Estimating the Benefits of Clean Energy Policies

Quickstart Tutorial: How To Use The CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool

Analytical Steps and Case Studies

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

State and Local
Energy and Environment Program

EPA United States Environmental Protection Agency

March 2021

Overview of Presentation

- How to conduct an analysis with COBRA
  - Summarizes six key analytical steps
- Two case studies illustrate how to apply these steps in two clean energy scenarios:
  1. Renewable Portfolio Standard
  2. Wind Energy Program

Note that these case examples were developed using COBRA v3.2

How to Conduct an Analysis with COBRA

Analytical Steps and Relevant Resources

COBRA
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Steps in COBRA Analysis

1. Select the analysis year
2. Create Emission Scenario
   - Estimate where (e.g., in one or more counties or states, regionally, nationally) and what emission changes will take place
   - Enter the location, types, and quantity of emission changes expected from the policy or activity in COBRA
3. Execute Run
   - Select a discount rate in COBRA to appropriately discount the value of future benefits
   - Run the model
4. View Health Effects and Valuation Results
   - Review the results

This presentation will:

- Walk you through these steps, and
- Lead you to other tools and resources that can help you develop your inputs.

COBRA uses your inputs to estimate the air quality, health, and related economic impacts of the scenario

Step 1: Select analysis year

- COBRA contains detailed 2016, 2023, and 2028 baseline emissions data for each county
- The emissions inventory in COBRA includes the 14 major emissions source categories (i.e., "tiers") of criteria pollutants included in the National Emissions Inventory (NEI):*
  - Chemical and Allied Product Manufacturing
  - Fuel Combustion - Electric Utility
  - Fuel Combustion - Industry
  - Fuel Combustion - Other
  - Highway Vehicles
  - Metal Processing
  - Miscellaneous
  - Natural Sources (Biogenics)
  - Off-Highway
  - Other Industrial Processes
  - Petroleum & Related Industries
  - Solvent Utilization
  - Storage & Transport
  - Waste Disposal & Recycling

*For more information about the NEI, see: https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place

- Decide on the geographic area where emissions are expected to change
- COBRA can assess actions that affect emissions in:
  - a single county or state,
  - groups of counties and states (contiguous or otherwise), or
  - the entire nation
- COBRA allows you to vary the types and amounts of emissions changes expected to occur in different locations

- Estimating what and where electricity will be displaced and emissions reduced presents challenges due to the:
  - Complex way electricity is generated and transmitted across the U.S.
  - Uncertainty about future emissions in places with market-based environmental programs, such as cap and trade
- Simplifying assumptions can be made when using COBRA but a highly sophisticated energy analysis of the impacts of a clean energy policy on a location will generate more reliable results
- For more information about the complexity of the energy system, see Chapters 3 and 4 of *Assessing the Multiple Benefits of Clean Energy: A Resource for States*, available at https://www.epa.gov/sites/production/files/2015-08/documents/epa_assessing_benefits.pdf

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- In COBRA, you can enter the emission changes as a percentage or in absolute terms
  - A **percentage** can be used when a policy is expected to reduce emissions or use of an energy source by a specific proportion
    - For example, if the use of renewable electricity generation increases from 0% to 20% of total generation, you could assume that the use of existing fuels for electricity generation would be reduced by 20%
  - An **absolute** number can be used for policies that do not lend themselves easily to percentage reductions or when you want to enter more specific emission changes
    - For example, 5,000 tons of sulfur dioxide

Resources for Calculating Emissions Changes from Electricity-related Policies

- If you do not have absolute emission reduction estimates, you can use:
  - A basic approach or tool, such as:
    - Applying an emission factor obtained from EPA's Emissions & Generation Resource Integrated Database (eGRID) https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid, or
    - EPA's AVoided Emissions and geneRation Tool (AVERT) https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert
  - More sophisticated approaches, such as those described in EPA guides:
    - *Assessing the Multiple Benefits of Clean Energy: A Resource for States*, Chapter 4 https://www.epa.gov/sites/production/files/2015-08/documents/epa_assessing_benefits.pdf
    - *Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans,* Appendix I https://www.epa.gov/sites/production/files/2016-05/documents/appendixi_0.pdf

Step 2: Create Emissions Scenario

Select and enter the types, location and quantity of emission changes expected

- There are two methods for entering emissions changes into COBRA:
  1. You can enter emissions changes *manually* or
  2. You can *import an emissions scenario of your own,* such as an automatically pre-formatted output file from EPA's AVoided Emissions and generRation Tool (AVERT)

Step 2: Create Emissions Scenario

Select and enter the types, location and quantity of emission changes expected – *manual entry*

- You will need to know what source categories of emissions will be affected by the policy
- Often, clean energy investments, such as those that increase the use of renewable energy or energy efficiency, will affect the "fuel combustion from electric utilities" category
- Within each category, there are fuel choices, such as coal, gas, and oil
  - If you know the specific fuel will be affected, you may choose it
  - If not, you can use the broader category
- Enter the estimated emission changes by the appropriate types and locations, ensuring that you save your inputs once you are finished

Step 2: Create Emissions Scenario

Select and enter the types, location and quantity of emission changes expected – *AVERT output*

- As an alternative to manually entering the emissions reductions and locations, you can import the results from EPA's AVERT tool into COBRA.
- After running AVERT, you can export your results in a format that can be imported by COBRA.
- In the "Create Emissions Scenario" tab in COBRA, you can click "Load AVERT output file" to import the AVERT file.
- These steps are explained in more detail in Case Study #2, below.

For more details, EPA's AVERT tool and documentation are available at https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert .

Step 3: Execute Run

Select a discount rate

- A discount rate is used to appropriately discount the value of future benefits
- Not all benefits occur in the year of analysis, and people are generally willing to pay more for something now than for the same thing later
- COBRA accounts for this time preference by discounting benefits received later

Step 3: Execute Run

Select a discount rate (cont'd)

- EPA's Guidelines for Economic Analysis recommend using both 3% and 7% discount rates to see how the conclusions of your analysis change. Both rates are available in COBRA
- The discount rate will affect the value of the benefits
  - A higher discount rate favors investments with immediate benefits and reduces the value of future benefits
  - A lower discount rate places a greater value on benefits which occur in the future
- You can run your scenario with both rates and then evaluate the effect of the change in discount rate on the results

Step 3: Execute Run

Run the model

- Once you have completed these four steps, you are ready to run the model
- The model will take at least five minutes to run and may take longer, depending on the speed of your computer
- The model may appear non-responsive while it is processing

Step 4: View Health Effects and Valuation Results

- You can view the results for the changes in air quality, health effects, and related economic value in table and map forms
- You can export results as tables and copy/paste screenshots into reports and presentations

Key Considerations when Interpreting Results

- COBRA is intended as a screening tool
  - COBRA does not predict the future but can be used to obtain ballpark health benefits estimates and to compare or rank options
  - When more detailed analyses are required, consider using more sophisticated modeling approaches

Key Considerations when Interpreting Results (cont'd)

- There is uncertainty surrounding the values of key assumptions embedded in COBRA (i.e., emissions inventory, health impact functions, and economic values)
  - You should review the limitations and assumptions described in the COBRA User Manual

Key Considerations when Interpreting Results (cont'd)

- COBRA does not account for changes in emissions that can result from changes in electricity market responses to policy.
  - For example, emissions in some states and regions are "capped" by laws or regulations
    - Emission allowances can then be traded across entities within a capped region
    - In these regions, a reduction in emissions in one location may result in an increase (rebound) in emissions in another area subject to the cap
    - COBRA does not automatically capture these types of potential effects in electricity market dispatch
- Care should be exercised when interpreting COBRA results to analyze the net impacts of a change in policy

Case Study 1:
Renewable Portfolio Standard

State and Local
Energy and Environment Program

This case study illustrates how to conduct an analysis of a clean energy policy with COBRA using a renewable portfolio standard as an example.

Note this case study was developed using COBRA v3.2

COBRA
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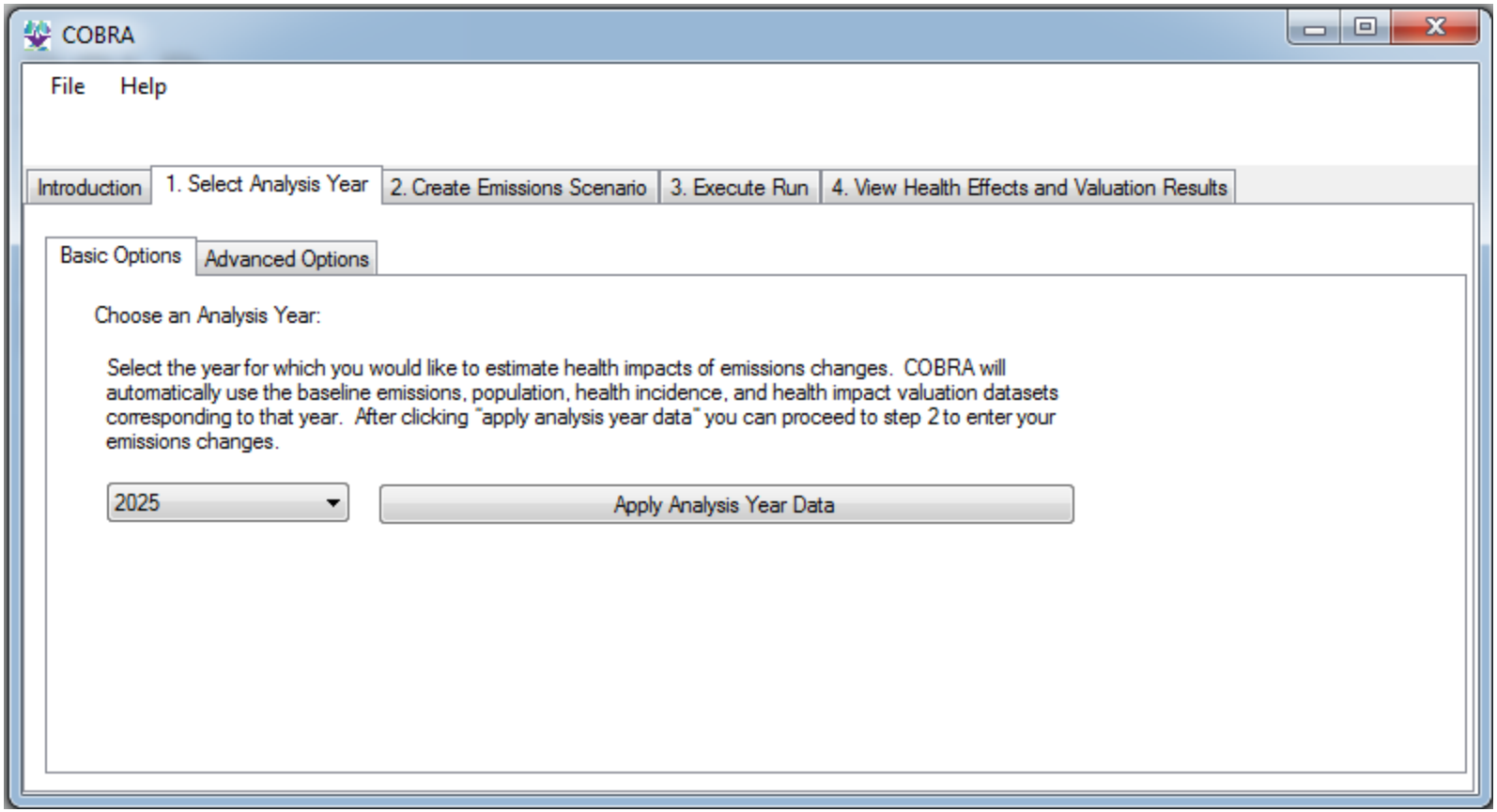
Analyzing the Health Benefits of a Renewable Portfolio Standard

