Electrical Accident Scenario in India: A Review

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1 Introduction

Electricity became one of the basic amenities of modern world and has rampaged growth of human kind since its discovery. The world's electricity production by 2015 has increased almost four times (International Energy Agency 2017) of 1973 energy production and highest growth rate in developing countries. Net electricity generation in developing countries like China, India, etc., increases by a mean rate of 1.9%/year from 2015 to 2040, compared to 1.0%/year in developed countries (Energy Information Administration 2016). As per predictions, the consumption of electricity increases in residential and commercial installations over the period of 2015–2040 as personal incomes rise and emigration to cities continues (U.S. Energy Information Administration 2017).

This rapid growth in consumption has been contributing not only for economic development, but also for the rapid increase in number of fatalities, even in developed countries such as USA, UK, etc. This is due to its nature of invisibility and light speed of travel (Bowers 2001) it poses a threat to surrounding life, if handled improperly. Thus, national governments and many international bodies such as Occupational Safety and health Organization (OSHA), International Electro-technical Commission (IEC), National Fire Protection association (NFPA), Health and Safety Executive (HSE), Institute of Electrical and Electronics Engineers (IEEE), etc., put efforts in framing standards to improve workplace electrical safety. Due to these efforts, the fatality rates reduced by 40% in USA—the home of OSHA and NFPA (Campbell and Dini 2015) but still electricity is one of the top most causes of fatalities. In India, fatalities due to electrocution, however, are increasing particularly in construction sector. Despite several legislations in place to ensure workplace safety (such as Indian

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Electricity Act-2003, Factories act and rules, etc., and regulations and bylaws made there under) in India death toll due to electrocution is increasing.

In this paper, an attempt has been made to review the workplace electrical accidents in India across various industrial sectors and overall death toll.

2 Electrical Accidents in India

Very few studies (Kumar et al. 2014; Mukherjee et al. 2015) are carried out regarding "electrical accidents in India," however, are limited to specific area/region. Hence, this paper entirely based on official reports of governmental bodies. Injuries/deaths and incidents/accidents in India are reportedly increasing as evident from the death toll (fatal injuries) figures given by National Crime Record Bureau (NCRB) (2001–15) (a statutory body under Central Ministry of Home Affairs (MHA)), under crime head "electrocution" (deaths due to electricity) for the period of 2001–2015 are as shown in Fig. 1.

However, Indiastat (2001–15) provided the same data along with no. of accidents collected from MHA. These numbers give an overall death toll estimate based on data collected from local police records, hospitals, etc. It is to note that deaths mentioned under crime head "electrical short circuit" are not considered, as that is a sub-category

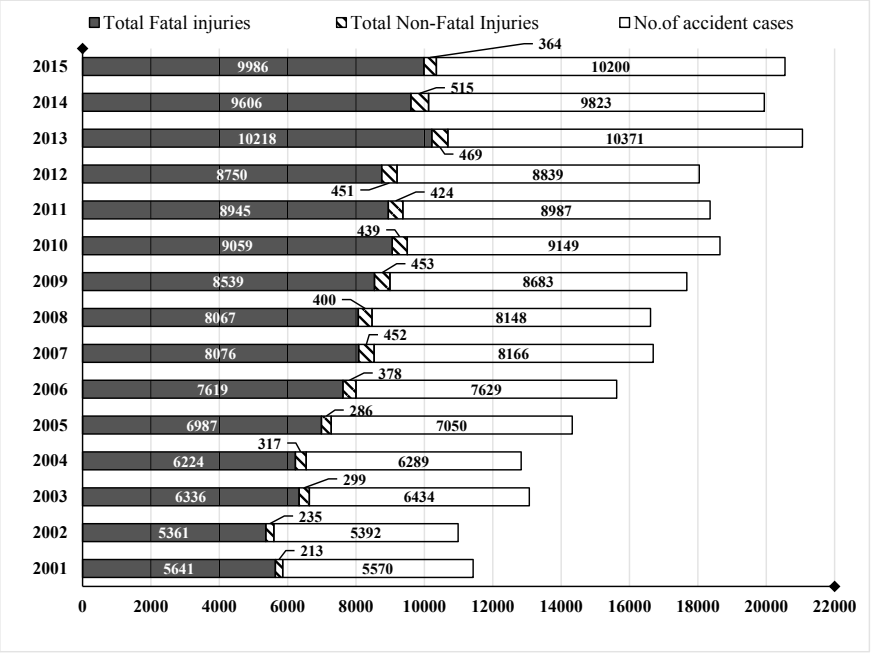

Fig. 1 No. of deaths due to electrical accidents in India

under crime head "fire." From 2001 to 2013, the graph is increasing with maximum death toll of 10,218 (2013) and hauled around ten-thousand for 2014 and 2015 and data of later years (2016 onwards) is unavailable.

