

COST

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Chapter 1

Introduction to the Control Strategy Tool (CoST)

This document is a user’s guide for the Control Strategy Tool (CoST) software. CoST was developed in cooperation between the [University of North Carolina Institute for the Environment](#) and the United States Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards, Health and Environmental Impacts Division (HEID). CoST estimates the air pollution emissions reductions and costs associated with future-year control scenarios, and generates emissions inventories with the control scenarios applied [Misenheimer, 2007](#); [Eyth, 2008](#). CoST includes a database of information about emissions control measures, their costs, and the types of emissions sources to which they apply. The purpose of CoST is to support national- and regional-scale multi-pollutant analyses. CoST helps to develop control strategies that match control measures to emission sources using algorithms such as “Maximum Emissions Reduction” (for both single- and multiple-target pollutants), “Least Cost”, and “Apply Measures in Series.” CoST includes a graphical user interface (GUI) for configuring CoST simulations and viewing the results.

Results from a CoST control strategy run include the estimated cost and emissions (tons) reduction achieved for each control measure-source combination. CoST is an engineering cost estimation tool for creating controlled inventories and is not currently intended to model emissions trading strategies, nor is it an economic impact assessment tool. Control strategy results can be exported to comma-separated-values (CSV) files, Google Earth-compatible (.kmz) files, or Shapefiles. The CoST results can be viewed in the GUI as graphical tables that support sorting, filtering, and plotting. The Strategy Detailed Results from a CoST strategy run can be input to the [Sparse Matrix Operator Kernel Emissions \(SMOKE\)](#) modeling system, which is used by the EPA to prepare emissions inputs for air quality modeling.

CoST is a component of the [Emissions Modeling Framework \(EMF\)](#), which is currently being used by the EPA to solve many of the long-standing complexities of emissions modeling [Houyoux, 2008](#). Emissions modeling is the process by which emissions inventories and other related information are converted to hourly, gridded, chemically speciated emissions estimates suitable for input into a regional air quality model such as the [Community Multiscale Air Quality \(CMAQ\) model](#). The EMF supports the management and quality assurance of

emissions inventories and emissions modeling-related data, and also the running of SMOKE to develop CMAQ inputs. Providing CoST as a tool integrated within the EMF facilitates a level of collaboration between control strategy development and emissions inventory modeling that was not previously possible. The concepts that have been added to the EMF for CoST are “**control measures**” and “**control strategies**.” Control measures store information about available control technologies and practices that reduce emissions, the source categories to which they apply, the expected control efficiencies, and their estimated costs. A control strategy is a set of control measures applied to emissions inventory sources (in addition to any controls that are already in place) to accomplish an emissions reduction goal. These concepts are discussed in more detail later in this document.

CoST is designed for multi-pollutant analyses and data transparency. It provides a wide array of options for developing emissions control strategies through the Control Measures Database (CMDDB). The CoST GUI provides a graphical interface for accessing the CMDDB, designing control strategies, and viewing the results from control strategy runs. CoST has been applied to develop strategies for criteria and hazardous air pollutants (HAPs). CoST has been used in some very limited analyses for greenhouse gases (GHGs). The main limiting factors in performing GHG analyses are the availability of (1) GHG emissions inventories with enough detail to support the application of control measures to individual sources or source groups, and (2) GHG control measures, with the associated technology implementation and costs.

The CoST algorithms for developing control strategies include:

- “Annotate Inventory”
- “Maximum Emissions Reduction”
- “Multi-Pollutant Maximum Emissions Reduction”
- “Least Cost”
- “Least Cost Curve”
- “Apply Measures in Series”

The first five algorithms are typically used for point and area sources; the last one is usually used for mobile sources, for which most control techniques are independent of one another.

This document provides information on how to use CoST to view and edit control measures and how to develop control strategies. This includes how to specify the input parameters to control strategies, how to run the strategies, and how to analyze the outputs from the strategies. This document was prepared using version 2.15 of CoST. For additional information on other aspects of CoST, please see the following independent documents:

- [Control Strategy Tool \(CoST\) Development Document](#): describes the algorithms implemented in the software
- [Control Strategy Tool \(CoST\) Control Measures Database Documentation](#): describes the contents of the Control Measures Database
- [Control Strategy Tool \(CoST\) Cost Equations Documentation](#): describes how CoST uses control measure engineering cost equations

These documents, and additional information about CoST, can be found at the EPA website on [Cost Analysis Models/Tools for Air Pollution Regulations](#).

Chapter 2

Installing the CoST Software and Data

2.1 Background on the CoST Client-Server System

Because CoST is fully integrated within the EMF, installing CoST is the same as installing the EMF. There are two parts of the CoST/EMF system: a client and a server. In this guide, it is assumed that you need to install both the client and the server.

In the CoST client-server system, client software that runs on a desktop computer is used to connect to a server running the CoST algorithms and database. The CoST/EMF client is a Java program that accesses Java and [PostgreSQL](#) software running on the CoST/EMF server. CoST/EMF requires that a recent version of Java be installed on each user's computer. The EMF database server stores information related to emissions modeling, including emissions inventory datasets and a database of emissions control measures. When a control strategy is developed, new datasets and summaries of them are created within CoST, and controlled emissions inventories can optionally be generated. These emissions inventories can be exported from CoST and then used as inputs to the SMOKE modeling system, which prepares emissions data for use in the CMAQ model. A schematic of the CoST/EMF client-server system see Figure 2.1.

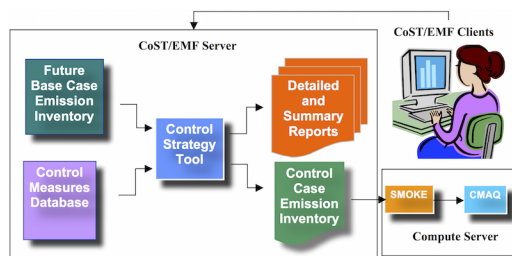


Figure 2.1: EMF Client-Server System

2.2 Download the Software Installation Package

The software installation package is a ZIP file (~300MB) that contains all the relevant supporting applications and software required to run the CoST system on a Windows-based machine. The installation package also contains the most recent version of the CMDB available at the time of the software release. Instructions for optionally updating the CMDB are provided at the end of this section.

The CoST server requires [Java Runtime Environment 7 or 8](#) (also known as JRE 1.7 or 1.8), [Tomcat](#) and [PostgreSQL](#). All of these components are in the CoST/EMF installation package.

The total space required for the software is 5GB. Around 1.2GB of space can be freed at the end of the installation process. Make sure you have enough storage space (~40-50 GB) available to allow for future usage with your own custom inventories and control measures in the CoST system.

The CoST/EMF software package can be downloaded via the [Community Modeling and Analysis System \(CMAS\)](#).

A. Download the CoST Windows Installation zip file from the CMAS software download site: <http://www.cmascenter.org/download/software.cfm>

B. Unzip the downloaded file into a known folder location on a Windows machine.

Figure 2.2 lists the batch file and the folders that are located in the install zip file; these are described below the figure.

- Install_EMF.bat - bat file to install the EMF Client and Server
- control_measures - contains measures in the database (note: These are already installed)
- database_backup - contains a backup of the database
- EMF_Client - includes client installation package (all the Java libraries etc.)
- EMF_Server - includes the emf.war file that will be pushed to the tomcat server
- inventories - contains inventories
- java_jre - includes the Java JRE installation package
- postgresql - includes the PostgreSQL installation package and postgresql jdbc driver
- tomcat - includes the Tomcat installation package

2.3 Install Java

Go to the `java_jre` directory and double click the executable file, `jre-8u51-windows-i586.exe`.

Follow the installation steps as illustrated in the figures: 2.3, 2.4, 2.5.

Click **Install** to accept the license agreement and start the installation process.

Click **Close** to finalize the installation process.

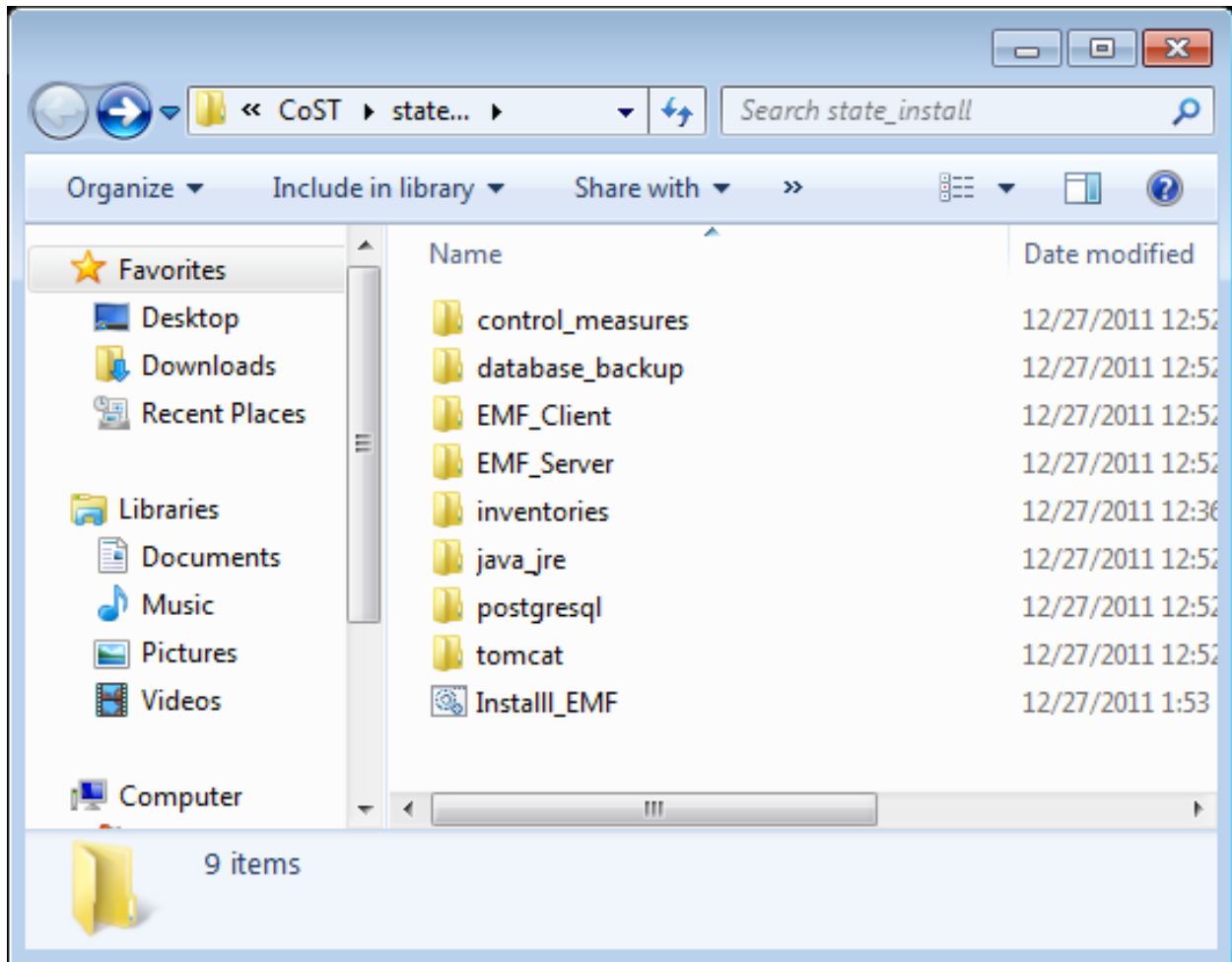


Figure 2.2: Installation Package Zip File Folder and File Structure

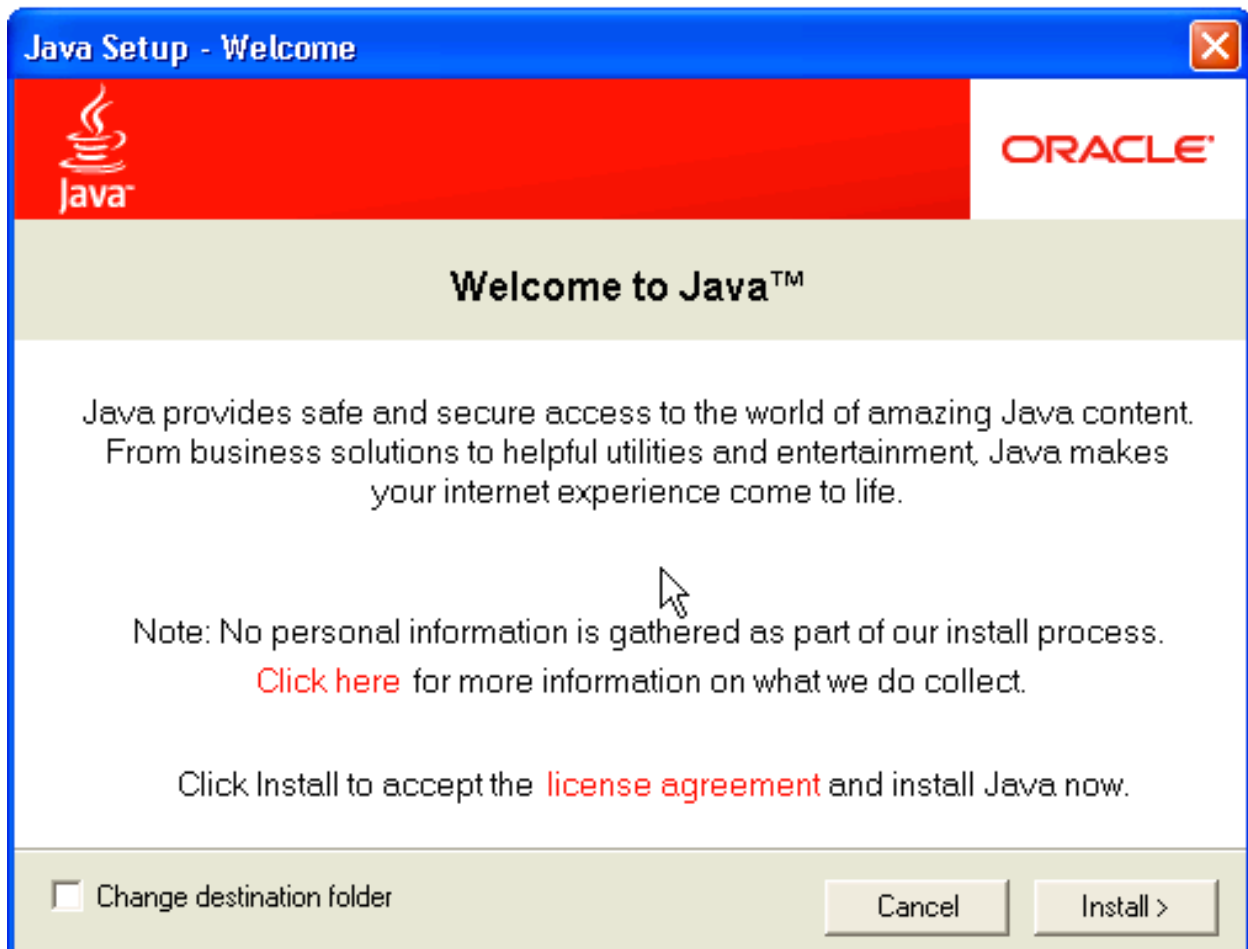


Figure 2.3: Java Setup Welcome

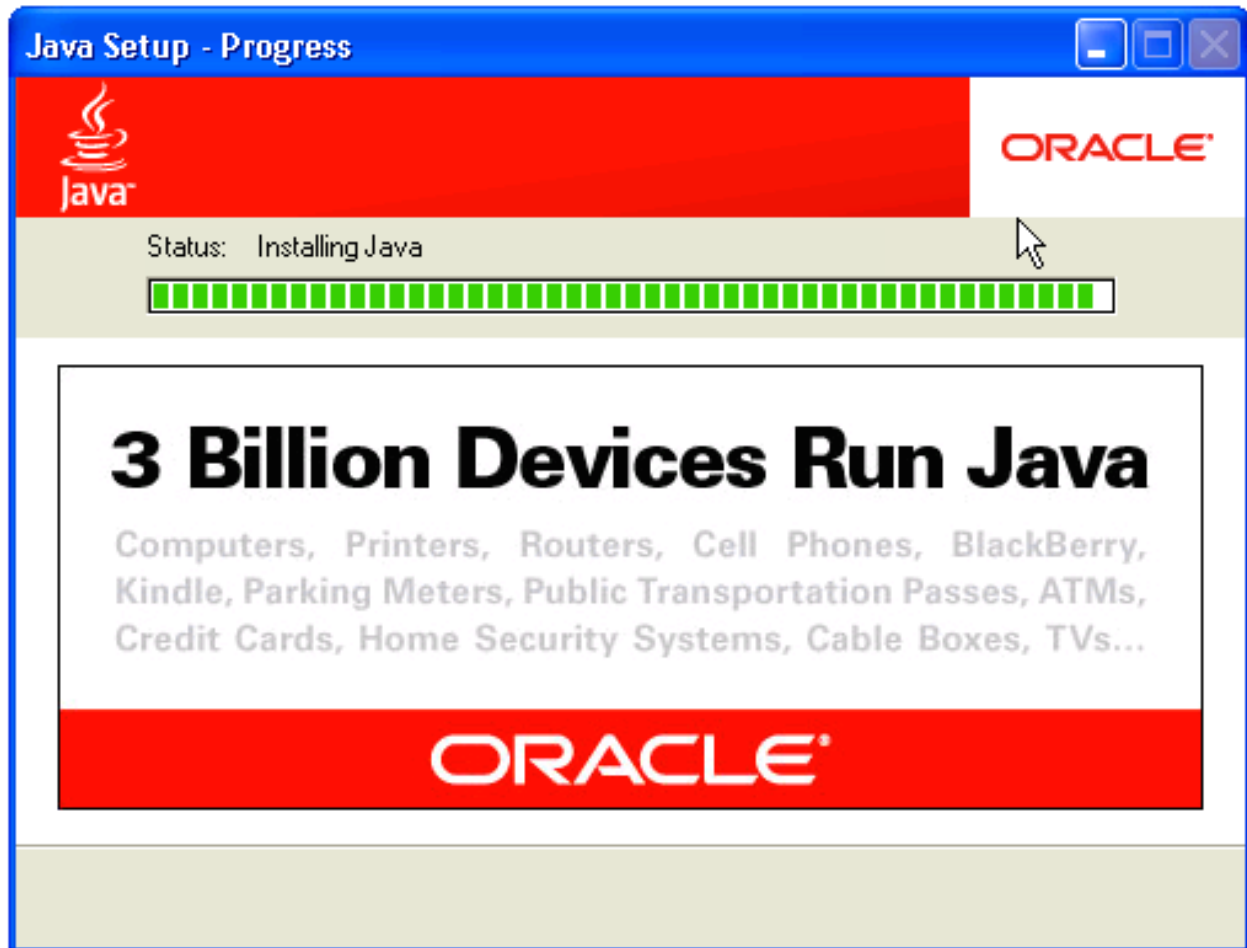


Figure 2.4: Java Setup Progress

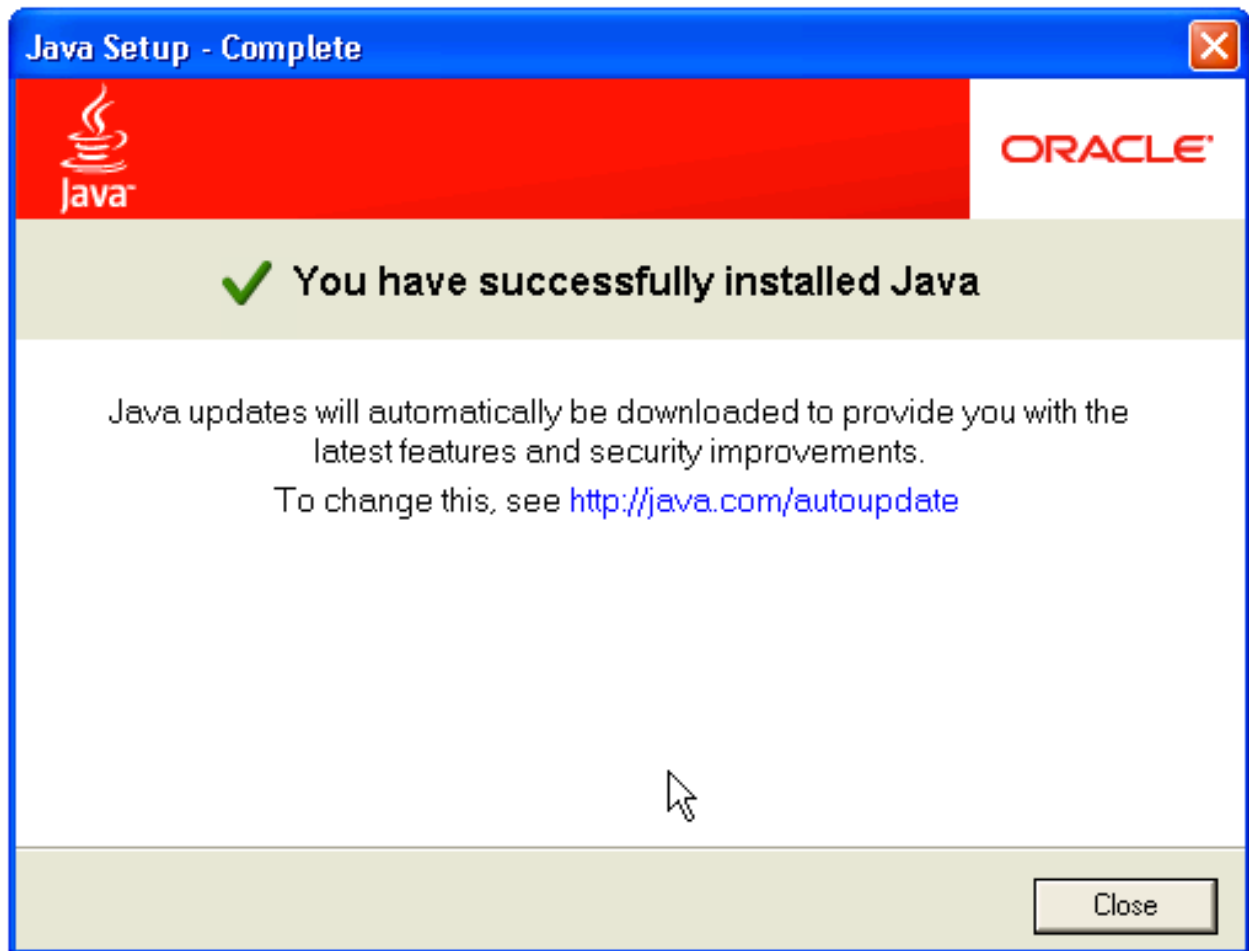


Figure 2.5: Java Setup Complete

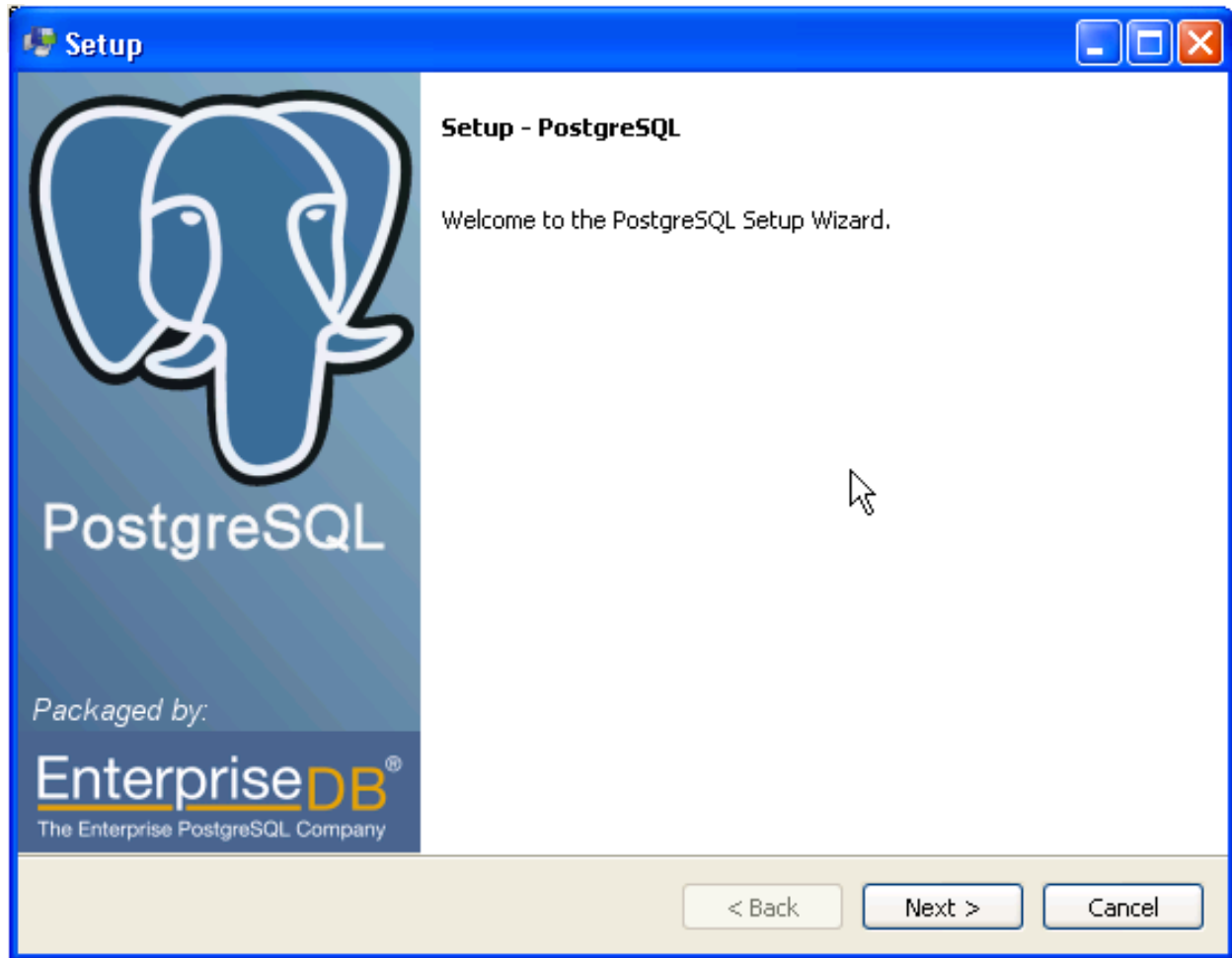


Figure 2.6: Postgres Welcome

2.4 Install the PostgreSQL Database

Go to the `postgresql` directory and double click the executable file, `postgresql-9.3.9-3-windows.exe`.

During the installation process, you'll be prompted to enter a database superuser password. Set a password, e.g., `postgres`, and take note of it for a later step of the installation process.

Follow the installation steps as illustrated in the figures: [2.6](#), [2.7](#), [2.8](#), [2.9](#), [2.10](#), [2.11](#), [2.12](#), [2.13](#), [2.14](#).

Click **Next** to begin the installation process.

The default directory location is sufficient, click **Next** to continue to the next step. Remember this directory for later use in the installation process.

The default location is sufficient, click **Next** to continue to the next step.

For this step, make sure you use the password that you set earlier in the installation, e.g., `postgres`. This password is also expected during a later step when installing the CoST database.

