State-of-the-Art Greenhouse Gas Emission Inventory Guidance and Tools

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ABSTRACT

The U.S. EPA State and Local Climate Change Program is unveiling the *Emission Inventory Improvement Program Volume VIII: Estimating Greenhouse Gas Emissions*, a revised guide for states conducting greenhouse gas emission inventories. The revised guidance is accompanied, for the first time, by the *State Tool for Greenhouse Gas Inventory Development*, a user-friendly inventory spreadsheet tool intended to reduce the burden associated with developing a new inventory or updating an existing inventory.

The revised guidance reflects the most recent information on data sources, emission factors, and methods that are consistent with the *Intergovernmental Panel on Climate Change Good Practice Guidance* and the *Inventory of U.S. Greenhouse Gas Emissions and Sinks.* The guidance and tools both cover the full range of greenhouse gases and sources included in the national inventory, including carbon dioxide emissions from fossil fuel combustion, industrial processes, land-use change and forestry, agricultural liming, and incineration; methane emissions from stationary combustion, mobile combustion, coal mining, oil systems, natural gas systems, manure management, enteric fermentation, rice cultivation, agricultural residue burning, landfills, and wastewater treatment; nitrous oxide emissions from stationary combustion, mobile combustion, nitric acid production, adipic acid production, manure management, agricultural soil management, agricultural residue burning, incineration, and wastewater treatment; and high-Global Warming Potential gas emissions from industrial processes and substitutes for ozone-depleting substances. Where possible, the tools provide state-level default activity data and emission factors for the full time series from 1990 through 2000. EPA plans to periodically update the tools to incorporate new methodologies and default activity data.

State-of-the-Art Greenhouse Gas Emission Inventory Guidance and Tools

The U.S. Environmental Protection Agency State and Local Climate Change Program (SLCCP) is releasing an updated version of the *Emission Inventory Improvement Program Volume VIII: Estimating Greenhouse Gas Emissions* (hereafter referred to as the *State Guidance*), a guidance manual for state greenhouse gas (GHG) emission inventory development. This version of the guidance is accompanied for the first time by the *State Tool for Greenhouse Gas Inventory Development* (hereafter referred to as the *State Inventory Tool*), a user-friendly inventory spreadsheet tool. The significantly revised inventory guidance reflects the latest information on data sources and provides emission factors and methodologies that are consistent with the *Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance* and the *Inventory of U.S. Greenhouse Gas Emissions and Sinks.* The spreadsheet tool drastically reduces the staff time and cost necessary for successful application of the inventory guidance, thereby encouraging the use of consistent emission estimation methods, facilitating state inventory development, and encouraging states to update inventories.

The Importance of State Inventory Development

Action at the state and local level is a key component of U.S. efforts to stabilize atmospheric concentrations of greenhouse gases (GHGs). The initial step for states interested in limiting GHG emissions is the preparation of a state-level GHG inventory. GHG inventories uncover the most significant emission sources and trends, allowing states to develop action plans (i.e., policies and programs) that maximize potential reductions while minimizing costs. Recognizing the importance of GHG stabilization, many states have already prepared GHG emission inventories, developed action plans, and implemented these plans resulting in significant GHG emission reductions. These action plans are generally designed to reduce emissions of GHGs without disrupting economic growth and development. To this end, states often consider a wide range of mitigation options, ranging from improved energy efficiency to reforestation, and from the recycling of wastes to mass transit. Current examples of state actions include the following:

- A California law calling for the California Energy Commission to study the potential impact of climate change on the state's energy supply and demand, the economy, the environment, and agricultural and water resources;
- A Connecticut law establishing a broad range of energy conservation measures;
- Minnesota's adoption of more stringent energy efficiency standards and the initiation of an energy efficiency program focused on the reduction of CO_2 emissions;
- New Jersey's commitment to reduce GHG emissions to 3.5 percent below 1990 levels by 2005;
- Requirements in Oregon and Massachusetts that new power plants offset their CO_2 emissions; and
- Vermont's energy efficiency standards for new residential construction (developed in cooperation with the building trades, construction industry, and lenders).