2.1 Industrial Scenario

To understand the industrial scenario, the workplace fatality statistics are necessary. The electrical accident/incident/injury data of various industrial sectors has been provided in the following three categories and is explained in subsequent sections.

- Industrial accidents/incidents (excluding mines and power sector) (DGFASLI 2006–2016)
- Accidents/incidents in coal and non-coal mines (Director General of Mines Safety 2005–14, 2010–15; Director General of Mines Safety)
- Accidents/incidents in power generation, transmission, distribution and/or utilization (Central Electricity Authority 2001–15).

2.1.1 Industrial Accidents (Excluding Mines and Power Sector)

Ministry of Labor and Employment (MoLE) is the nodal ministry for workplace safety in Indian industries through Director General of Factory Advisory Service and Labor Institutes (DGFASLI) that ensures compliance of acts, rules, regulations and bylaws made for wellbeing of employees. The industrial injury (fatal and non-fatal) data 2003–2013 has been collected from Standard Reference Letters published by DGFASLI 2006–16 published by DGFASLI and labor stats by MoLE together with injury data for 2001–2003 collected from secondary source mentioned under "electricity" are used to portray the industrial scenario for the period of 2001–2013. However, cause wise injury data after 2013 and number of incidents/accidents is unavailable (Fig. 2).

As per these stats, almost one quarter of total injuries caused by electricity and about thirty percent of total electrical injuries are fatal in nature. The injury graph (both fatal and non-fatal) has shown both positive and negative variations alternatively; however, with maximum number (92) of fatalities in 2010 and non-fatal injuries (205) in 2006. It is clear from the graph that both fatal and non-fatal injuries reduced considerably from 2011 and attained minimum values in 2013. On an average out of 691 injuries per annum, 116 occurred due to electricity causing about 51 fatalities, and in conclusion, the impact of electricity-related injuries is significant in industries. It is worthwhile to note that data mentioned under this section does not include information regarding nuclear, aviation and defense sectors.

