

US EPA ARCHIVE DOCUMENT

# Estimating the Co-Benefits of Clean Energy Policies

## The Co-Benefits Risk Assessment (COBRA) Screening Model

Air Quality | Human Health | Societal Benefits





# What is COBRA?



- The Co-Benefits Risk Assessment (COBRA) model is a peer reviewed screening tool that inexpensively and quickly estimates the air quality, human health, and associated economic impacts – the benefits - of various state and county level emission reduction scenarios.
  - The model presents the health effects and related economic value of the effects in tables and maps by county for state, region, U.S.
- COBRA enables users to obtain a first order approximation of benefits so that they can:
  - understand and communicate the potential for health and related economic benefits of clean energy
  - compare benefits to the costs of different policy scenarios
  - determine what options warrant further analysis or consideration based on their potential health benefits

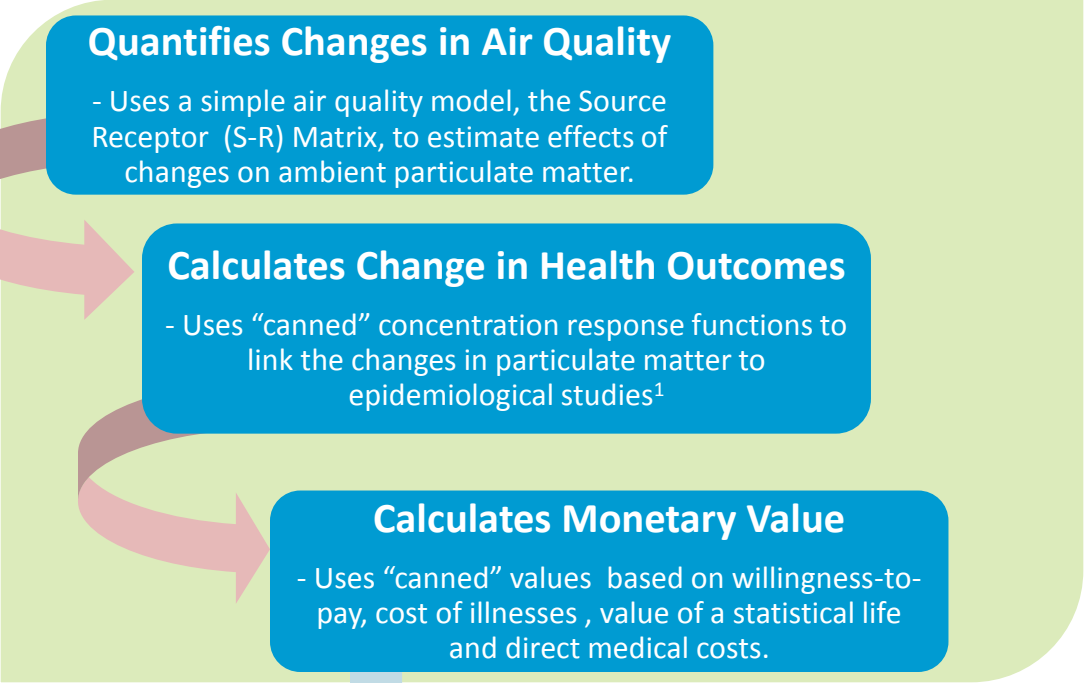


# How Does COBRA Work?



Users enter emissions change(s) and discount rate for 2017  
- PM2.5, SO2, NOx, NH3, VOCs

## COBRA:



**Outputs** = Tables and maps of illnesses and deaths avoided and the related economic value.

<sup>1</sup> COBRA excludes benefits beyond particulate matter-related ones and may be conservative in that respect.



# Human Health Effects and Their Related Economic Values in COBRA

- COBRA estimates the number of health incidences avoided AND the related economic value for the following:
  - Adult Mortality,
  - Infant Mortality,
  - Non-fatal Heart Attacks,
  - Respiratory Hospital Admissions,
  - Cardiovascular-related Hospital Admissions,
  - Acute Bronchitis,
  - Upper Respiratory Symptoms,
  - Lower Respiratory Symptoms,
  - Asthma Exacerbations (attacks, shortness of breath, & wheezing),
  - Asthma Emergency Room visits,
  - Minor Restricted Activity Days,
  - Work Loss Days





