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Renewable- Based Modern Energy
A Bottom up Approach
to Universal Access

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Renewable-based Modern Energy

A bottom up Approach to Universal Access

Summary
A bottom up approach is proposed to increase the access to modern energy in developing countries. The approach focuses on progressive removal of barriers preventing the valorization of natural resources and the production of modern energy; the essential input for poverty alleviation and economic growth. Through technology transfer, deployment and diffusion, the main purpose is to put in place the elements needed to create energy enterprises that deliver services, ranging from site identification, preparation of feasibility studies and bankable documents, to constructing the energy infrastructure, managing the energy enterprise and maintaining its facilities. Given the expected role of national Government, it is obviously an issue of public private sector partnership. Therefore, it needs the right enabling environment and policies framework. Depending on the level of development in a given country, the approach proposed proceeds in distinguished phases; starting with a learning and innovation phase, focusing on creating critical mass of technical capacities, identifying polices and financial mechanisms needs, and ending with fine-tuning and operationalization phase, where the public sector supported financial mechanisms are geared to promote the market based involvement of the trained SME as developers and technology suppliers to the 'off grid' energy facilities providing the energy access in off grid areas. In so doing, the process of providing energy access and scaling up the share of renewable energy in the energy mix will progressively be established and operational wherever there is available renewable energy resource, and whenever there is a need for the energy; be it for basic community needs and or for productive use.

1. Context and Background

The majority of the world's poor live in rural areas of sub-Saharan Africa. Many national governments throughout the region, along with development organizations, recognize the urgent need to provide the necessary inputs to reduce poverty and promote economic growth. To this end, access to modern energy[1] is critical. Currently, approximately two billion people (or one third of the world's population) have no access to modern forms of energy at affordable prices. Without significant intervention, this situation is likely to remain relatively unchanged in the foreseeable future. In addition, an estimated 2.6 billion people rely on traditional biomass for cooking. Of these, 1.6 million die annually from indoor air pollution, putting air pollution second only to malnutrition as the major cause of death among the world's poor. Increasing energy access therefore, is critical for addressing the inter-related issues of poverty reduction, improving health, environmental sustainability, and economic development. It is widely acknowledged that energy access is the missing Millennium Development Goal and therefore strategies for increasing energy access are increasingly becoming an essential part of national policies throughout Africa[2].

Producing modern energy from locally available renewable natural resources, such as hydro, solar, wind, and biomass, contributes to both preserving the environment, and reducing the costs to national governments (by offsetting the need to import fossil fuels). Moreover, a move to renewable energy sources provides domestic energy security and decreases the vulnerability of the economy to fluctuations in fossil fuel prices resulting from geo-political and financial instability, and, in the longer term, price increases due to the depletion of fossil fuel resources.

[1] Mainly electrical, but also mechanical energy forms, as opposite to the traditional use of charcoal, firewood and agricultural residues.
[2] e.g., Burundi, Rwanda, Senegal, Guinea, Cote d'Ivoire, Senegal, Sudan, Sri Lanka.

The use of proven and reliable generation and distribution technologies is a key factor contributing to the viability and economic sustainability of energy services, be they based on hydro, solar, biomass, etc. Lessons learned from various technical cooperation interventions have emphasized that technology transfer, deployment, and diffusion, especially across the African continent, remain a challenge that needs to be met effectively and efficiently for scaling up and rolling out of energy access to become a reality.

1.1 Present Situation and Issues

Across sub-Saharan Africa, the majority of the population live in remote areas far from the main electricity grid with little, or no, prospect of being connected within the near future. Therefore, it is expected that decentralized off-grid technologies will be the most economically viable solutions and, in some cases, might be the only option for providing energy services.

The current low electrification rates in sub-Saharan counties are in sharp contrast to the well-documented sizable renewable energy resources of these countries. The prospect for improvement for rural areas looks bleak given the focus, understandably, of local energy institutions on increasing the access, capacity, and reliability of urban electricity supplies. Given the limited budgetary resources of many governments, this is frequently to the detriment of scattered, remote rural communities with lower purchasing power.

Although most sub-Saharan countries both, recognize the need to increase access to modern energy to reduce poverty and promote economic growth, and, have abundant available natural resources for energy production, little or nothing has been done to match energy supply and demand through the development of a national grid, increasing energy efficiency, and/or implementing rural energy programmes.

Recent research indicates that some progress has been made on rolling out national grids, mainly through increased generation capacity, however, it is reported that functional rural energy programmes remain a challenge and bottleneck for increasing energy access in rural and peri-urban areas.

1.2 Problem Cause and Consequences

Studies commissioned in a number of countries have systematically revealed a number of barriers preventing the sustainable development of energy programmes in rural and peri-urban areas in sub-Saharan Africa, including:

- A LACK OF TECHNICAL CAPACITIES AND OPERATING EXPERIENCE to identify potential natural resources, undertake socio-economic evaluation, and construct, operate, and maintain power facilities using appropriate technologies and business models for rural energy;
- A LACK OF, OR INSUFFICIENT, AWARENESS OF PROVEN AFFORDABLE TECHNOLOGY SOLUTIONS;
- A LACK OF POLICIES, INNOVATIVE, PEFORMANCE BASED FINANCIAL MECHANISMS, AND INCENTIVES to promote rural energy development and encourage partnerships with the private sector.

A lack of access to modern, appropriate energy services is a barrier to the adoption of value adding, off-farm income-generating activities, and subsequent poverty alleviation. In addition, energy access also contributes to the provision of basic community services, such as clean water, health, and education, and revitalizes rural communities though increasing

economic development and stability – the latter being particularly important in post conflict situations.

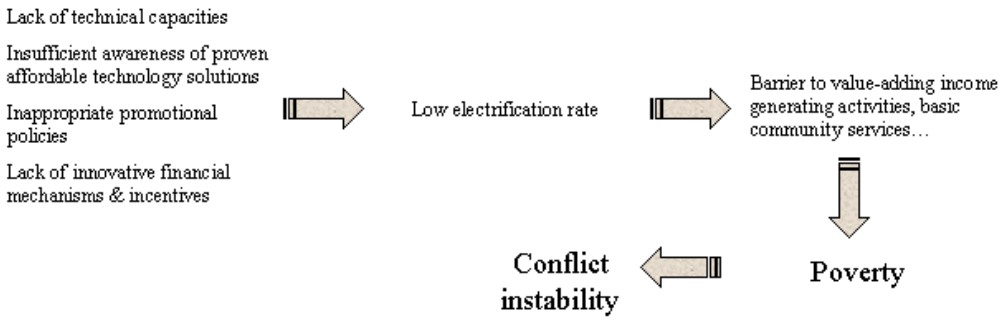

Figure 1: Consequences of barriers to increasing access to modern energy services

1.3 Energy for a Sustainable Future

The issue of energy access is now at the forefront of the global agenda. It is central to the issues of development, global security, environment protection, and achieving the Millennium Development Goals (MDGs). In June 2009, the UN Secretary General established the Advisory Group on Energy and Climate Change (AGECC), to advise him on the energy-related dimensions of the climate change negotiations. Chaired by UNIDO's Director General, the AGECC's multi stakeholders meetings and deliberations called for commitment and concerted action on two ambitious, but achievable, goals: universal access to modern energy services and improved energy efficiency by 2030.

