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SUSTAINING ENERGY ACCESS

Lessons from Energy Plus Approach and Productive Use in Developing Countries

This publication summarizes the report: 'Energy Plus Approach: Case studies in developing countries' by GNESD member Centres of Excellence. This summary for policymakers (SPM) and other reports can be freely obtained from the GNESD Secretariat and also from the website: www.gnesd.org



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Suggested Citation

Larsen, T.H., Ackom, E.K., Mackenzie, G.A. 2016. Sustaining Energy Access: Lessons from Energy Plus Approach and Productive Use in developing countries. Global Network on Energy for Sustainable Development (GNESD). Summary for policymakers (SPM). GNESD-SPM-E-Plus-12/2015.

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ISBN: 978-87-93130-78-4

Front cover

Photo source: Knut-Erik Helle (www.flickr.com)

Editing, design and layout by:

Magnum Custom Publishing
New Delhi, India
info@magnumbooks.org

Printed on environmentally friendly paper (without chlorine) with vegetable-based inks. The printed matter is recyclable.

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Global Network on Energy for Sustainable Development (GNESD)

GNESD is a UNEP-facilitated network consisting of Centres of Excellence which are dedicated to improving energy access for the poor in developing countries and helping those countries with energy access policy recommendations to achieve then, Millennium Development Goals (MDGs) and presently Sustainable Development Goals (SDGs). The current member Centres of Excellence from developing and emerging economies include institutions from China, India, Thailand, Brazil, Argentina, Mexico, South Africa, Kenya, Senegal and Tunisia. The network members are all renowned institutions in the energy sphere. GNESD membership facilitates coordinated analytical work, exchange of information and policy analysis on environmentally benign energy-policy options relevant to national and regional governments.

Research findings produced by the network are freely available to governments and regional organizations for formulating policies and programmes. The private sector can also use these findings in their efforts to attract investments.

GNESD activities are based on the firm belief that access to affordable, modern energy services is a pre-requisite for sustainable development and the alleviation of poverty. These activities are designed to:

- Strengthen South-South knowledge exchange and collaboration on environmentally benign energy access issues;
- Create a communications infrastructure that makes it easier for member centres to share experience and draw on each other's strengths, expertise and skills; and

- Engage member centres more actively in national and regional policy dialogues and outreach activities.

GNESD is one of several Type II partnerships in the field of energy that were launched at the World Summit on Sustainable Development (WSSD) in Johannesburg in September 2002.

Funds for GNESD activities had been made available by the governments of Germany and Denmark. In the past it has also obtained support from France, Italy and the United Kingdom. The network also receives support from the UN Foundation, UNDP and REEEP.

The GNESD Secretariat is hosted at the UNEP DTU Partnership. For more information, please visit GNESD's website: www.gnesd.org

Dedication

This study is dedicated to the memory of GNESD colleague and friend, Gisela Prasad who was an incredible person, admired for her great wisdom, insight, dedication and work in energy access and development. She is greatly missed in GNESD.

Acknowledgements

This Summary for Policymakers (SPM) is derived from country reports prepared by GNESD Member Centres of Excellence. The SPM has been written by Thomas Hebo Larsen, Emmanuel Ackom and Gordon Mackenzie. Our profound gratitude to GNESD member centres that participated in the Energy Plus study and to all GNESD member centres for reviewing this SPM. Our appreciation to our communication and outreach team, Mette Rasmussen and Surabhi Goswami for their invaluable effort in getting this SPM formatted and printed. This task was coordinated and led by Emmanuel Ackom, Manager of the GNESD Secretariat. Thanks to John Christensen for providing general direction and oversight.

GNESD member centres of excellence that authored the country reports that provided important background information in preparing this SPM include:

Africa

Environment and Development Action in the Third World (ENDA-TM), a non-governmental organization based in Dakar, Senegal. Its activities are aimed towards contributing to a better technical, economic and sociocultural understanding of energy issues in African countries (authors: Samba Fall, Secou Sarr).

Energy Research Centre (ERC), University of Cape Town, South Africa, a leading institution for the development of African energy and energy-environment policies (author: Louise Tait).

Latin America

The Bariloche Foundation, Rio Negro, Argentina, a private, non-profit institute founded in 1963 focusing on research, training, technical assistance,

diffusion and other activities in the area of energy and the environment (authors: Daniel Hugo Bouille, Rocío Aráoz, Raul Landaveri).

CentroClima, at the Federal University of Rio de Janeiro in conjunction with the Research Group on Bioenergy (GBIO), of the Institute of Energy and Environment at the University of São Paulo (authors: Emilio Lèbre La Rovere, Suani Teixeira Coelho, Maria Fernanda Gómez Galindo, Osvaldo Lívio Soliano Pereira, Alessandro Bezerra Trindade).

Asia

The Asian Institute of Technology (AIT), Thailand, an institute which promotes technological change and sustainable development in the Asia-Pacific region through higher education, research and outreach (authors: S. Kumar, P. Abdul Salam, S. Neupane).

The Energy and Resources Institute (TERI), a research institute located in New Delhi, India. It carries out research in the fields of energy, environment and sustainable development (authors: Debajit Palit, Arvind Garimella, Martand Shardul, Saswata Chaudhury).

