



# Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2005–2015

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## Executive Summary

This report summarizes non-fire carbon monoxide (CO) incidents associated with engine-driven generators and other engine-driven tools that occurred between 2005 and 2015, and were reported to U.S. Consumer Product Safety Commission (“CPSC”) staff as of June 1, 2016. It should be noted that due to incident reporting delays, statistics for the most recent years should be considered incomplete because data collection is still ongoing. In this report, the two most recent years, 2014 and 2015, are identified as being incomplete because the numbers for these years most likely will increase in future reports. Throughout this report, the number of deaths represents a count of the fatalities associated with generators and other engine-driven tools that were reported to CPSC staff. The generators and other engine-driven tools were power lawn mowers, garden tractors, portable pumps, power sprayers and washers, snow blowers, and concrete saws. Additionally included in this report are summaries of fatal, non-fire CO incidents, where an engine-driven tool (“EDT”) and one or more other fuel-burning consumer products<sup>1</sup> also may have been involved, and the EDT was believed to be, at least, a contributing factor to the fatal levels of CO. These fatalities are characterized in the “Multiple Product” category. This report also provides a more detailed summary of fatal, non-fire CO-poisoning incidents associated with engine-driven tools, with particular emphasis on cases involving generator use, based on information found in the CPSC’s In-Depth Investigation (“INDP”) File.

Some of the findings of this report are provided below:

### **CO Fatalities Associated with All EDTs and by EDT Product Type:**

- As of June 1, 2016, for the 11-year period 2005 through 2015, 880 fatalities from 677 incidents were associated with the use of engine-driven tools, or engine-driven tools used in conjunction with another potentially CO-emitting consumer product.
- The total number of reported fatalities for the 11-year period 2005 through 2015 (as compared to the 11-year period 2004 to 2014), had a net increase of 16 fatalities from the 864 fatalities summarized in the June 2015 report, including
  - 59 deaths reported for 2015 have been added;
  - based on new information, 16 deaths were added for 2014, and three for 2013; and
  - the 62 deaths reported for 2004 were removed because the updated report now covers only the 11-year period from 2005 through 2015.
- There were 59 reported non-fire engine-driven tool-related CO fatalities in 2015, from a total of 36 incidents. Fifty-one of these deaths (28 incidents) involved only a portable generator and no other product; one death involved a gasoline-fueled power washer; one death involved a riding lawn mower; one death involved a welder; and one death involved a gasoline-fueled water pump. Additionally, four deaths (four incidents) were associated with a generator and some other fuel-burning consumer product.
- From 2005 to 2015, of the 880 fatalities from 677 incidents:

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<sup>1</sup> Combustion consumer products produce heat or energy by burning a fuel source. It should be noted that all fuel-burning consumer products may produce gases that contain CO because CO is a by-product of incomplete combustion.

- 719 fatalities (82%) from 528 incidents were associated with generators (including five fatalities from three incidents involving fixed location, permanently installed stationary generators);
- 105 fatalities (12%) from 103 incidents involved other engine-driven tools; and
- 56 fatalities (6%) from 46 incidents involved multiple fuel-burning consumer products, where one product was either a generator (54 of 56 deaths) or an Other Engine-Driven Tools (OEDT) (2 of 56 deaths), and the other product was a non-EDT.
- In 45 of the 46 incidents that involved multiple consumer products, the second product involved was either a heating or cooking product. Most commonly, the second product was a portable liquid propane (“LP”)- or kerosene-fueled portable heater. The one incident not associated with a heating or cooking product involved a gas-fueled lawn mower and a gas-fueled hedge trimmer.
- Twenty-five percent of the generator-related, non-fire CO incidents (143 of 572) caused multiple fatalities; while only two of the 105 OEDT-related incidents (2%) involved multiple fatalities.

#### **Socio-Demographic Characteristics of Victims and EDT-Use Patterns:**

- Eighty-two percent of generator-related victims were known to be 25 years old or older. In contrast, 99 percent of OEDT-related victims (all but one) were 25 years old or older.
- More than three-quarters (76%) of the generator-related, non-fire CO victims were male; while 96 percent (all but four) of the OEDT-related fatalities were male.
- Twenty-five percent of generator-related, non-fire CO fatalities were non-Hispanic Black or African American, nearly double the non-Hispanic Black or African American proportion (13%) of the U.S. population. Eighty-eight percent of other engine-driven tool-related, non-fire CO fatalities were non-Hispanic White, much higher than the non-Hispanic White proportion (65%) of the U.S. population.
- Nearly half of generator-related, non-fire CO fatalities (371 of 773) occurred in the four cold months of the year (November through February); while CO fatalities associated with OEDTs were more evenly distributed across the year with the cold months (38%) slightly higher than in the transition and warm months (34% and 28%, respectively).
- Seventy-five percent of the generator-related fatalities occurred in fixed-structure homes; while 71 percent of OEDT fatalities occurred in fixed-structure homes.
- Fifty-six percent of the EDT-related fatalities are known to have occurred in urban areas. Eighteen percent occurred in small rural and isolated areas, double the proportion of the U.S. population that lives in such areas.

#### **CO Alarm Usage:**

- A CO alarm was reportedly present in only 23 of 250 incidents where alarm presence was known; this accounted for 33 of 361 (9%) EDT-related CO fatalities. In eight of the incidents (15 deaths), the alarm was inoperable due to no batteries, batteries inserted incorrectly, probable drained batteries, or no electric current. The alarm sounded in eight incidents (nine deaths), but the signal was either misunderstood, the alarm was subsequently disarmed (batteries removed after alarming), or the alarm sounded inside the house, while

the fatality occurred inside an attached garage (presumably, the death occurred in the garage before CO levels increased inside the house sufficient to set off the CO alarm). Additionally, there were seven incidents (nine deaths) in which the presence of a CO alarm was noted, but it is unknown if the alarm sounded during the event.

### **Hazard Patterns Associated with Generators:**

- Twenty-seven percent of all generator-related, non-fire CO deaths (207 of 773) from 2005 through 2015 were associated with power outages, mostly due to weather-related issues. The two most common causes of weather-related outages leading to fatal incidents were ice/snow storms (75 incidents, 99 deaths) and hurricanes/tropical storms (37 incidents, 53 deaths). The second most common reason for generator usage in the reported CO fatalities was due to power shut-off, accounting for 21 percent (165 deaths from 117 incidents) of the all reported fatalities. This latter scenario included an incident where a father and seven children died in 2015.
- Five hundred seventy-eight non-fire CO fatalities (423 incidents) that occurred in fixed-structure homes were associated with a generator, or a generator in use with another potential CO-generating consumer product. Seventy percent (405 deaths, 289 incidents) of those occurred when the generator was placed inside the living area of the home, including the basement, closets, and doorways, but excluding the attached garage, enclosed carport, or attached barn.
- The second most common location of generators associated with fatal CO poisoning incidents at a fixed-structure home was in an attached structure to the house like an attached garage, enclosed carport, or attached barn where 106 incidents involving 138 deaths were reported. Two-thirds of generator-related, non-fire fatal CO incidents (66%) in fixed-structure homes (for which information on ventilation of the generator was available) occurred when no apparent ventilation of the generator was attempted.
- Sixty-four percent of the generator-related, non-fire fatal CO incidents in fixed-structure homes, where the size of the home was known, and the generator was not located in an external structure, occurred in houses less than 1,500 square feet in size; 86 percent occurred in houses less than 2,000 square feet in size.

### **Carboxyhemoglobin Levels in CO Fatality Victims:**

- Of the CO fatality victims associated with engine-driven tools, 80 percent had carboxyhemoglobin (COHb) levels at or above the 50 percent level when the COHb level was known.<sup>2</sup>

*Note: Throughout this report, the years 2014 and 2015 are italicized in table headings, indicating that incident and death counts may change as additional information is received due to reporting delays. Incident and death counts may change for other years, but to a much smaller extent.*

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<sup>2</sup> As levels rise above 40 percent COHb, death is possible in healthy individuals and becomes increasingly likely with prolonged exposures that maintain levels in the 40 percent to 60 percent range.

## Introduction

The following U.S. Consumer Product Safety Commission (“CPSC”) databases were searched to prepare the statistics recorded in this report: the In-Depth Investigation (“INDP”) File, the Injury or Potential Injury Incident (“IPII”) File, and the Death Certificate (“DTHS”) File. See Appendix A for the codes and keywords used in the database searches. The data records were combined and collated to develop the most complete records possible in a single database. At this stage, each record was reviewed to determine whether the incident was in scope for this report and to correct any discrepancies between information from the different sources (See Appendix A for the specifics of scope determination). It should be noted that reporting may not be complete, and this report reflects only incidents reported and entered into CPSC databases on or before June 1, 2016. All fatal, unintentional, non-fire carbon monoxide (CO) incidents associated with engine-driven tools (“EDTs”) found during the database search that were determined to be in scope were included.