- 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

Analyzing the Health Benefits of a Renewable Portfolio Standard (cont'd)

- The next slides describe how to estimate the health and related economic benefits of a state or local RPS
  - Specifically, we assume a state (Michigan) has established an RPS requirement that 10% of electricity generation must be from renewable sources by 2025
    - We also could have looked at a county with a renewable target or requirement

Step 1: Select the analysis year



Step 2: Create Emissions Scenario

Estimate where and what emissions changes 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

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- For the Michigan RPS, we assume that all emission changes will occur statewide
- In COBRA, we create a scenario for an individual state and select Michigan

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- 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 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- For this example, we use emissions factors from EPA's Emissions & Generation Resource Integrated Database (eGRID)* to develop an absolute estimate
  - Using "eGRID2014 Summary Tables (PDF)," we found:
    - Net electric generation in Michigan: **107 million MWh**
    - Non-baseload output emissions rates for Michigan:

      SO_2: **4.1 lbs. per MWh**

      NO_x: **1.5 lbs. per MWh**
    - Percentage of electric generation that already comes from renewable sources in Michigan: **7.0%**

* eGRID is available at https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- Since 7.0% of electric generation already comes from renewable sources, we assume our scenario will reduce emissions by:

  10.0% - 7.0% = **3.0%**

- We calculate the reduction in MWh:

  3.0% × 107 million MWh = **3.2 million MWh**

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

  SO_2: 3.2 million MWh × 4.1 per MWh = 13 million lbs.

  = **6,600 tons**

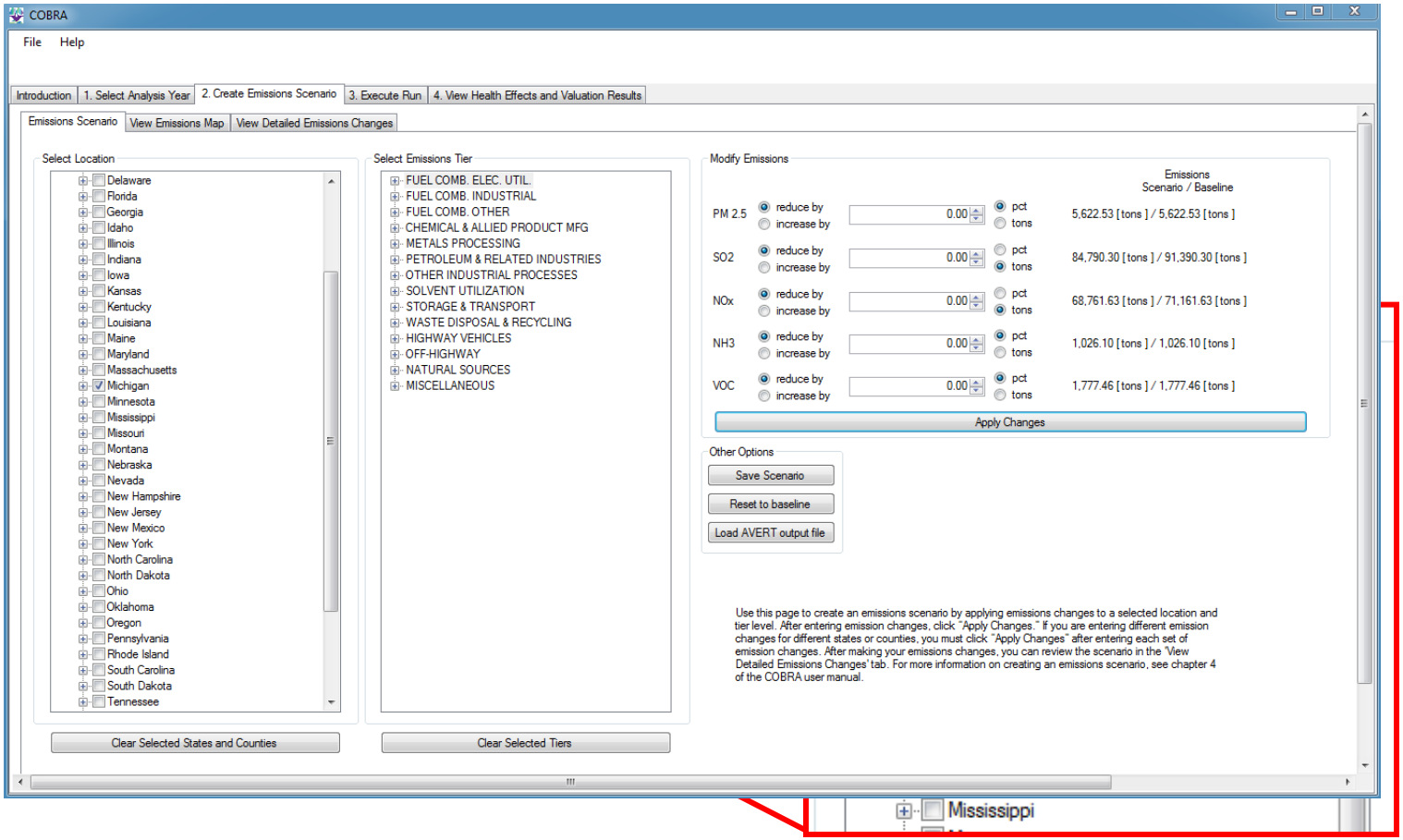
  NO_x: 3.2 million MWh × 1.5 per MWh = 4.8 million lbs.

  = **2,400 tons**

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

Step 2: Create Emissions Scenario

Location of emission changes expected



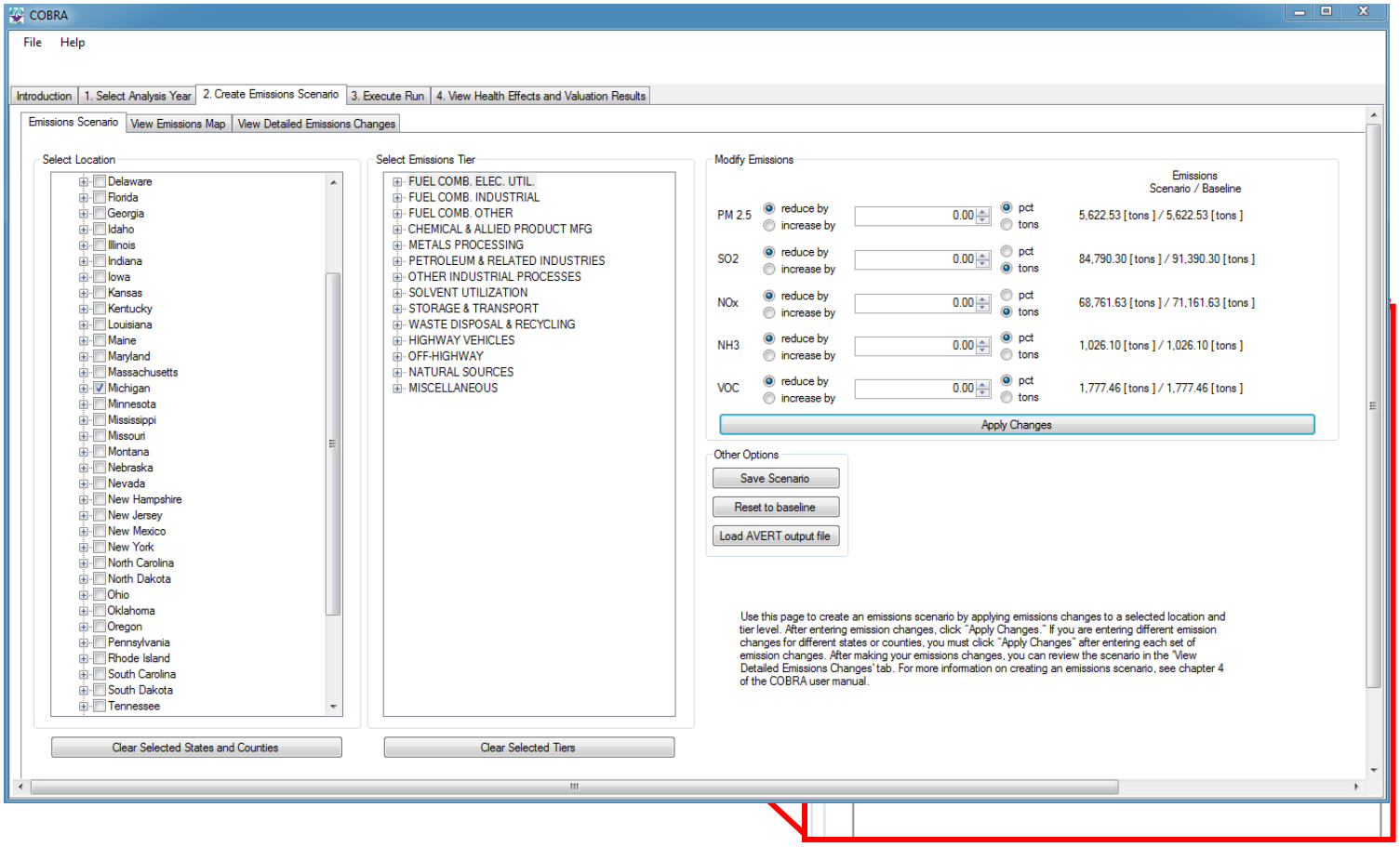
Step 2: Create Emissions Scenario

Types of emission changes expected

- A RPS affects the fuel combustion from electricity generation category
  - These categories include fuel choices (e.g., gas, coal)
  - You can select specific fuel choices that are expected to be affected if known or assume all fuel choices are affected
- For the Michigan RPS example, we assume that all fuel sources would be affected by the RPS (i.e., not just natural gas or just coal) and select the "fuel combustion from electricity generation" category

