CONDITION BASED MAINTENANCE FOR IMPROVING POWER PLANT ECONOMICS

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The per capita consumption of electrical power in India is around 300 units which is 1/10 of the average world per capita consumption and 57 times less than USA and 29 times less than Germany. The demand for power in the country has been growing at the rate of 8% per year. The present installed capacity in the country is around 95500 MW, 80% of which is supplied through fossil fuel (coal), about 17-18% through hydel where as the nuclear power contributes a little less than 3% of the total power. The nuclear energy share in the world is 16%. The demand for electrical energy in India is rapidly increasing due to industrial and population growth, outstripping the available generation.

India has planned to increase power production at the rate of 10000 MW/year in the ninth plan which is proposed to be increased to 12000 MW/year in the 10^{th} plan. Indian power generation has been and will continue to be predominantly coal based. India stands eighth in the world with an estimated coal reserve of 200 billion tonnes and it ranks fourth in terms of volume of production after China, USA and Russia. This increased power demand can be met with, only if available installed power generating capacity is effectively utilized adopting refined operating and maintenance practices. Power plants are characterised by large capital investments and high fuel costs creating a critical need for detecting, identifying and diagnosing machinery problems.

Electricity is slowly becoming an expensive commodity that cannot be doled out on non-economic considerations. When the country stands poised to record over 7-8% manufacturing growth rate on annual basis. The one major factor that is holding everything back is the widespread shortage of power.

The financial situation of the SEBs has been the prime cause of the weak revenue stream within the sector. The management is anything but commercial. They have been asked to sell power at a price lower than the cost of production. Their plant load factor is as low as 65.5% at 1999-2000 average value, and suffer high T&D (Transmission and Distribution) losses. The transmission and distribution losses in India have gone up to 23% in some cases it varies from 30-40% due to various non-technical reasons like pilferage etc. on average as compared to 8-10% in developed countries. It is estimated by Rajyadaksha Committee on power that the maximum power loss in T&D system can be brought down to about 15%.

The major portion of the technical losses is attributed to the distribution losses which is of the order of 19% where as the contribution of transmission losses is about 4%.

The growing demand for cheaper and more reliable electricity supply, are forcing power generating facilities to find alternate means to make better economical gains. When costs need to be cut and availability increased attention is ultimately drawn to the maintenance sector. It has been analysed that by improving monitoring and operating procedures 10% of the energy could be saved. In many cases, outdated equipment and processes in Indian industry and agriculture sectors consume more power than required due to inefficient operations as compared to Western countries.

Improving efficiency of existing power plants is the easiest way to make rapid strides in electricity because at present, efficiencies are low and decisions to improve efficiency are centralised. It is estimated that 1% reduction in plant efficiency (or 1% decrease in heat rate) amounts to annual loss of the order of 4 crores for a 210 MW unit or 10 crores for 500 MW on fuel cost alone for a pit head station. Even at 0.5% increase in boiler efficiency can result in a substantial saving of Rs. 80 lakh per annum for a typical 500 MW boiler.

As per national average, 10% auxiliary power is being consumed by power industry itself. As per 1997-98 figures, out of the 346710 MU (thermal) of power generated in the country, 34671 MU was lost as auxiliary power. 1% reduction in consumption of auxiliary power means a saving of the order of 3467 MU . Saving of the order of 3467 million units and supply the same to LT/HT consumers would lead to a cash earning of Rs. 1133.7 crores @ Rs.3.27 per unit sold. Rs.3.27 has been considered as cost of one unit of electricity (one KW/h) . This has been found to be the average value of unit cost of both LT & HT consumers.

As already stated in the previous paragraph, transmission and distribution (T&D) losses constitute nearly 23% of the generation. Therefore reduction of T&D losses shall play a vital role in reducing the cost of power to the consumers. Every unit saved is every unit generated.