To meet this AGECC energy access challenge, there is an urgent need to intensify efforts to translate this goal into actions on the ground. This paper outlines an approach proposed as a roadmap for increasing modern energy access, with a focus on African sub-Saharan conditions.

2. The Solution- Concept Outline

Any operational solution implies therefore, that the identified barriers are removed, leading to a situation where locally available natural resources are used, and transformed into energy through appropriate and efficient technologies. Therefore, rigorous technology transfer, deployment and diffusion programmes have to be put in place to make certain that the efforts to increase energy access will work and deliver results.

Sustainability and affordability
To ensure the affordability and sustainability of the energy generated and distributed, a number of additional key elements should be considered as essential parts of the solution, including: site selection criteria and potential productive use of energy; optimum design leading to lowest possible cost per kW[3]; involvement of 'national' qualified project developers; appropriate establishment and management of the prospective energy enterprises; established skills and networks for operation, maintenance, and spare parts; appropriate public private partnerships; etc.

Streamlining the process of providing energy access
Obviously, providing access to modern energy is not a one time operation or intervention.

[3] Based on a UNIDO implemented project's record, the per kW cost for a complete mini hydro facility, including transmission and distribution lines, is less than US$2000.

Rather, it is a process that must be undertaken wherever, and whenever, there is demand for energy, be it for basic community services, or for productive uses. Therefore, it is important to undertake technical assistance activities related to capacity building of various stakeholders (e.g., responsible ministries in the national government, local government and authorities, national development banks and financial institutions, regulatory entities, private developers, technicians and engineers, equipment suppliers, and assemblers, etc.). This is essential for both building the required technical capacities, and transferring the knowledge and information needed to establish and operationalize institutional frameworks and financial mechanisms. When reaching this stage of development, these institutions and mechanisms will be responsible for delivering affordable energy access through a transparent set of procedures with clear preset criteria and smart performance based incentives promoting public-private sector partnership.

Such technical assistance will ensure that the best practices and knowledge on affordable energy access are (i) built into local skills and technical capacity, (ii) streamlined in "national institutional and financial frameworks", and (iii) operationalized with clearly defined roles and responsibilities of all stakeholders. This will lead to streamlining the development and deployment of sustainable energy access, in terms of the increased access provided by an increasing number of energy facilities and enterprises (Figure 3).

Public Private Sector Partnership

It is the conjecture of the author that providing access to modern energy in rural and peri urban areas in developing countries is a public sector led initiative. The public sector should create, and establish, a conducive environment, in terms of policies, institutional frameworks and financial mechanisms, that encourages the private sector to become involved in the process. The private sector involvement and primary value-adding role is at the level of designing, constructing, managing, operating, maintaining, etc., of the energy facility and related enterprises.

However, in a large number of developing countries on the African continent, national governments face the problem that there is no private sector with the relevant or appropriate skills to get attracted and involved in the partnership. Thus, an integral part of the required effort by national governments and their international developmental partners is to create a critical mass of technical knowledge and skills. This is also why the proposed approach is designed to progress in phases. The first phase focuses on an innovative learning by doing approach and the creation of a critical mass of local technical knowledge among potential developers and services providers, mainly from the private sector. It also aims to raise awareness and knowledge of public sector stakeholders from local and central governments, as well as financial institutions.

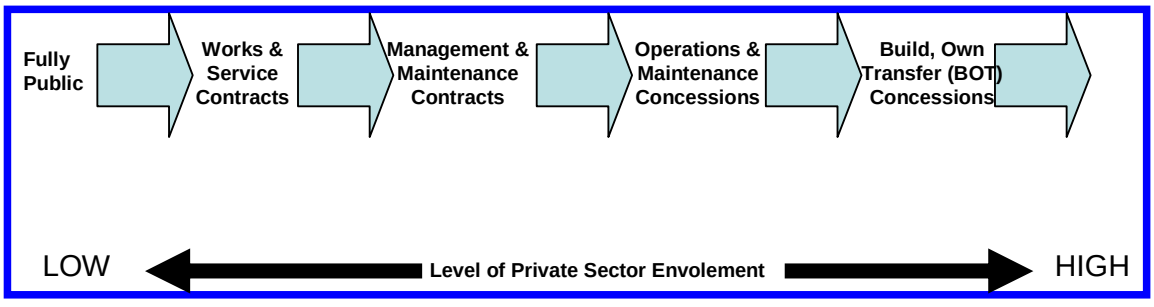

Figure 2: Various extent of public private sector partnership possibilities. It is expected that, for example, the smaller the capacity of energy facility or the community to be served, the

lower the extent of private sector involvement; for example. Peri-urban energy access would show more private partnerships than in remote and isolated rural areas.

Modern Energy Access for Basic Human Needs and for Productive Uses

Given the fact that poverty rates in rural areas are generally very high, and based on experience gained from various projects implemented in developing countries, clearly access to modern energy services must be affordable. Most often, this affordability is limited to a certain percentage of the population in a given community, particularly during the initial stages of a project. This percentage of population, or income class, is normally designated as 'primary beneficiaries'[4] and will define, among other factors, the financial viability of the energy access project.

