Preparing Control Case Emission Inventory Projections with EPA's Control Strategy Tool (CoST)

David Misenheimer, Darryl Weatherhead, Larry Sorrels
C439-02, U.S. EPA ABCG/HEID/OAQPS
Research Triangle Park, NC, 27711
Misenheimer.David@epamail.epa.gov

Alison Eyth, Darin Del Vecchio
Institute for the Environment, University of North Carolina at Chapel Hill
137 E. Franklin St., Chapel Hill, NC 27599-6116

ABSTRACT

EPA is developing the Control Strategy Tool (CoST) to support the preparation of future base case or control case emission inventories. This tool is a client-server system that allows the user to select a base year emission inventory, select a target year (e.g., 2030), apply emission reductions from known control programs or from a database of control measure options, and generate a future base case or control case emission inventory. The resulting projected inventory will reflect potential emission changes to multiple pollutants, depending on the co-impacts of the control programs or control measure options, and can be used as an input to air quality modeling of future control case scenario. This paper will describe the tool, the control programs and control measure databases which are critical inputs to the tool, and discuss its role in multi-pollutant control strategy analyses.

INTRODUCTION

The Control Strategy Tool (CoST) [http://www.epa.gov/ttn/ecas/CoST.htm] is a client-server system that is being developed by EPA's Health and Environmental Impacts Division (HEID) as a module of the Emissions Modeling Framework (EMF). CoST is currently available to EPA personnel through the EMF and is being tested outside of the EMF by the state of NY Division of Air Resources as part of an Air Quality Management multi-pollutant pilot. Documentation on CoST can be downloaded from the website listed above.

The purpose of CoST is to model the emission reductions and engineering costs associated with control strategies applied to point, area, and mobile sources of air pollutant emissions to support the analyses of air pollution policies and regulations. CoST accomplishes this by matching control measures to emission sources using algorithms such as "maximum emissions reduction", "least cost", and "apply measures in series". Control strategy results can be exported to CSV files or viewed in a graphical table that supports sorting, filtering, and plotting. The results can also be merged with the original inventory to create controlled emissions inventories that can be exported to files that can be input to the emissions model SMOKE.

The Control Strategy Tool is being developed as a replacement for the AirControlNET (ACN) software tool [http://www.epa.gov/ttn/ecas/AirControlNET.htm]. It was determined in 2006 that it was an appropriate time to replace the ACN software with newer software that could provide improved effectiveness, functionality, and transparency to support current and upcoming needs. A prototype version of the Control Strategy Tool was developed in 2006 and a fully functional version was

developed in 2008. Additional enhancements are underway in 2009. The tool has the functionality of AirControlNET but with added capabilities, including:

- the ability to make use of emissions inventories in the Emissions Modeling Framework (EMF) almost seamlessly
- the ability to insert new control measure data and view the details of existing data
- tracking of analyses and outputs
- Quality assurance (QA) steps to identify errors in and summarize emissions and control measure data
- an extensive set of mobile source control measures and functionality to apply control measures by month, seasonally, or annually.

Information on control efficiencies and costs is contained in the Control Measure Database. This database contains primarily criteria pollutants, but a project is currently being conducted to add control measure information and costs for HAPs and GHGs.

APPROACH

Steps for Generating a Control Strategy

In order to prepare a control Strategy, you must perform a number of basic steps. The most important is to clearly identify the overall goal of the exercise, and any objectives necessary to accomplish the overall goal. For example, for the recent ozone (O_3) NAAQS Regulatory Impact Analysis, the analysis involved the following steps:

1. Select Analysis Year - Selected year 2020 as the time period for the analysis
2. Identify Overall Goal and Objectives –
    - Forecasted O_3 monitor design values to the year 2020, assuming current conditions and future impacts of any rules or regulatory programs that were already "on the books"
    - Calculated "impact ratios" for each geographic area forecasted to exceed the new standard (75 ppb O_3) based on projected emission inventories and air quality modeling. The impact ratios are in terms of modeled air quality concentration changes (ppb O_3) per ton of emission change (tons NOx or tons VOC).
    - Calculated emission reduction targets for each geographic area based on forecasted design values and impact ratios
3. Run Control Strategy - Developed the optimum control strategy for each geographic area identified in the previous step, taking into account various constraints and costs, that would reduce emissions to meet the overall goal and objectives – in this example to bring air quality concentrations at or below the level of the new O_3 standard.

