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Renewable Energy Jobs & Access

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Solar panels being installed in Bangladesh

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Foreword

Achieving universal access to modern energy services is critical for improving the well-being, productivity and health of millions of people who currently suffer the depredations of energy poverty. Deployment of decentralised renewable energy solutions can have a transformative impact in this context. Meeting the objectives of the United Nations' International Year of Sustainable Energy for All will be essential to achieving the Millennium Development Goals.

While attention has been devoted to a broad range of issues surrounding rural energy access, the employment aspect has received comparatively scant attention to date. This IRENA report is among the first to address this topic in depth, bringing to light successful projects from around the developing world and giving greater visibility to this essential dimension of the energy access debate. The study also touches on financing models and on broader linkages, examining the extent to which the supply chain for renewable energy projects is integrated into the local economy and is thus able to generate additional downstream employment.

The report finds that energy access through renewable energy technologies can generate significant employment along the value chain and improve rural livelihoods. Furthermore, the potential for employment opportunities and income generation is considerably enhanced when renewable energy projects are well integrated with local commercial activities. The decentralised nature of renewable energy technologies makes them well suited to the rural context. Many of the skills required to deploy these technologies can be easily developed locally, thus limiting the need for imported expertise. The employment effect of energy access through renewable energy technologies adds to the well documented benefits of reduced household energy expenditures, improved health, greater opportunities for educational advancement, and creation of income generating activities, that all allow for a better quality of life.

I am confident that findings from this report will contribute to achieving IRENA's mandate and encourage policy makers to consider this fundamental socio-economic aspect of renewable energy deployment in the context of access to energy.

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Women moulding clay stoves in Burkina Faso (GIZ)

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Acronyms

Ah	Ampere-hour
ARE	Alliance for Rural Electrification
AGECC	The UN Advisory Group on Energy and Climate Change
BSP	Biogas Support Programme [Nepal]
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (The German Ministry of Economic Cooperation and Development)
CFA	Communaute Financiere Africaine (West African Franc)
DEEP EA	Developing Energy Enterprise Programme East Africa [GVEP programme]
DGIS	Directoraat Generaal Internationale Samenwerking (Directorate-General of Development Cooperation) in the Dutch Ministry of Foreign Affairs
E+Co	Energy Through Enterprise
ESMAP	Energy Sector Management Assistance Program [Multi-donor trust fund administered by the World Bank]
FAFASO	Foyers Améliorés au Burkina Faso [GIZ project]
FOMILENIO	Fondo del Milenio (Entity created to act on behalf the Government of El Salvador under an agreement with the U.S. Millennium Challenge Corporation)
GEF	Global Environment Facility
GERES	Groupe Energies Renouvelables, Environnement et Solidarités [France/Cambodia]
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit [Germany; formerly GTZ]
GIZ-EnDev	Deutsche Gesellschaft für Internationale Zusammenarbeit - The Dutch-German Energy Partnership Energising Development
GVEP	Global Village Energy Partnership
HH	Household
IADB	Inter-American Development Bank
ICS	Improved Cookstove
ICT	Information, Communication and Technology
IEA	International Energy Agency
ILO	International Labour Organization
IDCOL	Infrastructure Development Company Limited [Bangladesh]
kW	kilo-Watt
kWh	kilo-Watt-hour
LEDS	Light-Emitting Diodes
m^3	Cubic metre
MHP	Micro-Hydro Plant
MHFG	Micro Hydro Functional Groups [Nepal]

MFI	Microfinance Institution
MNRE	Ministry of New and Renewable Energy [India]
MW	Mega-Watt
MWh	Mega-Watt- hour
NGO	Non-Governmental Organisation
NLS	New Lao Stove [Cambodia]
PERZA4	Programa de Electrificacion Rural en Zonas Aisladas [Nicaragua]
PV	Photovoltaic
PO	Participating Organisation
REDP/RERL	Rural Energy Development Programme / Renewable Energy for Rural Livelihood [Nepal; UNDP/World Bank supported]
REF	Rural Energy Foundation [Netherlands]
REN21	Renewable Energy Policy Network for the 21st Century
RERED	Renewable Energy for Rural Economic Development Program [Sri Lanka]
RET	Renewable Energy Technology
SHP	Small Hydro Power
SHS	Solar Home System
SLRS	Solar Lantern Rental System [Sunlabob; Laos]
SPV	Solar photovoltaic
SWH	Solar Water Heater
TV	Television
TWh	Tera-Watt-hour = 1 billion kWh
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WB	World Bank
Wp	Watt-peak
WHO	World Health Organization
WRI	World Resources Institute

Executive Summary

The United Nations declared 2012 the International Year of Sustainable Energy for All, with the goal of supporting universal energy access by 2030. This comes in recognition of the fact that hundreds of millions of people, especially in rural areas, do not have access to affordable, reliable, and clean sources of energy. Traditional biomass—firewood, charcoal, manure and crop residues—still plays an important role, but leads to severe health and environmental problems including indoor air pollution, deforestation, soil erosion, and black carbon emissions that contribute to climate change.

Renewable energy technologies, including solar photovoltaic, small-scale wind, hydro, and biogas are becoming cheaper, more efficient and better adapted to the needs of rural populations in developing countries not being served by electricity grids. Improved cookstoves also play an important role since they allow for the more efficient use of biofuels. However, current information on job creation through renewable energy technologies in rural areas is quite sparse. Job creation figures are rarely being tracked in any systematic manner as there are few reporting channels, and many of the enterprises and projects working to enhance energy access are small and dispersed.

This report is among the first to delve into the topic of job creation in the context of rural access to energy. It presents twelve first-hand case studies from practitioners in Central America, Sub-Saharan Africa, and Asia, across a set of renewable energy technologies, including biogas, small-scale hydropower, improved cookstoves, solar home systems and other solar technologies. The projects cover a range of activities, including support for the sale, installation and maintenance of small solar systems; small-scale production of improved cooking stoves; investment and training in small hydropower plants; advice to business start-ups and marketing and networking for producers; among others.

The findings indicate that energy access through renewable energy technologies can generate significant employment: reaching the objective of sustainable energy for all could create almost 4 million direct jobs by 2030 in the off-grid electricity sector alone. Small-scale renewable energy technologies are well adapted to the rural context as the bulk of the skills and training required for their deployment can be developed locally. Importantly, this limits the need for developing countries to rely on foreign know-how and expertise. However, the case studies show that, in addition to formal or full-time employment, entrepreneurs in remote rural areas often take on labourers in highly informal arrangements in order to retain the flexibility needed for what are often fluctuating and uncertain business circumstances.

The findings of this report indicate that in designing and implementing policies to increase the number of renewable energy jobs, policy makers may want to consider the following:

Job Creation

As illustrated by the case studies, renewable energy jobs in rural areas of the developing world can be created in certain segments of the industry's value chain. A key question concerns the extent to which the renewable energy sector

is integrated into the local economy both via the supply chain (upstream linkages) and downstream businesses that are made possible by the provision of energy services. The case studies suggest that many, but not all, manufactured inputs such as photovoltaic panels, solar lanterns, and turbines for hydropower plants are imported from other countries. However, there is some domestic assembly of imported solar components, and batteries are often manufactured domestically. For improved cookstoves, supply chains are mostly domestic in nature. This is especially true for clay stoves, but in the case of metal stoves, scrap-metal is often imported. Likewise, for biogas plants, the bulk of inputs, especially construction materials, are likely to be sourced domestically.

Most developing countries continue to play a limited role with regards to the manufacturing of renewable energy equipment and components. However, there is greater employment potential in the downstream linkages, particularly in the distribution, sales, installation, operation, and service of such systems. Thepotential for employment opportunities and income generation is considerably enhanced when renewable energy projects are well integrated with local commercial activities, either through up-scaling of existing small businesses or the creation of new ones.

Improving Skills

Small-scale renewable energy technologies are generally well adapted to the rural context. Many of the required skills and training can be developed locally, thus limiting the need for imported expertise.

Nevertheless, developing appropriate skills along the renewables value chain remains critical to strengthening the rural renewable energy sector. In many cases, training can be done on-site or on the job. This is especially true for many micro-enterprises, and particularly those that rely on informal and temporary labour in addition to regular employees.

The case studies show that broader training encompassing the development of business skills is essential, as well as in product standards, and quality control, among others. Marketing skills are especially needed for renewable energy technologies that are sold individually to households such as solar home systems and solar lanterns.

Gender Impacts

Women derive some of the most important benefits from improving energy access. In rural areas, the burden of gathering fuelwood falls heavily on them, requiring hours of back-breaking work each day. Renewable energy technologies especially if combined with energy efficient cookstoves, reduce or eliminate this burden.

The case studies illustrate that women have an important role in producing improved cookstoves and briquette-making (which require less capital and less mobility), but far less so in solar technologies and biogas ventures due to various limitations. These include: mobility, capital requirements, and the perception that technology is better served by men – all of which preclude a larger role for females in many rural settings. Social structures and traditions also have an impact: some female entrepreneurs are limited in their activities by the need to remain in the household or help in the field. As such, in most renewable energy technologies enterprises, female employees are a minority, especially in managerial and technical positions.

Standards and Quality Assurance

Experience suggests that using quality materials, equipment and components is critical, not only to the sustainable development of the renewable energy industry in rural areas, but also to local job creation. Quality assurance helps to reinforce to prospective rural community customers that renewable energy is a credible and suitable alternative to traditional forms of energy. To facilitate this requires appropriate national-level administrative structures, as well as building capacity and technical expertise among importers, distributors and retailers of renewable energy technologies equipment. Governments are principally responsible for putting such standards and quality assurance measures in place.

Improving Primary Data

There is a need for better and more systematic efforts to track and monitor rural renewable energy employment in developing countries. Additional case studies are needed to ensure the availability of a robust set of examples for each renewable energy technology within different regions. This will allow for an enhanced connection to be made between specific local micro-conditions and the broader country context, including national policy-making. Local case studies could also be temporally extended to improve the evaluation of development impacts over a longer period of time. Establishing time-series data and monitoring qualitative aspects of employment would also facilitate a broader understanding of the evolution of the employment sector in rural areas. This requires drawing up common criteria, metrics, and reporting standards for rural case studies in order to make findings as comparable as possible and to support long-term monitoring and assessments.

The purpose of this report has been to explore the topic of job creation in the context of rural access to energy. The use of case studies has allowed for a multi-faceted analysis, highlighting where linkages between local job creation and renewable energy deployment occur. These include important aspects such as job creation by technology, integration of the renewable energy sector into local economies, skills and training, the gender impact well as standards and quality assurance measures. This report represents the initial step of an on-going effort to collect and monitor information through case studies on this important socio-economic dimension. It is envisaged that this report, and future initiatives, will support decision makers in designing rural energy policy.

Women purchasing briquettes for ccokstoves in Uganda (GVEP).

1. Introduction

The United Nations has designated 2012 as the "International Year for Sustainable Energy for All." The UN Secretary-General has set three objectives for 2030—achieving universal access to modern energy services; doubling the rate of improvement in energy efficiency; and doubling the share of renewable energy in the global mix. This comes in recognition of the fact that large numbers of people in developing countries do not have access to affordable, reliable and clean sources of energy. Expanding access to modern energy services is essential for reducing poverty, improving health and increasing productivity. Energy access is also a prerequisite for achieving a number of the Millennium Development Goals (United Nations Development Programme (UNDP), 2008).

This report addresses a dimension of energy access that has to date received only limited attention: employment. It is among the first to draw a comprehensive picture of how the deployment of modern renewable energy sources in rural areas of the developing world contributes to the creation of jobs and livelihoods. Much attention has been devoted to the technical aspects, the changing economics and the need for financing mechanisms. However, to make energy access a reality also requires that sufficient numbers of individuals are trained in the skills needed to manufacture, distribute, sell, install, operate and maintain renewable energy systems, ranging from solar home systems (SHS) to micro-hydro plants (MHP) to household biogas digesters.

The employment dimension of renewable energy development has received growing attention in recent years, although most studies have focused on those few countries that play a leading role in manufacturing renewable energy technologies (RETs). Similarly, most of these studies have concentrated more on industrial-scale solar photovoltaics (SPV) than on the pico solar systems that play a role for poor communities in the developing world; more on large hydro than small hydro; and more on biofuels for powering automobiles in cities than on biomass for village energy needs.

As this report discusses, the bulk of the literature on this subject does not engage the employment dimension in rural contexts or makes only passing reference to it. Yet there is tremendous potential for employment in processing renewable energy inputs (biomass), in producing, selling, installing and servicing both the equipment that transforms renewable energy sources into usable energy (solar panels and lanterns, wind turbines, biogas digesters, cookstoves, etc.), and the equipment or appliances that turn energy into desired services (heat, light, refrigeration, mechanical power, etc.).

It remains difficult to estimate how many jobs could be generated by fulfilling the goal of the International Year for Sustainable Energy for All. However, some of the present employment figures indicate significant potential. Already, India estimates that its off-grid SPV sector employs 72 000 people and its biogas sector 85 000 people. China's biogas industry has employed some 90 000 people in 2006-2010, and its solar water heating (SWH) sector - where it is the world's undisputed leader - may involve as many as 800 000 people. But smaller countries too, are beginning to create some substantial employment in off-grid renewable energy. Bangladesh has an estimated 60 000 people who are involved in the SHS sector, a figure that will grow larger as a bigger share of its rural population gains access to solar electricity. This report offers a rough estimate of almost 4 million direct jobs in off-grid renewable electricity generation that could be created by 2030 if the Energy Access for All scenario is fulfilled. Additional employment would be generated in renewable technologies for cooking and heating.

Beyond the renewable energy sector, another employment dimension is found in the downstream micro-businesses that are either newly created or able to expand due to improved energy access. Increased economic transactions are possible when stores and other businesses can stay open into the evening thanks to lighting. Furthermore, there are less-readily quantifiable impacts. They include time spent on education or income generating activities (previously

spent collecting fuelwood, for example), greater productivity that results from better-quality or more reliable lighting; better health and therefore more productive lives resulting from eliminating air pollution associated with conventional cooking fuels (kerosene or fuelwood) and from better vaccination made possible by reliable refrigeration; children's ability to study at night and the educational gains that may lead to more productive economies in future years.

An important finding is that rural RET projects typically do not need highly qualified skills. This means that rather than requiring extensive foreign expertise and personnel training, energy access can be provided by relying on people with fairly basic technical and business skills. The resulting employment from the dissemination of RETs offers important economic opportunities for the "bottom of the pyramid."

Section 2 of this report gives a brief overview of the energy access situation in developing countries with regard to electricity, modern fuels and cookstoves. It reviews the available estimates of numbers of people lacking access to modern energy and energy services. The section then discusses possibilities to improve access with the assistance of renewable energy options, the benefits of doing so, as well as the obstacles and ways to overcome them.

Section 3 provides a review of the available literature, highlighting what is known about employment opportunities that emerge from expanding renewable energy in rural areas. The discussion focuses on a number of key RETs, including SHS, solar lanterns, SWH systems, and biogas digesters for cooking and heating, as well as ICS. For each of these, selected country experiences are presented.

Section 4 is based on a series of case studies, provided by IRENA partner organisations, companies and development projects in Central America, Sub-Saharan Africa, and Asia that are intended to improve rural energy access and build local capacity. These ventures rely on a broad range of renewable energy sources and associated approaches, including biogas, briquette-making, small-scale hydropower, ICS, SHS and other solar technologies. The case studies offer specific data on employment and related experiences. Furthermore, the discussion of these case studies touches on financing aspects, and examines to what extent the supply chain for renewable energy projects is integrated into the local economy and is thus able to generate additional downstream employment. In addition to jobs that are directly linked to the deployment of renewable energy, there are a number of associated benefits (reduced household energy expenditures, improved health, greater opportunities for educational advances, and others) that allow people to live more productive lives and have more time to pursue income-generating opportunities. While these are often difficult to quantify, they nonetheless carry great importance for local communities. Lessons Learnt from these case studies are presented in section 5.

Finally, Section 6 provides policy-makers with recommendations on how best to enhance job creation in the context of RET deplyment in rural areas.

2. Energy Access Overview

This section first provides a brief overview of the extent to which different regions and countries of the developing world currently lack access to modern, clean energy. It then examines opportunities and investment needs for expanding access before discussing some key obstacles.

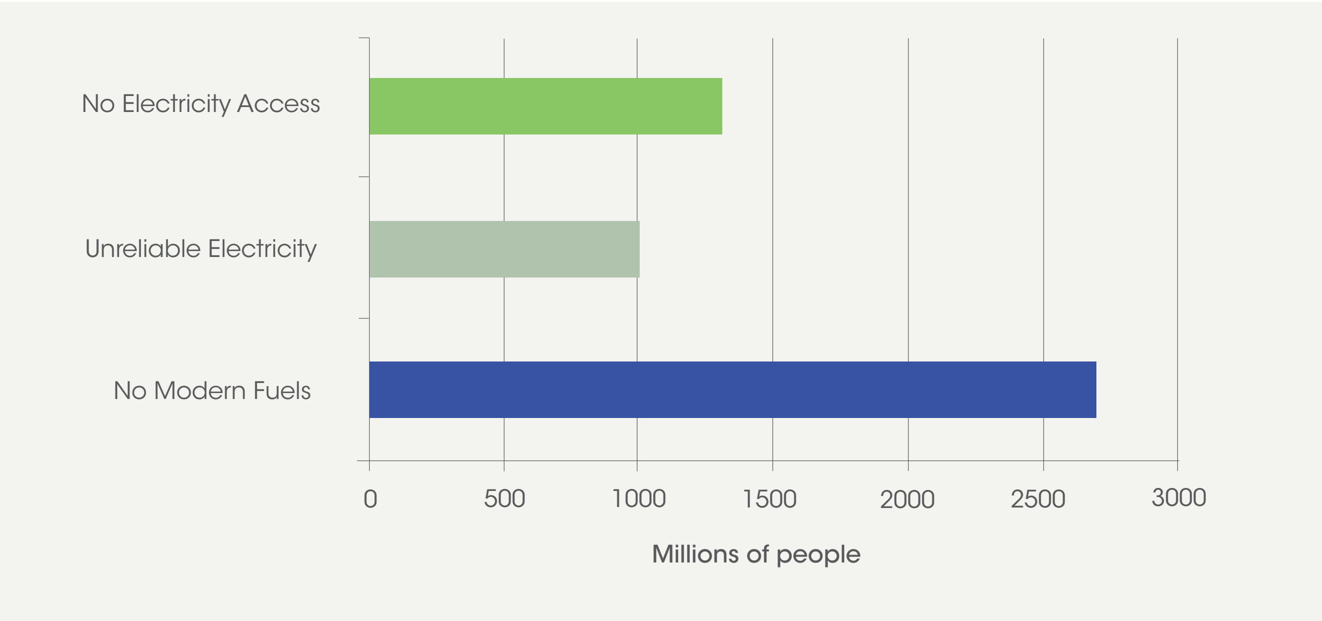
2.1. THE STATE OF ENERGY ACCESS

More than 1.3 billion people worldwide are without electricity access and another 1 billion have unreliable access. At least 2.7 billion people lack access to modern fuels. Traditional biomass plays an important role for these populations, but it is inefficient and generates severe health and environmental problems. Modern renewable energy sources offer economic, health and educational benefits. ICS also play an important role since they allow people either to make use of more modern fuels, or use traditional fuels much more efficiently, reducing or avoiding dangerous indoor air pollutants.

Hundreds of millions of people remain trapped in energy poverty - suffering from inadequate access to energy and especially to modern, clean energy sources. Traditional biomass (fuelwood, charcoal, manure and crop residues) still plays an important role in cooking, lighting and space heating needs for large numbers of people in developing countries, especially in rural areas. Not only is traditional bioenergy use energetically inefficient, its production and use also generate severe health and environmental problems, including indoor air pollution, forest and woodland degradation, soil erosion and black carbon emissions that contribute to global warming (United Nations Environment Programme (UNEP), n.d.).

There is a significant a difference between traditional and modern biomass usage. The latter includes not only energy for heating and cooking, but also transportation fuels and electricity generation (Goldemberg and Teixeiro Coelho, 2004). The range of modern sources of renewable energy extends far beyond biomass to include various forms of solar energy and wind and hydro power.

Figure 1. Number of People Lacking Access to Electricity and Modern Fuels



Sources: IEA, 2011-a; AGECC, 2010.

According to estimates by the International Energy Agency (IEA, 2011-a), there are more than 1.3 billion people currently without any access to electricity. The UN Advisory Group on Energy and Climate Change estimates that another 1 billion people have unreliable access; intermittent or poor quality electricity due to insufficient grid capacity, aging equipment, inadequate management and other reasons (AGECC, 2010). At least 2.7 billion people (IEA, 2011-a) and possibly more than 3 billion people (UNDP and WHO, 2009) lack access to modern fuels for cooking and heating (see Figure 1). Instead, they rely on burning wood, charcoal, dung, straw, or coal. Approximately 830 million people have access to ICS and they are mostly found in China. In Sub-Saharan Africa, only 34 million people have access to such stoves (UNDP and WHO, 2009).

The largest populations presently lacking access to electricity are in Sub-Saharan Africa and South Asia. The two regions combined account for more than 80% of all people worldwide without access to electricity (see Table 1). The problem is most pronounced in rural areas of Sub-Saharan Africa, where the electrification rate is just 14%. In contrast, 60% of south Asia's rural population has access to power.

In absolute terms, India has by far the most people - 289 million - lacking electricity. Another six countries have populations of at least 50 million lacking access and seven more have populations of at least 20 million lacking access. Within different regions of the developing world, there is considerable variation among individual countries. Unlike the rest of the world, electrification in Africa is not keeping pace with population growth. The continent's population without access to electricity is projected to grow to 630 million people (Lighting Africa, 2010-a). By 2030, the number may grow to 700 million, unless policies change (Lighting Africa, 2010-b).

With regard to cooking fuels, ICS play an important role since they allow people either to make use of modern fuels, or use traditional fuels much more efficiently. ICS can double or triple the thermal efficiency of cooking fuels, thereby reducing dangerous indoor air pollutants that cause pulmonary disease and premature death among many people from smoke inhalation and reducing black carbon emissions that contribute to climate change. Reducing or eliminating the long hours that women and children spend foraging for fuelwood frees up valuable time, can have a positive impact on gender equality and reduces pressures on forests and ecosystems.

The Renewable Energy Policy Network for the 21st Century (REN21) Global Status Report notes that significant progress has been made in promoting the spread of ICS in more recent years (REN21, 2011). However, half of all developing countries do not have reliable data for ICS.

Table 1. Lack of Electricity Access, by Region (2009)

	Population without Electricity			
	Millions	*%; rounded*		
	Total	Total	Urban	Rural
Africa	587	58	31	75
» North Africa	2	1	0	2
» Sub-Saharan Africa	585	70	40	86
Developing Asia	675	19	6	27
» China and East Asia	182	9	4	14
» South Asia	493	32	11	40
Latin America	31	7	1	26
Middle East	21	10	1	28
All Developing Countries	**1 314**	**25**	**9**	**37**

Note: OECD and Transition Economies are not included in the table since they have near universal electrification; 3 million, or 0.2%, of their inhabitants lack access to electricity.

Source: Adapted from IEA, 2011-a.

The largest populations relying on traditional biomass for cooking purposes are found in the developing regions of Asia, with by far the largest number in India (836 million) and more than 100 million in each of Pakistan, Bangladesh and Indonesia. Altogether, 54% of the total population of developing Asia relies on traditional biomass. In Africa, the absolute number is smaller (657 million people), but the share is higher (65%; see Table 2).

