POWER QUALITY PROBLEMS IN INDIA

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SUMMARY

The basic cause of deteriorating quality of power supply in India is widening gap between demand and supply. Frequent power cuts, inadequate transmission and distribution system, regular breakdowns and load shedding, theft of power, lack of service culture, low and high frequency regime in the power grid for about 60% of the time during the year, 220 kV system voltage goes to 165 kV and 400 V system goes below 300 V, harmonic levels touch 22% THD are responsible for loss, mal-operation or damage to consumer equipment. Setting rural co-operatives and professionalisation of power utilities will help to improve the power supply.

POWER QUALITY PROBLEM

In this paper, the power quality problem is defined as:

Any power problem manifested in no power supply that causes inconvenience or production loss; deviation in voltage, current, frequency that results in failure or mal-operation of consumer equipment; unsatisfactory consumer service.

It is important to understand the inter-related nature of power system and the consumer equipment, the power utility staff and the consumer which is inherent in the above definition. The various issues are discussed in this paper.

CONSUMER SATISFACTION

The electricity consumers aspire for the power supply of resonable quality at reasonable price to serve their local needs. The consumer needs:

- Continuity of power supply
- Good quality of power
- Prior intimation of power cuts
- Correct billing
- Better collection system to reduce hassle and time spent in queues
- Power on demand
- Faster redressal of complaints

There is large consumer dis-satisfaction towards to power supply facilities specially during summer peak of the year. In some places like Delhi, Haryana, there was situation of the type of civil riots in 1998 when people confronted frequent bad supply. The World Economic Forum carried out power supply survey of various countries. As per their 'the Global Competitiveness Report 1996', the rating point of 1 to 6 for poor to excellent position of power supply to meet business needs of consumer was given as below:

U.S.A.	5.66	Malaysia	4.13
France	5.56	Brazil	3.79
Singapore	5.45	Poland	3.71
South Africa	5.30	Maxico	3.69
U.K.	5.23	Indonesia	3.53
Germany	5.22	Philippines	3.51
Japan	5.00	Taiwan	3.18
Egypt	4.47	Russia	2.90
Korea	4.43	China	2.47
Thailand	4.18	India	1.85

From the above table, it is seen that India stands lowest in the power supply rating. However, Central Electricity Authority, under the Govt. of India prepared power development plans based on loss-of-load probability (LOLP) level of 2% and energy-not-served (ENS) less than 0.15% [4]. The plans did not mature due to lack of financial resources and inefficiency of power sector.

EQUIPMENT BREAKDOWNS

The equipment and line breakdowns in the power system are high. This lead to power cuts and load staggering. Notable high failure rate is for distribution transformers and energy meters. The failures are mainly due to bad quality of manufacture and inadequate operation and maintenance.

Distribution Transformers

The annual damage of distribution transformers in different states in India varies from 10 to 40%. For example, in Punjab it is +10% and in Haryana it is +40%. The damage in rural area is much high as compared to urban area. The average rate of annual damage in India is about 20% [1]. There are about 1.8 million transformers [6] in the country. This virtually indicates that on an average every 6th distribution transformer installed in the

country is damaged and repaired or replaced during a year. Repair/replacement of damaged transformer generally takes long time. In number of cases a period of upto 30 days including waiting period is taken. This causes lot of harassment and power interruption to the concerned consumers. The damage of distribution transformer should be limited to less than 3% as prescribed in IEEE 500/1984 Standard by procurement of proper quality of transformers and their better operation and maintenance later on.

Energy Meters

According to survey carried out in northern states, 10-15% energy meters (Ferraris kWh meters) at the consumer end become faulty during the year and are repaired or replaced or declared unserviceable. Besides that for about 5% faulty meters, the Meter Change Orders (MCO) remains unexecuted mainly due to short supply of meters. At present there are about 105 million meters installed [6] in the country. Virtually on an average every 7th meter installed become faulty during the year. This is mainly due to bad quality of meters which are procured usually on lowest quoted price. When changing the faulty meter, the consumer has to make efforts, bear harassment, and in most of the cases it will amount to power interruption. However, there are cases where meter is faulty because the consumer tampers with the meter to steal energy. Now solid state meters are being installed in phased manner by various power utilities to safeguard theft as these electronic meters are fraud-proof, stable and more accurate. For example, in Punjab State Electricity Board, solid-state meters have been almost installed for 3000 large industrial consumers (each above 100 kW load), And the visible reduction in theft has been noticed as because their is increase in consumption and increase in revenue after the installation of these meters. For medium industrial consumers (each 20-100 kW load) numbering 16000, the installation of the meters is under process. We are hopeful to improve the consumer service with the installation of these meters.