Running Control Strategies in CoST

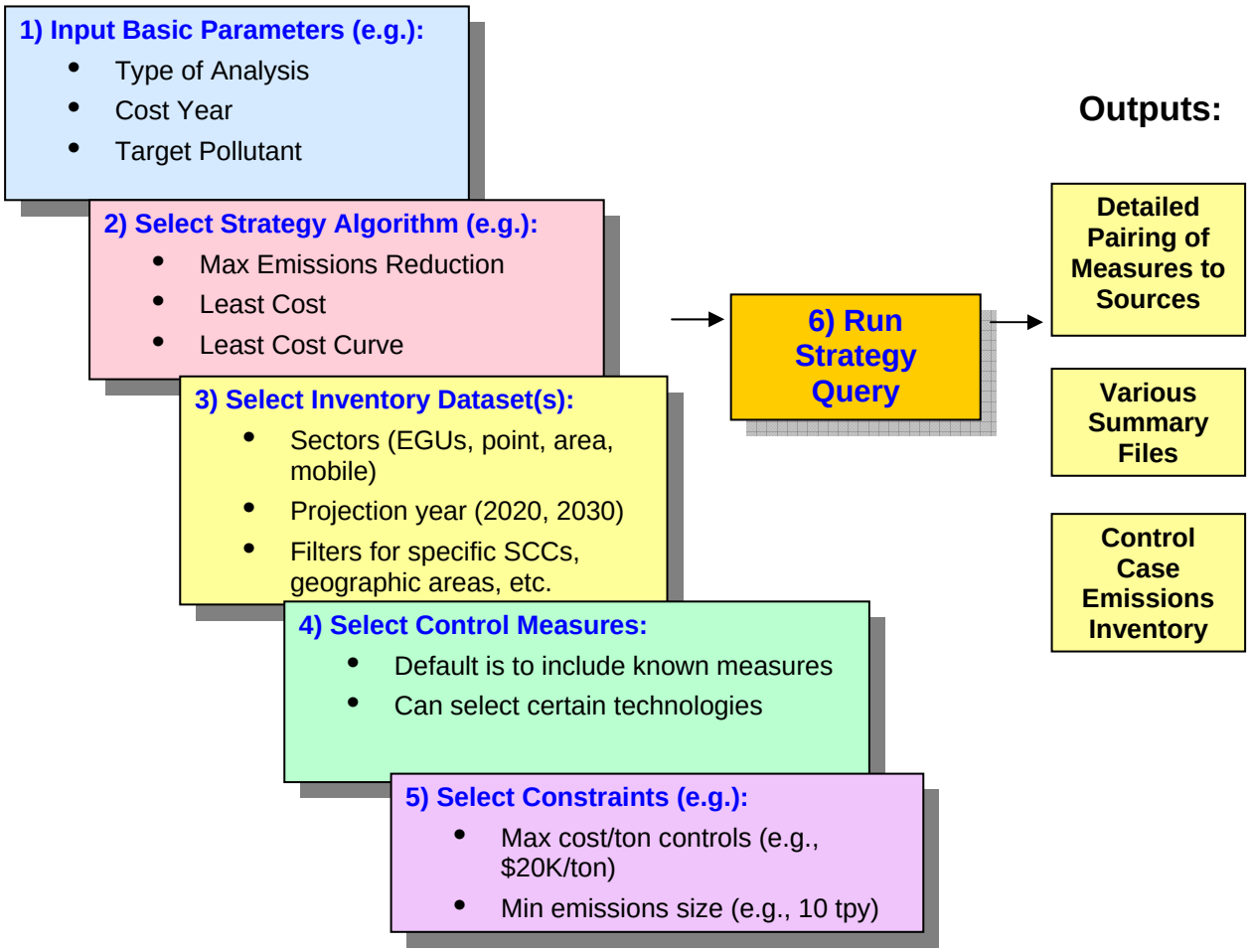
A control strategy is a set of control measures applied to emissions inventory sources in a specified geographic region (in addition to any controls that are already in place) to accomplish an emissions reduction goal. Such goals are usually set to improve air quality and/or to reduce risks to human health. CoST automates the key steps for preparing control strategies. The inputs to a control strategy consist of:

- a set of parameters that control how the strategy is run,

- one or more emissions inventory datasets,
- filters to limit the sources included from those datasets;
- filters to limit which control measures are to be included in the analysis; and
- constraints that limit the application of measures to specific sources based on the resulting costs or emissions reduction achieved.

A diagram of the steps for running a control strategy in CoST is shown in Figure 1.

Figure 1. Key Steps for Running a Control Strategy



CoST provides several types of algorithms for developing control strategies:

- **Maximum Emissions Reduction:** assigns to each source the single measure that provides the maximum reduction to the target pollutant, regardless of cost.
- **Least Cost:** each source may be assigned only a single measure to achieve a specified percent or absolute reduction in a region with the minimum possible annualized cost.
- **Least Cost Curve:** performs least-cost runs iteratively at multiple percent reductions so that a cost curve can be developed that shows how the annualized cost increases as the level of desired reduction increases.

- **Apply Measures in Series:** assigns all control measures that can be used for a source to the source in the specified order; this is often used for mobile sources, for which the control measures are typically independent of one another.

The first three algorithms are typically used for stationary sources; the last is usually used for mobile sources, for which most control measures are independent of one another. Note that CoST also includes algorithms that can be used to create altered emissions inventories, but may not typically be considered "control strategies" in the traditional sense. These algorithms are:

- **Annotate Inventory**: assigns control measures to the inventory based on their control efficiency, and can be used to fill in control measure information for inventory sources that are missing these details but have a control efficiency assigned (this strategy could be applied to either a base- or future-year inventory).
- **Project Future Year Inventory:** applies control programs and growth factors to sources, as would be needed to project a base-year inventory to a future-year inventory. This algorithm is used primarily to prepare future year base case emission inventories.

The final steps in running a Control Strategy are:

- Review the results in various summary formats to identify potential errors and to ensure results are acceptable
- Rerun Control Strategy if any problems are identified or if results do not meet the goals or objectives
- Once results are determined to be acceptable, generate a Control Case emission inventory

CoST includes a number of established summary reports for reviewing and quality assuring control strategy run results. The following figures show the outputs from a control strategy, with some of the summary reports that can be created, and a few examples of viewing the reports within CoST. The user may export the summary results in CSV format to be opened with Excel, Access, or other software packages. Another option for reviewing summary results is to build your own report, using Structured Query Language (SQL) codes to select the information to include in the report.

