Thematic Fiche no. 5

Solar PV for Improving Rural Access to Electricity

The ACP-EU Energy Facility co-financing instrument aims to support projects in the Africa, Caribbean and Pacific countries on increasing the access to sustainable energy in rural and peri-urban areas. The projects employ different technologies in their effort to increase the access to energy. This thematic fiche focuses on the use of solar PV technology and is based on a survey of 15 projects from the first Energy Facility. It aims to give a short insight into the technology and the preliminary project experiences from implementing solar PV systems.[1]

Access to modern energy services remains an important issue in relation to social and economic development. As of now more than a fifth of the world population are without access to energy. This problem is most pronounced in the developing countries, particularly in the rural areas located far from the grid-connected areas. Compared with urban areas, the electrification rate of rural areas is often far below the regional average. As visible in table 1 below, only 30.5 % have access to electricity in Sub-Saharan Africa (corresponding to 40 % of the whole population without electricity in developing countries), of which an average of 14.3 % of the population in rural communities has access to modern energy services. The expansion of the grid is a lengthy and expensive process which may not happen for a long time to come.

This severely affects the possibilities of developing these areas and ensuring that the rural communities have access to proper health and school services. Health clinics, schools and community centres which provide valuable services to rural and peri-urban areas would greatly benefit from electrification. Some of the particularly important services are ex. refrigeration for vaccinations, lighting for classrooms and health examinations (particular in relation to child birth) and communication services such as telephone and internet. Furthermore, supply of electricity to individual households and private enterprises could help drive entrepreneurship, trade and

[1] A list of the projects can be found at page 17 of this thematic fiche

growth forward.[2] Seen in the light of the UN Millennium Development Goals, it is essential to address the lack of electricity if these objectives are to be achieved.

Table 1 – Electricity Access in 2009: Regional Aggregates[3]

	Population without electricity (millions)	**Electrification rate** %	**Urban electrification rate** %	**Rural electrification rate** %
Africa	**587**	**41.9**	**68.9**	**25.0**
North Africa	2	99.0	99.6	98.4
Sub-Saharan Africa	585	30.5	59.9	14.3
Developing Asia	799	78.1	93.9	68.8
Latin America	31	93.4	98.8	74.0
Middle East	22	89.5	98.6	72.2
Developing Countries	**1,438**	**73.0**	**90.7**	**60.2**
Transition economies and OECD	**3**	**99.8**	**100.0**	**99.5**
World	**1,441**	**78.9**	**93.6**	**65.1**

However, when the prospects of being connected to the national grid are low, alternative solutions need to be assessed. Solar Photovoltaics (PV) is one of the technologies which are adept at addressing the rural demand for electricity. In general, the international market for photovoltaic systems is undergoing dramatic growth. Solar home systems have received attention as a stand-alone system able to expand rural electricity services in developing countries. These have typically been marketed commercially, used to provide fee-for-service electricity services and furthermore supported by many donor projects as an option for off-grid electrification across the continent. Recently, there has been a development of the market for smaller solar portable lights suitable for household use.[4] Solar PV products differ from other sources of renewable energy such as hydropower and wind, as it can be implemented for a single business or household. The increased availability of small solar powered systems have in the past few years given rise to private trade in solar products and allowed for increased private acquisition of products by individual households.

[2] Moner-Girona et al., Decreasing PV Costs In Africa

[3] Source: IEA, World Energy Outlook 2010, http://www.worldenergyoutlook.org/2010.asp

[4] Source: Lighting Africa, Solar Lighting for the BOP – Overview of an Emerging Market

The Technology behind Solar PV

Solar panels are photovoltaic (PV) generators which convert solar radiation directly into electric energy. The potential amount of produced energy thus depends on the solar radiation – or sunlight – available for the solar panels. Solar insolation is a measure of the solar radiation received on a surface. Figure 1 gives an overview of the differences in level of solar insolation around the world. The energy of the sun is more intense closer to the equator and as an effect more potential solar energy is available for being harnessed by solar panels.