By identifying the dominant emission sources and trends in each state, emission inventories play a key role in conceptualizing and implementing these types of programs.

The Development of the *State Guidance*

The SLCCP's Emission Inventory Improvement Program (EIIP) is designed to facilitate the development of cost-effective, reliable inventories of air pollutant emissions by improving the quality of emissions information and developing systems for collecting, calculating, and reporting emission data. An integral part of this program is the development of a series of guidance volumes designed to help

states estimate emissions of various air pollutants. The focus of EIIP Vol. VIII is to present emission estimation techniques for GHG sources and sinks in an unambiguous manner, provide concise example calculations to aid in the preparation of emission inventories, and suggest potential sources of state-level data.

The SLCCP provides states with guidance on GHG inventory development, in the form of the *State Guidance*, for a variety of reasons. First, as discussed above, the SLCCP believes that solid GHG inventories provide states with the best foundation for assessing their sources and identifying effective mitigation strategies. Second, the EPA has gained significant experience in inventory creation through its work in developing the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* and contributing to the *IPCC Good Practice Guidance*. Third, the SLCCP works to reduce the monetary, knowledge, and data constraints states face when they are attempting to develop inventories. Fourth, the development of state inventories with a standardized methodology will facilitate comparisons among state inventories and between state and national-level inventories.

The revised guidance provides states with transparent explanations of the methods used to calculate emissions from GHG sources and sinks. The guidance provides methods for the full range of GHGs and sources covered in the national inventory, including carbon dioxide emissions from fossil fuel combustion, industrial processes, land-use change and forestry, agricultural liming, and incineration; methane emissions from stationary combustion, mobile combustion, coal mining, oil systems, natural gas systems, manure management, enteric fermentation, rice cultivation, agricultural residue burning, landfills, and wastewater treatment; nitrous oxide emissions from stationary combustion, mobile combustion, nitric acid production, adipic acid production, manure management, agricultural soil management, agricultural residue burning, incineration, and wastewater treatment; and high-Global Warming Potential (GWP) gas emissions from industrial processes and substitutes for ozone-depleting substances. In addition to step-by-step guidance on applying the methods, the revised *State Guidance* provides sample calculations for each source category. The guidance includes information on how to find state-level activity data (e.g., heads of cattle, tons of coal), including contact information for relevant EPA Program representatives, references, and Internet links for appropriate data.

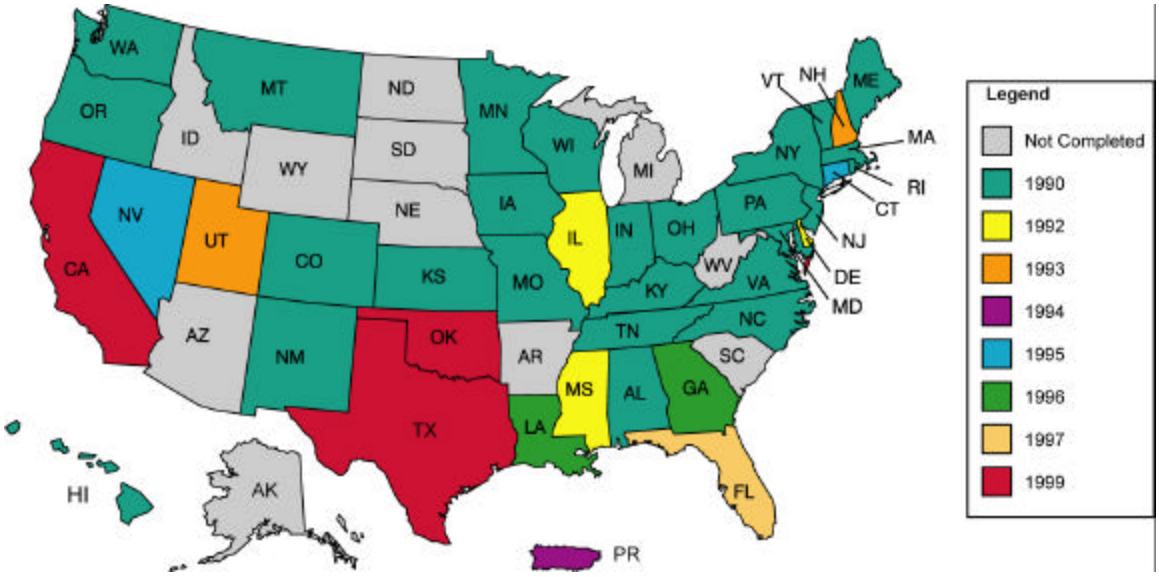
The revised guidance builds off of the previous EIIP report, *Volume VIII: Estimating Greenhouse Gas Emissions* (U.S. EPA 1999). It improves on the earlier edition by (1) increasing consistency with data sources, methodologies, and emission factors used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2000* (U.S. EPA 2002), (2) incorporating updated state-level data sources, methods and emission factors where applicable, and (3) adding references to the *State Inventory Tool*. Substantive revisions include a number of methodological improvements suggested by U.S. EPA and ICF emission source category experts, recent methods adopted in the course of developing the national inventory, and improved compatibility with international inventory guidelines and the *Good Practice Guidance* published by the Intergovernmental Panel on Climate Change (IPCC 1997, 2000). This edition does not include information on the "Data Attribute Ranking System" (DARS) found in the previous edition; new uncertainty guidelines are under development.

