AVERT Overview and Step-by-Step instructions

US Environmental Protection Agency
State Climate and Energy Program
February 2014

Overview of AVERT Development for Energy Efficiency and Renewable Energy (EE/RE) Programs

- AVERT (AVoided Emissions and geneRation Tool) translates the energy impacts of EE/RE policies and programs into emission reductions (NO_x, SO_2, and CO_2).
  - It aims to address a key reason states have not implemented previous EE/RE State Implementation Plan (SIP) guidance.
- AVERT has been thoroughly reviewed, well documented and tested. EPA has:
  - Conducted external and internal peer reviews.
  - Benchmarked AVERT against industry standard electric power sector model – PROSYM.
  - Worked with states to beta-tested tool for functionality, appropriate uses, and clarity of user manual.
- AVERT was built to be:
  - user friendly
  - transparent
  - credible

For more information on EPA's EE/RE SIP Roadmap visit:
http://www.epa.gov/airquality/eere/manual.html.

Emission Quantification Methods
Basic to Sophisticated

| **Basic Method**	**Intermediate Method**	**Sophisticated Method**
eGRID region non-baseload emission rates	Historical hourly emission rates	Energy Modeling
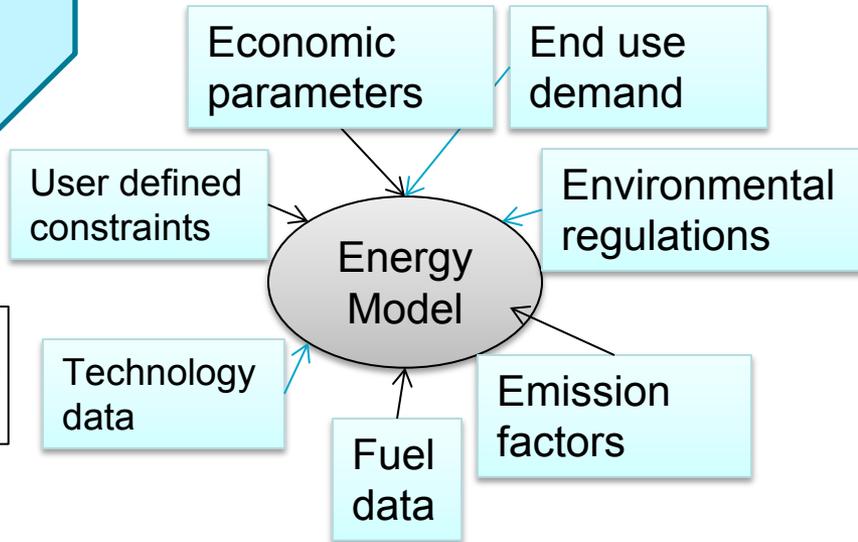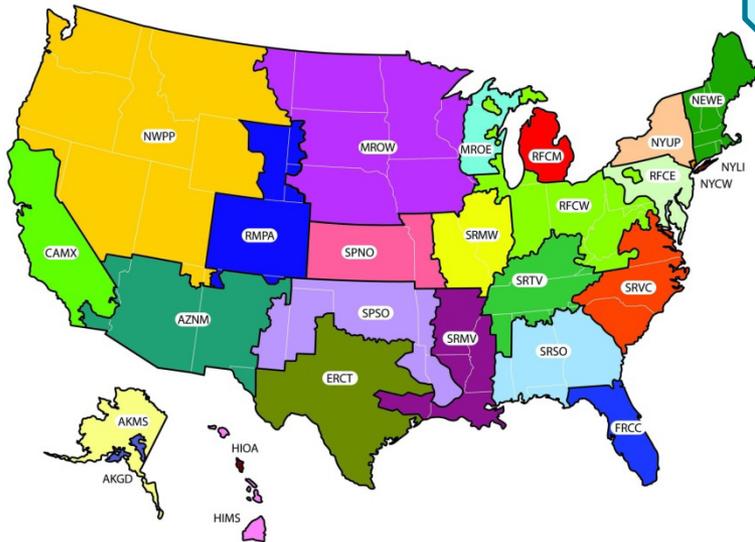
Applications for AVERT-Calculated Emissions

- SIP credit in a state's National Ambient Air Quality Standard Clean Air Act Plan

- Identify cohort of electric generating units (EGU) "on the margin" compared to baseline

- Compare emission impacts of different EE/RE programs

- Understand emission reductions during High Electric Demand Days

- This is not a projection tool, not intended for analysis more than 5 yrs from baseline

How AVERT Works

- AVERT's Main Module simulates the hourly changes in generation and air emissions (NO_x, SO_2, and CO_2) at EGU resulting from EE/RE policies and programs.

- User input: MWhs saved from EE programs, or wind and solar generation (MW)
  - Multiple options are built into the tool
  - EPA provides hourly profiles for some states with on-the-books EE programs not included in Energy Information Administration's Annual Energy Outlook (2013)

- User can retire, add and change emission rates of EGU and re-run simulation using AVERT's Future Year Scenario Template and Statistical Module.

For information on state EE on-the-books hourly profiles visit:
http://www.epa.gov/statelocalclimate/state/statepolicies.html.

AVERT's Modules and Data Files

Raw Hourly Generation and Emissions Data from Air Markets Program (AMP) Dataset

Text files

Future Year Scenario Template

User interface for retirements, additions, and retrofits

Excel workbook

AVERT: Statistical Module

Inputs AMP data, performs statistical analysis, outputs new Regional Data Files

MATLAB Code

Regional Data Files

Contains annual hourly load data and unit-level statistics on generation and emissions data

Text files

AVERT Main Module

User interface for creating EE/RE load curves, performs displaced emissions analysis, creates output charts and tables

Excel workbook

Most users will only need to use the Regional Data Files and AVERT Main Module to calculate emissions

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AVERT's Data Driven Analysis

- AVERT uses a data-driven analysis to distinguish which EGU respond to marginal changes in load reduction.
  - AVERT analyzes EGU datasets from EPA's Air Markets and Program Data (hourly, unit-by-unit generation & emissions).
    - Dataset includes EGUs with capacity of 25 MWs or greater.
  - AVERT's Statistical Module gathers statistics on EGU operations under specific load conditions, and then replicates changes through a Monte Carlo analysis.
  - AVERT's Regional Data Files contain hourly and unit-level emissions and generation data.

Part I
AVERT Main Module

AVERT Main Module Step-by-Step Overview

- Enabling Macros

- Using AVERT

- Step 1. Load Regional Data File

- Step 2. Set Energy Efficiency and Renewable Energy Data

- Step 3. Run Displacement

- Step 4. Display Outputs

AVERT Main Module Enabling Macros

- AVERT is compatible with Excel 2007, or newer versions.

- You may want to revert to the default macro settings after using the model. Enabling macros in other Excel files may allow potentially dangerous code to run.

