* Opportunities in Renewable Energy Business in South-East Asia: The case of Solar Photovoltaics and Solar Drying

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1. Introduction

Renewable energy is expected to play a larger role in the near future in view of the emerging problems of climate change due to the emission of green house gases. The yearly emissions of greenhouse gases by the developing countries is expected to catch up to that of the advanced countries around 2030 and by around 2100, the cumulative contribution of the developing countries is expected to reach 50 percent of the total (**Charles Weiss**, 1998).

The Kyoto protocol to the United Nations Framework Convention on Climate Change (UNFCCC) sets clear guidelines on aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases (GHG) with a view to reducing their overall emissions by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012 (**Kyoto Protocol**, 1997). The protocol calls for the formulation and implementation of cost-effective national and, where appropriate, regional programmes, to the extent possible, to improve the quality of local emission factors and to mitigate climate change. Clause 1(a), (iv) & (v) of Article 2 of the convention (**Kyoto Protocol**, 1997) calls for the implementation and elaboration of policies and measures:

(i) in the research, promotion, development and increased use of new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies; and
(ii) in the progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and application of market instruments.

The protocol (vide Article 3) establishes emissions trading, joint implementation between developed countries, and a "clean development mechanism" (vide Article 12) to encourage joint emissions reduction projects between developed and developing countries.

Among others, switching to renewable energy sources has been identified as a promising approach to reduce future emissions, by the Intergovernmental Panel on Climate Change. In the long run, renewables can meet a major part of the world's demand for energy. Technological advances offer new opportunities and declining costs for energy from renewable sources. Renewables can play a major role in mitigating the emissions of CO2 in the SE Asian region, especially in view of its large application potential in the region.

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However, renewable energy utilisation still continues to be rather insignificant. It competes well with conventional sources of energy - if environmental / social costs are also taken into account. Incorporating environmental costs into energy prices would be a strong and effective measure against polluting fossil fuels and an incentive to renewable energy development. For example, Sweden was one of the first countries to impose a CO2/energy tax, in 1991 **(Harrison and Kriström**, 1997), followed by Netherlands (**Wuppertal Bulletin**, 1997), Finland and Norway (**UNEP**, 1998).

This paper discusses the business opportunities for renewable energy generation with special reference to the recent developments in GHG emission mitigation in the South East Asian Region. Only solar photovoltaics (PV) and Solar Drying technologies have been considered in this paper.

2. Business opportunities in Solar Photovoltaics

The main PV applications in the developing world include independent Solar Home Systems (SHS), Street lighting, Water pumping, Battery Charging and Communication.

(i) Current installed capacity

South East Asia demonstrated a steady growth in PV stand-alone systems installations during the last decade. The estimated installed capacity of stand-alone PV systems in SE Asia increased from 960 kW_p in 1983 to about 20,710 kW_p in 1994 (**EPIA & Altener**, 1996). The installed PV capacities in some Asian countries are given in Table 1.

Table 1: Estimated installed capacity of PV systems in some Asian countries

Country	Total installed capacity (MW)
[1]China	8.000 (1995)
[2]Nepal	0.800 (1995)
[3]India	28.000 (1996)
[4]Sri Lanka	0.080 (1990)
[5]Thailand	2.500 (1996)
[6]Malaysia	0.120 (1994)
[7]Indonesia	2.900 (1993)
[4]Philippines	0.043 (1990)
[8]Vietnam	0.175 (1996)

Sources:

[1]Zhu Jungsheng, 1995
[2]WECS, 1995
[3]MNES, 1997
[4]ESCAP Report, 1995
[5]Thailand-Country Report, 1995
[6]Baharudin, 1995
[7]Neeny S. Utami, 1995
[8]Toan, 1996

(ii) Market potential for main application segments

The presently largest application market segments in South East Asia, in decreasing order are: Solar Home Systems, Water pumping and Communication. These three areas can have a significant impact on the success of education schemes and regional health care programmes, apart from providing the basic lighting requirements in the rural households.

EPIA & Altener (1996) estimated the market demand potential for stand-alone PV systems in South Asian and East Asian region for year 2010 (Table 2), considering the share of rural population in South East Asia having no access to basic infra-structural facilities, i.e. to the minimum services required for a decent living. The assumptions for the estimates include a minimum level of PV electrification in schools and health care centres, of 600Wp, and the requirement for Radio-transceivers and Relay Station at 80Wp and 750Wp respectively.