CPSC records contain information on 880 non-fire CO fatalities associated with EDTs during the years 2005 through 2015. Last year’s report, dated June 2015, contained summary information and analyses for the 11-year period, 2004–2014. This updated report adds information on 78 CO fatalities associated with engine-driven tools, reported to CPSC since the last report. Additionally, the 62 fatalities reported in last year’s report, occurring in 2004, have been dropped in the update.

Changes to previous report:

- 2004 – 50 incidents, accounting for 62 deaths removed as now out of time range.
- 2013 – Three incidents added, accounting for three deaths.
- 2014 – Fifteen incidents added, accounting for 16 deaths.
- 2015 – Thirty-six incidents added, accounting for 59 deaths.

Incidents associated with generators that were specifically reported as integral parts of recreational vehicles (“RVs”), motor homes, or boats are not within the jurisdiction of the CPSC. Thus, these incidents were considered out of scope and were not included. For example, generators that were reportedly mounted to an RV were not included; nor were boat generators that were installed by the boat manufacturer. Because incidents in recreational vehicles and boats can be associated with a portable generator or an integral generator, those incidents in which the type of generator could not be determined were also excluded from the analysis. Any incident that was determined to be other than unintentional in nature was considered to be out of scope, as were work-related incidents, which are not within the jurisdiction of the CPSC.

This report is divided into four sections:

- I. Reported Numbers of Fatalities by EDT Product Type. This presents an overall picture of CO fatalities associated with engine-driven tools.
- II. Socio-Demographics of Victims and EDT Use Patterns. This presents various socio-demographic summaries focused on identifying specific characteristics of CO fatality victims and usage patterns, such as when and where fatalities occurred.
- III. Alarm Usage. This presents information on CO alarm usage during fatal CO events.

- IV. Hazard Patterns Associated with Generators. This presents data specific to generator usage patterns that may lead to fatal CO poisoning events.

Additionally, Appendix B presents summary findings on carboxyhemoglobin (COHb) levels in the blood of victims of CO poisoning involving EDT use, which are helpful in assessing the hazard presented by the product and the speed of onset of harm.

## **I. Reported Numbers of Fatalities by Engine-Driven Tool (EDT) Product Type**

As of June 1, 2016, CPSC staff had records indicating that there were 36 fatal, non-fire CO exposure incidents involving EDTs between January 1, 2015 and December 31, 2015. Fifty-nine deaths occurred in these 36 fatal CO incidents. Table 1 presents the reported fatal incidents and the number of deaths in 2015, along with a summary of CO incidents and fatalities associated with engine-driven tools for the 11-year period from 2005 through 2015. The table records the number of incidents and deaths by the broad categories of “Generators,” OEDTs and “Multiple Products.” Multiple product incidents are fatal CO poisonings that involved multiple fuel-burning consumer products that generate CO, at least one being an EDT, or in which investigating authorities could not determine which of multiple consumer products in use at the time of the incident was the source of the CO. CPSC staff is aware of 56 fatalities associated with multiple consumer products, occurring between 2004 and 2015; four of these fatalities occurred in 2015. Multiple product incidents, where one of the sources of CO is not under the CPSC’s jurisdiction, such as automobiles, boats, or recreational vehicles, were determined to be out of scope and are not included in this report. Thus, this report may underestimate the incidents of CO fatalities. Following Table 1, Multiple Product incidents will be included in the summary for the involved engine-driven tool type, either “Generators” or OEDTs.

Within each broad category, the frequency of reports is summarized by product type. Staff is aware of 677 incidents with a total of 880 deaths due to non-fire CO exposure that occurred between 2005 and 2015, involving EDTs.

In Table 1, the product type “welder” appears in both the “Generator” and OEDT categories. Some welding equipment is designed to be used as a welder or as an electric generator. Three of the fatal, non-fire CO incidents associated with the use of welding equipment that occurred between 2005 and 2015, involved the use of the welder as a generator during a power outage. Each of these three incidents involved a single death. There were four fatal, non-fire CO incidents between 2005 and 2015, which were associated with the use of welding equipment, where it was not specifically identified as being used as a generator. Of these four incidents, one incident involved two deaths.

All but one of the 46 non-fire CO fatalities in the “Multiple Products” category for 2005–2015 involved a heating- or cooking-related consumer product other than an EDT. The one incident not involving a heating- or cooking-related consumer product involved a gasoline-fueled, walk-behind mower, and a gasoline-fueled trimmer, also running in a closed garage.

**Table 1: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools, 2005–2015**

Product	2014		2015		Total: 2005–2015	
	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths	Number of Incidents	Number of Deaths
<b>Total Engine-Driven Tools</b>	<b>41</b>	<b>51</b>	<b>36</b>	<b>59</b>	<b>677</b>	<b>880</b>
<b>Generators</b>	<b>31</b>	<b>40</b>	<b>28</b>	<b>51</b>	<b>528</b>	<b>719</b>
Generator, portable	30	39	28	51	522	711
Generator, fixed	0	0	0	0	3	5
Welder (used as a generator) <sup>1</sup>	1	1	1	1	3	3
<b>Other Engine-Driven Tools (OEDT)</b>	<b>7</b>	<b>7</b>	<b>4</b>	<b>4</b>	<b>103</b>	<b>105</b>
Lawn mowers	2	2	1	1	52	52
Riding lawn mower/Garden tractor	0	0	1	1	44	44
Push lawn mower	0	0	0	0	1	1
Powered lawn mower, unspecified type	2	2	0	0	7	7
Power washer/sprayer	2	2	1	1	12	12
Snow blower	1	1	0	0	12	12
All-terrain vehicle	1	1	0	0	7	8
Welder (used as welder or other reason) <sup>1</sup>	0	0	1	1	4	5
Water pump	0	0	1	1	5	5
Wood Splitter	1	1	0	0	2	2
Concrete saw	0	0	0	0	1	1
Air compressor	0	0	0	0	1	1
Paint sprayer	0	0	0	0	1	1
Snowmobile	0	0	0	0	1	1
Go-cart	0	0	0	0	1	1
Tiller	0	0	0	0	1	1
Edger	0	0	0	0	1	1
Stump Grinder	0	0	0	0	1	1
Small Engine	0	0	0	0	1	1
<b>Multiple Products<sup>2</sup></b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>46</b>	<b>56</b>
Generator + Other Consumer Product	3	4	4	4	44	54
OEDT + Other Consumer Product <sup>3</sup>	0	0	0	0	2	2

1 Some welding equipment is designed to be used as either a welder or a generator.

2 “Multiple Products” includes incidents involving generators or OEDTs with other combustion fuel-burning consumer products. “Other Consumer Products” includes one or more of the following: portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

3 The two incidents associated with an OEDT and another consumer product includes the following engine-driven tools: one incident involved two gasoline-fueled lawn mowers and an LP heater, and the other incident involving a gasoline-fueled lawn mower and a gasoline-fueled trimmer.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

Five hundred and twenty-eight of the 677 incidents (78%) reported to CPSC staff during the 2005–2015 period were associated with a generator and accounted for 719 of the 880 CO deaths (82%). Additionally, 54 other CO fatalities from 44 incidents were associated with the use of a generator and another combustion consumer product—most commonly an LP- or kerosene-fueled heater. Throughout the remainder of this report, incidents associated with all non-generator engine-driven tools are reported as a group. In addition, because the majority of incidents were associated with generators, characteristics of these incidents are reported separately in Section IV. More than half of the non-fire, non-generator engine-drive tool-related CO incidents (54 of 105, 51%) involved a garden tractor or other powered lawn mower (including both of the multiple product incidents). Deaths associated with powered lawn mowers were often associated with an individual repairing or working on the product in an enclosed space.

CPSC staff examined the number of deaths associated with each fatal incident (Table 2). Of the 677 fatal incidents, 79 percent involved a single fatality. Seventy-five percent (429 of 572) of the fatal generator-related incidents involved a single fatality. One incident in 2015, which involved a generator, resulted in the deaths of eight people (a single father and his seven children); and another incident in 2005, resulted in six fatalities. Of the 105 fatal incidents in the OEDTs category, only two incidents resulted in more than one fatality.

