

# SOLAR ENERGY TECHNOLOGIES, ENERGY-POVERTY NEXUS AND PUTTING THE LAST FIRST

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## ABSTRACT

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*This paper reviews how renewable energy applications in rural areas could reduce poverty, create income generating enterprises, and improve overall well-being of communities. In addition to highlighting a wide range of cases from developing countries, the research also points out to multifarious applications of solar energy technologies for rural development. The conventional myths that the poor cannot afford nor manage smart technologies are not true, as evidenced in the cases presented in this paper. Another objective of this paper is to highlight and emphasise the role of institutions, both formal and informal, with their nested partnerships in supporting, promoting and enhancing the use renewable energy technology-based solutions in rural communities of developing and emerging (BRICs) economies.*

**KEY WORDS:** solar energy, climate change, renewable energy, rural development, energy-poverty, sustainability, institutions, livelihoods, capacity building

## A.BACKGROUND

The application and scope of Renewable Energy Technologies and Clean Development Mechanisms (CDMs) have become all the more relevant, following the UN-defined sustainable development goals, to better address the debates on energy-poverty nexus. A fair range of empirical research evidences the role of energy in reducing poverty by improving potential of production and income, creation of jobs and reducing drudgery – even more so for rural lives. Energy implications can be realised in the health sector, e.g., increasing availability of energy for vaccination campaigns and clinics reduces death rates; Water won't be pumped or treated without energy; Acute respiratory infections, responsible for child deaths, will not be adequately tackled without dealing with smoke from cooking fires in the home. Children living in rural areas where there is no access or availability of electricity after dark cannot study at home thereby hampering learning progress and contributing to an increased drop-out numbers in school (Bourgeois, 2005). While energy goals were not specifically incorporated into the MDGs but have been heavily linked with several sustainable global goals today. Access to basic, clean energy services is essential for sustainable development and poverty eradication. It provides a large scale of benefits in the areas of health, literacy and equity amongst others. However, about two billion people today have no access to modern energy services. The issue of

energy choice remains fundamental to several other international development challenges as repeatedly highlighted by UN and other major development intervention agencies, and this paper aims to review of how obscene levels of poverty could be eliminated without further polluting the planet. ITDG

Sustainable (and responsible) development, defined as an umbrella term invites proactive participation from all types of institutions and actors in a society. Poverty alleviation and the environment protection have remained some primary yet long-standing goals over the years. The choice that once institutions intervening for development had, i.e. either fight poverty or protect the environment, now they are evidently inseparable goals. ITDG crucial to both is the rapid expansion of clean, sustainable and renewable energy. The inadvertent consensus amongst policy makers that energy is central to reducing poverty, hunger, improving health, increasing literacy and education, along with improving the lives of women and children. Some 1.6 billion people in the world, more than a quarter of humanity, have no access to electricity and 2.4 billion people rely on wood, charcoal or dung as their principal source of energy for cooking and heating (Urban, 2009). The use of this conventional fuel has continued to take lives away across the third world. Two and a half million women and children die each year from the indoor pollution from cooking fires. The poor in particular face another threat, paradoxically

because of the over consumption of this energy. It was previously held that excessive fossil fuel consumption by industrialised countries, and now also the third worlds (including emerging BRICs) energy use is a major driving force behind climate change. The poor are believed to be bearing the brunt the most because poverty makes them the most vulnerable and least able to cope. Thousands have already died and millions more made homeless due to extreme weather events, this has remained a reality for decades now (IEA 2009). The Intergovernmental Panel on Climate Change (IPCC, 2007) described Africa, the world's poorest region, as "*the continent most vulnerable to the impacts of projected change because widespread poverty limits adaptation capabilities*". The rapid expansion of clean and sustainable energy could offer a win-win for the poor and the environment. Particularly for the rural poor, without basic energy services, renewable energy is often the cheapest option. In India, the price of solar energy technologies (e.g., solar lamps, solar home lighting systems, solar irrigation pumps, etc.) have dramatically reduced and the adoption of solar renewables technologies in rural areas have exponentially skyrocketed. The use and adoption of renewable energy provides energy services without choking the planet additionally helps in developing economies of scale necessary for a global expansion of renewable energy.