AVERT Main Module Enabling Macros

In Excel 2010, click **File***> **Options**
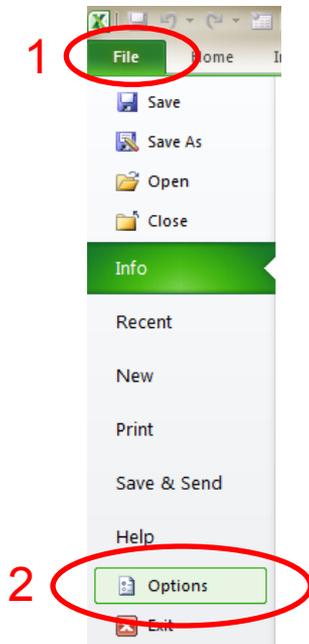
Next, click **Trust Center** > **Trust Center Settings** > **Macro Settings** > **Enable all macros**
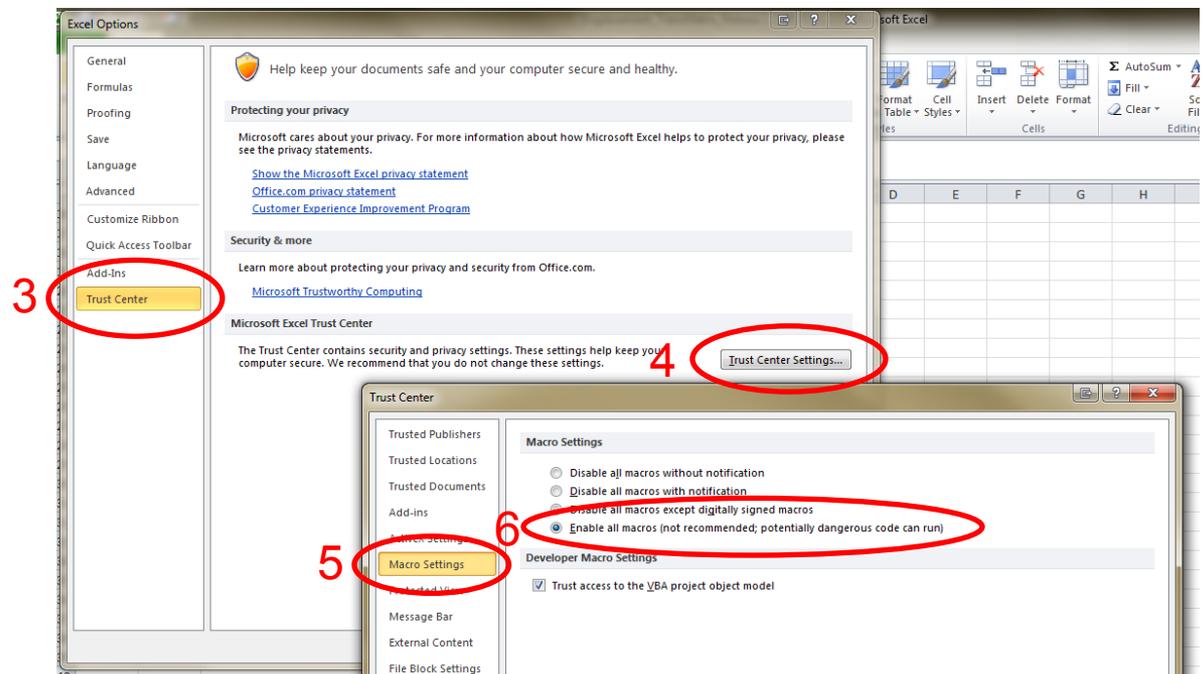
*If using Excel 2007, click the Microsoft Office Button

AVERT Main Module
Using AVERT

- Add details about the user, the date, and the EE/RE program for which displacements are to be estimated.

- Click on the button labeled "Click here to begin".

AVERT Main Module
Step 1. Load Regional Data File

Regions represent relatively autonomous electricity production zones, and are based on electricity market module regions.

Regions include
- California
- Great Lakes/Mid-Atlantic
- Lower Midwest
- Northeast
- Northwest
- Rocky Mountains
- Southeast
- Southwest
- Texas
- Upper Midwest

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AVERT Main Module
Step 1. Load Regional Data File

- Select a region for analysis by either using the dropdown or clicking the map.

Select region

Select a region for analysis by using the dropdown or by clicking the map.
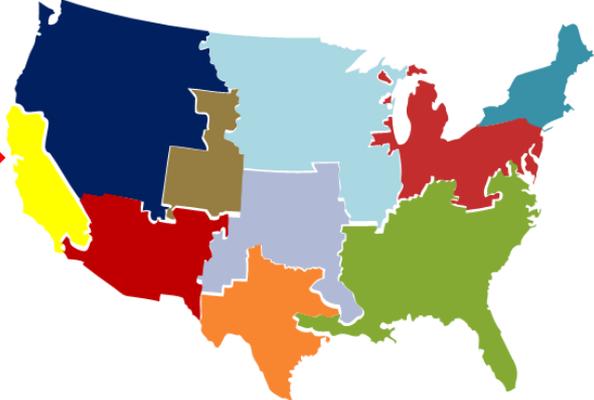
If you haven't yet saved a Regional Data File on your computer, click here.

- – Selecting a region loads region-specific data for wind and solar capacity factors, and dynamically creates a hyperlink to that region's data on EPA's website.

- After selecting a region, click the link under the map to download it from EPA's website.

AVERT Main Module
Step 1. Load Regional Data File

- In the box labeled "Enter filepath," double-click the blue area to navigate to the location of the downloaded regional data file.

Enter filepath

Double-click below to enter the location of the Regional Data File.
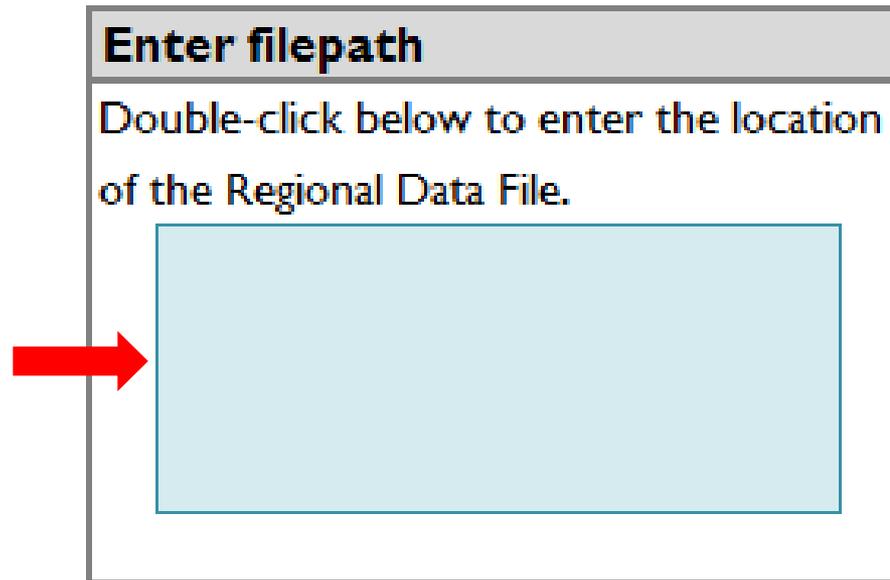
AVERT Main Module
Step 1. Load Regional Data File

- Click the button under "Load data" entitled:

Load data

Click here to load the Regional Data File
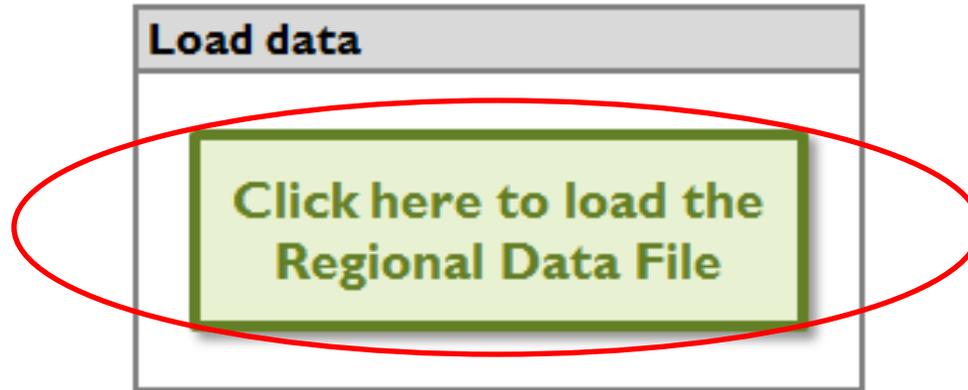
Clicking this button loads the following information from the regional data file:

- – Hourly fossil load

- – EGU information (e.g., location, fuel type)

- – Typical EGU performance for generation and emissions at a given regional load

AVERT Main Module
Step 2. Set EE and RE Data

- This page leads you through the process of creating a load impact profile depicting the load reductions expected from an EE/RE program.