**Table 2: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Number of Deaths per Incident, 2005–2015**

Number of Deaths Reported in Incident <sup>1</sup>	All Engine-Driven Tools (EDTs)		Generator		Other Engine-Driven Tools (OEDTs)	
	Count	Percentage	Count	Percentage	Count	Percentage
<b>All Incidents</b>	<b>677</b>	<b>100%</b>	<b>572</b>	<b>100%</b>	<b>105</b>	<b>100%</b>
1	532	79%	429	75%	103	98%
2	109	16%	107	19%	2	2%
3	21	3%	21	4%	0	0%
4	11	2%	11	2%	0	0%
5	2	< 1%	2	< 1%	0	0%
6	1	< 1%	1	< 1%	0	0%
7	0	0%	0	0%	0	0%
8	1	< 1%	1	< 1%	0	0%

SPECIAL NOTE ABOUT COUNTS IN THIS TABLE ONLY: One incident included in this table involved an in-scope, generator-related death and an out-of-scope death (work related). Because two fatalities were involved in the incident, this incident is included as a two-fatality incident. The out-of-scope fatality is not included elsewhere in the report. Therefore, in this table only, there is one additional fatality reported. The in-scope fatality was a generator-related fatality, so it is included in the “Generator” and “Total” columns.

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

CPSC staff summarized the number of reported deaths associated with EDTs by year of death (Table 3). It should be noted that the values in Table 3 represent the number of deaths reported to CPSC staff as of June 1, 2016. Some deaths are reported to CPSC staff shortly after an incident

occurs, while other deaths are reported to CPSC staff months, or even years, after an incident occurs. Therefore, counts for more recent years may not be as complete as counts for earlier years and may change in the future. Twenty-four percent (19 of 78) of the reported fatalities new to the report were for years before 2015.

The average number of non-fire CO fatalities associated with both generators and OEDTs for years 2011 through 2013, is also presented in Table 3. These 3 years represent the most recent years for which CPSC staff believes reporting are substantially complete. Due to reporting delays, these averages may change slightly in the future, when data are complete. Figure 1 in Appendix D illustrates the historical trend in EDT-related, non-fire CO fatalities since 1999.

**Table 3: Number of Reported Fatal Non-Fire Carbon Monoxide Exposure Incidents and Deaths Associated with Engine-Driven Tools by Year, 2005–2015**

Year	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
<i>Total</i>	<i>677</i>	<i>880</i>	<i>572</i>	<i>773</i>	<i>105</i>	<i>107</i>
2005	93	116	80	103	13	13
2006	79	109	63	93	16	16
2007	68	83	57	72	11	11
2008	77	102	70	95	7	7
2009	55	76	45	66	10	10
2010	47	58	37	46	10	12
2011	81	108	69	96	12	12
2012	47	53	42	48	5	5
2013	53	65	43	55	10	10
<i>2014</i>	<i>41</i>	<i>51</i>	<i>34</i>	<i>44</i>	<i>7</i>	<i>7</i>
<i>2015</i>	<i>36</i>	<i>59</i>	<i>32</i>	<i>55</i>	<i>4</i>	<i>4</i>
<b>Average: 2011–2013</b>	<b>60</b>	<b>75</b>	<b>51</b>	<b>66</b>	<b>9</b>	<b>9</b>

Notes: Detail averages may not sum to total average due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

## II. Socio-Demographic Characteristics of Victims and EDT Use Patterns

This section presents socio-demographic information about the victims of reported fatal CO incidents associated with EDTs. Tables 4, 5, and 6 present summaries of socio-demographic characteristics of the victims. Table 4 presents the distribution of ages of the victims. Victims age 25 years or older accounted for about 84 percent (736 of 872 where the age was known) of reported non-fire, CO poisoning deaths associated with all EDTs. By comparison, according to the 2010 Census, 66 percent of the U.S. population is over 25 years old. Victims with a reported age of 25 years or older accounted for about 82 percent (630 of the 765 victims where the age was known) of non-fire CO poisoning deaths associated with generators and accounted for all but one of the deaths (106 of 107) associated with other EDTs. Eighty-seven percent of the non-fire CO fatalities associated with non-generator, EDTs (93 of 107) involved victims age 45 or older.

It appears from the data summary that EDT-related CO fatalities have been occurring to older consumers at a higher rate. Fifty-six percent of the CO fatalities (where the age was known) were over the age of 44, while only 39 percent of the U.S. population was above 44 years of age during this time period. By contrast, only 16 percent of EDT-related victims (of known age) were below the age of 25, while 34 percent of the U.S. population was below 25 years of age during this time period.

**Table 4: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Age of Victim, 2005–2015**

Age	2010 Estimated U.S. Resident Population <sup>1</sup>	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTS)	
		Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
<b>Total</b>	<b>100%</b>	<b>880</b>	<b>100%</b>	<b>773</b>	<b>100%</b>	<b>107</b>	<b>100%</b>
Under 5	7%	9	1%	9	1%	0	0%
5–14	13%	38	4%	38	5%	0	0%
15–24	14%	89	10%	88	11%	1	1%
25–44	27%	248	28%	235	30%	13	12%
45–64	26%	337	38%	286	37%	51	48%
65 and over	13%	151	17%	109	14%	42	39%
Adult, age unknown	-	8	1%	8	1%	0	0%

This percentage represents the 2010 Census-estimated percentage of the U.S. population, the approximate mid-point of the 10-year range. Note: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

U. S. Census Department, Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2015

Table 5 presents the distribution of the gender of the victims. Male victims accounted for 78 percent of the deaths associated with all EDTs. Male victims comprised 76 percent of the deaths associated with generators and 96 percent of non-generator, EDT fatalities.

**Table 5: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Gender of Victim, 2005–2015**

Gender	All Engine-Driven Tools (EDTs)		Generators		All Other Engine-Driven Tools (OEDTs)	
	Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
<b>Total</b>	<b>880</b>	<b>100%</b>	<b>773</b>	<b>100%</b>	<b>107</b>	<b>100%</b>
Male	688	78%	585	76%	103	96%
Female	190	22%	186	24%	4	4%
Unknown	2	< 1%	2	< 1%	0	0%

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

Table 6 presents a summary of the race/ethnicity of the reported CO fatalities associated with EDTs. –The percentage of generator-related CO fatalities identified as “Black/African American” (25% of deaths) was nearly double the proportion classified by the U.S. Census Bureau as “Black/African Americans” in the U.S. population (an estimated 13%). The percentage of the non-generator, EDT-related CO fatalities identified as non-Hispanic “White” (88% of deaths) was much higher than the proportion classified as non-Hispanic “White” by of the U.S. Census Bureau (an estimated 64% of the U.S. population).

**Table 6: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Race/Ethnicity of Victim, 2005–2015**

Race / Ethnicity	2010 Estimated U.S. Resident Population <sup>1</sup>	All Engine-Driven Tools (EDTs)		Generators		All Other Engine-Driven Tools (OEDTs)	
		Deaths	Percentage	Deaths	Percentage	Deaths	Percentage
<b>Total</b>		<b>880</b>	<b>100%</b>	<b>773</b>	<b>100%</b>	<b>107</b>	<b>100%</b>
White	64%	540	61%	446	58%	94	88%
Black/African American	13%	198	23%	196	25%	2	2%
Hispanic (any race)	16%	80	9%	78	10%	2	2%
Asian	5%	14	2%	13	2%	1	1%
Native American	1%	6	1%	6	1%	0	0%
Other / Unknown	< 1%	42	5%	34	4%	8	7%

1 This represents the 2010 Census estimated percentage of the U.S. population, the approximate mid-point of the 10-year range. All categories, with the exception of “Hispanic (any race),” are non-Hispanic averages. Percentages represent single-race figures because multirace percentages are seldom available from available information. Two percent of the U. S. population identifies themselves as multiracial.

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Sources: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

U. S. Census Department, Annual Estimates of the Resident Population by Sex, Age, Race, and Hispanic Origin for the United States and States: April 1, 2010 to July 1, 2015

Staff examined reported deaths associated with EDTs by the time of year that the incident occurred (Table 7). The non-fire CO fatalities were classified into one of three categories, depending on the month in which the incident occurred: Cold months, Warm months, and Transitional months. “Cold months” are November, December, January, and February; “Warm months” are May, June, July, and August; and “Transitional months” are March, April, September, and October.

Nearly half (48%) of the non-fire CO deaths associated with generators occurred in the cold months of November through February. Many of the fatalities can be directly associated with the use of generators during power outages due to weather conditions, such as ice or snow storms. Thirty-one percent of the generator-related CO deaths occurred in the transitional months of March, April, September, and October. A large portion of the non-fire CO fatalities in the transitional months can be directly associated with the use of generators during power outages, due to hurricanes and tropical storms, many of which occurred in September, and to a lesser extent, October. Additional details on this issue are presented in Section IV of this report.

OEDT-related CO fatalities occur relatively evenly across the year. Thirty-eight percent of the fatalities occurred in the cold months, 34 percent in the transitional months, and 28 percent in the warm months.