Table 2. Populations Relying on Traditional Use of Biomass for Cooking (2009)

Regions and Selected Countries	Population	
	Millions	*%; rounded*
Africa	657	65
Developing Asia	1 921	54
Latin America	85	19
Developing Countries	2 662	51

Source: IEA, 2011-b, p.11.

2.2. RENEWABLE ENERGY TECHNOLOGIES AND ENERGY ACCESS

In the past several decades, access to electricity has expanded principally through extending the grid and relying on fossil fuel-generated power. Remote rural areas often do not benefit from grid extension and fossil fuels inflict substantial environmental and human costs, while also imposing import dependencies in most countries. Mini-grid and off-grid systems, based on small-scale renewable energy applications such as solar energy, hydropower and biogas, as well as ICS, offer increasingly attractive, reliable and affordable solutions and provide an opportunity for small and micro enterprise business models to be propagated. However, funding for RETs applications remains inadequate.

A growing number of governments, international agencies, non-governmental organisation (NGOs) and businesses are working to overcome energy poverty. To date, 68 developing country governments have adopted formal targets for improving access to electricity, although a far smaller number have targets for providing access to modern fuels (17 countries) and ICS (11 countries [UNDP & WHO, 2009]).

From 1990 to 2008, close to 2 billion more people secured electricity access (UNDESA, 2011). China, Vietnam, Thailand, Sri Lanka, South Africa and Brazil are among the countries that have had considerable success in expanding rural access since the 1990s, principally through large-scale grid-based electrification programmes, which have tended to rely mostly on fossil fuel-based generating technologies and large hydropower (AGECC, 2010). India raised the share of its rural population with electricity access from 56% to 75% between 2006 and 2009. In Vietnam, the share surged from less than 5% in the mid-1970s to 98% currently (IEA, 2011-b).

Access to electricity can be provided in three ways, namely grid extension, mini-grid or off-grid (see Box 1). In urban areas, the cost per mega-Watt-hour (MWh) for grid extension is lower than that of mini-grids or off-grid solutions. However, the cost of extending the grid to remote or sparsely populated rural areas can be very high, particularly in difficult terrain. Furthermore, long distance transmission lines typically suffer high technical losses (IEA, 2011-b).

A number of RETs offer viable options for both off-grid and mini-grid solutions for energy access in rural areas of the developing world. They include small hydropower plants, small wind turbines, biogas and other forms of bio-energy, as well as a range of solar technologies. Hybrid systems mix a number of these options and are often tied into a village-scale mini-grid of anywhere from 10 to 1 000 kilo Watt (kW [REN21, 2011]).

Off-grid renewable energy solutions offer a better perspective for expanding energy access in rural areas. Developing this potential is a technical issue only up to a point. It is necessary to develop the structures and organisational capacity that underpin reliable renewable energy systems - robust supply chains with sufficiently strong upstream and downstream linkages local enterprises, financing mechanisms and human capital (technical, economic and managerial skills).

Small Hydro Power. There is no single agreed definition to demarcate large from Small Hydro Power (SHP), but most countries consider 10 MW the threshold. SHP is often the cheapest option for rural electrification over the lifetime of a system, although initial capital outlays can be quite substantial (ARE, 2011b). Among small hydro facilities, mini hydro is usually defined as less than 1 MW (1 000 kW), micro-hydro is less than 100 kW and

Box 1

OPTIONS FOR EXTENDING ELECTRICITY ACCESS

Grid extension. Extension of existing transmission and distribution infrastructure to connect additional communities. This is most feasible in or near urban areas or in otherwise sufficiently dense communities.

Mini-grid. Local low-voltage grids fed by multiple small-scale energy sources and are often run by a village co-operative or an individual entrepreneur.

Off-grid. Decentralised power-generation, via SHS or other small-scale options. This is usually the only realistic option for remote rural locations, where populations are not concentrated enough or are too poor to afford the previous two options.

Source: IEA, 2011-b, p. 11.

pico-hydro is under 5 kW. Hydropower at the micro level is typically used by developing countries other than China. Micro and pico hydro are typical choices for small communities or local-level enterprises. It provides a feasible supply of energy in remote communities and allows local community involvement (Niez, 2010; Kumar et al., 2011).

Solar Energy. A wide range of solar technologies are available to provide electricity to communities in rural areas. These extend from local photovoltaic (PV) power plants to SHS, pico solar systems (solar lanterns, e.g.). More powerful PV systems offer a broad range of uses, including small motive power applications. SHS are stand-alone PV systems that can fulfil a household's basic electricity needs (lights, radios, small televisions [TV]) in rural areas not connected to the grid. A typical SHS ranges from 20 - 100 Watts-peak (Wp) but could go as high as 250 Wp; it includes a solar panel, a charge controller and a battery for energy storage. Pico solar systems are typically equipped with compact fluorescent lamps (CFLs) or with light emitting diodes (LEDs). They can also power various appliances, including mobile phones, small radios and a range of USB-devices. SWH produce clean hot water, typically include a roof-mounted solar collector and a storage tank that may also be roof-mounted or on the ground.

Small Wind Power. The U.S. Department of Energy's National Renewable Energy Laboratory defines small wind turbines as those with 100 kW capacity or less (NREL, 2011). REN21 (2011) further distinguishes household wind turbines as anything from 0.1 to 3 kW in capacity. At the end of 2010, more than 656 000 small wind units with a capacity of 443 MW were installed worldwide (WWEA, 2012).

Biogas. Aside from industrial-scale applications, biogas is typically used on a household scale in rural areas of the developing world for cooking and heating and to a lesser extent for lighting. Biogas digesters come in many forms and sizes. A small household system typically entails manure collection (unless it is fed with food waste or crop residues), an anaerobic digester, effluent storage (which has value as fertiliser and possible other uses), and gas handling. In general, it is a low-cost option, even though for low-income communities in the poorest countries, financing is often needed to cover up-front costs (Climate Tech Wiki, n.d.-a).

RETs have a wide range of possible applications in enabling energy access where it is lacking as well as in replacing fossil fuels and conventionally-generated electricity, as Table 3 suggests. These uses include lighting and refrigerating at homes, businesses, schools and in public places. For lighting and refrigeration, rural communities typically rely on candles, kerosene, small diesel generators and batteries. For communications needs, the conventional energy sources are dry cell batteries and generators. For cooking, wood, dung and straw play a major role. Process power and pumping energy is mostly derived from diesel engines.

Table 3. Applications of Renewable Energy Technologies

	Lighting / Refrigeration (Homes, stores, schools, street lights, vaccine storage)	Communi-cations (TVs, radios, phones, Internet)	Cooking (Homes, commercial stoves)	Heating / cooling (Hot water, crop drying, etc.)	Process power (Small industry)	Water pumping (Agriculture, drinking water)
SHS	✓	✓			✓	
Pico-scale SPV	✓	✓				
Solar thermal				✓		
Solar cookers			✓			
Solar crop dryers				✓		
SPV pumps						✓
Small hydro	✓	✓				
Small wind		✓			✓	✓
Mechanical wind pumps						✓
Household-scale biogas digester	✓	✓	✓	✓		
Biomass gasifier	✓	✓			✓	
Mini-grid / hybrid	✓	✓			✓	✓
ICS			✓			

Source: Adapted from REN21, 2011.

2.3. BARRIERS AND SOLUTIONS TO ENERGY ACCESS

Off-grid solutions face some obstacles, including up-front consumer costs that may surpass cash-flow, lack of appropriate technical skills, inadequate supply chains and distribution networks, weak business skills and others. Subsidies are often needed to overcome the weak financial means of many rural households. Yet, there is also a need to develop commercially viable micro-enterprises. Microfinance schemes can play an important role in this context, but need to accommodate households' cash flow. Other important aspects of enabling the spread of renewable energy include greater awareness building, ensuring product quality, offering after-sales services, consulting with communities, encouraging the use of local materials where possible and providing adequate training.

Given the range of obstacles to grid extension to rural areas, off-grid solutions are an important alternative in remote rural communities. Still, decentralised RETs do confront a number of challenges of their own. Table 4 offers an overview of potential barriers which need to be overcome.

The discussion here focuses primarily on ways to overcome up-front financing problems as a key dimension of providing broader energy access in poor rural areas, but also briefly engages a number of other needed measures.

>> Overcoming Up-front Costs: Poor households spend a fairly significant amount of money on kerosene and other conventional sources of energy - resources that can, in principle, be redirected toward the purchase of renewable energy equipment. On average, conventional energy expenditures run to USD 1 800 per family over a decade, whereas a simple SHS might cost USD 300 (Pope, 2012). The challenge is to overcome the upfront costs, which are often too steep for the rural poor relative to their available cash flow and limited access to credit. The World Bank (2008) estimates that in poor off-grid areas,

Table 4. Potential Barriers to Renewable Energy Deployment in Rural Areas

Market and Customer Information	» Lack of information about potential markets/ customer needs and preferences » Consumers lack awareness of RET products and their benefits
Legal Issues, Regulations and Administrative Barriers	» Lack of land title or title uncertainties, which can limit ability to sign contracts » Lack of regulatory predictability and long-term vision concerning rural electrification strategies and planning » Approval processes for RET projects may take a considerable amount of time » Unfair competition from conventional energy sources (subsidies) » Import tariffs increase costs of RETs and could make them prohibitively expensive
Remoteness, Physical infrastructure	» Remote communities are difficult to reach (increased costs for sales, after-sales service; repair; question of spare parts availability) » Harsh natural environment, extreme weather can degrade or destroy equipment
Skills and Training	» Difficult to recruit and retain staff with adequate technical skills to install, maintain, repair RETs » Limited business skills (literacy, book-keeping, computer-related) » Customers lack information/ skills needed to properly operate RETs
Cost and Access to Financial Services	» Up-front costs can be high compared to cash flow » Lack of access to credit (for entrepreneurs and end users); local banks need experience and greater awareness of how to finance RETs » Customers do not have access to financial services to make payments (bank accounts)
Supply Chains and Service Delivery Channels	» Insufficient development of supply chains » Retail and logistics services are limited in low-income communities » Geographical mismatch of sources and centres of energy consumption » Private companies face high costs of going into rural areas; often preferring donor contracts and capital cities
Performance of RETs	» Poor quality products can undermine reputation of RETs and diminish customer trust » If promised economics (payback period, etc.) fails to materialise, customer trust may suffer
Gender	» The fact that men are responsible for household investment in most rural developing regions but not for lighting and cooking energy often hinders investment in RET

Source: Adapted from Gradl and Knobloch, 2011; Deutsche Bank (DB) Climate Change Advisors, 2011; CEPAL, 2004.

2-3% of households are able to pay cash for electricity services. Microcredit can expand the market to 20-30% of rural residents and micro leasing and fee-for-service arrangements could further expand it to up to 70% of households. The remaining 30% or so - the poorest of the poor - may require fully subsidised services.

>> Development of Commercial Enterprises: Government subsidies and donor grants can thus play an important function in terms of overcoming financing hurdles. However, it is important to calibrate subsidies so that they do not undermine the development of a viable commercial market. The danger is that once the financing from a grant-driven project comes to an end, there may not be a lasting benefit. Especially in remote areas, small and micro-enterprises can, in principle, be effective actors in the delivery of energy products and services. Support for local micro-enterprises, generating robust supply chains and networks and building adequate local supply and demand, carry great importance.

>> *Microfinance:* Microfinance schemes can be effectively combined with renewable energy deployment in rural areas. The global microfinance sector is quite large - comprising about 10 000 individual institutions (microfinance institutions- MFIs) and serving more than 155 million clients. So far, however, a still rather small number - some 30 to 40 MFIs - offer loans in the energy sector, according to a 2010 study (Micro Energy International and PlaNet Finance Deutschland, 2010). Expanding microfinance and learning from the most successful efforts is crucial. A critical part of the equation is the nature of payment collection systems. Flexible schedules may be necessary to accommodate rural customers' limited financial abilities and avoid over-taxing their cash flow. Micro-finance schemes often operate on the basis of a community-responsibility for payments.

>> *Knowledge and Awareness of RETs:* At the most fundamental level, even basic knowledge about the availability of RETs is lacking among remote rural populations. Indeed, the transition to RETs involves far more than simply making a given technology available. Dissemination requires active marketing and public awareness campaigns including pilot programmes, demonstrations in villages and similar kinds of efforts, as well as support for marketing.

>> *Product Quality Guarantees:* Ensuring the quality and reliability of RETs is essential to build and maintain a sense among prospective rural community customers that renewable energy is a suitable alternative to traditional forms of energy. Government regulations establishing and enforcing appropriate product standards and requirements for manufacturers and installers to provide product warranties play an important role.

>> *After-Sales Service:* The provision of regular maintenance/repair and availability of spare parts are important aspects of quality assurance. This requires adequate training of personnel and working, as much as possible, through networks of local stores and establishing micro-franchises. It also requires the inclusion of the issue of operation and maintenance (O&M) in long-term business models.

>> *Design and Consultation:* The design of RETs, especially ICS, can have an impact on how readily or widely they are being adopted. Appropriate consultation with local communities, as well as government or donor-funded projects, for adaptation to local needs can facilitate the diffusion of RETs.

>> *Imports:* For RETs and equipment that are not readily available domestically, providing waivers on import duties can make a decisive difference in terms of their affordability.

>> *Training:* Adequately trained personnel is critical for the proper installation and maintenance of RET systems. Education and training on RET for access to energy should be facilitated, promoted and institutionalised to assure sustainability. Training programmes may vary from more formalised efforts especially for engineers and technicians to less formal and on-the-job training for other personnel. Part of the training that may be needed is to educate customers in the proper use and upkeep of RETs.

Economic and technical aspects play a strong role in efforts to improve energy access, but strong political commitment should not be overlooked as a critical factor. Designing and implementing robust policies in favour of RETs should entail incentives for poor rural households (including subsidies as needed), an enabling environment for the private sector to invest in RETs, creating a level playing field between grid electricity and stand-alone systems. Well-designed plans by beneficiary countries are needed to ensure the sustainability of donor-initiated RET projects, which too often fail to bring about the desired results because of a lack of sustainability measures and indicators.

2.4. BENEFITS OF ENERGY ACCESS

Renewable energy is becoming increasingly attractive for use in rural areas of the developing world. It allows people to redirect the many hours that are otherwise spent on fuelwood gathering and related activities toward income-generating activities, improves indoor health, offers better conditions for children studying at home, enables stores to stay open longer and may enable new businesses to start up. Distributing, installing, operating and maintaining RETs in rural areas have the potential for substantial employment creation.

RETs are getting cheaper, smaller and more efficient, as well as better adapted for the needs of users particularly in developing countries (REN21, 2011). Renewable energy, whether in the form of electricity or fuels, offers a range of important benefits. Though the particular circumstances vary, they include health and educational gains, improved living standards, greater household incomes, employment opportunities in the supply chain and in downstream enterprises.

>> *Economics:* Because the energy efficiency of kerosene is very low, providing light costs as much as USD 3 per kilo Watt-hour per kWh. This is higher than the cost of solar lighting at about USD 2.2 kWh in poor countries (UNDESA, 2011). The overall economics of renewables is becoming increasingly favourable. A 2008 World Bank evaluation estimated that household lighting adds between USD 5 and 16 per month in income gains for poor households in developing countries (World Bank, 2008). Factoring in enhanced entertainment, time savings, education and home productivity, the benefits of access to electricity could be even higher.

>> *New Business:* RET installations can enable new local business start-ups. For example, mobile phone charging has become an increasingly important local business in rural areas of developing countries. A third of the world's off-grid population, or some 1.6 billion people, now use a mobile phone. But at present, phone charging often can be difficult or expensive and RETs provide a solution. In Uganda, where more than 90% of the rural population has no access to the grid, almost half live near mobile phone broadcast towers (Energypedia, 2011-a). RETs may also provide a boost to existing businesses, by allowing them to stay open into the evening hours, which brings more customers and in ideal circumstances more employment.

>> *Gender Equality:* Access to renewable energy could allow poor people to devote more of their time to education, health services and other needs, thereby helping improve gender equity. In Cambodia, for instance, gathering wood, boiling water and cooking — activities that typically are seen as women's responsibilities — take as much as three to four hours a day (World Bank, 2010). The availability of electricity allows easier drawing of water using electric pumps or motorised milling machines for grinding grain (UNCTAD, 2010). The same United Nations Conference on Trade and Development (UNCTAD) study notes that dietary choices improve and that women and children gain time for education, leisure, or economic activity by using more efficient cooking technologies.

>> *Education and Information:* In households, the higher-quality light output of solar lamps compared with kerosene lamps allows more study time for children and thus aids in their education. According to the 2011 Human Development Report, in South Africa electrification has helped increase the likelihood of women participating in the labour market, while in Vietnam it boosted income and schooling rates (UNDP, 2011). Access to radios, TVs, and computers can provide farmers and fishermen with weather forecasts or information on crop and other market prices (UNCTAD, 2010).

>> *Health:* A key benefit associated with modern fuels and ICS is reduced indoor pollution and higher fuel efficiency. Air pollution from cooking and heating with traditional sources of energy causes worldwide annually almost 2 million deaths, through pneumonia, chronic lung disease and lung cancer. An estimated 44% of those who die are children. Among adult deaths, 60% are women (UNDP and WHO, 2009). Better health — avoiding respiratory infections and other problems caused by indoor smoke — permits more productive lives. Furthermore, electricity enables refrigeration of vaccines and use of medical equipment in rural health clinics.

3. Employment Data - Review of Existing Literature

This section draws on existing literature to examine what is known about employment opportunities in providing access to energy in rural areas of developing countries. It begins by assessing the relative dearth of information in the existing literature, and then examines the employment dimension of selected RETs for which more information is available—a more detailed discussion of SHS is followed by briefer discussions of portable solar, SWH, ICS and biogas.

3.1. A RELATIVE DEARTH OF EMPLOYMENT INFORMATION

> Renewable energy-related employment in rural areas of the developing world is not being tracked in any systematic manner. Neither are specific conditions that would paint a picture of the quality of such jobs, including wages, working hours, skills development and training. More attention is also needed with regard to the distinction between formal employment and more informal arrangements. In most developing countries, sales, installations, operations and maintenance are more important for job generation than manufacturing of renewable energy equipment.

Recent years have seen rapidly growing interest in the notion of "green jobs"— jobs in economic activities that are environment-friendly. Renewable energy development has been regarded as a key area of greening economies, and there is an ever-growing list of studies that examine employment implications of individual RETs and applications or particular country experiences.

But relatively limited attention has been devoted to the deployment of renewable energy in rural areas of developing countries. In its 2011 Global Status Report, the REN21 Network laments the fact that such statistics "are not being collected systematically" and explains that relevant data are available for individual programmes and countries, but not across the developing world as a whole (REN21, 2011).

This gap in knowledge exists even though the links between social and economic development, and modern sustainable sources of energy are well recognised. The IPCC's Special Report on Renewable Energy Sources and Climate Change Mitigation (Moomaw, et al., 2011) underscores that access to clean and reliable energy is critical for "economic activity, income generation, poverty alleviation, health, education and gender equality."

Yet, relatively little is known about the employment implications of providing energy access in rural areas of the developing world. A paper presented at the UN Research Institute for Social Development (UNRISD, 2011) conference in October 2011, notes that "statistics on job creation and labour within this sector are not collected at all and little is understood about the labour market and conditions within the sector." The UNRISD paper notes a lack of information concerning "a range of social indicators such as the total number of jobs created, the types of jobs, payments, gender, working hours, etc." (Bimesdoerfer, Kantz and Siegel, 2011).

Indeed, a review of key publications — including reports by the World Bank, IEA, the AGECC, UN agencies like UNEP, UNDP, or UNCTAD, the Global Alliance for Clean Cookstoves and others - confirms this conclusion. With few exceptions, such publications contain generic references to opportunities for job creation, but do not follow up with any detailed data or analysis.

What is true for broad assessments also holds up for many individual ventures. In Sri Lanka, for instance, the Renewable Energy for Rural Economic Development project and Sarvodaya Economic Enterprises Development Services have enabled the installation of more than 130 000 SHS units and several thousand households obtain electricity from micro-hydro minigrids (RERED, n.d.). But the project measures neither the jobs created nor the labour conditions or requirements (Bimesdoerfer, Kantz and Siegel, 2011).

It should be noted, however, that some efforts are being made to estimate job creation in the context of energy access. India's Ministry for New and Renewable Energy (MNRE), for example, has calculated employment factors derived from case studies of companies or projects in its renewable energy sector (see Table 5).

The particular conditions and circumstances of renewable energy deployment vary from country to country. India's employment factors may thus be applicable elsewhere only within limits. Nonetheless, they can serve at least as a rough guide for estimating employment arising from the deployment of renewable energy in rural areas of the developing world. Translating the estimates of needed renewable electricity generation under the Energy for All case from the IEA World Energy Outlook 2011 into needed capacity by 2030 yields an estimate of close to 148 000 MW for all off-grid sources.

Applying the Indian job factors to these capacity figures yields an estimate of almost 4 million direct jobs by 2030 in the electricity sector alone. Table 6 offers details of this calculation. Additional employment will be generated as access to renewable cooking fuels and ICS expands, but efforts to calculate specific figures are complicated by the diverse and fragmented nature of the cooking energy markets.

In many developing countries, sales, installations, operations and maintenance will likely be more important in terms of employment generation or livelihood support than manufacturing of renewable energy equipment. This is particularly the case if renewable energy projects are locally well integrated, so that income generation and employment opportunities emerge from downstream commercial activities. Such opportunities may come in the form of scaling up of existing small businesses or setting up new ones. Local economic opportunities are more likely to materialise where there are adequate skill-building and training efforts. Equally critical is the promotion of local research, development and demonstration programmes, as well as efforts to adapt renewable energy systems to local needs and circumstances

Table 5. Estimated Employment Factors in India's Renewable Energy Sector

	Jobs per MW of Capacity	Typical Plant Size
SPV, Off-Grid		n.a.
» Direct employment	30	
» Indirect employment	60	
» Total employment	90	
Biomass Power, Grid		4-8 MW
» Direct employment	15[a]	
» Indirect employment [b]	28	
» Total employment [c]	43	
Biomass Gasifier		20 kW
» Employment in Manufacturing	100	
» Employment in Operations	200	
Small Hydropower		n.a.
» Direct employment	4	
» Indirect employment	1	
» Total employment	5	

[a] Of which 40% is skilled labour. [b] Fuel collection, handling, processing. [c] Employment in utilities only; manufacturing of power equipment not included.
Source: Calculated from MNRE and CII, 2010.

Table 6. Potential Employment Creation through Off-Grid Renewable Electricity

	Energy Use (TWh)	Load Factor (%)	Capacity (MW)	Job Factor (Jobs per MW)	Employment (Thousands)
Solar	169.2	25	77 260	30	2 318
Small Hydro	37.6	70	6 132	4	31
Biomass	98.7	80	14 084	15	211
Wind	131.6	30	50 076	22	1 102
Total	*437.1*		*147 552*		*3 661*

Note: Given that the table offers a very rough sketch of potential job creation, the employment figures in the final column have been rounded to the nearest thousand.

Source: IRENA estimates based on IEA 2011-b and CII 2010.

(as has been done successfully by Grameen Shakti in Bangladesh, SELCO in India and others).

Not all the work associated with extending energy access necessarily involves formal employment. As the case studies presented later in this report attest, small entrepreneurs in remote rural areas often take on labour in highly informal arrangements, to retain the flexibility needed under fluctuating and uncertain business circumstances. The construction and operations of household or village equipment like small biogas digesters or pico-hydro plants may also not always entail formal employment. Casual employment or community-level involvement may be the more typical types of arrangements.

