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Present Situation of Solar Photovoltaic (SPV) Electricity in Different Countries

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Abstract

Alternative source for rural electrification is essential at this moment due to the want of conventional energy system. In this paper, a broad discussion has been presented on rural electrification, giving emphasis on the existing systems in developing countries as well as some developed countries like Japan. Different projects are reviewed, along with early implementation experience. Some recommendation for photovoltaic (PV) installation for rural electrification has also been outlined in developing countries for future improvement.

Introduction

Developing countries are presently experiencing unprecedented demand for energy to improve their condition. 2 billion people around the world are still without any access of electricity. A vast majority of these live in rural and remote locations in developing nations. Photovoltaic (PV) technique is emerging as an effective alternative to grid supplied electricity in many applications among which rural electrification is the most popular. However, there are a number of barriers which hinder the widespread use of PV system in rural areas. There are some technical problems and some non-technical issues which include institutional, social and cultural. As an infrastructure development program, rural electrification is supposed to have multifarious and far-reaching impact on the rural economy in general. Rural electrification is supposed to widen the productive sphere of the rural economy.

World Bank Solar Household System (SHS) Projects

Twelve World Bank Group projects [Eric *et. al.* (2000)] provide basic 'energy services' such as lighting, radio, television and operation of small appliances to rural households without access to electricity grids through the use of solar home systems (Table 1).

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Table 1. World Bank Group Projects With Solar Home System (SHS) Components

Project Name (Bank approval date)	Finance GEF	Bank	SHS component description
India Renewable Resources Development Projects (1992)	26	190	2.5 MWp of PV in various applications, (commercial, water pumping & SMS)
Small & Medium Scale Enterprise Program in Vietnam, Bangladesh & Dominican Repub. (1995 by IFC)	1.6	.....	Finance commercial SHS business ventures
Indonesia SHS Project (1997)	24	20	200,000 SHS sold & installed by private dealers/entrepreneurs
Sir Lanka Energy Services Delivery Project (1997)	5.9	24	30,000 SHS sold & installed through dealers & microfinance organizations
PV Market Transformation Initiative in India, Kenya & Morocco (1998 by IFC)	30	.....	Finance commercial SHS business ventures
Lao PDR Southern provinces Rural Electrification Project (1998)	0.7	1.5	20 solar battery charging stations by national utility & village electricity associations
Argentina Renewable Energy in Rural Markets Project (1999)	10	30	66,000 SHS in households through regulated energy-service concessions
Cape Verde Energy & Water Sector Reform & Development (1999)	4.9	1.8	4,000 SHS in households through regulated energy-service concessions
Solar Development Group (1999 by IFC)	10	6	Finance PV-regulated businesses & provide technical assistance & business services
China Renewable Energy Development (1999)	35	100	10 MWp of SHS & PV –wind hybrid systems installed thriugh private dealers
Benin Off-Grid Electrification (under preparation; GEF grant approved in 1998)	1.1	2.2	5,000 SHS through regulated energy-service concessions
Togo Off-Grid Electrification (under preparation; GEF grant approved in 1998)	1.1	2.2	5,000 SHS through regulated energy-service concessions

'Note amounts (in million USD) are for project: most project: contain other components besides SHS. Total project costs are often much greater than amounts shown, as recipient governments and other donors provide funding [*Eric et. al. (2000)*].

Most projects are just beginning implementation, none are yet completed. Five leading projects in Bangladesh, the Dominican Republic, India, Srilanka and Vietnam have installed approximately 8000 systems. Installation targets from all projects could total more than 500,000.

Case Studies for Different Countries

Bangladesh: In Bangladesh only 15% of the total population has got access to the electricity [Ministry of Energy & Mineral Resources, Bangladesh (1999)]. The electricity sector in Bangladesh is handled by three state-owned agencies and Rural Electrification Board (REB) is one of them which is concerned with the rural areas where about 85% of its population live. REB has implemented a PV program in a reverie area for 750 customers. It provides various types of systems: lantern, stand-alone home solar systems and battery charging facilities from central charging stations. The rural cooperative society of REB, the *Palli Biddut Samity (PBS),* acts as the Energy Services Company (ESCO). PBS owns the systems and the customers pay monthly fixed energy bills. Student show [Alamgir (1999)] that customers prefer stand-alone solar home systems, especially systems of 46 wp or more, as against charging facilities and lantern.