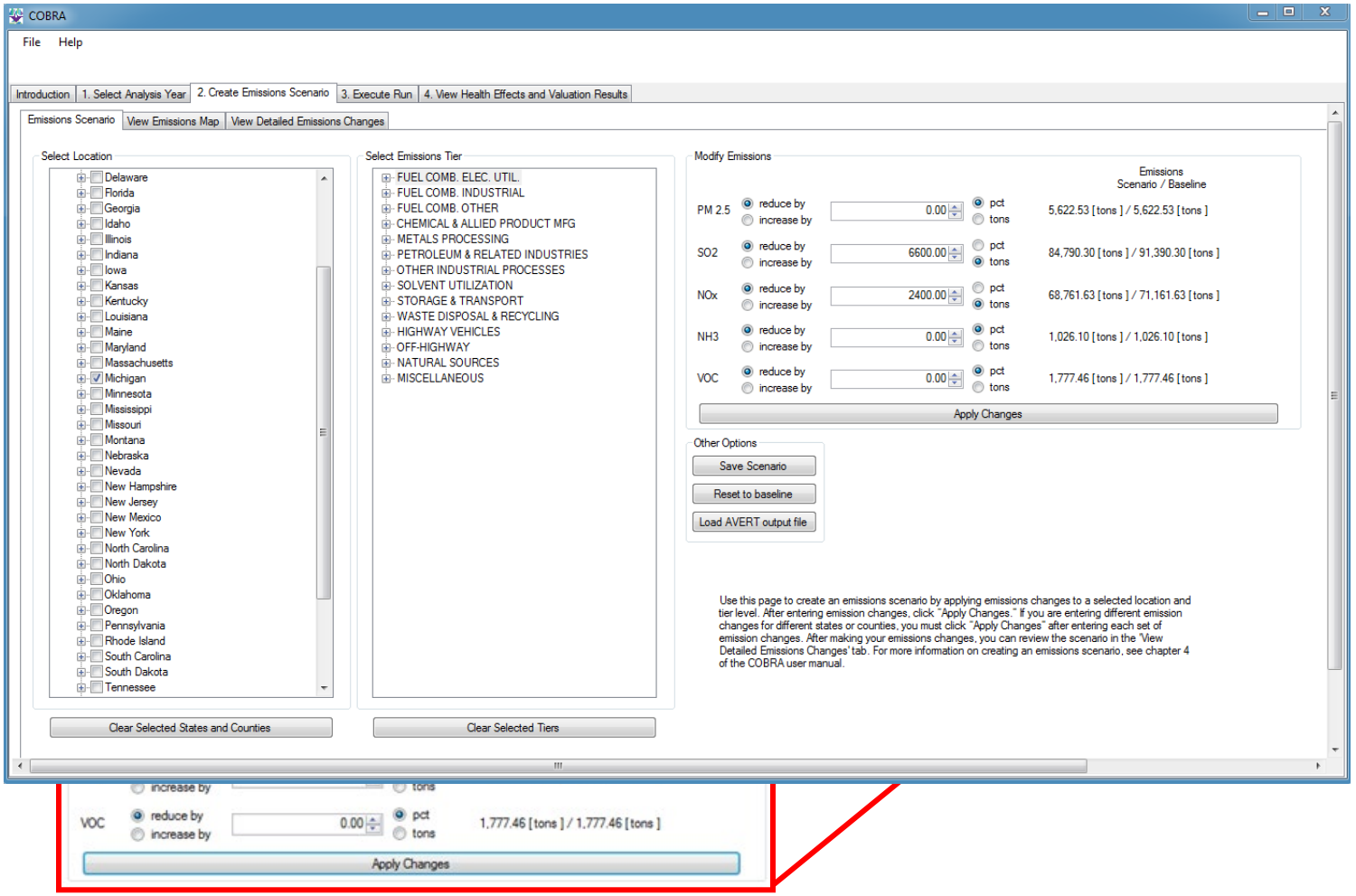
Step 2: Create Emissions Scenario

Types of emission changes expected



Step 2: Create Emissions Scenario

Quantity of emission changes expected



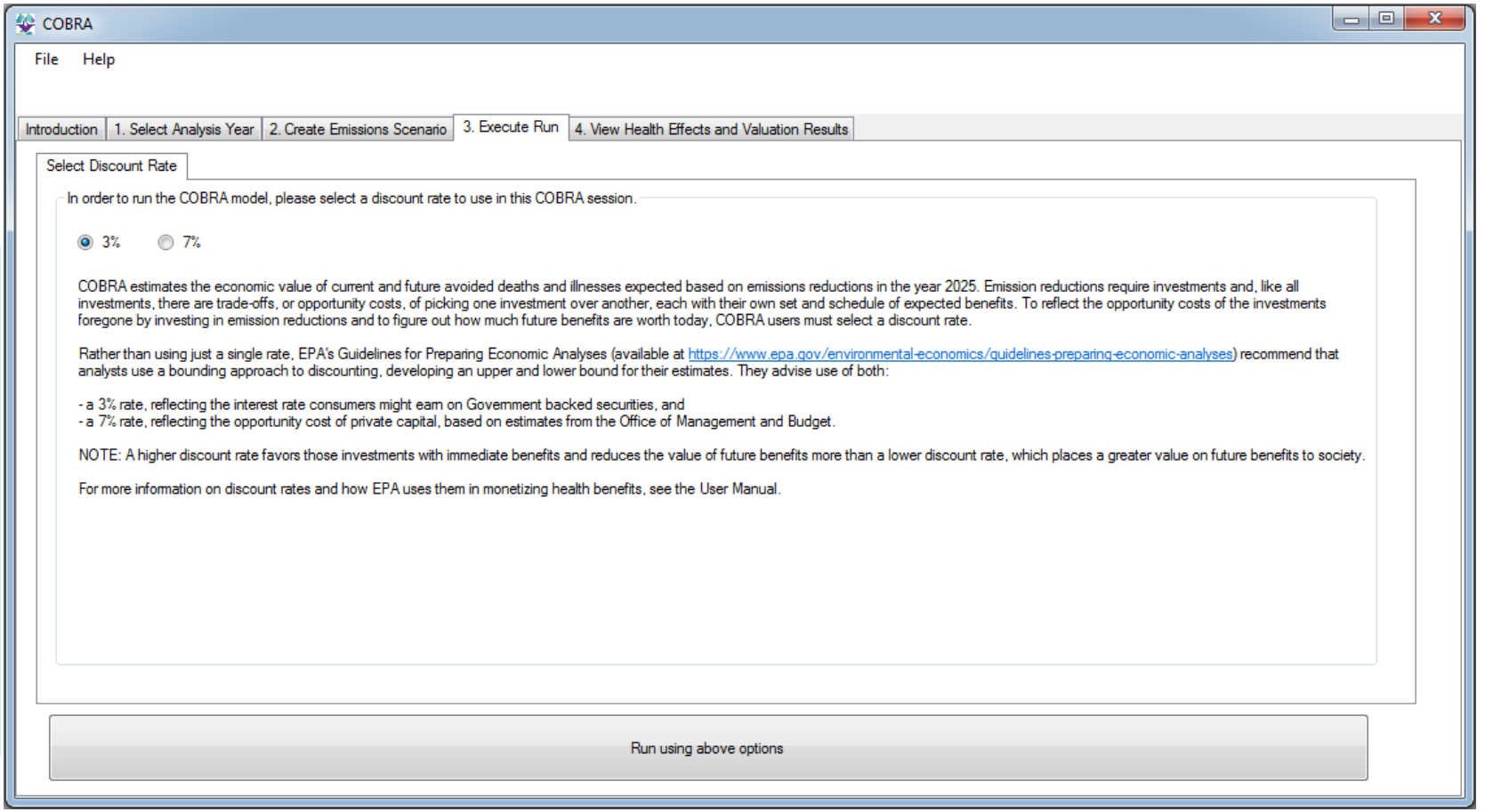
Step 3: Execute Run

Select a discount rate

- A discount rate is used to appropriately discount the value of future benefits
- In this case study, we use a 3% discount rate
- This discount rate provides an upper bound for the estimated benefits and places a greater value on future benefits to society, compared to higher discount rates

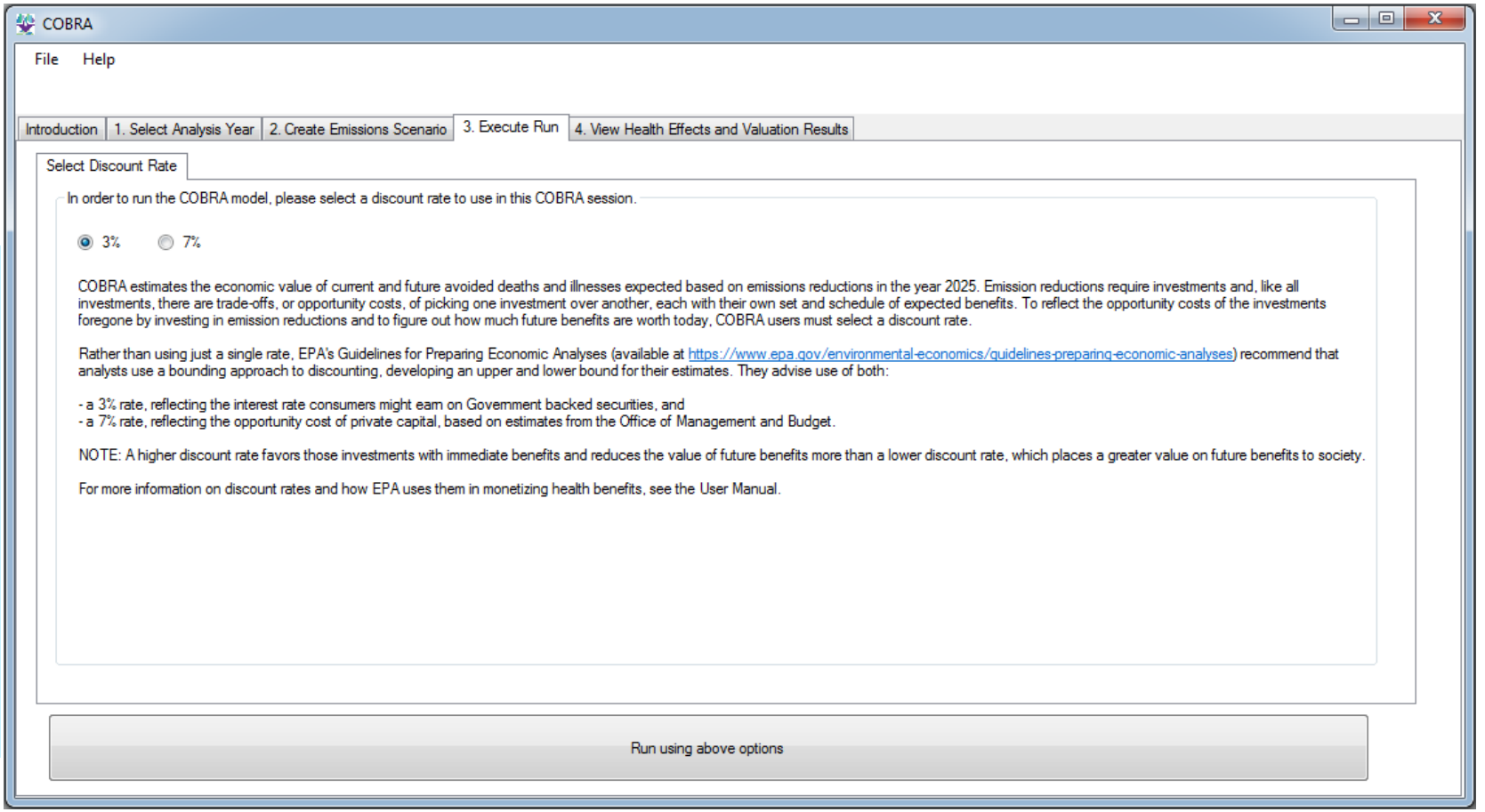
Step 3: Execute Run

Select a discount rate (cont'd)



