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MARKET POTENTIAL FOR LEAD/ACID BATTERIES FOR RURAL ELECTRIFICATION NEEDS IN INDIA

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Introduction

India has made significant strides in the energy sector, though a chronic energy scarcity, arising out of demand always exceeding production, still prevails. Thus, even when the planned power projects become effective, and the total generation could reach a value of around 600 billion kW h, taking power to a large number of villages in areas far removed from the urban and suburban conglomerates will not be achieved, as the process will be prohibitively costly. Obviously, the transmission and distribution costs will far outweigh the benefits if power is to be transmitted and distributed to remote villages.

A solution to this problem is sought through decentralisation of energy generation centres and changes in the modes of generating energy. The strategy to meet the basic energy needs of remote villages is to change the means of energy generation from the conventional fossil-fuel, hydro, and nuclear-energy base establishments to non-conventional energy base centres that have very short commissioning times and do not involve transmission and distribution costs. In India, out of a large number of villages, an initial 10 000 have been identified for service by non-conventional energy sources. This work will start in the current Five-Year Plan (*viz.*, the 7th Plan) and the succeeding two Five Year Plans, *i.e.*, up to the turn of the century. Decentralised non-conventional energy systems are the most suitable for remote rural application on account of their low running costs and their negligible impact on the environment. The principal sources of renewable energy are: solar (thermal and photovoltaic), wind, and bio-energy (including biogas and biomass). These are planned for implementation in remote-area power supplies as follows:

(i) rural electrification through small hydrosystems, solar photovoltaics, gasification of biomass, and wind power;

(ii) micro-irrigation and drinking-water supply through water pumping mills;

(iii) application of solar thermal energy for crop drying, wood seasoning, water desalination, etc.;

(iv) energy plantation for fuel, fodder, and as feedstock for biomass gasifiers and Stirling engines;

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(v) use of agro-residues and wastes for energy;

(vi) domestic cooking and lighting energy through family-size biogas plants and improved "chulhas" (hearths or stoves).

Energy-dedicated organisations exist at the national level to implement the strategy of remote rural electrification, *viz.*, the Rural Electrification Corporation and the Department of Non-conventional Energy Sources (Ministry of Energy). The organisations work in close collaboration with the various State Electricity Authorities in the country.

Need for storage batteries

Of the various programmes in this endeavour, the need for better storage batteries is important in the areas of solar photovoltaic energy conversion and small wind electric generators. For energy supply, a photovoltaic system consists of three parts: (i) photovoltaic panels that generate the electricity; (ii) batteries that store the energy and then supply the latter independent of solar conditions; (iii) an electronic power-conditioning system that controls the transfer of energy from the panels to the batteries. The two most commonly used types of batteries are the lead/acid and the nickel/cadmium systems. The advantages often quoted for nickel/cadmium batteries are: long life, moderate resistance to overcharge, tolerance of high intensity charging, ability to operate at low temperature and, in the case of sealed batteries, no maintenance and the ability to be used in any position. Maintenance-free lead/acid batteries also exist, however, and have characteristics that are even superior to those of nickel/cadmium. At present, only lead/acid, and some types of nickel/cadmium, have acceptable performance characteristics and life-cycle costs for photovoltaic power-system applications. Several other battery systems are under development, however. To date, totally sealed, maintenance-free lead/acid batteries have not proved cost-effective and feasible in India because of environmental and climatic limitations on the performance of the calcium–lead alloys used in the batteries.

For the above reasons, conventional lead/acid batteries are used to meet most of the requirements of photovoltaic applications. A typical 12 V automotive battery has an energy capacity of approximately 0.78 kW h. The photovoltaic batteries are designed to meet the specific requirements of terrestrial, remote, stand-alone power applications and are optimised to provide the low-rate (*i.e.*, $C/500$ rate) operation typical of these systems. The batteries may employ large electrolyte volumes and/or high specific gravity (1.300 at full charge) to provide added protection against freezing and low-maintenance operations. The storage requirements of batteries for wind electric generators are similar to those for solar photovoltaic installations.

