Off-grid Energy in Rural India:

Policy Recommendations for Effective UN Projects

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This paper represents my own work according to University Regulations.

Abstract

Rural areas in developing countries suffer significantly from energy scarcity, forcing people to rely on traditional biomass as their primary energy source. The current approach of the government of India (GOI) to solve this problem focuses on extending the electricity grid, which fails to attend the real needs of poor people and is too expensive. This paper discusses the potential use of off-grid energy technologies, like improved cooking stoves, biogas digesters, and micro hydropower, as an alternative for grid extension. This is followed by four policy recommendations to ensure that UN rural energy projects are effective in complementing the GOI's efforts and attending the basic energy needs of the most poor in rural India. These recommendations are: to provide micro-credit and consulting for the promotion of off-grid renewable energy technologies (RETs); to focus on alleviating women's energy needs, particularly cooking; to include capacity building in energy projects by creating partnerships with the community and providing technical assistance; and to financially support local entrepreneurs who could either benefit from energy access or supply their communities with energy services.

Timeline

I. Introduction

Energy, an essential need for every individual and for economic development, has always been particularly lacking in rural areas of developing countries, were rural areas are defined as sparsely separated, faraway from large cities and in many cases, in difficult terrain. Most people who live in rural areas rely primarily on farming, although some times they have small businesses or the main income-providers commute for jobs in urban centers. Rural areas in developing countries are severely deprived of dependable energy, which they need primarily for household use (mainly cooking), water pumping for agriculture and domestic use, and small scale industry, as shown in table 1. Most of the energy needs in rural areas are met with traditional biomass for household uses, and human and animal power for agriculture.

This paper will first analyze the main problems involving energy provision for poor people in rural areas of developing countries, with a focus in India. Although the focus of this paper is energy, not electricity, access to electric connectivity and the reasons for low electrification rates in rural areas will be analyzed in order to show the urban-rural differences and the challenges for the government in rural areas. Other topics that will be covered are: the dependence on biomass, the energy ladder, the negative effects of energy scarcity, and the additional benefits for development that are possible with access to energy. This paper will then review available off-grid technologies that can be promoted by the UN, development institutions, and NGOs in rural India. These technologies focus on particular end-uses, like efficient wood-fueled cooking stoves, biogas digesters for fuel production, or wind turbines for water pumping, as well as independent electricity systems for households and village micro-grids.

This will be followed by an explanation and analysis of the Government of India's (GOIs) approach and goals in respect to rural electrification. Considering that the GOI's plans are over-ambitious and that they do not attempt to solve the main energy needs of the most poor, this paper will then discuss and offer recommendations on four elements that must be included in the United Nation's rural energy projects in order to complement the GOI's efforts and make off-grid energy affordable and available in rural India. The focus of these elements will be on the end-use of alternative off-grid technologies that meet the needs of families and individuals who suffer the most from energy scarcity. It is important to note that this paper does not aim to either improve government rural electrification programs or improve projects the UN has done in the past. These four elements are: the use of renewable energy technologies (RETs), the importance of prioritizing women's energy needs, the need for capacity building and technology development with local resources, and the importance of linking increase in energy access to income generation and wealth creation.

II. Understanding the Energy Problem

A. Lack of Energy in Rural Areas

Although this paper is about energy needs, not necessarily electric connectivity, electrification rates are a good benchmark to measure urban-rural differences. Currently, there are 1.6 billion people in the world who lack electric connectivity in their homes, and four fifths of these people, or about 1.3 billion, live in rural areas, most of them in Africa and Asia (Priddle 2002).[1] It is important to note that even in rural areas where electricity is accessible, connectivity is often severely interrupted, resulting in high rate of burnouts of pumps, motors, and transformers (Rizvi 2004, p. 9). With 580 million people lacking electricity connection,

[1] Although this number is staggeringly high, there have been connectivity rate increases in the past 30 years, as world rural electricity rates have gone from 12% in 1970 to 57% in 2000 (Priddle 2002). Most of this improvement, which has occurred primarily in the last 15 years, has taken place in China, a country that has extended rural electrification to about 500 million people since 1990 (McDade 2004). Despite the percentage drop, the number of people without access to electricity in rural areas has remained the same because of population increase (Johansson et. al. 2004).

India is the country with the most people without access to electricity in the world. Just about 56% of its population has access to electricity at the national level, and 44% in rural areas (Priddle 2002). This means that more than 400 million people in rural areas are still lacking access to electric services (Rizvi 2004).[2]

The main reason for lower electrification rates and higher costs in rural areas worldwide is that grid extension is more expensive in rural than in urban areas. The high transmission and distribution costs in rural areas make it unattractive, especially since most people are poor and thus unable to pay for electric services (Johansson et. al. 2004).[3] In other cases, when subsidized grid extension does reach rural areas, the tariffs are too high for people to pay because the existent demand is too low (United Nations 2005). For example in India, according a report from the International Energy Agency, "the electricity network is technically within reach of 90% of the population, [but] only 43% are actually connected because people cannot afford the cost of connection" (Priddle 2002, p. 376).

