



U.S. Environmental Protection Agency's (EPA's) CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool

February 22, 2022 | 3 PM Eastern

Three audio options:

1. Listen via computer
2. Use the “Call Me” feature
3. Dial 1-415-655-0002 or 1-855-797-9485; Event number: 2434 711 7855

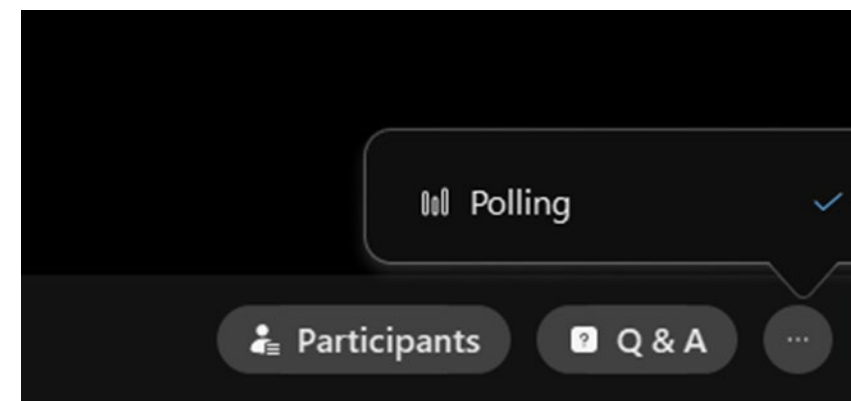
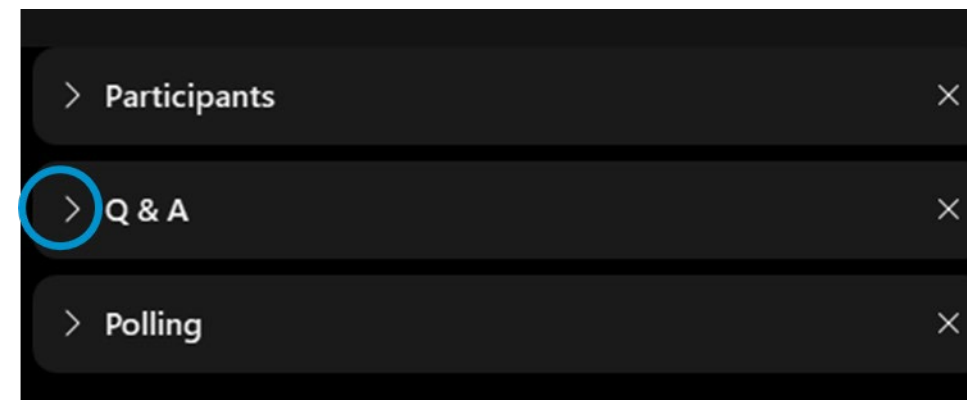
Webinar Panels

We'll use three panels

- Participants, Polling, and Question & Answer (Q&A)
- Use the arrow to expand or collapse the panels

Adding Panels

- If some panels don't appear, hover over the bottom of the screen and select the desired panels
- Select More Options (...) for additional panels
- Highlighted backgrounds indicate active panels



Participants

Q&A

More Options
Polling

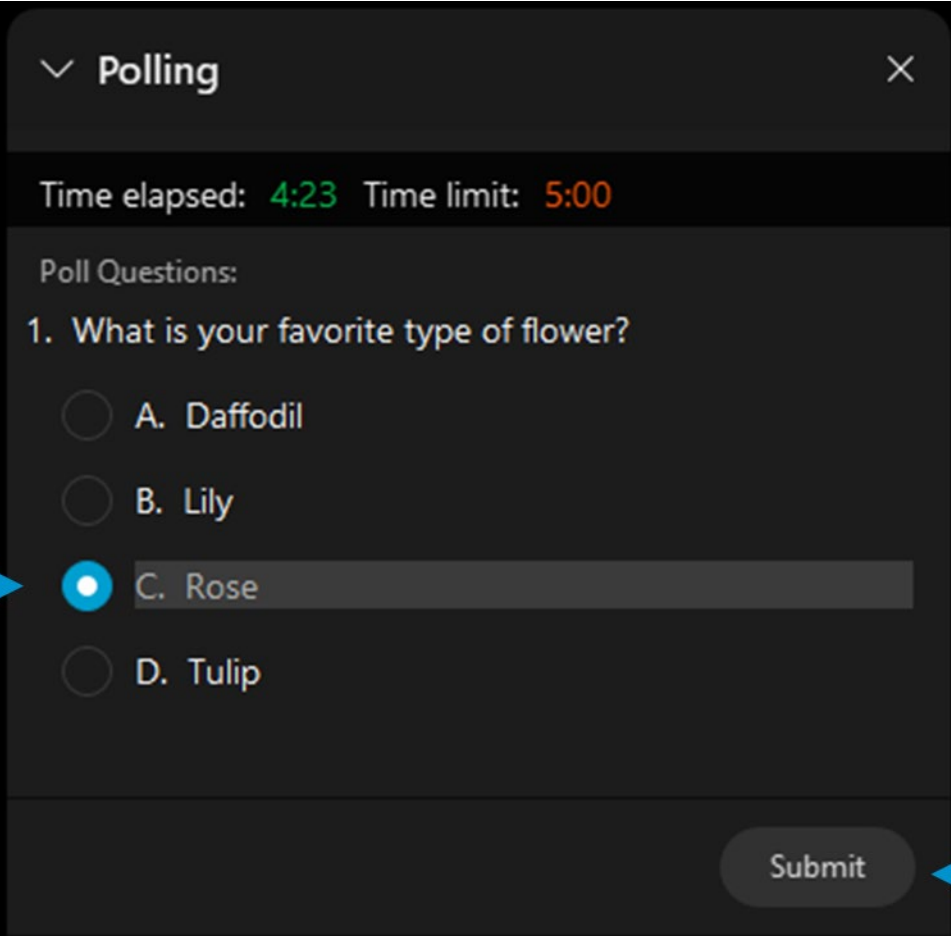
Polling and Feedback

Polling

- We'll ask several poll questions during the webinar
- The polling panel will appear when we open the first poll
- Select your desired response and hit "Submit"

Webinar Feedback

- A feedback form will pop-up when you exit today's webinar



▼ Polling ×

Time elapsed: 4:23 Time limit: 5:00

Poll Questions:

1. What is your favorite type of flower?

☐ A. Daffodil

☐ B. Lily

☒ C. Rose

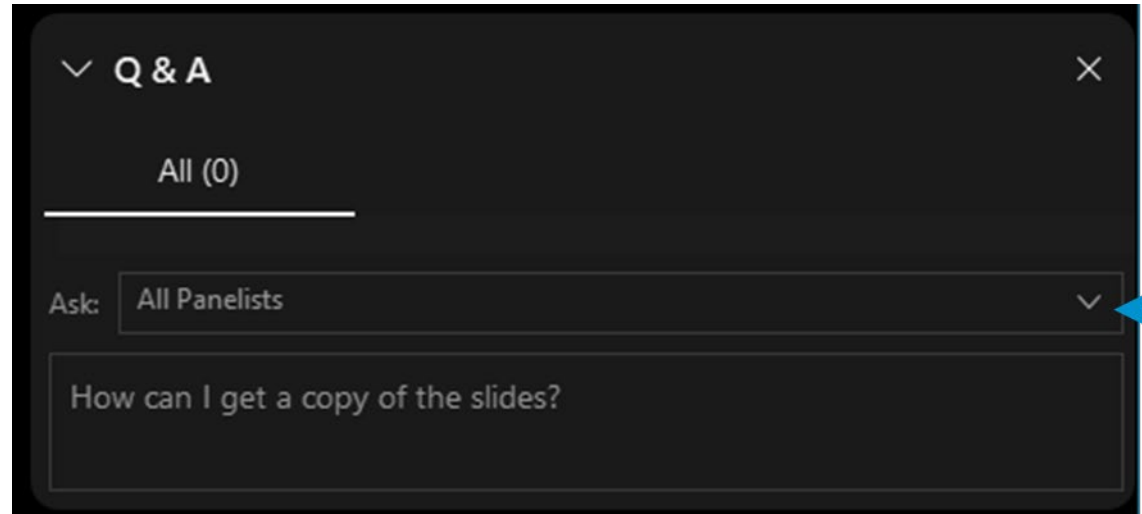
☐ D. Tulip

Submit

Q&A

- Participants are muted
- Questions will be moderated at the end
- To ask a question:

1. Select “All Panelists” from the drop-down menu
2. Enter your question in the Q&A box
3. Hit “Enter”

A screenshot of a dark-themed Q&A interface. At the top, there's a header with a downward arrow, 'Q & A', and a close button (X). Below this is a section titled 'All (0)'. Underneath, there's a label 'Ask:' followed by a dropdown menu currently showing 'All Panelists'. A blue arrow points to the dropdown arrow on the right of this menu. Below the dropdown is a large text input area containing the text 'How can I get a copy of the slides?'.

- EPA will post final materials on the Webinar Series page:
www.epa.gov/statelocalenergy/state-local-and-tribal-webinar-series

Today's Speakers

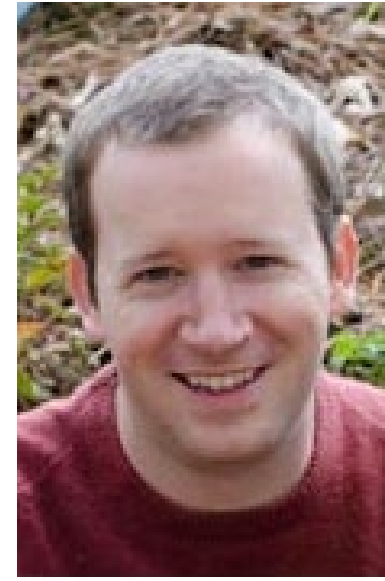


Emma Zinsmeister

Master of Public Health (MPH)

Senior Health Analyst

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David Cooley

Master of Environmental Management (MEM)

Senior Associate

Abt Associates

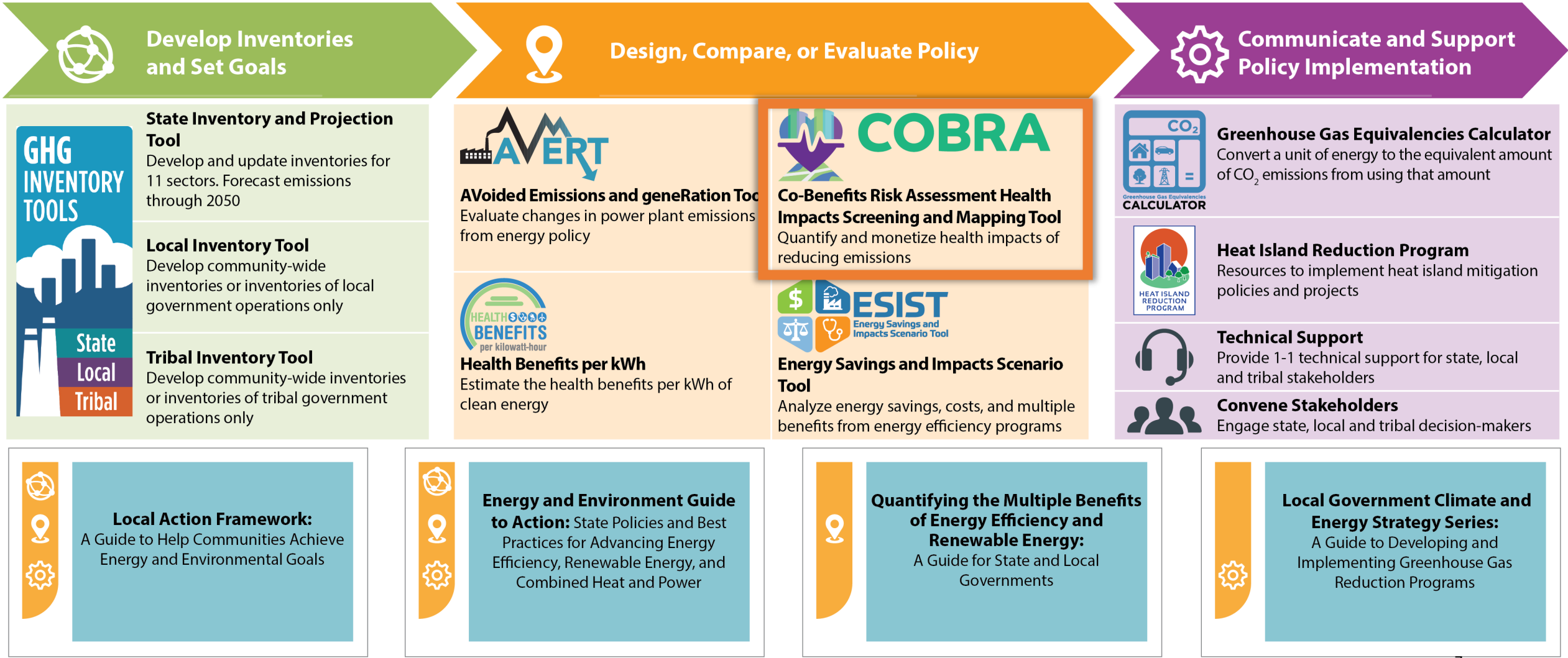
- Welcome to COBRA (25 mins)
 - How COBRA works
 - Comparison of Desktop and Web Edition
 - How COBRA has been used
- Live demonstration (15 mins)
 - 100-megawatt (MW) utility solar in Tennessee
- Questions and discussion (15 mins)
- Appendix A: Web Edition step-by-step
- Appendix B: Desktop Edition step-by-step