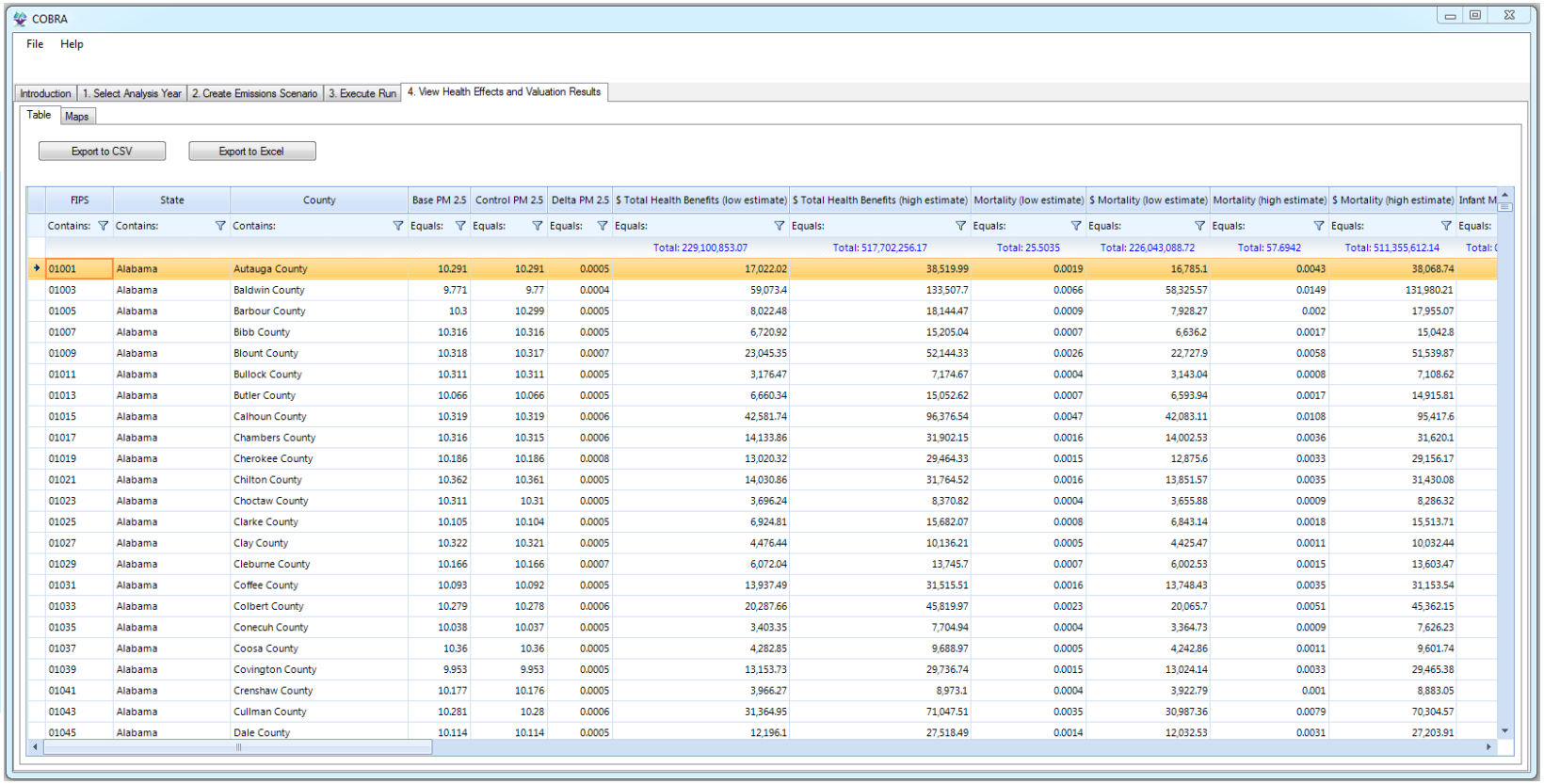
Step 3: Execute Run

Run the model



Step 4: View Health Effects and Valuation Results

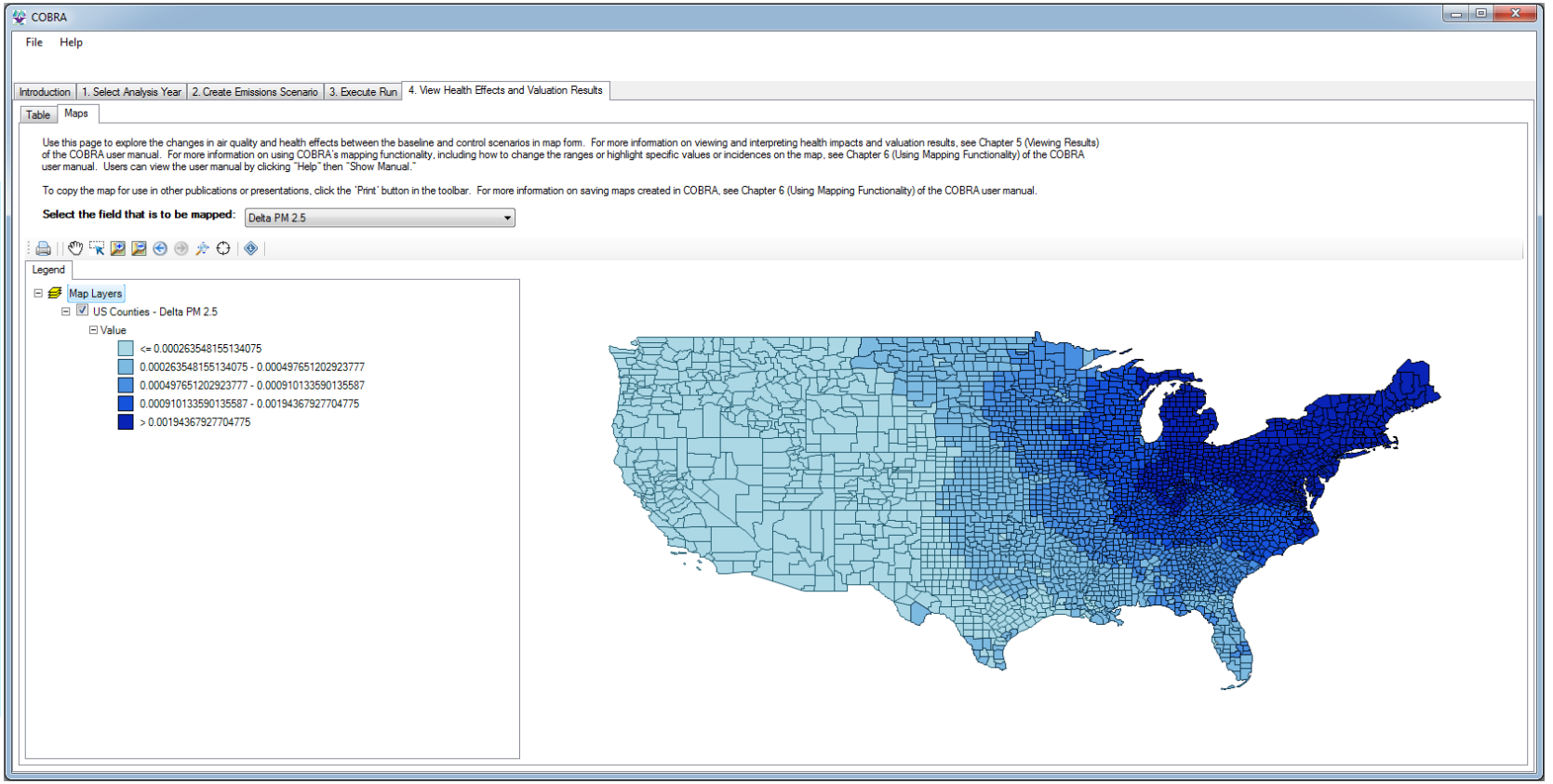
View in table form



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)	Mortality (high estimate)	$ Mortality (high estimate)	Infant M
Contains:	Contains:	Contains:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:
						Total: 229,100,853.07	Total: 517,702,256.17	Total: 25.5035	Total: 226,043,088.72	Total: 57.6942	Total: 511,355,612.14	Total:
01001	Alabama	Autauga County	10.291	10.291	0.0005	17,022.02	38,519.99	0.0019	16,785.1	0.0043	38,068.74	
01003	Alabama	Baldwin County	9.771	9.77	0.0004	59,073.4	133,507.7	0.0066	58,325.57	0.0149	131,980.21	
01005	Alabama	Barbour County	10.3	10.299	0.0005	8,022.48	18,144.47	0.0009	7,928.27	0.002	17,955.07	
01007	Alabama	Bibb County	10.316	10.316	0.0005	6,720.92	15,205.04	0.0007	6,636.2	0.0017	15,042.8	
01009	Alabama	Blount County	10.318	10.317	0.0007	23,045.35	52,144.33	0.0026	22,727.9	0.0058	51,539.87	
01011	Alabama	Bullock County	10.311	10.311	0.0005	3,176.47	7,174.67	0.0004	3,143.04	0.0008	7,108.62	
01013	Alabama	Butler County	10.066	10.066	0.0005	6,660.34	15,052.62	0.0007	6,593.94	0.0017	14,915.81	
01015	Alabama	Calhoun County	10.319	10.319	0.0006	42,581.74	96,376.54	0.0047	42,083.11	0.0108	95,417.6	
01017	Alabama	Chambers County	10.316	10.315	0.0006	14,133.86	31,902.15	0.0016	14,002.53	0.0036	31,620.1	
01019	Alabama	Cherokee County	10.186	10.186	0.0008	13,020.32	29,464.33	0.0015	12,875.6	0.0033	29,156.17	
01021	Alabama	Chilton County	10.362	10.361	0.0005	14,030.86	31,764.52	0.0016	13,851.57	0.0035	31,430.08	
01023	Alabama	Choctaw County	10.311	10.31	0.0005	3,696.24	8,370.82	0.0004	3,655.88	0.0009	8,286.32	
01025	Alabama	Clarke County	10.105	10.104	0.0005	6,924.81	15,682.07	0.0008	6,843.14	0.0018	15,513.71	
01027	Alabama	Clay County	10.322	10.321	0.0005	4,476.44	10,136.21	0.0005	4,425.47	0.0011	10,032.44	
01029	Alabama	Cleburne County	10.166	10.166	0.0007	6,072.04	13,745.7	0.0007	6,002.53	0.0015	13,603.47	
01031	Alabama	Coffee County	10.093	10.092	0.0005	13,937.49	31,515.51	0.0016	13,748.43	0.0035	31,153.54	
01033	Alabama	Colbert County	10.279	10.278	0.0006	20,287.66	45,819.97	0.0023	20,065.7	0.0051	45,362.15	
01035	Alabama	Conecuh County	10.038	10.037	0.0005	3,403.35	7,704.94	0.0004	3,364.73	0.0009	7,626.23	
01037	Alabama	Coosa County	10.36	10.36	0.0005	4,282.85	9,688.97	0.0005	4,242.86	0.0011	9,601.74	
01039	Alabama	Covington County	9.953	9.953	0.0005	13,153.73	29,736.74	0.0015	13,024.14	0.0033	29,465.38	
01041	Alabama	Crenshaw County	10.177	10.176	0.0005	3,966.27	8,973.1	0.0004	3,922.79	0.001	8,883.05	
01043	Alabama	Cullman County	10.281	10.28	0.0006	31,364.95	71,047.51	0.0035	30,987.36	0.0079	70,304.57	
01045	Alabama	Dale County	10.114	10.114	0.0005	12,196.1	27,518.49	0.0014	12,032.53	0.0031	27,203.91	

Step 4: View Health Effects and Valuation Results

View in map form



Step 4: View Health Effects and Valuation Results

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

Annual Emission Reductions (short tons)

Pollutant	Amount
Sulfur Dioxide (SO_2)	6,600
Nitrogen Oxides (NO_x)	2,400

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	25.5 – 57.7
Asthma Exacerbations	625
Heart Attacks	3.3 – 31.0
Hospital Admissions	17.4
Acute Bronchitis	33.1
Respiratory Symptoms	1,027
Asthma ER Visits	13.0
Minor Restricted Activity Days	16,600
Work Days Lost	2,800

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