**Table 7: Number of Reported Non-Fire Carbon Monoxide Incidents and Fatalities Associated with Engine-Driven Tools by Season, 2005–2015**

Season Incident Occurred		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
<b>Total</b>	<b>Incidents</b>	<b>677</b>	<b>100%</b>	<b>572</b>	<b>100%</b>	<b>105</b>	<b>100%</b>
	<b>Deaths</b>	<b>880</b>	<b>100%</b>	<b>773</b>	<b>100%</b>	<b>107</b>	<b>100%</b>
Cold months	Incidents	327	48%	287	50%	40	38%
	Deaths	412	47%	371	48%	41	38%
Transitional months	Incidents	198	29%	163	28%	35	33%
	Deaths	274	31%	238	31%	36	34%
Warm months	Incidents	152	22%	122	21%	30	29%
	Deaths	194	22%	164	21%	30	28%

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

Incidents involving deaths are further summarized in Table 8 by the location where the death occurred. The majority of non-fire, CO poisoning deaths (757 of 880, or 86%) reported to CPSC staff associated with EDTs occurred at home locations. Seventy-four percent of the deaths occurred at fixed-structures used as a residence, which include houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Another 8 percent occurred in external or detached structures at home locations, such as detached garages or sheds. A large portion of these external structure fatalities were related to OEDTs, such as lawnmowers running in sheds or detached garages. Twenty-seven percent (20 of 74) of fatalities occurring in external structures at the home involved OEDTs.

Three percent of deaths associated with engine-driven tools occurred in nontraditional homes, such as travel trailers, houseboats, or storage sheds used as permanent residences. The “Temporary shelter” category includes incidents in which victims died from CO poisoning from portable generators or other EDTs, while the victims were temporarily occupying trailers, horse trailers, RVs, cabins (used as a temporary shelter), tents, and campers. Incidents that occurred in a temporary shelter, where the generator was an integral part of the temporary shelter, such as built-in generators or generators built specifically for use in an RV, are not within the CPSC’s jurisdiction; thus, these are out of scope for this report and were excluded from the analyses. The “Boat/Vehicle” category only includes incidents in which a generator or other engine-driven tool was not an integral part of the boat—but was brought onto the boat—and includes incidents where an EDT was brought into a vehicle, such as a van. As with temporary shelters, incidents involving generators that were built-in or specifically designed for a boat, are not within the CPSC’s jurisdiction and are not included in this report. The “Other” category includes incidents that occurred in office buildings, utility buildings, and storage sheds (offsite from home).

**Table 8: Number of Reported Non-Fire Carbon Monoxide Incidents and Fatalities Associated with Engine-Driven Tools by Location, 2005–2015**

Location		All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
<b>Total</b>	<b>Incidents</b>	<b>677</b>	<b>100%</b>	<b>572</b>	<b>100%</b>	<b>105</b>	<b>100%</b>
	<b>Deaths</b>	<b>880</b>	<b>100%</b>	<b>773</b>	<b>100%</b>	<b>107</b>	<b>100%</b>
Home, fixed Structure <sup>1</sup>	Incidents	498	74%	423	74%	75	71%
	Deaths	654	74%	578	75%	76	71%
Home, detached Structure <sup>2</sup>	Incidents	72	11%	52	9%	20	19%
	Deaths	74	8%	54	7%	20	19%
Home, non-house <sup>3</sup>	Incidents	22	3%	18	3%	4	4%
	Deaths	29	3%	25	3%	4	4%
Temporary shelter	Incidents	48	7%	48	8%	0	0%
	Deaths	76	9%	76	10%	0	0%
Boat/Vehicle	Incidents	22	3%	21	4%	1	1%
	Deaths	28	3%	26	3%	2	2%
Other	Incidents	13	2%	9	2%	4	4%
	Deaths	15	2%	11	1%	4	4%
Not reported	Incidents	2	< 1%	1	< 1%	1	1%
	Deaths	4	< 1%	3	< 1%	1	1%

1 This refers to a fixed-structure used as a residence, including: houses, mobile homes, apartments, townhouses, and structures attached to the house, such as attached garages.

2 This refers to detached structures at home locations, including detached garages and sheds.

3 This refers to non-fixed location residences, including travel trailers and houseboats.

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

Table 9 presents the number of non-fire, CO poisoning deaths reported to CPSC staff and associated with EDTs, categorized by the population density of the place of death. All fatal incidents were assigned to one of four rural/urban categories, based on the Rural-Urban Commuting Area (“RUCA”) codes developed by the Economic Research Service (“ERS”) of the U.S. Department of Agriculture (“USDA”). The four categories are “Urban Core,” “Sub-Urban,” “Large Rural,” and “Small Rural/Isolated.” Details on the process of determining population density or rurality can be found at the USDA website at: <http://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx>. Additional information regarding the cross-referencing of zip codes to RUCA codes can be obtained from the University of Washington, WWAMI<sup>3</sup> Rural Health Research Center website at: <http://depts.washington.edu/uwruca/>.

<sup>3</sup> The WWAMI name is derived from the first letter of each of the five cooperating states in a partnership between the University of Washington School of Medicine and the states of Wyoming, Alaska, Montana, and Idaho.

Fifty-six percent (497 of 880) of CO fatalities associated with the use of EDTs reported to CPSC staff occurred in urban areas, while the estimated proportion of the U.S. population living in urban core areas is 71 percent. Forty-four percent (383 of 880) of CO fatalities occurred in non-urban core areas (sub-urban, large rural, and small rural/isolated areas), where an estimated 29 percent of the U.S. population lives. There appears to be an unusually high proportion of fatalities in small rural/isolated areas. Eighteen percent (156 of 880) of the CO fatalities known to CPSC staff to be associated with EDTs occurred in small rural and isolated areas, where only an estimated 9 percent of the U.S. population lives.

**Table 9: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools by Population Density of Place of Death, 2005–2015**

Population Density		Estimated Percentage of U.S. Population <sup>1</sup>	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
Total	Incident	100%	<b>677</b>	<b>100%</b>	<b>572</b>	<b>100%</b>	<b>105</b>	<b>100%</b>
	Deaths		<b>880</b>	<b>100%</b>	<b>773</b>	<b>100%</b>	<b>107</b>	<b>100%</b>
Urban Core	Incident	71%	380	56%	328	57%	52	50%
	Deaths		497	56%	444	57%	53	50%
Sub-Urban	Incident	10%	86	13%	69	12%	17	16%
	Deaths		109	12%	92	12%	17	16%
Large Rural	Incident	10%	99	15%	77	13%	22	21%
	Deaths		118	13%	95	12%	23	21%
Small Rural /Isolated	Incident	9%	112	17%	98	17%	14	13%
	Deaths		156	18%	142	18%	14	13%

<sup>1</sup> Percentages are determined from the estimated 2010 U.S. population categorized by RUCA designation. U.S. population estimates by RUCA classification were determined by cross-referencing the WWAMI RUCA zip code table with the 2010 U.S. Census population estimates by zip code area, the most current census data available by zip code area. The year 2010 is the approximate mid-point year of the 10-year range.

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

WWAMI Rural Research Center at the University of Washington Economic Research Group, USDA.

U.S. Census Bureau, 2011.

### III. Alarm Usage

Table 10 presents a summary of known CO fatalities characterized by CO alarm usage and alarm status. In 63 percent of the fatal incidents (427 of 677), and 59 percent of reported CO poisoning deaths (519 of 880), the presence of a CO alarm at the location of the incident was unknown or unreported. Of the 250 fatal incidents (361 CO fatalities) associated with EDTs in which it was known whether a CO alarm was present, a CO alarm was present in only 23 incidents (9%) involving 33 CO fatalities. Of these 23 fatal incidents, the alarm was known to be inoperable in eight incidents (15 fatalities) due to missing, improperly installed, or possibly drained batteries in a battery-powered alarm (non-plug-in type), or because the alarm was a plug-in type and power was out at the location of the incident. All eight fatal incidents (15 fatalities) with inoperable alarms were associated with generator usage.

For the remaining 15 fatal incidents (18 fatalities) where an alarm was known to be present, the alarm was known to have sounded in only eight incidents (nine deaths):

- In one incident, the victim's family reportedly did not understand that the alarm-sounding pattern (sounding every few minutes) was indicating CO present in the home; they thought the alarm sounding simply meant that the alarm was working.
- In one fatal incident, the victims thought the "beeping" meant that the batteries were low, so they replaced the batteries. The batteries were inserted incorrectly, thus disabling the alarm. One family member died and two survived.
- In one incident, the alarm sounded, and the victim removed the batteries, thus disabling it. The victim was transported to the hospital but was pronounced dead.
- In three incidents, a CO alarm was heard sounding inside the house when the victim was discovered. In these cases, the victims were found inside an attached garage, apparently working on or using an engine-driven tool (a lawn tractor in one case, and a snow blower in the other), which presumably had been running.
- In one incident, the victim was working on a power washer inside a building equipped with a CO alarm system. The victim was found deceased with the alarm sounding.
- In another incident, two victims were found in a home in which a CO alarm was sounding. It is unclear if the alarm triggered after the victims became incapacitated by CO poisoning, or if the victims simply misunderstood or ignored the signal.

