Adopting low carbon strategy for ensuring universal energy access in India: Innovative governance and institutional mechanisms

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Abstract: India has a formidable challenge to face in ensuring security of access to modern energy carriers to the majority of its rural population. In 2011, out of a rural population of about 826 million, 365 million were without access to electricity and 715 million were depending on solid fuels for cooking. This is an outcome of ineffective government policies and programs implemented over the past several years. The fossil-fuel dominated centralized energy supply system has proved to be ineffective in creating physical access to modern energy carriers for the majority of rural population as well as ensuring adequate and reliable energy supply to those who have at least physical access. These suggest that India needs a radical approach to bridge energy access gaps. In this paper, we discuss such an approach, which recommends adoption of (i) modern bioenergy technologies as effective solution for providing affordable, reliable and adequate access to both electrical and heat (cooking) energy for all rural households by 2030 and (ii) an innovative implementation mechanism for effective rural energy governance with specific proposals for effective institutions, rural energy policies, regulatory practices, multi-stakeholder partnerships and entrepreneurial models for energy service delivery. In the next step, this approach is subjected through three-pronged evaluation for its effectiveness by assessing – (i) the implications for energy resources, energy needs and environment, (ii) the economic cost-benefit analysis at the macro level, and (iii) financial cost-benefit analysis at the energy enterprise level. The summary of the results indicate that such a proposal needs an investment of about US$37 billion over a

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period of 20 years and an estimated annual cost of about US$5.2 billion for a GHG mitigation potential of 213Tg CO_{2e} at an abatement cost of US$40/t$CO_{2e}$. The financial feasibility analysis suggests that the proposition is profitable for the enterprises with Internal Rate of Returns (IRRs) in the range of 39%-66%. The households will get reliable access to modern energy carriers for lighting and cooking at an affordable monthly cost of about US$ 2.0.

1 Introduction

India's energy challenges are accentuated by the presence of majority energy poor lacking access to modern energy services, need for expanding the energy system both to bridge this access gap as well as to meet the requirements of fast growing economy and imperative of partnering with global economies in climate change mitigation. Ideally, the desired outcome would be to achieve all the three objectives without compromising on any one. In this context, the burning question, India needs to answer is how to expand access to basic energy services for the large number of energy poor and at the same time make contributions to climate change mitigation. This leads to questions like can climate change mitigation become a stimulus for expanding rural energy access in India and can bioenergy technologies make significant contribution to meeting both the objectives. This study makes an attempt to answer these questions.

Climate change is the most important global environmental challenge facing humanity with implications for sustainable development. Historically, compared to the developed countries, developing countries like India have contributed little to the climate change in the form of GHG emissions. However, in future, growing consumption of energy as well as other resources will influence India to emerge as one of the significant emitters of GHGs. There will be pressures internally as well as internationally to alter the path of development by adopting environment friendly alternatives. In the long run this might prove advantageous to India because it can leapfrog the process of development through adopting advanced technologies, which are energy efficient and use renewable sources of energy. Among the renewable energy sources, biomass energy is the most versatile energy carrier and there are technologies which can transform various forms of biomass into energy carriers that are useful for human kind.

Lack of energy access has implications for economic, social and environmental sustainability (Saghir, 2005, UNDP, 2007, Ezzati and Kammen 2002, Kanagawa and Nakata 2008, Johnson and Lambe, 2009). Even though there is recognition of these linkages as well as the need for expanding energy access, the experiences as well as the literature suggest that the gap between recognition of the need for expanding energy access and action towards this is very wide and ever expanding (Balachandra, 2011a, UNDP, 2007). Partially, this is because energy governance is always biased towards "supply-side" and suggested solutions always revolve around "hardware" aspects (Balachandra 2011a, Srivastava and Rehman 2006). The "demand-side" aspects of energy have always been neglected. The presence of 365 million people without access to electricity and 715 million relying on solid fuels for cooking out of a total rural population of 826 million in 2011 indicate the seriousness of challenge. This is an outcome of ineffective government policies and programs implemented over the past several years (Balachandra, 2012, Balachandra, 2011a, Reddy et al, 2009, Srivastava and Rehman 2006, Planning Commission, 2002, Bhattacharya and Srivastava, 2009, Bhattacharya, 2006, Modi, 2005, Neudoerffer et al, 2001). The fossil-fuel dominated centralized energy supply system has proved to be ineffective in creating physical access to modern energy carriers for the majority of rural population as well as ensuring adequate and reliable energy supply to those who have at least physical access. These suggest that India needs a radical approach to bridge energy access gaps. In this paper, we discuss such an approach, which recommends adoption of (i) modern bioenergy technologies as effective solution for providing affordable, reliable and adequate access to both electrical and heat (cooking) energy for all rural households by 2030 and (ii) an innovative implementation mechanism for effective rural energy governance with specific proposals for effective institutions, rural energy policies, regulatory practices, multi-stakeholder partnerships and entrepreneurial models for energy service delivery. In the next step, this approach is subjected through three-pronged evaluation for its effectiveness by assessing – (i) the implications for energy resources, energy needs and environment, (ii) the economic cost-benefit analysis at the macro level, and (iii) financial cost-benefit analysis at the energy enterprise level.