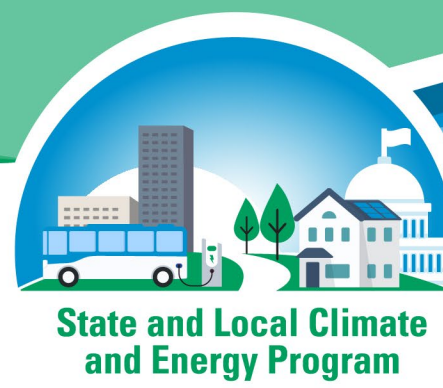


COBRA
Co-Benefits Risk Assessment
Health Impacts Screening and Mapping Tool



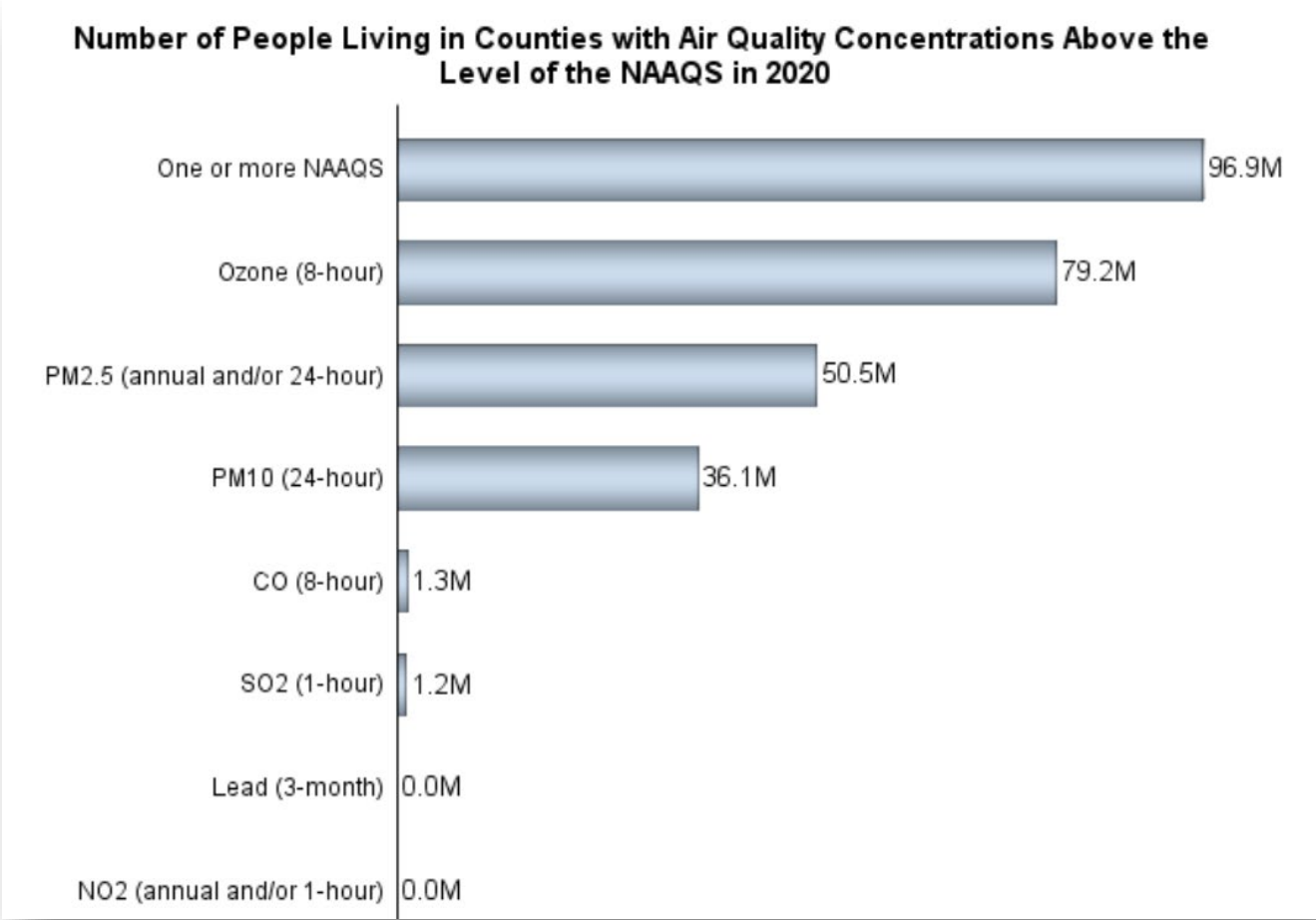
Our Tools and Resources Support State, Local and Tribal Stakeholders on Climate and Energy





Welcome to COBRA

Air pollution remains a concern across the United States



NAAQS: National Ambient Air Quality Standards
PM_{2.5}: Particulate matter 2.5
PM₁₀: Particulate matter 10
CO: Carbon monoxide
SO₂: Sulfur dioxide
NO₂: Nitrogen dioxide

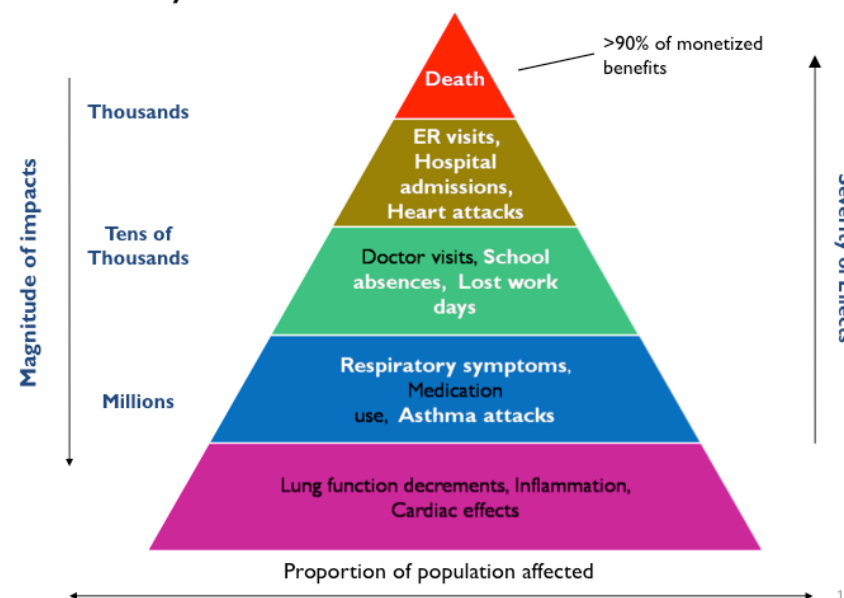
Health effects of air pollution

61,000 deaths attributed to air pollution in the United States (2019)

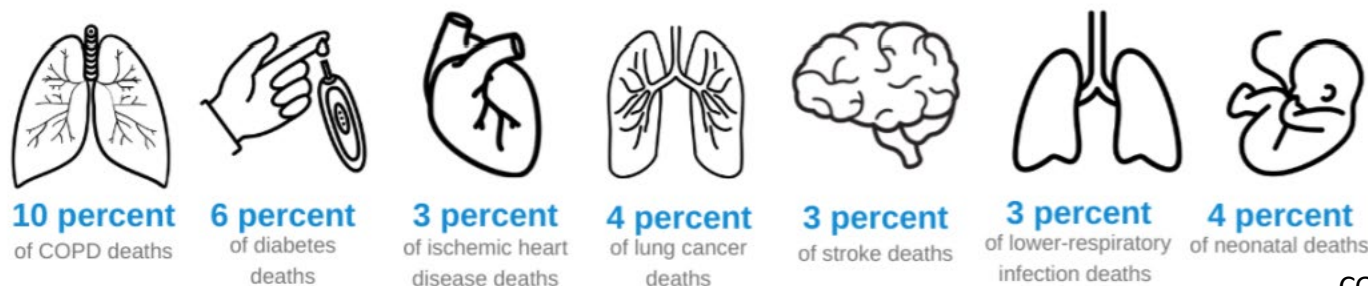


48,000 from PM_{2.5} exposure
13,000 from ozone (O₃) exposure

A “Pyramid of Effects” from Air Pollution



Percentage of Deaths (by Cause) Attributed to Air Pollution in the United States in 2019



COPD: Chronic obstructive pulmonary disease

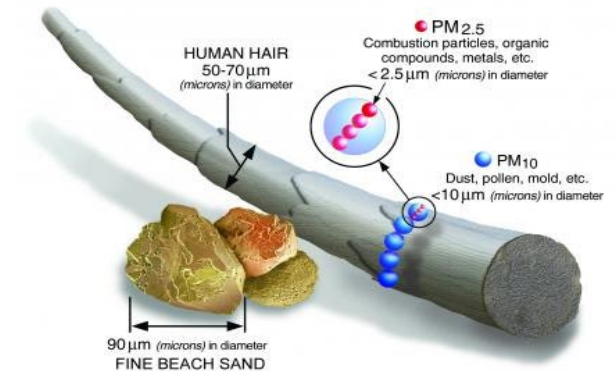
Fine PM 2.5

Primary PM_{2.5}

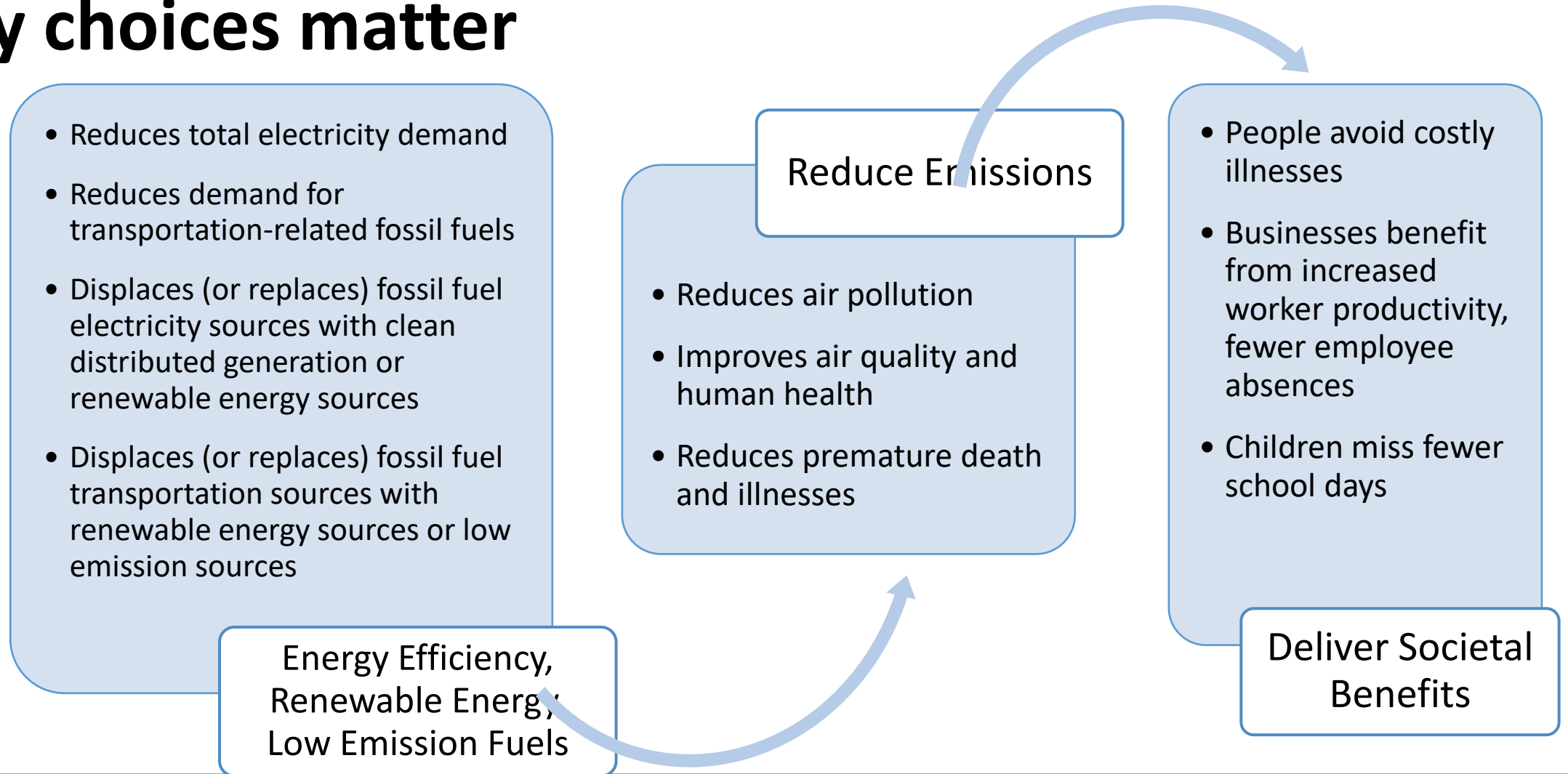
- Emitted directly into the atmosphere
- Sources:
 - Smokestacks
 - Construction sites
 - Unpaved roads
 - Fields
 - Fires

Secondary PM_{2.5}

- Formed through complex atmospheric reactions of
 - SO₂
 - Nitrogen oxides (NO_x)
 - Ammonia (NH₃)
 - Volatile organic compounds (VOCs)
- Sources:
 - Pollutants emitted from power plants, industries and automobiles



