Publications that Cite EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool

Publication type	Date Published	Location	Summary	URL	Citation
Article	March 2024	United States	This study focuses on air quality and health impacts of electricity and natural gas-related recommendations from the IAC program in 2022. Using AVERT, the regional electricity emissions, published natural gas emission rates, and COBRA, the estimated total annual health outcomes associated with these savings range from 4.85 to 16.9 million USD (2023). Additionally, an energy savings health estimator (ESHE) tool is used to calculate air emissions and associated health outcomes of energy savings measures. The authors apply this to the 2022 IAC recommendations and compare the health outcomes to those calculated using AVERT and COBRA separately.	https://doi.org/10.1007/s12053-024-10210-3	Kouchaksaraei, E.S., & Kelly, K.E. "Air emission and health impacts of a US industrial energy efficiency program." Energy Efficiency, 17, 22.
Article	June 2023	United States	This article cites COBRA when discussing the results from Shukla et al., (2022): "*Shukla et al., developed a hybrid modeling approach that combines C-TOOLS, a local-scale dispersion model for primary PM2.5 with the CoBenefits Risk Assessment (COBRA) Screening model with secondary PM2.5 components. This model was used to characterize ZIP-code level air pollution estimates of PM2.5 in New York City for performing rapid assessment for evaluating health benefits of emissions reduction measures."*	https://doi.org/10.1371/journal.pone.0286406	Valencia, A., Serre, M., & Arunachalam, S. "A hyperlocal hybrid data fusion near-road PM2. 5 and NO2 annual risk and environmental justice assessment across the United States." PLoS One, 18(6), e0286406.
Article	December 2023	United Sates	This article cites COBRA when discussing the results from Mailloux et al., 2022. Mailloux et al. applied COBRA to access health benefits resulting from the removal of PM2.5-related emissions from six energy-related sectors including electric generation, residential/commercial, industrial, onroad vehicles, nonroad vehicles, and oil and gas production/refining in the contiguous U.S. (see publication below for additional details)	https://doi.org/10.1016/j.renene.2023.119536	Tran, H., Juno, E., & Arunachalam, S. "Emissions of wood pelletization and bioenergy use in the United States." Renewable Energy, 219, 119536.

Publication type	Date Published	Location	Summary	URL	Citation
Article	December 2023	United States	This study estimated and valued the air quality health effects of potential land-use policies and projected trends in the United States, alongside carbon sequestration and economic returns to land, until 2051. They show that air quality health effects are of first-order importance in land-use decisions, often larger in value than carbon sequestration and economic returns combined. When air quality is properly accounted for, policies that appeared beneficial are shown to be detrimental and vice versa. Land-use-driven air quality impacts are largely from agricultural emissions and biogenic forest emissions, although incentives for reduced deforestation remain beneficial overall. COBRA is referenced in this article when employing a "cessation lag" that distributes the change in health outcomes associated with a change in pollution across a 20-year period from when the change in pollution occurs. Additionally, COBRA was used when using the EPA's central estimate of the Value of Statistical Life (VSL) to estimate the cumulative discounted value of changes in excess mortality from land-use-related changes in air quality.	https://doi.org/10.1021/acs.est.3c02280	Thakrar, S.K., Johnson, J.A., & Polasky, S. "Land-Use Decisions Have Substantial Air Quality Health Effects." Environmental Science & Technology, 58(1), 381-390.

Publication type	Date Published	Location	Summary	URL	Citation
Article	December 2023	NY, CA, WI, TX, United States	This study evaluates the techno-economic feasibility of hybrid renewable energy systems (HRES) for providing electricity in four example localities in the United States: western New York; San Diego, California; Milwaukee, WI; and the entire state of Texas. Emission rates for various generation sources were obtained from the U.S. EPA and health benefits were analyzed using COBRA. By coupling the EPA's AVERT and COBRA tools, this study assesses potential emission reductions from fossil fuels owing to this requirement and regional health benefits via improved air quality, as well as how these benefits vary spatially under high and low projected electricity demands in 2030. Successful implementation of the RPS could produce health benefits equivalent to USD 3–8 million per year for Nevada residents and up to USD 164 million per year for the entire U.S. Lowering electricity demands by 5% in Nevada would lead to a ~10% increase in health benefits.	https://doi.org/10.1016/j.egyr.2022.12.038	Khosravani, Ali, et al. "Challenges of reaching high renewable fractions in hybrid renewable energy systems." Energy Reports, 9, 1000-1017.
Report	December 2023	Maryland, United States	To estimate the impacts of the Current + Planned Policies scenario, RESI translated the outputs from the Global Change Analysis Model (GCAM) and the Co-benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) into inputs for REMI.	Economic Impact Analysis.pdf (maryland.gov)	Towson University: Regional Economic Studies Institute (RESI). "Economic and Fiscal Impacts of Maryland's Greenhouse Gas Reduction Policies."

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Report	September 2023	United States	To address the state carbon tax proposal, emissions taxes on conventional pollutants contributing to PM2.5 (NOX, SO2, and direct particulates) are needed by sector. This report assumed that the taxes would equal the dollar benefits to the US per ton of emissions reduced in New York State. The literature offers such estimates for regions and cities, as well as by source because sources (e.g., power plants) have a different pattern of dispersal and chemical transformation than ground-level sources (e.g., transportation, home heating by natural gas). However, the literature doesn't provide these estimates for New York. COBRA was used to determine these estimates.	https://media.rff.org/documents/Report_23-12.pdf	Krupnick, A., et al. "Prioritizing Justice in New York State Climate Policy: Cleaner Air for Disadvantaged Communities?."
Article	September 2023	United States	This study describes the process for generating a new source-receptor matrix for PM2.5 and O3 based on the source apportionment feature in CAMx. The resulting PM2.5 concentrations from this matrix are compared to the concentrations estimated using the source receptor matrix in COBRA v4.1. The new matrix from this paper is incorporated into COBRA v5.0, which allows for improved estimation of PM2.5 and estimation of O3, which was not previously included in COBRA.	https://doi.org/10.1021/acs.est.3c03317	Baker, K.R., et al. "Source–Receptor Relationships Between Precursor Emissions and O3 and PM2. 5 Air Pollution Impacts." Environmental Science & Technology, 57(39), 14626-14637.

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Article	August 2023	United States	COBRA is used in this study when comparing health impact assessment tools to estimate the health and economic value associated with changes in air quality. The authors discuss that "*COBRA uses a similiar approach to BenMAP-CE but has a reduced-form air quality model built into the assessment tool. COBRA can only be used for studies within the U.S. and the model is run at a coarser resolution (county-level) than that of BenMap-CE. Modelling tools such as the ZIP Code Air Pollution Policy Assessment (ZAPPA) tool utilize reduced-form models, including COBRA, to assess health and monetary benefits at a neighborhood scale.*"	https://doi.org/10.1016/j.envres.2023.116242	O'Regan, A.C., & Nyhan, M.M. "Towards sustainable and net-zero cities: A review of environmental modelling and monitoring tools for optimizing emissions reduction strategies for improved air quality in urban areas." Environmental Research, 116242.
Article	April 2023	United States	COBRA was referenced here when discussing heath related analysis. The health analysis used attributable fraction of disease burden due to exposure to air pollutants. The attributable fraction (AF) is based on a log-linear concentration-response function for mortality due to exposure to air pollutants. The log-linear relationship between ambient air pollutant concentration and health outcome is defined as: $AF = 1 - \exp^{-\beta \Delta X}$ where AF is the attributable fraction, β is the concentration-response coefficient (the slope of the log-linear relationship between concentration and relative risk (RR) reported in epidemiological studies), and delta X is the change in concentration for PM2.5 or NO2.	https://doi.org/10.1038/s43247-023-00799-1	Chang, S.Y., et al. "Electric vehicle fleet penetration helps address inequalities in air quality and improves environmental justice." Communications Earth & Environment, 4(1), 135.

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Report	April 2023	United States	The COBRA health impacts screening and mapping tool was used to calculate health impacts. Particulate emission reductions are converted to changes in the incidence of mortality, heart attacks, asthma, and lost workdays, using COBRA.	Delivering impact from us green bank financing.pdf (jaipuria.ac.in)	Buehler, K., Eis, J., & Levy, C. "Delivering transformative impact from US green bank financing."
Article	March 2023	Virginia, United States	This study presents an analysis of the health and health cost benefits from transitioning to fossil fuel-free electric generation in Virginia following the recently enacted Virginia Clean Economy Act (VCEA). Their analysis uses COBRA to investigate, at the county level, the health and health-cost benefits of decarbonization of the power sector in the state. Their co-benefits include avoided deaths, fewer hospital admissions from respiratory and cardiovascular issues, and fewer work loss days due to exposure to harmful pollutants like PM2.5. They also present significant economic benefits, with the highest estimates showing nearly $350 million in avoided health and health-care costs per year once full shift towards non-carbon emitting generation is achieved in 2045.	https://doi.org/10.1016/j.heliyon.2023.e20198	Ortiz, Luis E., et al. "Public health benefits of zero-emission electric power generation in Virginia." Heliyon, 9.9.
Report	February 2023	Virginia, United States	The analysis conducted in this study use COBRA's 2023 estimates as the demographic and emissions baseline for the analysis and projected a consistent rate of emission reductions between 2023 and 2045 to reach 0% in 2045. Their results reflect ranges from low and high estimates of the effect of pollutants on mortality and health which are pooled from peer-reviewed studies. The scenarios evaluated were based only on reducing fossil fuels used in electric utilities to generate electric power by utilities; they do not account for fossil fuel use in transportation and resource extraction or account for future changes in electricity consumption.	FinalReport.pdf (squarespace.com)	George Mason University Virginia Climate Center. "The public health benefits of a zero-emissions power sector in Virginia."

Publication type	Date Published	Location	Summary	URL	Citation
Article	February 2023	United States	This study references COBRA when citing the multiple RCMs that are available. Reduced-complexity models (RCMs) simplify the full simulation pathway and allow for predictions of both PM2.5 concentrations and the monetized health impacts (i.e., social costs) of PM2.5 concentrations from a perturbed set of emissions much faster than traditional models.	https://doi.org/10.1021/acs.est.2c06317	Gentry, B.M., Robinson, A.L., & Adams, P.J. "EASIUR-HR: A Model to Evaluate Exposure Inequality Caused by Ground-Level Sources of Primary Fine Particulate Matter." Environmental Science & Technology, 57(9), 3817-3824.
Working Paper	January 2023	United States	This study uses COBRA to project each county's ground-level airborne PM2.5 concentration based on projected emissions. PM2.5 accounts for most of the damage from poor air quality. COBRA is used to estimate county-by-county premature mortality, illness, and the dollar value of the health damages caused by changes in the PM2.5 concentrations in ground-level air.	WP_23-01_3VmQdgg.pdf (rff.org)	Funke, Christoph, et al. "What Are the Climate, Air Pollution, and Health Benefits of Electric Vehicles?."
Doctoral Thesis	January 2023	Delhi, India	This thesis compares AP-HRA Tools, including their study area, health impacts, pollutants, spatial resolution, strengths, weaknesses, opportunities, and threats.	Microsoft Word - V8 Tavoos-FinalThesis (kyushu-u.ac.jp)	Bhat, T.H., "Model development for quantifying the multiple environmental-health-economic benefits from low-emission urban transport development strategies in Delhi, India." Dissertation, Kyushu University.
Article	November 2022	California, United States	The study used COBRA to estimate the public health impact reductions at the county level within the state of California. The study estimated the benefits from the avoided gas use from residential appliance electrification and the impacts from the increased output of the grid's fossil EGUs required to supply newly electrified loads. By comparing these two over time, the study estimated the overall net public health benefits from the different electrification pathways previously described.	https://www.sciencedirect.com/science/article/pii/S2210670722004413#bib0021	Fournier, E., et al., "Net GHG Emissions and Air Quality Outcomes from Different Residential Building Electrification Pathways Within a California Disadvantaged Community." Sustainable Cities and Society 86 (2022): 104128

Publication type	Date Published	Location	Summary	URL	Citation
Article	October 2022	United States	Using COBRA, three decarbonization scenarios and their impacts at the regional and county scales are compared. The changes in county-level ambient fine particulate matter (PM2.5), and associated mortality impacts for each decarbonization scenario are compared with demographic data to evaluate the relative exposure reduction benefit across race and ethnicity. Carbon-free electricity would reduce national average ambient PM2.5 concentrations by 0.21 μg m−3 , compared with a 0.19 μg m−3 reduction associated with carbon-free industrial activity, and a 0.08 μg m−3 reduction associated with carbon-free light duty vehicle (LDV) transportation.	https://doi.org/10.1088/1748-9326/ac99ef	Gallagher, C.L., & Holloway, T. "US decarbonization impacts on air quality and environmental justice." Environmental Research Letters, 17(11), 114018.
Report	September 2022	United States	For health damages, the study used a linear approximation of the U.S. Environmental Protection Agency's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to estimate the number of premature deaths due to emissions, and then translated those into costs using values of $12 million per adult premature death and $13.4 million per infant premature death based on updated in accordance with.	https://www.rff.org/publications/reports/pathways-toward-grid-decarbonization-impacts-and-opportunities-for-energy-customers-from-several-us-decarbonization-approaches/	Shawhan, D., Witkin, S., & Funke, C. "Pathways Toward Grid Decarbonization: Impacts and Opportunities for Energy Customers from Several U.S. Decarbonization Approaches."