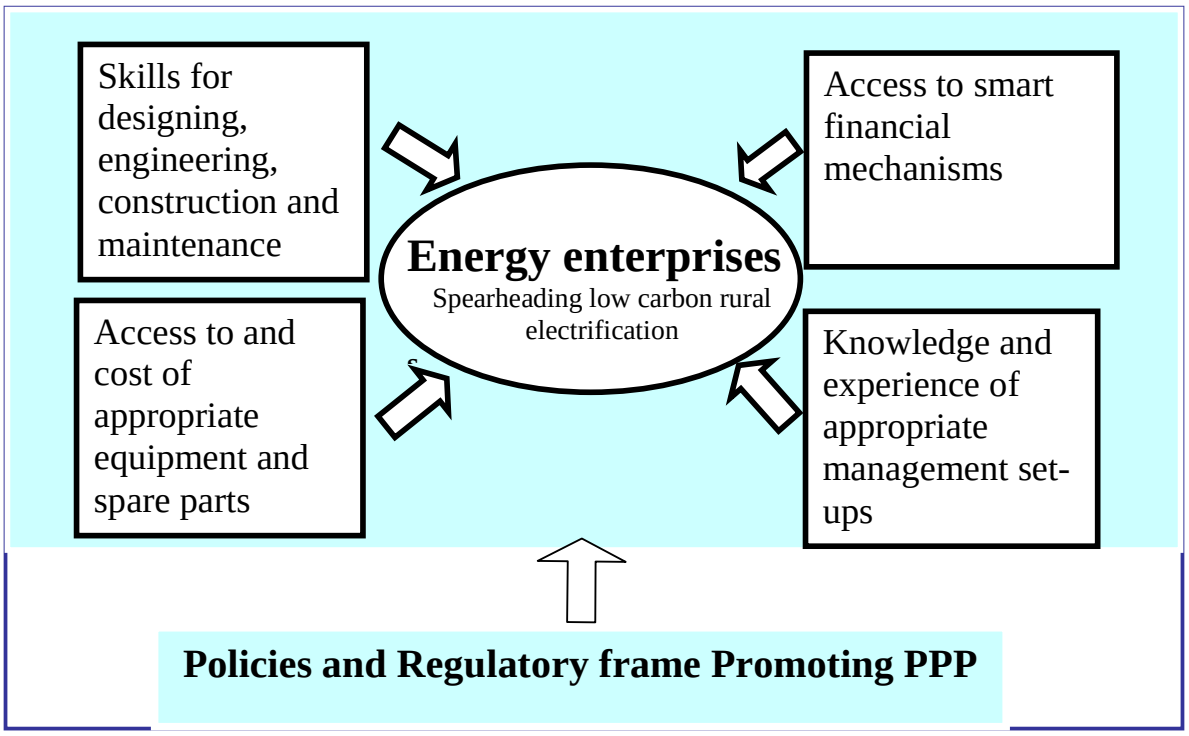

Figure 3: The ultimate goal is to put in place the necessary information, knowledge, and technical capacities to promote the creation of SMEs, which will spearhead rural electrification within a well-defined policy and regulatory framework

2. Approach Outline

The bottom up approach being proposed is designed to remove the barriers to increasing energy access by putting in place a process to 'industrialize' the delivery of modern energy services in rural and peri-urban areas. This delivery process integrates the key elements of technology transfer, deployment, and diffusion, to ensure that (i) information, knowledge,

[4] Primary beneficiaries can afford paying for the energy services for household use and for economic activities leading to increased employment creation for others. Secondary beneficiaries initially cannot afford the cost of energy services, however they benefit from the 'energy-improved basic community', as well as, the productive uses, by earning better incomes, and at certain breakeven point start to afford the energy services themselves. The end result is economic development and sustainability for both the community and the energy services enterprise.

and technical capacity, (ii) institutional and financial frameworks, and (iii) technology, are progressively established and operationalized in an innovative learning set of activities (Figure 4).

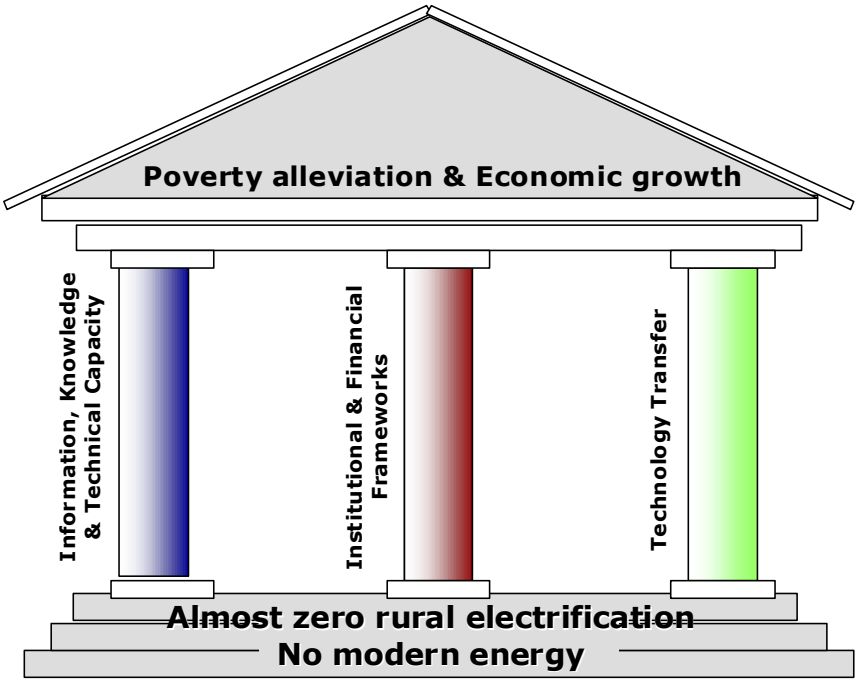

Figure 4: Essential key inputs to the process of providing modern energy access; the industrialization of the delivery process.

The approach proceeds by establishing a critical mass of technical capacities and knowledge, in a 'learning by doing' initial phase, with fine-tuning, up scaling, and integration of outcomes, during subsequent phase(s), into a delivery process that is devised to facilitate the establishment of small low carbon energy enterprises for access services.

A multidisciplinary team of nationals will be selected to be trained, on a learning-by-doing basis, in the identification and preparation of pre-feasibility studies for a number of renewable energy sites, of which two to three sites will be prioritized and selected for full feasibility studies, construction, and commissioning. Ideally, the multidisciplinary team will comprise central and local government officers dealing with issues of rural energy development, graduates, private sector engineers interested in becoming project developers, NGOs, etc.

The training will focus on the key issues that experience has shown to be important for successful rural energy development; covering both technical aspects (e.g., design optimization, technology choice, maintenance, etc,) and institutional/financial arrangements (e.g., defining the role of stakeholders in providing the required technical and financial support to energy developers and service providers, etc,). Therefore, the core activities will be undertaken by the national multidisciplinary team supported by international subcontractors with proven records of accomplishment in similar projects in developing countries, (Figure 5).

This should result in a streamlined process through which renewable energy sources are developed by trained and qualified developers, and financed primarily through public sector

funds with incentives for private sector and community participation. Appropriate business models, management structures, and maintenance and spare parts networks will also be developed.

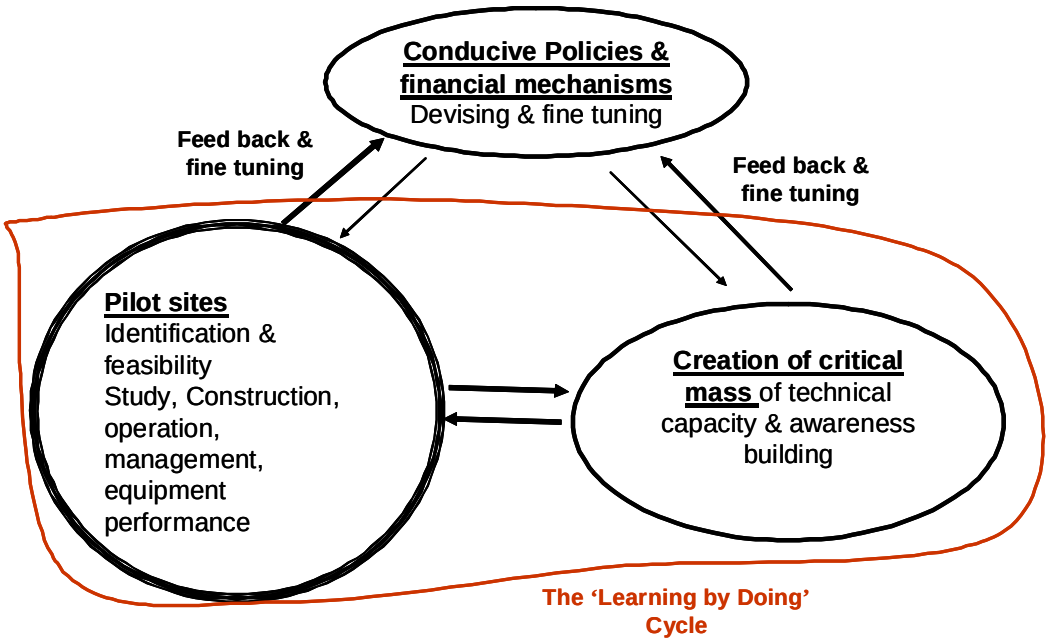

Figure 5: Phase 1: Demonstration projects promotion sustainable and affordable rural energy development - Learning by Doing capacity building

The path from almost no access to modern energy to a streamlined process for establishing modern energy 'small' enterprises providing access services is expected to evolve in a more or less predefined manner through a series of distinguishable phases over time.