# Strengths of COBRA



- Enriches discussion of co-benefits and supports a balanced decision-making process that considers both the potential costs and benefits of policy choices.
- Easy-to-Use screening tool
  - Requires minimal inputs
  - Includes “canned” equations and approaches generally consistent with EPA practices
  - Detailed User’s Guide describes all assumptions and equations
- Flexible for User
  - Can enter data for a single county, group of counties, statewide, outside of state, and/or group of states
  - Can enter reductions in absolute terms or as percentage change
- Inexpensive (free!) compared to rigorous air quality models
  - Results from COBRA approach have fared well in informal comparisons;
  - Enables analysts to narrow a list of options at no/low cost and then devote resources to analyzing only those options with the best prospects using more expensive air quality models.
- Quick to generate results
- Mapping of results facilitates visualization of impacts
  - Provides very localized health effects and valuations: county level



# Limitations of COBRA



- EPA is a free, screening tool not a highly sophisticated model.
  - Air Quality (AQ) model is “quick and dirty”
    - COBRA is best used as screening tool, followed up with comprehensive AQ analysis and health impact assessment
  - Somewhat inflexible and simple
    - Limited timeframe for analysis (currently 2017 only)
    - Inability to import own baseline
    - Must use “canned” equations (C-R functions, economic values)
    - Does not address cap issues
  - Relies upon inputs generated elsewhere
    - Assumptions about statewide % reductions may be an oversimplification
- While there are limitations that users should understand, technical peer reviewers found COBRA to be “a valuable model that produces a screening tool that can contribute to policy analysis and public dialogue.”



# Steps for Running An Analysis With COBRA



1. Estimate what and where (e.g., in one or more counties or states, regionally, nationally) emission reductions will occur
  - COBRA uses **your** emission inputs to estimate the air quality, health, and health-related economic impacts of the scenario
  - We provide tips on our website as to what tools and approaches (e.g. emissions factors from eGRID\*, sophisticated models) you can use to estimate the emission reductions
2. Enter the location, types, and quantity of emission reductions expected from the policy or activity in COBRA
3. Select a discount rate in COBRA to appropriately discount the value of future benefits
4. Run the model and review the results

\* e-GRID is available at <http://www.epa.gov/cleanenergy/energy-resources/egrid/>





## Example: Evaluate the Health Benefits of a Renewable Portfolio Standard with COBRA



- A renewable portfolio standard (RPS) requires electric utilities to switch a particular percentage of electricity generation to renewable sources
- If electricity had previously been generated with fossil fuels, the RPS will result in criteria air pollutant reductions and health benefits
- A state or local government can use COBRA to come up with a rough estimate of the health and related economic benefits of a state or local renewable energy standard
  - Let's assume this illustrative scenario: Suppose a state (Michigan) has established an RPS requirement that 10% of electricity generation must be from renewable sources by 2015
    - NOTE: We also could have looked at a county with a renewable target or requirement



# Step 1: Estimate what and where emissions reductions will take place



- Select what geographic locations you expect to be affected by the emissions change
  - You can enter emissions changes at the national, regional, state or county levels
  - If you know that specific plants will be affected, you can enter emissions changes only in those counties
  - Or you could use more sophisticated energy modeling approaches or tools to identify any and all plants that may be affected by a state or local RPS and manually enter those changes for the counties with affected plants
- For the Michigan RPS, we assume that all emission changes will occur statewide



# Step 1: Estimate what and where emissions reductions will take place

- To determine the emissions reduced, you can:
  - Assume that a switch of 10% of electricity generation from fossil fuels to renewable sources that do not generate air pollution will reduce 10% of all pollutants, or
  - Estimate absolute emission reductions using:
    - An emission factor approach as described earlier
    - A more sophisticated modeling approach, if available





# Step 1: Estimate where and what emissions reductions will take place

- For this example, we use emissions factors from EPA's Emissions & Generation Resource Integrated Database (eGrid)\* to develop an absolute estimate
  - Using “eGRID2012 year 2009 Summary Tables (PDF),” we found:
    - Net electric generation in Michigan: **88 million MWh**
    - Non-baseload output emissions rates for Michigan:
      - SO<sub>2</sub>: **6.6348 lbs. per MWh**
      - NO<sub>x</sub>: **1.9392 lbs. per MWh**
    - Percentage of electric generation that already comes from renewable sources in Michigan: **3.1%**