B. Dependence on Traditional Biomass

Poor people lacking adequate energy services in rural areas rely mainly on traditional biomass: firewood, charcoal, and animal dung. In fact, for the purposes of this paper, the use of traditional biomass is a better standard than electric connectivity to help understand the breadth of the energy problem and the urban-rural differences in regards to energy. As shown in table 1, cooking is the main use of energy in rural households, consuming up to 85% of the total energy use (Aeck et. al. 2005). Currently, about 2.4 billion people, mostly in developing countries,

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[2] Of the 138 million households in rural areas, just about 60 million have access to electricity (Rizvi 2004).

[3] According to a World Bank study on several developing countries, "grid extension to rural areas typically ranges from $ 8,000-$ 10,000 per kilometer, not including the cost of materials, which adds an additional $ 7,000. This high cost, coupled with low capacity utilization of such grids due to very small loads, makes extension economically unviable to utilities" (Aeck et. al. 2005, p. 17).

depend on traditional biomass, representing 40% of the world population.[4] The use of traditional biomass is more prevalent in rural areas, simply because biomass is more available and other fuels are harder to get (Aeck et. al. 2005). This number is greater than the number of people who lack electric connectivity because cooking with electricity is too expensive, and thus many people who do have electricity access continue to rely on biomass until they move up to kerosene or liquefied petroleum gas (LPG). In India, the number of people still using traditional biomass lies at about 585 million, representing 58 % of the population (Priddle 2002, p. 11). As Rangan Banerjee points out in *Energy Policy*, overall "biomass (fuel wood, crop residues and cattle dung) accounts for about 40% of India's primary energy use," with the largest portion being consumed in rural areas (Banerjee 2006, p. 106).

C. Climbing the Energy Ladder

The "energy ladder" is a concept that describes the resources and end uses of energy in poor rural areas relative to income, showing how poor people in rural areas meet their energy needs as their income increases. For household use, the first footstep of the ladder is biomass, with the second step being kerosene and LPG, and finally electricity, as shown in table 2. It must be noted that for different uses, like agriculture and small businesses, there variations to the energy ladder, particularly with the increased used of animal and human power.

As this paper tries to analyze alternative solutions to the traditional energy sources, there are three issues of the energy ladder that are of paramount importance: the first one is that biomass is the hardest footstep to move past because it is regarded as "free;" families in rural areas simply gather firewood, there is no monetary cost involved. Thus, the idea of paying for technology, especially renewable energy technologies (RETs, which have high capital costs),

[4] About 50% of the population in Africa, 25% in Asia and 18% of the population in Latin America depend on biomass (Martinot 2005).

does not make sense for poor people in rural areas. The second issue is that, as an International Energy Agency report indicates, there is a "widespread misconception that electricity substitutes for biomass. Poor families use electricity selectively – mostly for lighting and communication devices. They often continue to cook and heat with wood or dung, or with fossil-based fuels like LPG and kerosene" (Priddle 2002, p. 369). Thus, moving up the energy ladder includes both, innovative technologies for specific end-uses and modern improved uses of traditional fuels. Finally, the third issue is that there is a misconception that moving up the energy ladder is completely dependent on affordability (or income), but it must be noted that availability and cultural acceptance are equally important (Priddle 2002).

D. Negative Effects of Energy Scarcity

Before looking into potential solutions to the energy problem, the negative social and environmental effects of lacking energy in rural areas must be visited in order to have a clearer understanding of what issues need to be addressed. One of the worst effects of energy scarcity is the time spent by women and children finding firewood, particularly for cooking. According to Practical Action, an international NGO that aims to provide practical solutions to poverty and sustainable development, "poor people spend up to a third of their time on energy, mostly to cook food. Women, in particular, devote considerable amount of time collecting, processing and using traditional fuels for cooking. In India, two to seven hours each day can be devoted to the collection of fuel for cooking" (Practical Action 2005, p. 7). Aside from the cost and time, women are exposed to snake bites, threats, assault, and health problems like back pain, neck pain and fatigue from carrying heavy loads for long distances (McDade 2004). The time that women spend finding firewood and water for the household could be used for income-generating activities, and the time children spend could be spent in schools. Indoor air pollution is also a major negative effect of dependence on biomass because of the emissions of carbon monoxide, nitrogen oxides and most importantly, particulate matter. Up to one billion people, mostly women and children, are daily exposed to indoor air pollution at levels exceeding WHO guidelines by 100 times, causing respiratory illnesses to children, premature deaths, and miscarriages to pregnant women. Approximately 1.6 million people die from indoor pollution every year, making indoor smoke the fourth greatest health-associated killer (Wilkins 2002, p. 27; Practical Action 2006b, p. 2).[5] A third negative effect is the harm caused to the environment, since the use of firewood for households is not done in a sustainable fashion, although it is much less than the deforestation caused by the clearing of land for agriculture and grazing (United Nations 2003).[6] One final problem is the trade-off between using biomass for energy versus agricultural purposes, particularly when the biomass used is animal dung, since it could be used as fertilizer (Priddle 2002).