One area where a focused effort is needed concerns training. The success of rural renewable energy projects ultimately rides on qualified, trained staff. Each step along the supply chain requires different types of skills and occupations, including manufacturing workers, engineers, technicians, sales staff, managers and entrepreneurs. In this broad array of occupational profiles, some jobs require formal training and high technical qualifications.

Still, the vast majority of jobs require few high level skills that are more easily imparted through easily accessible training and mentoring efforts. Local capacity-building for entrepreneurs, small and micro enterprises, is key to rural electrification programmes and the creation of green jobs. The World Bank's Energy Sector Management Assistance Program (ESMAP) has started to provide targeted training via its Energy Small and Medium Enterprise Development Programme (Bimesdoerfer, Kantz and Siegel, 2011). Local training institutions such as the Barefoot College based in Rajasthan, India, play a critical role. Barefoot College is working with grassroots partner organisations on solar electrification and other projects in two Asian, one Latin American and 16 Sub-Saharan African countries, providing training for installation and repair services (Barefoot College, n.d.).

3.2. DEVELOPMENTS BY SELECTED RENEWABLE ENERGY TECHNOLOGIES

This section examines some trends in the deployment of renewable energy sources in mini-grid or off-grid applications, with a view toward the employment dimension. It first offers an analysis of PV SHS, portable solar lights, SWH, ICS and biogas. For each of these RETs, it offers a brief look at selected country experiences. Small and micro-hydropower is also an important RET for many rural areas. For biomass, comparatively little information is available about employment impacts beyond a number of specific projects.

3.2.1. Photovoltaic Solar Home Systems

The number of SHS deployed in developing countries now surpasses 3.6 million. India and China have relatively large numbers installed, but Bangladesh is the global leader with 1.2 million SHS. It has had a particularly successful experience with the help of microfinance and a strong vocational system for training solar technicians, employing an estimated 60 000 people along the SHS supply chain. Bangladesh's experience contrasts with that of Kenya, which has Africa's largest number of SHS, but has encountered difficulties with the quality of solar panels and remains highly import dependent.

In lower-income rural communities, efforts to improve electricity access often focus on SHS. REN21 (2011) reports that worldwide small PV systems provide electric power to only a few million households. Altogether, "just one percent of the world's solar panel production has been installed in developing countries." (Woody, 2009).

Energypedia reports that in 2002, an estimated 1.3 million SHS had been installed in developing countries (Energypedia, 2011-a). Table 7 offers an overview for more recent years, listing selected countries for which such information is available. It suggests that the number today is at least 3.6 million, thus indicating strong growth. However, data gaps remain, the information provided is for a range of years and the numbers in the table do not permit a firm conclusion about numbers of SHS deployed in the developing world as a whole.

Country Experiences

A growing number of developing countries are gaining experience in rural off-grid electrification efforts with the help of solar technologies. India estimates that its off-grid SPV sector now employs about 72 000 people. Out of this number, some 48 000 are indirect jobs, including dealers, marketing staff, lantern manufacturers manufacturers of SHS kits, battery manufacturers, lamp manufacturers and others (MNRE and CII, 2010).

This sub-section discusses the successful experience of Bangladesh, the country with the largest number of SHS installed, contrasting it with those of Kenya, Tanzania and Sri Lanka. It suggests that training and financing are critical elements of rural electrification.

Bangladesh. Bangladesh has successfully developed a domestic solar industry, for a number of reasons (UNDESA, 2011):

- Relying on its vocational education system and pursuing on-the-job training, Bangladesh was able to build a capability to operate and maintain off-grid solar equipment and to create ancillary businesses;
- Domestic research played an important role, helping to reduce the cost of PV panels, adapt the technology to local needs and develop accessories, such as mobile phone battery chargers;
- Bangladeshi government enforced equipment quality standards;
- Co-ordination among firms, regulators and universities proved to be an important element of Bangladesh's success.

Table 7. Solar Home Systems in Use in Selected Developing Countries

Country / Region	Year	Numbers
Asia		
Bangladesh	2011	About 1 200 000
India	2010	600 000
China	2008	> 400 000
Indonesia	n.a.	250 000
Sri Lanka	2011	132 000
Nepal	n.a.	69 000
Latin America		
Mexico	n.a.	80 000
Africa		890 000
Kenya	2005	300 000
Morocco	n.a.	128 000
South Africa	n.a.	150 000
Zimbabwe	n.a.	113 000
Tanzania	n.a.	65 000

Sources: REN21, 2011; IDCOL, 2011-a; RERED, n.d.; Energypedia, 2011-a; Lighting Africa 2010-a.

At first, most of the panel components were imported from countries like Singapore, India and China, but today, Bangladesh has the capability to produce them domestically (UNDESA, 2011). Bangladeshi firm Rahimafrooz Renewable Energy manufactures rechargeable solar batteries, charge controllers and fluorescent lamps and has also developed a solar-powered irrigation system. It set up Bangladesh's first solar panel assembly plant and has signed a memorandum of understanding with India's TATA BP Solar to build another 5 MW plant (Power Today, 2010).

Microfinance has played a critical role in the spread of SHS in the Bangladeshi countryside. With financing from international development banks and bilateral donors, the state-owned Infrastructure Development Company Limited (IDCOL) is managing the Rural Electrification and Renewable Energy Development Project (REN21, 2011). IDCOL provides participating organisations (PO) with subsidies and concessional loans to purchase PV systems in bulk. There are about 30 POs, but the leading force in this effort has been Grameen Shakti, which set up in 1996 and has been able to build on the successful and previously existing network and micro-lending experience of the Grameen Bank (IDCOL, 2011-a).

Between 1996 and 2003, some 10 000 SHS were sold to Bangladeshi households. Installations have since grown rapidly, reaching a cumulative 320 000 at the end of 2009 and 1.2 million at the end of 2011 (IDCOL, 2011-a). Today, an estimated 30 000 units are sold each month (REN21, 2011). The goal is to install 7.5 million systems by 2015, which would serve half of the total rural population of Bangladesh. In June 2010, the government of Bangladesh issued a road map for extending electrification to all Bangladeshis (Bimesdoerfer, Kantz and Siegel, 2011).

This widening success story has had some important employment impacts. The rapid expansion of Bangladesh's solar sector has created jobs for an estimated 60 000 people (Barua, 2011). The country's renewable energy sector (including SHS, biogas and ICS) is expected to provide jobs for at least 100 000 persons by 2014 (Strietska-Ilina, et al., 2011).

Solar manufacturing accounts for a small portion of the jobs (Mondal, Iqbal and Mehedi, 2010). The bulk of jobs belong to young field assistants with basic technical and vocational skills who sell and install SHS, provide maintenance, and as part of Bangladesh's microfinance network, collect monthly payments on solar loans (Bimesdoerfer, Kantz and Siegel, 2011). The leading PO, Grameen Shakti, directly employs more than 7 500 individuals. It also operates 45 rural technology centres that are run by female engineers. The centres have so far trained about 10 000 students; more than 1 000 female technicians were trained to install, assemble components and maintain SHS (UNDESA, 2011; Strietska-Ilina, et al., 2011).

These developments are very encouraging, but it is important to improve the information regarding temporary versus permanent jobs and the broader prospects for sustaining these efforts by building commercially viable structures. Such questions are prompted in part by the contrasting experience in Sri Lanka, briefly discussed below.

In contrast, many countries have not been as successful and therefore have not been able to generate as much employment as Bangladesh. For example, despite some successes experienced in Kenya (it is Africa's leader in SHS installations) its solar industry confronts a number of problems hampering its growth and thus that of job creation. These include lack of domestic financing and therefore ability to pay, quality standards of imported PV panels, inadequate expertise and training as well as weak regulatory framework (UNDESA, 2011). Additional problems faced by Tanzania, for example, include difficulties in enforcing control of quality standards (Hankins, Saini and Kirai, 2009).

Skill gaps still exist in many developing countries particularly for electrical engineers and technicians — key occupations for SPV (Strietska-Ilina, et al., 2011). To benefit from the potentially large-scale employment opportunities as solar energy use expands, training programmes for assembly, sales, installation, maintenance and repair are essential. Vocational training of villagers is also a key task. In Laos, for instance, training has been carried out by the commercial enterprise Sunlabob (also see the case study section), which is a pioneer in building local skilled workforces in rural areas (Bimesdoerfer, Kantz, and Siegel, 2011). In Uganda, where the government hopes to boost the share of renewables from 4 to 60% of total energy use by 2017, some workforce training has been carried out by international consultants (Strietska-Ilina, et al., 2011).

In general, country experiences suggest the central importance of training programmes — both in the solar sector itself as well as in the downstream applications of solar technologies. Bangladesh's success shows that training needs to be pursued not on a project-by-project basis, but in terms of a more general vocational structure. The country has also shown how important proper financing and financing mechanisms are to a rural electrification efforts.

3.2.2. Portable Solar Lights

> For solar lanterns, India has by far the largest market. African countries may be on the cusp of rapid growth in demand for solar lanterns, but because they are not involved in manufacturing them, job opportunities will principally be in sales and distribution.

India is the country with the largest market for solar lanterns, with an estimated 700 000 - 800 000 units as of 2010 (Energypedia, 2011-a; REN21, 2011). The global market potential is difficult to predict, but principally huge, given the large numbers of people who have no access to electricity and rely on kerosene for their lighting needs. Currently, annual expenditures for kerosene amount to an estimated USD 40 billion globally — some USD 17 billion in Africa and USD 23 billion in Asia (Rowlands-Rees, 2011). Lighting Africa, a programme run jointly by IFC and the World Bank, argues that the solar portable light market is poised for rapid growth over the next five years, as the technology is improving, better business models and distribution networks emerge, and cost continues to decline. Lighting Africa (2010-a) predicts that 5-6 million African households and small businesses will own solar portable lights by 2015 even under business as usual trends, and as many as 12 million under more favourable circumstances.

The employment implications of a growing solar lantern market remain to be seen. The bulk of the world's lantern production is low-cost and takes place in China. The Poor People's Energy Outlook (Practical Action, 2012) notes that "although local manufacture [in other developing countries] would create more local jobs than distributing imported lanterns, at present, this is not as viable from an end cost point of view."

Solar lanterns and similar products do not need any installation, and the implication is that there is less need for technicians and repair personnel than for SHS, and thus fewer employment opportunities. Employment opportunities in most developing countries would thus appear to be principally in marketing, distribution and sales.

About 110 companies are active in the solar portable light manufacturing industry worldwide. About 40% of all manufacturers are headquartered in India (with 30% of global sales), 34% in China (42% of sales), 20% in industrialised countries (19% of sales). Less than 5% of the companies are in Africa (Lighting Africa, 2010-a).

3.2.3. Solar Water Heaters

> China is the leader in the SWH industry, with an estimated 800 000 people employed. Limited affordability still constricts the spread of such systems in much of the developing world. But the potential is large.

In the SWH industry, China is the undisputed global leader - largely owing to the strength of its domestic market, but the country is also an important exporter. The country's Ministry of Human Resources and Social Security estimates that 800 000 people are employed in this industry (ILS and MOHRSS, 2010). India, as mentioned above, has an estimated i.e., 41 000 solar thermal jobs.

Country Experiences

South Africa initiated a "1 Million Solar Water Heaters Programme" in November 2008, to be completed by 2014. Some 156 000 systems were installed as of November 2011. Among the objectives of the programme is the creation of a "competitive and sustainable local SWH equipment manufacturing, installation and maintenance industry in South Africa", as well as job creation (South African Department of Energy, n.d.). South Africa's SWH suppliers have expanded 20-fold between 1997 and 2011. Some 122 are accredited under the programme, along with 351 distributors and 180 independent installers (Eskom, 2011). In 2009, SWH manufacturing employment stood at about 200, with another 150 persons in sales and administration, 400 in installation, giving a total of slightly more than 700 direct jobs (Eskom, 2009). This is up from an estimate of 300 in 2002 (Agama, 2003).

The biggest obstacles to greater SWH use in South Africa include relatively high cost, supply chain constraints and limited local supply capacity, including a shortage of fully-trained plumbers. In response, the Department of Public Enterprises' Employment and Skills Development Agency developed a programme to train plumbers in SWH installation and maintenance, and to attract new entrants to the trade (South African Department of Energy, 2009).

In Ethiopia's capital Addis Ababa, the removal of government electricity and fuel subsidies increased demand for SWH. By 2006, at least five local companies manufactured SWH. Several other companies are importers of equipment, typically from China, and about ten companies are active in the installations business. The greater local economic activity generated local skilled employment and increased local cash flow. Still, only about 10% of the city's population is thought to be able to afford the upfront cost of a SWH (UN-Energy, 2007). In rural areas, affordability is presumably even lower.

3.2.4. Improved Cookstoves

An estimated 830 million people have access to ICS — mostly in China, but less so in Sub-Saharan Africa. Much of ICS manufacturing takes place locally, offering important employment opportunities. In Cambodia, production of 290 000 improved stoves annually has led to at least 1 100 local jobs, and has supported skill-building and greater incomes.

The most prevalent type of ICS is the improved biomass cookstove. Unlike traditional stoves, for which fuel efficiency has not been a key consideration, such a stove reduces the need for fuelwood (thus reducing pressure on forests), charcoal, or other biomass fuels through more efficient combustion. Other types of ICS use cleaner fuels (including biogas, methane, ethanol, etc.) and also offer higher efficiency, but their affordability in rural areas of the developing world is still limited. The cleanest type, the electric cookstove, is rarely used due to high cost and limited availability of electricity in rural areas of the developing world (Differ, 2012). Biogas systems and solar cookers occupy small niches of the market in most countries, sometimes limited by affordability or practicability, and sometimes by cultural preferences and traditions (ClimateTechWiki, n.d.-a). Solar cookers do not require any fuels and do not emit air pollutants, but are inconvenient because they almost double the amount of time it takes to boil water relative to traditional stoves and other ICSs (Differ, 2012).

According to a 2009 World Health Organization (WHO)/UNDP survey of 140 countries, an estimated 3 billion people rely on solid fuels such as wood, straw, dung, and coal for their cooking needs. About 830 million people have access to ICS. Based on an average figure of five persons per household, this means 166 million households. Of these, 116 million are in China, more than 13 million in other East or Southeast Asian countries, 20 million in South Asia, more than 8 million in Latin America, and 7 million in Sub-Saharan Africa (UNDP and WHO, 2009; REN21, 2011).

Other sources put the number of ICS in China at 189 million and 35 million in India. In Kenya, Thailand and Sri Lanka, significant numbers have also been disseminated (ClimateTechWiki, n.d.-a). Currently, more than 160 programmes exist to promote ICS throughout the developing world (Chum et al., 2011). The Global Alliance for Clean Cookstoves, launched in 2010, has the goal of promoting more than 100 million stoves by 2020 (REN21, 2011).

ICS production varies widely. Some takes place on a large-scale, with centralised production and distribution channels and upwards of 100 000 stoves produced annually by some firms. By contrast, small-scale local production is undertaken by trained artisans. It is lower-cost and requires little or no transportation to reach intended customers and offers local employment opportunities in rural areas. There is now also a growing trend toward semi-industrial production of improved biomass stoves, with imported components, local production and assembly (Chum et al., 2011; Differ, 2012).

Depending on the type of stove and its durability, together with the supply chain of materials and inputs required for producing stoves, more labour may be required for an improved stove than a traditional one (see the following Cambodian discussion). A highly-efficient mass assembly in a country like China is likely to churn out large numbers with comparatively few people, whereas the small-scale, hand-produced production typical of many developing countries requires more labour.

Country Experiences

The production of cookstoves in rural areas often takes place in informal settings and information on employment and livelihoods is sparse. The work of Groupe Energies Renouvelables, Environnement et Solidarités (GERES) in Cambodia offers some important insights with regard to employment impacts. This sub-section also offers a few additional observations based on experiences in Mexico and Kenya.

GERES introduced the efficient New Lao Stove (NLS) in Cambodia in 1998, with funding from the European Union, UNDP, World Bank ESMAP, and others. Annual NLS sales reached more than 290 000 stoves in 2010. In March of that year, the milestone of 1 million stoves was reached; 10% of all Cambodian households have adopted the stove. The NLS's higher efficiency has translated into some 5 000 hectares of forests being spared during the first decade and families have saved the equivalent of USD 9 million in fuelwood costs (GERES, 2010).

In 2004, stove manufacturing and distribution enterprises set up a professional association known as ICOPRODAC (Improved Cookstove Producers and Distributors Association in Cambodia). Some 113 enterprises are members. A GERES survey offers some insights into employment and skills aspects. It found that NLS producers employ an average of 10-14 workers each, with skills relating to moulding, carving, cutting, punching, bucketing and assembly. These figures do not include family members who may be involved as well. Also, 1-2 additional workers per enterprise may be employed at peak production times. By contrast, enterprises producing traditional stoves employ an average of only 3 workers each because they are quicker to produce (fewer parts to assemble, etc.). Producers rely largely on their own families and tend to hire few external workers. These GERES findings offer evidence that ICS can be beneficial not only for environment and health, but also for employment — not only in the sense of greater quantities of labour, but also qualitatively. The new stoves require greater skills and workers are therefore better paid. NLS stoves are reported to last 2-3 times longer than the traditional variant (AFD & GERES, 2009).

GERES has provided training to producers making the new stoves. In a 2010 report, the group makes reference to an aggregate figure of 1 100 local jobs (GERES, 2010). It is not clear whether this figure refers only to stove manufacturers or also distributors. Also, it is not clear whether any of these can be considered newly created jobs or simply represents people who have switched from traditional stove production to NLS.

The NLS is sold at a price almost three times higher than the traditional version, reflecting higher raw materials and labour costs and higher margins for retailers (AFD & GERES, 2009). This fact has put somewhat of a limit on the stove's distribution. In 2001, GERES also developed the more affordable "Neang Kongrey Stove" intended for poor rural communities (World Bank, 2010). About 180 000 stoves have been sold since they were introduced (GERES, n.d.).

The World Bank has helped train a small group of ten female potters in producing the Neang Kongrey Stove. After one year, a single potter produced on average more than 200 stoves per month, or about 2 400 in a year. The goal is to train traditional stove makers, open new facilities, and strengthen and expand distribution channels (World Bank, 2010). It is efforts like these in support of specific skills training and overall local human capital development that are key to expanding energy access.

In Africa, the Kenya Ceramic Jiko charcoal stove has been successful. By 2001, it had been disseminated to more than two million households, and its design was replicated across many other countries in Sub-Saharan Africa. Components were produced by 15 major enterprises and more than 100 independent trained artisans. However, because Kenya has no certification programmes for such stoves, the Kenya Ceramic Jiko has been plagued by quality control problems from the beginning (Bailis et al., 2009). As with SPV panels and other RETs, quality assurance — the need for training, as well as standard-setting and enforcement — is an important, though at times neglected, element of a successful effort to expand energy access. These qualitative aspects need to be part of a comprehensive employment agenda.

There seem to be no broad-based figures indicating employment in ICS production by country, let alone globally. At any rate, mass-production implies very different labour intensities than the small- or micro-scale production that takes place in rural areas of the developing world. But the findings from Cambodia suggest that ICS may well require more labour input than traditional stoves. It is still clear that ICS entail a range of important socio-economic benefits, even if it is unclear how these might translate into jobs.

3.2.5. Biogas - Cooking and Heating

> Most of the developing world's 44 million biogas plants are found in China, where some 90 000 jobs were created during 2006-2010. Although there is a growing domestic biogas industry in India, some problems have emerged with regard to materials, construction practices, as well as with maintenance of plants. Nepal, by contrast, seems to have fared much better, creating some 11 000 direct and indirect jobs.

REN21's 2011 Global Status Report estimates that worldwide more than 44 million households use biogas generated in small-scale digesters (REN21, 2011). The use of household-size biogas digesters has proliferated in China and India in particular, but much less so in most other developing nations.

Country Experiences

This sub-section briefly discusses the experience of four countries - China, India, Nepal, and Bangladesh. In quantitative terms, China towers over every other country in the number of biogas plants installed. The number of India's biogas plants, although impressive, needs to address quality concerns. The efforts in Nepal and Bangladesh are at a considerably smaller scale, and most other Asian countries are in relatively early stages of their biogas programmes. Vietnam's programme has provided training and work for more than 1 800 local masons, and Cambodia's is providing employment to 450 persons; 370 farmers and 80 technicians (ARE, 2012; NBP, 2011).

China. China leads the world in the number of installed household biogas plants. The country completed about 400 000 units by 1975. The official 1985 target of 20 million units was missed by a wide mark (with less than 4 million by 1984 due to a lack of maintenance skills [UNDESA, 2011]). But by 2006, the number had risen to about 18 million (ClimateTechWiki, n.d.-b). Following a renewed push by the Ministry of Agriculture, an astounding 22 million household systems were added between 2006 and 2010, reaching a total of 40 million systems in early 2011 (REN21, 2011). This effort created close to 90 000 jobs, as shown in Table 8. The goal is to install 80 million household-scale units by 2020 (Raninger et al., 2011).

State subsidies were a key factor behind the rapid expansion of the biogas sector. Between 2000 -2010, the Ministry of Agriculture invested more than CNY 24 billion (or about USD 3.8 billion) into construction of biogas plants, with annual investment support reaching an average of CNY 5-6 billion (about USD 0.8-1 billion) in recent years. Additional investment subsidies come from the provincial and municipal governments. As of 2010, some 4 000 companies were involved in planning, construction and maintenance activities. However, the role of subsidies is expected to gradually decline in coming years (Raninger et al., 2011; GIZ, n.d.). In its 2007 "Medium and Long-Term Development Plan for Renewable Energy", China's National Development and Reform Commission set government subsidies at CNY 1000 (or about USD 158) per household biogas digester, or roughly one-third the total cost. The subsidy comes in the form of building materials and equipment that are provided, as well as expertise lent by technicians, while households provide labour (Energypedia, 2011-b).

Table 8. Employment Effects of Biogas Digester Construction in China (2006-2010)

Sector	Direct Jobs	Indirect Jobs	Total
Construction	4 500	6 600	11 100
Non-metal Mineral Products	13 100	35 100	48 200
Electronics, Machinery and Equipment Manufacturing	2 400	8 700	11 100
Metal Smelting and Pressing	500	2 100	2 600
Technical Service Industry	3 400	3 500	6 900
Residential Service and other services	2 400	7 700	10 100
TOTAL	**26 300**	**63 600**	**89 900**

Source: International Labour Organization (ILO), 2010.

India. With a total of 4.1 million family-size biogas plants (with 1 to 6 m^3 capacity) installed, India is a distant second to China (MNRE and CII, 2010). MNRE estimated that some 12 million plants could be supported on the available dung (Arora, et al, 2010). Just slightly more than 100 000 such plants were installed during financial year 2008–2009, saving 120 000 tons of fuelwood. The Indian government estimates the number of current jobs in the biogas sector at 85 000 (MNRE and CII, 2010), and eventually some 200 000 jobs could be created. An October 2010 assessment concludes that Indian manufacturers of biogas plants are "steadily improving their technology and products, which has led to an establishment of Indian companies in the global market. Thus, foreign companies trying to break into the Indian market face strong competition from established Indian companies in the Indian market who have knowledge of local conditions and requirements." (Arora et al., 2010).

India's experience with biogas is mixed. Nominally, it has a large and growing number of plants. However, a large number of household-scale plants face some difficulties, with the main reason being the lack of appropriate skills among installers and training for users. Households are typically neither made aware of the need for maintenance nor trained to perform it properly. Consequently, most of the plants become non-functional within a year of construction (this is an experience that has also been made in Burkina Faso, for instance).