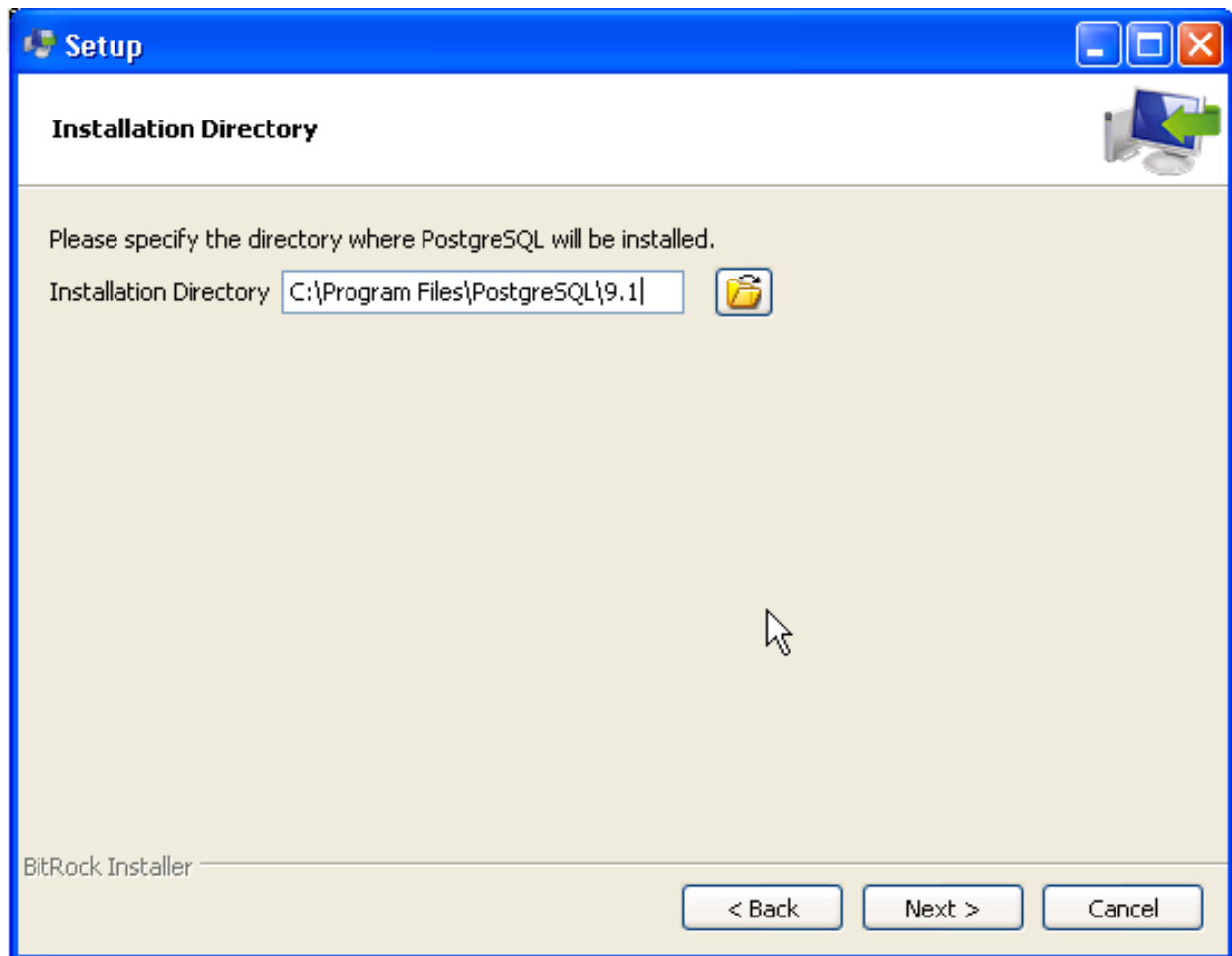


Figure 2.7: Postgres Installation Directory

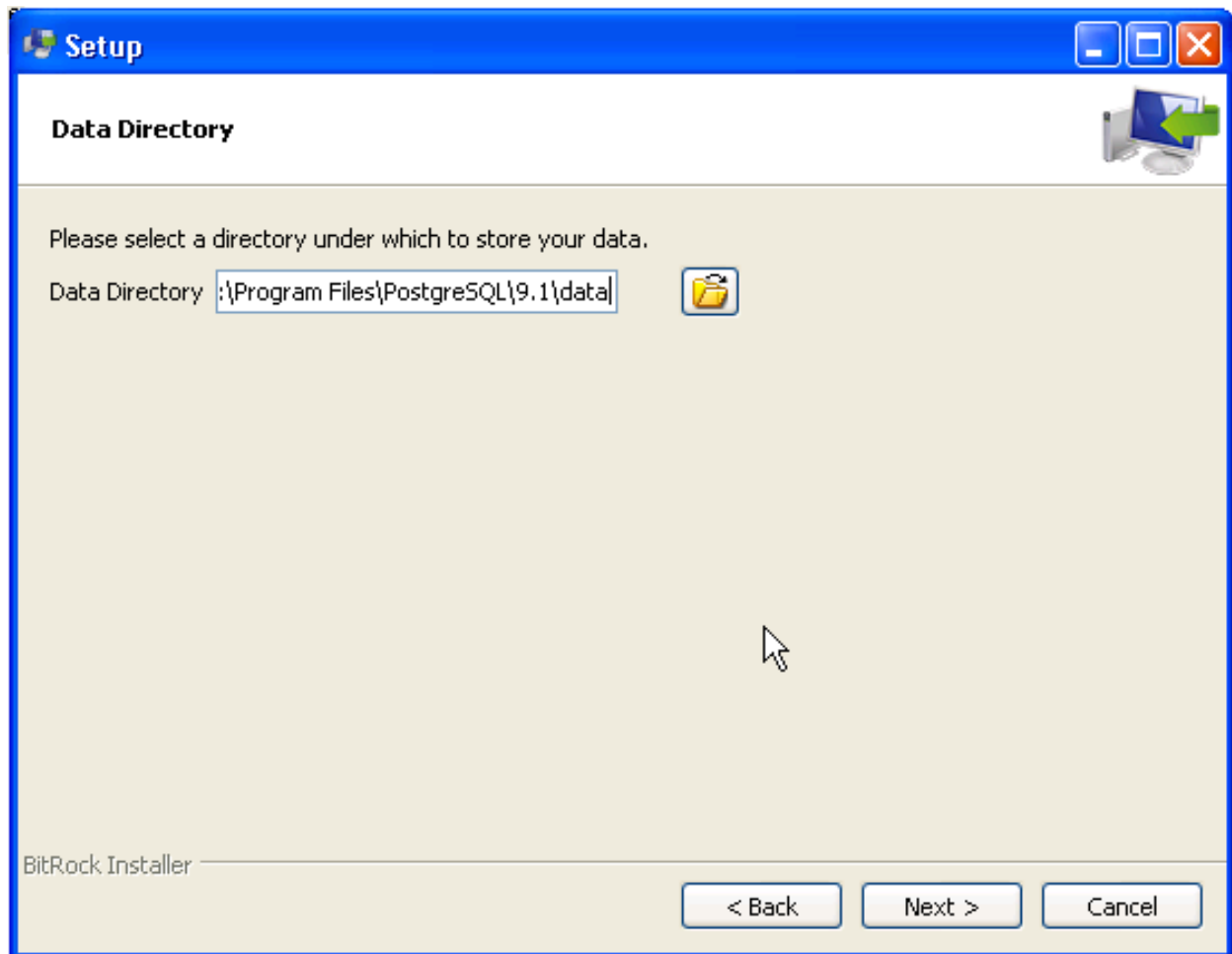


Figure 2.8: Postgres Data Directory

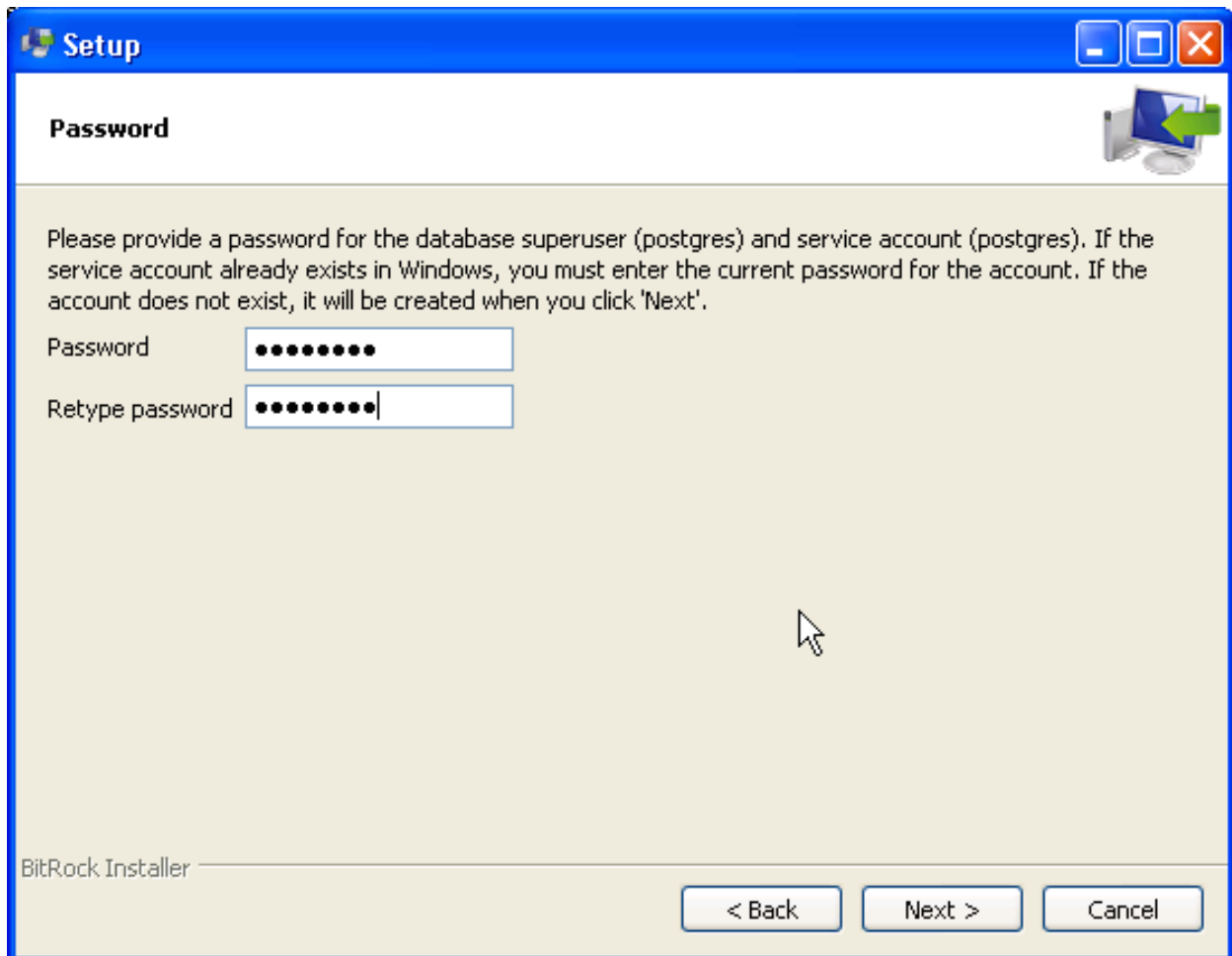


Figure 2.9: Postgres Password

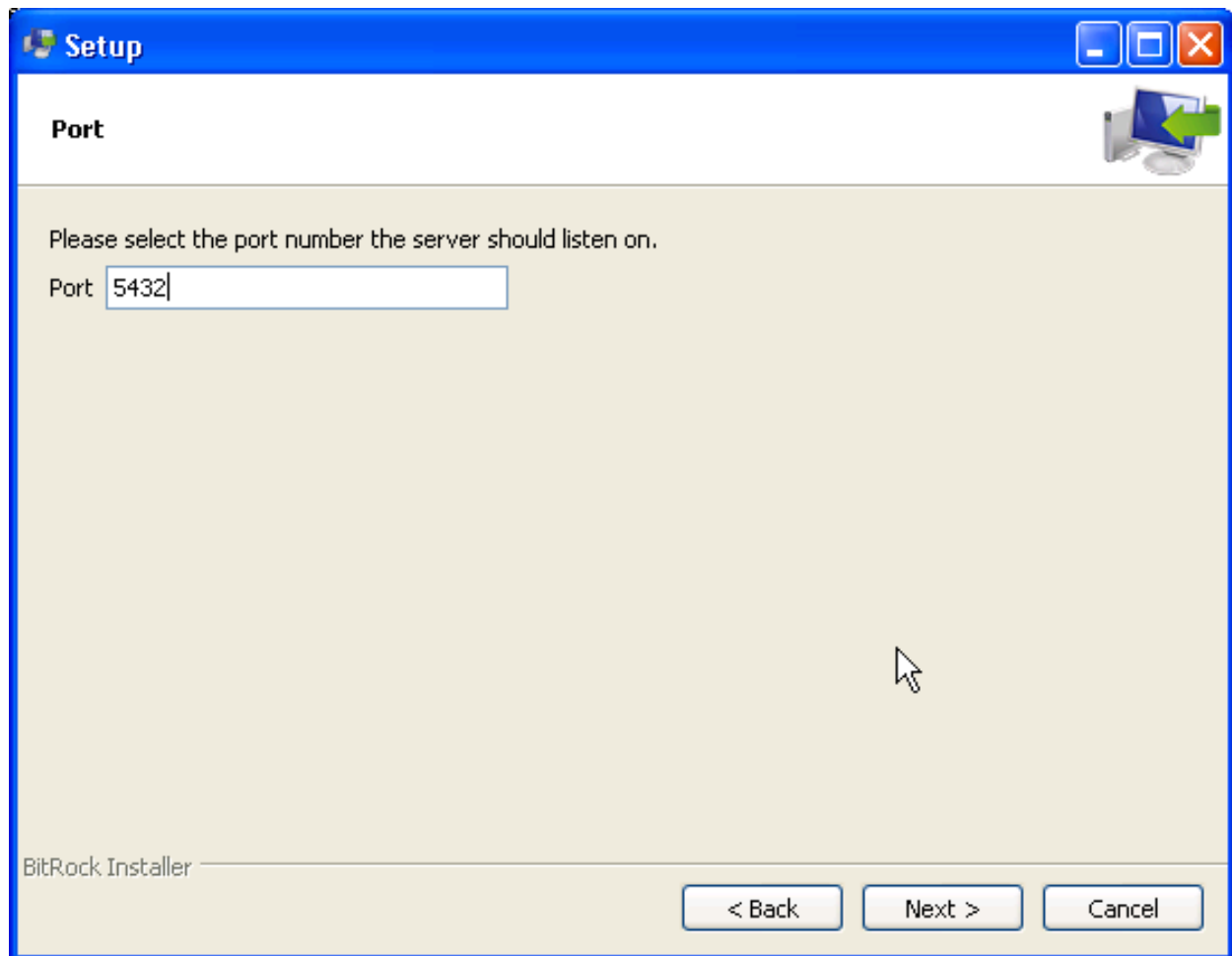


Figure 2.10: Postgres Port

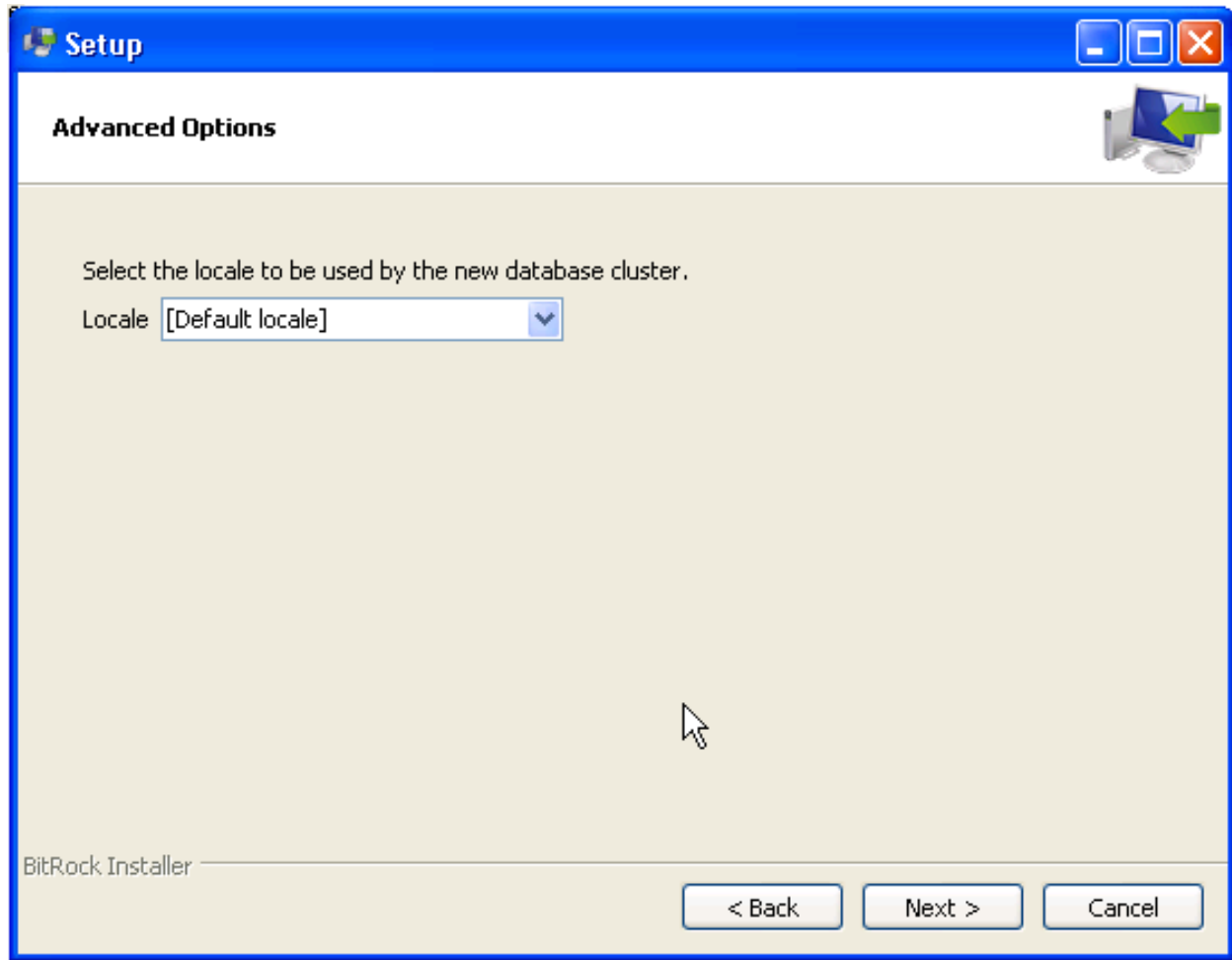


Figure 2.11: Postgres Locale

The default **Port** is sufficient, click **Next** to continue to the next step.

The default **Locale** is sufficient, click **Next** to continue to the next step.

Click **Next** to install the PostgreSQL database server.

Click **Next** to finalize the PostgreSQL installation.

When you reach the end, uncheck the **Launch Stack Builder** option and click **Finish**.

The PostgreSQL database is now installed and ready for the CoST system database. This database will be installed in a later step.

2.5 Install the Tomcat Web/Application Server

Go to the **tomcat** directory and find the executable file, **apache-tomcat-7.0.63.exe**. Double click the file to install Tomcat. Follow the installation steps as illustrated in the figures: [2.15](#), [2.16](#).

