Impact of power thefts and Power system quality standards in Indian scenario:-Survey

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Abstract:-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 [1]. 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 India stands lowest in the power supply rating However, Central Electricity Authority, under the Govt. of India prepared power development plans [2]. In the Indian scenario, power quality issues are of increasing importance these days due to the enhanced use of sensitive equipment .such as adjustable speed drives, medical electronic systems and switched mode power supplies. In India, essentially IEEE standards are referred as guidelines in electricity sector and in manufacturing sector normally IEC standards are complied to meet global market demands. The theft of power overloads the distribution system and causes low voltage, voltage dips problem and generate heavy harmonics in power system.

Keyword:-Power System, Power Quality, THD, IEEE-519, IEC Standard, CEA.

1. Introduction

India has 28 states and 7 union territories. It faces a formidable challenge in providing adequate energy supplies to users at a reasonable cost. India as a country suffers from significant energy poverty and pervasive electricity deficits. In recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development, even though the base rate may be somewhat low. According to Integrated Energy Policy Report of Planning Commission of India, 2006, if the country is to progress on the path of 8-9% GDP growth rate during the next 25 years, it would imply quadrupling of its energy needs [3]. The electricity consumption per capita for India and other countries or regions in the world is given in table (1).

Table 1.The electricity consumption per capita for India and other countries or regions in the world

COUNTRIESWISE/REGIONS	ELECTRIC CONSUME/CAPITA(KWH)
WORLD	2782
ECD	8486
FORMER USSR	3384
MIDLE EAST	4660
CHINA	3378
ASIA(WITHOUT CHINA)	2471
LATIN AMERICA	719
AFRICA	571
INDIA	566

(SOURCE: 2010 KEY WORLD ENERGY)

The electricity consumption per capita for India is just 566 KWh and is far below most other countries or regions in the world. Even though 85% of villages are considered electrified, around 57% of the rural households and 12% of urban households, i.e. 84 million households in the country, do not have access to electricity. Electricity consumption in India is expected to rise to around 2280 BkWh by 2021-22 and around 4500 BkWh by 2031-32.

The Aggregate Technical & Commercial (AT&C) losses which include theft, non billing, incorrect billing, inefficiency in collection and transmission and distribution losses exceeded 40% for the country as a whole in 2005. The extent of power shortage varies from state to state. Table 2 gives the comparative status of power supply in various states and union territories from April 2010 till February 2011 [4].

Power tariffs are structured on the basis of industrial and commercial users cross subsidizing agricultural and domestic power consumption. The agricultural sector is supplied with un-metered power in almost all states and the farmers pay a highly subsidized lump sum based on the declared horse power of their pumps (generally 3hp, 5hp, 7.5hp). The domestic sector also has a range of subsidies based on the level of consumption including heavily subsidized power for the poorest segment wherein households pay a low lump sum monthly charge. With the rising cost of supply, the burden of these cross-subsidies has increased and is disproportionately loaded on the

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paying industrial, commercial and large household consumers.

Power Theft

The habit of stealing power is now widespread. The theft of power overloads the distribution system and causes low voltage, voltage dips problems. As per study, about 30% of electricity is stolen in India. The

Table2. Base and Peak Demand Deficit in India.

