1.6 Action plan for large solar PV technology

1.6.1 About the large solar PV

The costs remain very high: for instance a 5 MWe of PV had its initial capital cost of 7 060 USD/kWe during the baseline year 2005 against the projections for the year 2015 of about 5 000 USD/kWe .The generating costs are projected, for the year 2015, to about 29 US cents/kWh against an average of 42 US cents/kWh in the year 2005 (ESMAP, 2007). The potential installation of remote mini-grids but also the direct connection to the national EWSA grid are appropriate for reducing the costs; avoidance of use of batteries is also a positive factor of the large solar PV.

Another scenario for reducing the capital cost is the use of the optional concentrated solar photovoltaic cells which are in fact characterized by less size of solar modules in line with the coefficient rate of concentrating the direct normal component of solar radiation. The mitigation potential (Reduction of GHG Emissions) is one the highest with regard to other technologies. In fact the solar PV is a non carbon technology and the batteries are not required in case of grid-connected option.

Replacing the existing thermal oil power plants by the large solar PV will result in a reduction of GHG emissions by about 79%. In fact the emission factor of solar PV grid is about 155 kg / MWh against 750 kg/MWh. Another alternative: the development of the solar PV technology on a large scale in Rwanda will result in reducing or avoiding the use of peat resources (GHG emissions of about 1075 kg/MWh) for generating electricity. Finally and in addition to above environmental issues, expected economic benefits are quite significant:

- Promotion of exploitation of local natural resources for electric power generation
- Reduction of exodus from rural to urban areas
- Small scale business and factories are created to generate more wealth.
- Increased rate of access to electricity services, resulting in healthier economy growth.
- Creation of jobs.

1.6.2 Targets for large solar PV transfer and diffusion

- Development of a national strategy for operation and maintenance of large solar PV system
- Exempting all types of solar equipments and components from import duties;
- Basic electrification of all schools, all health centers and all administrative offices in remote rural areas;
- Based on lessons learnt from the 250 kWe pilot plant installed in Kigali at Mount Jali, replication and installation of solar PV connected to the national EWSA grid;
- Development of guidelines on sizing and tender for provision of solar systems with high quality[3] standards.

[3] *Such adequate procurement can also take in account of new solar products more efficient like concentrated solar photovoltaic (CPV)*

1.6.3 Barriers to diffusion of large solar PV

Table 14: Economic and financial barriers for large solar PV

Barriers	Elements of barriers	Presentation and dimensions
high cost of investment and equipments	High Initial Capital Cost	The Photovoltaic systems, compared to other commercial energy technologies remain very expensive; Subsidies and low taxes have not yet resulted in larger diffusion of PV modules in Rwanda; Only some institution(Schools, Health Centers) can just afford an installation of about 3kW for mainly lighting purposes; EWSA installed just only a small plant with a capacity of 250 kWe in Rwanda, near Kigali.
	Limited access to loans from banks and leasing programs	Acquisition of solar modules is limited by the initial capital cost which has to be paid cash; Lack of access to credit is limiting both investors and end users to small scale size of solar products.
	Limited information and network to different manufacturers	Poor knowledge in PV sector results in buying non tested solar modules ; ,very often second hand products are taken for new on local market; new equipment remain expensive In addition, imported products from Europe, China, USA or Japan to Rwanda,(a landlocked country) are quite expensive due to transport .
	High cost installing private grids	Absence of decentralized mini-grid for distribution of electric energy is limiting deployment and diffusion of large solar PV system

Table 15: Non Financial Barriers for large solar PV

Barriers	Elements of barriers	Presentation/ and dimensions
Imperfection of solar market	Non-existent local industry for solar	An initiative of assembling the solar modules was set up before 1993 in Kabgayi headquarters of Catholic Church; it is no longer operational while it was expected to play a key role in making solar cells for local deployment.
	Unfamiliarity with solar PV technology	Design, preparation and implementation of solar PV, especially for larger scales, require more skilled labor and expertise which are currently minimal in Rwanda ; among others, more special skills in setting up local mini-grids are limited; all phases of installation, operation and maintenance lack accurate information on solar resources (variability within the year)
	Low competitiveness	From schools and universities to stakeholders' relative low awareness to solar PV technology, especially for large scale size, is noted; this option is found useful only for very small application of lighting just like the option of simple batteries charged at any available station. Compared to ordinary supply of energy from EWSA, the solar PV supply is negligible l in the context of power generation while its cost of acquisition is relatively high.
	Access to enough land	Due to the limited efficiency of converting solar light into electricity, required land area where to install a large solar PV is also too large for a country with the highest population density in Africa
Human and institutional capacity	Limited skilled expertise	Technicians trained for designing and installing the large solar PV plants are very few in Rwanda
	Non-existent centre for promoting solar application	Knowledge and expertise are limited

Social and cultural behavior	Resistance to change and investing in large solar	Different promoters and developers of solar are still limiting their business to standalone solar systems