Figure 6 outlines the phases leading towards the 'industrialized status' of providing access to modern, affordable energy, using natural resources, in rural and peri-urban areas in developing countries. For each phase of the process the type of activities undertaken, and expected outcomes, are shown for each of three critical 'pillars' or 'tracks', *viz*: (i) capacity and awareness building, (ii) technology and equipment, and (iii) policies and financial mechanisms.

The outcomes of the approach will be achieved, therefore, through a multidisciplinary process of constructing pilot sites. This construction process will be used to gradually build up a critical mass of technical knowledge, with the pilot sites themselves serving to showcase the approach and build awareness of stakeholders. In addition, by replicating the process, it is expected that a knowledge base on technology and equipment related issues will develop, thus decreasing equipment costs. Moreover, in-depth knowledge will be gathered on the most appropriate financing mechanisms and the role of stakeholders, such as project developers, financing institutions, local governments, and beneficiaries. This information provides the foundation for the further development and operationalization of conducive policies and financial mechanisms, etc.

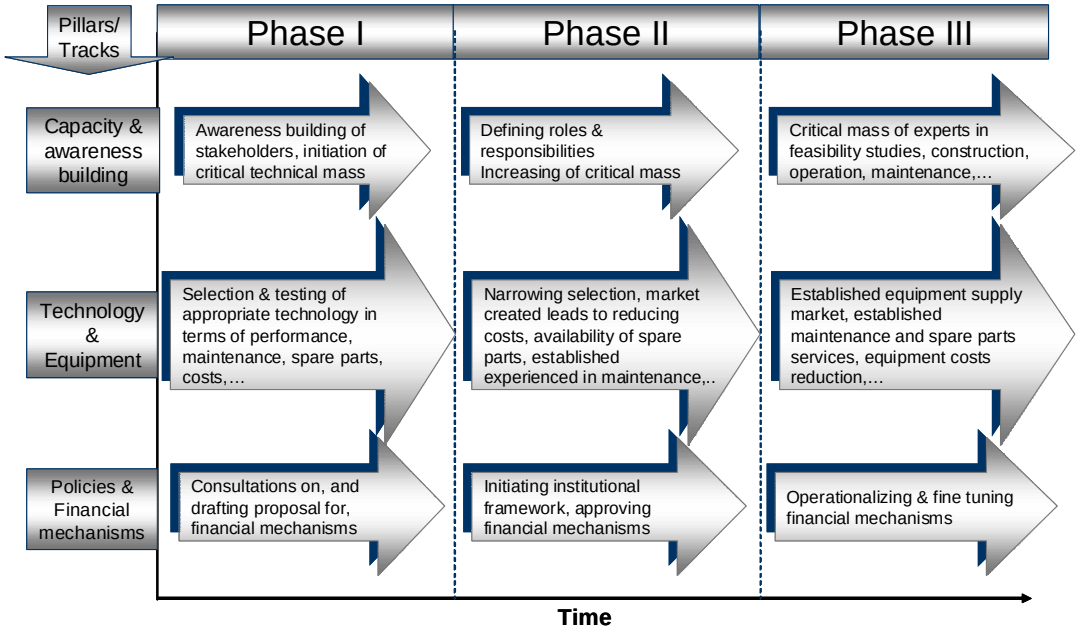

Figure 6: Outline of phases for the industrialization process

2.1. Initial /Starting Phase – Technology Transfer

Phase I involves the design and implementation of an integrated suite of technical cooperation activities to establish the foundations necessary to remove barriers and increase energy access through the creation of energy enterprises. It focuses on an innovative learning by doing approach, while establishing demonstration 'renewable' energy facilities, and using the process for the creation of a critical mass of local technical knowledge among potential developers and services providers, mainly of the private sector. It also aims at raising the awareness and knowledge of public sector stakeholders from local and central governments as well as financial institutions.

Typical major activities during this Phase are:

- Building awareness and technical capacity of central and local government officials, private developers, banks, universities, R&D, etc., through the establishment of demonstration sites;
- Developing a knowledge base on appropriate technologies, cost vs. quality and life cycle performance, maintenance and spare parts availability, etc; and
- Reviewing and identifying gaps in policies and financial mechanisms for promoting rural energy development and encouraging private sector involvement.

The specific activities undertaken during this phase will depend on the outcomes of consultation with stakeholders, their absorption capacities and ability to design and implement appropriate interventions. It will also depend on the level of local awareness, technical knowledge and required skills, especially of the private sector.

2.2. Technology Deployment Phase

The major activities of this phase are:

- Creating a critical mass of local technical capacity of central and local government officials, private developers, banks, universities, R&D, etc., through demonstration

sites with increased participation of relevant national institutions;

- Developing outlines for policies and financial mechanisms promoting rural energy development and encouraging private sector involvement;
- Developing a knowledge management platform of appropriate technologies, and actively promoting the establishment of maintenance and spare parts enterprises, exploring possibilities for local assembly and/or manufacture, consequences for cost reduction; and.
- Exploring regional opportunities for replication, integration, etc.

2.3 Technology Diffusion Phase

The major activities of this phase are:

- Expanding local technical capacity of central and local government officials, private developers, banks, universities, R&D, etc., through demonstration sites with increased participation of relevant national institutions;
- Operationalizing the policies and financial mechanisms put in place to promote rural energy development and to encourage private sector involvement;
- Operationalizing the knowledge management platform of appropriate technologies, and further promoting the establishment of maintenance and spare parts enterprises, exploring possibilities for local assembly and/or manufacture, consequences for further cost reduction; and
- Expanding regionally to benefit from economies of scale.

