amount of clean cooking fuels (LPG and Kerosene) and electricity are merit goods, which justifies subsidies for these goods for the poor. If they are implemented properly, they could, especially for women, relieve drudgery, reduce negative health impact, increase productivity and enhance livelihood options.[45] IEP has specific policy recommendations for expanding cooking energy access, especially in rural areas.

- Goal to provide clean cooking energy such as LPG, natural gas, biogas or kerosene to all within 10 years.
- Support formation of fuel wood plantations within one kilometer of all habitations. Provide finance through self-help groups to transform women, who today are only energy gatherers, into micro-entrepreneurs engaged in rural energy markets and management.
- The best way for providing subsidy for electricity and cleaner fuels, kerosene or LPG, is to entitle targeted households to 30 kWh of electricity per month and LPG, kerosene or bio-gas purchased from a local community size plant equivalent to 6 kg of LPG per month.

In the 1980s, with the identification of the second energy/fuel wood crisis, the emphasis of the government shifted to energy conservation and fuel switching, with a focus on renewable energy sources.[21] In 1981–82, the government launched the National Project on Biogas Development (NPBD) and in 1983 the National Programme on Improved Chulhas (NPIC) or improved cookstoves. The NPBD is the largest rural energy programme in terms of investment and the NPIC is the largest in terms of the number of devices disseminated. Additionally, in 1982, the Department of Non-Conventional Energy Sources (DNES) was set up for R&D, demonstration, and dissemination of renewable and rural energy technologies. These programmes of the government through the 1980s focused on intensive R&D, setting up demonstration projects, and creating demand through government subsidies. In 1987, Indian Renewable Energy Development Agency (IREDA) was established under DNES for developing, promoting, and financing commercially viable new and renewable energy alternatives. In 1992, DNES was upgraded into a full-fledged Ministry, the Ministry of Non-Conventional Energy Sources (MNES), making India the only country with a separate Ministry for the promotion of renewable energy sources.[21] In 2006, the MNES was renamed as Ministry of New and Renewable Energy (MNRE) reflecting the fast-paced changes happening in the realm of renewable energy and emerging technologies.

4.1.1 Biogas technology for expanding cooking energy access: The National Project on Biogas Development (NPBD) was started by MNRE in 1981–82 to promote family type biogas plants. The implicit objective of the programme was to reduce the consumption of non-renewable fuels and fuel wood. The specific objectives of the NPBD programme are as follows:[46]

- To provide fuel for cooking purposes and organic manure to rural households through biogas plants;
- To mitigate drudgery of rural women, reduce pressure on forest and accentuate social benefits;
- To improve sanitation in villages by linking toilets with biogas plants.

Under the NPBD programme, various biogas plant models have been approved by MNRE for implementation. Some of the MNRE approved models include KVIC floating drum, Deenbandhu, Pragati, KVIC plant with ferrocement digester, KVIC plant with Fibre Reinforced Plastic Gas Holder, and FLEXI. All these models are based on one of the two basic designs available; fixed masonry dome type, floating metal drum type including FLEXI, a portable model made of rubberized nylon fabric. The latest in the R&D is the development of biogas plants with leafy biomass as feedstock. Experimental biogas plants have been setup to demonstrate this technology.[47] Biogas plants are designed for operation at either the household or the community level to generate gas which is used as an ideal fuel for meeting cooking energy needs in rural areas. The NPBD was renamed as the National Biogas and Manure Management Project (NBMMP) in 2002–03 retaining the same objectives.

At the household level, the cumulative number of biogas plants built from 1982 to 2009 is estimated to be 4.17 million[46] against a potential of 12 to 17 million. The total number of large community and institutional biogas plants installed until 2006 was about 3,902, and only 1,228 plants

were built during 1999–2006. This is a small achievement compared to the potential for a community biogas plant each in the majority of the 500,000 villages.[48]