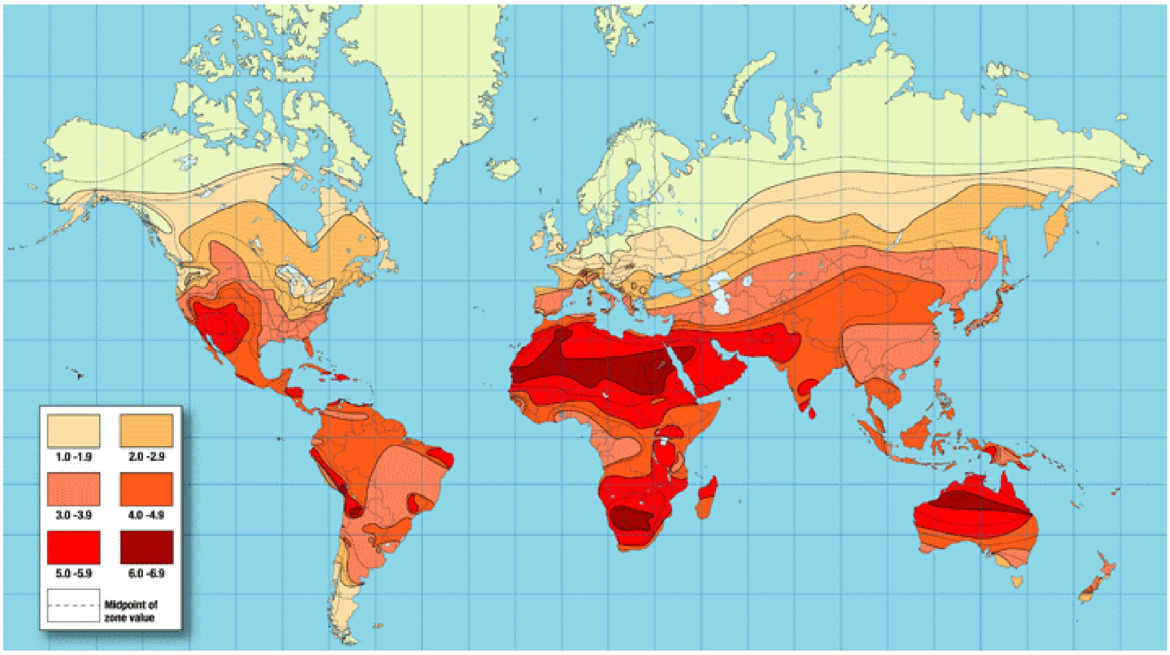


Figure 1 – Solar Insolation Map. The map is based on accumulated worldwide insolation data and pictures the amount of solar energy in hours, received each day on an optimally tilted surface during the worst month of the year.[5]

The level of solar insolation is often done on 'a worst month' basis. For installations with a consistent consumption throughout the year, installations should be optimized to capture the maximum radiation during the winter months when radiation is at its lowest. The ACP-EU Energy Facility projects implementing a component of Solar PV are all situated in areas favourable to the employment of photovoltaic technologies and experience high levels of annual average solar insolation as visible in table 2.

[5] http://www.altestore.com/howto/Tools-Calculators-Reference/Reference-Materials/Solar-Insolation-Map-World/a43/

Table 2 – Solar Insolation at Selected Project Locations[6]

Energy Facility Project	Country	Annual Average Solar Insolation (kWh/m2/day)
Servicio Energetico Sostenibile para poblaciones Rurales Aisladas mediante Micro-redes con energia renovables (SESAM-ER), 9 ACP RPR 139-13	Cabo Verde	6.3
Community Managed Renewable Energy Project for Rural Ethiopia, 9 ACP RPR 139-6	Ethiopia	5.4
Electrification rurale décentralisée par énergies renouvelables dans le sud de Madagascar (RESOUTH), 9 ACP RPR 49-41	Madagascar	5.2
Msamala Sustainable Energy Project, 9 ACP RPR 49-29	Malawi	5.9
Tsumkwe Energy, 9 ACP RPR 49-21	Namibia	5.9
Increased Rural Energy Access in Rwanda through PPP (IREA RPPP), 9 ACP RPR 173	Rwanda	5.5
Somalia Energy and Livelihood Project (SELP), 9 ACP RPR 49-01	Somalia	5.6
Providing Access to Modern Energy in Northern Uganda (PAMENU), 9 ACP RPR 49-11	Uganda	5.1

Concerning the technology of the solar panels utilized, it is normal to distinguish between three main PV cell types. They differ according to the mode of production and their capacity to convert solar radiation into electric energy.

The most widely used semiconductor is silicon. *Mono-crystalline silicon* cells are the most efficient with an efficiency rate of 14 to 17 %, however they are also the most expensive to produce. The production of *polycrystalline silicon cells* is slightly more cost-effective. The efficiency of energy conversion is lower, approximately 13 to 15 %, hence the size of the finished module is normally greater per watt than with mono-crystalline modules. They are less expensive than mono-crystalline, however more or larger panels are needed to create the same output wattage as with mono-crystalline cells.

Figure 2: Mono-crystalline Module

A new generation of PV technology is the *amorphous silicon* (thin-film). This has no crystalline structure but is a thin film of semiconductor material usually applied on glass or metal. Therefore, the advantages are high versatility and lower production costs due to the low material costs. The disadvantages are a an uncertain durability and lower efficiency compared to the two other cell types and is down to 5 to 7 %. The technology is still fairly new, compared to other photovoltaic technologies;

[6] Data provided by the projects

however, this type is being greatly improved as a result of the price demands of the consumer market.[7]

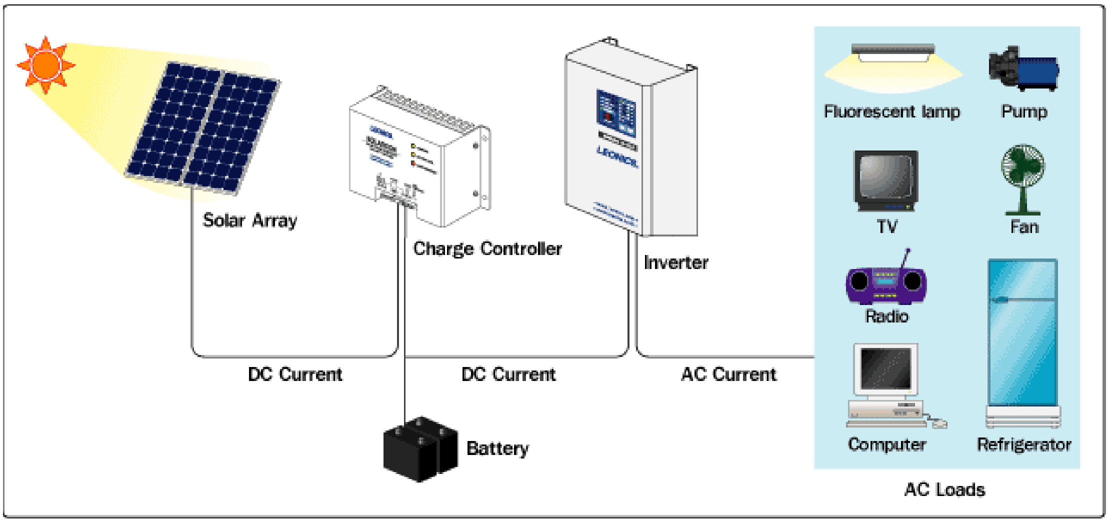


Figure 3 – The setup of a Solar Home System generating electricity for various uses.[8]