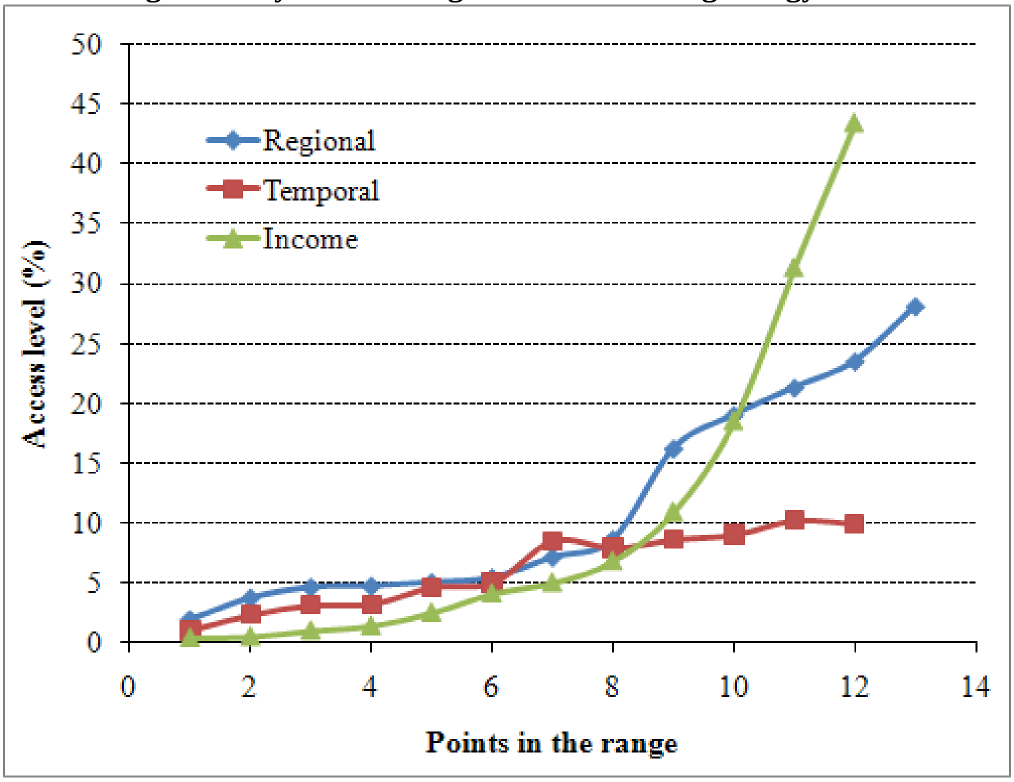
2 Need for expanding rural energy access in India

The rural cooking energy scenario is characterized by inadequate, poor and unreliable supply of energy services and large dependence on biomass fuels. The findings of the National Sample Survey (NSS) indicate that, although about 80% of the Indian villages were electrified as of 2007, only 56% of the households had access to electricity, while the remaining depended on kerosene lamps for lighting. Also in 2007, only 9% of rural households had access to liquefied petroleum gas (LPG) and about 90% were still depending on solid fuels for their cooking energy needs, with only 1.0% having access to kerosene (Balachandra, 2012).

Figures 1 and 2 show an attempt to capture dynamic changes in rural cooking energy and electricity access that have happened over a time period of 23 years, across different income classes and across regions represented by different states in India using the National Sample Survey results (NSSO, 1997, NSSO, 2001, NSSO, 2007, NSSO, 2008). In assessing the status of rural energy access, we have limited our analysis to two indicators, access to electricity for lighting and other basic end-uses, and modern fuels for cooking, in the residential sector. The modern fuels for cooking include Liquefied Petroleum Gas (LPG), Biogas, Kerosene and Electricity.

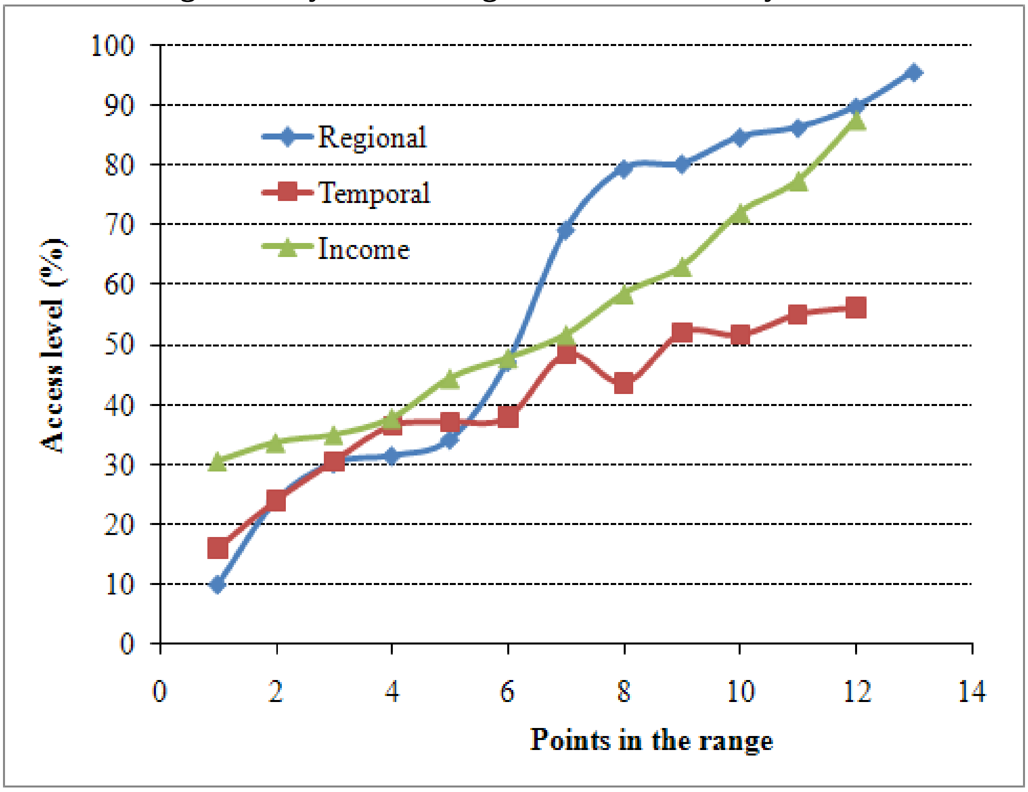
In Figures 1 and 2, the y-axis indicates the access levels whereas the x-axis indicates various points in the range given by the 12 yearly data points during 1984 to 2007, 12 income classes represented by per capita monthly expenditure (PCME) classes in 2005 as a proxy, and 13 states representing various 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 high growth in cooking energy access levels, which is not the case, access level has increased from1% to just 10% in about 23 years. The analysis of the trend shows that the household access levels were growing at a rate of 16.4% annually during pre-1991 period came down to 10.5% during 1991-2001 and further reduced to 3.8% in the post-2001 period. On the other hand the slopes are high for both the graphs showing changes in access levels with respect to income and regions. These are again undesirable trends. One could observe significant variations in access to modern fuels with respect to income levels. The access levels are close to zero at low income levels and they increase to 43% for the highest income level. The regional variations in cooking access levels are again high, which ranges from a low of 1.9% to a high of 28.1%. This suggests that the pro-poor energy access policies of government have failed to achieve the desired results. Similarly, some states have miserably failed in providing energy access to the rural population.