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Abbreviations

AIT	Asian Institute of Technology
CBO	Community Based Organization
ENDA	Environment and Development Action in the Third World
ERC	Energy Research Centre
FB	The Bariloche Foundation
GBIO	Research Group on Bioenergy
GHG	Green House Gases
GNESD	The Global Network on Energy for Sustainable Development
LPG	Liquefied Petroleum Gas
NGO	Non-governmental Organization
SDG	Sustainable Development Goals
SPM	Summary for Policymakers
TERI	The Energy and Resources Institute
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme

1. Background

In spite of the considerable progress in universal energy access, an estimated 1.1 – 1.6 billion people lack access to electricity in low-income countries (GTF, 2015; IEA 2013). Furthermore, 2.6 – 2.9 billion people rely on traditional biomass for cooking and are exposed to risks of lung diseases, burns and even death (GTF, 2015; IEA 2013). The importance of this topic is evident in the ongoing Sustainable Energy for All (SE4All) and the 2030 Agenda for Sustainable Development – Goal 7 (SDG 7) regarding affordable and clean energy which was adopted by world leaders on 25 September 2015 at the United Nations Sustainable Development Summit. Additionally, energy is an enabler for the achievement of other SDGs such as No Poverty (SDG 1), Zero Hunger (SDG 2), Good Health and Well-Being (SDG 3), Quality Education (SDG 4), Gender Equality (SDG 5), Decent Work and Economic Growth (SDG 8), and Climate Action (SDG 13).

The link between access to modern energy and livelihood improvement has been firmly established, for example, by generating income activities. However, simply providing people with access to electricity is not sufficient for poverty alleviation – such an intervention must be solidly linked to productive use. Additionally, non-energy inputs would be required in order to ensure the longevity of energy access interventions. In contrast to the conventional ‘Minimalist Approach’ to energy access that focused solely on connectivity, the ‘Energy Plus Approach’ which is reported to have been originally developed by UNDP, seeks to complement energy access with non-energy inputs such as access to capital, business development services, market access, management and cooperative structures (UNDP, 2012; Velumail et al., 2015). Evidence seems to indicate that connecting provision of energy with income-generating activities, tends to

yield better livelihood outcomes and poverty eradication. The Energy Plus studies undertaken by the Global Network on Energy for Sustainable Development (GNESD) Member Centres of Excellence which have been summarized in this SPM, focused primarily on how to sustain energy access in developing countries through non-energy and energy inputs and their linkages to productive use.

The study investigated the barriers and opportunities on energy and non-energy inputs and combined linkages to productive use with the goal of achieving sustained energy access. The paper also highlights direction for further research in this area.

2. Research Framework

The studies covered in this Summary for Policymakers (SPM) were carried out within the context of the 'Energy Plus' approach and investigated the topic of energy access in combination with the productive use of energy for income generation. As such, this study holds the viewpoint that a minimalist approach that focuses only on connectivity, reliability and quality of modern energy services is good (and should be seen only as the beginning) but not sufficient. What is required is an approach that focuses on energy inputs, respective non-energy inputs and productive use of energy for income generating activities which would ensure sustainability of energy access.

A few studies have explored the Energy Plus approach including UNDP, 2012 and Velumail, 2015.

The GNESD Member Centres of Excellence conducted primary surveys in six selected countries in order to collect specific information and to better understand the impact of energy access and other factors on livelihood improvement and income generating activities (GNESD 2015a). Each GNESD Member Centre undertook an outreach activity as part of the study for dissemination of the study results.

The six studies have been grouped into two categories. The first category identifies the barriers to satisfying energy needs in both rural and urban populations, and proffers policy recommendations for addressing challenges. The countries covered in this category include Myanmar, Paraguay and South Africa (GNESD 2015b, GNESD 2015c, GNESD 2015e). The second category focuses on the use of modern energy for productive purposes and takes into consideration various examples where modern energy has provided social,

economic and environmental benefits. Countries covered in this category are India, Brazil, Colombia and Senegal (GNESD 2015a, GNESD 2015d, GNESD 2015f).

3. Summary

The 'Sustaining Energy Access: Lessons from Energy Plus Approach and Productive Use in Developing Countries' work was undertaken with an aim to investigate the barriers and opportunities for sustained energy access. The Energy Plus approach and productive use of energy were identified as two options with good potential towards achieving sustained energy access.

One barrier found to be restricting the productive use of energy was the low quality of electricity supply. Voltage fluctuations and frequent interruptions in power supply had negative effects especially for productive use of energy purposes and livelihood improvement. Another main barrier hindering increased modern energy use was observed to be the inability of the poor to purchase energy efficient electrical appliances and equipment due to the relatively high upfront costs. To overcome this barrier, innovative solutions need to be considered which can help subsidize the purchase of these by the poor. Furthermore, it was found that infrastructure in densely populated urban areas often acted as a barrier to satisfying energy needs properly and this could be addressed by carrying out projects for upgrading slums. Based on the findings of the case studies it is recommended that energy access policies are integrated more broadly into other policies related to the overall development agenda.