Poverty does not preclude people's role in the market, as recognised by Prahalad and Hart (2002). Their work frames the global economy as a pyramid based on the 4 billion poorest people, was something of a wake-up call for the private sector. Energy is a key area for the 'Base of the Pyramid' (BoP) approach. Around 1.6 billion people in low-income countries lack access to electricity. Some 2.4 billion use highly inefficient forms of biomass as primary cooking and heating fuels. (IPCC, 2011). Poor people spend a significant sum on energy, but not necessarily on the cheapest, healthiest or cleanest products and services. The market potential for clean, affordable energy is however huge. The basic energy needs of the poor include safe lighting, healthy cooking and heating fuel, communications, crop irrigation, enterprise operations (such as market kiosk lighting), public services (school computers or clinic refrigeration, for example) and transportation. Many countries in Asia, Africa and Latin America possess abundant energy resources, including solar, wind and hydro-power, mineral resources and biofuels. Clean and renewable energy includes various forms of modern biomass, geothermal, wind, solar, small scale hydropower and marine energy.

Sustainable, clean energy can play a key role in reducing the huge burden of poverty and environmental degradation around the world. In order to maximise the role of clean and renewable energy in poverty reduction significant steps forward must be made to - implement strategies which will allow access to clean energy for the world's two billion poorest people in ten to fifteen years, greatly expand global renewable energy markets particularly in the North to create economies of scale, stimulate clean and renewable energy markets in developing countries to increase energy options available for sustainable development. Various empirical and evidence-based studies have illustrated links between renewable energy projects and the benefit for the poor. A selected global platter of cases from both national level as well as local level renewable energy initiatives that made a positive impact on the poor are in the following sections of the paper.

## **B.RENEWABLE ENERGY TECHNOLOGIES FOR IRRIGATION IN BRAZIL**

Studies in the semi-arid north-eastern region of Brazil shows the great extent to which this area get affected by droughts and lack of adequate water irrigation systems (Cesano & Corral, 2007). Water scarcity, therefore affecting effective irrigation practices has remained a continual challenge for the local farmers in the area, who live at the subsistence level. This part of the country has not experienced modernisation of agricultural and therefore depend heavily on trenches and inundation that are outdated. If irrigation methods could be improved, agricultural production would improve enabling the farmers to have more access to local markets to sell the surplus output. REDEH, SouthSouthNorth and Ambiente Italia together with CO2nnect in collaboration with La Guardia Foundation and Econengenho Institute aimed to develop a fully replicable model (Cesano & Corral, 2007) that address issues of technical, social, economical and ecological sustainability and replicability.

Strategies concentrating on sensitisation, awareness raising and capacity building and focusing on the implementation of 5 pilot projects were the two phases of how clean energy-led intervention was made in the region. One PV pump serving one family farmer and one bio diesel pump serving 4 family farmers were installed. These pumps have been connected directly to small-scale drip irrigation systems of 500 m<sup>2</sup> to 1000 m<sup>2</sup> aiming at increasing local agricultural production (Cesano & Corral, 2007). Progress monitoring was done in relation to social, technical, economical and environmental factors that could influence the project's success and opportunities for replication in the region. The efficacy of this project would be accrued to the collaborative experience and best practice shared mechanism among farmers which consequently had increased cohesion within the community. This progress, thereby enhanced agricultural output, raising employment levels and improving technical skills. Resultantly, these cumulative benefits of agriculture offered new opportunities to the local youth who would now be less likely to move away to urban areas in search of employment.

Ordinarily, either a PV or a bio diesel water pump supplies a drip irrigation system. The advantage of the bio diesel water pump is that it can be shared among users and the investment costs are lower compared to a PV water pump, which is also difficult to move and, therefore, remains in a fixed place. For these reasons the PV system can be used preferably in situations where a single farmer has limited access to agricultural fields (an area of less than 2,000 m<sup>2</sup>) and have no access to electricity. Another important issue to understand would be the technological sustainability of the project, which was in this case assured through the establishment of a commercial partnership with national technology providers. The technical partners of the project have provided a user's manual for implementation and maintenance, which will include also lessons learnt, and that enables the farmers to manage the irrigation system themselves. The level of interest and more importantly confidence among the farmers has been looking north and thus not only is the project sustainable in the long run but also it will continue to shower increased benefits to the poor farmers over time. Apart from formal public and private

institutions, there was a heavy recognition of user (i.e. farmers) collaboration in the process that propelled the effectiveness of the intervention. A particular lesson to take away from this case, therefore, would be to understand the nature of nested institutional arrangement, looking beyond the conventional public-private partnerships but more importantly recognising the emergence of public-private-people partnership (Mukhopadhyay, 2017).