Consumer Complaints

In Punjab, James Martin & Co, [2] carried out electricity consumer service survey in 1995, it was reported that service quality in urban area is satisfactory though there is lot of scope for improvement. For rural area, the service quality is very poor to non-existent. On the whole consumer complaint service culture was found as fire-fighting instead of planned actions. It was reported that annual average number of consumer complaints are about 350 and 700 for urban and rural area respectively. The situation in most of other states in the country can be taken as more adverse as Punjab power sector is considered relatively better managed.

The root cause of higher level of complaints is bad condition of distribution system, lack of focus on maintenance, lack of infrastructure and material for handling complaints, indiscipline among staff.

POWER CUT

In India, frequent power cuts and power use restrictions are imposed due to power shortage or due to inadequacy in local distribution system or some breakdown in the system. Regular power cuts are announced during summer peak period. Also unannounced power cuts are common. As per report of Ministry of Power, Government of India, the power shortage for FY 1997-98 was 11.1% in peaking and 8.1% in energy. The cuts create lot of inconvenience to people and production loss. For example it has been estimated that due to power cuts on HT Industry in the country, the production loss in FY 1992-1993 and FY 1993-94 was Rs. 40000 million and Rs. 32100 million respectively.

The power cuts needs to be rationalised and value based. To agriculture consumers, power can be given for 6-8 hours in a day. It is acceptable with low tariff. Only question is that for 6-8 hours, the continuous power supply should be available. Demand side management (DSM) measures are urgently required to contain the peak demand. Industry weekly off days can be staggered. Power intensive industry can be closed or staggered for their 2-3 off days in a week. Power restrictions on industry can be for the evening peak. Time-of-Day (TOD) meters can help to shave peak in all types of consumers. Integrated operation of power grid will also help to meet power peak. The focus on energy conservation can be increased by enacting energy conservation act by Govt. of India.

THEFT OF POWER

The theft of power overloads the distribution system and causes low voltage, voltage dips problems. As per study, about 15% of electricity is stolen in India. The theft varies from 10 to 30% in different states as given below:

State	%age energy stolen
Punjab	10%
Haryana	15%
Delhi	35%
Gujarat	10%
U.P.	25%
J & K	30%
Orissa	25%

There is a tendency to hide the theft and to adjust the stolen power towards agriculture consumption which is normally unmetered supply in the country.

The power utilities in India have started installing micro-processor based energy meters for industrial consumers

which have visibly shown the results of reducing theft specially where meter tampering method is employed for stealing energy in case of Ferraris (induction) meters. The electronic meters are fraud-proof. Energy accounting for each feeder, vigilance on consumption, strong enforcement and also providing electronic meters for all other categories of consumers will help to reduce theft.

The electronic meters are cheaper and versatile now-a-days. The present kWh consumer metering is inefficient as reactive power consumed is ignored. We can say that reactive power is pilfered by the consumer without any notice. Total electricity metering should be the motto for the next century i.e., kVAh metering as this will give signal to end users to use the electricity efficiently. That is to use efficient equipment and to install capacitor to reduce reactive power demand. Earlier it was difficult to introduce this metering because of high cost of induction type kVAh meter. Now electronic meters has made it possible. The Indian Electricity Act 1910 may be amended to provide kVAh metering for all consumers. The meters may be installed in phased manner for existing consumers. New connections should be released with kVAh metering.

POLLUTED SUPPLY

Growing use of non-linear loads such as semi-conductor devices in power/control circuits of household electrical items and industrial devices, lot of distortion in the voltage/current waveforms has been experienced. Examples are railway elctrification, computers, flourescent lights, colour TVs, arc/induction furnances, rolling mills and induction motors with speed control devices. These loads create harmonics. The hormonics flow through the distribution system and may be transmitted from one consumer to other consumer. The harmonics create extra heating of rotating machines and cables, can cause mal-operation or failure of consumer equipment, introduce noise to communication circiuts, stress insulation level of equipment, create flicker, make unbalance and demand more reactive power (see Fig. 1 and 2). As per harmonic studies carried out, the following maximum total harmonic distortion have been found in India [5].