States/UT/Region	Requirement	Availability	Surplus /Deficit (%)	Requirement	Availability	Surplus /Deficit (%)
	Power Supply (in MU)			Peak Demand (in MW)		
Chandigarh	1413	1413	0	301	301	0
Delhi	23863	23800	-0.3	4810	4739	-1.5
Haryana	31762	29912	-5.8	6142	5574	-9.2
Himachal Pradesh	6964	6713	-3.6	1278	1187	-7.1
Jammu & Kashmir	12427	9268	-25.4	2500	1690	-32.4
Punjab	41226	38649	-6.3	9399	7938	-15.5
Rajasthan	40956	40552	-1.0	7582	7408	-2.3
Uttar Pradesh	70098	59306	-15.4	11082	10672	-3.7
Uttrakhand	9022	8451	-6.3	1520	1520	0
Chhatisgarh	9250	9096	-1.7	2913	2759	-5.3
Gujarat	65217	61199	-6.2	10786	9947	-7.8
Madhya Pradesh	43873	35018	-20.2	8864	8068	-9.0
Maharashtra	115824	96566	-16.6	19766	15479	-21.7
Daman & Diu	1987	1822	-8.3	353	328	-7.1
Dadar Nagar & Haveli	4047	4044	-0.1	594	594	0
Goa	2856	2806	-1.8	544	460	-15.4
Andhra Pradesh	70860	68577	-3.2	12018	11232	-6.5
Karnataka	44970	41600	-7.5	8137	7815	-4.0
Kerala	16275	16052	-1.4	3295	2946	-10.6
Tamil Nadu	72712	68140	-6.3	11728	10436	-11
Puducherry	1929	1847	-4.3	319	300	-6
Lakshwadweep	22	22	0	6	6	0
Bihar	11621	10007	-13.9	2073	1659	-20
DVC	15045	13777	-8.4	2206	2046	-7.3
Jharkhand	5651	5482	-3.0	1012	1012	0
Orissa	20429	20368	-0.3	3505	3468	-1.1
West Bengal	33349	32715	-1.9	6162	6112	-0.8
Sikkim	361	361	0	100	99	-1
Andaman & Nicobar	220	165	-25	40	32	-20
Arunachal Pradesh	463	394	-14.9	101	85	-15.8
Assam	4992	4669	-6.5	971	937	-3.5
Manipur	522	464	-11.1	118	115	-2.5
Meghalaya	1405	1225	-12.8	294	284	-3.4
Mizoram	332	282	-15.1	76	70	-7.9
Nagaland	543	485	-10.7	118	110	-6.8
Tripura	813	735	-9.6	220	197	-10.5
India	783057	715795	-8.6	120575	108212	-10.3

(Source: Central Electricity Authority, Government of India)

theft varies from 10 to 30% in different states as given table (3):

Table (3): electricity is stolen in India state wise

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

The utilization of theft power in India in following field

(A) Domestic (tagging) :- in domestic generally the loads are mobile charger, inverter , freezer, television , amplifier, microwave oven, CFL, induction cooker, press iron, heater, fan, laptop, desktop computer, printer, monitor, scanner, water filter, vacuumed cleaner , motor (1/2 Hp, 1Hp) etc.

(B) Small commercial place(bypassing meter connection): in small commercial place generally the loads are mobile charger, inverter , freezer, television , amplifier, microwave oven, CFL, induction cooker, heater, fan, laptop, desktop computer, printer, monitor, scanner, water filter, vacuum cleaner motor (1/2 Hp, 1Hp,3 Hp) Photostat machine .

(C) Agriculture:-in this filed generally large no of AC motor (3 hp, 5hp, 7hp) are used may be on fixed monthly charge or power stolen.

(D) On road vender (thelawala):- these days many thelawala used non-linear device for his commercial purposes such as microwave oven, induction cooker, CFL, amplifier, mixture, fan etc.

All the reasons discussed above are basic cause of the deterioration of power supply in India. About 100% load is non-linear load in nature and generate heavy harmonics in power system without following the quality standard, metering rule and without penalty. It t means the 40% harmonics is generated in the power system by thieves. Consumers and the economy bear a large burden due to the poor quality of power supply. Due to This State Electricity Boards remain financially sick and are unable to attract finances for investment.

In the Indian scenario, power quality issues are of increasing importance these days due to the enhanced use of sensitive equipment such as adjustable speed drives, medical electronic systems and switched mode power supplies. It is an important issue for electricity consumers at all levels of usage, particularly industries including service sector (especially IT/ITES and Health sector). With the extensive application of sensitive power electronic equipment and proliferation of non-linear loads in digital environment of our industrial and commercial/domestic applications, problems like power surges/sags, poor voltage and frequency regulation, harmonics, switching transients, electrical noise, EMI effect etc are frequently encountered. This leads to damage of capital-intensive appliances, raises safety concerns, cause loss of reliability and above all results in a huge economic loss. Industry requires Standards and or Guidelines to observe and follow norms in handling effectively such issues of concern. In India, essentially IEEE standards are referred as guidelines in electricity sector and in manufacturing sector normally IEC standards are complied to meet global market demands. The goal of applying the harmonic limits specified in IEEE 519 is to prevent one customer from causing harmonic problems for another customer or for the utility The PCC is the only point where we must meet the IEEE 519 limits, if IEEE 519 is incorporated into the contract or applicable rate (IEEE 519 is a Recommended Practice).

Bureau of Indian Standards (BIS) have been facilitating to bring in such standards to compliment global effort with harmonization of Standards. In view of this an effort namely, ASIA POWER QUALITY INITIATIVE (APQI), has been undertaken by International Copper Promotion Council of India and other stakeholders interested in power quality [5].