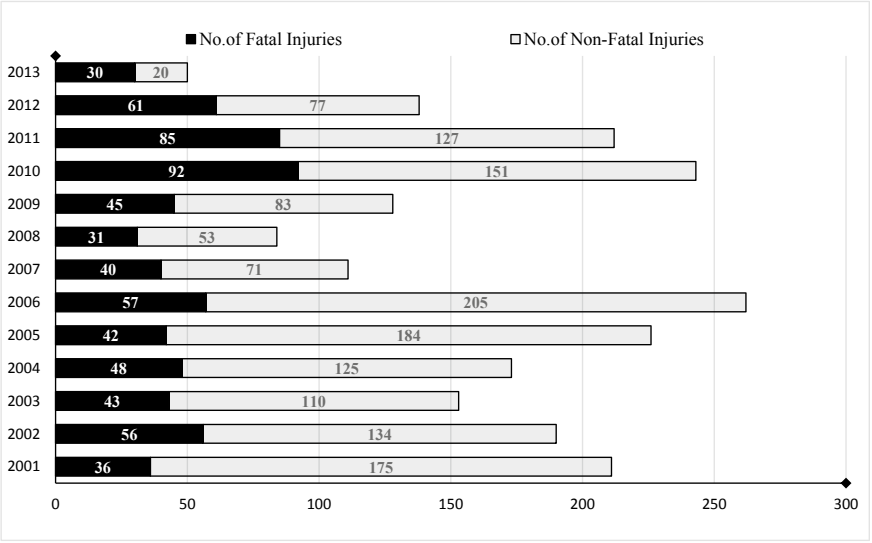

Fig. 2 Injuries in factories due to electricity—2001–2013

2.1.2 Accidents/Incidents in Coal and Non-coal Mines

Accident data for mines collected from annual reports of Director General of Mines Safety (DGMS) a government agency under MoLE, looks after health and safety practices in mining industry. Accident/incident data has been collected from annual reports published by the agencies. The incident/accident data collected for the period of 2001–2015 presented here has been in the form of statistical charts (Figs. 3 and 4) and tables (Tables 1 and 2). Unlike DGFASLI that noted no. of injuries, DGMS presented (cause wise) no. of incidents and no. of resultant casualties for coal and non-coal mines. The electrical fatalities represented as percentage of total fatalities for easy understanding. Fortunately, in both coal and non-coal mines, the fatalities due to electrocution are less and particularly in non-coal mines it is almost zero. On an average:

- One fatal incident out of fifty incidents (total-fatal and non-fatal) is due to electricity, resulting almost one out of sixty fatalities, in case of non-coal mines.
- Almost four fatal incidents out of eighty incidents (total-fatal and non-fatal) are due to electricity, resulting into almost six causalities out of ninety-five fatalities, in case of coalmines.

It is to be noted that number of incidents/accidents and resulting fatalities/injuries are comparatively less than DGFASLI. However, electricity is one of the best sources of ignition in areas prone to fire damps and thus proper safety measures be applied to avoid/reduce fatalities.