Another specialized renewable company in the non-government sector is Grameen Shakti (GS). They provide finances for purchase of solar home systems (SHS). Typically a customer pays a down payment of 25% of the price of the system and the remaining amount is paid within two years in monthly installments including a service charge of 8% on outstanding credit. Up to November 1999, GS had 1651 solar home systems and the installed capacity was 79.14 KWp [Alamgir (2000)]. GS usually opens an office in remote areas where either there is no grid power or coverage is very low. It has been found that easier financing is key to the growth of PV system use in rural areas where income of the various obstacles for expansion of PV program in rural Bangladesh, high cost of PV module is the main. The other major obstacles of rapid expansion of PV systems is lack of awareness about it, lack of adequate fund at reasonable cost of the PV systems providers, etc. Training programs were conducted by GS for technicians as well as their customers who own SHSs — already trained 200 technicians under its PV program.
Bangladesh government has provided a number of fiscal incentives who are engaged in renewable energy sector. Following are the important remuneration [Ministry of Energy & Mineral Resources, Bangladesh (1999)]:

a. Any renewable energy sponsors whether government, private (foreign or local), NGOs shall be exempted for corporate income tax for a period of 15 years from the date of commercial operation.
b. 100% depreciation in the first year for solar PV, solar thermal, solar ovens projects.
c. The sponsors will he allowed to import plant and equipment without payment of customs duties, VAT (Value Added Tax) and any other surcharges.

India: The Electricity Board of India claims that it covers electrification in her 82% rural areas. But the fallacy lies in the fact that most of the tube wells even today remain inoperative because of non- supply of electric power [Aich (1999)]. So the acceptance level of solar electricity in India is very high. Corporation of the USA proposed a 150 MW solar PV project with the Indian Government. Also even after absorbing all of its local manufacturing output, India alone has imported 50000 solar panels of 70 watts each from Showa Solar of Japan [Trouchet]. These show the interest of India for photovoltaic systems. India offers a very lucrative market for solar PV

devices and systems. There are more than 52 local industries involved in the manufacturing of solar cells, modules and balance of the systems (BOS). The Government offers a special subsidy for the installation of solar systems. It has announced a scheme for grid support (T&D) systems. Under this scheme the Ministry of Non-conventional Energy Sources (MNES) envisages [Dilawar (1996)] the following targets to be achieved by the year 2002 (Table 2).

Table 2. Solar PV Target of Government of India

Sl. No.	Type of System	Nos.	Capacity
1	Solar Home Systems	1,000,000	120 MW
2	Solar Lanterns	1,000,000	
3	Pumping Systems	40,000	
4	Power Sources for Rural Radio Telephones	300,000	
5	Medium/High power Grid Connected Systems (up to 100 KW)	10	
6	Hybrid Systems	-	80 MW
7	Site Specific Programs	-	
8	Domestic Power Packs for Urban Areas	-	
9	PV Installation in Factories, Resorts, Farm Houses etc.	-	
		Total	**200 MW**

India has set-up the Ministry of New and Renewable energy . India is producing more power from renewable energy under the supervision of this ministry.

Nepal: Nearly 80% of the Nepali citizens do not have access to grid electricity. Very difficult terrain and scattered settlement makes centralized grid supply to all the population in Nepal very difficult PV technique is deemed to be one of the most appropriate means to provide electrical energy in remote areas in Nepal. Solar Electric Light Fund (SELF) of USA initiated stand-alone. PV solar home system (SHS) in Nepal in late 1993. The current status of use [(2000)] is given in Table 3.

Table 3. PV Application in Nepal

Organization	Peak Power (KWp)	No. of Installation	Application
Nepal Telecom	745	3000+	Rural Telecommunication
Nepal Electricity	130	3	Rural Electrification
Civil Aviation	20	45	Remote Airports
Security (Police & Army)	30	8	Telecommunication
Water Supply	56	8	Water Supply
Private Consumer	100	2000+	Household Electrification
Total	**1081**	**564+**	

On October 10, 2010, Gham Power, A Nepali Solar Company participated in the “10-10-10 350 ppm” event organized at Bhaktapur Durbar Square- “A Day to Celebrate Climate Solutions” - collaborating with Saurav Dhakal of Nepal Info Park, and also Storycycle.com (Online Platform), British Council (Supporter), and Planet Green Nepal (Local Partners).