Publication type	Date Published	Location	Summary	URL	Citation
Report	August 2022	United States	The EnergyPATHWAYS model now calculates changes over time in PM2.5, NOx, and SOx emissions from demand technologies, most notably vehicles and building technologies. The RIO model calculates changes in emissions from new and existing power plants. These results are then used to construct Air Quality Scenarios using the EPA's COBRA model, which employs a reduced form air quality model to estimate ambient concentrations of PM2.5, NOx, and SOx by county. These county-level estimates are translated into health outcomes through concentration-response functions, and then into economic benefits using assumptions about the economic costs of each type of health impact. This allows us to compare the potential range of societal health benefits on a dollar basis across all scenarios.	https://www.evolved.energy/post/adp2022	Haley, B. et al. "United States Annual Decarbonization Perspective 2022."
Article	May 2022	United States	This model references COBRA when introducing RCMS. The authors acknowledge that complex CTMs are time and resource intensive, but that modelers can instead use reduced-complexity air quality models (RCMs). COBRA is referenced when citing gaussian RCMS.	https://doi.org/10.1016/j.scitotenv.2022.153418	Thind, M.P., Heath, G., Zhang, Y., & Bhatt, A. "Characterization factors and other air quality impact metrics: Case study for PM2.5-emitting area sources from biofuel feedstock supply." Science of the Total Environment, 822, 153418.
Report	May 2022	United States	The study used EPA's CO-Benefits Risk Assessment screening tool to estimate health benefits resulting from the removal of PM2.5-related emissions from these energy-related sectors. The study found that nationwide efforts to eliminate energy-related emissions could prevent 53,200 (95% CI: 46,900–59,400) premature deaths each year and provide $608 billion ($537–$678 billion) in benefits from avoided PM2.5-related illness and death. It also found that an average of 69% (range: 32%–95%) of the health benefits from emissions removal remain in the emitting region.	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2022GH000603	Mailloux, N. et al. "Nationwide and Regional PM2.5-Related Air Quality Health Benefits form the Removal of Energy-Related Emissions in the United States." GeoHealth.

Publication type	Date Published	Location	Summary	URL	Citation
Article	April 2022	United States	We explore economic, distributional and health consequences of U.S. greenhouse gas emissions objectives that could be achieved using Section 115 of the Clean Air Act (international air pollution), which has only recently received detailed legal analysis as a potential U.S. climate policy tool. COBRA was used in this study to provide county level population and all-cause mortality incidence rates for the year 2025.	https://doi.org/10.1088/1748-9326/ac6227	Yuan, Mei, et al. "Meeting US greenhouse gas emissions goals with the international air pollution provision of the clean air act." Environmental Research Letters, 17.5, 054019.
Report	April 2022	New York City, United States	The study developed a new ZIP Code-Level Air Pollution Policy Assessment (ZAPPA) tool for NYC by integrating two reduced form models–Community Air Quality Tools (C-TOOLS) and the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)–that propagate emissions changes to estimate air pollution exposures and health benefits.	https://pubs.acs.org/doi/full/10.1021/acs.est.1c07325	Shukla, K. "ZIP Code-Level Estimation of Air Quality and Health Risk Due to Particulate Matter Pollution in New York City." Environ. Sci. Technol 56 11 (2022): 7119-7130.
Report	March 2022	United States	This report presents the findings from an evaluation of the Building Energy Modeling (BEM) program in the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Building Technologies Office (BTO). The evaluation calculated emissions of NOx, PM2.5, SO2, VOC, and NH3 by multiplying net DOE funded BEM energy savings by various emissions factors from the AVERT tool (electricity) and EPA's AP-42 Compilation of Air Emissions Factors database (natural gas). The evaluation calculated CO2e emissions using emissions factors from eGRID for electricity and EPA's Greenhouse Gas (GHG) Emission Factors Hub for natural gas. Next, the evaluation converted the emissions related to ambient air quality into avoided health endpoints and healthcare benefits using COBRA. COBRA results were population-adjusted using U.S. Census Data to reflect the changing U.S. population during each year of the study period.	Evaluation of Building Energy Modeling Technology Research and Development Activities for Building Technologies Office.pdf	Owens, M., et al. "Evaluation of Building Energy Modeling Technology Research and Development Activities for Building Technologies Office."

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Article	January 2022	United States	This article reviews the current state of advancing energy equity in the United States. The authors list COBRA as a tool used to estimate the monetary effects of energy operations on environmental exposure to communities.	https://www.sciencedirect.com/science/article/pii/S1040619021001548	McNamara, W., Passell, H., Montes, M., Jeffers, R., & Gyuk, I. "Seeking Energy Equity through Energy Storage." The Electricity Journal, 35.
Article	December 2021	United States	Underserved communities are disproportionately impacted by acute pollutants from operation of the energy sector compared to other communities. COBRA is used in this study when discussing approaches to measure these effects for underserved communities. *"One such approach is termed mortality risk valuation, which allows for a monetary value to be placed on the increased mortality posed by environmental conditions. A second such metric is the monetary value associated with increased medical expenses and lost economic opportunity such as time away from work caused by poor environmental conditions. These factors combined can be added and compared using risk-based approaches via cost benefit analysis. A common tool for estimating these effects is COBRA".*	https://doi.org/10.1016/j.tej.2021.107063	McNamara, W., et al. "Seeking energy equity through energy storage." The Electricity Journal, 35(1), 107063.
Article	November 2021	Utah, United States	Uses COBRA to assess the air quality benefits of reductions of mobile-source air pollutants during the pandemic-induced shutdown from March to April 2020 in Utah's Wasatch Front and compares the benefits to the social costs of reduced vehicle trips. Results showed that the social costs of reduced vehicle trips outweighed the air quality benefits in most cases.	https://doi.org/10.4236/jep.2021.1211052	Hartley, E. & Caplan, A.J. "Measuring the Social Net Benefits of COVID-19 Restrictions: The Case of Reduced Vehicle Use in a Pollution-Prone Region of Utah." Journal of Environmental Protection, 12, 887-902.
Article	November 2021	Georgia, United States	Uses COBRA to assess source-specific impacts on $PM_{2.5}$ pollution to understand the health impacts of prescribed fire. Estimates that prescribed burning can result in hundreds of cases per year of morbidity and mortality.	https://www.sciencedirect.com/science/article/abs/pii/S0048969721037840	Afrin, S., & Garcia-Menendez, F. "Potential Impacts of Prescribed Fire Smoke on Public Health and Socially Vulnerable Populations in a Southeastern US State." Science of The Total Environment, 794.

Publication type	Date Published	Location	Summary	URL	Citation
Presentation	October 2021	New York, United States	Uses COBRA to quantify and monetize the health co-benefits of New York's Climate Leadership and Community Protection Act, which will result in net zero GHG emissions in New York by 2050. Estimates tens of thousands of avoided deaths and monetized benefits of up to $120 billion by 2050.	https://climate.ny.gov/-/media/Migrated/CLCPA/Files/2021-10-14-CAC-Meeting-presentation.ashx	New York State Climate Action Council. Meeting Minutes, Meeting 16, October 14, 2021.
Book	September 2021	United States	COBRA is referenced in this book when discussing risk assessment tools. *"The Co-Benefits Risk Assessment (COBRA) model (Environmental Protection Agency, 2004) which uses built-in source-receptor atmospheric sensitivity matrices in place of atmospheric modelling, allows quick estimates of health impacts from various emission sources."*	https://doi.org/10.1007/978-3-030-76235-3_11	Borisova, T. "Environmental nanoparticles: focus on multipollutant strategy for environmental quality and health risk estimations." In: Stoika RS (ed) Biomedical nanomaterials. Springer, Cham.
Brief	September 2021	United States	COBRA and AVERT are used to combine the outputs for power plant analysis in 14 regions across the United States. The health benefits vary dramatically by region, depending on two key factors: the types of power plants that will be displaced by energy efficiency and renewable energy, and the proximity of those power plants to population centers. The lowest impacts are in California and the Northwest, where coal is seldom the marginal generating resource and where high-emitting power plants are primarily located in remote areas away from population centers. The highest impacts are in the mid-Atlantic, Midwest and Carolinas, where the opposite is true. The Appendix to this brief provides the full published EPA results.	Health Benefits by the Kilowatt-Hour: Using EPA Data to Analyze the Cost-Effectiveness of Efficiency and Renewables (raponline.org)	Seidman, N.L., Shenot, J., & Lazar, J. "Health Benefits by the Kilowatt-Hour: Using EPA Data to Analyze the Cost-Effectiveness of Efficiency and Renewables."

Publication type	Date Published	Location	Summary	URL	Citation
Report	August 2021	United States	This report cites COBRA when discussing a 2009 case study: *"Considering local-level demographic risk factors would improve our understanding of both the aggregate and distributional impacts of many regulations. For instance, the average dose-response function between particulate matter concentration and mortality identified in a 2009 study of the American Cancer Society is widely used in the quantification of costs related to pollution exposure, including by EPA's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool."*	**[PDF]** bakerbotts.com	Lienke, J., Paul, I., Sarinsky, M., Ünel, B., & Varela, A. "How Cost-Benefit Analysis Can Promote Equity and Advance Environmental Justice". Institute for Policy Integrity. New York University School of Law.
Presentation	August 2021	New Mexico, United States	This presentation uses COBRA when presenting the monetized associated negative heath affects and estimated carbon prices when considering NOx, PM2.5, or SO2. The two problem statements in this talk are: (1) *"What combination of battery power, battery energy, and PV power capacity will match the peak load support service of a given peaker plant at minimum cost?"* (2) "*How well would the BESS+PV sized for <=10 hour periods preform when trying to match the unmodified Reeves dispatch power?*"	https://www.osti.gov/servlets/purl/1826738	West, A., & Rosewater, D. Energy Storage Peaker Plant Replacement: Battery/PV Sizing and Control (No. SAND2021-10123PE). Sandia National Lab. (SNL-NM), Albuquerque, NM (United States).
Report	August 2021	Oregon, United States	Uses COBRA to quantify and monetize the health co-benefits of Oregon's Climate Protection Program, which will reduce GHG emissions to nearly 20% below 1990 levels by 2050. Estimates up to $2 billion in cumulative health benefits between 2020 and 2050.	https://www.oregon.gov/deq/ghgp/Pages/modelingstudy.aspx	State of Oregon Department of Environmental Quality. "Modeling Study on Program Options to Reduce Greenhouse Gas Emissions."
Report	June 2021	New Jersey, United States	Uses COBRA to calculate health benefits under New Jersey's proposed rule: Advanced Clean Trucks Program and Fleet Reporting Requirements. Estimates total health benefits between $288 million - $648 million.	https://njadapt.rutgers.edu/images/NJ_Climate_Change_Alliance_comments_on_ACT_Rule_2_1.pdf	Lowrie, K.W., Kilkelly, E., Herrera, A., & Petrozzo, K. "Health Note on the New Jersey Department of Environmental Protection proposed regulation: Advanced Clean Trucks Program and Fleet Reporting Requirements."