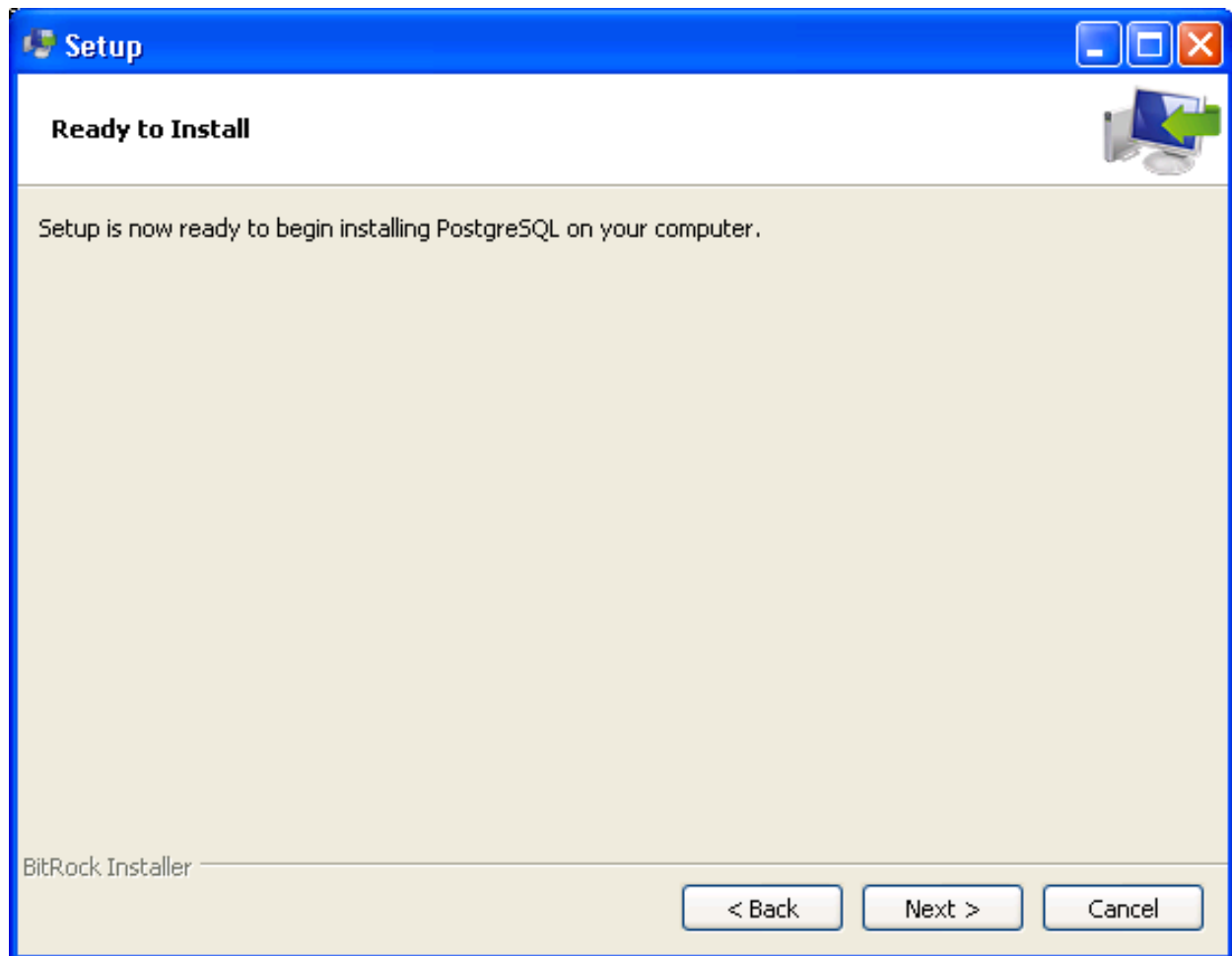


Figure 2.12: Postgres Ready to Install

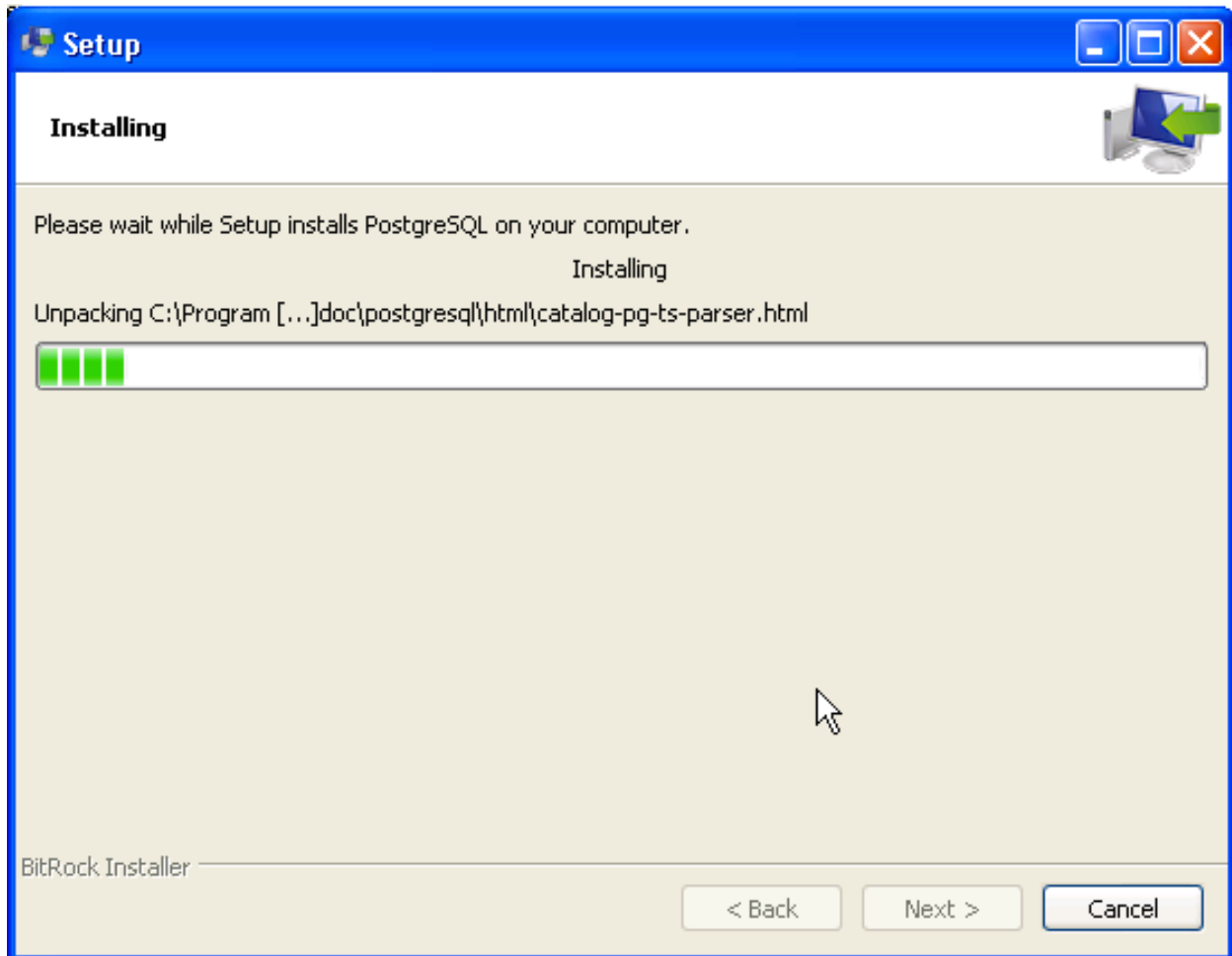


Figure 2.13: Postgres Installing



Figure 2.14: Postgres Complete

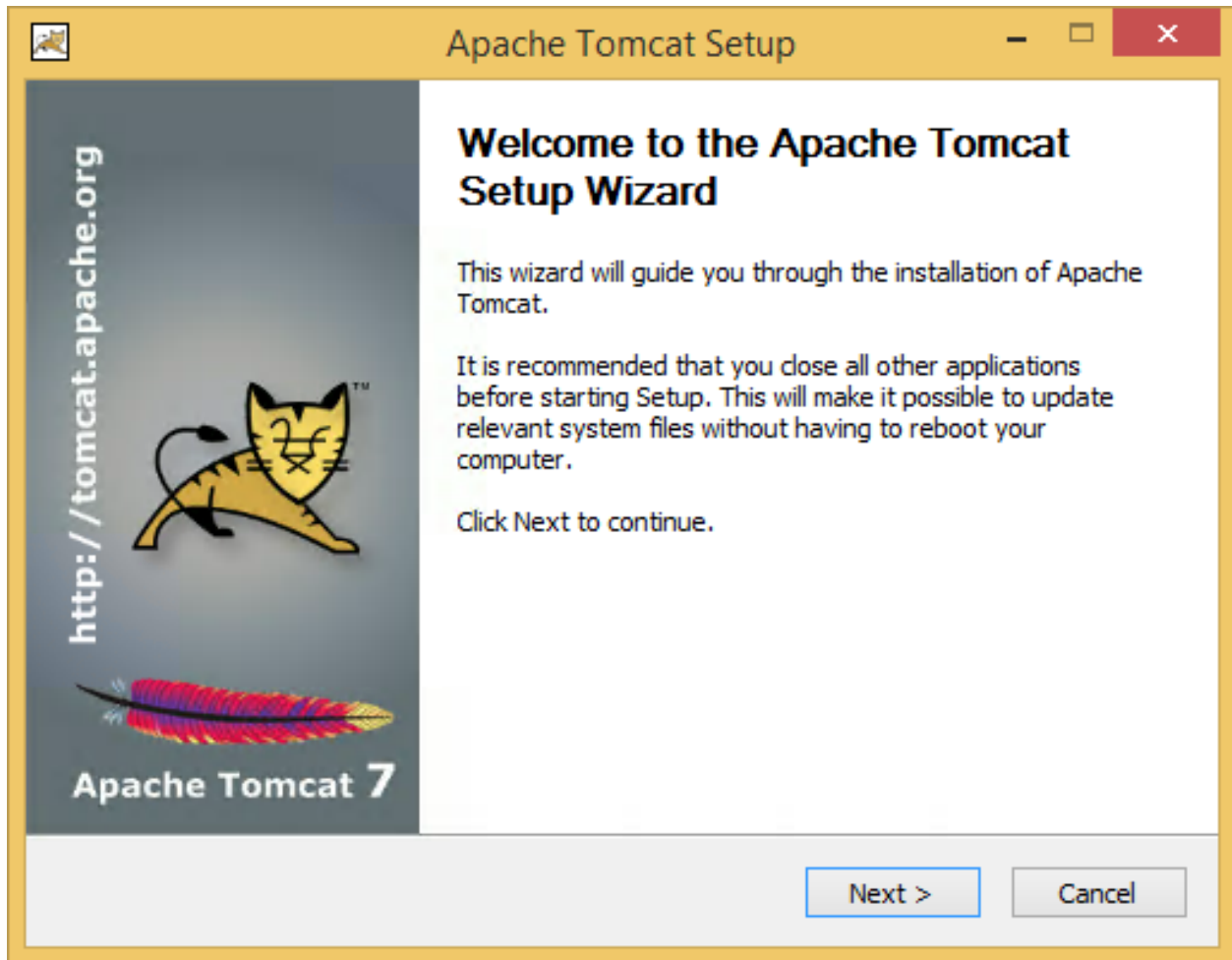


Figure 2.15: Tomcat Welcome

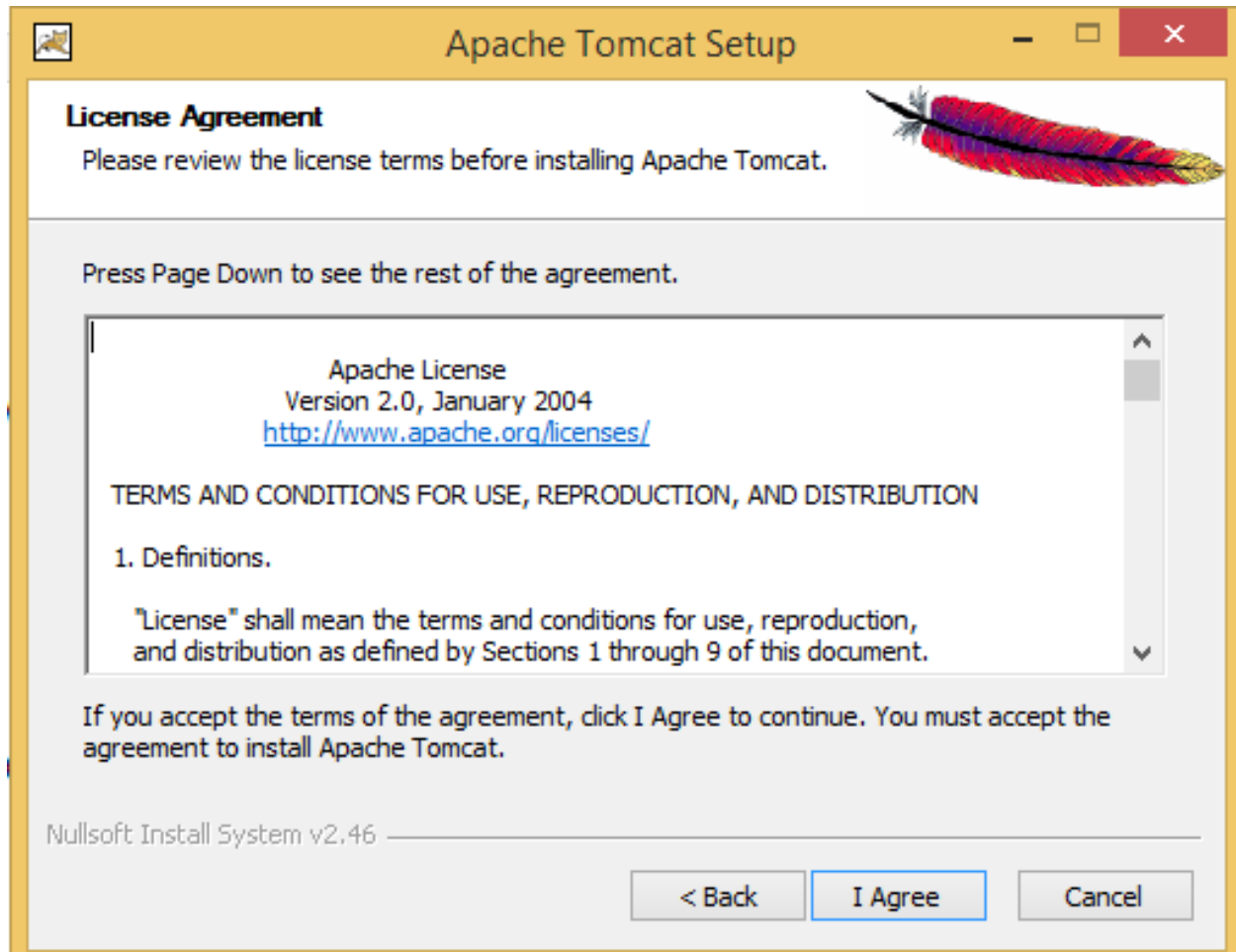


Figure 2.16: Tomcat License

Click **Next** to begin the installation process.

Click **I Agree** to continue to the next step.

Expand the **Tomcat** option and check the **Service Startup** and **Native** components and then click **Next**. Note that the required **Service Startup** option ensures that the application server is available on startup when the machine is rebooted.

The default settings are sufficient, click **Next** to continue to the next step.

The default location is sufficient, click **Next** to continue to the next step.

The default location is sufficient, click **Install** to install the Tomcat web server. Remember this folder for use in a later step of the installation process.

Once the program files have been installed click **Next** to finalize installation process.

When you reach the end, click **Finish**. The Tomcat application server is now installed and ready for the CoST system application. This CoST application will be installed in the next step.