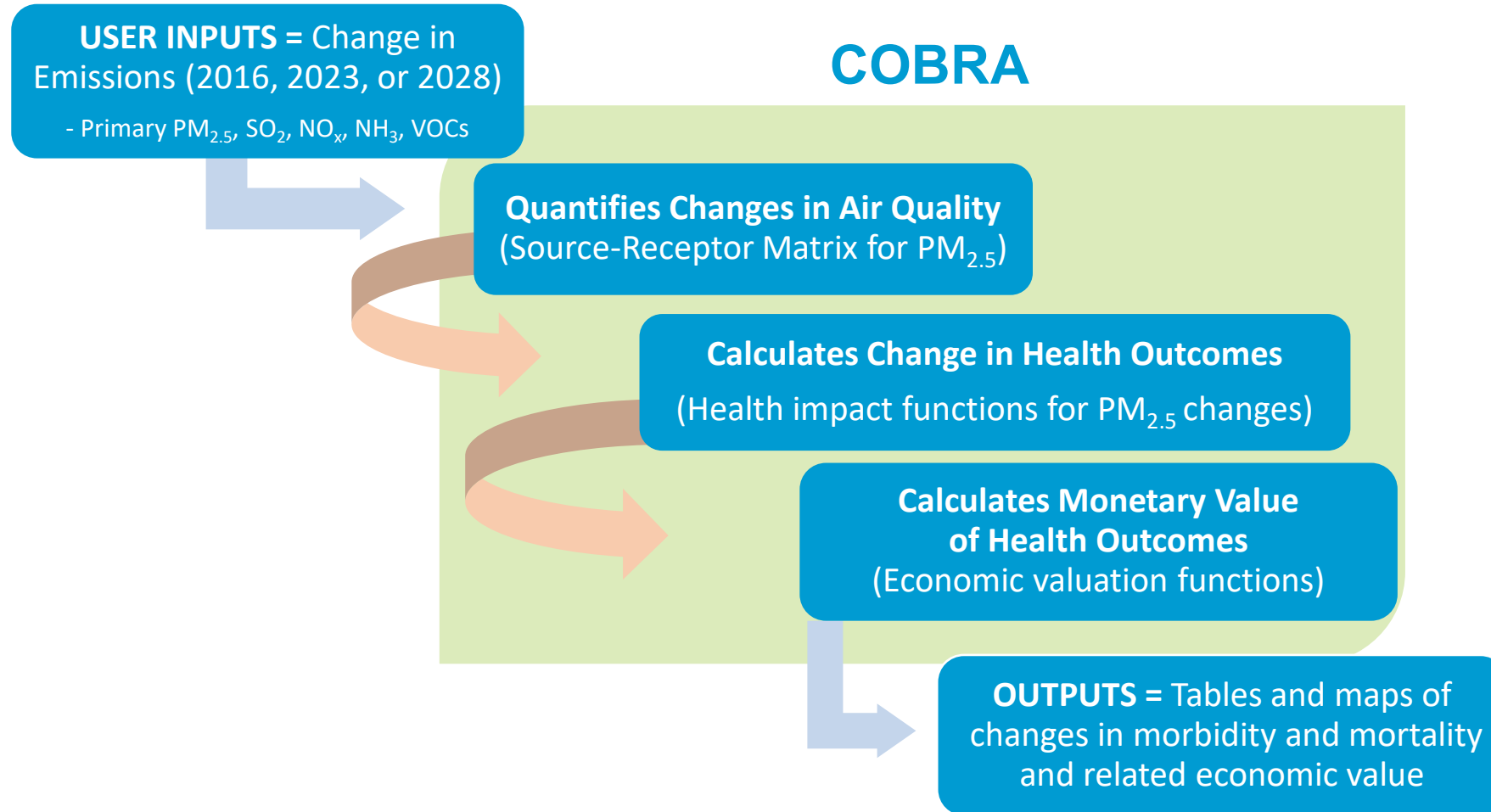
Energy choices matter



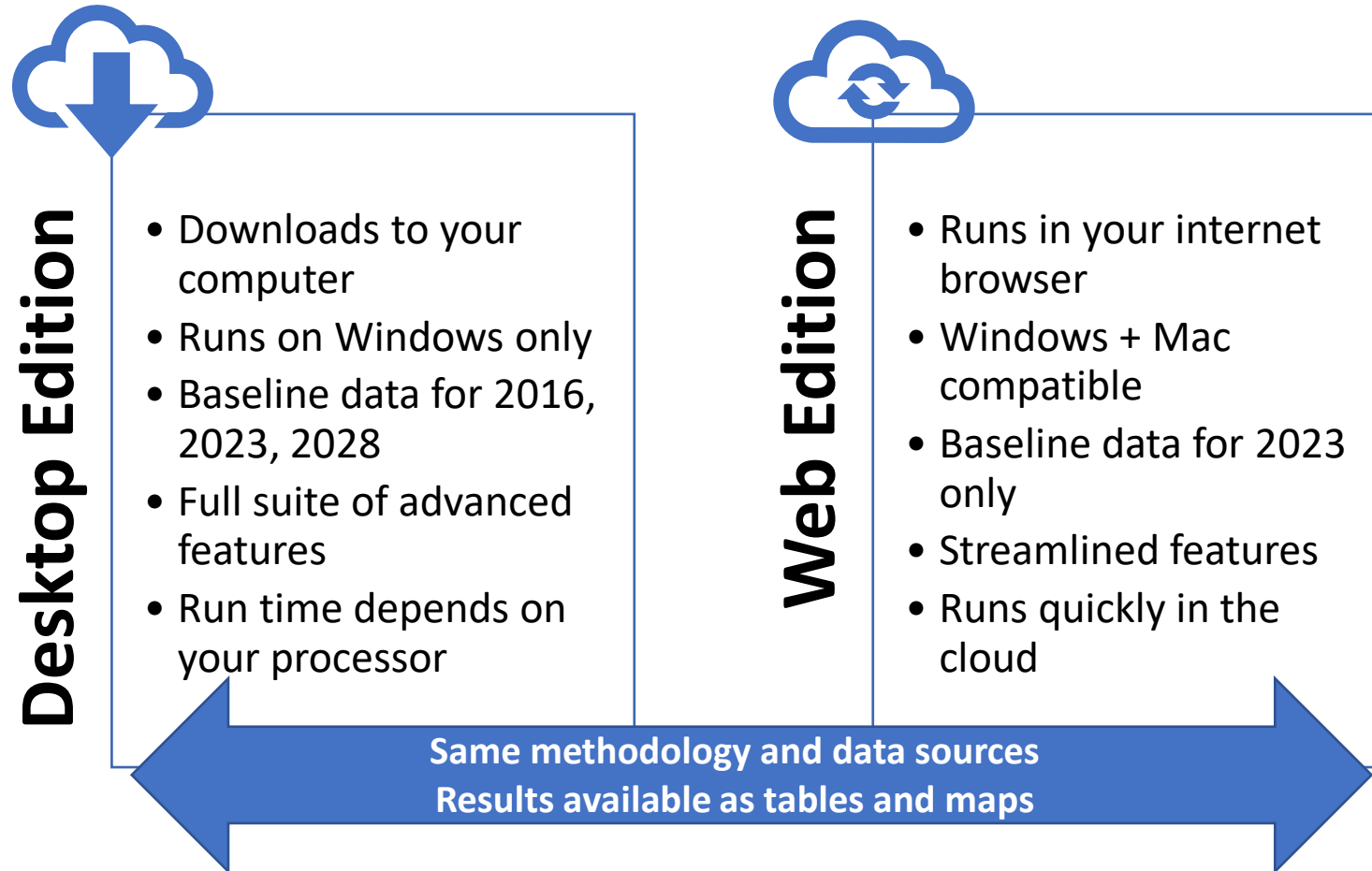
What is COBRA?

- COBRA is a free, easy-to-use, peer reviewed screening model that quickly:
 - Estimates county-level **health impacts** from changes in criteria air pollutants that affect PM_{2.5} concentrations;
 - Monetizes the **economic value** of those benefits; and
 - Presents results via **tables and maps** that facilitate visualization of the results.
- COBRA uses approaches and assumptions consistent with EPA's standard practices.
- It is intended to enrich the discussion of co-benefits and foster balanced decision-making that considers both the costs and health benefits of policy choices, especially related to energy.

How does COBRA work?



What are the options for running COBRA?



Where do the emissions baseline data come from?

- COBRA contains detailed emissions inventories for the years 2016 and 2023, and 2028 derived from EPA's 2016v1 Air Emissions Modeling Platform.
 - Reflect federal and state measures (promulgated or under reconsideration) as of May 2018.
- The 2016, 2023, and 2028 base cases include:
 - Electrical generating unit emissions (reflecting the implementation of the Cross State Air Pollution Rule Update);
 - The Mercury and Air Toxics Rule (MATS);
 - The Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources;
 - Mobile emissions (reflecting changes in activity data and the impacts the Tier 3 Motor Vehicle Emission and Fuel Standards Rule and local inspection and maintenance programs); and
 - Base year-specific fire data for 2016.

How does COBRA quantify PM_{2.5}-related air quality changes?

- COBRA translates air pollution emissions changes into changes in **ambient PM_{2.5}** using a reduced form air quality model, the Source-Receptor (S-R) Matrix.
- The **S-R Matrix consists of fixed transfer coefficients** that reflect the relationship between annual average PM_{2.5} concentration values at a single receptor in each county and the contribution by PM_{2.5} species to this concentration from each emission source.
- Since the S-R Matrix is not a sophisticated model, COBRA is most appropriately used as a **screening tool**.

What human health effects are included?

- COBRA estimates the number of health incidences avoided AND the related economic value for:

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

How does COBRA quantify and monetize health impacts?

- Uses a range of health impact functions to translate changes in ambient $PM_{2.5}$ into health incidences.
- Includes estimates of baseline incidence rates and prevalence rates for the health effects.
- Uses population and income projections based on U.S. Census of Population & Housing and forecasting models developed by Woods & Poole.
- Applies economic valuation functions and discount rates to develop dollar estimates.

Which epidemiological studies are used to estimate adverse health impacts of PM_{2.5}?

Endpoint	Author	Age
Mortality, All Cause	Krewski et al. (2009)	30-99
Mortality, All Cause	Lepeule et al. (2012)	25-99
Mortality, All Cause	Woodruff et al. (1997)	Infant
Acute Myocardial Infarction, Nonfatal	Peters et al. (2001)	18-99
Acute Myocardial Infarction, Nonfatal	Pope et al. (2006)	18-99
Acute Myocardial Infarction, Nonfatal	Sullivan et al. (2005)	18-99
Acute Myocardial Infarction, Nonfatal	Zanobetti and Schwartz (2006)	18-99
Acute Myocardial Infarction, Nonfatal	Zanobetti et al. (2009)	18-99
HA, All Cardiovascular (less Myocardial Infarctions)	Bell et al. (2008)	65-99
HA, All Cardiovascular (less Myocardial Infarctions)	Moolgavkar (2000b)	18-64
HA, All Cardiovascular (less Myocardial Infarctions)	Peng et al. (2008)	65-99
HA, All Cardiovascular (less Myocardial Infarctions)	Peng et al. (2009)	65-99
HA, All Cardiovascular (less Myocardial Infarctions)	Zanobetti et al. (2009)	65-99
HA, All Respiratory	Zanobetti et al. (2009)	65-99
HA, All Respiratory	Kloog et al. (2012)	65-99
HA, Asthma	Babin et al. (2007)	0-17
HA, Asthma	Sheppard (2003)	0-17
HA, Chronic Lung Disease	Moolgavkar (2000a)	18-64
Emergency Room Visits, Asthma	Mar et al. (2010)	0-99
Emergency Room Visits, Asthma	Slaughter et al. (2005)	0-99
Emergency Room Visits, Asthma	Glad et al. (2012)	0-99
Acute Bronchitis	Dockery et al. (1996)	8-12
Asthma Exacerbation, Cough	Mar et al. (2004)	6-18
Asthma Exacerbation, Cough	Ostro et al. (2001)	6-18
Asthma Exacerbation, Shortness of Breath	Mar et al. (2004)	6-18
Asthma Exacerbation, Shortness of Breath	Ostro et al. (2001)	6-18
Asthma Exacerbation, Wheeze	Ostro et al. (2001)	6-18
Minor Restricted Activity Days	Ostro and Rothschild (1989)	18-64
Lower Respiratory Symptoms	Schwartz and Neas (2000)	7-14
Upper Respiratory Symptoms	Pope et al. (1991)	9-11
Work Loss Days	Ostro (1987)	18-64

What are the unit values of the health effects estimated in COBRA?

Health Incidence Avoided	Economic Value in 2023 (2017\$)	
	3% discount rate	7% discount rate
Adult Mortality*	\$9,748,682	\$8,682,996
Infant Mortality	\$10,866,012	\$10,866,012
Non-Fatal Heart Attacks*	\$39,174 - \$309,825	\$37,038 - \$297,494
Hospital Admissions	\$17,655 - \$47,581	\$17,655 - \$47,581
Asthma ER Visits	\$457 - \$547	\$457 - \$547
Acute Bronchitis	\$550	\$550
Respiratory Symptoms (upper + lower)	\$24 - \$38	\$24 - \$38
Asthma Exacerbations	\$66	\$66
Minor Restricted Activity Days	\$78	\$78
Work Loss Days	\$178	\$178

*Discounted due to time lag between PM_{2.5} exposure and health outcome; low and high values based on assumptions of how sensitive outcomes are to unit change in PM_{2.5} exposure

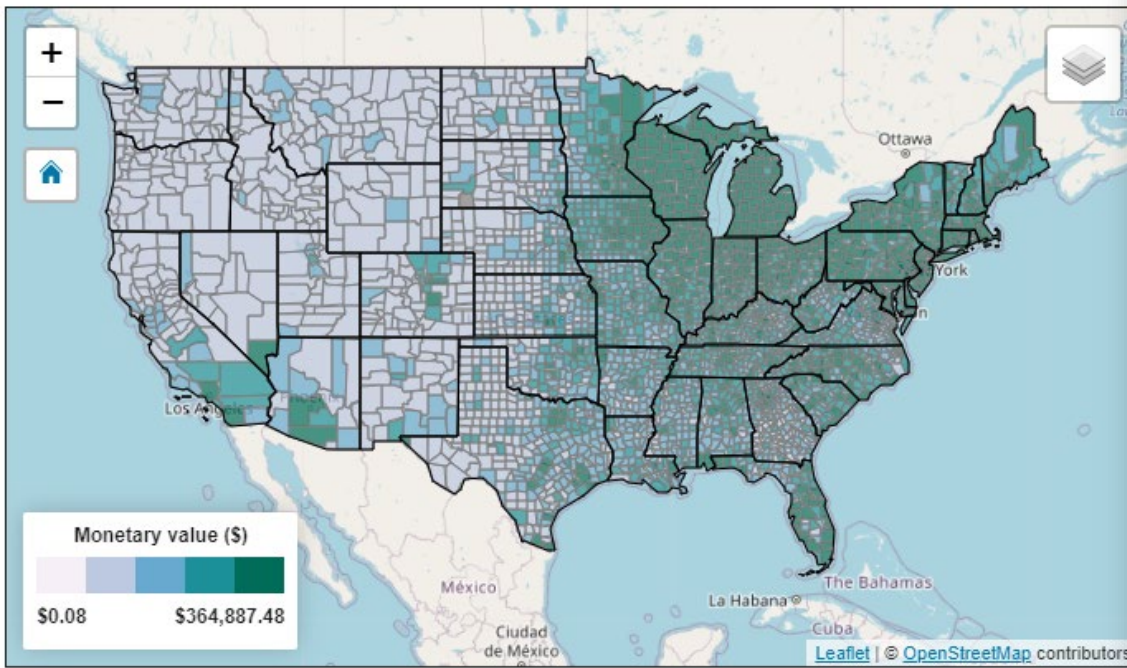
What methods are used to determine the economic value of different health effects?