Publication type	Date Published	Location	Summary	URL	Citation
Article	May 2021	United States	Uses COBRA within the Engineering, Economic, and Environmental Electricity Simulation Tool (E4ST) to examine the health impacts and monetized benefits of US tax law policy that provides subsidies for coal that has been "refined" prior to burning with the intention of emitting less nitrogen oxides (NO_x), sulfur dioxide (SO_2), and mercury (Hg). Finds that the policy reduces social welfare because the subsidy extends the operational life of some coal plants.	https://www.sciencedirect.com/science/article/pii/S0140988320303637	Prest, B. C., & Krupnick, A. How Clean is "'Refined Coal'? An Empirical Assessment of a Billion-Dollar Tax Credit." Energy Economics, 97.
Report	May 2021	Illinois, United States	Scientists at the University of Wisconsin--Madison use COBRA to estimate the health benefits of avoided PM2.5 exposure resulting from decarbonizing Illinois' electricity sector by 2030. Total PM2.5 includes direct emissions, as well as nitrate and sulfate particles formed in the atmosphere due to emissions of NOx and SO2. Illinois residents were projected to avoid annually: 3,570 lost-work days, 1,980 cases of respiratory and asthma symptoms, 3 - 28 heart attacks, and 30 - 69 premature deaths. These health benefits, especially the avoided deaths, are valued at $293 and $740 million dollars per year.	https://resphealth.org/wp-content/uploads/2021/05/Health-Benefits-from-Carbon-Free-Electricity.pdf	Meier, P., & Holloway, T. "Illinois Health Impacts from Transitioning to 100% Carbon-Free Electricity." The Holloway Group @ SAGE.
Policy Paper	April 2021	United States	This paper references COBRA when stating: *"County level population and all-cause mortality incidence rates are from EPA's COBRA model for the year 2025."*	https://scholarworks.smith.edu/env_facpubs/13/	Yuan, M., et al. "Meeting Potential New U.S. Climate Goals" (2021). Environmental Science and Policy: Faculty Publications, Smith College, Northampton, MA
Report	April 2021	Massachusetts, United States	Uses COBRA for county level population and all-cause mortality incidence rates to estimate national net benefits of climate policies in 2030. Finds the net benefits of such policies range from $72 billion - $156 billion, including avoiding 3,544 – 14,356 premature deaths.	https://globalchange.mit.edu/sites/default/files/MITJPSPGC_Rpt351.pdf	Yuan, M., et al. "Meeting Potential New US Climate Goals." MIT Joint Program on the Science and Policy of Global Change, Report 351.

Publication type	Date Published	Location	Summary	URL	Citation
Master's Project	April 2021	California, Florida, and Massachusetts, United States	Includes a reference to COBRA in a literature review of Net Energy Metering policy benefits.	https://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/22629/MP%20Final%20Report_Ghadiri_Krishnan_Li.pdf?sequence=1	Ghadiri, F., Krishnan, A., & Li, R. "Reforming Solar Net Metering: Master's Project." Duke University.
Article	March 2021	New York, United States	Includes COBRA in a list of a models that can be used to estimate reductions in the numbers and related costs of adverse health-outcomes using exposure outcome relationships.	https://www.sciencedirect.com/science/article/pii/S1309104221000295	Hopke, P. K., & Hill, E. L. Health and Charge "Health and Charge Benefits from Decreasing PM2. 5 Concentrations in New York State: Effects of Changing Compositions." Atmospheric Pollution Research, 12(3), 47-53.
Article	February 2021	United States	Evaluates several Air Pollution Health Risk Assessment tools, including COBRA, taking into account their spatial resolution, technological factors, pollutants addressed, geographical scale, quantified health effects, method of classification, and operational characteristics. Conducts a comparative analysis of these tools, including COBRA.	https://www.mdpi.com/1660-4601/18/4/1935/htm	Hassan Bhat, T., Jiawen, G., & Farzaneh, H. "Air Pollution Health Risk Assessment (AP-HRA), Principles and Applications." International Journal of Environmental Research and Public Health, 18.
Report	February 2021	United States	This study obtains PM2.5 concentration change into PM2.5-health concentration-response (C-R) functions using COBRA. COBRA was also used for its list of unit values relevant to each health endpoint.	Rpt_21-04_final.pdf (rff.org)	Villaneuva, S., Cleary, K., & Krupnick, A. "The Societal Value of the HYSPLIT Air Dispersion Model."
Article	2021	Global	Cites COBRA as a widely used reduced-complexity air quality model.	https://chemrxiv.org/engage/chemrxiv/article-details/6154935bd1fc332d77f868e1	Thakrar, S., et al. "Global, High-Resolution, Reduced-Complexity Air Quality Modeling Using InMAP (Intervention Model for Air Pollution)". ChemRxiv. Cambridge Open Engage.

Publication type	Date Published	Location	Summary	URL	Citation
Abstract	2021	United States	EPA's COBRA model was used to estimate U.S. public health benefits and their economic value from reduced emissions and used Social Cost of Carbon estimates to value reduced GHG emissions. Results: In an achievable 2050 scenario for the transition to ZEVs paired with increasing renewables on the electric grid could reduce national NOx, VOC, and PM2.5 emissions by 1.3 million, 0.84 million, and 53,000 tons. These reductions could result in avoiding 6,300 premature deaths and other adverse health effects nationally, with public health improvements valued at $72 billion (2017 USD, 3% discount rate), and GHG emissions reductions resulting in $110 billion in avoided climate change impacts globally, all for 2050.	https://apha.confex.com/apha/2021/meetingapi.cgi/Session/63641?filename=2021_Session63641.pdf&template=Word	Belova, A., Cochran, F., & Billings, P. "Connecting Science and Policy Via Integrated Health Impact Assessments-Environment-Oral Virtual." APHA 2021 Annual Meeting and Expo. APHA.
Report	2021	New York, United States	Uses AVERT and COBRA to estimate the human health benefits of building 5 GW of mid- to large-scale solar in the Northeast Region. Estimates benefits of up to 36 lives saved and a value of up to $345 million.	http://solarroadmap.org/report/	Price, J., Delach, A., Leu, K., Morris, C., Schelly, C., & Thapaliya, R. "Long Island Solar Roadmap: Advancing Low Impact Solar in Nassau and Suffolk Counties." The Nature Conservancy and Defenders of Wildlife.
Report series	2020-present	Wisconsin, United States	The goal of the report series is to investigate how energy transitions can alleviate the compounding burden of the intersecting disparities between air pollution, climate change, and energy inequity.	https://hollowaygroup.org/project/environmental-justice-dimensions-of-air-pollution	Gallagher, C., & Holloway, T. Office of the Vice Chancellor for Research and Graduate Education at UW–Madison.
Chapter	2020	United States	Given the policy-relevant implications of co-benefits at the city scale, this review evaluates the existing tools/models to assess both carbon and air pollution in urban environments.	https://www.taylorfrancis.com/chapters/edit/10.1201/9781003043461-46/review-fine-scale-air-quality-modeling-carbon-health-co-benefits-assessments-cities-andrew-fang-anu-ramaswami	Fang, A., & Ramaswami, A. "Review of Fine-Scale Air Quality Modeling for Carbon and Health Co-Benefits Assessments in Cities." In Managing Air Quality and Energy Systems. CRC Press.

Publication type	Date Published	Location	Summary	URL	Citation
Working Paper	December 2020	United States	For health damages, the authors use a linear approximation of COBRA to estimate the number of premature deaths due to emissions, and then translate those into costs using values of $13.4 million per infant premature death and $12 million per adult premature death based on (EPA, 2013) updated to 2050 in accordance with (EPA, 2014).	https://media.rff.org/documents/Advanced_Energy_Technologies_Part_1__Modeling_Results.pdf	Shawhan, D., Funke, C., & Witkin, S. "Benefits of Energy Technology Innovation."
Article	November 2020	United States	This study states that seven reduced-form models were used across eleven studies to calculate ambient air quality effects, as well as health and economic metrics. COBRA is mentioned here and it is noted that they are cited in two studies.	https://doi.org/10.3389/fpubh.2020.563358	Gallagher, C.L., & Holloway, T. "Integrating air quality and public health benefits in US decarbonization strategies." Frontiers in public health, 8, 563358.
Master's Thesis	November 2020	Arizona United States	Uses COBRA and BenMAP to compare estimated benefits of different wood biomass energy-use scenarios.	https://www.proquest.com/openview/f9da009ddd0e8cc8085cffa2f22dbcc7/1?pq-origsite=gscholar&cbl=18750&diss=y	Hedgepeth, M. "Quantifying and Monetizing the Benefits of Displacing Fossil Fuels with Woody Biomass Energy for Electricity Generation in the Southwestern United States." Dissertation, Northern Arizona University.
Report	2020	United States	Uses COBRA to estimate the health impacts of transitioning to electric vehicles along with increasing renewable generation. Estimates 6,300 premature deaths avoided, resulting in $72 billion in benefits.	https://www.lung.org/clean-air/electric-vehicle-report	American Lung Association. "The Road to Clean Air: Benefits of a Nationwide Transition to Electric Vehicles."
Conference proceeding	October 2020	United States	Includes COBRA as a method for benefits estimation in state climate plans, including how COBRA can be used to quantify benefits and demonstrate that climate action and decarbonization can achieve multiple policy objectives.	https://apha.confex.com/apha/2020/meetingapi.cgi/Paper/479753?filename=2020_Abstract479753.pdf&template=Word	Zinsmeister, E., Cooley, D., Griot, O., & Assmus, P. "Public Health Co-Benefits of Greenhouse Gas Emission Reductions: Methods for Benefits Estimation in State Climate Plans." APHA's 2020 VIRTUAL Annual Meeting and Expo.

Publication type	Date Published	Location	Summary	URL	Citation
Report	September 2020	North Carolina, United States	Uses COBRA to estimate the financial impact on public health from North Carolina's Clean Energy Plan, which includes a 70% reduction in emissions by 2040. Estimates cumulative health-related savings to be between $309,093,000 and $699,712,000 from 2021 to 2040.	https://www.aceee.org/sites/default/files/pdfs/u2007.pdf	Gold, R., Cohn, C., Hoffmeister, A., & Molina, M. "How Energy Efficiency Can Help Rebuild North Carolina's Economy."
Article	September 2020	United States	Uses COBRA for a spatial analysis of the overall health benefits from simultaneous emission reductions. Estimates savings to be between $437 million and $988 million with savings especially in the Eastern half of the United States (with the NAAQS at 10 $\mu g/m^3$ and 25 $\mu g/m^3$). Also estimates the NAAQS at 8 $\mu g/m^3$ and 25 $\mu g/m^3$ and finds estimated savings to be between $1.9 billion and $4.4 billion, especially concentrated in the Northeast United States.	https://jareonline.org/articles/evaluating-the-efficacy-of-ambient-air-quality-standards-at-coal-fired-power-plants/	Raff, Z, & Walter, J.M. "Evaluating the Efficacy of Ambient Air Quality Standards at Coal-Fired Power Plants." Journal of Agricultural and Resource Economics, 45:428-444.
Report	August 2020	United States	COBRA and AVERT are used to estimate the value of public health benefits resulting from changed electricity generation. A range of public health benefit estimates was constructed, reflecting either a uniform efficiency impact or peak period efficiency impact, and either a 3% discount rate or a 7% discount rate.	Microsoft Word - 1-0376_0549_000494-LANGEVIN thirddraft.docx (lbl.gov)	Langevin, J., Satre-Meloy, A., & Fadali, L. "Attaching public health benefits to building efficiency measures at the national and regional scales." ACEEE Summer Study on Energy Efficiency in Buildings.