Figure 1: Dynamic changes in rural cooking energy access



Source: Balachandra (2012)

Figure 2: Dynamic changes in rural electricity access



Source: Balachandra (2012)

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. The lowest and highest electricity access levels are significantly high at 10% to 96% compared to cooking energy access which range between 0% and 43%. As in the case of cooking energy access, the temporal variations in electricity access levels are lower than income and regional variations. There is a significant increase in percentage access to electricity with the rise in income levels. Similarly, increase in electricity access also can be seen with respect across regions.

3 Modern bioenergy technologies: A low-carbon solution for universal energy access

Biomass is typically classified into two types, woody and non-woody. Woody biomass is derived from forests, plantations and forestry residues. Non-woody biomass comprises agricultural and agro-industrial residues, and animal, municipal and industrial wastes. The proposal is to use woody biomass for electricity generation through biomass gasification route and soft-biomass (including cattle dung) for biogas production through bio-methanation route.

3.1 Biomass for power generation through biomass gasifier

India's biomass resource base for power generation is substantial. There are large tracts of degraded lands that can be used for growing biomass. An area of about 107 million hectares has been estimated to be degraded with 64 million hectares categorized as wasteland (GOI, 2005). As per the estimates, the minimum waste-land area that might be available for biomass production is about 35 million hectares. Agro-forestry can also be promoted through contract farming whereby corporate bodies can organize groups of farmers to produce the required biomass under contract through development of wastelands. The potential for additional production of woody biomass in the country has been estimated at 255 MT. Out of this, forests wastelands are estimated to contribute 171 MT and the marginal cropland to contribute the rest of 84 MT (Ravindranath and Balachandra, 2009).

Woody biomass can be converted to producer gas for use in internal combustion engines/alternators for electricity generation. Biomass gasifiers are devices performing thermo chemical conversion of biomass through the process of oxidation and reduction under sub-stoichiometric conditions. These systems are used to meet both power generation using reciprocating engines or for direct usage in heat application. Among the biomass power options, small-scale gasifiers (of 20 to 500 kW) have the potential to meet all the rural electricity needs and leave a surplus to feed into the national grid. Indigenously developed technologies for biomass gasifiers have been demonstrated successfully for their rural electrification potential, though on a relatively smaller scale.

3.2 Biomass for biogas production through biomethanation

Currently, biogas is produced in India only through cattle dung as the feedstock. India has the highest bovine population of about 273 million (Kishore, et al, 2007) that produces a total dung of 1,190 MT/year. All of this cattle dung is not available for biogas production and even if the total recoverable dung of 458 MT per year (Vijay, 2006) is used for biogas, it is possible to produce 16 billion m^3 of biogas per year, which can generate 336 PJ of energy per year. The biogas generated will be adequate to meet the cooking energy requirements of about 250 million people. Another alternative is to use soft-biomass as feedstock to produce biogas. The non-fodder soft biomass available in India is estimated to be between 300-600MT (dry) per year (Ravindranath, et al, 2005). Even if we assume that only 300 MT of dry soft-biomass is available per year for biogas production that can produce about 90 billion m^3 of biogas per year at 0.30 m^3 of biogas per kg of dry biomass.

Biogas, a mixture of about 60% methane and 40% carbon dioxide, is a combustible gas, which is the product of anaerobic fermentation of cellulosic materials such as animal dung, plant leaves and waste from food processing and households. Biogas can be combusted directly as a source of heat for cooking. In India, several types of biogas plant designs are being promoted, which use either cattle dung or soft-biomass as feedstock.

3.3 Medium-term potential and achievements

India has a large potential to meet the modern energy needs of cooking and electrification for lighting (Table 1). These estimates of potential are for medium term and are technically and economically feasible. India has implemented a large number of programs to promote bioenergy technologies. However, it can be observed from Table 1 that the spread of bioenergy technologies is marginal compared to the potential available.

Table 1: Bioenergy technology potential and achievements

Item	Potential	Energy Potential	Cumulative Achievements (as on 31-01-2012)
Bioenergy power generation			
Waste land for bioenergy plantation	20 million hectares	45,000 MW	0
Surplus biomass	120-150 MT/year	16,000 MW	1638.71 MW
Bioenergy for cooking/heating			
Cattle dung	458 MT/year	16.03 billion M^3/year	1.22 billion M^3
Soft biomass	300 (dry) MT/year	90 billion M^3/year	0

Source: Based on (Planning Commission, 2006, MNRE, 2012, Ravindranath, et al, 2005, Vijay, 2006)

3.4 Climate change mitigation imperatives and benefits of biomass energy

The common belief is that the GHG emissions from the rural household energy consumption are negligible. The underlying assumption is that most of energy consumed is for cooking and this is mostly derived from renewably harvested fuel wood or agricultural waste, which are considered carbon neutral. This is not entirely true. 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 source (Parikh and Reddy, 1997). The situation might have worsened now considering that biomass use for cooking has consistently remained at same level and availability of firewood is declining. In India, cattle dung is first converted into cakes (mixing the wet dung and loose biomass from crop waste) and dried before being used in cookstoves. This open exposure of dung results in emission of CH_4. The 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. This is equal to about 104 kg CO_2 equivalent per tonne of dung (Chanakya and Balachandra, 2012).In addition, rural household use LPG, kerosene and coal for meeting their cooking needs. Similarly, these households use electricity and kerosene for lighting. Thus, total emissions of GHG from all these energy carriers are likely to be significant.

