Electricity safety: Tragically falling through the governance gaps

A Discussion Paper

Prayas (Energy Group)

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Executive summary

One of the unfortunate side effects of electrification is electricity accidents, which cause loss of human or animal life and damage to property. The objective of this paper is to highlight the seriousness of electricity accidents and suggest steps to reduce them. Accidents, as the saying goes, do not just happen, but are caused. Power utilities, regulators, consumers, sector professionals and the general public have roles in causing accidents and they have to work together to reduce them.

Two major sources which provide information on electrical accidents are the annual Accidental Deaths and Suicides in India (ADSI) report prepared by National Crime Records Bureau and annual General Review of the Central Electricity Authority (CEA). As per the 2020 ADSI report, 15,258 people died in 2020 (Calendar year – Jan to Dec) due to electrical shocks and fires. CEA reports 7,717 fatal human accidents and in 2020 (financial year – Apr 2019 to Mar 2020). The numbers are vastly different perhaps due to data collection and reporting issues, which is an area of major concern. Whatever be the actual numbers, a worrying trend is that the number of accidents and also accidents normalised with parameters like population, number of consumers or energy handled, have been steadily increasing over the years. Fatalities per 100,000 population (also called as fatality rate) is the most used parameter to compare across different accident causes or geographies. In India, fatality rate has been increasing over the years and is little above 1, as per ADSI data and around 0.6 as per CEA data in 2020. This is one order of magnitude more than what is reported by many advanced countries, where one observes a downward trend in accidents.

Most of the electrical accidents in India happen in rural areas and affect the public. They occur mostly in the distribution system or at non-industrial consumer locations. Therefore, accident reduction is a public challenge and efforts should focus on rural areas and distribution systems. A state-wise analysis of accidents indicates that 85% of the accidents occur in 11 states, namely Andhra Pradesh, Chhattisgarh, Gujarat, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Telangana and Uttar Pradesh. There is a need to strengthen efforts to reduce accidents in these states. Within the states, there is variation in the number of accidents based on consumer mix, state of maintenance of the distribution network, climatic conditions and safety awareness.

The major immediate cause of accidents is contact with live conductors. Root causes include low priority to safety, bad design, poor maintenance, un-authorised repair, bad quality earthing, and inadequate protection systems. Addressing the root causes requires an understanding of the safety governance structure and identifying the gaps. CEA prepares safety regulations, which all utilities are expected to follow. Electrical Inspector at the national and state levels have a mandate to implement these regulations. State Electricity Regulatory Commissions (SERC) have a broad mandate over the functioning of the sector, but do not explicitly have a role in safety. Since most accidents occur in the distribution system, Distribution Companies (DISCOMs) have the highest role to play in reducing accidents. But for them, improving financial health, reducing energy losses and providing reliable power to consumers are a higher priority. Safety is not high in their performance metric. National policies or initiatives do not currently have any safety components. Therefore, electricity safety is tragically slipping through governance gaps.

Accident reduction requires technical and management measures, over a period of many years. Specific safety initiatives by the central government, increased priority to safety by distribution companies, strengthening the role of state electrical inspectorates, proactive efforts by electricity regulators to ensure implementation of safety measures and building safety awareness in the general public are crucial if accidents have to be reduced. CEA, some utilities, SERCs, professional organisations and consumer organisations have initiated small steps to reduce accidents, but these need to be significantly strengthened. Only concerted efforts by all sector actors over a period of few years can reverse the trend and bring down the number and rate of accidents.

1. Introduction

Importance of electricity access to catalyse development has been recognised by all. Massive rural electrification initiatives supported by the central government from 2005 have resulted in the spread of electrification and near universal connections. But challenges in quality of supply and availability of affordable power supply remain, which in turn are due to short-comings in planning and implementation of these initiatives.[1] One of the unfortunate and neglected side effects of electrification is electricity accidents - the focus of this paper.

Electricity systems up to the point of supply (generation, transmission and distribution) or end-use (consumer premises), can cause electric shocks (also called electrocution) and fires due to electrical faults.[2] These in turn lead to human or animal injuries or deaths, and also appliance or property damage. This paper focuses on accidents caused due to electric systems and its impact on humans, especially deaths (also referred to as fatalities). Lightning also causes electrical accidents through direct strike or high voltage surges in the electrical network. Since lightning is a natural phenomenon requiring separate protection measures, it is not covered in this paper.[3] As per the Accidental Deaths and Suicides in India (ADSI) 2020 report by the National Crime Records Bureau (NCRB), over 15,000 people died due to electrical accidents in 2020. It is a matter of concern that this number has been increasing over the years.[4]

This paper is based on the data collected from ADSI reports, reports of the Central Electricity Authority (CEA) and from the tariff submissions by Distribution Companies (DISCOM) of some states. Background information has been gathered from reports of the Chief Electrical Inspector (CEI) of CEA, Chief Electrical Inspector to the Government (CEIG) of some states, Comptroller and Auditor General (CAG), electricity safety manuals of some states and few research papers. Since accidents involving humans are very serious and likely to be better reported, this paper gives more attention to electrical accidents which lead to injuries or deaths of humans. Deaths due to lightning and fire due to electrical faults, accidents affecting animals and those causing property damage (not easily available) are not covered in this paper. Data and information availability and consistency has been a challenge. Hence, most of the analysis is conducted using data from one source, namely the Annual General Reviews of the CEA. Observations and suggestions in this paper are based on inputs consolidated through field visits, discussions with grass root organisations, interactions with sector professionals and a few analysis reports.

1. For an elaboration of these challenges, please refer to our 2018 article: "Rural Electrification in India: From 'Connections for All' to 'Power for All'", available at: https://energy.prayaspune.org/our-work/research-report/rural-electrification-in-india-from-connections-for-all-to-power-for-all.

2. Electrical faults are also called short circuits. Faults are caused due to different reasons. Examples include loose contact (at connection or joints); accidental contact (one conductor with another or with tree, animal, ground or any object), insulation failure and persistent overload. Sparks due to fault can lead to fire if not controlled in time. These are called electrical fires in this paper, and is also called fires due to electrical short circuit in some reports.

3. Out of the 7,405 deaths due to natural causes in 2020, (which amounted to only 2% of the total), the single major contributor was lightning at 39%.

4. ADSI 2020 report available at: https://ncrb.gov.in/en/ADSI-2020. For comparison, number of suicides in farming sector in 2020 reported by ADSI is around 11,000. It is pertinent to mention that electricity is not the major killer among all the natural or non-natural causes. Of the total 3.74 lakh accidental deaths in 2020, road accidents were the major contributor to deaths (36%), whereas the contribution of electrocution and electrical fires were only 4%.

The next section draws attention to the magnitude of the issue by presenting some quantitative analysis of electricity accidents in India, based on data from NCRB and CEA. This is followed by an analysis on "who dies, where and why", based on DISCOM submissions, reports by CEIGs and inputs from sector professionals. The subsequent section covers our observations, including governance gaps which lead to neglect of electricity safety.

The objective of the paper is to highlight the seriousness of electricity accidents and suggest steps to reduce them. Accidents, as the saying goes, do not just happen, but are caused. All actors, including consumers, electrical contractors, consultants, building architects, local bodies issuing occupancy certificates and permissions, appliance manufacturers, DISCOMs, CEIGs, regulators and governments have roles in causing accidents and can play their own roles in reducing them. Without focussing on fixing the blame on some specific actors, this paper tries to identify the root causes of accidents and suggests action ideas for all actors to reduce accidents. This is covered in the last section, which has suggestions – immediate, and medium term, technical and management – to reduce accidents.

2. The magnitude of the issue

Based on available data, a quantitative national overview and state-wise analysis are given in this section. National overview is presented using data from two sources – annual ADSI reports and annual CEA General Reviews. NCRB and CEA report state-wise breakup of electrical accidents. From this, it appears that number of accidents are higher in some states. This is to be expected since the population, energy handled, consumer mix and nature of distribution infrastructure vary across states.[5] State-wise analysis is based on data from CEA General Reviews.