There were also nine deaths from seven incidents in which a CO alarm was present in the house, but it was unknown whether the alarm sounded or if the alarm was operable.

**Table 10: Carbon Monoxide Alarm Usage Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 2005–2015**

CO Alarm Status	Number of Deaths and Percentage of Deaths when Alarm Status was Known								
	All Engine-Driven Tools (EDTs)			Generators			Other Engine-Driven Tools (OEDTs)		
	Incidents	Deaths	% of Deaths	Incidents	Deaths	% of Deaths	Incidents	Deaths	% of Deaths
<b>Total</b>	<b>677</b>	<b>880</b>	<b>-</b>	<b>572</b>	<b>773</b>	<b>-</b>	<b>105</b>	<b>107</b>	<b>-</b>
<b>Alarm Status Known</b>	<b>250</b>	<b>361</b>	<b>100%</b>	<b>221</b>	<b>330</b>	<b>100%</b>	<b>29</b>	<b>31</b>	<b>100%</b>
<b>No Alarm</b>	<b>227</b>	<b>328</b>	<b>91%</b>	<b>203</b>	<b>302</b>	<b>92%</b>	<b>24</b>	<b>26</b>	<b>84%</b>
<b>Alarm Present</b>	<b>23</b>	<b>33</b>	<b>9%</b>	<b>18</b>	<b>28</b>	<b>8%</b>	<b>5</b>	<b>5</b>	<b>16%</b>
Alarmed	8	9	2%	5	6	2%	3	3	10%
Did not alarm, batteries removed, incorrectly inserted, or drained	5	10	3%	5	10	3%	0	0	0%
Did not alarm, plug-in type, no power	3	5	1%	3	5	2%	0	0	0%
Alarm present, Unknown if it alarmed	7	9	2%	5	7	2%	2	2	6%
<b>Alarm Status Unknown</b>	<b>427</b>	<b>519</b>	<b>-</b>	<b>351</b>	<b>443</b>	<b>-</b>	<b>76</b>	<b>76</b>	<b>-</b>

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

## **IV. Hazard Patterns Associated with Generators**

This section presents information about the usage patterns associated with fatal CO poisoning specific to generators, as well as information about the homes where fatal generator incidents occurred. As of June 1, 2016, CPSC staff is aware of 572 generator-related incidents from 2005 through 2015, which resulted in non-fire CO fatalities. Staff completed, or otherwise resolved, IDIs for 541 of 572 (95%) fatal CO incidents associated with generators that occurred from 2005 through 2015. For the remaining 31 incidents in which an IDI was not performed or was not completed by the cut-off date of June 1, 2016, attempts were made to augment the data from reports of the incident in IPII records or from death certificate information. Summaries of generator-related incidents in this section also include incidents where multiple fuel-burning consumer products were involved, including a generator.

A review of records for the 572 incidents resulting in 773 generator-related, non-fire CO deaths reported to CPSC staff suggests two primary reasons reported for using a generator. One reason cited was to provide electricity to a location that did not have electricity due to a temporary situation (*e.g.*, a power outage), and the other was to provide power after a shutoff to the residence by the utility company, due to bill dispute or nonpayment. Table 11 provides a breakdown by year, listing the reasons why a generator was in use at the time of the incident. Twenty-six percent of the incidents (27 percent of the reported deaths) involving generator-related, non-fire CO fatalities were associated with the use of generators during a temporary power outage stemming from a weather problem or a problem with power distribution. Twenty percent of the fatal incidents (21 percent of deaths) were associated with the use of generators after a power shutoff by the utility company for nonpayment of a bill, a bill dispute, or other reason. For 20 percent of the fatal incidents (18 percent of deaths), it could not be determined why the generator was in use, or why there was no electricity at the location of the incident.

Most of the generators that were associated with fatal CO poisoning were gasoline-fueled. In 54 of the 572 incidents, the fuel type could not be ascertained. Of the 518 cases where the fuel type used in the generator was known, 99 percent (514 of 518) were gasoline-fueled. Of the remaining incidents, three involved propane-fueled generators, and the other incident involved a diesel-fueled generator.

**Table 11: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents Associated with Generators<sup>1</sup> by Reason for Use, 2005–2015**

Reason for Use		Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	Incidents	572	80	63	58	70	45	36	69	42	43	34	32
	Deaths	773	103	93	73	95	66	45	96	48	55	44	55
Power outage due to weather, or problem with power distribution	Incidents	150	37	11	15	19	10	5	19	15	11	5	3
	Deaths	207	53	17	23	26	17	6	27	16	12	5	5
Electricity turned off by power company due to bill dispute, nonpayment, or other reason	Incidents	117	11	17	13	13	6	12	17	5	9	7	7
	Deaths	165	12	23	16	19	9	16	25	6	11	10	18
Provide power to storage shed, trailer, boat, camper, cabin, campsite	Incidents	69	8	13	8	5	8	2	8	5	5	2	5
	Deaths	97	11	19	9	7	11	5	13	6	5	3	8
New home or homeowner, and power not yet turned on, home under construction or renovation	Incidents	53	4	6	5	7	5	5	5	3	6	5	2
	Deaths	79	6	9	5	13	6	5	10	4	11	5	5
Provide power to home or mobile home that normally does not have electricity	Incidents	42	6	3	4	4	3	3	4	4	2	5	4
	Deaths	57	6	5	5	5	7	3	4	6	2	8	6
Working on or preparing a home for predicted storm	Incidents	6	0	1	0	4	0	0	0	0	0	0	1
	Deaths	6	0	1	0	4	0	0	0	0	0	0	1
Provide power to a shed or garage that normally does not have electricity	Incidents	6	0	0	0	2	0	1	2	1	0	0	0
	Deaths	6	0	0	0	2	0	1	2	1	0	0	0
Other (previous fire in house, power shut off by owners, servicing power supply, or other usage)	Incidents	15	1	1	0	3	2	1	1	1	1	1	3
	Deaths	17	1	1	0	3	2	1	2	1	2	1	3
Unknown why electricity off	Incidents	114	13	11	12	13	11	8	13	8	9	9	7
	Deaths	139	14	18	14	16	14	9	13	8	12	12	9

<sup>1</sup> Number of deaths associated with generators includes incidents where other consumer products may also have been involved.

Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

For the 150 fatal incidents associated with a power outage due to weather or a problem with power distribution, Table 12 provides a further breakdown by year and cause of the power outage. Ninety-four percent of the fatal incidents associated with power outages were known to be due to specific weather conditions. Ice or snow storms are associated with the largest percentage of weather-related CO fatal incidents accounting for half (50%) of the power outage-related incidents. Hurricanes and tropical storms are also associated with 25 percent of CO fatal incidents over the 11-year period from 2005 to 2015. Fifty-eight percent (31 of 53) of the generator-related CO fatalities that were hurricane- or tropical storm-related (20 of 37 fatal incidents) occurred in 2005.

**Table 12: Number of Reported Non-Fire Carbon Monoxide Fatalities for Incidents Associated with Generators<sup>1</sup> by Reason for Power Outage, 2005–2015**

Reason for Power Outage		Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	Incidents	150	37	11	15	19	10	5	19	15	11	5	3
	Deaths	207	53	17	23	26	17	6	27	16	12	5	5
Ice or snow storm	Incidents	75	15	6	9	7	9	3	10	5	8	<i>1</i>	2
	Deaths	99	20	8	13	9	14	4	14	5	8	<i>1</i>	3
Hurricane or tropical storm	Incidents	37	20	1	0	6	0	0	3	7	0	<i>0</i>	<i>0</i>
	Deaths	53	31	1	0	8	0	0	5	8	0	<i>0</i>	<i>0</i>
Wind storm	Incidents	8	0	2	1	1	0	0	1	1	0	<i>1</i>	<i>1</i>
	Deaths	13	0	6	1	1	0	0	1	1	0	<i>1</i>	2
Thunderstorm or rainstorm	Incidents	10	1	2	1	1	0	2	2	0	0	<i>1</i>	<i>0</i>
	Deaths	12	1	2	1	2	0	2	3	0	0	<i>1</i>	<i>0</i>
Tornado	Incidents	3	0	0	0	2	0	0	1	0	0	<i>0</i>	<i>0</i>
	Deaths	5	0	0	0	3	0	0	2	0	0	<i>0</i>	<i>0</i>
Storm, unspecified	Incidents	8	0	0	2	1	0	0	1	2	1	<i>1</i>	<i>0</i>
	Deaths	10	0	0	4	1	0	0	1	2	1	<i>1</i>	<i>0</i>
Unknown or other reason for outage	Incidents	9	1	0	2	1	1	0	1	0	2	<i>1</i>	<i>0</i>
	Deaths	15	1	0	4	2	3	0	1	0	3	<i>1</i>	<i>0</i>

<sup>1</sup> Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

Note: Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

As shown in Table 8 above, 578 generator-related, non-fire CO fatalities occurred in a fixed-structure home. The category “fixed-structure home” is defined as a permanent, fixed-structure used as a residence, including: houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Travel trailers, campers, and RVs are not included in this classification, nor are external structures at the home, such as detached garages or sheds.