Health Incident Avoided	Source of Value
Adult Mortality	Value of a statistical life (VSL)*
Infant Mortality	VSL*
Non-Fatal Heart Attacks	Cost of Illness (COI) = Direct medical costs, opportunity cost (OC)
Hospital Admissions	COI = Hospital charges, OC
Asthma Emergency Room Visits	COI = Costs to the hospital
Acute Bronchitis	Willingness To Pay (WTP) = Coughing and chest tightness (CT) or restricted activity day
Respiratory Symptoms	WTP = Symptoms such as coughing, head/sinus congestion, eye irritation, CT, coughing up phlegm, and/or wheeze
Asthma Exacerbations	WTP = Bad asthma day
Minor Restricted Activity Days	WTP = Combination of coughing, throat congestion, and sinusitis
Work Loss Days	WTP = Median annual earnings divided by (5 × 52)

How are results displayed?

Tables & maps

Displaying: Total Health Benefits (\$, low estimate)



(screenshots from Web Edition)

Step 3: View Results

[BUILD NEW SCENARIO](#)

A. Summary of Health Effects Results

Below is a table with the health effects results based on your scenario.



You are viewing results for all contiguous U.S. states. This is because changes in air quality can impact health endpoints in multiple locations due to the transportation of emissions across state and county lines.

Use the filters below to see health effects for a specific state or county.

1. Filter by state:

All contiguous U.S. states

2. Filter by county: (optional)

All counties

Results for: All Contiguous U.S. States

[Export: All results](#) | [Current filter](#)

Health Endpoint ¹	Change in Incidence ¹ (cases, annual)		Monetary Value ¹ (dollars, annual)	
	Low	High	Low	High
Mortality *	0.435	0.984	\$4,757,095	\$10,765,302
Nonfatal Heart Attacks *	0.045	0.415	\$7,136	\$66,308
Infant Mortality	0.002	0.002	\$24,826	\$24,826
Hospital Admits, All Respiratory	0.084	0.084	\$4,806	\$4,806
Hospital Admits, Cardiovascular **	0.094	0.094	\$3,395	\$3,395
Acute Bronchitis	0.550	0.550	\$339	\$339
Upper Respiratory Symptoms	9.930	9.930	\$424	\$424
Lower Respiratory Symptoms	6.985	6.985	\$189	\$189
Emergency Room Visits, Asthma	0.189	0.189	\$107	\$107
Asthma Exacerbation	10.375	10.375	\$770	\$770
Minor Restricted Activity Days	292.579	292.579	\$25,649	\$25,649
Work Loss Days	49.376	49.376	\$9,885	\$9,885
Total Health Effects			\$4,834,620	\$10,901,999

¹ The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low 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.

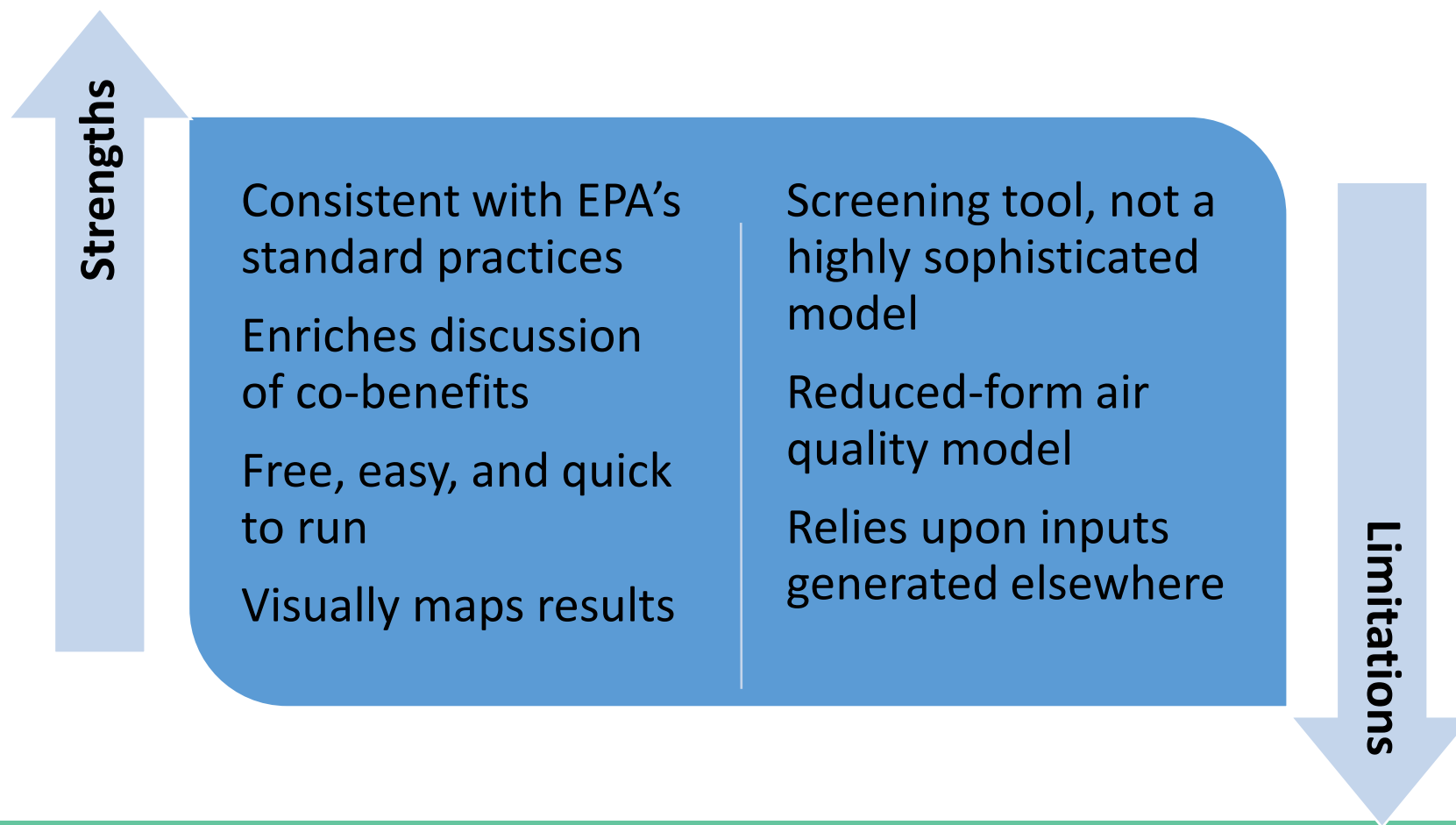
What do the results represent?

- Results represent the **annual change** in average PM_{2.5} microgram per cubic meter (µg/m³) concentration, health incidence, and monetary value (2017 \$) for the year of analysis (2016, 2023, or 2028).
- Incidence refers to the number of new cases of a health outcome over a specified time period. The change in incidence is not necessarily a whole number because COBRA calculates small **statistical risk reductions** that are then aggregated over the entire population.

What do the results represent?

- COBRA calculates **low and high values** because two different sets of health impact functions are used to estimate adult mortality and non-fatal heart attacks based on assumptions of the sensitivity of these outcomes to PM_{2.5} concentrations.
- 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.

What should you keep in mind when using either the Desktop or Web Edition?



How has COBRA been used?



State-level Climate Action Plans

- Maryland, New York, and Oregon



Renewable energy policies and programs

- Renewable policies in Illinois
- Solar installations in Long Island, NY



Energy efficiency policies and programs

- North Carolina's Clean Energy Plan
- Illinois Energy Efficiency Portfolio Standard



Transportation policies

- Analysis of reduced vehicle trips in Utah
- Public transit program in Nevada



Other analyses

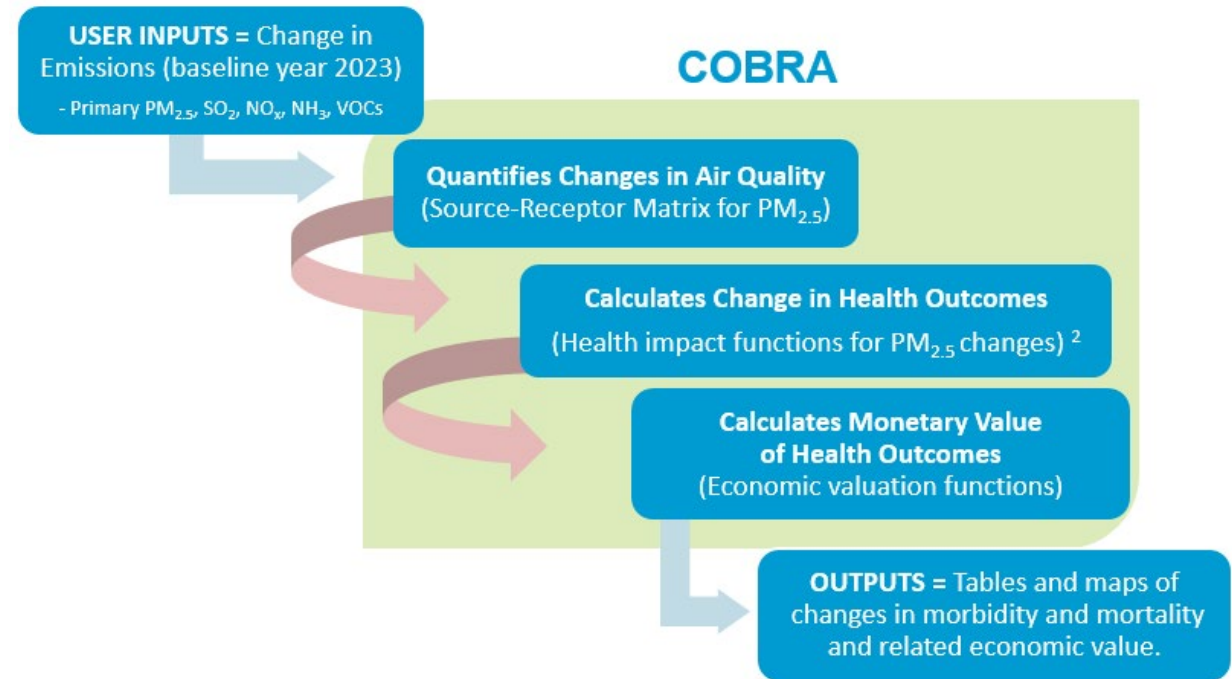
- Impacts of prescribed fires
- Benefits of urban tree planting

More than 130 citations as of February 2022

Pop Quiz

Q: What makes COBRA a screening-level tool?

- a) The source-receptor matrix for PM_{2.5}
- b) The health impact functions
- c) The economic valuation functions
- d) All the above





Live Demonstration

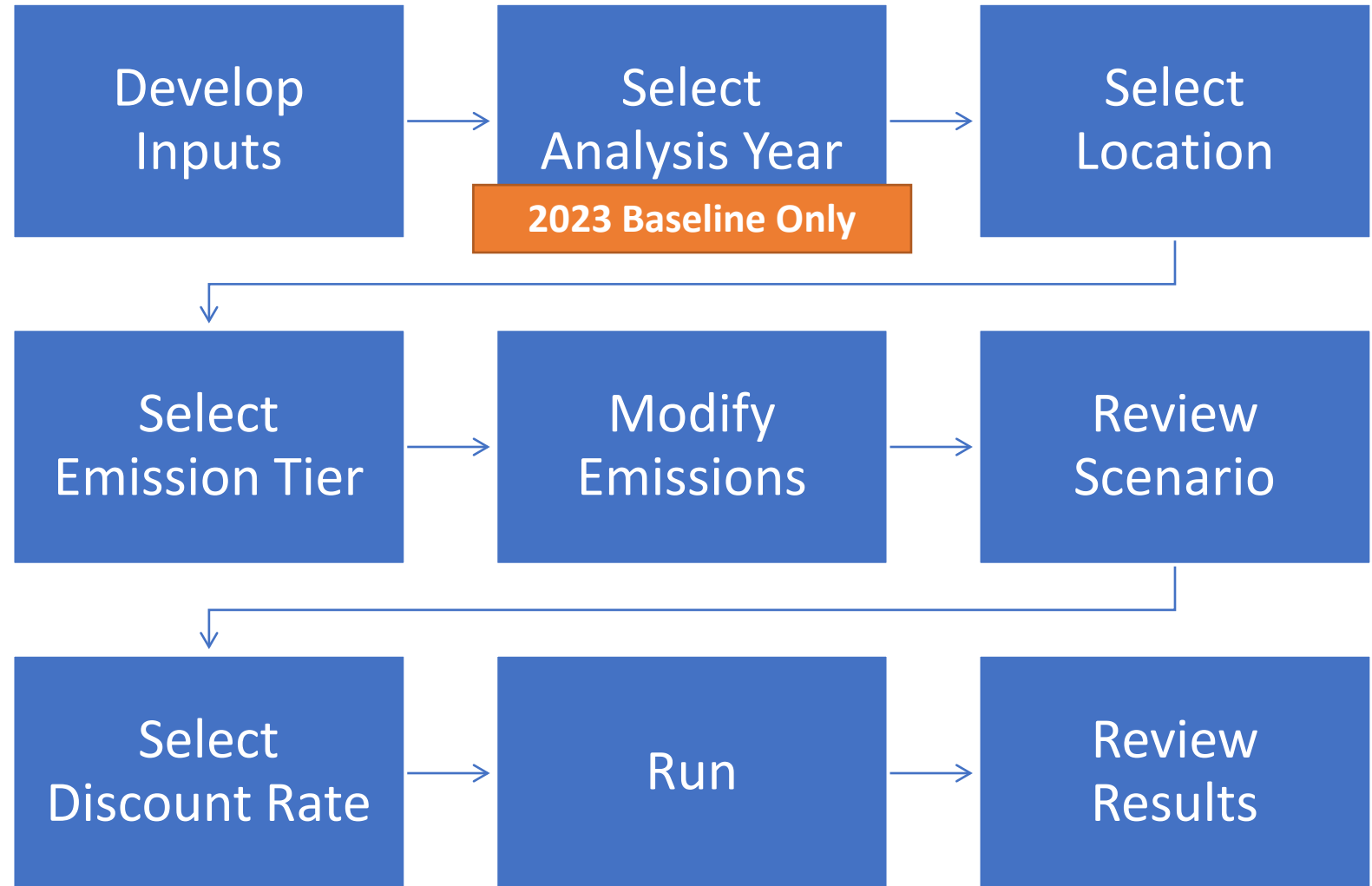
www.epa.gov/cobra

Demo: Assessed with COBRA Web Edition



What are the air quality and health impacts of a **100 MW** utility solar installation in **Nashville, Tennessee?**

