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Government Promotion of Photovoltaics: Evidence from the Hotel Industry in India

Raja Peter*, Laurence Dickie, and Vasanthi Peter*****

*Department of Management and Enterprise Development
Massey University
Private Box 756 Wellington
NEW ZEALAND

**Teaching & Learning, Research
CBS – International Programs
Curtin Business School
Curtin University of Technology
GPO Box U 1987
Perth 6845
WESTERN AUSTRALIA

***Whitireia Community Polytechnic
Wineera Drive
Private Bag 50910
Porirua City
Wellington
NEW ZEALAND

ABSTRACT

India faces a tremendous challenge in meeting its domestic and commercial energy requirements. Power from Photovoltaic (PV) systems offers a viable solution to bridge the energy gap. Therefore, the current paper is an empirical examination of the role of the government in promoting PV systems. Primary research was conducted in the hotel industry, as it is not exempt from the detrimental effect of frequent scheduled and unscheduled power-cuts. A structured questionnaire was used through a prestigious market research firm in India to collect relevant data from 205 hotels located in different parts of India.

Empirical results show that the majority of respondents consider the initiatives taken by the government to be very important in fostering the commercialisation of PV systems. Therefore, the government should play a leadership role in regard to policy development, legislation, fund mobilisation, institutional support, tariff formulation, training, information dissemination and education. In effect, a variety of government initiatives are required to stimulate a 'market pull' for every alternative energy source, including PV systems. When the goal is to increase the market demand for environmentally friendly technologies such as PV systems, their adoption can be hastened to meet an established need since India is endowed with plenty of sunshine.

1. INTRODUCTION

India, like other developing countries, faces a tremendous challenge in meeting its domestic and commercial energy requirements. Approximately a third of the world's population still does not have access to electricity. The annual demand for electricity in developing countries is expected to grow at 4.6%, which is higher than the projected global demand for electricity which is estimated to grow at 2.8% per year [1, 2]. Fortunately, India has the opportunity to move towards alternative energy sources to meet its energy requirements, because power from solar photovoltaic (PV) systems offers effective and viable solutions to bridge the energy gap.

Solar photovoltaic energy is one of the special-purpose decentralized forms of power-generating units that the Ministry for New Energy Sources is trying to promote in an attempt to alleviate the power problem in the country. The way forward is to adopt the 'sustainable energy path' which requires the formulation of a national master plan; a plan which needs to be supported by appropriate policy, legislative and regulatory measures. The measures that are required to foster the promotion of alternative energy sources are linked inextricably to the support that renewable energy technologies (RETs) require at the national level and at the state level. Hence, this paper discusses the support that RETs require; once these mechanisms are in place, undoubtedly they will help the cause of solar based photovoltaic (PV) systems, too.

The traditional electricity production, distribution and transmission systems in India are characterised by highly centralized generation, costly grid systems and poorly managed State Electricity Boards (SEBs). To a large extent developing countries are dependent on grid supply of electricity and the beneficiaries are largely the urban and industrial sectors because the vast majority of the population still lives in rural villages [2]. Thus, there is opportunity for a big shift in power generation and distribution from the traditional approach to alternative modes such as decentralized PV systems. Long-term benefits of the change to PV systems include reducing the cost of supplying energy and related services as well as reducing emission of carbon dioxide and other pollutants. Further, users and commercial establishments will have access to a reliable, continuous supply of good quality power. Policy measures and corresponding mechanisms can be developed to remove the barriers for the commercialisation of technologies such as PV systems [3] whose modular characteristics enable them to readily function as a decentralized system. Therefore, the contention is that government initiatives should address the issue of restructuring the prevailing centralised system to encourage power generation through alternative renewable energy technologies such as decentralized PV systems.

The current paper is the result of empirical research to examine the role of the government in fostering adoption of alternative energy sources such as PV systems, particularly in the context of a developing country. The paper commences with an overview of the energy scenario in India which is followed by an integration of the research findings in the areas of RETs and the diffusion of PV technology. The focus is on solar PV, the commercial sector and government initiatives in India. The paper also discusses solar PV penetration in the commercial sector.

The methodology section includes a discussion on the sampling methods used, operationalisation of the variables, and the methods employed to collect data. Analysis of the data provides empirical evidence about the role of government initiatives in fostering the adoption of photovoltaic technology in a developing country, viz., India.