\* eGRID is available at <http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>



# Step 1: Estimate where and what emissions reductions will take place



- Since 3.1% of electric generation already comes from renewable sources, we assume our scenario will reduce emissions by:

$$10\% - 3.1\% = \mathbf{6.9\%}$$

- We calculate the reduction in MWh:

$$6.9\% \times 88 \text{ million MWh} = \mathbf{6 \text{ million MWh}}$$

- Assuming the renewable energy used does not emit any air pollution, we calculate the emission reductions as:

$$\begin{aligned} \text{SO}_2: 6 \text{ million MWh} \times 6.6348 \text{ per MWh} &= 40 \text{ million lbs.} \\ &= \mathbf{20,000 \text{ tons}} \end{aligned}$$

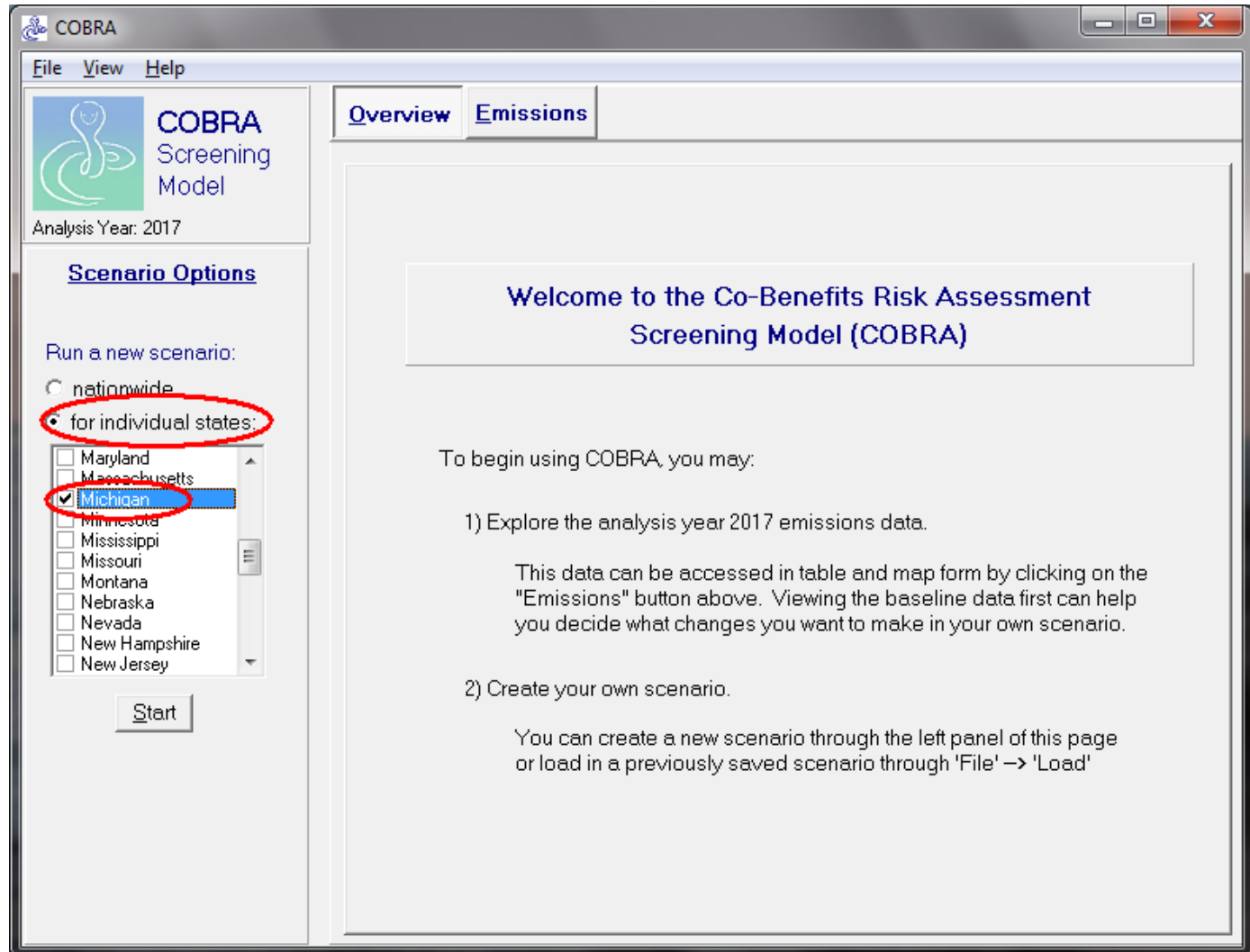
$$\begin{aligned} \text{NO}_x: 6 \text{ million MWh} \times 1.9392 \text{ per MWh} &= 12 \text{ million lbs.} \\ &= \mathbf{6,000 \text{ tons}} \end{aligned}$$