Figure 2. Outputs Tab of Edit Control Strategy Window

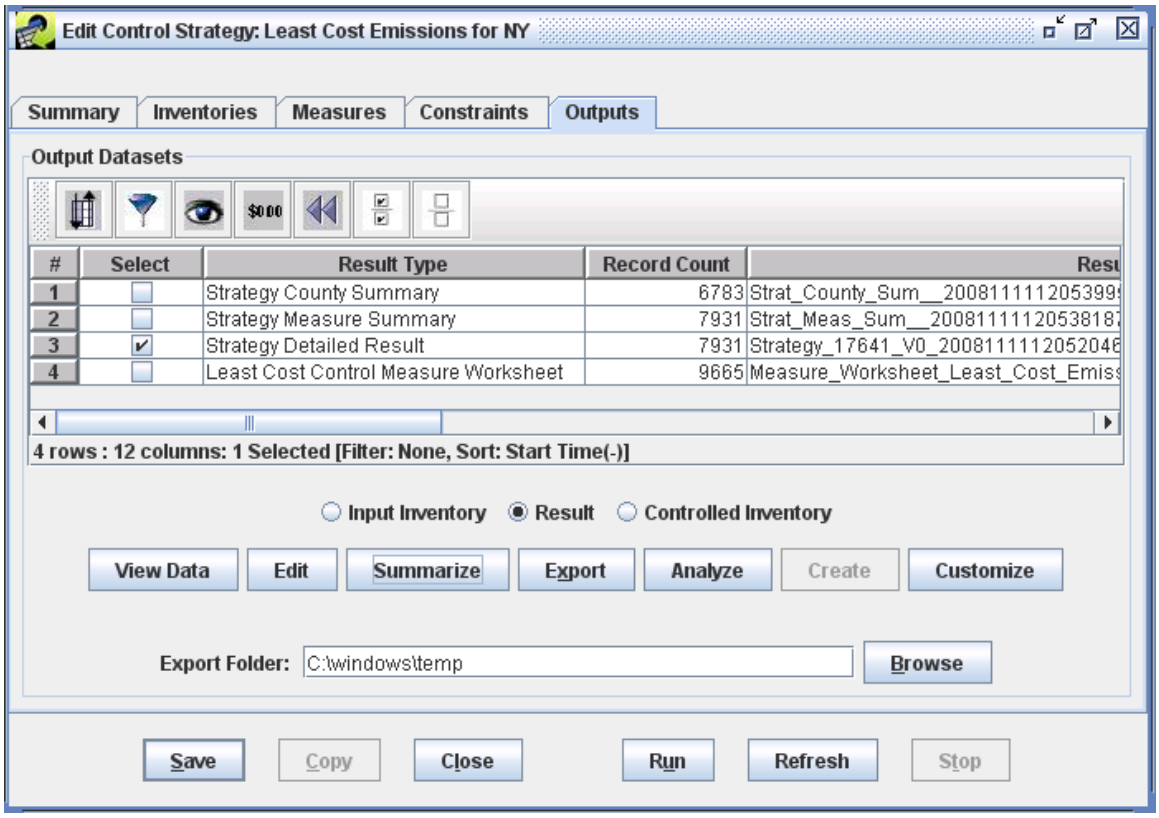