2. LITERATURE REVIEW

2.1 Energy Consumption Trends in the Commercial Sector

India's commercial energy demand is expected to grow at a faster rate compared with that of other developing economies. Primary commercial energy demand tripled by growing at an annual rate of 6% per annum during the period 1981 to 2001. Nevertheless, despite the growth in energy consumption, a large part of India's population does not have access to commercial energy.

As can be seen from table 1, in relation to the types of fuel used in the total energy consumption the share of coal decreased from 75.3% in 1960 - 61 to 28.9% in 1996 - 97, while in the same period the share of oil/gas and electricity increased steadily from 19.9% to 54.0%.

Traditionally, India has relied heavily on imports for meeting the increasing demand for energy. Further, in order to reduce the severe power shortages, the Government of India has introduced reforms through both restructuring and deregulation of the energy sector [4].

Besides, the country has witnessed an expansion in energy use during the past 5 decades, with a movement from non-commercial to commercial sources; table 2 shows that the production of commercial energy has increased significantly.

Table 1. Trends in Commercial Energy Consumption

(*Figures in percentages*)

	1960-61	1970-71	1980-81	1990-91	1996-97
Coal	75.3	56.1	47.9	35.9	28.9
Oil and natural gas	19.9	34.7	41.4	49.1	54.0
Electricity	4.8	9.2	10.7	15.0	17.1

Source: *Ninth Five-Year Plan 1996-2001*

Table 2. Trends in Commercial Energy Production

	1950-51	1970-71	1993-94	2001-02
Coal (million tonnes)	33	76	246	326
Oil Crude (million tonnes)	0.3	7	27	32
Electricity Installed Capacity (MW)	1 710	14 710	76 860	104 900

Source: Adapted from Economic Survey 1994-95 and Economic Survey 2002-03

Table 3 illustrates the patterns of electricity consumption. The industrial sector is the largest consumer of electricity, followed by the agriculture sector; together they account for about two thirds of the electricity consumed, as shown.

Table 3. Patterns of Electricity Consumption

(*Figures in percentages*)

	1960-61	1970-71	1980-81	1990-91	2000-01
Industries	75.5	73.5	64.1	50.1	41.1
Agriculture	6.0	10.2	17.6	26.4	26.8
Domestic	10.7	8.8	11.2	16.8	23.9
Railway Traction	3.3	3.2	2.7	2.2	2.6
Others	4.5	4.3	4.4	4.5	5.6
	100.0	100.0	100.0	100.0	100.0

Source: *Adapted from Economic Survey 2002-03*

In 2000-01, the commercial uses of power required 76.1% of production and the non-commercial use comprised 23.9% of the total production. *Commercial* use of power refers to the use of electric

power in industries, agriculture and transport. *Non-commercial* uses include electric power required for domestic lighting, cooking and domestic electrical appliances such as refrigerators, air conditioners and such goods.

Many large industrial organizations have set up their own captive power generating units instead of having to depend upon the inadequate and undependable public utilities [5]. The generation of power in these privately owned power plants is around 11 to 12 per cent of the total power production in the country and it is steadily increasing.

Table 4. Installed Power Capacity

(MW)

	1953-54	1970-71	1990-91	1998-99
Public Utilities	1 710	14 710	66 060	83 769
Non-public Utilities	590	1 560	8 400	11 140
Total	2 300	16 270	74 460	94 909

Source: *Adapted from Economic Survey 1994-95 and TERI Yearbook 2000/2001*

2.2 Chronic Power Shortage

According to Gulyani [5] industrial firms have to contend not only with an insufficient electric power supply, but also with poor quality of supply. The shortage of power supply has lead to frequent blackouts and brownouts [6]. Companies face frequent scheduled and unscheduled power cuts. The power cuts issue is compounded by the quality problem; inconsistent quality results in fluctuations in voltage and frequency of power supplied that cause difficulties such as machine damage, production losses and variations in product quality. The loss of production stemming from India's energy shortage is estimated to be around 2% of its national income [7].

India's power sector has been characterised by shortage of supply vis-à-vis demand (see table 5). Datt and Sundharam [8] have pointed out the main reasons for this as follows:

- Growing demand for electric power at all levels.
- Power generation and distribution has not kept up with the rising demand.
- The variations in the generation of hydroelectric power due to its dependence on the vagaries and failure of monsoons.
- Failure of new capacity additions to meet targeted levels.
- Below par performance of a number of thermal units.
- High transmission and distribution (T&D) losses; against the international average T&D losses of 9%, the figure for India is close to 22%.

