ELECTRICITY DEMAND SIDE MANAGEMENT (DSM) IN INDIA – A STRATEGIC AND POLICY PERSPECTIVE

Overview

The Indian power sector has more than tripled its installed capacity, from 30,000 MW in 1981 to over 100,000 MW in 2001. Despite this growth in supply, its power systems are struggling to overcome chronic power shortages and poor power quality. With demand exceeding supply, severe peak (around 18%) and energy (around 10%) shortages continue to plague the sector. Shortages are exacerbated by inefficiencies in power generation, distribution and end-use systems. The inefficiencies in the end-use systems is due to irrational tariffs, technological obsolescence of industrial processes and equipment, lack of awareness, nascent energy services (ESCO) industry, and inadequate policy drivers (such as energy efficiency standards and labeling system, financial incentives) in India.

The elementary problem being faced by the power sector is the poor financial conditions of the State Electricity Boards (SEBs) or successor entities in most states. Over the years, the SEBs have been causing an increasingly larger drain on the State Government budgets, contributing to 10-15% of the state fiscal deficits adversely impacting much needed investments in the social sectors of health and education. The power sector is operating with very low or no returns on the equity and no contribution to future investments from internal resources. This results in inadequate investment in additional generation capacity which is likely to further exacerbate the existing gap between power supply and demand. In 1991, IPP proposals exceeded 150,000 MW, while as of Jan 2001, just 3,500 MW of IPP power was actually operational.

Even if captive market capacity addition of 1,500-2,000 MW per year is included, a total capacity addition of not more than 6,000 MW a year over the next 4-5 years is expected. This translates into US$6 billion of investments and several million tons of additional pollutants but would still not be close enough to meet the targeted capacity increases of 111,500 MW by 2007. The direct and indirect economic impact of outages resulting from the capacity shortages is enormous. Some of the tangible impacts range from millions of dollars of losses in the industrial sector to over sizing of pumping systems resulting in falling groundwater levels at an alarming rate in the agricultural sector.

Thus, the Indian power sector faces two fundamental and interdependent issues: inferior operational performance leading to poor revenue cash flow, and as a consequence, inadequate capital mobilization for sector expansion. Current approaches do not completely address these issues. Power sector plans focus exclusively on new supply and lately, to an extent, on improving supply efficiency and reducing T&D losses (for instance, the latter through the Accelerated Power Development Program). A major omission is the neglect of demand-side management (DSM) opportunities in India.

There is a clear role and potential for utility driven DSM programs in India. It is estimated that the end-use efficiency improvement potential in industry and building sector alone is of the order of Rs. 10,000 crores and Rs. 2000 crores per year respectively. To capture some of this potential, the Government of India has targeted 15% improvement in energy efficiency by 2007-08. The new Energy Conservation legislation seeks to implement energy efficiency policies that lead to widespread market development though better standards for appliances and equipment, energy efficiency labeling, rational cost-of-service based tariffs, mandatory energy audits, awareness and training, financial and fiscal incentives (eg. 100% accelerated depreciation).

In this paper, we address the importance, benefits and role of DSM in India, with emphasis on agricultural sector applications.[1]

What is DSM ?

DSM is a concept in which a power utility, such as an vertically integrated SEB or an unbundled distribution utility, manages the demand for power among some or all its customers to meet its current or future needs. DSM is either implemented directly through utility sponsored programs or through market intermediaries like ESCOs. In India, DSM can be achieved through energy efficiency, which is the reduction of kilowatt hours (kWh) of energy consumption or demand load management, which is the reduction of kilowatts (kW) of power demand or the displacement of demand to off-peak times. In the former category are programs such as awareness generation programs, customer or vendor rebates for efficient equipment, etc., while the latter includes time-of-use tariffs, interruptible tariffs, direct load control, etc. Specific type of programs depend on the utility objective: peak clipping, load shifting, strategic conservation or strategic load growth.

Reductions in energy demand and consumption at the end user's premises can free up electricity generation, transmission and distribution capacity at a fraction of the costs required to provide new capacity. The cost of saved energy has been estimated to be as low as 10% of the cost of added capacity for some DSM measures. In addition to avoided and deferred capacity costs, support for energy efficiency at its customers' installations brings a utility into closer contact with its clients, often resulting in better service, and allowing a more efficient future planning process.