A frequent arrangement of solar technology is a solar home system, where the solar panels are typically placed at the rooftop. It is a stand-alone system operating independently from the grid. Its advantage is its size as it is able to produce power for several electrical appliances. The main disadvantage is the price, as it is significantly more expensive than smaller solar PV products.

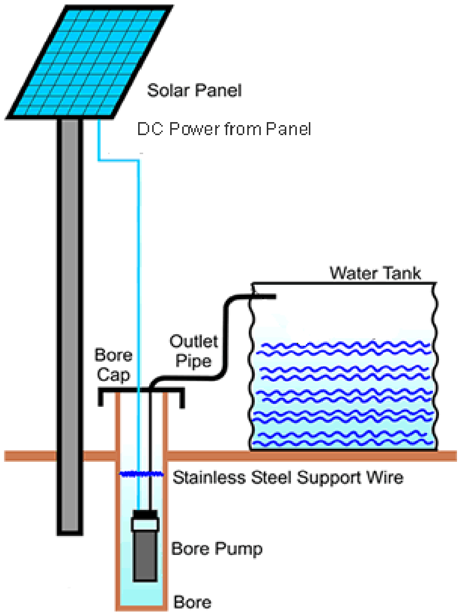
Figure 4 – Example of a Solar Powered Lamp.[9]

Accordingly, portable solar power devices are in increased use. It is a small, more affordable photovoltaic system which generates energy for a limited amount of purposes. It can either be a flexible system where the generated power can be used for various purposes, such as a light bulb or charging a mobile phone. Other products have integrated solar panels, which provide power for the product, such as a task light. The disadvantage is the low amount of power it generates compared to larger installed systems.

Solar powered water pumps are likewise a solution for rural areas which are not connected to the grid. Here, solar panels are being installed for the specific purpose of generating power for the electric pump. As the pump is working during daytime, the water is typically stored in a water tank for later use, such as drinking water or irrigation.

[7] http://www.solarserver.com/knowledge/basic-knowledge/photovoltaics.html, http://hubpages.com/hub/types-of-pv-cells
[8] http://www.leonics.com/system/solar_photovoltaic/solar_home_system/solar_home_system_en.php
[9] http://www.dlightdesign.com/products_D.LIGHT_S10_global.php

The ACP-EU Energy Facility projects often install a combination of these different types of solar PV technologies in order to serve different needs in the communities. The larger installed systems are often for community use in schools or health clinics or installed as a multiservice platform, where beneficiaries have access to electricity and various types of facilities (freezer, milling, phone charging, etc), typically on a fee-for-service basis. The smaller systems are often implemented for household use, where a task light or a single plug is useful.



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Decreasing costs – Increasing Competition

The costs of solar PV systems have dropped significantly over the past few decades. This tendency is primarily due to larger scale of production, advances in technology, innovation in manufacturing and recent declining prices of polysilicon. Data for the international manufacturing of solar PV products shows a 20 % drop in price for every doubling of cumulative MW installed. At the same time, prices on traditional sources of energy such as kerosene, gasoline and oil have been steadily rising the last decades.

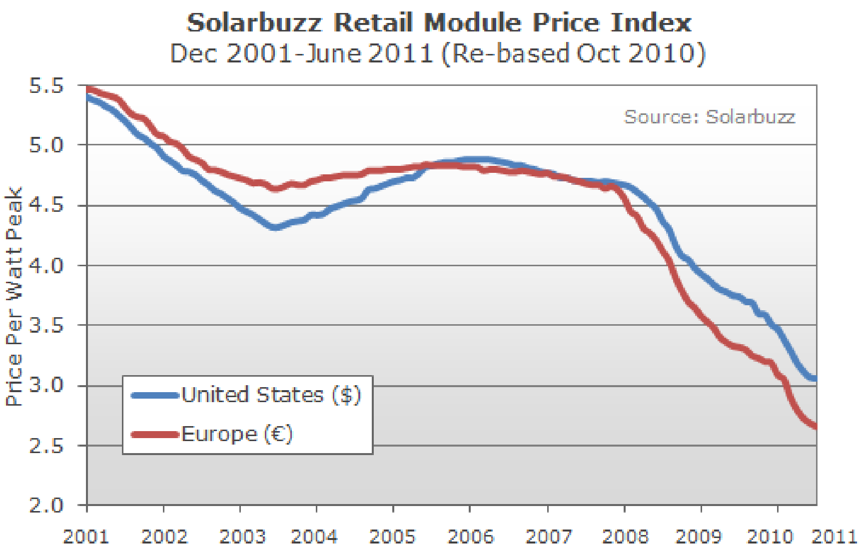

Figure 6 – Price Index for solar modules 2001 – 2011.[11]