Publication type	Date Published	Location	Summary	URL	Citation
Master's Thesis	August 2020	Massachu-setts, United States	Uses COBRA to evaluate the health savings of eliminated VOC, NO_x, SO_x, and $PM_{2.5}$ emissions from a fleet-wide transition to electric school buses. Estimates total benefits (over 20 years) to be between $1,578,664 and $3,565,071. Other results include savings from avoided mortality ($1,557,552-$3,519,989), non-fatal heart attacks ($2,893-$26,883), hospital admissions ($3,960.6), acute bronchitis ($109), upper respiratory symptoms ($138), lower respiratory symptoms ($61), minor restricted activity days ($8,659), work loss days ($3,390), and asthma exacerbation ($250).	https://capstone.extension.harvard.edu/files/capstone/files/massoli_paola_082120.pdf	Massoli, P. "Clean Ride to School: Viability and Opportunities of School Bus Electrification in Massachusetts."
Report	August 2020	Nebraska, United States	Uses COBRA to evaluate the health benefits from eliminated coal emissions in the Omaha metro area and Nebraska. Monetized benefits from statewide reductions in emissions would result in $62 million to $140 million and $55 million to $125 million in total avoided healthcare costs overs 20 years (at 3% and 7% discount rate, respectively).	https://capstone.extension.harvard.edu/files/capstone/files/lepesuastegui_jose_20.08.23.pdf	Lepesuastegui, J.L., & Wetzler, R.E. "Rethinking Nuclear Waste: Recycling Spent Fuel in the Era of Renewable Energy."
Comments	May 2020	United States	Cites recent EPA air actions that rely on underlying scientific data that would be restricted from consideration based on the proposed rule "Strengthening Transparency in Regulatory Science". COBRA is included in this list.	https://www.nrdc.org/sites/default/files/media-uploads/2020-05-18_censoring_science_supplemental_proposal_-_nrdc_comments_final.pdf	Natural Resources Defense Council. Comments of Natural Resources Defense Council on "Strengthening Transparency in Regulatory Science (Supplemental notice of proposed rulemaking)."
Comments	April 2020	Missouri, United States	Explains how COBRA can be used to quantify and monetize air quality and health impacts from the displacement of emissions at power plants by energy efficiency and renewable energy. Also explains COBRA's simplified air quality model to convert air pollution changes to air quality impacts.	https://static1.squarespace.com/static/5936d98f6a4963bcd1ed94d3/t/5e8dd9e5c19cc97b1dc2b72e/1586354662259/Sierra+Club+2020+Ameren+IRP+Comments.pdf	Sierra Club. "Sierra Club's Initial Comments on Ameren Missouri's 2020 Integrated Resource Planning Process."

Publication type	Date Published	Location	Summary	URL	Citation
Master's Dissertation	2020	Illinois, United States	Uses COBRA to demonstrate that increased compliance with an energy-efficiency portfolio standard in Illinois will reduce $PM_{2.5}$ emissions by 8.8 tons, contributing to an additional $1.2 million to $3.2 million saved from avoided health impacts.	https://digitalcommons.mtu.edu/cgi/viewcontent.cgi?article=2174&context=etdr	Turegeldin, A. "Linking Energy Efficiency and Public Health: A Case Study of Illinois." Michigan Technological University Dissertations, Master's Theses and Master's Reports.
Article	August 2020	Italy	Uses COBRA to account for the health benefits in an analysis of a hydrogen production facilities for power-to-gas and hydrogen mobility under different renewable sources.	https://www.sciencedirect.com/science/article/pii/S0196890420308700	Petronilla, F., & Genovese, M. "Technical-Economic Analysis of a Hydrogen Production Facility for Power-to-Gas and Hydrogen mobility under different renewable sources in Southern Italy." Energy Conversion and Management, 223.
Conference proceeding	2020	Illinois, United States	Uses COBRA to evaluate monetized health benefits associated with four ComEd energy efficiency programs from 2018-2034. Researchers worked with EPA to develop a customized COBRA model for ComEd's discount rate of 2.38 percent. Estimates savings to be $70,250,000 from reduced mortality, $500,000 from reduced work loss, $130,000 from reduced other health impacts, and $130,000 from reduced hospital and emergency room visits.	https://www.greenandhealthyhomes.org/wp-content/uploads/How-much-are-non-energy-benefits-worth.pdf	Plympton, P., Eakin, B., Erickson, J., Gunderson, S., Gunn, R., Halbach, G., Minor-Baetens, J., Podolefsky, M., Williams, B., Young, E., Johnson, K., & Klein, W. "How Much are Non-Energy Benefits Worth? Quantifying and Monetizing Values to Include in ComEd's Income Eligible Energy Efficiency Programs' Cost-Effectiveness Tests." ACEEE.
Article	June 2020	United States	References COBRA's use in a summary of papers that modeled alternative energy scenarios in North America, China, Taiwan, Europe, or Brazil.	https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/7318470	Tham, R., Morgan, G., Dharmage, S., Marks, G., & Cowie, C. "Scoping Review to Understand the Potential for Public Health Impacts of Transitioning to Lower Carbon Emission Technologies and Policies." Environmental Research Communications, 2.
Report	May 2020	United States	Lists how two studies have used COBRA. One study provides a detailed example of critical steps in COBRA mortality calculations. Another study uses COBRA to estimate changes in ambient concentrations of air pollution due to changes in emissions of primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$.	https://escholarship.org/content/qt1924c3g9/qt1924c3g9.pdf?t=qbnieu	Sutter, M., Mitchell-Jackson, J., Schiller, R., Schwartz, L., & Hoffman, I. "Applying Non-Energy Impacts from Other Jurisdictions in Cost-Benefit Analyses of Energy Efficiency Programs: Resources for States for Utility Customer-Funded Programs." Lawrence Berkeley National Laboratory Recent Work.

Publication type	Date Published	Location	Summary	URL	Citation
Article	July 2020	United States	Uses COBRA to estimate how changes in NO_x and SO_2 emissions would impact ambient concentrations of $PM_{2.5}$ in the Regional Greenhouse Gas Initiative and neighboring states.	https://ehp.niehs.nih.gov/doi/pdf/10.1289/EHP6706	Perera, F., Cooley, D., Berberian, A., Mills, D., & Kinney, P. "Co-Benefits to Children's Health of the U.S. Regional Greenhouse Gas Initiative." Environmental Health Perspectives, 128.
College Senior Thesis Paper	May 2020	South Carolina, United States	References a study that used COBRA to evaluate the health impacts of transitioning public buses from diesel to compressed natural gas in Nevada.	https://scholarcommons.sc.edu/senior_theses/377	James, E.L. "Assessing the Feasibility, Costs, and Benefits of Transitioning Part of the University of South Carolina Shuttle Fleet to an Alternative Fuel Source and Promoting Anti-idling Strategies" Senior Theses. 377.
Article	March 2020	United States	References two studies that used COBRA to evaluate the monetary benefits of reduced health incidences from particulate matter exposure.	https://doi.org/10.1016/j.apenergy.2019.114449	Wiser, R., & Millstein, D. "Evaluating the Economic Return to Public Wind Energy Research and Development in the United States." Applied Energy 261.
Master's Thesis	November 2019	Qatar, West Asia	A field study was conducted in six office spaces, three as treatment groups and three as control groups, using EM purifiers, plants and a fake purifier to test the placebo effect. During the study, PM2.5, VOC and carbon dioxide (CO2) were monitored as air pollutants. As response variables, changes in self-reported productivity, satisfaction and health symptoms were captured by a weekly occupant survey. COBRA is listed as a tool used in this study.	https://www.proquest.com/openview/16d391ec1bb62039ee44f7b93410cef6/1?pq-origsite=gscholar&cbl=18750&diss=y	Salem, L. "Impact of Botanical and Electrostatic Mechanical Air Purifiers on Office Indoor Air Quality, Occupants Productivity and Satisfaction in Qatar: A Cost-Benefit Analysis." Harvard University ProQuest Dissertations Publishing, 28276009.

Publication type	Date Published	Location	Summary	URL	Citation
Report	October 2019	Long Island, New York, United States	The Nature Conservancy used COBRA to estimate the human health benefits of building 1 GW of utility-scale solar in the Northeast Region, based on the above AVERT estimates of emissions reductions. Because of air circulation patterns, air pollution can impact human health far from the source of emissions. Table 8 summarizes the total human health benefits and health-related economic benefits across the whole US, the total benefits realized across all of New York, and the benefits that would occur in Nassau and Suffolk counties. This analysis shows that installing 1 GW of utility-scale solar PV would result in 3-7 lives saved and up to $67 million in avoided health harms over 20 years.	Long-Island-Solar-Roadmap_Interim-Economic-Research-Report.pdf (solarroadmap.org)	Price, J., & Boerner, R. "Long Island Solar Roadmap Economic Research Report."
Working Paper	September 2019	United States	COBRA is listed as one option for estimating the health benefits of changes in air pollution, but the paper does not use COBRA.	https://cdn1.sph.harvard.edu/wp-content/uploads/sites/1273/2019/09/Gilmore-Heo-Muller-Tessum-Hill-Marshall-Adams-2019.pdf	Gilmore, E., Heo, J., Muller, N., Tessum, C., Hill, J., Marshall, J., & Adams, P. "Developing Estimates of the Social Costs of Air Pollutants and their Uncertainty using Reduced Complexity Models (RCM)." Prepared for Harvard Center for Risk Analysis "Risk Assessment, Economic Evaluation, and Decisions" workshop.
Article	August 2019	Midwest United States	Uses COBRA to evaluate the health impacts of sub-Renewable Portfolio Standards in the United States. Estimates a health co-benefit of $94/ton CO_2 reduced in the Rust Belt Region.	https://doi.org/10.1088/1748-9326/ab31d9	Dimanchev, E., Paltsev, S., Yuan, M., Rothenberg, D., Tessum, C., Marshall, J., & Selin, N. "Health Co-Benefits of Sub-National Renewable Energy Policy in the US." Environmental Research Letters, 14.
Article	July 2019	United States	Study compares marginal costs from emission sources in the U.S. for multiple GHGs and PM 2.5 from several reduced complexity models, including Air Pollution Emission Experiments and Policy (AP2) Equates COBRA to AP2 and therefore does not examine COBRA.	https://iopscience.iop.org/article/10.1088/1748-9326/ab1ab5	Gilmore, E. et al. "An Inter-Comparison of the Social Costs of Air Quality from Reduced-Complexity Models." Environmental Research Letters.