Biomass residues in Brazil and Colombia have been found to offer good potential for providing sustained electricity generation for productive activities. However innovative financing is required for making the process economically feasible. In the case of Senegal, the integration of modern energy into the production and processing segments of rice production value chains was highlighted. Findings show that such an integration offered good benefits for the Senegalese farmers. Findings from

the Indian case study buttresses the importance of non-energy inputs in ensuring sustained energy access and livelihood improvement.

Based on the findings from the GNESD studies, a number of policy recommendations have been suggested below, that could help livelihood improvements and the durability of energy access interventions in developing countries, modeled on the Energy Plus approach. For more details, please refer to the respective GNESD country reports on the GNESD website (www.gnesd.org) which have provided invaluable information for preparing this Summary for Policymakers (SPM).

Key policy recommendations

Recommendation 1: *Provide consistent and regular power supply to properly satisfy energy needs.* This recommendation emphasizes the need to invest in the maintenance of distribution networks to avoid frequent interruptions and blackouts in order to secure a consistent power supply for productive use of energy.

Recommendation 2: *Subsidize electrical appliances and energy efficient equipment.* The high upfront cost of efficient electrical appliances and equipment is often one of the main barriers for their use in residential as well as productive use to bring about livelihood improvement.

Recommendation 3: *Raise awareness in local communities with regards to the benefits associated with modern energy services.* This suggests that governments could team up with local NGOs and CBOs to help overcome the cultural habit of using traditional fuels and inefficient cooking and heating methods.

Recommendation 4: *Incorporating energy access into housing policy and slum upgrading initiatives.* Informal settlements and lack of formal residence are often a barrier for the urban poor in terms of being connected to the public grid by municipal and national governments.

Recommendation 5: *Ensure a well-defined institutional structure with a clear division of roles and responsibilities between government entities.* It is recommended that governments assign a single governmental body with the overall responsibility of coordinating efforts related to energy for developmental and related issues.

Recommendation 6: *Focus energy access policies on the needs of the poor.* This recommendation points to the need for social inclusion policies and subsidy schemes that effectively target energy use by the poor and are carefully designed to facilitate productive use.

Recommendation 7: *Provide innovative financing for facilitating the production and use of alternative energy sources.*

For example, in Brazil and Colombia it is found that there is great potential for using biomass residues for electricity generation, but this requires considerable support in terms of funds in order to be feasible.

Recommendation 8: *Scaling-up of successful energy access interventions.* It is recommended that best practices be scaled up via public-private partnership activities and support.

Recommendation 9: *Provide non-energy inputs in addition to providing energy connectivity.* Non-energy inputs such as management structures, societal and sociological imperatives (and not only hardware energy technologies) are important for improving livelihoods and sustained energy access in communities. The study recommends encouraging the establishment of local Self-Help Groups in addition to supporting existing ones as a means of channeling vital non-energy inputs to residents for the optimal improvement of livelihoods.

4. Barriers to Energy Access and Productive Use

This section focuses on barriers hindering energy access in the studied countries. The Myanmar study, for example, assessed the current state of, and barriers to the adequate supply of modern energy in urban and peri-urban areas of Yangon City, while the South African study investigated the country's electrification programme and its effect on productive use of energy. The results of the programme were evaluated by applying a multi-dimensional approach to energy service delivery, while a process-based evaluation examined the programme design. The Paraguayan study investigated the linkages between energy access and poverty alleviation. The study assessed how modern energy demand is being met via different types of energy carriers, in addition to the use of appliances as an indicator of the improvement of livelihoods.

A general finding from the Myanmar, South African and Paraguayan studies is that in spite of more people being connected to the grid, the quality of modern energy supply is often poor and the capacity of supply itself is too low to properly meet current demands. The high upfront cost of energy-related equipment and appliances for residential or productive activities was found to be a barrier for the increased use of energy for livelihood improvement. Furthermore, the lack of tenure and often illegal status of households in informal settlements within urban areas in developing countries results in residents being denied access to modern energy services by municipal and national governments. Findings show that slight revisions to existing policies, for example provision of 'quasi-residential identification' status to households in these informal settlements enables utility companies to provide them with access to modern energy services and additionally, helps them obtain access to credit and finance (which are otherwise denied to them due to the lack of legitimate address).

The Energy Plus approach and energy for productive use are typically cross-sectoral. Thus, having a single government agency with proper capacity to be responsible for the coordination, implementation, monitoring and evaluation of policies across the different sectors helps to streamline activities and ensure efficiency in institutional framework and use of resources. These should, moreover, specifically target the energy access needs of the poor and consider off-grid and alternative energy solutions in addition to expanding the national grid. Many of these findings were also observed in one or more of the three remaining studies focusing on the productive use of energy where other stand-alone findings were likewise highlighted (GNESD 2015a, GNESD 2015d, GNESD 2015f). For example, in India it was found that the electrification programme is deeply anchored in a subsidy culture, making further expansion of energy access very costly and thus acting as a main barrier (GNESD 2015a).