According to Jagdeesh [9], some of the critical issues which India currently is facing include the crippling effects of power shortage, the staggering increase in oil import burden and deterioration in environmental quality. Given such an energy environment, photovoltaics (PVs) appear to have an important role to play in providing much needed power in the Indian context, amidst growing global concern about sustainable energy supplies and protecting the environment from the adverse effects of fossil fuel utilization.

Table 5. Power Shortage

	(billion kWh)			
	1990-91	1993-94	1996-97	1997-98
Demand	267.632	323.252	413.490	313.098
Supply	246.560	299.494	365.900	286.190
Shortfall	21.072	23.758	47.590	26.908
Percent Shortfall	7.870	7.350	11.510	8.600

Source: *http://www.indiacore.com/energy.html*

2.3 Photovoltaics

Photovoltaics (PVs) have attracted increased attention in the recent years. Since 1954 photovoltaic technology has progressed in leaps and bounds. Improvements in efficiency, progressive reductions in cost and increasingly high reliability have contributed to the expansion of PV technology globally [10]. PVs are commonly cited as one of the 'bright lights' for future electricity generation [11] and they have many advantages over other energy technologies such as:

- PV systems are dependable, reliable and they have a long life, often with a lifespan of about 20 years. Many of them have a guarantee of at least 10 years [2, 12-14].
- They are simple to install and easy to maintain. Since PV systems are modular, they facilitate easy installation at a site where power is needed [12, 15].
- Construction of PV systems can be very quick. Hence there are almost no interest payments during construction or an extended start up period for a purchaser [14].
- PV systems can be designed to fit specific needs and because of the proximity between supply and demand, distribution losses are minimal. Since PVs are a modular technology, arrays can be built to suit any application [15, 16].
- PV systems have low operation and maintenance costs. Even large sites are unmanned and there are no consumables [12-14].
- PV systems have diverse uses and are able to provide economical power to applications as diverse as calculators, wristwatches, telecommunications, satellites, remote industrial applications and remote communities. They are capable of providing power from less than 1 watt to many megawatts [15, 16].
- PVs are cost-effective for numerous applications in remote locations [13] and peakpower generation where demand matches solar insolation extremes [17]. PV systems in remote areas compare favourably in cost with diesel generators and with national grid extensions [15]. The world's largest solar powered microwave systems through the northwest of Western Australia are now into their third set of batteries and have out-performed their diesel counterparts in cost, maintenance and reliability [18].
- PV systems are flexible. They can be used to meet immediate demands as well as being modified for unusual surges in demand. By comparison a conventional grid is not very efficient in handling demand fluctuations. PVs can be applied with a power invertor to nearly any end-use. Coupled with a battery back up, they are capable of providing power on a continuous and indefinite basis.

- PV systems emit no pollution. They do not emit any fumes and they do not contribute towards acid rain or the greenhouse effect. PVs are a clean energy provider [2, 12, 13, 17].
- PVs have no moving parts, need no fuel transport and no ill-health effects result from their use. No other electricity-generating technology has lower risk in terms of accidents, pollution or ill effects to humans or the ecosystem [11, 12].
- PV systems have shown good performance reliability [12, 14, 15].
- The voltage produced by PV modules is quite constant and there is little variation with changing solar radiation intensity; therefore PV systems are suitable for storage using batteries. The stored energy, then, can be used at night [13].

2.4 Photovoltaic Technology in India

Traditionally, the power sector in India is associated with large-scale power generation under the auspices of both central and state governments. Although the transmission distribution network is widespread, it is still controlled by the government. Despite the increasing budgetary allocation given to the power sector in every Five-Year Plan, government efforts have not been successful in achieving the desired standard for the power sector [19].

The Government of India has introduced reforms in the power sector and has introduced new strategies in the scale of operation, ownership patterns and distribution networks. The government is seeking to promote small and medium scale power generation and is encouraging large-scale generation by private sector and joint sector participation. Undoubtedly, there is a shift towards decentralized power generation and private entrepreneurship in the provision of power. Solar photovoltaic energy is one of the special-purpose decentralized forms of power-generating units that the Ministry for Non-Conventional Energy Sources (MNES) is trying to promote to alleviate the power problem in the country [19].

India has a vast land area of over 3.2 million square km and a population of nearly a billion people. The solar radiation received by the country is over $5'10^{15}$ kW h/yr with the daily average incidence varying between 4 and 7 kW h/m^2. There are over 80,000 villages that are yet to be electrified and about 70 million households without conventional electricity [20]. Hence, there is a large scope and potential for the use of solar-based technology in India.