Indonesia: Since 1987, the government has installed more than 16,000 SHSs in remote villages on Java, Sulawesi and other islands. After being used for 11 years, most of the PV modules are still in good condition [Djamin (2000)]. AusAID funds of 13 million dollars linked with a soft loan from EFIC will potentially enable the government to install 33,400 additional SHSs in eastern Indonesia. Further, under a World Bank/GEF project 200,000 SHSs is on the way of installment. The estimated cost of this project is $72 million [Dilwar (1996)1. The report helps to comprehend the solar cell industry and the regulatory framework regarding the solar market in Indonesia. It offers interesting results on the market share of the top manufacturers in the Indonesia solar cell industry.

Srilanka: The 4,500 systems installed since 1982 serve a small portion of the 2 million households without access to grid-based electricity services. A $30 million Srilanka Energy Service Delivery Project is being funded by the World Bank [Eric *et. at.* (2000)]. This project is designed to encourage the participation of the private sector, NGOs and co-operatives in provision of grid- connected and off-grid renewable energy services, support development of a demand side management (DSM) strategy and strengthen the public and private institutional capability to deliver energy services through renewable energy technologies and DSM. Under this project 30,000 SHSs are now on the process of installation. Nikini Automation Systems,A Sri Lankan company has told **PV magazine** it has made Sri Lankan history by becoming the country's first company to enter into a net metering agreement for its solar photovoltaics (PV) system. The company also called on Sri Lanka's businesses to make PV a part their corporate activities.

Philippines: The dissemination only just of SHS in the Philippines has been dominated by two rural PV electrification programs assisted by BMZ/GTZ. Moreover, more than 10 local private companies sell 100- 200 units annually. Under Australian Aid, a solar PV project of appropriate value of $90 million had been planned.The present situation of SPV in Different Countries are given in table 4 in the next page:

Table 4: PV Application in Different Countries.

Solar Power Projects In Progress	Capacity	Completion Date
Abertura FV Solar Photovoltaic Project, Spain – PV	20MW	2008
Almeria Photovoltaic Park, Spain – PV	15.4MW	2008
Sinan Power Plant, South Korea – PV	20MW	2008
Solar Villar De Canas 2, Spain – PV	9.5MW	2008
Ocean City $4M Solar Energy Project – PV	540kW	2008
Waldpolenz Solar Park – PV	40MW	2009
Solana Generating System Solar Power Plant – CSP	280MW	2011
Solar Energy Plant in Mendota California – PV	5MW	2009
Whyalla Power Plant, Australia – CSP	TBC	2009
Yingli Power Plant, Beijing – PV	10MW	TBC
Pennsylvania Solar Park	10.6MW	2009
Solar Tres Power Tower, Spain – CSP	17MW	TBC
Andasol 1, 2 and 3, Spain – CSP	150MW	2010
Shams 1 Project, Abu Dhabi – CSP	100MW	2010
Hawaii Planning 34 MW of Solar Energy – PV	34MW	2010
Cloncurry Solar Power Plant, Australia – CSP	10MW	2010
Sarnia Solar Project, Canada – PV	80MW	2010
Mojave Solar Park, USA – CSP	553MW	2011
Ivanpah Solar Electric Generating System, California – CSP	400MW	2011
Kings River Conservation District Solar Plant	80MW	2011
Solar Systems Solar Power Plant in North West Victoria	154MW	2013
Carrizo Energy Solar Farm, San Luis Obispo, California – CSP	177MW	2012
Stirling Energy Systems, Victorville California – CSP	500MW	TBC
Asharim, Negev Desert Power Plant, Israel	250MW	TBC
Coventry Solar Farm, Rhode Island	8MW	2013

Vietnam: After two decades of PV development, solar electricity is fast becoming a practical alternative to grid supplied electricity in 'Vietnam. During 1989-1999, about 65 solar stations and solar villages have provided solar electricity to over 3000 families in rural and remote mountainous regions of Vietnam. Since 1990, Solar Lab has played a key role in the development of PV in Vietnam and the total capacity of these installations now exceed 100 KWp [Dung (2000)].