Publication type	Date Published	Location	Summary	URL	Citation
Report	July 2019	Colorado, United States	Uses COBRA to estimate the monetized value of the health impacts of the Colorado Advanced Clean Car Program. Estimates the annual value of health benefits, which ranges from $14 million to over $100 million.	http://blogs.edf.org/climate411/files/2019/08/FINAL-EDF-Colorado-ZEV-report-2019.pdf	Rykowski, R. "Colorado Zero Emission Vehicle Program Will Deliver Extensive Economic, Health and Environmental Benefits."
Report	June 2019	United States	Uses COBRA to evaluate adult mortality risk reductions from $PM_{2.5}$, NO_x, and SO_2 emissions. Estimates benefits to be $8.64-$0.04 million.	https://media.rff.org/documents/Refined_Coal_Report_11.pdf	Prest, B., & Krupnick, A. "How Clean is 'Refined Coal'? An Empirical Assessment of a Billion-Dollar Tax Credit." Resources for the Future, (2019).
Article	September 2019	United States	Uses COBRA for a spatial analysis of the overall health benefits from simultaneous emission reductions of $PM_{2.5}$ and precursors. Estimates savings to be between $437 million and $988 million, with savings especially occurring in the Eastern half of the United States (with the NAAQS at 10 $\mu g/m^3$ and 25 $\mu g/m^3$). Also estimates the NAAQS at 8 $\mu g/m^3$ and 25 $\mu g/m^3$ and finds estimated savings to be between $1.9 billion and $4.4 billion, especially concentrated in the Northeast United States.	https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3335401	Raff, Z., & Walter, J. "Evaluating the Efficacy of Ambient Air Quality Standards at Coal-Fired Plants." University of Wisconisn-Stout.
Report	May 2019	United States	Uses COBRA to evaluate health benefits from different carbon pricing modeling scenarios. Estimates health benefits to be 3,500-80,000 avoided cases of premature morality and 90,000 cases of exacerbated asthma based on an average reduction in SO_2 and NO_x emissions.	https://www.brookings.edu/wp-content/uploads/2019/05/ES_20190507_Morris_CarbonPricing.pdf	Barron, A., Hafstead, & M., Morris, A. "Policy Insights from Comparing Carbon Pricing Modeling Scenarios." Climate and Energy Economics Discussion Paper.
Article	May 2019	United States	Uses COBRA to evaluate the health damages from plans to expand power grid capacity. Estimates health damages to be $1,173 billion. They also estimate approximate health damages for the following regions: New Jersey ($130 billion), MDDE ($145 billion), New York ($160 billion), Northeast ($210 billion), NYC ($225 billion), and RoPJM ($310 billion).	https://doi.org/10.3390/ijerph16101857	Rodgers, M., Coit, D., Felder, F., & Carlton, A. "A Metamodeling Framework for Quantifying Health Damages of Power Grid Expansion Plans." Int. J. Environ. Res. Public Health, 16.

Publication type	Date Published	Location	Summary	URL	Citation
Article	April 2019	United States	Mentions COBRA as a tool to provide social costs of air quality policy. Discusses COBRA's similarities with Air Pollution Emission Experiments and Policy (AP2).	https://iopscience.iop.org/article/10.1088/1748-9326/ab1ab5/meta	Gilmore, E., Heo, J., Muller, N., Tessum, C., Hill, J., Marshall, J., & Adams, P. "An Inter-Comparison of Air Quality Social Cost Estimates from Reduced-Complexity Models." Environmental Research Letters.
Article	February 2019	United States	Uses COBRA as part of an effort to explore the health impacts of freight truck and trail transport under various policy scenarios.	https://www.nature.com/articles/s41893-019-0224-3	Liu, L., Hwang, T., Lee, S., Ouyang, Y., Lee, B., Smith, S., Tessum, C., Marshall, J., Yan, F., Daenzer, K., & Bond, T. "Health and Climate Impacts of Future United States Land Freight Modelled with Global-to-Urban Models." Nature Sustainability.
Article	February 2019	Nevada, United States	This study assessed the health benefits of transitioning from diesel to CNG buses in Clark County, NV using COBRA, considering the emission and exposure changes from the 2017 baseline for two hypothetical scenarios: (1) no transition (CC_D) and (2) complete transition (CC_N). Estimates $0.98-$2.48 billion per year in health benefits, 114-258 premature deaths, and >5000 avoided respiratory and cardiovascular illnesses.	https://www.mdpi.com/1660-4601/16/5/720	Olawepo, J., & Chen, A. "Health Benefits from Upgrading Public Buses for Cleaner Air: A Case Study of Clark County, Nevada and the United States." International Journal of Environmental Research and Public Health 16.
Article	December 2018	United States	Uses COBRA to estimate health impacts of rolling back environmental regulations on coal-fired power plants. Estimates 17,000 - 39,000 increased mortalities per year. Compares impacts to voting patterns in 2016 election.	https://www.sciencedirect.com/science/article/pii/S0301421518306277X	Thomson, V., Huelsman, K., & Ong, D. "Coal-Fired Power Plant Regulatory Rollback in the United States: Implications for Local and Regional Public Health." Energy Policy: 123.
Article	September 2018	United States	Uses COBRA to evaluate the health impacts of electricity capacity expansion models to incorporate the health impacts into optimization of electricity planning. Estimates $1,013 billion in societal costs.	https://www.sciencedirect.com/science/article/abs/pii/S0360544218317584	Rodgers, M., Coit, D., & Felder, F., Carlton, A. "Generation Expansion Planning Considering Health and Societal Damages–A Simulation-Based Optimization Approach." Energy 164.

Note that links to some publications require a subscription.
Note that inclusion in this list does not necessarily constitute an endorsement of a publication or its methods. Updated April 2024

Publication type	Date Published	Location	Summary	URL	Citation
Case Study	August 2018	Kansas City, Missouri, United States	COBRA is used to quantify the dollar value of the avoided health effects due to the avoided emissions from power plants. The county-level emissions reductions of PM2.5, NOx, and SO2 within AVERT's Lower Midwest region were entered into COBRA to estimate the public health benefits. The emissions reductions from AVERT were entered into COBRA at the county level for the Fuel Combustion from Electric Utilities emissions tier one, using the 2017 emissions baseline. COBRA was used to estimate the monetary value of the benefits of reducing emissions.	C02-075 - Estimating the Environmental Effects of Green Roofs - US.pdf (cedengineering.com)	U.S. Environmental Protection Agency. "Estimating the environmental effects of green roofs: A case study in Kansas City, Missouri." EPA 430-S-18-001.
Report	July 2018	United States	Uses COBRA to evaluate the health impacts of electricity capacity expansion models to incorporate the health impacts into optimization of electricity planning.	https://www.sciencedirect.com/science/article/pii/S0038012117302823	Rodgers, M., Coit, D., Felder, F., & Carlton, A. "Assessing the Effects of Power Grid Expansion on Human Health Externalities."
Report	July 2018	United States	Adds functionality similar to COBRA to Engineering, Economic, and Environmental Electricity Simulation Tool (E4ST). The authors met with Abt Associates to understand the functionality of COBRA, including the S-R Matrix and atmospheric chemistry. Estimates 352-815 premature deaths from additional emissions compared to 24-53 premature deaths when other nuclear power policies are implemented.	http://www.rff.org/files/document/file/RFF%20WP%2018-18.pdf	Shawhan, D., & Picciano, P. "Retirements and Funerals: The Emission, Mortality, and Coal-Mine Employment Effects of a Two-Year Delay in Coal and Nuclear Power Plant Retirements."
Article	March 2018	United States	Uses COBRA to estimate the projected health effects for the average reduction in SO_2 and NO_x in 2025 from a $25 carbon tax. Results are on the order of 3,500–8,000 avoided cases of premature mortality and 90,000 avoided cases of exacerbated asthma. This corresponds roughly to a monetized value of $31–71 billion in health benefits (3% discount rate), with the bulk of the benefits accruing in the upper Midwest and East Coast.	https://www.worldscientific.com/doi/pdf/10.1142/S2010007818400031	Barron, A., Fawcett, A., Hafstead, M., McFarland, J., & Morris, A. "Policy Insights from the EMF 32 Study on US Carbon Tax Scenarios." Climate Change Economics, 9.

Publication type	Date Published	Location	Summary	URL	Citation
Report	March 2018	United States	COBRA is listed and described in "Methodologies for Calculating the Damage per Unit of Emissions for Pollutants that Depend on Time and Location" section. Estimates the dollar value per MWh of SO_2 ($52-171), NO_x ($3-12), and $PM_{2.5}$ ($7-22) and the value of avoided emissions from two natural gas power plants ($30-40/MWh).	https://policyintegrity.org/files/publications/valuing_pollution_reductions2.pdf	Shrader, J., Unel, B., & Zevin, A. "Valuing Pollution Reductions." Institute for Policy Integrity.
Report	February 2018	United States	Analyzes the health impacts of a hypothetical 15% reduction in energy consumption nationwide. Uses AVERT to estimate emission reductions and COBRA to find avoided health harms per capita in states and cities with the highest being $184/per capita in West Virginia and $210/per capita in Pittsburgh. Also finds the avoided costs of adult mortality, nonfatal heart attacks, minor restricted-activity days, infant mortality, lost work days, and respiratory-related symptoms totaling $630,431,926.	http://efficiencyforall.org/wordpress/wp-content/uploads/2017/04/h1801.pdf	Hayes, S., & Kubes, C., "Saving Energy, Saving Lives: The Health Impacts of Avoiding Powerplant Pollution with Energy Efficiency."
Article	February 2018	United States	Analyzes the general equilibrium costs of climate policies that levy taxes on carbon dioxide (CO_2) emissions in the United States and return the revenue in the form of lump-sum rebates and tax relief over the years 2020 to 2040. Uses the US regional version of the Applied Dynamic Analysis of the Global Economy (ADAGE-US) forward-looking dynamic Computable General Equilibrium (CGE) model for this analysis. Uses COBRA to approximate the value of co-benefits to these policies that arise from concomitant reductions in non-greenhouse gas (GHG) emissions. Finds co-benefits per household, including $PM_{2.5}$ co-benefits ($547-$1,234), avoided mortality ($539-$1,217), and avoided morbidity ($3-$12).	https://www.worldscientific.com/doi/abs/10.1142/S2010007818400067	Woollacott, J. "The Economic Costs and Co-Benefits of Carbon Taxation: A General Equilibrium Assessment." Climate Change Economics 9.

Publication type	Date Published	Location	Summary	URL	Citation
Environ-mental Impact Statement	February 2018	New York, United States	Draft EIS for New York State's procurement of 2,400 MW of off-shore wind energy uses COBRA to estimate how the emission reductions from implementation off-shore wind energy would affect ambient air quality and adverse health impacts throughout the coastal region. Finds that the implementation of 2,400 MW of offshore wind energy would result in 8 to 18 fewer premature deaths annually and would avoid multiple adverse health outcomes in 2030 across the northeast United States.	https://tethys.pnnl.gov/publications/draft-generic-environmental-impact-statement-procurement-offshore-wind	New York State Department of Public Service and Ecology and Environment, Inc. "Draft Generic Environmental Impact Statement for Procurement of Offshore Wind".
Report	January 2018	New York, United States	Final report and master plan for New York State's procurement of 2,400 MW of off-shore wind energy uses COBRA to estimate how the emission reductions from implementation of off-shore wind energy would affect ambient air quality and adverse health impacts throughout the coastal region. Found that the implementation of 2,400 MW of offshore wind energy would result in 8 to 18 fewer premature deaths annually and would avoid multiple adverse health outcomes in 2030 across the northeast United States.	https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/About-Offshore-Wind/Master-Plan	New York State Energy Research and Development Authority. "New York State Offshore Wind Master Plan: Charting a Course to 2,400 Megawatts of Offshore Wind Energy".
Public Comments	January 2018	United States	Uses results from COBRA in developing public comments on the proposed Glider Vehicles Rule to estimate the potential public health impacts that could occur should glider vehicles go unregulated. Finds that controlling emissions of these vehicles would reduce 70-160 premature deaths and generate $0.3-$1.1 billion worth of health benefits.	https://www.edf.org/sites/default/files/content/Appendix%20B%20-%20Emission%20and%20Health%20Effects%20of%20Glider%20Vehicles.pdf	Environmental Defense Fund Comment on EPA Proposed Glider Vehicles Rule, Docket ID EPA-HQ-OAR-2014-0827. "Appendix B: Potential Emission and Health Impacts of Glider Kits."

