SOLAR-PHOTOVOLTAICS IN THE DEREGULATED ELECTRICITY INDUSTRY OF DEVELOPING COUNTRIES

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Abstract

Several social, economic, technological and political factors have slowed down infrastructural development and access to electricity in developing countries. In most developing countries, there is a monopoly of electricity generation, transmission and distribution by certain agencies, resulting in little or no access to electricity in rural communities where a larger proportion of the population resides. Deregulation in the electricity industry holds the key to increased access to electricity in developing countries. This paper discusses the present scenario of the electricity industry in developing countries, the deregulation initiatives of some of them and the possible impact of deregulation on the dissemination of Photovoltaics systems.

1. INTRODUCTION

Photovoltaic solar electric generation technology is one of the best means to provide electricity in a clean manner virtually everywhere around the world. Photovoltaic systems are modular, producing electricity directly from sunlight and do not give rise to emissions harmful to health or climate. They can be deployed very rapidly in both rural and urban environments. A PV module rated at 120W ($1m^2$) together with a suitable battery can be installed in a very short time and will provide enough power for several compact fluorescent lights and a radio or TV for four to five hours a day. This can be truly life-changing for a family in rural Africa, Asia or Latin America where small levels of electric power could make a significant impact in their standard of living.

In view of the growing demand for environmentally friendly technologies for electricity generation, coupled with the finite nature and rising cost of fossil fuel for conventional electricity generation, global attention has shifted to the harnessing of renewable technologies for electricity generation. These technologies include those based on small-hydro power, wind, biomass and solar energy.

For several decades, the electricity generation in most of the developing countries of Africa, Asia and Latin America have been under the monopolistic management of agencies controlled and funded by the governments. Experience has shown that most of these agencies have for reasons of poor funding, mismanagement of resources, interference from the government, inadequate technical capacity, been unable to sustain quality service and ensure the expansion of the utility grid to the rural population. Poverty alleviation is now a global concern that has prompted the United Nations to set Millennium Development Goals

(MDGs). These goals will be fostered partly by ensuring that energy is made available to the rural populations of the world, majority of which are found in developing countries. The need to harness renewable energy resources for electricity generation arises for the following reasons:

(i) The resources are abundant
(ii) They are well dispersed
(iii) Electric power from the national grid system has not reached many of the highly populated rural communities.
(iv) Rural dwellers require very little power to meet their basic needs and these levels of power can be satisfied with renewable energy sources.
(v) Availability of electricity in rural areas will stimulate commercial and industrial development and alleviate poverty.
(vi) Renewable energy resources generate electricity without atmospheric pollution.
(vii) They are easily adaptable to decentralized electricity generation.

In this paper, PV applications and market up to the year 2020 are considered. Issues related to deregulation, its advantage and the attraction it holds for PV applications are highlighted. The constraint to the widespread dissemination of PV in developing countries and the policy, financing and implementation issues to be considered are discussed.

2. GLOBAL STATUS OF SOLAR PV APPLICATIONS

The main application of photovoltaic electricity generation can be divided into four categories namely grid connected systems, off-grid industrial applications, rural electrification in developing countries and consumer application. With a share of 71%, grid-connected systems dominate the PV market with Japan and Germany having the largest installations. These are mainly residential roof-top systems. However, within the last five years, a growing number of larger systems between 100KW and a few MW power have been installed on public and industrial buildings and on the ground. Building integrated PV (BIPV) systems with special PV modules used for facades, roofs and shadowing elements are becoming prominent.

Off-grid industrial applications have a market share of 15% and represent stand-alone generators used to provide electricity for telecommunications, telemetry, traffic signs, corrosion prevention, water desalination and similar applications. With a share of 7%, rural electrification in developing countries represents a major market and an opportunity for improving living conditions of approximately 2 billion people living in those countries who currently do not have access to electricity for lighting, water pumping, telecommunication and healthcare. The consumer market with a share of 7% provides for a variety of application from substitution of batteries in small devices to the electrifications of recreational vehicles and sailing boats.