Figure 3. Data Viewer Window

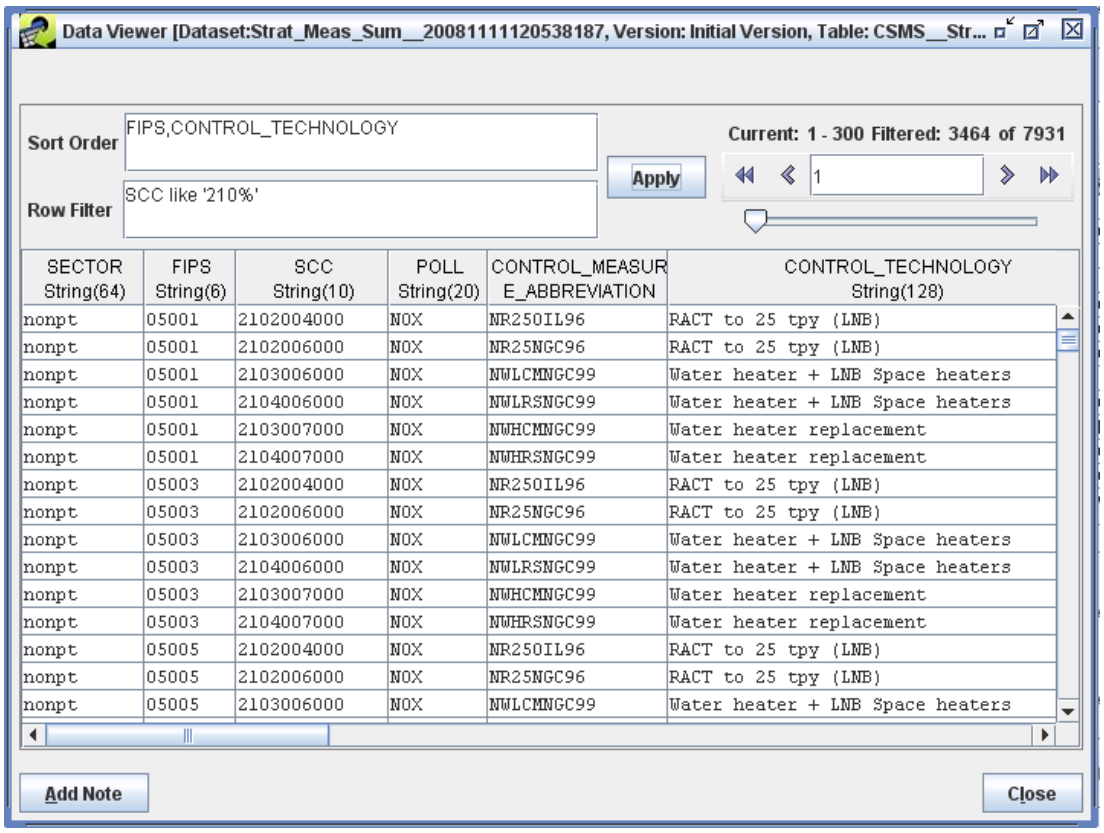