Annual Benefits (2017, $1,000s)

Dollar Value
$254,000 – $574,000
$40.9
$445– $4,140
$659
$18.0
$32.8
$6.21
$1,290
$502
$257,000 - $581,000

total

* Don't forget to consider the caveats from slides 16 through 18

Case Study 2:
Wind Energy Program

State and Local
Energy and Environment Program

This case study illustrates how to conduct an analysis of a clean energy program with COBRA using wind energy capacity as an example.

Note this case study was developed using COBRA v3.2

COBRA
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EPA United States Environmental Protection Agency

Using COBRA to Evaluate the Benefits of Wind Energy Production

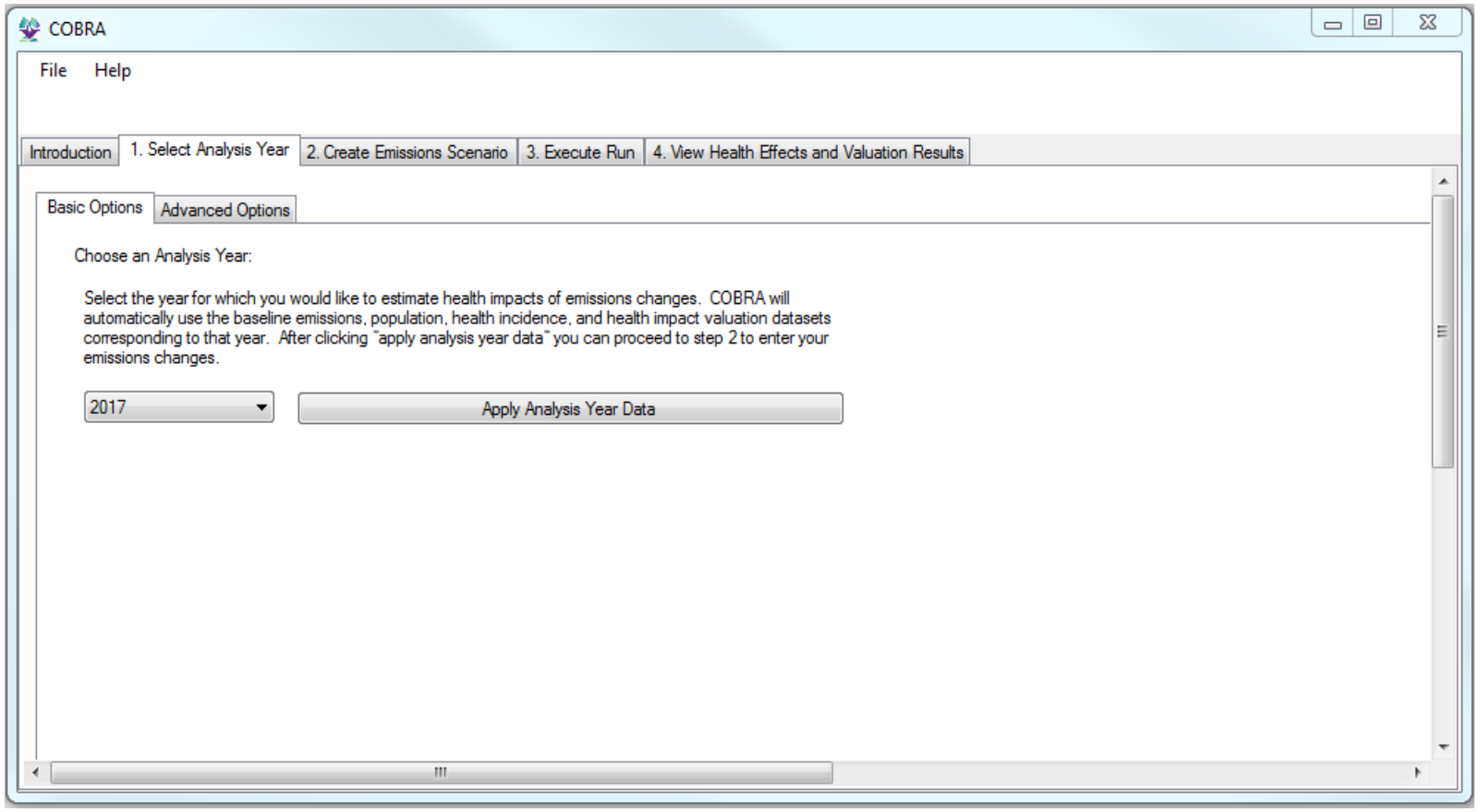
- Wind energy is used across the country, whether it is produced in-state or purchased from other states
- If the electricity had previously been generated with fossil fuels, wind energy production can lead to criteria air pollutant reductions and health benefits

For more details, see: the American Wind Energy Association's "The Clean Air Benefits of Wind Energy" report, available at http://awea.files.cms-plus.com/FileDownloads/pdfs/AWEA_Clean_Air_Benefits_WhitePaper%20Final.pdf.

Using COBRA to Evaluate the Benefits of Wind Energy Production (cont'd)

- The next slides describe how to estimate the health and related economic benefits of increasing a state's wind energy capacity
  - Specifically, we assume Texas has decided to explore the benefits associated with a new wind energy program

Step 1: Select the analysis year



Step 2: Create Emissions Scenario

Estimate where and what emissions changes 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 wind energy program and enter those changes in manually

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- For this example, we assume that the wind energy impacts will take place throughout Texas
- Due to the interconnectedness of the grid, these impacts will affect electricity providers and emissions beyond this state

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- To estimate the electricity changes expected from the program, you can either:
  - Estimate how many MWh you expect to save from your program, or
  - Find a similar program to use as a proxy
- In this hypothetical example, we estimate emissions reductions due to a 7,000 MW wind energy program in Texas
  - The American Wind Energy Association (AWEA) reported installed wind power capacity by state, with a total of 12,355 MW for Texas*
  - Another 7,000 MW of wind energy projects are currently under construction in Texas*

*Source: AWEA's "AWEA U.S. Wind Industry Fourth Quarter 2013 Market Report", available at http://www.awea.org/4q2013.

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- To estimate the annual emissions reduced from 7,000 MW of installed wind capacity, you can use:
  - A basic tool that estimates emissions changes from renewable energy programs
  - A more sophisticated modeling approach, if available

Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- For this example, we use EPA's AVoided Emissions and geneRation Tool (AVERT)* to:
  - Apply a 7,000 MW increase in installed wind capacity in Texas
  - Calculate the county-level emission reductions (in lbs)
  - Sum the emission reductions to state level
  - Generate a COBRA input text file in AVERT, which also convert emissions reductions to tons

For more details, EPA's AVERT tool and documentation are available at https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert .

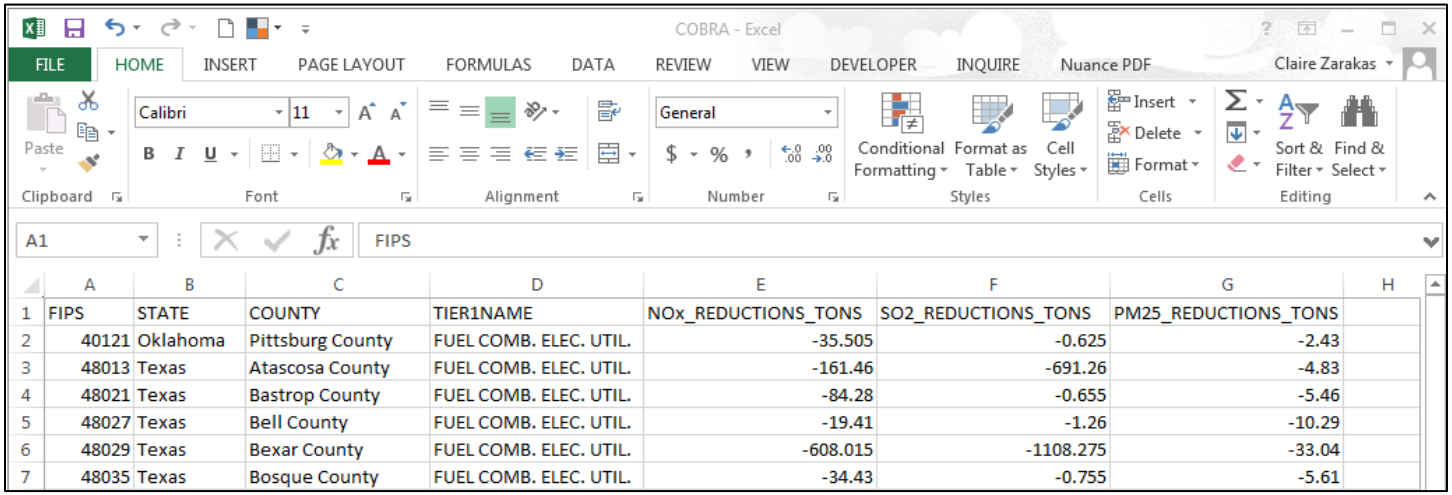
Step 2: Create Emissions Scenario

Estimate where and what emissions changes will take place (cont'd)

- Annual emission reductions (in tons) from a 7,000 MW wind energy program in Texas using AVERT:

State/County	SO_2	NO_x	$PM_{2.5}$
Texas	17,211.7	6,756.7	846.5
Oklahoma*	0.6	35.5	2.4

*Note that Oklahoma also experiences emissions reductions from the wind program in Texas.



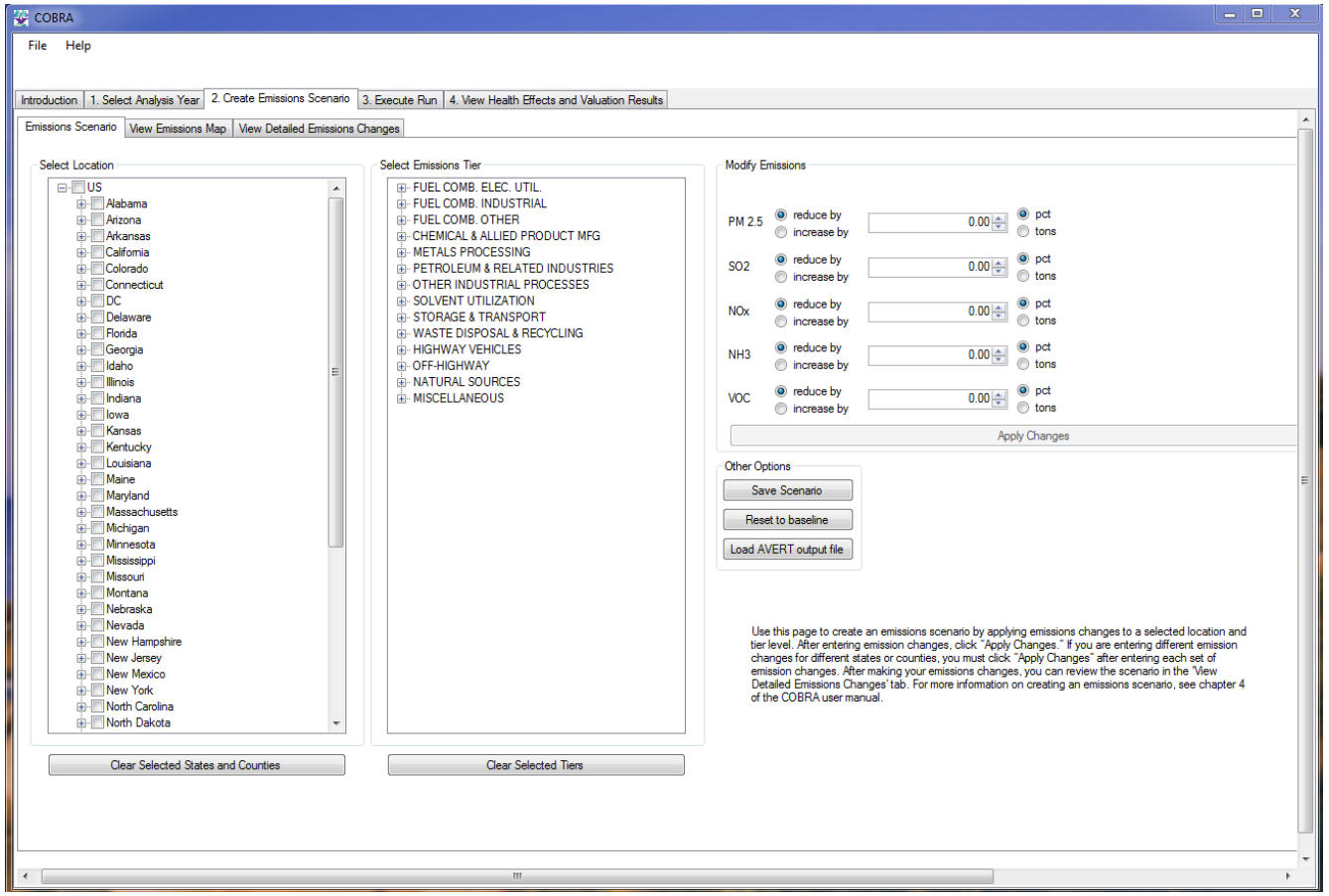
	A	B	C	D	E	F	G	H
1	FIPS	STATE	COUNTY	TIER1NAME	NOx_REDUCTIONS_TONS	SO2_REDUCTIONS_TONS	PM25_REDUCTIONS_TONS	
2	40121	Oklahoma	Pittsburg County	FUEL COMB. ELEC. UTIL.	-35.505	-0.625	-2.43	
3	48013	Texas	Atascosa County	FUEL COMB. ELEC. UTIL.	-161.46	-691.26	-4.83	
4	48021	Texas	Bastrop County	FUEL COMB. ELEC. UTIL.	-84.28	-0.655	-5.46	
5	48027	Texas	Bell County	FUEL COMB. ELEC. UTIL.	-19.41	-1.26	-10.29	
6	48029	Texas	Bexar County	FUEL COMB. ELEC. UTIL.	-608.015	-1108.275	-33.04	
7	48035	Texas	Bosque County	FUEL COMB. ELEC. UTIL.	-34.43	-0.755	-5.61	

Sample AVERT output file for the Texas region

Step 2: Create Emissions Scenario

Import AVERT emissions scenario

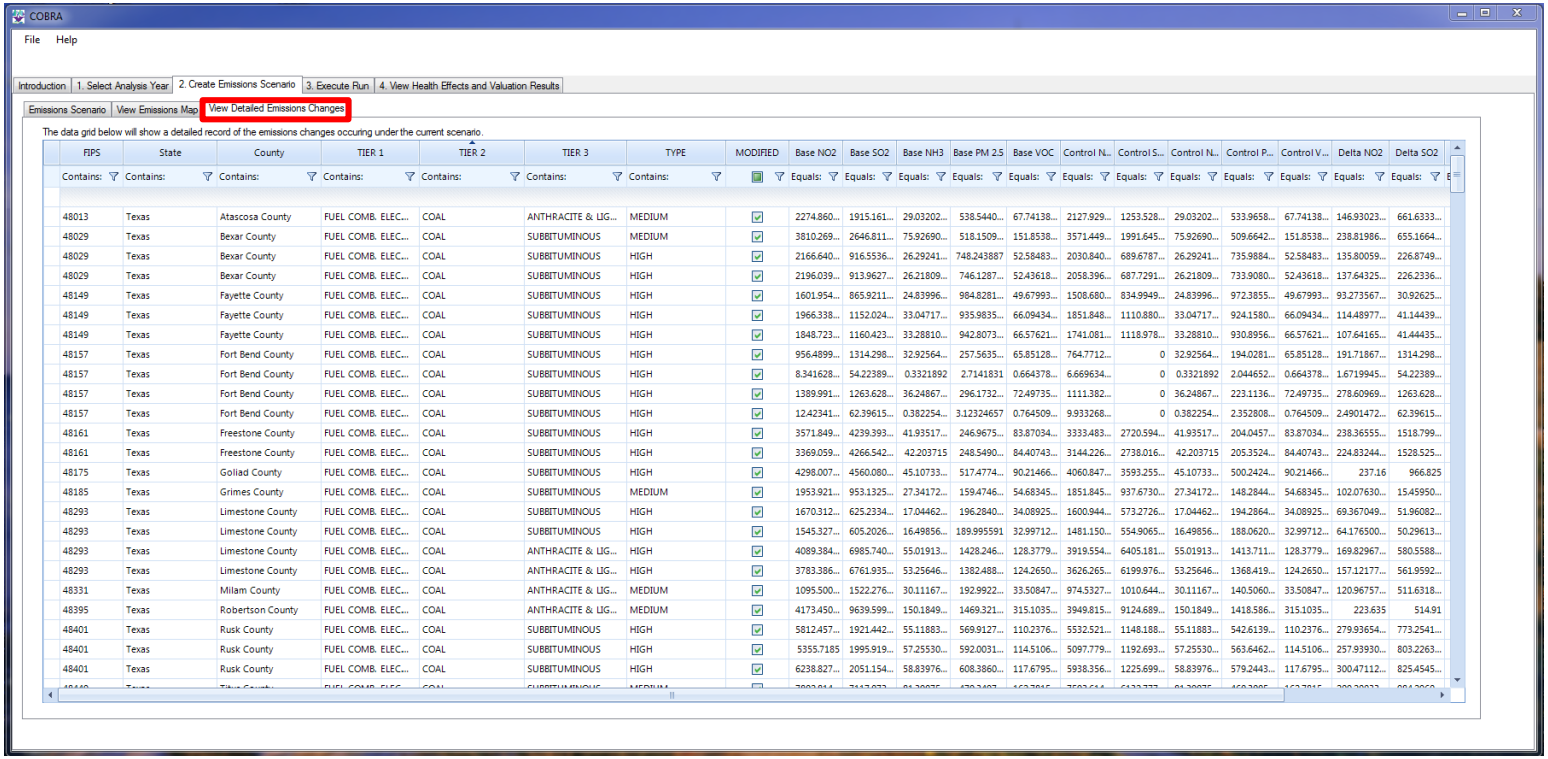
- After applying 2017 baseline, click “Load AVERT output file”



Step 2: Create Emissions Scenario

View Detailed Emissions Changes

- The AVERT scenario includes changes to the "fuel combustion from electricity generation" emissions category