Type of Consumer	Maximum % THD
Traction	22.43
Cement Industry	6.50
Casting plants	7.79
Chemical plants	4.5

The above %THD is more than tolerable limits. In India, Madhya Pradesh Electricity Board has prescribed limits of tolerable limits of harmonics for HT consumer as THD not more than 3% and individual harmonic distortion not more than 1%. A limit of THD of 5% and for any single harmonic content not exceding 3% should be acceptable in India. The power utility while sanctioning the new power connection to non-linear load consumers, the harmonics generation from such loads should be assessed to ensure that connection of these loads does not exceed the harmonic prescribed limits at the point of common coupling. If the limit is exceeding, the consumer can be enforced to install harmonic filters. Hand-held power quality analyser meters are available to check THD and individual harmonic distortion up to 51st harmonic [7].

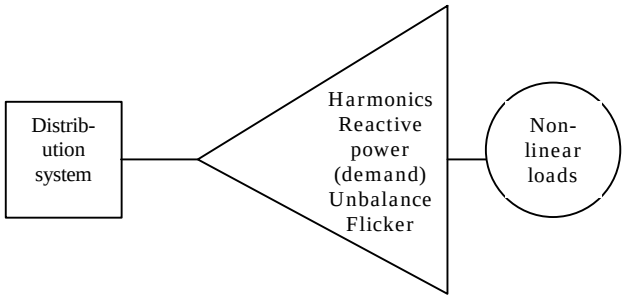

Fig. 1: Power Quality Problems Caused by Non-Linear Loads

RURAL CO-OPERATIVES

In India, about 70% people live in rural area. The rural electricity supply is highly unsatisfactory. Generally the distribution lines are lengthy and heavily loaded. The continuous supply to villages at par with urban area is still a dream. The quality of construction and operation and maintenance is poor. The faults on distribution network are frequent besides that there is lot of theft of power. Each village should be empowered to undertake the job of rural electrification and power distribution. The co-operative model needs to be introduced to improve the power supply.

A local individual from a village should be appointed to monitor the village power supply through meter installed by the state power utility. All power users of the village then form a power users' co-operative at the village level. Then users get together and form a union. This co-operative can be entrusted to take up electrification work. The individual who want to take new power connection should be on self-finance basis. Each individual prospective consumer should provide labour and materials including meter for one’s power connection. Village co-operative will contribute some capital to the power utility for system improvement before the village meter if required. The electric co-operatives will improve the consumer satisfaction and reduce theft of power as is the experience with the existing 33 rural electric co-operatives working in India. Ultimately rural electric co-operatives should be under state organisation 'State Rural Electric Co-operative Federation (SRECF). Each state government should pass the law in this respect and to facilitate soft loans to the co-operatives and to afford commerical and technical input.

WEAK POWER GRID

There are 5 regional grids in India which are weakly interconnected through HVDC/HVAC links. National grid is still not operative. Surplus power available in eastern and north-eastern regions cannot be transmitted to short supply northern and southern regions. The power system lacks reactive power during summer peak period when agricutlure load to 12.1 million pumpsets is at the peak. The system starves of reactive power. For example [3] in northern region, the shunt capacitors working capacity is 10813 MVAr against the requirement of 15030 MVAr. Thus there is shortage of reactive power by 30%. The system voltage goes very low i.e. 220 kV system touches 165 kV, 400 V LT system voltage goes to 300 V or even less. The system frequency remains low (<49 Hz) and high frequency (>50.5 Hz) for about 60% of the time during the year. Low frequency is unavoidable due to power shortage.Low frequency and low voltage has occassionally resulted in grid failures, blackouts, causing damage to equipments. The heavily loaded transmission and distribution system create voltage sags, swells and magnify unbalance in the system (see Fig. 2). High frequency is due to the tendency on the part of plant operators to maintain high generation even during slack period when the machines should backdown. The frequency analysis of northern grid for the FY 1997-98 shows the following frequency regime of the grid [3].