Publication type	Date Published	Location	Summary	URL	Citation
Report	December 2017	Virginia, United States	Uses COBRA to analyze the effects of whether Virginia linked to RGGI and established its CO_2 Budget Trading Program. The EPA uses two sets of assumptions: the RGGI Scenario and the Virginia (VA) Scenario. Finds that the RGGI Scenario would reduce mortality 5.3-12 by 2029 and the VA Scenario would reduce mortality 4.4-10 by 2029.	http://townhall.virginia.gov/L/GetFile.cfm?File=C:%5CTownHall%5Cdocroot%5C1%5C4818%5C8130%5CEIA_DEQ_8130_v2.pdf	Virginia Department of Planning and Budget, Economic Impact Analysis.
Article	November 2017	Ohio, United States	Uses COBRA to estimate the economic value of health effects under various scenarios of opting out of energy efficiency programs. Finds the increase health costs of opting out are $564-$1.3 billion in Ohio and $4.1-$9.3 billion in the greater region.	https://www.sciencedirect.com/science/article/pii/S1040619017302440	Baatz, B., Relf, G., & Kelly, M. "Consequences of Large Customer Opt-Out: An Ohio Example," The Electricity Journal.
Report	October 2017	United States	Uses COBRA to calculate avoidable health care costs for acute myocardial infarctions, other cardiovascular diseases, asthma, and respiratory conditions to measure the benefits of urban tree planting. Finds that the avoidable annual health care costs could be $13.2 million and work loss costs could be $11.9 million (12.5 percent of the estimated annual costs for tree planning and maintenance).	https://global.nature.org/content/funding-trees-for-health	The Nature Conservancy. McDonald, R., Aljabar, L., Aubuchon, C., Birnbaum, H., Chadler, C., Toomey, B., Daley, J., Jimenez, W., Trieschman, E., Paque, J., Zeiper, M. "Funding Trees for Health: An Analysis of Finance and Policy Actions to Enable Tree Planting for Public Health."
Article	August 2017	United States	Uses COBRA to estimate the value of reductions to the pollutants SO_2, NO_x, and $PM_{2.5}$, as part of use a suite of models also including EASIUR, the impact factor model developed in Penn et al. and Levy et al., Air Pollution Emission Experiments and Policy analysis model (AP2, formerly APEEP: Muller et al.), and EPA RIA benefits per-tonne estimates. Finds cumulative benefits of $29.7-$112.8 billion from 3,000-12,700 avoided premature mortalities.	https://www.nature.com/articles/nenergy2017134	Millstein, D., Wiser, R., Bolinger, M., & Barbose, G. "The Climate and Air-Quality Benefits of Wind and Solar Power in the United States," Nature Energy 6.
Dissertation	August 2017	United States	Uses COBRA to estimate the estimate of air-pollution costs by modes of transportation. Finds human health externality unit costs to be $0.57/vehicle mile traveled and $0.91/passenger mile traveled.	http://tigerprints.clemson.edu/all_dissertations/2018/	Sun, J. "External Economic Costs of Intelligent Urban Transportation Systems: A Method to Evaluate the Externalities of Comparative Technology Adoption Pathways in the Urban Mobility Service sector." Clemson University, PhD Thesis.

Publication type	Date Published	Location	Summary	URL	Citation
Dissertation	June 2017	Michigan, United States	Uses COBRA to estimate the health impacts from reductions in SO_2 and NO_x due to energy savings from light programs in Michigan. Finds benefits from avoided pollutants to be $36-$81 million.	http://scholarworks.wmich.edu/dissertations/3145/	Ephraim Amough, T. "A Meta-Analysis of Energy Savings from Lighting Programs in Michigan." Western Michigan University, PhD Thesis.
Article	April 2017	N/A	Compares InMAP outputs to outputs from WRF-Chem and COBRA. Finds that COBRA performs similarly to InMAP but not as much spatial detail as WRF-Chem.	http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0176131	Tessum, C. W., Hill, J. D., & Marshall, J. D. "InMAP: A Model for Air Pollution Interventions." PloS one.
Report	January 2017	United States	Does not use COBRA, but explains that this inventory of emissions from agriculture and livestock could be coupled with an air quality screening tool such as COBRA to evaluate potential changes in human health from changes in emissions concentrations.	https://energy.gov/sites/prod/files/2017/02/f34/2016_billion_ton_report_volume_2_chapter_9.pdf	Efroymson, R.A., Langholtz, M.H., Johnson, K.E., & Stokes, B.J. "2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 2: Implications of Air Pollutant Emissions from Producing Agricultural and Forestry Feedstocks." U.S. Department of Energy, Oak Ridge National Laboratory.
Report	January 2017	United States	Uses COBRA to estimate how changes in NO_x and SO_2 affect ambient $PM_{2.5}$. Finds the health impacts of the Regional Greenhouse Gas Initiative to be 300-830 lives saved, 8,200 asthma attacks avoided, 39,000 lost work days avoided, and $5.7 billion in health savings and other benefits.	https://www.abtassociates.com/insights/publications/report/analysis-of-the-public-health-impacts-of-the-regional-greenhouse-gas	"Analysis of the Public Health Impacts of the Regional Greenhouse Gas Initiative." Abt Associates.
Working Paper	November 2016	United States	Analyzes COBRA as a tool to measure the impacts of energy efficiency in buildings. Finds that COBRA has an interactive approach, with a policy scope, is used at the design stage of policy, and has a targeting city focus.	http://www.sustainablesids.org/wp-content/uploads/2016/12/UNEP-Tools-Energy-Efficient-Buildings-2016.pdf	Petrichenko, K., Aden, N., & Tsakiris, A. "Tools for Energy Efficiency in Buildings: A Guide for policy-makers and experts." Working paper, C2E2, Copenhagen and WRI, Washington DC. For further information or to provide feedback, please contact Ksenia Petrichenko.
Article	September 2016	United States	Uses COBRA to calculate reduced morbidity and mortality outcomes and total monetary value from net emissions changes due to state RPS programs. Finds reduced air pollution provide $5.2 billion in health and environmental benefits.	http://www.sciencedirect.com/science/article/pii/S0301421516303408	Barbose, G. et al. "A Retrospective Analysis of Benefits and Impacts of US Renewable Portfolio Standards." Energy Policy 96.

Publication type	Date Published	Location	Summary	URL	Citation
Working Paper	September 2016	N/A	References COBRA as "an example of a framework for air quality improvements that can be used to quantify changes in air quality and the resulting calculated health outcomes in both epidemiological and monetary terms. COBRA as well as other work from the US EPA suggests that measures for producing both local air quality and associated GHG co-benefits offer compelling value for health and wellbeing that can be pursued irrespective of a climate change agenda. As understanding grows and data become more readily available, frameworks and analyses can consider additional co-benefits such as ecosystem benefits or avoided material damages, as well as potential economic opportunities to develop and deploy innovative clean technologies (US EPA 2004)."	http://eprints.lse.ac.uk/68876/1/Cobenefits_Of_Urban_Climate_Action.pdf	Floater, G. et al. "Co-Benefits of Urban Climate Action: A Framework for Cities." Economics of Green Cities Programme, LSE Cities, London School of Economics and Political Science.
Article	September 2016	N/A	Analyzes COBRA as part of a survey of tools to measure ambient air pollution health risks. This paper discusses the differences between tools for factors such as information source, format, and technical complexity.	https://www.ncbi.nlm.nih.gov/pubmed/26742852	Anenberg, S., et al. "Survey of Ambient Air Pollution Health Risk Assessment Tools." Risk Analysis.
Article	July 2016	United States	Uses COBRA to analyze the social costs of $PM_{2.5}$ pollution in 3,000 U.S. counties. Finds the marginal social costs for SO_2 ($\$10^4$/t), NO_x ($\$10^3$-$10^4$/t) and NH_3 ($\$10^{3.5}$-$10^{4.5}$/t).	http://www.sciencedirect.com/science/article/pii/S1352231016303090	Heo, J., Adams, P. J., & Gao, H. O. "Reduced-Form Modeling of Public Health Impacts of Inorganic PM 2.5 and Precursor Emissions." Atmospheric Environment, 137.
Report	July 2016	Ohio, United States	COBRA is used to model health impacts from each power plant in Ohio using estimated primary $PM_{2.5}$ and historic NO_x and SO_2 emissions. Finds that $PM_{2.5}$ emissions from power plants account for 940- 2130 premature deaths/year and Clean Power Plan implementation would reduce health burdens by $8.1-18.2 billion.	https://www.psehealthyenergy.org/wp-content/uploads/2017/04/CPP.OH_1.pdf	PSE Healthy Energy. "The Clean Power Plan in Ohio: Analyzing Power Generation for Health and Equity."

Publication type	Date Published	Location	Summary	URL	Citation
Report	July 2016	Pennsylvania, United States	COBRA is used to model health impacts from each power plant in Pennsylvania using estimated primary $PM_{2.5}$ and historic NO_x and SO_2 emissions. Found that power plant emissions contribute to 1,000-2,300 premature deaths and the Clean Power Plan will reduce health burdens by $8.9-$20 billion.	https://www.psehealthyenergy.org/our-work/publications/archive/our-air-health-and-equity-impacts-of-pennsylvanias-power-plants/	PSE Healthy Energy. "The Clean Power Plan in Pennsylvania: Analyzing Power Generation for health and Equity."
Report	June 2016	California, United States	COBRA is used to estimate the health effects from reduced SO_2 or NO_x emissions resultant from the California Energy Commission's 2016 proposed efficiency standards for computers, computer monitors, and signage displays. Estimates health benefits to be $4.7-$10.6 million from 2018-2030.	http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/SRIA_APPEFF_2016_All.pdf	Roland-Host, D., Evans, S., Han Springer, C, & Emmer, T. Prepared for California Energy Commission. "Standardized Regulatory Impact Assessment: Computers, Computer Monitors, and Signage Displays."
Article	May 2016	United States	Uses COBRA as part of a reduced-form model to estimate the mortality costs per tonne of PM2.5 inorganic air pollution. Estimates the aggregate social costs to be $1.0 trillion.	http://pubs.acs.org/doi/abs/10.1021/acs.est.5b06125	Heo, J., Adams, P.J., & Gao, H.O. "Public Health Costs of Primary PM2. 5 and Inorganic PM2. 5 Precursor Emissions in the United States." Environmental Science & Technology, 50.
Public Comments	May 2016	District of Columbia, United States	COBRA is used to estimate the effect of reduced air pollution on premature deaths and economic growth due to improved health outcomes. Finds clean energy measures will prevent 27-60 premature deaths and increase regional economic growth by $253-$572 million from improved health outcomes.	http://chesapeakeclimate.org/wp/wp-content/uploads/2016/05/CCAN_B21-0650_testimony_DC-RPS.pdf	Chesapeake Climate Action Network. Comments on "B21-0650 – Renewable Portfolio Standard Expansion Amendment Act of 2016."
Article	May 2016	United States	COBRA is used to quantify the health and economic impacts of extra NO_x emissions attributable to non-compliant Volkswagen vehicles in the U.S. Finds extra NO_x emissions for one year equal 5-50 premature deaths, 247-1,061 episodes of respiratory symptoms, 3-14 cardiovascular hospital emissions, 3-13 emergency asthma visits, 687-17,526 work days with restricted activity, and economic costs of $43,479-$432,268,502.	http://www.mdpi.com/1660-4601/13/9/891/html	Hou, L., Zhang, K., Luthin, M., & Baccarelli, A., "Public Health Impact and Economic Costs of Volkswagen's Lack of Compliance with the United States' Emission Standards." Int. J. Environ. Res. Public Health, 13.