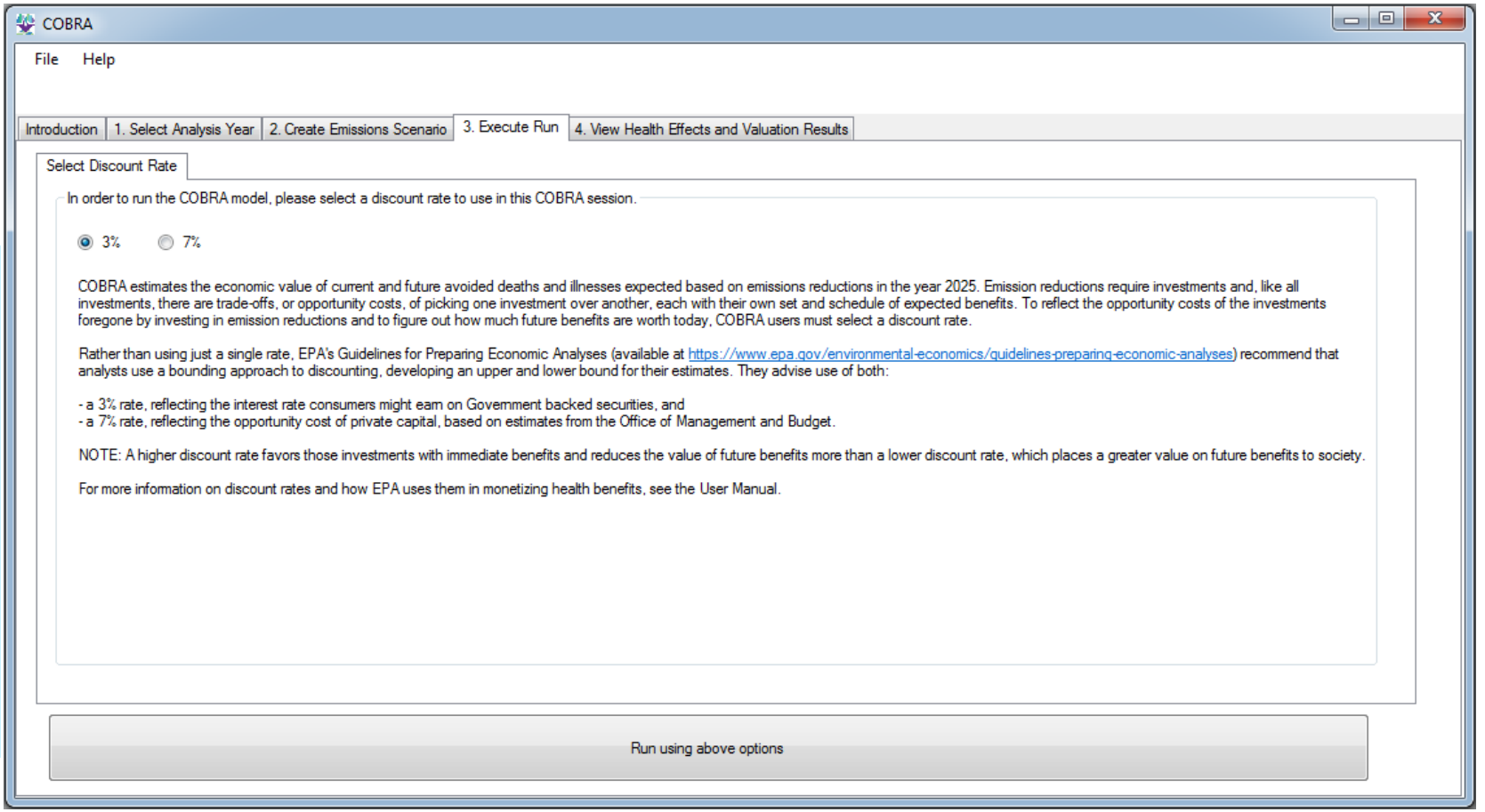
Step 3: Execute Run

Select a discount rate

- A discount rate is used to appropriately discount the value of future benefits
- In this case study, we use a 3% discount rate
- This discount rate provides an upper bound for the estimated benefits and places a greater value on future benefits to society, compared to higher discount rates

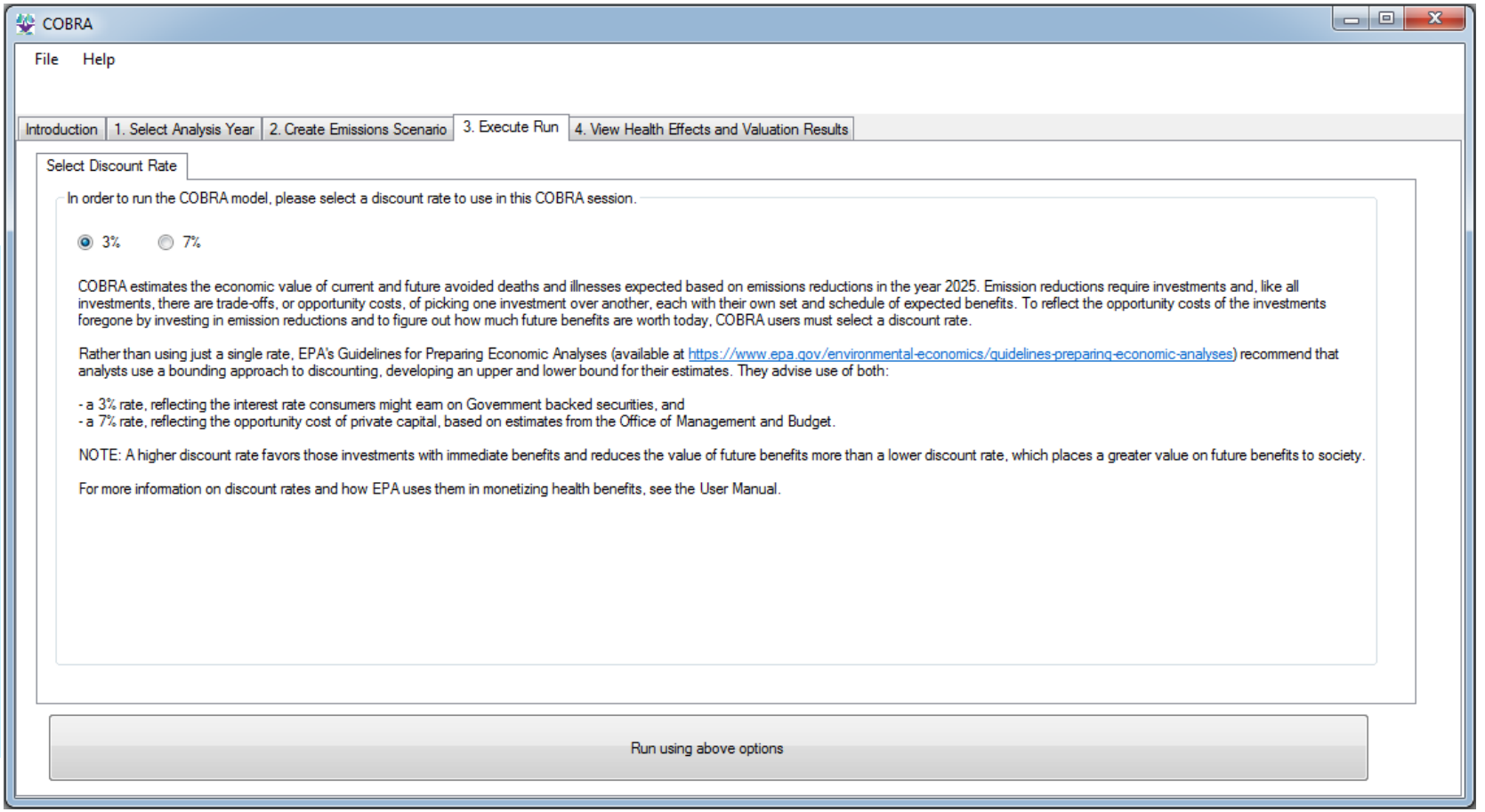
Step 3: Execute Run

Select a discount rate (cont'd)