The aggregate capacity of PV modules in India is around 80 MW_p and this includes 53 MW_p of PV systems that have been deployed over a number of small-decentralized applications. About 27 MW_p of PV products have been exported between 1996 and 2001. There are 9 manufacturers of solar cells and 20 manufacturers of PV modules. Approximately 50 companies manufacture PV systems and, primarily, these are small businesses. It is estimated that 14 MW_p of solar cells and 17 MW_p of modules were produced in the financial year 2000-01. In effect, the total turnover of the Indian PV industry is estimated at US$ 120 million [21].

The Department of Telecommunications is the largest user of PV modules in India, accounting for 16.6% of the PV modules used. This is followed by solar home lighting (8.8%), solar lanterns (8.7%), solar street lighting (8.1%), solar power plants (8.0%) and water pumping (6.6%). Other applications account for 16% and they include telemetry on offshore oil platforms, railway signalling, low-power TV transmitters and microwave repeaters. The remaining 27% is accounted for by the export sector [21].

2.5 Government Initiatives

The government can play a leading role through the formulation of favourable policies by showing a practical commitment which enhances public awareness of the potential of PV in all walks of life. Often, the majority of the people constituting the potential market are unaware of the existence of PV technology let alone the systems' capabilities [22]. The lack of information about renewable energy benefits, economic and financial costs is a major barrier to adoption [23]. Not only could the government assume responsibility

for creating awareness among the industry and public about the benefits of PV, it could disseminate information pertaining to the environmental and other benefits of PV with a view to educating the public [24]. Public education can be achieved through a variety of strategies including advertising campaigns, PV documentation programs that reach the people through radio, television, newspapers, highway billboards and setting up demonstration sites [15]. It is reported that the publicity and awareness campaign undertaken in Zimbabwe generated an awareness and demand for solar systems in the country [25].

According to Adurodija [15] the government could establish a financing system which favours PV diffusion and, simultaneously, provide financing and access to affordable credit line plans in order to convert potential users into actual users. The government could promote the development of the local PV market by encouraging local manufacturing of PV components and the removal of constraints on the market growth by providing temporary tax exemptions for the purchase of PV equipment. Additionally, allowing duty free imports of solar equipment, components and appliances would help in lowering the initial costs of PV systems. It is widely regarded that the high initial costs of PV systems often slow down the growth of the PV market; hence, any measure taken by the government to lower the initial cost of PV systems is a step in the right direction.

At the national level, the government could establish a strong scientific, technological and industrial development programme with the active participation of national and international developmental agencies. Similarly, the government can support and promote national Research and Development institutions and use the purchasing power of the state to obtain resources for PV research programmes. It can facilitate the forging of collaboration and technology transfers, and render institutional support for local and international research institutions [15]. Additionally, the government can consider providing incentives for research and development [24].

Another option for the government is to attract foreign investment in the production of PV systems by the creation of an appropriate economic and political climate. The progressive removal of barriers to foreign investment and the easing of restrictions for the import of PV technology has led to the establishment of joint ventures between Indian and foreign companies [20]. The government should adopt measures to promote local industries and contractors by encouraging them to take an active role in the production and promotion of PV technology; that is, the government could ensure a healthy market by restricting monopolies, fostering the development of standards and developing codes of practice [15].

The success of the wind energy programme in India is attributed to the proactive policies of the Ministry of Non-Conventional Energy Sources [26] in the Government of India. The key elements of this programme include wind resource assessment, government-sponsored demonstration projects, awareness creation and provision of operating experience to industry and State electricity boards (State-run utilities). Incentives were made available to wind-power plant entrepreneurs which included tax concessions such as accelerated depreciation, tax holidays, customs and excise duty relief, soft loans and liberalized foreign investment procedures [27].

Government intervention for fostering the diffusion of renewable energy technologies includes provision of information to consumers and manufacturers, tax benefits, subsidies, credit services and direct support of the distribution system [22, 23]. In an effort to promote the use of solar systems the government also should publish the results of comparative analysis of solar systems and conventional systems [24]. Therefore, as argued by Roy and Gupta [19] government intervention is necessary in a number of ways to promote solar energy.