The estimated GHG emission in 2005 by rural households due to use of various energy carriers was 150 Tg (Teragram). Similarly, the estimated GHG emission in 2005 from lighting energy was close to 20 Tg with almost 58% contribution from electricity consumption and kerosene makes up the remaining share. If we include the electricity used for other end-uses then emissions will increase to about 41 Tg. Thus, household cooking and lighting, the most critical basic end-uses together are responsible for around 170 Tg of GHG emissions annually as in 2005. This is equivalent to per capita (for the rural population) emissions of 210 kgCO_2e per year. If we add the emissions due to electricity consumed for other end-uses, then the total would be about 191 TgCO_2e and the rural per capita household emissions will be about 236 kgCO_2e per year.Global climate change mitigation imperatives have resulted in market mechanisms that, in turn, have created a demand for carbon credits, which then can be translated into revenue opportunities for reducing the cost of energy access. The Clean Development Mechanism (CDM) is a particularly important market for developing countries like India. The estimates suggest that the annual GHG mitigation potential could be as high as 213Tg by 2030.

4 Scenarios of universal rural energy access in India: Cost-benefit analysis at the macro level

The proposal targets at 100% access to modern energy carriers for cooking and lighting by 2030, i.e., in another 20 years starting from 2010. The energy needs are proposed to be met with a judicious mix of energy supply from centralized energy system (electricity grid and LPG) and decentralized renewable energy-based system (electricity and biogas from distributed biomass energy systems). The modern energy carrier considered for lighting is electricity and that for cooking is either LPG or biogas. In the case of lighting, the energy efficient lighting technologies like compact fluorescent lamps are proposed to be used. It is proposed that the programme of expanding rural energy access through decentralized energy systems would be based on market principles by adopting a public-private partnership driven business model approach. The approach adopted here is to construct scenarios of rural cooking and lighting energy access with an a priori target of 100% access by 2030.

The 2010 access levels for modern energy carriers are estimated using growth rates obtained from the household energy dependency shares during 1999-2000 and 2004-05 (NSSO, 2001, NSSO, 2007). The number of rural households in 2010 is estimated using data from United Nations Population Division (UNPD) and 2001 Census (Census, 2005, UNPD, 2008). Having derived 2010 status and decided about the 2030 status of rural household energy access, the next step is to determine the trajectory of the path of the growth in energy access till 2030. Only two aspects become important for this, speed at which the target is to be achieved and willingness to make the investments by the government, public and private sectors. The objective of developing these scenarios is to ascertain the implications for energy resources, investments, operating costs and carbon emissions.

Table 2 contains the summarized scenario results of cooking and lighting energy needs in 2030. Results for two alternatives, LPG-based and biogas-based cooking for all the households, are presented. As per the predictions, there are expected to be about 188.2 million rural households in India. Out of these, about 25 million have access to modern energy carriers for cooking in 2010 and the remaining 163 million requires to be provided access during the next 20 years. Out of these, about 48 million are expected to have LPG connections whereas the remaining 115 million biogas connections. The total biogas requirement is about 33.6 billion M^3 and for this, the estimated annual soft biomass (dry) requirement is about 67 million tonne, and the annual wet dung requirement is about 355 million tonne. The demand for LPG would be about 9.4 million tonne by 2030. The transformation from biomass to modern energy carriers for cooking has significant cost implications (Table 2). All the cost estimates are in 2009 Indian Rupees (Rs.). The cooking energy access scenario has an annual cost implication of about Rs. 336 billion by 2030 including the annualized capital cost discounted 10%. The total investment over a period of 20 years is about Rs. 867 billion.

The GHG mitigation benefits of the proposed cooking energy access scenarios are significant. The baseline scenario for 2030 representing no interventions to expand rural energy access is expected to contribute nearly 184 million tCO_{2e} annually. The proposed scenario results in significantly lower emission levels of just 29 million tCO_{2e} per year. There is an additional benefit of mitigation of CH_4 emissions equivalent of 37 million tCO_{2e} per year by avoiding the open exposure of cattle dung. Thus, the proposed scenario, if adopted, can contribute to GHG mitigation of nearly 192 million tCO_{2e} annually. The GHG abatement cost of Rs. 1,756/tonne (US$ 37.4/tonne) is attractive considering related development benefits.

Similar scenario results for 100% electricity-based lighting access are presented in Table 2. As per the projections made about 105.5 million households are estimated to have access to electricity for lighting in 2010 and the remaining 82.8 million households requires to be provided access in the next 20 years. Out of these rural households, about 49.7 million are expected to have grid-based electricity connections whereas the remaining 33.1 million households are to be connected to the biomass-based distributed electricity systems. The results indicate that by 2030, the centralized grid is expected to supply about 90% of the electricity needs of the rural households for lighting and the remaining 10% to be contributed by the distributed electricity. The installed capacity required to provide lighting access for the incremental households is approximately 6,500 MW with 4,000 MW from the grid and 2,500 MW from distributed biomass power. From Table 2, it may be observed that the total investment over a period of 20 years is about Rs. 697 billion with grid supply accounting for Rs. 493 billion and biomass gasifier power for Rs. 204 billion. On the other hand, the total annual cost (including annualized capital cost and recurring cost) of biomass gasifier-based electricity access is at Rs. 22.9 billion compared to grid-based access at Rs. 29.6 billion. The annual GHG mitigation potential is expected to be 12.4 million tonne. The GHG abatement cost of about Rs. 4,233/tonne (US$ 90.1/tonne) is relatively high in the present context.