Beyond connectivity – the quality of electricity supply

Findings from the Myanmar, South African and Paraguayan studies show that there is still a lot to achieve in order to improve energy access and ensure that more people are not only being connected to modern forms of energy but are also having their energy needs met for productive use and residential consumption (GNESD 2015b, GNESD 2015c, GNESD 2015e). Taking medium-income households as a baseline for meeting energy needs, the study conducted in Paraguay shows that households being characterized as either low-income or destitute consume 37% and 56% less energy respectively than medium-income households. This indicates that lower-income households in Paraguay are still not having their energy needs being met to a sufficient extent. Results from Myanmar furthermore show that less

than 1% of households consume more than 200 kWh per month (GNESD 2015b). The Myanmar and South African studies indicate that despite high electrification rates, the quality of the service delivered is often poor and characterized with frequent interruptions. A majority of households in the studied areas of Myanmar and South Africa reported dissatisfaction with the modern energy service received, with more than 90% of residents in Masilunge, Cape Town, South Africa being dissatisfied (GNESD 2015b, GNESD 2015e). Frequent interruptions to supply complicate the use of electronic equipment and appliances thus constituting a barrier for using energy for income-generating activities and improvement in livelihoods.

The country experiences from South Africa and Myanmar highlight the importance of adequate and reliable power supply. Furthermore, achieving universal access to modern forms of energy requires long-term effort and relevant financial support and institutional framework in place as shown in the findings from Paraguay. For South Africa the importance of adopting a multi-dimensional approach to energy access in urban poor settlements was highlighted as a preferred option to an otherwise single metric that considers only connectivity.

The approach adopted in the South African study took into account four dimensions that is – energy access and fuel use, affordability, safety, and reliability of electricity supply – to be able to fully evaluate the degree to which energy access is being achieved. Making use of these dimensions, the settlement of Masilunge, Cape Town for instance has a great need for safety improvements, while on the other hand it was found that the settlement of Manenberg, Cape Town could benefit from measures to enhance affordability.

Making energy use affordable

Satisfying basic energy needs and facilitating the productive use of energy is inextricably connected to the provision of affordable electricity. The Myanmar study shows that enterprises that

are connected to a reliable supply of electricity provided by the grid enjoy various economic and social benefits as compared to other enterprises. The findings from Paraguay, South Africa and Myanmar highlight the fact that high up-front costs of electronic equipment and appliances constitute a considerable barrier for the use of these (GNESD 2015b, GNESD 2015c, GNESD 2015e). This is particularly evident in the case of Paraguay which shows that households that are 'hung'¹ on the network and thereby not paying for the electricity have a lower level of electricity consumption than households paying for electricity. This finding indicates that it is the cost of acquiring energy efficient equipment and appliances rather than electricity itself that constitutes a barrier for increasing use of modern energy.

In addition, the study conducted in Paraguay demonstrates that the use of wood and charcoal is more common among the lower-income ranks because they find such fuels economically cheaper and more easily available (GNESD 2015c). Moreover, the Myanmar study highlighted that the purchasing power which is low to start with is nevertheless compounded by the fact that they additionally spend a disproportionately amount of their total income on energy. This is primarily due to the fact that the poor make use of inefficient energy appliances and equipment due to economic challenges which make it difficult for them to afford more energy efficient options (GNESD 2015b). Therefore, innovative business models that help absorb the high upfront cost of efficient equipment and appliances and spread the payment over a period of time would be recommended. In most of the studies, the lack of awareness about the benefits associated with the use of modern energy, coupled with apparent habits of biomass use, constitute a major barrier to the uptake of modern energy (GNESD 2015b, GNESD 2015c, GNESD 2015e). For example, the various health-related benefits associated with the use of modern energy

¹ Being 'hung' on the network refers to a situation common in many Latin American countries where poor people are provided electricity through public utilities without having to pay for the service.

for cooking are not generally known among large parts of some communities (GNESD 2015b). In many cases, particularly in rural areas, the culture of biomass use goes back many generations and people are reluctant to give it up (GNESD 2015c).

The country experiences from Paraguay and Myanmar suggest that there is a need for subsidizing the purchase of efficient energy equipment and appliances in order to facilitate increased use of modern energy. Particularly for Myanmar, it was suggested that the establishment of enterprises producing more efficient cookstoves should be encouraged (GNESD 2015b). The findings from Paraguay and Myanmar indicate that the high spending on energy by the poor could be alleviated to some extent via efficient combustion of traditional fuels i.e., wood and charcoal. Further, the study conducted within the context of Myanmar recommends that the government partners with NGOs and CBOs to raise awareness in local communities concerning the benefits associated with modern energy as a way of overcoming the historical dependence on conventional biomass (GNESD 2015b). In this regard, the study found that the involvement of women was particularly important for facilitating the shift in habits from traditional biomass utilization to modern energy usage. This is because in most of these countries, women happen to be the principal energy users in households.