2.1 National overview

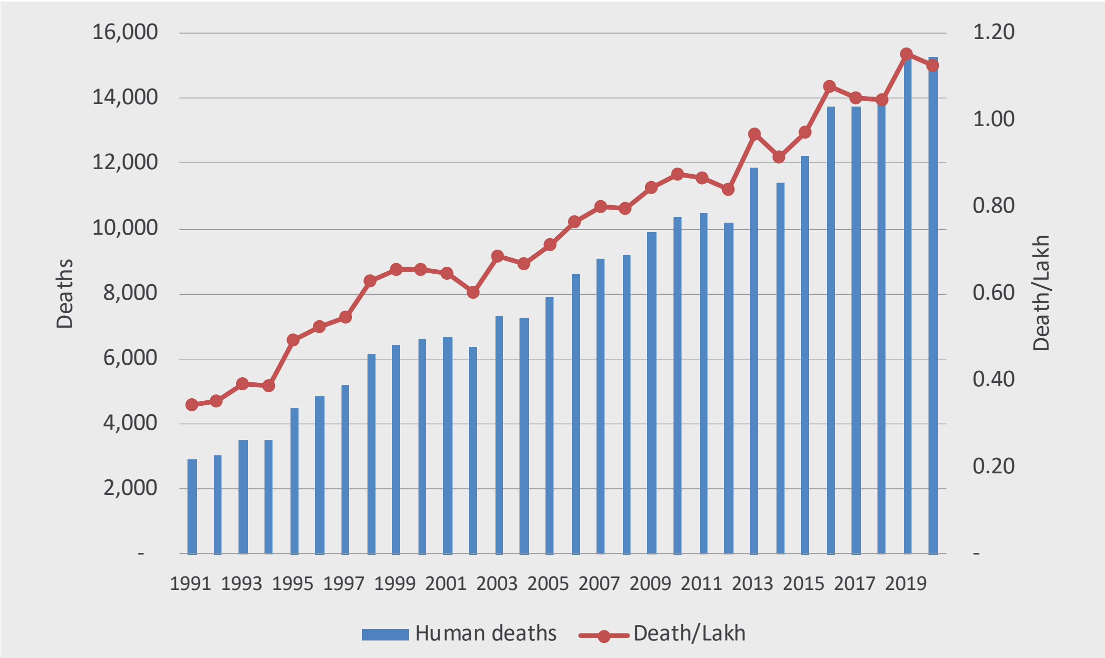
ADSI reports are based on data on human deaths collected by police departments of states. Reports from 1967 are available at the website of NCRB. In these reports, accidents due to lightning data was reported from 1967, electrocution from 1984, fires due to electrical short circuit (ADSI uses this term for electrical fires) from 1995 and break-up of electrical accidents in cities till 2013. In the past decade, electrocution accounted for about 73% of the total human deaths due to electrical accidents, electrical fires accounted for about 11% and lightning about 16%. Number of deaths due to lightning (a natural cause) has been relatively constant over the years, but deaths due to other two causes have been increasing. ADSI gives the number of electrical incidents (accidents) and deaths. Our analysis indicates that most of the incidents lead to deaths, with the ratio of deaths to incidents being very close to 1. One possible reason could be that fatal accidents are more likely to be reported by the police and hence compiled into ADSI reports.

Figure 1 shows the number of human deaths due to electrocution and electrical fires, as reported by ADSI, from 1991 to 2020. The bars represent the number of human deaths and it can be seen that the number has increased more than five times from 2,933 deaths (1991) to 15,258 deaths (2020), indicating a Compounded Annual Growth Rate (CAGR) of 5.9%. The line with dots give the incidence of human deaths (deaths/100,000 or lakh population), with the scale given on the right-hand axis.[6] It can be seen that the incidence has been steadily increasing from 0.35 (1991) to 1.13 (2020), indicating a disturbing increasing trend. Higher incidence could be due to spread of electrification and/or growing neglect of safety.

5. Another possible reason is that some states are better at reporting accidents. But this is not easy to establish.

6. ADSI reports incidence of deaths calculated as the number of deaths divided by mid-year population in lakhs.

Figure 1. Human deaths due to electrical accidents – ADSI

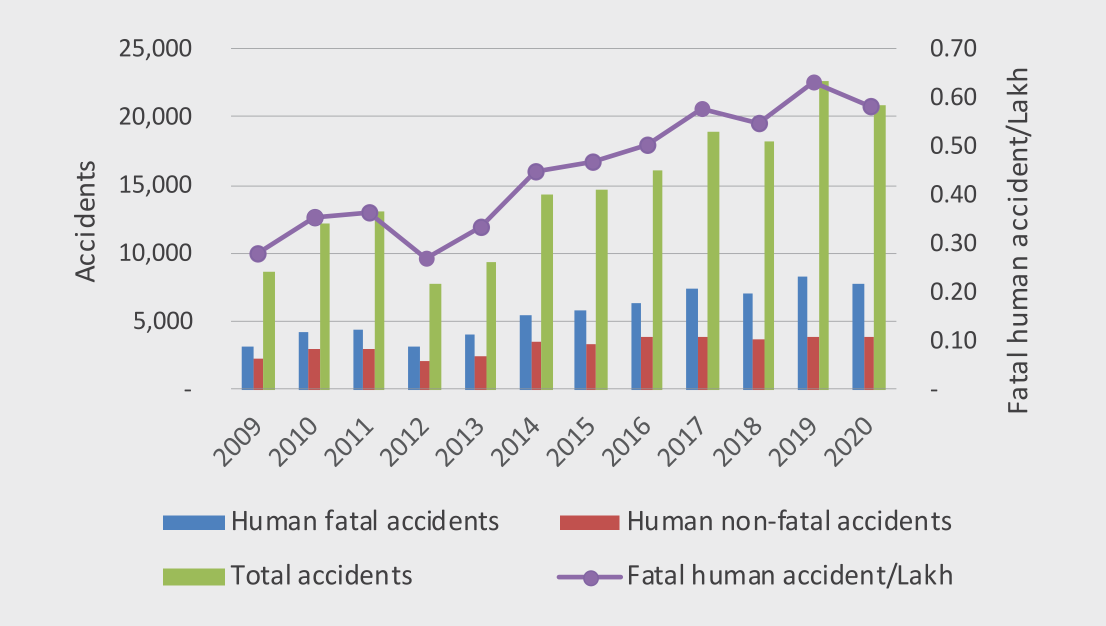


Source: Prayas (Energy Group) compilation based on ADSI reports 1990 to 2020 (Year is Calendar Year)

CEA, in its annual All India Electricity Statistics (also called General Review) provides data about electrical accidents affecting humans and animals – both fatal and non-fatal.[7] Figure 2 gives human fatal accidents, human non-fatal accidents, total accidents (affecting human or animal, fatal or non-fatal) and human fatal accidents/lakh population, based on CEA statistics from 2009 to 2020. The bars represent the number of accidents and it can be seen that human fatal accidents have increased from 3,239 (2009) to 7,717 (2020), indicating an increase of 2.5 times in 11 years and CAGR of 8.2%. Number of non-fatal human accidents have not increased as much. Number of total accidents (human or animal, fatal or non-fatal) have been increasing from 8,751 (2009) to 20,951 (2020), an increase of 2.4 times and CAGR of 8.4%. The line with dots indicate the fatal accident rate (number of fatal human accidents per 100,000 or lakh population), which has significantly increased from 0.28 to 0.58 during this period.

7. From 2020, soft copies of these reports are available at the CEA website, whereas the hard copies of previous reports were available for sale.

Figure 2. Fatal human accidents and total accidents - CEA



Source: Prayas (Energy Group) compilation based on CEA General Reviews 2010 to 2021 (General Review 2010 provides data for 2009, Year is Financial Year)

In addition to humans, animals, appliances and property are also affected by electrical accidents. Appliance and property damage are not reported by ADSI or CEA. CEA reports fatal and non-fatal animal accidents. From these reports, it is seen that the number of fatal animal accidents increased from 3,248 (2009) to 9,219 (2020), an increase of nearly three times. 95-99% of the animal accidents are fatal, perhaps because only serious accidents are reported.

From Figure 1 and 2 it is evident that the numbers of fatalities reported by ADSI and CEA for the same year are different. For 2020, ADSI reports 15,258 human deaths, whereas CEA reports 7,717 fatal human accidents. The reasons for this difference could be many. ADSI reports are for calendar year (Jan-Dec), whereas CEA reports are for financial year (Apr-Mar, hence 2020 is actually Apr 2019 to Mar 2020). But this alone does not explain the big difference in numbers. ADSI reports human deaths, whereas CEA reports fatal human accidents - more than one person may have died in one fatal accident.[8] CEA reports are based on inputs from DISCOMs and state CEIGs, and may not include accidents due to electrical fires.[9]

8. Two observations on data issues: 1) Number of fatal accidents reported by few state DISCOMs are higher than that reported by CEA. The reason could be that DISCOMs are reporting number of fatalities, whereas CEA reports number of fatal accidents. 2) ADSI reports electrocution cases (accidents) and number of deaths. Data from 2012-2020 show that the ratio of deaths to cases is between 0.98 and 1, implying that number of cases is a good proxy for number of deaths. It is possible that only cases involving deaths are reported to police.

