Translating ACT/HDO emissions reductions to health benefits using COBRA

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Approach

First, I gathered data on emissions reductions from ICCT's November 2021 analysis of the ACT, HDO, and GHG Phase 2 Standards (updated in 2022). I'll be using the Tank-to-Wheel NOx and PM2.5 emissions reduction numbers by year and then accumulating the benefits from 2020 to 2050. Given differences in adoption years and the small impact on emissions in the initial years, I accounted for the full extent of what the ICCT scenarios accounted for.

- These are Tank-to-Wheel reductions and so are underestimates of total impacts given upstream emissions.

U.S. EPA's CO–Benefits Risk Assessment (COBRA) screening model is a free tool developed by the EPA that helps translate changes in air pollution from clean energy policies and programs to human health impacts at different spatial scales. The model also estimates the economic value of these health benefits.

- The model can account for emissions of particulate matter (PM2.5), sulfur dioxide (SO2), nitrogen oxides (NOX), ammonia (NH3), and volatile organic compounds (VOCs). In this case, only changes in PM2.5 and NOx are made in the scenarios. All emissions changes are translated into primary and secondary PM2.5 pollution for analysis of health impacts.
- COBRA calculates the emissions impact using a county-level Source-Receptor Matrix that is not as robust as regulatory models but is good enough as a screening tool.
- Baseline emissions levels for 2016, 2023, and 2028 are estimated using EPA's Air Emissions Modeling Platform.
- The concentration response relationships used in COBRA are compiled from the most relevant literature and are listed in COBRA's methodology document.

Input to COBRA includes:

- Year of analysis for baseline emissions, population, incidence, and valuation data. Can also input your own.
- Emissions scenarios by location (up to county specification) and by "Emissions Tier" (i.e. sector, using the National Emissions Inventory system).

My inputs will be:

- I will decrease emissions proportionally from the three emissions categories containing heavy duty vehicles within the "Highway Vehicles" tier (on-road vehicles). This most accurately matches the vehicles the ACT and HDO will affect.

    - I will model the emissions reduction numbers from the baseline in the ICCT analysis, pretty much ignoring the absolute levels. It helps that COBRA results are mostly linear in emissions reductions.
- I will utilize the "All EVs" scenarios in the ICCT analysis, given that it accounts for emissions benefits even after vehicles cross state lines.
- I will run COBRA in each year from 2020-2050 using the ICCT reduction scenario. I will use the 2016 year as the baseline for all of these scenarios, given the limited projection files and the fact that the 2016 year provides conservatively low estimates, due to a combination of factors given population projects, incidence (existing mortality, hospital, and health data), and valuation (monetizing health benefits).
    - Sensitivity test scenario: 100 ton reduction of PM2.5, 1000 ton reduction of NOx, diesel vehicles in Maryland, done for all 3 years.

	$ Total Health Benefits (low estimate)
2016	Total: $51,509,483.73
2023	Total: $56,212,962.95
2028	Total: $63,379,734.68

    - A batch run can make this quicker. I did this!
- A discount rate of 3% for conservativeness. Then, each year's monetized health benefits will be discounted by that amount for the cumulative number in 2022$.
- I will only report cumulative 2020-2050 numbers. Year-by-year numbers are too specific for the detail of this model.
- As in previous UCS reports, I will report avoided premature deaths, avoided hospital visits (hospital admissions and emergency room visits), and avoided minor cases (reduced cases of acute bronchitis, exacerbated asthma, and other respiratory symptoms, and reduced restricted activity days and lost workdays), and total monetized health benefits.
    - I will report the "high" estimates, as done by CATF's Diesel Deaths study.

Creating Scenario Files

Scenario files are around 69MB, and I will have 30 of them, one for each year. I will keep these files on my computer and have cleaned up some .zip packages for reference, but if you want more details, please reach out!

I will use the COBRA desktop GUI in order to create scenario files (it saves to .xlsx but needs to save to .csv) for each year according to the emissions reductions.

- The GUI helps allocate absolute reductions in emissions across different counties in an even percentage.
- The baseline will have a different absolute number of PM2.5 and NOx emissions from the ICCT numbers, given the mismatch in accounting styles. I will only investigate the impact of the decreases from baseline in the ICCT results.
- I will allocate the emissions reductions across all "Heavy Duty" vehicle tiers (CNG, Diesel, and Gasoline) proportionally and within Maryland. This is a useful approximation, and I will not be reporting spatially differentiated results. EPA's Source Classification Codes usually define "Heavy Duty" as all vehicles from Class 2B-8, the same as the ACT's affected vehicles.

    - Allocating to different fuel types is largely negligible, as the spatial distribution of emissions is probably similar (health impacts would be the same) and diesel accounts for around 95% of heavy duty vehicle emissions in Maryland.
        - There may be some other fuel-specific factors (e.g. non-combustion emissions factors) that COBRA takes into account here though, which this allocation accounts for.
- I will calculate the benefits of just the ACT first, and can implement an ACT+HDO scenario if desired in the future.
- Tons = short tons usually in EPA datasets like National Emissions Inventory
- Manually inputting the scenarios in the GUI takes ~30 min, I'd recommend automating it or doing 5 year intervals and interpolating.

Executing Runs

- Need to reformat files so they can fulfill the CSV Validator (frustrating part of COBRA's scenario export)
- Rename "base NO2" etc… to "NO2" manually within each CSV.
- Change all file outputs and inputs to .csv
- List of health effects at "Exhibit 8. Description of Health Effects and their Economic Values" in COBRA user manual
- Created a batch run file as per Appendix G in COBRA user manual

Results

- Monetary benefits adjusted using 3% discount rate.
- Monetary results, no matter which year is run, are reported in 2017$. Need to adjust to account for that.
- Hospital admissions and ER visits includes: nonfatal myocardial infarctions (high); Emergency Room Visits, Asthma; HA, All Cardiovascular (less Myocardial Infarction); HA, Respiratory; and HA, Chronic Lung Disease
- Premature deaths includes both All-Cause Mortality (high) and infant mortality
- Minor cases include: Acute Bronchitis; Asthma Exacerbation, Cough; Asthma Exacerbation, Shortness of Breath; Asthma Exacerbation, Wheeze; Upper Respiratory Symptoms; Lower Respiratory Symptoms; Minor Restricted Activity Days; and Work Loss days

Gut check comparison with another COBRA study: similar orders of magnitude to a similar emissions reduction, different population densities and incidence rates can account for the higher health impacts per emission. Impacts are mostly proportional to each other, so it checks out to me.

	These results for MD	CT+MA+RI Trucks Study
NOx cumulative reduction (short tons)	**69490**	92,000
PM2.5 cumulative reduction (short tons)	**613**	690
Premature Mortality	**271**	113
Hospital Admissions and ER	**230**	113
Minor Cases	**116,214**	64,821

Total $	**$1.661B**	$1.326B

Doing the same methodology including the HDO scenario:

"the ACT and HDO rules would bring over $2.2 billion in public health benefits to Maryland from 2020-2050, by avoiding over 314 hospital admissions and emergency room visits, 370 premature deaths, and 158,100 cases of respiratory illnesses like asthma."