1.6.4 Proposed action plans for Large Solar PV

Table 16: Technology Action Plan for Large Solar PV

Measure	Justification	Activities	Responsible	Timeframe	Estimated cost (USD)	Source of funds	Success indicators	Risks indicators
Creation of network of all key players in solar energy	Opportunity of developing a local industry and reduce cost of relevant equipment	-Inventory of all solar companies and investors in Rwanda; - Setting up units for assembling solar modules; - Formation of an solar association with to IRENA	MINICOM; Private sector	10 years	8 million	GoR	-Reports on joint ventures and actions; -Reports on visits done at local level and international large solar plants sites; -A solar industrial unit is operational	-Industrial unit set for solar doesn't attract local purchasers;
Law and regulation on long term incentives and taxes exemption	To handle the high cost of conventional solar components	-Elaboration of road map for the development of the large scale solar PV; -Elaboration of laws and	MININFRA; EWSA; RFPS (FRPS)	5 years	63,000	GoR	-Published laws in official gazette; - A published road map	- Laws are established but incentives are not influencing the diffusion

		regulatory frameworks						
Reviews of tariffs and access to grid networks	Need of agreement between EWSA and developers of large solar PV	-Elaboration of regulatory framework for tariffs, feed-in-tariffs; - Inventory and feasibility study of potential grid-connected PV systems	RURA and EWSA	10 years	63,000	GoR	Number of new developers and companies added to the list of promoters of solar PV systems connected to EWSA electric grid	-Grid-solar connection option is providing ; - Saturation of the EWSA grid and a temporal un-ability to buy solar electricity
-Subsidies -Soft loans and leasing programs; benefits from the carbon credits	-Required before reaching the stage of economy of scale -To handle the high initial capital cost	- Negotiate the access facilities to subsidies and carbon credits; -Set up a fund for soft loans and leasing programs; - Establish the CDM projects	MINECOFIN; MINICOM; Local Banks; International financial institutio	10 years	18 million	GEF; EU; WB	-Annually added power capacity generated by solar PV subsector; - The number of promoters benefitting from financial facilities is significant	-change in interest rate; - inflation ; -Carbon credits limited to small scale solar

			ns; REMA					
Set up a unit for training and research applied to solar exploitation and solar hybrids	Need of well skilled technicians and experts for installation and maintenance of grid and solar components	-Elaboration of design models for solar systems; - Establish a monitoring model of solar resources 'variability and solar components	EWSA; MINEDUC; MIFOTRA; Universities and colleges	5 years,	200,000	GoR	-Number of technicians awarded every year; -Number of jobs created; -Number of new local experts involved in setting up new large solar PV projects	- Uncertainties and climate variability affecting the direct normal radiation and efficiency of concentrators; - in Rwanda: low values of wind for solar hybrids

In addition to the relative familiarity with scale solar PV product on Rwanda market, potential developers of large solar PV technology, if facilitated, will be easily involved in local diffusion of such a technology; therefore the following factors have to considered:

- Existing subsidies and lowered taxes and fees have not yet significantly induced a larger diffusion of solar PV systems in Rwanda; only some institution(Schools, Health Centers) can just afford an installation of about 3kW for mainly lighting purposes;
- The Photovoltaic systems, compared to other commercial energy technologies, remain very expensive, especially the cost of equipment;
- It is important to mention that a private company in close collaboration with EWSA has installed a small solar PV plant with a capacity of 250 kWe directly connected to national electricity grid. Such an approach of grid-connected plants driven by renewable energy resources is quite an interesting step towards the anticipated development of large scale solar PV technology;
- Absence of decentralized mini-grid for distribution of electricity limits deployment and diffusion of large solar PV system;
- An initiative of assembling the solar modules was set up before 1993 in Kabgayi headquarters of Catholic Church; it is no longer operational while it was expected to play a key role in the process of the solar systems development and diffusion in Rwanda;
- Design, preparation and implementation of solar PV, especially for large scales, require more skilled labor and expertise which are currently limited in Rwanda ; among others, more special skills in setting up local mini-grids are minimal; all phases of installation, operation and maintenance lack accurate information on solar resources (variability within the year).

Specific consideration of energy storage is required. It is further necessitated by the potentially high risk of poor diffusion due to a possible poor design and availability limited by the stochastic (random) character of solar energy resources in a cloudy equatorial zone..

Specific measures to remove barriers hindering the diffusion of the Large Solar PV technology in Rwanda are mainly as follows: enactment of agreements for connections to the national electric grid; application of the feed-in tariffs; establishment of an updated solar map including the direct beam normal component used as an input i.e. ingredient for the optional concentrated photovoltaic(CPV);provision of subsidies to the developers of the solar mini-grids; Setting up a

partnership between stakeholders for a local solar industry promotion towards mainly an assembly plant ; Set up a pilot project of large scale solar PV plant; Introduction of f payment for equipment in installments instead of paying cash (leasing programs); Promotion of solar modules installed on buildings; subsidies for an introduction of the CPV and CSP (concentrated solar thermo-electric power) products in Rwanda.