AVERT Main Module
Step 2. Set EE and RE Data

- If the hourly load reductions expected from a particular EE/RE policy, program, or measure are known, a manual stream of load reduction values can be entered for every hour of the year by clicking the "Enter hourly data manually" button.

Enter hourly data manually

Northeast, 2012 **AVERT**

Manual EERE Data Entry

When complete, click here to return to
Step 2: Enter Energy Efficiency and Renewable Energy Data

Date	Hour	Day of Week	Regional Fossil Load (MW)	Manual EE RE Profile (MW)	Total Change (MW)
1/1/2012	1	Sunday	9,182		0
1/1/2012	2	Sunday	8,084		0
1/1/2012	3	Sunday	7,072		0
1/1/2012	4	Sunday	6,666		0
1/1/2012	5	Sunday	6,726		0
1/1/2012	6	Sunday	6,986		0
1/1/2012	7	Sunday	7,330		0
1/1/2012	8	Sunday	7,051		0
1/1/2012	9	Sunday	7,401		0
1/1/2012	10	Sunday	7,841		0
1/1/2012	11	Sunday	8,135		0
1/1/2012	12	Sunday	8,445		0
1/1/2012	13	Sunday	8,581		0
1/1/2012	14	Sunday	8,615		0

AVERT Main Module
Step 2. Set EE and RE Data

This page also allows you to estimate a load reduction from basic characteristics:

- Reduce fossil-fuel generation by a percent in some or all hours
- Reduce fossil-fuel generation by total GWh
- Reduce each hour by a constant MW
- Renewable energy proxy
- Combination of EE/RE programs including combining pre-set options with manual entry

Enter EE impacts based on the % reduction of regional fossil load

Reduce generation by a percent in some or all hours		
Apply reduction to top X% hours:	0%	% of top hours
Reduction % in top X% of hours:	0.0%	% reduction

And/or enter EE impacts distributed evenly throughout the year

Reduce generation by annual GWh:	0	GWh
OR		
Reduce each hour by constant MW:	0.0	MW

And/or enter annual capacity of RE resources

Wind Capacity:	2000	MW
Utility Solar PV Capacity:	0	MW
Rooftop Solar PV Capacity:	0	MW

AVERT Main Module
Step 3. Run Displacement

- Run displacement by selecting the button entitled "Click here to calculate displaced generation and emissions."

AVERT Main Module
Step 3. Run Displacement

- This step calculates hourly displaced generation and emissions (SO_2, NO_X, CO_2) for each fossil EGU within the selected region.

- Note that this is a processor-intensive step. When using an older computer, or when analyzing regions with many fossil EGU, this step may take up to ten minutes.

AVERT Main Module
Step 4. Display Outputs

- The data generated in Step 3 are aggregated in two groups of charts and tables in Step 4.

Summary tables

Annual regional displacement data	Displacement data for top ten peak days
Annual displacement data by county	Monthly displacement data by county

Charts and figures

Displaced generation and emissions map	Hourly displacements by week
Monthly displacements by selected geography	Signal-to-noise diagnostic
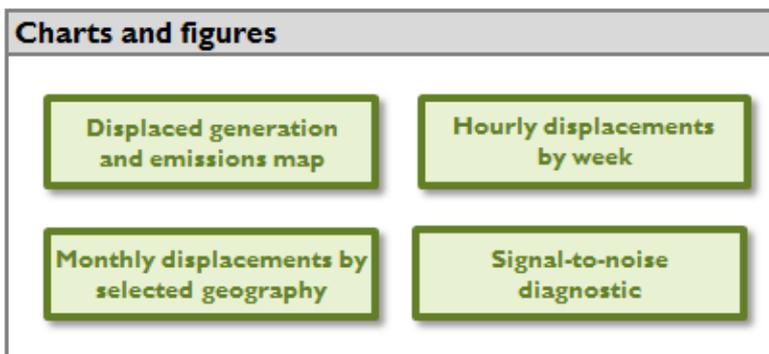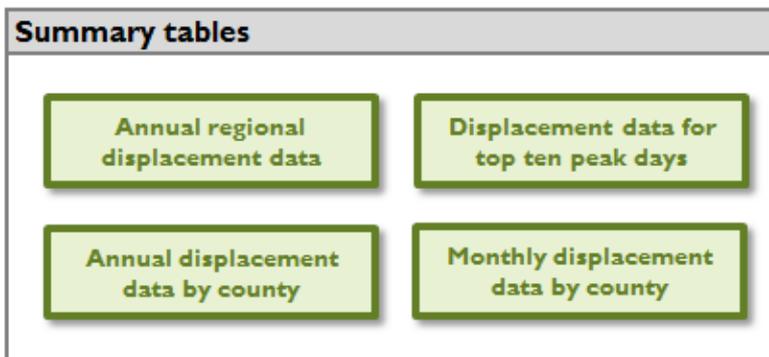
AVERT Main Module
Step 4. Display Outputs

Annual regional displacements

- This table displays the total annual generation and emissions as reported for the region in the base year ("Original") and as calculated by AVERT's Main Module after the EE/RE reduction ("Post-EERE").

Upper Midwest, 2012			AVERT

Output: Annual Regional Displacements

Click here to return to Step 4: Display Outputs

|	Original	Post-EERE	Impacts
Generation (MWh)	245,694,500	235,514,500	- 10,180,000
Total Emissions			
SO_2 (lbs)	956,871,300	921,132,200	- 35,739,100
NO_x (lbs)	416,259,200	400,349,300	- 15,909,900
CO_2 (tons)	246,098,700	236,856,400	- 9,242,300
Emission Rates			
SO_2 (lbs/MWh)	3.895	3.911	
NO_x (lbs/MWh)	1.694	1.700	
CO_2 (tons/MWh)	1.002	1.006	

All results are rounded to the nearest hundred. A dash ("—") indicates a result greater than zero, but lower than the level of reportable significance.

AVERT Main Module
Step 4. Display Outputs

Annual displacement data by county

- This table presents a summary of the displaced generation and emissions for each of the counties from each of the states contained within the region. A line for each county containing an EGU is displayed.