[Note that 1 ton = 2,000 lbs.]

# Step 2: Set up Scenario in COBRA

## (a) Location of Emission Reductions Expected





# Step 2: Set up Scenario in COBRA

## (b) Types of Emission Reductions Expected



Define scenario

MI

All Counties

To change emissions estimates, click on a source category and enter your changes in the panel below. You MUST click the Apply Edits button after editing each source category for your changes to be recorded.

**Currently active category:**  
FUEL COMB. ELEC. UTIL.

- CHEMICAL & ALLIED PRODUCT MFG
- FUEL COMB. ELEC. UTIL.
- FUEL COMB. INDUSTRIAL
- FUEL COMB. OTHER
- HIGHWAY VEHICLES
- METALS PROCESSING
- MISCELLANEOUS
- NATURAL SOURCES
- OFF-HIGHWAY
- OTHER INDUSTRIAL PROCESSES
- PETROLEUM & RELATED INDUSTRIES
- SOLVENT UTILIZATION
- STORAGE & TRANSPORT
- WASTE DISPOSAL & RECYCLING

PM 2.5:  reduce by   increase by   percent tons  tons

SO2:  reduce by   increase by   percent tons  tons

NOx:  reduce by   increase by   percent tons  tons

NH3:  reduce by   increase by   percent tons  tons

VOC:  reduce by   increase by   percent tons  tons

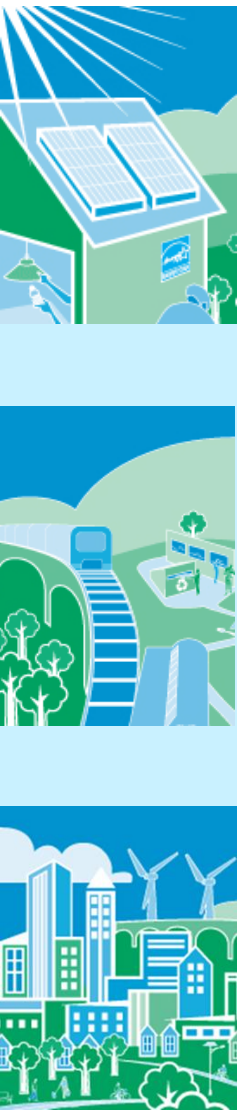
Apply Edits

<- Back Summarize Edits Run Scenario ->



# Step 2: Set up Scenario in COBRA

## (c) Quantity of emission reductions expected



Define scenario

MI

All Counties

To change emissions estimates, click on a source category and enter your changes in the panel below. You MUST click the Apply Edits button after editing each source category for your changes to be recorded.

**Currently active category:**  
FUEL COMB. ELEC. UTIL.

- ☐ CHEMICAL & ALLIED PRODUCT MFG
- ☐ **FUEL COMB. ELEC. UTIL.**
- ☐ FUEL COMB. INDUSTRIAL
- ☐ FUEL COMB. OTHER
- ☐ HIGHWAY VEHICLES
- ☐ METALS PROCESSING
- ☐ MISCELLANEOUS
- ☐ NATURAL SOURCES
- ☐ OFF-HIGHWAY
- ☐ OTHER INDUSTRIAL PROCESSES
- ☐ PETROLEUM & RELATED INDUSTRIES
- ☐ SOLVENT UTILIZATION
- ☐ STORAGE & TRANSPORT
- ☐ WASTE DISPOSAL & RECYCLING