As per the 2001 Census, only about 850,000 households (or 0.50% of the rural and 0.40% of the urban households) in India were using biogas as a primary fuel for cooking.[49] However, the MNRE data suggests that the cumulative number of biogas plants disseminated till March 2001 was about 3.2 million.[50] This suggests that only about 26.5% of the biogas plants are either fully functioning or being used for producing biogas for cooking as primary energy carrier. The cumulative dissemination of biogas plants reached a number of about 3.7 million by the beginning of 2005.[51] The extrapolated results for 2005 based on census data indicate that 0.55% of the rural and 0.32% of the urban households use biogas as primary fuel for cooking. This is equivalent of about 1.05 million households using biogas as primary cooking fuel and about 28.3% of the biogas plants disseminated till now. Even the estimate of biogas using households of 1.1 million based on the National Family Health Survey for 2005–2006 is very close to this number.[52] It is possible that the actual number of functioning biogas plants may be higher than this figure of 1.05 million. There may be households using biogas as secondary or tertiary fuel for cooking. The evaluation study on national programme on biogas development (NPBD) conducted by the planning commission in 2001 revealed that about 45% of the biogas plants were working properly and another 10% were used partially in the sample villages.[53] It is possible that all the 45% of the biogas plants, though functioning properly, may not be contributing biogas as the primary cooking fuel. This can be observed from the results based on the 2001 Census data, where it was found that only 27% of the biogas plants provided primary fuel for cooking. The above assessment leads to following conclusions:

- The NPBD has not been successful in expanding access to modern cooking fuels (promoting biogas as main fuel for cooking) though it was quite successful in disseminating large number of biogas plants in India. The failure appears to be due to lack of "post-installation" efforts to ensure the survival and continuous operation of the biogas plants. This is a typical outcome when success is measured in terms of numbers disseminated rather than their sustainable performance for a longer period. The main reasons for biogas plants becoming non-functional are structural and operational problems, non-availability of adequate cattle dung, easy availability of other convenient fuels, chocking of inlet/outlet, corrosion/leakage in pipeline, scum formation in digester slurry and water accumulation in gas pipe.[53] Some of these problems could have been rectified by the beneficiaries themselves, had they been trained properly. Additionally, lack of technical and service infrastructure for maintenance and repairs is a major reason for the lack of success.
- The estimates for 2005 suggest that only about 0.55% of the rural households rely on biogas as a primary fuel for cooking and only about 28.3% of the biogas plants disseminated till now are able to survive and contribute biogas as a primary cooking fuel. Even the evaluation study found out that only 7% households in sample villages were found using biogas, often as a supplementary source of fuel and concluded that the NPBD programme failed to make any significant impact.[53]
- The NPBD programme has been implemented more as a renewable energy technology demonstration and dissemination programme rather than as an expanding rural cooking energy access programme.

Since the objective is technology dissemination rather than expanding energy access, the NPBD scheme never targeted any section of the rural population. Rural poor being the major sufferers of lack of access to modern cooking fuel were hardly the beneficiaries of this programme. With cattle ownership and availability of adequate dung being the criteria for installation of biogas plants, the poor got excluded from the programme. Thus, the government subsidy for installing biogas plants benefited mostly the rural high income families. Even the evaluation study found out that the majority of biogas user households were well-to-do farmers and subsidy was not important to them since they could have easily afforded the cost.[53] Evidence based on the analysis performed on NSS data for 2005[22] also suggest the same (Figure 4). It is clear from the figure that the biogas and LPG using households belong to the same expenditure classes. That is, both biogas and LPG using households mostly belong to the high income category. It may not be entirely wrong to conclude that the subsidized NPBD scheme facilitated access to modern cooking fuels for the high income rural households who could not avail LPG connections due to lack of physical access.

The biogas technology dissemination programme of the government of India has not been