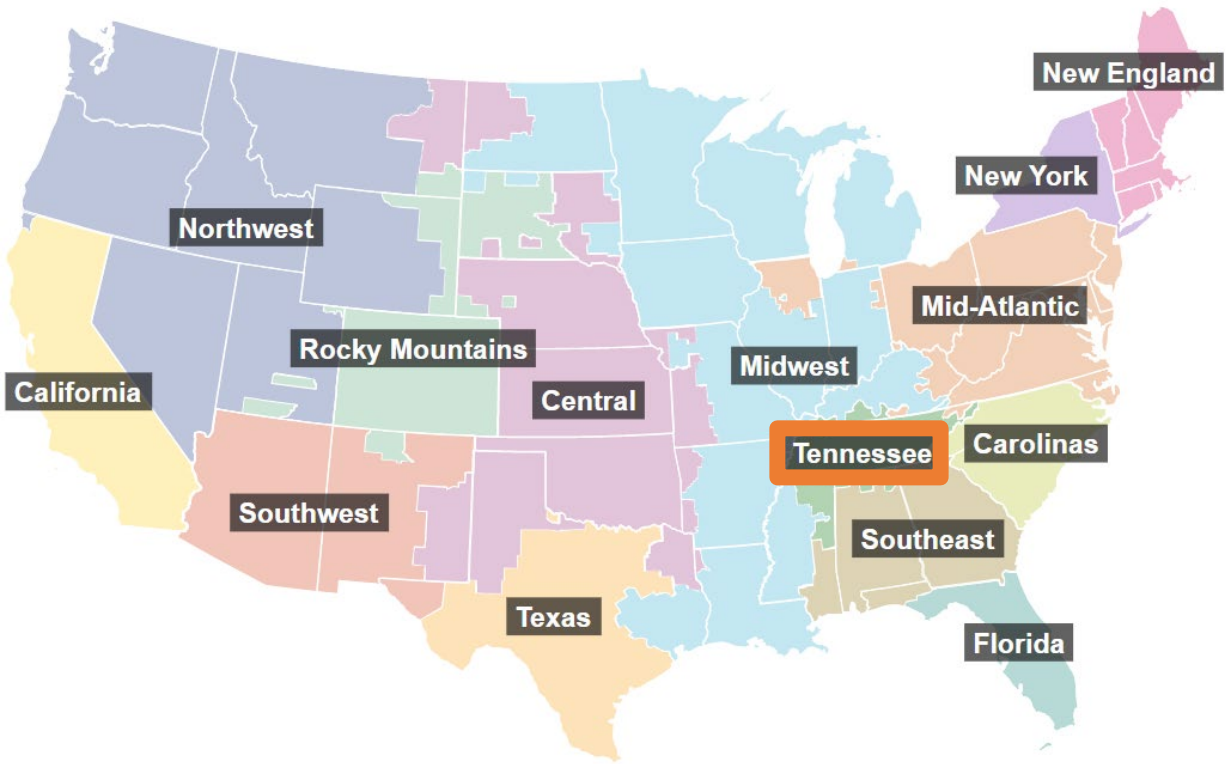
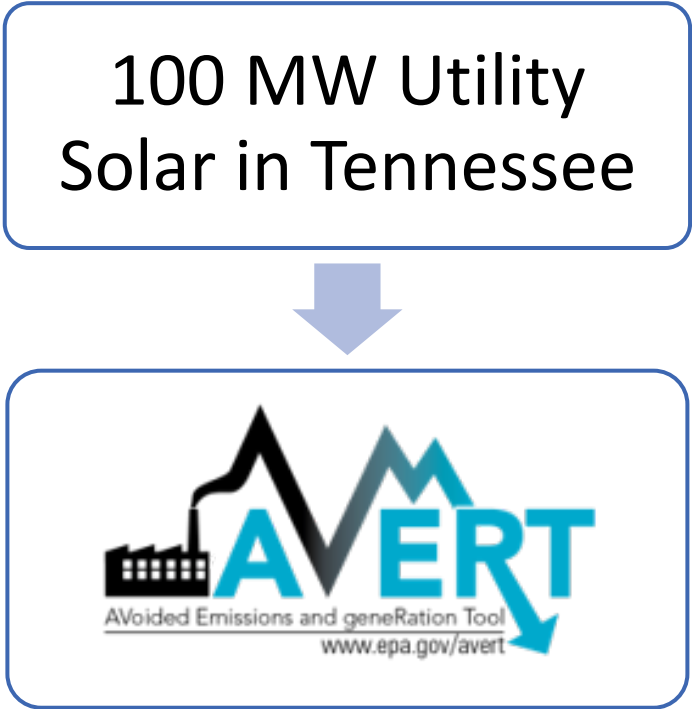
How do you run the COBRA Web Edition?



Develop Inputs

- When are the emissions changes taking place?
- Where are the emissions changes occurring?
- What is the source of the emissions?
- What emissions are changing and by how much?

Generate emissions inputs



Select “Tennessee” region

Emissions estimates from AVERT

Annual State Emission Changes:
Tennessee Region

State	SO ₂ (lb)	NO _x (lb)	CO ₂ (tons)	PM _{2.5} (lb)	VOCs (lb)	NH ₃ (lb)
Alabama	-90	-1,400	-10,010	-390	-130	-750
Kentucky	-59,240	-43,600	-26,250	-3,140	-1,000	-510
Mississippi	-230	-6,000	-24,400	-2,760	-980	-2,600
Tennessee	-82,440	-53,870	-83,620	-14,400	-3,340	-3,780

Convert from pounds (lbs) to tons (2,000 lbs = 1 ton)



State	SO ₂ (tons)	NO _x (tons)	PM _{2.5} (tons)	VOCs (tons)	NH ₃ (tons)
Alabama	-0.05	-0.7	-0.2	-0.07	-0.38
Kentucky	-29.62	-21.8	-1.57	-0.5	-0.26
Mississippi	-0.12	-3	-1.38	-0.49	-1.3
Tennessee	-41.22	-26.94	-7.2	-1.67	-1.89

AVoided Emissions and geneRation Tool (AVERT) – COBRA connection

Direct Connection to COBRA

EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool is a free tool that quantifies the air quality, human health, and health-related economic benefits from reductions in emissions that result from clean energy policies and programs. Outputs from AVERT can serve as inputs to COBRA. The button below will open a new browser tab and load your AVERT results directly into the COBRA Web Edition.

[Submit Results to COBRA](#)

Data Download

Download monthly displacement data for each county, state, and region in this analysis, in CSV format.

[Download County Level Results](#)

Download formatted outputs for use in EPA's COBRA Screening and Mapping Tool.

[Download COBRA Results](#)

Demo of COBRA Web Edition



CO-Benefits Risk Assessment (COBRA) is a screening tool that enables state, local, and tribal government staff and others interested in the effects of air pollution to estimate the air quality and health benefits of different emissions scenarios.

You are using the web-based version of COBRA. For the COBRA desktop application, visit the [COBRA download page](#).

START

Step 1: Build Scenario

Complete the sections below and click "Add to Scenario."

A. Select Location REQUIRED

Select the states or counties where the emissions changes will occur. [i](#)

- > ☐ Alabama
- > ☐ Arizona
- > ☐ Arkansas
- > ☐ California
- > ☐ Colorado
- > ☐ Connecticut
- > ☐ Delaware
- > ☐ District of Columbia
- > ☐ Florida

Step 2: Review Scenario



Build scenario to begin

Step 3: View Results

Results

Total Health Benefits	Low, 3% (2017\$)	High, 3% (2017\$)
Nationwide	3,254,497	7,350,807
Alabama	103,466	233,807
Kentucky	169,617	383,457
Mississippi	68,497	154,562
Tennessee	532,747	1,211,078
Davidson County	13,815	31,358



You are viewing results for all contiguous U.S. states. This is because changes in air quality can impact health endpoints in multiple locations due to the transportation of emissions across state and county lines.

Use the filters below to see health effects for a specific state or county.

1. Filter by state:

All contiguous U.S. states

2. Filter by county: (optional)

All counties

Results for: All Contiguous U.S. States

Export: [All results](#) | [Current filter](#)

Health Endpoint ¹	Change in Incidence ¹ (cases, annual)		Monetary Value ¹ (dollars, annual)	
	Low	High	Low	High
Mortality *	0.292	0.662	\$3,197,199	\$7,240,122
Nonfatal Heart Attacks *	0.040	0.368	\$6,438	\$59,826
Infant Mortality	0.002	0.002	\$19,037	\$19,037
Hospital Admits, All Respiratory	0.091	0.091	\$3,327	\$3,327
Hospital Admits, Cardiovascular **	0.091	0.091	\$4,650	\$4,650
Acute Bronchitis	0.345	0.345	\$213	\$213
Upper Respiratory Symptoms	6.244	6.244	\$267	\$267
Lower Respiratory Symptoms	4.390	4.390	\$119	\$119
Emergency Room Visits, Asthma	0.137	0.137	\$77	\$77
Asthma Exacerbation	6.529	6.529	\$484	\$484
Minor Restricted Activity Days	186.819	186.819	\$16,377	\$16,377
Work Loss Days	31.517	31.517	\$6,309	\$6,309
Total Health Effects			\$3,254,497	\$7,350,807

* The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low 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.

** Except heart attacks.

Results

How to get a screen capture:

Ctrl+PrtSc
(Windows)

Shift+Command+3
(Mac)

B. Map of Health Effects and Air Quality Results

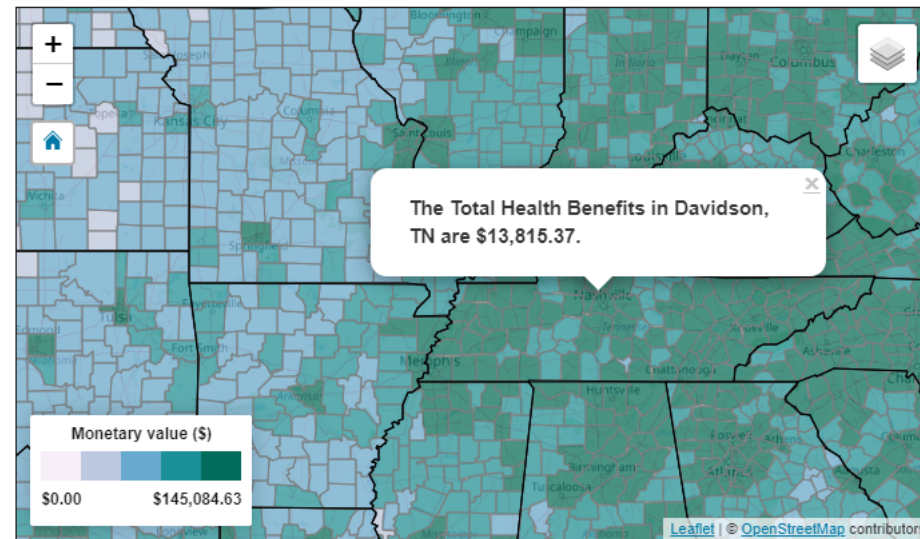
Below is a map showing health effects and air quality data based on your scenario.

Use the filter below to change the map's data layer. Click on a county on the map to explore the data.

Select the map's data layer:

Total Health Benefits (\$, low estimate)

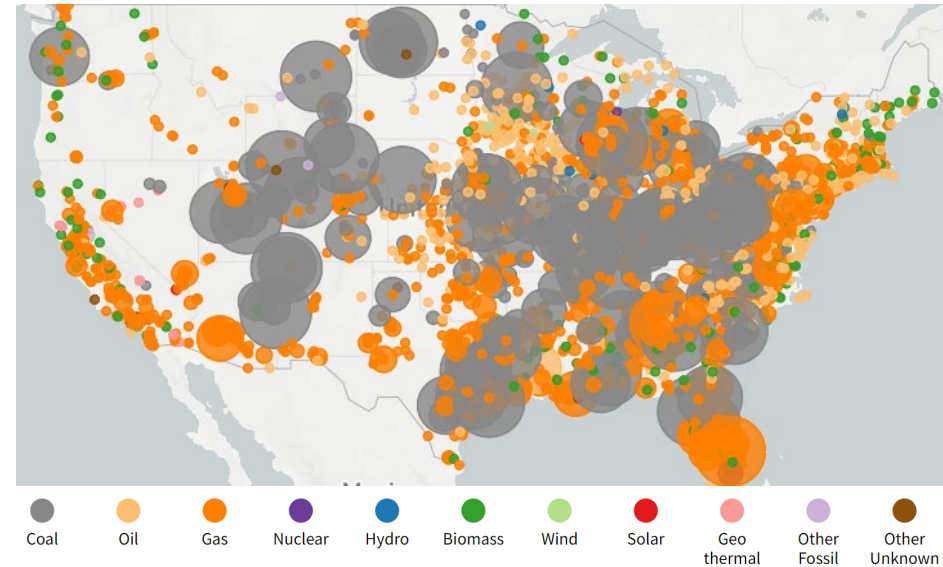
Displaying: Total Health Benefits (\$, low estimate)



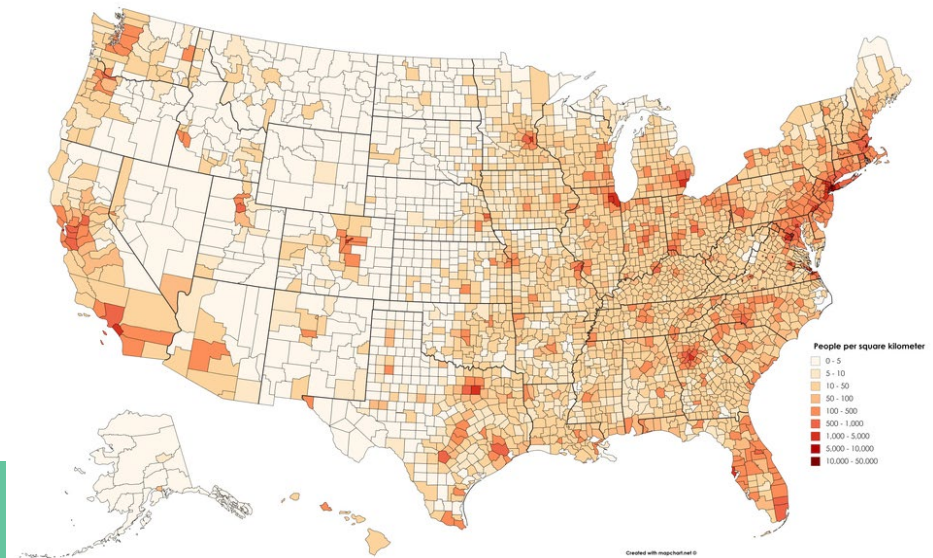
What's driving the results?