Upper Midwest, 2012

Output: Annual Displacement Data by County

Click here to return to Step 4: Display Outputs

State	County	Peak Gross Generation, Post-EERE (MW)	Annual Gross Generation, Post-EERE (MWh)	Annual Displaced Generation (MWh)	Annual Displaced SO$_2$ (lbs)
IA	Allamakee	250	1,152,800	-91,800	-639,700
IA	Appanoose	17	2,700	-600	-5,300
IA	Audubon	125	39,100	-8,800	–
IA	Black Hawk	109	42,300	-8,900	-30,700
IA	Cerro Gordo	522	772,800	-154,400	-600
IA	Clay	30	11,000	-2,300	-21,000
IA	Clinton	143	583,900	-30,500	-195,700
IA	Des Moines	210	1,195,400	-58,200	-438,500
IA	Dubuque	42	91,300	-1,600	-500
IA	Louisa	770	5,304,300	-197,800	-642,500
IA	Marshall	57	32,500	-1,700	-200
IA	Muscatine	262	960,200	-79,200	-353,300
IA	Polk	481	343,100	-59,900	-2,100

For each county, annual output statistics are given for:

- Peak Gross Generation Post-EE/RE
- Annual Gross Generation Post-EE/RE
- Capacity Factor
- Annual Change in Generation
- Annual Change in Heat Input/ SO_2/NO_X/CO_2
- Ozone Season Change in SO_2/NO_X
- Ozone Season, 10 Peak Days Change in SO_2/NO_X

AVERT Main Module
Step 4. Display Outputs

Displacement data for top ten peak days

- This table displays a summary of the ten days in the region featuring the highest level of fossil fuel load.

Upper Midwest, 2012 — **AVERT**

Output: Displacement Data for Top Ten Peak Days

Click here to return to Step 4: Display

Day Rank	Date	Total Fossil Generation (MWh)	Expected Displaced Generation (MWh)	Displaced Generation (MWh)	Displaced NO$_x$ (lbs)	Displaced SO$_2$ (lbs)	Displaced CO$_2$ (Tons)
1	Jul 26	990,200	-32,800	-32,000	-56,500	-58,900	-23,300
2	Jul 27	966,700	-26,300	-26,300	-57,000	-42,500	-19,800
3	Jul 25	963,900	-35,800	-35,900	-69,600	-62,700	-27,100
4	Jul 14	963,400	-21,800	-21,800	-42,400	-36,800	-16,500
5	Aug 01	954,200	-16,500	-16,400	-35,900	-27,700	-12,800
6	Jul 06	953,600	-16,000	-16,000	-37,400	-26,700	-12,600
7	Jul 13	950,100	-17,000	-16,400	-37,800	-29,900	-13,100
8	Jul 07	928,900	-19,000	-19,100	-41,100	-29,600	-14,600
9	Jul 10	927,500	-18,400	-18,500	-42,700	-31,400	-14,400
10	Aug 12	923,200	-15,500	-15,500	-34,200	-21,500	-12,000

Negative numbers indicate displaced generation and emissions.

All results are rounded to the nearest hundred. A dash ("—") indicates a result greater than zero, but lower than the level of reportable significance.

AVERT Main Module
Step 4. Display Outputs

Displaced generation and emissions map

- This dynamic map allows the user to view where emissions have been displaced within the selected region. Users can view changes in generation, heat input, SO_2, NO_X, and CO_2.
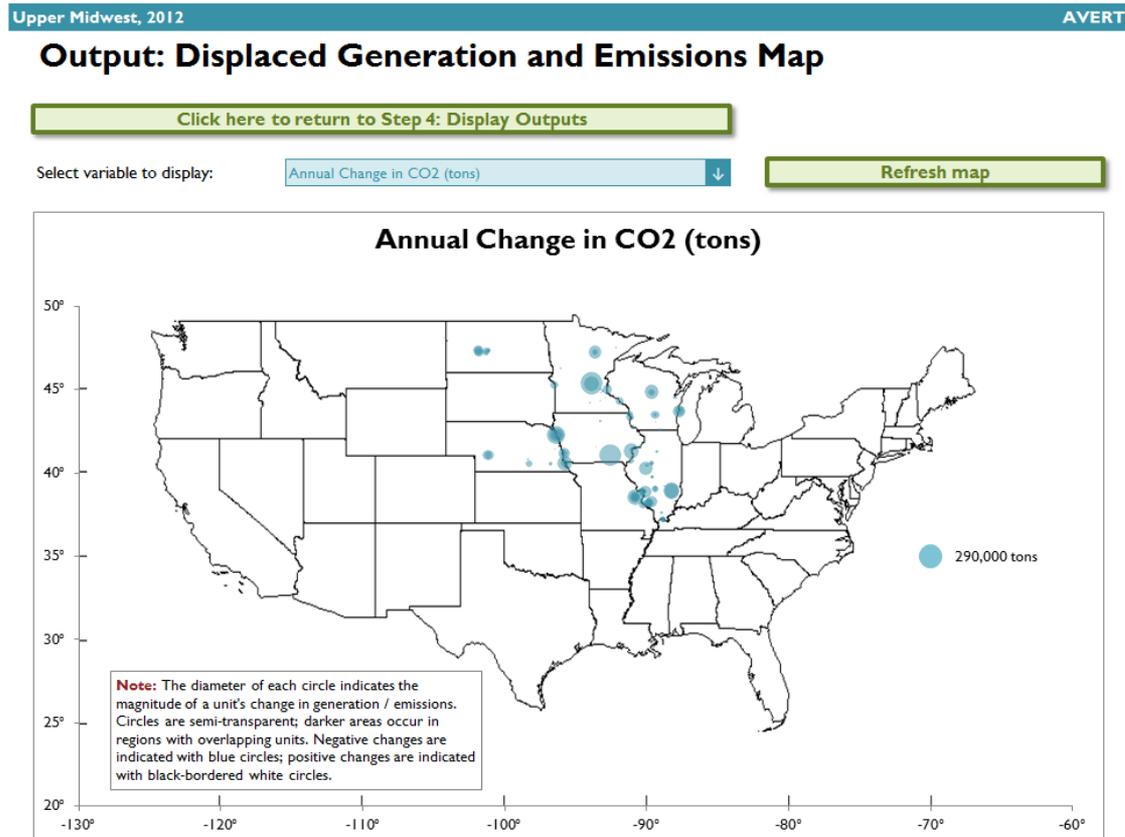
AVERT Main Module
Step 4. Display Outputs

Displacement data by month

Monthly output can be viewed over the entire region, or a specific state or county within the region.

- First select region, state, or county in the top dropdown menu.

- If selecting a state, choose the state in the next dropdown menu.

- If selecting a county, choose both the state and the county in the next two dropdown menus.

Upper Midwest, 2012 — AVERT

Output: Monthly Displacements by Selected Geography

Click here to return to Step 4: Display Outputs

Select level of aggregation: State
Select state: IA

Monthly Emission Changes, Upper Midwest (IA)
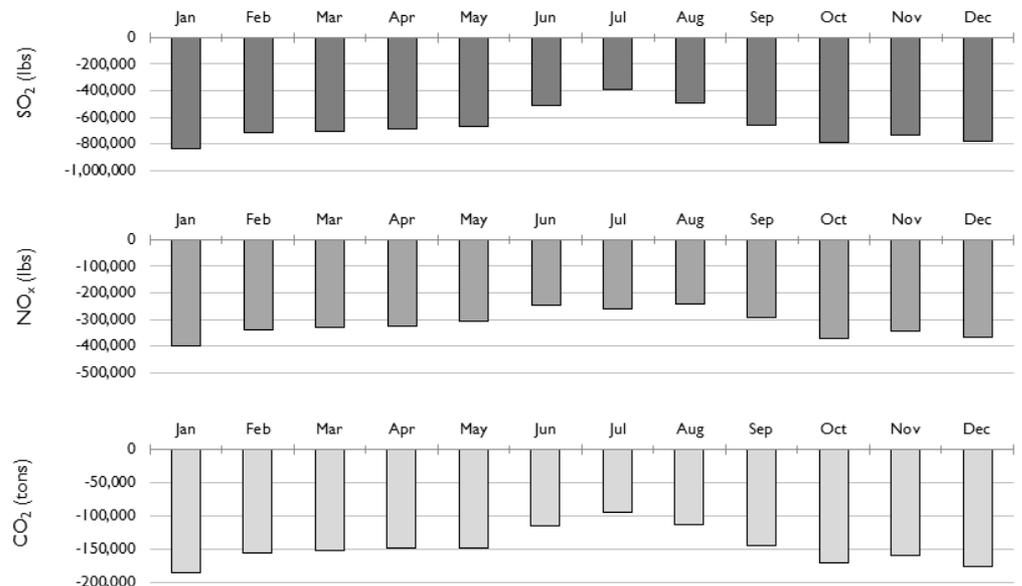
AVERT Main Module
Step 4. Display Outputs