Table 2: Demand potential for PV required for infra-structural facilities

Region	PV capacity demand forecast for infra-structure facilities [during year 2010]			
	Safe drinking water		**Rural education**	
	Peak power required MWp[$]	Energy required MWh/year[$]	Peak power required MWp[$]	Energy required MWh/year[⊕]
South Asia	530.4	875.5	749.2	714,384
East Asia	293.5	435.4	305.4	209,184

Region	PV capacity demand forecast for infra-structure facilities [during year 2010]			
	Rural minimum health care		**Minimum communication**	
	Peak power required MWp[$]	Energy required MWh/year[⊕]	Peak power required MWp[$]	Energy required MWh/year[⊕]
South Asia	43.5	52,272	107	670,050
East Asia	6.9	9,600	34	213,100

[$]EPIA & Altener, 1996
[⊕]estimated

Table 3 presents the estimated demand potential for PV electrification of individual family households in rural non-electrified areas, considering the minimum solar PV system configuration as: one PV module of 50Wp power rating, a charge regulator and one 12V/35 Ah storage battery (**EPIA & Altener**, 1996).

(iii) Market development issues

Generally, the barriers hindering the market development of PV technology may be of technical, economic, financial, social, cultural, institutional and regulatory nature. As of today, the ***technological barriers*** appear to be only minor as the technology capable of satisfying the needs of users is mostly available. Poor performance of PV systems is most often due to cheaper and apparently equivalent low quality Balance of System (BOS) components, which become the weakest link of the chain during operation (**EPIA & Altener**, 1996). Inadequate application and system design, in many cases, is also a reason for poor performance. Here again, the reason is to be found in lack of appropriate quality and reference standards and not in adequate technology.

Table 3: Demand potential for PV Solar Home Systems
[Basis: EPIA & Altener, 1996]

Region	Rural population not electrified [million inhabitants]	Energy required Million MWh/year	PV peak power demand forecast (MWp) [during year 2010]
South Asia	819.726	2.92*	3,272
East Asia	219.059	1.75'	1,947

* estimated for 2000MW normal load, @ 4 hours/day
' estimated for 1200MW normal load, @ 4 hours/day

As far as ***economic barriers*** are concerned, the most significant barrier is the high cost. However, it is possible to reduce the cost to a considerable extent, even with the existing technologies, if the economies of scale are applied (**Biermann** et al., 1995). Due to the current low demand for PV appliances, their production runs are presently very small, and the producers are not in a position to exploit the economies of scale.

The present conventional energy technologies cost in the range of 30-40 US$/MWh for bulk power generation, and 100-150 US$/MWh for peak power generation. Costs of renewables are in the range of 500-600 US$/MWh for grid-connected solar PV power generation and 600-800 US$/MWh for PV stand alone generation (**EPIA & Altener**, 1996). The above cost however, does not take into consideration other cost items such as the following:

1. In remote areas not covered by the electric grid, power has to be generated by means of conventional stand-alone generator sets. In such cases, the transportation costs for fuels, lubricants, spares and related qualified manpower significantly increase the cost of conventional energy.
2. The environmental or social costs arising from pollution and health hazards are not usually considered in the case of fossil fuel use.

If such additional costs are also taken into consideration, in many circumstances, the cost comparison reveals PV technology to be competitive or even cheaper in comparison to conventional energy sources (**EPIA & Altener**, 1996).

Of the ***financial barriers***, lack of adequate financing and loan/credit schemes allowing potential user categories to meet the investment initially required for the installation of a PV energy system is of particular importance. Other financial barriers include: macroeconomic pricing, policy distortions, donor and power utility preferences for large, centrally-managed energy projects, and emphasis on capital rather than life cycle costs.

The generally poor financial and institutional performance of power utilities, by their limited willingness to adopt innovative approaches to energy service delivery, contribute highly to the ***institutional barriers***. The ***regulatory barriers*** include mainly the utility grid interface regulations that had been developed principally for large rotating generators. These may not be particularly relevant for PV electricity generation.

(iv) CO2 emission mitigation potential

The CO2 mitigation potential of solar PV can be estimated for South Asia and East Asia for the year 2010, by considering that solar PV generation replaces a certain capacity of fossil fuel-fired power generation, which would mean an avoidance of CO2 at that rate. The total fossil fuel generation displacement potential by SPV has been arrived at from Tables 2 & 3. The CO2 emission mitigation potential has been estimated with the consideration that in the absence of any solar PV systems, conventional fossil fuel generation systems will have to be set up, to satisfy the minimum basic requirements of the region. Installation of solar PV generation systems, in such case, would mean an avoidance of CO2 emission from these conventional generation systems. The avoided emission of CO2 has been estimated for different fossil fuels and generation technologies and presented in Table 4. Assuming an application potential of 20% (i.e. if SPV reduces the conventional electricity generation by 20%), the resultant CO2 emission reductions have been estimated and compared with an ideal situation of achieving 100% market realisation of the PV potential in the region.