All sub-station equipments must therefore receive high standard of maintenance so that they perform reliably throughout their life span. Generally the consequences of not maintaining them properly will have cascading effect resulting into power tripping, loss of system stability and break down leading to damages to neighbouring costly equipment. Besides this, the loss of production in a process plant(s) or in a manufacturing unit(s) and many down stream units is to be taken into account.

The total annual energy consumption for 1999-2000 was 470 giga units. It would be worthwhile to note that a mere 1% reduction in energy losses in India is equivalent to the output of about 500 MW which needs an investment of more than 1500 crores. Most of the losses in distribution are traced to be due to simple problems like poor joints, sagging, overloading, HT/LT jumper burnt, HT/LT conductor broken, jumper loose, burnt etc. All these problems arise out of improper maintenance.

In India failure of Distribution Transformers (DT) are in the range of 20% to 40% as against 1 to 3% in Western countries. It is known that failure due to inadequate maintenance is very high which can be brought down to 4-5% by proper maintenance strategy. The number of such transformers which are generally deployed is very high. To cite an example, MSEB has got 1.35 lakhs DTs spread over a vast area. MSEB also adds 5000 new DTs every year at a cost of nearly 25 crores.. Though the estimated life of each transformer varies between 20-25 year depending on KV rating, in reality they are failing after a life of 5-6 years. There are many instances in the records of SEBs where DTs have failed even within 1 or 2 years due to poor quality. It may also be mentioned that PMP can be used to check quality at production stage of transformers. Though modernisation of T&D system is called for improving this situation, it would cost enormous amount of capital.

In summary, it can be stated that there is large scope to cut down costs of energy generation, transmission and distribution which can be achieved through proper maintenance strategy. In an economic survey report carried out in March ‘97, it is stated that unless infrastructure facilities such as power generation are maintained so as to produce the same at lower cost, the momentum of growth in Industry will be reduced. If the cost of power can be reduced, then most of the industrial sectors such as steel, cement, fertilizers, petrochemicals and many other down stream industries will become much more competitive when compared to global market. Here it may be mentioned that energy consumption in steel industry is the highest in India. It is 142 dollars/ ton of saleable steel, while it is only 79 to 87 $/ton in UK, USA & Japan.

Similarly, Indian pulp and paper industry's energy consumption stand at 31-51GJ per tonne of product which is roughly twice the norm in North America and Scandinavia, other major paper and pulp industries countries in the world.

Another major important aspect is providing power not only at cheaper cost, but providing it without unplanned interruptions. In one fertilizer plant in which there is no captive power plant, the cost of fertilizer plant tripping due to power supply problems alone cost Rs.4 crores/year. Though it is difficult to estimate the cost of lost production due to improper supply of power, in nearly 4000 industries in India, one can guess it will be phenomenal.

In fossil stations alone they have monitored 5000 numbers of power generating machinery and the number of monitoring points is about 47000 before coming to the conclusion that PMP is one technique which will stay in reducing the cost of power generation.

2. PMP AS MAINTENANCE STRATEGY IN POWER INDUSTRY

The Department of Energy, USA and Electric Power Research Institute, USA have

demonstrated the potential of PMP in a number of power utilities to reduce forced outages in both fossil and nuclear power stations. In fossil stations alone they have monitored 5000 numbers of power generating machinery and the number of monitoring points is about 47000 before coming to the conclusion that PMP is one technique which will stay in reducing the cost of power generation. EPRI had spared time to take every fault identified during 1986 and to postulate a reasonable scenario of events had the fault gone undetected. The maintenance and replacement spares cost associated with the postulated scenario were estimated and compared to those which actually occurred from taking action. From this study, EPRI who had monitored this programme had estimated a net cost savings of $990,000 for the total of all stations monitored at one utility.

In another report, it is mentioned that in one Western Texas facility, the cost of co-generation was reduced from $7.0/HP to $3.5/HP through PMP. The same report also states that in a nuclear power plant in USA, the estimated savings were $2 million in the first year and $3.5 million in the second year following a well designed PMP.

