COBRA User Fact Sheet

EPA United States Environmental Protection Agency

State and Local Energy and Environment Program

COBRA Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool

Analyzing Avoided Natural Gas Emissions Using COBRA

The U.S. Environmental Protection Agency's (EPA) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) estimates and monetizes the health impacts resulting from changes in outdoor air pollution emissions. To conduct analyses in COBRA, users must enter data on emissions of primary fine particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen oxides (NOx), ammonia (NH_3), and volatile organic compounds (VOCs). This fact sheet explains how to use COBRA to analyze energy efficiency programs or policies that reduce or avoid natural gas consumption.

Background: According to the U.S. Energy Information Administration (EIA), the residential sector consumed over 4.4 trillion cubic feet of natural gas in 2017.[1] Natural gas combustion leads to significant criteria pollutant emissions, particularly emissions of NOX, which impact public health. In 2017, EPA reported that residential natural gas combustion led to 205,415 tons of NOx emissions.[2]

EPA's COBRA tool can help users assess the change in health effects and monetized public health benefits of efficiency programs that reduce or avoid natural gas use. This fact sheet explains how to use the desktop software version of COBRA to assess a hypothetical program in the state of California.[3] It provides step-by-step guidance on how to calculate avoided emissions from natural gas reductions and then enter these data into COBRA to estimate and monetize the public health benefits from improved outdoor air quality.[4] For more detailed information on using COBRA, see the COBRA User's Manual.

Calculating Emission Changes: An Example Scenario: To illustrate how to use COBRA to analyze natural gas efficiency program, we present an example analysis based on a hypothetical residential natural gas efficiency program in California that led to a savings of **60 million therms[5] of natural gas** in 2017. To understand the health impacts of this program, you must first use emissions factors for residential natural gas to calculate avoided emissions of $PM_{2.5}$, SO_2, NOx, NH_3, and VOCs. The emissions factors for residential natural gas listed in Table 1 are from the EPA reference document AP-42 Compilation of Air Emissions Factors, which is a comprehensive source of air emissions factors from multiple sectors and emissions sources in the U.S.[6] Emission factors are reported in units of pounds (lbs.) of pollution per million cubic feet (MMcf) of natural gas.

Table 1. Residential Natural Gas Emission Factors
Source: U.S. EPA.[7]

Pollutant	Emissions Factor (lbs./MMcf)
Primary $PM_{2.5}$	0.43
SO_2	0.6
NOx	94
NH_3	20
VOC	5.5

To use these emissions factors, you must convert natural gas savings from units of therms to MMcf using the conversion factor 1 therm = 96.4 cubic feet of natural gas. Therefore, in the hypothetical California example:

60 million therms × 96.4 cf per therm ÷1 million = 5,786 MMcf of natural gas

Next, multiply the MMcf of natural gas saved by each of the emissions factors to determine the emissions of each pollutant avoided through natural gas efficiency in California.

5,786 MMcf of natural gas × 0.43 lbs. $PM_{2.5}$ per MMcf ÷ 2000 lbs. per ton = 1.24 tons $PM_{2.5}$

Since the COBRA tool accepts emissions input in units of short tons, you next need to convert the units from lbs. to short tons of emissions using the conversion factor 2,000 lbs. = 1 short ton. The following calculation demonstrates how to estimate reductions in primary $PM_{2.5}$ emissions:

lbs. $PM_{2.5}$ per MMcf÷2000 lbs. per ton = 1.24 tons $PM_{2.5}$

Table 2 shows the results of these calculations for all pollutants in this example using the emission factors from Table 1.

Table 2. California Example Results: State-level Avoided Emissions from Natural Gas Efficiency

Pollutant	Avoided Emissions (short tons
Primary $PM_{2.5}$	1.24
SO_2	1.74
NOx	271.94
NH_3	57.86
VOCs	15.91

Estimating Health Impacts with COBRA

STEP 01 Select Analysis Year

Open the COBRA software and click on the "Select Analysis Year" tab. Choose 2016 from the drop-down menu since you are assessing the impact of emissions reductions in 2017 and this is the closest baseline year available.[8] Click "Apply Analysis Year Data."

STEP 02 Select Location

Next, open the "Create Emissions Scenario" tab. Click the box next to California under "Select Location" since this is the location of the gas efficiency program. You have the option to select individual counties when you have data on emissions changes at that level. For this example, you only need to select the state of California. COBRA will distribute the emissions changes across counties within the state based on the proportion of baseline emissions in each county.

STEP 03 Select Emissions Tier

Under "Select Emissions Tier" click on the + sign next to "Fuel Combustion: Other" to expand the next tier level. Click the + sign next to "Residential Other" and then select "Natural Gas" to indicate that the emissions changes stem from changes in household natural gas use.