Nepal. The Biogas Support Programme (BSP), which is funded by the Netherlands and Germany, brings together the private sector, MFI, community groups and NGOs, has allowed a steady expansion of biogas use. Adding 25 000 plants in 2010, the country now has a total of about 225 000 systems (REN21, 2011). Typically, a third of the cost (USD 280 - 360 for a 6 m^3 plant) is paid in kind, with the beneficiary household providing labour and materials. As a result of BSP, a private biogas business sector has emerged in Nepal, with more than 55 construction companies, 15 biogas appliance manufacturers and 80 finance institutions (UNCTAD, 2010). By the end of 2005, 11 000 direct and indirect biogas jobs were created (ADDCP, 2009).UNCTAD refers to an additional 65 000 jobs through spin-offs, but does not offer any description or analysis of what these jobs entail (UNCTAD, 2010).

Bangladesh. Bangladesh had about 21 700 biogas plants installed as of the end of 2011 (IDCOL, 2011-b; Wadud, 2012). The country has a target of adding 27 000 plants in 2010-2012, ranging in capacity from 1.2 to 4.8 m^3 per day of gas production (IDCOL, 2009). The 2010-12 Implementation Plan for Bangladesh's National Domestic Biogas and Manure Programme (NDBMP) expects that 162 000 people will benefit during this time and that 3 300 jobs could be generated. It is further anticipated that there will be about 25 000 additional beneficiaries through "capacity development activities." This is principally in reference to training sessions and on-the-job training offered to new masons in construction, maintenance, and slurry utilisation. Additional training will also be provided to NGOs, agriculture extension workers, and others to ensure households' proper use of the biogas plants. The Implementation Plan argues that biogas plants will help reduce poverty through savings on energy expenditure and increase agriculture production by using the residue that comes as a by-product of biogas generation as high-quality fertiliser. Women are to have a strong role in the biogas programme and thus empowering them in decision-making (IDCOL, 2009).

Pilot projects have been carried out in countries like Ghana, Kenya, Niger, Burkina Faso, Mali, Ethiopia, Senegal and Rwanda both for cooking and decentralised electrification efforts (UNIDO, 2009). A 2009 assessment found that Rwanda's Domestic Biogas programme "is one of the best designed biogas programmes in Africa," but difficulties with initiating a credit programme kept the number of plant installations to just 11% of the planned 3 450 units in 2007-2008 (Heegde, Michel and de Wilde, 2009). In South Africa, a feasibility study done for the Department of Minerals and Energy in preparing its own national biogas programme identified over 310 000 households that could participate (Engineering News, 2008).

This brief discussion of selected country experiences suggests that the manner in which biogas development is undertaken makes a critical difference to the success of such efforts, and by implication, the quality and sustainability of jobs in the biogas sector. China's performance stands in stark contrast to the problems India has experienced in terms of quality and reliability. However, as additional countries invest in expanding their biogas facilities, more case studies are needed to expand lessons learnt and compare best practices. The introduction of biogas digesters has proved difficult in most African countries, with adverse factors including high capital costs, insufficient feedstock and water, and negative public perceptions.

4. Case Study Analysis

To assess employment impacts, analysts often rely on input-output studies, employment factors (such as in the case of India in the previous section), and modelling tools.[1] There are some disadvantages associated with such quantitative approaches. They often require assumptions that may heavily influence outcomes; involve a high degree of generalisation and aggregation; and do not normally capture local context and complexities well. By contrast, case studies allow a closer examination of particular, on-the-ground circumstances as well as non-economic- i.e., social, political and environmental -factors that influence outcomes. On the other hand, a drawback of case studies, particularly those that focus on small communities, is that it may not be possible to draw broad, generalising conclusions.

4.1. OVERVIEW OF CASE STUDIES

This section of the report is based on a total of 15 case studies that were contributed by IRENA partners: ARE, E+Co, GIZ, GVEP and UNDP/World Bank (see Table 9). These organisations have supported the projects and businesses examined in the case studies in variety of ways, i.e., through grants, investments, training activities, mentoring, etc. Table 10 lists these case studies and offers summary information about where the projects concerned operate and which RETs they employ. The majority (nine) are in Sub-Saharan Africa, four operate in Central America, with two in Asia. Given that populations of Sub-Saharan African countries suffer the most from lack of energy access, this focus is entirely appropriate. The Table also offers an overview of the types of renewable energy applications that are used by the case studies.

4.2. INDIVIDUAL CASE STUDIES

The companies and projects included in this study come from diverse backgrounds. Most of them are private companies, but donor-supported projects, commercial entities and environmental NGOs are also included. The projects also engage in a wide range of activities, including support for sales, installations and maintenance of

Table 9. IRENA Partner Organisations

	Description
ARE (Alliance for Rural Electrification)	International business association based in Brussels, focusing on the promotion and the development of off-grid renewable energy for rural electrification in developing countries
E+Co (Energy Through Enterprise)	Investing in clean energy in developing countries. Established in 1995 with headquarters in New Jersey, has offices in 8 locations worldwide and works in over 20 developing countries
GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit)	German development co-operation agency established in 1975, headquartered in Eschborn, operating in many fields in more than 130 countries
GVEP International (Global Village Energy Partnership)	Non-profit organisation established in 2006 and headquartered in London, working to increase access to modern energy and reduce poverty. Projects across Africa, Latin America and the Caribbean
UNDP (UN Development Programme)	UNDP is a United Nations agency with 135 country offices worldwide and working in 177 countries
WB (World Bank)	An international financial institution that has the official goals of reducing poverty and provides loans to developing countries

[1] *For more information on this topic, see IRENA (2012).*

Table 10. Case Study Overview: Projects, Countries, and Types of Renewable Energy Technologies, by Region

Operating in Region / Country (Number of Case Studies)	Support/ Sponsor	Company or Project	Biogas	Bri-quettes[1]	Hydro	ICS	SHS	Pico-Solar	SWH, Solar Water Pumps
Central America									
Honduras	E+Co	Hydro A			✓				
Guatemala	E+Co	Hydro B			✓				
Nicaragua	E+Co	Solar A					✓		✓
Nicaragua, El Salvador, Panama, Honduras, Guatemala	E+Co	Solar B					✓		✓
Sub-Saharan Africa									
Tanzania	E+Co	Solar A					✓	✓	
Tanzania	E+Co	Solar B					✓		
Burkina Faso	GIZ	FAFASO [3]				✓			
Kenya	GVEP	DEEP EA [4]	✓	✓		✓	✓	✓	✓
Uganda	GVEP	DEEP EA [4]	✓	✓		✓	✓	✓	✓
Tanzania	GVEP	DEEP EA [4]		✓		✓	✓	✓	✓
Kenya	GVEP	SCODE	✓			✓		✓	
Burkina Faso, Mali, Senegal, Ghana, Ethiopia, Tanzania, Uganda, Zambia, Mozambique	ARE	REF-Solar-Now [5]					✓	✓	
Gambia, Tanzania, Zambia	ARE	NICE Interna-tional							✓
Asia									
Laos	ARE	Sunlabob						✓	
Nepal	UNDP/ WB	REDP/ RERL [6]	✓		✓	✓	✓		

Note: No real company names are given for the six E+Co cases.

[1] Briquettes are "low cost alternative to environmentally damaging fuels such as fuelwood, kerosene and charcoal. They are similar in appearance to regular charcoal but they are made out of charcoal waste, agricultural residues or sawdust, which are normally considered unusable waste."

www.gvepinternational.org/en/business/briquettes.

[2] Includes solar water heating, solar drying (produce) and solar irrigation pumps.

[3] Foyers Améliorés au Burkina Faso.

[4] Developing Energy Enterprise Programme East Africa.

[5] Rural Energy Foundation (SolarNow has a network of 120 authorised dealers; teams in individual countries may have anywhere from 20 to 100 local staff (SolarNow, n.d.).

[6] Rural Energy Development Programme / Renewable Energy for Rural Livelihood.

small solar systems; production of ICS on a small- or micro-scale; investments and training in small hydropower plants; advice for business start-ups, marketing and networking for producers. Many of the case studies also concern micro-enterprises which employ a very small number of people and sometimes there are no employees at all beyond the entrepreneur or only casual labourers who may not be working year-round.

4.2.1. Solar Projects

4.2.1.1. ARE-Rural Energy Foundation SolarNow Projects in Sub-Saharan Africa

The Rural Energy Foundation (REF) is a non-profit organisation founded in 2003 and based in the Netherlands. In 2010, REF won the EU Sustainable Energy Europe Award and the International Ashden Award (2006). By strengthening entrepreneurship and the supply chain, REF hopes to increase the use of solar energy in rural Africa. Currently REF carries out operations in 8 Sub-Saharan African countries – Burkina Faso, Ethiopia, Mali, Mozambique, Senegal, Tanzania, Uganda and Zambia (operations in some other countries, including Sudan and in Ghana, were discontinued because the local conditions—ranging from the market situation to safety considerations—were unfavourable).

REF started its SolarNow programme in 2007, an initiative to identify and support suitable local retailers and distributors, technicians and sales personnel; training them in solar energy technology, marketing, sales and business administration, thus helping them start up and expand businesses selling solar energy products. REF focuses primarily on SHS and solar lanterns. The SHS promoted by REF use modules in the range of 11-50 Wp, capable of charging mobile phones and running small electrical appliances. The solar lanterns typically use a 1-10 Wp PV module.

Since 2007, REF has sold over 57 000 SHS costing USD 250 to 630 each. REF has also sold some 36 000 lanterns. Their cost is much more moderate, ranging from USD 25 to 90. The initial objective was to provide access to affordable solar energy to 110 000 households and small businesses. The number of people reached as of late 2011 has already surpassed 492 000, indicating greater-than-expected success. Marketing campaigns, such as village demonstrations, newsletters and radio shows, play a crucial role in stimulating awareness and demand for solar technologies.

JOBS AND TRAINING

REF seeks to develop a sustainable supply chain, providing employment and income opportunities to local people and increasing their skills. Product quality, reputation and client trust (buffeted by the quality of good after-sales service and warranties) are key to this effort. It has proved more efficient to work with local staff than rely on regional managers and volunteers (as was initially planned). Local entrepreneurs who adhere to REF's quality requirements and complete the offered training are allowed to use the SolarNow brand name and become part of its supply chain. Importantly, REF does not impose a choice of brands on the retailers, though they are advised on the best options available, and could lose the right to use the SolarNow brand name if found to be repeatedly selling poor quality products. This approach combines individual initiative with measures to ensure quality and reliability, thus building and reinforcing a key asset of the SolarNow network, namely its good reputation.

As of late 2011, there were 200 SolarNow retailers working in the eight African countries. The expansion of local retail networks has created jobs and provided skills-training for about 200 technicians. There are no fixed prices for the solar products. Local SolarNow retailers are encouraged to study and understand the market, such as what customers can afford, reinforcing capacity building as well as the initiative of individual retailers. The overall capacity of the retailer network is being improved constantly, through trainings, coaching sessions and after-sales visits to local retailers.

SUPPLY CHAIN

Upstream Linkages

The PV modules and charge controllers for the products sold by SolarNow are manufactured in China, the United States and Europe. Solar systems are assembled and installed by local technicians who are trained by REF.

A four-day training course provided by REF focuses on technologies, marketing and sales. REF staff often visits the technicians on-site, which allows any problems encountered whilst demonstrating the newest products to be discussed. Furthermore, retailers frequently visit villages to demonstrate solar products. These visits, along with REF's large-scale marketing campaigns, have proven to be an effective tool to raise awareness of solar products in rural areas.

Downstream Benefits

The cost of electricity for local communities decreases significantly with the use of solar technologies. In REF's experience, a SHS system pays for itself in one to three years through savings in kerosene and batteries. REF estimates that an average household using an SHS saves about 30% on energy expenses. These savings mean that less money flows out of the local community. The money can then be used for other purposes and income-generating activities.

FINANCING

Customers pay the full price for SHS and solar lanterns normally in cash. However, the initial investment is still a huge burden for many households. In response, REF developed several financial models to improve the ability of lower-income households to afford solar technology and especially to meet the up front costs. REF began to work with MFIs in 2008, in order to provide local retailers and customers with more affordable loan options. Encouraging results of a 2010 hire purchase pilot in Uganda prompted REF to replicate the model in other countries.

4.2.1.2. ARE-Nice International Project in Gambia

NICE International BV is a Netherlands-based initiative of Energy4All Foundation, and operates as a social venture. It promotes solar-powered information, communications and technology (ICT) service centres for people living on less than USD 5 a day, in peri-urban and rural areas with either no grid access or very poor grid connection. Four types of services are made accessible: battery charging, information (access to TV, communication tools, internet), value-added services (business and banking education) and income generation (online trading, outsourcing).

The project started in 2006 with two pilot centres in The Gambia. Five more centres were opened in 2009-2010. Each is operated as a franchise by a local entrepreneur. Entrepreneurs are able to run such centres without the need of a large up-front investment and with additional funding from several sources, including the EU Energy Facility, the network will be scaled up to a total of 50 centres in the next few years, supported by three country organisations. By 2014, 16 additional locations will be established in Gambia, 20 in Tanzania and 14 in Zambia.

SolarNow retailer in Tanzania-2009

The franchise model benefits franchisees via a package of support services from the NICE Country Organisation, which is a joint venture between NICE International and one or more local partners, including banks, telecom firms and internet service providers. The Country Organisation, in turn, benefits from direct local market and business expertise. A key advantage of the network model used by NICE International is that it allows it to scale-up without compromising or undermining local entrepreneurship. Experience to date suggests that a NICE Centre's services are used by 1 000 people in the first year of operation, rising to 3 000 by the third year. On average, each NICE Centre will be located within easy reach of about 20 000 people. Altogether, the 50 locations are expected to offer access to energy and ICT services for up to 1 million people, providing opportunities for income-generating activities.

The NICE Centres are mostly grid-connected, but in some cases run exclusively on their own SPV power and are thus capable of operating in off-grid locations. On average, the solar systems produce 7.5 kWh per day. Although addressing the lack of reliable energy supply is a key aspect, it is equally important to go beyond electricity access and to provide associated development services. Even though internet access in African countries is spreading, many local providers (internet café owners) lack skills and knowledge. NICE Centres can provide capacity-building, coaching and help with finding financial solutions for these fledgling local businesses.

JOBS AND TRAINING

Each NICE Country Organisation employs at least a local managing director, finance manager, technical manager and a service manager. Each NICE Centre is run by a local entrepreneur and employs on average five staff members. However, the technical and business skills needed to successfully operate a NICE Centre are scarce in developing countries. As such, NICE offers the required capacity-building at the country level and through the franchising model, supports individual centres with training and coaching for entrepreneurs.

SUPPLY CHAIN

Upstream Linkages

The solar systems used by the NICE Centres are advanced systems assembled from components of different suppliers. Solar and ICT equipment are purchased internationally. Therefore, employment benefits in the supply chain arise principally outside of Gambia, aside from jobs related to imports and distribution.

Downstream Benefits

Locally, each NICE Centre supports several local businesses, including: internet service providers, technical installation, maintenance and repair, products and services. Maintenance and support of the equipment is carried out by the NICE Country Organisation, with back-up from international suppliers. The franchisees pay a lease fee for the use of the equipment. Technical contractors to the NICE Centres are trained in specific skills in order to effectively support the business. There is a certain degree of dissemination of important technical and business skills locally.

Further downstream, reliable access to energy is the enabler of local development, for the benefit of people at the base of the economic pyramid. The NICE Centres are considered 'supermarkets' for products and services that help people in their personal and economic development (e.g. solar products, IT education, online healthcare, financial and government services). Their focus is on youth (which represent 50% of users), women (25%), and small entrepreneurs (10%). Experience to date suggests that the centres have helped to:

- Increase employment and disposable incomes locally;
- Improve the quality of the workforce available for local businesses;
- Provide access to international expertise (technical and management capacity) for local partners, as well as information about international markets, institutions, services and tools;
- Strengthen the market position of local contractors;
- Improve the quality, effectiveness and competitiveness of local businesses through ICT skills and business networks;
- Offer low cost access to office facilities with stable energy supply and high quality equipment;
- Provide training opportunities to improve business skills;
- Serve as a platform for knowledge exchange with other local entrepreneurs.

ICT skills are demanded by many employers but are not taught at most schools, thus making them a major asset in the labour market for the youth. Regionally and nationally, the centres' ICT services increase access to and the quality of education, facilitate and reduce the cost of delivery of information and services (by reducing the need to travel to the main cities where most basic services are provided).

FINANCING

NICE Centres are set up as local business entities to make them financially sustainable. Through the fees charged to customers on a pay-per-use basis for development services, they are able to generate revenues. The franchise and lease arrangement allows local entrepreneurs to run a high-tech business without having to make a large investment. The expansion of NICE Centres will be financed by franchise fees of the NICE Country Organisations, a subsidy from the European Union's Energy Facility (30%), and private investments (The Netherlands Development Finance Company, Rabobank, Schneider Electric). Experience suggests that the NICE Centres reach a positive cash flow within one year of their establishment and run at a profit within three years.

4.2.1.3. ARE-Sunlabob Project in Laos

Sunlabob is a private commercial company from Laos, licensed in 2001. It provides a range of renewable energy services for remote off-grid areas that are not being served by the public electricity grid. In addition, the company set up an Energy Efficiency Department in 2008, which allowed it to focus on urban areas. This department conducts energy audits and efficiency consulting as well as supplying and installing better energy-efficient materials. Sunlabob became the first Laotian energy services company in 2009.

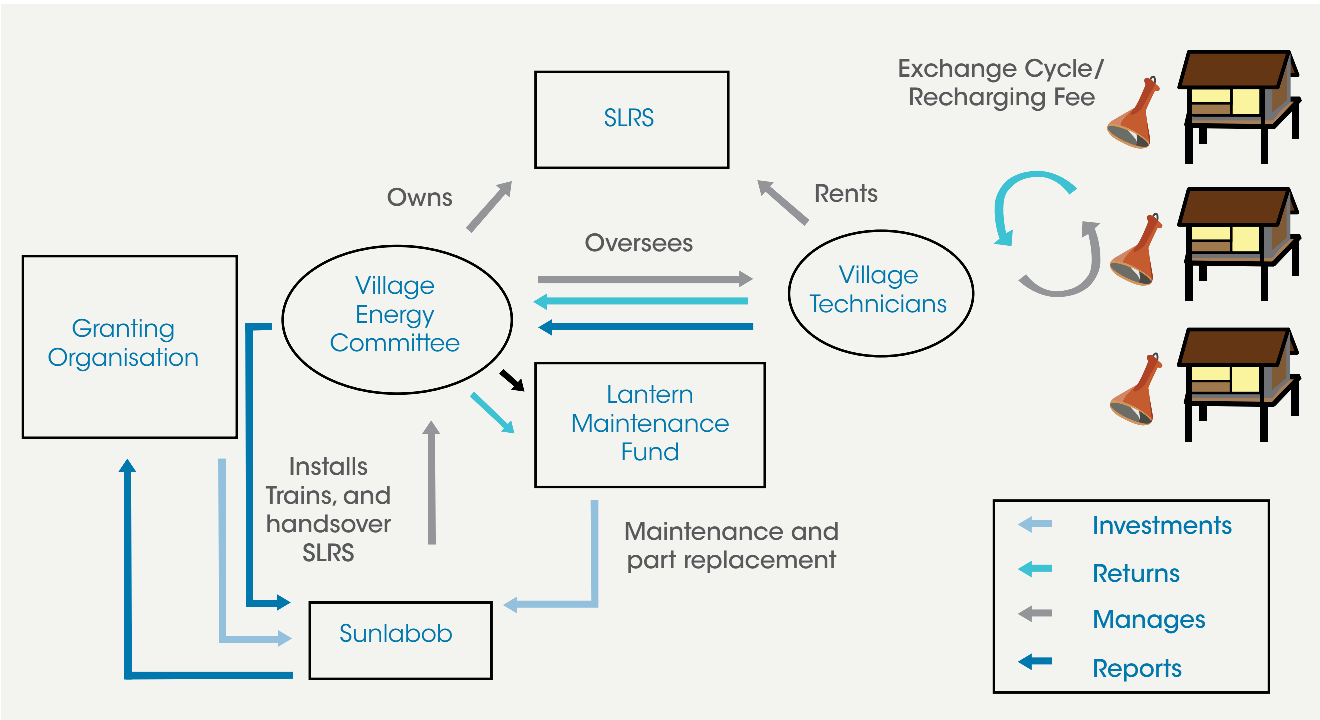
Solar lanterns often fail much earlier than expected, either because low-quality components are used to keep overall costs down or because batteries are misused or irregularly charged by users. As a result, kerosene lamps continue to dominate the off-grid lighting market. To overcome these problems, Sunlabob has developed an innovative solution to provide access to electricity in rural areas. Its award-winning Solar Lantern Rental System (SLRS) is based on a fee-for-service concept, under which end users purchase a service rather than a piece of equipment as such (see Figure 2). Beyond making clean energy available to poor communities, the model also aims to create opportunities for micro-enterprise formation and thus for local economic structures that may be capable of generating lasting broader socio-economic benefits.

The systems that Sunlabob promotes consist of a solar charging station operated by a village entrepreneur and a number of lanterns (typically between 20 and 50) that are communally owned. A 50-lantern charging station is comprised of a 120 Wp PV panel, a 100 Ah battery, a charge controller and a set of charging cables. It takes about half a day to install the system, an additional day is required for accounting and technical training and a lamp is charged in about 2-2.5 hours. Households pay a small fee for a fully charged solar lantern. When the battery is depleted, a customer exchanges it for a fully charged one. Use of a solar lantern offers a 75% reduction in a typical household's lighting bill, as well as a better quality and safer lighting than kerosene lamps. Additionally, lanterns have the capacity to charge mobile phones.

JOBS AND TRAINING

New workplaces are created for people to operate and oversee the system. A village technician/entrepreneur is responsible for operating the charging station. This person collects the fees from households renting the lanterns, and he is further in charge for running the micro enterprise associated with the system. A share of the fee is transferred to the maintenance fund for future replacement of components, such as batteries and other

Figure 2. Structure of Solar Lantern Rental System (stakeholders and their responsibilities)



Source: Sunlabob

Biodigester in Kenya

Sunlabob staff providing training to village technicians on how to operate and maintain the Solar Lantern Rental System in Laos (ARE)

maintenance needs. A village energy committee, consisting of three to four people, is selected to oversee system operations, together with managing the maintenance fund and general financing. The committee receives a small income for its activities.

Technical and entrepreneurial capacity-building are incorporated into the installation process. The village technician and the committee receive training in system operation, maintenance, trouble-shooting, as well as in accounting procedures to track the lanterns and the system's finances. Proper training and follow-up visits after installation are critical to guard against misuse of the system that can shorten its lifespan. This also ensures that maintenance funds and spare parts are properly tracked. Experience suggests that in some cases the village technician and the village energy committee need to receive additional training.

SUPPLY CHAIN

Upstream Linkages

Sunlabob sources all components locally. However, more sophisticated items are imported from abroad, although some pre-assembly is done in Laos. Once the system is installed, it is managed locally.

Downstream Benefits

The SLRS project creates jobs, generates income opportunities, and enables better conditions for micro enterprises in off-grid communities with the help of improved lighting. Access to electricity allows engagement in several activities not previously possible, such as reading and doing homework at night, handicrafts, using a mobile phone and having access to information and communication. Local people benefit from reduced energy bills, significantly lowering the financial burden on households. The revenue generated by the system is kept within the community, providing income for the village entrepreneur and system maintenance and hence strengthening local economies.