PM 2.5:  reduce by   percent tons  
 increase by

SO<sub>2</sub>:  reduce by   percent tons  
 increase by

NO<sub>x</sub>:  reduce by   percent tons  
 increase by

NH<sub>3</sub>:  reduce by   percent tons  
 increase by

VOC:  reduce by   percent tons  
 increase by

Apply Edits


<- Back Summarize Edits Run Scenario ->



# Step 3: Select a discount rate



Select a Discount Rate for the Scenario

 COBRA estimates the economic value of current and future avoided deaths and illnesses expected based on emissions reductions in the year 2017. Emission reductions require investments and, like all investments, there are trade-offs, or opportunity costs, of picking one investment over another, each with their own set and schedule of expected benefits. To reflect the opportunity costs of the investments foregone by investing in emission reductions and to figure out how much future benefits are worth today, COBRA users must select a discount rate.

Rather than using just a single rate, EPA's Guidelines for Economic Analysis recommend that analysts use a bounding approach to discounting, developing an upper and lower bound for their estimates. They advise use of both:

- a 3% rate, reflecting the interest rate consumers might earn on Government backed securities, and
- a 7% rate, reflecting the opportunity cost of private capital, based on estimates from the Office of Management and Budget.

NOTE: A higher discount rate favors those investments with immediate benefits and reduces the value of future benefits more than a lower discount rate, which places a greater value on future benefits to society. For more information on discount rates and how EPA uses them in monetizing health benefits, see the User Manual.

In order to run the COBRA model, please select a discount rate to use in this COBRA session.

3%  
 7%

Continue



# Step 4: Run the model and review the results



We calculated absolute emissions reductions of Michigan's renewable portfolio standard of 10%.

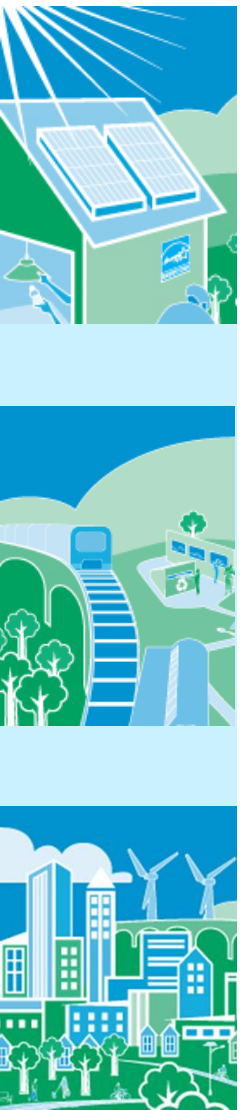
| Annual Emission Reductions (short tons) |        |
|---|--------|
| Pollutant                               | Amount |
| Sulfur Dioxide (SO <sub>2</sub> )       | 20,000 |
| Nitrogen Oxides (NO <sub>x</sub> )      | 6,000  |

COBRA (1) converted emissions reductions into air quality improvements, and (2) estimated annual adverse health impacts avoided.

| Annual Adverse Health Impacts Avoided |           |
|---------------------------------------|-----------|
| Outcome                               | Number    |
| Mortality                             | 119 - 304 |
| Asthma Exacerbations                  | 3,236     |
| Heart Attacks                         | 16 - 146  |
| Hospital Admissions                   | 93        |
| Acute Bronchitis                      | 169       |
| Respiratory Symptoms                  | 5,233     |
| Asthma ER Visits                      | 68        |
| Minor Restricted Activity Days        | 88,325    |
| Work Days Lost                        | 14,784    |

COBRA monetized the value or benefits of the avoided adverse health effects.

| Annual Benefits (2010, \$1,000s)       |
|--|
| Dollar Value                           |
| \$1,000,174 - \$2,563,875              |
| \$372                                  |
| \$1,923 - \$17,864                     |
| \$3,107                                |
| \$81                                   |
| \$294                                  |
| \$29                                   |
| \$6,006                                |
| \$2,232                                |
| <b>total</b> \$1,014,218 - \$2,593,859 |





# Step 4: Review & Promote Results

- COBRA gives you the results in summary tables and maps

COBRA Screening Model  
Analysis Year: 2017

**Results Map Options**

Current map view:  
Scenario Name: Michigan RPS - 3%

Quantity:  
Delta PM 2.5 (ug/m3)

Change map quantity:  
Delta PM 2.5 (ug/m3) [dropdown]

[View]

Change numeric ranges:  
[Change]