The Development of the *State Inventory Tool*

The *State Guidance* is the complete reference guide for states designing emissions inventories. Despite the availability of clear inventory guidance, the inventory development process is time- and resource- intensive. As a result, not all states have undertaken inventory development and even fewer have tried to estimate emissions for multiple years. As shown in Figure 1 below, one state (WV) was in the process of creating an emission inventory, while thirty-nine states and one territory had completed emission inventories as of January 2003. The figure also indicates that the majority of states have 1990 as the most recent year for which an inventory was created. The dearth of recent inventories and

inventories with estimates for multiple years prevents states from identifying trends that would enable them to focus their mitigation efforts on the most significant and fastest-growing sources. Twenty-seven of the states with completed inventories have initiated or completed action plans; however, many of these action plans were created using outdated inventory data.

Figure 1. State Greenhouse Gas Inventory Progress



The SLCCP designed the *State Inventory Tool* for release with the updated *State Guidance* to address the aforementioned problems and to reduce the barriers that states face in developing and updating inventories without sacrificing the transparency and completeness of the *State Guidance*. The *State Inventory Tool* was developed with five goals in mind. First, the tool had to provide maximum transparency in the use of emission factors, activity data, and methods. Second, the tool had to provide default state-specific data wherever possible, while simultaneously allowing users to easily enter their own data whenever these data were available. This reduces the amount of time required to locate data while still allowing maximum flexibility. Third, the tool had to allow the user to estimate emissions and sinks for each year starting in 1990 to enable states to analyze trends. Fourth, past experience in the GHG inventory process indicated that the tool needed to allow experts from variety of state agencies (environment, energy, forestry, agriculture, planning) to work simultaneously on the inventory. Fifth, the tool had to be based on a framework that was as user-friendly and familiar as possible, while still providing the necessary functionality.

The State Inventory Tool designed to meet all of these goals comprises eleven Excel®-based modules. Ten of the eleven modules calculate GHG emissions from a source category or a collection of related source categories. The modules are modified Excel workbooks containing a number of spreadsheets designed to calculate emissions. The eleventh module is a Synthesis Module, which functions as a controlling workbook capable of producing a complete inventory from the data provided by the other ten modules. Excel functions as the platform for these modules because the program has an extensive user base in the United States and provides graphical and workbook linkage features that are ideal for this application.

The list below contains the GHG sources and sinks for which the source category modules produce emissions estimates.

- Agriculture (including manure management, enteric fermentation, agricultural soil management, rice cultivation, and agricultural residue burning)
- Carbon Dioxide from Fossil Fuel Combustion
- Coal Mining Activities
- Industrial Processes
- Land Use Change and Forestry
- Methane and Nitrous Oxide from Mobile Combustion
- Methane and Nitrous Oxide from Stationary Combustion
- Municipal Solid Waste
- Natural Gas and Oil Activities
- Wastewater

Each module contains an introductory sheet (the control sheet), which provides step-by-step instructions for completing the calculations for each source category (Figure 2 provides a sample control sheet).