Table 2: Rural household energy scenario in 2030

	Cooking		**Lighting**	
Characteristic	**LPG**	**Biogas**	**Grid**	**Biomass gasifier**
Total households in 2030 (Million)	188.2			
Households with access as on 2010 (Million)	24.7	0.3	105.5	0.0
Households provided with access during 2010-2030 (Million)	48.4	114.8	49.7	33.1
Annual fuel/electricity usage per household (kg or M^3 or kWh)	128	292	65.0	65.0
Annual energy requirements (Million Tonne or billion M^3 or GWh)	9.4	33.6	20,627	2,152
CO_2 emission factor (kg/GJ or kg/kWh)	67.4	0	0.83	0.0
Baseline CO_2 emissions per year (Million Tonne)	61.3	122.2	23.4	6.0
Alternative CO_2 emissions per year (Million Tonne)	29.0	0	17.1	0.0
CO_2 emissions mitigation potential per year (Million Tonne)	32.3	159.2	6.4	6.0
Annual recurring cost (Rs. Billion)	131.0	95.5	3.8	7.0
Installed capacity required (MW)	---	---	4,022	2,500
Initial investment for generation capacity (Rs. Billion)	---	---	175.8	81.2
Initial investment for transmission system (Rs. Billion)	---	---	128.7	0
Initial investment for stoves (Rs. Billion)	130.6	114.8	---	---
Initial investment for biogas plant (Rs. Billion)	0	356.8	---	---
Initial investment for distribution system (Rs. Billion)	0	265.2	64.4	40.0
Initial investment for final connection (Rs. Billion)	---	---	109.2	72.8
Initial investment for CFLs (Rs. Billion)	---	---	14.9	9.9
Total investment (Rs. Billion)	130.6	736.8	493	204

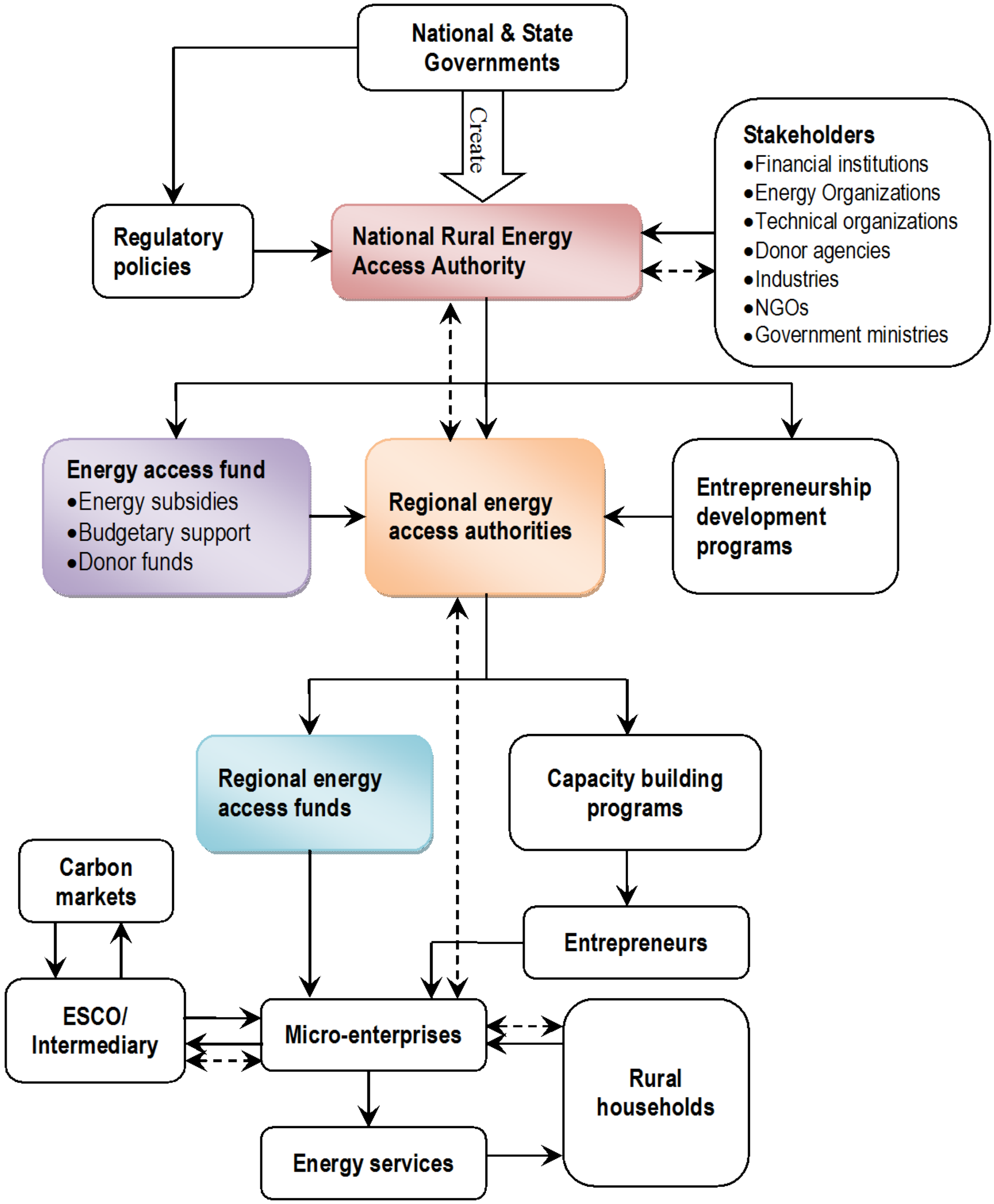
The overall annual cost implication of providing access to modern energy is about Rs. 389 billion (about US$ 8.6 billion). In addition to providing energy access, the proposed programme contributes to annual GHG mitigation of 213 million tonne at an abatement cost of Rs. 1,826/tCO_{2e} (US$ 40.6/tCO_{2e}).The whole programme needs an overall investment of Rs. 1,571 billion (US$ 35 billion) over a period of 20 years. Out of this, the major shares are accounted by the investments required for establishment of the distribution systems to supply biogas and electricity to the households at 24%, construction of biogas plants at 23%, and purchase of end-use devices and addition of new generation capacity at 17% each.