9. As per section 161 of the Electricity Act 2003, all accidents are to be reported to the electrical inspector or anyone else authorised by the government. Central and state governments are expected to prepare rules (as per section 176 and 180 respectively) for this. It is possible that all accidents are not being reported (to electrical inspector or electric utilities) and there are gaps in information flow between the police, fire, power utility and electrical safety departments.

Key points

The key takeaway from the analysis of the national data (even with some data gaps) is that the number of electrical fatal human accidents are steadily increasing over the years in absolute and per-population terms. The number of consumers, spread of electrical network and energy handled have also increased over the years. But based on CEA data, it appears that the number of fatal human accidents per 100,000 consumers has increased from 1.72 to 2.45 during the period 2009-2020. The number of fatal human accidents per Billion Units handled has increased from 4.38 to 5.58. These are disturbing trends. Available data on fatal human accidents from countries like the USA, European Union, Australia-New Zealand or Japan show the fatal accidents steadily reducing over the years and fatality rate (deaths/100,000) around 0.03 to 0.04 (0.01 in Japan), an order of magnitude smaller than the Indian figures of 0.5 to 0.6. Data from countries like Brazil or South Africa show similar trends of increasing number of fatal accidents and comparable fatality rates.[10]

2.2 State-wise analysis

This section examines data on human accidents (fatal and non-fatal) reported by CEA to shortlist a few states for closer analysis.

Table 1 gives data on human accidents reported by CEA for 2020 (FY2019-20), accidents/lakh of mid-year population, proportion of mid-year population and proportion of energy handled. It can be seen that accidents/lakh population vary widely across states. Eleven states which account for more than 3% of the total accidents are marked in bold. These states, namely Andhra Pradesh, Chhattisgarh, Gujarat, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Telangana and Uttar Pradesh, are selected for detailed analysis. These states together account for around 85% of the total accidents and 75% of the total energy handled by the grid.

10. Data for USA from Electricity Safety Foundation International, for EU from Health & Safety Executive (UK) report, Australia- New Zealand from Electricity Regulatory Authorities Council reports, for Brazil from an invited paper (by Chisholm WA et al, in International Symposium on Lightning Protection, Sao Paolo 2019), for South Africa from mortality reports of the Department of Statistics: https://www.statssa.gov.za/?page_id=1854&PPN=P0309.3 .

Table 1. Human accidents in 2020

S.No	State	Number of human accidents	% of total accidents	Accident rate: Accident/ 100,000 population	% of total population	% of total energy
1	**Andhra Pradesh**	**449**	**3.9**	**0.9**	**4.0**	**5.6**
2	Arunachal Pradesh *	-	-	-	0.1	0.1
3	Assam	293	2.5	0.9	2.6	0.6
4	Bihar	300	2.6	0.3	8.2	2.6
5	**Chhattisgarh**	**383**	**3.3**	**1.4**	**2.0**	**8.6**
6	Goa	26	0.2	1.2	0.2	0.0
7	**Gujarat**	**785**	**6.8**	**1.2**	**4.9**	**9.0**
8	Haryana	332	2.9	1.2	2.2	1.3
9	Himahcal Pradesh	55	0.5	0.8	0.6	3.1
10	Jammu & Kashmir	51	0.4	0.4	1.0	1.4
11	Jharkhand	41	0.4	0.1	2.7	1.9
12	**Karnataka**	**1,648**	**14.3**	**2.6**	**4.9**	**5.1**
13	**Kerala**	**447**	**3.9**	**1.2**	**2.8**	**0.5**
14	**Madhya Pradesh**	**1,106**	**9.6**	**1.4**	**6.2**	**9.4**
15	**Maharashtra**	**1,518**	**13.2**	**1.2**	**9.5**	**10.5**
16	Manipur *	-	-	-	0.2	0.0
17	Meghalaya	40	0.3	1.4	0.2	0.1
18	Mizoram	57	0.5	5.2	0.1	0.0
19	Nagaland *	-	-	-	0.2	0.0
20	Odisha	161	1.4	0.4	3.3	3.5
21	Punjab	149	1.3	0.5	2.3	2.1
22	**Rajasthan**	**1,133**	**9.8**	**1.5**	**5.8**	**5.1**
23	Sikkim	2	0.0	0.3	0.1	0.8
24	**Tamil Nadu**	**905**	**7.8**	**1.3**	**5.3**	**7.5**
25	**Telangana**	**756**	**6.6**	**2.0**	**2.9**	**4.2**
26	Tripura	18	0.2	0.5	0.3	0.4
27	**Uttar Pradesh**	**550**	**4.8**	**0.2**	**17.4**	**9.3**
28	Uttarakhand	80	0.7	0.7	0.8	1.3
29	West Bengal	185	1.6	0.2	7.3	5.5
	Union Territories + Others	71	0.6	0.2	2.2	0.5
	Total	**11,541**		**0.9**		

Source: Prayas (Energy Group) compilation from CEA Annual statistics report 2021

Notes: * indicates that data is not available, but the number is relatively small (24 for these states) based on data for previous years; Rows marked in bold are states with > 3% of the total accidents; Total mid-year population = 132 crores, total energy = 1,383 BU.

This paper does not analyse accidents related to animals, even though most of the accidents affect animals, such as cows, buffaloes and goats, which are crucial for rural livelihood.[11] There were 9,410 animal accidents (98% of them fatal) in 2020 and these same 11 states accounted for 93% of them.[12] Further analysis focusses on these 11 states.

Number of accidents depend on parameters like the population, number of consumers, number of irrigation pump sets, energy handled by the grid, quality of the electrical network, quality of maintenance and safety awareness. It is not easy to establish correlation with all these parameters, but a study of data trends across past few years would give some pointers. Table 2 gives such an analysis, using average numbers for the past six years, from 2015 to 2020 for 11 states. Average of the annual number of human accidents, CAGR, accidents/100,000 (lakh) of mid-year population, accidents/lakh consumers, accidents/lakh irrigation pump sets and accidents/Billion Units handled by the state utilities are given in Table 2.

Table 2. State-wise averages of human accident parameters - 2015-2020

S.No	State/ Parameter	Average number of human accidents	% of total accidents	CAGR 2015-2020 %	Accidents/ 100,000 Population	Accidents/ 100,000 Consumers	Accidents/ 100,000 Irrigation Pumpsets	Accidents/ Energy handled in BU
1	Andhra Pradesh	584	5.4	-2.5	1.1	3.3	46.3	8.6
2	Chhattisgarh	340	3.1	3.8	1.3	6.8	87.0	3.3
3	Gujarat	762	7.0	2.0	1.2	4.5	51.5	6.7
4	Karnataka	1,468	13.5	13.8	2.3	6.2	60.6	23.8
5	Kerala	370	3.4	34.4	1.0	3.0	71.7	53.9
6	Madhya Pradesh	978	9.0	4.3	1.2	7.0	66.7	8.9
7	Maharashtra	1,515	14.0	0.5	1.2	5.2	35.1	11.2
8	Rajasthan	979	9.0	2.1	1.3	7.1	71.0	15.4
9	Tamil Nadu	967	8.9	-1.0	1.4	3.4	46.3	10.2
10	Telangana	925	8.5	22.3	2.5	6.9	47.3	19.0
11	Uttar Pradesh	553	5.1	-2.1	0.2	2.6	55.5	4.5
	India	**10,841**		**4.5**	**0.8**	**4.0**	**51.3**	**8.6**

Source: Prayas (Energy Group) compilation from CEA annual statistics reports 2016-2021

Note: Coloured cell indicates high number of accidents or that the parameter is higher than national average

11. Elephants, pigs and wild animals are sometimes electrocuted on electric fences or bare conductors. Pets also get affected, but detailed break-up on this is not available.

12. But three among these 11 states – Andhra Pradesh, Kerala and Tamil Nadu - had % share of total animal accidents less than 3%, with Kerala share being the lowest at 0.6%.

From 2015 to 2020, on an average, every year in the country, there were 10,841 human accidents, growing at a CAGR of 4.5%. The Table also gives accident rates with respect to different parameters. It can be seen that average accidents/ lakh population is 0.8, accidents/lakh consumers is 4, accident/lakh irrigation pumpsets is 51.3 (includes all accidents, not just pumpset related) and accident/Billion Units handled is 8.6. Further study is required to establish the extent of correlation of accidents with different parameters.