### **C.SOLAR ENERGY FOR MOBILE PHONE CHARGING IN NAMIBIA**

Only about 40 percent of Namibians and 12 percent of their rural population have access to electricity and thus the demand for charging of mobile phones remains an issue (Schultz, 2007). Small businesses have evolved to provide this service for a small fee. However, these businesses are confined to locations with grid access and it forces off-grid community members to travel long distances in order to charge their mobile sets. As grid extension is costly and also prone to theft, solar energy technologies provided an affordable and sustainable alternative energy supply. In an informal settlement in Windhoek, the first solar home system was established in a shop. A pre-feasibility study assessed the demand for such a service and commissioned the local construction of a prototype. The shop owner offered 10 terminals for charging mobile phones, at a rate below the market price. The project was based on PV technology and the system operated on a 20Wp PV module and had included two lights, a socket for a 9V radio and 10 mobile phone charging terminals. The system could charge about 20 mobile phones per day and also provide energy for lighting and a radio. Since then, the programme was escalated exponentially across the land.

The project offered improved access to communications and electricity (MME, 2017) through the establishment of a sustainable business in an informal off-grid settlement that had a secure client base with a demand for mobile phone charging. This service initially managed to improve the living conditions of between 20-100 people by providing them with the opportunity of regular communication. With time, the project facilitated off-grid businesses through modular expansion by providing additional services such as entertainment, refrigeration and charging facilities for other power tools. The project deemed financially, socially and technologically sustainable in the long run as the electricity is purely renewable and, after the initial investment, no further energy or financial input would be needed. The system came with a life span of solar panels which was 7 years thereafter which they were either serviced or replaced; this kept the overall maintenance costs low and reduced the risk of loss of income. Furthermore, the project encourages energy efficiency because the possibility of generating income from the PV system acts as an incentive to avoid wastage of energy by e.g. unnecessary lighting, radio usage, etc. The PV system was locally manufactured, thereby providing local employment opportunities. Other job opportunities emerged from the higher rate of mobile phone usage as people profited from improved communication and most importantly, flow of information. Moreover, entrepreneurship and employment from the collection of old batteries and the resale of these to the manufacturer also benefitted the communities.

### **D. RENEWABLE ENERGY, RURAL JOB CREATION AND POVERTY ALLEVIATION**

Renewable energy technologies (or simply, RETs) have also been noticed spurring the growth of micro-enterprises, stimulating economic development by engaging local people in harnessing energy and providing energy services. RETs can fight poverty in a much better way if linked with income-generating uses of energy. The GEF and UNDP recently developed a “*Programming Kit on Productive Uses of Renewable Energy*” to shape future renewable energy programs in off-grid rural areas of developing countries (Mukhopadhyay, 2017). Renewable energy projects have dual roles to play; *firstly*, to support income-generating uses of renewable energy and *secondly*, to meet essential human needs for cooking, lighting, heating, and water supply. RETs are needed for development activities - water, health, education, while also to build entrepreneurship and project planning which should also consider poor women’s needs for reducing labor, improving health, and providing security and income. State managed energy institutions in developing nations have the option to consider integrating renewable energy into rural electrification, rural development, poverty-alleviation, and social welfare programs; thereby advancing the outreach and effectiveness of these programs.

To extend such options, several other examples of success stories could be further cited. *Tata BP Solar* in India produced domestic and industrial solar water heating systems, home lighting, water pumps and streetlights. This being a joint venture with the Government provides a long-term service to customers, underpinned by contractual relations with local government; benefits from government subsidies and tax incentives for solar PVs. Users are charged for installation and maintenance, while local residents are trained in operations and maintenance skill. *Tata BP Solar* have reached some of the poorest and most isolated communities in India. In the Himalayan region of Ladakh it worked with government agencies to provide solar home systems to 80 mountain villages, and in the north-western state of Punjab, they collaborated with the Punjab Energy Development Agency to deliver 225 solar water-pumping systems to farmers (Mukhopadhyay, 2017). Not only this saves much time invested in the farming process and improves the income and livelihood of the farmers’ family but also enhances the scope for the family members to engage in other income-generating activities.

Another similar example in this field would *be to look at Tecnosol, in Nicaragua*, which sells and installs distributed solar photovoltaics (PV), wind and hydropower systems to mostly rural Nicaraguans lacking access to electricity. *Tecnosol’s* success could be attributed to its excellent knowledge of the local market and emphasis on good quality and customer services, e.g., issues like post-installation maintenance. *Tecnosol* targets mainly farmers and landowners who can more easily afford their systems, but they also offer a 14-watt PV system for *poorer* customers (Wilson and Zarsky, 2009). Much alike is the project of *Grameen Shakti* (meaning, power of the villages), in India, a renewables company with a market-driven approach to deliver energy services to the poor. Its financing system is based on Grameen

Bank's micro-credit programme and includes payment methods like supplying livestock on credit. Although direct subsidies are avoided yet low-interest loans are provided to reduce costs. Their success could also be accrued to having a good understanding of the local market and emphasis on good quality and ongoing support service just like Tecnosol in Nicaragua. The company links renewable energy technologies with other income-generating activities and train local entrepreneurs in maintenance skills that leads to development of entrepreneurial skills and education.