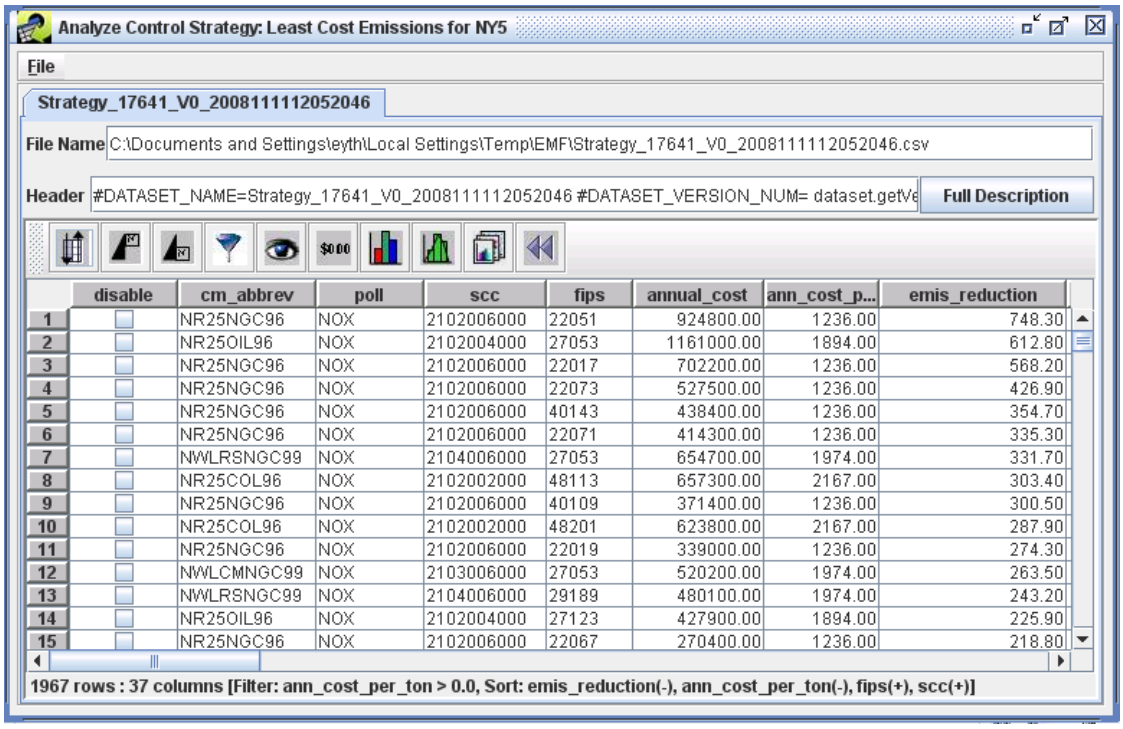
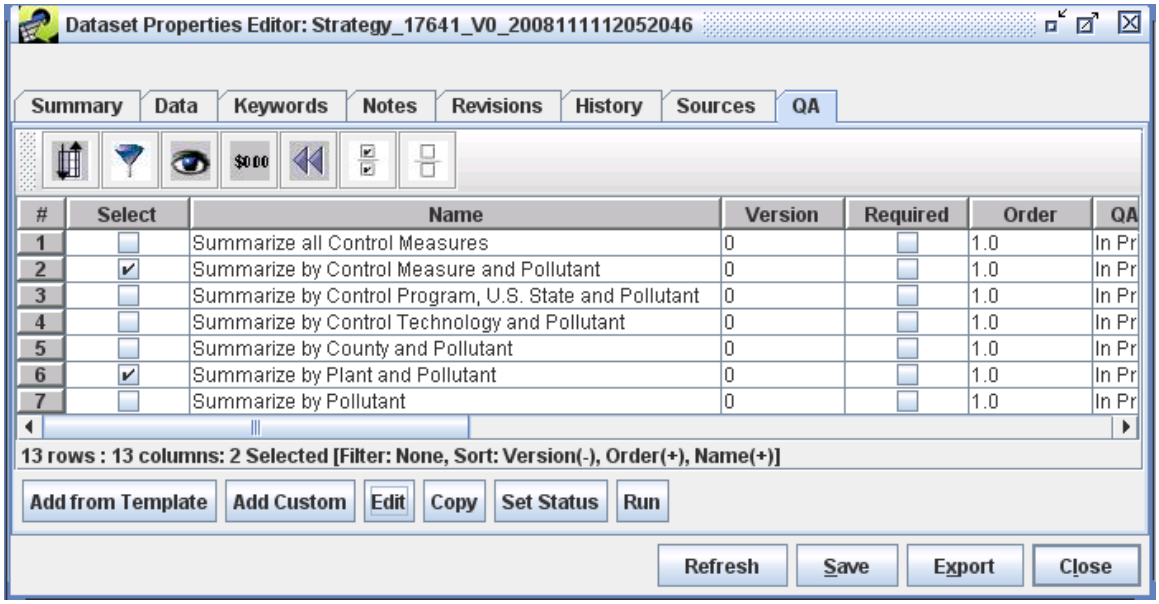