FINANCING

Hardware and system installation are sponsored by a donor organisation. A village energy committee oversees the operations of each system and the management of the maintenance fund. Villagers are freed from the high up-front capital costs that are a key obstacle for many rural communities in the developing world. Without the initial cost and risks, growing numbers of villagers have been motivated to try this system out and Sunlabob's model has been adopted rapidly.

As mentioned, households pay a small fee, which is either similar or possibly even lower than the typical expense for kerosene, for the maintenance of the lanterns. A village technician is responsible for collecting fees from households renting lanterns and is also in charge of running the micro-enterprise associated with the system. A share of the fee is then transferred to the maintenance fund for future replacement of components, such as batteries and other maintenance needs.

4.2.1.4. E+Co Project A in Nicaragua

Solar Company A was established in 1999 as a "spin-off" of a non-profit student initiative at National Engineering University in Nicaragua, promoting solar energy and training local people on solar technologies. It promotes, sells, installs and services SPV and solar thermal equipment, as well as small-scale wind power systems. The company also sells energy-efficient appliances such as garden lights, compact fluorescents, mobile phone chargers and efficient stoves.

Headquartered in Managua, the company has four branches in the countryside. Initially, the firm focused on the provinces of Zelaya, Jinotega and Metagalpa, which had particularly low rates of electricity access. Today, its activities extend throughout Nicaragua and the majority of installations have been in rural communities.

The SPV stand-alone systems sold by the company include 50 Wp, 80 Wp, 100 Wp and 120 Wp modules. Households make up 85% of the company's customers; 10% are institutions and 5% are commercial or business enterprises.

As of December 31st 2010, the company had served 2 118 households. At an average of five persons per household, this translates into more than 10 000 people benefiting from energy access. The firm's 3 000 installed solar systems have generated a cumulative 591 MWh of electricity. Although Nicaragua remains highly dependent on fossil fuel-based electricity generation, SPV retail businesses and MFIs are increasingly providing energy alternatives and improving overall energy access.

JOBS AND TRAINING

The company employs 13 persons (of whom four are women) full-time in Managua. These are employed as managers, technicians and administrative and support staff. Salaries for non-managers range from USD 200 to 350 per month.

The company has 15 sales representatives in the field and has created micro-franchises to distribute products and offer solar solutions. This is providing employment to the heads of family in charge of local branches as well as providing income to women in rural co-operatives. Employee benefits include social security and employer loans for education, health and house improvements. In late 2011, the company began to distribute 30% of its shares to its employees as bonuses.

E+Co has provided training to the company related to operations, management and finance. The company enhances skills and capacity among several groups of people:

- Local technicians and salesmen are trained to understand the systems they are selling;
- Branch managers receive training on installation, product specifications, battery maintenance, basic finances, etc.;
- Women from co-operatives are taught how SPV-based products such as lanterns work and how to keep track of sales;
- Buyers are instructed on how to keep their systems working optimally.

SUPPLY CHAIN

Upstream Linkages

The company purchases all components of the PV systems from international suppliers. Technicians install the PV panels and produce metal structures to attach panels to roofs (initial plans to refurbish broken PV panels from U.S. suppliers proved unworkable). Suppliers are carefully chosen to ensure product quality and to avoid any negative social impacts (such as child labour) along its supply chain. However, none of the suppliers are local to Nicaragua. The company is focused on selling high-quality systems, works with firms in Germany (such as Phocos and SMA) and in the United States (DC Power), as well as other well-known manufacturers such as Sharp, Kyocera, etc.

The company adheres to Nicaragua's import restrictions to ensure that batteries comply with adequate safety and environmental standards. SPV systems sold in rural areas are distributed via local retailers who keep a small inventory of SPV panels. The company not only sells household-scale systems, but also installs larger projects on behalf of NGOs, governments and international actors. One example is the Eurosolar2 project that included solar kits for medicine refrigeration and education (powering computers) in off-grid rural communities.

Downstream Benefits

One of the important downstream effects the firm has had is that some SPV system owners are setting up small grocery shops. SPV systems give them access to affordable and reliable refrigeration, and allow them to keep their stores open for longer hours, translating into greater business and more income generation. Since E+Co's investment began, SPV owners have been able to displace about 1 million litres of kerosene and 4.2 million paraffin candles, providing substantial savings.

FINANCING

Company operations are based primarily on cash sales to households and other customers. Since E+Co first invested in the company, its employees have derived incomes estimated at USD 47 000. Rural households usually see their finances improve after the purchase of a SPV system, as they are able to save the kerosene, firewood and candle purchase expense. Households also experience improved health, translating into decreased medical needs and costs. Household finances may eventually also benefit in terms of educational and safety improvements that become possible with reliable access to electricity. These are, of course, less tangible and harder to measure than direct savings on fuel purchases, and may materialise only over time.

4.2.1.5. E+Co Project B in Nicaragua

Solar Company B was established in 1998, and has 17 branches in Nicaragua. It entered El Salvador in 2009 and is currently implementing a 500-system installation for the government's FOMILENIO Programme, which was created to act on behalf of the Salvadoran government in the context of an agreement with the U.S. Millennium Challenge Corporation. In 2010, the company established a presence in Panama after winning a concession for PV installations in rural homes, schools, and health centres (under the aegis of the government's Rural Electrification Office and the Inter-American Development Bank [IADB]). Further expansion into Honduras began in November 2011 and is targeted for Guatemala in mid-2012. The company benefits from a strong distribution network, and relies on a computerised accounting system that keeps track of branch sales and inventory. Unlike most other solar companies in Nicaragua, the company has also set up a battery collection programme.

In Nicaragua, the company was one of just three domestic solar companies that became eligible to participate in the Government/World Bank PERZA[2] (Programa de Electrificacion Rural en Zonas Aisladas) programme that offered subsidies and micro-financing for PV systems. The four year project (which ended in 2009) also allowed the firm to act as a micro-credit financier. A USD 200 000 IADB loan allowed it to set up a successful credit line for PV end users.

In Panama, the company won a concession with the government's Rural Electrification Office (REO). The REO created a ten year plan to electrify 70 000 households with the help of PV equipment, as part of the government's overall goal to raise the national electrification rate to 95% by the end of 2013. Funding comes from the Panamanian government and multilateral institutions such as the IADB.

Company B offers predominantly five PV packages of 14 W, 25 W, 50 W, 75 W and 100 W. All of the PV panels used by the company include a certificate of guarantee from the manufacturer for between 10 and 25 years and if they fail due to a manufacturing problem, they are replaced by the manufacturer at no cost to the end-user or to the company. In the 14 years of its existence, the company has installed more than 50 000 PV systems that provide electricity to about 300 000 people. It plans to sell 40 000 systems in the next five years, thus more than doubling the pace of installations. Additionally, the company sells solar water pumps (providing 163 households with access to water), SWH other solar-powered equipment and energy-efficient appliances.

JOBS AND TRAINING

As of late 2011, the company employed 98 people in Nicaragua, El Salvador, and Panama. It expects to add 12-15 positions as it expands to Honduras and Guatemala. There are also additional indirect jobs among installers and electricians in the field. The company enhances skills and capacity among several groups of people:

[2] *Programa de Electrificacion Rural en Zonas Aisladas provided a total of USD 2 million.*

» Technical staff is trained at a laboratory in Managua. Staff from rural branches also receives training there;

» The company encourages its managers to attend courses that will result in better operations control (for example, TIMe training provided by E+Co and World Resources Institute (WRI)'s New Ventures is aimed at improving resource management and monitoring);

» End users receive basic instructions to learn how their systems work.

SUPPLY CHAIN

Upstream Linkages

There is no local sourcing of PV equipment or components and hence no benefit for the local economy in terms of supply as the company imports its entire inventory. It works with a number of Spanish, German, U.S., Japanese, Chinese and other manufacturers and suppliers, including Isofoton, Solarworld, Komaes, Sony, Phocos, Black & Decker, Morningstar, Alari, Magnum, Motorola, Picana, DEKA, Synthesis Power and Trojan.

Downstream Benefits

Company B generates incomes of about USD 545 000 a year for all of its employees. The installed PV systems assist with income generating activities in local communities. This includes opening small businesses such as cell-phone-charging facilities and small shops known as "pulperias". Access to electricity allows easy refrigeration of goods and store lighting, hence longer operating hours. Solar company B also sells refrigerators that have been adapted to work with the PV systems it sells.

Households incur savings by not having to buy kerosene, candles or wood, allowing them to spend incomes on other goods or services. Since 2003, the company has reported kerosene savings of 10.3 million litres among users of its products (an average household uses about 20 litres per month).

FINANCING

Since 2003, E+Co has invested USD 1.8 million in the company to support its growth. However, PV buyers in Central America have so far depended mainly on government/foreign donor assistance. There is also significant capacity for end-user finance. Due to this, the company has to continue strengthening its sales through MFI's and Agricultural Co-operatives.

Installation and orientation of a solar PV panel (ARE)

4.2.1.6. E+Co Project A in Tanzania

Solar Company A retails, installs and maintains SPV systems in both rural and urban areas of Tanzania. The company is headquartered in Dar es Salaam, Tanzania's capital with 2.5 million inhabitants. The office serves as the overall hub of operations.

An office in Arusha handles sales and maintenance activities in the northern rural areas of Tanzania, where the primary economic activity consists of agriculture. Karatu is one of the five districts in the Arusha Region of Tanzania being served by the company. It has a population of 178 434 out of Arusha's total of 1.3 million people (2002 census).

The company offers PV systems in the 20-500 W range for households and schools, up to 3 000 W for health centres and further sells household appliances to be used with solar equipment (lights, mobile phone chargers, radios, and lanterns). It has sold more than 1 000 PV systems since it was established in 2002 and expects 15-20% sales growth in the next five years. About 80% of its business consists of contracts with institutions in rural areas such as health centres and schools and the remainder includes commercial enterprises and households. Selling to multiple types of customers and offering a diverse product range helps to mitigate risks. The company uses a variety of marketing techniques for different customers, including brochures, participation in trade fairs, radio and TV advertising, as well as word of mouth.

The company is one of a growing number of PV sellers in African countries experiencing fast growth in Tanzania. This growth is driven by the difficulties in providing reliable electricity services and extending access into the countryside. Meanwhile, there is rising demand for power by urban industries and for communications. The small diesel generators that are prevalent in remote rural areas are becoming more expensive to run due to increases in fuel costs. As such, the Tanzanian government is aggressively promoting the reliability, usefulness and safety of SPV systems via a nationwide SPV awareness campaign on radio and television. These factors all contribute to the growing demand for solar products in rural areas.

JOBS AND TRAINING

Company A currently has 14 staff—including four managers, an accountant, a driver, administrative staff/secretaries, three technicians and three sales officers. All employees are Tanzanian nationals. Two sales officers, as are two administration/support staffs are women. Salaries range from USD 150-200 per month for technicians and sales officers and USD 70-100 per month for other staff. Information regarding managers' salaries is not available. The company has 20 technical contractors and two drivers on call. It provides health insurance to its full time employees, as well as housing and transport allowances and a professional education fund for staff.

The company, along with others in Tanzania, has benefited from numerous technical training programmes offered by UNDP/GEF and other development aid groups. These training programmes have created a well-trained pool of technicians available to meet the demands of growing solar companies. Solar battery recycling remains a challenge in Tanzania. Some outlets sell used batteries, but a reliable recycling infrastructure remains to be built and could become an additional source of jobs.

SUPPLY CHAIN

Upstream Linkages

Tanzania does not manufacture solar equipment and thus the value chain in the country consists of wholesale importers, retailers and end users. The company imports its inventory from manufacturers and distributors in the United States, China, India and Germany. The products imported include: solar panels, solar batteries, regulators, inverters and solar lights. African Energy, a U.S.-based distributor, supplies over 80% of the company's inventory. The company sources its DC lights from Phocos in Germany and solar lanterns from D.Light (India and China). The company itself does not produce equipment, but adds value by installing SPV systems and training customers to maintain these systems.

Downstream Benefits

The most typical type of business created with the help of small-scale SPV systems are barber/hair cutting shops; mobile charging stations; and small enterprises such as inns and bars. PV systems used for lighting also helps rural entrepreneurs extend service hours, thereby increasing the flow of income to the business owners and improving services to customers. In fact, the cost of a 135 W PV system used for a mobile phone-charging business can be earned back within seven months or less. Given that PV components can last up to ten years, and PV modules as long as 25 years, a PV-based phone charging system can generate a stream of revenues for many years.

FINANCING

The company secured debt financing from E+Co to procure its inventory in 2006 and in 2011. This allowed the company both to compete for larger government tenders and to purchase and install the products before payment was received. The company sells to small clients paying cash, as well as to larger institutional clients on a contract basis. This multi-customer approach allows the enterprise to diversify its product offerings and revenue sources and therefore to mitigate risks. For future growth, the company will identify micro-finance partners to facilitate credit sales. It will pilot its first credit project in early 2012.

4.2.1.7. E+Co Project B in Tanzania

Solar Company B retails, installs, and maintains SHS (14-80 W) for residential (40% of sales) and institutional customers (60%). It is headquartered in Mbinga, a peri-urban town in the Ruvuma region of south-western Tanzania which is home to about 1.1 million people.

The company estimates that 10% of households in the region can afford a SHS. The company offers three sizes of PV panels, ranging from 14 Wp to 56 Wp for households and 80 Wp systems for institutional customers. The prices range from USD 225 to 1 400. Altogether, the company has sold close to 300 PV systems since it was established in 2006 and expects 10-15% sales growth in the next five years.

JOBS AND TRAINING

The company's majority owner and managing director is a trained economist. His long career in Tanzania's administration prior to setting up Company B has given him the managerial skills and experience needed to run the firm. Company B currently has nine employees—including one manager, two technicians/shopkeepers, one part-time support staff and five sales representatives. Only one staff member, a technician/shopkeeper, is female. Salaries for technicians range from USD 100-150 per month, while support staff earns USD 50-70.[3]

The company, along with others in Tanzania, has benefited from numerous technical training programmes offered by UNDP/GEF and other development aid groups. These training programmes have created a well-trained pool of technicians available to meet the demands of growing solar companies. The company's sales technicians were trained by a joint Swedish International Development Agency (SIDA)/Ministry of Energy and Minerals (MEM) programme, additionally one of the salesmen has a bachelor's degree in Economics.

SUPPLY CHAIN

Upstream Linkages

There are six large wholesalers of SPV panels and accessories in Dar es Salaam: Solatek, Chloride Exide, BP Solar, Rex Investments, Zara Solar and Umeme Jua Limited (UJL). Batteries are purchased from Chloride Excide and Victron (with one and three year warrantees, respectively). Sundaya, an Indonesian company, is the supplier of solar lights. Rex Investment and Zara Solar specialise in SPV panels and accessories for 50 Wp and higher capacities, which are obtained from NAPs, General Electric (GE) Energy and Steca. Given that all equipment is manufactured abroad, the economic benefit to Tanzania is limited to the wholesaling mark-up, as well as local retailing and installations.

Downstream Benefits

The most typical type of business created with the help of small-scale SPV systems are barber/hair cutting shops (four new shops resulted from PV systems sold by Company B); mobile charging stations; and small enterprises such as inns and bars. PV systems used for lighting also help rural entrepreneurs extend service hours and thus an increased flow of income.

A rural family in Africa uses about 60 litres of kerosene a year—the second-largest expenditure after food. PV systems allow substantial savings of kerosene, candles, or wood, it also offers substantial health benefits. Patients at rural health clinics benefit from improved quality of services (night deliveries of babies; refrigeration of medicines, etc.).

FINANCING

In 2007, E+Co provided a USD 50 000 loan to the company to purchase its inventory as the company was unable to secure local financing. The company sells on a cash basis to residential and institutional customers and sales are made directly to customers through a shop. Retail prices range from USD 225 to 650 for household SHS and USD 1 400 for larger institutional systems. Partnership with a local MFIs and building a track record of successfully running government contracts would be required to scale up the company's household market.

4.2.2. Small Hydro Projects

4.2.2.1. E+Co Project A in Honduras

Hydro Company A, a Honduran corporation, developed a 13.5 MW run-of-the-river hydroelectric project in a rural town in the Department of Intibucá in western Honduras (with a population of about 45 000), close to the border with El Salvador. The project entails a cascade of three powerhouses on the Intibucá River. The hydroelectric plant was constructed between 2004 and 2008, on the site of an abandoned 500 kW facility from the 1940s. In several phases, capacity was increased from 1.4 MW to 13.5 MW.

Electricity generated by the plant is fed into the national grid, which supplies an estimated 11 000 people in the local community with power. The project provides a reliable energy source for communities that are often plagued by black-outs. In addition, two local communities are grid-connected as a result of this project, allowing an additional 1 200 people to use electricity for lighting instead of relying on candles, kerosene and batteries. Such projects contribute to achieving the government's target of increasing national electricity coverage to 80% by 2015,

[3] *Salaries for the manager and sales representatives are not available and the company does not provide health insurance.*

with equal attention to urban and rural needs. Electricity access has already improved significantly, from 43% in 1994 to about 70% at present.

JOBS AND TRAINING

The total workforce at the hydropower plant comprises 83 persons. The company's core management team (President, General Manager, Administrative Manager and Project Manager) includes two Canadians and two Hondurans. There are seven technicians and 62 workers/labourers (of which ten are women). Along with five female administrative/support staff, the workforce's share of women is 24%. Workers and administrative staff earn USD 250-350 per month and technicians earn 25-30% more than labourers.[4] Since the majority of the employees of the project are nationals, the income directly benefits the local economy. However, no medical insurance is provided, although a doctor is on-site for any emergencies or accidents at work. The company provides 12 days paid vacation and three paid sick days for full-time employees.

From 2004 to 2008, more than 100 workers were hired from the community when the plant was constructed. These were temporary jobs and employment ended when the plant was completed. Now, specialised contractors are hired as needed for tasks such as building construction, turbine installation, or pipe layout. Management consists of trained and experienced engineers. The managers have trained maintenance and nursery labourers to perform their jobs.

SUPPLY CHAIN

Upstream Linkages

The company bought the main technology components, the Pelton turbines, from an international supplier. No data is available to quantify supply-chain impacts. Construction materials were sourced in Honduras and thus provided employment locally along with the direct (but temporary) construction jobs. No data is available to quantify the impact on the supply chain.

Downstream Benefits

Because it is virtually impossible to trace the point of power generation origin to the specific households that use grid-electricity, only generic observations are possible with regard to downstream linkages.

The company also offers a micro-credit programme to its employees, which has helped generate additional local economic demand. Finally, the company engages with the local community in a number of activities, including environmental training and tree-planting programme for local schools.

FINANCING

The total project cost was USD 16.5 million. E+Co made several debt and equity investments totalling USD 1.35 million (or 8% of total capital costs). The project was also able to attract financing from local banks and international development finance institutions, playing an essential role in demonstrating more broadly to local Honduran banks the investment opportunities present in the hydro sector. The company has also signed an agreement to sell carbon-offset credits generated by the hydro plant, one of few privately owned projects to successfully do so, helping to increase the company's net cash flow.

4.2.2.2. E+Co Project B in Guatemala

Hydro Company B, a Guatemalan private company, upgraded and revitalised an existing 400 kW plant to 1.1 MW. It is located in the municipality of El Rodeo (36 000 inhabitants) in the Department of San Marcos (total population of about 800 000). The project will generate approximately 5.7 million kWh of electricity per year. The company is planning to undertake feasibility studies for additional hydro projects in Guatemala. As Guatemala's energy use grows at 8% annually, renewable energy sources—wind and solar in addition to hydropower—are expected to play a major role in meeting the country's energy demand and improving rural energy access.

Guatemala's state-owned utility INDE has promoted the connection of isolated small hydro plants into the national grid, and the Ministry of Energy and Mines has promoted a series of private sector incentives for renewable energy development, including exemptions from income tax, machinery import tax, as well as freeing carbon credits from taxation. These policies created an enabling environment for the development of hydropower in Guatemala. Overall access to electricity has risen from 66% in 1998 to 84% in 2008. Populations of lower income and un-electrified populations are found mainly in the rural areas specifically in the northern region of Guatemala in Peten and Zacapa. A large percentage of this population is indigenous and is spread across large portions of land where distribution lines are difficult and costly to install.

[4] *The company does not make manager income data available.*

JOBS AND TRAINING

The total workforce at the hydropower plant comprises 14 persons. All are Guatemalan nationals, and thus their salaries directly benefit the local economy. This comprises one manager, three engineers, and ten operator/administrative/support staff. Just two (or 14%) of the staff are female. Support staff and operators earn USD 200-300 per month, with a higher rate for operators than for administrative staff. No salary information is available for the manager and engineers; however an estimate for the engineers is that earnings are 15-20% higher than those of operators. From 2008 to 2009, 96 workers were hired from the community when the plant was constructed. These were temporary jobs, however, and employment ended when the plant was completed.

The company does not provide formal medical insurance. However, it does pay for employees' medical treatments as the need arises. The company provides 21 days of paid vacation and three paid sick days per year to full time employees. The project manager is a professional engineer and project developer. His technical team includes civil and electrical engineers with experience in building and operating hydro-electric projects. The remaining staffs receive on-the-job training from the manager and engineers.

SUPPLY CHAIN

Upstream Linkages

The company bought the turbine and other electromechanical equipment from an Italian-owned company manufacturing in Guatemala. The total value was more than USD 800 000. Construction materials for the initial infrastructure for the facility (including wood, steel, cement, etc.) were purchased locally.

Downstream Benefits

Because it is virtually impossible to trace the point of power generation origin to the specific households that use grid-electricity, only generic observations are possible with regard to any community downstream linkages.

FINANCING

The total project cost was USD 1.54 million. E+Co provided a loan of USD 1.1 million or 72% of the total project cost. The remaining 28% of the investment cost (USD 437 650) was covered by the company itself, which also invested USD 286 000 for feasibility studies. The project has a cost of USD 1 398 per installed kW, a rate judged to be competitive for Central America.

MHP power distribution line (100 kW) in Nepal (UNDP/WB)

4.2.2.3. UNDP/WB Project in Nepal

Renewable Energy for Rural Livelihood (RERL) is a joint programme of UNDP and the World Bank with the Government of Nepal. It was initiated in April 2011 upon the successful conclusion of the Rural Energy Development Programme (REDP), which itself was started in 1996. In three distinct phases, activities were scaled up. The main objective is to increase equitable access to energy services for the poor, women and socially excluded groups. Beyond the provision of energy services, social inclusion and community mobilisation are important aspects. In fact, REDP was designed from the very beginning to be aligned with Nepal's existing development strategy and its focus on decentralisation and community mobilisation.

RERL primarily promote MHPs (10-100 kW), as well as SHS (10-30 Wp), biogas (4-6 m^3), and ICS. From 1996 to 2011, not only did the number of MHPs increase, but so did the average size of the plants. To date, close to 58 000 households, with 350 000 people, have derived energy access benefits in the form of multiple applications such as; lighting, refrigeration, communications (powering radio, TV, video), operating irrigation pumps and agro-processing mills, and running a variety of rural businesses or income-generating activities that include handicrafts, carpentry, black-smithy and poultry-farming. RERL works with multiple communities, civil society, donor and private sector partners in tandem at various levels (community, district, national). The institutionalisation of rural energy development efforts via a set of committees is a key ingredient in this context. Simultaneously, there is a strong focus on decentralised planning and implementation. Transparent decision-making and consensus-building are crucial to the success of this multi-level approach.