3. Expected results of the three phases programme

- PRE-FEASIBILITY STUDIES and FEASIBILITY STUDIES for a number of energy facilities sites – outlining the socio-economic, demand-supply, and technological issues as well as construction and commissioning plans for the identified sites;
- PILOT DEMONESTRATION SITES CONSTRUCTED – showcasing affordable and participatory approaches, appropriate technologies and equipment, appropriate management models, operation and maintenance issues, and serving as a means of building awareness for stakeholders;
- TECHNICAL CAPACITIES STRENGTHENED of a core team of multidisciplinary national experts. The preparation of feasibility studies and construction of demonstration sites will serve as training for the multidisciplinary team in the areas of site identification, with a focus on cost reduction, technical design optimization, links to productive use of energy, socio economic and technical analysis, construction, operation and maintenance of facilities;
- AWARENESS INCREASED of a wide range of local and central government agencies, as well as financial institutions, especially local banks, on their key role in facilitating technical and financial inputs to energy services developers from the private sector and local communities; and
- TECHNOLOGIES TRANSFERED resulting in knowledge and expertise transferred to, e.g. private sector and R&D institutes enabling future assembly and manufacture of needed equipment. This will be undertaken through South-South exchange and networking opportunities.

- A critical mass of technical capacity in the various required disciplines established on a learning by doing bases as well as specially designed training sessions;
- Financial mechanisms promoting rural energy development with private sector involvement conceived and operationalized;
- 'Recommendations for' institutional structures and policies formulated/put in place; and
- A number of small and medium energy enterprises (engineering offices and project developers, energy service providers, etc.) established and spearheading the electrification of rural areas with indispensable support from the public sector.

4. Critical Factors for the Sustainability of a Renewable Energy Enterprise

4.1 Financial Mechanisms and Institutional Frameworks

Critical for successful deployment and diffusion of renewable energy solutions through the creation of renewable energy based SMEs is the existence of smart financing mechanisms. Importantly, these mechanisms need to encourage trained (and certified) people/SMEs to become services providers specialized in one or more of the domains needed to construct, operate, and maintain modern energy facilities, such as: identification of sites and appropriate technologies; concept and detailed engineering design and preparation of 'bankable' documents; mobilization of beneficiaries and consumer societies; construction and installation of civil and electromechanical facilities; and/or management, operation and maintenance.

Public sector institutions, central and local governments, government energy related agencies, and financial institutions, such as development and commercial banks, each have a role and responsibility in the establishment and operationalization of these financial mechanisms including: conducting energy market studies; preparing master plans; certifying eligible SME service providers; mobilizing funds, defining criteria for grants and soft loans; reviewing designs and bankable documents; validating and controlling constructed facilities; etc., (Figure 7)

The processes and activities involved in the establishment of pilot demonstration sites for modern energy access help create the much needed critical mass of local technical capacities of the various stakeholders through a learning-by-doing approach. When this critical mass operates in a streamlined manner within an institutional framework, with clearly defined roles, responsibilities, and criteria, a breakthrough in access to modern energy is possible that attains the set targets and delivers, in public private sector partnership, small and medium modern energy enterprises.

Below is an outline of a typical institutional framework for delivering energy access that could be considered:

4.1.1. Energy access policy

The Rural Energy Policy can clearly expresses the intentions of the Government to enabling greater access to modern energy sources and to enhance the economic and social development of the rural communities in the country. These policy intentions need to be given effect through appropriate legislative, regulatory and financial instruments and establishing institutional structures to ensure implementation.

The Energy Access Policy will have to be in compliance with the Poverty Reduction Strategy Programme (PRSP) by creating jobs and low the proportion of the population remaining below the poverty line with less US$ 1 of income per day mainly in rural areas. The National Poverty Reduction Programme, as well as conventions to which the country has subscribed, usually impose the obligation of having an energy policy in respect of principles of lasting development and contribution to the achievement of Millennium Goals.

4.1.1.1 Objectives

The Government needs to promote and support energy access development aiming at:

- Combining the hydro, wind, solar, and biomass potential in order to meet the electrical energy needs with greater emphasis on hydropower, solar and wind.
- Establishing an energy access level of 100% by 2030 and expanding electricity access in the most economically efficient manner, including connection to the main grid and, where this is not feasible, off-grid services at the village or household scale.
- Maximizing the leveraging of government resources through participation of the private sector and other members of the civil society
- Maximizing the economic, social, and environmental benefits of energy access through the promotion of productive uses and income generating activities.
- Minimizing the pressure on biomass resources by encouraging efficient use of biomass and switching to other energy sources in domestic cooking.

4.1.1.2. Policy Elements

In order to achieve these objectives the following policy elements needs to be recognised and necessary steps need to be taken to establish the required legal, regulatory, financial, and institutional mechanisms consistent with these policy elements.

Coordination of modern energy access activities and procedures
The government needs to take measures to ensure proper coordination of the activities involving modern energy access by establishing an appropriate agency for the same. This agency will act as the planning and implementing agency of rural and peri urban energy access programmes. Such an agency will be able to provide a focused attention on the rural energy development activities taking the burden of regular project planning and implementation related interventions away from the Ministry of Infrastructure/energy.

Recognition of private sector participation and ownership in modern energy access programmes
The government will encourage the private sector, including the community owned entities, to play a major role in rural and peri-urban energy access programmes. This will include allowing private sector ownership and operation of isolated or grid connected mini grids in rural areas. The government will take measures to establish necessary legal and regulatory framework for the same.

Level Playing field in rural energy access development
The government will provide a necessary framework to ensure that all the energy suppliers, particularly electricity suppliers, to rural consumers can compete on equal terms. Any subsidy will be made available to all parties interested in energy access development on merit basis. These subsidies can be initially allocated to community based organizations and other private sector institutions, in the form of grant funding for technical feasibility studies, capital grants and performance based grants.

Enabling Regulatory Framework
Separation of policy-making, regulation and operations: The government will confine itself to policy-making and planning while the utilities and other institutions will be made responsible

to carry out the energy sector operational activities. A national Regulatory Agency will be given the complete freedom to regulate the energy sector including off-grid systems.
"Light-handed regulation": Small stand alone systems such as village-hydro schemes and mini-grid systems with photovoltaic or other source of electricity generation in rural areas needs to be subjected to a separate fast-track and less cumbersome licensing process while maintaining the required safety standards.

Cost reflective electricity tariff setting encompassing any subsidies provided
A tariff regime that enables cost recovery at a reasonable return on investment needs to be allowed, particularly in isolated mini-grid systems in rural areas accepting the principle of differential pricing. Further, the system of regulation will ensure that bulk supply tariff of the main grid will be made cost reflective so that any isolated mini-grid can compete with the main grid supply on a level playing field.

Third party access to the networks
Small producers of electricity will be allowed to sell directly to any consumer connected to the main grid using the distribution and transmission network at a cost reflective network service charge.

Subsidy Mechanism for Energy Access
A Subsidy Mechanism will be established to support necessary subsidy requirements of the rural energy access programmes. Finances for this mechanism will be made available through the state budget and through donor assistance. A levy may be imposed at a later stage, on the electricity tariffs of all the consumers to supplement these finances**.**

Transparent subsidy transfer and financing mechanism
All the energy access projects, both by the government and by the private sector will be subsidized by the government based on transparent criteria where subsidies are allocated on merit basis considering the expected economic, social and environmental benefits. Necessary incentives aimed at maximizing the net benefits will be provided to the rural energy suppliers.