Table 4: CO2 emission mitigation potential for the fossil fuel generation displacement by SPV in South Asia and East Asia

Fossil fuel Generation Technology	CO2 Emission Factor* [kg/MWh]	Equivalent Carbon Emission# [kg C/MWh]	Total fossil fuel generation displacement potential by SPV [MWh/year]	Total avoided carbon emission potential from CO2 emission [million tons/year] Market Realisation	
				20%	*100%*
South Asia					
Anthracite	354	97	3,687,530	0.0715	0.3577
Rich Coal	323	88		0.0649	0.3245
Lignite	392	107		0.0789	0.3946
Coke	385	105		0.0774	0.3872
Crude Oil	289	79		0.0583	0.2913
Natural gas	191	52		0.0384	0.1918
East Asia					
Anthracite	354	97	2,182,220	0.0423	0.2117
Rich Coal	323	88		0.0384	0.1920
Lignite	392	107		0.0467	0.2335

Coke	385	105		0.0458	0.2291
Crude Oil	289	79		0.0345	0.1724
Natural gas	191	52		0.0227	0.1135

*Göttlicher, 1998; # estimated

These data are significant when compared to the estimated carbon emission from fossil fuel burning in several South and East Asian countries as shown in Table 5.

Table 5: Carbon Emission for selected countries in South/East Asia during 1991

Country	Carbon Emission [Million Ton C]	Country	Carbon Emissions [Million Ton C]
Bangladesh	4.2614	Thailand	23.0196
Myanmar	1.0605	Vietnam	5.4759
Malaysia	13.8758	Indonesia	42.6879

Source: Bhattacharya et al., 1993

3. Business opportunities in Solar Drying

Drying is a requisite process for proper storage of agricultural products. Traditionally, it is accomplished through direct open air sun drying in the domestic sector or through the use of mechanical dryers in the industrial sector, using steam/hot air. Mechanical dryers generally use fossil fuels and electricity. Solar dryers are used occasionally, but only in small scale, and for limited applications.

(i) <u>Market overview and application potential</u>

Drying products vary from fruits and vegetables to grain and paddy, fish, various processed food items, raw materials, chemicals, etc. In the South East Asian region, the following fruits are generally dried: mango, tamarind, banana, coconut, jujube, santol, leech lime, pineapple, carambola, bale fruit, roselle, gooseberry and durian. The popular drying method is open air sun drying for local consumption, although electric or gas based dryers are used in some cases (e.g.: banana, mango). Mango, tamarind and gooseberry are also oven-dried in Phitsanulok , in Northern Thailand (**Kumar and Rakwichian** , 1997).

Vegetables dried include chilli, radish, bamboo shoots, leaf mustard, ginger, corn, soya beans and mung beans, among a variety of other vegetables. Open air sun drying is popular for domestic consumption, but on concrete floors. Corn is usually dried using a gas oven. In almost all cases, where electric, gas or oven drying is employed, technology is locally available, and the dryers are usually self-made. However, for products meant for the export market, conventional industrial dryers are used. Cabbage, Carrot, Onion leaf and Garlic are some of the vegetables being industrially dried for the export market. Their initial moisture content and desirable final moisture content are: Cabbage: 80%, 5%; Carrot:70%, 5%; Onion leaf 80%, 4%; and Garlic: 80%, 4% respectively. The normal maximum temperature for drying these products is in the range of 58-66°C.

Solar drying has its own attractive advantages against other drying techniques. It consumes no fuel for its operation, requires less maintenance and the quality of dried product is superior. There will be no dust and dirt contamination in the dried product, there is no pilferage by animals and birds, and solar drying is non-polluting. However, the share of solar dryers is negligibly small in the total drying activities in the region.

Solar dryers have large potential in the region in view of the export potential for dried fruits, vegetables and processed fish. The region already exports large quantities of dried fruits and vegetables to the Far East, Europe, USA and Australia, and also between the regional countries themselves. Table 6 gives the export of selected dried fruits and vegetables from Thailand during 1995. By replacing the conventional dryers with solar dryers, a large saving in energy can be realised, and a resultant reduction in CO2 emission.