[10] http://www.solar-for-energy.com/solar-powered-water-pump.html

[11] Source: http://solarbuzz.com/facts-and-figures/retail-price-environment/module-prices

These tendencies on the international market are a great advantage for the expansion of solar markets and eventually rural electrification in ACP countries. However, even with falling prices, electricity produced from renewable energy sources is still more expensive than electricity produced from conventional sources. The purchase of PV equipment is still beyond the reach of most rural households and thus the importance of subsidizing investments and tariffs is still prevalent.[12]

A prevailing problem is that the products often are imported fully assembled from the international market as the local solar industry is still at its initial phase or non-existing. Moreover, 95 % of the world's solar cell production capacity is still located in the industrialized countries. The expansion and consolidation of local module assembly has the potential to develop existing markets, reduce the costs of solar modules and effectively create jobs and new businesses. This development is among other things dependent on the national politically and economically commitment to renewable energy, on the local capacity for further technological development and innovation, and on the access to finance and investments for new businesses.[13]

Solar PV and the ACP EU Energy Facility Projects

Solar PV technology forms a large component of the Energy Facility projects as 20 projects of the total of 73 have employed this type of renewable energy technology. A survey carried out in mid 2011 on 15 of the 20 projects covered areas such as target groups, capacity and number of installations, subsidies and tariffs, issues of maintenance and project experiences derived from project implementation and management so far. The projects differ highly in terms of size and modality of implementation.

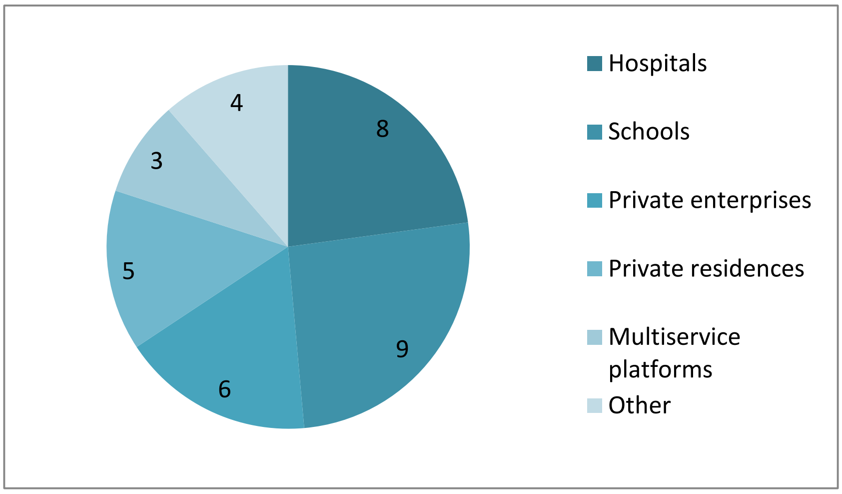

Figure 7: Number of projects which have listed the type of beneficiary as a direct target group.[14]

[12] Source: Lighting Africa, Solar Lighting for the BOP – Overview of an Emerging Market

[13] Moner-Girona et al., Decreasing PV Costs In Africa, Lighting Africa; Solar Lighting for the BOP – overview of an emerging market

[14] 14 out of the 15 projects have more than one target group. 'Other' includes community freezers, public lighting etc.

The main target groups under the Energy Facility are hospitals and health clinics, schools, private enterprises and households. The projects are often directed at one or two of these target groups, however, in most projects the final impact is assumed to be broader as more people than the direct target group will benefit from project implementation in the long run.[15]

Figure 8: Projet d'électrification Rurale dans le Brakna, Mauritania – Multiservice Platform powered by rooftop solar PV system

Figure 9: Solar Energy Solutions for Motive Power Needs, Nigeria – a solar driven water pump is tested by an engineer

Modality of Implementation

The modality of implementation varies from project to project and is dependent on the intended use of the technology. Installations meant for public good or employed in the context of a fee-for-service scheme are the most applied setups.

The supply and installation is generally sub-contracted to a local private service provider, which often imports the technology. The responsibility for the systems is placed locally, often in newly created village committees for the management of the solar installations, maintenance and setting of tariffs if relevant. In the *Community Managed Renewable Energy Project for Rural Ethiopia*, the project has initiated the formation and training of 20 renewable energy committees which are responsible for the maintenance and management of the solar energy systems, which have been installed in 33 service facilities. Sometimes this responsibility is given to local authorities or shared among relevant existing community groups, such as a Parent-Teacher Association or the school management. This delegated responsibility ensures a greater degree of involvement and sustainability among the beneficiaries.

Other projects take on a more market-based approach. The project *Providing Access to Modern Energy in Northern Uganda* has commercialized the approach to delivering access to electricity by providing support to companies selling solar PV equipment. Private households and enterprises thus receive no direct subsidy for the

[15] As an example, the project, *Solar Energy for Improved Livelihood in Burkina Faso*, is directed at approximately 3,000 households in the province of Kénédougou unable to afford significant investments. However, households not included in the direct target group may also be benefitting from increased economic activities. They may for example be offered mobile recharging services if entrepreneurs start utilizing their newly installed solar home systems.

procurement of solar PV equipment. Only social institutions, such as schools and health clinics, which have difficulties affording the high investment costs on institutional solar PV systems, receive an 80 % subsidy for the procurement of a system from the project while the institution itself invests the remaining 20 %. The *Somalia Energy and Livelihood Project* also employed a different approach than most of the projects. They have initiated training for local technicians and entrepreneurs in solar PV equipment and connected them to the market and potential business opportunities through several minor trade fairs and an international energy trade fair. The new companies which supply the renewable energy systems were urged to cooperate with local trained technicians.