STEP 04 Modify Emissions

Under "Modify Emissions" enter the emissions changes for each pollutant as shown above in Table 2. Select the "reduce by" and "tons" radio buttons, then click "Apply Changes." COBRA allows users to assess the cumulative impact of emissions changes from programs in multiple locations or different emissions tiers. To enter changes from additional programs, simply repeat Steps 1-2 and click "Apply Changes" each time. For this example, you can proceed directly to Step 3.

STEP 05 Select Discount Rate

After you have entered the emissions reduction inputs, open the "Execute Run" tab. Your last step before running the tool is to select a discount rate to use in the analysis. COBRA uses a discount rate to express future economic values in present terms because not all health effects and associated economic values occur in the year of analysis. COBRA assumes changes in adult mortality and non-fatal heart attacks occur over a 20-year period. Based on EPA's Guidelines for Preparing Economic Analyses, the desktop version of EPA recommends using two default real discount rates: 3 percent and 7 percent.[9]

When you have selected a discount rate, click "Run using above option." COBRA will then estimate changes in total annual ambient concentrations of $PM_{2.5}$, including primary $PM_{2.5}$ emissions and the formation of secondary $PM_{2.5}$ from precursor pollutants, such as SO_2, NOx, NH_3 and VOCs. COBRA then uses a series of health impact functions, taken from the peer-reviewed epidemiological literature, to estimate how changes in outdoor air quality result in changes in the incidence of a variety of health outcomes (e.g., premature mortality, heart attacks, asthma exacerbation, lost work days). Finally, COBRA multiplies the change in incidence for each health outcome by a monetary value specific to that outcome.

STEP 06 View Results

Once the model has finished running, COBRA will automatically open the "View Health Effects and Valuation Results" tab with a table of nationwide results. Even though this example involves emissions changes only in the state of California, COBRA calculates health benefits in all counties in the contiguous United States due to the transport of outdoor air pollutants between counties and states. You can filter the table to show results for a particular state or county. Click on the "Map" tab to view the results in map form. Both the table and the map provide county-level changes in air quality (total annual average $PM_{2.5}$ concentration in $\mu g/m^3$), incidence of each health endpoint, and associated economic values.

Table 3 summarizes the results for this example by health endpoint. Based on this analysis, a natural gas efficiency program in California that saved 60 million therms of gas in 2017 would provide approximately $12.8 million to $28.9 million in nationwide health benefits due to improved outdoor air quality.

Table 3. Nationwide Public Health Benefits of Natural Gas Efficiency in California in 2017, 3% discount rate

Health Endpoint	Incidence (cases, annual)†	Monetary Value ($2017, annual)
Mortality*	1.18 – 2.68	$12,564,950 -$28,524,102
Infant Mortality	0.01	$83,006
Nonfatal heart attacks*	0.07 - 0.64	$10,920 - $101,472
All Respiratory Hospital Admissions	0.24	$9,303
All Cardiovascular Hospital Admissions	0.23	$11,666
Acute Bronchitis	2.13	$1,299
Upper Respiratory Symptoms	38.66	$1,634
Lower Respiratory Symptoms	27.10	$724
Emergency Room Visits, Asthma	0.53	$299
Minor Restricted Activity Days	1,186.57	$102,945
Work Loss Days	201.10	$40,257
Asthma Exacerbation	40.26	$2,956
Total		**$12,829,959 - $28,879,663**

* Avoided mortality and nonfatal heart attacks are presented as a range to represent important uncertainties in the estimates of the health impacts of changing air quality. For example, results for avoided premature mortality are based on two different epidemiological studies of the impacts of $PM_{2.5}$ on mortality in the United States.

† Incidence refers to the number of new cases of a health endpoint over a specified period of time. The change in incidence is not necessarily a whole number because COBRA calculates statistical risk reductions which are then aggregated over the population.

1. U.S. EIA. 2020. Natural Gas Consumption by End Use. https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm

2. U.S. EPA. 2017. National Emissions Inventory. https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data

3. EPA also offers the COBRA Web Edition that users can run within their internet browser. Although the Web Edition has streamlined features and a slightly different layout, users can still follow the basic steps outlined in this factsheet. Access the COBRA Web Edition at www.epa.gov/cobra/cobra-web-edition.

4. COBRA assesses the air quality and health impacts from changes in total outdoor $PM_{2.5}$ concentrations (annual average $\mu g/m^3$). It does not assess any impacts related to changes in indoor air quality that may also occur.

5. A therm is a unit of heat energy equivalent to 96.4 cubic feet of natural gas.

6. U.S. Environmental Protection Agency. AP-42: Compilation of Air Emissions Factors. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

7. U.S. EPA. 2021. 2017 National Emissions Inventory: January 2021 Updated Release, Technical Support Document. Available: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-technical-support-document-tsd

8. The COBRA Web Edition only provides baseline data for the year 2023.

9. The COBRA Web Edition also includes an option for users to enter a custom discount rate.