Eleven listed states account for 87% of human accidents in the six years, 2015-2020. Karnataka and Maharashtra have the highest share of accidents. Number of accidents have been increasing in this period at a CAGR of 4.5%, with some states having negative growth rates and some higher than national average. Kerala, Karnataka, Madhya Pradesh. Rajasthan and Telangana have many parameters above the respective national averages.[13]

Key points

Based on 2020 data, it appears that 11 states – namely Andhra Pradesh, Chhattisgarh, Gujarat, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Telangana and Uttar Pradesh – account for 85% of all human accidents. Analysis of data for the period 2015 - 2020 shows that on an average 10,841 human accidents occur in India every year and this number is growing at a CAGR of 4.5%. Human accidents/100,000 population is 0.8. Among the 11 states, Karnataka and Maharashtra have the highest share of accidents. Different growth rates of accidents across states and extent of correlation of accidents with different parameters require further study.

13. These are based on available data in CEA reports. Very high CAGR for some states (Kerala, Telangana) and very low or negative CAGR (Gujarat, Maharashtra, Rajasthan) seem to be exceptions and require further study. As mentioned before, low number of accidents in some states could be also due to gaps in reporting.

3. Who, where and why of accidents

The previous section provided a macro picture of human electrical accidents and identified few states, which need higher attention. A study to understand the who, where and why of electrical accidents will help to plan steps to reduce them.

The first question is 'who' suffers the most due to electrical accidents – utility employees, contract workers or general public. The next one is 'where', the geographical location of accidents. These could be villages, towns, cities, some districts or regions. Location can also be electrical, based on electrical parameters like voltage level or functional aspect in the electrical system. To illustrate, one could examine accident occurrence at utility locations, consumer locations or public spaces. Accidents could happen at generation, transmission, High Tension (HT) distribution, Distribution Transformers (DTs), Low Tension (LT) distribution, or consumer locations. Enquiry into 'why' these accidents occur should begin with immediate causes and then deepen to identify root causes. The next sections elaborate on these aspects, based on available data from ADSI, CEA, DISCOM tariff submissions and CEIG reports.

3.1 Who are affected by accidents?

Utility staff, contract staff, employees in industrial or non-industrial establishments, consumers and the general public are affected by electrical accidents. CEA or ADSI reports do not have information about this break up, but the tariff submissions by some DISCOMs and some CEIG reports (for example, Karnataka and Kerala) provide this. These are good sources to assess who is affected, since the majority of the accidents occur in the distribution systems or at consumer locations, as described in section 3.2.

Table 3. Who are affected by fatal accidents?

DISCOM name & year	DISCOM/Contract staff	Public	Total	Public %
APEPDCL 2017	2	197	199	99
Karnataka 2019	18	405	423	96
KSEB 2019	12	237	249	95
MSEDCL 2017	32	799	831	96
TSSPDCL 2017	29	320	349	92

Source: Prayas (Energy Group) compilation based on Tariff submissions of Andhra Pradesh (AP) and Telangana State (TS) DISCOMs; Karnataka DISCOMs accident statistics; KSEB CEIG accident statistics, MSEDCL ARR submissions[14]

14. Karnataka DISCOM data available at: https://karnataka.data.gov.in/catalog/details-electrical-accidents-escoms#web_catalog_tabs_block_10, Kerala data at: http://ceikerala.gov.in/index.php/electrical-accident-statistics/electrical-accident-statistics-details/59-accident-list-30-sept-2017.

Table 3 gives a breakup of those affected by fatal accidents. The data is not for the same year, but given as per data availability for different DISCOMs. From the last column, it can be seen that in more than 90% of the cases, the general public is affected. As per the data for the five Karnataka DISCOMs for the financial years 2019-2021, human fatalities of public were 95% of the total, whereas only 49% of the non-fatal accidents affected public. It is seen in few other DISCOMs that, in case of non-fatal accidents, DISCOMs and contract staff are affected as much as the public. In DISCOMs which have significant contract staff, they are more affected in all accidents (fatal and non-fatal), compared to DISCOM staff.[15]

Key points

From analysis of data from a few DISCOMs, it is clear that more than 90% of electrical accident fatalities happen to general public. DISCOM staff and the public are equally affected by non-fatal accidents. While it is true that non-fatal accidents can cause life-long disabilities and some may result in death at a later time, fatal accidents are more serious. Hence any attempt to reduce accidents should prioritise accidents affecting general public.

3.2 Where do accidents happen? Geographical and Electrical break-up

It is important to understand the geographical and electrical spread of electrical accidents. Geographical spread analysis is to understand distribution of accidents across states, regions, districts, and urban – rural areas. Electrical spread study is to identify the locations in electrical network, which are more prone to accidents.

3.2.1 Geographical spread

In section 2.2, it was noted that 11 states have a higher proportion of accidents. These states also have an extensive rural distribution network and most of them have a high number of irrigation pump sets.

ADSI annual reports until 2013 provide break-up of accidents in megacities (cities with population greater than 1 million or 10 lakhs). In 2013, electrocution deaths in 55 megacities were 11% of the total, which correlates with the proportion of population in megacities. Considering that the proportion of rural population was around 70%, it can safely be estimated that 70% of the accidents occur in rural areas. This hypothesis is supported by few other observations. All India human fatalities (due to electrocution and electrical fires) per lakh population based on ADSI for 2012 is 0.84 and this parameter is lower in cities like Ahmedabad, Bengaluru, Hyderabad or Mumbai. Delhi with 2% of the national population and 2% of electricity consumers, accounted only for 0.4% of the total accidents in 2020. In Telangana state in 2017, the highly urbanised Hyderabad district, with 26% of the state population, had only 7% of the total accidents.

Looking at the break-up of circle or district-wise accidents in some states, it is seen that a high number of accidents occur in districts which have high density of agriculture pump sets, are arid or have high incidence of poverty. Examples are Mahbubnagar and Nalgonda circles (Telangana), Anantapur and Kurnool circles (Andhra Pradesh) and Akola, Yavatmal, Nagpur (Rural), Aurangabad (Rural) and Ahmednagar circles (Maharashtra). But a proper assessment is possible only if division

15. In most DISCOMs, functions like operation, maintenance and repair are outsourced to contract staff, whose salary, qualifications and working conditions are at lower levels compared to that of regular DISCOM staff.

wise and urban-rural segregated accident data is available. It should also be kept in mind that India is urbanising fast and attention to urban areas, especially slums, would be also be required.

This analysis relates to electrocution or electric shock accidents. ADSI reports deaths due to fire caused by electrical short circuits also. In 2013, out of the total 1,690 deaths due to this, 25% occurred in megacities. This indicates that electrical fire accidents are more common in cities, whereas shock accident deaths, much higher in number (10,218 in 2013) are more prevalent in rural areas.

3.2.2 Electrical spread

ADSI reports do not cover electrical spread of accidents. But reports by CEA, few state CEIG reports and some DISCOM tariff submissions provide this information.

CEA seeks data from DISCOMs and state CEIGs using data formats 19 and 20.[16] Format 19 seeks accident occurrence at three major locations, namely supplier, industrial consumer and non-industrial consumer locations. Supplier location is further divided into generation, transmission and distribution. Industrial consumer location is divided into government and private. Non-industrial location is divided into government, private and persons. CEA may be collecting this data, but all of it is not made publicly available. CEA annual statistics provides accident break-up under three heads – supplier, covering 'generation, transmission and distribution', industrial consumers and non-industrial consumers. A more detailed break-up of electrical location of accidents is available in reports of some state CEIGs.

As per CEA Annual statistics report, in 2020 (FY20), out of the total 11,541 human accidents, 89% occurred at supplier location, 1% at industrial consumer location and 10% at non-industrial consumer locations. As per a CEA safety training presentation, 1% accidents occur in generation, 29% in transmission and 70% in distribution.[17] The 2019 report of the Gujarat CEIG gives break-up as per CEA format 19. As per this report, out of the 585 human fatal accidents in 2019, only 2 occurred in generation, 36 (6%) in transmission, 201 (34%) in distribution, 73 (13%) in industrial consumer locations, 46 (8%) in non-industrial (company or government) consumer locations and 227 (39%) at small consumer (non-industrial, commercial, agriculture or domestic) locations.[18]

From these reports, it is clear that most of the accidents occur in the distribution or non-industrial consumer locations.