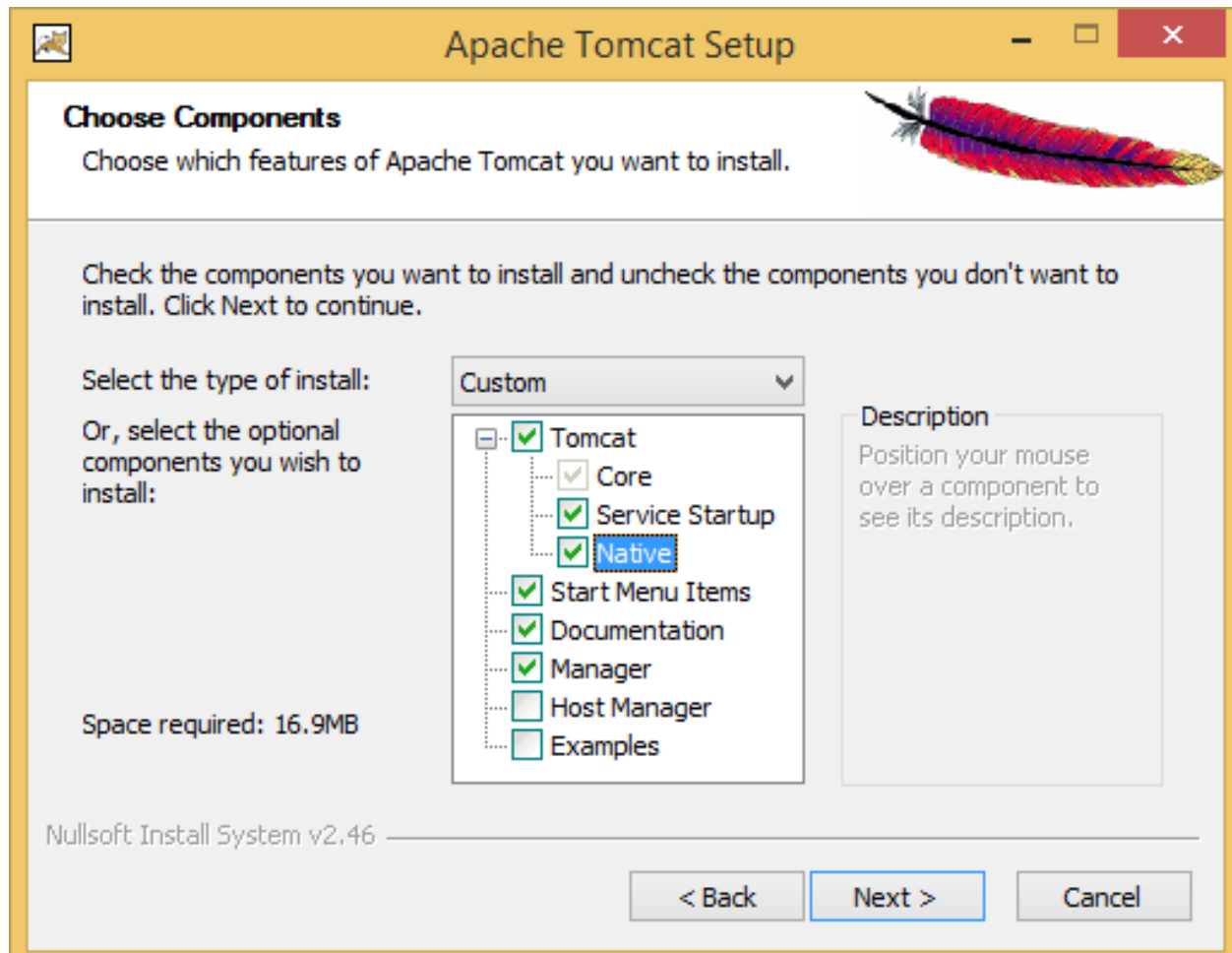


Figure 2.17: Tomcat Components

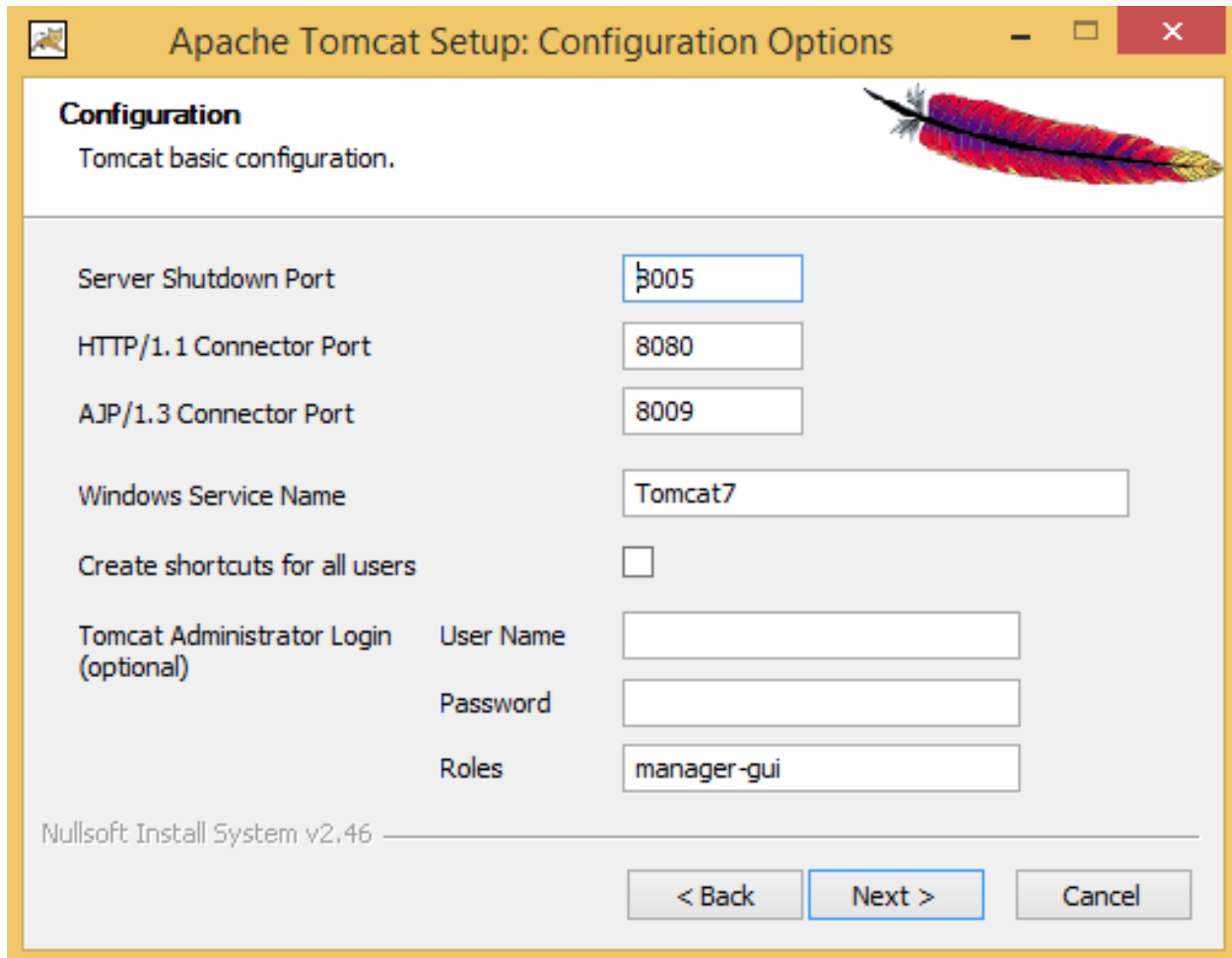


Figure 2.18: Tomcat Options

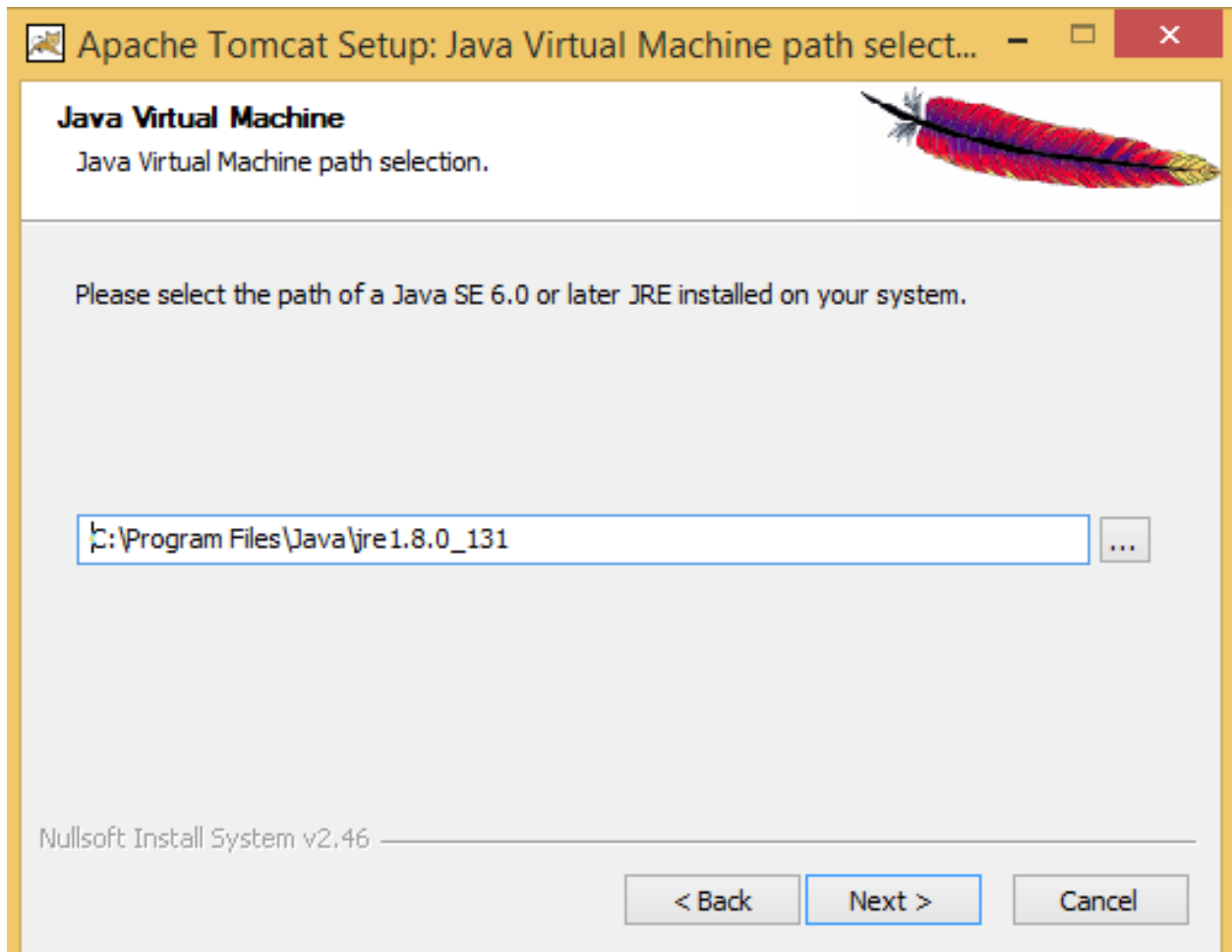


Figure 2.19: Tomcat JVM

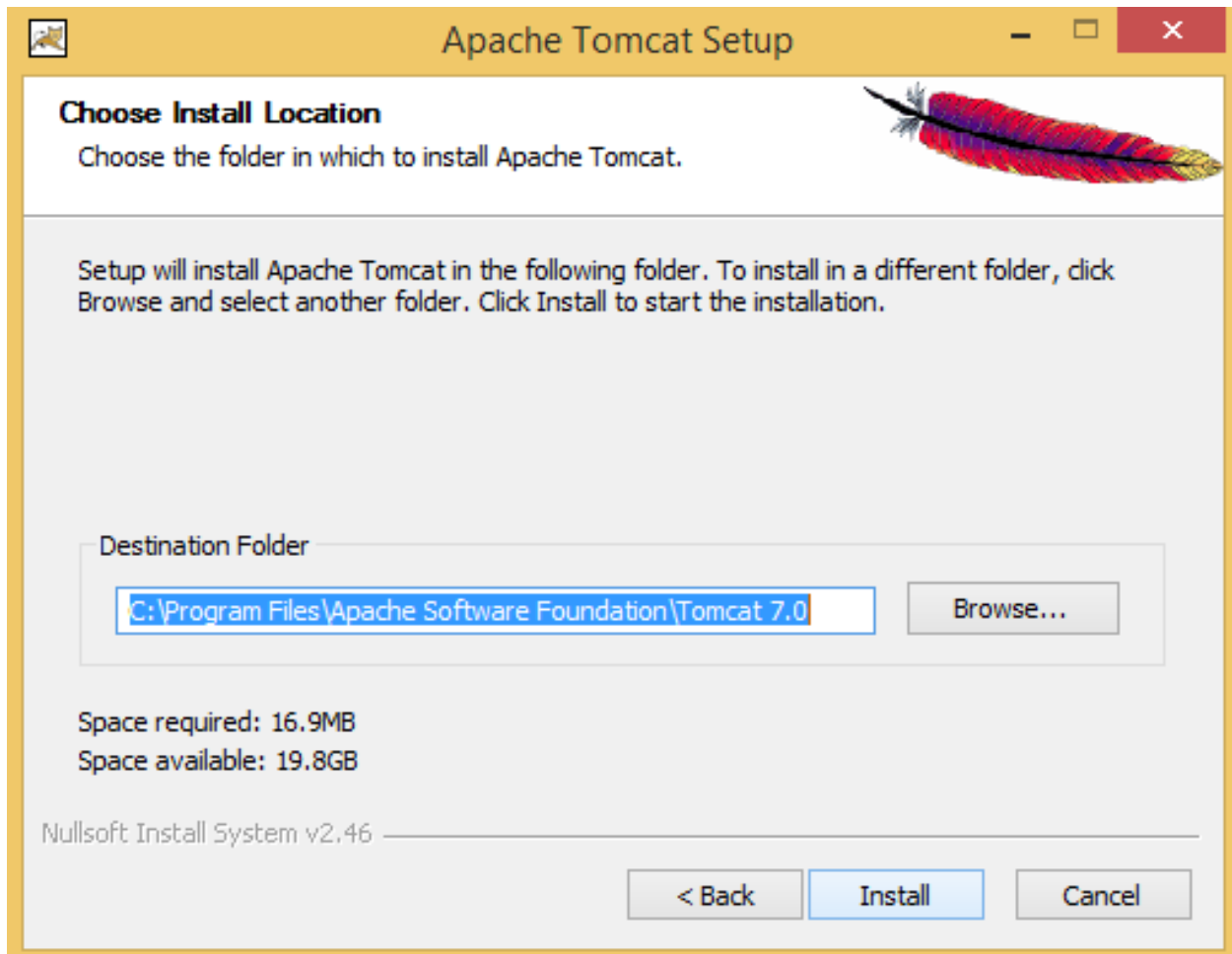


Figure 2.20: Tomcat Install Location

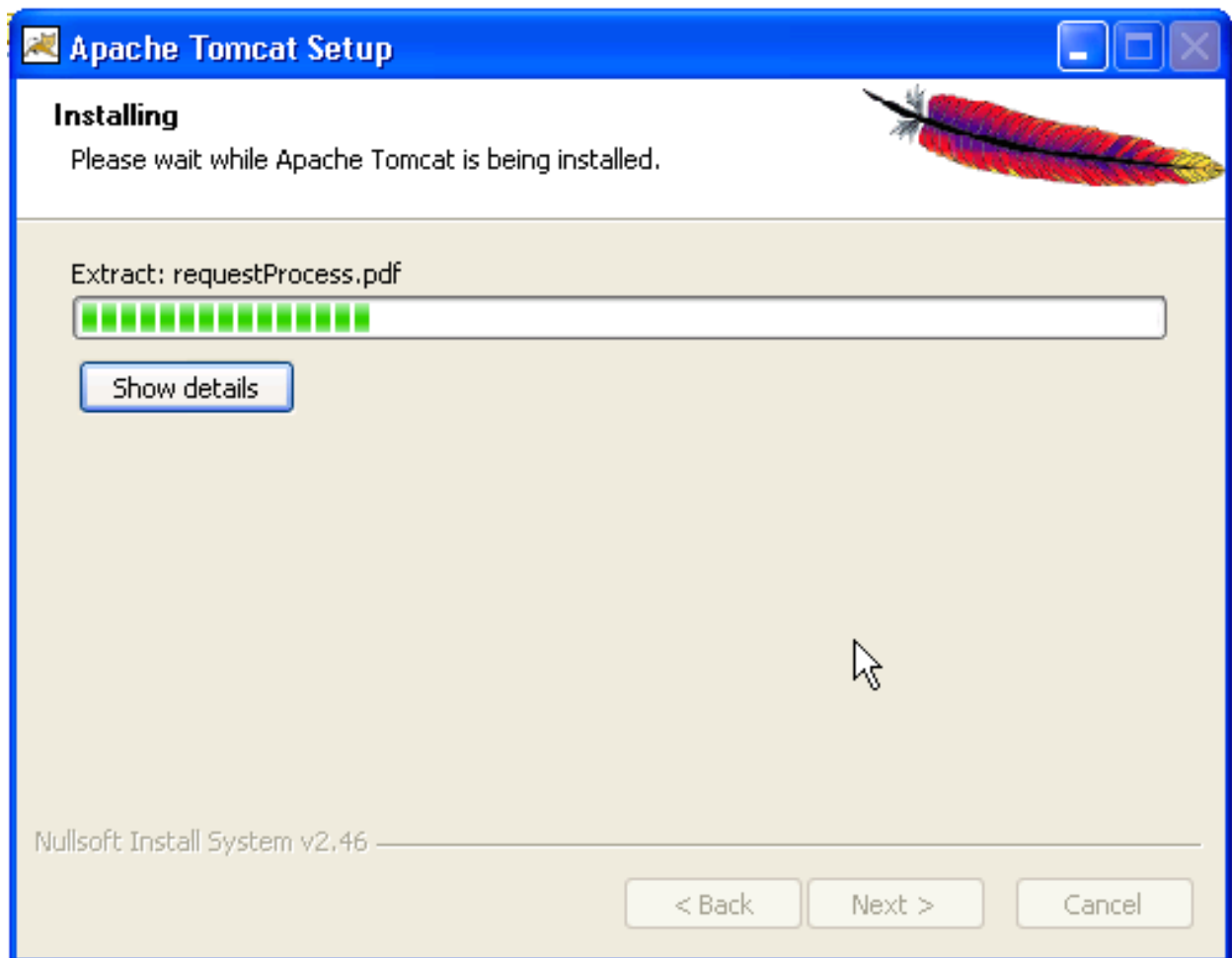


Figure 2.21: Tomcat Installing

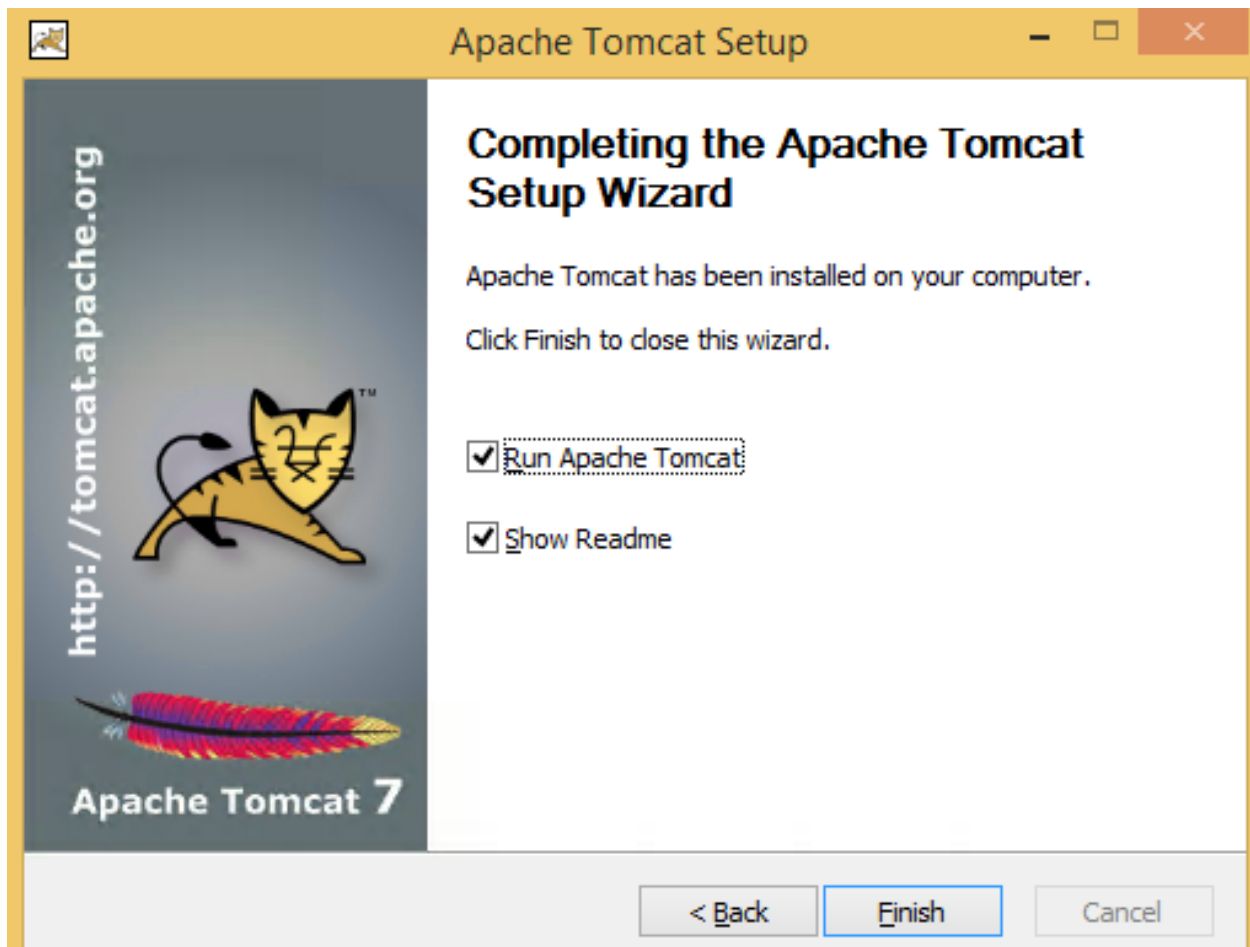
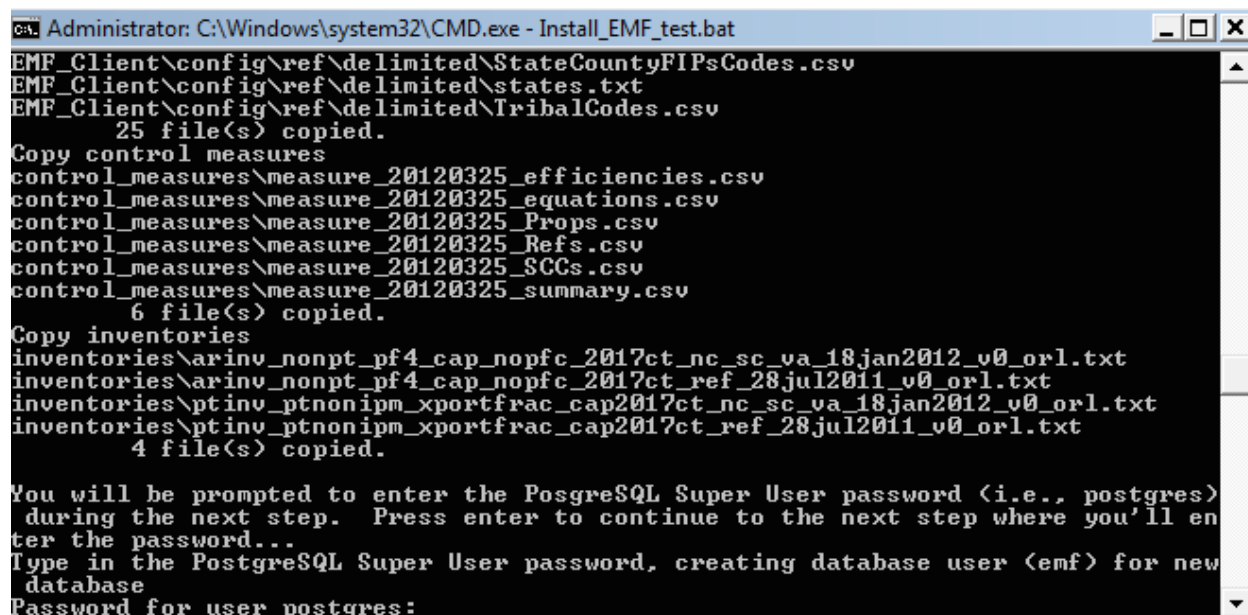


Figure 2.22: Tomcat Complete



```
Administrator: C:\Windows\system32\CMD.exe - Install_EMF_test.bat
EMF_Client\config\ref\delimited\StateCountyFIPsCodes.csv
EMF_Client\config\ref\delimited\states.txt
EMF_Client\config\ref\delimited\TribalCodes.csv
    25 file(s) copied.
Copy control measures
control_measures\measure_20120325_efficiencies.csv
control_measures\measure_20120325_equations.csv
control_measures\measure_20120325_Props.csv
control_measures\measure_20120325_Refs.csv
control_measures\measure_20120325_SCGs.csv
control_measures\measure_20120325_summary.csv
    6 file(s) copied.
Copy inventories
inventories\arinvt_nonpt_pf4_cap_nopfc_2017ct_nc_sc_va_18jan2012_v0_orl.txt
inventories\arinvt_nonpt_pf4_cap_nopfc_2017ct_ref_28jul2011_v0_orl.txt
inventories\ptinv_ptnonipm_xportfrac_cap2017ct_nc_sc_va_18jan2012_v0_orl.txt
inventories\ptinv_ptnonipm_xportfrac_cap2017ct_ref_28jul2011_v0_orl.txt
    4 file(s) copied.
You will be prompted to enter the PostgreSQL Super User password (i.e., postgres)
during the next step. Press enter to continue to the next step where you'll en
ter the password...
Type in the PostgreSQL Super User password, creating database user (emf) for new
database
Password for user postgres:
```

Figure 2.23: CoST Installation

2.6 Installing CoST

Go to the root installation directory where the CoST/EMF zip file was installed and find the Install_EMF.bat executable file. Edit the bat file and change the following variables to match your computer's settings:

```
SET EMF_CLIENT_DIRECTORY=C:\Users\Public\EMF
SET EMF_DATA_DIRECTORY=C:\Users\Public\EMF_Data
SET POSTGRES_DIR=C:\Program Files\PostgreSQL\9.3
SET TOMCAT_DIR=C:\Program Files\Apache Software Foundation\Tomcat 7.0
```

- EMF_CLIENT_DIRECTORY sets the location where the EMF client application will be installed. This is the location where you will find the CoST executable.
- EMF_DATA_DIRECTORY sets the location where the EMF data files (e.g., inventories and control measure import files) will be installed.
- POSTGRES_DIR sets the location where the PostgreSQL application is installed.
- TOMCAT_DIR sets the location where the Tomcat application is installed.

Save, exit and double-click the file Install_EMF.bat to start the CoST/EMF server installation.

Note: This installation process can take around 30-40 minutes to finish. During the installation process, you will be prompted once (see Figure below) to enter the PostgreSQL superuser password, e.g., postgres.

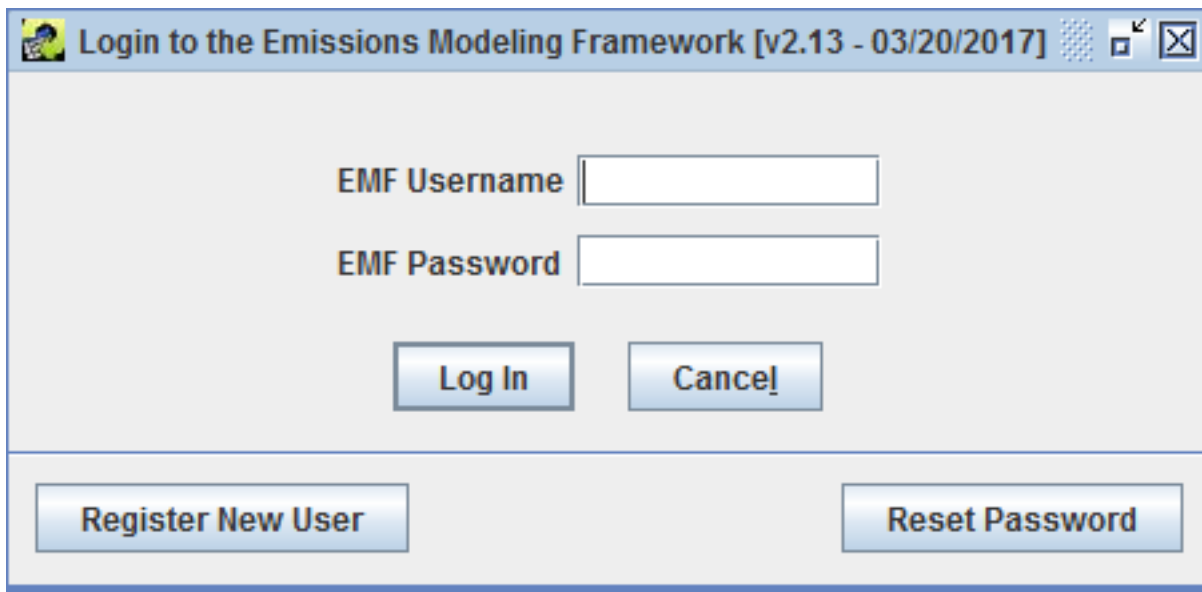


Figure 2.24: Login to the Emissions Modeling Framework Window

After the server installer completes, go to the directory containing the EMF client application; this was specified in the `Install_EMF.bat` file via the `EMF_CLIENT_DIRECTORY` variable. Edit the `EMFClient.bat` batch file to match your computer's settings:

```
set EMF_HOME=C:\Users\Public\EMF
set JAVA_EXE=C:\Program Files\Java\jre1.8.0\_51\bin\java
```

- `EMF_HOME` sets the location of EMF client application (set to be the same as `EMF_CLIENT_DIRECTORY` from the server installer above)
- `JAVA_EXE` sets the location of Java runtime application (note that the directory is `C:\Program Files\Java\jre1.8.0_51\bin` and `java` is the Java runtime application)

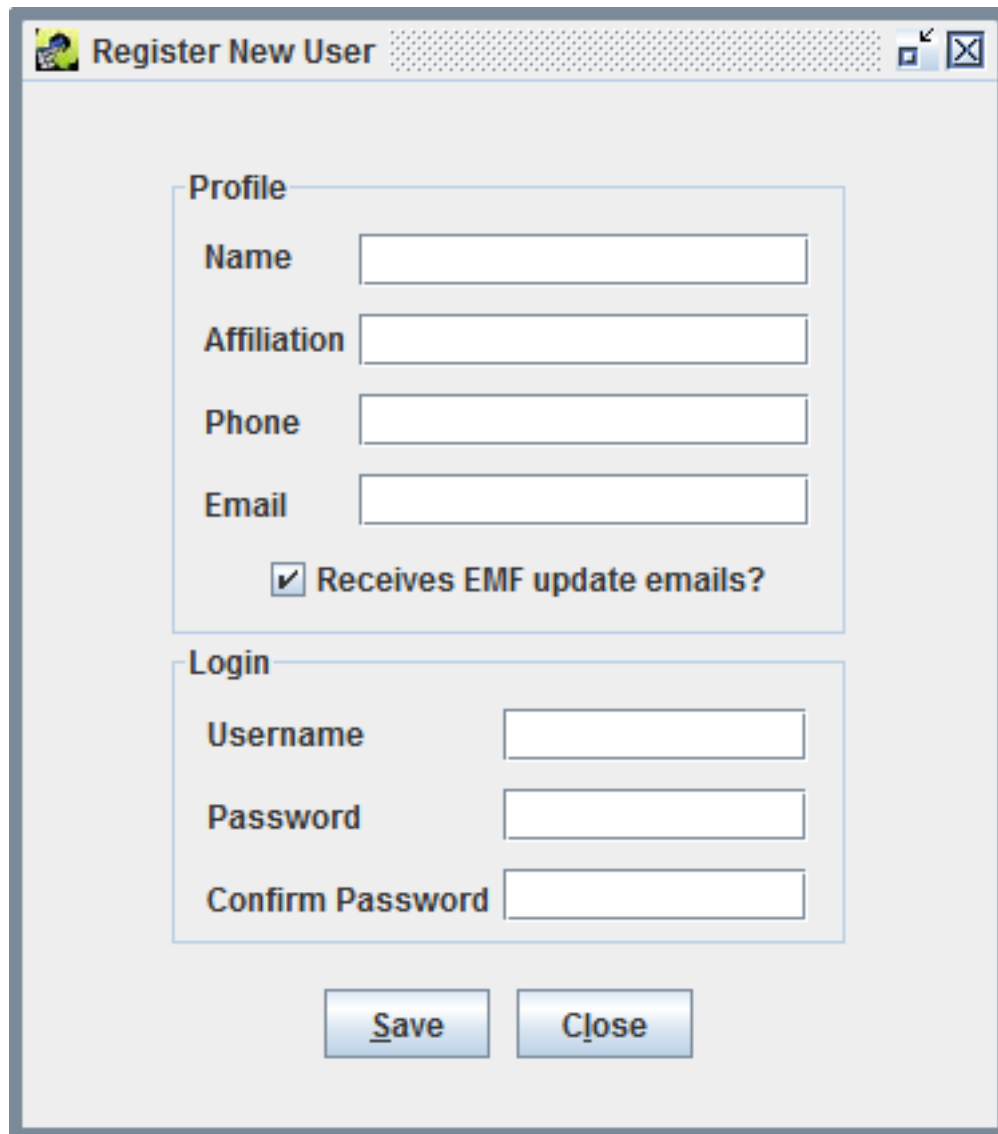
Save and exit from the file `EMFClient.bat`.

>>>>>> parent of 376088f... The method I used to put the images inline used html div tag, that doesn't allow the images to be visible in the browser in markdown.

2.7 Running CoST and Logging into the EMF Server

The CoST application can now be run by going to the EMF client directory and locating the `EMFClient.bat` file. Double click this file, and you will then be prompted to log in to the system. If the configuration was specified properly and the server is running, you should see the following window.

If you have never used the EMF before, click the **Register New User** button. You will then see the following window:



The image shows a software window titled "Register New User". It contains two main sections: "Profile" and "Login". The "Profile" section has four text input fields for "Name", "Affiliation", "Phone", and "Email", followed by a checked checkbox labeled "Receives EMF update emails?". The "Login" section has three text input fields for "Username", "Password", and "Confirm Password". At the bottom are two buttons: "Save" and "Close".

Register New User

Profile

Name

Affiliation

Phone

Email

☒ Receives EMF update emails?

Login

Username

Password

Confirm Password

Save **Close**

Figure 2.25: Register New User Window

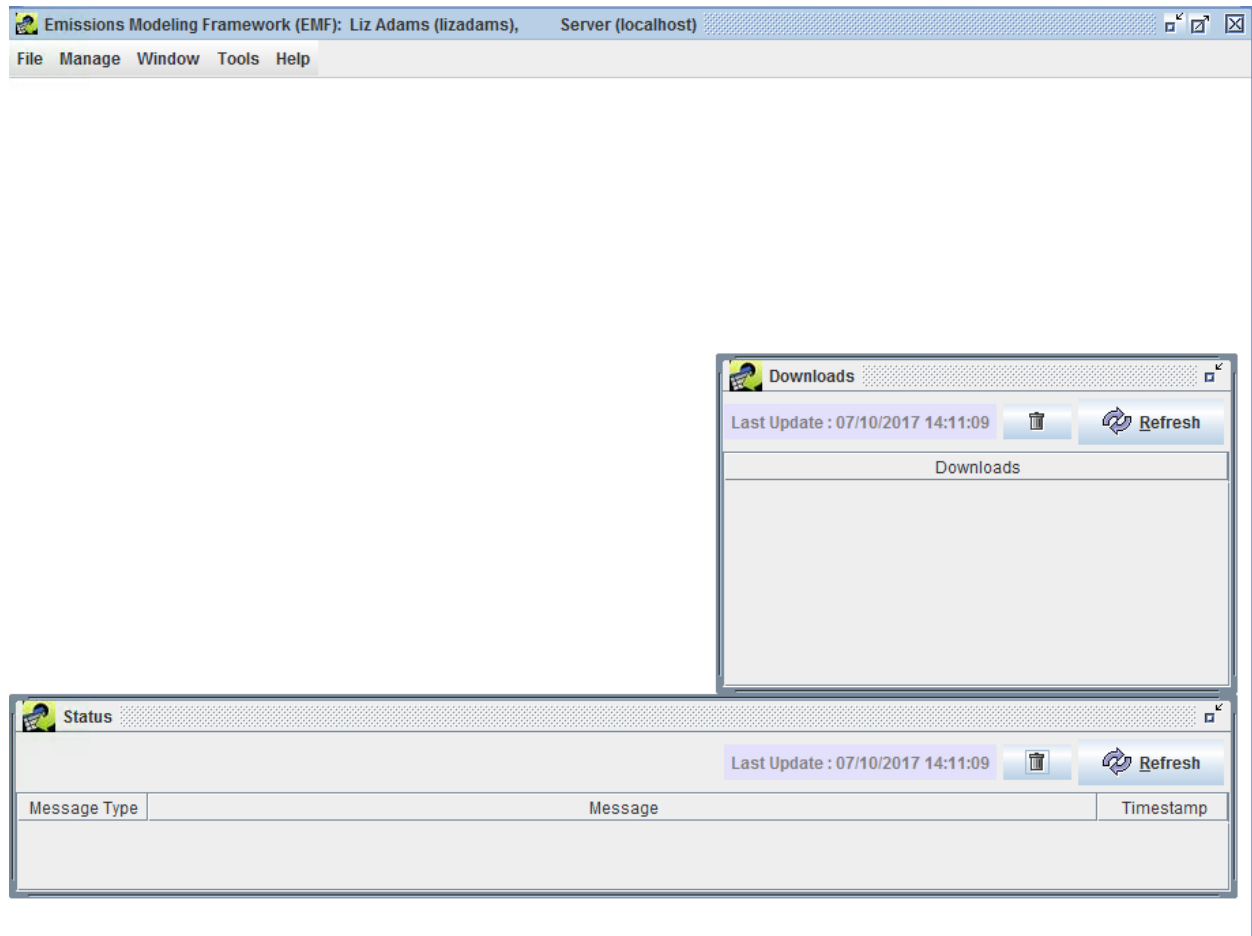


Figure 2.26: EMF Main Window

In the **Register New User** window, fill in your full name, affiliation, phone number, and email address. You may then select a username with at least three characters and enter a password with at least 8 characters and at least one digit and then click **OK**. Once your account has been created, the EMF main window should appear (see below).

If have logged into the EMF previously, enter your EMF username and password in the **Login to the Emissions Modeling Framework** window and click **Log In**. The following EMF main window will appear on your screen

*Note: The administrator EMF login name is **admin**, with a password **admin12345**.*

After successfully logging into CoST the main EMF window shown below will display.

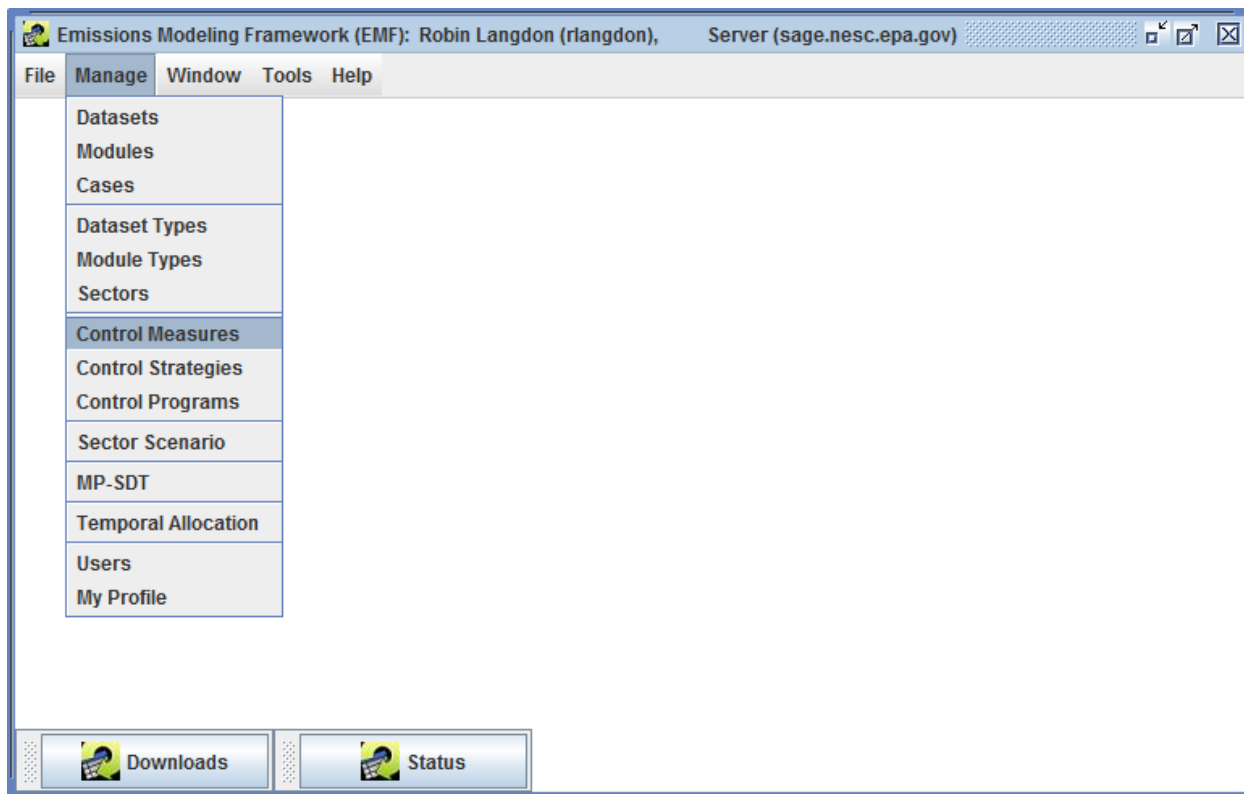


Figure 2.27: EMF Manage Control Measures

2.8 (Optional) Upgrade the Control Measures Database (CMDB)

The CMDB includes all of the emissions control technology information, emissions reductions, and associated costs used by the EPA for developing emissions control strategies for stationary sources. The latest CMDB is available from the [EPA CoST Website](http://www.epa.gov/cost).

The CoST/EMF installation package includes the latest version of the CMDB. The instructions here are provided to guide the upgrade of an existing EMF installation with a new version of the CMDB.

To install the CMDB in the EMF, first download the latest CMDB CSV file from the EPA website. You must login to the EMF Client as Administrator to add to the CMDB to the CoST PostgreSQL database. After logging in as administrator select **Control Measures** from the **Manage** drop down menu at the top of the EMF Client window:

Click the **Import** button to see the Import Control Measures screen:

Use the **Browse** button to find the CMDB CSV file downloaded from the EPA website. Select the file and click **OK**.

Click **Import** to add the EPA CMDB to the CoST/EMF database.

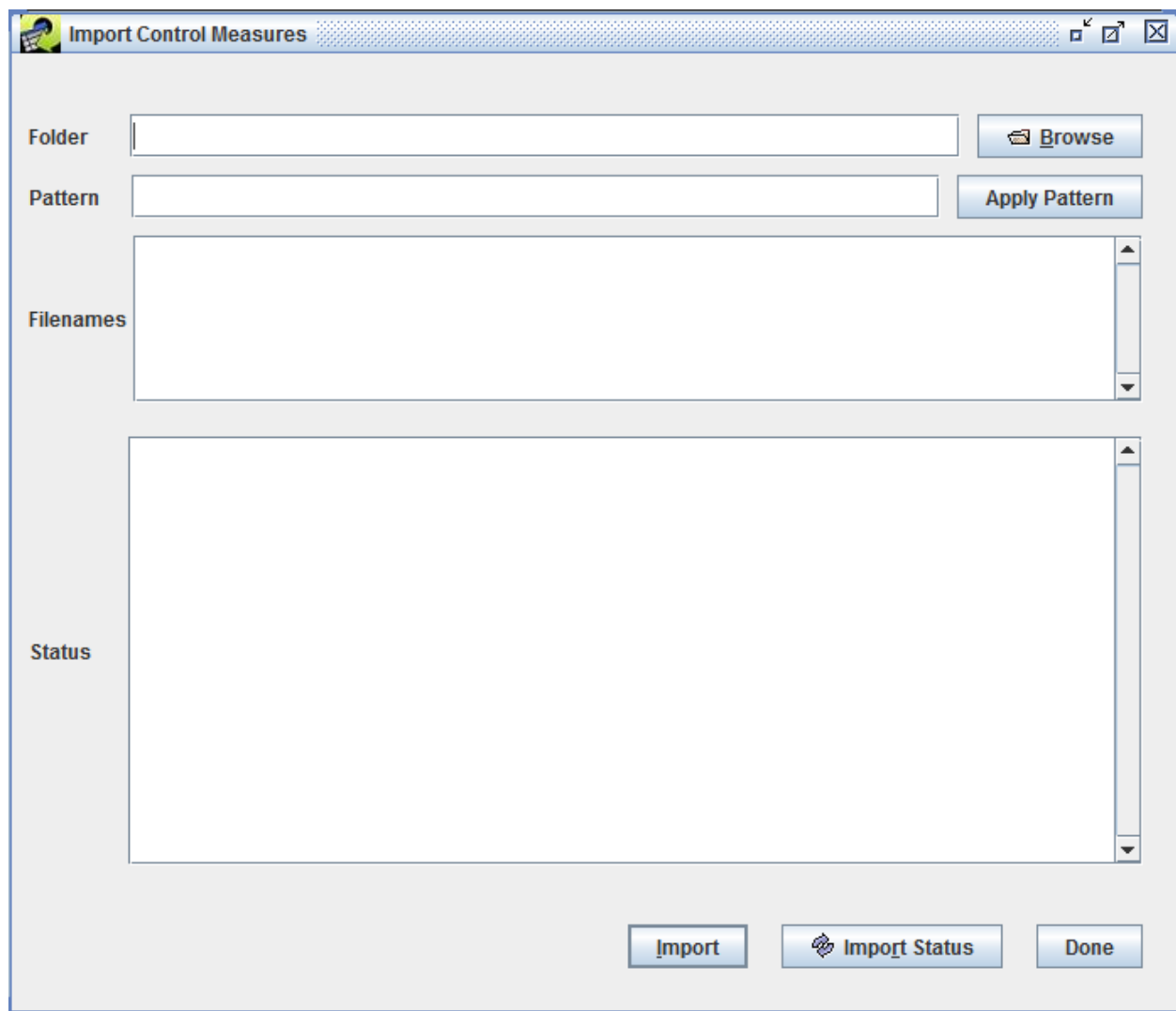


Figure 2.28: EMF Import Control Measures

2.9 (Optional) Removing CoST Installation Package

To remove the CoST installation package, go to the root directory where the EMF/CoST Installer zip file was installed and manually remove all files and sub folders from this directory. The original zip package contains a compressed version of the installation package and can be kept for reference purposes. Removing these files and directories will free up around 1.2GB of space.