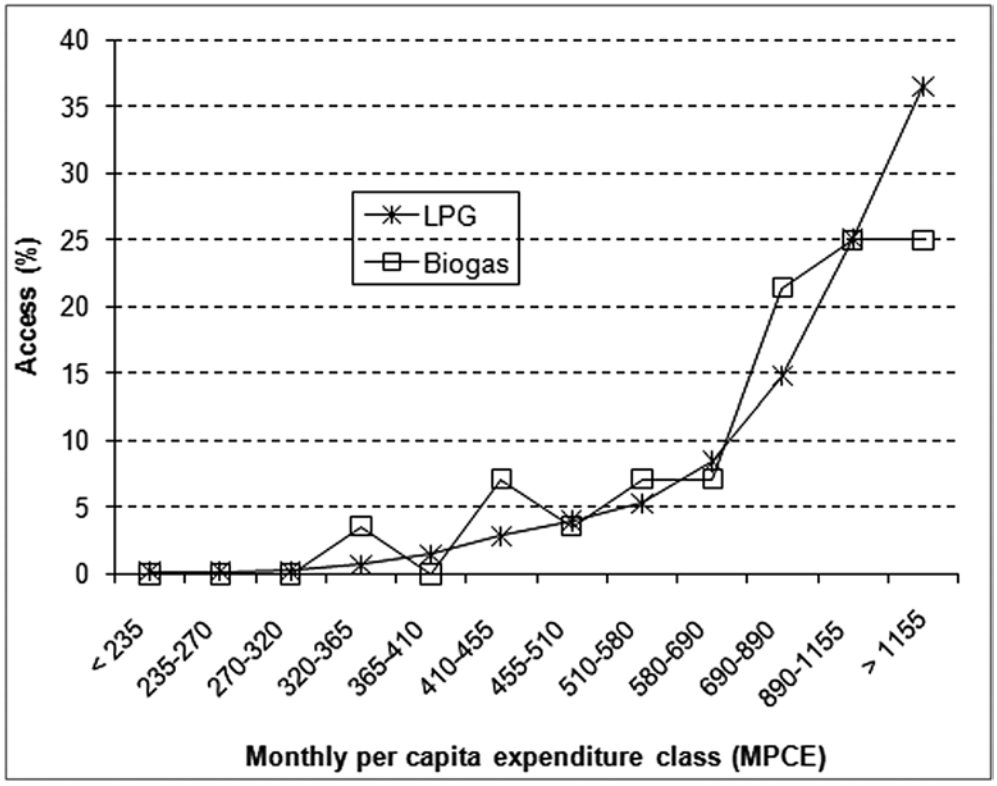

Figure 4: Biogas and LPG reached only high-income rural households.

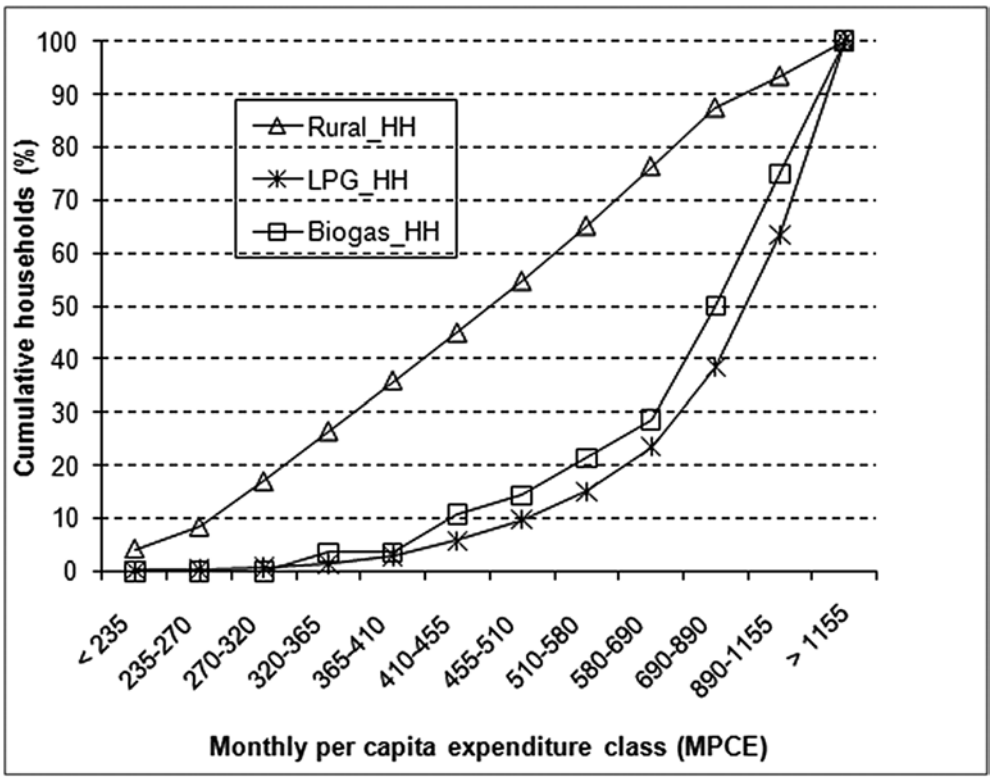

Figure 5: Government programmes failed to eradicate energy poverty.