In Vietnam, they established a partnership with the Vietnam Woman's Union that effectively organized credit programs and trained women in solar installation.
Many Vietnamese expected to get electricity free from the government, and could not understand why they had to pay for solar electricity. But women, the main beneficiaries of electricity in the home, and who handle household expenses in Vietnam, quickly came to understand the market economy.

Japan: In fiscal 1999, the Japanese government decided to provide 16 billion yen in subsidies to users of home solar power generating systems that will produce about 50 MW in the home PV power generating system market [Kuwano *et. al.* (2000)].

Policy Changes Trigger Resurgence of Japan's Solar Market- November 2010: SEPA annually leads a group of utility leaders on a fact-finding mission to learn how solar markets are developing in different parts of the world. In July 2010, SEPA traveled to Japan to study the experience of Japanese utilities and industry in integrating large amounts of distributed photovoltaics (PV) into the grid, to explore the solar research initiatives being undertaken by the Japanese government and its research bodies, and to investigate Japan's solar policies, and the effect of those policies on the commercialization of solar technologies. The key takeaways from the SEPA fact finding mission are explored in this report.

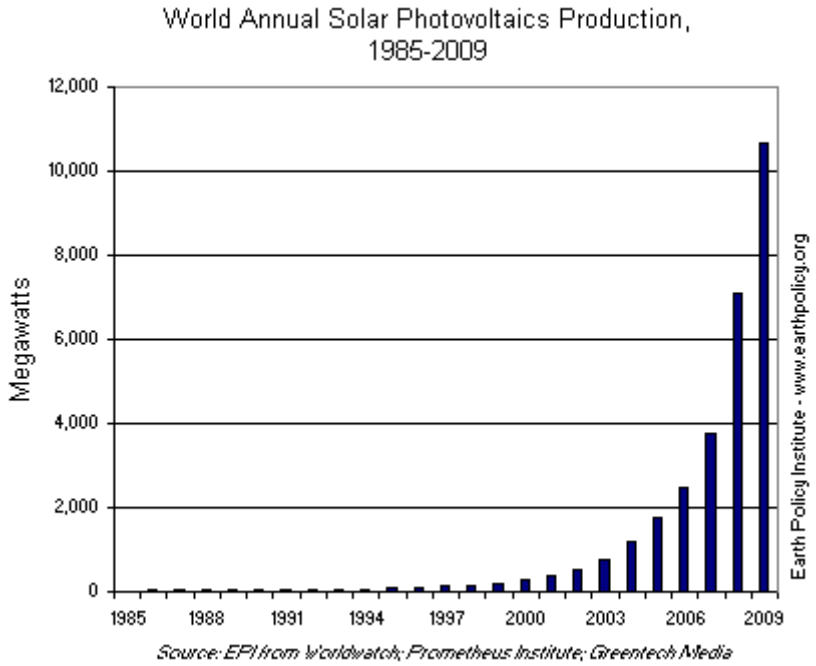
China: It produced 3,800 megawatts of PV in 2009, leading all countries for the second straight year. Together China and third place Taiwan accounted for 49 percent of all PV manufacturing, a share that should keep climbing as companies there grow larger and more quickly than competitors based in countries where operating costs are higher. Rounding out the top five producers in 2009 were Japan in second place, Germany in fourth, and the United States in fifth. (See data.) These traditional industry leaders have lost significant market share with the recent ascent of China and Taiwan. Indeed Japan, which dominated the global market in 2004, controls just 14 percent today.

Status of other countries: Asian Institute of Technology (AlT) in Thailand has a great contribution in the rural electrification project in Thailand. The current installed PV capacity in Thailand is of the order of 4 MW. In China, it is estimated that more than 600,000 households are under SHSs installation. Here grants provide equipment and training to create a national PV testing arid certification center [Martinot *et. al.* (2000)]. In the past 15 years, several PV systems have been installed at a variety of sites in the Caribbean region. 70% rural area of Combodia has no electricity facilities PV systems have been installed in Combodia since 1997.