Hourly displacements by week

- This graph displays a dynamic representation of hourly displacement from each EGU in a region. Individual plants are stacked as gradated bar plots.
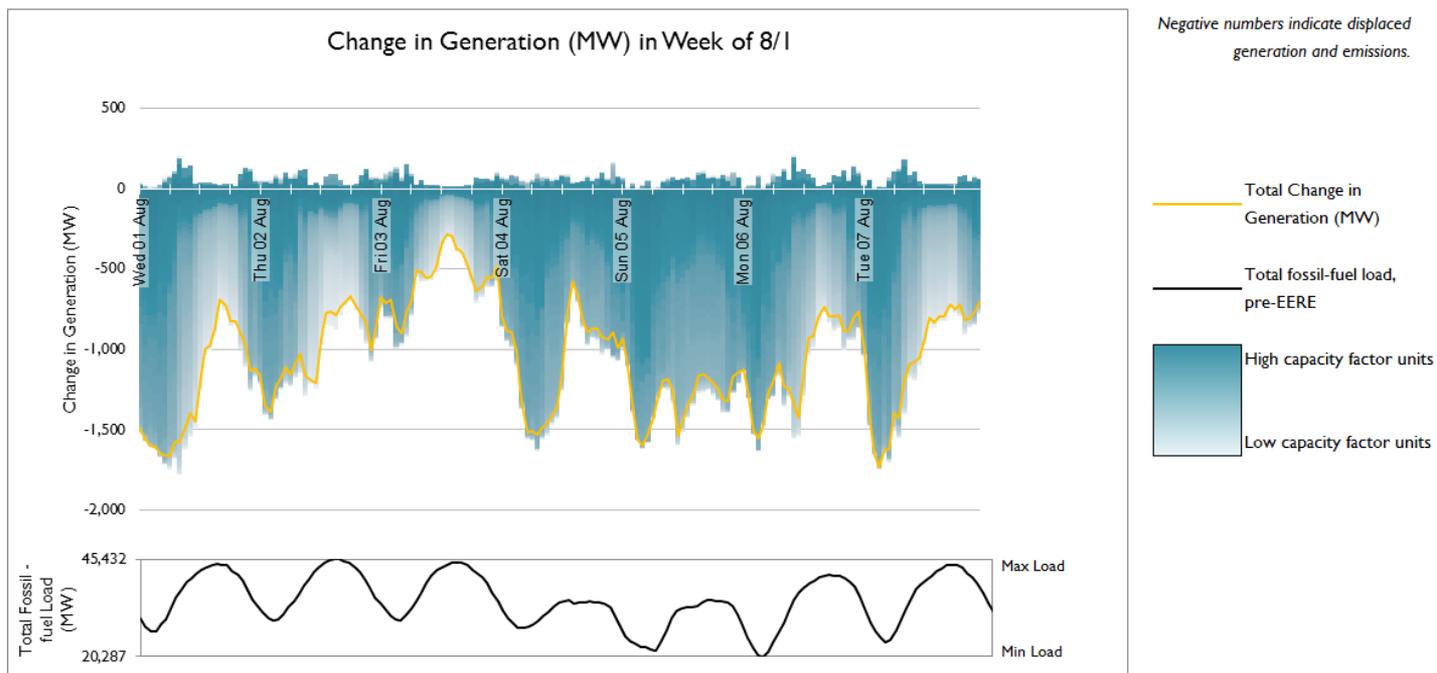
AVERT Main Module
Step 4. Display Outputs

Hourly displacements by week

- The second figure shows the same week-long load impact profile, but presents the displaced load in reference to the total fossil-fuel load to illustrate the degree of change represented by the EE/RE program relative to the baseline.

Fossil-fuel load, pre- and post-EERE, in Week of 8/1
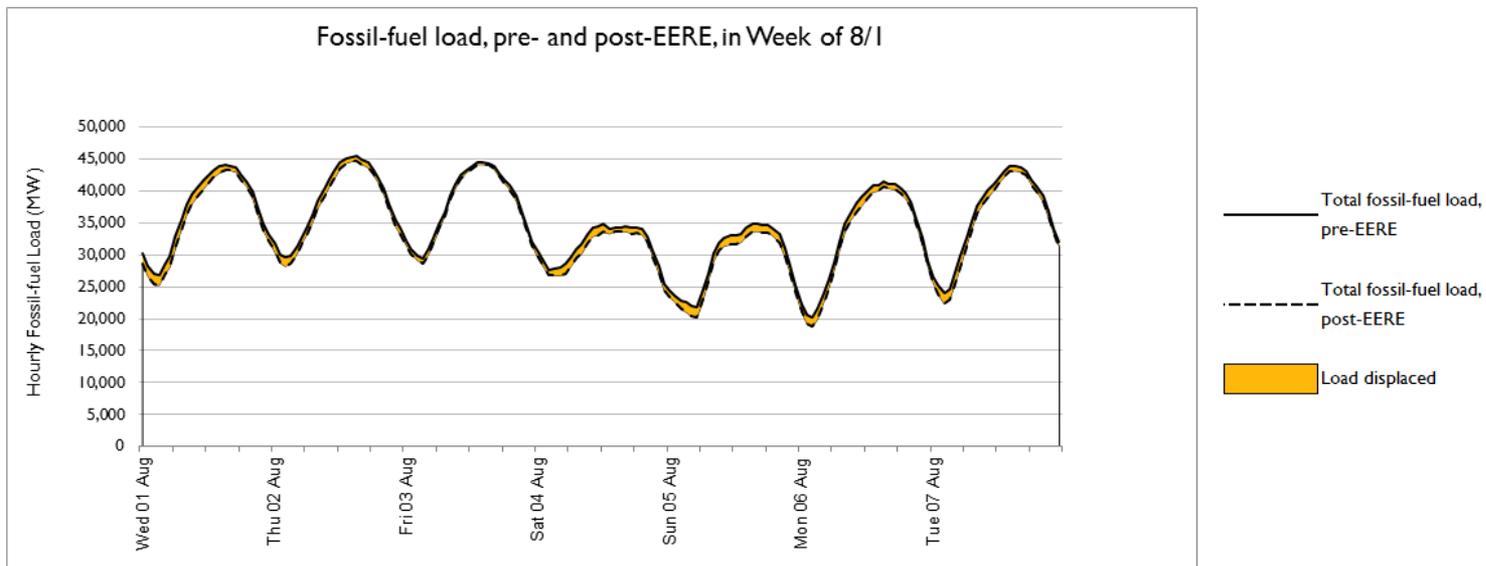
AVERT Main Module
Step 4. Display Outputs

Signal-to-noise diagnostic

- This chart is a scatterplot of every hour of the year, showing calculated total generation reduction in each hour (y-axis) against the user-input EE/RE load reduction in each hour (x-axis).

