Portland Clean Air

Dec 2023 DMV & ODOT Diesel Fleets

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Executive Summary:

Oregon Department of Transportation (ODOT, diesels 26k lb. and up) and Department of Motor Vehicles (DMV, diesels under 26k lb.) records were obtained by Portland Clean Air in December 2023 and I was asked in February 2024 to conduct analysis, render visualizations, and deliver xlsx files with counts of filtered and unfiltered diesel vehicles per fleet. The problem of diesel air pollution is a serious health concern, and in the context of environmental eugenics and class warfare, also a matter of grave social injustice[1].

The estimate of emissions in Portland metro area for personal diesel vehicles is a large portion of the lighter class (82%), relative to commercial (11%) and government (7%); however, when the heavy class fleets based in Oregon are considered, the proportions are different (24%, 74%, 2%, respectively); that is taking neither operational frequency nor fuel efficiency into account, except for TriMet, as detailed further on. The common logic is that an average heavy class commercial diesel vehicle operates for many times more hours and combusts a much larger volume of diesel than an average personal diesel vehicle.

Relative proportions of heavy class emissions are very likely underestimated on the assumptions used, and if fleets with more than 15 unfiltered heavy class diesel vehicles are required to filter all their vehicles, that filters over 40% of heavy class unfiltered diesel vehicles. To get over 50%, target those with 9 or more to replace or retrofit them. Over 40% of the lighter class unfiltered diesel fleet is operated by owners with more than 6 of them, and over 50% by those with 3 or more.

Concerns come to mind about legislative strategies, such as if a rule is created to limit the number of unfiltered heavy diesel vehicles per owner to 8 or fewer per operator, then owners may create new companies to shift unfiltered fleets to or sell them to companies with fewer than the limit to fund their transition. Alternative strategies to put filters on the outdated fleet or otherwise get them out of our neighborhoods entirely are preferable, of course.

Methods

To begin the analysis, I deleted unneeded columns in the original xlsx files for faster loading in Python, renamed them "DMV_DEC_2023_LITE" and "ODOT_DEC_2023_LITE" and handled each with unique logic. References to vehicle "class" or "classes" ("light" or "heavy") distinguish between DMV and ODOT, respectively. Let's begin with DMV, and inspect the remaining columns:

"Owner Name", "Address", "Customer Type", "Plate ID", "Plate Type", "Vehicle ID", "Year", "Title Status", "Registration Expiration Date", "Registration Cease Date", "Cease Reason", "Gross Vehicle Weight"

The subset of current on-road registrations is selected by excluding rows where:

- "Title Status" is "CANCEL"
- "Cease Reason" is "Cancelled"
- "Plate Type" is "No Valid Plate"
- "Registration Expiration Date" is null or before the present year.
- "Gross Vehicle Weight" equals or exceeds 26k lb.

Active government fleets are handled separately, since their "Registration Expiration/Cease Date" is always "1999-12-31", Cease Reason" is "No Valid Registration", and "Title Status" is either "ISSUED" or "CANCEL"; except in the latter case or when weight equals or exceeds 26k lb., all diesel vehicles with a "Plate Type" of "Government Exempt Vehicle" are included.

Vehicles are separated by "Year" into "Filtered" and "Unfiltered", if built after 2007 or before 2008, respectively. In references to "type" or "types", the distinction being made is whether the year of a vehicle is after or before filters were required in new diesels, and "sector" or "sectors" are references to "government, commercial, private" fleets. Government fleets are sorted into types in the same way as commercial; the fleets are grouped by "Owner Name" and counts are summed per fleet for total "Filtered" and "Unfiltered" in those sectors for each unique 'Vehicle ID'.

The next procedure is zip code sortation. I compiled a list for Portland Metro area (Multnomah, Clackamas, Washington) from Zillow, and made the Boolean column "Is Metro", set to "True" if a zip code in the "Address" appears in the list, or else "False". Similarly, a Boolean column named "Is Gov" is set to "True" or "False" if the "Plate Type" is "Government Exempt Vehicle" or not.

Subsequently, where I refer to "locale" or "locales", the distinction is whether the address is within "metro" or "outer" areas. Outer areas include the rest of Oregon and areas beyond. For known sectors, counts of types by sector are calculated within metro and outer areas for visualization and summed by locale for estimation of private sector counts by type and locale, since the "Address" for privately-owned diesels is private.

To make the estimations, the sums of known sectors by locale and type are divided by inclusive totals of types. In essence, counts of types within locales are divided by counts of types among locales to find proportions of types in locales. By the 'Year' sortation and summing methods used on the other sectors, private diesels are summed by type, and those sums are multiplied by their corresponding proportions to get count estimates of types by locales.