E. Energy and Rural Development

Aside from cooking, energy could also benefit families in rural communities by providing thermal comfort and allowing them to pump water for drinking and irrigation. Electricity is used mainly for lighting and electronic equipments used for information and communications, like TVs, radios, and telephones. However, with domestic access to electricity it is hard to know its final effect on a family's wellbeing. According to a study by the United Nations, "rural electrification benefits higher-income segments of populations more than lower-income segments, and it often exacerbates rural poverty gaps and gender inequities" (United Nations 2005, p. 33). Other experts show that the difference between connectivity and no

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[5] This accounts for 20% of child deaths, more than those from malaria (McDade 2004). "In India, the pollution from household solid fuel use causes an estimated 500,000 premature deaths a year in women and children under the age of five" (Wilkins 2002, p. 30).

[6] It must be noted that there is a common misconception that firewood for energy is a major cause of deforestation, but the reality is that most people who fetch firewood get already dead wood.

connectivity (even if the use of energy is minimal) is significant. Akanksha Chaurey, in *Energy Policy*, points out that the "positive contribution of electricity to the Human Development Index is strongest for the first kilowatt-hour" (Chaurey et. al. 2004, p. 1).

At a community level, energy needs such as water pumping are absolutely necessary, yet the best way to improve wellbeing is with electricity. For example, electricity can have a major positive effect on education, as it enables the use of photocopiers, computers and other educational media, opens the possibility of having night classes, mainly for the education of adults, and attracts teachers that would otherwise be shied away, especially if their accommodations have electricity (Aeck et. al. 2005). Energy services are also beneficial for health as it provides improved access to better medical facilities, including refrigeration, equipment sterilization, and operating theatres (McDade 2004).

Energy services also enable income-generating activities and micro-enterprise, a topic that will be emphasized strongly in this paper given that the most effective policies for increasing energy access and electrification rates have to go hand-in-hand with increasing income, creating jobs, and empowering poor rural communities. Some forms of energy (that are not electricity) for business in poor rural areas can range from food processing, brick making, pottery and water pumping for irrigation (Rogers et. al. 2000). In India, most of the energy use in rural areas is for agriculture irrigation, and this energy is mostly met with animal and human power. Electricity is also beneficial for business as they allow longer operating hours, cleaner and safer working conditions, consumer draw (radio, fans, and televisions), mechanization/automation, product preservation (refrigeration), ice making, communications and workers' training (Rogers et. al. 2000).

III. Off-Grid Alternative Technologies

Before analyzing the elements that must be included in UN projects for rural energy, this paper will review some off-grid technologies that can serve as solutions to the rural energy problem in India. The following sections lay out the available off-grid technologies, analyzes their advantages and disadvantages, and helps understand the different end-uses each technology can meet. Both, off-grid technologies for different direct-uses and technologies for electric-micro-grids are considered.

As mentioned above and as shown in table 1, poor families use energy mainly for cooking. The cooking stoves they use are mainly made of mud and brick, and According to Practical Action, they are 10-15% efficient. Thus, the first technology to be considered for improved access in rural areas are more efficient cooking stoves, called improved chulas (IC) in India, which continue to burn wood, but have much higher efficiencies, reaching up to 40% (Practical Action 2006). Today, a number of low-priced modern wood-fueled ICs have been developed, with improvements based on enclosure to retain heat, maximization of heat transfer to the pot and improvement in combustion. Aside from being more efficient and thus enabling women to spend less time finding wood, emissions of indoor pollutants are also reduced. An International Energy Agency report states that "because biomass with continue to dominate energy demand in developing countries in the foreseeable future, the development of more efficient biomass technologies is vita for alleviating poverty, creating employment and expanding rural markets" (Priddle 2002, p 390). A second technology for cooking is thermal solar cooking, which uses the heat from the sun (Rogers et. al. 2000). Solar thermal cookers can be 30% to 70% more efficient than regular cooking stoves, and the production costs are decreasing dramatically. The main problem with solar thermal energy is the drastic differences with traditional uses for cooking, which might result in significant cultural barriers.

Biogas digesters also hold great promise in delivering change in rural areas, especially in India, where there are large amounts of cattle. Biogas is produced from animal and human waste through a process known as anaerobic digestion, done with organic matter.[7] The marsh gas, or methane, produced, can be used as fuel, replacing traditional biomass or even kerosene and LPG. Some of the advantages of biogas are that there are lots of animals in India, thus it can be produced at low cost, and that the technology to make biogas can be produced locally as well. Furthermore, as Practical Action states, "small-scale biogas production in rural areas is now a well-established technology," particularly China and India (Practical Action 2006).

Other modern uses of biomass are also great alternatives for replacement of traditional forms, especially in India. Alternative biomass consists mainly of agricultural residues, like rice and coffee husk, and sugar bagasse. The biggest problem with agricultural residues for energy is the low energy per volume, which makes it difficult to handle and transport, but there are several ways of solving this problem, like the making of briquettes (pieces of condensed agricultural residues). One of the main advantages of biomass residues is that they can replace traditional fuel wood directly.

Solar Photovoltaic (PV) Panels have recently become a popular solution to target energy problems in disconnected areas. PV panels are particularly good for independent systems for the production of electricity, like street lighting, community facilities, or solar home systems (SHS) (Rodolico 2005).[8] This is different from hydropower, for instance, where a minimum size is required and there are expansionary limits based on the size of the river and the capacity of the

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[7] The waste is fed into a digester and an anaerobic decomposition inside the digester produces methane and carbon dioxide (in a ration of about 6:4) (Practical Action 2006).