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Report	May 2016	United States	COBRA is used to estimate air quality benefits of the 20 GW of solar power installed by the end of 2014 by region or state. Finds emissions reductions would result in $420-1,590 million per year in benefits, higher in regions with high population densities and greater power-sector emissions (e.g., Great-Lakes-Mid-Atlantic).	https://www.nrel.gov/docs/fy16osti/65628.pdf	Wiser, R., Mai, T., Millstein, D., Macknick, J., Carpenter, J., Cohen, S., Cole, W., Frew, B., Heath, G. "On the Path to Sunshot: The Environmental and Public Health Benefits of Achieving High Penetrations of Solar Energy in the United States." Lawrence Berkeley National Laboratory (LBNL) and National Renewable Energy Laboratory (NREL). Powered by SunShot U.S. Department of Energy.
Report	January 2016	United States	Uses COBRA to calculate reduced morbidity and mortality outcomes and total monetary value from net emission changes. Finds health and environmental benefits (primarily from SO_2, NO_x, and $PM_{2.5}$ reductions) to be between $4-$10 billion. Additional benefits include avoiding 160-290 emergency room visits for asthma, 195-310 hospital emissions for respiratory and cardiovascular symptoms, 40-560 non-fatal heart attacks and 38,000-64,000 lost work days.	https://www.nrel.gov/docs/fy16osti/65005.pdf	U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) and National Renewable Energy Laboratory (NREL) "A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards."
Conference proceeding	November 2015	United States	COBRA is used to estimate the health co-benefits from different scenarios of renewable energy deployment in the United States by converting changes in air pollutant emissions to changes population health outcomes.	https://apha.confex.com/apha/143am/webprogram/Paper336283.html	Bast, E. "Analyzing the Health Co-Benefits of Renewable Energy Deployment in the United States." 2015 APHA Annual Meeting & Expo (Oct. 31-Nov. 4, 2015). APHA.
Article	September 2015	Utah, United States	Uses COBRA to estimate the benefits associated with a seasonal gas tax to reduce vehicle trips in Cache Valley, Utah. Estimates the total health benefit to be $782,750.	http://link.springer.com/article/10.1007/s10640-015-9968-z	Moscardini, L., & Caplan, A. "Controlling Episodic Air Pollution with a Seasonal Gas Tax: The Case of Cache Valley, Utah." Environmental and Resource Economics

Publication type	Date Published	Location	Summary	URL	Citation
White Paper	July 2015	New York, United States	COBRA is used to estimate the marginal cost in health effects of SO_2 or NO_x emissions. The authors run a scenario for each pollutant by specifying a reduction of a fixed amount of emissions from the COBRA control case for electricity generating units in NY. Find the dollar/MWh value for SO_2, NO_x, and CO_2 for 2017-2035. 2035 estimates are $42-78/MWh.	http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/26be8a93967e604785257cc40066b91a/$FILE/Staff_BCA_Whitepaper_Final.pdf	New York Department of Public Service. "Staff White Paper on Benefit-Cost Analysis in the Reforming Energy Vision Proceeding."
Article	March 2015	N/A	References COBRA as a computational tool to evaluate energy policy and planning alternatives in order to determine which scenarios are most likely to meet climate and energy goals.	http://www.sciencedirect.com/science/article/pii/S2214629614001364	Bridges, A., Felder, F.A., & McKelvey, K., Niyogi, I. "Uncertainty in Energy Planning: Estimating the Health Impacts of Air Pollution from Fossil Fuel Electricity Generation." Energy Research & Social Science 6.
Report	February 2015	California, United States	Uses COBRA model for the Energy Commission's first "Standardized Regulator Impact Assessment" for appliance efficiency standards division. Estimates proposed standards would avoid $1.0-$2.3 million in health impacts in the first year. By 2025, the range increases to $5.8 -$14.8 million.	https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-AAER-01	"Revised Standardized Regulatory Impact Assessment of 2014 Proposed Appliance Efficiency Regulations: Regulations for Toilets, Urinals, Faucets, Dimming Ballasts, Air Filters, and Heat-Pump Water-Chilling Packages."
Legal Brief	January 2015	United States	Examines question of whether the EPA unreasonably refused to consider costs of regulating air pollutants from electric utilities. COBRA cited as one of the methods EPA uses to calculate causal connection between PM 2.5 reduction and health benefits.	https://www.edf.org/sites/default/files/content/14-46_amicus_pet_cato.authcheckdam.pdf	Supreme Court of the United States: State of Michigan , et al. v. Environmental Protection Agency. "Brief for the Cato Institute as Amicus Curiae in Support of Petitioners"
Book	January 2015	N/A	COBRA is used to value the avoided health impacts from the reduction in air quality pollutants from electric drive vehicles.	http://www.routledge.com/books/details/9781138811102/	Link, A.N., O'Connor, A.C., & Scott, T.J. "Battery Technology for Electric Vehicles: Public Science and Private Innovation."
Article	January 2015	N/A	Results from InMAP, a comprehensive air quality model for estimating the air pollution health impacts of emission reductions and other potential interventions, are compared against COBRA because it is an existing reduced-form model.	http://www.geosci-model-dev-discuss.net/8/9281/2015/gmdd-8-9281-2015.pdf	Tessum, C.W., Hill, J.D., & Marshall, J.D. "InMAP: A New Model for Air Pollution Interventions." Geoscientific Model Dev. Discuss., 8.

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Working Paper	November 2014	N/A	Explains COBRA's use in calculating morbidity endpoints including mortality, chronic bronchitis, non-fatal heart attaches, respiratory hospital admissions, and acute bronchitis, among others.	http://www.theicct.org/sites/default/files/publications/ICCT_morbidities_20141112.pdf	Chambliss, S. et al. "Morbidities Calculation: Guidelines and Walkthrough." The International Council on Clean Transportation. Working Paper 2014-10.
Working Paper	November 2014	United States	Uses COBRA to measure the health impacts from current electricity generation infrastructure. SO_2 and NO_x pollutants are expected to add $125 billion to health care costs in 2013, leading to 18,000 premature deaths, 27,000 cases of acute bronchitis, 240,000 episodes of respiratory distress, and 2.3 million lost work days.	https://www.edf.org/sites/default/files/edf_laitner-mcdonnell-energy-efficiency-as-a-pollution-control-technology.pdf	Laitner, J.A., & McDonnell, M.T. "Energy Efficiency as a Pollution Control Technology and a Net Job Creator under Section 111(d) Carbon Pollution Standards for Existing Power Plants." Working paper prepared for the Environmental Defense Fund.
Report	August 2014	United States	Uses COBRA to evaluate the health impacts of energy efficiency and renewable energy research and development programs. Finds avoided incidences and monetary benefits of adult and infant mortality, heart attacks, hospital admissions, respiratory symptoms, and work loss days, resulting in $17.7-$45.2 million in benefits.	https://energy.gov/sites/prod/files/2015/05/f22/evaluating_realized_rd_mpacts_9-22-14.pdf	O'Connor, A., & Loomis, R. "Evaluating Realized Impacts of DOE/EERE R&D Programs."
Report	April 2014	United States	Uses COBRA to measure the health impacts of four state policies to improve energy efficiency. Finds ACEEE scenario would avoid over 147,000 asthma attacks, 5000 premature deaths, and $100 million due to lost work days.	http://climateandenergy.org/resources/ACEEE111droleofefficiency.pdf	American Council for an Energy-Efficient Economy. "Change Is in the Air: How States Can Harness Energy Efficiency to Strengthen the Economy and Reduce Pollution."
Master's Thesis	January 2014	Utah, United States	COBRA is used to estimate Cache County's potential public health savings from a seasonal gas tax. Finds benefits to be $479,403-$1,086,075.	https://digitalcommons.usu.edu/etd/3870/	Moscardini, L.A., "Estimating the Effectiveness of a Seasonal Gas Tax for Controlling Episodic PM2.5 Concentrations in Cache County, Utah" All Graduate Theses and Dissertations. Paper 3870.
Report	December 2013	United States	Uses COBRA to quantify and monetize the value of changes in the incidence of avoided adverse health events associated with emissions reductions. Finds avoided incidences and economic value for mortality, respiratory and cardiovascular measures, and work loss days, totalling $1.76-$45.2 million.	https://www1.eere.energy.gov/analysis/pdfs/2013_bca_vto_edvs.pdf	Link, Albert N., et al. "Benefit-Cost Evaluation of US DOE Investment in Energy Storage Technologies for Hybrid and Electric Cars and Trucks."

Publication type	Date Published	Location	Summary	URL	Citation
Article	February 2013	California and Idaho, United States	Uses COBRA to calculate the benefits of wind energy derived from two locations: a 580 MW wind farm at Altamont Pass, CA, and a 22 MW wind farm in Sawtooth, ID. The turbines in CA will likely avoid $560 million-$4.38 billion in health costs and the ID turbines will likely avoid $18-104 million.	https://www.sciencedirect.com/science/article/pii/S0301421512009696X	McCubbin, D. & Sovacool, B.K. (2013). Quantifying the Health and Environmental Benefits of Wind Power to Natural Gas." Energy Policy 53.
Book	January 2013	N/A	Analyzes COBRA as a tool for program evaluation to discuss the many factors that affect the utility of each technique and how that impacts the technological, economic and societal forecasts of the programs in question.	https://www.e-elgar.com/shop/handbook-on-the-theory-and-practice-of-program-evaluation	O'Connor, A. et al. "Estimating Avoided Environmental Emissions and Environmental Health Benefits" Chapter 9, Handbook on the Theory and Practice of Program Evaluation, 247.
Article	November 2012	United States	"In this example, the original air quality modeling entailed a significant investment of time and resources, but the resulting benefit per ton estimates enable analysts to quickly estimate benefits. In other approaches, a simplified air quality model is developed based on the responsiveness of ambient pollutant levels to changing emissions. These source–receptor relationships are then used to calculate health impacts and benefits. Though the development of the air quality model is resource intensive, its subsequent application to various policy scenarios is not." Finds the value of reducing directly emitted $PM_{2.5}$ and NOx ranges between approximately $1,300 for reducing a ton of NO_x from Ocean-Going Vessels to about $450,000 for reducing a ton of directly emitted $PM_{2.5}$ from Iron and Steel facilities.	http://www.sciencedirect.com/science/article/pii/S0160412012001985	Fann, N., Baker, K. R., & Fulcher, C.M. "Characterizing the PM 2.5-Related Health Benefits of Emission Reductions for 17 Industrial, Area and Mobile Emission Sectors Across the US. Environment International" 49.
Working Paper	July 2012	North Carolina, United States	Uses COBRA to determine the portion of Clean Smokestacks emissions reduction benefits realized in North Carolina under the Clean Smokestacks Act. Finds mortality benefits from reduced SO_2 emissions to equal $6.365-$16.032 million.	http://nicholasinstitute.duke.edu/climate/policydesign/benefits-of-early-state-action-in-environmental-regulation-of-electric-utilities/	Hoppock, D, et al. "Benefits of Early State Action in Environmental Regulation of Electric Utilities: North Carolina's Clean Smokestacks Act." Nicholas Institute for Environmental Policy Solutions, Duke University: Durham, NC.