One particularly important element is the active community involvement and ownership of the project from the very beginning, supported by capacity-building efforts. REDP/RERL requires that all households in a community participate in programme activities. Village Development Committees are charged with planning, implementation, operation and maintenance of community energy systems. Also at the local level, non-governmental organisations and private-sector Rural Energy Service Centres provide technical and other support. Different community organisations come together in so-called Micro Hydro Functional Groups (MHFGs) to co-ordinate on the different aspects of hydro-plants, from project formulation to operations. After they have run successfully for at least half a year, MHFGs may convert to Micro Hydro Co-operatives.

At the District level, District Development Committees are focused on policy and operational frameworks in support of decentralised energy planning and management, project monitoring and evaluations, as well as assistance to communities. In addition, District Energy and Environment Sections are supposed to co-ordinate day-to-day activities and mobilise financial and other support. At the central (national) level, RERL provides support to the Ministry of Environment's Alternative Energy Promotion Centre—the implementing agency—with a view toward overall policy co-ordination, support and lessons learned. Indeed, effective co-ordination is critical to make the array of different committees and other actors work together and ensure their effectiveness.

JOBS AND TRAINING

As of late 2011, 555 micro-enterprises had been established in REDP/RERL programme areas. Of these, 323 are MHPs that were completed and put into operation since 1998. The number of new plants completed per year has fluctuated considerably since 1998, from as few as five in 2006 to as many as 75 during the following year. A typical MHP requires two personnel for its operation.

The man-days required for running the growing number of MHPs has expanded from 8 760 in 1998 to 225 570 in 2010, and 117 895 during the first half of 2011. Figure 3 expresses this information in terms of full-time equivalent employment; rising from 24 full-time equivalent jobs in 1998 to 618 in 2010. For the first half of 2011, the number is 323 jobs.

Capacity building has been a priority, and it has included training for staff and community representatives on how to operate and manage MHPs and other RETs; establishment of Rural Energy Service Centres; income generating and environmental related activities; institutional development; book-keeping; and decentralised planning. Priority is accorded to women, dalits,[5] ethnic groups, and the poorest of poor. So far, a total of 34 050 people, including 15 000 women, have received training. Some 2 596 people have been trained on the technical aspects of MHP operations.

SUPPLY CHAIN

Upstream Linkages

The turbines, penstock pipes, and accessories for the MHPs are locally fabricated, and the electronic load controller was locally assembled, but the generators are imported. The REDP/RERL programme puts strong emphasis on local enterprise development, and especially its contribution to community development. This is done through the Enterprise Development Fund (EDF). Each MHFG receives assistance to create an enterprise fund to provide loans to needy villagers at convenient terms.

Downstream Benefits

All households equally contribute to, own and benefit from local MHPs (electricity and revenue). Communities have instituted mechanisms to help poor households gain access to electricity:

- Poor households unable to contribute cash or raise collateral for a bank loan are allowed to contribute in kind and labour;
- Those unable to pay the electricity tariff in cash are allowed to contribute through canal cleaning and/or repairing.

[5] Dalits is a word used to describe a group of people traditionally regarded as "untouchable". Dalits consist of numerous castes from all over South Asia and come from a variety of religions.

In RERL-supported communities, 100% of Dalit, Janajati and ethnic/religious minorities are connected to energy services. A quarter of all energy enterprises are owned by these groups, and 41% of those enterprises are owned by female entrepreneurs.

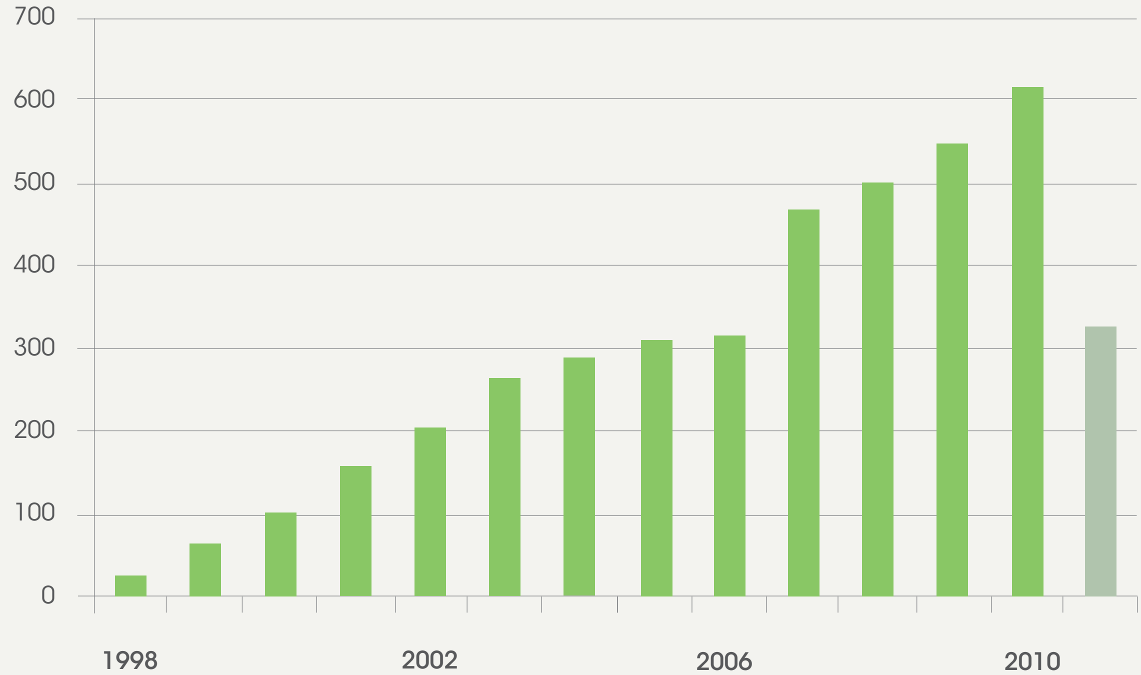
FINANCING

REDP/RERL provides grants in support of local energy projects. Project funds are channelled via a District Energy Fund, which in turn channels funds to Community Energy Funds. The Community Energy Funds are established by each MHFG and by Micro Hydro Co-operatives to receive funds and to collect revenues from local households and businesses that use energy from RERL-supported projects. RERL makes an initial contribution of 10 000 Nepalese Rupees (USD 125) per kW (up to a maximum of 250 000 Rupees, or USD 3 125) to each MHFG for creating the enterprise fund. Priority is given to poor households to obtain loans to carry out income generating activities or create micro-enterprises.

Community member operating an agro processing mill in Nepal (UNDP/WB)

FIGURE 3. DIRECT MHP EMPLOYMENT (1998-2011)*

[= first 6 months in 2011]*



Women making briquettes in Jude Kabanda's business (GVEP)

Norah Mukasa cooking with an improved cookstove (GVEP)

4.2.3. Improved Cookstoves Projects

4.2.3.1. GIZ FAFASO Project in Burkina Faso

FAFASO ("Foyers Améliorés au Faso" = improved stoves in Burkina Faso) is a Deutsche Gesellschaft für Internationale Zusammenarbeit - The Dutch-German Energy Partnership Energising Development Project (GIZ-EnDEV), supported by co-financing from the Dutch Ministry of Foreign Affairs (DGIS) and the German Ministry of International Co-operation (BMZ). It started officially in 2005; on-the-ground activities commenced in 2006. It will probably conclude at the end of 2012, after which activities will continue in an autonomous way. FAFASO covers all of Burkina Faso, with a focus on the capital, Ouagadougou (2 million inhabitants), the second-largest city (Bobo Dioulasso, with 500 000 inhabitants) and the south-western and eastern regions. The project helps to disseminate ICS that save 35–80% of wood or charcoal compared to the traditional three-stone-fire. During the period 2006–2011, about 180 000 ICS were sold at market prices to households, institutions and productive units.

Most of the stoves disseminated are mobile, metal household stoves that are 35–45% more efficient in fuel use. For poorer households, a mobile ceramic stove is also available that saves 40% fuel. In addition, FAFASO offers big mobile metal stoves for restaurants and school canteens (saving around 60%) as well as mud stoves for traditional beer brewing (saving about 80%).

The overall objective was to train ICS producers and help them sell the stoves commercially, so that dissemination would continue even in the absence of subsidies, or other dependence on external resources or technologies. A key objective of the project has been to promote decentralised production located as close as possible to potential markets. From 2006 to 2010, training sessions were conducted in five towns with about 30 000-50 000 inhabitants each, as well as about 40 smaller towns with 5 000-10 000 inhabitants each. Training sought to impart a range of skills including quality production, marketing techniques, price design, budgeting and reinvestment, and associative organisation. The project also entails marketing (large-scale efforts via TV and radio; smaller-scale through cooking demonstrations, sales events, etc.); introduction of an ICS quality label and efforts to strengthen the commercial supply chain.

JOBS AND TRAINING

Two thirds of the overall budget of USD 3.2 million (up to late 2011) has gone into training and marketing efforts; the fixed costs for project personnel account for one third. A typical training session involves an average of 30 trainees. As of early 2012, FAFASO had trained a total of 807 people, 313 metal smiths, 314 masons, and 180 potters. Initially, the numbers were quite low, but expanded dramatically in 2009, when the project began to train masons and potters, in addition to metal smiths (see Figure 4).

These numbers cannot be considered to constitute new jobs. Rather, the individuals concerned are experienced craftsmen. The training allows for higher qualifications and an opportunity for a sustained role for themselves in the market. As part of the training, all producers are taught to calculate the prices for the stoves, putting them in a better position in markets. Many of the metal smiths and masons also employ apprentices (who are all men).

Most of the potters, however, are women whose main occupation remains fieldwork and household duties. The project allows them to acquire knowledge that helps generate additional income (and cope with competition from plastic products). It must also be kept in mind that pottery is caste-bound work dominated by certain families who are unlikely to employ apprentices. Except for the potters who are organised in associations and share revenues, stove producers work individually and revenues stay strictly within family circles.

SUPPLY CHAIN

Upstream Linkages

The stoves disseminated by FAFASO were originally developed by the government's Institute of Research of Applied Sciences and Technologies in the 1980s. However, ICS production was virtually abandoned prior to FAFASO's launch because of the lack of a viable market at unsubsidised prices. FAFASO was thus confronted with the need to establish new training for stove producers. The project also focused on marketing and public relations, deciding to create a distinctive logo for improved stoves of good quality, and working to strengthen the value of the commercial chain.

The stoves are produced domestically, in a decentralised small-scale fashion. In general, the materials used are indigenous. Previously imported scrap metal is now locally procured. However, this does not necessarily indicate increased overall demand for metal scrap. Although FAFASO has sought to strengthen the commercial chain (bringing together producers and salesmen, installing special shops at central places, etc.), the majority of

Figure 4. Number of FAFASO Trainees

sales are still made directly at producers' workshops or through close contacts. Nearly all efforts to create new distribution models failed.

Downstream Benefits

The dissemination of ICS did not generate new downstream businesses as such. Users like beer brewers and restaurant owners were already in business. However, beer brewers and to a lesser degree restaurant owners were able to realise higher returns due to savings in fuel expenses, allowing them to send children to school, afford medical fees, etc. Also, housewives are now able to engage in small professional activities (preparation of cookies, roasting of maize, etc.) thanks to reduced fuel expenses. Among households, fuel savings from ICS use have also allowed improvements in diet.

FINANCING

The official minimum income in Burkina Faso is around USD 70 per month. Based on official statistics, more than half the population has incomes below this level. In Burkina Faso's towns, daily expenditures for fuel are about USD 0.2, a little over USD 6 per month, close to 10% of the minimum income. ICS can cut this expense by a third. The following information provides a sense of how quickly fuel savings help pay for the cost of improved stoves:

- *Metal household stoves* (cost: USD 5.20; lifespan 2 years) offer daily fuel savings of USD 0.21, and are amortised within a month;
- *Metal stoves for institutional / professional use* USD 56; lifespan 1.5 to 3 years) offer fuel savings of USD 1 day.
- *Ceramic household stoves* (USD 2.10; lifespan 1.5 years) offer daily fuel savings of USD 0.21, and amortise within 10 days;
- *Mud stoves for beer brewing* (USD 42) offer savings of up to USD 28 per week, and are amortised in less than 2 weeks.

A 2009 impact study conducted by GIZ indicated that at least half the metal stove producers in the two biggest cities reported higher incomes. Circumstantial information suggests that these findings may well be on the conservative side, as living conditions of producers have visibly improved. For a household metal stove, one fifth of the sales price is usually marked as earnings for the producer, thus typically CFA[6] 500 (about USD 0.75) out of a stove's price of CFA 2 500 (USD 3.75).

4.2.4. Projects with a Mix of Technologies

4.2.4.1. GVEP The Developing Energy Enterprises Project in East Africa

The Developing Energy Enterprises Project East Africa (DEEP EA) is a five-year initiative funded by the European Union and the Dutch Government (DGIS). It was initiated in 2008 to provide support for the development of a sustainable and widespread industry of micro- and small-scale energy enterprises in Kenya, Uganda and Tanzania. The project flows from the recognition that small enterprises in East Africa face many challenges. Entrepreneurs are often working in isolation from each other, linkages to suppliers and financial institutions are weak or non-existent, whilst consumer awareness and limited purchasing power, present additional obstacles. Entrepreneurs also often fail to reach their full potential due to lack of certain skills.

However, small enterprises tend to use locally-available resources more than larger ones. They tend to use more labour and so strengthen local economic linkages. The project assists the entrepreneurs with the identification of viable energy market opportunities, technology options and service structures to generate revenue and sustain business. DEEP EA also assists entrepreneurs through training and mentoring to develop business plans, access financing thereby enabling businesses to survive and grow:

- Entrepreneurs are taught how to keep basic records for their business, including expenditure, sales, and profit figures. This has helped the entrepreneurs set aside money for savings and reinvestments;
- The programme offers an International loan guarantee fund, enabling entrepreneurs to access loans. GVEP is working with several financial institutions in East Africa to achieve this;
- The programme assists entrepreneurs in linking to new markets. Group networking and information sharing sessions bring entrepreneurs, customers, suppliers and other stakeholders together. Entrepreneurs are able to promote their products to customers and learn about new products from suppliers.

Challenges remain in that entrepreneurs do not always pay sufficient attention to product standards and quality, assuming that short-lived products will translate into greater sales. They often lack appropriate marketing skills

[6] *CFA: Franc de la Communauté Financière Africaine (West African Franc)*

(with regard to recognising market segments and the need for product customisation). They maintain a strong belief that grant support for their businesses is needed.

JOBS AND TRAINING

By the end of 2011, there were 819 entrepreneurs that had received DEEP EA support in Kenya, Uganda and Tanzania. Most of the entrepreneurs are involved in ICS, solar technologies and briquette-making (see Figure 5). ICS and solar have received the bulk of donor funding over the years. In Kenya, ICS ventures are most prevalent (59.4% of all DEEP EA businesses); in Tanzania, solar technologies (51.3%) and in Uganda, briquettes (40.5%).

Altogether, females represent 42% of all entrepreneurs, they are mostly involved in ICS and briquette-making, but only marginally in solar, battery-charging and biogas ventures. Female entrepreneurs are more involved in RETs that do not need a high level of capital or mobility. Employment in the DEEP EA enterprises has fluctuated through the course of the programme. From a baseline assessment that showed an average of 1.6 employees per enterprise, the most recent year's data indicate an average of 2.2 employee per enterprise. ICS liner and briquette production are the more labour intensive processes. ICS liner production involves preparing the raw materials, mixing, moulding and firing. Solar phone-charging, on the other hand, requires relatively little labour. The total number of employees in the three countries has thus risen from 878 to 1 803 by the end of 2011 (see Figure 6). Although the Kenyan numbers have fluctuated, on average there has been strong growth.

Enterprises engaged in briquette and ICS liner production have experienced some fluctuations in employment over time, corresponding to highs and lows in orders, seasonal variations and other factors. Among ICS producers, Ugandan enterprises have slightly higher than average numbers of employees compared with Tanzania and Kenya. The difference may be due to the availability of locally skilled labour, wage differentials, or differences in markets for the type of products. Casual employment plays an important role in these cases. It affords entrepreneurs flexibility (with regard to salary levels, taxes and other dues, etc.). Often, family members are employed by entrepreneurs.

Figure 5. Share of Renewable Energy Technologies, by DEEP EA Businesses

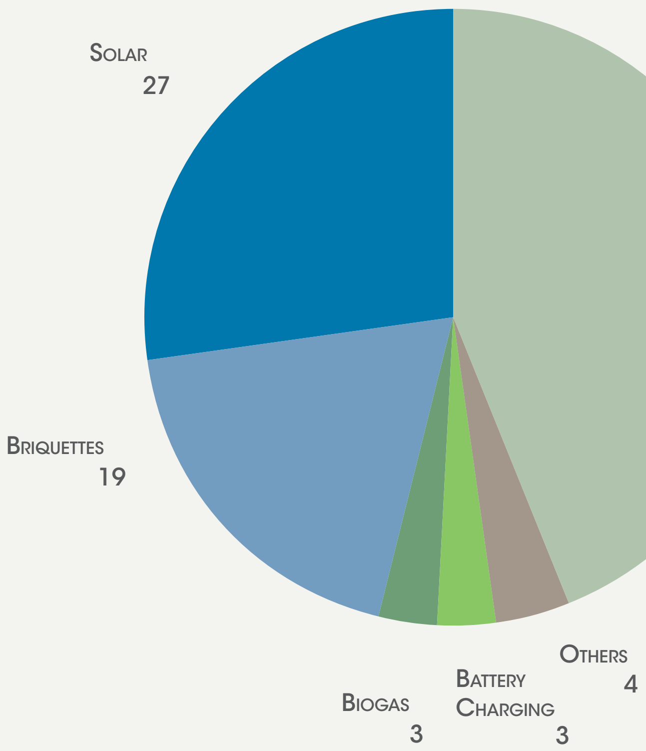
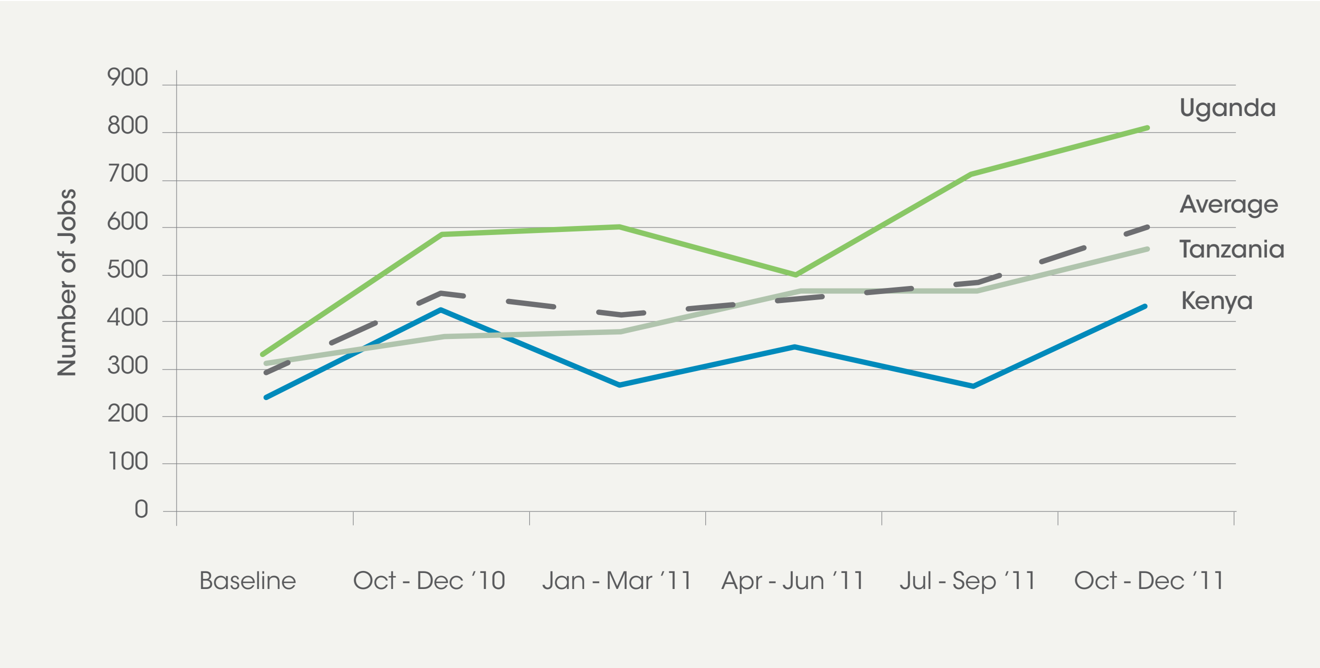


Figure 6. Total Employees, by Country (2010-2011)



SUPPLY CHAIN

Upstream Linkages

Enterprises that make use of locally sourced materials may be more sustainable than those that depend on suppliers that are based far away. For example the positive uptake of briquettes in Uganda is encouraged by the relatively low cost of accessing charcoal dust which is often wasted. Similarly, cookstove technology production is produced and sold in all three countries using local resources.

Dissemination of RETs in isolated areas with poor road networks can be a big challenge. Transportation of products represents additional costs and entrepreneurs' knowledge of new products may be limited. DEEP EA focuses on a value chain approach to each technology and works with stakeholders along the supply chain. The strengthening of supply chains in this manner can help increase an enterprise's chance of survival.

Downstream Benefits

***ICS* - Kenya:** A complex local value chain means that employment generation spans the whole process from the supply of raw materials to production and sales to end users. The GVEP case study profiles one case—Janet Atieno, a member of Keyo Pottery Enterprises in western Kenya—whose business has grown with the help of GVEP training. Atieno now employs between two to six casual employees, up from just one. Employees are paid on a piece basis (earning USD 6.25 per day for making 150 liners). Atieno sources the clay and sand for making her liners from local businesses that also benefit from the group's activities.

***Briquettes* - Uganda:** The supply chain for briquettes is principally local. With DEEP EA's help, one entrepreneur, Jude Kabanda and his sister Amelia Nabagala, expanded sales more than 13-fold since 2008. The acquisition of several briquette machines helped improve the quality and types of briquettes, and sales were further increased, to about USD 144 per month, with the help of a loan to improve the packaging and branding of the briquettes. Four casual employees were added (earning USD 11-22 per month), and another five may be needed. Kabanda has trained ten other briquette entrepreneurs. His employees have also started up other enterprises, including a poultry business.

***SPV* - Tanzania:** A third GVEP case study, of Tanzanian solar technician and phone-charging entrepreneur Joseph Robert, also indicates a growing business; he is now offering solar technician services and sells solar parts. Two people were hired, and a further one to two others are casually employed when the need arises, given the fluctuations in sales. Joseph earns about USD 175 per month and pays his employees monthly USD 58 each.

Finding staff qualified in installation and maintenance of solar systems is a challenge. The installed solar systems have allowed new phone-charging businesses to be set up in neighbouring villages, providing additional employment. The cumulative impact of the DEEP EA project is estimated at more than 2 million beneficiaries. The vast majority of these relate to stove production.

FINANCING

As mentioned earlier, GVEP has started to link some of the entrepreneurs with whom it works to financial institutions through a loan guarantee programme, enabling them to access loans. As of September 2011, GVEP was working with six financial institutions across the three countries. To date, five DEEP entrepreneurs have received and repaid loans; 47 others are currently being financed.