It has been reported in a study carried out by a US based Thomas Marketing Information Centre (TMIC) that a medium sized power plant in New Haven, Connecticut saved well over $4,56,000 a year by installing PMP system. It has also been stated that the

system paid for itself in the first 12 months. It has been reported by the same study group that they have recorded 18,255 forced outages in the US Power industry in a single year which was costing upto $125 billions.

PMP has also been employed with excellent results in an Austrian hydro electric power plant in 1994-95. Similar success stories regarding the power of PMP has been reported in various other power utilities across many continents.

In the Indian context, the study carried out by the author indicated that the potential of PMP has not yet been applied in power industry as a cost reduction measure. Though some of the power plants are having PMP equipment as part of

OEM units supplied, no sincere efforts are made to use it as important maintenance tool.

Still it is very common in India to hear that a particular power plant was shut down due to sudden equipment failure. Such situations could easily be avoided if proper PMP is implemented. Lack of training, commitment and belief that PMP will give good results are some of the reasons which were found to be a common thinking in many power plants personnel.

The results show that manufacturer defects and inadequate maintenance are responsible for the majority of power transformer failures (i.e. 60%). Since PMP can be used not only to assist maintenance people, but as a quality tool, PMP can be used effectively to reduce these failures of 60% down to 4.5%.

Today, a number of components in power plants, (fossil, nuclear and hydro electric plants), including Transmission and distribution system can be effectively monitored through PMP. These include boilers, turbines, gear boxes, motors, bearings, transformers, circuit breakers, loose contact switches, circuit jumpers, control equipment etc. There are sufficient number of PMP techniques (Thermography, vibration, wear debris etc) which can be applied without taking items such as transformers, contact switches, boilers etc. out of service and determine the maintenance requirements.

It has been well established that by improving monitoring and operating procedures, 10% of the energy could be saved in generation. Motor driven pumps are used in every industry, agriculture sector and every walk of life. Pumping is one area which alone accounts for more than 30% of the total power consumption in the country. Rectification of these pumps from defects such as mis-alignment alone can result into huge savings of over 4000 MW of electrical power. In a steel plant, nearly

20000 motors are used for various applications. Since the motors are running and doing their work, nobody suspects their operation. But they may be consuming more power than they are in healthy condition. PMP identifies such motors so that they can easily be repaired and original operating condition will be restored. From many case studies, it has been established that a minimum of 2% of energy consumption can be saved using PMP in any industry.

Similarly a study was carried out by the author in a pulp and paper plant where a number of machinery will be operating throughout the year. The energy consumption, for a typical 100 TPD plant is about 2690 kwh/tonne of paper produced. A saving of 2% in power consumption means saving of 53.8 kwh units/tonne of paper production. At kwh unit cost Rs.3.27, this works out to saving of Rs.176 per every one ton of paper produced (or 17600 per 100 ton produced in a day). What PMP does is to make sure the machinery are operating in healthy condition to realise this savings.

3. LIKELY SAVINGS DUE TO IMPLEMENTATION OF PMP IN INDIAN POWER INDUSTRY

In the power industry the potential for savings in maintenance exists in three areas. They are power generation (Production side), power Transmission and distribution (Supply side) and power consumption (demand side). Proper PMP should yield good savings in all these three areas. By using PMP at the power generating stations, it is possible to increase the efficiency of the plant operation resulting in at least 2% increase in production units. Similarly, through PMP, it has been well established that at least 7% reduction in T&D losses can be realized. A number of illustrations cited in the foregoing paragraphs bear testimony to this.

Percentage of shortage in the power can be made good to a large extent by proper implementation of PMP in all power utilities and corresponding T&D systems. The total energy savings mounts to 33.8 million MWh and cost savings works out to Rs.11,061 crores across the whole country.

(a) This is as good as generating additional power of 6666 MW. This will bring down the energy shortage to 2.7% from 6.5% at normal load. But at peak load, the energy shortage will come down to 12.2% from 16%.