successful in expanding energy access to the rural poor can be further established through Figure 5, which has been developed using the NSS data for 2004–05.[22] It may be observed from the figure that the majority of the rural households that use LPG or biogas as primary cooking fuels fall in the middle and higher income groups. This trend is indicated by the wide gap between the curves representing LPG/Biogas using households and rural households. The rural poverty line for 2004–05 based on monthly per capita expenditure (MPCE) level of Rs. 446.68 is used as a reference point for estimating the number of rural poor households in India.[54] However, NSSO survey-based data for 2004–05 contains information only in terms of MPCE ranges, and the range containing the above rural poverty line is Rs. 410–455. Therefore, in this study, as a next best approximation, we have assumed the MPCE of Rs. 455 as a rural poverty line. Based on this, it is estimated that about 44.9% of the rural households in India belong to BPL or just above that category (i.e., MPCE of Rs. 455 and below). According to the planning commission report, about 41.8% of the rural population in India falls under BPL category according to the rural poverty line of Rs. 446.68.

The analysis suggests that in 2005 only about 5.8% of the rural households using LPG as primary cooking fuel belonged to the poor category of rural households. The above result translates into only 1.1% of the rural poor households using LPG as a primary fuel and this is equal to about 740,000 out of a total of about 67 million rural poor households. On the similar lines, even biogas also has failed to reach the rural poor households. The results suggest that only about 10.7% of the primary biogas using rural households belong to the poor category. In other words, only about 0.1% of the rural poor households use biogas as a primary cooking fuel. This is about 88,000 poor households in a total of 67 million rural poor households. In total, about 0.83 million rural poor households use gaseous fuel as a primary cooking fuel equaling to just about 1.24% share. With kerosene, another modern fuel for cooking, this percentage climbs up to 1.89%.

4.1.2 Improved cookstoves for expanding cooking energy access: The national pilot project for the demonstration of improved chulhas (or improved cookstoves) was designed and launched in 1983 by the then Department of Non-conventional Energy Sources (DNES) with the following objectives:[55]

- To conserve and optimize the use of fuelwood, especially in the rural and semi-urban areas;
- To help alleviate deforestation;
- To reduce the drudgery associated with cooking, especially on women, and the health hazards caused by smoke and heat exposure in the kitchen;
- To bring about improvements in household sanitation and general living conditions.

In view of the positive response from the beneficiaries, the pilot project was subsequently converted into the "National Programme on Improved Chulhas" (NPIC) in 1985.[55] The NPIC was implemented through various national, state and local mechanisms. At the national level, the Ministry of Non-Conventional Energy Sources (MNES), Government of India was responsible for setting the development policy and direction, securing the central government funding and providing support to various implementation networks. In addition, the programme planning, management/operation, monitoring and evaluation, overseeing R&D progress, etc. were mandated for MNES. At state level, designated state nodal agencies were made responsible for the dissemination of approved stove models within the state or territory through various local implementing bodies, state government departments, agro-industry corporations, Khadi and village industry commissions (KVIC), women's organizations and NGOs. Since the central government supporting fund was channeled through these state nodal agencies, they were responsible for the dissemination plan, providing support to the implementing bodies, coordinating field activities as well as monitoring of the programme. The actual installation of improved chulhas was carried out by a trained workforce of Self Employed Workers who were engaged on a contract basis and were responsible for chulha construction, installation, repair and maintenance and users' education. Twenty Technical Back-up Units (TBUs) have been created in various educational institutions. They are responsible for carrying out R&D, testing of models, training, demonstration and field trials, conducting technical and need-based surveys and monitoring & evaluation.[55]

The cookstoves were usually built by entrepreneurs trained by professional institutions and were supported through MNRE incentives. MNRE used to evaluate the improved stoves for efficiency and then certifies them for dissemination. These designs received subsidy to meet the cost of the stoves. As on 31 March 2003 over 35 million stoves had been built across the nation. However, the NPIC was found to be ineffective over the long term in promoting a fundamental

shift to improved stoves in India.[56] In 2002, MNRE deemed NPIC a failure, funding was stopped and the responsibility of continued ICS dissemination was passed to the states. Since then, a small number of state governments and NGOs have continued ICS dissemination; however, with the lack of central government support and limited funding the success rates are negligible.[48] In December 2009, the MNRE re-launched a re-structured programme on biomass cookstoves, with primary aim of enhancing the availability of clean and efficient energy for the poor.[57] It is named as National Biomass Cookstove Initiative.

