CHAPTER I

INTRODUCTION

Rural electrification programs in many countries have met with varying degrees of success, but many other countries do not have such a program yet. With approximately 3 billion people living in Asia and the Pacific region, representing huge 46 per cent of global total population. The rural areas are generally characterized by a high population growth rate, inadequate infrastructure and social amenities, low levels of economic activities resulting low income, and concentrated poverty. For example, about three quarters of the total population in Bangladesh, China, India, Indonesia, Nepal, Papua New Guinea, Sri Lanka and Thailand live in rural areas. Table 1 shows the total population and percentage of urban and rural population of some of these countries. In the region, 80 percent of total energy consumption comes from fossil fuels used in conventional ways, which have significant impacts on the local and global environment. About 33% of the world's populations are still without access to electricity. Nearly 50% of the world's population still relies upon traditional sources of fuel such as biomass, and it is associated with inefficient combustion technologies contributing heavy indoor air pollution. As illustrated in Table 2, rural population's access to electricity is still very low and per capita energy consumption in these countries still very low compared to some of the rapidly developing countries in the region. One option to the high cost of developing electric power plants and extension of grid to rural areas is to install Photovoltaic (PV) systems. The advantages of PV are its modularity, easy operation, high reliability, and no fuel requirements, making them very desirable for rural electrification projects. For example in French Polynesia, 30,000 - 40,000 people live on the outer islands, separated by hundreds of miles of rugged terrain. Centralized generation is impossible; fuel delivery and servicing make diesel generation impractical. Since 1981, the South Pacific Institute for Renewable Energy has electrified nearly 2,500 homes on 23 different island using individual PV systems.

Table 1 Population Data of some countries in Asia

Countries	Total population Mid-2005 (Millions)	Rate of natural increase (%)	Urban population (% of total population)	Urban population growth rate (%)	Rural population (% of total population)	Rural population growth rate (%)
Cambodia	13.3	2.2	15	5.0	85	0.7
Lao PDR	5.9	2.3	19	5.6	81	0.5
Nepal	25.4	2.2	14	5.4	86	0.4
Myanmar	50.5	1.8	29	3.1	71	0.6
Pakistan	162.4	2.4	34	4.3	66	0.6
Sri Lanka	19.7	1.3	30	2.3	70	0.6
Thailand	65	1.0	31	2.3	69	0.4
Vietnam	83.3	1.6	26	2.0	74	0.8

Source: Energy Service for Sustainable Development in Rural Areas in Asia and Pacific, Economic and Social Commission for Asia and the Pacific, Energy Resources Development Series No. 40, 2005, page. 8.

The 1997 Asian economic crisis has suspended or diminished the activities of many government-subsidized programs. Rural electrification programs are no exception of this. As commercial markets for PV rural electrification have not been developed, there are now few new installations taking place. In existing installations where demand has grown up, there are no mechanisms to overcome the significant cost barriers to increase the system capacity. The shrinking government budgets may now be forcing policy-makers to turn to new market-based approaches with less dependency upon government support.

Table 2 Electricity services in South and South-East Asia: 2002

South and South-East Asian countries	Electricity consumption (billion kWh)	Percentage of population below poverty line	Percentage of population below US$1	Percentage of population below US$2	Electrification levels (%)	Per capita energy consumption (kWh)
Bangladesh	11.87	35.6 (1996)	29.1	77.80	30	89
Bhutan	Na	Na	Na	Na	11	Na
India	391.65	26.10 (2000)	44.20	86.20	46	379
Indonesia	73.70	27.1 (1999)	7.70	55.30	67	345
Malaysia	58.87	15.5 (1999)	Na	Na	90	2,474
Maldives	Na	Na	Na	Na	62	Na
Nepal	1.11	42.0 (1996)	37.70	82.50	15	47
Pakistan	45.41	34.0 (1991)	31.00	84.70	55	321
Philippines	34.97	40.0 (2001)	Na	Na	87	454
Singapore	27.25	25.0 (1996)	Na	Na	Na	6,641
Sri Lanka	5.01	Na	6.60	45.40	50	255
Thailand	82.79	13.1 (1992)	2.00	28.20	97	1,352
Vietnam	20.04	50.9 (1993)	Na	Na	58	252

Source: Energy Service for Sustainable Development in Rural Areas in Asia and Pacific, Economic and Social Commission for Asia and the Pacific, Energy Resources Development Series No. 40, 2005, page. 102.

The large market distortions may make it difficult to move to a market-based dissemination program. Villagers who are interested in moving from PV battery charging stations to a higher level of electricity service may be stymied by the fact that their current costs (for new batteries) in the subsidized Battery Changing Station (BCS) are only 1% of the costs of commercial Solar Home System (SHS). Another factor which may make the cost of a SHS less attractive in rural electrification is that the distribution utilities rural electricity prices are cross-subsidized by urban electricity prices. Because of the subsidies for rural users on both sides of the SHS market, completely commercial dissemination of SHS faces large barriers.