Chapter 3

Control Measure Manager

3.1 Introduction

This chapter demonstrates the features of the CoST Control Measure Manager. The initial CoST installation includes area- and stationary-source control measures. The pre-loaded measures can be used directly for CoST control strategy runs, the measures are editable through the CoST/EMF client, and new measures may be imported through the client. **Control measures store information about control technologies and practices that are available to reduce emissions, the source categories to which they apply, the expected control efficiencies, and their estimated costs.**

The Control Measure Manager allows control measure data to be entered, viewed, and edited. The data that are accessible through the Control Measure Manager are stored in the [CoST Control Measures Database \(CMDB\)](#). The CMDB is stored as a set of tables within the EMF database. Control measures can also be imported from files that are provided in a specific CSV format and exported to that same format. In CoST, the control measures are stored separately from the emissions inventory data and are matched with the emissions sources using a list of Source Classification Codes (SCCs) that are specified for each control measure.

The Control Measure Manager has the following major features:

- Facilitates storing and maintaining control measure data
- Shows minimum, maximum, and average control efficiency, cost per ton (based on year 2013 values), and average rule effectiveness and rule penetration
- Displays other control measure attributes (e.g., abbreviation, major pollutant, source group, equipment life, emissions inventory sectors, class)
- Allows import of control measure information into the system from CSV files
- Enables export of control measure to CSV files

In this chapter, you will learn how to:

- View, sort, and filter a list of control measures from the Control Measure Manager window

- Find control measure that apply to selected SCCs
- View the detailed data available for a control measure, including control efficiencies, SCCs, cost equations, and properties
- Copy control measures
- Edit data for control measures
- Create new control measures
- Filter and display cost and control efficiency information for major and co-benefit pollutants of the measures
- See cost per ton information for different cost years
- Export control measures data

This chapter is presented as a series of steps in a tutorial format.

3.1.1 Introduction to the Control Measure Manager

Begin by opening the Control Measure Manager and exploring the buttons and menus in the upper portion of the window.

Step 1-1: Open Control Measure Manager. To open the Control Measure Manager, choose **Control Measures** from the **Manage** drop down menu on the EMF main window see Figure 2.26. The Control Measure Manager window will appear 3.1. When the window first appears, it will be empty. Notice that the window appears within the EMF main window.

Notice the different parts of the Control Measure Manager window. There is a **Pollutant Filter** drop down menu at the top, a **Show Details** checkbox, a **Refresh** button, and a **Name or Abbr contains** dialog box. Below those buttons is a toolbar with buttons that operate on the data shown in the table below the toolbar, which by default is empty. There is another set of buttons and pull-down menus below the table. The functions of all of these buttons are discussed below.

Step 1-2: Display Control Measures. To display control measures from the CMDB in the Control Measure Manager window, select a pollutant from the **Pollutant Filter** pull-down menu at the upper left corner of the Control Measure Manager. For this example, use the scroll bar to find and select PM10-PRI. Information about any control measures that control the selected pollutant will appear in the Control Measure Manager window (Figure 3-3). The control measure **Name**, **Abbreviation**, **Pollutant**, **Sector**, and **Class** are shown in the window. Note that name of each control measure must be unique within the database, and that the control measures appear in a table in which the data can be sorted by clicking on the row headers.

The control measure abbreviation is a set of characters that is a *short-hand* for the control measure. Typically, the abbreviation should express the name of the control measure in an abbreviated form such that if someone is familiar with the abbreviation conventions, the person might be able to infer the name of the measure. Typically the first character of the measure denotes the major pollutant (e.g., ‘P’ for PM controls, ‘N’ for NO_x controls, ‘S’ for SO₂ controls). The next few characters usually denote the control technology (e.g., ‘ESP’ for

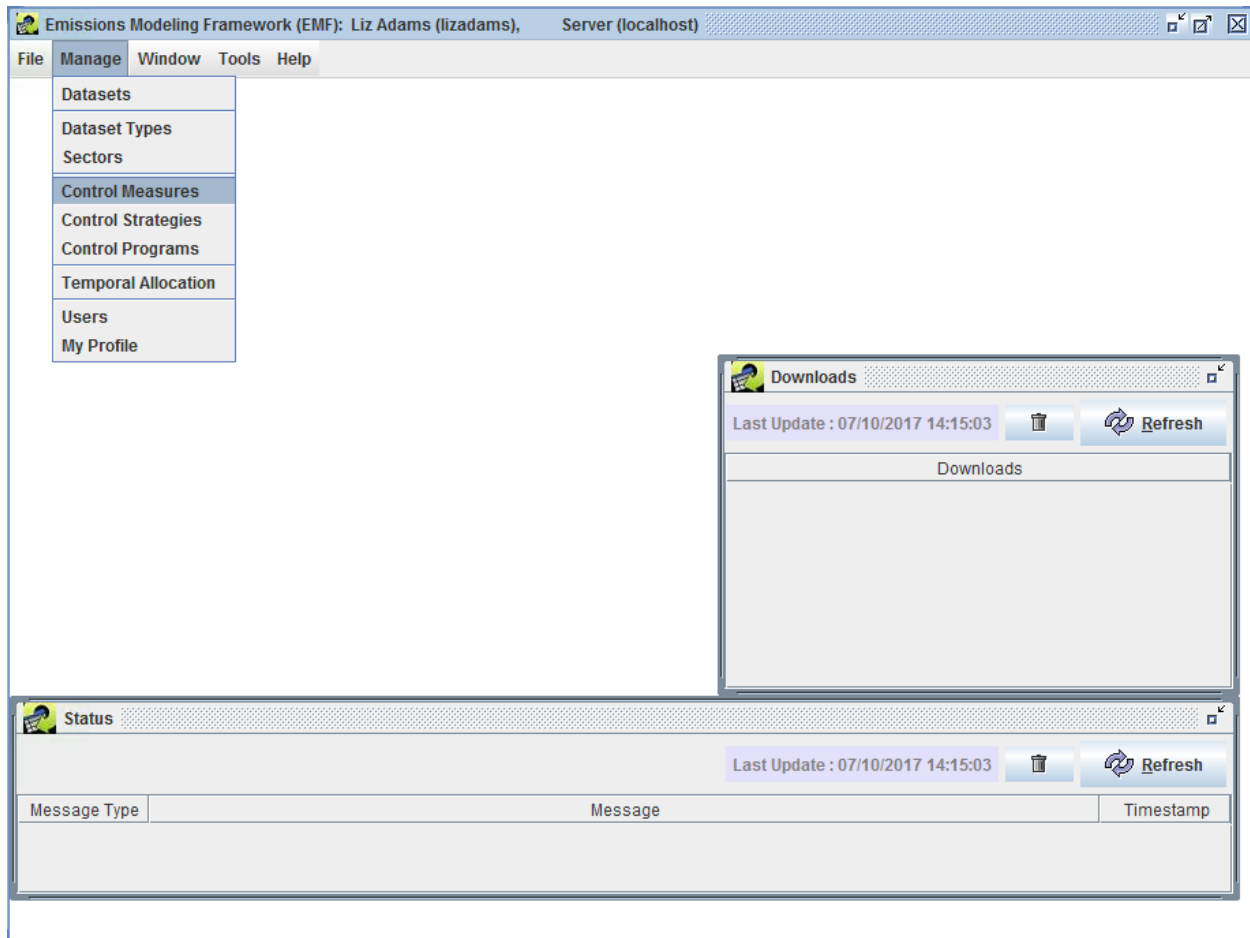


Figure 3.1: Manage Menu of EMF Main Window

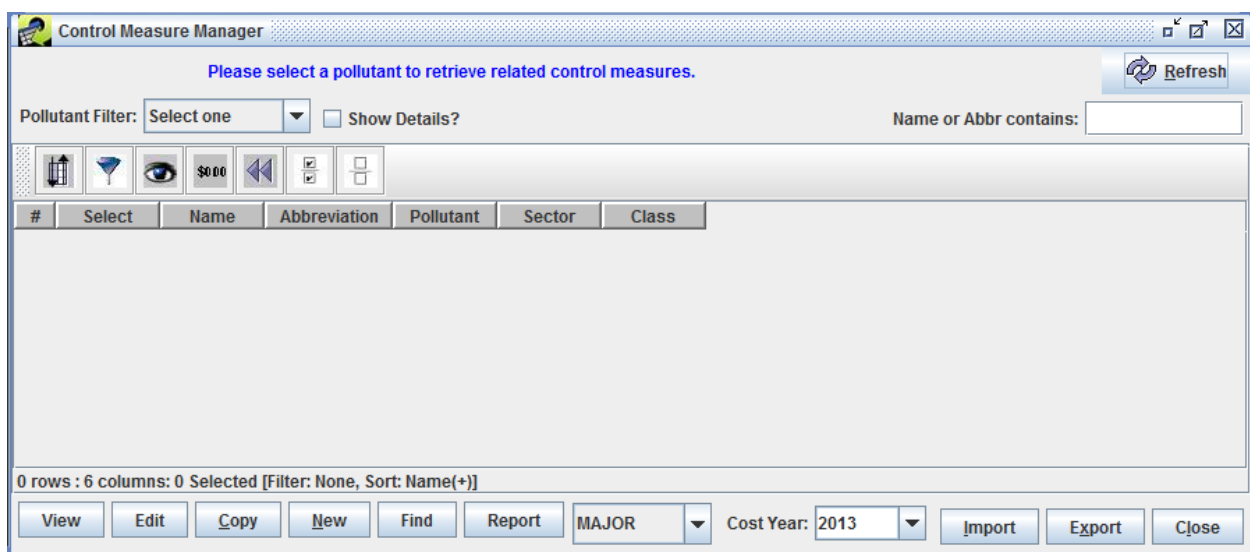


Figure 3.2: Control Measure Manager before Control Measures are Loaded

Control Measure Manager

Pollutant Filter: PM10-PRI ☐ Show Details? Name or Abbr contains:

140 rows : 6 columns: 0 Selected [Filter: None, Sort: Name(+)]

View Edit Copy New Find Report Pollutant: MAJOR Cost Year: 2013 Import Export Close

#	Select	Name	Abbreviation	Pollutant	Sector	Class
1	<input type="checkbox"/>	Catalytic Oxidizer;Commercial Cooking (Charbroiling)	PCHRBCAOX	PM25-PRI	nonpt	Known
2	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 1)	PUCHS150	PM10-PRI	afdust	Known
3	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 2)	PUCHS170	PM10-PRI	afdust	Known
4	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 3)	PUCHS190	PM10-PRI	afdust	Known
5	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 4)	PUCHS210	PM10-PRI	afdust	Known
6	<input type="checkbox"/>	Diesel Oxidation Catalyst (DPF infeasible);IC Diesel Engine	PDIEOXCAT	PM25-PRI	ptnonipm	Known
7	<input type="checkbox"/>	Diesel Particulate Filter;IC Diesel Engine	PDIEPRTFIL	PM25-PRI	ptnonipm	Known
8	<input type="checkbox"/>	Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Ferrous Metals Processing - Ferroalloy Production	PDESPMPFP	PM25-PRI	ptnonipm	Known
9	<input type="checkbox"/>	Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Ferrous Metals Processing - Iron & Steel Production	PDESPMPIS	PM25-PRI	ptnonipm	Known
10	<input type="checkbox"/>	Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Mineral Products - Cement Manufacture	PDESPMICM	PM25-PRI	ntnonipm	Known

Figure 3.3: Control Measure Manager with Control Measures

Control Measure Manager

Pollutant Filter: PM10-PRI ☒ Show Details? Name or Abbr contains:

140 rows : 24 columns: 0 Selected [Filter: None, Sort: Name(+)]

View Edit Copy New Find Report Pollutant: MAJOR Cost Year: 2013 Import Export Close

#	Select	Name	Abbreviation	Pollutant	Avg CPT	Avg CE	Min CE
1	<input type="checkbox"/>	Catalytic Oxidizer;Commercial Cooking (Charbroiling)	PCHRBCAOX	PM25-PRI	3,442.45	83.00	83.00
2	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 1)	PUCHS150	PM10-PRI	1,934.18	38.00	38.00
3	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 2)	PUCHS170	PM10-PRI	4,622.68	38.00	38.00
4	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 3)	PUCHS190	PM10-PRI	5,049.65	38.00	38.00
5	<input type="checkbox"/>	Chemical Stabilization;Unpaved Roads (UnKnown 4)	PUCHS210	PM10-PRI	4,984.89	38.00	38.00
6	<input type="checkbox"/>	Diesel Oxidation Catalyst (DPF infeasible);IC Diesel Engine	PDIEOXCAT	PM25-PRI	1,848.96	20.00	20.00
7	<input type="checkbox"/>	Diesel Particulate Filter;IC Diesel Engine	PDIEPRTFIL	PM25-PRI	12,942.72	85.00	85.00
8	<input type="checkbox"/>	Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Ferrous Metals Processing - Ferr...	PDESPMPFP	PM25-PRI	246.97	95.00	95.00
9	<input type="checkbox"/>	Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Ferrous Metals Processing - Iron...	PDESPMPIS	PM25-PRI	217.16	95.00	95.00
10	<input type="checkbox"/>	Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Mineral Products - Cement Manu...	PDESPMICM	PM25-PRI	268.26	95.00	95.00

Figure 3.4: Control Measure Manager showing Control Measure Details

Electrostatic Precipitator, 'FFM' for fabric filter mechanical shaker). Abbreviations must be unique within the database (i.e., no two control measures can use the same abbreviation).

Step 1-3: Show Details of Control Measures. To see more information about the measures, check the **Show Details** checkbox - additional columns will appear on the right of the table. An example is shown in Figure 3.4.

Step 1-4: Configure the Control Measure Window. To better see the additional columns, you can make the Name column narrower by positioning your mouse on the line between **Name** and **Abbreviation** on the table header; this will cause a special mouse pointer with arrows to appear and you can then use the mouse to drag the column edge to resize the column width.

Step 1-5: Examine Control Measure Details. Scroll to the right to examine the detail columns that are available in the Control Measure Manager. *Note that you may move the columns around by grabbing the column's header with your mouse and dragging them. You*

may also change their widths as desired. You can also resize the Control Measure Manager window within the EMF Main Window as desired, such as to make the entire window wider so that you can see more columns.

Step 1-6: View Measure Name. After you scroll to the right in the window, if you hover your mouse over one of the columns other than **Name**, you will see that the name of the measure corresponding to the row you are on will appear briefly as a “tooltip”. This is so that you can tell what the name of the measure is even if it has scrolled off the window.

The columns shown on the Control Measure Manager with brief descriptions are shown in Table 3.1. The control measures table supports sorting and filtering the data. Tables of this same type are used many places throughout CoST and the EMF.

Table 3.1: Control Measure Manager Columns.

Column Name	Description
Select	This column will allow the user to view, edit, or copy the measure by clicking the corresponding button at the bottom of the manager window. These features will be discussed later in the training.
Name	A unique name for the measure.
Abbreviation	A unique abbreviation for the measure.
Pollutant	A pollutant (e.g., NO _x , PM ₁₀ -PRI) that the measure might control. Note that any pollutant-specific information in the row is for this pollutant.
Avg, Min, and Max CE	Average, minimum, and maximum control efficiencies for the specified pollutant, aggregated across all locales, effective dates, and source sizes.
Avg, Min, and Max CPT	Average, minimum, and maximum cost per ton for the specified pollutant aggregated across all locales, effective dates, and source sizes.
Avg Rule Eff.	Average rule effectiveness aggregated across all efficiency records for the specified pollutant.
Avg Rule Pen.	Average rule penetration aggregated across all efficiency records for the specified pollutant.
Control Technology	The control technology that is used for the measure (e.g., Low NO _x burner, Onroad Retrofit).
Source Group	The group of sources to which the measure applies (e.g., Fabricated Metal Products - Welding).
Equipment Life	Expected lifetime (in years) of the equipment used for the measure.
Sectors	An emissions inventory sector or set of the EPA’s emissions inventory sectors to which the measure applies (e.g., ptipm, afdust, nonpoint). A sector represents a broad group of similar emissions sources.
Class	The class of the measure. Options are Known (i.e., already in use), Emerging (i.e., realistic, but in an experimental phase), and Hypothetical (i.e., the specified data are hypothetical).
Eq Type	The type of COST equation to use

Column Name	Description
Last Modified Time	The date and time for which the information about the measure was last modified in the editor or imported from a file.
Last Modified By	The last user to modify the measure.
Date Reviewed	The date on which the data for the measure were last reviewed.
Creator	The user that created the measure (either from the import process or by adding it via the “New” button).
Data Source	A description of the sources or references from which the values were derived. Temporarily, this is a list of numbers that correspond to references listed in the References Sheet from when the control measures were imported.
Description	A textual description of the applicability of the measure and any other relevant information.

Step 1-7: Sort Control Measures. To sort based on data in one of the columns, click on the column header. For example, to sort based on the average control efficiency of the measure click on the column header for the “Avg CE” column. The table will now be sorted by the values of “Avg CE” in descending order. *Notice that information about the currently specified sort is reflected in the line just below the table.*

Step 1-8: Reverse Sort. Click on the header of the “Avg CE” column a second time, the sort order will be reversed.

Step 1-9: Multi-Column Sort. To perform a multicolumn sort, click the sort button and then click **Add** to add an additional column to sort by (e.g., **Name**). Notice that you can control whether the sort is **Ascending** and whether it is **Case Sensitive**. Click **OK** once you have made your selection. The data should now be sorted according to the column(s) you specified.

Step 1-10: Apply Filters to Control Measure Table. To use a filter to limit the measures shown, click the button on the toolbar that looks like a filter . When you do this the “Filter Rows” dialog appears (Figure 3.5).

- Enter a criterion for the filter by clicking **Add Criteria**.
- Click in the cell under “Column Name” to make a pull-down menu appear, from which you may choose a column to filter on (e.g., **Name**).
- Click in the cell under **Operation** to see the available operations and, if desired, select an operation (**contains** is the default).
- Enter a value in the **Value** cell (e.g., **Scrubber**). Note that the filter values are case-sensitive (e.g., Measure names containing “scrubber” will not match a filter value of “Scrubber”).

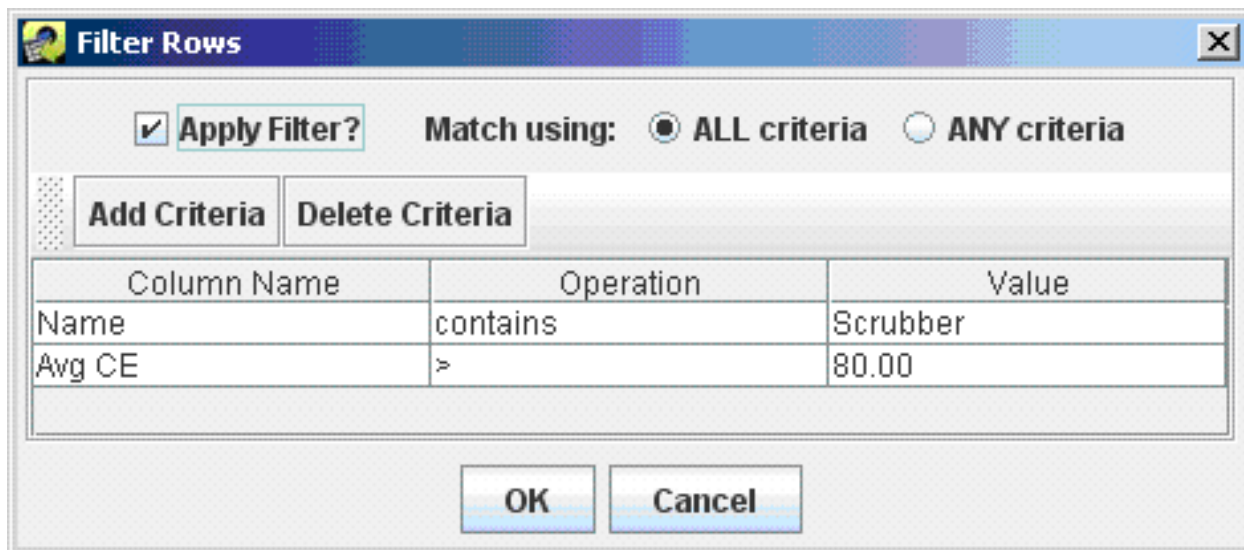


Figure 3.5: Filter Rows Dialog

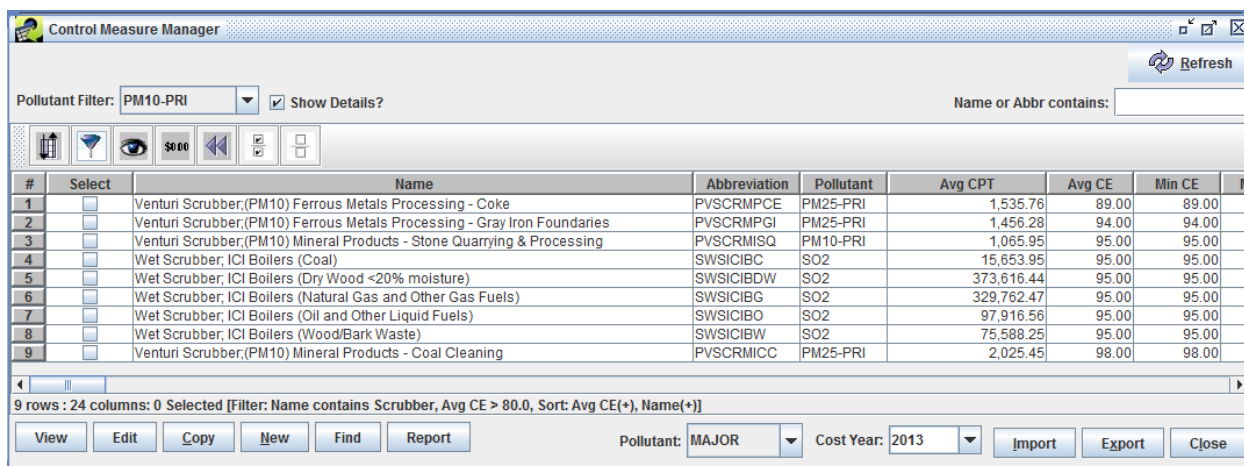


Figure 3.6: Control Measure Manager with Filter Applied

To add a second criterion click **Add Criteria** again on the **Filter Rows** dialog (e.g., enter ‘**Avg CE > 80**’). Note that if **Match using** is set to **ALL criteria** then only rows that match all the specified criteria will be shown in the table after you click OK. If **Match using** is set to **ANY criteria**, then rows will be shown in the table if they meet any of the criteria that are listed.

Click OK to close the **Filter Rows** dialog and to apply the selected filter. Figure 3.6 shows the table that results from the selections shown in Figure 3.5. Notice that the currently applied filter is reflected in the line under the horizontal scrollbar of the table.

Open the filter dialog again by clicking the **Filter rows** button. Set **Match using** to **ANY criteria** and then click OK to see what effect it has on the measures shown. Hint: you should see more measures displayed than when **Match using** is set to **ALL criteria**.

Step 1-11: Remove Filters from the Control Measures Table. Open the filter dialog again by clicking the **Filter rows** button. Remove one of criteria by clicking somewhere in one of the rows shown on the Filter Dialog and then clicking **Delete Criteria**. Now click **OK** to have the less stringent filter take effect.

Step 1-12: Select and Unselect Control Measures. To select all of the control measures that meet your filter criteria, click the **Select All** button on the toolbar . You will see that the checkboxes in the **Select** column are now all filled with checks. You may select or deselect individual measures by clicking their checkboxes in the **Select** column. In the next subsection, we will discuss operations that can be performed on selected measures, such as viewing them and exporting their data.

To unselect all of the measures, click the **Clear all the selections** button and you will see that all of the checks in the **Select** column are now removed.

Step 1-13: Show/Hide Columns. To hide some of the columns that are shown in the table, click the **Show/Hide columns** button . On the Show/Hide Columns dialog that appears (similar to the one shown in Figure 3.7, uncheck some of the checkboxes in the **Show?** column and then click **OK**. The columns you unchecked will no longer display in the control measures table.

Click the **Show/Hide columns** button again and scroll down through the list of columns at the top of the dialog to see others that are farther down the list. To select multiple columns to show or hide, click on the first column name of interest, hold down the shift key, then click a second column name to select the intervening columns, and then click the **Show** button or the **Hide** button to either show or hide those columns.

To select columns that are not next to each other, hold down the control key and click on the columns that you want to select; when you are finished selecting click **Show** or **Hide**. The remaining buttons on the dialog are not used frequently: (a) **Invert** will invert the selection of highlighted columns. (b) The **Add Criteria/Delete Criteria** Filter section at the bottom can be used to locate columns when there are hundreds of column names, but there are no tables that large used in CoST.

Step 1-14: Format Columns. Click the **Format Columns** button, , to open the Format Columns dialog and examine the options for controlling how data in the table are shown. For example, check the checkboxes in the **Format?** column for one or more of the column names “**Avg CE**”, “**Min CE**”, and “**Max CE**” (note that you may first need to unhide the columns if you hid them in the previous step). Because these columns are all numeric, some controls used to format numbers will appear in the lower right corner.

Change the **Font** to **Arial**, the **Style** to **Bold**, the **Size** to **14**, the **Horizontal Alignment** to **Left**, the **Text Color** to **blue**, the **Column Width** to **6**, the number of **Decimal Places** to **0**, and select **Significant Digits**. Once these selections have been made, the dialog should look similar to the one in Figure 3.8. Click **OK** after making these selections to apply the formatting to the Control Measures table. The columns selected for formatting will have the attributes specified on the Format Columns dialog. In practice, this dialog is not used very often, but it can be particularly helpful to format numeric data by changing the number of decimal places or the number of significant digits shown.