- Ideally, AVERT perfectly matches unit generation reductions to the amount of EE/RE load reduction requested by the user.

- This graphic shows where that assumption holds, where it does not hold, and to what extent.

Upper Midwest, 2012   AVERT

Output: Signal-to-noise diagnostic

Click here to return to Step 4: Display Outputs

Reduction in Total Unit Generation Relative to EERE Load Reduction (MW) for All Hours, R^2=0.99

Expected EERE Load Reduction (MW)

Resulting Reduction in Generation (MW)
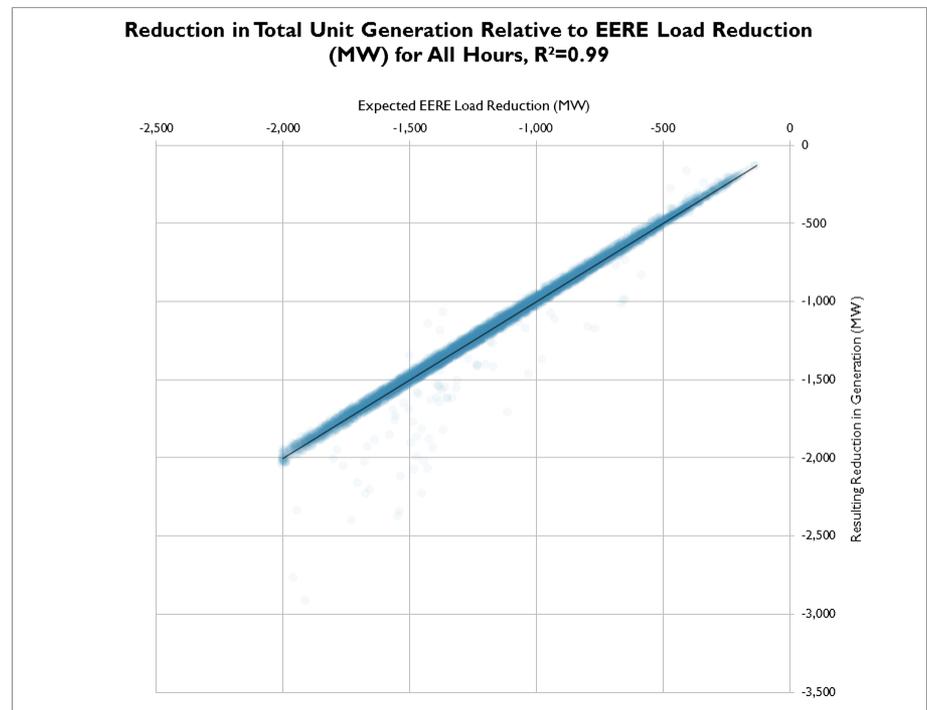
Part II
AVERT Statistical Module Operation

AVERT Statistical Module Overview

- Purpose
  - Basis of AVERT analysis
  - Processes raw CAMD data to determine behavioral characteristics of fossil-fired EGU
  - Returns expected generation and emissions behavior to AVERT Main Module
  - Allows users to alter EGU characteristics, retire and add EGU with Future Year Template

- Advanced use of AVERT
  - Most users will not require the Statistical Module
  - Based in MATLAB
  - Executable version available for public use
  - Requires MATLAB Compiler Runtime (MCR) to be installed (free from Mathworks)

- Output file can be used directly in Main Module

AVERT Statistical Module Obtain Correct Version

- AVERT Statistical Module is sensitive to PC specifications.

- 32-bit and 64-bit operating system versions available.

- Obtain correct version of AVERT Statistical Module.

- Obtain correct version of MCR from Mathworks.

- Determine if your Windows system operates in a 32-bit or 64-bit environment.
  - Find this information in "properties" of "My Computer" in Windows XP, or "Computer" in Windows Vista, Windows 7, or Windows 8.
  - Follow these instructions: http://windows.microsoft.com/en-us/windows7/find-out-32-or-64-bit.

AVERT Statistical Module Unpacking and Startup

- Download the AVERT Statistical Module package.

- Run the executable to decompress the package to three files and three subfolders.
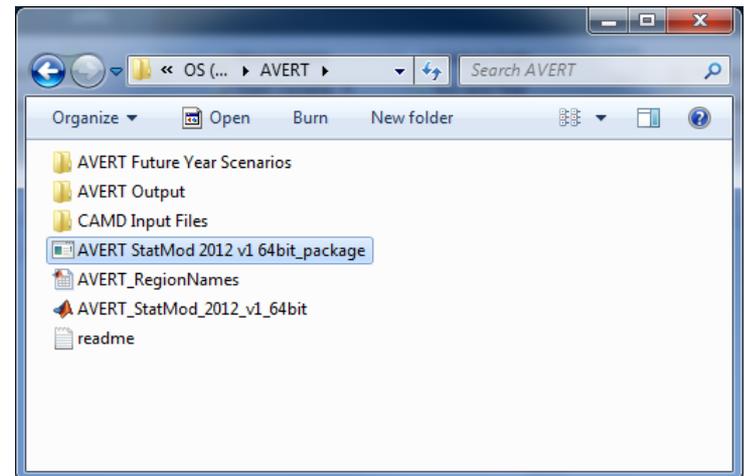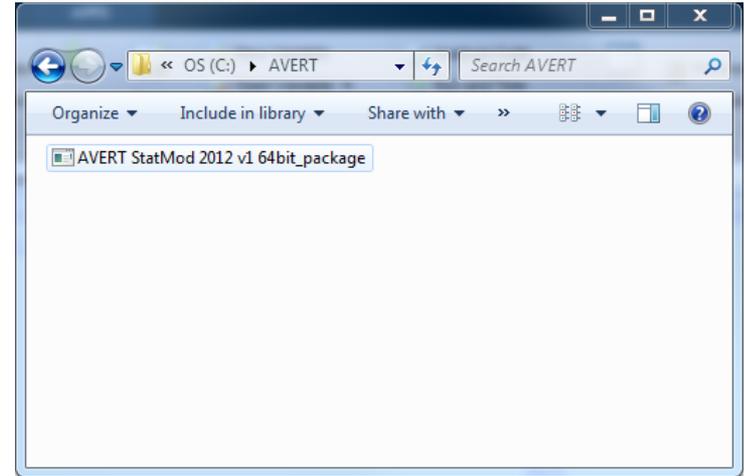
To obtain historic base years, visit http://epa.gov/statelocalclimate/resources/avert-download.html and obtain both the CAMD input file and the Future Year Scenario Template for that same year.

AVERT Statistical Module File Structure

- **AVERT Future Year Scenarios**
  - Excel-based input files for altering EGU

- **AVERT Output**
  - Statistical Module output files
  - These become Main Module input files

- **CAMD Input Files**
  - Processed CAMD data files
  - New versions expected 2nd quarter annually

- **AVERT_StatMod_2012_v1_64bit**
  - Executable

AVERT Future Year Scenarios
AVERT Output
CAMD Input Files
AVERT StatMod 2012 v1 64bit_package
AVERT_RegionNames
AVERT_StatMod_2012_v1_64bit
readme
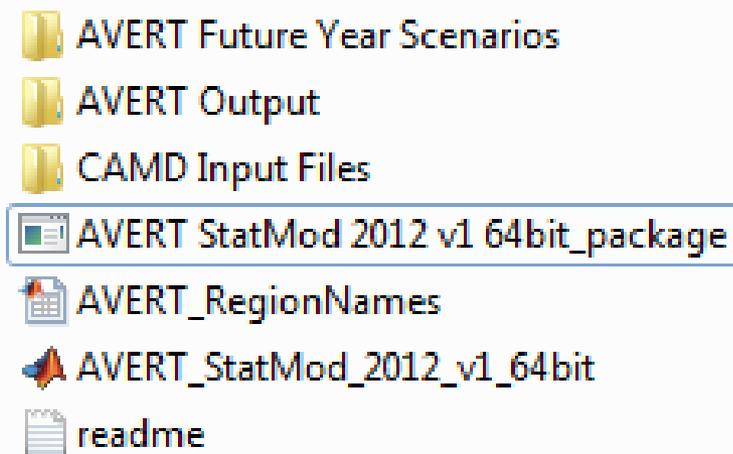
Obtaining Other Base Years

To obtain additional historic base year data, visit:
http://epa.gov/statelocalclimate/resources/avert-download.html.