5 Sustainable Energy for All: An Innovative Governance and Institutional Mechanism

The proposed approach is a public-private-partnership-driven 'business model' with innovative institutional, regulatory, financing, and delivery mechanisms. Some of the innovations recommended for adoption are (Balachandra, 2011b) – (i) *Multi-stakeholder and multi-level* implementation programme, (ii) Enacting an exclusive *integrated rural energy policy*, (iii) Creation of exclusive *rural energy access authorities (REAAs)* within the government system as leadership institutions, (iv) Establishment of *energy access funds (EAFs)* to enable transitions from the regime of *investment/fuel subsidies* to *incentive-linked* delivery of energy services, (v) *Integration of business principles* to facilitate affordable and equitable energy sales to households and carbon trade, and (vi) Treatment of *entrepreneurs as implementation targets* and not millions of rural households.

An earlier paper by the author describes the proposed implementation framework (Figure 3) in detail (Balachandra, 2011b). The framework represents a top-down approach with the government/s represented by the appropriate ministries at the top and the rural households, at the other end reaping the benefits. The framework entails establishment of the rural energy access authorities (REAAs) both at the national and regional levels to be empowered with enabling regulatory policies and supported by the multi-stakeholder partnership. The national REAA is expected to establish the national energy access fund (EAF), support the creation of and coordinate with the regional REAAs, and develop a comprehensive entrepreneurship development programme with inputs from stakeholders. The regional REAAs are expected to manage the regional EAFs and facilitate the conduct of intensive capacity building programmes for the prospective entrepreneurs. At the other end, the trained entrepreneurs are envisaged to establish village-level energy micro-enterprises to produce and distribute energy carriers to rural households at affordable cost. The energy service companies (ESCOs) will function as intermediaries between these enterprises and the international carbon market in aggregating certified emission reductions (CERs) and trading them under clean development mechanism (CDM) or similar mechanisms. As per the proposal, the ESCOs would share carbon trade proceeds with energy enterprises at pre-determined rates. The financial institutions are expected to lend to these energy enterprises as well as ESCOs at soft interest rates under priority lending schemes.

Figure 3: An Innovative Governance and Institutional Framework



Source: Balachandra (2011b)

5.1 *Integrated rural energy policy*

The proposal recommends introduction of an integrated rural energy policy (IREP). The advantage is that most of the components of this proposed policy framework already exist in various energy policy documents developed by Indian government at different times. Therefore the recommendation is to extract relevant policies from these documents and include them in the proposed IREP. In addition, IREP also needs to include some new policy guidelines to facilitate establishment of new institutions and to expand the scope of currently pursued initiatives on expanding energy access (Balachandra, 2011b). It is proposed that the IREP need to include policies to enable setting-up of exclusive REAAs both at the national and regional (states) level as nodal agencies. These authorities need to be empowered with exclusive powers to initiate, establish, manage, support and supervise programmes for expanding energy access. It is also required to establish EAFs both at the national and regional level to support implementation and sustainable operation of the programme. The EAF should be established with contributions from the diverted fossil fuel subsidies, budgetary allocations, plan grants and donor funding. The proposed IREP should have policy guidelines to facilitate establishment of a large number of rural energy enterprises. They should be enabled to carry out the business of all-inclusive energy service providers including production of energy carriers. The scope of these enterprises should be enlarged to include electricity generation from distributed power generation systems, performing transactions between the distributing utilities and the rural households, LPG distribution, usage of the infrastructure created by the government and establishment of biogas supply systems for supplying cooking gas.

5.2 *Rural energy access authorities*

Second critical recommendation is to establish rural energy access authorities (REAAs) both at the national and regional levels. The national REAA could be established on the lines of Central Electricity Authority (CEA) including the bureaucratic structure. Empowered group of ministers (EGoM) from all the relevant ministries under the chairmanship of the Prime Minister could perform the leadership roles and take crucial policy level decisions. In addition, there could be an advisory group with representatives from relevant stakeholders providing technical as well as expert inputs. The role of REAA is to design implementable programmes, support its actual implementation along with regional REAAs and other stakeholders, and monitor its progress. The regional REAAs also could be structured on similar lines keeping the state-level administrative system in mind. They are the ones who would be implementing the programmes, conducting entrepreneurship development programmes, interacting with the entrepreneurs, and providing incentives.

5.3 Energy Access funds

Third most important proposal is to establish energy access funds (EAFs) at the national as well as state levels. The past efforts in expanding energy access have shown that providing capital subsidies do not ensure success of the initiatives. Just establishing energy infrastructure at free of cost cannot guarantee their continuous operation because energy benefits alone may not motivate individuals to use these assets continuously. Surplus revenue streams or cash incentives are likely to be better motivators for sustained performance of energy systems. The need is to convert “capital subsidies” into “operational incentives”. Further, the entrepreneur would be more responsible towards the asset provided he has invested into the asset either through a loan from a financial institution or equity contribution or both. Thus, “burden of investment” and “operational incentives” can be expected to be more effective. It is proposed that the EAFs will contribute to the payment of operational incentives to the entrepreneurs. These incentives should be linked to the performance levels of the energy enterprises in terms of quantity of energy carriers sold to the rural consumers.