[8] SHS consist of a PV module with 18-75 W capacity and a battery (Chaurey et. al. 2005, p. 15).

turbine. Another advantage of PV panels is that most of them have proven to be reliable, durable, require low maintenance, and last up to 30 years.[9] The main problems with PV panels for SHS are the high capital cost (as well as installation cost), the need of a battery, which has to be replaced every four to five years thus increasing operating costs, and the fact that they cannot be produced locally and that spares are expensive. Larger PV panels can be used for electricity-micro grids, although the technology might still be too expensive.

A second technology that has become increasingly popular in the last years for rural energy supply is wind energy.[10] One of the main advantages of wind turbine generators is that they can be used for both, a household system, or an integrated grid. In the same way as PV panels, the more windmills are installed, the more energy is generated. One of the problems with wind, however, is its intermittence, and thus they are not as reliable as other sources. Using wind for electricity might also be too expensive due to the high replacement costs of batteries. However, for other applications like mechanical energy for water pumping, wind can be extremely beneficial. One final advantage of wind power is that the larger part of the structure can be locally produced, with laminated wood, plastics and welded or galvanized steel for the tower, and thus communities would only have to import the generator and gearbox.

For electricity micro-grids, there are two particular technologies that have a great potential in India: micro hydropower, and biomass gasifiers.[11] Small hydropower (SHP), of about 5 kW to 100 kW, basically consists of a small channel that takes the water from a small river or creek to a settling basin and then to a forebay tank, where the water is stored at a higher

[9] This is true for panels from certified producers; there are also many low-quality PV panels for which this statement does not apply.

[10] A typical small wind generator has capacity between 50 W and two kW, "has a rotor that is directly coupled to the generator which produces electricity" (Practical Action 2006).

[11] "A mini-grid refers to small power plants that supply 220 volts 50 Hz three-phase AC electricity through low-tension distribution networks to households for domestic power, commercial activities, and community requirements such as drinking water supply and street lighting" (Chaurey et. al. 2005, p. 16).

altitude so that it gets potential energy. The water is then fed into a tube or penstock that brings the water down to a power house in the form of mechanical power, where the mechanical power itself can be used or a turbine can generate electricity. The main advantages of SHP are that hydropower is technologically mature, easy to maintain, reliable (as long as the river has a continuous flow), and has low operating costs. Its main disadvantage is, similar to other RETs, the high capital costs. SHPs are particularly good for micro-grids, but they can also be used for mechanical power.

Another technology that could be used for production of electricity and has a great potential in India is biomass gasification. Biomass gasifiers basically convert biomass into “producer gas” through a thermo-chemical process, the producer gas is then cleaned, and then powers and internal combustion engine for generation of electricity. This method is particularly good for small capacities in the kW range (Chaurey et. al. 2005). Biomass gasifiers are advantageous because they use local resources in a sustainable manner, yet they have higher operation and maintenance costs and the technology is not fully developed yet (Chaurey et. al. 2005). For more details on the status of different energy technologies for rural India, see table 3 and table 4.

IV. Government of India’s (GOI) Rural Electrification Program

A. An Impossible Challenge

The main approach of the GOI to increase energy access in rural areas is by increasing electric connectivity through subsidies. There are two main problems with the government’s rural electrification plans. First, rural electrification focuses on supply, as they just aim to ensure that houses are simply connected to the grid, but fail to solve the real challenges of rural energy mentioned in sections *II.D* and *II.E*. In other words, rural electrification programs provide electricity for the sake of increasing access, but do not provide solutions to the basic energy needs for poverty alleviation, which are mainly cooking and water pumping. The second problem is, as explained below, that it is simply too expensive.

Currently, the GOI has two goals with respect to rural electrification: extending electricity to all rural villages by 2008 and to all households by 2012 (Rizvi 2004). These goals form part of the Rural Electricity Act 2003, which as Rangan Banerjee points out in *Energy Policy*, has "made it a statutory obligation to supply electricity to all areas including villages and hamlets" (Banjaree 2006, p. 102). More details of this act can be found in table 6. Right now, about one million new rural customers are connected every year, but there are 1.85 million new customers ever year, so the growth rate is currently higher than the connectivity increase rate (Rizvi 2004, p. 9). According a World Bank report the total necessary investment to meet these goals is approximately $ 95 billion, equaling about 15 billion per year, or 2.1 % of GDP. This number is significantly larger than the current budget for rural electrification (1997-2002), currently at about 350 million per year (Rizvi 2004, p. 10).

Furthermore, the GOI's method of electrification has several deficiencies. The same report from the World Bank explains that there are three different institutions working on this endeavor without sufficiently coordination between each other and with "overlapping mandates for rural electrification oversight and funding" (Rizvi 2004, p. 16). Furthermore, the majority of the rural connections do not have a meter because they have a flat tariff, leading to major inefficiencies. These inefficiencies, together with poor collection practices, have led the Indian electricity sector into a financial crisis (Rizvi 2004, p. 19).