In the regime of tariff rationalization following upon the establishment of state regulatory agencies end-use efficiency improvements through DSM at the customer end could mitigate the adverse impact of increased rates on residential, commercial and agricultural customers. At the same time, DSM helps industries to be placed more competitively in increasingly open markets in the age of globalization.

[1] Although the term DSM may be used in a broader sense, this paper uses the classical definition of DSM, in terms of a utility-driven program only.

DSM in India

The historic problems of the Indian power sector can be traced to three root issues – unacceptably high T&D losses, large commercial losses due to poor billing, metering, collection and energy theft, and, low end-use efficiency of energy use specifically in agriculture. There is now widespread agreement that restoration of the financial health of the sector can be only enabled by demand side initiatives. To be specific, the electricity distribution area is where the historic problems converge. This convergence is most felt in the agricultural sector where the water-energy nexus is a major root cause for the precarious financial condition of the power sector in India today. Water withdrawal is an energy intensive operation throughout the agricultural sector, with the result that 30-40% of India's power consumption is used for irrigation. The irrigation pumping electricity use is at the heart of the subsidy issue and along with electricity theft and T&D losses, comprise the root cause for the sector's financial dilemma.

The reasons a power utility in India may undertake DSM include: a) demand outstripping the capability to provide supply, particularly peak supply, b) improve the cash flow revenues of the utility, c) improve the quality and reliability of power supply, and d) mitigate the impact of rising tariffs to the subsidised customers. For agricultural sector particularly, utility DSM is highly beneficial because of the subsidized prices and high costs of supply resulting from technical and commercial losses.

Natural Laws of Financing

The strategic value of DSM and energy efficiency lie in their ability to improve the financial cash flow of Indian utilities. The natural laws of financing requires that revenues from electricity sales are used to service debt interest payments and principal due on capital loans. If the flow of revenue is choked on account of commercial and technical losses in distribution and poor end-use efficiency, the ability of the utility to attract private investments towards financing IPPs or other utility services is severely undermined.

Economies are also realized on the capital account. Studies in India and elsewhere on the cost-effectiveness of DSM have reported that it costs between $1/5^{th}$ to $1/10^{th}$ to save a megawatt of power as compared to the capital investment needs to generate an equivalent megawatt in a power plant.

DSM and Power Quality

The link between quality and reliability of power supply and energy efficiency is self evident. The primary casualty on account of indifferent power supply is reduced end-use efficiency. The use of voltage stabilizers, battery powered inverters and robust yet low efficiency irrigation motor-pumpsets point out to the coping strategy employed by urban and rural power consumers at the cost of efficiency. Improvement in quality of power supply is sine qua non to achieving higher end-use efficiency. Quality improvement also has its own positive implications. Anecdotal evidence tells us that consumers are willing to

pay higher prices provided there is commensurate improvement in the quality and reliability of power supply.

The improvement in power quality and hence energy efficiency has major socio-political implications. A subject of considerable political sensitivity is that associated with tariff increases for power supply to agriculture and the urban poor. DSM and energy efficiency has the inherent potential to mitigate the rising impact of such politically sensitive tariffs through an integrated program of metering, installation of energy conservation devices and efficient system operation and maintenance.

Utility Driven DSM in Reforming Utilities

Utility-driven DSM applications in India have been limited largely to non-agricultural sectors. In one of the first DSM programs in India, the Ahmedabad Electricity Company (AEC), a DSM cell was set up in 1994 that has worked with customers to develop load research data, screen alternative energy efficiency measures and implement some of those measures through the involvement of ESCOs. Two ESCOs have worked with AEC to implement efficient lighting and reactive power compensation (though capacitor installations) measures at its HT and LT customers that has led to peak load savings of about 10% thereby reducing the need for expensive imported power in peak load hours. The ESCOs have raised finances from institutions like IREDA and have installed the efficient equipment at customer premises on a guaranted performance basis. The utility, AEC, escrows the savings which are used for loan repayments and ESCO charges.

Similar DSM cells have been established in Tamil Nadu Electricity Board and, more recently, at Jaipur DISCOM, one of the unbundled distribution utilities of the erstwhile Rajasthan State Electricity Board.

As experience from other countries reveal, in India also, the future success of DSM would be driven by the support of regulators. Regulators will have to incorporate provisions that would provide incenetives for utilities to promote DSM.