It is important to understand at which voltage levels in the distribution system and at which consumer locations do most accidents occur. CEIG reports by Karnataka (2012), Tamil Nadu (2010) and KSEB Officers Association (KSEB OA) report (2012) give some information on this.[19] As per

16. These formats are available at the CEA website, Format 19 at: https://cea.nic.in/old/reports/regulation/furnishing_statistics_returns_inf/format%2019.pdf, and Format 20 at: https://cea.nic.in/old/reports/regulation/furnishing_statistics_returns_inf/format%2020.pdf

17. This data was available in the presentation made by Er. P Peddi Reddy (CEI – Western Region) in the workshop conducted by CEI (WR and POWERGRID (WR) on 21/01/2022. Supporting analysis was not available.

18. Break-up of accidents at different consumer locations is not easily available. In addition to those mentioned, it is likely that many accidents occur at temporary connection locations – given for construction sites, functions etc.

19. Karnataka CEIG report 2012: http://www.ksei.gov.in/pdf/Electrical_Accident_Analysis.pdf, Tamil Nadu CEIG report 2010: https://www.tnei.tn.gov.in/pages/down/3, and "Safety in KSEB - A Roadmap Towards Zero Accidents", a report by KSEB Officers Association (2012), shared with the author.

these reports, maximum number of accidents occur due to contact or snapping of conductors, both of which occur on 11 kV (lines, poles and Distribution Transformers) or Low Tension (LT) systems (lines, poles and service wires). In LT system, in addition to those mentioned, consumer locations (like irrigation pump sets and houses) are another major site for accidents. This is also supported by sector professionals from different states.

Key points

To summarise, geographically most of the accidents appear to be taking place in rural areas, but considering the rapid urbanisation, poor urban localities also need attention. In electrical terms, most accidents occur in the distribution system and non-industrial consumer locations. In terms of voltage level, distribution network (specifically 11 kV and LT systems) and Low-Tension consumer locations are the major electrical sites for accidents, and hence need higher attention.[20]

3.3 What causes accidents? Immediate and root causes

As mentioned in the introduction, accidents do not happen, they are caused. Repeatedly raising the question 'why do accidents happen' could lead to root causes, which could vary from situation to situation.

From ADSI reports over many years, it is seen that deaths due to electric shock form around 88% of the total deaths due to electrical accidents. Hence, electric shock is the major immediate cause of accidents.

Some answers to the next question 'why accidents?', are available in reports of state CEIGs (Karnataka, Tamil Nadu, Gujarat) and the report of KSEB OA. As per these reports, the major causes of accidents are the following.

i) Accidental contact with live conductor due to reasons like lack of boundary fencing, low hanging conductor, open switch boards, carrying long metal objects near conductors, exposed conductor on poor quality service wire or temporary connections and un-authorised repair (without safety precautions like switching off supply and using protective gloves)

ii) Contact due to snapping or low hanging of 11 kV and LT lines due to aging of conductors, having multiple joints (much more than the maximum stipulated 'one joint' in CEA safety regulations) and poor maintenance

iii) Failure to isolate faults - the circuit breaker at the substation or fuse at the DT often do not isolate live sections when there is snapping or accidental contact.[21]

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20. In addition to 11 kV, voltage levels like 22 kV (Maharashtra) and 6.6 kV (HVDS SWER as in Telangana) are employed for primary distribution, which is stepped down by DT to 415 V 3-phase or 240 V single phase. But 11 kV is used in this paper to denote all primary distribution voltage levels.

21. Issues include: wrong design or specification, malfunctioning or sheer absence of protection equipment.

It is not easy to isolate live sections after snapping or touching, since the fault currents are often low, and not sufficient to operate the circuit breaker or fuse. Sophisticated costly relays are needed to detect and isolate such faults. Also, very often fuse rating or trip setting at DTs or consumer locations are kept very high, to reduce tripping.

iv) Fire and explosions, especially at oil cooled Distribution Transformers, due to poor maintenance or leakages.

v) Poor earthing at consumer locations and/or absence of residual current protection.

vi) Poor or badly maintained earthing at DT results in high voltage in the neutral wire, leading to accidents and damage to appliances.[22]

vii) In case of High Voltage Single Wire Earth Return (HVDS - SWER) systems, it is extremely important to construct and maintain very low earth resistance at DT locations. When this is not done, high voltage (to the tune of 6.6 kV) can develop at the electrical wiring at consumer location, leading to shock accidents.[23]

viii) Electrical fires, caused due to sparks or over-heating, which in turn are due to reasons like faulty wiring, poor maintenance, or failure of protection systems

In addition to these, there are some special cases. One is related to electric fencing, constructed to protect crops from wild animals. In these cases, poor construction, bad maintenance and lack of awareness leads to accidental contact. Another is the inadvertent back-feed from home back-up inverters or grid connected solar roof top systems, which results in power flowing back into distribution network from consumer locations, during power outage. DISCOM staff engaged in repair can get electric shocks during such occasions.

Key points

To summarise, accidental contact with live parts of 11 kV/ LT distribution system or at non-industrial consumer location is the major immediate cause for accidents. Poor design, construction, inadequate maintenance, inadequate protection systems and lack of safety awareness are important root causes.

22. As per CEA safety regulations (Regulation 16), for voltages less than 250 V, DISCOMs are expected to provide earthing at consumer premises. For higher voltages, consumers are also expected to provide earthing system designed as per standards. Proper construction and maintenance of earthing, especially at LT consumer premises, is unfortunately neglected.

23. In this case of HVDS-SWER, a single conductor (with 6.6 kV line to ground voltage) is run from a substation, and 25 kVA single phase DTs are located near consumer locations. This reduces cost and losses, but pose safety hazards also. A field study was undertaken by IEEE Hyderabad chapter in Shahbad area in Telangana in 2016. Sagging LT lines, very poor-quality pump set motor starters with metal enclosure and no earthing and DTs mounted at very low height without proper fencing and poor earthing were observed. Earth resistance measurement at few SWER DTs showed earth resistance as high as 65 ohms (should be below 5 ohms for LT earth and below 1 ohm for HT), neutral voltages as high as 70 Volts (ideally to be below 10 or maximum 20 Volts) and poor state of the mandatory well separated (10 feet) earth pits – one for HT and DT body and second for LT. For more details, see: "Reducing Electrocution Fatalities in India- An IEEE SIGHT and IAS Project", available at: https://cmte.ieee.org/ias-wesafe/wp-content/uploads/sites/27/2018/11/Indian-experience-on-electrical-accidents-problem-Full-paper.pdf

4. Key observations and governance gaps

As mentioned in the introduction, the objective of this paper is to initiate steps to reduce accidents, especially those affecting humans. Key observations from the previous sections relevant to meet this objective are summarised here. A macro observation is about the governance gaps in ensuring electricity safety, which is elaborated here.

4.1 Accident causes and trends

Electric shocks are a major cause of accidents, which occur mostly in the distribution system and affect the rural public. Accidents due to electrical fires occur mostly in urban centres, leading to loss of property, but relatively fewer human deaths. Electricity accidents have been significantly increasing over the years, in absolute terms and when normalised with population. It appears that there is marginal increase in accidents when normalised with the number of consumers, energy handled or expansion of network.

There is wide variation in the number of accidents across states and districts. This is to be expected since accidents depend on the spread of the distribution network, its quality and safety awareness of all concerned. But 11 states (listed in Table 2) and among them, Karnataka and Maharashtra have the highest number of accidents. Within states, some districts or regions have a higher number of accidents. Understanding the key reasons for such variation requires further study. States which have been recently electrified, like Uttar Pradesh and Bihar have relatively fewer accidents as of now. But this could be because the electricity network is new and the electrification drive was focussed on household connections. There is a possibility of accidents increasing in these states too, as the network ages and geographically spread-out consumers (like irrigation pump sets) increase.[24]

In electrical terms, most accidents occur in the 11 kV and LT network of DISCOMs, as well as at non-industrial consumer locations. Hence, any initiative to reduce accidents should focus on rural 11 kV and LT network and rural consumers.

4.2 Data challenges

There are many data gaps, but some quantitative analysis has been carried out using available data from multiple sources. There are differences in the way data is reported by ADSI, CEA, CEIGs and DISCOMs. Annual ADSI reports prepared for calendar year are based on inputs from state police departments and provide number of accidents and human deaths due to electrocution, electrical fires and lightning. CEA Annual statistics reports and reports of the Chief Electrical Inspector (CEI) provide data on electrical accidents (fatal and non-fatal) affecting humans and animals.