In 2003 700MWp of PV modules were sold and with a growth rate of 25%/year, it is expected that annual production will rise to 1GWp in a few years. Currently, the PV industry provides employment for over 35,000 people. The projected global electricity production by 2020 is 25,578TWh and at the present growth rate of PV production, it is expected that 282TWh or 1.1% of this total production level will be contributed by PV. Table 1 shows the values of the projected parameters.

TABLE 1: Projections for PV by 2020

PV Systems capacity	205GWp
Grid connected consumers	93 million Worldwide
Off-grid consumers	950 million Worldwide
Employment Potential	2.25 million Worldwide
PV market volume	€108 billion per annum
Prices for grid connected PV systems	€2 per Wp
Cumulative carbon savings	730 million tones of CO_2

Source: Solar Generation, EPIA/ Greenpeace, 2004

Although the key markets are now located mainly in the industrialized world, a global shift will result in a significant share 30GWp – being taken by the developing world in 2020. Since system sizes are smaller and the population density much higher, it is expected that up to 1 billion people in developing countries would by then be using solar electricity. To achieve this would however, depend on the market development initiative in the public and private sectors of the economies of the developing countries, to foster the dissemination PV systems.

3. THE NEED FOR ELECTRIC POWER SECTOR RESTRUCTURING

Industrialization and improvements in technologies have brought about an increase in the standard of living, particularly within the industrialized countries.

Despite this, there is still a larger population in the rural communities of developing countries without access to proper lighting, clean water, health care and communication facilities. These communities are not grid-connected and may never be connected for economic and other reasons such as;

- Monopoly of generation, transmission and distribution of electric power mostly by government agencies.
- Insufficient capital to expand the utility networks to cover rural areas.
- Mismanagement of available financial resources.
- Inaccessible geographical terrain to rural areas.
- Inadequate manpower for design, installation and maintenance of systems.

Provision of reliable and cost-effective electricity sources in the rural communities of developing countries for the achievement of social and economic empowerment and poverty alleviation is imperative within the context of the global millennium development goals (MDGs). Restructuring of the electricity industry will encourage the availability of reliable and cost-effective power supply in view of the following conditions which will manifest[2].

- Removal of monopoly in power generation, transmission and distribution and the encouragement of competition in power delivery.
- Reliability in power delivery
- Lower energy tariffs
- Increasing the scope for choice
- Incorporation of more energy technologies into the energy supply mix.

4. THE ROLE OF PV IN A DEREGULATED ELECTRICITY INDUSTRY

Among the several energy technologies available, solar Photovoltaics has the potential to meet the electricity needs of rural communities in developing countries in view of the dispersed nature of solar resource which makes PV systems adaptable to distributed power generation. Distributed generation has the following advantages, amongst others.

i) The generator can be sited close to end-users, thus decreasing transmission and distribution costs and electrical losses.
ii) Sites for small generators are easier to find.
iii) They offer reduced planning and installation time.
iv) They offer and environmentally clean and low-noise source of power.
v) From the end-users perspective, power is readily available and likely to be more reliable.

In view of the above advantages, governments and their agencies, electric utilities and stakeholders in the electricity industry ought to consider solar-PV as a very viable option not only for expanding the power system networks and increasing their markets, but also as a means of improving the standard of living in the rural communities. In doing this, however, it is necessary to consider the fact that new and emerging technologies suffer initial setbacks due to constraints which take some time to overcome. For solar-photovoltaic technologies, experiences gathered over more than four decades of field applications and usage have stimulated actions by developed countries to minimize the constraints.