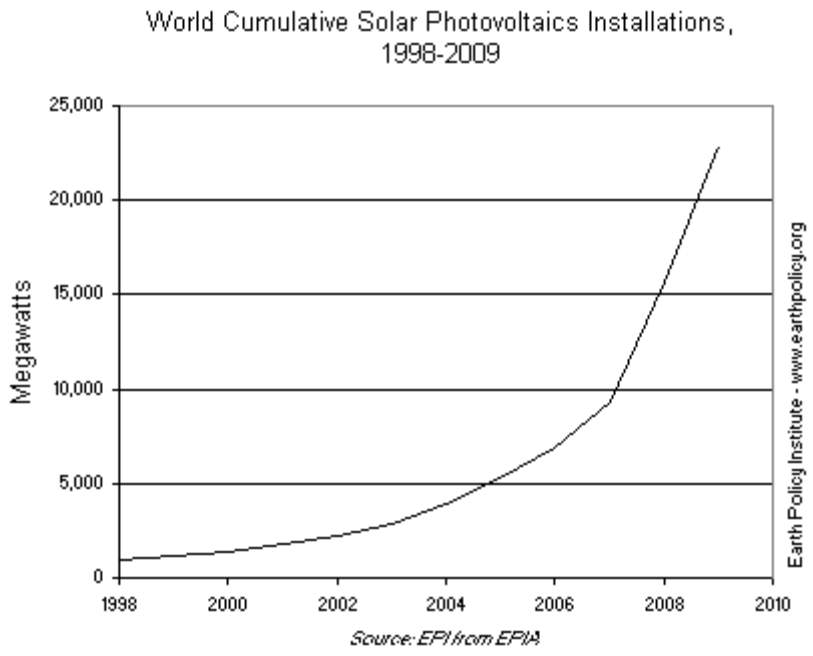
Likewise the Government of Pakistan, Pacific Islands. Fiji, Nigeria, Mongolia, Argentina Jordan, Algeria, Brazil, Amazon Rain Forest, many countries of Sub-Africa are keen to promote the use of solar PV technology in their soil. Definitely the potential is enormous but these countries do not have their own financial power to commit for the PV market.

Solar photovoltaic (PV) cell manufacturers produced a record 10,700 megawatts of PV cells globally in 2009—an impressive 51-percent increase from the year before. While growth in 2009 slowed from the remarkable 89-percent expansion in 2008, it continued the rapid rise of an industry that first reached 1,000 megawatts of production in 2004. By the end of 2009, nearly 23,000 megawatts of PV had been installed worldwide, enough to power 4.6 million U.S. homes. Solar PV, the world's fastest-growing power technology, now generates electricity in more than 100 countries.

The world annual Solar Photovoltaic Production is given by the following:



World installed PV capacity has grown 16-fold over the past decade in large part due to government incentives encouraging the use of solar power. Although PV production and installation costs have fallen substantially over time, government support will be necessary until solar reaches grid parity (price competitiveness) with heavily subsidized fossil fuels. Incorporating fossil fuels' largely externalized costs, such as climate change and pollution-related illnesses, into the price of fossil-generated electricity would further accelerate PV's march to grid parity.



Recommendation

The above discussions lead to the following recommendations for the improvement of rural electrification using photovoltaic technology. The organization should conduct consumer awareness and marketing programs; e.g., the Indian project has been conducting promotional campaigns for PV technologies in the media. The Sri Lankan project has conducted village-level workshops throughout the country to promote the solar home systems [Headley (2000)]. PV system marketing organizations also should develop more flexible and easier financing scheme for the system buyers. Government should give more financial incentives to private and non-governmental organizations so that they can come forward with broad sector for the remote and rural areas. Moreover, the developed countries should allow more fund for this purpose and side-by-side they must take care so that the fund is really used because of the massive mishandling in most of the developing countries.

Presently the need is to make these programs a people-oriented program and make them sustainable offering, suitable software for design manufacture and O&M services after installation. Villages in the third world lie in such a micro-world for which the scenario of energy planning is still unclear. This is a challenge that has to be faced with confidence and vision.

Conclusion

To resolve the environmental problem facing us today and to live comfortable lives in the next century, we must build a global PV power generating system using solar cells. For this purpose, the application of solar cell to houses and buildings is of primary importance as the first step. PV technique in many countries, especially in rural areas, is still immature. For successful marketing of such a technique, a strong dissemination program is needed.

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