4.1.2. Strategies and actions

To implement the Energy Access Policy the following strategies and actions are proposed.

Establishment of a legal framework: Identify rural energy access as a separate subject in the energy legislation and assign different responsibilities on energy access to relevant agencies. The policy elements need to be addressed in the new legislation.

Division for Energy Access Project Implementation (DEPIM) or Energy Agency (EA): A separate division needs to be created within the Ministry of Energy to plan, implement and coordinate energy sector activities inclusive of rural and peri urban energy access programmes. This division can evolve into separate agency at a later stage when the number of energy sector programmes implemented increase to significant level.

Administrative Unit in a national development bank, NDB (AUNDB): Establish a separate unit within a national development bank to manage loan funds for rural energy access. This unit will work in coordination with the local government which provides grant funding for rural energy development

Energy Access Master Plan: Prepare a master plan for providing energy access in the un-served areas, identifying different geographical locations where grid-electricity and off-grid systems can be in place along with corresponding time frames. This will enable the developers to plan for the most appropriate energy supply systems for these un-served areas.

Energy Access Subsidy Mechanism: Establish a subsidy mechanism, mainly for the purpose of supporting the both capital and recurrent subsidies for rural energy access programmes. This can be in the form of an Energy Access Fund.

Allocation of Subsidies: Entrust the task of allocating the subsidies on a competitive basis to the DEPIM which needs to work in collaboration with the NDB and other possible special funds at local government levels, to coordinate subsidies and loan funds disbursed for the projects.

Setting of Tariffs/Tariff Regulation: Take appropriate action for the utilities/Developers to set their distribution tariffs on a cost reflective basis taking into consideration any subsidies received. Regulate these tariffs both in the utility supplies and in isolated mini-grids through regulatory agency.

Third party access to the networks and Costing of Network Services: Open access to the transmission and distribution networks for third party use within an appropriate time frame. Request the utilities to cost the use of their transmission/distribution network services and publish a cost reflective tariff for the same to be charged from the users of the networks. These charges are to be regulated by the regulatory agency.

4.1.3. Institutional structure

In most of the sub Saharan African countries, most of the institutions required for smooth development of the modern energy access sector are already in place. However, proper linkages between these institutions and coordination of their activities are paramount in ensuring optimal utilization of resources available in this sector.

4.1.3.1. Institutional Structure and Flow of Funds for Energy Access

Institutional structure and flow of funds are depicted in the Figure 3.1. Funding for provision of rural energy services can come in three different forms. They can be in the form (i) donor funding to central government (ii) direct central government allocation for energy access projects and (iii) allocation from the grants to local governments through existing common development fund.

The block diagram in Figure 3.1 shows the proposed flow of funds to energy access programmes from different sources**.** Targeted donor funds as well as central government funds which come in the form of grants can be channelled through DEPIM or EA to the local government. Any loan components of such funds are channelled through central government, NDB to the local government. In addition, the local government can receive funds for rural energy access programmes through its allocation from existing common development funds. These funds are then used by the local government as the developer, to establish rural energy access projects through contractors.

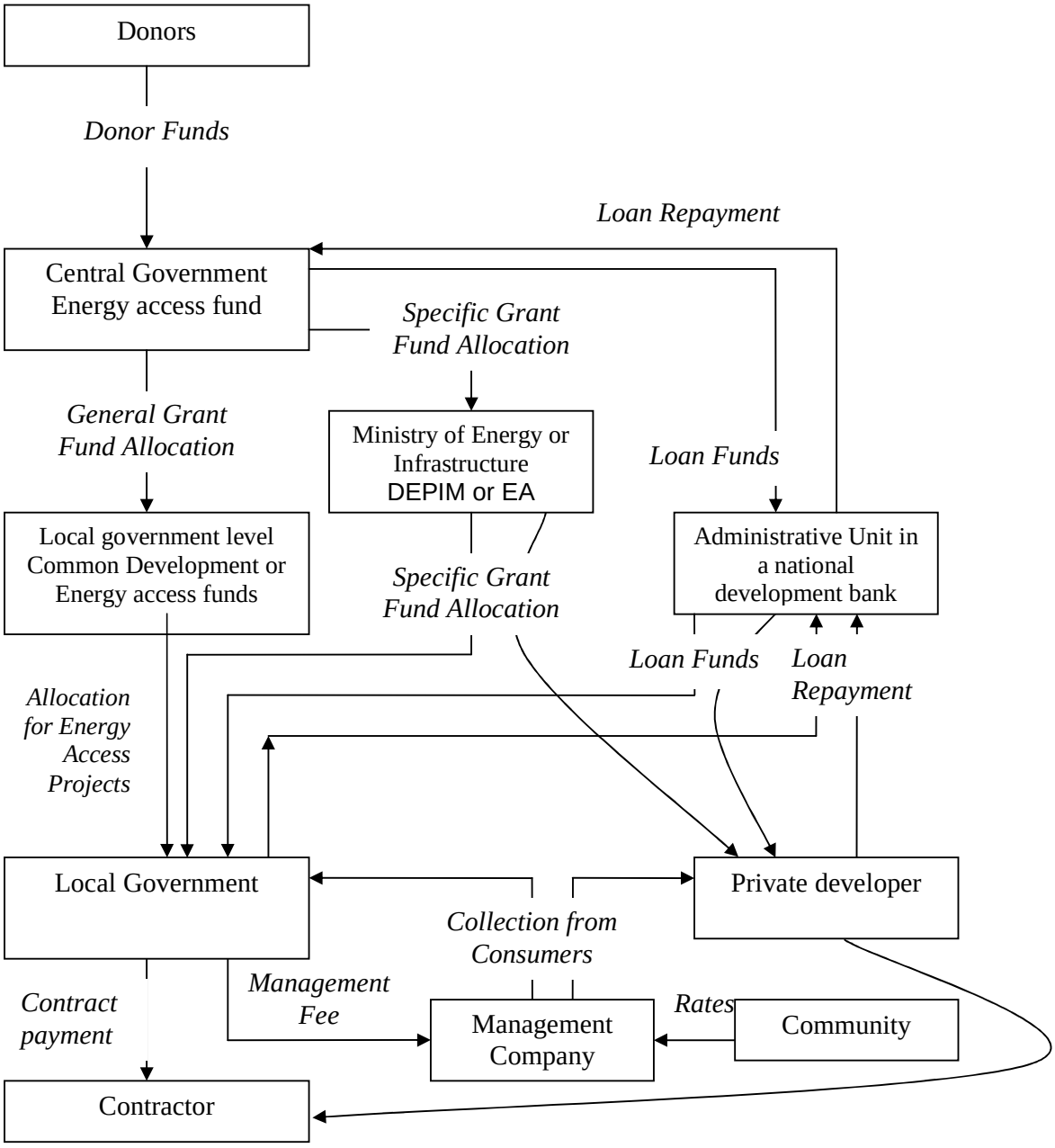

Figure 7: Flow of Funds in Energy Access Programmes

Also private developers will be able to access grant and loan funds available for energy access projects. While private contractors are secured for construction of these projects private management companies can be set up to manage day-to-day operation of these rural energy systems. These companies collect revenue from the community on behalf of the developers (local government or private sector) at an agreed management fee.