Experience in India and elsewhere indicates that the establishment of a dedicated DSM cell is one of the key to its success. The cell comprises of members who focus on specific functional areas like marketing, data analysis, One of the very first activities of the DSM cell is to develop load research (LR) through metering, consumer surveys, billing data, etc. A proper LR phase leads to the utility load curves that could be disaggregated by sectoral end-uses during different times of the day, month and year. The ultimate objective of the cell is to become an interface with customers, equipment/appliance manufacturers, ESCOs, regulators, and the utility top management.

DSM in the Agricultural Sector

The agriculture sector in India uses 85% of the available fresh water. However, on-farm irrigation efficiency is only 20-50%. The other 50-80% is wasted . Combining these data

indicate that the agricultural sector in India is wasting from about one half of the country's total fresh water supply.

On the energy front there are inefficiencies as well. The agricultural sector, on the average, accounts for about 27% of the total electricity consumption in India. The figure is somewhat higher in the agricultural states like AP, Gujarat, MP, UP, Karnataka, Haryana, etc. where agricultural electricity use is between 35-45%. However from a revenue perspective, the sale of this electricity amounts to no more than 5-10% of the state electricity board's revenues. The reason for this perverse state of financial affairs is the adoption of flat rate pricing for agricultural power. Under this system, when a farmer pays a fixed price per horse power per month for electricity, or what is termed as a flat-rate system, the marginal cost of pumping water is zero. This leads to energy wastages, over pumping and inefficient selection of crops. Moreover flat rate pumping masks the true cost of power to farmers. When unreliability is factored in, most farmers incur costs of Rs. 2-3/unit – more than what typical urban dwellers pay. From a political-economic perspective, the flat rate structure enables the state to give the impression of providing subsidized power to the rural voting population whether or not that population actually receives the intended subsidy.

Summing up, the tariff structure and the poor combination of technology and management are responsible for water loss, unsustainable exploitation of ground water and the high energy losses associated with the distribution and end-use of electricity in irrigation water pumping.

Causes of Energy Loss

Significant energy losses are associated with the distribution of electricity and in the poor selection, installation, maintenance and operation of the electrical motor-pump set system. A careful examination of the causes for such losses reveals that a vicious cycle exists that involves two sub-systems operating in tandem with one another: the electrical distribution system and the water pumping system. This vicious cycle comprises of three sub-cycles: The technology sub cycle, the financial sub-cycle and the socio-economic sub-cycle.

The Technology Sub-cycle: A starting point in the vicious cycle involving the electricity distribution system alone is the poor design and installation of the main distribution LT feeder line (11 kV) followed by overloading of the 11 kV/415 V distribution transformers (DTRs) and long lengths of undersized secondary lines characterized by high line losses and large voltage drops. Farmers typically have no control in power supply decision-making and, thus no control over the quality of supply and on the timing and duration of supply (when and how much depends upon grid supply and demand balances and is decided by the utility in advance and implemented through a rostering schedule).

Several consequences arise as a direct result of the poor quality of power. Firstly, frequent motor burn-outs occur causing continual anguish to the farmer and leading to additional costs that they have to bear to get the motor rewound and installed. Secondly, the farmer tends to select robust motors that have thicker armature coil windings and thus

can withstand the large current and consequent localized heat generation without coil burn-outs. These motors are characterized by low efficiency and furthermore, to ensure that the flow rate of water pumped out is not reduced due to power voltage conditions, the farmer tends to replace the existing motor with a higher capacity rating. From the farmer's viewpoint a 10 hp motor operating under low voltage conditions is likely to perform as well as a 5 hp motor. It has been the experience that in both Haryana and A.P., farmers use oversized pumpsets to obtain the required discharge.

Compounding the problem of poor power quality is the problem associated with management of load demand by the local distribution sub-station authorities in their desire to maintain system stability. The sub-station personnel follow a prescribed system of power regulation (power curtailment policy) whereby power is rotated among the farmers in two blocks of 4-8 hours per day. This system of power rationing, also known as rostering, causes certain undesirable practices to creep in that further increases system losses and affects power quality, and eventually leads to system failure. A common enough practice is for farmers to keep their motors switches turned on in the hope that whenever the rostering schedule is in effect for a particular block of farmers, water is pumped. Ad-hoc changes in the schedule have altered the farmer to follow such practices which lead to a number of pumps coming together at the same time – a load demand diversity of nearly unity. This in turn causes the 11 kV/415 V DTR to trip; and, in cases where the transformer fuses have been tampered with, and, with the absence of this basic protection, the transformer burns-out. Restoration of power to the farmers connected to the transformer takes several days and sometimes weeks further impacting their financial situation.