Aside from expansion of rural electricity from the central grid, independent providers have played a big role in making electricity accessible in rural India. These providers, known as

Rural Electric Cooperatives (RECs), are inefficient because the government has imposed strict regulations on them. Two of these regulations are: low tariffs and forced supply of free electricity for street lighting and irrigation pumping (Rizvi 2004, p. 27). Furthermore, licenses for new providers are complicated and hard to get (Rizvi 2004, p. 23). These issues must be considered because even if UN projects for energy in rural India have the right approach, technologies and finance mechanisms, government impediments can drastically limit their ability to effect change.

Policy recommendations

To improve the conditions for off-grid energy providers in rural India, the United Nations could propose to the GOI to facilitate the entrance and operation of individual electricity providers by:

- *Simplifying licensing and reducing regulations for providers of off-grid alternative energy services and micro-grid electricity.*

V. Elements for Effective Rural Energy Development

The next sections address the four main issues and policy recommendations that should be considered by the UN in order to have rural energy projects in India that one, complement the GOI's rural electrification program, and two, meet the basic energy needs of the most poor by focusing on the end-use of off-grid alternative technologies.

A. Using Renewable Energy Technologies (RETs)

Traditionally, there has been a misconception that energy development in rural areas is specifically electricity provision for home lighting and appliances, diesel for engines producing mechanical power, and LPG and Kerosene for cooking. However, with renewable energy technologies (RETs), which have a plethora of end-uses, this misconception and limitation, could be overcome. RETs, defined as technologies that are powered by self-producing and self-maintaining resources, including sustainable use of biomass are advantageous because they can replace and improve the specific end-uses of many energy-requiring needs, overcoming the limitations of traditional use of firewood and decreasing the dependence on fuels that in many cases are inaccessible, as shown in table 5. Secondly, RETs have lower transmission and distribution costs than fossil fuels and extension of electricity grid lines. Third, RETs are advantageous because they are environmentally clean, both in terms of pollution that is harmful for human health as well as lower emissions of greenhouse gases (GHGs) that contribute to global climate change (Aeck et. al. 2005).

Finally, RETs have high capital costs but low operating costs, unlike the traditional technologies that have higher operating costs. Thus, as an expert from the Renewable Energy Policy Network for the 21st Century states, "over time the low operating costs of renewable energy systems offset their high capital costs through avoided fuel expenses" (Aeck et. al. 2005, p. 17). Furthermore, the cost of making RETs is decreasing due to technological advances, economies of scale, declining costs and political support, hence they are becoming even more attractive and almost cost-competitive (for initial purchase) with traditional technologies (Aeck et. al. 2005). These high costs, both capital and operating, are even further decreased if local materials and skills are used for the production, maintenance and reparations of RETs. According to Gill Wilkins, an expert on RETs and author of *Technology Transfer for Renewable Energy*, the main impediment to the dissemination of RETs has been information exchange, education, and training, and not necessarily the lack of developed technologies (Wilkins 2002). This means that one of the most important factors for the promotion of RETs is the dissemination of information about the low operating costs and other benefits.

Policy Recommendations

To introduce RETs in rural India and overcome their higher capital costs:

- *The UN's rural energy projects in India should focus on micro-credit provision, allowing poor families to purchase direct-use energy technologies. The UN should encourage NGOs and other development institutions to focus on micro-credit projects as well.*
- *The UN should institute education campaigns and provide consultancy to families in rural areas explaining the advantages of RETs, like long-term economic benefits and health benefits.*
- *The UN should ensure that any social project it finances (e.g. education and health) in rural India includes RETs for provision of energy as part of the project.*

B. Targeting Women's Energy Needs

Focusing on solving the energy problems that women face is one of the most important factors when assessing energy policies in rural areas. While energy policies and projects have technically been gender-neutral, the needs of women are different from those of men and they must be acknowledged in order for projects and policies to have a net positive effect on the wellbeing of families. While men see energy as a luxury enabling more time for leisure, energy helps women accomplish their daily tasks. According to a report from the UNDP, "in many cases, the provision of electricity without attention to the provision of modern cooking fuels or appliances has resulted in rural electrification that in fact increases the hardships of women because the working day is prolonged while the traditional fuel use patterns remain in place" (McDade 2004, p. 10).

There are three main reasons for why UN projects should focus on helping women with energy development in rural areas: first, most of the burden of not having adequate energy services falls on women, as they waste large parts of their time finding energy and as women are who suffer the most from indoor air pollution. Women are also in charge of getting water for the household, a task that could be facilitated with access to mechanical or electrical energy for water pumping. Secondly, 70% of the people living in poverty worldwide are women, which means that if their needs are attended, the chances of decreasing poverty are increased. Finally, since women are responsible of meeting household needs, benefits to women are more likely to have a positive impact on the wellbeing of the whole family (than benefits to men). Thus policies should not be gender neutral, but rather attempt to solve women's problems specifically.

This prioritization of women can be done at the household level, by meeting women's energy needs: at the community level, like street-lighting; and at the micro-enterprise level, recognizing that the businesses that women tend to be involved in are different from men's businesses. This last point of income generation must be prioritized so that women who are saving time due to improved energy services can have income-generating activities that keeps them busy and allows them to pay for energy service.