An academic literature review indicates from 2022 indicates that in recent years, the efficiency of Diesel Particulate Filters typically exceeds 90% [2], so unfiltered diesels are given an order of magnitude increase when calculating emissions, relative to filtered diesels. I was unable to find a citation, yet a prior Portland Clean Air report [3] asserts that by using biodiesel, TriMet has

reduced their fleet emissions by half, and news sources corroborate the reasonableness of that [4], so I reduced TriMet fleet by half for emission calculations, and their actualized diesel air pollution reductions are increasing as their diesel fleet size decreases, enroute to being entirely electric [5].

On the ODOT records, I applied the same sortation and assignment methodologies:

- type by "MODEL_YEAR" ("Year")
- group by "CARRIERNAME" ("Owner Name")
- sum counts of unique vehicles by "VIN" ("Vehicle ID")

The ODOT records are assumed current, already precleaned. Nothing is evident in the records received to determine any cancellations or vehicles that are no longer in operation, so all ODOT records are included. To reduce the workload of copying and pasting addresses, I reformatted the multiple columns ("ADDRESS", "CITY", "STATE", "ZIP") to a single column ("Address") in the xlsx deliverable file.

Cumulative Percentages

After taking counts by owner, I sorted owners by the number of each type of vehicles, low to high, and iterated over them, keeping a cumulative count of all prior fleets and the current fleet in the iteration, dividing the cumulative count by the total sum of all vehicles of the type, multiplying that by 100 to get a percentage from the proportion, and recording that as the cumulative percentage.

With these datapoints, I plotted cumulative percentages for each fleet size; also, the point sizes have direct proportionality to the relative amounts that fleets with each count of diesels of the labeled type add to the total count among all fleets of the type in the class.
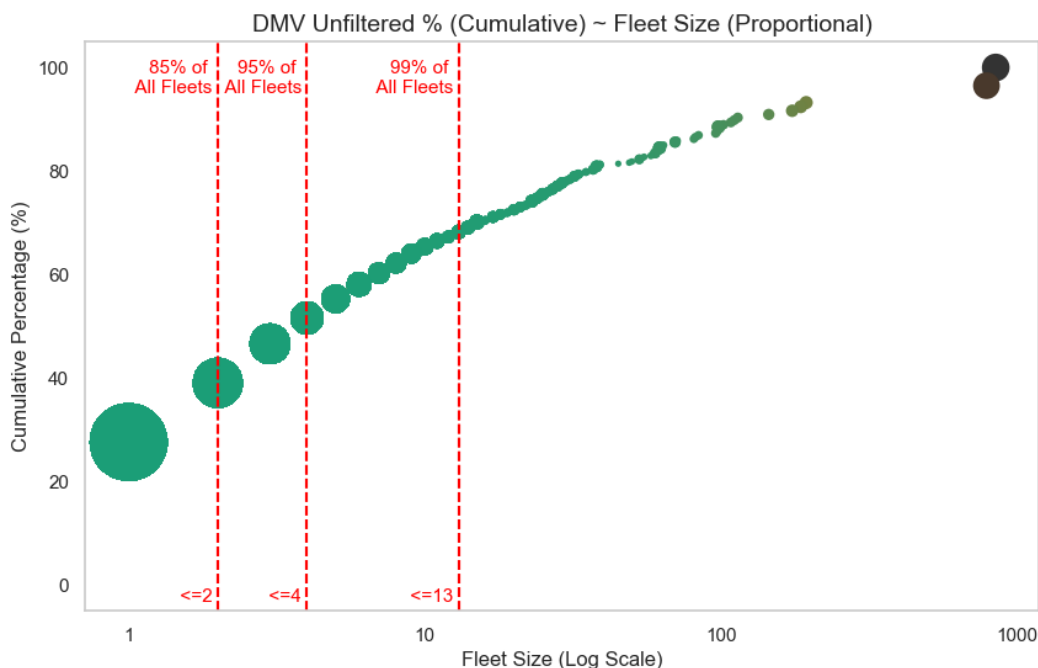
Distributions

To show how fleet sizes are distributed among operators, I plotted fleet size on the x-axis, and when multiple fleets appear with the same size, each is given a random negative offset value between -0.95 and -0.05 on the x-axis, to shift the datapoint left from its true value on the axis and provide a better visualization of fleet distributions. Similarly, they are moved vertically with a random spread from the y-axis center, though the y-axis has no value in this plot style; the spread simply enhances visualization of how many fleets own each count of diesels of the labeled type.