5.4 Multi-stakeholder partnerships

These kinds of innovative processes aiming at universalization of energy access through bioenergy, in addition to centralized access through grid connection and LPG supply, have to pass through a number of hurdles. These barriers are created by various stakeholders of energy systems and their involvement is absolutely necessary to overcome them. Government/policy makers, energy organizations/utilities, technical institutions and R&D organizations, industries, entrepreneurs, financial institutions, donor agencies, NGOs and rural households need to join together to achieve the objective of universal rural energy access.

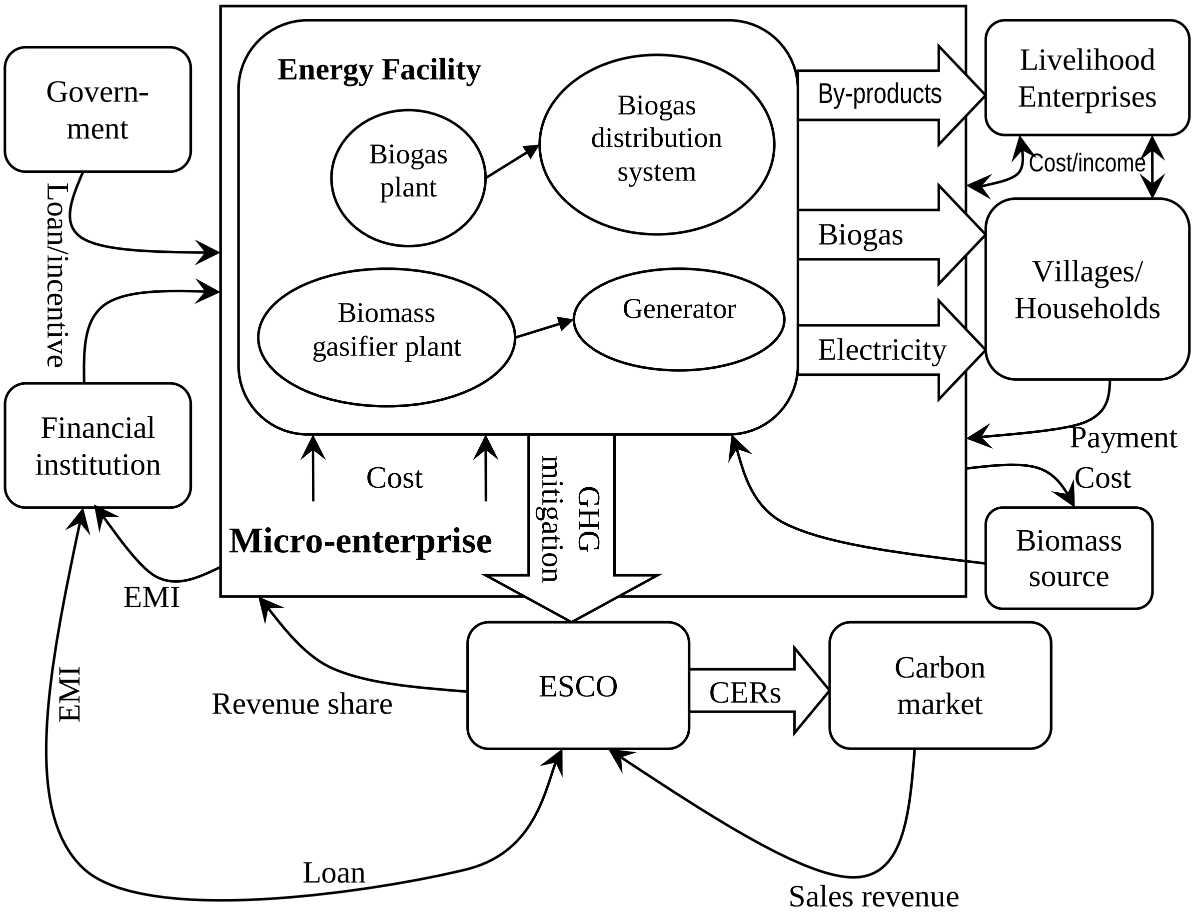
5.5 Micro-enterprise for rural energy services

The final delivery of energy services to the rural households is to be performed by the micro-enterprises. The overall structure of the micro-enterprise would be as shown in Figure 4 (Balachandra, 2011b). The enterprise would own an energy facility consisting of biogas plants, either based on biomass or cattle dung or both types, for producing biogas and biomass gasifier plants for generating electricity. The energy infrastructure would also include biogas distribution system connecting every household in the village/s. This would ensure piped biogas supply to the households. For electricity access, the existing electricity distribution infrastructure would be used under lease from the government utilities at pre-determined leasing rates. The entrepreneurs are also can directly purchase electricity from the grid and perform only the distribution of it to the rural customers. Similarly, LPG also can be procured from the government agencies and distributed to the households. A mixed strategy with purchased quantity complementing own production, especially for electricity, could be the preferred choice.

The financial institutions are expected to support the enterprise with loans at favorable terms and government entities to support with incentives to enhance profitability. In addition, the entrepreneur is expected to invest in the enterprise as his or her equity contribution. For the entrepreneur, the financial inflow is in the form of payments received from the households, revenue share from the ESCO due to CER sales and operational incentives from the government. The enterprise could enhance its revenue by selling the surplus energy carriers at higher prices to other sectors of the rural economy and to households for other than basic end-uses (lighting and cooking). The financial outflow for the entrepreneur would be for equated monthly installments (EMI) for loan repayment, and expenses related to O&M and purchase of biomass.