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Note that inclusion in this list does not necessarily constitute an endorsement of a publication or its methods. Updated April 2024

Publication type	Date Published	Location	Summary	URL	Citation
Article	January 2012	California, United States	Uses COBRA to estimate the health impacts of plug-in electric vehicles in California. Estimates the value of benefits at $750 to $1,500 per vehicle in an expected PEV penetration scenario and $1,000 to $2,500 per vehicle in an aggressive penetration scenario.	https://journals.sagepub.com/doi/10.3141/2287-19	Witt, M. et al. “Plug-in Vehicles in California: Review of Current Policies, PEV-Related Emissions Reductions for 2020, and Policy Outlook.”
Book	January 2012	N/A	Uses COBRA to measure the health impacts from decreases $PM_{2.5}$, SO_2, and NO_x from public investments in energy technologies. Finds adverse health incidences to be $90,500 (on-grid centralized systems), $11.8 million (grid-connected distributed systems), and $28.7 million (off-grid systems).	https://www.e-elgar.com/shop/usd/public-investments-in-energy-technology-9780857931573.html	Gallaher, M., Link, A., & O'Connor, A. “Public Investments in Energy Technology.” Edward Elgar Publishing.
Article	November 2011	United States	Uses COBRA to estimate the health benefits of wind power. The turbines in CA will likely avoid $560 million-$4.38 billion in health costs and the ID turbines will likely avoid $18-104 million.	http://www.sciencedirect.com/science/article/pii/S1040619011002351	McCubbin, D., & Sovacool, B. "The Hidden Factors that Make Wind Energy Cheaper than Natural Gas in the United States." The Electricity Journal 24.
Book	January 2011	United States	Uses COBRA to estimate the health costs of air pollution by mode of transportation including road, rail, air, and water. Estimates air-pollution costs by road (LDVG: 0.91¢/pmt; HDVD: ¢1.55/tm), rail (¢0.35/tm), air (¢0.39/pmt; ¢1.88/tm) and water (¢1.74/tm).	https://escholarship.org/uc/item/13n8v8gq	Delucchi, M., & McCubbin, D. "External Costs of Transport in the United States." Chapter 15 in A Handbook of Transport Economics 341.
Report	August 2010	United States	Uses COBRA to calculate the health benefits of reductions in air pollutants resulting from using PV systems rather than the next best technology alternative for electricity production. Estimates environmental health benefits to be to be $237 million.	https://energy.gov/sites/prod/files/2015/05/f22/solar_pv.pdf	O’Connor, Alan C., Loomis, R., & Braun, F. "Retrospective Benefit-Cost Evaluation of DOE Investment in Photovoltaic Energy Systems." RTI International.

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Report	August 2010	United States	RTI International (2010): RTI, for the U.S. Department of Energy (DOE), estimates health benefits associated with two types of geothermal technologies in which DOE has invested using COBRA. The study calculates a net reduction in PM, NO_x, and SO_2 associated with geothermal energy produced by geothermal plants that otherwise would have been produced by fossil fuel plants. Total environmental health benefits are estimated to be $155.7 million.	https://www.energy.gov/sites/prod/files/2014/02/f7/gtp_benefit-cost_eval_aug2010.pdf	"Retrospective Benefit-Cost Evaluation of U.S. DOE Geothermal Technologies R&D Program Investments: Impacts of a Cluster of Energy Technologies."
Report	June 2010	United States	Uses COBRA to quantify and monetize the value of changes in the incidence of avoided adverse health events associated with emissions reductions from electric vehicle investments. Finds $1,107,053 in avoided mortality and health care incidents.	https://www1.eere.energy.gov/analysis/pdfs/wind_bc_report10-14-10.pdf	"Retrospective Benefit–Cost Evaluation of U.S. DOE Wind Energy Program: Impact of Selected Energy Technology Investments."
Report	May 2010	United States	"Health benefits associated with reduced diesel fuel consumption and reduced NOx, PM, and Sox emissions are quantified in monetary terms using the COBRA." Finds $53.7 million in health benefits from reduce environmental emissions.	https://www1.eere.energy.gov/analysis/pdfs/advanced_combustion_report.pdf	Link, A. "Retrospective Benefit-Cost Evaluation of US DOE Vehicle Combustion Engine R&D Investments: Impacts of a Cluster of Energy Technologies," USDOE EERE, UNC at Greensboro Dept of Economics.
Report	May 2010	Utah, United States	Mentions COBRA as an option for estimating the co-benefits of emissions reductions from energy efficiency and renewable energy. Finds mortality benefits to be $7.39-7.79/MWh and mobility benefits to be $0.48/MWh.	http://www.synapse-energy.com/sites/default/files/SynapseReport.2010-05.UT-EO.Utah-Co-Benefits.08-064.pdf	Fisher, Jeremy, et al. "Co-Benefits of Energy Efficiency and Renewable Energy in Utah." Synapse Energy Economics (2010).
Report	January 2010	Iowa, United States	Physicians for Social Responsibility, a non-profit organization, uses COBRA to estimate the health benefits of a scenario in which the percentage of Iowa's electricity generation derived from coal is reduced from its current level of 72% to the national average of 47%. Health benefits total $71.8 million, of which 92.1% were derived from reduced mortality.	https://iowaenvironmentalfocus.org/tag/iowa-coal-health-a-preliminary-mapping-study/	"Iowa Coal & Health: A Preliminary Mapping Study"

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Article	January 2010	United States	"To estimate health effects from changes in air pollution emissions attributed to the program cluster evaluated, the US Environmental Protection Agency's (EPA) COBRA model (Co-Benefits Risk Assessment Model, described in US EPA [6]) is used. To apply COBRA, it is necessary to enter the estimated changes in air emissions of particulate matter (PM), sulphur dioxide (SO2), nitrogen oxide (NOx), and volatile organic compounds (VOCs) into the model. Because not all air pollutants are taken into account by the model, the results obtained from using COBRA for the analysis is taken as a lower bound estimate of impact of health effects and their economic value. Table 2 shows the health effects included in COBRA, by type of effect. The model provides estimates of the incidence of each type of effect and related healthcare costs."	https://www.witpress.com/Secure/elibrary/papers/EEIA10/EEIA10009FU1.pdf	Ruegg, R. T., & Jordan, G.B. "New Benefit-Cost Methodology for Evaluating Renewable and Energy Efficiency Programs of the US Department of Energy." WIT Transactions on Ecology and the Environment 131.
Book; Section 1	2010	United States	COBRA was used to estimate the health effects from changes in air pollution emissions (PM, SO2, NOx, and VOCs) attributed to the program cluster evaluated. Because not all air pollutants were taken into account by the model, the results obtained from COBRA for the analysis were taken as a lower bound estimate of impact of health effects and their economic value.	Environmental Economics and Investment Assessment III - Google Books	Lindskog, S., & R. Sjöblom. "Implementation of the polluter pays principle–example of planning for decommissioning." Environmental Economics and Investment Assessment III, 131, 11127.

Publication type	Date Published	Location	Summary	URL	Citation
Article	July 2009	United States	"For each power plant, we estimated the relationship between emissions and incremental contribution to ambient concentrations using an S-R matrix. S-R matrix is a reduced-form model based on the Climatological Regional Dispersion Model, a sector-averaged Gaussian dispersion model that includes wet and dry deposition and first-order chemical conversion of SO2 and NOx to sulfate and nitrate particles. More detail about the model is available elsewhere" Finds the economic valuation premature mortality to be $5.5 million.	http://onlinelibrary.wiley.com/doi/10.1111/j.1539-6924.2009.01227.x/full	Levy, J. I., Baxter, L. K., & Schwartz, J. "Uncertainty and Variability in Health-Related Damages from Coal-Fired Power Plants in the United States. Risk Analysis, 29.
Report	July 2009	California, United States	COBRA is analyzed as part of an effort to identify methodological alternatives for quantifying the benefits of renewable energy, including the pros and cons of the tool.	http://www.nrel.gov/docs/fy09osti/45639.pdf	Mosey, G., & Vimmerstedt, L. "Renewable Electricity Benefits Quantification Methodology: A Request for Technical Assistance from the California Public Utilities Commission." National Renewable Energy Laboratory.
Report	January 2009	Virginia, United States	Abt Associates performs an analysis of the health effects impacts of a proposed coal-fired power plant in Wise County, Virginia. The study estimates that the plant would contribute to two to five premature mortality events annually in Virginia, and five to fourteen premature mortality events nationwide. Total annual economic impacts of health effects in Virginia range from $16 to $52 million, and $44 to $135 million nationwide.	https://www.abtassociates.com/insights/publications/report/assessing-the-economic-impact-of-dominion-virginia-powers-coal-fired	"Assessing the Economic Impact of Dominion Virginia Power's Coal-Fired Power Plant in Wise County," Abt Associates, Prepared for: Wise Energy for Virginia Coalition c/o Appalachian Voices.
Working Paper	November 2007	United States	"For a tool for calculating co-benefits, see Mulholland (2007). For estimates of damages from releases of particulates, sulfur dioxide, and nitrogen oxides in the U.S., see Muller and Mendelsohn (2007)."	http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1121&context=peri_workingpapers	Boyce, J., & Riddle, M. "Cap and Dividend: How to Curb Global Warming while Protecting the Incomes of American Families."

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Article	May 2007	United States	Uses COBRA to model the public health benefits and the change in the spatial inequality of health risk for a number of hypothetical control scenarios for power plants in the United States to determine optimal control strategies. Benefits range from 17,000–21,000 fewer premature deaths per year.	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1867973/	Levy, J., Wilson, A., & Zwack, L. "Quantifying the Efficiency and Equity Implications of Power Plant Air Pollution Control Strategies in the United States." Environmental Health Perspectives.
Memorandum	April 2007	Wisconsin, United States	Uses COBRA to determine the public health benefits of implementing the NO_x RACT rule. The benefits amount is compared to compliance costs. Finds the NO_x RACT rule would provide $80,000,000/year in public health benefits.	http://dnr.wi.gov/about/nrb/2007/April/04-07-3A1.pdf	DATE: April 9, 2007; TO: Members of the WI Natural Resources Board ; FROM: Scott Hassett, Secretary; SUBJECT: Reasonably Available Control Technology (RACT) program for major sources of nitrogen oxides (NOx) in the moderate ozone nonattainment; http://dnr.wi.gov/air/pdf/AM1705.pdf
Article	February 2007	United States	"The S–R matrix is a regression-based derivation of output from the Climatological Regional Dispersion Model (CRDM) which uses assumptions similar to the Industrial Source Complex Short Term model (ISCST3). It was developed by Pechan and Associates for Abt Associates and used in past regulatory impact analyses (US Environmental Protection Agency, 1999d). S–R matrix provides a database of transfer factors that summarize the impact that mobile source PM2.5 and precursor emissions from any one county have on ambient PM2.5 concentrations in that county as well as all other counties (Abt Associates, 2003)"	http://www.sciencedirect.com/science/article/pii/S1352231006009654	Greco, S.L., Wilson, A.M., Spengler, J.D., & Levy, J.I. "Spatial Patterns of Mobile Source Particulate Matter Emissions-to-Exposure Relationships Across the United States." Atmospheric Environment, 41.

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Article	April 2006	United States	Other options include the Co-Benefits Risk Assessment (COBRA) model, 34 which features built-in source-receptor atmospheric sensitivity matrices in place of atmospheric modeling by the user to allow quick estimates of the health impacts from various emission sources; the Ozone Risk Assessment Model,35 which operates in a similar fashion to BenMAP; and the Air Strategy Assessment Program, currently under development by EPA to link BenMAP with AirControlNET costing software36 for full-stream assessment of both costs and benefits of attainment options (B. Hubbell, EPA, personal communication, March 8, 2005). These and other tools, along with an improved understanding of the potential role of benefit analysis in integrated air quality management, could provide the necessary impetus for its greater incorporation in upcoming SIP development. Estimates net benefits of alternative control strategies to be between $1.5-1.6 million.	http://www.tandfonline.com/doi/abs/10.1080/10473289.2006.10464524	Chestnut, L., Mills, D., & Cohan, D. "Cost-Benefit Analysis in the Selection of Efficient Multipollutant Strategies." Journal of the Air & Waste Management Association 56.4 (2006): 530-536.
Report	November 2004	Connecticut, United States	REMI, for EPA and the State of Connecticut, analyze the impacts of oil and natural gas conservation policies in Connecticut. The study integrates estimates of reduced mortality and the value of health improvements from COBRA into a simulation of the impacts of these policies on the state's economy.	http://www.remi.com/uploads/File/Articles/Economic_Impact_of_Oil_and_Natural_Gas_Conservation_Policies.pdf	"Economic Impact of Oil and Natural Gas Conservation Policies, Regional Economic Models, Inc." (2004). Prepared for U.S. EPA and the State of Connecticut.

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