View Scenario Definition  
Export Scenario Definition

COBRA Screening Model  
Analysis Year: 2017

**Health Effects Table Options**

Current table:  
Scenario Name: Michigan RPS - 3%

View:  
Michigan

View new table by:  
Michigan [dropdown]

[View]

View Scenario Definition  
Export Scenario Definition

Overview Emissions Michigan RPS -

Air Quality: Tables Health Effects: Tables Results: Maps

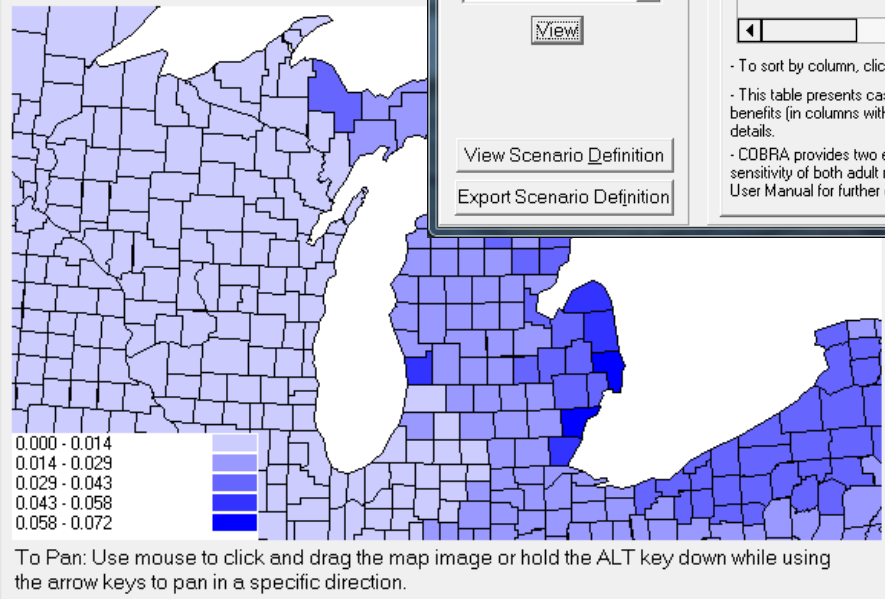
Export current data view

| State | County  | FIPS  | \$ Total Health Effects (low) | \$ Total Health Effects (high) |
|-------|---------|-------|-------------------------------|--------------------------------|
| MI    | Alcona  | 26001 | 267,918.1                     | 683,610.54                     |
| MI    | Alger   | 26003 | 96,053.2                      | 245,133.79                     |
| MI    | Allegan | 26005 | 620,551.95                    | 1,582,053.78                   |
| MI    | Alpena  | 26007 | 494,347.13                    | 1,266,272.17                   |
| MI    | Antrim  | 26009 | 295,999.81                    | 755,786.41                     |
| MI    | Arenac  | 26011 | 281,391.34                    | 718,198.61                     |
| MI    | Baraga  | 26013 | 33,100.96                     | 84,431.24                      |
| MI    | Barry   | 26015 | 448,022.08                    | 1,143,785.41                   |
| MI    | Bay     | 26017 | 2,225,878.42                  | 5,678,942.81                   |
|       |         |       | \$154,356,466.05              | \$395,280,273.32               |

To sort by column, click on the column title. To filter the data view, use the arrows on the state/county columns.

This table presents cases of health effects avoided (in columns with blue text) and the monetary values of those benefits (in columns with black text). Any negative values indicate costs. Please refer to the User Manual for further details.

COBRA provides two estimates of total health effects (low and high) which reflect two sets of assumptions about the sensitivity of both adult mortality and adult myocardial infarction to changes in ambient PM2.5 levels. Please refer to the User Manual for further details.





# How can I get more information?

## Visit Our Website

<http://www.epa.gov/statelocalclimate/resources/cobra.html> where you can:

- Learn more through online presentations, including:
  - Why Use COBRA?
  - How Does COBRA Work?
  - Quick start Tutorial: How To Use COBRA
- Find all of the documentation for COBRA
- Download the model

## Contact EPA:

Denise Mulholland

EPA State and Local Climate and Energy Programs

(202) 343-9274

[Mulholland.Denise@epa.gov](mailto:Mulholland.Denise@epa.gov)



State and Local  
Climate and Energy Program