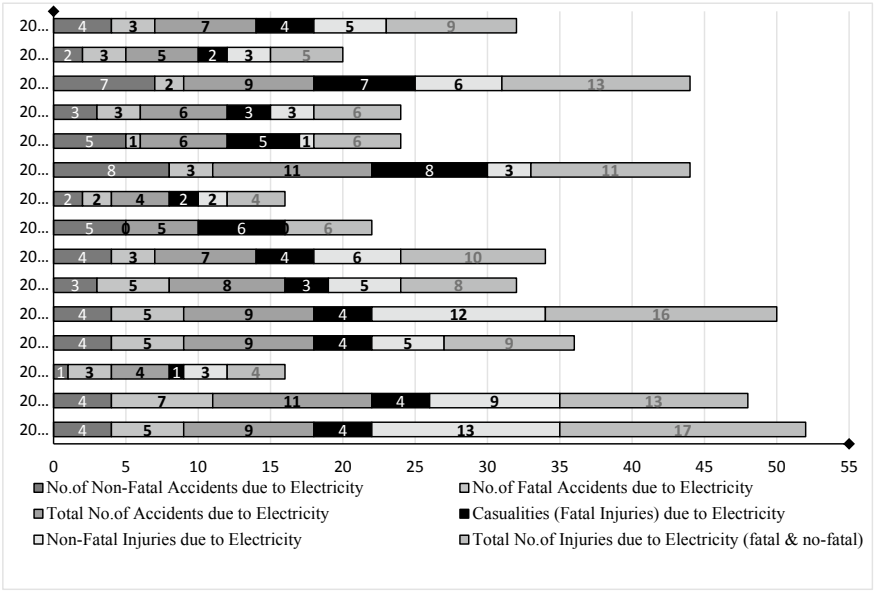

Fig. 3 Accidents and injuries in coal mines

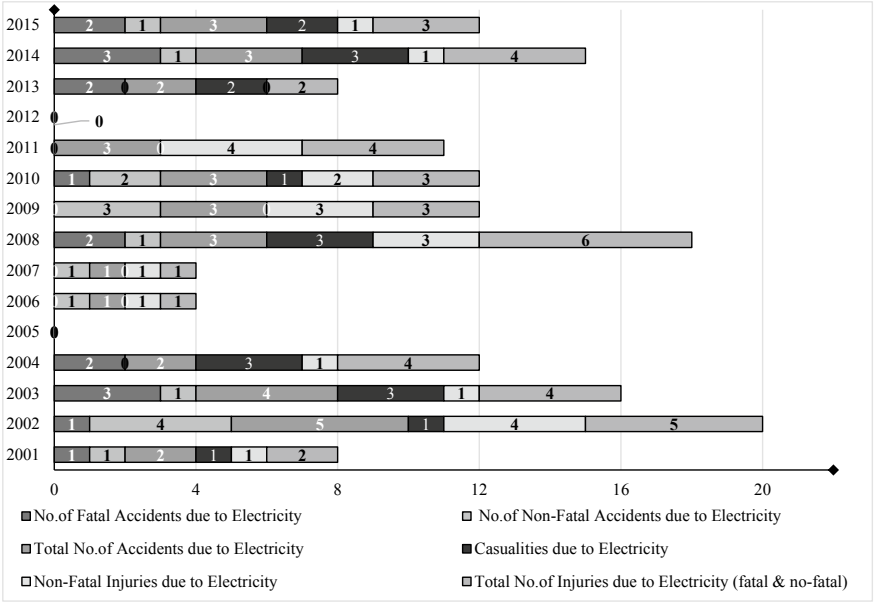

Fig. 4 Accidents and injuries in non-coal mines

Table 1 MHA versus CEA comparison of data components

S. No.	Component of comparison	MHA	CEA
1.	Data coverage	• The overall death toll, injury data against no. of accidents and fatalities/injuries due to electricity for entire India (i.e., every accident and injury occurred in India)	• The data regarding number of accidents in relation to electrical supply
		• Covers data of entire India	• Excludes UTs
		• Data for the selected duration 2001–2015	• Data of 2003–2004 and 2011–2012 are missing
2.	Type of data	• Number of accidents (sum/total of fatal and non-fatal) • Number of injuries (fatal and non-fatal)	• Number of accidents (fatal and non-fatal)
3.	Cause wise distribution of data	• All the accidents are "electrocutions"	• Categorized under seven causes as per CEA regulations
4.	Source of data	• NCRB "accidental deaths and suicides in India" available from 1967 to 2015, gives death toll	• CEI and the cause wise distribution is available 2013–2016 only
		• The number of accidents and no. of injuries derived from Indiastat	• The data prior to 2013 taken from Indiastat

2.1.3 Accidents/Incidents in Power Generation, Transmission, Distribution and/or Utilization

Apart from industrial/occupational, data obtained from DGFASLI and DGMS Chief Electrical Inspectorate (CEI) [*the regulatory and reporting authority situated under CEA according to Indian Electricity, 2003, being surveillance of safety as one of its prime functions*] provided electrical accident stats for the period of 2013–16 (2013–14, 2014–15 and 2015–16). All these stats give the information about accidents that happened in relation to electrical supply, i.e., the accidents occurred in any premises, in relation to electrical supply lines, transmission and distribution equipment installed/maintained electricity boards. It is to appreciate that no. of fatal and non-fatal incidents affected humans or animals listed in detail against seven different causation factors as:

1. Snapping of conductors: Breakage of conductors due to short circuit, over loading, etc.
2. Accidental contact of the electric wire or equipment: Contact with live equipment

Table 2 DGFASLI and DGMS versus CEA comparison of data components

S. No.	Component of comparison	DGFASLI	DGMS	CEA
1.	Data coverage	• The overall injury data against for *factories* (except nuclear, mining, defense and aviation sectors)	• Coal and other mineral mines data reg. number of accidents (fatal and non-fatal) and injuries (fatal and non-fatal)	• The data regarding number of accidents in relation to electrical supply
		• Does not cover UT Lakshadweep and states Mizoram, Arunachal Pradesh and Sikkim	• Data covers entire India	• Excludes UTs
		• Data available for duration 2001–2013 and for 2014 and 2015 yet to be published	• Data exists for entire selected period of study	• Data available for selected period except that 2003–2004 and 2011–2012 are missing
2.	Type of data	• Number of accidents (sum/total of fatal and non-fatal)	• Number of accidents (sum/total of fatal and non-fatal) • Number of injuries (fatal and non-fatal)	• Number of accidents (fatal and non-fatal)
3.	Cause wise distribution of data	• All the accidents occurred due to "electricity"	• Categorization of causes found in statistical reports of DGMS as: accidents due to—overhead conductors, switch gears and other electrical accidents	• Categorized under seven causes as per CEA regulations
4.	Source of data	• NCRB "accidental deaths and suicides in India" available from 1967 to 2015, gives death toll	• DGMS annual reports 2005–2014	• CEI and the cause wise distribution is available 2013–2016 only
		• The number of accidents and no. of injuries derived from Indiastat	• DGMS statistics of mines vol. I and II for 2010–2015	• The data prior to 2013 taken from Indiastat