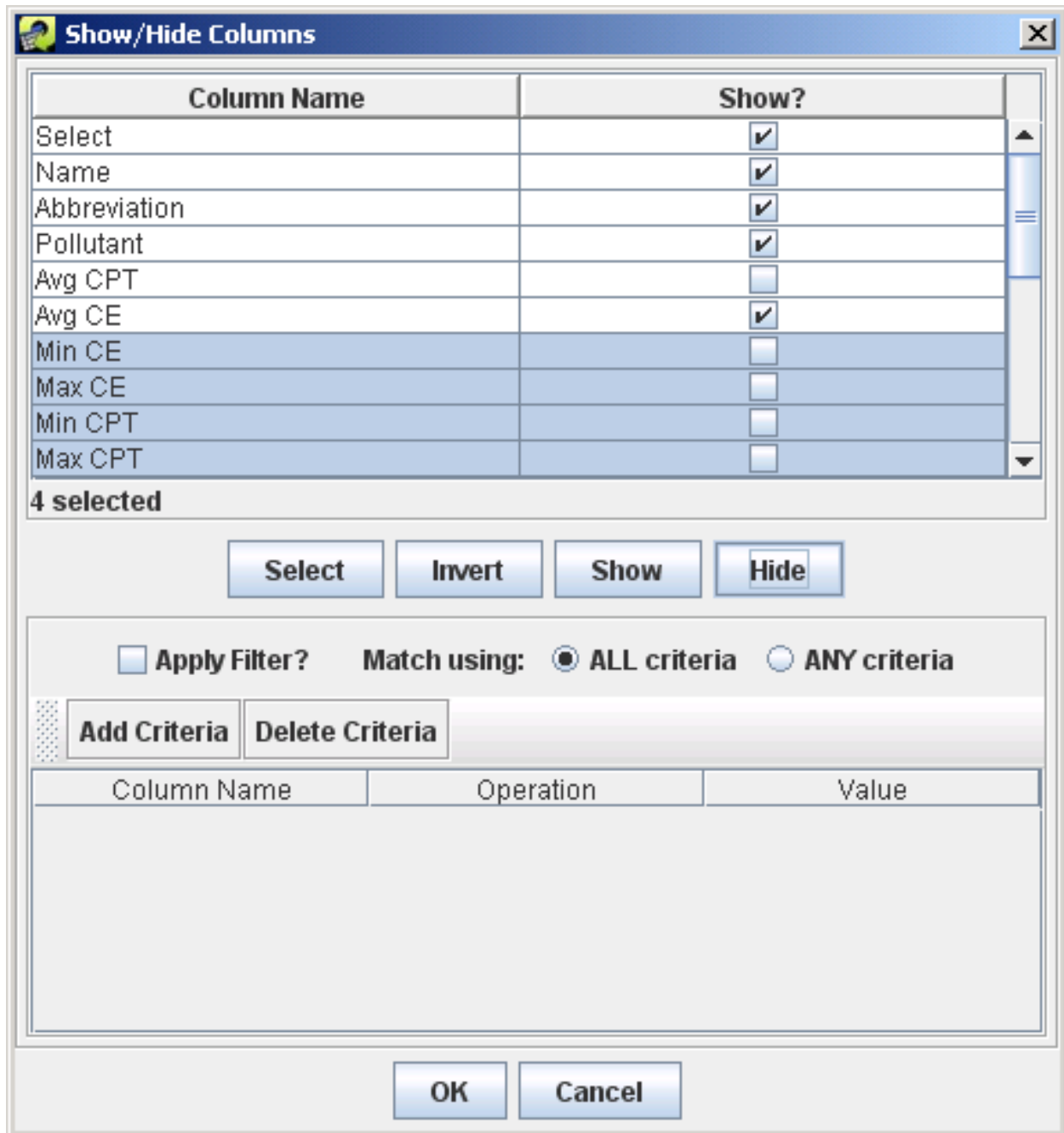


Figure 3.7: Show/Hide Columns Dialog

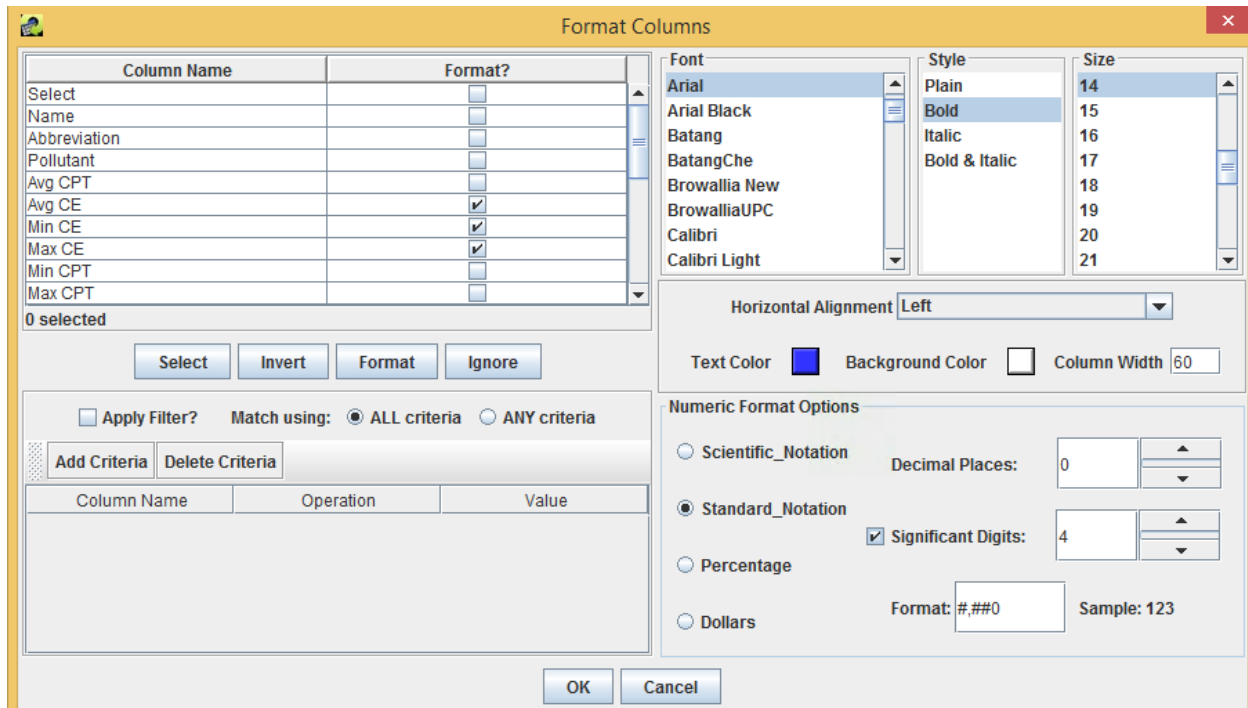


Figure 3.8: Format Columns Dialog

Step 1-15: Reset Control Measures Table. To remove sort criteria, row and column filters, and formatting, click the **Reset** button in the Control Measure Manager window.

Step 1-16: Mouse Hover Tooltip. If you are unsure of what a button does when using CoST, place your cursor over the button and wait; in many cases, a small piece of text called a “**tooltip**” will appear. For example, place your cursor over one of the buttons on the Control Measure Manager window and hold it still. You will see a tooltip describing what the button does. Many of the buttons and fields used in CoST have tooltips to clarify what they do or what type of data should be entered.

Step 1-17: Update Control Measures List. If you wish to retrieve an updated set of control measures data from the CoST server, click the **Refresh** button at the upper right portion of the Control Measure Manager. Note that this will also reset any special formatting that you have specified, but any sort and filter settings will be preserved.

3.2 Viewing Data for an Existing Control Measure

In this section you will learn about viewing the detailed data for a control measure.

Step 2-1: Select a Control Measure. Select the control measure for which to view the underlying data. For example, in the Control Measure Manager, set the **Pollutant Filter** to **PM10-PRI**, and then in the table locate the Control Measure with the Name “**Dry Electrostatic Precipitator-Wire Plate Type;(PM10-PRI) Municipal Waste Incineration**” (Abbreviation = **PDESPMUWI**).

View Control Measure: Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Municipal Waste Incineration

Summary | Efficiencies | SCCs | Equations | Properties | References

Name: Dry Electrostatic Precipitator-Wire Plate Type;(PM10) M **Abbreviation:** PDESPMUWI

Description: Application: This control is the use of dry electrostatic precipitators (ESP) to reduce PM emissions. An ESP uses electrical forces to move particles in an exhaust stream onto collector plates. **Creator:** Catherine Seppanen

Last Modified Time: 2016/09/22 16:35 **Last Modified By:** Catherine Seppanen

Major Pollutant: PM25-PRI **Class:** Known

Control Technology: Dry Electrostatic Precipitator-Wire Pla... **Equipment life (yrs):** 20.0

Source Group: Municipal Waste Incineration **Date Reviewed:** 01/01/2006

NEI Device code(s): 10, 11, 12, 128

Sectors: ptnonipm **Months:** All Months

Report **Close**

Figure 3.9: Summary Tab of View Control Measure Window

*Hint: Typing the abbreviation into the **Name** or **Abbr contains** box will display the measure directly.*

Step 2-2: View Control Measure Data. Click the checkbox in the **Select** column next to the measure and click **View**. The View Control Measure window will appear as shown in Figure 3.9. There are several tabs available on the window; the Summary tab will be shown by default.

3.2.1 Control Measure Summary

Step 2-3: Examine Control Measure Summary. The Summary tab of the View Control Measure window contains high-level summary information about the measure. Table 3.2 shows brief descriptions of the fields on this tab.

Table 3.2: Control Measure Summary Tab Contents.

Component	Description
Name	A unique name that typically includes both the control technology used and the group of sources to which the measure applies.

Component	Description
Description	A description of the applicability of the measure and any other relevant information.
Abbreviation	A multi-character unique abbreviation that is used to assign the control measure to sources in the inventory. Ideally, the abbreviation should be somewhat readable so that the user has some idea of what type of measure it is from reading the abbreviation (e.g., the DESP in PDESPIBCL is short for ‘Dry Electrostatic Precipitator, the IB is short for ‘Industrial Boiler’, and the CL is short for ‘Coal’).
Creator	The name of the user who imported or created the measure.
Last Modified Time	The date and time on which the information about the measure was last modified in the editor or imported from a file.
Last Modified By	The last user to modify the measure.
Major Pollutant	The pollutant most controlled by the measure. This is used to group the measures only, and has no impact on how the measure is assigned to sources.
Control Technology	The control technology that is used for the measure (e.g., Low NOx burner). You can type a new entry into this field and then choose it from the pull-down menu in the future.
Source Group	The group of sources to which the measure applies (e.g., Fabricated Metal Products - Welding). You can type a new entry into this field and then choose it from the pull-down menu in the future.
NEI Device Code	The numeric code used in the NEI to indicate that the measure has been applied to a source. A cross-reference table to match the control measure abbreviations and NEI Device Codes to one another may be created.
Class	The class of the measure. Options are Known (i.e., already in use), Emerging (i.e., realistic, but in an experimental phase), Hypothetical (i.e., the specified data are hypothetical), and Temporary (i.e., the specified data are temporary and should be used only for testing purposes).
Equipment Life	The expected life of the control measure equipment, in years.
Date Reviewed	The date on which the data for the measure were last reviewed.
Sectors	An emissions inventory sector or set of emissions inventory sectors to which the measure applies. A sector represents a broad group of similar emissions sources.
Months	The month(s) of the year to which the control measure is applicable. This is either “All Months” or a list of individual months (e.g., March, April, and May for measures applicable only in spring months).

When viewing a control measure (as opposed to editing a control measure), you cannot make changes to any of the selections. However, you can review the available selections for some

#	Select	Pollutant	Locale	Effective Date	Cost Year	CPT	Ref Yr CPT	Control Efficiency	Min Emis
1	<input type="checkbox"/>	PM10-PRI						98.00	
2	<input type="checkbox"/>	PM25-PRI			1995	137.00	194.45	95.00	

Figure 3.10: Efficiencies Tab of View Control Measure Window

fields. Use the pull-down menus next to the fields **Major Pollutant**, **Control Technology**, **Source Group**, and **Class** to see the available options for each of these fields. Note that if you make a selection that differs from the original value on one of these menus, the new value will not be saved when you close the window because you are only viewing the measure data.

3.2.2 Control Measure Efficiencies

Step 2-4: Examine Control Measure Efficiencies. Click on the **Efficiencies** tab in the View Control Measure Window to see the data that are available from this tab. You will see a table with many columns. Each row in the table corresponds to a different “efficiency record” in the database. An efficiency record contains cost and control efficiency information about the control measure. In the example shown in Figure 3.10, notice that the **Control Efficiency** and **cost per ton data (CPT)** vary by pollutant. Scroll to the right in the table to see some of the other columns that are not immediately visible.

If the cost or control efficiency varies over region or time, it is possible to specify different records in the table for each **Locale** (i.e., state or county) or for each **Effective Date** if the measure will be “phased in” over time. Different efficiency records can also be entered to account for different source sizes using the **Min Emis** and **Max Emis** columns.

The **Row Limit** and **Row Filter** fields are helpful when there are hundreds of efficiency records (e.g., some data may be county specific and available for multiple pollutants). The

Row Limit is the maximum number of records that will be displayed on the page. For example, if there were several hundred records, it could take a long time to transfer all of those data from the server, so by default only 100 records will be transferred if the Row Limit is set to 100.

Step 2-5: Apply a Row Filter to Control Measure Efficiencies. To apply a Row Filter to the control efficiencies, enter `Pollutant='PM10-PRI'` into the text field and then click **Apply** to display only the record for PM10-PRI. The Row Filter follows the syntax of a Structured Query Language (SQL) 'WHERE' clause. Note that the filter may not seem necessary in this particular example that only has a few records, but if this measure had entries for every county and pollutant, as do some mobile measures, then the filter is useful for limiting the number records displayed. If desired, you may try some other filters with this measure, such as:

```
Pollutant like 'PM%'
Pollutant='PM10-PRI'
Control Efficiency > 95
```

Here are some examples of other types of filters that illustrate other aspects of the syntax, although they may not all be applicable to this particular measure:

```
Pollutant <> 'PM10-PRI'
Locale LIKE '37%'
Pollutant IN ('EXH__CO', 'EXH__VOC', 'EXH__PM10-PRI')
```

Step 2-6: View an Efficiency Record in a Separate Window. To see the data for an efficiency record in a separate window, check the checkbox in the **Select** row for the PM25-PRI efficiency record, and click **View**. A View Efficiency Record window will appear as shown in Figure 3.11. The fields of the efficiency record are shown in Table 3-3.

Notice that most of the fields in Figure 3.11 are set using text fields. The **Ref Yr Cost Per Ton Reduced** is shown with a label because this value is automatically computed for the reference year (currently 2013) according to the cost year and the specified **Cost Per Ton Reduced**. Note that the cost per ton reduced should take into account the specified rule effectiveness and rule penetration, which can 'dilute' the effectiveness of the control measure, but are not taken into account when the **Ref Yr Cost Per Ton Reduced** is computed. Other fields that are labels are **Last Modified By** and **Last Modified Time**. These fields are automatically updated and tracked by CoST when someone edits the efficiency record, although editing is done from the Edit Efficiency Record window instead of the View Efficiency Record window.

Note: The efficiency records must be unique according to the contents of the following fields: Pollutant, Locale, Effective Date, Minimum Emissions, Maximum Emissions, and Existing Measure Abbreviation. This means that two records cannot have the same values for all of these fields.

Table 3-3. Efficiencies Record Window Contents.

View Efficiency Record 0 for Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Municipal Wast...

Pollutant:*	PM25-PRI	Rule Effectiveness (%)	100.0
Locale:		Rule Penetration (%)	100.0
Effective Date:		Equation Type:	cpton
Existing Measure Abbreviation:		Capital Recovery Factor:	
Existing NEI Device Code:	0	Discount Rate (%)	
Cost Year:	1995	Incremental CPT (Based on specified cost year dollars):	
Cost Per Ton Reduced:	137.0	Minimum Capacity (MW):	
Capital to Annual Ratio:		Maximum Capacity (MW):	
Ref Yr Cost Per Ton Reduced:	194.454376	Last Modified By:	Catherine Seppanen
Control Efficiency (% Red):*	95.0	Last Modified Time:	09/22/2016 16:36
Minimum Emissions:			
Maximum Emissions:			

Details:

Close

Figure 3.11: View Efficiency Record Window

Component	Description
Pollutant	The pollutant for which this record applies (emissions are either decreased or increased). An asterisk appears beside this field because a value for it must be specified.
Locale	A two-digit Federal Information Processing Standards (FIPS) state code, or a five-digit FIPS county code, to denote that the information on the row is relevant only for a particular state or county. If left blank, it is assumed to apply to all states and counties.
Effective Date	The month, day, and year on which the record becomes effective. The system will find the record with the closest effective date that is less than or equal to the date of the analysis. If this is left blank, the record is assumed to apply to any date.
Existing Measure Abbreviation	This field should be populated when the data on the row are provided, assuming that a control measure has already been applied to the source. The contents of the field should be the control measure abbreviation that corresponds to the existing measure. The reason for this field is that the efficiency of and cost of applying the measure may vary when there is already a control measure installed on a source.
Existing NEI Device Code	This is used in conjunction with Existing Measure and should specify the device code used in the NEI that corresponds to the currently installed device.
Cost Year	The year for which the cost data are provided.
Cost per Ton Reduced	The cost to reduce each ton of the specified pollutant.
Capital to Annual Ratio	The ratio of capital costs to annual costs. <i>Applicable only for equation-based annualized costs.</i>
Ref Yr Cost per Ton Reduced	The cost per ton to reduce the pollutant in 2013 dollars.
Control Efficiency	The [median] control efficiency (in units of percent reduction) that is achieved when the measure is applied to the source, exclusive of rule effectiveness and rule penetration. An asterisk is shown next to the field because a value for the field is required, whereas other fields are optional. Eventually, statistical distributions for percent reduction may be provided to facilitate uncertainty analysis. <i>Note that there are sometimes disbenefits for certain pollutants as a result of the control device, so control efficiency can be negative to indicate that the amount of a pollutant actually increased.</i>
Minimum Emissions	The lower limit of emissions from the inventory required for the control measure to be applied.
Maximum Emissions	The upper limit of emissions from the inventory for the control measure to be applied.

Component	Description
Rule Effectiveness	The ability of a regulatory program to achieve all the emissions reductions that could have been achieved by full compliance with the applicable regulations at all sources at all times. A rule effectiveness of 100% means that all sources are fully complying at all times. Rule effectiveness can sometimes vary by locale.
Rule Penetration	The percent of sources that are required to implement the control measure. Rule penetration might vary over time as a new rule is “phased in” gradually, and can sometimes vary by locale.
Equation Type	The type of cost equation to use.
Minimum Capacity (MW)	The minimum capacity for the control measure (megawatts).
Maximum Capacity (MW)	The maximum capacity for the control measure (megawatts).
Last Modified By	The last user to modify the efficiency record.
Last Modified Time	The last date and time a user modified the efficiency record.
Details	Text that specifies information about the source of data for this row or reason they were changed.

When you are done examining the information on the View Efficiency Record Window, click **Close**.

3.2.3 Control Measure SCCs

Step 2-7: View the Control Measure SCCs. The inventory sources to which a control measure could be applied are listed in the **SCCs** tab for the control measure.

Note that while multiple SCCs can be specified for a measure, if the control efficiency or cost data differs for any of the SCCs, then a separate measure must be created to contain that data.

Click on the **SCCs** tab in the View Control Measure window to see the SCCs associated with the measure. An example of this tab is shown in Figure 3.12. The selected control measure is applicable only to SCCs listed on this tab.

Note that CoST currently does not support wildcards in the SCC list for a control measure. There is no expanding of SCC codes ending in zeros; therefore each applicable SCC must be explicitly listed on this tab. You may sort and filter the SCCs in the table to get a better idea of what SCCs are associated with the measure.

Do not click **Close** after examining the SCC list as this will close the View Control Measure window, which we will use for the next step.

#	Select	SCC	% capacity	description
1	<input type="checkbox"/>	50100101	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Starved Air: Multiple Chamber
2	<input type="checkbox"/>	50100102	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Mass Burn: Single Chamber
3	<input type="checkbox"/>	50100103	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Refuse Derived Fuel
4	<input type="checkbox"/>	50100104	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Mass Burn Refractory Wall Combustor
5	<input type="checkbox"/>	50100105	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Mass Burn Waterwall Combustor
6	<input type="checkbox"/>	50100106	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Mass Burn Rotary Waterwall Combustor
7	<input type="checkbox"/>	50100107	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Modular Excess Air Combustor
8	<input type="checkbox"/>	50100108	100.00	Waste Disposal; Solid Waste Disposal - Government; Municipal Incineration; Fluidized Bed: Refuse Derived Fuel

Figure 3.12: SCCs Tab of View Control Measure Window

3.2.4 Control Measure Equations

As an alternative to using a simple ‘cost per ton of pollutant reduced’ value to compute the cost of a control measure, an engineering cost equation can be specified. The cost equation will then be used to associate emissions control costs with a particular pollutant. The equation must be selected from a list of pre-specified equation types. The cost will be computed using the form of the equation specified on the equations tab, source-independent variables listed in the equations tab, and source-dependent variables from the emissions inventory (e.g., stack flow rate). Currently, only a single equation can be specified for any given measure.

Step 2-8: View the Control Measure Equations. Click on the **Equations** tab on the View Control Measure window to see information associated with the cost equations for the selected measure. An example of this tab is shown in Figure 3.13. If the measure does not use a cost equation, this tab will be blank. The table at the bottom of the **Equations** tab shows the **Equation Type** (the same type is repeated in every row), in addition to the **Variable Name** and **Value** for that variable. The fields of the **Equations** tab are shown in Table 3-4.

Each type of equation uses a different set of variables. CoST supports fourteen different types of cost equations. Additional types of equations may be added in the future. For more information on the equations and their input variables, see the [Documentation of Cost Equations in the EPA’s Control Strategy Tool \(CoST\)](#). The appropriate form of the equation will be used in conjunction with the specified values to compute the total cost of applying the measure to the source for the specified pollutant and cost year.

Do not click **Close** after examining the **Equations** tab as this will close the View Control Measure window, which we will use for the next step.

View Control Measure: Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Municipal Waste Incineration

Summary Efficiencies SCCs **Equations** Properties References

Equation Type:
 Name: Type 8
 Description: Non-EGU PM
 Inventory Fields: stack_flow_rate

Equations:

Capital Cost= Typical Capital Cost x Min. Stack Flow Rate
 O&M Cost= Typical O&M Cost x Min. Stack Flow Rate
 Total Cost = Capital Cost x CRF + 0.04 x capital cost + O&M Cost

Equation Type	Variable Name	Value
Type 8	Pollutant	PM2_5
Type 8	Cost Year	1995
Type 8	Typical Capital Control Cost Factor	27.0
Type 8	Typical O&M Control Cost Factor	16.0
Type 8	Typical Default CPT Factor - Capital	710.0
Type 8	Typical Default CPT Factor - O&M	41.0
Type 8	Typical Default CPT Factor - Annualized	110.0

Report Close

Figure 3.13: Equations Tab of View Control Measure Window

Table 3-4. Efficiencies Record Window Contents.

Component	Description
Name	The name of the engineering cost equation type (e.g., Type 8).
Description	The description of the engineering cost equation type (e.g., Non-EGU PM Cost Equation).
Inventory Fields	The input parameters to the cost equations found in the inventory (e.g., stack velocity and temperature or design capacity).
Equations	The cost equation definitions.

3.2.5 Control Measure Properties

Step 2-9: View the Control Measure Properties. Click on the **Properties** tab on the View Control Measure window to see the data that are available from this tab. Each row in the Properties tab corresponds to a different “property record” in the database. A property record allows for generic information to be stored about the control measures (e.g., metadata). The control measures example in Figure 3.14 shows property information that happened to be archived from the AirControlNET software when the measures were transferred into the CMDB.

Step 2-10: View a Properties Record in a Separate Window. To see the data for a property record in a separate window, check a checkbox in the **Select** column and click **View**. For example, select the **STEAM_PCT** property record and click **View**. Figure 3.15 shows the View Property Record window that will appear. The fields of the property record are shown in Table 3-5.

Notice that most of the fields in Figure 3.15 are set using text fields. The **Category** is a free-form drop down, where an existing category could be used or a new one could be used by typing in the new category.

Do not click Close after examining the Properties tab as this will close the View Control Measure window, which we will use for the next step.

Table 3-5. Property Record Window Contents.

Component	Description
Name	The name of the property.
Category	The category for the property (e.g., AirControlNET Properties, Cost Properties, or Control Efficiency Properties).
Units	The units for the property (e.g., % for percentage).
Data Type	If applicable, this defines the data type of the property (e.g., double precision/float for numeric values, or a varchar/string for textual information).

Component	Description
DB Field Name	If specified, this is a placeholder to help identify the database field name from the particular data source reference that supplied the property information (e.g., an ancillary dataset has a steam percentage stored in the STEAM_PCT table field/column).
Value	The value of the property.

3.2.6 Control Measure References

Step 2-11: View the Control Measure References. Click on the **References** tab of the View Control Measure window to see the report and literature citations associated with a control measure (Figure 3.16). Each row in the table corresponds to a different “reference record” in the database. A reference record stores source and reference information for the primary information used to create a control measure.

Step 2-12: View a References Record in a Separate Window. To see the data for a reference record in a separate window, check a checkbox in the **Select** column and click **View**. For example, check the checkbox for the first reference record and click **View**. A View Reference Record window will appear (Figure 3.17) with an editable source/reference description text field.

When you are done examining the information on the View Reference Record Window, click **Close**.

This concludes the exercises on examining existing control measures. Click **Close** to close the View Control Measure window.

3.3 Copying a Control Measure

One way to create a new control measure in CoST is to copy an existing control measure and then edit its data.

Step 3-1: Copy a Control Measure. To copy a control measure, first find a measure to copy. Start by clicking the **Reset** button on the toolbar of the Control Measure Manager to remove any previously specified filters.