As per harmonic studies carried out, the following maximum total harmonic distortion has been found in India [5].Type of Consumer and Maximum THD in India are given in table (4)

Table (4): Type of Consumer and Maximum THD in India

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. A limit of THD of 5% and for any single harmonic content not exceeding 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 analyzer meters are available to check THD and individual harmonic distortion up to 51st harmonic [6].

2. IEEE 519:-Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

In 1981, the IEEE 519 harmonic standard was issued for harmonic related issues; it was revised in 1992. IEEE 519 attempts to establish reasonable harmonic goals for electrical systems that contain nonlinear loads. The objective is to propose steady state harmonic limits that are considered reasonable by both electric utilities and their customers. IEEE 519 applies to all voltage levels, including 220 V single-phase residential services.

The table (5, 6, 7) describe the Recommended practice for individual customers for voltage < 69 KV, 69-161KV, and >161KV respectively [7].

Table (5): Recommended practice for individual customers for voltage < 69 KV

Utility Voltage Limits Below 69 kilo volt						
Individual Harmonic 3%			Voltage Total Harmonic Distortion(THD) 5%			
Customer Current Limits						
Isc/Il ()	h<11	11<-h<17	17<h<23	23<h<35	h>35	TDD
<20	4%	2%	1.5%	0.6%	0.3%	5%
20 - 50	7%	3.5%	2.5%	1%	0.5%	8%
50 - 100	10%	4.5%	4%	1.5%	0.7%	12%
100 - 1000	12%	5.5%	5%	2%	1%	15%
> 1000	15%	7%	6%	2.5%	1.4%	20%

Table (6): Recommended practice for individual customers for voltage 69 – 161 KV

Utility Voltage Limits 69 - 161 kV						
Individual Harmonic			Voltage Total Harmonic Distortion(THD)			
1.5%			2.5%			
Customer Current Limits						
Isc/Il ()	h<11	11<-h<17	17<h<23	23<h<35	h>35	TDD
<20	2%	1%	0.75%	0.3%	0.15%	2.5%
20 - 50	3.5%	1.75%	1.25%	0.5%	0.25%	45
50 - 100	5%	2.25%	2%	0.75%	0.35%	6%
100 - 1000	6%	2.75%	2.5%	1%	0.5%	7.5%
> 1000	7.5%	3.5%	3%	1.25%	0.7%	10%

Table (7): Recommended practice for individual customers for voltage below >161 KV

Utility Voltage Limits 69 - 161 kV						
Individual Harmonic 1.5%			Voltage Total Harmonic Distortion(THD) 2.5%			
Customer Current Limits						
Isc/Il ()	h<11	11<-h<17	17<h<23	23<h<35	h>35	TDD
<20	2%	1%	0.75%	0.3%	0.15%	2.5%
20 - 50	3.5%	1.75%	1.25%	0.5%	0.25%	45
50 - 100	5%	2.25%	2%	0.75%	0.35%	6%
100 - 1000	6%	2.75%	2.5%	1%	0.5%	7.5%
> 1000	7.5%	3.5%	3%	1.25%	0.7%	10%

3. IEC Standard

The **International Electrotechnical Commission** (IEC) is the world's leading organization that provides a platform to companies, industries and governments for meeting, discussing and developing the International Standards they require for all electrical, electronic and related technologies.

According to IEC 61000-3-2 equipment are classified in four classes: these are

Class A: balanced 3-phase equipment (r.m.s line current differing less than 20% and all other equipment except those in of class B,C, and D equipment.

Class B: portable tools

Class C: lighting equipment including dimming devices with active input power above 25W.

Class D: equipment having and input current with a "special wave shape" and a fundamental active input power between 75 and 600 w. Whatever the wave shape of their input current , class B ,class C, and provisionally motor-driven equipment are not considered as class D equipment.

ICE 61000-3-2 describe the harmonic limits for class A and Class B ,class C and Class D equipment given in table(8), table(9), table(10) respectively and compatibly levels for individual harmonic voltages in low-voltage networks [8].

Table (8): Harmonic Limits for Class A and Class B

Harmonic order(n)	Class A Maximum permissible harmonic current A	Class B Maximum permissible harmonic current A
Odd Harmonic		
3	2.3	3.45
5	1.14	1.71
7	0.77	1.155
9	0.40	0.60
11	0.33	0.495
13	0.21	0.315
15<=n<=39	2.25/n	0.375/n
Even Harmonic		
2	1.08	1.62
4	0.43	0.645
6	0.30	0.45
8<=n<=40	1.84/n	2.76/n

Table (9): Harmonic Limits for Class C<25W

Harmonic Order(n)	Maximum value expressed as a percentage of the fundamental input current of the luminaries
2	2
3	30 λ*
5	10
7	7
9	5
11<=n<=39	3