The control sheet begins with a drop-down box where the user selects the appropriate state. Once this selection has been made, users proceed through the control sheet entering their own emission factors for the various emission sources or selecting the default emission factors. Once a user has finished entering the emission factors for a given source, they can select a navigation button that will take them to the sheet where emissions from that source will be calculated. The control sheet also includes common conversion factors for the sources included in the workbook.

The calculation sheets (see Figure 3) for each GHG source begin with important background information. A data source "bubble" is provided in the upper left hand corner of each calculation sheet. The data source bubble is a link to a table of possible sources of activity data. In the center of the top of each calculation sheet, a summary of the methodology used to estimate emissions for each source category is provided. The methodology box includes a reference to the relevant chapter of the *State Guidance*, where users can go for more information. The body of each calculation sheet begins with activity data on the left hand side. Users may enter their own data, or they may select the default data already loaded into the tool. Although the tool does not have default data for all sources and states, it does contain default data for many of the most data-intensive source categories (e.g., fuel combustion, manure management, enteric fermentation, coal mining). Once the user has completed data entry, emissions are calculated on this sheet. Users then return to the control sheet using one of the navigation buttons in the top right-hand corner of the calculation sheet.

After all of the individual source calculations are complete, the user is prompted to move to the summary sheet, which includes a summary of emissions over time and accompanying graphs (see Figure 4). When the user is satisfied with the results of each module, he or she can activate the "Export Data" button at the bottom of the control sheet; this button exports the summary emissions data into a small file that can be easily sent to the Synthesis Module operator.

The Synthesis Module collects all the data from the individual source category modules and produces a summary of GHG emissions and sinks for the 1990 – 2000 time period. The control spreadsheet (see Figure 5) within the Synthesis Module enables the user to import data from each module.

Figure 2. The Control Sheet in the Carbon Dioxide from Fossil Fuel Combustion Module