CEA Annual statistics reports available for many financial years, are based on data provided by DISCOMs (and perhaps CEIGs) using Format 19, which gives break-up for fatal and non-fatal

24. There could also be reporting or data issues, since the deaths due to electrical shocks as per ADSI reports are quite high in UP in Bihar. For example, 2019 ADSI report gives 773 electric shock deaths in Bihar and 1353 deaths in UP, whereas a near equivalent 2020 CEA report (Apr 2019 to Mar 2020) gives 294 fatal accidents in Bihar and 385 fatal accidents in UP.

accidents affecting humans and animals at different electrical locations. One fatal accident may cause multiple deaths, but it is not clear if this aspect is captured. Format 19 requires information on "number of human/animals affected" to be submitted and the number of accidents to be given in brackets. But, the available reports from CEA, CEIGs and DISCOMs provide only one data – either the number of accidents or the number of human/animals affected.

Ministry of Power had prepared a format in December 2004 to report electricity accidents (called Form A), which clearly suggests that details of victims in an accident are to be reported.[25] Form A has been improved by some states (Maharashtra is one) and data on accidents and victims may be being captured. But CEA reports currently show only fatal and non-fatal accident numbers – not the number of victims.

It is also not clear if deaths due to electrical fires are included in CEA reports, though some CEIG reports (for example, Karnataka, Kerala) give number of fire accidents. It can also be observed that updated data for a few states are not available in the CEA reports. It is perhaps due to all these reasons that CEA numbers of fatal accidents for a Financial Year (say FY 2020 - Apr 2019– Mar 2020) are about half of ADSI numbers of human deaths for 2019, the near equivalent calendar year (2019 is Jan 2019 – Dec 2019, and has nine months of the financial year 2020).

Reports of Chief Electrical Inspector (of CEA) are based on data provided by states (possibly CEIG) using Format 20, which gives break-up of fatal and non-fatal accidents affecting humans and animals due to seven different reasons.[26] As of May 2022, CEI electrical accident statistics are publicly available only for three years, namely 2014 (2013-14), 2015 and 2016.[27]

Some DISCOMs submit data on electrical accidents – fatal, non-fatal, human and animals and affecting DISCOM staff/Contract staff and public, in the section on performance analysis, in their tariff submissions to the State Electricity Regulatory Commissions (SERC) broadly as per the formats prescribed by SERC. Data for Andhra Pradesh, Telangana, Maharashtra and Uttar Pradesh were studied as part of this paper. These are useful since they also provide circle wise data. But there is no uniformity in formats used by different states and in some states, by different DISCOMs (APSPDCL and APEPDCL use different formats, cause-wise analysis formats are different in TSSPDCL and TSNPDCL etc.) Even though this covers only accidents in DISCOM area, the number of accidents given in these sources are in some cases higher than that given in CEA (examples: AP FY20, TS FY15 and 16, UP for FY13 to FY17).[28]

25. Form A is available at: https://cea.nic.in/wp-content/uploads/page/2020/07/notification_information_accident.pdf

26. These reasons are: 1) Snapping of conductors, 2) Accidental contact with live electric wire/equipment, 3) Violation/neglect of safety measures/lack of supervision, 4) Defective appliances/apparatus/tools, 5) Inadequate/lack of maintenance, 6) Unauthorised work and 7) Any other reasons.

27. CEI reports are available at: https://cea.nic.in/cei-electrical-accident-statistics/?lang=en

28. There are many other issues with data given in CEA General Review. For example, accident data for some states are not available for some years (perhaps because they are not provided by the states) or data for some states for some years are very different from the general trend. The number of consumers reduced from 27.58 crores (FY13) to 22.06 crores (FY14), with states like AP, Karnataka and UP reporting significant reductions.

4.3 Challenges in the safety governance framework

CEA prepares and updates regulations on electricity safety, which are expected to be followed by all power utilities.[29] For recent amendments, CEA has been requesting suggestions from the public before finalising them. This is a welcome step, but it is not clear how these suggestions are handled. Submitted comments and explanation on how they were handled are not available. The current regulations cover electricity safety aspects in many other sectors like mining, railways and oil fields, which have their dedicated safety governance structures. Combining electricity sector with all these sectors introduces challenges in formulation and implementation of safety regulations in electricity sector.

CEIGs have the responsibility to inspect and certify the safety of electrical installations. State CEIGs come under the state energy department and their main focus is on electricity duty collection and audit of HT consumers. Based on the CEA (Measures relating to safety and Electric Supply) Amendment 2015 and Amendment 2018, states are to notify voltage levels below which self-certification is possible. A brief study of few states show that notified self-certification voltage varies from 66 kV (Punjab), to 33 kV (Haryana, MP, Rajasthan) to 11 kV (AP, Maharashtra) to 650 V or below (Karnataka, Kerala, Odisha). Periodic inspection and testing (once in 5 years or better) are to be carried out and the procedure for this also varies across states. Variation is understandable, but the criterion used for arriving at the notified voltage and inspection process is not clear.

The concept of Chartered Electrical Safety Engineer (CESE) was also introduced as an amendment to the CEA safety regulations in 2015 and guidelines issued in 2018.[30] This has some potential, especially since the capacity of CEIG is limited. To illustrate, CAG Report 5 of 2018, reviewing the Telangana CEIG notes that there are shortfalls in inspections, shortage of staff - with each official having to conduct 466 inspections in a year.[31] Based on notified certification process, chartered engineers could undertake safety inspection and certification. The progress on this does not look good. Thus, CEIG's role in implementing safety regulations especially at LT voltage level is near zero.

Another important observation is that electricity safety does not seem to be a top priority for many sector actors and there is confusion as to who should play a key role in reducing accidents. The central government has many initiatives to promote electricity connections, renewable energy, energy efficiency, financial health of the sector and markets. But electricity safety targets or specific measures to improve safety are not part of distribution reform programs or National Electricity Policy.

CEI of CEA and state CEIGs have key role in promoting electricity safety, as per the Electricity Act 2003. CEA has been preparing and updating safety related regulations, and of late has been doing so, after inviting public comments. But there is no clear thrust or mechanisms to implement these regulations. The Electricity Act does not give SERCs specific mandate on safety.[32] But SERCs

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29. CEA Electrical Safety Regulations are available at: https://cea.nic.in/regulations-category/measures-relating-to-safety-and-electric-supply/?lang=en

30. CESE guidelines available at: https://cea.nic.in/wp-content/uploads/page/2020/07/guidelines_cese.pdf

31. This is available in Section 5.3 of the CAG performance audit of Telangana Energy Department, Report 5 of 2018, available at: https://cag.gov.in/cag_old/sites/default/files/audit_report_files/Report_No_5_of_2018_-_Revenue_Sector_Government_of_Telangana.pdf

32. The Orissa Electricity Reform Act 1995, AP Electricity Reform Act 1998 and Central Electricity Reform Act 1998, do include safety in the scope of SERCs. These are available at: https://energy.odisha.gov.in/sites/default/files/2021-02/Odisha%20electricity%20reform%20act%201995_0.pdf, https://www.ap.gov.in/wp-content/uploads/2021/10/AP-Electricity-Reform-Act-1998.pdf, and https://cercind.gov.in/electregucommiact1998.pdf.

have a broad role in regulating the sector, and hence could prepare and enforce safety through Standards of Performance Regulations or directives to DISCOMs. Only some SERCs (MP, Gujarat, AP, Rajasthan, Telangana) have attempted this, but with limited success. With proper coordination with CEA, SERCs could play a more active role in implementing safety regulations.

Safety professionals and organisations have been focussing on industrial or occupational safety and not on safety issues that affect the rural public. For most ordinary consumers, continuity of supply with minimum investment (of time and money) is the priority. Because of this and the lack of awareness, they are victims of electricity accidents. Many rural and farmer organisations have been focussing on compensation for accident victims. This is no doubt important, but no amount of monetary compensation is enough for loss of life of the bread earner.[33] Equal efforts need to be made to reduce accidents.

DISCOMs, the first interface to the consumers, have a key role in safety, since they are responsible for network expansion, operation & maintenance and revenue collection. DISCOM staff (including contract staff) and public are the most affected by accidents. But there is absence of periodic safety audits, planned actions to reduce accidents and elevating electricity safety to a key performance metric. In the recent years, there has been some increased attention to quality of supply and service parameters like power outage and low voltage, but not as much on safety. Many of the measures to address quality of supply can also help to reduce accidents, especially if safety is also considered as a standard of performance.