Solar photovoltaic applications in rural regions

Technico-economic considerations indicate that solar electric power systems (SEPS) may be more attractive as rural energy centres for small,

remote villages in India than a conventional rural electrification programme. The potential application of SEPS in India and similar countries is thus likely to be considerable with the associated demand for storage battery capacity. Some of the applications envisaged are:

(i) provision of street lights;

(ii) water-pumping systems for drinking water or irrigation of small farms;

(iii) community lighting, radio-receiving and television systems, and other recreational activities at community centres;

(iv) night schools;

(v) centralised photovoltaic systems for larger power needs;

(vi) battery charging systems for wireless communication;

(vii) solar-powered refrigerators, etc.

Street lighting

As mentioned above, some 10 000 villages have been identified as being at such considerable distances from power grids that it will be economical to provide electrification through alternative sources of energy. Of these, 5000 are scheduled to be electrified during the 7th Five-Year Plan period (1985 - 90). This will involve the installation of 20 000 solar photovoltaic (SPV) panels for street lighting; this started in 1984. The phased-out activities for the 7th Plan period, together with battery requirements, are shown in Table 1.

TABLE 1

Street lighting for remote villages in India (7th Five-Year Plan period: 1985 - 90)

Units already in operation/installed during 1985 - 87	3000 - 4000
Units required in the current financial year (1987 - 88)	5000 - 7000
Projected requirement of units during total period	20 000
Battery types/characteristics	12 V, 70 - 100 A h; 12 V, 80 - 120 A h (6 V systems are also used in series)
Estimated battery population in terms of 12 V, 60 A h as standard unit	30 000
Remarks	Each unit/PV panel requires one battery.

Domestic lighting

Kerosene or other oil lamps and lanterns are the prevalent lighting aids in remote villages where the power grid does not reach. The gradual increase in prices of fossil fuels, and their scarcity at times, have forced some people in rural regions to adopt domestic lighting and other systems using SPV panels. The more affluent not only could afford this facility, but also found

it an inevitable necessity due to the popularity of radio and television. The latter have been further stimulated by the establishment of a large number of low-power relay transmitters that broadcast and telecast not only regional programmes and newscasts, but also programmes on the national network through a satellite communications system. Thus, domestic power systems are gradually being accepted by rural households for these, emergency lighting, and other needs. The requirements in this sector are presented in Table 2.

TABLE 2

Domestic lighting for remote villages under 7th Five-Year Plan (1985 - 90)

Units already in operation/installed during 1985 - 87	500 - 1000
Units required in the current financial year (1987 - 88)	Likely to grow
Projected requirement of units during total period	5000
Battery types/characteristics	12 V, 70 - 100 A h; 12 V, 80 - 100 A h (6 V systems are also used in series)
Estimated battery population in terms of 12 V, 60 A h as standard unit	7000
Remarks	Each unit/PV panel requires one battery

Community lighting and television systems

Small photovoltaic power packs are being used to power either lighting systems in community centres and night schools, or community television sets for adult education and recreation. The requirements of this programme are outlined in Table 3.

TABLE 3

Community lighting for remote villages under 7th Five-Year Plan (1985 - 90)

Units already in operation/installed during 1985 - 87	50
Units required in the current financial year (1987 - 88)	100
Projected requirement of units during total period	300
Battery types/characteristics	12 V, 120 A h
Estimated battery population in terms of 12 V, 60 A h as standard unit	2000
Remarks	Each unit requires 3 or 4 battery packs.

Small power plants

For meeting the electrical energy requirements of some villages by providing power for street lights, domestic lights, and a community television in each village, small power plants with photovoltaic systems are being installed with battery banks. The capacity ranges are 2 kW, 5 kW and 10 kW with an aggregate capacity presently of 100 kW. There are also other centralised photovoltaic systems for larger power needs. The estimates are not available at present for the small power plants but some reasonable projections are shown in Table 4.

TABLE 4

Development of small power-plants under 7th Five-Year Plan (1985 - 90)

Units already in operation/installed during 1985 - 87	2 kW, 5 kW & 10 kW power plants (exact numbers not available)
Units required in the current financial year (1987 - 88)	100 kW (aggregate capacity)
Projected requirement of units during total period	Not available, but likely to grow.
Battery types/characteristics	Battery banks with 180 V, 1000 A h packs
Estimated battery population in terms of 12 V, 60 A h as standard unit	6000 (?)
Remarks	Exact quantity has not been assessed.