Inhibiting infrastructure

Although national grids have been expanding greatly in many countries, the case studies find that there are large numbers of people still unconnected to the grid, despite living in areas with connectivity. Especially in urban informal settlements where , many households are in areas not formally legalized and hence cannot be connected to the grid. This has especially been observed in Paraguay, Myanmar and South Africa. These households tend to find other less desirable solutions for energy provision. Some households manage to connect to the grid illegally, resulting in loss of revenue to the utility. In Cape Town,

for example, urban dwellers in slum areas get access to electricity through illegal connections by tapping power from a few legally connected houses at elevated prices determined by the host houses and thereby cause loss of revenue to the utility company. The enormous pressure on the few points of legally connected houses results in poor voltage (GNESD 2015e). The density of houses in these areas is furthermore associated with high risk of fires from overloaded electrical connections or in the case of cooking fuels, where safety aspects for the use of LPG are not properly followed, there is increased risk of fire and burns (GNESD 2015e)

For both rural and urban consumers it was found that poor infrastructure in the form of weakly maintained distribution networks is a considerable barrier to satisfying energy needs (GNESD 2015b, GNESD 2015c, GNESD 2015e). In spite of electricity being abundant in Paraguay, the country has one of the lowest levels of electricity consumption per capita in the region and the level of losses amounts to almost 30% (GNESD 2015c). Under-investment in the distribution network leads to poor quality of supply as well as frequent interruptions, thereby negatively affecting the daily lives of consumers and inhibiting the productive use of energy.

Consequently, the case studies emphasize the need for carrying out slum upgrading and housing projects that take into account energy and non-energy inputs, in addition to other basic needs (GNESD 2015b, GNESD 2015c, GNESD 2015e). It is recommended that energy should be more integrated with housing policy and more emphasis should be devoted to maintaining existing distribution networks. The Myanmar study suggests learning from the example of Thailand's Housing Registration Act that offered the urban poor a quasi-housing identity enabling them to apply for basic utilities such as electricity and water (GNESD 2015b).

Enabling framework and the need for a broadly integrated energy policy

Policy support is crucial for achieving universal access to modern forms of energy, and most countries do indeed have energy policies that focus on this aspect. However, the studies find that there is potential for achieving even more by better integrating energy policy into other national policies and the broader development agenda (GNESD 2015b, GNESD 2015c, GNESD 2015e). As an example, in South Africa universal access to electricity has had strong political support and is well established in both national and sub-national policies, but could benefit from energy access being more widely integrated with housing policy (GNESD 2015e). Another finding from the countries studied is that further improvements within energy access could be achieved by having a government agency with the overall responsibility for this domain. In Myanmar there are a number of ministries involved in energy planning with the Ministry of Energy being the focal point of coordination, but it is unclear which ministry deals specifically with energy access (GNESD 2015b). Therefore, a structure that shows clearer roles and responsibilities among government agencies is recommendable. Additionally, the country experiences show that the potential for enhancing energy access could be greatly increased by having effective monitoring and evaluation mechanisms within the energy sector (GNESD 2015b, GNESD 2015c, GNESD 2015e). The case study from South Africa indicates that a more holistic approach to evaluating energy access could be initiated by moving beyond the single metric of connectivity and taking into account the aspects affordability, safety and reliability (GNESD 2015e). Further, the three studies on Paraguay, Myanmar and South Africa converge on the observation that greater capacity building in government entities responsible for the implementation of energy access policies could contribute to increasing the number of people with adequate access to modern energy (GNESD 2015b, GNESD 2015c, GNESD 2015e).

In order to fully achieve universal access and make sure that energy needs are being met, the

studies point to the need for energy policies to specifically target the energy access of the poor (GNESD 2015b, GNESD 2015c, GNESD 2015e). Due to the inherent economic profile of this group the poor are often restricted from having their energy needs met even when they inhabit areas with high connectivity. The South African study finds that subsidies intended for the poor have not been successful in actually benefitting them (GNESD 2015e). More work would be required to design subsidy schemes that target the poor specifically to facilitate adequate energy access to them for productive use. Findings from the studies highlight furthermore that progress within energy access could be achieved by considering greater deployment of alternative energy to expand the national grid (GNESD 2015b, GNESD 2015c, GNESD 2015e). In Paraguay, for instance, various solar power projects have been implemented that are reported to have improved the lives of the poor (GNESD 2015c).

Overall, the lessons from the case studies point to the need for a well-defined institutional structure with clear roles and responsibilities between various government agencies in order to ensure that universal access to modern forms of energy and its connection to productive use are achieved in the longer term. Additionally, the implementation of effective monitoring and evaluation mechanisms that ensure the timely and effective maintenance of distribution networks should be encouraged, for example, developing a detailed and comprehensive energy database (GNESD 2015b). The studies furthermore suggest that energy policies ought to focus more specifically on the energy needs of the poor and devise subsidy schemes that properly facilitate their use of energy (GNESD 2015b, GNESD 2015c, GNESD 2015e).

Applying the Energy Plus approach to energy access

Providing people with access to electricity goes a long way to improve livelihoods and eradicate poverty. However, to truly enable the increase of incomes, the Energy Plus approach argues that energy access will have to be coupled with energy and non-energy inputs.

The Indian study evaluated the country's electrification programme by comparing the change in income of Indian states before and after electrification. Furthermore, with a particular emphasis on the provision of non-energy inputs, the study investigated how the states successfully providing these inputs performed, relative to those that did not apply non-energy inputs to a considerable extent.

The Indian study investigated the state of energy access and the importance of effective non-energy inputs in the context of local Indian circumstances (GNESD 2015a). Despite 96% of Indian villages having access to electricity only 67% of households are electrified and rural households are particularly suffering from a lack of access to reliable and quality supply of electricity. Mandated by law, every person is entitled to receive at least eight hours of electricity per day but due to challenges in maintaining the current distribution network, let alone expanding it, people rarely receive the required amount. Hence, there is significant unmet demand in rural areas where off-grid solutions are often applied because of high costs associated with expanding the national grid to remote areas.