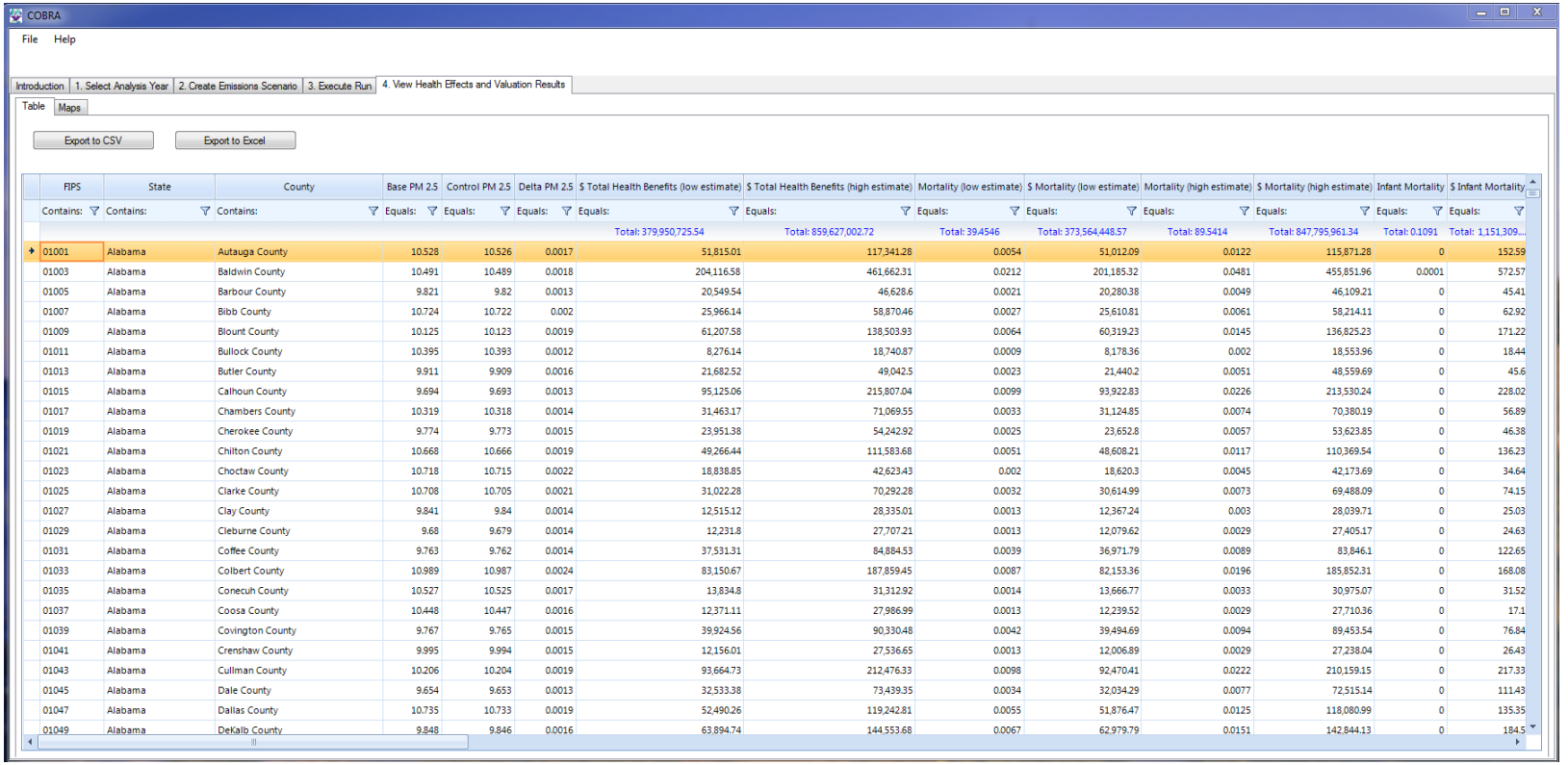
Step 3: Execute Run

Run the model



Step 4: View Health Effects and Valuation Results

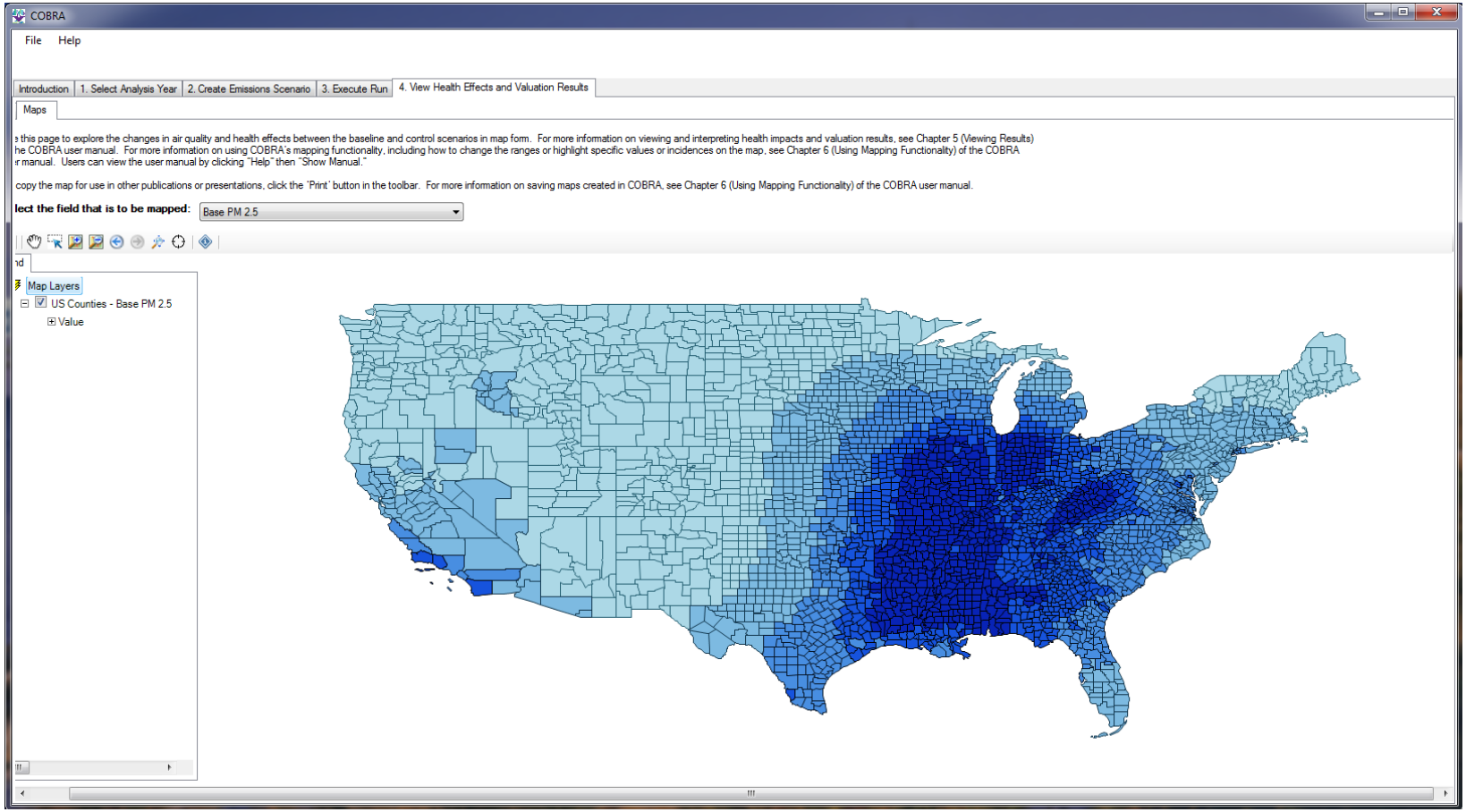
View in table form



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)	Mortality (high estimate)	$ Mortality (high estimate)	Infant Mortality	$ Infant Mortality
Contains:	Contains:	Contains:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:	Equals:
						Total: 379,950,725.54	Total: 859,627,002.72	Total: 39.4546	Total: 373,564,448.57	Total: 89.5414	Total: 847,795,961.34	Total: 0.1091	Total: 1,151,309...
01001	Alabama	Autauga County	10.528	10.526	0.0017	51,815.01	117,341.28	0.0054	51,012.09	0.0122	115,871.28	0	152.59
01003	Alabama	Baldwin County	10.491	10.489	0.0018	204,116.58	461,662.31	0.0212	201,185.32	0.0481	455,851.96	0.0001	572.57
01005	Alabama	Barbour County	9.821	9.82	0.0013	20,549.54	46,628.6	0.0021	20,280.38	0.0049	46,109.21	0	45.41
01007	Alabama	Bibb County	10.724	10.722	0.002	25,966.14	58,870.46	0.0027	25,610.81	0.0061	58,214.11	0	62.92
01009	Alabama	Blount County	10.125	10.123	0.0019	61,207.58	138,503.93	0.0064	60,319.23	0.0145	136,825.23	0	171.22
01011	Alabama	Bullock County	10.395	10.393	0.0012	8,276.14	18,740.87	0.0009	8,178.36	0.002	18,553.96	0	18.44
01013	Alabama	Butler County	9.911	9.909	0.0016	21,682.52	49,042.5	0.0023	21,440.2	0.0051	48,559.69	0	45.6
01015	Alabama	Calhoun County	9.694	9.693	0.0013	95,125.06	215,807.04	0.0099	93,922.83	0.0226	213,530.24	0	228.02
01017	Alabama	Chambers County	10.319	10.318	0.0014	31,463.17	71,069.55	0.0033	31,124.85	0.0074	70,380.19	0	56.89
01019	Alabama	Cherokee County	9.774	9.773	0.0015	23,951.38	54,242.92	0.0025	23,652.8	0.0057	53,623.85	0	46.38
01021	Alabama	Chilton County	10.668	10.666	0.0019	49,266.44	111,583.68	0.0051	48,608.21	0.0117	110,369.54	0	136.23
01023	Alabama	Choctaw County	10.718	10.715	0.0022	18,838.85	42,623.43	0.002	18,620.3	0.0045	42,173.69	0	34.64
01025	Alabama	Clarke County	10.708	10.705	0.0021	31,022.28	70,292.28	0.0032	30,614.99	0.0073	69,488.09	0	74.15
01027	Alabama	Clay County	9.841	9.84	0.0014	12,515.12	28,335.01	0.0013	12,367.24	0.003	28,039.71	0	25.03
01029	Alabama	Cleburne County	9.68	9.679	0.0014	12,231.8	27,707.21	0.0013	12,079.62	0.0029	27,405.17	0	24.63
01031	Alabama	Coffee County	9.763	9.762	0.0014	37,531.31	84,884.53	0.0039	36,971.79	0.0089	83,846.1	0	122.65
01033	Alabama	Colbert County	10.989	10.987	0.0024	83,150.67	187,859.45	0.0087	82,153.36	0.0196	185,852.31	0	168.08
01035	Alabama	Conecuh County	10.527	10.525	0.0017	13,834.8	31,312.92	0.0014	13,666.77	0.0033	30,975.07	0	31.52
01037	Alabama	Coosa County	10.448	10.447	0.0016	12,371.11	27,986.99	0.0013	12,239.52	0.0029	27,710.36	0	17.1
01039	Alabama	Covington County	9.767	9.765	0.0015	39,924.56	90,330.48	0.0042	39,494.69	0.0094	89,453.54	0	76.84
01041	Alabama	Crenshaw County	9.995	9.994	0.0015	12,156.01	27,536.65	0.0013	12,006.89	0.0029	27,238.04	0	26.43
01043	Alabama	Cullman County	10.206	10.204	0.0019	93,664.73	212,476.33	0.0098	92,470.41	0.0222	210,159.15	0	217.33
01045	Alabama	Dale County	9.654	9.653	0.0013	32,533.38	73,439.35	0.0034	32,034.29	0.0077	72,515.14	0	111.43
01047	Alabama	Dallas County	10.735	10.733	0.0019	52,490.26	119,242.81	0.0055	51,876.47	0.0125	118,080.99	0	135.35
01049	Alabama	DeKalb County	9.848	9.846	0.0016	63,894.74	144,553.68	0.0067	62,979.79	0.0151	142,844.13	0	184.5

Step 4: View Health Effects and Valuation Results

View in map form



Step 4: View Health Effects and Valuation Results

We used AVERT to calculate the emissions reductions due to an increased wind capacity of 1,000 MW.

Annual Emission Reductions (short tons)

Pollutant	Amount
Sulfur Dioxide (SO_2)	16,180
Nitrogen Oxides (NO_x)	6,749

Note: These reductions are aggregated across all affected states.

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	39 - 90
Asthma Exacerbations	1,281
Heart Attacks	5 - 44
Hospital Admissions	25
Acute Bronchitis	68
Respiratory Symptoms	2,120
Asthma ER Visits	21
Minor Restricted Activity Days	32,331
Work Days Lost	5,443

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

Annual Benefits (2017, $1,000s)

Dollar Value
$37,564 - $847,796
$82
$657 - $6,101
$950
$37
$66
$10
$2,457
$976
$379,951 - $859,672

total

* Don't forget to consider the caveats from slides 16 through 18

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

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