2.6 Subsidies

In both developed and less-developed economies technologies such as grid power and diesel generators have enjoyed a series of subsidies such as tariff support and tax holidays [22]. It has been argued that tax concessions such as accelerated depreciation, tax holidays, customs and excise duty

reliefs, soft loans and liberalized foreign investment procedures, will foster incentives for the diffusion of renewable energy technology [27]. Likewise, it is believed that governments should consider subsidies for PV technologies in order to stimulate the PV market [22]. In the initial stages of market development the government should examine using international tenders to supply quality equipment at subsidised price; such subsidies could be phased out as the price of PV system falls [15]. Thus, the government has a key role to play not only in providing fiscal incentives and subsidies but also ensuring that an appropriate institutional framework is in place to accelerate the commercialization of PV systems.

2.7 Institutional framework

Despite the work done by the Ministry of Non-Conventional Energy Sources over the years, PV technology is still new to India, resulting in a greater thrust being required to promote the use of PV systems as an alternate source of power supply. Because the industry is relatively new, the existing market infrastructure which includes marketing networks and support systems need to be strengthened so as to provide the necessary after sales service and ongoing maintenance needs [30, 42]

Similarly, there is a need to develop system standards for all the main system components. Standards are required to be established for certification or qualification for designers and installers. Agreement on performance standards for PVs, establishing independent testing centres and government endorsement of solar systems are measures that will serve to boost the confidence level of PV users [24]. Standards are necessary to guarantee the satisfactory performance of solar systems and to ensure the high quality of installations. The standards are set with the assistance of industry and the Standards Association of the respective country. These standards, then, are used while inspecting the systems that have been installed [25]. In addition to specific PV standards, each country has regulations governing the connection of independent generators to the utility grids. These regulations are often inappropriate for PVs and, therefore, have to be revised.

The absence of institutional frameworks and legal structures that create the proper climate for investments in renewable energy have been barriers in many countries [28]. India is one of the few countries which has a separate government department to accelerate the deployment of renewable energy technologies; the Ministry of Non-Conventional Energy Sources [26] is responsible for the development, production and utilisation of PV devices in India [20].

2.8 Lack of strong private sector participation

The slow rate of participation in renewable energy by the private sector is because of issues relating to economic viability and inadequate infrastructure to support the industry [29]. An interesting development is the 'Photovoltaic Market Transformation Initiative' (PVMTI) which is designed to increase the participation of the private sector in market development activities leading to the creating and sustaining of new markets for PV systems. The PVMTI has been initiated in India by the International Finance Corporation (IFC) and the Global Environmental Facility (GEF). An estimated US $15 million is available under this initiative to provide long-term low interest loans to companies and to refinance consumer credit schemes. In an effort to support market development initiatives the fund provides a one-time grant of up to 10% of the loan to cover costs associated with Market development [21, 30].

It is argued that the private sector needs to view PV systems as alternative solutions to the problem of power shortages, power-cuts and erratic power supply; this can be achieved by developing marketing strategies, providing financial support, fiscal incentives and technical know-how for installation, operations and maintenance. Because the technology is relatively new, firms that use PV systems for captive consumption need to be assured of reliable performance, service guarantees and adequate warranties to minimise the perceived risk and uncertainty associated with their implementation. Financial institutions and IREDA can assist the private sector by developing financing instruments which render PV systems to be operationally viable. The government and SEBs need to provide the

required policy, legislative and regulatory framework. The combined effort of the government, financial institutions and the private sector will lead to the much needed strengthening of the infrastructure in the power sector in India [31].

3. METHODOLOGY

3.1 Data Collection

The Directory of Hotels and Resorts in India was used as the sampling frame to provide a comprehensive listing of the target population. The hotels were categorized according to their star ratings and adequate care was taken to ensure a representative sample size of 205. Sampling error and non-sampling errors are two key factors which affect the overall quality of data [32]. Sampling error is the difference between the result of a sample and the result of a census conducted using identical procedures. It is a statistical fluctuation that occurs because of chance variations in the elements selected for a sample. Sampling errors arise from errors in constructing a sampling frame and selecting a sample. Adequate steps were taken to minimise such potential sources of error during the process of data collection.

The target population consisted of 769 hotels and, as in the case of many industrial products, a census approach was feasible since the target population was not very large. The questionnaires initially were administered to the population through mail surveys. The mail survey was administered across all the elements of the target population. In order to establish a higher credibility for the study and to facilitate return of the completed questionnaires to a local address in India, it was decided to enlist the help of a local academic in India. The respondents were requested to mail the completed questionnaires back to the local academic's contact address via provided mail-back envelopes. The response rate (3%) was very low despite the respondents being requested to mail the questionnaires back to the address of a local academic in India and the response rate for the follow up mail out was no different. Such low response rates (3%) were inadequate, necessitating a change to the adoption of administering the questionnaires through trained interviewers who were part of a large market research company. Although this method of administering the questionnaires was expensive, it was adopted in view of the time constraints and the need for high quality data for the current research.