- Download AVERT Future Year Scenario for the same historic base year.
  - Place the file in "AVERT Future Year Scenarios"

- Download the CAMD input file for the historic base year.
  - Place the file in "CAMD Input Files"

- AVERT Future Year Scenarios
- AVERT Output
- CAMD Input Files
- AVERT StatMod 2012 v1 64bit_package
- AVERT_RegionNames
- AVERT_StatMod_2012_v1_64bit
- readme
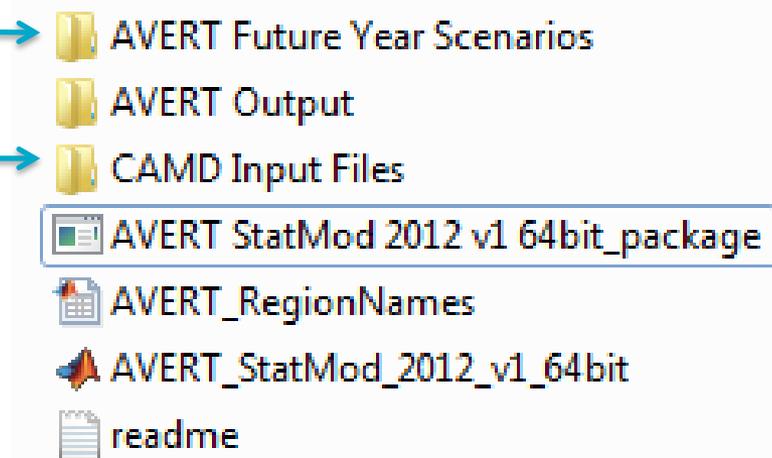
Note: Historic base years must match-up with the Future Year Scenario Template.

AVERT Statistical Module Input Parameters

- Higher number of Monte Carlo (MC) runs reduces noise.
  - For test runs, use a low number of MC runs (10) and generation-only MC runs (5).
  - For final runs, use a high number of MC runs (1,000) and generation-only MC runs (500).
- Select "Y" to write output and save runs.
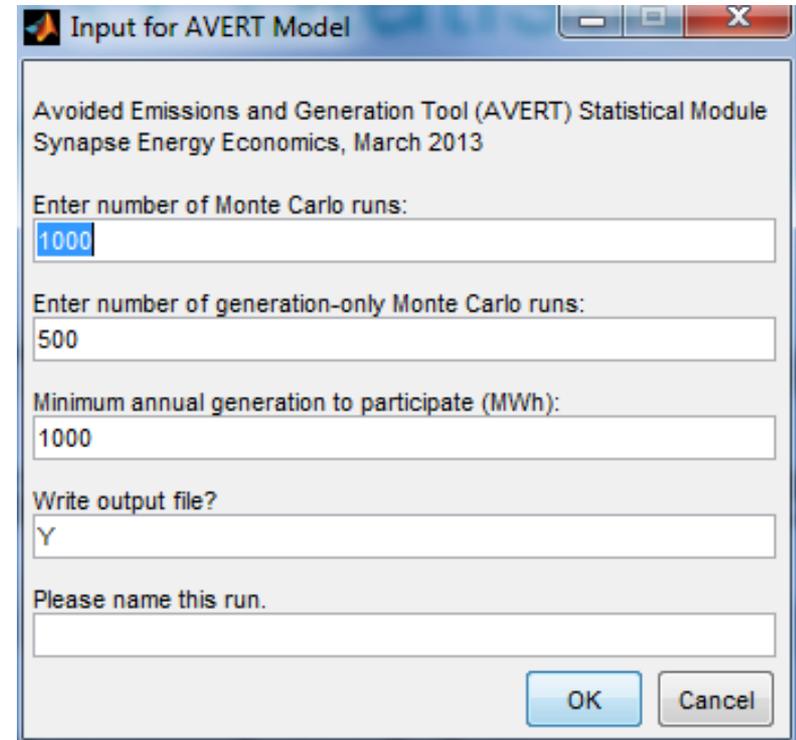
Input for AVERT Model

Avoided Emissions and Generation Tool (AVERT) Statistical Module
Synapse Energy Economics, March 2013

Enter number of Monte Carlo runs:
1000

Enter number of generation-only Monte Carlo runs:
500

Minimum annual generation to participate (MWh):
1000

Write output file?
Y

Please name this run.

OK   Cancel

Use letters and numbers only.
No special characters and no spaces.

AVERT Statistical Module Choose Data File

- Choose base year for analysis.
  - Data from 2007 through 2013 are available.
  - New data will be ready by the second quarter of the next year.
    - Requires data to be vetted by EPA and post-processed.

MENU

Choose CAMD Dataset

AVERT_CAMDArray_2008.mat

AVERT_CAMDArray_2009.mat

AVERT_CAMDArray_2010.mat

AVERT_CAMDArray_2011.mat

AVERT_CAMDArray_2012.mat
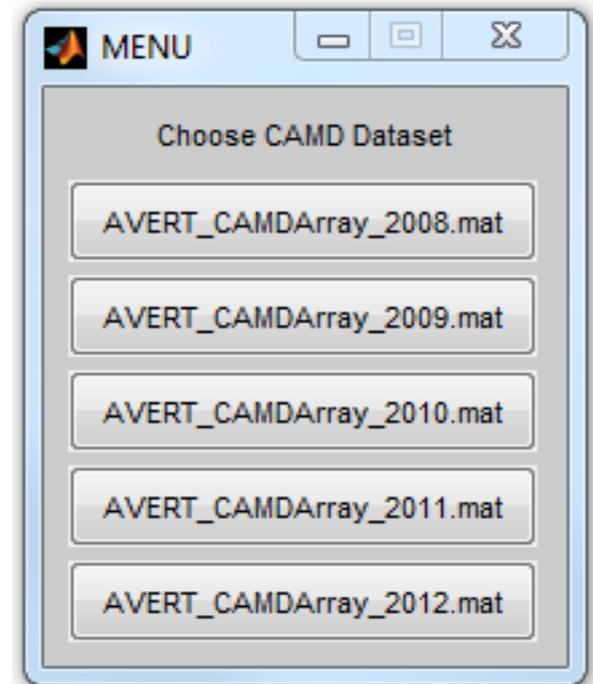
AVERT Statistical Module Choose Future Year Scenario

- Select either
  - Saved future year scenario (see slide 41)
  - Present year analysis
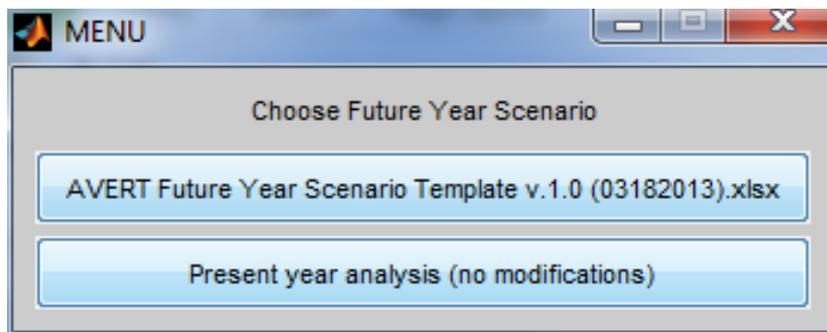
Present year analysis makes no modifications to the AVERT dataset.