Of these 578 generator-related deaths that occurred in a fixed-structure home, information was available for 488 deaths (84%) regarding the victim’s location in relation to the generator. One hundred and eleven of these 488 fatalities (23%) occurred in the same room or space as the generator.

The 578 deaths that occurred in a fixed-structure home were the result of 423 incidents (Table 13). These incidents were further classified by the specific location of the generator within the home. The category “Living Space (non-basement)” includes rooms reported as bedrooms, bathrooms, dens, living rooms, landings, home offices, rear rooms, enclosed porches, and converted garages. This category does not include attached garages or basements. The category “Outside the home” includes incidents where the generator was placed outside a home but near an open window, door, or vent of the home. Sixty-eight percent (289 of 423) of the CO fatal incidents at home locations occurred when a generator was known to be placed inside the home, including the living space (146), a basement (100), closet (5), doorway (1), or inside the house, with no further information provided (37). Another 25 percent of the fatal incidents (106 of 423) occurred when the generator was placed in an attached garage, enclosed carport, or attached barn. Nearly half (49%) of the fatal incidents (206 of 423) occurred when the generator was placed in an attached structure (106) or in the basement or crawlspace (100).

Seventeen deaths from 13 incidents were associated with the use of a generator placed outside the home. Usually, this involved placing the generator too near an open window or vent. This category also includes incidents where a generator was running outside the home but inside a building (*e.g.*, outside an apartment but still inside the building). Additional fatalities occurred with generators placed outside in non-fixed structure house incidents. A summary of all fatal scenarios where generator was located outside is given in Appendix C to this report.

Please note that there are a number of small changes to the Location classifications from previous reports. This is due to an additional review of many of the IDIs favoring another generator project several CPSC analysts. For consistency, these classification changes are reflected here also.

**Table 13: Non-Fire Carbon Monoxide Poisoning Deaths in the Fixed-Structure Home Location<sup>1</sup> by Location of the Generator,<sup>2</sup> 2005–2015**

Generator Location		Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 <sup>3</sup>
Total	Incidents	423	55	40	45	52	35	29	54	35	33	26	19
	Deaths	578	70	57	59	72	52	35	76	40	44	34	39
Living space (non-basement)	Incidents	146	17	12	15	20	15	14	17	9	9	10	9
	Deaths	206	23	17	19	27	21	14	24	13	11	16	22
Garage/enclosed carport / attached barn	Incidents	106	17	13	10	13	8	5	14	14	8	2	2
	Deaths	138	18	20	17	15	11	6	19	14	12	2	4
Basement/crawlspace	Incidents	100	12	9	10	12	6	5	16	5	11	9	5
	Deaths	143	15	11	13	21	11	8	25	5	15	11	8
Inside house, no further information reported	Incidents	37	2	4	5	4	4	1	4	5	3	3	2
	Deaths	42	2	4	5	5	6	2	4	5	3	3	3
Closet in home	Incidents	5	1	1	1	0	1	0	0	0	1	0	0
	Deaths	12	6	3	1	0	1	0	0	0	1	0	0
Outside the home	Incidents	13	4	0	3	0	0	1	1	1	1	1	1
	Deaths	17	4	0	3	0	0	1	2	2	2	1	2
Doorway to home	Incidents	1	0	1	0	0	0	0	0	0	0	0	0
	Deaths	2	0	2	0	0	0	0	0	0	0	0	0
Unknown location, but at home	Incidents	14	2	0	1	3	1	3	2	1	0	1	0
	Deaths	17	2	0	1	4	2	4	2	1	0	1	0

1 This refers to a fixed-structure used as a residence, including houses, mobile homes, apartments, townhouses, and structures attached to the house, such as an attached garage. Not included here are incidents that occurred in detached structures at home locations (e.g., detached garages, sheds), or at non-fixed location residences (e.g., travel trailers, houseboats).

2 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

3 In 2015, there was one incident (one fatality) where the victim was running two generators simultaneously, one in the living space and one in the basement. This incident was included in the “living space” category as the victim was found in the living space.

Notes: Totals may not add to 100 percent due to rounding.

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

Table 14 presents a summary of non-fire CO fatalities that occurred in the fixed-structure home characterized by ventilation status. Many of the incidents with generator-associated fatalities in the home (192 of the 423 incidents) did not contain information about the ventilation of the generator.

In 148 of the 231 incidents (64%), accounting for 217 deaths, in which information on ventilation of the generator was available, there was no ventilation when the incident occurred. In four of these fatal incidents (six deaths), a window or door was open during some period of use but later closed. There were 83 incidents associated with generators in which it was reported that some type of ventilation was attempted. Of these 83 incidents, 57 were associated with incidents in which it was reported that there was an open or partially open window, door, garage door, or a combination of these, accounting for 71 CO deaths. As noted here and in Table 13, 13 incidents (17 deaths) were associated with generators that were placed outside the home near open windows, doors, or vents, where carbon monoxide entered the home. In thirteen incidents (24 deaths), consumers actively attempted to vent generator exhaust outside through a window or door, or through the use of a fan, but these measures failed to adequately vent the CO from the victims' location. This included one case in which a victim placed a generator outside an apartment in the unventilated hallway of a building.

**Table 14: Non-Fire CO Fatalities in the Fixed-Structure Home<sup>1</sup> Reported to CPSC Staff and Associated with Generators<sup>2</sup> Categorized by Status of Ventilation, 2005–2015**

Ventilation Status	Number of Incidents	Number of Deaths	Percentage of Deaths	Percentage of Deaths Where Ventilation is Known
<b>Non-fire CO fatalities in the home</b>	<b>423</b>	<b>578</b>	<b>100%</b>	<b>100%</b>
<b>Some ventilation attempted</b>	<b>83</b>	<b>112</b>	<b>19%</b>	<b>34%</b>
Open window(s), open door(s), an open garage door, or a combination of these	57	71	12%	22%
Actively trying to vent either by fans or by directing exhaust out a window or door	13	24	4%	7%
Placed outside, but near a window, door or A/C unit <sup>3</sup>	13	17	3%	5%
<b>No ventilation</b>	<b>148</b>	<b>217</b>	<b>38%</b>	<b>66%</b>
<b>Unknown ventilation</b>	<b>192</b>	<b>249</b>	<b>43%</b>	<b>-</b>

1 This refers to a fixed-location structure used as a residence, including houses, mobile homes, apartments, and townhouses, as well as structures attached to the house, such as an attached garage. Not included here are incidents that occurred in detached structures at home locations (e.g., detached garages and sheds) or at non-fixed location residences (e.g., travel trailers and houseboats).

2 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

3 One death occurred when a generator was placed outside an apartment in an unvented hallway and one occurred when the generator was placed outside a trailer that was located inside an enclosed, unvented garage.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

Table 15 presents a summary of the fatal CO incidents and fatalities characterized by the size of the home in which the fatalities occurred. For 29 percent (121 of 423) of the fatal incidents and 28 percent of the deaths (159 of 578), CPSC staff could not ascertain the size of the home. Home size information was available for 302 of 423 fatal incidents (419 of the 578 deaths). Information

regarding the size of the homes reported in this document comes from one of two sources: (1) CPSC IDIs, which include information gathered from police, fire department, or public records; and (2) Internet databases of real estate information, which contain public record data. In most cases, Internet databases agree on the size of the home because both databases are based on public records from the county, state, or municipality.