Targeting women through improved energy services does not entail a particular challenge, bur rather a change in focus that will make energy projects effective.

Policy Recommendations

Considering that women in rural areas suffer the most from energy scarcity and that by helping women there is a higher net positive effect on families:

- *The UN should make assessments of the main energy needs of women in rural communities in India and focus on supporting energy development projects that are consistent with those energy needs, particularly energy for cooking and water pumping. The UN should encourage the GOI, development institutions and NGOs to do the same.*

- *The UN should support income-generating activities for women that depend on energy by providing technical assistance and consultancy, like baking and pottery.*

C. Capacity Building and the use of Local Resources

A third consideration is the need for technology development to be carried on with as many local resources as possible; local resources referring to both human capital and materials. This is extremely important because it lowers the production and maintenance costs, creates wealth within the benefited community, promotes innovation, and increases the social acceptance of the developed technology. In fact, many studies have shown that the best way to improve technology penetration is having the community members as partners (Practical Action 2004). As Practical Action states, "projects characterized by high levels of community engagement will typically generate a greater sense of community empowerment, ensure that improvements are tailored to a community's specific needs, and create a much higher chance that the improvement will be well maintained by the community after installation" (Practical Action 2005, p. 30). This has not been the case in traditional ways of providing energy services in rural areas since grid extension does not involve people from the community and since there is a large disjunction between those who produce technologies and the users. According to Wilkins, "'technology' should be regarded not only as the equipment, but also as the information, skills and knowledge which are needed to fund, manufacture, install, operate and maintain the equipment. 'Transfer' should be regarded as putting the technical concepts into practice locally in a sustainable framework so that local people can understand the technology, use it in a sustainable manner, and replicate projects to speed up sustainable implementation" (Wilkins 2002, p. 44). Eventually, as human capacity is built, individuals gain the confidence to maintain and repair their own equipment, as well as the experience to be self-sufficient.

Capacity building and the use of local resources are also effective in overcoming cultural barriers in rural areas. Cultural barriers are of great importance since most people in rural areas are poor and thus the levels of education are low. The idea behind this focus on capacity building is to "empower" the poor, and help them lift themselves from poverty, cutting the reliance on subsidies and hand-outs from NGOs.

Policy Recommendations

To promote capacity building and development of energy with local resources:

- *The UN should make local assessments of the skills and resources in different rural communities in India in order to identify local skills and materials that could be used for off-grid energy technology development; the UN should use these assessments to inform and provide consultancy to communities of potential solutions to their energy problems based on their own resources.*
- *The UN should include capacity building in every energy development project it promotes, whereby members of the community are taught the necessary technical skills to operate, maintain and repair the equipment and energy systems.*
- *UN projects should focus on the development of technologies and provision of energy services with strong local partners through energy service companies, where villagers are the main suppliers of energy services and technologies for their own community.*

D. Increasing Energy Penetration through Wealth Creation

Finally, and most importantly, energy technologies must be closely linked with income-generation, creation of jobs, sustainability, and empowerment in order to have a real effect on income and people's wellbeing for a sustained period of time, an idea that shares a consensus between different experts and institutions (United Nations 2003). This idea has proven true not only for energy but for development in general, because even though billions of dollars have gone into helping development in the past years, they have not created the necessary framework to break the cycle of poverty. According to the Rural Energy Enterprise Development, a part of the United Nations Environmental Program, "in the energy sector, international development stakeholders and investors have too often ignored the potential of innovative local enterprises to deliver essential energy services" mainly for three reasons: the small size, operation in remote areas, and focus in centralized programs for electrification by government and international institutions (Wirth et. al. 2003, p. 4). Energy for income-generation has two different potentials: increasing income by allowing locals to produce and sell energy services to their community, and increasing productivity by the added value that the use of energy-for-business provides, allowing entrepreneurs to start certain businesses and allowing already-existent business to grow (Aeck et. al. 2005).

One particular innovative way of creating alternatives for business development using energy is creating a micro enterprise zone (MEZ), defined by the National Renewable Energy Laboratory (NREL) as "a facility powered by a centralized electrical system that serves a strategically located cluster of micro enterprises in an area without access to the electric grid. The MEZ can function both as a business incubator and a permanent business haven conducive to nurturing income-producing activities in rural, lower-income areas" (Rogers et. al. 2000, p. 35). It is important to note, however, that not all enterprises need electrical power. In fact, one of the major energy needs for industry is heat (for bakeries and brick makers, among others), which in many cases comprises up to three quarters of the total production cost.