An ESCO would bundle many such enterprises and present a single potential CDM project to the international carbon market. It will transform the GHG emissions mitigated into CERs and trade them in the carbon market. In this process, the ESCO need to bear both the fixed and variable transaction costs and again it would seek loans from the financial institutions. The revenue from CER sales would be shared with the entrepreneurs. Thus, financial inflow for the ESCO would be revenue from CER sales and the outflow would be the EMI for loan repayment and the revenue shared with the entrepreneurs.

Figure 4: Micro-enterprise for rural energy services



Source: Adapted from Balachandra (2011b)

6 Micro-enterprises for expanding rural energy access: A financial feasibility analysis

The success of any business is dependent on the level of profits it could earn. Thus, a financial feasibility analysis of a business proposition is very much critical to assess its profitability potential. The estimates of net present value (NPV) and internal rate of return (IRR) are excellent indicators of profitability of a business. The financial feasibility assessment of two possible rural energy enterprises is performed. The first one is adopting biomethanation technology for producing biogas for cooking by using cattle dung and biomass gasifier technology for generating electricity for lighting and other end-uses. The second enterprise uses soft biomass for producing biogas and biomass gasifier for generating electricity. For ease of understanding, the first enterprise is named as Biomass-Dung-Energy-Enterprise (BDEE) and the second one as Biomass-Biomass-Energy-Enterprise (BBEE).In both the enterprises, energy efficiency is integrated with the inclusion of compact fluorescent lamps (CFL) for household lighting. While performing the financial feasibility study of energy enterprises, the following assumptions have been used – (i) The number of households per enterprise is assumed to be equal to 1000, (ii) an equity contribution of 20% of the investment will be contributed by the entrepreneur. Remaining 80% will be obtained as a loan at a subsidized interest rate of 6% with a repayment period of 5 years, (iii) a discount rate of 10% is used for estimating the present values of cash flows happening in different years, (iv) a price for Certified Emissions Reduction (CER) of US $20/t$CO_2$ and a conversion rate of Rs. 50/US$, and (v) the benefits for households are on account of cost and efforts saved due to non-use of biomass, and the cost is the monthly payment to be made to the entrepreneur. All the costs related to distribution infrastructure, operations and maintenance (O&M) and end-use devices are to be borne by the entrepreneur.

The results show that the Net Present Value (NPV) for the entrepreneur from BDEE model is about Rs. 21.1 million and that for BBEE model is about Rs. 13.4 million and this could be compared with the original equity contribution of Rs. 2.5 million (Table 3). The internal rate of returns (IRRs) of 66% and 39% respectively for the two types of enterprises show the benefits are significantly higher than the costs. The profitability analysis shows that the financial performance of both enterprises is extremely high and can be attractive even without government incentives. The avoided methane emissions are mainly responsible for higher returns in the case of BDEE. For a bundling intermediary (an ESCO), a bundle of either 20 BDEEs or 30 BBEEs would be feasible from the point of view of cost implications and the need for retaining the status of small-scale CDM project. The results suggest that the financial returns with NPVs of about Rs. 12.9 million and Rs. 15.4 million respectively for the two project cases seem to be very attractive (Table 4). Again the IRRs of 68% and 47% further prove the profitability nature of these CDM projects for the ESCOs.

Table 3: Financial feasibility of energy enterprise from entrepreneur's perspective

Characteristic	BDEE	BBEE
Contribution by entrepreneur @ 20% equity (Rs. million)	2.50	2.50
Loan amount (Rs. million)	10.0	10.0
Equated monthly installment, EMI (Rs.)	197,977	197,977
O&M cost (Rs./month)	221,577	221,577
Annual CO_2 emissions reduction (tonne)	2,688	1,682
CDM revenue from intermediary (Rs./month)	199,685	121,868
Household repayment (Rs./month)	340,944	340,944
Profit per month for the first 5 years (Rs.)	121,075	43,258
Profit per month for the remaining 20 years (Rs.)	319,052	241,235
Internal rate of return (IRR) - %	66%	39%
Net present value (Rs.)	21,131,724	13,426,090

Table 4: Financial feasibility of energy enterprises from ESCOs perspective

Characteristic	BDEE	BBEE
No. of enterprises	20	30
Annual CERs available for sale	53,759	50,460
Revenue from CERs (Rs. million)	53.76	50.46
Transaction cost (Rs. million) - One time	3.5	4.0
Transaction cost (Rs. million) - Annual	3.	3
Intermediary’s contribution @ 20% equity (Rs. million)	0.7	0.8
Loan amount (Rs.)	2.8	3.2
Equated monthly installment, EMI (Rs.)	55,392	63,306
O&M cost (Rs./month)	120,000	180,000
Net profit from CER sales (Rs. million)	48.65	44.54
Share of profits @1.5% for the first 5 years (Rs. Million)	0.7	0.7
Share of profits for the remaining 20 years (Rs. Million)	1.4	1.4
Share of profit for entrepreneurs (Rs. million)	47.92	43.87
Internal rate of return (IRR) - %	107%	88%
Net present value (Rs)	8,580,346	8,436,599

7 Conclusions

The study discusses an innovative governance and institutional approach to simultaneously address the challenges of sustainable access to modern energy carriers in rural India and global climate change mitigation by adopting modern bioenergy technologies, a low carbon alternative. The results establish the fact that such a model if implemented will result in a win-win situation for all the participating stakeholders. The rural households can enjoy the benefits of modern energy carriers at affordable cost; the rural entrepreneurs can run the profitable energy enterprises; carbon markets can have access to large quantity of carbon credits; the Indian government can have the satisfaction of securing energy access to a large section of the rural population; and globally, there is a benefit of climate change mitigation. The outputs also falsify the notion that the social enterprises are always bound to make losses. It has been proved in this study that the enterprises created to maximize the social benefits can also maximize the private benefits. By adopting a proper business model integrated with efficient incentive schemes can simultaneously provide economic/livelihood benefits to the rural population while earning handsome profits to the entrepreneurs.

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