  - Uses EGU that exist in data year
  - No changes in emissions rates

AVERT Statistical Module Choose Region(s) of Interest
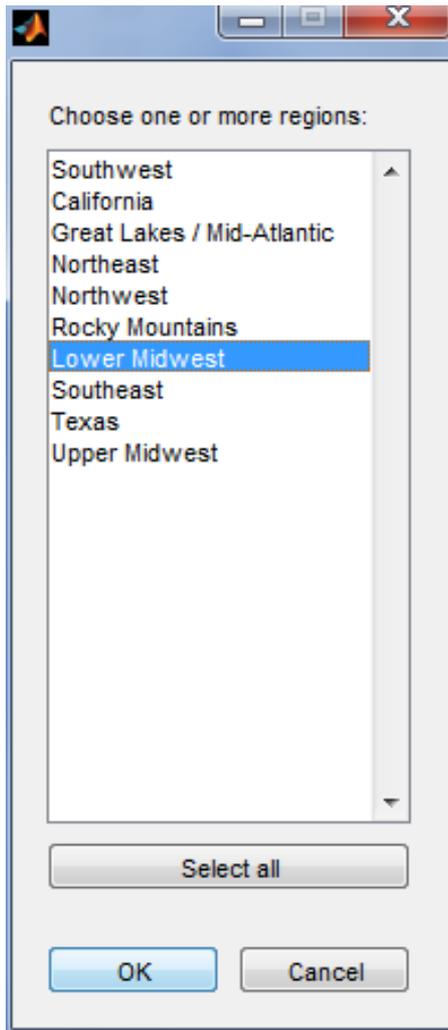
- Choose region (or multiple regions) of interest.

- Same regions as in AVERT Main Module

- Once you hit "OK", the program will run uninterrupted until completion.

  – Program returns updated run status on a regular basis.

  – Output graphic and file indicate successful completion.
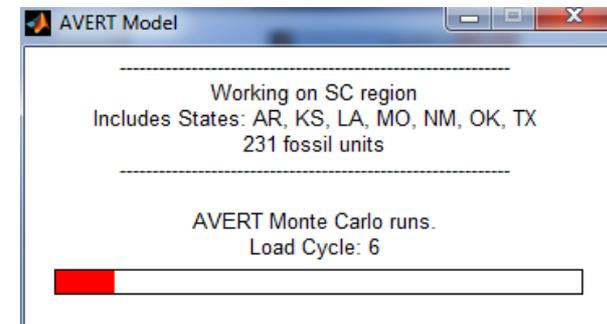
Part III
AVERT Future Year Scenario Template

AVERT Future Year Scenario Overview

- Purpose
  - AVERT is not forward-looking: cannot predict EGU retirements, new additions, or emissions modifications.
  - Future Year Scenarios allow users to
    - Remove EGU from analysis.
    - Include additional proxy EGU.
    - Modify emissions characteristics.

- Advanced use of AVERT
  - Excel spreadsheet
  - Read into AVERT Statistical Module

- Each spreadsheet becomes a scenario.
  - Spreadsheet becomes input file for AVERT Statistical Module.
  - Each future year scenario template is specifically designed to match the same historic base year.

Use AVERT Future Year Scenario in Statistical Module

- Obtain Future Year Scenario Template (slides 33-36).

- Modify Future Year Scenario Template (slides 44-46).

- Save Future Year Scenario Template with a meaningful name.

- Run Statistical Module (slides 37-40).

  – Provide a unique name for the statistical module run (slide 37).

  – Choose saved future year scenario (slide 39).

AVERT Future Year Scenario Retires and Modifications

- Find EGU of interest, or filter by state or region.
- To retire, select "Yes" in the "Retire?" column.
- To change emissions rate, select "Yes" in the "Revise Emissions Rates?" column and enter new rate(s) in columns I, J, or K.

AVERT Future Year Scenario Additions

In order

1. Select region
2. Select fuel type
3. Select generator type
4. Select specific EGU (unit)

Description will appear about EGU type automatically.

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AVERT Future Year Scenario Additions

- Choose proxy unit capacity (will scale all other factors)
- Choose state (within region)
- Choose county (within region)
- Save file

Use AVERT Future Year Scenario in Statistical Module

- Run Statistical Module (slides 37-40).

- Provide a unique name for the statistical module run (slide 37).

- Choose saved future year scenario (slide 39).
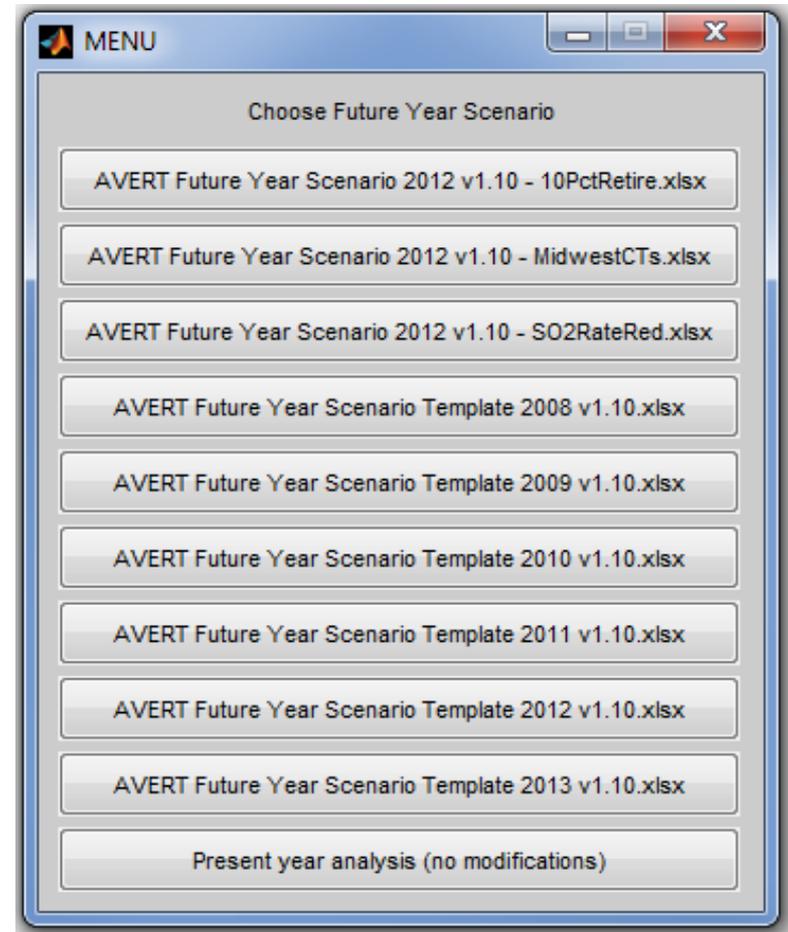
For More Information

- Visit the AVERT website at www.epa.gov/avert.

- Contact EPA's State and Local Climate and Energy Program at avert@epa.gov.