4.1.3 Subsidies on household fuels for expanding cooking energy access: Both LPG and kerosene are subsidized heavily in India. But they are not essentially targeted at the poor. In other words, subsidies on both kerosene and LPG are applicable to all categories of consumers of these products. In the case of kerosene, in addition to subsidized pricing, it is distributed through a government controlled public distribution system with quantity restrictions. The latest data[58–60] suggest that the Indian government contributed a total amount of Rs. 26.7 billion in 2008–09 towards subsidizing kerosene and LPG for households (Table 2). Out of this, about Rs. 17 billion is provided for subsidizing LPG, which is predominantly used by middle and high income urban households. The subsidy component provided by the government does not compensate the losses incurred by the public sector oil companies due to selling of kerosene and LPG below market prices. As per the estimates available, the total under-recovery due to the sale of these fuels is to the tune of Rs. 458 billion in 2008–09. Nearly 62% of the under recovery is accounted by the under-priced sale of kerosene through PDS. It is also clear from Table 2 that though the under-recovery has grown significantly during the past four years, the subsidy contribution by government increased only marginally. This has resulted in increasing the burden on the oil companies. The oil companies partially recover this amount through cross-subsidization by selling gasoline and diesel at higher prices. It is also crucial to note that all the under-recoveries do not turn into losses for the oil companies. Basically, they represent lost opportunity to earn profits for them, and taxes and duties for the governments by not selling LPG and kerosene at market prices.

The above initiatives have been taken mainly to target the poor in creating affordable access to cooking fuels. However, in reality, the benefit of

Table 2: Subsidies and under recoveries details for petroleum products sold to the residential sector (Rs. Millions)[59,60]

	2004–05	2005–06	2006–07	2007–08	2008–09
Subsidies provided by the central government					
Kerosene (PDS)	9,790	9,760	9,690	9,640	9,671
LPG	14,680	15,200	15,720	16,310	17,072
Total	24,470	24,960	25,410	25,950	26,743
Under recoveries by the public sector oil companies					
Kerosene (PDS)	94,800	143,840	178,830	191,020	282,250
LPG	83,620	102,460	107,010	155,230	176,000
Total	178,420	246,300	285,840	346,250	458,250
Subsidies and under recoveries on the basis of per unit (Rs.)					
LPG—Per Cylinder of 14.2 kg					
Subsidy	22.8	22.8	22.8	22.8	22.8
Under-recovery	124.89	152.46	156.08	214.05	234.88
Total subsidy to consumer	147.69	175.26	178.88	236.85	257.68
Kerosene (PDS)—Per liter					
Subsidy	0.82	0.82	0.82	0.82	0.82
Under-recovery	7.96	12.1	15.17	16.23	24.06
Total subsidy to consumer	8.78	12.92	15.99	17.05	24.88

subsidized LPG is largely enjoyed by the middle and higher income urban households and that of PDS kerosene by the urban poor. In the rural areas, kerosene is predominantly used for lighting by the poor households that are not connected to grid electricity. In India, only 1.3% of the rural households use kerosene as primary cooking fuel whereas about 44% of the rural households use it as primary lighting fuel.[22] This reflects a failure of the policy. Majority of the rural households prefer to use freely accessible biomass for cooking rather than opting for kerosene even at subsidized prices. Biomass is a preferred choice even though it involves drudgery of collection, mainly for women and children, and health hazards due to indoor pollution. Since the opportunity cost of women labour is low in villages and low awareness on health impacts, the obvious choice for the cash-starved rural poor is free biomass. The rural rich households opt for LPG rather than kerosene, as their primary cooking fuel.[16] Another reason for low adoption of kerosene as a cooking fuel may be its diversion to other sectors making its availability limited in rural areas. The study carried out by the National Council for Applied Economic Research revealed that nearly 39% of the PDS kerosene was being illegally diverted.[61] It is generally believed that the diverted kerosene is used to adulterate diesel and petrol for transport on account of price differential between these fuels.