3. Violation/neglect of safety measures/lack of supervision: Intentional violation of safe working procedures, for example, removal of safety guards while operation
4. Defective appliances/apparatus/tools: Improper or defective tool/appliance usage; for example, using uninsulated tools for repairing/maintenance
5. Inadequate/lack of maintenance: Improper maintenance of conductors/switchgear/any other equipment; for example, improper lubrication/cooling of equipment
6. Unauthorized work: Unauthorized access to live equipment; for example live line work without permit
7. Any other reasons: Other miscellaneous reasons.

CEA distributed accidents into three categories: Accidents in:

- Generating stations, transmission and distribution
- Industrial installations and
- Non-industrial installations.

With no mentioning of number of fatalities, i.e., no. of accidents are mentioned rather than no. of persons killed/injured. Both the categorization of accident under various causes and the format of statistical information collection are as per regulations set by CEA. About 24,030 total accidents in three-year duration (in which humans are affected) 14,907 are fatal accidents, i.e., about sixty-two percent. Among these, accidents/incidents due to cause-2 have maximum share with thirty-seven percent out of total fatal incidents occurred in three years. Prior 2013–2014, the detailed cause wise distribution of accidents and post 2015 accident data is unavailable (Fig. 5).

However, it is to note that the data does not include accidents of UTs and provide information of all accidents (industrial and non-industrial). Hence, exclusively industrial accident data is represented in Fig. 6; however, cause wise distribution is unavailable and accidents in which humans are harmed only considered. Total number of fatal accidents is more than double than that of no. of non-fatal accidents. It is to note that though all these accidents reportedly occurred within the industrial premises though related to electrical supply (lines and/or equipment) as previously mentioned and includes all sorts of industries. This means the CEA industrial accident data can be correlated with that of DGFASLI and DGMS data.

2.2 Critical Comparison

The CEA data quoted as “number of electrical accidents in India”; also, there is variation in number of accidents and death toll given by MHA that it does not match the total of DGFASLI, DGMS and CEA figures. On the other side, the variation found in CEA industrial accident figures and those mentioned in DGFASLI and DGMS. Hence, a close examination of these variations presented in this section in two categories:

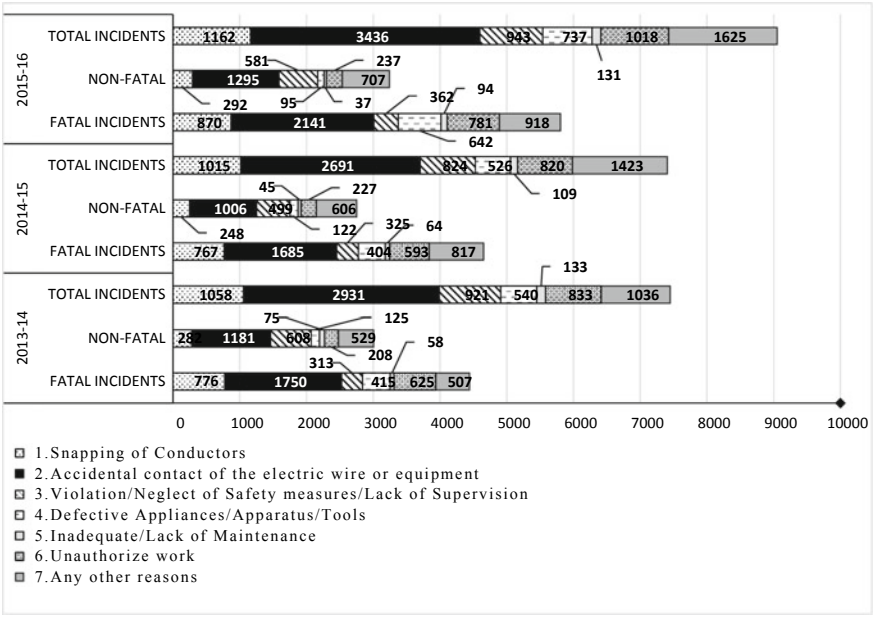

Fig. 5 Numbers of accidents by CEA

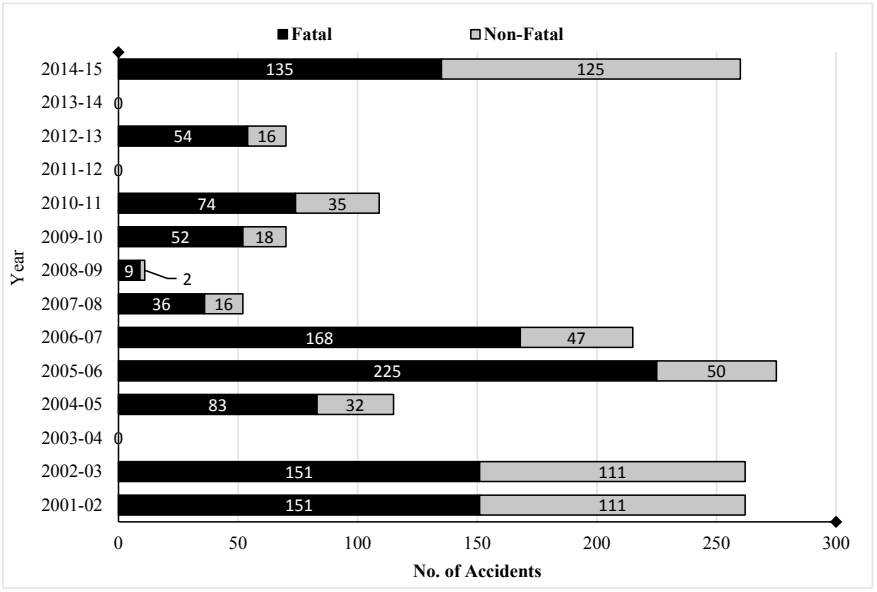

Fig. 6 Industrial accident data-CEA

1. CEA data versus MHA data
2. DGFASLI and DGMS data versus CEA data on industrial accidents.

2.2.1 CEA Versus MHA

As mentioned previously, the figures quoted by according to statistics, available (Indiastat) only no. of incidents related to human fatalities are considered (Fig. 5), i.e., no information regarding fatalities has been provided. In contrast, as per the CEA's format (Format no. 19 of CEA's "Furnishing of Statistics, Returns and Information Regulations 2006") of statistics collection, mandates reporting no. of fatalities/injuries to note with no. of accidents marked in brackets; but, nowhere it is mentioned in this way. This raises confusion that existing data whether belongs to "no. of incidents/accidents" or "no. of resultant fatalities/injuries"; however, according to Indiastat, these numbers indicate number of accidents. A comparison of CEA and MHA accident figures is as shown in Fig. 7 and component wise comparison is presented in Table 1.

Apart from this comparison (Table 1), it is surprising to note that even with limited scope of monitoring, number of accidents quoted by CEA exceed that of MHA for years 2001 and 2002 (Fig. 7) and for rest of the years, they are less than that of MHA figures.