4.1.3.2. Institutional Responsibilities

This chapter outlines proposed activities of different institutions dealing with energy access delivery.

Central Government
The main task of the central government is to obtain assistance from bilateral and multilateral donors based on the plans submitted by the Ministry of Energy / Infrastructure. Further, it allocates general grant funds from the budget to the local governments for common development purposes including energy access, while providing specific grant and loan funds for rural energy services directly to the DEPIM or Energy Agency.

Common Development Funds or Energy Access Fund
Frequently, local governments, especially under decentralized regimes, receive from the central government funds dedicated for various development purposes. This common development funds could provides finances for projects only based on the proposals submitted by the local government. It is therefore the responsibility of the local authorities to persuade and obtain proposals for rural energy access projects from the local government. The local government will scrutinize these proposals for technical feasibility. The DEPIM can provide assistance in this regard. Once finalized and accepted funds can be provide for such projects.

Division for Energy Access Project Implementation (DEPIM) or Energy Access Agency
One of the major tasks of DEPIM or Energy Agency is to provide all the technical inputs required for the Ministry of Energy / Infrastructure to formulate its policy in the energy sector. Also development of a Master Plan for energy access delivery with emphasis on electrification is an important activity which can be undertaken by DEPIM. Further it needs to ensure that the developmental activities in this regard are in line with this master plan.

DEPIM can coordinate channelling of specific grant funds made available by the central government for energy access projects to the local government. Furthermore, DEPIM could provide the required technical assistance and inputs to help NRB or local governments developing or scrutinizing proposed projects. Private (or community owned) management companies needs assistance on technical matters too when operating and maintaining the rural energy access systems and such assistance also needs to be provided by DEPIM. In addition DEPIM EA will have the task of monitoring overall performance of these schemes and make recommendations to the Ministry of Energy/Infrastructure on policy modifications to be adopted to ensure optimal utilisation of the limited resources.

Local government
Local government has access to funding for energy access from the Central Government channelled through DEPIM-EA and NDB, in addition to the possibilities under the common development funds. Therefore its task is to propose appropriate projects with the technical assistance of DEPIM EA while adhering to the master plan.

Also the local government needs to select and monitor those who carry out construction and later manage these projects during operation.

Administration Unit established at a National Development Bank (NDB)
The available expertise and capacity of the development banks like NDB can be used to managing funding made available for the energy access projects. A separate division within BRD can be established to channel funds from the central government to the local governments as well as to private developers. This can include not only the loan funds but also grant funds.

Management Company
The main task of the management company is to manage day-to-day operation of the energy access schemes on behalf of the local government or any private developer for a management fee. In case of a private developer this can be the developer himself. The management company has the responsibility of collecting the charges for electricity supplied

to the consumers and transfer the same to the local government or to the private owners of the schemes where appropriate. Further, it needs to interact with DEPIM through the local government or directly on any technical advice/assistance.

Private Developers
Private developers can identify and develop projects with either grant funding from the central government disbursed through DEPIM (or AU-NDB) or loan funds arranged with AU-NDB or commercial banks. Further it needs to interact with DEPIM as well as the local government in developing acceptable projects for the communities of their interest.

4.2 The Productive Uses of Energy

An essential factor for ensuring the economic sustainability and affordability of energy services is the **use of energy for productive activities**. The reality is that communities and regions without access to modern energy are, in the majority of cases, very poor[5], and cannot afford energy services[6]. Therefore, the selection and prioritization of sites for energy production will not only be dependent on the availability of natural sources to be utilized, but equally important, a function of the socio-economic profile of the beneficiaries, together with the potential for economic activities in the region.

Energy provided for productive use will, by definition, generate income that will enable beneficiaries to pay for the energy services received, including that portion not directly used for productive activities, such as lighting and community services, which in turn will lead to improvement in other developmental indicators (e.g., health and education). Moreover, the productive use of energy will also increase the number of kWh 'sold', especially during daytime (Figure 8), which, for the same initial installation costs, will result in more affordable services, thereby reaching a wider range of beneficiaries who otherwise could not afford the service. Both factors will enable the energy enterprise or service provider to operate in an economically sustainable manner.

[5] It is observed that a high poverty rate leads to a persisting lack of affordable energy, however, it is also proven that lack of access to modern energy leads to increase in poverty rate!
[6] Either provided through, e.g., grid extension, or the establishment of isolated grids

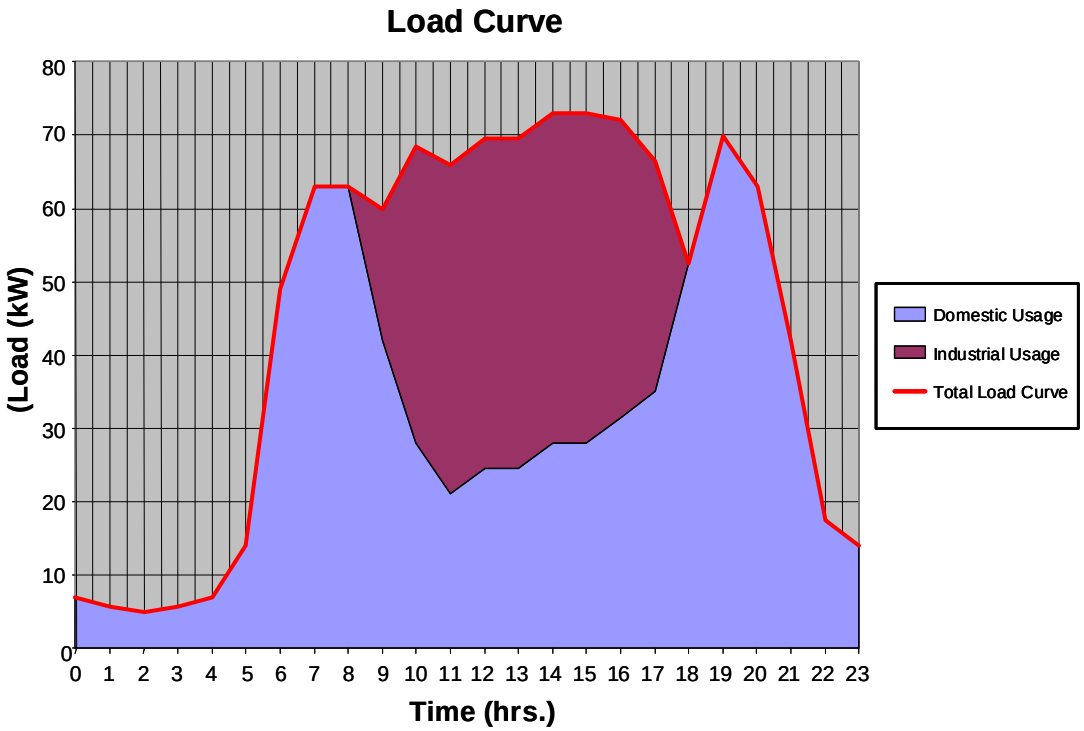

Figure 8: A load curve of a mini hydro site. As more kWh are used over 24h, for households & productive uses (community services & income generating activities), this leads to more affordable energy service and increased accessibility to a wider number of poor beneficiaries

4.3 Technology Choices

The use of proven and reliable technologies is another key factor affecting the viability and economic sustainability of energy services provision, be it based on hydro, solar, wind, biomass, etc. The technology must be, among others things, suitable for the prevailing, and/or achievable, levels of local technical skills, in terms of management, operation, and maintenance of the energy enterprise. In this regard, mini hydro, solar photovoltaics, and wind are considered as suitable technologies (see Annex 1). In addition, they have been shown to operate reliably on small scales in rural and peri-urban conditions of developing countries, including sub-Saharan Africa. Therefore, these technologies are widely recognized as serious options for further expansion of energy access in rural areas.