(b) The cost of the PMP implementation will usually be paid back within 6 to 12 months. Rather, this cost is very insignificant. The cost savings through PMP will help many industries to off-set some of their losses or improve bottom line profits.

TABLE 1

ENERGY & MONETARY SAVINGS THROUGH PMP :

POWER GENERATION SIDE (1999-2000)

Sl.No.		Installed capacity (MW)	PLF	No. of Hrs of Plant run	Total Units of Energy (MWh)
1	Without PMP	95500	65.5	7512	469.9 million
2	With PMP	95500	66.8*	7663 +	488.9 million

Total Energy Savings : 18,959,042 MWh
(from column (6))

Total monetary savings : 61,996,067,340 i.e. Rs.6199 Cr @ Rs.3270 per MWh

Equivalent Power generation (EPG) : 3703 MW since energy saved is energy generated.

Note :
- * : 2% increase in PLF due to PMP
- + : 2% increase in plant uptime
- MW : Mega Watt Power
- MWh : Mega Watt Hour = 1000 KWh
- PLF : Plant Load Factor

TABLE 2

ENERGY AND MONETARY SAVINGS THROUGH PMP :

SUPPLY SIDE (T&D) (1999-2000)

Sl.No.	Total energy units generated (MWh)	T&D (Technical) losses (%)	Total energy units (MWh) after T&D losses	Energy savings	Cost savings (Rs.Crores)
1	2	3	4	5	6
1	488.9 million with PMP implemented at Generation side	22% without PMP in supply side	381.0 million	-	-
2	488.9 million with PMP implemented at Generation side	20% with PMP in supply side also	391.0 million	9.8 million (1976 MW) Power equivalent)	3197
3	488.9 million with PMP implemented at Generation side	18% with PMP in supply side also	401.0 million	19.5 million (3974 MW)	6394

Note : It has been projected that India can bring T&D losses to 20% within next decade [Jim Bever, (Feb 2000)]. But efforts from all agencies such as State Electricity Boards, etc should lead to further reduction in T&D losses upto 18%.

Equivalent Power generated at 20% T&D losses : 1976 MW

Equivalent Power generated at 18% T&D losses : 3974 MW

TABLE 3

ENERGY AND MONETARY SAVINGS THROUGH PMP :

CONSUMER SIDE (Demand Side) (1999-2000)

Sl. No.	Installed capacity MW (1999-2000)	Total energy generated without PMP (MWh) million	Total energy generated with PMP (MWh) million	Total energy after account-ing for T&D losses at 20% with PMP (MWh) Million	% energy used by Indus-try & Agriculture	Total energy by Indus-try & Agriculture (MWh) million	Savings in energy through PMP by 2% (MWh) million	Savings in amount	Savings in Power generation
1	95,500	469.9	488.9	392.0	65%	254.0	5.0	1665 Cr	993 MW

Note : Energy used by domestic consumers is not taken into account since PMP is not expected to be cost effective.

TABLE 4

POWER SECTOR :

SUMMARY OF ENERGY & MONETARY SAVINGS DUE TO PMP

Savings	Generation	Supply (at 20% T&D losses)	Demand	Total
Energy (MWh)	18,959,042	9,777,068	5,084,075	33,820,185
Power (MW)	3703	1970	993	6666
Amount (Rs. Crore)	6199	3197	1665	11,061

Formulae used for conversion from Power to Energy is given by

$$\text{Energy} = \frac{\text{Power X PLF\% X No. of hours}}{100}$$

- PLF value used is 66.8
- No. of operating hours per annum : 7763
- Cost of MWh = Rs. 3270/- (i.e. cost of KWh = Rs. 3.27)

TABLE 5

INFLUENCE OF PMP IMPLEMENTATION ON POWER SECTOR SCENARIO

	Total energy generated (MWh)	Energy shortage (%)	
		Normal load	Peak load
Without PMP	469,894,380	6.5	16
With PMP	488,853,422	2.7	12.2