Policy Recommendations

To promote the use of energy for wealth creation and not simply for improved wellbeing:

- *The UN should identify entrepreneurs and already existent businesses that could benefit from the use of energy and finance them to improve productivity and expand their markets.*
- *The UN should identify entrepreneurs and already existent businesses that could provide energy services, and finance them to improve productivity and expand their markets.*
- *The UN should provide financing for the creation of micro-enterprise zones, and encourage NGOs and other development institutions to work with micro-enterprise zones as well.*

VII. Conclusion

As explained above, the policies in this paper do not aim to improve past projects of the United Nations, but rather discuss and give recommendations on four elements that would add great value to the UN's energy projects. The inclusion of these elements ensures that UN rural energy projects in India complement the GOI's rural electrification program and are effective in tackling the energy problems of the most poor, focusing on the end-use of different off-grid technologies. These four elements are: the use of RETs, the focus on women, capacity building, and energy for micro-enterprise. The main policies for their promotion are: increase micro-credit programs to overcome the high capital cost of RETs; energy programs that promote improved cooking practices and efficient water pumping to alleviate women's hurdles; including capacity building with any UN rural energy projects, as well as making strong partnerships with locals for the provision of energy services; and the use of energy for micro-enterprise as a stepping stone for energy access. The backbone of these polices is to empower the poor and allow them to use energy in a sustainable fashion, braking the cycle of poverty that has traditionally made them dependent on the subsidized extension of the central grid and hand-outs from NGOs.

Table 1: Supply and Demand of Energy in Rural Areas

Energy consumption in rural areas	Energy supply in rural areas
• **Households** are the biggest energy consuming sector in rural areas. • Cooking is the major end use, about 85% of total rural energy use. • Cooking devices are inefficient, inconvenient, and dirty. • Household lighting consumes about 2 to 10% of total rural energy use. • Energy use for household appliances (radio, TV, etc.) is insignificant.	• **Wood fuels and crops residues** meet 80 to 90% of total energy needs in rural households. • **Kerosene and electricity** supply energy for lighting about 10 to 15% of rural households have access to electricity. • **Batteries and electricity** supply energy for operation of small appliances.
• The **agriculture sector** consumes about 2 to 8% of total energy use in rural areas. • Energy is used for irrigation and mechanical farm equipment.	• **Petroleum fuels and electricity** meet energy needs for irrigation and mechanical farm equipment use.
• Energy consumption in **rural industries**, including both cottage industries and village level enterprises, amounts to less than 10% of total energy use in Asian developing countries. The low level of energy consumption is one indication of the low level of industrial and enterprise activities in rural areas. • Energy is used for heating and operation of mechanical and electrical equipment.	• **Human and animal power** meet bulk of energy needed for mechanical energy use in agriculture and other rural activities. • **Wood fuels** meet energy for heating needs of rural industries. • **Electricity** also provides motive power for rural industries, but at an insignificant level.
• Electricity demand curves have high peaks in the early evening hours and low overall load. • Religious festivals, celebrations, burials and other occasional functions produce ‘spikes’ in energy demand, which are usually unaccounted in total annual energy consumption estimates. • Rural women play a key role in managing household energy needs, shouldering the responsibility of collective, processing and using biomass fuels. As a result, it is the women who are the worst impacted by biomass scarcities as well as from exposure to health hazards leading to respiratory infections, chronic lung disease and eye problems related to indoor cooking fires.	

(United Nations 2003, p. 18)

Table 2: Domestic Energy Ladder

		ICT: *electricity* Cooling: *electricity* Other Appliances: *electricity*
	Water pump: *diesel electricity* Refrigeration: *electricity, batteries* Basic Appliances: *electricity, batteries* Transport: *oil*	Refrigeration: *electricity* Basic Appliances: *electricity* Transport: *oil*
Cooking: *biomass* Heating: *biomass, candles* Lighting: *candles, batteries*	Cooking: *biomass, kerosene, LPG* Heating: *biomass, coal* Lighting: *kerosene, batteries, electricity*	Cooking: *gas, electricity, LPG* Heating: *gas, coal, oil* Lighting: *electricty*

INCOME →

(NOTE: this energy ladder does not include human and animal power, which is used for many purposes, especially getting water).

(Priddle 2002, p. 370)

Table 3: Example of End-uses for Energy Off-Grid Technologies

Technology	Application	Pros	Cons
Small biomass plants	*Water pumps* *Mills* *Refrigeration* *Lighting and communication*	*Allows for income-generating activities* *Base load operation, continuous operation possible*	*Noxious emissions*
Mini-hydro	*Mills* *Lighting, communication and other*	*Long life, high reliability* *Allows for income-generating activities*	*Site-specific* *Intermittent* *Water availability*
Wind	*Lighting and communication* *Mills* *Pumps*	*No fuel cost*	*Expensive batteries* *Intermittent energy services*
PV/Solar	*Basic lighting and electronic equipment*	*No fuel cost*	*High capital costs* *High cost of battery replacement* *Needs further R&D*

(Priddle 2002, p.382)

Table 4: Status of Technologies for Micro-Grids in India

Technologies	**Degree of Maturity**	**Degree of Penetration**	**Advantages**	**Disadvantages**	**Minimum requirement for application**	**Cost $**
Small hydro	*High*	*Medium*	*Low structure (installation and O&M), easy maintenance, indigenous manufacturing of all components, low energy cost*	*Very less power in lean period, most hydro sites are inaccessible*	*For 1 kW, if head is 30 m then minimum flow rate should be 4 L/s^2*	*$2500-3000/kW*
Solar PV (for minigrid)	*High*	*High*	*Negligible O&M cost, easy maintenance, environment friendly, easy installation, certainty in availability of resources*	*High initial investment, battery replacement in interval of around 5 years*	*Minimum 4-4.5 KWh/sw.m/day of solar insolation*	*$7335-7780/kW*
Biomass gasifer	*Medium*	*Low*	*Low cost of installation, local manufacturing of all components, low energy cost*	*Community mobilization is needed*	*1.5-2 kg of biomass for producing one unit of electricity*	*$2225-2250/kW*
Wind mills	*High*	*Medium*			*Start up wind speed of 2.5-3 m/s*	*$2225-2250/kW for small aero generator*