- Regional emissions sources & changes
- Airshed dynamics
- Population density
- Population proximity to emissions sources
- Sensitivity of health outcomes to emissions changes
- Other factors?

U.S. Power Plant Emissions by Source, 2020



2020 Population Distribution in The United States



Poll Question

- What types of policies or programs do you plan to analyze using COBRA? (select all that apply)
 - GHG mitigation / climate action plans
 - Renewable energy
 - Energy efficiency
 - Vehicle electrification
 - Building electrification
 - Waste sector
 - Industrial sector
 - Wildfire emissions



State and Local Climate
and Energy Program



COBRA

epa.gov/cobra

Co-Benefits Risk Assessment
Health Impacts Screening and Mapping Tool

Contact us: cobra@epa.gov

Join our Office Hours: Feb. 24, 2-3pm (ET)

Register at epa.gov/statelocalenergy/state-local-and-tribal-webinar-series

References

Slide 6

- U.S. EPA. Air Quality National Summary. www.epa.gov/air-trends/air-quality-national-summary

Slide 7

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Slide 14

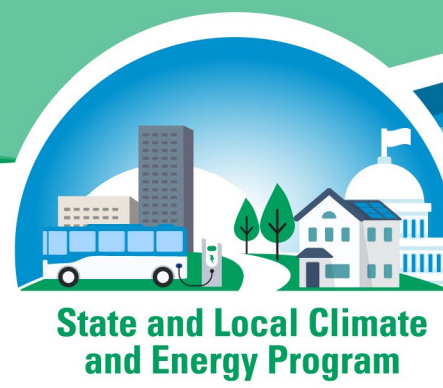
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Appendix A

COBRA Web Edition Step-by-Step

Step 0. Develop Your Inputs

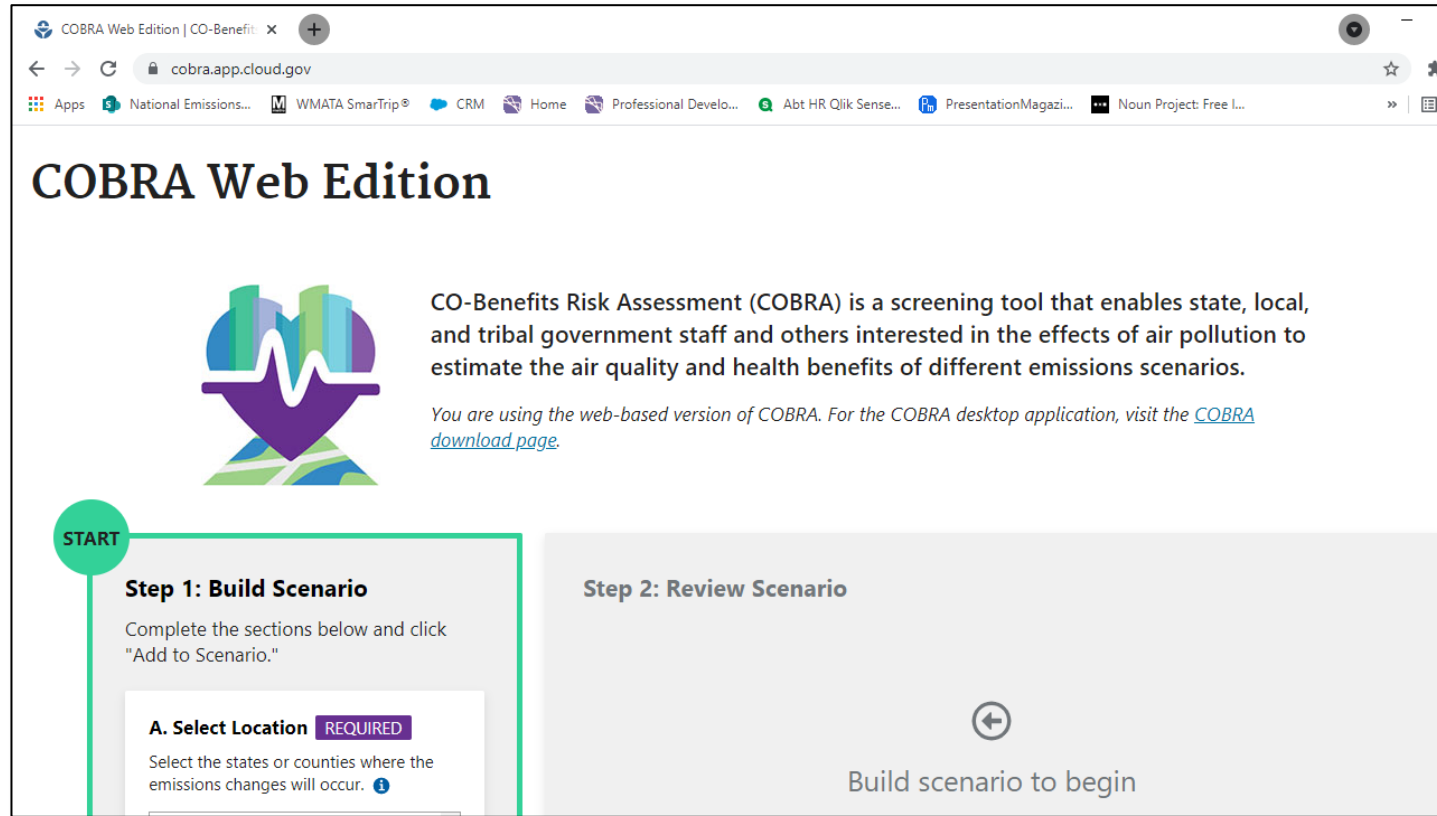
Part 1: Woodstove Changeouts
Location: Wisconsin
Sector: Fuel Combustion Other; Residential Wood; Woodstoves
Emissions Changes: <ul style="list-style-type: none">- PM_{2.5}: Reduce by 31.5 tons- VOCs: Reduce by 80.7 tons
Discount Rate: 3%

Part 2: 440 kW Solar Photovoltaic (PV)
Location: Wisconsin
Sector: Fuel Combustion Electric Utility
Emissions Changes: <ul style="list-style-type: none">- PM_{2.5}: Reduce by 1.7 tons- SO₂: Reduce by 9.2 tons- NO_x: Reduce by 6.5 tons- VOCs: Reduce by 1.2 tons
Discount Rate: 3%

Target completion date: 2024

kW: Kilowatt

Step 1. Access COBRA



The new COBRA Web Edition can be accessed at: www.epa.gov/cobra

Step 2. Select Location

Scroll through the list of locations to select the one you are interested in. Check the box to make a selection.

START

Step 1: Build Scenario

Complete the sections below and click "Add to Scenario."

A. Select Location REQUIRED

Select the states or counties where the emissions changes will occur. ⓘ

> ☐ South Dakota

> ☐ Tennessee

> ☐ Texas

> ☐ Utah

> ☐ Vermont

> ☐ Virginia

> ☐ Washington

> ☐ West Virginia

> ☒ Wisconsin

[Select All](#) | [Deselect All](#)

Step 3. Select Sector

Select the sector you are interested in from the dropdown menu.

B. Select Sector REQUIRED

Select the industry or sector where the emissions changes will occur. i

Sector

Fuel Combustion: Other

Subsector (optional)

Residential Wood

Subsector (optional)

All subsectors

All subsectors

Fireplaces

Other

Woodstoves

Select any subsectors you are interested in from the dropdown menus.

C. Modify Emissions REQUIRED

Enter emissions changes for **at least one** of the five pollutants below. [i](#)

PM_{2.5} (Baseline = 11,730.15 tons)

reduce by **increase by**

31.5 ☒ tons ☐ percent

SO₂ (Baseline = 281.57 tons)

reduce by **increase by**

enter # ☒ tons ☐ percent

NO_x (Baseline = 1,112.44 tons)

reduce by **increase by**

enter # ☒ tons ☐ percent

NH₃ (Baseline = 600.4 tons)

reduce by **increase by**

enter # ☒ tons ☐ percent

VOC (Baseline = 11,793.29 tons)

reduce by **increase by**

80.7 ☒ tons ☐ percent

Step 4. Modify Emissions

PM_{2.5} (Baseline = 11,730.15 tons)

reduce by **increase by**

31.5 ☒ tons ☐ percent

VOC (Baseline = 11,793.29 tons)

reduce by **increase by**

80.7 ☒ tons ☐ percent

ADD TO SCENARIO


Enter your emissions information and select **ADD TO SCENARIO**.

Step 5. Review Scenario


Step 2: Review Scenario

Review the scenario below. To add changes to more locations or sectors, repeat Step 1 to continue building your scenario.

Location(s)	Sector	Emissions Modification(s)	
Wisconsin - All Counties	Fuel Combustion: Other Residential Wood	PM _{2.5} reduce by 31.5 tons VOC reduce by 80.7 tons	×



Need to continue adding emissions changes to locations or sectors? Repeat Step 1.

Discount rate: 

☒ 3%

☐ 7%

☐ Custom:

RUN SCENARIO

Review your scenario and ensure the correct discount rate is selected.

Step 6. Add Additional Location Information

Scroll through the list of locations to select the one you are interested in. Check the box to make a selection.

START

Step 1: Build Scenario

Complete the sections below and click "Add to Scenario."

A. Select Location

REQUIRED

Select the states or counties where the emissions changes will occur. ⓘ

> ☐ South Dakota

> ☐ Tennessee

> ☐ Texas

> ☐ Utah

> ☐ Vermont

> ☐ Virginia

> ☐ Washington

> ☐ West Virginia

> ☒ Wisconsin

[Select All](#) | [Deselect All](#)


U.S. Environmental Protection Agency

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Step 7. Add Additional Sector Information

Select the sector you are interested in from the dropdown menu.


B. Select Sector **REQUIRED**

Select the industry or sector where the emissions changes will occur. 


Sector

Fuel Combustion: Electric Utility 

Subsector (optional)

All subsectors 

Subsector (optional)

All subsectors 

Select any subsectors you are interested in from the dropdown menus.

Step 8. Add Additional Emissions Information

PM_{2.5} (Baseline = 1,351.15 tons)

reduce by

increase by

1.7

☒ tons ☐ percent

NO_x (Baseline = 12,175.19 tons)

reduce by

increase by

6.5

☒ tons ☐ percent

SO₂ (Baseline = 5,795.31 tons)

reduce by

increase by

9.2

☒ tons ☐ percent

VOC (Baseline = 912.96 tons)

reduce by

increase by

1.2

☒ tons ☐ percent

Enter your emissions information and select ADD TO SCENARIO.

ADD TO SCENARIO

Step 9. Review Scenario

Step 2: Review Scenario

Review the scenario below. To add changes to more locations or sectors, repeat Step 1 to continue building your scenario.

Location(s)	Sector	Emissions Modification(s)	
Wisconsin - All Counties	Fuel Combustion: Other Residential Wood	PM _{2.5} reduce by 31.5 tons VOC reduce by 80.7 tons	×
Wisconsin - All Counties	Fuel Combustion: Electric Utility	PM _{2.5} reduce by 1.7 tons SO ₂ reduce by 9.2 tons NO _x reduce by 6.5 tons VOC reduce by 1.2 tons	×

Review your scenario and ensure the correct discount rate is selected. If you are satisfied with your scenario, select RUN SCENARIO.