Sixty-four percent (192 of 302) of the reported fatal incidents (270 of 419 CO fatalities) associated with generators that occurred in the home, where the size of the structure was known, occurred in homes that were less than 1,500 square feet; and 86 percent (261 of 302) of the reported incidents and 87 percent of the deaths (364 of 419) occurred in houses that were less than 2,000 square feet. This portion of the fatal incident location includes most incidents that occurred in apartments and mobile homes. Fatal incidents that occurred in a detached structure are not included in this figure. The median home size involved in fatal generator-related CO poisoning deaths, where home size information is known, was 1,292 square feet. As a point of reference, according to the U.S. Census Bureau’s, *American Housing Survey for the United States: 2011*, the median housing unit as of 2010 was 1,800 square feet. Comparing the percentages of fatal incidents by home size to the U.S. Census figures, it appears that the fatal CO incidents are skewed toward smaller homes. Whether this is due to economic reasons, because smaller-volume structures are filled more quickly by deadly carbon monoxide, a combination of the two factors, or some yet-unidentified reason, is unclear.

**Table 15: Non-Fire CO Fatalities in the Fixed-Structure Home<sup>1</sup> Reported to CPSC Staff and Associated with Generators<sup>2</sup> Categorized by Size of Home, 2005–2015**

Home Size (in sq. feet) <sup>3</sup>	Number of Incidents	Number of Deaths	Percentage of Incidents	Percentage of Incidents Where Home Size is Known	Estimated Percentage of U.S. Occupied Housing Units (2010) <sup>4</sup>
<b>Total</b>	<b>423</b>	<b>578</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Under 500	4	5	1%	1%	1%
500–999	80	102	19%	26%	9%
1,000–1,499	108	163	26%	36%	24%
1,500–1,999	69	94	16%	23%	25%
2,000–2,499	19	30	4%	6%	18%
2,500–2,999	12	14	3%	4%	9%
3,000 or Larger	10	11	2%	3%	14%
Unknown	121	159	29%	-	-

1 This refers to a fixed-location structure used as a residence, including houses, mobile homes, apartments, and townhouses and structures attached to the house, such as an attached garage. Not included here are incidents that occurred in detached structures at home locations (e.g., detached garages and sheds) or at non-fixed location residences (e.g., travel trailers and houseboats).

2 Number of deaths associated with generators includes incidents where other consumer products may also have been involved. Other products include one or more of the following: lawn mowers, portable LP-fueled heaters, portable kerosene-fueled heaters, camp stoves, lanterns, outdoor cookers, furnaces, and wood stoves.

3 Home size based on CPSC IDIs or from various Internet real estate databases.

4 The 2011 housing unit figures represent an approximate mid-point year.

Note: Totals may not add to 100 percent due to rounding.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

U.S. Census Bureau, *American Housing Survey for the United States: 2011*.

## Conclusions

Between 2005 and 2015, 880 non-fire CO-poisoning deaths from 677 incidents that were associated with EDTs were reported to CPSC staff. The majority of these deaths (773) involved generators, or a generator and another consumer product. OEDTs, including garden tractors, lawn mowers, power washers or sprayers, and others, were associated with a much smaller number of deaths. The majority of fatal incidents reported to CPSC staff involved a single fatality. Most reported deaths occurred while an individual was at home.

Seventy-five percent of the reported deaths associated with generators occurred at fixed-structure home locations. Sixty-eight percent of the fatal incidents known to have occurred in the home and involving generators occurred when a generator was placed in the living area or basement of the home. Another 25 percent occurred when a generator was used inside an attached garage or shed.

Generators were often used as alternative sources of electricity due to temporary power outages or as power sources for temporary shelters. Power outages, most commonly weather-related, were the single most common reason for generator usage that resulted in a non-fire CO fatality, accounting for at least 207 of the 773 fatalities (27 percent). Generators were often used with little or no ventilation. In only about 9 percent of the fatalities was it known that there was a CO alarm installed—and many of these were inoperable at the time of the fatal incident. Conclusions about why consumers used generators indoors or determinations about whether users were aware of the potential non-fire CO-poisoning hazard were not possible to make with the available information.

Victims age 25 years and older accounted for about 82 percent of the non-fire CO poisoning deaths that were associated with generators reported to CPSC staff, and the majority (76 percent) of the victims were male. Victims age 25 years and older accounted for 99 percent of the non-fire CO poisoning deaths reported to CPSC staff that were associated with OEDTs. Males accounted for 96 percent of the deaths associated with OEDTs. Deaths associated with garden tractors and lawn mowers were often associated with an individual repairing or working on the product in an enclosed space.

Visit the CPSC's Carbon Monoxide Information Center—<http://www.cpsc.gov/en/Safety-Education/Safety-Education-Centers/Carbon-Monoxide-Information-Center/>—for the latest information on recalls, safety tips, safety standards, CO alarms, and downloadable injury prevention materials.

## References

Hnatov, Matthew V. *Incidents, Deaths, and In-Depth Investigations Associated with Non-Fire Carbon Monoxide from Engine-Driven Generators and Other Engine-Driven Tools, 2004-2014*. U.S. Consumer Product Safety Commission. June 2015.

<http://www.cpsc.gov/Global/Research-and-Statistics/Injury-Statistics/Carbon-Monoxide-Posioning/GeneratorsandOEDTFatalities2015.pdf>

Hnatov, Matthew V. *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products: 2011 Annual Estimates*. U.S. Consumer Product Safety Commission. October 2015.

<http://www.cpsc.gov/Global/Research-and-Statistics/Injury-Statistics/Carbon-Monoxide-Posioning/2012NonFireCODEaths.pdf>

U.S. Census Bureau. American FactFinder. Population, Housing Units, Area, and Density: 2010 - State— 5-digit ZIP Code Tabulation Area: 2010 Census Summary File 1

[http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC\\_10\\_SF1\\_GCTPH1.ST09&prodType=table](http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_GCTPH1.ST09&prodType=table)

U.S. Census Bureau. American Housing Survey for the United States: 2011.

<https://www.census.gov/content/dam/Census/programs-surveys/ahs/data/2011/h150-11.pdf>

U.S. Census Bureau, 2010 Census Data <http://www.census.gov/2010census/data/>

U.S. Department of Agriculture. Rural-Urban Commuting Area Codes

<http://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx>

University of Washington, WWAMI Rural Health Research Center. Rural-Urban Commuting Area Codes (RUCAs) <http://depts.washington.edu/uwruca/>

## **Appendix A: Epidemiology Data Retrieval Specifics**

The queries below were submitted through EpiSearch, CPSC staff's epidemiology data access application, accessing data from the Consumer Product Safety Commission Risk Management System ("CPSRMS"). Query results were reviewed to include only non-fire carbon monoxide poisoning fatality incidents related to EDTs and to exclude duplicates and out-of-scope cases, which were cases that were intentional in nature or that occurred during a work-related activity.

For this report, a fatal incident was deemed in scope if none of the following criteria were violated:

- Carbon monoxide was the primary or contributing factor in the fatality.
- The carbon monoxide was not fire-related.
- The source of the CO was an EDT, or an EDT used in conjunction with another non-fire-related CO generating source.
- The fatal injury was unintentional in nature.
- The EDT involved was a consumer product.
- The incident was not work related.

Date of Queries: 06/01/2016

Incident Dates: 1/1/05-12/31/15

Product Codes: 113, 606, 800-899, 1062, 1400-1464, 3285-3287

Narrative/Text Contains: "CARB" or "MONO"

## **Appendix B: Engine Class of Generators Involved in Fatal CO Incidents**

Table B-1 provides a summary of generator incidents and fatalities broken down by engine classification and year of incident<sup>4</sup>. Note that this summary includes stationary generators (3 incidents, 5 deaths) and generator-welders (3 incidents, 3 deaths). These incidents are footnoted below the table. In the majority of cases (55%), CPSC staff was unable to obtain sufficient information about the engine class of the involved generator. In the incidents where engine classification could be determined, slightly more than one third (35%) involved Class I powered generators, and slightly less than two thirds (63%) involved Class II powered generators. Handheld class generators were known to be involved in two incidents (two fatalities) during this time period; while twin cylinder, Class II powered generators were known to be involved in three incidents and seven fatalities.

Additionally, note that an incident in 2015 involved both a Class I and Class II, single-cylinder generator. This case was included in the “Class II” category in the summary table.

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<sup>4</sup> Staff used engine classifications defined by the U.S. Environmental Protection Agency (“EPA”) and also the number of cylinders that the engine has. EPA broadly categorizes small SI engines as either non-handheld or handheld and within each of those categories further distinguishes them into different classes, which are based upon engine displacement. Non-handheld engines are divided into class I and class II, with class I engines having displacement above 80 cc up to 225 cc and class II having displacement at or above 225 cc but maximum power of 19 kilowatts (“kW”). Handheld engines, which are divided into classes III, IV, and V, are all at or below 80 cc.