Next, uncheck the **Show Details** button at the top of the Control Measure Manager (to speed the data transfer) and set the **Pollutant Filter** at the top of the Control Measure Manager to the pollutant of interest. For this example select **NOx** and find the measure named “**Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas**” (Abbreviation = **NSNCRIBNG**). *Hint: You may want to apply a filter to the manager to make it easier to find this specific measure.*

Once you have found the measure to copy, check the corresponding checkbox in the **Select** column and then click the **Copy** button. CoST will create a new control measure called

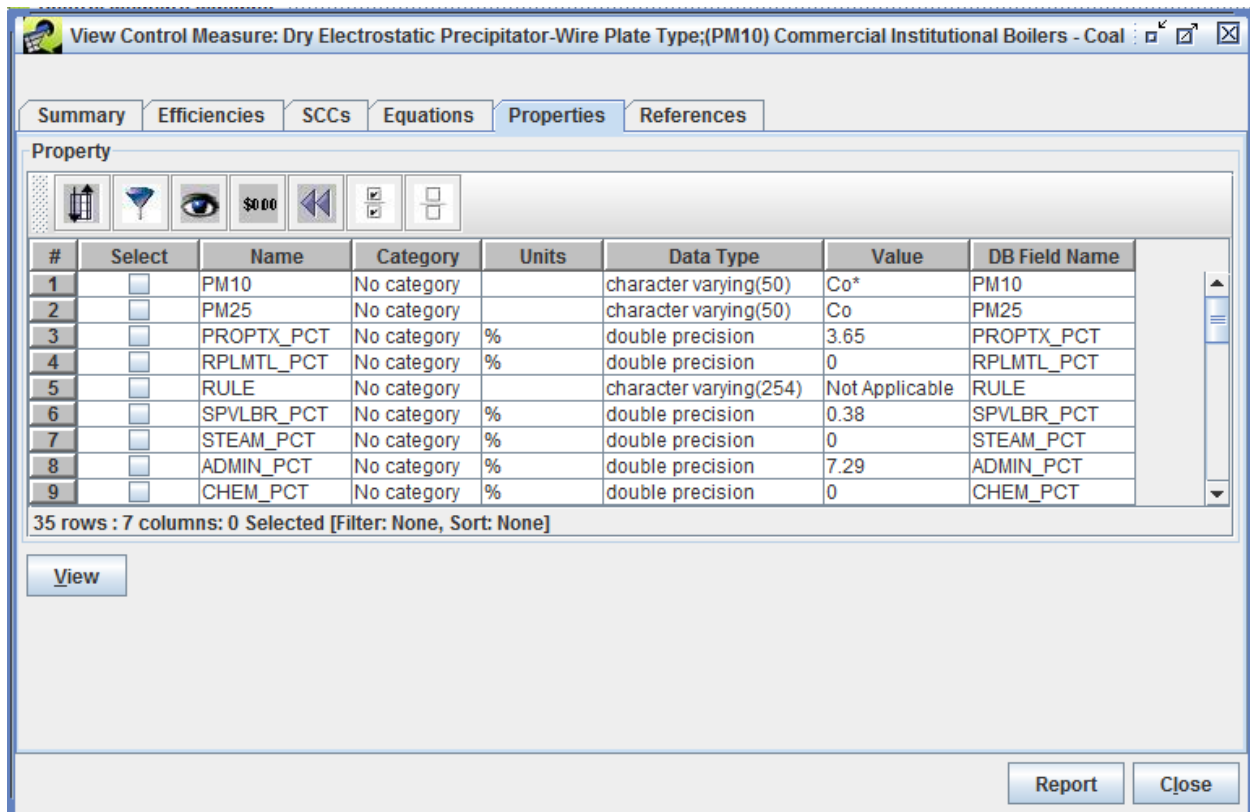
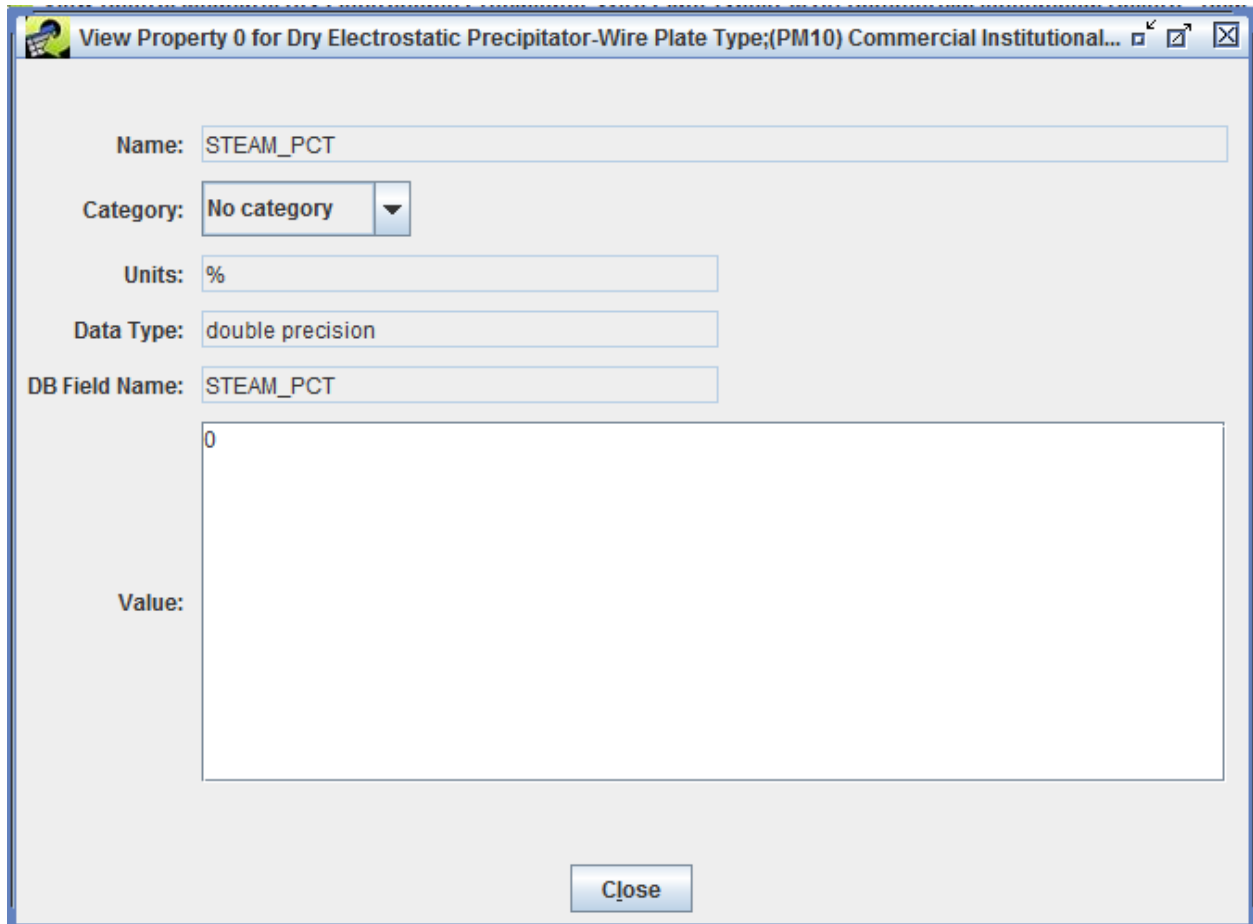


Figure 3.14: Properties Tab of View Control Measure Window



The screenshot shows a window titled "View Property 0 for Dry Electrostatic Precipitator-Wire Plate Type;(PM10) Commercial Institutional...". The window contains the following fields and controls:

- Name:** A text box containing "STEAM_PCT".
- Category:** A dropdown menu currently showing "No category".
- Units:** A text box containing "%".
- Data Type:** A text box containing "double precision".
- DB Field Name:** A text box containing "STEAM_PCT".
- Value:** A large text area containing the number "0".
- Close:** A button at the bottom center of the window.

Figure 3.15: View Property Record Window

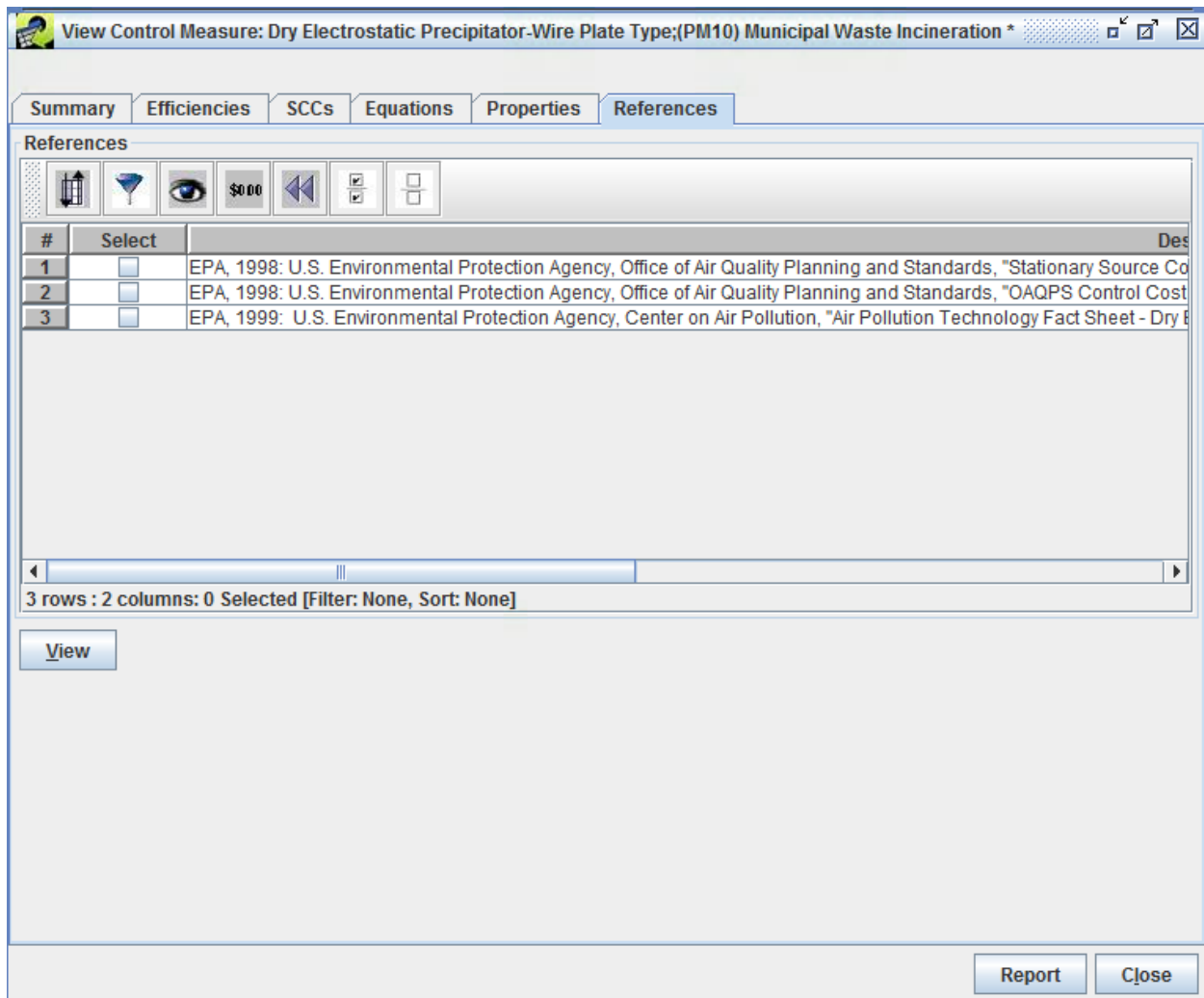


Figure 3.16: References Tab of View Control Measure Window

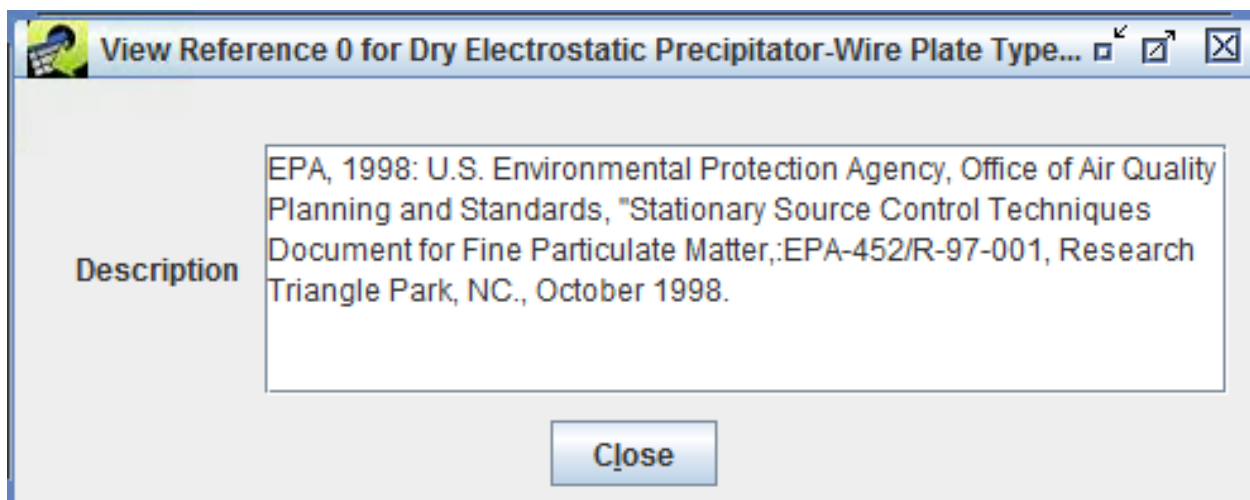


Figure 3.17: View Reference Record Window

“Copy of *the starting measure name your name unique #. A unique abbreviation will also be automatically generated for the measure.

Step 3-2: View the Copied Control Measure. To see the new control measure in the Control Measure Manager, **Scroll** to the top of the window. If you do not see the measure, click the **Refresh** button at the top right of the Manager window to obtain updated data from the CoST server.

Note: If the measure named ‘Copy of Selective Non-Catalytic Reduction; ICI Boilers...’ still does not appear, a filter may be active that is preventing the measure from showing up. Remove any filters to see the newly copied measure.

View the contents of the copied measure by selecting the checkbox next to the measure and clicking the **View** button. The new measure will be edited in the next section.

3.4 Editing Control Measure Data

Only control measures created by the current CoST user can be edited through the Control Measure Manager. CoST Administrators can edit all of the measures in the CMDB.

Step 4-1: Find a Control Measure to Edit. First, click the **Clear all the selections** button to unselect any previously selected measures. For this exercise, find the measure created using the copy button ([Section 3](#)) in the Control Measure Manager and check the corresponding select box in the **Select** column. Click **Edit** to edit the data for the control measure. The Edit Control Measure window will appear [Figure 3.18](#).

3.4.1 Editing a Control Measure Summary

Like the View Control Measure window, the Edit Control Measure window has six tabs, and the **Summary** tab is shown by default. The main difference between the View and Edit windows is that the control measure contents can be changed in the Edit window, rather than just viewing the information.

Notice that most of the fields have white backgrounds, which usually indicates that the field is editable; fields that are not contained within boxes are set by the software and cannot be changed by the user. In addition, there are **Add** and **Remove** buttons for the lists of Sectors and Months.

Step 4-2: Change a Control Measure Name. The name of a control measure can be changed on the **Summary** tab of Edit Control Measure window. For example, you may change the part of the measure name that deals with the affected sources, such as **Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas and Oil**. Recall that measure names must be unique.

When the measure was copied, the abbreviation was set to a number that was known to be unique so that it could be saved in the database. Replace the automatically generated **Abbreviation** for the new measure with something else (e.g., **NSNCRIBNGO**). Try to

Edit Efficiency Record 1 for Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas

Pollutant:*	NOX	Rule Effectiveness (%):	100.0
Locale:		Rule Penetration (%):	100.0
Effective Date:		Equation Type:	cpton
Existing Measure Abbreviation:		Capital Recovery Factor:	
Existing NEI Device Code:	0	Discount Rate (%):	
Cost Year:	2008	Incremental CPT (Based on specified cost year dollars):	
Cost Per Ton Reduced:	5215.0	Minimum Capacity (MW):	
Capital to Annual Ratio:		Maximum Capacity (MW):	
Ref Yr Cost Per Ton Reduced:	5617.87158	Last Modified By:	Catherine Seppanen
Control Efficiency (% Red):*	45.0	Last Modified Time:	08/27/2017 16:03
Minimum Emissions:	100.0		
Maximum Emissions:			

Details:

Save **Cancel**

Figure 3.18: Summary Tab of Edit Control Measure Window

follow a similar naming convention as the other measures, but your new abbreviation must be unique in the database.

Step 4-3: Edit Other Fields in the Control Measure Summary. Edit the other **Summary** fields of the measure as desired. For this exercise, change the **Equipment Life** to **10**, change the **Date Reviewed** to **today's date**, set **Class** to **Emerging**, and make any other changes you wish, such as entering a more detailed **Description**.

Click the **Add** button under the **Sectors** list to add another sector for the measure. For example, from the **Select Sectors** dialog, choose **ptipm** (i.e., point sources handled by the Integrated Planning Model) and click **OK**. You will then see the new sector added to the list of applicable sectors. *Note that the sectors listed here are informational only; they do not affect the use of the measure in control strategies in any way.*

Step 4-4: Remove a Control Measure Sector. To remove a sector from a Control Measure, click on the sector in the list and click **Remove** and it will no longer appear on the list.

Step 4-5: Setting Months for a Control Measure. Adding and removing **Months** to which a control measure applies works similarly to adding and removing sectors. For this exercise, specify some particular months to which the measure should apply (e.g., **March**, **April**, and **May**).

Note: the feature of setting specific months for which a measure applies is effective only when applying measures to monthly emissions inventories. Specifying months in this way is not effective when applying measures to annual emissions inventories.

To set the months back to All Months, select all of the months in the **Months** list by clicking on the first month, scrolling to the last month in the list, and using **shift-click** with your mouse to select all of the months in the list. Click **Remove** to remove specific months and to set the measure to be applicable to all months.

Step 4-6: Discard Changes. Now that you have changed information for the measure, notice that an asterisk (*) appears after the measure name in the title for the window. This means that CoST is aware that you have made changes. If you try to **Close** a window on which you have made changes to the data without saving it, CoST will ask you “Would you like to discard the changes and close the current window?” If you want to discard (i.e., undo) ALL of the changes made since you started editing the measure, click **Yes**. If you prefer to not to close the window so that your changes stay in-tact, click **No**. For this exercise, click **No** to preserve the changes that you made.

3.4.2 Editing Control Measure Efficiencies

Step 4-7: Edit Control Measure Efficiencies. Go to the **Efficiencies** tab of the **Edit Control Measure Window** Figure 3.19. The buttons on the **Efficiencies** tab of the **Edit** window are different from those on the **View** window. The available buttons are **Add**, **Edit**, and **Remove**. Notice the efficiency record for the measure shown in Figure 3.19 is for only one

Edit Control Measure: Copy of Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas Liz Adams 1359 *

Summary Efficiencies SCCs Equations Properties References

Row Limit: 100 Row Filter: Apply

Icons:

#	Select	Pollutant	Locale	Effective Date	Cost Year	CPT	Ref Yr CPT	Control Efficiency	Min Emis	Max I
1	<input checked="" type="checkbox"/>	NOX			2008	2,430.00	2,617.72	45.00	25.00	

1 rows : 24 columns: 1 Selected [Filter: None, Sort: None]

Add Edit Copy Remove

Report Save Close

Figure 3.19: Efficiencies Tab of Edit Control Measure Window

Edit Efficiency Record 1 for Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas

Pollutant:* NOX	Rule Effectiveness (%): 100.0
Locale:	Rule Penetration (%): 100.0
Effective Date:	Equation Type: cpton
Existing Measure Abbreviation:	Capital Recovery Factor:
Existing NEI Device Code: 0	Discount Rate (%):
Cost Year: 2008	Incremental CPT (Based on specified cost year dollars):
Cost Per Ton Reduced: 5215.0	Minimum Capacity (MW):
Capital to Annual Ratio:	Maximum Capacity (MW):
Ref Yr Cost Per Ton Reduced: 5617.87158	Last Modified By: Catherine Seppanen
Control Efficiency (% Red):* 45.0	Last Modified Time: 08/27/2017 16:03
Minimum Emissions: 100.0	
Maximum Emissions:	

Details:

Save Cancel

Figure 3.20: Edit Efficiency Record Window

pollutant, and that this record can be applied only to sources emitting at least 25 tons/yr as specified in the **Min Emis** field.

Scroll to the right to examine additional fields. Note that more of the fields are filled in for NO_x than for the PM measure that you examined in [Section 2](#). The additional data allows CoST to compute the capital and operating and maintenance (O&M) costs in addition to overall annualized costs when this measure is used in a control strategy.

To edit an efficiency record, check the checkbox in the **Select** column for the pollutant to edit and then click **Edit**. The Edit Efficiency Record window will appear [Figure 3.20](#).

Edit the values for the efficiency record to configure the new control measure. For this exercise, set **Maximum Emissions** to **5000** and click **Save**. The value for this field is now updated in the table in the Edit Control Measure window. The measure will apply only to sources that emit between 25 and 5000 tons of NO_x annually.

Step 4-8: Add a Control Measure Efficiency Record. To add a new efficiency record, click **Add** in the Edit Control Measure **Efficiencies** tab. Fill in the fields in the Add Efficiency Record window to create the new Efficiencies record. For this exercise, select **CO₂** as the **Pollutant**, set **Locale** to **06**, set **Effective Date** to **01/01/2025**, and set **Control**

Efficiency (% Red) to **10**. Click **Save** to save the new record. A new row will appear in the table on the **Efficiencies** tab in the Edit Control Measure window. The effect of this new record will be to include a 10% reduction to CO₂ emissions for sources in California (FIPS=06) starting on 01/01/2025 when this control measure is applied.

Step 4-9: Remove a Control Measure Efficiency Record. To remove one or more efficiency records, click the corresponding checkboxes next to the record and then click **Remove** to remove those records. For this exercise, click the checkbox in the **Select** column for the CO₂ record that you just added and click **Remove** to remove that record. When asked to confirm removal of the selected record, click **Yes**. The record will disappear from the Efficiencies tab.

Additive impact of multiple efficiency records. If cost per ton (CPT) values are specified for multiple efficiency records, they are additive when they are used in a control strategy. For example, if a CPT is specified for both NO_x and VOC for a measure, the total cost of applying the measure is the sum of (1) the CPT for NO_x times the NO_x emissions reduced and (2) the CPT for VOC times the VOC emissions reduced.

3.4.3 Editing Control Measure SCCs

Step 4-10: Edit Control Measure SCCs. Click on the **SCCs** tab on the Edit Control Measure window to show the SCCs for inventory sources to which the edited measure can be applied. SCCs may be added or removed for a measure from this window. An example of this tab is shown in Figure 3.21.

To add new SCCs, click the **Add** button to display the Select SCCs window (Figure 3.22). Note that there are over 11,900 possible SCCs to use for developing control measures. The number of available SCCs can be found in the lower left hand corner of the Select SCCs dialog.

To filter the SCCs for the new measure on the Select SCCs window, click the **Filter Rows** button on the toolbar. For this exercise, when the **Filter Rows** dialog that appears, click **Add Criteria** three times, enter the following criteria, then click **OK**:

- Description contains Natural Gas
- Description contains Boiler
- SCC starts with 1

The Select SCCs window will show only the SCCs that met the above criteria, such as the 13 SCCs shown in Figure 3.22. While many of these SCCs are already associated with the measure (i.e., they are already shown on the SCCs tab of the Edit Control Measure window in Figure 3.21, a few additional SCCs (i.e., the ones starting with 101 and 105) are also relevant for this measure.

Step 4-11: Add SCCs to a Control Measure. Click the checkbox in the **Select** column for the SCCs to add to the measure. For this exercise, select **10100601** and then click **OK**. The SCC will now appear in the list of applicable SCCs for the measure in the Edit Control

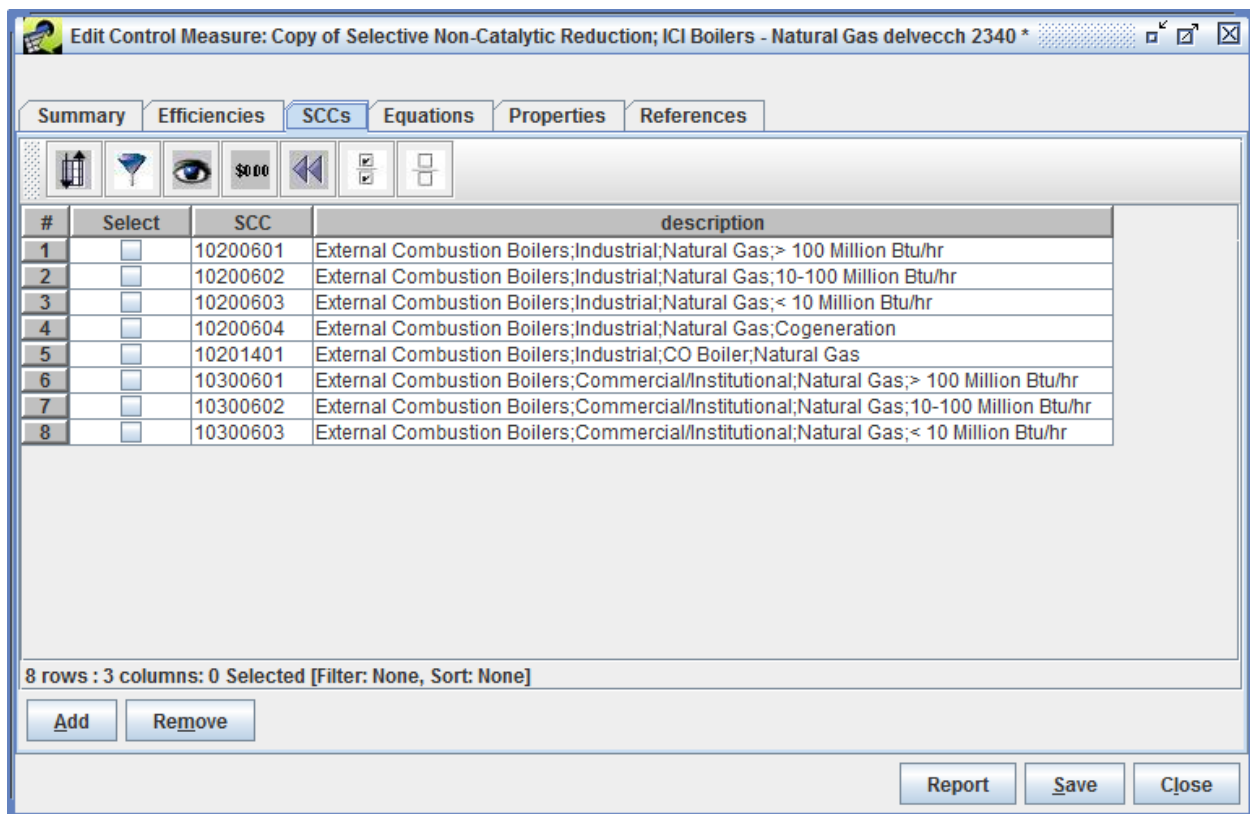


Figure 3.21: SCCs Tab of Edit Control Measure Window

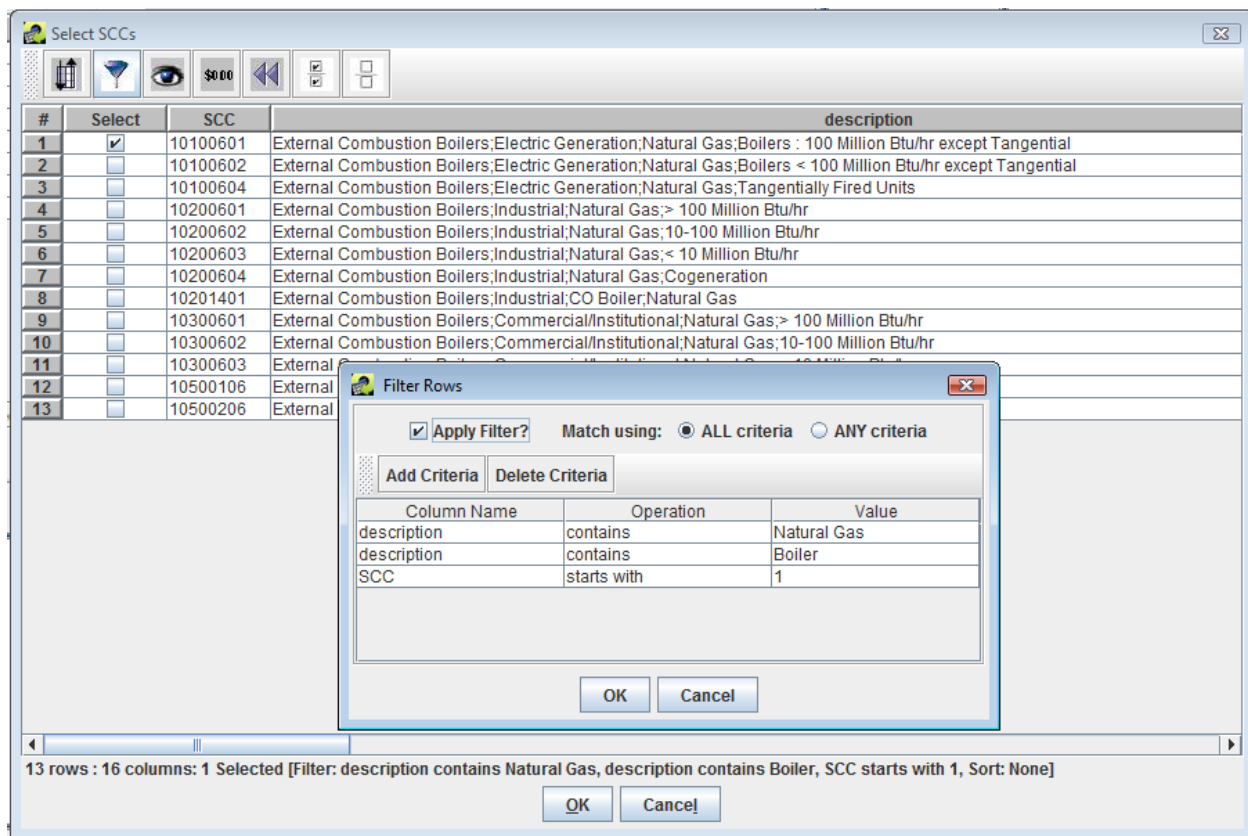


Figure 3.22: Select SCCs and Filter Rows Dialogs

Measure window. *Note: If you select an SCC to add that was already on the SCCs tab, it will not cause any problems and it will not add the SCC for a second time.*

Tip for adding multiple of SCCs: If you need to add several SCCs and are able to specify a filter on the Select SCCs dialog box that results in only the SCCs that are appropriate for the control measure being shown, click the **Select All** button on the toolbar to select all of the SCCs at once. Then, when you click **OK**, all of the SCCs will be added to the SCCs tab for the measure. This avoids requiring you to click all of the individual Select checkboxes. Alternatively, if most but not all of the SCCs were appropriate, you could select all of them and then click on a few checkboxes to deselect the ones that were not needed and then click **OK** to add only the ones that remained selected.