As Thailand is mainly composed of one main island, extension of electricity grid was fairly easy. Figures for the extent of rural electrification vary, but grid availability appeared widespread with over 99% of villages connected to the grid and 86% of rural households electrified. The needs of decentralized electrification are therefore restricted to isolated communities where village cooperatives tend to own any generating facilities with supports from the Department of Pubic Works and the Department of Alternative Energy Development and Efficiency (DEDE) former Department of Energy Development and Promotion.

The major organization governing electricity generation and distribution is the Electricity Generating Authority of Thailand (EGAT); whereas, Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) are responsible for supplying the electricity to Bangkok metropolis and its vicinities and provinces respectively. EGAT has a program to develop alternative energy sources, including wind, geothermal and fuel cells. The company already has installed approximately 70 kW_p of PV, mainly for commercial applications (e.g. communication repeaters and navigation aids), but still is reportedly considering large scale PV installations (centralized PV power plants connected to a grid) in future plans. Thailand also has considerable hydropower potential - estimated at 8 GW – but large-scale dam construction is continued to prove controversial, making further hydro capacity expansion unlikely impossible to implement beyond the ones that were already being planned. There are some potential small hydro power plant projects in the mountainous Northern provinces, and wind energy potentials in southern coastal areas.

National Energy Planning is the responsibility of the National Energy Policy Committee (NEPC), which governed strategies for electricity generation, energy conservation and development of alternative energy sources. DEDE was responsible for overall rural energy matters, even though rural electrification is the responsibility of the Provincial Electricity Authority (PEA). There is a New & Renewable Energy Program under the Energy Conservation Program, which recognized that renewable energies are expected to play a major role in the future Thai energy economy. Under this program, investment subsidies of between from 20% to 60% are available to the organizations for pilot projects, project preparation and management, program marketing, training, and after-sales service and maintenance. The projects must satisfy the eligibility criteria which are based on a calculation of internal rates of return – projects with an internal rate of return of less than 9% are considered not be to eligible for subsidy.

Most PV projects in Thailand were initiated independently by government departments, resulting over 90% of Thailand's installed PV capacity were being government funded. DEDE has utilized PV for battery charging station program under the sixth Five-year Plan and committed itself to install PV in 50–100 villages per year. PWD has also undertaken some PV water pumping projects. The Ministry of Public Health, Ministry of Education, Royal Irrigation Department and Royal Agriculture Program have each used PV for various applications including water pumping, health care centers and schools. For example, the Ministry of Education had installed 20 kW_p in remote primary schools using locally manufactured modules.

In Thailand, PV systems applications for electrification, such as central PV power plants for rural areas and roof –top grid-connected systems for urban households, are not economically viable based on current economic conditions.

At present, the government is supporting the PV industry through the large programs being implemented by PEA, DEDE, EGAT and other government agencies.
PV is already competitive for some small applications like lighting, television and water pumping etc. in remote areas. During the next few years, PV will be more acceptable in

those remote communities which cannot be served by the Rural Electrification Program through grid extensions.

Even though, Photovoltaic for electrification may not always be economically viable depending upon the difficult geographical conditions and scattered rural settlement far away from the grid lines, but it still could provide a very valuable service to people living in remote unelectrified areas with no hopes of grid connection in the medium and long terms. The progress of these areas would ultimately contribute to the continued economic and social development of the country.

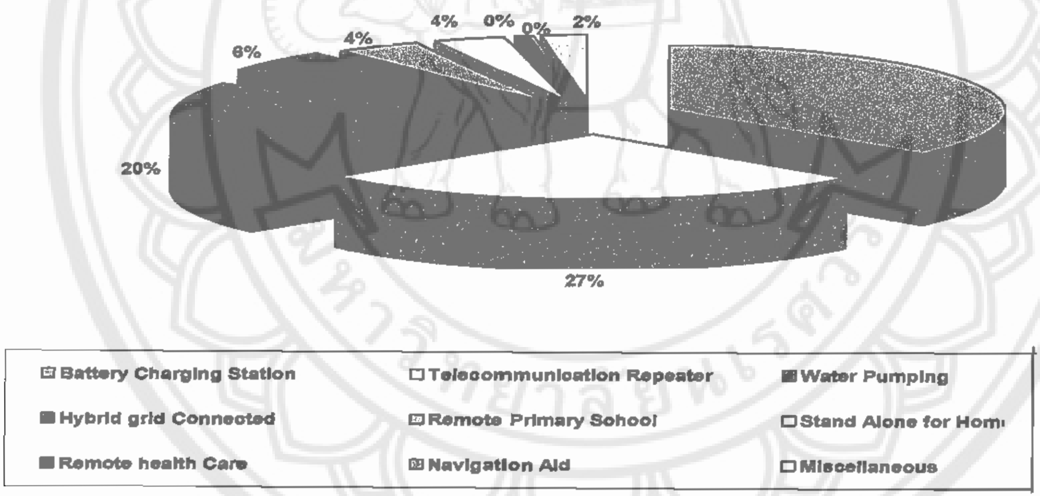

Figure 1 The Photovoltaic System in Various Applications in Thailand

Source: Department of Alternative Energy Development and Efficiency, 2001.