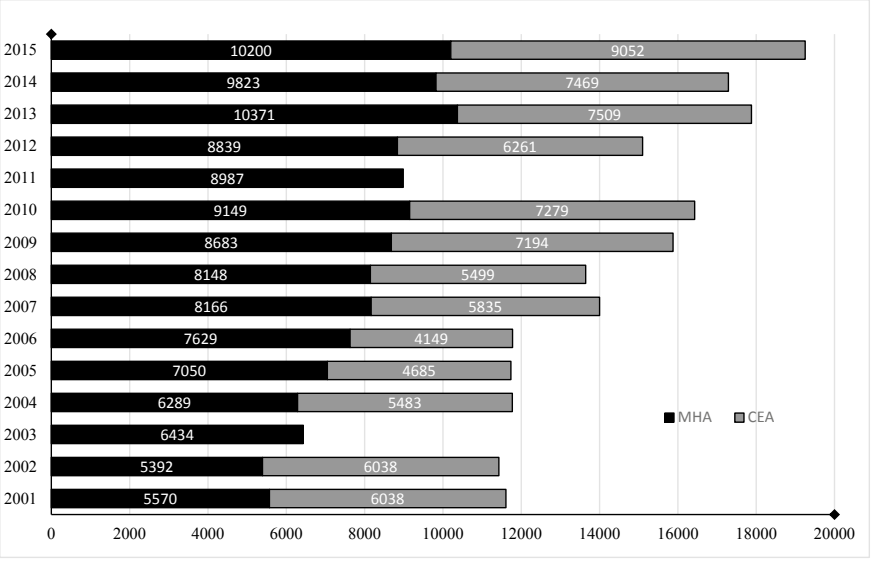

Fig. 7 Comparison of accident data from CEA and MHA

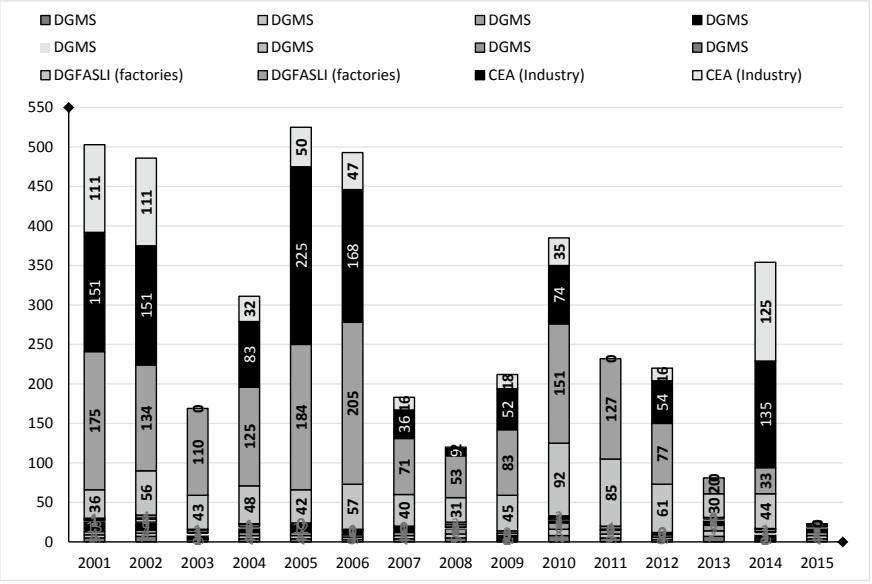

Fig. 8 DGFASLI and DGMS versus CEA industrial accidents

2.2.2 DGFASLI and DGMS Versus CEA

As mentioned earlier, CEA data accounts industrial accidents too; and these figures can be correlated with that of DGFASLI and DGMS. However, DGFASLI provided information only regarding number of injuries, whereas CEA portrayed number of accidents. Unlike DGFASLI, both fatality/injury along with incident/accident data is available. Detailed comparison of these stats is given (Table 2 and Fig. 8).

It is clear that number of accidents and injuries/fatalities are relatively low in mines compared to factories and DGMS data is more complete in nature than rest two, i.e., in DGFASLI data information about number of accidents due to electricity is missing and in CEA number of fatalities/injuries. However, as CEA has wider scope than rest two, it can be concluded that number of accidents in industries is significant and if sector-wise segregated data provided by CEA or if DGFASLI could segregated number of accidents by cause, comparison could be done more effectively and efficiently. In addition, it is worthwhile to note that the format of collection of accident stats (Central Electricity Authority 2007) of CEA mandates mentioning of fatalities/injuries in parenthesis along with accidents/incidents; however, the same is missing in CEA reports.

3 Summary

A review of electrical accidents in India for fifteen years duration (2001–2015) carried out by collecting analyzing and comparing accidents and/or injuries from official reports of various governmental bodies-MHA (NCRB), DGFASLI, DGMS and CEA. However, the format of data collection followed is different and thus in-depth comparison of these stats is necessary to know the actual accident scenario. The overall accident data of CEA is comparable with that of MHA; similarly, the correlation in industrial stats could only be possible all the stats have at least same basis; for instance, if injury data of CEA available, one can compare it with DGFASLI and conclusion can be drawn on actual scenario in industries. The no. of accidents and injuries in mines relatively lower than occurrences in factories. All these figures show the need of "electrical safety" in India.

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