Several other scenarios in addition to this basic scenario can also occur. During the evening hours, as darkness enters, village households and rural services (street lighting) are provided power. Since peak power capacity is limited, farmers are discouraged from using their motor-pumpsets, which operate on three-phase supply. This is achieved by "single-phasing" the supply to alternating groups of feeders in rural areas. Cutting off the supply (as simple rostering would result in) prevents all consumers from consuming electricity since the rural feeder serves mixed loads, viz. Pumps on farms, light in homes and streets, etc. Single-phasing involves cutting-off one of three phases so that three-phase pumpsets cannot operate but single-phase lights and appliances in households can.

However, many farmers circumvent single-phasing by installing dummy capacitors that permit them to operate their three-phase pumpsets on two phase supply. In addition to the resulting increase in peak demand, this causes problems for utility in the form of overloading of the phases, harmonic disturbance and lower power factor.

***Financial Sub-Cycle* :**Combined with the poor quality of power and the resultant impact it has on the performance and efficiency of the farmer's pumpsets, is the financial impact of low crop yields and low incomes, which in turn generates farmer dissatisfaction with the state electricity board and the bureaucracy. Under these conditions, electricity tariff revisions for farmers are politically resisted and payments on electricity bills are

postponed, resulting in low cost recovery and the ensuing political pressure by farmers not to pay for a service that is not responsive to their needs.

Low cost recovery, in turn, is linked to under funding of the operations and maintenance of the power delivery systems which, coupled with the poor engineering standards and state of the LT distribution systems, and compounded by the inappropriate structure, policies and staff skills of many SEBs, closes the circle by providing poor quality of supply service. This in turn, sets off a chain-reaction of events of motor burnouts/transformer overloading, etc. that give rise to a host of problems, whose tendency is then to further depress the cost-recovery levels and the cycle goes on. Sub-optimal allocation of resources towards the distribution system places further burden on the already vulnerable system causing deterioration in the quality and reliability of supply.

Socio-Economic Sub-Cycle: Exacerbating the low cost recovery issue are the twin issues of illegal connections and thefts. The former is a direct result of the long waiting periods that farmers have to suffer (upwards of 2-3 years) to obtain sanction for a new pumpset connection and the latter is due to the ease by which unscrupulous elements can tap into the long winding secondary distribution lines. These combined with the near-universal practice of "motor nameplate switching" whereby higher capacity motors have their labels altered to indicate lower ratings. In a flat rate tariff system as is prevalent in Haryana and A.P. and most other Indian states, this further robs the utility of its legitimate revenue.

Summing up, therefore, the inefficient distribution systems with poor voltage profiles and high distribution losses result in motor burnouts. Low diversity factor caused due to the load shedding in rural areas also results in high rate of distribution transformer burnouts. As a result, customers are dissatisfied with the utility power supply and install higher capacity motors. Since they also have to incur expenditures on account of frequent motor rewindings, their operational expenditures escalate and they are reluctant to pay more to the utility on account of higher capacity motors. This leads to the use of spurious nameplates on agricultural pumpsets and resistance to tariff increases. Customers also resist metering of pumpsets. Utility revenues deteriorate and less resources are available for maintenance and rehabilitation of distribution systems. This results in sub-optimal planning, low quality of works and further forces utility to consider load shedding. Thus, the vicious cycle is completed. Let us now turn to the subject of water use in agriculture, specifically water losses and tariffs.

Conclusions

A fundamental problem being faced by the power sector is the poor financial conditions of the State Electricity Boards (SEBs) or successor entities in most states. There are economic, environmental and social reasons to promote utility driven DSM as a precursor to the ongoing power sector reforms in India. Although limited experience with DSM in India has proven its importance in the power scenario, there exists an enormous untapped potential. There has been very little application of this innovative concept in the agricultural sector where the benefits are going to be significant.

THE VICIOUS CYCLE IN ENERGY AND WATER USE IN AGRICULTURE