4.4 Good practices

It should also be mentioned that there are good practices in some states, which need to be followed by many more. SERCs in Madhya Pradesh and Gujarat include safety as part of their standards of performance regulations for DISCOMs.[34] Rajasthan SERC gave a land mark order in 2019, directing the DISCOMs to carry out independent safety audits and safety training programs.[35] GERC has given orders on safety and compensation, based on petitions by consumer organisations. [36]APERC, in its tariff order for FY22, directed DISCOMs to designate safety officers, submit monthly safety audit reports and organise training programs for their staff and electricians.[37] Rural Electrification Corporation (REC) has sponsored training programs for DISCOM staff in many states. CEI wings of CEA have organised many training programs on electricity safety. Many states like Maharashtra, Gujarat, Karnataka, Kerala, Haryana, Odisha, Assam and Tata Power,

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33. Efforts by many organisations in some states have resulted in increase of ex-gratia for accidents (involving humans and animals) and simplification of procedures, so that many are given ex gratia on a humanitarian basis. Typical ex gratia amounts for human deaths are Rs. 10 lakhs (Mizoram 2021), Rs. 5 lakhs (Kerala 2018, AP 2017), Rs 4 lakhs (Odisha 2020, Telangana 2015). Many states like Maharashtra, Kerala, Mizoram and Odisha give ex-gratia for injuries also.

34. GERC, in its quarterly reports on DISCOM standards of performance, provides accident data as well. Available at: https://gercin.org/standard-of-performances-quarter-year-discom/.

35. This is based on a review petition by Mr. BM Sanadhya of Samta power and gives many directions to Rajasthan DISCOMs on safety audit and training. The order is available at this link: https://rerc.rajasthan.gov.in/rerc-user-files/tariff-orders.

36. Examples are the 2011 order on HT line snapping and 2012 order on compensation, based on petitions by CERS, a consumer organisation (https://cercindia.org/).

37. AP 2022 Tariff order available at: https://aperc.gov.in/admin/upload/RSTOrderFY20212208042021.pdf

have prepared detailed safety manuals.[38] Mobile application of Maharashtra State DISCOM has features which allow public to report potential accident situations like leaning poles, low hanging conductors, sparking joints etc. KSEB limited has detailed processes and institutional structure for safety, headed by a Director level person.[39] Professional organisations like IEEE, International Copper Association, KSEB Officers' Association (KSEB OA) have conducted studies on accidents, organised many training programs and prepared safety awareness videos.[40]

Key points

To summarise, the number and rate of electrical accidents have been increasing over the years. The 11 kV and LT distribution system and non-industrial consumer locations are the major accident sites and rural public are the most affected. There is variation in the number of accidents across states, and within states, across regions. The major immediate cause of accidents is inadvertent contact with live conductor, in turn due to a multitude of root causes like poor construction, bad maintenance, and neglect of safety. These observations are based on analysis of available data, which have many gaps in collection and reporting. There are many governance gaps in implementing the CEA safety regulation to ensure electricity safety, especially where most accidents occur. There are some good practices towards reducing accidents, initiated by CEA, Electrical Inspectors, utilities, regulatory commissions, safety professionals and consumer groups, which need to be improved and replicated.

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38. These manuals are available at the utility websites. Some of these manuals cover only transmission. There is scope of improving these manuals and ensuring that the given guidelines are followed.

39. Available at: https://www.kseb.in/index.php?option=com_jdownloads&view=download&id=2739:implementation-of-safety-procedures-in-kseb-ltd-organizational-structure-of-safety-wing&catid=2&Itemid=673&lang=en

40. Examples of safety awareness videos: IEEE Hyderabad (Telugu with English subtitles, https://www.youtube.com/watch?v=ux8V-nL9Ak0), International Copper Association India (https://www.youtube.com/watch?v=GMgXW6WhYBw), Kerala CEIG (Malayalam), web resources by Er.Jameskutty (https://jameskutty.info/), a retired Kerala electrical inspector.

5. Suggestions

The consideration that electricity safety largely affects public interacting with rural distribution network has been neglected for long. It is also clear that safety is not a challenge that one agency can handle alone. The focus of data collection, analysis and accident reduction initiative should change based on this understanding. Reducing accidents require technical and governance challenges to be addressed through coordinated sustained efforts of multiple sector actors over a period of few years. Safety is to be considered as a public interest challenge by national and state actors and location specific initiatives need to be taken up. Suggestions are both technical and governance related and are organised under two heads – immediate (1-2 years) and medium term (3-5 years).

It is our hope that these suggestions are taken in a positive spirit, and discussed among all concerned actors to plan appropriate initiatives to reduce accidents. With all the actors playing their complimentary roles in a consistent fashion, it is possible to bring down accidents over a few years.

5.1 Immediate action ideas

5.1.1 Improve data quality

There is an urgent need to improve the data collection and reporting by CEA and DISCOMs. CEA should publish all the data collected and improve the formats to indicate actual number of human/animals affected and give further break-ups, like electrical location of accidents. There should be better data coordination across different agencies, such as CEIG, DISCOMs, fire department and the police department, which collect safety data. Formats prepared by SERCs and used by different DISCOMs need to be improved. Forum of Regulators could suggest better formats and SERCs could ensure that DISCOMs routinely file this information. DISCOMs/CEIGs are currently categorising majority of the accidents as "consumer / victim's fault". Basis for such categorisation and the details of accident investigation report(s) should be available in the public domain. CEA or SERCs could commission independent safety surveys or audits with focus on high accident areas to get a better idea of ground reality.

5.1.2 Safety initiatives as part of national programs

At the national level, Ministry of Power should prepare accident reduction initiatives with clear targets and road map for zero accidents. Safety should form an integral part of initiatives like the new distribution reform program (RDSS), so that sustainable, affordable, quality and safe electricity access is ensured for all. DISCOMs should implement such initiatives.

5.1.3 Developing a safety metric

Top management of DISCOMs, CEIGs and SERCs should give high priority to the neglected safety dimension – public safety at the low end of the distribution network. There is a need to provide sufficient field staff for distribution operation & maintenance. DISCOMs should ensure regular training and safety awareness programs of all its field staff, electrical contractors, consumers and general public. Pilot projects involving technical and management innovations should be implemented in high accident areas.

SERCs should include safety as part of Standard of Performance regulations. SERC could prepare a suitable safety matric, and ensure regular monitoring. Sanctions for capital expense and Operation & Maintenance expenses should be also linked to the safety metric. There should be mechanism to fix accountability of accidents, by having thorough enquiry to fix responsibility and penalising the responsible staff or DISCOM management.[41]

5.1.4 Strengthen the safety institutional structure in states

State CEIGs, DISCOMs and SERCs should work together on accident reduction initiatives. The idea of an independent safety institution, which covers safety aspects in all areas, could be explored. This could be along the lines of disaster management missions. Dedicated safety officers should be identified at state, circle, division and subdivision levels of DISCOMs, who are accountable for monitoring and improving safety. Efforts should be made to ensure that there are sufficient Chartered Electrical Safety Engineers to take up periodic inspection of distribution network. Organisations like Institution of Engineers could be involved for certification and training.

In urban areas, the urban local body should take up the responsibility of coordinating between distribution companies and a variety of other agencies. This includes authorities who provide building permission (to ensure that power lines are not very close to buildings), agencies who re-carpet roads (so that repeated carpeting does not reduce ground clearance), internet and cable TV providers (who string their wires on electric poles, very near conductors), street light maintenance agencies (so that switchboards are not left open) etc.

5.1.5 Attention by professionals and grass root organisations

Professionals and academics should give high focus to the safety issues elaborated here, rather than limiting attention to industrial safety or technical issues. Rural and farmer organisations should focus on accident reduction rather than limiting to timely payment of accident compensation.

5.2 Medium term action ideas

5.2.1 Giving teeth to safety regulations

CEA should give more attention to ensure that its safety regulations are implemented by DISCOMs, and enforced by CEIGs. Since electricity safety challenges are mostly in electricity distribution and supply, it would help if safety regulations for this area is separated from other sectors like railways, mining and oil fields. This would make it easier to introduce amendments and follow up implementation of regulations. In order to continuously improve safety regulations and ensure their proper implementation, CEA should allow professionals and non-government actors to participate in all its processes. This should not be a one-way process of providing comments, but result in a two-way interaction, as followed by some processes of Bureau of Indian Standards or SERCs.

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41. Penalties are steep in many foreign countries. Attention to safety will be proportional to the economic and social cost of non-compliance of safety regulations. Some personal accounts like that described in the book on the Uphaar cinema fire (1997), "Trial by Fire: The Tragic Tale of the Uphaar Fire Tragedy"(Penguin Random House 2016), describe the challenges in fixing accountability of electricity accidents.