Discount rate: ⓘ



3%



7%

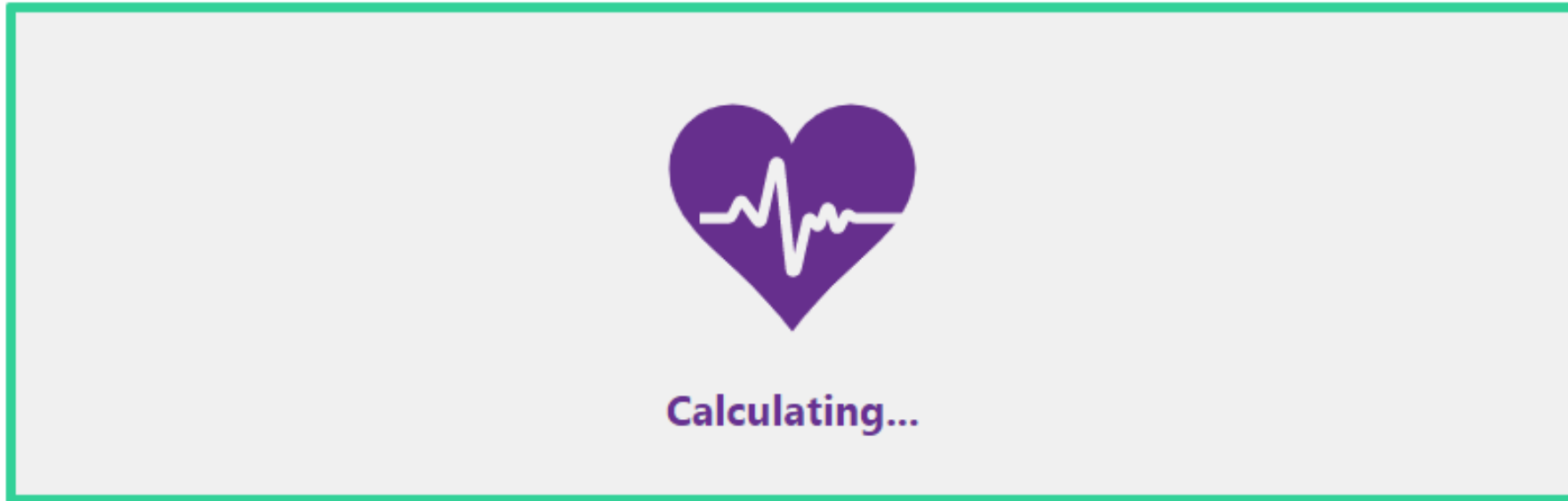


Custom:

enter %

RUN SCENARIO

You will see the following screen as your results are calculating...



Step 10. View Results

View the Summary of Health Effects Results. Look to the bottom of the chart to find the Total Health Effects.

Step 3: View Results

[BUILD NEW SCENARIO](#)

A. Summary of Health Effects Results

Below is a table with the health effects results based on your scenario.



You are viewing results for all contiguous U.S. states. This is because changes in air quality can impact health endpoints in multiple locations due to the transportation of emissions across state and county lines.

Use the filters below to see health effects for a specific state or county.

1. Filter by state:

All contiguous U.S. states

2. Filter by county: (optional)

All counties

Results for: All Contiguous U.S. States

[Export: All results](#) | [Current filter](#)

Health Endpoint ⁱ	Change in Incidence ⁱ (cases, annual)		Monetary Value ⁱ (dollars, annual)	
	Low	High	Low	High
Mortality *	0.435	0.984	\$4,757,095	\$10,765,302
Nonfatal Heart Attacks *	0.045	0.415	\$7,136	\$66,308
Infant Mortality	0.002	0.002	\$24,826	\$24,826
Hospital Admits, All Respiratory	0.084	0.084	\$4,806	\$4,806
Hospital Admits, Cardiovascular **	0.094	0.094	\$3,395	\$3,395
Acute Bronchitis	0.550	0.550	\$339	\$339
Upper Respiratory Symptoms	9.930	9.930	\$424	\$424
Lower Respiratory Symptoms	6.985	6.985	\$189	\$189
Emergency Room Visits, Asthma	0.189	0.189	\$107	\$107
Asthma Exacerbation	10.375	10.375	\$770	\$770
Minor Restricted Activity Days	292.579	292.579	\$25,649	\$25,649
Work Loss Days	49.376	49.376	\$9,885	\$9,885
Total Health Effects			\$4,834,620	\$10,901,999

ⁱ The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low 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.
^{**} Except heart attacks.



Total Health Effects

\$4,834,620 \$10,901,999

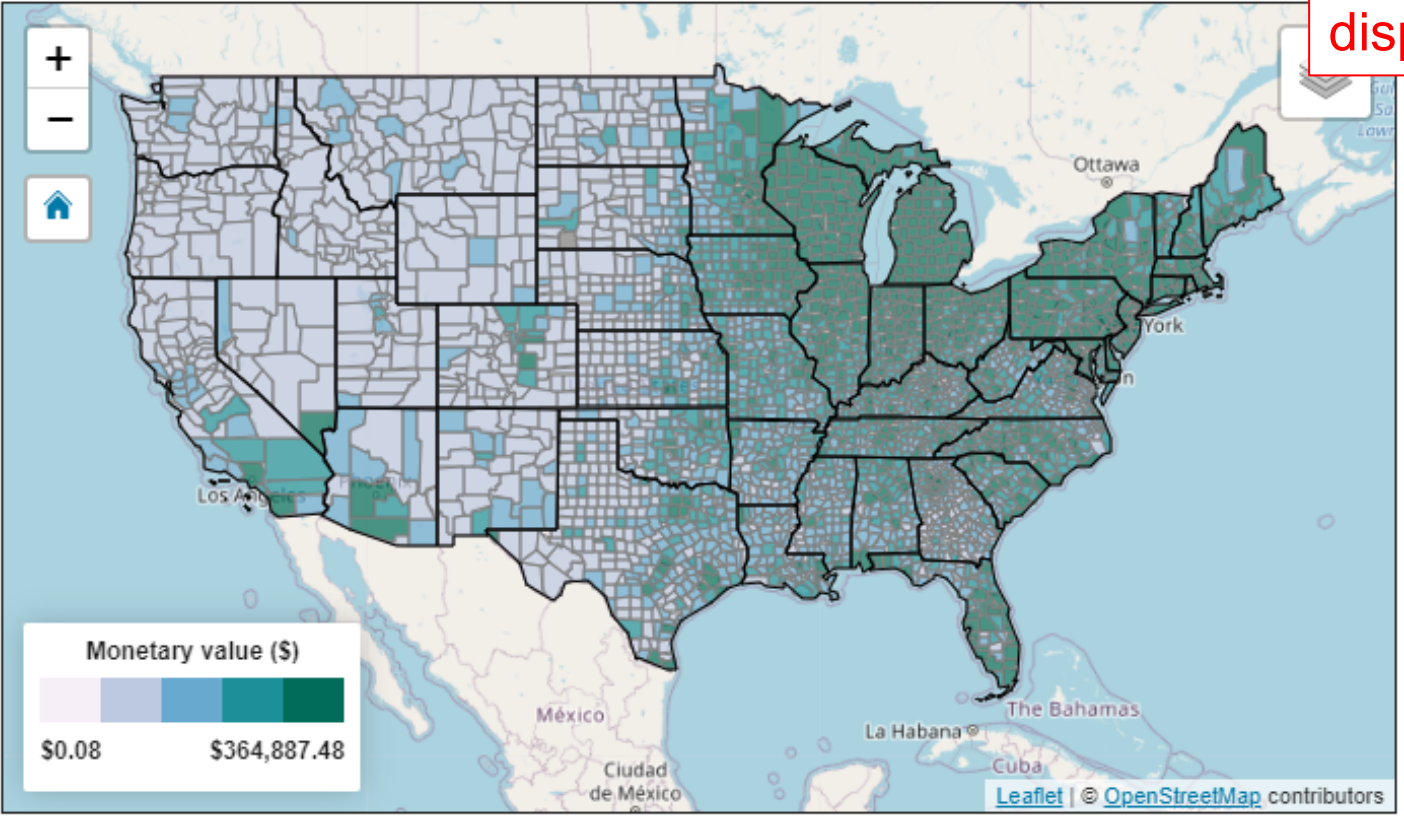
Step 10. View Results (continued)

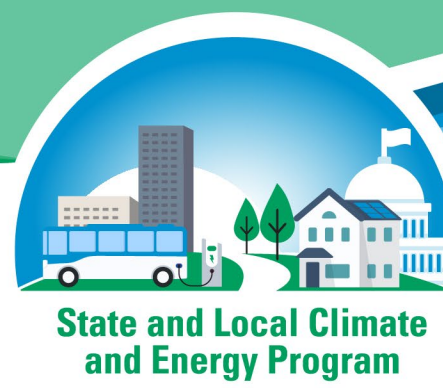
Select the map's data layer:

Total Health Benefits (\$, low estimate) ▾

Displaying: Total Health Benefits (\$, low estimate)

You can also view your results on a map. Use the filter to see other data displayed.





Appendix B

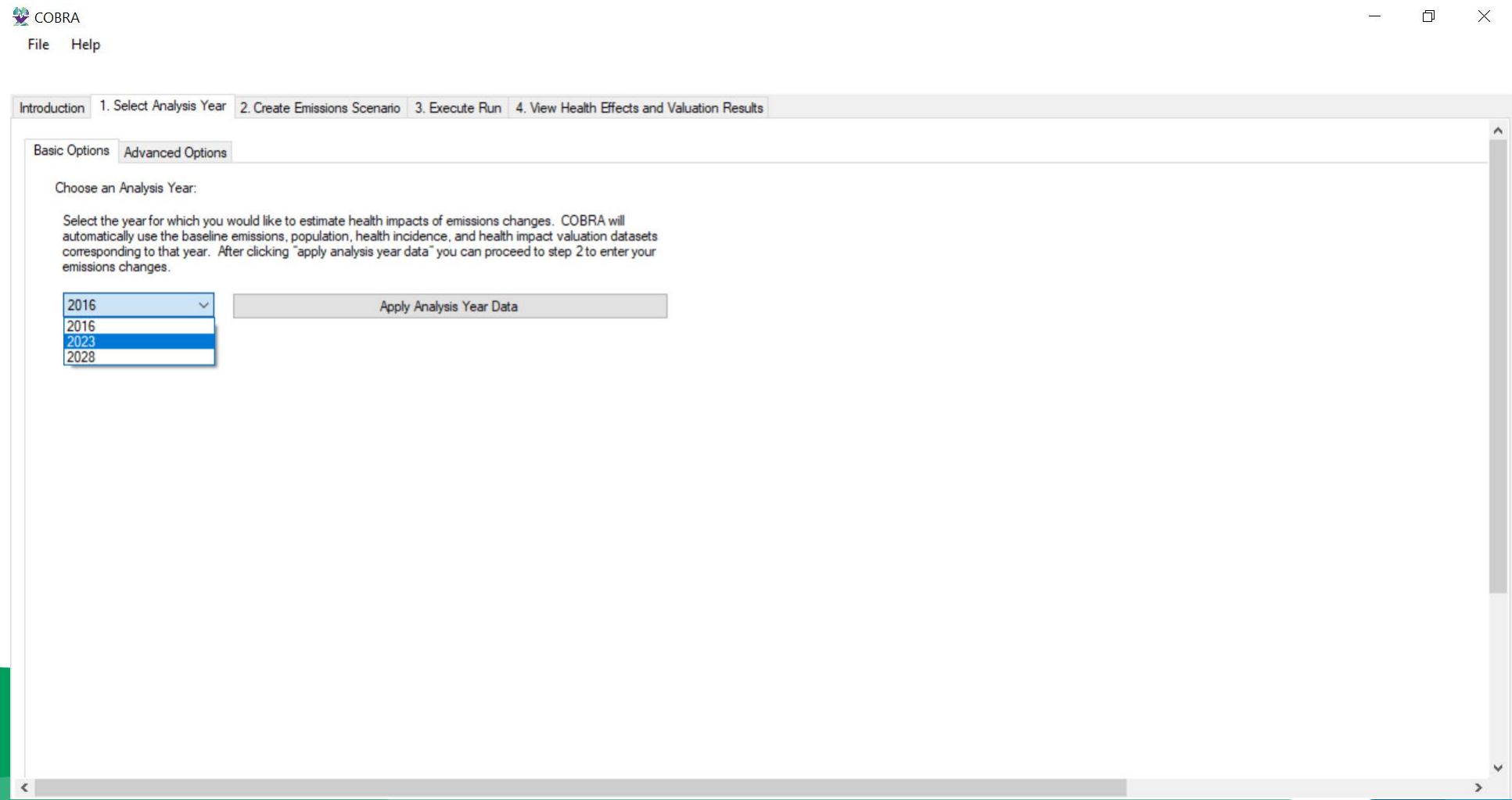
COBRA Desktop Edition Step-by-Step

Step 0. Develop Your Inputs

Part 1: Woodstove Changeouts	Part 2: 440 kW Solar PV
Location: Wisconsin	Location: Wisconsin
Sector: Fuel Combustion Other; Residential Wood; Woodstoves	Sector: Fuel Combustion Electric Utility
Emissions Changes: <ul style="list-style-type: none">- PM_{2.5}: Reduce by 31.5 tons- VOCs: Reduce by 80.7 tons	Emissions Changes: <ul style="list-style-type: none">- PM_{2.5}: Reduce by 1.7 tons- SO₂: Reduce by 9.2 tons- NO_x: Reduce by 6.5 tons- VOCs: Reduce by 1.2 tons
Discount Rate: 3%	Discount Rate: 3%

Target completion date: 2024

Step 1. Apply Analysis Year



Step 2. Create Emissions Scenario

Introduction1. Select Analysis Year2. Create Emissions Scenario3. Execute Run4. View Health Effects and Valuation Results

Emissions ScenarioView Emissions MapView Detailed Emissions Changes

Select Location

☐ US

Alabama

Arizona

Arkansas

California

Colorado

Connecticut

DC

Delaware

Florida

Georgia

Idaho

Illinois

Indiana

Iowa

Kansas

Kentucky

Louisiana

Maine

Maryland

Massachusetts

Michigan

Minnesota

Mississippi

Missouri

Montana

Nebraska

Nevada

New Hampshire

New Jersey

New Mexico

New York

North Carolina

North Dakota

Select Emissions Tier

FUEL COMB. ELEC. UTIL.

FUEL COMB. INDUSTRIAL

FUEL COMB. OTHER

CHEMICAL & ALLIED PRODUCT MFG

METALS PROCESSING

PETROLEUM & RELATED INDUSTRIES

OTHER INDUSTRIAL PROCESSES

SOLVENT UTILIZATION

STORAGE & TRANSPORT

WASTE DISPOSAL & RECYCLING

HIGHWAY VEHICLES

OFF-HIGHWAY

NATURAL SOURCES

MISCELLANEOUS

Modify Emissions

PM 2.5

☐ reduce by

☒ increase by

0.00

☐ pct

☒ tons

SO2

☐ reduce by

☒ increase by

0.00

☐ pct

☒ tons

NOx

☐ reduce by

☒ increase by

0.00

☐ pct

☒ tons

NH3

☐ reduce by

☒ increase by

0.00

☐ pct

☒ tons

VOC

☐ reduce by

☒ increase by

0.00

☐ pct

☒ tons

Apply Changes

Other Options

Save Scenario

Reset to baseline

Load AVERT output file

Use this page to create an emissions scenario by applying emissions changes at the tier level. After entering emission changes, click "Apply Changes." If you are entering different emission changes for different states or counties, you must click "Apply Changes" after entering each set of emission changes. After making your emissions changes, you can review the scenario in the "View Detailed Emissions Changes" tab. For more information on creating an emissions scenario, see chapter 4 of the COBRA user manual.