5. CONSTRAINTS OF SOLAR PHOTOVOLTAICS

There are technical, economic, social, political and financial constraints to be minimized or overcome before the dissemination of PV systems can reach a level where they make a substantial contribution to the electricity supply mix of developing countries and an impact on the socio-economic life of the rural populations

5.1 Economic

Although PV systems may be cost-effective on a life-cycle cost basis, their initial costs are high, usually beyond the reach of the poor rural populations in developing countries. A 50Wp solar home system costs about $650 in Nigeria. The statistics on different technology options for distributed power generation is presented in Table 2. It is noted that while a micro-hydro and wind system can be installed for around $1000/kW(2), a PV system can be installed at $6600/kw. These compare unfavourably with an engine generator system with an initial cost of $200-300/kw. The poverty environment in developing countries constrains consumers to procure goods and services based on the initial cost and PV systems are not exempted from this kind of mindset, despite the fact that they may be cost-effective over 20 to 25 years of the lifespan of the module. It is expected, however, that with module price reduction to about $2/w by 2009(3), PV will become more cost-competitive. Also initiatives to provide low-interest loans repayable over several years will go a long way to boost the procurement of PV systems by rural dwellers.

5.2 Technical

Local manufacture of PV modules and most system components is yet to start in many developing countries. Virtually all PV system components are imported at costs which include the high import duties. Enough technical manpower has not been developed to

support the design, installation and monitoring of systems. These deficiencies have often created a wrong impression about the viability of PV systems which have been badly designed, installed and poorly managed.

5.3 Social

A vast majority of the population in developing countries are not aware of the technical viability and commercial availability of PV to meet their electricity needs. The inertia to adopt a new and "untested" technology for electricity supply has prevented the few who can afford to acquire the system from doing so. Also, managers of current conventional electricity generating technologies have often expressed a lack of conviction about the potentials of PV as a viable alternative source of electric power.

5.4 Political

For PV and other renewable energy technologies to be widely adopted, governments have to give their political backing through the promulgation of energy policies with the necessary regulatory framework that would encourage the private sector to invest in PV systems for power delivery. Until recently, countries like Nigeria have not considered PV for power generation partly because of the abundance of other energy resources such as fossil fuels. Others have, because of lack of funds, relied on International donor agencies to provide seed money to stimulate the dissemination of PV systems. Political will is required by government's developing countries to create the right policy, regulatory and market environment that would attract private investors to adopt renewable energy technologies for power generation in a deregulated electricity industry.

5.5 Financial

For many developing countries, financing mechanisms for PV are not available at the moment. There are no subsidies and interest rates are very high, up to 21% or more for Nigeria. Local banks are not willing to give loans to corporate and individual investors in PV because of their lack of conviction on the viability of the technology. Although opportunities for financing exist through facilities such as the World Solar Programme or the Global Environment Facility, the impact of these facilities are yet to be felt in many developing countries.

TABLE 2: Distributed Generation Technology Options

	Engine Generator	Turbine Generator	Micro turbine Generator	Photovoltiac	Wind Turbine	Fuel cell
Fuel	Diesel or Gas	Gas	Gas or liquids	Sun	Wind	Gas
Efficiency %	35	29-42	27-32	6-19	25	40-57
Energy Density (kw/m^2)	50	59	59	0.02	0.01	1-3
Capital cost US$ / kw	200-300	450-870	1000	6600	1000	3000-5000
O&M cost US$/kw	0.01	0.005-0.0065	0.005-0.0065	0.001-0.004	0.01	0.0017
Energy storage required	No	No	No	Yes	Yes	No
Technology Status	Commercial	Commercial	Commercial	Commercial	Commercial	Soon to be commercial

6. POLICY, REGULATORY AND LEGAL FRAMEWORK TO ACCOMMODATE PHOTOVOLTAICS.

With some form of deregulation and bold initiatives, several countries have increased the share of renewable energy sources to the electricity supply sector. In the United States of America, a national strategy was initiated to promote wholesale competition in the sale of electricity throughout the country. This was begun in 1978 when the US congress passed the Public Utilities Regulatory Policies Act which required utilities to purchase power from independent power producers, thus breaking the utility monopoly on generation. This paved the way for developers and marketers of solar energy and other renewables to contract for renewable power delivery into the electricity grid. Government intervention in deregulation was strengthened in 1992, with the passage of the Energy Policy Act which, among other things, broke the utility monopoly hold on transmission access and encouraged regional transmission grids, again of major importance to renewable energy suppliers who need to transmit power from the renewable energy resources sites to the regions of electricity demand (4).