### ***E.Solar Energy-based Entrepreneurship in India***

On an average, out of the total installed generation capacity of 243,030 MW, the private sector has contributed 82,715 MW (Barpatragohain, 2015). The Government of India has continued to encourage privatization through combined efforts of public and private sectors for the development of power generation from renewable sources, so as to meet the increasing demand of electricity and also to reduce the emission of greenhouse gases (MNRE, 2009). A MoU between Ministry of New & Renewable Energy (MNRE, hereafter) and Ministry of Petroleum & Natural Gas (MoPNG) was signed to improve energy security along with clean energy development through investments in large solar, wind and other renewable energy projects by developing two special purpose vehicles (SPV) (MNRE, 2009). In an initiative of Ministry of Heavy Industries and Public Industries, Ministry of New & Renewable Energy and Ministry of Power, BHEL, SECI, Sambhar Salts Limited, Power Grid Corporation, Sutlej Jalvidyut Nigam Limited and Rajasthan Electronics & Instruments Limited have signed a MoU in Jan, 2014 for setting up of an ultra-mega solar power project with a total capacity of 4000 MW at Sambhar in Rajasthan on BOO basis (Barpatragohain, 2015).

Rural household and remote areas, however, remains the key focus of PV programmes in India. This has resulted in promotion of a large number of small PV systems, e.g. Solar home lighting systems, solar lanterns, solar irrigation pumps etc. PV manufacturing in India is set to grow significantly in the near future with a number of manufacturer ready to scale production capacity and establish newer production lines. One example would include the use of Solar dryer in Agriculture, a sector that involves various time-consuming stages in processing, and drying is one of them. Drying in the open sun is not only time consuming but also unhygienic. Solar dryers can be used to dry crops and other products. They come in a variety of shapes and sizes, and therefore they can be utilised for various domestic purposes as well as in agricultural processes. One notable disadvantage of these systems is that they are slower than the dryers using conventional fuels and that they can be used for drying only at 40–50 °C (UNDP, 2012), newer product developments have also been showing promises to overcome this limitation.

Reducing the use and thereby the effects of kerosene remains a challenge in rural communities. In Sundarban islands, ONergy has installed solar systems in 5 schools providing lighting to thousands of school students who have suffered reading under the poor kerosene light. Students are now able to study longer into the evening without the harmful effects and smoke from kerosene lamps (Mukhopadhyay, 2017). With the support of Odisha Tribal Empowerment & Livelihoods Programme, ONergy has installed 33 solar streetlights in remote tribal areas of Western Odisha in India.

Community members benefit from increased security, safely moving around at night without the fear of snakes, animals, and other predators (ONergy, 2015). ONergy has installed a 4000 litres Solar Water Heater to directly provide hot water to all the patients in their bathrooms, operation theatre and canteen at hospitals as well. Furthermore, entrepreneurship based out of these alternative technologies, particularly solar, have become instrumental in transforming rural livelihoods and productivity (Mukhopadhyay & Mukhopadhyay, 2018).

There have been a range of institutions, both formal and informal, that have effectively applied solar energy technologies in rural areas to improve overall well-being and output. For example, TERI works under the Government of India initiative called the Jawaharlal Nehru National Solar Mission (JNNSM) and was delegated with the task of enhancing access to clean energy in remote energy-impooverished regions of the country. Due to these interventions, tribal communities in the state of Odisha have been effectively using solar lanterns at homes, to increase study hours of children and silk-weaving work by women (Mukhopadhyay, 2017). Another example would be to look at Dandipadiya village of Odisha that uses solar lanterns to deter animals from approaching human settlements that effectively limits prospects of human and wildlife conflict (TERI, 2016). The implication from these cases shared the paper highlights the ever-growing significance of a) multi-nested partnerships, including introducing public-private-public partnerships, when deemed necessary, b) inclusion of community members in the process of development interventions, and endeavouring to make rural development initiatives more hands-on, c) training, building and supporting renewable energy-based enterprises and the emergence of entrepreneurship, d) indigenising the production of renewable energy technologies since specific understanding of individual household/ community energy needs would call for customised technologies; this needs a close interactive relationship with the technology provider, suppliers and end users.

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