4.2 *Initiatives for expanding rural electricity access*

In India, electricity generation, transmission and distribution was always controlled by the individual state governments. The state electricity boards, managed by the state governments were given the responsibility of electricity supply. The role of central government was predominantly limited to creating legislations and policies. However, it was realized during the seventies that the state electricity boards (SEBs) were unable bear the burden of adding new capacities, both generation and transmission, on account of the high costs of investment and the Indian government intervened, and amended the Electricity Supply Act in 1976. This led to the setting up of the National Hydro-Power Corporation and the National Thermal Power Corporation initially, and the other Central Public Sector Undertaking subsequently.[62] This change to a large extent reduced the domination of state governments, at least in generation and interstate transmission of electricity. Further amendments to the Electricity Supply Act of 1948 were made during 1992 to open the power sector to private sector participation. But private participation was encouraged only in generation, thus protecting SEBs from competition in other domains.[6] The culmination of decades of such limited efforts in reforming the power sector was happened with the introduction of the Electricity Act, 2003, which has been designed to address systemic deficiencies in the Indian power sector and to attract capital for large-scale power projects.

4.2.1 Rural electrification Policy initiatives: The Electricity Act 2003 is a central unified legislation and replaces the multiple legislations that previously governed the Indian electricity sector. The objective is to introduce competition, protect consumer's interests and provide power for all. Additionally, the Electricity Act provides for rural electrification, open access in power transmission and distribution, de-licensing of power generation, and distribution and power trading.[63] The government of India notified the National Electricity Policy in February 2005. This policy aims to accelerate development of the power sector, to provide supply of electricity to all areas and to protect the interests of consumers and other stakeholders, with attention on the availability of energy resources, technology available to exploit these resources, economics of generation using different resources and energy security issues. The following sections present brief discussions on the policies/acts which have direct bearing on rural electrification and expanding rural household electricity access.

The Electricity Act 2003: It was notified on June 02, 2003, and had specific directions for expanding rural electricity access and for the first time mentions rural electrification in a statute. The Act Mandates universal service obligation and formulation of a national policy on rural electrification, focusing especially on management of local distribution networks through local institutions. Further, the Electricity (Amendment) Act, 2007 notified on May 29, 2007 states that the state and central governments shall jointly endeavour to provide electricity access to all through development of rural electricity infrastructure and electrification of households.[64]

National Electricity Policy: The Central Government notified the National Electricity Policy on 12th February 2005. It states that electricity is an essential requirement for all facets of life and is a basic human need. It is also stated that the supply of electricity at reasonable rate to rural India

is essential for its overall development. The Policy aims at achieving the following objectives:[65]

- Access to electricity for all households in next five years and ensure the availability of power to fully meet the demand by 2012.
- Supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates.
- Per capita availability of electricity to be increased to over 1000 kWh by 2012.
- Minimum lifeline consumption of 1 kWh/household/day as a merit good by year 2012.

It recommends that the Rural Electrification Corporation (REC) of India will be the nodal agency at national level. The operational viability is to be ensured by recovering at least the cost of electricity and related O&M expenses from consumers, except for lifeline support to households below poverty line who would need to be subsidized. The government is to provide necessary capital subsidy and soft long-term debt finances. The policy also has recommendations for creating appropriate institutional framework to ensure creation of rural electrification infrastructure, and to operate and maintain reliable supply system. Capacity development through education, training and awareness programmes is considered to be essential for achieving the objective of effective stakeholder participation.

Rural Electrification Policy: The central government notified the Rural Electrification Policy in August 2006.[66] The rural electrification policy elaborates on the issues mentioned in the national electricity policy. In addition, it has specific recommendations for effective implementation of rural electrification programme:

- The state governments should prepare and notify a rural electrification plan to achieve the goal of providing access to all households.
- Ministry of power in association with ministry of Panchayat Raj to put in place a coordination mechanism for implementing various schemes.
- To ensure involvement of local communities, the state governments to set up a committee at the district level with representations from concerned local agencies, consumer associations and other stakeholders. Since the women suffer most due to lack of energy access, their participation should be ensured.
- To ensure financial sustainability, recommendations are made to opt for least cost options after taking into account the implications of full life cycle costs, and explicit as well as implicit subsidies in different delivery options and mechanisms.
- Specific policy provisions for permitting stand-alone systems for rural areas.
- Policy provisions for bulk power purchase and management of local distribution through deployment of franchisees.