The local technicians were often involved in the installation process in order to ensure sustainability. Thus, they have an opportunity to practice the installation, maintenance and trouble-shooting of the systems. Furthermore, in general, the projects implemented awareness raising campaigns among the beneficiaries on the prospects of renewable energy sources and the projects activities themselves.

Capacity and Investment Costs

The scale of the projects varies in terms of number of installations and the expected wattage output. Table 3 depicts some of these differences. The installed capacity is the results achieved so far independent from their targets.

Table 3 – Capacity and investment costs for selected projects[16]

Project	Installed capacity and number	Investment costs per installation[17]	Average annual production of electricity per installation
Community Managed Renewable Energy Project for Rural Ethiopia, 9 ACP RPR 139-6	10 solar PV systems (34 kW) at Primary Schools 10 solar PV systems at health clinics (22 kW) 2 solar powered water schemes (12 kW)	16,858 EUR 11,177 EUR 25,993 EUR	2864 kWh 1153 kWh 7637 kWh
Providing Access to Modern Energy in Northern Uganda, 9 ACP RPR 49-11[18]	6 schools (8.9 kW) 14 hospitals (14.4 kW) 261 systems at private enterprises (9.1 kW)	28,732 EUR 19,280 EUR Not available	1576 kWh 995 kWh Not available

[16] The installed systems are often a combination of SHS and portable devices depending on the individual beneficiary. The investment costs in Ethiopia have been converted from USD, based on the June 2011 rates, http://ec.europa.eu/budget/inforeuro/index.cfm?Language=en.

[17] Investments costs per installation covers the costs incurred at installation, but not later operation and maintenance

[18] No initial target was set for capacity

Project	Installed capacity and number	Investment costs per installation[17]	Average annual production of electricity per installation
	645 systems in households (13.6 kW)	Not available	Not available
Somalia Energy and Livelihood Project, 9 ACP RPR 49-01	31 solar PV systems at schools (9.3 kW) 21 solar PV systems at health clinics (5.1 kW) 2 systems at fishing cooperatives (0.9 kW) 13 systems at community sites (13.1 kW)	2928 EUR 3686 EUR 7099 EUR 6813 EUR	876 kWh 709 kWh 1314 kWh 2942 kWh
Projet d'électrification rurale dans le Brakna, Mauritania, 9 ACP RPR 49-30	7 multiservice platforms (21 kW)	26,000 EUR	4800 kWh
Tsumkwe Energy, Namibia, 9 ACP RPR 49-21	None. One solar/diesel hybrid system (200 kW) commissioning due June 2011	*Expected* 1,077,602.37 EUR, hereof solar 947,130.37 EUR	*Expected* 839,500 kWh, hereof solar: 335,800 kWh

As it is visible, all the selected projects but *Tsumkwe Energy* in Namibia have reached the stage of system installation. The projects are fairly different in scope, where some of the projects aim to disseminate many solar PV systems and portable devices, whereas some focus on one or a few installation with a larger capacity and hence annual production.

Further to this, the installation costs are in general relatively high for each installation under the Energy Facility. However, contrary to non renewable sources of energy traditionally used such as kerosene and diesel, the operation of the systems carries no fuel expenses after the point of installation. Potential needs for repairs or replacements within the expected service life of the solar PV systems should of course be taken into consideration. The project *Solar Energy for Improved Livelihood in Burkina Faso* expects an annual reduction of 711,714 litres of kerosene and 124,100 litres of petrol as a result of the implementation of solar PV replacing the old fuel generated sources of energy for 3,000 households in the Kénédougou province. The project *Tsumkwe Energy*, Namibia expects the fuel requirements to be reduced by 60 % over the next 5 years after project implementation. The targeted area is currently receiving energy from diesel generators. Annual sales of electricity currently generate an income of 30,000 EUR however the fuel expenses alone amounts to 85,000 EUR creating an annual deficit of 55,000 EUR to the operator. The new hybrid system is expected to change these system shortcomings.

Table 4 shows a tentative estimate of the future consumption cost of electricity generated from the solar PV systems. It is based on the information given by the projects on price of installation and annual production of kWh, so it does not include for example operation and maintenance (O&M) costs and provision of depreciation. As solar PV modules are produced with a lifespan of approximately twenty years, this perspective has been included. However, the numbers can be affected by costly repairs, replacement of faulty equipment, problems caused by low quality and so forth. Therefore, the five year perspective has been included in order to give an impression of the prices should the equipment only last five years due to low quality or bad maintenance.