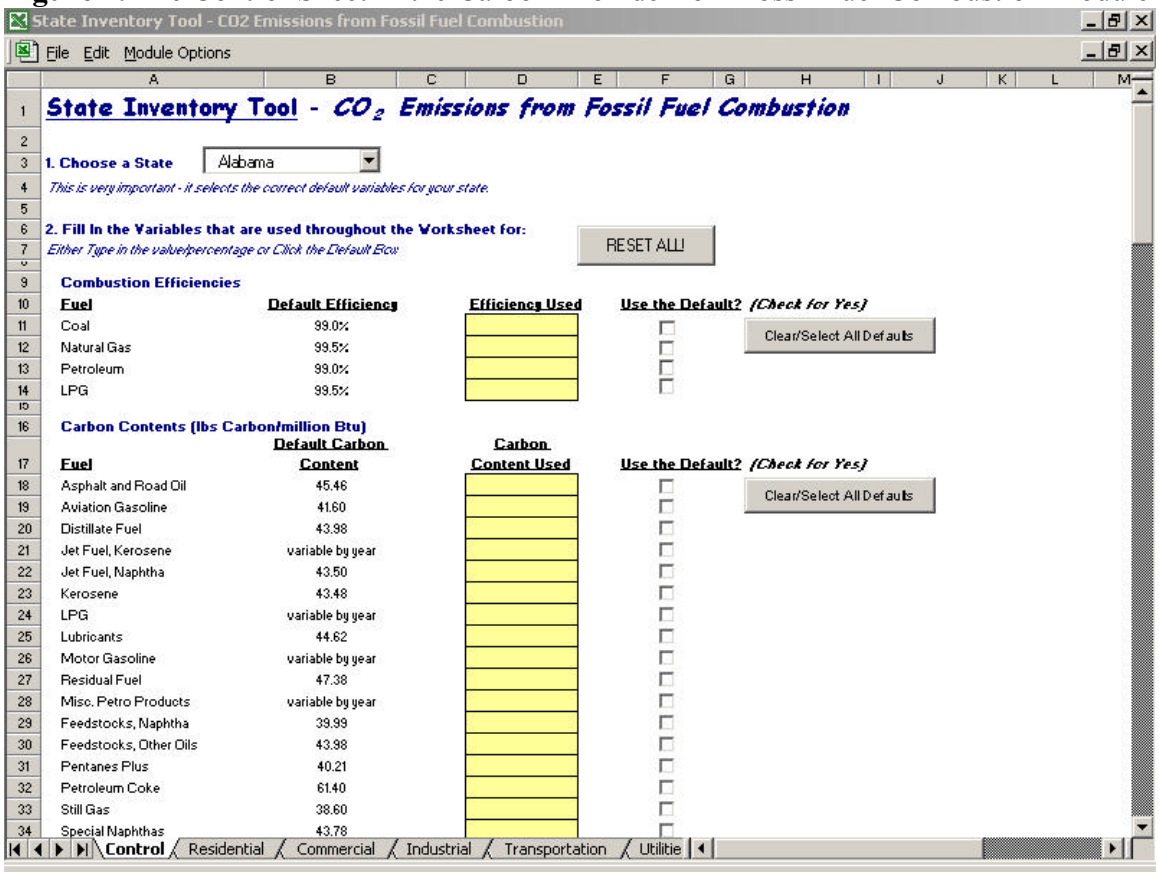


Figure 3. A Calculation Sheet in the Carbon Dioxide from Fossil Fuel Combustion Module