3.2 Sampling

Stratified random sampling was used to ensure that the sample adequately represented the population. More particularly, the proportional stratified random sample was used to ensure that the number of sampling units drawn from each stratum was in proportion to the relative population size of that stratum. The target population, the distribution of these hotels across the four different regions and their different star ratings are given in table 6.

Table 6. Population of Hotels

	North	South	East	West	All India
Total number of 4, 5 star hotels	77	45	17	70	209
Total number of 3 star hotels	91	74	32	62	259
Total number of 1, 2 star hotels and Govt. Approved Hotels	90	82	20	109	301
Total	**258**	**201**	**69**	**241**	**769**

Source: *Compiled from the Directory of Hotels and Resorts*

In order to ensure randomness of the sample drawn, a computer program called 'Research Randomizer' was used to generate random numbers from the list of hotels in the different regions. Consequently, the distribution of hotels in the sample has been maintained as the same as the population distribution of hotels across the four different regions in India. In choosing the stratification variable, Malhotra [32] recommends that the elements within the stratum should be as homogeneous as possible whereas the elements in the different strata should be as heterogeneous as possible. This criterion has been followed and the star rating of the hotels has been used as the stratification variable. Therefore, in selecting the sample for administering the questionnaires through trained interviewers, the process of stratification and randomization was followed in order to minimise sampling errors. Thus, great care was taken to avoid imbalances in the representative nature of the sample. The sample distribution of hotels is given in table 7.

Table 7. Sample Distribution of Hotels

	North		*South*		*East*		*West*		*All India*	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
4, 5 star hotels	20	(37%)	12	(22%)	4	(8%)	18	(33%)	55	(27%)
3 star hotels	23	(35%)	18	(29%)	8	(12%)	17	(26%)	65	(32%)
1, 2 star hotels and Govt. Approved Hotels	25	(30%)	23	(27%)	6	(7%)	31	(36%)	85	(41%
Total	68	(34%)	53	(26%)	18	(9%)	66	(32%)	205	100%)

As stated earlier, the target population for the primary data collection in this study was the hotels and resorts in India. The unit of analysis is the individual hotel/resort. Managers can be used as proxies for the decision-making unit, which in this case is the respective hotel [11]. In diffusion studies, the adoption of technology has been widely predicted using the perceptions of individuals to situational and technology related factors [33]. In studies of this kind it is necessary to survey those with a high information level [34]. The decision makers/utility managers of the hotels are considered to be individuals with specialized knowledge for the purposes of this research since they have access to the relevant information. Hence they were chosen as the respondents for this study. The profile of the respondents is given in table 8.

8.3% of the respondents were either Managing Directors or Chief Executive Officers or Presidents or Vice Presidents of these organisations. 21% of the respondents were General Managers and 7.8% held the position of Manager–In-charge. Further, 26.3% were Chief Engineers, 8.3% were Utility Service Managers, 22.4% were Maintenance Engineers, and 5.9% held a variety of other positions in the organisation. Thus 37.1 % of the respondents were decision makers in these hotels and 57% were engineers responsible for technical issues

3.3 The Government Initiatives Construct

Government initiatives refer to the actions that are required to be taken by the government to promote and foster the adoption of solar-based power supply systems. The operational definition of 'government initiatives' relates to how the concept is measured. It involves a combination of sets of questions, types of scales used and the anchor points of these scales [35]. In this research, the construct 'Government Initiatives' was assessed by eleven items (GI1 to GI11) drawn from Cesta and Decker [24], DeLaquil [36] Adurodija *et al.* [15] and Muntasser [22]. Respondents were asked to rate the importance

of the role of government in fostering the commercialization of solar PV systems on a seven point Likert type scale from 1 = Not Important to 7 = Very Important as the anchor points [24]. The eleven variables measuring government initiatives are:

- GI1: Creating awareness by providing helpful information [15, 24].
- GI2: Disseminating relevant information [15, 24]
- GI3: Promoting use of solar systems [24].
- GI4: Publishing results of comparative analysis of solar systems with conventional systems [24].
- GI5: Providing tax incentives for users [24, 36].
- GI6: Providing tax incentives for producers [24, 36].
- GI7: Providing subsidies for installing PV systems [24].
- GI8: Providing concessional financing for installing PVs [15, 24]
- GI9: Establishing performance standards for PVs [15, 24].
- GI10: Establishing independent testing centers for PVs [24].
- GI11: Removing subsidies to fossil fuels such as diesel [36, 37].