Table 4: Estimated electricity production costs (without O&M, depreciation provision)

Project	**Site of Installation**	**Costs per kWh the first 5 years (EUR/kWh)**	**Costs per kWh the first 20 years (EUR/kWh)**
Community Managed Renewable Energy Project for Rural Ethiopia, Contract no. 2007/195-954	School	1,1772	0,2943
	Health clinic	1,9388	0,4847
Providing Access to Modern Energy in Northern Uganda, Contract no. 2007/195-984	School	3,6462	0,9115
	Health clinic	3,8754	0,9688
Somalia Energy and Livelihood Project, Contract no. 2007/195-974	School	0,6685	0,1671
	Health clinic	1,0398	0,2599
	Community site	0,4632	0,1158
Projet d'électrification rurale dans le Brakna, Mauritania, Contract no. 2007/196-007	Multiservice Platform	1,0833	0,2708
Tsumkwe Energy, Namibia, Contract no. 2007/195-994	Solar/diesel hybrid system	0,2567[19]	0,0642
		0,5641[20]	0,1410

The numbers are tentative and shown in order to give an impression of the costs of providing electricity to rural areas. The reason for the variation in costs can be many. First of all, a large multi platform installation will generate power at a comparable lower cost than smaller installations. Furthermore, there can be deviations in purchase cost, different levels of market competition, variations in effectiveness and so forth. What the costs indicate is that though an extension of the grid would be a costly affair, the provision of energy through isolated solutions can be expensive as well. However, comparing the output with some of the other solutions available for the population in rural areas, such as kerosene and candles, solar PV and other

[19] Note: For the complete solar/diesel hybrid system

[20] Note: For the solar component of the hybrid system

forms of renewable energy is a more sustainable, healthy and inexpensive solution. Kerosene is one of the most widespread solutions for lighting. It is estimated that more than half of the off grid households in Africa employ a kerosene lamp as their primary source of lighting. With rising prices, kerosene has become an expensive source of energy-[21] The project *Providing Access to Modern Energy in Northern Uganda*, has analysed the financial viability of the solar PV systems. It is estimated that the savings for a household will amount to 1,450 EUR in avoided costs for kerosene, batteries and charging of mobile phone during the lifespan of a solar home system. This is based on the following average expenses:

Old system:	Per year	Per 20 years
Household expenses on kerosene/candles	36 EUR	720 EUR
Household expenses on dry cell batteries	18 EUR	360 EUR
Household expenses on mobile phone charging	36 EUR	720 EUR
Total expenses over 20 years		1800 EUR
New system:		
Investment cost of SHS (2 lights, 1 radio, mobile phone charging)		200 EUR
O&M cost of SHS over lifespan		150 EUR
Total expenses over 20 years		350 EUR
Savings per household during lifespan		1450 EUR
Pay-back time for SHS		3.8 years
Average lifespan of SHS		20 years

Naturally, the actual savings depend on many different factors, such as the price development on kerosene, the actual use of electricity and the actual lifespan of the SHS. However, it is noteworthy that solar PV systems are increasingly cost competitive as the quality of the products rises and the price drops.

Project Approaches to Tariffs

Nine projects responded that they used a form of fee-for-service scheme. This is common in the projects which have installed a central solar charging system or platform, where residents can acquire different electric services, such as battery charging, telephone charging etc. A direct comparison of the level of tariffs is not possible, as the type of tariff systems highly differ among the projects. The three main approaches are described below through case studies:

Example: Consumption-based tariffs

The project *Tsumkwe Energy* in Namibia is centred on the installation of a solar/diesel hybrid system, which is feeding into an isolated mini-grid. The total capacity of the mini-grid is 200 kWp and is estimated to be able to supply the entire settlement. The grid is estimated to have an annual average production of 839,500 kWh of which the solar panels generate 335,800 kWh. The project is led by a NGO in partnership with a national power utility and a local authority. The local authority is responsible for the service provision and maintenance of the system.

The tariffs are cost-reflective and operational:

- New tariff: 0.35 EUR/kWh
- Previous tariff: 0.59 EUR/kWh

The lower tariffs are a reflection of the lower costs of electricity production, which has been optimized further by the instalment of energy efficient water heaters, energy saving lights etc. An overview of the estimated cost changes of electricity production has been provided by the project. The table shows the economic impact of the new solar hybrid system compared with the previous diesel-only system:

Cost of electricity production		**Current**	**New**
Diesel operation	% of total generation	100%	60%
Cost reflective Tariff	Euro cents/kWh	59	35
Annual operating profit (loss)	Euro	-120,240	-27,148
Operating profit/loss as % of turnover	% of turnover	-158%	-10%
Network and distribution costs	Included/excluded?	excluded	included
Energy efficiency equipment	Included/excluded?	excluded	included

Example: Service-based tariffs

Projet d'Électrification Rurale du Brakna in Mauritania plans to install 25 multiservice platforms with an average of 3 kWp. They have currently installed seven of the planned platforms that offer access to mobile phone charging, battery charging, milling, and so forth. The platforms and the setting of tariffs are managed by a village committee which offers the services to local artisans. In this project, the users are charged on the basis of a service.

- Charging of a telephone: 50 UM (~ 0.13 EUR)
- Charging of a battery: 200 UM (~ 0.52 EUR)
- Milling per kg of grain: 10 UM (~0.03 EUR)

The project has operated with a double strategy, both to make solar kits available to individual households as well as enhancing the collective access to energy through these platforms. Parts of the investment costs (ex. Production equipment such as the mill) and parts of the maintenance costs are borne by the beneficiaries.

Example: Fixed Monthly Tariff

The project *RESOUTH* in Madagascar has based their fees on a fixed monthly tariff. The project will install solar systems at schools, hospitals, private enterprises etc. They are going to operate with two levels of monthly tariffs dependent on the wattage the user will have at disposal.