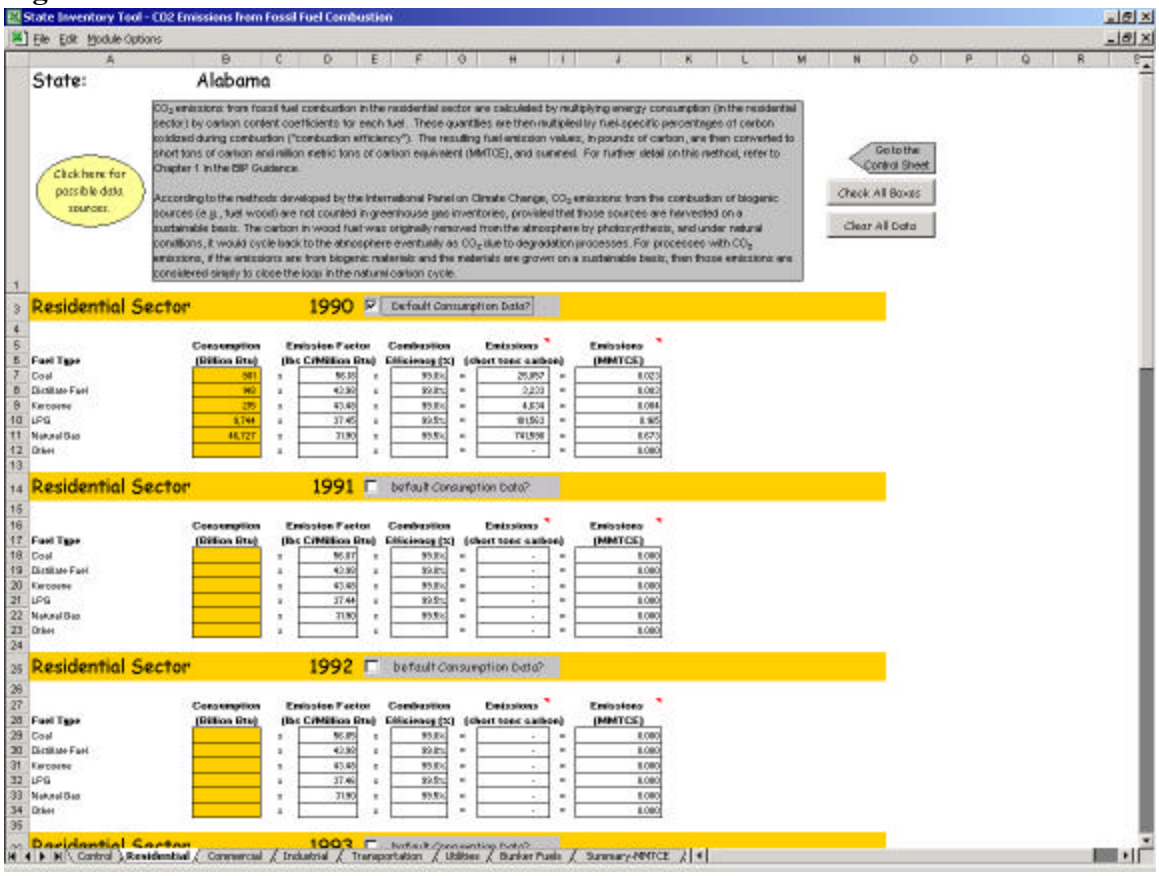


Figure 4. The Summary Sheet in the Carbon Dioxide from Fossil Fuel Combustion Module

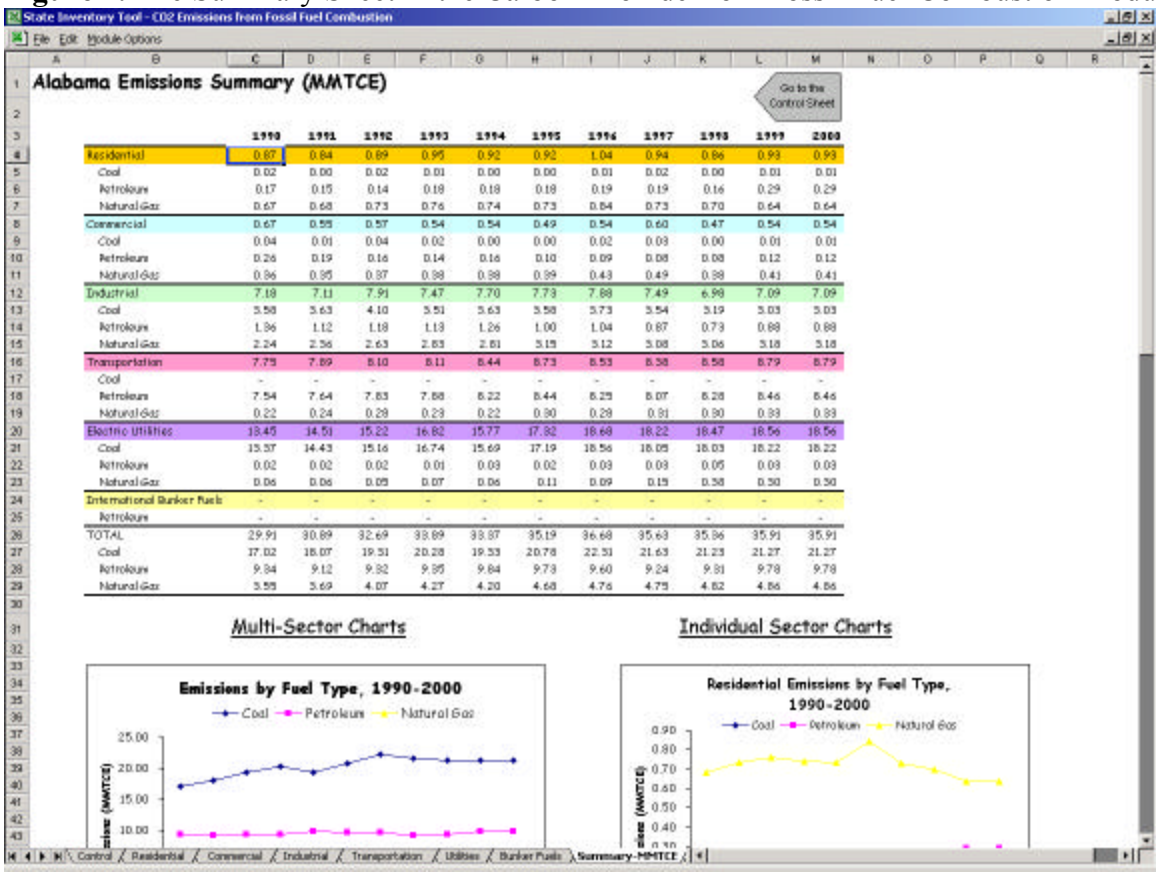
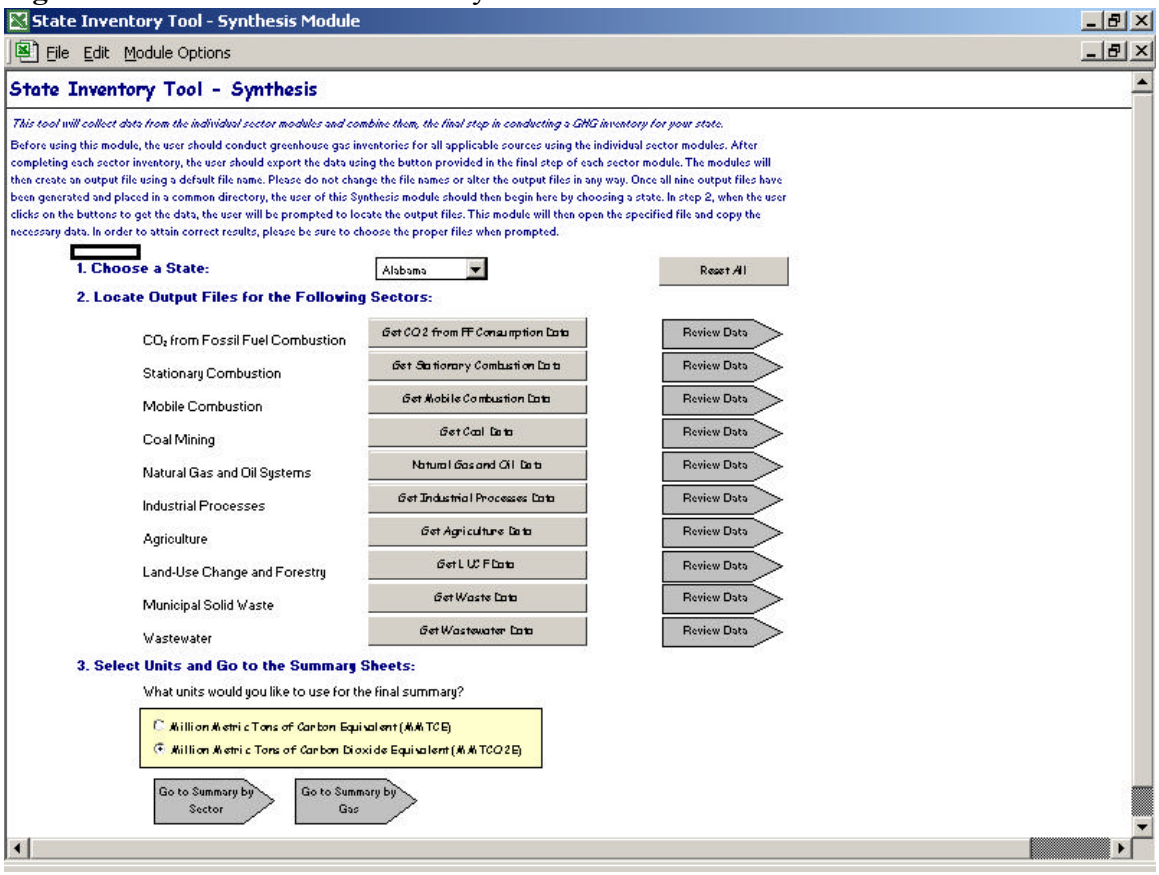