Table 8. Profile of the Respondents

	N*	%**
MD / CEO / President / VP	17	8.3
General Manager	43	21.0
Manager – In-charge	16	7.8
Sub-total – Decision Makers	76	37.1
Chief Engineer	54	26.3
Utility Service Manager	17	8.3
Maintenance Engineers	46	22.4
Sub-total – Engineers responsible for technical issues	117	57.0
Others	12	5.9
Total	*205*	*100*

*Number (N) of responses; N = 205
**Percentage of responses

4. RESULTS

Results as shown by the mean values in figure 1 indicate that respondents considered ten of the eleven items as very important and one item as important. There was no great deal of variation in the mean values of these ten items as can be seen from figure 1. Creating awareness by providing helpful information had the highest mean rating (GI1: $\bar{x}$ = 6.11) followed by: Providing tax incentives for users (GI5: $\bar{x}$ = 6.06); Promoting the use of solar systems (GI3: $\bar{x}$ = 6.02); Providing subsidies for installing PV systems (GI7: $\bar{x}$ = 6.02); Establishing performance standards for PVs (GI9: $\bar{x}$ = 6.00); Providing concessional financing for installing PVs (GI8: $\bar{x}$ = 5.99); Publishing results of comparative analysis of solar systems with conventional systems (GI4: $\bar{x}$ = 5.93); Disseminating relevant information (GI2: $\bar{x}$ = 5.91); Providing tax incentives for producers (GI6: $\bar{x}$ = 5.86) and Establishing independent testing centres for PVs (GI10: $\bar{x}$ = 5.84). The eleventh item, which is removing subsidies to fossil fuels such as diesel had the

lowest mean (GI11: $\bar{x}$ = 4.78). These findings also are highlighted in the analysis of frequencies of responses shown in table 9.

Nearly 80 % of the respondents indicated that the government has a very important role to play in fostering the commercialization of PV systems, indicating very strong support for the view that government has an important role. In this regard, 86.3% specified that 'promoting the use of solar systems' (GI3) and 'creating awareness by providing helpful information' (GI1) are important; 84.4% revealed that 'providing tax incentives for users' (GI5) is important; 83.9% indicated that 'disseminating relevant information' (GI2) is important, 83.4% stated that 'establishing performance standards for PVs' (GI9) is important; 82.9% revealed that 'publishing the results of comparative analysis of solar systems with conventional systems (GI4)', providing subsidies for installing PV systems (GI7), and 'providing concessional financing for installing PVs' (GI8) are important; 81% indicated that 'establishing independent testing centres for PVs' (GI10) is important; 79% have specified that 'providing tax incentives for producers' (GI6) is important; and lastly, 55.1% indicated that 'removing subsidies to fossil fuels such as diesel' (GI11) is important.

In the case of frequency analysis, those who circled a 1, 2 or 3 as their response were grouped together to denote 'Not Important', which is the lower end of the scale. Those who circled a 5, 6 or a 7 were grouped together to denote 'Very Important', the higher end of the scale. In a seven point scale, 4 represents a neutral response and, therefore, those who had indicated 4 as their response to a particular statement were not included in the frequency analysis. Hence, the percentages shown in the table 9 do not add to 100 percent.

Table 9. Government Initiatives – Frequencies and Percentages (N = 205)

	Not Important		Very Important	
	N*	%**	N*	%**
Creating awareness by providing helpful information (GI1);	6	2.9	177	86.3
Providing tax incentives for users (GI5)	8	3.9	173	84.4
Promoting use of solar systems (GI3)	2	1.0	177	86.3
Providing subsidies for installing PV systems (GI7)	7	3.4	170	82.9
Establishing performance standards for PVs (GI9)	6	2.9	171	83.4
Providing concessional financing for installing PVs (GI8)	6	2.9	170	82.9
Publishing results of comparative analysis of solar systems with conventional systems (GI4)	3	1.5	170	82.9
Disseminating relevant information (GI2)	6	2.9	172	83.9
Providing tax incentives for producers (GI6)	11	5.4	162	79.0
Establishing independent testing centres for PVs (GI10)	8	3.9	166	81.0
Removing subsidies to fossil fuels such as diesel (GI11)	37	18	113	55.1