Figure 4. Strategy Detailed Result in Analysis Engine Window



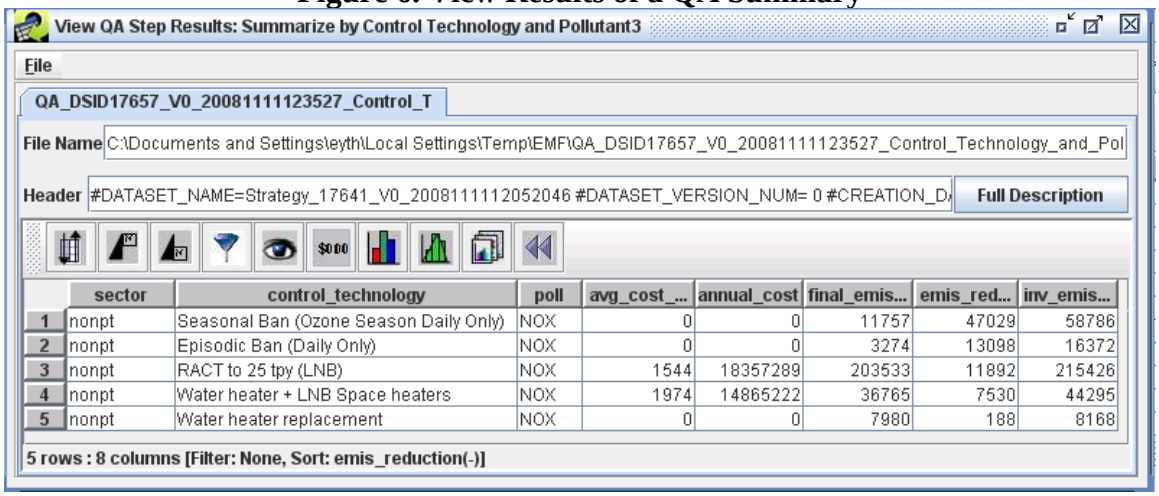
	disable	cm_abbrev	poll	scc	fips	annual_cost	ann_cost_p...	emis_reduction
1		NR25NGC96	NOX	2102006000	22051	924800.00	1236.00	748.30
2		NR25OIL96	NOX	2102004000	27053	1161000.00	1894.00	612.80
3		NR25NGC96	NOX	2102006000	22017	702200.00	1236.00	568.20
4		NR25NGC96	NOX	2102006000	22073	527500.00	1236.00	426.90
5		NR25NGC96	NOX	2102006000	40143	438400.00	1236.00	354.70
6		NR25NGC96	NOX	2102006000	22071	414300.00	1236.00	335.30
7		NWLRSNGC99	NOX	2104006000	27053	654700.00	1974.00	331.70
8		NR25COL96	NOX	2102002000	48113	657300.00	2167.00	303.40
9		NR25NGC96	NOX	2102006000	40109	371400.00	1236.00	300.50
10		NR25COL96	NOX	2102002000	48201	623800.00	2167.00	287.90
11		NR25NGC96	NOX	2102006000	22019	339000.00	1236.00	274.30
12		NWLCMNGC99	NOX	2103006000	27053	520200.00	1974.00	263.50
13		NWLRSNGC99	NOX	2104006000	29189	480100.00	1974.00	243.20
14		NR25OIL96	NOX	2102004000	27123	427900.00	1894.00	225.90
15		NR25NGC96	NOX	2102006000	22067	270400.00	1236.00	218.80

Figure 5. QA Window for Creating Summaries



#	Select	Name	Version	Required	Order	QA
1		Summarize all Control Measures	0		1.0	In Pr
2	✔	Summarize by Control Measure and Pollutant	0		1.0	In Pr
3		Summarize by Control Program, U.S. State and Pollutant	0		1.0	In Pr
4		Summarize by Control Technology and Pollutant	0		1.0	In Pr
5		Summarize by County and Pollutant	0		1.0	In Pr
6	✔	Summarize by Plant and Pollutant	0		1.0	In Pr
7		Summarize by Pollutant	0		1.0	In Pr

Figure 6. View Results of a QA Summary



	sector	control_technology	poll	avg_cost_...	annual_cost	final_emis...	emis_red...	inv_emis...
1	nonpt	Seasonal Ban (Ozone Season Daily Only)	NOX	0	0	11757	47029	58786
2	nonpt	Episodic Ban (Daily Only)	NOX	0	0	3274	13098	16372
3	nonpt	RACT to 25 tpy (LNB)	NOX	1544	18357289	203533	11892	215426
4	nonpt	Water heater + LNB Space heaters	NOX	1974	14865222	36765	7530	44295
5	nonpt	Water heater replacement	NOX	0	0	7980	188	8168

To illustrate the types of control information that might be included in a control strategy, the following tables contain excerpts from a NOx control strategy run in CoST for a region of the U.S.