In Uganda, ICS sold in Namigadde Mwamin's shop help women reduce their energy expenses (GVEP)

5. Lessons Learnt

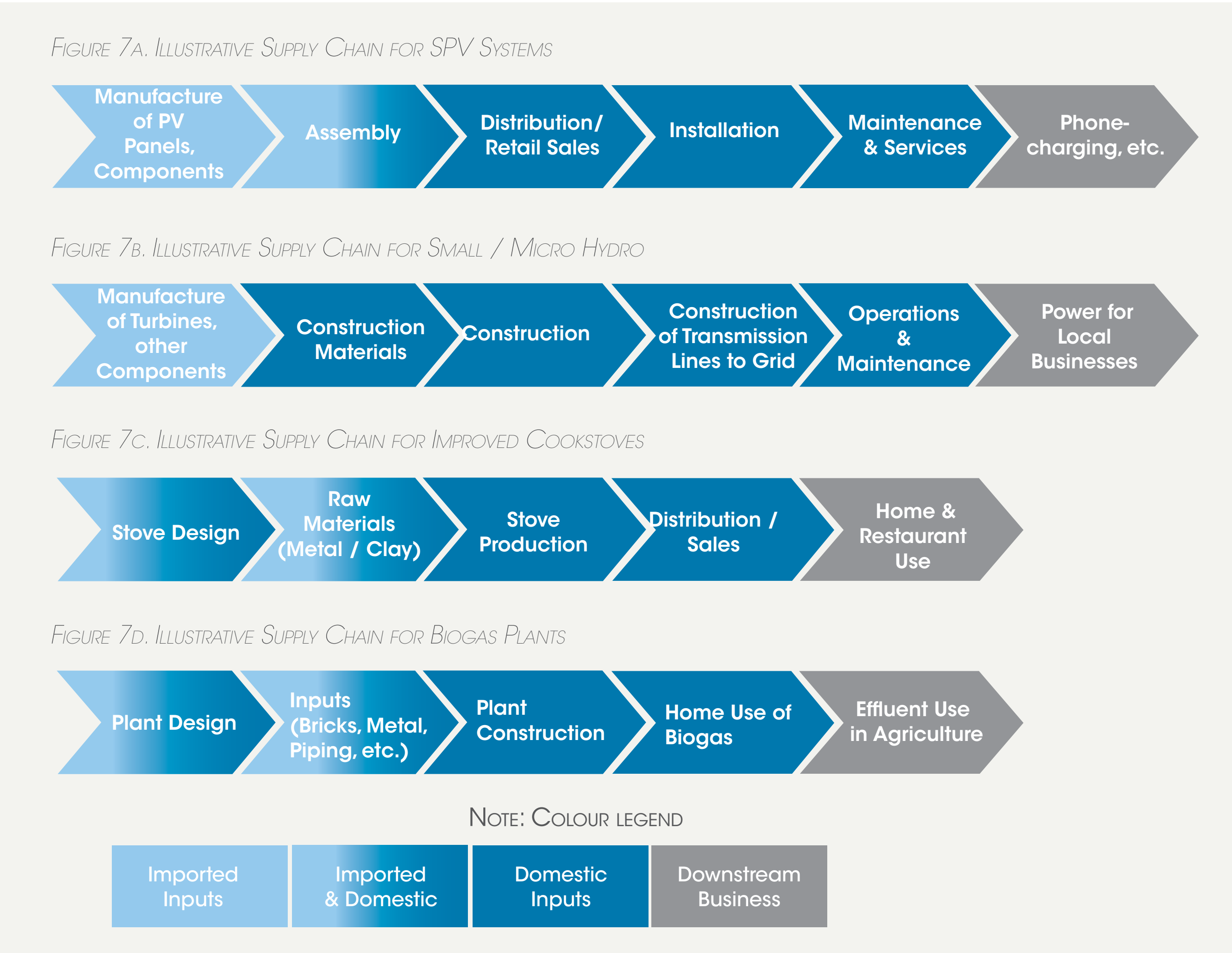
The following are lessons learnt from both the review of the literature and the analysis of the case studies presented in this study. They relate to the supply chain, employment, gender, quality and training aspects.

5.1. SUPPLY CHAIN: IMPORTS AND DOMESTIC SOURCING

Upstream and downstream linkages, i.e., the extent to which renewable energy enterprises are integrated into the local economy via the supply chain (upstream linkages) and the downstream businesses that are made possible by the provision of energy services (downstream linkages), are important factors for employment creation. The literature review and the case studies support the conclusion that little manufacturing of RET equipment takes place in developing countries (with the important exception of China and the partial exception of India and Brazil). Some assembly, however, is taking place in developing countries.

For some RETs, such as household biogas plants and ICS, non-manufacturing inputs like construction materials and feedstock are easily sourced domestically and indeed even locally within rural areas.

Figure 7. Illustrative Suplly Chains for various Renewable Energy Techonologies in Developing Countries



Renewable energy employment opportunities in most developing countries are centred on wholesaling, retailing, installing, operating and repairing equipment, as well as local "downstream" businesses which are made possible by improved energy access. Figure 7 illustrates schematically the parts of the supply chains for SPV, small/micro-hydro, ICS, and biogas plants that are typically domestic or import-dependent.

The case studies offer specific information about the mix of domestic and imported inputs along the supply chains for different RETs:

SPV. Most of the inputs for the profiled solar companies are imported. For instance, the solar companies in Nicaragua and Tanzania derive their PV panels and components from Germany, the United States, China, India and Japan. Interestingly, Solar Company B in Tanzania also imports solar lanterns from another developing country, Indonesia. Similar import patterns also characterise the inventory of solar products used in projects run by REF - SolarNow and at the NICE International Centres in Africa. However, some domestic assembly of purchased components from different countries takes place, for example, Sunlabob in Laos.

Hydropower. The various hydropower plants in the case studies present a mixed picture, with certain inputs sourced domestically, but large turbines and advanced electronics are still imported. The turbine used by Hydro Company A in Honduras was purchased from an unnamed international supplier. By contrast, the turbine at the much smaller Hydro B plant in Guatemala was purchased from a local (Italian-owned) company and other electro-mechanical equipment with a value of USD 800 000 was also manufactured domestically. For both hydropower plants, the materials needed for project/facility construction were procured from domestic sources, and local labour was used to construct both plants. In Nepal, the turbines, penstock pipes, and accessories for MHPs were locally fabricated, the electronic load controller was locally assembled, but the generators were still imported.

ICS. For ICS, supply chains are more typically domestic in nature. This is especially true for clay stoves. However, imports do play a role for metal stove producers, which often rely on imported scrap-metal. This is the case for the FAFASO project in Burkina Faso, for instance (where recent price increases in the international scrap metal market have negatively affected producers).

Biogas. For biogas plants, the bulk of inputs—bricks or other materials—are also likely to be sourced domestically, as is the labour to construct the digesters. The case studies do not offer sufficient detail beyond these general observations.

The case studies provide evidence that energy access—particularly access to electricity—can have a range of positive "downstream" effects for rural economies, enabling a range of micro-enterprises. Table 11 provides a summary of supply chain and downstream effects for the individual case studies. Small stand-alone PV modules like SHS frequently help spawn cell-phone charging businesses, which in turn can have further positive spinoff effects for the communities. In several of the case studies, income earned from battery or lantern charging has provided the capital needed for new micro-enterprises such as restaurants, snack bars, bakeries, convenience stores, barbers shops, tailors, guesthouses, village cinemas and handicraft enterprises (knitting, sewing, carpentry, pottery). Detailed profiles of such downstream businesses and longer-term assessments are needed to determine how sustainable and successful they will be.

Similar benefits arise when renewable energy access and availability of ICS make it possible for households to save on conventional fuel expenses. In Burkina Faso, fuel savings from ICS have allowed women entrepreneurs to set up small food-service businesses (maize, cookies). In Nepal, MHPs set up under the REDP/RERL project have also provided support for a range of agriculture-related businesses, including agro-processing mills, irrigation pumps and poultry-farming.

5.2. EMPLOYMENT CHARACTERISTICS

Most of the case studies profile a single commercial enterprise or donor-funded project, as discussed in section 4.2. The single largest companies in terms of employment are Solar Company B in Nicaragua, with 98 permanent employees and Hydro Company A in Honduras with 83 employees. Most of the case study enterprises are much smaller. Some employ roughly a dozen or so people. Many others are micro-enterprises with just a handful of permanent or casual employees, and in some cases there are no employees at all beyond the entrepreneur him- or herself.

Table 11. Supply Chain Aspects of the Case Studies

Company or Project (RET used)	Supply Chain	Downstream Effects
Solar		
Solar A — Nicaragua (Mostly SHS; also Solar Thermal, Small Wind)	All PV panels and components imported Roof attachment structures built in Managua	Local retailers and micro-franchises (women organised in co-operatives) Some PV owners set up small stores (refrigerating grocery supplies)
Solar B — Nicaragua (Mostly SHS; also Solar Water Pumps and Water Heaters)	No local supply chain. Entire inventory is imported.	Cell-phone charging Small shops ("pulperias")
Solar A — Tanzania (PV systems and solar appliances)	All equipment is imported	Mobile phone-charging; barber shops; village cinemas; bars and shops; guesthouses
Solar B — Tanzania (SHS)	Imported PV panels and solar lights	Mobile phone-charging; barber shops; inns and bars
REF SolarNow — Burkina Faso, Mali, Senegal, Ghana, Ethiopia, Tanzania, Uganda, Zambia, Mozambique (SHS and solar lanterns)	PV panels and charge controllers imported Batteries often manufactured domestically	No specific information given
NICE International — Gambia, Tanzania, Zambia (Solar-powered ICT)	Solar and ICT equipment purchased internationally Domestic assembly of components	Local businesses include ISP, technical installation, maintenance and repair, products and services
Sunlabob — Laos (Solar lanterns)	Components sourced locally, but sophisticated items imported with pre-assembly in Laos	Local micro-enterprise activities, including stores, handicraft, mobile phone-charging
Hydro		
Hydro A — Honduras (Hydropower)	Turbines purchased from an international supplier Local construction materials	More reliable power supply allows shopkeepers to open longer
Hydro B — Guatemala (Hydropower)	Turbine and other electro-mechanical equipment manufactured in Guatemala. Local construction materials	More reliable power supply allows shopkeepers to open longer
REDP/RERL — Nepal (Primarily MHPs, but also ICS, Biogas, SHS)	Turbine, penstock pipes, accessories locally fabricated Electronic Load Controller locally assembled Generators imported	Local micro-enterprises: agro-processing mills, irrigation pumps, refrigeration (medicines, etc.) carpentry, battery-charging, handicrafts, tailors, sewing, knitting, poultry farming, communications/computer centres
Improved Cookstoves		
FAFASO — Burkina Faso (ICS)	Small-scale production with local materials, but scrap-metal supply for metal stoves imported	Brewers and restaurant owners Fuel savings permit ICS users to set up new small businesses (maize, cookies)
All technologies		
DEEP EA — Kenya, Uganda, Tanzania (ICS, Briquettes, Solar, Biogas, etc.)	Mostly localised supply chains within area of operation	Employees and customers of micro-entrepreneurs started their own small businesses

Labour Quality and Intensity

Among the case studies, cookstove enterprises on average create a higher number of local jobs than any of the other renewable energy companies. ICS manufacturing requires numerous artisans and is labour intensive. However, as the experience in Burkina Faso suggests, switching from the production of more conventional stoves to improved models does not necessarily mean that new jobs are being created. While there is some evidence that local production of improved models requires more labour than manufacturing of traditional stoves, many of the individuals involved are already experienced craftspeople. Where ICS training is provided, it offers higher qualifications and an opportunity for a sustained role for craftspeople in the market, and these are important factors in making employment more secure and sustained.

The type of ICS makes a difference as well. In the case of Burkina Faso, many of the metal smiths and masons do employ apprentices and create temporary additional employment. Among the makers of clay stoves, most of the potters are women, whose main occupation remains work in the field and household. Social structures and traditions have an impact on employment: Pottery in Burkina Faso is caste-bound work dominated by certain families that are unlikely to employ apprentices.

Due to their greater labour-intensity, liner production for ICS, briquette production and biogas digester installations, all require higher than average numbers of employees compared to other RETs, as evident from several case studies in East Africa. A rural solar phone charging business can typically be run by as few as one to two people. By contrast, for liner production it may take several people to prepare the raw materials and to do the mixing, moulding and firing. At a DEEP EA-supported briquette-making enterprise in Uganda, employment rose from two to six people following the purchase of several briquette-making machines, which were acquired to improve product quality and expand the types of briquettes. With plans for the purchase of a motorised briquette machine, another five permanent employees are expected to be hired.

In addition to permanent jobs, a significant number of temporary jobs are created among renewable energy enterprises. Among a total of 166 enterprises in developing countries in which E+Co has invested, temporary jobs account for 22 to 26% of all employment. By far most of

Ruth and Thomas lease solar lanterns in Tanzania (GVEP)

the temporary positions are found in hydropower; where they actually account for as much as 70%, the only RET in which temporary positions outnumber permanent ones. The ratios are far lower or even negligible for other RETs like biogas, biomass, and cookstoves.

Some work is temporary simply owing to the nature of the activity, such as construction of a hydropower plant or a biogas facility. But in other instances, the distinction is not concerned with the type of work being performed, but rather with formal and informal employment structures. A number of East African cookstove, biogas, briquette, and solar case studies feature micro-entrepreneurs who hire labourers for a limited period of time or on a highly flexible basis so that they can retain the control needed to adjust to changing and often uncertain business conditions or to seasonal variations. Fluctuations in business and employment are in some cases also due to the fact that some entrepreneurs engage in part-time business activities to supplement incomes from other livelihoods.

Another divergence from conventional employment creation is found in two other case studies from Laos and Nepal. In Laos, a village energy committee of three to four people is responsible for overseeing operations of communal solar charging stations. While committee members receive a small income for their work, they are not full-time employees. In Nepal, active community participation and ownership of MHPs is a key ingredient, with a Village Development Committee charged with planning, implementation, operation and maintenance of community energy systems.

Salaries

Salary information is relatively limited among the case studies. However, cases contributed by E+Co offer some insights (see Table 12), although information about management salaries is not available. E+Co offers the general comment that the companies it invests in appear to be paying competitive wages for their sectors and countries. Because up to date and sector-specific salary information for many developing countries is difficult to come by, Table 12 compares salary information with average GDP per capita data for the countries concerned. This comparison indicates that the salaries compare very well against the general economic conditions of these countries.

Gender Aspects

Women derive some of the most important benefits from improving energy access. In rural areas, the burden of gathering fuelwood falls heavily on them, requiring hours of back-breaking work each day. However, they have established an important role in producing RETs such as ICS.

In the majority of the cases presented in this report, female employees are a distinct minority, especially in managerial and technical positions. This is quite apparent from the E+Co companies, for which Table 13 shows total staff, women employees and the female share of total staff. For Hydro Company B in Guatemala and Solar Company B in Tanzania, the female share is particularly low at 14%

Table 12. Monthly Salaries at Hydro and Solar Companies in Central America and Tanzania

	Salaries (USD)		GDP per Capita (USD)
	Technicians, Sales Officers	*Operators, Administrative and Support Staff*	
Solar Company A, Nicaragua	200 - 350		94
Solar Company A, Tanzania	150-200	70-100	44
Solar Company B, Tanzania	100-150	50-70	44
Hydro Company A, Honduras	325-455	250-350	169
Hydro Company B, Guatemala	240-360	200-300	239

Note: E+Co offers a salary range for workers and administrative staff at the two Hydro companies. It estimates that technicians and sales officers' salaries at Hydro Company A in Honduras are 25-30% higher than those of workers and administrative staff, and 15-20% higher in the case of Hydro Company B in Guatemala. For simplicity's sake, this table shows figures that result from applying a 30 and a 20% differential, respectively. For Solar Company A in Nicaragua, a single range is given for non-management staff.

Source: E+Co, 2011; World Bank (2012), Databank (GDP per capita data are for 2010).

Table 13. Share of Female Staff at Hydro and Solar Companies in Central America and Tanzania

	Employees		Share of Females (%)
	Total	*Women*	
Solar Company A, Nicaragua [a]	13	4	31
Solar Company A, Tanzania [b]	14	4	29
Solar Company B, Tanzania	9	1	11
Hydro Company A, Honduras	83	15	24
Hydro Company B, Guatemala	14	2	14

[a] The Company also employs 15 external sales representatives, but no gender breakdown is available. [b] The company also has 20 technical contractors and 2 drivers on call; no gender breakdown is available.

Source: E+Co, (2011).

and 11%. At the Guatemalan hydro company, women are found only among the administrative/support staff; at its Honduran counterpart, 20% of maintenance workers, as well as all support staff are female. Solar Company A in Nicaragua has the highest share (31%) of female staff out of all the E+Co portfolio companies listed here. It has also created micro-franchises for female-run co-operatives that distribute solar products and trains women on SPV-based products such as lanterns. In Tanzania, the support staffs at Solar Company A, as well as two of the three sales officers are women.

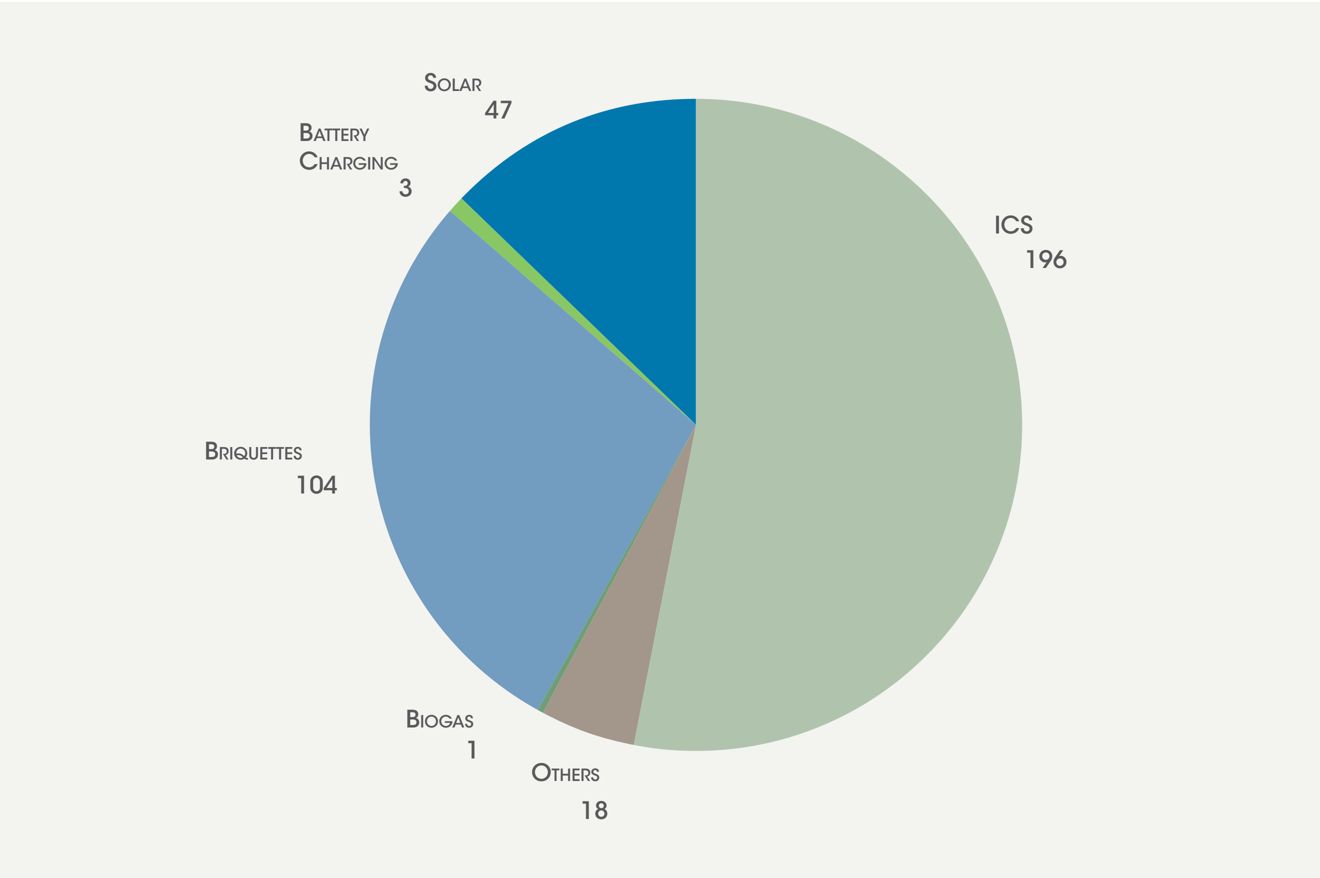
Women play more prominent roles in case study enterprises in Nepal and in East Africa. In Nepal, in communities supported by REDP, 41% of all energy-based enterprises are owned by women entrepreneurs. Among the 800 renewable energy entrepreneurs in Kenya, Tanzania, and Uganda who receive support through the DEEP EA project, females account for 42%. Figure 8 illustrates where women entrepreneurs are primarily active. They own 62% of briquette-making and 51% of cookstove-producing enterprises. These typically do not require much mobility or a high level of capital. But women play only a marginal role in solar technologies (20%), battery-charging (10%), and biogas ventures (3%). As noted earlier, among cookstove producers in Burkina Faso gender is essentially separated according to the different materials used. Metal smiths and masons are typically men, but potters are principally women.

5.3. SKILLS AND TRAINING

An important point that emerges is that small-scale RET is on the whole well adapted to the rural context. The bulk of the skills and training that are required can be developed locally. This is of great importance because there is limited need for foreign know-how and expertise.

In most renewable energy enterprises, only a limited number of people need to have advanced or specialised technical skills such as engineering. The majority of jobs have less-demanding skill profiles and the training needed can therefore in many cases be imparted in a relatively short length of time.

Figure 8. Female Entrepreneurs in Kenya, Tanzania, and Uganda Case Studies, by Renewable Energy Technology (as of late 2011)



In many cases, training can be done on-site or on-the-job. This is especially true for many micro-enterprises and particularly those that rely on casual labour in addition to the regular employees. Experience from the case studies suggests that business skills such as accounting and record-keeping, price design, inventory, quality assurance, etc., are often as critical to the success of rural energy enterprises as the technical aspects. (see Box 2 on Standards and Quality Assurance).

In contrast, for RETs that are sold individually to households such as SHS, solar lanterns and ICS, marketing skills (including awareness campaigns, product demos, etc.) are critical, but so are after-sales services. Solar enterprises in particular depend strongly on the abilities of retail staff and franchise owners. Solar training is carried out on marketing and product demos, competent after-sales services, and other similar skills. Marketing plays an equally critical role for ICS and briquette producers, though the model of dissemination used—commercial markets or locally by word-of-mouth and reputation—makes a key difference.

A different form of training is important among the NICE International Centres in Africa, Sunlabob in Laos, and REDP/RERL-supported MHPs in Nepal. The NICE Centres offer ICT skills training for local youth—a clear-cut example where energy access offers new career and employment perspectives in remote rural areas. Sunlabob's village solar-charging stations entail a more communal form of instructions to ensure that all members of a village's energy committee receive proper training in how to operate the charging station and solar lanterns. Similarly, in Nepal, technical capacity-building has been carried out in a more communal form, to ensure that beneficiaries of local hydro plants understand how these micro-systems work.

A final aspect of training efforts that emerges from the case studies is that cross-mentoring among local entrepreneurs can play an important role in the success of enterprises. This is the case, for instance, among entrepreneurs that are being supported by the DEEP EA project in East Africa. In Uganda, for example, more experienced briquette-making entrepreneurs mentor others and local entrepreneurs have been encouraged to attend networking sessions.