Battery charging systems for communication and other needs

These are photovoltaic systems for battery-charging applications used for border outposts, para-military forces and other remote locations, and for other miscellaneous items such as solar-powered refrigerators. India has a vast potential for such applications, both in civilian and defence communication needs, *e.g.*, coast-guard and border security force posts. Such systems are also useful in hospitals, especially in remove locations. The battery characteristics depend on the particular charging system provided by the photovoltaic array. The estimated requirements are presented in Table 5.

Wind electric generators and associated battery chargers

These are employed for power requirements by the Posts & Telegraphs (P&T) and railways organizations, as well as by battery-charging communities. The systems are also used for lighting, inductive loads, and water pumps with battery back-up. The storage capacity of these systems is calculated on a six-hours per day basis. There are several factors, such as wind conditions, operational time, and power requirements, that vary considerably. The capacity range is from 500 W to 5 kW; a few sets up to 10

TABLE 5

Battery-charging systems for communications under 7th Five-Year Plan (1985 - 90)

Units already in operation/installed during 1985 - 87	350 (during 1986 - 87)
Units required in the current financial year (1987 - 88)	Not available
Projected requirement of units during total period	1500 - 2000
Battery types/characteristics	The voltage and capacity depend on the size of individual systems
Estimated battery population in terms of 12 V, 60 A h as standard unit	2000

TABLE 6

Batteries for wind electric generators under 7th Five-Year Plan (1985 - 90)

Units already in operation/installed during 1985 - 87	Not available
Units required in the current financial year (1987 - 88)	100
Projected requirements of units during total period	Definite growth area (exact number not assessed)
Battery types/characteristics	24 V, 100 - 300 A h deep cycling with 80% depth-of-discharge.
Estimated battery population in terms of 12 V, 60 A h as standard unit	3000
Remarks	Some 25 to 40 units of systems up to 10 kW also required every year.

kW are also required each year. Estimates of the requirements are not readily available, but some projections are given in Table 6.

Market potential for lead–acid batteries for rural electrification

From Tables 1 - 6 it can be inferred that the total estimated battery population (taking a 12 V, 60 A h battery as the standard unit) will be about 50 000 for rural electrification requirements under the 7th Five-Year Plan (1985 - 90). This is expected to lead to further significant growth by the end of this century (Table 7).

Conclusions

The problem of remote-village electrification in India has been reviewed. It is now generally appreciated that while small and decentralised

TABLE 7

Energy generation/saving from selected non-conventional energy sources during the 7th, 8th and 9th Five-Year Plan periods (in MW)

System	7th Plan (1985 - 90)	8th Plan (1990 - 95)	9th Plan (1995 - 2000)	Total
Power from solar systems	60	440	1500	2000
Photovoltaic pumps	1.5	4.5	9.0	15.0
Wind pumps	5.0	15.0	30.0	50.0
Small battery chargers & stand-alone systems	1.0	3.0	6.0	10.0
Estimated lead/acid battery needs*	50 000	150 000	300 000	500 000

*In terms of 12 V, 60 A h standard unit.

systems can serve widely spread areas, the alternative large and centralised systems are extremely costly. The role of renewable energy sources in meeting this challenge has been discussed in terms of development programmes initiated by the government.

Some of the non-conventional systems require batteries for storing the derived energy. Mostly, lead/acid batteries are being employed. An assessment has been made of the battery requirements during the 7th Five-Year Plan period (1985 - 90) for solar photovoltaic and wind electric energy applications in rural regions for street lighting, domestic and individual lighting systems, community lighting/television, small power plants, battery charging stations for communication and other needs, and wind electric generators and associated battery chargers.

According to the "Energy 2001" plan formulated by the Department of Non-conventional Energy Sources, there is a considerable growth potential for the lead/acid battery market in rural electrification needs for the next fifteen years. Additional programmes are being implemented by 20 of the 25 federal states in India through their respective Energy Development Agencies.

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