Nevertheless, the findings from India highlighted that the income of both electrified and non-electrified households had increased after the national electrification programme, however, the income of electrified households was considerably higher than the latter (GNESD 2015a). The same was found for enterprises that had access to electricity whose revenues were higher than enterprises not connected. A vast majority of respondents said that they perceived electricity to be greatly or partly responsible for the increase in income and even the improvement of health and children's education. Moreover, grid-connected households had experienced higher increases in income compared to households relying on off-grid solutions, which emphasizes the importance of a reliable and stable energy supply for the productive use of energy.

The findings from India confirmed that the Energy Plus approach to provide non-energy inputs is

vital for helping people escape poverty (GNESD 2015a). The study compared micro-enterprise clusters in an Indian state that had successfully provided non-energy inputs to households and enterprises with micro-enterprise clusters in another state where this provision was lacking and found that the average monthly income of the former was considerably higher than the latter. The study indicates that the provision of non-energy inputs are equally important along with provision of energy access as the former seem to encourage a willingness in local communities to engage in entrepreneurial activities. Further, households receiving effective non-energy inputs were also in possession of electrical appliances more often than those not receiving these inputs. The most critical non-energy input within the Indian context was found to be 'institutions' such as Self-Help Groups as these, among other things, help introduce new technology to facilitate the productive use of energy (GNESD 2015a). However, other non-energy inputs were likewise important and these concern start-up finance, access to markets, the supply of raw materials, and training and capacity building. In general, some sort of non-energy input is needed as a catalyst for the mechanization of productive activities and it is the quality and strength of the inputs that is important rather than simply providing it.

The findings from the study show that the availability of reliable and quality supply of electricity is essential, especially during peak hours (GNESD 2015a). The study stresses the need to leverage local networks of institutions and encourage the establishment of these in areas where they are not present (GNESD 2015a). In areas with no effective institutions the establishment of Self-Help Groups and Community-Based Organizations as a means of providing critical non-energy inputs should be encouraged. Consequently, development goals and energy access policies could preferably be coupled together to complement each other in line with the Energy Plus approach.

Potential roles of renewables in the Energy Plus approach

Bioenergy potential for productive use in Brazil and Colombia

In order to fully improve livelihoods through access to energy it is vital to not only satisfy energy demand for basic needs such as lighting, but also enable the sufficient supply of energy for productive activities. This task is particularly challenging in rural and remote areas where the costs of expanding the national grid often make off-grid solutions such as biomass and solar PV more relevant (GNESD 2015d). However, these solutions are not sufficient for satisfying energy needs for productive activities and the study by CentroClima/GBIO confirmed that even though most municipalities have covered basic energy needs, they are far from achieving a level that would facilitate the use of energy for productive activities (GNESD 2015d).

The use of biomass residues for energy production in remote and rural areas of Brazil and Colombia could potentially lead to environmental and social benefits such as job creation, reduced CO₂ emissions, improved recycling and empowerment of women (GNESD 2015d). Thus, energy production through biomass residues has the potential to spur economic activities in these areas by generating income in the biomass-power value chain from the harvesting and selling of residues, management of the facility, to end-user economic activities. Conveniently, the regions of Brazil and Colombia with the lowest Human Development Index are also the regions with greatest abundance of biomass material. The study by CentroClima/GBIO shows that especially for Amazonian villages there is the advantage of replacing costly diesel fuel with a locally available and relatively cheap alternative, which further improves livelihoods (GNESD 2015d).

The most common sources of biomass residues in the municipalities studied were agricultural residues and animal residues and to a lesser extent urban waste and wood residues (GNESD 2015d).

The study found that in some municipalities, biomass residues are sufficiently abundant to not only replace diesel-based electricity generation but to expand energy supply as well and facilitate productive activities. For example, there is great potential for using wood residues for electricity production and the two Brazilian municipalities with greatest potential are located close to forests (GNESD 2015d). However, the study also highlights that this potential is not very well known to the public. Findings from the case studies in Brazil and Colombia also indicate that there are vast amounts of agricultural residues that likewise could potentially be used for biomass-based electricity generation (GNESD 2015d).

A main barrier for utilizing biomass residues for electricity production in Brazil and Colombia is economical viability (GNESD 2015d). Furthermore, it was found that the regional know-how to fulfill the potential is indeed available in Brazil and political initiatives to incentivize the use of biomass could contribute to making it economically feasible. Securing proper funding and subsidies for electricity to be generated from biomass on equal footing with other energy sources such as diesel constitutes a main challenge for realizing the overall potential of biomass residues. The case study in Brazil showed how the introduction of an isolated system relying on biomass residues could replace diesel oil and generate savings of up to 3,000 USD per month (GNESD 2015d). This would save the utility considerable amounts of money intended for subsidies to diesel-generated power systems. In turn, these savings could finance more biomass powered installations based on biomass residues in addition to building local capacity in municipalities to operate and maintain the equipment. Summarizing, biomass residues were found to have great potential for supplying modern energy for productive activities in rural and poor municipalities of Brazil and Colombia although the economic feasibility of this process remains a major challenge that should be addressed (GNESD 2015d).