With deregulation, the European Union (particularly Germany) and Japan have also been the main players in the fostering of more positive legal frameworks to enable grid connection of PV systems. India's Renewable Energy Programme is the largest and most extensive among the developing countries of the world. The increased use of renewable energy technologies has been facilitated by a variety of policy and support measures by the government of India.
The India programme is administered by the Ministry of Non-convention Energy Sources (MNES) which has the responsibility of policy formulation, planning, promotion and coordination of various aspects of renewable energy. For the commercialization of renewable energy technologies MNES, in 1987, set up the Indian Renewable Energy Development Agency (IREDA) with a mandate to develop, promote, support and extend financial assistance to renewable energy projects. Since 1989, RE technologies have been promoted

through a favourable fiscal/policy environment. Research and Development, demonstration projects, dissemination projects/programmes are being supported by government subsidies and fiscal incentives such as, income tax holiday, accelerated depreciation, concessional custom duty/duty free import, capital/interest subsidy, energy buyback and sales tax concession/benefits among others(5). These incentives have led to a cumulative installation of 283MW as far back as 1998. Deregulation of the electricity sector in India started in 1991 when the government threw open generation of power to the private sector, thus giving opportunity to many Independent Power Producers (IPPs) to install projects based on both conventional and renewable natural resources(6).
The government of Zambia, through its Department of Energy is currently running a pilot project to develop a mechanism for providing electricity services to rural households. The project was designed to establish a model for providing rural communities with PV electricity services using the concept of Energy Service Companies (ESCOs) through which rural people pay for energy services, not hardware. Through a monthly service fee paid by households, the ESCO would cover the cost of hardware and costs related to service provision. The ESCO would in turn, repay financing provided by the government at the beginning of the project (7).

In line with contemporary global phenomenon, African countries have taken bold initiatives to restructure their electric power sector by relinquishing ownership and management of the establishments/investments for power generation, transmission and distribution to the private sector. Their (government) role now is to provide the regulatory framework, initiate policy and control mechanisms for industry players. A regional power pool being developed in the continent will create the capability for generating and distributing enough power to all the nations in the continent. The New Partnership for Africa Development (NEPAD) is poised to constitute a credible reinforcement to the power sector expansion projects. It is expected that the deregulation in the power sectors in Africa will attract investments to harness the abundant solar energy sources in the continent, to meet the electricity requirements of the rural communities, through the application of PV and other renewable energy-based systems.

7. DEREGULATION IN THE ELECTRICITY SECTOR: *NIGERIA'S EXPERIENCE*

The electricity power reform bill of Nigeria, passed in 2005, has the potential to revolutionize the electricity sector through the liberalization of electricity generation to accommodate renewable and other sources of energy. The bill seeks to, among other things, provide for the formation of companies to take over the functions, assets, liabilities, and staff of the National Electric Power Authority; develop competitive electricity markets, establish the Nigerian Electricity Regulatory Commission; provide for the licensing and regulation of the generation, transmission, distribution and supply of electricity.

The way for the privatization of the National Electricity Power Authority has been paved by the unbundling of the generation sector into seven Business Units or Generating Companies (GENCOS). In the first and second quarters of 2004, the Distribution/Marketing and the Transmission/Operation sectors had earlier been unbundled. The privatization of these shadow generation, transmission and distribution companies and the licensing of new companies will boost rural access to electricity (8).

One major provision of the Electric Power Sector Reform Bill is the establishment of a Rural Electrification Agency (REA). The Agency and the Nigerian Electricity Regulatory Commission shall be involved in the formation of a sustainable and coordinated Rural Electrification Strategy and Plan which shall provide for the following:

i) The expansion of the main grid
ii) The development of isolated and mini-grid systems and
iii) Renewable energy power generation

It is provided that the REA shall set up a Rural Electrification Fund (REF). The purpose of the fund shall be to promote, support and provide rural electrification programmes through public and private sector participation in order to:

i) Achieve more equitable regional access to electricity;
ii) Maximize the economic, social and environmental benefits of rural electrification subsidies;
iii) Promote expansion of the grid and development of off-grid electrification;
iv) Stimulate innovative approaches to rural electrification.