Table 6 : Export of selected dried fruits and vegetables from Thailand during 1995

Product	Quantity (Tons)	Product	Quantity (Tons)
Fruits:		**Vegetables**:	
Banana	9.157	Onion	180.210
Pineapple	435.740	Mung Beans	8,697.233
Grapes	56.149	Black Matpe Beans	16,224.836
Prunes	31.200	Golden Beans	2,926.846
Longans	3,649.569	Black Beans	2,057.655
Tamarind	10,118.268	Rice Beans	10,026.130
Apple	1.791	Red Beans	1,734.694
Betel Nut	11,611.030	Other Beans	4,861.840
Other fruits		Other vegetables	3,776.560
Total dried fruits	25,912.904	Total dried vegetables	50,486.004

Source: Kumar and Rakwichian, 1997

(ii) <u>Market development issues:</u>

Small-scale drying systems are used mainly by individual users, who will produce only modest surpluses for drying. An inexpensive and easy-to-operate design, of moderate capacity would be the requirement there. Large-scale operations, on the other hand, are generally well established and employ industrial dryers. Reliability plays an important role in large-scale industrial applications. Solar dryers with an option of integrated fossil-fuel or biomass fuel operation would be a desirable characteristic of such dryers.

The main types of solar dryers in use in the region are the cabinet type, rack type, and the recently introduced tunnel dryer. In Cambodia, solar drying of food is completed on a very basic level with people normally drying food in bamboo baskets or in some cases, on a wire mesh rack openly exposed to the sun (**Cumberland**, 1996). High investment cost is a major deterrent to penetration of solar dryers in the local market. Approximately fifteen types of solar dryers are currently in use in Nepal (**WECS**, 1995), for drying apples, ginger, cardamom, herbarium plant specimen, tree barks, medicinal herbs, fruits etc.

(**Joshi**, 1993). But the high initial investment cost, lack of product and quantity-specific designs, absence of effective institutional arrangements for the production and promotion of solar dryers, and a lack of government interest in the development of solar energy in Nepal - both in terms of policy planning as well as implementation, have all hindered its growth. The solar tunnel dryer developed by Hohenheim University (Germany) has been successfully used for drying a variety of fruits and vegetables, and is being introduced into this region (**Universität Hohenheim**, 1995). This addresses the major difficulties of conventional solar dryers and is poised for widespread use.

(iv) CO2 emission mitigation potential:

The industrial dryers consume fossil fuels such as fuel oil, and electricity. The estimation of CO2 mitigation potential has been attempted by replacing the fossil fuel-based hot air generation with solar dryers, by considering vegetables that are dried for export, in Thailand. A summary of the energy audit data from three vegetable drying factories in Northern Thailand is presented in Table 7.

Considering the specific energy consumption from these factories, and noting the total export of dried fruits and vegetables by Thailand (Table 6), the total electrical and thermal energy consumption in the country for drying fruits and vegetables meant for export, is estimated at 7,785 MWh/year and 522,568 GJ/year respectively. If solar dryers are employed to generate the required hot air for drying, and assuming that 5% of the conventional dryers are replaced with solar dryers, an estimated 26,128GJ of energy could be saved annually in the form of fuel oil, amounting to 0.965 million litres of boiler fuel oil annually.

Considering the CO2 emission factor for boiler fuel oil (crude oil) from Table 5, the total CO2 emission mitigation potential for dried vegetable & fruit exports of Thailand is estimated at 41,950 tons annually.

Table 7: Production of dried vegetables and energy consumption during drying in three factories of Thailand

	Production (Tons/year)	Energy Consumption		
		Grid Electricity [kWh/year]	Boiler Fuel Oil	
			[lt./year]	['000 GJ]
Factory 1	8,800	923,550	1,744,000	69.30
Factory 2	2,481	175,940	163,880	6.63
Factory 3	224	72,760	76,600	2.79
Total	11,505	1,172,250	1,984,480	78.72

Source: Wipawadee W., 1997

4. Conclusion

Renewable energy application has assumed greater significance after the Kyoto Protocol of December 1997. The present status of solar photovoltaics and solar drying in this region has been presented and the future market potential estimated based on the demand potential. The total CO2 emission mitigation potential of solar PV for South and East Asia has been estimated to be in the range of 0.3053-0.6281 million tons annually. For a market realisation of 20%, the mitigation potential amounts to approximately 0.0611 - 0.1256 million tons/year. The energy saving potential of solar dryers in the dried fruit and vegetable export sector of Thailand, has been estimated at 0.965 million tons of fuel oil/year, if only 5% of application potential is considered for this sector. The related CO2 emission mitigation potential has been estimated at 41,950 tons annually.

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