Based on the assessment of the potential for using biomass residues for energy production the study recommends that government and

international agencies ensure that adequate financing is provided to make the process economically feasible (GNESD 2015d). The know-how and relevant technologies are available to some extent but need financial backing. The study suggests that this could be achieved by extending subsidies for energy generation to biomass and renewable energy while local and foreign banks could likewise play a role in providing adequate financing programmes. Also, the contexts of Brazil and Colombia indicate that a pilot demonstration plant in one municipality could preferably be implemented to explore the most relevant biomass residues and bioenergy technological option to be used, and to build local capacity.

Solar PV powered irrigation in small-scale agricultural activities in Senegal.

Most of the work done on energy access has focused to a large extent on provision of modern energy services to households or communities and enterprises. Relatively less emphasis has been given to linking such interventions to other productive use such as agricultural activities. For Africa, agriculture is particularly relevant since 65% of the continent's population is employed within this sector (GNESD 2015f). Furthermore, it has been highlighted in an earlier report by the Food and Agriculture Organization (FAO, 2000) on the positive linkages between food production and higher per capita consumption of modern energy, which only further supports the need to investigate energy access within an agricultural context (GNESD 2015f). Yet, most agricultural practices in the Economic Community of West African States (ECOWAS) still rely on human labour and animal strength.

Therefore, the study on Senegal investigated the energy access situation of rice value chains in Senegal due to their potential for adding value at the local level, for their high labor intensity and potential for scaling-up (GNESD 2015f). The Senegalese study assessed the use of electricity in small-scale agriculture in Senegal and the effects it has on income generation. By disaggregating the energy use according to the various links in

the agricultural value chain the study analyzed the potential for applying modern energy in Senegal's farming activities as opposed to the current traditional agricultural practices. The rice value chains in Senegal are currently characterized by minimal mechanization with resultant low agricultural production yields and quality. However, there is significant market potential for agricultural produce in the country. For example, 75% of all rice in Senegal is imported (GNESD 2015f).

The case study observed two production models generally being applied within rice value chains in Senegal. One model relies on diesel-driven pumps for irrigation with service providers carrying out the harvest with motorized equipment. In the other model the irrigation is based on electric water pumps and human labour utilized in the harvesting. The case study further found that for processing, smaller sized farms tend to make use of village huskers as opposed to semi-industrial processors being utilized by larger farmers and agribusinesses. Semi-industrial processing provides higher quality rice resulting in higher prices and sales. Larger farmers and agribusinesses tend to sell their products in urban and more distant markets whereas smaller farmers mainly sell in local weekly markets where rice is generally sold at a lower price (GNESD 2015f). The Senegal study showed that the production segment of the rice value chain accounts for the vast majority of energy use within the chain with energy for water pumping being particularly significant. Further, it was found that energy needs for fertilization, soil preparation and rice processing have a relatively high influence on the economic performance of farmers. In terms of the environment, the production segment accounts for more than 90% of GHG emissions of the value chain, which indicates that energy efficiency measures within production could greatly result in GHG emission reductions.

Overall, the experience from Senegal emphasizes how the performance of rice value chains could be greatly improved through energy efficiency measures that focus on irrigation and the mechanization of soil preparation and harvesting

(GNESD 2015f). Also, the study highlights how the greater adoption of semi-industrial processing of paddy could not only reduce energy use but also improve the quality of processed rice thereby enabling higher sales prices and increased earnings for farmers. The Senegalese study suggests that the application of solar power could further reduce the use of diesel oil thereby ensuring lower emissions of greenhouse gases. Overall, the findings depict how the greater integration of modern energy services throughout the rice value chain, but particularly in the production stage, could offer great benefits for both farmers and the environment.

Based on the case study it is recommended to encourage the use of renewable energy to reduce fuel consumption and improve productivity in rice value chains. It is recommendable to put in place appropriate financing mechanisms to support the acquisition of efficient pumps. Also, political and financial support could preferably be devoted to the adoption of semi-industrial processing, which could bring about both energy-related and economic benefits. Overall, the study highlights the need for better ensuring that agricultural and energy policies are targeted at addressing the critical needs of the sector such as energy and related energy efficiency improvements in a synergistically beneficial manner.

5. Concluding policy recommendations

The main findings and policy recommendations resulting from the case studies have been summarized in the following.

1. Provide consistent and regular power supply to properly satisfy energy needs

The provision of reliable power supply is essential for facilitating the productive use of energy as a foundation for improving livelihoods. This emphasizes the need for investing in the maintenance of distribution networks to avoid frequent interruptions and blackouts. A multi-dimensional approach to energy access could be adopted that incorporates aspects of affordability, safety, and reliability in energy access interventions and evaluations.

2. Innovative models that enable the poor to acquire energy efficient electrical appliances and equipment

Innovative business models and government subsidies directed towards absorbing the high upfront cost of efficient electrical appliances and equipment and spreading it over time would contribute to cheaper electricity bills per kWh usage being paid by the poor. This is because the poor happens to pay more for electricity due to their usage of inefficient electrical appliances and equipment which tend to be more expensive over time per kWh usage.