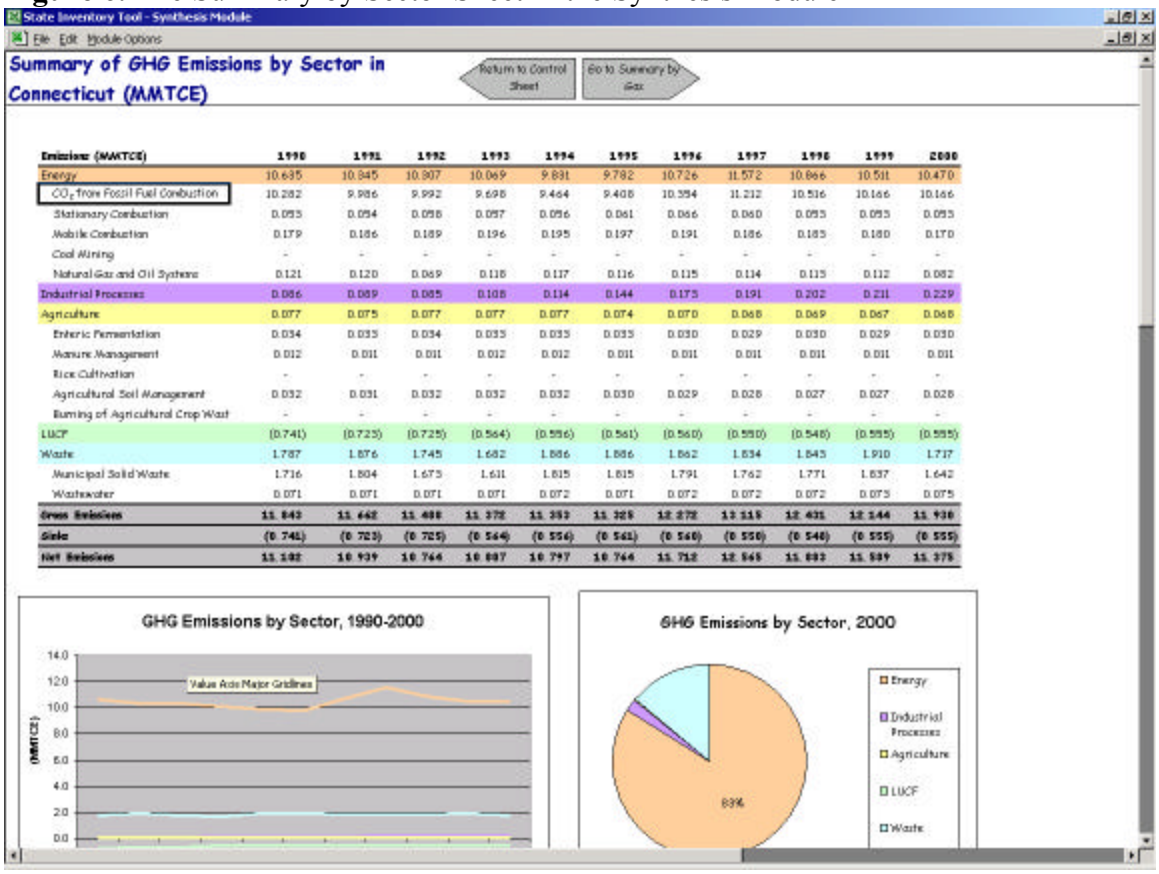
Figure 5. The Control Sheet in the Synthesis Module