The points are scaled in direct proportion to the true fleet size; along with vertical (0.1 x-axis) gaps between fleet sizes, proportionality helps show fleets of each size amid random distributions of the x-value left-shift. Each fleet with the same number of diesels of the labeled type is represented by a point the same size as all other fleets with the same fleet size of the type, and they are scaled so the point of a fleet with 20 vehicles is 10 times larger than that of a fleet with 2. The percentile lines show the relative proportions of operators with fleets of each size, so the 95th percentile of less than or equal to 12 means at least 95% of operators have 12 or fewer unfiltered diesel vehicles in the ODOT fleet (Fig 2.).
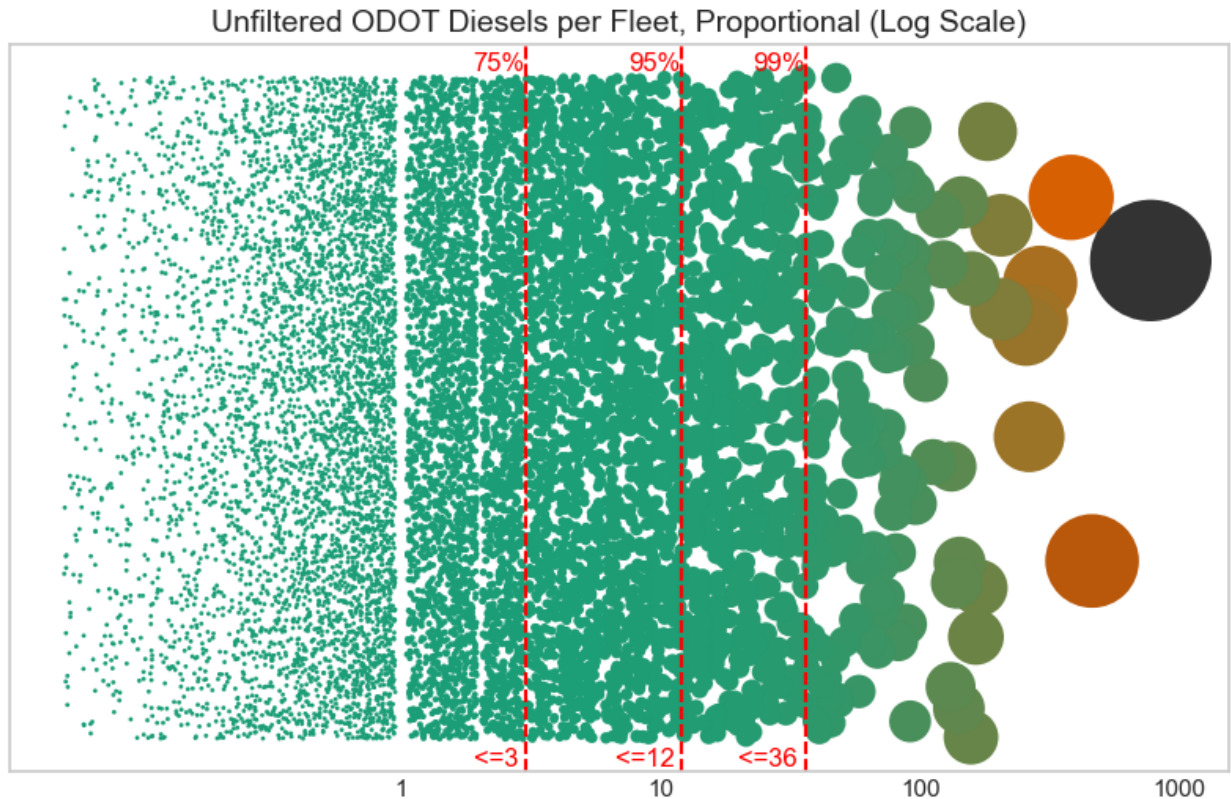

Figure 2. Distribution of unfiltered ODOT fleets by counts per operator with points proportional to counts, shifted random amounts to the left (between the true count tick mark and one fewer)

and shifted random amounts vertically to make the number of fleets with each count more visible.

Integrated Application

The cumulative percentage and distribution plots provide the required perspectives for targeting counts of unfiltered vehicles through legislation; for example, if ODOT operators with 9 or more unfiltered diesels are targeted, to keep at least half of the unfiltered heavy diesels from toxifying our neighborhoods, that requires a change for under 8% of fleets with unfiltered heavy class diesels in operation. Percentile (quantile) parameters in the Jupyter notebook can be adjusted on both the plot types and cumulative percentages are in the Excel files for each type, size, and class of fleet.