1.1 Rationale for the Study

The lack of provision of electricity to rural areas derives important social and economic benefits to remote communities throughout the world. Lack of electrical power supply to remote houses or villages deprives the electrification of the health care facilities, irrigation and water supply and treatment systems are just few examples of to mention here.

The potentials of PV powered rural applications are enormous. The UN estimates that two million villages within 20 of the equator have neither grid electricity nor easy access to fossil fuel. It also estimates that 80% of all people worldwide do not have an access to electricity, with a large number of these people living in climates, where it ideally suited to PV applications. Even in Europe, several hundred thousand houses with permanent occupations (and not yet considering more holiday homes) do not have access to grid electricity.

The economics of PV systems compares favorably with the usual alternative forms of rural electricity supply, grid extension and diesel generators. The extension and subsequent maintenance of transmission lines over long distances of often a difficult terrain is expensive, particularly if the loads are relatively small. Regular fuel supply to diesel generators, on the other hand, often present problems in rural areas, in addition to the maintenance of the generating equipment.

However, the demand for electricity is expected to double within the next 10 years while the construction of conventional electricity plants will become increasingly difficult. Data from the Public Work Department indicates that there are 1,000,000 households in remote areas which do not have access to electricity supply. They are situated far from the grid distribution line of the PEA. Some villages located deep within the forest are difficult to access and are unsuitable for grid extension. Effective from 1997, a new constitution stipulates that any equity infrastructure provided to the people must not have negative impacts to their lives and living environment. The Photovoltaic System is available for solving the above problems.

In country having many villages that can be electrified either by stand alone systems or by urban grid extensions, there must be a mechanism to determine which electricity authority should provide services. Often the decision as to which form of electrification prevails is one of chance and opportunity seized by competing grid based and stand-alone based electrification authorities. This should not be the case. The determination should be made by the government department overseeing the two electricity authorities and should be based on a balanced consideration of many factors.

1.2 Statement of the Problem

Most rural electrification policies and programs have focused on connecting rural areas to the grid. However, grid-supplied electricity is not always the least-cost option, so planners need to consider other possibilities.

Thailand is considered a success story and its grid-based rural electrification program, which began in 1974, has increased the number of electrified villages from 20% to a current 99%. Its success is created to careful expansion planning, efficient billing, a cross-subsidizing rate structure designed to charge large users higher amounts than small users, responsiveness to customers and good marketing program. However, despite such widespread access, in 2002 is 99% of households were electrified; grid extension alone then does not ensure that all will have the ability to access that electricity. Thus, the government concerns for planning a rural electrification development for grid extension accessibility while they are facing obstacles of high investment and social constraints. Extending an electricity grid to households in rural areas can cost seven times more than for grid electricity in urban areas. Promising new approaches to providing electricity services to new rural customers far from the grid are beginning to emerge. The 1% left of household is very challenging to renewable energy especially photovoltaic.

To determine how the photovoltaic system fits into the overall electricity sector and what the best economic approach to rural electrification would be for Thailand. The suitable for remote areas and non-electrified villages is very necessary to provide basic need for people.

1.3 Purpose of the Study

1. To determine the suitable photovoltaic systems for rural electrification in Thailand
2. To study the energy and economic evaluation model of photovoltaic systems for rural electrification in Thailand
3. To study the socio-economic impact of the PV rural electrification

1.4 Scope of the Study

There are 3 major types of photovoltaic systems, which have been successfully used for rural electrifications. The advantages of each photovoltaic system will be illustrated in this research by benefit – cost evaluation method and environment impact under the same condition of electricity supplied by each of the following systems:

1. Stand -alone Solar Home System
2. Battery Charging Station
3. Centralized Mini-Grid

An intra-comparison of these systems compared with the Diesel Generator. Data from interview end-users were collected from the system installation sites around Thailand based on purposive samplings. The whole point of a model is to give a simplified representation of reality. The model system will be optimizing simulated for 1% of un-electrification household.

1.5 Benefit of the Study

1. The research would play key role for government's investment decision making for rural electrification and would guide in selecting suitable PV system for different geographical rural areas.

2. With the availability electricity to rural people from photovoltaic system; provide basic needed of electricity for lighting and news for people who live in un-electrified area where PEA Grid can not access.