Once the data has been imported, the Synthesis Module operator can generate a complete emission inventory. On the summary sheet in the Synthesis Module (see Figure 6), emissions can be viewed by sector or by gas and in units of MMTCE or $MMTCO_2$. In all cases, charts and graphs accompany the emission estimates to facilitate interpretation of the data. The Synthesis Module design enables the operator to outsource the task of completing each individual module to various source category experts. The import/export functionality allows multiple experts to work on their respective source categories simultaneously during the inventory development process.

The potential benefit of the *State Inventory Tool* for state inventory development and updating is significant. The tool dramatically reduces the amount of time necessary to complete an inventory, provides states with a rough cut at their emissions from most sources using state-specific default data, and enhances consistency across states. The SLCCP is currently designing a supplementary *State Inventory Projections Tool* designed to project a state's emissions from each sector through 2020. This tool will further assist states in the development of effective and efficient GHG mitigation action plans.

Figure 6. The Summary by Sector Sheet in the Synthesis Module



Conclusions

The SLCCP's release of the revised *State Guidance* in combination with the brand new *State Inventory Tool* signifies a gigantic step forward in the development of state-level inventories. The revised *State Guidance* reflects the latest information on data sources, emission factors, and methodologies. The *State Inventory Tool* reduces the resource burden states face when developing inventories and encourages consistency. With these resources at their side, state officials can cost-effectively develop emission inventories, knowing that the methods they are using are in line with state-of-the art guidance at the state and national levels.

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KEY WORDS

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