These initiatives provided in the bill are expected to stimulate the adoption of the PV and other well dispersed renewable energy sources, first for decentralized power generation in rural areas and subsequently for grid connected power generation for urban and rural consumption.

In November 2005, a Renewable Energy Master Plan (REMP) drawn up for the country was presented to stakeholders in the electricity sector. The master-plan provides electricity generation targets for PV, wind, solar-thermal, small hydro and biomass. For PV, the targets set in the short, medium and long term are shown in Table 3(9).

Table 3: Target for Electricity Generation from PV

Time Frame	**Year**	**MW Capacity**
Short Term	2007	5
Medium Term	2015	75
Long Term	2025	500

The implications of the targets are presented in Table 4

Table 4: Implications of REMP targets for PV

System	Number of systems installed		
	2007	2015	2025
Solar Home Systems	40,000	400,000	4,000,000
Water Pumping	2,500	37,500	250,000
Community Service	50	1,500	10,000
Street & Traffic Lighting	10,000	100,000	500,000
Large-Scale PV plants	-	30	50

The target set in the REMP would only be achieved when the policy, regulatory and financing mechanisms set out in the Electric Power Sector Reform bill are vigorously pursued.

Conclusion

For several decades, electricity generation, transmission and distribution in developing countries have been monopolized by agencies, mostly controlled and funded by governments. These agencies, for lack of adequate funding, mismanagement and other reasons, have not been able to provide adequate and reliable services, and for most rural areas, no services at all. Several developing countries have taken bold initiatives to restructure their electric power sector, with remarkable improvements in the availability and quality of electric power supply. The experience of India, through the Indian Renewable Energy Agency has shown that renewable energy resources, and in particular, solar Photovoltaics, have the potential to meet the electricity needs of developing countries in a deregulated electricity industry. Several constraints exists which hinder the dissemination of PV systems but these can be surmounted through policy, regulatory and financial provisions and the political will to achieve the millennium development goals, through the adoption of environmentally friendly technologies for electricity generation.

References

1. **Casazza J. A., Boudreaux G.** (2000); "Institutional Arrangements For Restructuring - The Case for Cooperatives", Proc. of the 4th International Conf. on Power Systems Operation and Planning; Accra, Ghana, P. 19-22

2. **Petrie E. M., Willis H. L., Takahashi M.** (2001). "Distributed Generation In Developing Countries, "Cogeneration and On-Site Power Production. Vol. 2, 5 P.41-49.

3. European Photovoltaics Industry Association, Technology Development, EPIA Roadmap, P.22

4. **Aitken D.,** Overcoming obstacles: Utility Restructuring, Sunworld, Renewable Energy And The Environment, Vol. 20, Number 4; P. 4-5

5. **Bakthavatsalam V.,** Renewable Energy Financing –An India View, In Financing Renewable Energies:Windows of opportunities, European Renewable Energy Association P. 56-61

6. **Bakshi R.,** (1999), Financing Renewable Electric Technologies in Developing Countries – An India View, In Financing Renewable Energies: Windows of opportunities, European Renewable Energy Association. P. 63.

7. **Kalumiana O. S.,** (2002) Promoting Solar Home Systems in Rural Areas of Zambia-A Case Study; World Renewable Energy Congress VII (Book of Abstracts) P. 775.

8. **Udom E.E., Omotomilola T**.; "*Private Sector Investors will Boost Rural Access to Electricity"*; NEPA News, March 2005, p.1-2

9. Energy Commission of Nigeria and United Nations Development Programme (2005), "*Targets, in Renewable Energy Master Plan (Draft Copy)*"; p.112 –121.