- Option 1: 10,000 MGA (~ 3.59 EUR)/month for 100 Wh/day
- Option 2: 15,000 MGA (~ 5.38 EUR)/month for 130 Wh/day

Some of the projects do not operate with tariffs, as all the solar system are owned by the individual users in the end or when the installations are for general public purposes like public lighting. Others like the Somalia Energy and Livelihood Project have limited the use of tariffs as the community members are too poor to pay for the energy. It should likewise be taken into consideration that most of the tariffs are subsidized, meaning that the beneficiaries pay a lower price than the actual production costs of electricity. The tariff in the Tsumkwe Energy project as an example will be subsidized initially with a phase-out period of five years.

Solar PV Technology – Successes and Challenges

The projects implementing a solar PV component have reached different stages of implementation. Some are well underway with several solar systems installed while others have been delayed and have only signed the contract for supply and installation of the technology. However, it is still possible to conclude on some of the more common successes and challenges experiences by the projects.

Some of the project successes are:

Solar PV well received among beneficiaries: 6 of the projects which have reached implementation stage report that this technology is generally very well received among the beneficiaries. This is a tendency among both larger solar systems and portable PV kits (such as task lights and lanterns). This has meant a strong ownership by the beneficiaries and in some cases a higher local demand than expected.

Successful output of installations: The installation of solar PV technology has been successful in terms of offering a basic level of electricity services, achieving energy efficient improvements or reducing energy consumption. Improvements are visible at many different types of project sites, ex.:

- *Somalia Energy and Livelihood Project:* "Twenty one rural clinics were installed with solar PV systems, mainly for lighting and powering basic health instruments such as microscopes, refrigerators, radio, television and providing lights. About 12,626 people were benefiting monthly from the energy services derived from these solar PV systems. Between 7-10 % of these patients are attended to in the evenings/night time."
- *Solar Energy for Improved Energy Services in Rural Areas, Burkina Faso:* "A small company in Koloko specialized in frozen fish has changed their gas driven freezer in a Solar PV system and is able to save 2,744 euro per year and at the same time they are selling more due to the fact that they can be longer available since they have also light."
- *Msamala Sustainable Energy Project, Malawi:* "Provision of solar PV to schools has improved recruitment and retention of teachers in remote rural areas and permitted evening study for school pupils and adult learners."
- *Community Managed Renewable Energy Project, Ethiopia:* "33 solar PV systems for school and health clinics are internationally procured and imported duty-free. Out of the 33 solar PV systems, 22 are installed and functional."

Involvement of the private market: Some of the projects underline the fact that the project has strengthened income generating activities in the communities (e.g. offering mobile charging services) and that they have witnessed the creation of new rural micro enterprises. An example is the project in Burkina Faso. Here, new commercial activities have been created in the city of Samogohiri such as stands for mobile recharging, night cafés and shops employing several new members of staff.

Cooperation among actors: The projects have responded that the cooperation among project partners and other involved actors has been positive and dedicated towards the project goals for the most part. The establishment of an integrated approach between project, relevant governmental levels, financial institutions and beneficiaries is an important part of project progress.

The projects have, however, also experienced a number of challenges in the procurement, installation and maintenance of Solar PV technologies.

Some challenges have been mentioned by several projects. This includes:

Capacity to maintain the solar systems: Several projects state maintenance as one of the biggest challenges. Some of the projects point to the fact that it is difficult to ensure that the beneficiaries will maintain the systems, and that regular check-ups are not done even when offered for free. All of the projects have a plan for maintenance. Most of the projects take time to train users and local technicians connected to the projects. Others have made maintenance agreements with the installation company. However, one project points out that when the *fundi* (a local skilled technician) has reached a skilled level in photovoltaic technologies, he/she has the opportunity to get more work in other areas.

Figure 10: SELP, Somalia – Training of Solar PV Technicians in Puntland

Quality assurance of solar PV equipment: It is a large investment to procure most solar equipment, however the quality of the products varies. Local stores are at times inadequately stocked to provide high quality equipment as low quality sells better because of the large price differences. This is a bigger issue in projects with a market approach, where the beneficiaries will invest in their own equipment; hence the price is of greater importance.

Low awareness of the technology among end-users: Many projects have experienced a low awareness among the local communities about the significance of renewable energy, especially solar energy. Most projects have initiated awareness campaigns and some have been innovative in their efforts. As an example, the *Best Ray* project in Tanzania has carried out an extensive campaign, where small boxes of solar equipment have been used as prizes in primary and secondary schools in order to promote the technology in the community. Despite the efforts, the projects report that low awareness has had an influence on the project. It means that it can be difficult to meet the expectations and specific needs of the beneficiaries as they are unsure about the technology.

Investment costs and affordability: As solar PV equipment is expensive, the affordability is still not guaranteed without extensive funding; hence it can be difficult to expand the technology after project end if the government or other involved actors does not subsidize further investments. In projects, where beneficiaries are investing in equipment the high up-front costs can be a problem even if the prices are heavily subsidized. It is a big investment in relation to their purchasing power and some have problems accessing financial loans, ex. in areas without any banks or other financial institutes.

Slow decision-making process: Slow decision-making applies both to the local communities, which are dominated by a patriarchal decision-making process which is slow and rarely includes women and children, which are often most affected by the projects. Furthermore, limited human resources and lengthy processes in government and local authorities have been a challenge in several projects. Examples are lack of staff and resources to carry out specific project tasks (such as issuing duty-free letters to import solar PV equipment as a part of the project agreement and a high staff turnover due to the limited career prospects offered at local and regional governmental offices). These problems have meant delays for several of the projects in the initial phases of the project.