There is a national Standing Committee on Electrical Safety (SCES, formed in 2017), but with only central and state government officials as members.[42] Representatives of public and private sector companies and safety professionals should also be included in SCES so that their expertise could also be used for effective implementation of safety regulations.[43] Ideas like safety awareness building, strengthening the institution of Chartered Electrical Safety Engineer and centralised safety cell with a helpline number, discussed during meetings of SCES should be brought to a logical conclusion. Since states have more significant role in accident reduction, formation of similar electricity safety committees at the state level should be taken up. This would help to finalise the notified voltage (which should be 11 kV or below), ensuring periodic inspection and testing, fixing accountability for accidents and implementing accident reduction programs.

5.2.2 Facilitating public reporting of accident-prone situations

Many DISCOMs have mobile apps, currently used mostly to pay bills and register complaints. These could be improved so that public in all DISCOM areas can report accident prone situations like lines touching trees, sparking joints or leaning poles. Toll free numbers for complaints should accept and follow up such complaints also.

5.2.3 Exploring technical innovations

There are many technical measures, which could lead to reduction of accidents, some are tried and proven while some needs pilot testing.

Good earthing practices and robust fault tripping systems at 11 kV and LT systems are crucial. Bare conductors should not be left sagging beyond the permissible levels and poles should not be leaning. Deployment of insulated Aerial Bunched Cables (ABC) could be explored for long LT lines, which would reduce accidents and power theft.[44] Pole guards at 11 kV poles, used in parts of Tamil Nadu and Karnataka ensure that circuit breaker at the substation trips when there is a ground fault on 11 kV line.[45] Residual current circuit breakers at households reduce shock accidents and should be popularised.[46] DTs should be installed on high pedestals and have good fencing. Motor starters at irrigation pump set locations should have non-metal enclosures and standard protection

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42. SCES held its first meeting in 2017 and has Chief Electrical Inspector (CEA) as Member-Secretary. Members include nominated officers from State Governments, nominated members from Railways, Directorate General - Factory Advice Service & Labour Institutes (DGFASLI) and Directorate General of Mines Safety (DGMS). As per the website, four meetings have been held till 2019. Details at: https://cea.nic.in/old/cei_sces.html

43. Even though, in the first meeting of SCES, the idea of co-opting non-voting members to SCES from public and private sector companies was discussed and rejected. It was decided that they could be called for some meetings as special invitees. Details available at: https://cea.nic.in/old/reports/others/ps/pce2/cei/sces/mom1.pdf

44. See the 2021 order by KSEB on use of ABC for future LT lines and service connections, available at: https://kseb.in/index.php?option=com_jdownloads&task=download.send&id=18748&catid=2&m=0&lang=en

45. These are metal hooks on poles, installed below conductors. These hooks are connected to the neutral wire or earthed at each pole. When conductor snaps, it touches the hooks, resulting in high fault current, which would trip the circuit breaker. For more details refer the technical paper "A Cost-Effective Solution for Clearing High-Impedance Ground Faults in Overhead Low-Voltage Lines", by Massimo M etal, in IEEE transactions in industry applications, March/April 2019, available at: https://ieeexplore.ieee.org/document/8558096.

46. Residual Current Circuit Breaker (RCCB) is mandatory as per the 2015 amendment of CEA safety regulation, which gives 30 mA threshold for domestic and 100 mA for other consumers. Trip at 30 milli Ampere (mA) is ideal for human safety, though as per some sources, to avoid nuisance tripping, 60 or 100 mA is also used.

devices. If the enclosure is of metal, it should be properly earthed. Some of these measures should be part of the newly launched Revamped Distribution Sector Scheme (RDSS) initiative.[47]

5.2.4 Increasing accountability for safety

Available data indicates that DISCOMs accept responsibility only for a small proportion of accidents. This has to be checked through credible third-party audits. In cases where they are responsible, there is no clear mechanism to fix accountability and prevent recurrence. A reward–disincentive mechanism should be prepared to motivate field staff to proactively work to prevent accidents.

CEIG is currently accountable only to the state government and hardly to the public. SERCs have a much better system to increase accountability of service providers and it is better to bring CEIG oversight to SERC's ambit, especially for distribution at 11 kV and below. This would require amendments to the Electricity Act or coordinated working of CIEGs and SERCs.

Key points

To conclude, electricity safety is a public interest challenge, which can be met only through coordinated action involving all sector actors. There is scope to improve the current safety regulations. But the implementation of the current safety regulatory regime can be significantly tightened through better data collection, introducing safety aspects in national programs, strengthening safety institutions, developing safety metric for DISCOMs, involving public and professionals in safety initiatives and utilising technological innovations. The need of the hour is a concrete accident reduction program in the distribution sector, with clear scope of work, sufficient resource allocation and robust monitoring & verification mechanism. Only this can ensure that our electricity supply is not only universal, affordable and good quality, but also safe.

47. RDSS is a five-year long electricity distribution sector upgrade initiative by the Government of India, launched in 2021, with an outlay of over Rs. 3 Lakh crores. For more details, see: https://recindia.nic.in/revamped-distribution-sector-scheme.

Selected Publications of Prayas (Energy Group)

1. Five stitches in time: Regulatory and policy actions to ensure effective electricity service (2019) https://energy.prayaspune.org/our-work/research-report/five-stitches-in-time-regulatory-and-policy-actions-to-ensure-effective-electricity-service

2. Consumer's Guide for Electricity Service—Information on consumer related rules and regulations (2019) https://energy.prayaspune.org/our-work/research-report/consumers-guide-for-electricity-service-information-on-consumer-related-rules-and-regulations

3. A Primer on Power Sector: Know your Power – A Citizen's Primer on the Electricity Sector: 3rd Revised Edition (2019) https://energy.prayaspune.org/our-work/research-report/know-your-power-a-citizens-primer-on-the-electricity-sector

4. Rural Electrification in India: From 'Connections for All' to 'Power for All' (2018) https://energy.prayaspune.org/our-work/research-report/rural-electrification-in-india-from-connections-for-all-to-power-for-all

5. Bricks without Clay: Crucial data formats required for effective tariff processes (2018) https://energy.prayaspune.org/our-work/research-report/bricks-without-clay-crucial-data-formats-required-for-effective-tariff-processes

6. Demanding Electricity Service: A Guide for the Community Activist (English and Hindi) (201 https://energy.prayaspune.org/our-work/research-report/demanding-electricity-service-a-guide-for-the-community-activist

7. Electricity for All: Ten Ideas towards Turning Rhetoric into Reality - A Discussion Paper (English and Hindi) (2010) https://energy.prayaspune.org/our-work/policy-regulatory-engagements/electricity-for-all-ten-ideas-towards-turning-rhetoric-into-reality-a-discussion-paper

8. Awareness and Action for Better Electricity Service—An agenda for the community (2008) https://energy.prayaspune.org/our-work/research-report/awareness-and-action-for-better-electricity-service-an-agenda-for-the-community

9. Quality of Service of Distribution Utilities–Need for End to End Commitment (2005) https://energy.prayaspune.org/our-work/policy-regulatory-engagements/quality-of-service-of-distribution-utilities-need-for-end-to-end-commitment

Other resources

1. Short video about common electricity complaints faced by small consumers, and methods to address them (English, Hindi, Marathi, Telugu, 2018) https://energy.prayaspune.org/our-work/capacity-buildings/consumer-information

2. Short video on electricity safety awareness, Telugu with English sub-titles, prepared by IEEE – Hyderabad section (2016) https://www.youtube.com/watch?v=a_7rRUxhvVs&t=1s

A disturbing side effect of electrification is the increasing number of electrical accidents. Over the years, there has been a big increase in the number of accidents in both absolute and per population terms. The rural public is a major victim of these accidents, which are largely caused due to contact with conductors in the distribution system or at non-industrial consumer locations. Poor design, sub-standard construction, poor maintenance and lack of safety awareness contribute to the increase of accidents. The attention given to many other challenges in the electricity sector – access, renewable energy, market or financial health – is unfortunately not given to electricity safety. National programs or policies do not provide clear targets or road maps to reduce accidents. Safety professionals give more attention to industrial safety and efforts of grass root organisations are more focussed on ensuring compensation to electricity accident victims. This discussion paper analyses the magnitude of the electricity safety challenge, the 'who, where and why' of accidents, identifies important governance gaps, and proposes some suggestions to reduce accidents.

Prayas (Energy Group)