**Table B-1: Engine Class of Generators Involved in Fatal CO Incidents, 2005–2015<sup>1</sup>**

Year	Handheld		Class I		Class II, Single Cylinder		Class II, Twin Cylinder		Unknown		Total	
	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths	Incidents	Deaths
<b>Total</b>	<b>2</b>	<b>2</b>	<b>87</b>	<b>126</b>	<b>160</b>	<b>233</b>	<b>3</b>	<b>7</b>	<b>314</b>	<b>397</b>	<b>566</b>	<b>765</b>
2005	1	1	10	13	23	33			46 <sup>#</sup>	56 <sup>#</sup>	80 <sup>#</sup>	103 <sup>#</sup>
2006			13	18	21	34			29	41	63	93
2007			9	13	16	22	1 <sup>#</sup>	1 <sup>#</sup>	31	36	57 <sup>#</sup>	72 <sup>#</sup>
2008			12	17	22	29	1	1	35	48	70	95
2009			5	8	12	19			28	39	45	66
2010	1	1	6	8	13	15			17	22	37	46
2011			13	22	15 <sup>+</sup>	24 <sup>+</sup>	1	5	40 <sup>+</sup>	45 <sup>+</sup>	69 <sup>+</sup>	96 <sup>+</sup>
2012			7	10	6	7			29	31	42	48
2013			8	12	17	21			18	22	43	55
2014			2	3	5	10	1 <sup>#</sup>	1 <sup>#</sup>	26	30	34 <sup>#</sup>	44 <sup>#</sup>
2015			2	2	11 <sup>*</sup>	21 <sup>*</sup>	1	1	18	31	32	55

\* One incident in 2015 involved both a Class I and Class II generator. This case was included in the “Class II” category.

# These counts include an incident with one fatality that involved a generator/welder.

+ In 2011, three incidents involved stationary generators: one incident classified as a Class II, Single Cylinder (two deaths), and two incidents of unknown classification (one involving two deaths and the other involving a single death).

1 – In 2004, there were 5 “Class I” incidents (5 deaths), 14 “Class II, Single Cylinder” incidents (21 deaths), and 16 “Unknown” incidents (21 deaths).

Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports.

Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

When the IDI did not report the generator’s engine displacement or it was not obtainable from other information in the IDI, staff classified generators with a reported wattage of 3.5 kW and larger as being powered by a class II engine and those less than 3.5 kW as powered by either a handheld or a class I engine. To distinguish the handheld powered generators from the class I powered generators when there was no information to ascertain the engine displacement, generators with wattage 2 kW and larger, up to 3.5 kW, were considered to have a class I engine. There was only one generator with wattage below 2kW in which the engine displacement could not be ascertained. That was a 1,000 watt generator, which staff classified as a handheld generator because staff’s online review of generators nominally, in this size, showed them being powered by handheld engines. To distinguish the single-cylinder class II engines from the twin-cylinder class II engines, staff found from looking at the EPA’s exhaust emission certification database at: [www3.epa.gov/otaq/certdata.htm#smallsi](http://www3.epa.gov/otaq/certdata.htm#smallsi) that twin-cylinder class II engines largely have a maximum engine power of nominally 12 or 13 kW and higher. Staff then found, from looking at manufacturers’ generator specifications available online, that generators with engines having power equal to or greater 12 or 13 kW, typically have a rated power of 9kW and higher. Therefore, generators with rated power of 3.5 kW up to 9 kW were considered powered by a single-cylinder class II engine and those 9 kW and greater were considered powered by a twin-cylinder class II engine.

## Appendix C: Fatal CO Exposure Incidents Where Generator Was Located Outside the Victim Location

Table C-1 provides a summary of portable generator incidents and fatalities where the generator was placed outside the victim’s location. The table presents the data broken down by the specific type of incident location. This table demonstrates that even when a generator is placed outside the victim location, there can still be potentially fatal scenarios. In fact, 7 percent of all generator incidents (41 of 572) and fatalities (56 of 773) occurred when the victim placed the generator outside of their occupied area.

Note that the incidents and deaths presented in this table do not directly correspond to those shown for “Outside the Home” incidents as shown in Table 13 because the latter table only presents incidents that occurred in fixed-structure homes. This table includes all locations, including vehicles, apartments in business locations, cabins and trailers.

The last two categories in the table are included, even though the generator was placed inside a building. It is surmised that the victims believed that they had adequately mitigated the dangers of CO exposure by placing the generator outside their living space. But, even if these two categories are eliminated from the summary, the generator placed “outdoors” scenario still represents 6 percent of all generator-related CO fatalities (49 of 773) and incidents (35 of 572).

**Table C-1: Fatal CO Generator Incidents Where the Generator Was Located Outside the Occupied Space, 2005–2015<sup>1</sup>**

Location	Incidents	Deaths
<b>Total – Occupied Area</b>	<b>41</b>	<b>56</b>
House/Mobile Home	10	12
Apartment	1	2
Cabin	1	1
Vehicle: RV/Camper Shell	10	19
Vehicle: Automobile/Truck	3	3
Camper Trailer/Horse Trailer	8	10
Boat	2	2
Outside Apartment, Inside Building	4	5
Outside Trailer, Inside Building	2	2

Note: 1 – In 2004, there was one incident (two fatalities) in a house where the generator was placed outside.  
Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

## Appendix D: Carboxyhemoglobin Levels Present in CO Fatalities

Carboxyhemoglobin (COHb) is a complex of carbon monoxide and hemoglobin that forms in red blood cells when carbon monoxide is inhaled. COHb poisoning can be fatal in large doses because it hinders delivery of oxygen to the body. COHb data are helpful in estimating the concentration of CO in the product exhaust and the lethality of the product, which can affect the speed of onset of harm. This information may be used by CPSC staff to assist in determining the best way to address the CO hazard presented by generators and other EDTs.

In healthy adults, a COHb level of 40 percent–50 percent in the blood approximately correlates with symptoms of confusion, unconsciousness, coma, and possible death; a level of 50–70 percent approximately correlates with symptoms of coma, brain damage, seizure, and death; and a level greater than 70 percent is typically fatal.<sup>5</sup> COHb levels were available for 490 of the 880 fatalities (56% of the CO fatalities). Table D-1 shows the frequency of reports by COHb level categories. Percentages in the table are the category proportions of reported COHb levels. Eighty percent (394 of the 490) of fatalities had reported COHb levels of 50 percent or greater.

**Table D-1: Carboxyhemoglobin Levels Associated with Engine-Driven Tools Non-Fire Carbon Monoxide Poisoning Deaths, 2005–2015<sup>1</sup>**

COHb Level	All Engine-Driven Tools (EDTs)		Generators		Other Engine-Driven Tools (OEDTs)	
	Count	Percentage	Count	Percentage	Count	Percentage
<b>Total</b>	<b>880</b>	<b>-</b>	<b>773</b>	<b>-</b>	<b>107</b>	<b>-</b>
<b>Reported Levels</b>	<b>490</b>	<b>100%</b>	<b>430</b>	<b>100%</b>	<b>60</b>	<b>100%</b>
Less than 30%	27	6%	25	6%	2	3%
30–39.9%	25	5%	22	5%	3	5%
40–49.9%	44	9%	37	9%	7	12%
50–59.9%	100	20%	92	21%	8	13%
60–69.9%	138	28%	123	29%	15	25%
70–79.9%	124	25%	104	24%	20	33%
80–89.9%	27	6%	22	5%	5	8%
90–99.9%	5	1%	5	1%	0	0%
<b>Not reported</b>	<b>390</b>	<b>-</b>	<b>343</b>	<b>-</b>	<b>47</b>	<b>-</b>

<sup>1</sup> Percentages shown are the percentage of reported COHb levels per category. Italicized numbers indicate that reporting of incidents is ongoing. Counts may change in subsequent reports. Source: U. S. Consumer Product Safety Commission, Directorate for Epidemiology, 2016.

<sup>5</sup> Inkster S.E. *Health hazard assessment of CO poisoning associated with emissions from a portable, 5.5 Kilowatt, gasoline-powered generator*. Washington, D.C.: U.S. Consumer Product Safety Commission. 2004.

## Appendix E: Historical Data

Figure 1 illustrates the trend in the number of non-fire CO fatalities associated with the use of generators and other EDTs from 1999 to 2015. The number of generator-related fatalities increased at a steady rate from six in 1999 to 103 in 2005. After which, the number of yearly fatalities has oscillated between 40 and 100 fatalities per. It should be noted that, due to reporting delays, fatality counts reported in future annual reports for the most recent years are likely to increase. Over the last seven annual reports, including this one, the most recent year's counts have increased by an average of about 28 percent from the previous report. Between the second and third year, the average increase, report to report, is about an additional 9 percent.

The number of CO fatalities associated with the use of non-generators EDTs has been relatively steady over the period 1999 through 2015.

**Figure 1: Number of Reported Non-Fire Carbon Monoxide Fatalities Associated with Engine-Driven Tools, 1999–2015**