Frequency (Hz)	% time of FY 1997-98
Above 51.00	13.69
51.00-50.5	17.41
50.5-50.2	9.51
50.2-49.8	9.49
49.8-49.5	7.92
49.5-49.0	13.47
49.0-48.5	12.73
48.5-48.0	13.70
Below - 48.0	1.73

Grid discipline is urgent. The national grid operation must be expedited.

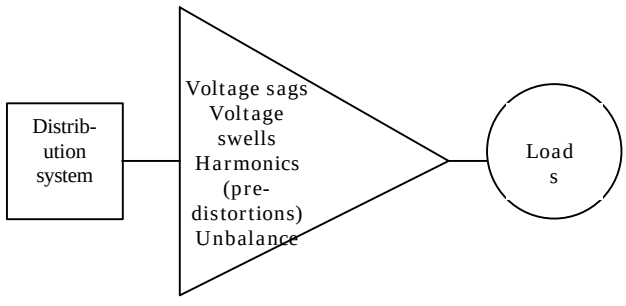

Fig. 2: Power Quality Problems Caused by Heavily Loaded Distribution System and Affecting the Loads

SYSTEM FAILURE

At present, the state power utilities are thriving on corruption, inefficiency, incurring heavy financial losses, and above all, the blatant harassment to the honest consumer. During FY 1997-98, the power utilities in India had the financial loss of Rs. 100000 million. Generally, the consumer has to pay some money to utility staff for expediting various services such as change of meter, change of transformer, rectification of faulty line etc. There are poor norms of accountability. Those who are keen to perform lack protection while non-performers and corrupt walk-off without any remorse. All this add to cost of electricity supply to the consumer. This is system failure. The power generation efficiency in India is 4646 kWh/kW of generation capacity installed. Transmission and distribution losses are 22%, theft of power is nearly 15%.

Restoration of autonomy and professionalisation of state electricity boards (SEBs) could bring requisite efficiency and improve service to the consumer. Vision, values, mission should be to supply good quality of power at low price and to provide excellent service to the consumer. Reforms must facilitate engineering input, introduction of information technology infrastructure, work skills training. Urban distribution may be entrusted to competitive private companies. Value added consumer service will be cutting edge for power utility survival in the next century. The quality management system as per ISO 9002 must be adopted by each power utility at the earliest possible. With the aid from World Bank and Asian Development Bank, some of the state electricity boards namely, Orissa, U.P., Haryana, Gujarat, Andhra Pradesh, Rajasthan, Goa, Tamil Nadu are under reform process to improve overall efficiency on commercial lines. Each state electricity board must issue 'Charter' for electricity services to the consumer. According to this charter any deficiency could be challenged in the Local Consumer Forum under Consumer Protection Act 1986 or any other court of law. Under the Electricity (Supply) Act, 1948, the existing State Electricity Councils and Local Electricity Advisory Committees at district level should be properly formed so that they play effective part in improving the power supply position and service to the consumer.

CONCLUSION

Good quality power supply is most requisite to-day than every before. The consumer satisfaction will be cutting edge in the competitive environment in the 21st century. The power cuts can be accepted for some categories of consumers but availability of power during agreed slot of time must be uninterrupted. The right priorities must be set up to solve the various quality problems. Professional-isation of management of power sector, integration of grid operations, operations of SEBs on commercial basis,

demand side management, kVAh electronic metering for consumer, privatisation of urban distribution, limitation of harmonics, setting rural electric co-operatives and to give continuous supply to villages are urgent measures.

REFERENCES

[1] P.N. Khare 'Minimization of Failure Rate of Conventional Transformers', *Proceedings 1997 Seminar on Distribution transformers - Failures and New Developments*, CBI&P, pp. 1-32.

[2] James Martin and Co. *'Punjab State Electricity Board - Business Re-engineering of Customer Complaint Handling Report*, December, 1995.

[3] *NRLDC Annual Grid Report*, July 1998, Power Grid Corpooration of India, New Delhi, pp. 71.

[4] *Annual Report 1996-97*, Central Electricity Authority, Government of India, New Delhi, pp. 15.

[5] *Guide for Limiting Voltage Harmonics*, Publication no. 251, CBI&P, New Delhi, pp. 29-34.

[6] *Public Electric Supply - General Review* (1995-96), Central Electricity Authority, Government of India, New Delhi, pp. 151-164.

[7] *asian Electricity*, September 1998 pp.37.