Visual Summary

The next plots include the counts for both weight classes, based on the previously detailed assumption that ODOT registered fleets based in Oregon (in Portland metro and outer areas) are burning at least as much diesel in the metro area (on average) as DMV personal and government vehicles registered to operators at addresses located in the metro area. Those are quite reasonable hypotheses, in accord with logical common sense, and these plots thus point to the most urgent weight class and operator sizes. The clear contrast of the ODOT inclusive (Fig. 3) and only DMV (Fig. 4) pie plots emphasizes the point of where our efforts are most effectively focused.
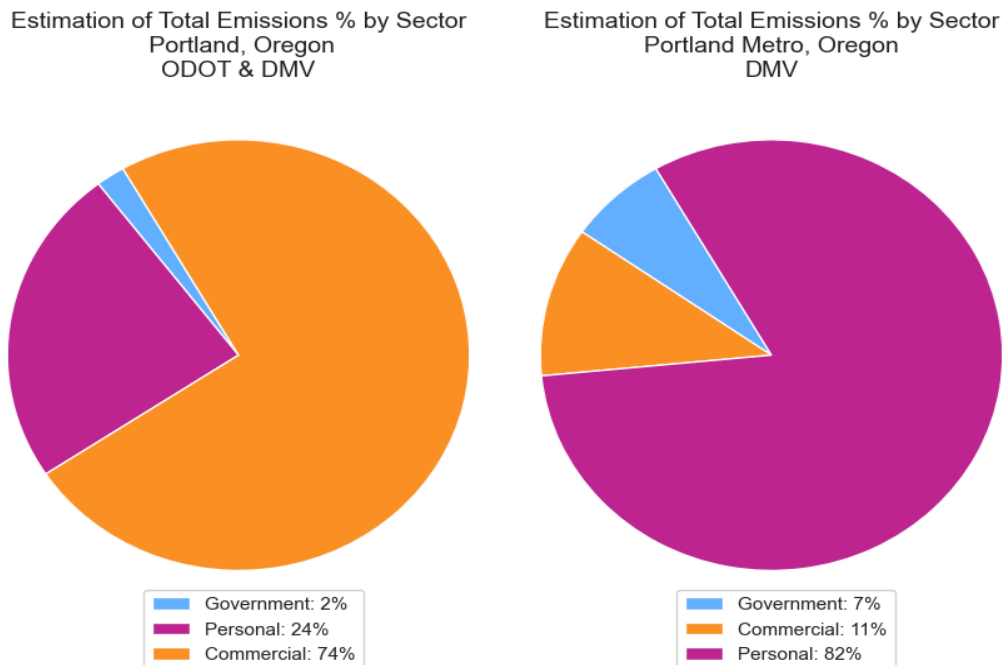
Figures 3 & 4. Relative percentages by sector, with ODOT included versus only DMV.

Excel Files

The files "dmv_fleets.xlsx" and "odot_fleets.xlsx" have identical format, with contact information, counts and their proportions per operator for both types, and cumulative proportions from the methodology detailed previously. Additionally, "dmv_summary.xlsx" and "odot_summary.xlsx" have totals of types, by sector in the former, and by "Oregon" or "Other" from cross-referencing the owner addresses in the latter.

References

1. Rothstein, Mark A., et al. "Transgenerational Epigenetics and Environmental Justice." Environmental Epigenetics, vol. 3, no. 3, 1 July 2017, https://doi.org/10.1093/eep/dvx011. Accessed 29 Aug. 2019.
2. Dong R, Zhang Z, Ye Y, Huang H, Cao C. Review of Particle Filters for Internal Combustion Engines. Processes. 2022; 10(5):993. https://doi.org/10.3390/pr10050993
3. Doug, Loqa. Who Is Causing Portland's Diesel Particulate Problem? Cascadia Action. 1 Feb. 2024.
4. York, Tia. "Portland Metro Region Avoids Millions of Pounds of Greenhouse Gas Emissions with TriMet's Switch to Renewable Diesel." TriMet News, 5 Dec. 2022, news.trimet.org/2022/12/portland-metro-region-avoids-millions-of-pounds-of-greenhouse-gas-emissions-with-trimets-switch-to-renewable-diesel/. Accessed 26 Mar. 2024.
5. Miller, Mark. "Extended-Range Electric Buses Supercharge TriMet's Zero-Emissions Push." TriMet News, 26 Feb. 2024, news.trimet.org/2024/02/extended-range-electric-buses-supercharge-trimets-zero-emissions-push/. Accessed 26 Mar. 2024.