5.4. IMPROVING PRIMARY DATA

As mentioned in Section 3, renewable energy development has been regarded as a key area of greening economies, with the notion of "green jobs" gaining increased interest. Yet, relatively little is known about the employment implications of providing energy access in rural areas of the developing world. This gap in knowledge exists even though the links between social and economic development and modern sustainable sources

Box 2

STANDARDS AND QUALITY ASSURANCE

Establishing and enforcing appropriate quality standards for the use of renewable energy equipment and components is an important undertaking, especially in countries which do not manufacture RET equipment and thus depend on imports. Frequent malfunctioning or breakdown of RET equipment can overburden supply chains in remote rural areas, which even under normal conditions face a challenging task in providing adequate maintenance services and spare parts. Well-functioning and reliable RETs help reinforce among prospective rural customers the sense that renewable energy is a workable and attractive alternative to traditional forms of energy. This is ultimately critical for sustaining renewable energy jobs in rural areas.

The experience of different countries suggests that designing and enforcing quality standards for RET equipment is a critical element. This necessitates building competent national-level administrative structures, but also relates to skill-building and technical expertise among importers, distributors and retailers of RET equipment, as well as establishing a domestic capacity to adapt RETs to specific local needs. Governments are principally responsible for putting such standards and quality assurance measures in place, but capacities vary across the developing world and some countries could benefit from targeted capacity-building efforts.

Table 14. Jobs, Skills and Training at Enterprises included in the Case Studies

Enterprise — Country (RET)	Jobs	Skills / Training
Solar		
Solar A — Nicaragua (Mostly SHS; also Solar Thermal, Small Wind)	13 permanent jobs (9 men, 4 women) in Managua Plus 15 Sales Personnel at 4 branch offices	» Professional training for PV Technicians, Salesmen » Women from co-ops trained on PV lanterns and other solar products
Solar B — Nicaragua (Mostly SHS; also Solar Water Pumps and Water Heaters)	98 permanent jobs Plus 12-15 jobs through expansion of activities.	» Technical and branch staff trained in Managua laboratory » Managerial staff trained in operations control
Solar A — Tanzania (PV systems and solar appliances)	4 Managers, 3 Technicians, 4 Admin./Support, 3 Sales Officers 20 Technical Contractors, 2 Drivers on call	» No information available
Solar B — Tanzania (SHS)	1 Manager, 2 Technicians/ Shopkeepers, 1 Support, 5 Sales Officers	» Owner has MA in Economics » No further information available
REF SolarNow — Burkina Faso, Mali, Senegal, Ghana, Ethiopia, Tanzania, Uganda, Zambia, Mozambique (SHS and solar lanterns)	200 retailers in 9 countries About 200 technician jobs created through retailer expansion	Training for retailers, incl.: » After-sales advice, Marketing campaigns and product demos
NICE International — Gambia, Tanzania, Zambia (Solar-powered ICT)	Operated by local Entrepreneurs. Currently 7 Centres, growing to 50 by 2014.	» Business skills (franchise model)ICT skills for youth
Sunlabob — Laos (Solar lanterns)	Per village: 1 Entrepreneur, 3-4 Village Energy Committee Members, 1 or more Technicians	» Training for Entrepreneur and village Energy Committee
Hydro		
Hydro A — Honduras (Hydropower)	4 Managers, 7 Technicians, 62 Workers/Labourers, 10 Admin./ Support	» Employs already-trained Engineers. Specialised Contractors hired for specific tasks
Hydro B — Guatemala (Hydropower)	1 Manager, 3 Engineers, 10 Operators, Admin./Support	» Employs already-trained Engineers. Other Staff trained by the Engineers
REDP/RERL — Nepal (Primarily MHPs, but also ICS, Biogas, SHS)	Direct employment: 1.4 million person-days or 3 852 full-time equivalent jobs (at 2 persons per MHP)	» To date, 3 000 persons trained on technical aspects of micro-hydro systems
Improved Cookstoves		
FAFASO — Burkina Faso (ICS)	Trained 285 Metal Smiths, 264 Masons, 180 Potters	» Quality control » Marketing, sales » Price design » Financial advice
All technologies		
DEEP EA — Kenya, Uganda, Tanzania (ICS, Briquettes, Solar, Biogas, etc.)	885 Entrepreneurs (44% in ICS; 27% in solar; 19% in briquettes; 10% other)	» Record keeping » Product-standard awareness » Marketing skills

of energy are well recognised. As far as data requirement the following efforts should be supported:

Tracking Employment - There is a need for better and more systematic efforts to track rural renewable energy employment in developing countries. At present, there are somewhat disconnected snapshots of employment—typically focused on a particular RET or on a particular community or project. There are very few available time series that would allow a solid understanding of how renewable energy employment is evolving in different countries, and there is little information about qualitative aspects of employment. Better reporting concerns not just absolute job numbers, but also employment factors per unit of capacity for each RET, and better insights into the RET employment potential at different scales. Other dimensions that deserve closer scrutiny include the impacts of seasonal changes, as well as a better differentiation of data between permanent/temporary employment.

Expanding Case Studies - Case studies like those examined in Section 4 of this report reveal important insights, particularly with regard to downstream economic opportunities that macro-level studies do not offer. But they need to be extended in two ways. One, the connection between particular local micro-conditions and the broader situation in a given country needs more attention. How representative is the local case study, both in terms of success and problems encountered? How do local enterprises and projects interact with national policy, and is there a positive dynamic? Second, local case studies need to be extended temporally, so as to allow an evaluation of longer-term developments and impacts. It will be important to develop a set of common metrics across different case studies, so that findings become more broadly comparable. Additional case studies are desirable so as to ensure a robust set of examples for each RET and for different regions of the developing world.

Exchange of Lessons-Learnt - Many renewable energy micro-enterprises in rural areas are struggling to succeed. As case studies presented in this report underscore, access to financing, reliability of equipment and service, entrepreneurial/managerial capacities and the availability of adequately skilled employees are key factors influencing whether enterprises succeed and thus whether rural renewable energy employment can not only be sustained but also expanded.

Beneficiary of solar home system in Tanzania (GVEP)

6. Conclusions

Renewable energy technologies in the context of energy access have proven to be reliable and with the appropriate business model affordable for poor households. They can support the UN goal of reaching full energy access by 2030 and have the potential to create almost 4 million direct jobs in the off-grid electricity sector alone. Successful initiatives have some elements in common, including building qualified skills, setting quality standards for equipment and providing financial support to entrepreneurs. Therefore, in designing and implementing policies to increase sustainable jobs when introducing Renewable Energy Technologies for access, policy makers may want to consider the following aspects:

Job Creation

Renewable energy jobs in rural areas of the developing world can be created across all segments of the industry's value chain, although there is greater potential for job creation during the distributing, selling, installing, operating, and servicing stages than the manufacturing stage. Some assembly is also taking place in developing countries, particularly for household biogas plants and improved cookstoves, where non-manufacturing inputs such as construction materials and feedstock can be easily domestically sourced (in particular for clay stoves).

It is also essential to consider that some renewable energy technologies are more labour-intensive than others. For example, the manufacturing of clay cookstoves involves liner production, a process which requires several people to prepare the raw materials and mix, mould and fire the clay. At the other end of the spectrum, a solar phone-charging business or a micro-hydro plant can typically be run by 1-2 people. It must be underlined that employment is generated not only across the renewable energy technology value chain, but even in a variety of other "downstream" micro-businesses, such as mobile phone charging businesses, battery or lantern charging, food-service businesses, barber shops and tailors, guesthouses, agriculture-related businesses, and internet cafes.

In addition, employment in various renewable energy technology enterprises fluctuates considerably for a variety of reasons, including seasonal changes, local business cycles, and the supplemental nature of some businesses. In fact, a number of temporary jobs are created among rural renewable energy enterprises due to the nature of the activity, i.e., the construction of hydropower plants or biogas facilities. Another important distinction concerns formal and informal employment. Micro-entrepreneurs may hire labourers contingent on the need to adjust to changing and often uncertain business conditions.

Improving Skills

Small-scale renewable energy technologies are generally well adapted to the rural context, considering that highly advanced skills are not necessary. Furthermore, the bulk of skills and training can be developed locally, meaning a limited need for foreign know-how and expertise. In many cases, training can be done on-site or on-the-job.

Nevertheless, greater efforts need to be made to map skills for different renewable energy technologies in order to gain a clearer picture of existing strengths and weaknesses of vocational policies in local areas. Creating strong vocational policies, setting up rural training centers as needed, and encouraging private sector companies to build apprenticeship programs can all help to strengthen the skills base.

Experience from the case studies in this report suggests that business skills such as accounting and record-keeping, price design, inventory, quality assurance, etc., are often as critical to the success of rural renewable energy enterprises as the technical aspects. Additionally, proper marketing skills, with a strong view toward consumer awareness-building, are critical, as are the skills to ensure adequate after-sales services to build consumer trust that Renewable Energy Technologies are reliable alternatives to conventional forms of energy.

Gender

Women derive some of the most important benefits from improving energy access. In rural areas, the burden of gathering fuelwood falls heavily on them, requiring hours of difficult work each day. Renewable Energy Technologies, especially if combined with energetically efficient cookstoves, can reduce or eliminate this burden.

Within the renewable energy technologies sector in rural areas, gender roles are not in balance. In most renewable energy enterprises, female employees are a minority, particularly in managerial and technical positions. Their role is critical in producing renewable energy technologies such as improved cookstoves. But it is far less so in solar and biogas ventures due to various limitations, including mobility, capital requirements, and the perception that technology is better served by men –all of which preclude a larger role for females in many rural settings. Social structures and traditions have an impact: some female entrepreneurs are limited in their activities by the need to remain in the household or help in the field. Policy makers may want to consider the gender specific aspects of various renewable energy technologies.

Standards and Quality Assurance

Establishing quality standards for the use of renewable energy materials, equipment and components, as well as ensuring their successful enforcement are critical not only to the sustainable development of the renewable energy industry in rural areas, but also to local job creation. These components also help reinforce among prospective rural community customers the belief that renewable energy is a credible and suitable alternative to traditional forms of energy. This necessitates building appropriate national-level administrative structures, but also relates to skill-building and technical expertise among importers, distributors and retailers of renewable energy technologies equipment. Governments are principally responsible for putting such standards and quality assurance measures in place.

Improving Primary Data

There is a palpable need for more comprehensive and systematic efforts to monitor rural renewable energy employment in developing countries. Additional case studies are desirable so as to ensure a robust set of examples for each renewable energy technologies and for different regions of the developing world. They would be of great value to give proper attention to the connection between particular local micro-conditions and the broader situation in a given country, including national policy-making. Local case studies need to be extended temporally to assist in an evaluation of developments and impacts over a longer period of time. Having time-series and qualitative aspects of employment would also facilitate a broader understanding of the evolution of the employment sector in rural areas. This requires drawing up common criteria, metrics, and reporting standards for rural case studies in order to make findings as comparable as possible and to support long-term monitoring and assessments.

Table A. Overview of Case Studies — Activities, Sales, Training, and Employment

Company or Project	Country	RET	Type of Activity	Sales / Recipients[1]	Skills / Training	Jobs
Hydro A (Since 2008)	Honduras	Hydro [13.5 MW]	Power generation sales through national grid	11 000 people in region with more reliable access to power 1 200 gained access	Employs already-trained engineers Specialised contractors hired for specific tasks	4 managers 7 technicians 62 workers/Labourers 10 admin./support 100 construction
Hydro B (Since 2009)	Guatemala	Small Hydro [upgraded to 1.1 MW from smaller capacity]	Power generation sales through national grid. Isolated small plants inter-connected for grid-access	15 000 people in region with more reliable access to power	Employs already-trained engineers Other staff trained by the engineers	1 manager 3 engineers 10 operators, admin./ support 96 construction
Solar A (N) (Since 1999)	Nicaragua	Mostly SHS Solar Thermal Small Wind	Promotions, sales, installations service (85% rural customers)	> 10 000 people served From 2009 to June 2011: 2 217 SHS sold and 3 000 systems installed	Professional training for PV technicians, salesmen Women from co-ops trained on PV lanterns and other solar products End-user training	In Managua: 13 permanent Staff (9 men, 4 women) Plus 15 sales personnel at 4 branch offices
Solar B (N) (Since 1999)	Nicaragua Expanding to: El Salvador, Panama, Honduras, Guatemala	Mostly SHS Solar Water Pumps Water Heaters	Promotions, sales, installations, distribution network and battery collection	Installed > 50 000 PV systems, serving 300 000 people 163 new HH with access to water pumps	Technical and branch staff trained in Managua laboratory Managerial staff trained in operations control	98 permanent jobs Plus 12-15 jobs through expansion of activities
Solar A (T) (Since 2002)	Tanzania	PV systems and solar appliances	Sales, installations and maintenance (80% rural installations, incl. health centres and schools)	> 1 000 systems installed	No information given	4 managers 3 technicians 4 admin./ support 3 sales officers 20 technical contractors, 2 drivers on call
Solar B (T) (Since 2006)	Tanzania	SHS	Retail, installations and maintenance Direct sales (shops) to households; marketing to institutions	Almost 300 sold In 2010, 80 sold	Owner has MA in Economics No training information given	1 manager 2 technicians, shopkeepers 1 support 5 sales officers

TABLE A. OVERVIEW OF CASE STUDIES — ACTIVITIES, SALES, TRAINING, AND EMPLOYMENT (CONTINUED)

Company or Project	Country	RET	Type of Activity	Sales / Recipients[1]	Skills / Training	Jobs
FAFASO (2006-2012)	Burkina Faso	ICS	Small-scale production of stoves	180 000 stoves	Quality control Marketing, sales Price design Financial advice	Trained: 285 metal smiths 264 masons 180 potters
DEEP EA (2008-2012)	Kenya Uganda Tanzania [2]	ICS Briquettes Solar Biogas Others (such as fireless cookers and battery charging)	Assist entrepreneurs to identify viable market and revenue-generating opportunities, technical options Networking among entrepreneurs, suppliers and customers	From April-Dec. 2011: 1.1 million beneficiaries	Record keeping Product-standard awareness Marketing skills	885 entrepreneurs [average jobs per enterprise grew from a baseline of 1.6 to 2.4 by Sept. 2011] 44% in ICS; 27% in solar; 19% in briquettes; 10% other]
	Kenya: Keyo Pottery Enterprises	ICS	Stove production	From April 2010 to Dec 2011: Total of 108 983 units sold	Business training and mentoring	Grew from 6 to 17 member potters over a number of years Example of Janet Atieno: from 1 to average of 4 casual employees
	Uganda: Friends of Environment	Briquettes	Briquette production	From June 2010 to Dec 2011: 2297 units (each unit is 1 kg)	Business and marketing skills Networking sessions Mentoring of other entrepreneurs	Example of Jude Kabanda: Expanded from 2 to 4 employees, more in future. Employees starting other businesses.
	Tanzania: Joseph Robert	Solar	Phone-charging, solar technician services, and solar parts sales	April 2010 to Dec 2011: 6 751 phone charging units Sept - Dec 2011: 6 solar installations	Same as above	Example of Joseph Robert: Expanded to employ 2 persons, plus 2 occasional labourers
SCODE	Kenya	Solar Lanterns ICS Biogas	Sales Assembly and sales Construction	From Oct. 2009-Dec. 2011: 6 057 ICS, 92 fireless cookers, 91 biogas systems, 3 institutional cookstoves, 70 big and 416 small solar lanterns	Business trainings	Employees expanded from 5 to 11; distributors from 8 to 25

Table A. Overview of Case Studies — Activities, Sales, Training, and Employment (continued)

Company or Project	Country	RET	Type of Activity	Sales / Recipients[1]	Skills / Training	Jobs
REF – SolarNow (Since 2007)	Burkina Faso, Mali, Senegal, Ghana, Ethiopia, Tanzania, Uganda, Zambia, Mozambique	SHS and Solar Lanterns	Help with business start-ups and expansions Quality assurance (brands) Support for retailers, distributors, technical personnel	> 57 000 SHS sold 36 000 lanterns sold > 492 000 HH reached	Training for retailers, incl.: After-sales advice Marketing campaigns and product demos to improve village distribution channels	200 retailers in 9 countries About 200 technician jobs created through retailer expansion
NICE International (Since 2007)	Gambia, Tanzania, Zambia	Solar-powered ICT	NICE Centres offer: Battery charging Access to Internet, TV Business, banking advice Income generation opportunities	NICE Centres provide energy / ICT services for: 1 000 people in 1st year, 2 000 people in 2nd year, 3 000 people in 3rd year By 2014: 100 000 served	Business skills (franchise model) ICT skills for youth	Operated by local entrepreneurs. Currently 7 Centres, growing to 50 by 2014.
Sunlabob	Laos	Solar Lanterns	Solar-charging stations (for 20-50 lanterns), operated by village entrepreneurs	No information given	Training for entrepreneur and village energy committee	Per village: 1 entrepreneur 3-4 village energy committee members 1 or more technicians
REDP/RERL (Since 1996; 3 phases to 2012)	Nepal	Primarily MHP, but also ICS, Biogas, SHS	Collaborative programme with multiple partners at community, district, and national levels Establishment of Rural Energy Service Centres	Population benefiting: 350 000 (52 788 HH)	To date, 3 000 persons trained on technical aspects of micro-hydro systems Capacity of > 34 000 people has been developed	Direct employment: 1.4 million person-days or 3 852 full-time equivalent jobs (at 2 persons per MHP)

[1] Cumulative figures, unless a specific year is specified. [2] More detailed information for these three countries follows below.

Table B. Overview of Case Studies — Supply Chain, Downstream Effects, and Financing

Company or Project	Country	RET	Supply Chain	Downstream Effects	Financing
Hydro A (Since 2008)	Honduras	Hydro [13.5 MW]	Pelton turbines from an international supplier Local construction materials No further supply chain information given	More reliable power supply allows shopkeepers and other businesses to open longer: Restaurants, snack bars, barber shops, tailors Education benefit: Children can study longer	Project cost was USD 16.5 million E+Co debt equity investment of USD 1.35 million Carbon offset credits
Hydro B (Since 2009)	Guatemala	Small Hydro [upgraded to 1.1 MW from smaller capacity]	Turbine purchased from a local (Italian-owned) company Other electro-mechanical equipment manufactured in Guatemala (total value of USD 0.8 million) Local construction materials	More reliable power supply allows shopkeepers and other businesses to open longer: Restaurants, snack bars, barber shops, tailors	Project cost was USD 1.5 million E+Co loan of USD 1.1 million
Solar A (N) (Since 1999)	Nicaragua	Mostly SHS Solar Thermal Small Wind	PV panels and components imported from Germany, USA and Japan Only roof attachment structures are built locally, in Managua Some panels produced locally from broken panels	Local retailers and micro-franchises (women in co-operatives) PV owners set up small stores in homes (refrigerating grocery supplies; operations after dark)	Buyers finance out of pocket, plus micro-finance options Finances tend to improve (saving on kerosene, candle, fuelwood expenses)
Solar B (N) (Since 1999)	Nicaragua Expand-ing to: El Salvador, Panama, Honduras, Guatemala	Mostly SHS Solar Water Pumps and Water Heaters	No local supply chain. Entire inventory is imported.	Cell-phone charging Small shops ("pulperias")	IADB and E+Co loans to Solar B, plus donor/government subsidies and micro-finance for end-users: Nicaragua: PERZA (World Bank) programme El Salvador: FOMILENIO programme Panama: IADB/RENO (USD 2.25 million)
Solar A (T) (Since 2002)	Tanzania	PV systems and solar appliances	Equipment imported from manufacturers and distributors in USA (80%), China, India and Germany Local: training and installations -related	Mobile phone-charging Barber shops Village cinemas Bars and shops Guesthouses	Company debt financing from E+Co for inventory (2006, 2011) Presently, company sells on cash and contract basis 2012: micro-finance pilot planned

Table B. Overview of Case Studies — Supply Chain, Downstream Effects, and Financing (continued)

Company or Project	Country	RET	Supply Chain	Downstream Effects	Financing
Solar B (T) (Since 2006)	Tanzania	Mostly SHS Solar Lanterns	Imported equipment: PV panels: Europe and USA Solar lights: Indonesia Six large wholesalers in the capital	Mobile phone-charging Barber shops Inns and bars	E+Co loan to company of USD 50 000 for inventory (2007) Local financing unavailable Sales to end-users on cash basis (but only 10% of HH can afford SHS)
FAFASO (2006-2012)	Burkina Faso	ICS	ICS developed in-country in 1980s, but abandoned Scrap-metal supply for metal stoves from abroad Small-scale production with local materials	Brewers and restaurant owners Fuel savings permit women to set up new small businesses (maize, cookies)	Co-financing by DGIS (Netherlands) and BMZ (Germany)
DEEP EA (2008-2012)	Kenya Uganda Tanzania [2]	ICS Briquettes Solar Biogas Others	Various—depending on technology, but most are localised supply chains within area of operation. Since 2011, focusing on specific supply chain models per type of technology	See below for details	Funding from EU and DGIS (Netherlands) GVEP loan guarantee fund (working with 6 financial institutions in the 3 countries)
	Kenya: Keyo Pottery Enterprises	ICS	Complex domestic supply chain, from raw materials to stove production to sales	No information given	Linkages to financing for some group members through networking sessions, or direct intervention by GVEP
	Uganda	Briquettes	Localised supply chain	Example of Jude Kabanda's business: Employees started up other businesses (poultry, etc.)	Micro-loan secured with DEEP EA help
	Tanzania	Solar	Same as above	Barbers shops and phone-charging businesses Example of Joseph Robert's business: A customer started a phone-charging business	No information given
SCODE	Kenya	Solar Lanterns ICS Biogas	SCODE has about 25 micro-distributors of their products	Most customers are households. Positive health impacts (ICS) Children can study longer (Solar)	Loan guarantee from GVEP

Table B. Overview of Case Studies — Supply Chain, Downstream Effects, and Financing (continued)

Company or Project	Country	RET	Supply Chain	Downstream Effects	Financing
REF – SolarNow (Since 2007)	Burkina Faso, Mali, Senegal, Ghana, Ethio-pia, Tanzania, Uganda, Zambia, Mozambique	SHS and Solar Lanterns	PV panels and charge controllers imported from China, USA, Europe Batteries: often manufactured domestically Assembly and installation by local technicians	No information given	REF itself was initially funded through Dutch lottery, foreign ministry, and private donors REF is involved in micro-finance schemes; 2010: pilot with hire purchase (Uganda) Upfront cost still a big burden for customers
NICE International (Since 2007)	Gambia, Tanzania, Zambia	Solar-powered ICT	Solar and ICT equipment purchased internationally Domestic assembly of components from different suppliers	Local businesses: ISP, technical installa-tion, maintenance and repair, products and services	Franchise and lease agreement for NICE Centres. Centres are financially self-sustained, typically run a profit within 3 years Customers pay on a per-use basis
Sunlabob	Laos	Solar Lanterns	Components are sourced locally More sophisticated items are imported, but with pre-assembly in Laos Revenues generated stay within villages	Local micro-enterprise activities, includ-ing stores, handicraft, mobile phone-charging	Fee-for-service concept: SLRS—Solar Lantern Rental System customers buy a service rather than lanterns (regular, small fees for a fully-charged lantern System installation and hardware initially sponsored by donors, eliminating up-front costs
REDP/RERL (Since 1996; 3 phases to 2012)	Nepal	Primarily MHP, but also ICS, Biogas, SHS	Turbine, penstock pipes, locally fabricated accessories Locally assembled electronic load controller Generators imported	Local micro-enterprises like: agro-processing mills, irrigation pumps, re-frigeration (medicines, etc.) carpentry, battery-charging, handicrafts, tailors, sewing, knitting, poultry farming, com-munications/computer centres	Grants for Community Energy Funds established by Micro Hydro Functional Groups, and District Energy Funds

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