3. Raise awareness in local communities of the benefits associated with modern energy

Information dissemination and outreach on modern energy usage and its related economic, social, health, and environmental benefits by

governments, local NGOs and CBOs would go a long way to help overcome perceptions against modern energy and/or affinity for inefficient and polluting traditional fuel preferences by some communities.

4. Incorporating energy access into housing policy and slum upgrading initiatives

Adjustments to existing housing policies especially in informal settlements such as provision of 'quasi-housing identification' as well as having the energy agenda explicitly indicated would go a long way to help improve energy access and livelihoods in such communities.

5. Ensure a well-defined institutional structure with a clear division of roles and responsibilities between government entities

Having clearly defined objectives, and assignment of roles and responsibilities among government departments and agencies helps to ensure efficiency and effectiveness in sustaining energy access initiatives by mainstreaming it into the policies, measures and strategies in the national development agenda.

6. Focus energy access policies on the needs of the poor

Target subsidies that effectively ensure that energy access interventions indeed get to the intended beneficiaries and not 'free riders'. Additionally, the needs for social inclusion perspectives in energy access initiatives are imperative.

7. Scaling-up of successful energy access interventions for wider dissemination

It is recommended that success stories and best practices be examined in the context of how they could be applied in other areas (given similar conditions) as well as their potential scale-up to ensure wider reach to a sustained energy intervention.

8. Provide non-energy inputs in addition to providing energy connectivity

Non-energy inputs such as management structures, local institutions, Self-Help Groups, access to markets, finance, training or capacity building is vital for sustaining energy access interventions as well as the adoption of entrepreneurial activities by local residents. The study recommends encouraging the establishment of local Self-Help Groups in addition to supporting existing ones as a means of channeling vital non-energy inputs to residents for the optimal improvement of livelihoods.

6. Suggestions for further research

The findings and policy recommendations from the case studies highlight various aspects of energy access that need to be researched further. As quality of energy supply is critical once a high level of connectivity has been achieved, the case study on South Africa points to the need for more research into how to devise and implement a multi-dimensional approach to energy access that takes into account elements such as affordability and reliability (GNESD 2015e).

Furthermore, based on the findings from Paraguay and Myanmar it seems to be of paramount importance to investigate how to set up subsidy schemes that facilitate the purchasing of electrical appliances and energy efficient equipment (GNESD 2015b, GNESD 2015c). These applications were seen as vital for encouraging use of modern energy for productive activities and to the overall well-being of residents. The observed need to focus energy access policies on the needs of the poor makes it essential to research how public subsidies for electricity consumption can be devised to efficiently target the poor and needy (GNESD 2015b, GNESD 2015c, GNESD 2015e).

The findings from Myanmar, Paraguay and South Africa indicate that a way to improve the energy access situation of many urban dwellers appears to be through slum upgrading projects where illegal households are provided with some sort of quasi-housing identity (GNESD 2015b, GNESD 2015c, GNESD 2015e). This calls for more research looking into how government and municipal authorities can organize similar initiatives most effectively.

In addition, the experiences from the case studies emphasize the relevance of investigating successful examples of institutional setups for the energy industry and how roles and responsibilities

can be divided among government entities in order to avoid issues being left unsolved (GNESD 2015b, GNESD 2015c, GNESD 2015e). In addition to this, studies of effective monitoring and evaluation mechanisms are highly relevant, based on the observations from Myanmar and South Africa as these systems allow for the continuous maintenance of distribution networks (GNESD 2015b, GNESD 2015e).

The case study from Brazil and Colombia highlights the relevance of investigating further the potential of using biomass residues for energy production (GNESD 2015d). This would entail assessing the most optimal technology solutions as well as the biomass residues that can be collected most easily for electricity generation and potentially coupled to income generating activities for local residents. The study in Senegal emphasizes the potential of integrating modern energy services into the value chain of small-scale agriculture (GNESD 2015f). Thus, other research projects could preferably look into how to integrate renewable and energy efficient appliances into the production and processing segments of the value chain as well as evaluate how best to finance this initiative and take into consideration the gender dimension to facilitate access to energy services for vulnerable groups (low-income family farms, women heads of households etc.).

Lastly, findings from India show that applying the Energy Plus approach to energy access, highlights the need to consider non-energy inputs in addition to connectivity (GNESD 2015a). Thus, more research could be done in terms of determining which non-energy inputs have greater potential for encouraging entrepreneurial activities. In addition, it would be very relevant if future studies could investigate more closely the successful establishment and dynamics of local institutions

and Self-Help Groups as a means of channeling non-energy inputs to local residents. This would be one step closer to illuminating how energy access and the provision of non-energy services can help the poor escape poverty and improve their livelihoods.

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Appreciation

The GNESD Secretariat is very grateful to the following governments and organizations for supporting its work:

Government of Germany
Government of Denmark
Government of France
Government of Italy
Government of the United Kingdom
The UN Foundation
UNDP
REEEP

The GNESD Secretariat is facilitated by UNEP and hosted at the UNEP DTU Partnership in Denmark.

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ISBN: 978-87-93130-78-4