Other renewable technologies, such as biomass conversion, also provide possible pathways for renewable based energy access. However, these technology options are more appropriate to circumstances other than supplying remote rural communities. For example, the economic viability of the combustion and gasification of biomass relies on generation capacities of 200 to 300kW, which practically translate into industrial production and/or application facilities. At these capacities: (i) the biomass feedstock can be secured at economically and environmentally acceptable costs (either as waste or a by-product available at the site, or cultivated for the purpose); (ii) the technology used already incorporates the features needed to ensure the desired quality of synthetic gas for reliable operation of the facility (these technology features are not available for lower kW capacities due to cost effectiveness, and this, among other things, places additional requirements on the skill level of operators at smaller facilities); and (iii) the level of skilled operators and technicians are not readily available and difficult to keep in rural access energy facilities.

4.4 Appropriate management, operation, and maintenance arrangements

Based on UNIDO's experience in undertaking small hydro energy access projects in a number of countries across sub-Saharan Africa it is clear that establishing management, operating, and maintenance arrangements and structures appropriate to the local conditions is a critical success factor. There is a number of possible options available including: (i) government owned energy utilities; (ii) private sector enterprises; and (iii) community-based arrangements. A single entity may assume responsibility for all aspects of the project or different enterprises may take on one or more specific roles.

As government owned utilities often have high associated costs, and are typically focused on centralized large-scale generation for urban and industrial uses, they are not always best suited to fragmented small-scale remote energy projects.

Private sector involvement will be critical to the long-term sustainability of remote energy access projects and markets. However, government support, in terms of financial and market incentives, will be required in the initial stages due to the perceived lack of profitability. However, profitability may be seen to increase as more and more consumers are able to pay. In addition, private companies may be able to reduce costs, thereby increasing profits, by operating a number of small-scale projects. Governments will play a critical role in setting market conditions and providing a regulatory framework for private sector participation.

For smaller capacity facilities, community management and operation may be an appropriate option, however, experience has shown that this is vulnerable to the way consumers and local authorities perceive their roles and responsibilities.

Regardless of the type of institution or enterprise undertaking these roles, an adequate supply of relevant skills is essential.

4.5 Environmental sustainability

Although most renewable energy technologies are, by their very nature, more environmentally sustainable than fossil fuel based energy generation systems, they are not without environmental concerns, particularly for hydropower.

UNIDO's experience with a mini-hydro project in Rwanda found severe erosion of soil and river banks, resulting in sand laden water entering the turbines following heavy rain, causing increased wear and shortened turbine life span. This problem resulted from a lack of hydrological and topographical data associated with the project thereby preventing the implementation of protective measures prior to operationalization of the facility.

The development and implementation of environmental sustainability criteria and environmental impact assessments will need to be an integral part of renewable energy access projects. However, this may prove problematic as long-term baseline environmental data is often lacking in many developing countries, particularly across Africa.

5. Concluding remarks

A bottom up approach is proposed that aims to:

- Progressively create local technical capacities through a learning-by-doing process of establishing pilot demonstration energy access facilities.

- Subsequently, establish an institutional framework of regulatory and financial mechanisms to streamline the delivery process of energy access, in public private sector partnership.

The decision to establish the necessary institutional frameworks and regulatory and financial mechanisms is a political one that will ideally take place at the start of Phase 3, once the critical mass of required local technical capacities is available.

The time needed to build the required capacities of the various stakeholders, including the private sector (Phases I and 2), will depend on the initial developmental status of the country and the absorption capacity of its institutions.

The target set by the AGECC of universal access to modern energy is achievable through the implementation of this approach. However, to achieve the target within the set time frame, that is 2030, the effectiveness and efficiency of the interventions have to be maximized through:

- Close cooperation between national governments, international technical cooperation organizations, and financial institutions;
- At the national level, close cooperation between the various responsible ministries and stakeholders; those benefiting by having access to modern energy for their developmental plans;
- Taking into account the lessons learned elsewhere;
- Using south-south cooperation wherever applicable , and
- Seeking regional integration to promote economies of scale.

Annex 1

Renewable Energy Technology Options

Small-scale hydropower, solar photovoltaics, and wind are considered the most applicable renewable energy technologies for providing clean electricity generation in rural and peri-urban areas in developing countries. Some of the advantages of these options are listed below.

1. Mini-hydro

- A high efficiency (70–90%) – by far the best of all energy technologies;
- A high capacity factor (typically >50%) – compared with 10% for solar and 30% for wind;
- A high level of predictability – varying with annual rainfall patterns;
- Slow rate of change – the output power varies only gradually from day to day (not from minute to minute);
- It is a long-lasting and robust technology – systems can readily be engineered to last for 50 years or more; and
- Cost per kW capacity installed – although a function of many factors that are site specific (such as civil work, type of equipment, length of transmission lines, etc) the acceptable range is up to $US5500 per installed kW.

Small hydro is in most cases 'run-of-river'; in other words any dam or barrage is quite small, usually just a weir, and little or no water is stored. Therefore, run-of-river installations do not have the same kinds of adverse effect on the local environment as large-scale hydro.

2. Solar PV

- Can be installed and operated anywhere including areas of difficult access and remote locations;
- PV cells are modular – a small initial system can be expanded as demand increases;
- Minimal operating costs – generates free energy from the sun;
- Have no moving parts thus requiring minimal maintenance;
- Non-polluting – has no direct impact on the environment; and
- Systems have a long life and durability – cells last 25–30 years.

The cost of Solar PV panels has dramatically reduced in recent years, making it more competitive with other renewable technologies.

3. Wind

- Can be installed and operated anywhere including areas of difficult access and remote locations;
- Non polluting;
- Requires very little space – the land beneath wind turbines can be used for other purposes, including agriculture;
- Turbines are available in a range of sizes making them accessible to a vast range of people and businesses, including single households to small towns and villages;
- Relatively low generation costs of 4–6 c/kWh (excluding initial capital costs); and
- Turbines are self sufficient with few moving parts – thus low operating and maintenance costs.

Although wind turbines have relatively high initial capital and establishment costs these have reduced by more than 80% over the last decade.

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