4.2.2 Rural electricity access programmes: Rural electrification was given due importance just after independence. The 1st Five-year Plan (1951–56) emphasized support for projects to ensure exploitation of irrigation potential. The 2nd Five-year Plan (1957–62) named rural electrification as an area of special interest. The 3rd Five-year Plan (1963–68) for the first time raised the issue of efficiency in the sector. Review of rural electrification programmes in the 1950's and 60's shows that despite their implied objectives, rural electrification was essentially an attempt by the state electricity boards to connect cities and towns.[6] REC was created in 1969 with support from USAID and is mandated to facilitate availability of electricity in rural areas. During its 35 years of existence, REC has financed numerous village electrification, pump set energization and low tension system improvement projects. However, with the focus being extensive (number of villages electrified) rather than intensive electrification (% of households covered), large gaps remain in rural electrification.[6] The target based approach of rural electrification was developed in the 4th and 5th Five-year Plan periods, with a focus on pump set energization and village grid connectivity. The following are some of the important programmes developed for expanding rural electricity access in India.[6,67,68]

- *Minimum Needs Programme* was started during the 5th Five-year Plan period with rural electrification as one of the important components with central assistance in the form of grants and loans to the states.
- *Kutir Jyoti Scheme* was launched in 1988–89 to provide a single point lighting connections to below poverty line (BPL) households[6] and about 7.2 million BPL households were provided with electricity connection at a total cost of 6.12 billion.[63]
- *Pradhan Mantri Gramodaya Yojana (PMGY)* had rural electrification as one of the many programmes and it offered financing through loans (90%) and grants (10%).

- *Accelerated Rural Electrification Programme (AREP)* was provided interest subsidy of 4% on loans availed by state governments from financial institutions for carrying out rural electrification programme. The focus was on electrification of smaller settlements of lower-caste people and tribal villages.
- The scheme on *Accelerated Electrification of One lakh villages and One crore households,* which means accelerated electrification of 100,000 villages and 10 million households was created by merging the AREP and Kutir Jyoti programmes. It supported rural electrification programmes by providing 40% capital subsidy and the balance as loan assistance on soft terms.
- *Rural Electricity Supply Technology Mission (REST)* was started with an objective of electrification of all villages and households by year 2012 through decentralized renewable energy technologiesand conventional grid connection.
- *Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)*, a scheme for developing rural electricity infrastructure and expanding household electrification was launched by the government of India in 2005 with the objective of providing access to electricity to all households. With Rural Electrification Corporation (REC) as the nodal agency, individual state governments and power utilities were responsible for programme implementation under the overall supervision of the ministry of power. Under this scheme, 90% capital subsidy was provided for developing rural electrification infrastructure through creation of rural electricity distribution backbone, village electricity infrastructure, and promotion of decentralized distributed generation system from renewable energy sources for villages where grid supply was not feasible. Balance 10% was given as loan assistance on soft terms by REC. The scheme provided for funding of electrification of all BPL households with 100% capital subsidy. Above the poverty line rural households were expected to pay the final connection costs. At the time of inception, the scheme aimed at electrification of over 100,000 un-electrified villages and free electricity connections to 23.4 million rural BPL households. Uniqueness of the RGGVY programme is the involvement of franchisees as the link between the households and electricity utilities as well as functioning as local energy service providers. The franchisees could be NGOs, individual entrepreneurs, cooperatives or local governments.

The status as in 2010 suggested that an amount of about Rs. 287.3 billion was allotted for the scheme. As an outcome, out of about 118,500 un-electrified villages, 79,315 villages were electrified, and a total of 11.8 million households were provided with electricity connections by April 2010.[69] In terms of household electrification, India could electrify only about 28.4% of the targeted rural households (including BPL households) during the four-years, and the achievement was nearly 43% for BPL households, which was a priority target for RGGVY programme.

4.2.3 Salient features and outcomes of these initiatives and programmes: The status of rural electricity access as shown in Figure 2 suggests that all the rural electrification programmes of the past have failed to deliver the desired objective of providing reliable and sustainable electricity access to all. Individually many of the programmes can claim some degree of success, but collectively they have failed to achieve the most important objective of universal access to electricity at least for basic end-use like lighting. Some of the important reasons for such a situation are discussed in the following paragraphs.