Table 1. Example of Stationary Source Control Strategy Results

Control Technology	Sector	Pollutant	Emission Reductions (tons/yr)	Total Cost ($/yr)	Cost/Ton
SCR + Steam Injecti; Gas Turbines - Natural Gas	ptnonipm	NOx	9,166	$ 29,257,564	$ 3,192
SCR; ICI Boilers - Coal/Wall	ptnonipm	NOx	9,092	$ 17,227,199	$ 1,949
LNB + FGR + Over Fire Air; ICI Boilers - Gas	ptnonipm	NOx	6,237	$ 8,278,427	$ 1,399
SCR; ICI Boilers - Coal	ptnonipm	NOx	5,302	$ 12,447,214	$ 2,348
SCR; Sulfate Pulping - Recovery Furnaces2	ptnonipm	NOx	5,286	$ 14,036,805	$ 2,734
SCR; ICI Boilers - Residual Oil	ptnonipm	NOx	4,001	$ 9,403,444	$ 2,350
SCR; Cement Manufacturing - Wet2	ptnonipm	NOx	3,509	$ 12,054,027	$ 3,435
OXY-Firing; Glass Manufacturing - Flat	ptnonipm	NOx	2,787	$ 8,408,206	$ 3,017
SNCR - Urea; ICI Boilers - Wood/Bark/Stoker	ptnonipm	NOx	2,233	$ 5,105,206	$ 2,287
SNCR; Internal Combustion Engines - Gas	ptnonipm	NOx	2,149	$ 1,166,884	$ 543

Table 2. Example of Mobile Source Control Strategy Results

Control Technology	Sector	Pollutant	Emission Reductions (tons/yr)	Total Cost ($/yr)	Cost/Ton
Continuous Inspection	Onroad	NOx	1,290	$ -	$ -
Eliminate Long Duration Idling	Onroad	NOx	955	$ -	$ -
Diesel Retrofits	Onroad	NOx	809	$ 2,560,635	$ 3,165
Commuter Programs	Onroad	NOx	805	$ 15,296,977	$ 18,997
NRRetrofit	Nonroad	NOx	330	$ 1,392,596	$ 4,225

CoST can also be used to generate summary results in map formats for ArcGIS (shapefile outputs) and Google Earth (kmz outputs).

Once the user is satisfied with the control strategy results, they can run the algorithm to generate the Control Case Emission Inventory. This algorithm applies the control scenario to the selected emission inventory to create a complete controlled inventory, including emissions sources to which control measures were applied as well as emissions sources to which no additional measures were applied. The Control Case Emission Inventory is necessary for such applications as future year air quality modeling. Running the Control Case Inventory through an air quality model is a critical step in confirming that the desired goals and objectives in terms of air quality were indeed met. CoST currently outputs the Control Case Inventory in ORL format for input to the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system. ORL is a type of emissions inventory format used as input to SMOKE that has one record per pollutant per line instead of multiple pollutants on a single line, thereby making it possible to use the format for CAP inventories and also for HAP inventories, which have hundreds of pollutants.

CONCLUSIONS

CoST is a powerful and flexible tool that can be used to generate and analyze control strategies for point, area, and mobile sources. A number of different control strategy algorithms are available, including: maximum emissions reduction, apply measures in series, least cost, and least cost curve. Additional algorithms to prepare and enhance emission inventories are also available in CoST. The client-server framework that CoST resides within provides for a powerful platform that can provide high throughput analyses on inventories in excess of two million records along with control measures with collective efficiency records in excess of one million records. Multiple average day or annual inventories can be processed in a single strategy run. The archival of CoST strategy run configuration settings and results supports comparative analyses and the ability to reproduce results when needed. Information about control measures is readily visible within the tool and new control measure data can be added easily.

KEY WORDS

Control Measure
Control Program
Control Strategy
Emissions Inventory
Emissions Modeling Framework
Emission Projection