Lessons Learned and Recommendations

Based on the experiences from the projects, a number of recommendations can be made for implementation of solar PV projects. In general, it is evident that solar PV is an efficient and flexible technology for making energy both accessible and efficient in rural areas. The recommendations are surrounded around different managerial and technology issues.

Table 5 – Conditions to be considered – solar PV for improving rural access to energy

Condition	Concept	Project applications
Awareness	Sufficient awareness among the beneficiaries helps clearly identifying the needs and improves the implementation	Different types of awareness raising activities are an important part of the project as many solar PV products are to be handled by the individual end user, ex. campaigns, public demonstration of solar PV equipment, lessons on renewable energy and solar PV in schools
Market oriented approaches	Support to local manufacturing and assembling of solar PV equipment, rather than increasing the import of fully finished solar systems from industrialized countries	Focusing on and subsidising local producers help generating economic activity, increases the competition and further reduces the prices of solar PV equipment. This is especially relevant for smaller portable solar products, where there is a large potential sale to private households
Training for technicians	Training of technicians is essential for later maintenance as there are currently few technicians in rural areas familiar with photovoltaic systems	Train technicians in solar PV equipment; promote the development of a country or regional wide curriculum which can ensure the quality of training and the expansion of solar PV technology. Select already experienced electricians as trainees to ensure that they have an understanding of the underlying concepts

Condition	Concept	Project applications
Quality assurance	Quality assurance of the equipment in order to ensure its service life, the project investments and the credibility of renewable energy technologies among the beneficiaries	Increased awareness on the growth of quality testing of solar PV products and certification programs at national and international level, such as Lighting Africa's Product Quality Assurance initiative[22]
Household oriented products	Smaller solar PV products fit for private households	The market for smaller portable devices has the potential to expand as these products increasingly become financially accessible for households

Energy Facility Projects surveyed

This thematic fiche is based on a survey of the following 15 projects:

- SETUP: Services Energétiques et Techniques à Usage Productif au Bénin, Benin
- Solar energy for improved livelihood in Burkina Faso, Burkina Faso
- Servicio Energetico Sostenibile para poblaciones Rurales Aisladas mediante Micro-redes con energia renovables en l'Isla de Santa Antao, Cabo Verde
- Community Managed Renewable Energy Program For Rural Ethiopia, Ethiopia
- Electrification rurale décentralisée par énergies renouvelables dans le sud de Madagascar (RESOUTH), Madagascar
- Msamala Sustainable Energy Project, Malawi
- Projet d'initiatives Locales d'electrification Solaire (PILES), Mauritania
- Projet d'électrification Rurale dans le Brakna, Mauritania
- Improved access to Energy services in isolated rural areas of Mozambique by application of photovoltaic systems, Mozambique
- Red de centros de servicios energéticos básicos alimentados con sistemas fotovoltaicos basados en la mejora de servicios sociales básicos y en el desarrollo de capacidades locales y la autogestión energética para comunidades rurales aisladas de Mozambique (Red SECRAM), Mozambique.
- Tsumkwe Energy, Namibia
- Increase Rural Energy Access in Rwanda through Public Private Partnership (IREA RPPP), Rwanda
- Somalia Energy and Livelihood Project, Somalia
- Best Ray (Bringing energy services to Tanzanian rural areas), Tanzania
- Providing access to modern energy for northern Uganda (PAMENU), Uganda

Please consult the ACP-EU EF Project Database on www.energyfacilitymonitoring.eu for more information about these projects.

[22] http://www.lightingafrica.org/product-quality-assurance.html

Useful links

1. Website on solar irradiance – calculate the solar energy available on a specific project site, http://solarelectricityhandbook.com/solar-irradiance.html
2. Website offering different tools, calculators and reference material on solar PV, http://www.altestore.com/howto/Tools-Calculators-Reference/c36/
3. On-line calculator of PV plant developed by Joint Research Centre of the EU: http://re.jrc.ec.europa.eu/esti/index_en.htm Downloadable Decisional Support System for Renewable Energy projects: http://www.retscreen.net/
4. Market research report from Lighting Africa on 'Solar Lighting for the Base of the Pyramid – Overview of an Emerging Market', http://www.lightingafrica.org/resources/market-research.html
5. Article on the availability and costs of solar PV in Africa: Moner-Girona, et al.: 'Decreasing PV costs in Africa: Opportunities for Rural Electrification using Solar PV in Sub-Saharan Africa'. Published in Refocus 2006.
6. Online portal on solar energy: http://www.solarserver.com/
7. Website on solar energy offering general knowledge on solar energy http://www.solar-for-energy.com/
8. Market information on solar PV modules http://solarbuzz.com/facts-and-figures/retail-price-environment/module-prices

Thematic Fiche No. 5 "Solar PV for Improving Rural Access to Electricity"

European Union Energy Initiative (EUEI)
http://www.euei.net

ACP-EU Energy Facility
http://ec.europa.eu/europeaid/energy-facility
E-mail: EuropeAid-Energy-facility@ec.europa.eu

Monitoring of the ACP-EU Energy Facility - 1st Call for Proposals
http://www.energyfacilitymonitoring.eu
E-mail: acp_eu_energy_facility@danishmanagement.dk

Technical assistance by
Danish Energy Management

acp-eu energy facility

euei EUROPEAN UNION ENERGY INITIATIVE