(Chaurey et. al. 2005, p. 20)

Table 5: Renewable Energy Technologies (RETs) for Rural Areas

Rural areas that are not connected to the national grid:

Energy Service	**Renewable Energy Application**	**Conventional Alternatives**
Cooking	*Efficient cookstoves* *Biogas* *Solar cookers*	*LPG, Kerosene*
Lighting and other small electronic needs (homes, schools, street, telecom).	*Pico- and micro-hydropower, biogas and biomass gasifier, solar/wind mini-grids, solar home-systems*	*Candles, kerosene, batteries, diesel generators*
Small industry	*Small hydropower, biomass for generation.*	*Diesel engines and generators*
Water pumping (agriculture and drinking)	*Wind and PV pumps*	*Diesel pumps*
Heating and cooling (water, space, crop drying).	*Biomass for combustion, biogas digesters, solar water heaters, food preservation.*	*LPG, kerosene, diesel generators*

(Martinot 2005, p. 30)

Table 6: India's "Electricity Act 2003"

Electricity Act 2003 – India's New Sector Legislation

The Electricity Act 2003, recently approved by Parliament, contains provisions supportive of the rural-electrification approach proposed in this paper. In particular, it provides for:

i. The principle that distribution licenses should not grant exclusive right to provide service.
ii. Distribution licensees to subcontract of franchise electricity supply within their service area without the need to obtain additional licenses.
iii. Exemptions form the requirement for licensing the generation and distribution of electricity in rural areas (as determined by the State Government).
iv. Regulatory commissions, when determining tariffs, to differentiate prices according to geographical location, among other things.
v. Open access to distribution of transmission networks, opening the possibility for consumers and distributors to develop their own generation in locations far from the point of consumption and competition for retail supply.
vi. Preparation of a national policy permitting stand-alone systems for supply in rural areas.
vii. Preparation of a national policy for rural electricity supply by Panchayat Institutions, user associations, cooperative organizations, NGOs, and franchises.

(Rizvi 2004, p. 21)

Bibliography

Aeck, Cristopher Flavin and Molley Hill. Energy Development: The Potential Role of Renewable Energy in Meeting the Millennium Development Goals. Paris: Renewable Energy Policy Network for the 21st Century, 2005.

Akanksha Chaurey, Malini Ranganathan, Parimita Mohanty. "Electricity Access for Geographically Disadvantages Rural Communities – Technology and Policy Insights." Energy Policy 32 (2004).

Banerjee, Rangan. "Comparison of Options for Distributed Generation in India." Energy Policy 34 (2006).

Chaurey, Kusum Lata, Parimita Mohanty, Amit Kumar and Akanksha. Renewable Energy in South East Asia for Improving Access to Energy. New Delhi: The Energy and Resources Institute, 2005.

Johansson, Jose Goldenberg and Thomas. World Energy Assessment. New York: United Nations Development Program, 2004.

Martinot, Eric. Renewables Report: Global Status Report. Paris: Renewable Energy Policy Network for the 21st Century, 2005.

McDade, Susan. Gender and Energy for Sustainable Development: A Toolkit and Resource Guide. New York: United Nations Development Program, 2004.

Practical Action. Powering Poverty Reduction. London: Practical Action, 2004.

Practical Action. Sustainable Energy for Poverty Reduction: An Action Plan. London: Practical Action, 2005.

Practical Action. Smoke: The Killer in the Kitchen. London: Practical Action, 2006.

Practical Action. "Energy." London: Practical Action, www.itdg.org, 2006. 04/09/2006

Priddle, Robert. World Energy Outlook 2002. Paris: International Energy Agency, 2002.

Rizvi, Rajesh Sinha, Joseph Wright and Andrea. Rural Access to Electricity: Strategy Points for India. Washington, DC: World Bank, 2004.

Rodolico, Gina. "A Guide for Entrepeneurs on Income Generating Activities: Applications of Clean Energy Technologies for Productive Uses." Energy Through Enterprise, 2005.

Rogers, April Allderdice and John. Renewable Energy for Micro enterprise. Golden, Colorado: National Renewable Energy Laboratory (NREL), 2000.

United Nations. Guidelines on the Integration of Energy and Rural Development: Policies and Programs. New York: UN Economic and Social Commission for Asia and the Pacific, 2003.

United Nations. Energy Services for Sustainable Development in Rural Areas in Asia and the Pacific: Policy and Practice. New York: United Nations, 2005.

Wilkins, Gill. Technology Transfer for Renewable Energy: Overcoming Barriers in Developing Countries. London: Earthscan Publications, 2002.

Wirth, Klaus Topfer and Tim. Open for Business: Entrepreneurs, Clean Energy and Sustainable Development. London: Rural Energy Enterprise Development, 2003.