Clear Selected States and Counties

Clear Selected Tiers

1. Select the state or county

2. Select the emissions tier or subtier

3. Enter your emissions changes


4. Click Apply changes

5. To enter additional emission changes for another location or tier, click "Clear" and repeat steps 1-4.

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Step 3. Execute Run

 COBRA

File Help

Introduction1. Select Analysis Year2. Create Emissions Scenario3. Execute Run4. View Health Effects and Valuation Results

Select Discount Rate

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

☒ 3% ☐ 7%

COBRA estimates the economic value of current and future avoided deaths and illnesses expected based on emissions reductions in the year 2025. 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 Preparing Economic Analyses (available at <https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses>) 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](#).

Run using above option

Select discount rate and click "Run using above option"

Step 4. View Health Effects and Valuation Results

COBRA

File Help

Introduction1. Select Analysis Year2. Create Emissions Scenario3. Execute Run4. View Health Effects and Valuation Results

TableMaps

Export to CSVExport to Excel

FIPS	State	County	Base PM 2.5	Control PM 2.5	Delta PM 2.5	\$ Total Health Benefits (low estimate)	\$ Total Health Benefits (high estimate)	Mortality (low estimate)	\$ Mortality (low estimate)
Contains: Contains: Contains:			Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:
Total: 4,834,619.81						Total: 10,901,998.73	Total: 0.4347	Total: 4,757,095.	
01001	Alabama	Autauga	8.197	8.197	0	206.16	466.31	0	
01003	Alabama	Baldwin	7.565	7.565	0	955.62	2,161.64	0.0001	
01005	Alabama	Barbour	8.111	8.111	0	91.21	206.28	0	
01007	Alabama	Bibb	8.249	8.249	0	100.11	226.54	0	
01009	Alabama	Blount	8.298	8.298	0	274.95	620.96	0	
01011	Alabama	Bolivar	8.185	8.185	0	33.06	74.82	0	
01013	Alabama	Bullock	7.923	7.923	0	85.75	193.76	0	
01015	Alabama	Butler	8.714	8.714	0	555.46	1,254.97	0	
01017	Alabama	Calhoun	8.166	8.166	0	155.92	353	0	
01019	Alabama	Chambers	8.571	8.571	0	168.04	380.17	0	
01021	Alabama	Cherokee	8.221	8.221	0	181.93	410.77	0	
01023	Alabama	Chickasaw	7.417	7.417	0	54.97	124.44	0	
01025	Alabama	Chilton	7.682	7.682	0	100.87	228.23	0	
01027	Alabama	Clay	7.759	7.759	0	56.03	126.77	0	
01029	Alabama	Cleburne	8.418	8.418	0	75.96	171.77	0	
01031	Alabama	Coffee	7.879	7.879	0	163.84	370.73	0	
01033	Alabama	Colbert	7.042	7.042	0	349.22	788.93	0	
01035	Alabama	Conecuh	7.83	7.83	0	51.52	116.62	0	
01037	Alabama	Coosa	8.199	8.199	0	48.43	109.63	0	
01039	Alabama	Covington	7.871	7.871	0	166.45	375.91	0	
01041	Alabama	Crenshaw	7.977	7.977	0	56.67	128.14	0	
01043	Alabama	Cullman	7.741	7.741	0	406.59	920.07	0	
01045	Alabama	Dale	7.774	7.774	0	137.16	309.86	0	

Nationwide or filtered totals appear in blue

Filter by state or county of interest

Step 4. View Health Effects and Valuation Results (continued)

COBRA

File Help

Introduction 1. Select Analysis Year 2. Create Emissions Scenario 3. Execute Run 4. View Health Effects and Valuation Results

Table Maps

Use this page to explore the changes in air quality and health effects between the baseline and control scenarios in map form. For more information on viewing and interpreting health impacts and valuation results, see Chapter 5 (Viewing Results) of the COBRA user manual. For more information on using COBRA's mapping functionality, including how to change the ranges or highlight specific values or incidences on the map, see Chapter 6 (Using Mapping Functionality) of the COBRA user manual. Users can view the user manual by clicking "Help" then "Show Manual."

To copy the map for use in other publications or presentations, click the "Print" button in the toolbar. For more information on saving maps created in COBRA, see Chapter 6 (Using Mapping Functionality) of the COBRA user manual.

Select the field that is to be mapped:

Base PM 2.5

Base PM 2.5

Control PM 2.5

Delta PM 2.5

\$ Total Health Benefits (low estimate)

\$ Total Health Benefits (high estimate)

\$ Mortality (low estimate)

\$ Mortality (high estimate)

\$ Mortality (low estimate)

\$ Mortality (high estimate)

\$ Mortality (low estimate)

\$ Mortality (high estimate)

\$ Infant Mortality

\$ Infant Mortality

\$ Nonfatal Heart Attacks (low estimate)

\$ Nonfatal Heart Attacks (low estimate)

\$ Nonfatal Heart Attacks (high estimate)

\$ Nonfatal Heart Attacks (high estimate)

\$ Nonfatal Heart Attacks (low estimate)

\$ Nonfatal Heart Attacks (high estimate)

\$ Hospital Admits, All Respiratory

\$ Hospital Admits, All Respiratory Direct

\$ Hospital Admits, Asthma

\$ Hospital Admits, Chronic Lung Disease

\$ Hospital Admits, All Respiratory

\$ Hospital Admits, Cardiovascular (except heart attacks)

\$ Hospital Admits, Cardiovascular (except heart attacks)

\$ Acute Bronchitis

\$ Acute Bronchitis

\$ Upper Respiratory Symptoms

\$ Upper Respiratory Symptoms

\$ Lower Respiratory Symptoms

\$ Lower Respiratory Symptoms

\$ Emergency Room Visits, Asthma

\$ Emergency Room Visits, Asthma

Legend

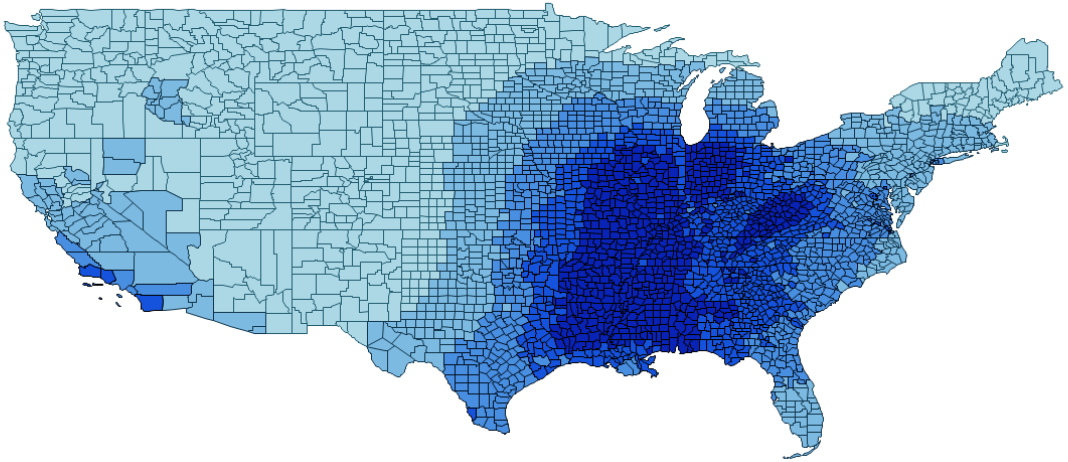
Map Layers

US Counties - Base PM 2.5

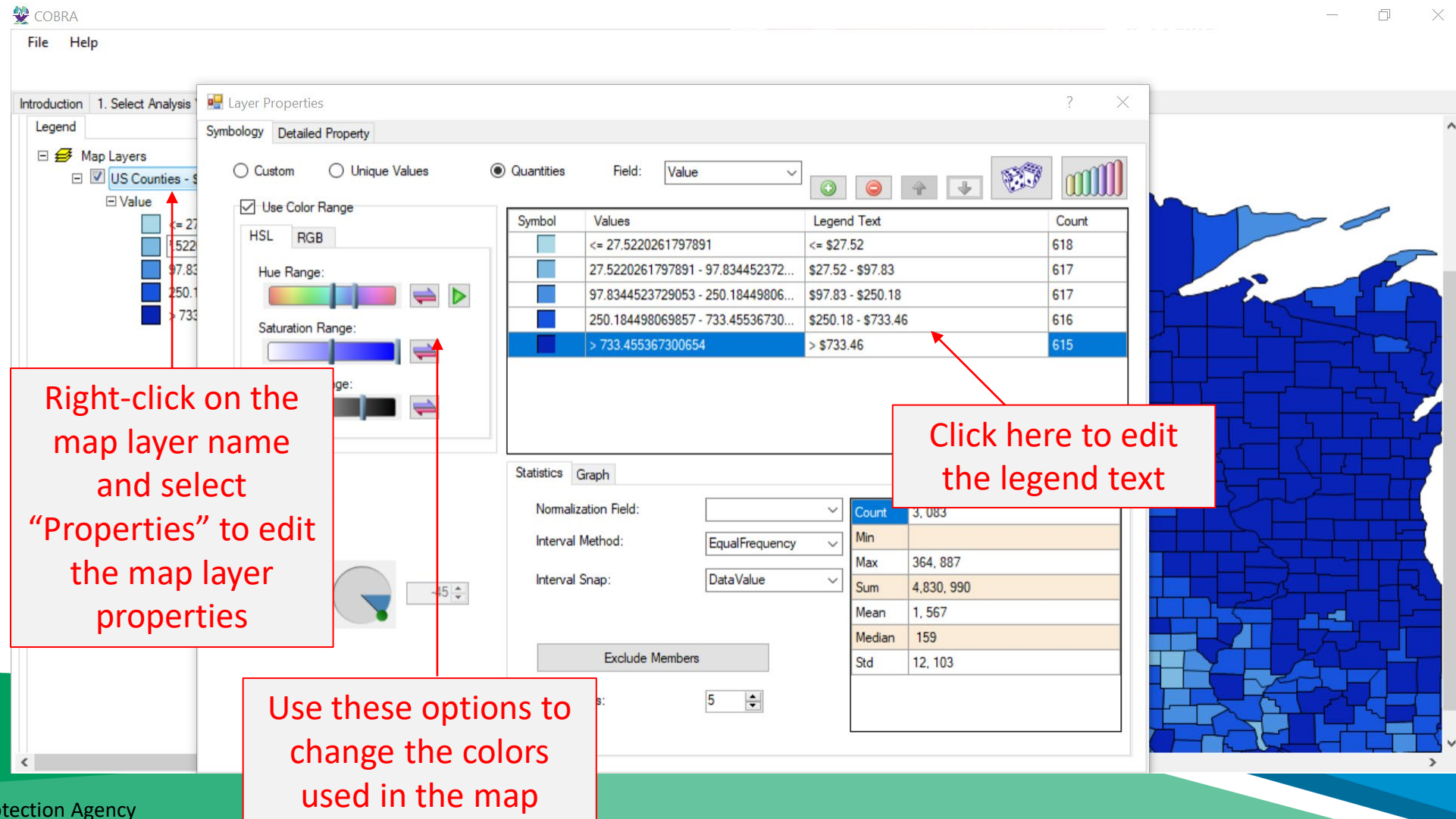
Value

Select result of interest to populate map

Options to zoom, pan, and export the map



Step 4. View Health Effects and Valuation Results (continued)



Step 4. View Health Effects and Valuation Results (continued)

COBRA

File Help

Introduction 1. Select Analysis Year 2. Create Emiss

Table Maps

Use this page to explore the changes in air quality of the COBRA user manual. For more information user manual. Users can view the user manual by

To copy the map for use in other publications or p

Select the field that is to be mapped: \$

Legend

Map Layers

- US Counties - \$ Total Health Benefits

Value

- <= \$27.52
- !5220261797891 - 97.8344
- \$97.83 - \$250.18
- \$250.18 - \$733.46

DotSpatial Print Layout

File Select View

35%

Use these tools to add text boxes, a legend, and a scale bar

North Arrow 1

Legend 1

Layout

- Location 75, 697
- Name Text Box 1
- Size 599.999939, 52.94
- Symbol
 - Background [Edit...]
 - Color Black
 - ContentAlignr TopLeft
- Font
 - Font Arial, 20.25pt, styl
 - Text Figure 1. Total \$ H
 - TextHint AntiAliasGridFit

Name

Click on the printer icon to create a map for export

Figure 1. Total \$ Health Benefits (low, 3%)

Use these options to change the color, size and font of text

Step 4. View Health Effects and Valuation Results (continued)

The screenshot shows the COBRA software interface. On the left, a legend titled 'Map Layers' shows 'US Counties - \$ Total Health Benefits' selected. Below it, a 'Value' legend shows color-coded ranges: blue for values less than or equal to \$27.52, and darker shades of blue for higher values up to over \$733.46. The main map area displays a map of the United States with these color-coded regions. A red arrow points from the legend to the map. Overlaid on the map is a 'Save Print Layout As' dialog box. The dialog box shows the file path 'This PC > Desktop' and a list of files. The 'File name' field is empty, and the 'Save as type' is set to 'Portable Network Graphics (*.png)'. A red arrow points from a text box to the 'Save as type' dropdown. Another red arrow points from a text box to the 'Save' button in the dialog box.

Click save to export the map

We recommend saving it in the .png file format

Final Results

Table 1. Estimated health benefits of woodstove changeouts and 440 kW solar PV in Wisconsin

Total Health Benefits	Low, 3% (2017\$)	High, 3% (2017\$)
Nationwide	\$4,834,620	\$10,901,999
Nevada	\$2,365,991	\$5,335,684