*Number (N) of responses

**Percentage of responses

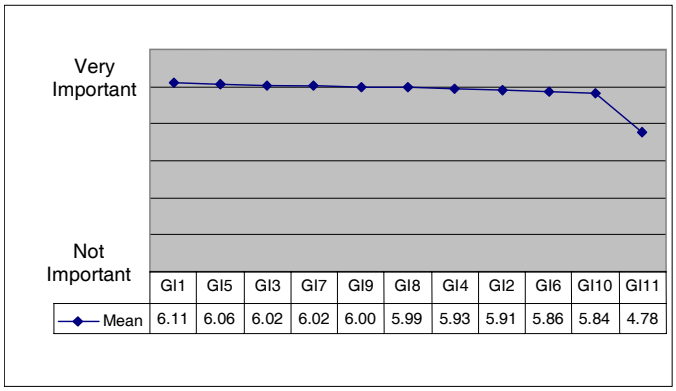

Fig. 1. Government initiatives.

5. IMPLICATIONS

An overwhelming majority of the respondents have emphasised that the initiatives taken by the government were very important in fostering the commercialisation of PV systems. These relate to creating awareness by providing helpful information ($\bar{x}$ = 6.14); disseminating relevant information ($\bar{x}$ = 5.91); promoting the use of solar systems ($\bar{x}$ = 6.02); providing tax incentives for producers ($\bar{x}$ = 5.86); providing concessional financing for installing PVs ($\bar{x}$ = 5.99); and establishing independent testing centers for PVs ($\bar{x}$ = 5.84).

As potential users of PV systems, respondents noted that it was important for the government to provide tax incentives for users ($\bar{x}$ = 6.06) and provide subsidies for installing PV systems ($\bar{x}$ = 6.02) as these measures directly benefit the users. They also pointed out that the government must take appropriate steps to establish performance standards for PVs ($\bar{x}$ = 6.00); publish results of comparative analysis of solar systems with conventional systems ($\bar{x}$ = 5.93) and remove subsidies to fossil fuels such as diesel ($\bar{x}$ = 4.78).

Empirical results show that, in order to foster the commercialisation of PV systems, the government must do all that it can to create awareness of PV systems by stepping up its promotional effort and providing helpful information. Appropriate policy measures must be put in place to provide the needed incentives, subsidies and concessional financing. The government should take the leadership role in establishing performance standards for PV systems, setting up independent testing centres for PV systems and in publishing the results of comparative analyses of solar systems with conventional systems

In a country like India, where chronic power shortages are rampant, there is a strong market potential for PV systems. Power from PV systems offers effective and viable solutions to bridge the energy gap. Creation of an effective institutional framework involves close co-operation between policy makers, government agencies such as MNES and IREDA, manufacturers, dealers, vendors, providers of after-sales service and financial intermediaries. India is endowed with plenty of sunshine and there is urgent need to hasten the adoption of environmentally friendly technologies such as PV systems. This can be accomplished by providing appropriate financial incentives, subsidies, strengthening of the supporting infrastructure to ensure reliability, quality and efficiency. Further it is necessary to provide the required regulatory, legislative and policy support for the rapid diffusion of PV systems.

6. CONCLUSION

The development of the renewable energy industry in India is still in its early stages. Therefore, the government should continue to play a leadership role in regards to policy, legislation, fund

mobilisation, institutional support, tariff formulation, pricing of electricity from renewable energy sources, testing and standards, training, information dissemination and education. Nevertheless, greater involvement by the private sector is required to expand the marketing infrastructure. Private sector participation has to be supported by R&D, demonstration projects and support needed to commercialise new technologies. A variety of financial incentives, subsidies and tax rebates are required to stimulate a 'market pull' for RETs. The goal is to increase market demand for RETs and accelerate the adoption of technologies such as PV systems. It is expected that implementation of all these measures will aid the adoption and diffusion of PV systems and other RETs.

The contribution of the study emerges from the integration of literature in the areas of renewable energy technologies and the diffusion of photovoltaic technology in developing countries. The significance of this research is that it provides empirical evidence to enhance the understanding of the role of government initiatives in fostering the adoption of photovoltaic technology in a developing country, India. An area for further research that emerges from this study is to examine the impact of government interventions in various solar PV distribution programmes in India. Further study can also be undertaken to cover other segments of PV systems as this would be useful to assess the generalisability of the results across other solar PV markets.

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