*λ is power factor

Table (10): Harmonic Limits for Class D (Rated load condition)

Harmonic Order(N)	75W<P<600 W Ma/W	P<600 W Ma/W
3	3.4	2.30
5	1.9	1.44
7	1.0	0.77
9	0.5	0.40
11	0.35	0.22
13	0.296	0.21
15<=N<=39	0.85/N	0.25/N

NOTE:- no limit apply for equipment below 75W input power

According to IEC 61000-2-2 the individual harmonic voltage in low-voltage network are given in table (11)

Table (11) **compatibly levels for individual harmonic voltages in low-voltage Networks – (extract from IEC 61000-2-2)**

Odd harmonics non-multiple of 3		Odd harmonics multiple of 3		Even harmonics	
Harmonic order n	Harmonic voltage %	Harmonic order n	Harmonic voltage %	Harmonic order n	Harmonic voltage %
5	6	3	5	2	2
7	5	9	1,5	4	1
11	3,5	15	0,3	6	0,5
13	3	21	0,2	8	0,5
17	2	>21	0,2	10	0,5
19	1,5			12	0,2
23	1,5			>12	0,2
25	1,5				
25	0,2+0,5 × 25/n				
NOTE – All the above harmonic levels are assumed not to occur simultaneously.					

NOTE 1 – A decrease in frequency is assumed not to coincide with an increase in a.c. line voltage and vice versa.

4. CEA Standard India

According to grid Side Voltage Criteria CEA Standards, at present Indian Electricity Grid Code is followed in the transmission system. It specifies the voltage at transmission level to be maintained as follows:

VOLTAGE:

System voltage	Max(RMS)	Min(RMS)
400KV	420KV	360KV
220KV	245KV	200KV
132KV	145KV	120KV

Frequency:

For frequency the standard id given as table2

According to the standard the assured frequency of supply is 50hz cycles per second with permitted variation of (-) or c(=) 3%.

statuary limits Hz	48.5 to 51.5
CERC Standard Hz	49.5 to 50.5

Maximum limit of voltage harmonic distortion in HT and EHT system given in table (12), table (13), table (14) respectively [9].

Table (12): Maximum limit of voltage harmonic distortion in HT nad EHT system for Odd, Non triplen

Harmonic Order(n)	Distortion (%)	
Odd, Non triplen	HT(11KV)	EHT(35KV)
5	6.0	2.0
7	5.0	2.0
11	3.5	1.5
17	3.0	1.5
19	2.0	1.0
23	1.5	1.0
25	1.5	1.0
>25	0.2+1.3*25/n	0.1+0.6*25/n

Table (13) Maximum limit of voltage harmonic distortion in HT and EHT system for Odd triplen

Harmonic Order(n)	Distortion (%)	
Odd, Non triplen	P>10KW or V<33KV	P>50KW or V>33KV
5	12	6
7	8.5	5.1
11	4.3	2.2
13	3	2.2
17	2.7	1.8
19	1.9	1.7
23	1.6	1.1
25	1.6	1.1
>25	0.8+0.8*25/n	0.4

According to standard the maximum limit of current harmonics distortion in HT and EHT system in below table (14)

Table (14): maximum limit of current harmonics distortion in HT and EHT system

Harmonic Order(n)	Distortion (%)	
Odd, triplen	HT(11KV)	EHT(35KV)
3	5	2.0
9	1.5	1.0
15	0.3	0.3
21	0.3	0.2
>25	0.2	0.2

The total harmonics distortion by the different non linear load which is hugely used in power system.

Table (15): Total Harmonics Distortion on power system due to non linear load measured by Harmonic Analyzer

LOAD	THD (%)
Computer monitor	116.345
Personal computer	118.354
printer	36.893
Photo state	69.995
scanner	132.391
Fluorescent lamp(44w)	10.396
CFL(10.3W)	108.852
CFL(16.6W)	105.471
CFL(22W)	123.356
Refrigenerator	13.322
Microwave oven	39.332
Laptop	83.876
Amplifier	48.134
Television	72.512
Adjustable speed drive(PWM Chopper) with Induction motor	71.09
freezer	61.845

5. Conclusion

The paper shows that the availability of power in India is far from its demand as discussed in table (2). The thefts of power is extra load on power system without billing and generate heavy harmonics in power system so the total harmonics distortion is high by thieves, for the improving power quality the IEEE519-1992 and IEC standard follows. The Bureao of Indian standard and Central Electric Authority control try to maintain the quality but target is very tuff in Indian scenario

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