Energy provision, rural or urban, in India was always dominated by strong public sector presence and prevalence of excessive subsidies and cross-subsidies. Rural Electrification programme in India was launched with two distinct dimensions, village electrification and connecting irrigation pumps. Indicator of electrification was not based on the percentage of households with access to electricity but merely extension of electricity lines to a particular area. State involvement for providing electricity to rural and disadvantaged section of the population was always prominent.[18]

A number of programmes attempted to enhance rural electricity access either as part of overall rural development or specifically targeting rural electrification. However, multiplicity of programmes meant that the funding for each programme was limited and implementation was ineffective. State utilities received funds for rural electrification mostly as loans from the central government and hence the loan repayment burden had to be borne by them. Further, as electricity regulatory commissions started to monitor functioning of the utilities, and the states were being urged to provide subsidies, the utilities became reluctant to promote rural electrification.[18] Experience from the past programmes suggested that: (a) utilities had difficulties in managing the rural activities due to high cost of operation, low cost recovery, and other administrative issues; (b) utilities had

difficulties in repaying the loans despite availing of cheap loans because of financial difficulties; and (c) where connections were provided, supply was unreliable and the quality of supply poor.[68]

In the Indian context, RGGVY is the largest rural energy access programme implemented till now. The uniqueness of the programme is the involvement of the governments and government agencies at multi-levels in the implementation process. National government and its agencies are involved in funding as well as in implementing the programme along with individual state governments/agencies and the local governments. Corporate level inputs are largely restricted to the involvement of the central and state public sector organizations in the energy sector. Most unique aspect of the RGGVY scheme is the involvement of franchisees as the last mile link between the distributing utilities and consumers. These franchisees are basically the local entrepreneurs functioning as electricity service providers.

RGGVY programme has showed how an effective partnership of stakeholders within the government systems can function efficiently and produce good results, which was not the case with earlier programmes. Unless governments or government agencies get involved and provide large funding, such programmes cannot be implemented successfully in the short-run and maintain & operate sustainably in the long-run. Second important deviation from earlier programmes is that the central government and its agencies are actively participating in the implementation and operation of the programme. Prior to this it used to be carried out entirely by the state governments and agencies including most of the funding for rural electrification. Thirdly, the funding for the programme is borne by the central government to the tune of 90%. The cost of final connection is free for BPL households (one lighting point). Combination of all these has ensured some degree of success of the programme albeit at a slower rate because of the inherent inefficiency of the government system.

However, the focus of the programmes on rural electrification including RGGVY was on providing electricity connections to the households, irrigation pump-sets and other rural entities in addition to building the local electricity distribution infrastructure. To a large extent these programmes ignored the issue of reliability and adequacy of electricity supply. Even in electrified villages, for the households that are connected to the grid there is no guarantee that they will be supplied with electricity continuously. The rural consumers always have to manage with power cuts and load shedding. The physical connectivity provided to them with the development of electricity distribution infrastructure did not ensure access to electricity quality lighting.

5 Summary and Conclusion

The assessment presented in the paper clearly suggests that India has a formidable challenge to face in ensuring security of access to modern energy carriers and associated services to the majority of its rural population and lack of energy access has implications for sustainability of human development. The issue of lack of energy access, especially in the rural context, was always a concern for the government of India. The government came up with many interventions both in terms of new policy initiatives as well as focused national programmes. Even state governments implemented targeted programmes to overcome the energy poverty prevailing in rural regions. However, earlier discussions have clearly brought out that these policies and programmes have failed to achieve the desired objectives. The main reasons for failures of these programmes are the lack of integrated approach, narrow focus, government apathy, bureaucratic inefficiency and ineffective delivery mechanisms. Specifically, expanding rural energy access has been basically guided by target-oriented and subsidy driven national programmes that have either been technology centric (e.g., NPBD, NPIC) or end-use based (e.g., Kutir Jyoti) without having any interlinkages. Further, such a programmatic approach has resulted in an undue emphasis only on meeting the physical targets with hardly any attention being given to either the effectiveness of these programmes or the issues that require a coordinated approach to development. Hence, in spite of many decades of the existence of these programmes their impact on expanding rural energy access and on the development scenario, in general, has been limited, as is evident from the pathetic access levels to modern fuels in rural areas. These suggest that India needs an innovative as well as more radical approach to bridge these energy access gaps.

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