3.4.4 Editing Control Measure Equations

Step 4-12: Edit Control Measure Equations. Go to the **Equations** tab of the Edit Control Measure window (Figure 3.23). Double click your mouse in the **Value** column in the cell next to the variable named **Cost Year**. For this exercise, change the Cost Year value to **1995** and then press the **Enter** key on your keyboard. You will see that the new cost year is set to 1995. Note that the values for other fields could be changed in a similar way.

Step 4-13: Remove Control Measure Equation Data. To remove all of the equation information, click the **Remove** button. You will see a dialog that says “Are you sure you want to remove the equation information?”. To demonstrate how removing and resetting equation information works, click **Yes** to remove the equation information. All of the equation information will be removed from the **Equations** tab.

Step 4-14: Add Control Measure Equation Data. To add equation information to a measure, click the **Add** button on the **Equations** tab. You will see a Select Equation Type dialog. Click the pull-down menu to see the available types of equations and select the desired equation type. For this exercise, select **Type 1 - EGU** and click **OK**. You will see that there are eight variables for this equation type. Note that the variables differ somewhat from the variables for the Type 13 equation shown in Figure 3.23, and that the Type 1 equation is for NOx controls.

Details on the types of cost equations and their variables are given in the [Documentation of Cost Equations in the EPA’s Control Strategy Tool \(CoST\)](#).

For this exercise, click the **Remove** button again and click **Yes** to confirm removal of the equation information. Click the **Add** button on the **Equations** tab and select **Type 13 - ICI Boiler Cost Equations**. Next, fill in the values for the variables as they are shown in Figure 3.23 by double clicking on the field corresponding to each value and then entering the appropriate information.

Note: You can enter cost equations in terms of only one pollutant, even if the measure reduces emissions for multiple pollutants.

Click **Save** at the bottom of the Edit Control Measure window to save the changes you made to the control measure and to close the window. To see the revised name and abbreviation

Edit Control Measure: Copy of Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas delvecch 2340 *

Summary Efficiencies SCCs **Equations** Properties References

Equation Type:
 Name: Type 13
 Description: ICI Boiler Cost Equations
 Inventory Fields: design_capacity, design_capacity_unit_numerator, design_capacity_unit_denominator, stack_flow_rate, stack_velocity

Equations:

$$\text{Capital Cost} = \text{var1} * \text{input1}^{\text{var2}} + \text{var3} * \text{input1}^{\text{var4}}$$

$$\text{O\&M Costs} = \text{var5} + \text{var6} * \text{input1}^{\text{var7}} + \text{var8} * \text{input1}^{\text{var9}} + \text{var10} * \text{input3} + \text{var11} * \text{input2}$$
 where

Equation Type	Variable Name	Value
Type 13	Pollutant	NOX
Type 13	Cost Year	2008
Type 13	Capital Cost Size Multiplier No. 1	208706.86
Type 13	Capital Cost Exponent No. 1	0.21
Type 13	Capital Cost Size Multiplier No. 2	0.0
Type 13	Capital Cost Exponent No. 2	0.0
Type 13	O&M Known Costs	133401.0
Type 13	O&M Cost Size Multiplier No. 1	8348.3
Type 13	O&M Cost Exponent No. 1	0.21
Type 13	O&M Cost Size Multiplier No. 2	0.0
Type 13	O&M Cost Exponent No. 2	0.0
Type 13	O&M Flowrate Multiplier	19.24
Type 13	O&M Emissions Multiplier	425.3

Add Remove

Report Save Close

Figure 3.23: Equations Tab of Edit Control Measure Window

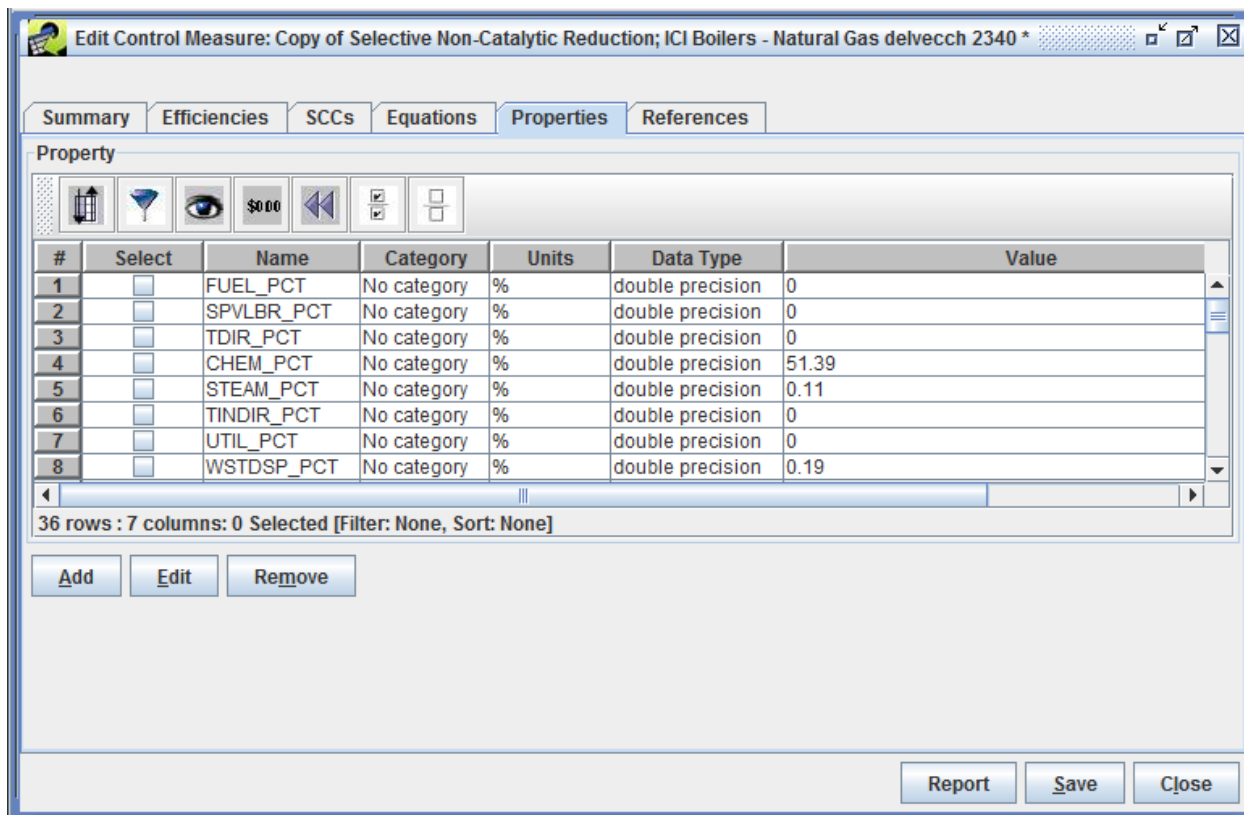


Figure 3.24: Properties Tab of Edit Control Measure Window

for the new measure, click the **Refresh** button at the upper right of the Control Measure Manager to load the updated data from the server.

3.4.5 Editing Control Measure Properties

Step 4-15: Edit Control Measure Properties. Go to the **Properties** tab of the Edit Control Measure Window (Figure 3.24). The buttons on the **Properties** tab of the Edit window are different from those on the View window. The available buttons are **Add**, **Edit**, and **Remove**. The property record allows for freeform property metadata/information to be associated with the measure. The property can be assigned a category grouping (e.g., Steam Factors), units (e.g., MW/hr), and a data type (e.g., numeric).

To edit a property record, scroll down to the **COST_BASIS** property, and check the corresponding checkbox in the **Select** column for the **COST_BASIS** property and then click **Edit**. The Edit Property Record window will appear (Figure 3.25). The data type is text, which means the property will contain textual information about the measure. Note also how the value field contains detailed information about the methodologies used for costing this control measure.

Edit the value for the property record as needed to reflect the new control measure. For this exercise, add some additional text to the **Value**, then click **Save**.

The screenshot shows a window titled "Edit Property 0 for Copy of Selective Non-Catalytic Reduction; ICI Boilers - Natural Gas delvecch 23...". The window contains the following fields and controls:

- Name:** A text box containing "COST_BASIS".
- Category:** A dropdown menu currently showing "No category".
- Units:** An empty text box.
- Data Type:** A text box containing "text".
- DB Field Name:** A text box containing "COST_BASIS".
- Value:** A large text area containing the following text:

Sources are distinguished by NOx emission levels (Pechan, 1998).

Small source = emission levels less than 1 ton per ozone season day

Costs for stationary source NOx control are based on an analysis of EPA's NOx State Implementation Plan (SIP) Call (Pechan, 1998). From this analysis, default cost per ton values are assigned for small sources. A discount rate of 7 percent and a capacity factor of 65 percent are assumed, along with an equipment life of 20 years (EPA, 1994).

In general, the incremental default cost is used for sources where there are existing controls (RACT baseline), with efficiencies less than or equal to 70% (Pechan, 2001).

At the bottom of the window are two buttons: "Save" and "Cancel".

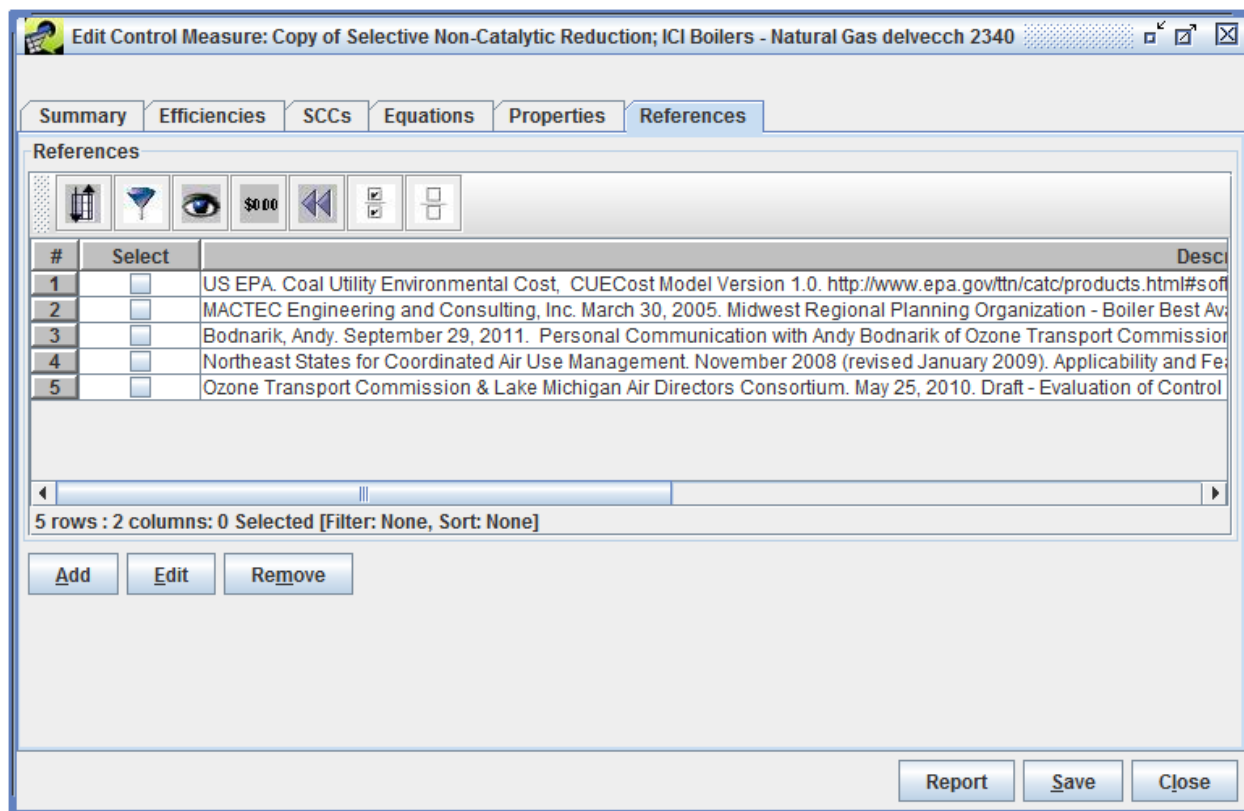
Figure 3.25: Edit Property Record Window

Step 4-16: Add a New Control Measure Property. To add a new property record, click **Add** in the **Properties** tab. Fill in the appropriate values in the Add Property Record window that appears. For this exercise, set the **Name** to “POWER_LOSS”, select **No** category as the **Category**, **MW/hr** for the **Units**, **numeric** for the **Data Type**, **POWER_LOSS** for the **DB Field Name**, and **5** as the **Value**. Click **Save** once this information is entered and a new row will appear in the table in the Edit Control Measure window.

Step 4-17: Remove a New Control Measure Property. To remove one or more property records, click the corresponding checkboxes and then click **Remove**. For this exercise, click the checkbox in the **Select** column for **POWER_LOSS** and then click **Remove** and confirm with **Yes** to remove that record. The **POWER_LOSS** record will disappear from the table.

3.4.6 Editing Control Measure References

Step 4-18: Edit Control Measure References. Go to the **References** tab of the Edit Control Measure Window (Figure {fig:references_tab_of_edit_control_measure_window}). The available edit buttons in this window are **Add**, **Edit**, and **Remove**.



{fig:references

To edit an existing reference record, check the corresponding checkbox in the **Select** column and click **Edit**. For example, click the box next to the “**MACTEC Engineering and Consulting...**” reference entry and then click **Edit**. The Edit Reference Record window will appear (Figure 3.26).

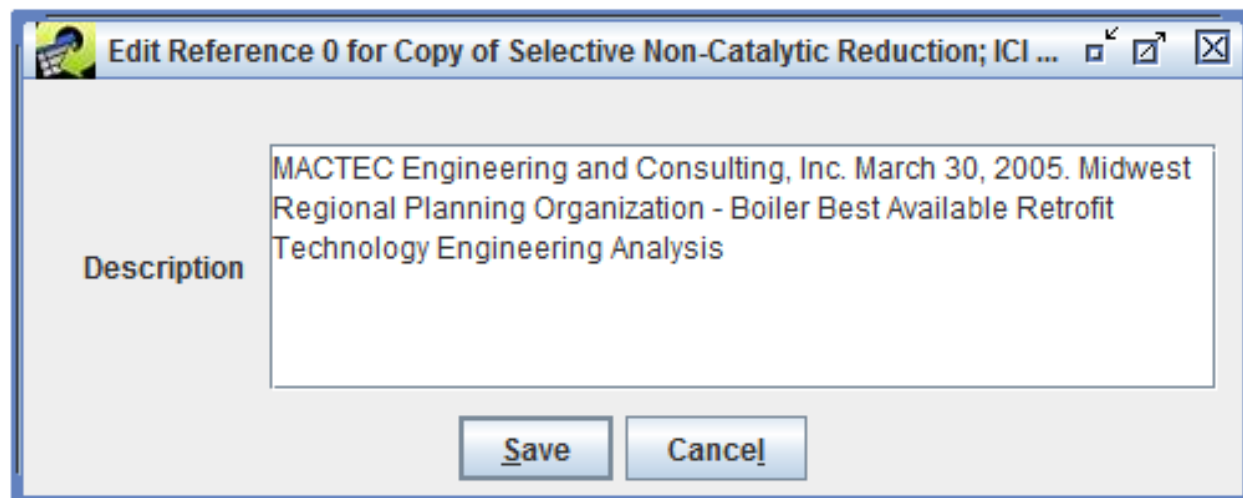


Figure 3.26: Edit Reference Record Window

Edit the value for the reference record as needed to reflect information for the new control measure. For this example, add some additional text to the **Description** box, then click **Save**.

Step 4-19: Adding Control Measure References. To add a new reference for a control measure, click **Add** in the **References** tab, and the **Add Reference Record** window will appear (Figure 3.27). Either choose a reference that already exists in the database, or add a new reference.

To choose an existing reference, click on the **Use existing reference** option and then search for the reference by filling in the **Text contains** field, then click **Search**. When you have located the correct reference, select the item in the **References** box and click **Save** to add the reference to the control measure.

To create a new reference, click on the **Create new reference** option and then type the reference in the **Description** field, then click **Save** to add the reference to the control measure. For this exercise, click on **Create new reference** and then add “**sample technical reference**” to the **Description** field. Click **Save** and a new row will appear in the **References** table in the **References** tab of the Edit Control Measure window.

Step 4-20: Remove Control Measure References. To remove one or more reference records in the **References** tab, click the checkbox(es) next to the reference(s) to remove and then click **Remove**. For this exercise, click the checkbox in the **Select** column for the record for “sample technical reference” that you just added and click **Remove** and **Yes** to confirm to remove that record. The record will disappear from the references table.

Click **Save** at the bottom of the Edit Control Measure window to save the changes you made to the control measure and to close the window.

Figure 3.27: Add Reference Record Window

3.5 Creating a New Control Measure

This section describes how to create new CoST control measures through the Control Measure Manager.

Step 5-1: Add a New Control Measure. To create a new control measure, click **New** on the Control Measure Manager to display the New Control Measure window as shown in Figure {[@fig:#summary_tab_of_edit_control_measure_window](#)}, except with none of the control measure information filled in.

Step 5-2: Adding a New Control Measure: Summary. Enter a unique name (e.g., New PM10-PRI Control Measure) in the **Name** field and a unique abbreviation (e.g., PNCM) in the **Abbreviation** field for the control measure. You must also set the **Major Pollutant** (e.g., PM10-PRI) and **Class** (e.g., Known) and the **Date Reviewed** for the measure before the measure can be saved into the CMDB. For more information on the fields in the Summary tab, see [Section 2](#) and [Section 4](#) above.

Step 5-3: Adding a New Control Measure: Efficiencies. Go to the **Efficiencies** tab of the New Control Measure window and add at least one efficiency record for the measure; otherwise it will have no effect on any emissions sources. The efficiencies tab for the new measure will look similar to [Figure 3.19](#), except initially there will be no efficiency records. For more information on the data needed for efficiency records, see [Section 2](#) and [Section 4](#). Add as many efficiency records as needed to describe the control efficiency and cost of the measure.

Step 5-4: Adding a New Control Measure: SCCs. Go to the **SCCs** tab of the New Control Measure window and add at least one SCC record for the measure; otherwise it

will have no effect on any emissions sources. The SCC tab for the new measure will look similar to Figure 3.21, except initially there will be no SCC records. Note that the same control efficiency and cost information must apply to all sources with SCCs listed on this tab, otherwise the information must be stored in a separate measure for the other SCCs. For more information on the data needed for SCCs, see Section 2 and Section 4.

Step 5-5: Adding a New Control Measure: Equations. To associate a cost equation with the new measure, go to the **Equations** tab and add an equation. The tab should look similar to the one shown in Figure 3.23. Cost equations are optional. If you do not have a cost equation, cost per ton information from one or more of the efficiency records will be used to estimate the cost of applying the measure.

Step 5-6: Adding a New Control Measure: Properties and References. To associate a property with the measure, go to the **Properties** tab and add a property. The tab should look similar to the one shown in Figure 3.24. Properties are optional.

To associate a reference with the measure, go to the **References** tab and add a reference. The tab should look similar to the one shown in Figure {`@fig:references_tab_of_edit_control_measure_window`}

After all of the relevant information for the measure has been entered, click **Save** at the bottom of the New Control Measure window.

Step 5-7: View the New Control Measure. Set the **Pollutant Filter** in the Control Measure Manager to a pollutant specified for one of the new measure's efficiency records (e.g. PM10-PRI), and you will see the new measure listed in the Control Measure Manager window. If you do not see it, try clicking the **Refresh** button to reload the measures from the server.

3.6 Finding Available Control Measures for Specific SCCs

If the SCCs are known for a source, the **Find** button on the Control Measure Manager (e.g., see Figure 3.4) can be used to display which control measures are available for sources with those SCCs.

Step 6-1: Find Control Measures for SCCs. Before using the Find feature, set the **Pollutant Filter** (in the top left corner of the Control Measure Manager) to **Select one**, and click the **Reset** button on the toolbar, so that no pollutant or other filters will be applied prior to performing the next step. Click the **Find** button. You will see the Select SCCs window, similar to the one shown in Figure 3.22, except that all 11,900+ SCCs will be shown.

Use the **Filter Rows** button on the toolbar of the Select SCCs window to enter a filter that will help identify SCCs for which you would like to see available control measures. For this example, click **Add Criteria** twice and add the filters **SCC starts with 103** and **SCC starts with 305006**, select **Match using ANY criteria**, and click **OK**. You should see 83 SCCs that meet this criterion.

Click the checkbox in the **Select** column for a few of the SCCs (e.g., select at least **10300101** and **30500606**) and then click **OK**. If there are measures available for the selected SCC(s), they will be shown in the table. If you selected an SCC for which there are no measures available, none will be shown.

Click **Find** again and enter a filter on the Select SCCs window based on the SCC description instead of the SCC itself. For example, use the **Filter Rows** button on the Select SCCs window toolbar to enter the filter **description contains Cement**, then click on the checkbox in the **Select** column for a few of these SCCs (e.g., 30500606) and click **OK**. If there are measures in the database for the selected SCCs, they will be shown in the Control Measure Manager table. Note that there may be some SCCs for which there are no measures available in the database. In that case, no measures would be shown in the table after applying the SCC filter. For the measures that are returned, notice whether they all have the same value for Pollutant (e.g., measures for SCC 30500606 target NO_x, PM₁₀-PRI, and SO₂).

3.7 The Pollutant Menu

The **Pollutant** pull-down menu near the bottom of the Control Measure Manager selects the pollutant for which the **CPT**, **Control Efficiency (CE)**, **Rule Effectiveness**, and **Rule Penetration** data are shown in the Control Measure Manager. Note that to view these fields **Show Details** must be checked and you may need to scroll right or widen the window. Recall that each control measure can have efficiency records for multiple pollutants. By setting the **Pollutant Filter** at the top of the window, any measures that controls the selected pollutant will be shown in the table. The **Pollutant** pull-down menu displays the specific setting for the selected pollutant.

Step 7-1: Use the Pollutant Menu. To see the effect of the Pollutant pull-down menu, click the **Reset** button on the Control Measure Manager toolbar to remove any previously specified filters. Set the **Pollutant Filter** to **PM25-PRI** and make sure that **Show Details?** is checked. Set the **Pollutant** menu at the bottom of the window to **MAJOR**.

Examine the values in the **Avg CPT**, **Min CPT**, **Max CPT**, **Avg CE**, **Min CE**, and **Max CE** columns for some of the measures. Notice that for some of the measures, PM25-PRI is not the pollutant listed in the **Pollutant** column (e.g., sort on the Pollutant column by clicking on it once or twice to find other pollutants). These measures are shown in the manager because they all apply to PM25-PRI, even if PM25-PRI is not the major pollutant for the measure. In this case, the CPT and CE values are shown for the major pollutant specified for the measure, not necessarily for PM25-PRI.

Change the value of the **Pollutant** menu to something other than **MAJOR** (e.g., **PM10-PRI**). All entries in the **Pollutant** column are now set to the pollutant specified in the **Pollutant** menu, and the cost per ton (CPT) and control efficiency (CE) values are specific to the selected pollutant instead of being for the major pollutant specified for the measure. Note that CPT values may not be filled in for some measures. For PM measures, the cost information is typically associated with PM10-PRI, as opposed to PM25-PRI. Therefore,

if the **Pollutant** menu is set to PM25-PRI, fewer CPT values will be shown than when **Pollutant** is set to PM10-PRI.

3.8 The Cost Year Menu

The **Cost Year** pull-down menu near the bottom of the Control Measure Manager controls the year for which the cost data are shown in the Manager. The default cost year is 2013. The cost data are converted between cost years using the Gross Domestic Product (GDP): Implicit Price Deflator (IPD), issued by the U.S. Department of Commerce, Bureau of Economic Analysis. Details of the computation used are given in the “Control Strategy Tool (CoST) Development Document.”

Step 8-1: Change the Cost Year. Change the cost year in the **Cost Year** menu from 2013 to an earlier year (e.g., 2010). Note how the CPT values decrease. If the cost year is changed to a later year, the CPT values increase.

Note that due to the method used to convert the costs between years, it is not possible to show costs for a future year (e.g., 2025); costs can be shown only for years prior to the current calendar year. The Cost Year cannot be set to the current calendar year because the economic data needed to make adjustments is not made available until after the end of each calendar year.

If an equation is specified for a measure, and there are no default CPT data available for that measure, the CPT will not be shown in the Control Measure Manager because it must be applied to an emissions source for the cost to be computed.

3.9 Importing and Exporting Control Measure Data

Control measure data can be exported from the Control Measure Manager to a set of CSV files. First identify a set of control measures for which to export data. Measures may be exported based on specifically selected control measures via the Control Measure Manager, or an entire set of measures associated with a certain sector may be exported.

3.9.1 Exporting Control Measures

Step 9-1: Export PM10-PRI Control Measures. To export measures that control PM10-PRI, set the **Pollutant Filter** on the Control Measure Manager to **PM10-PRI**. Next, use the **Filter Rows** button the toolbar to enter the following criterion: **Name contains Fabric Filter**. The Manager will display 44 measures.

Click the **Select all** button on the Control Measure Manager toolbar, and then click the **Export** button. The Exporting Control Measures window (Figure 3.28) will appear.

To export by selected measures, select the **Export By Measure** option. The list of measures displayed for export are the same measures that were chosen from the Control Measure

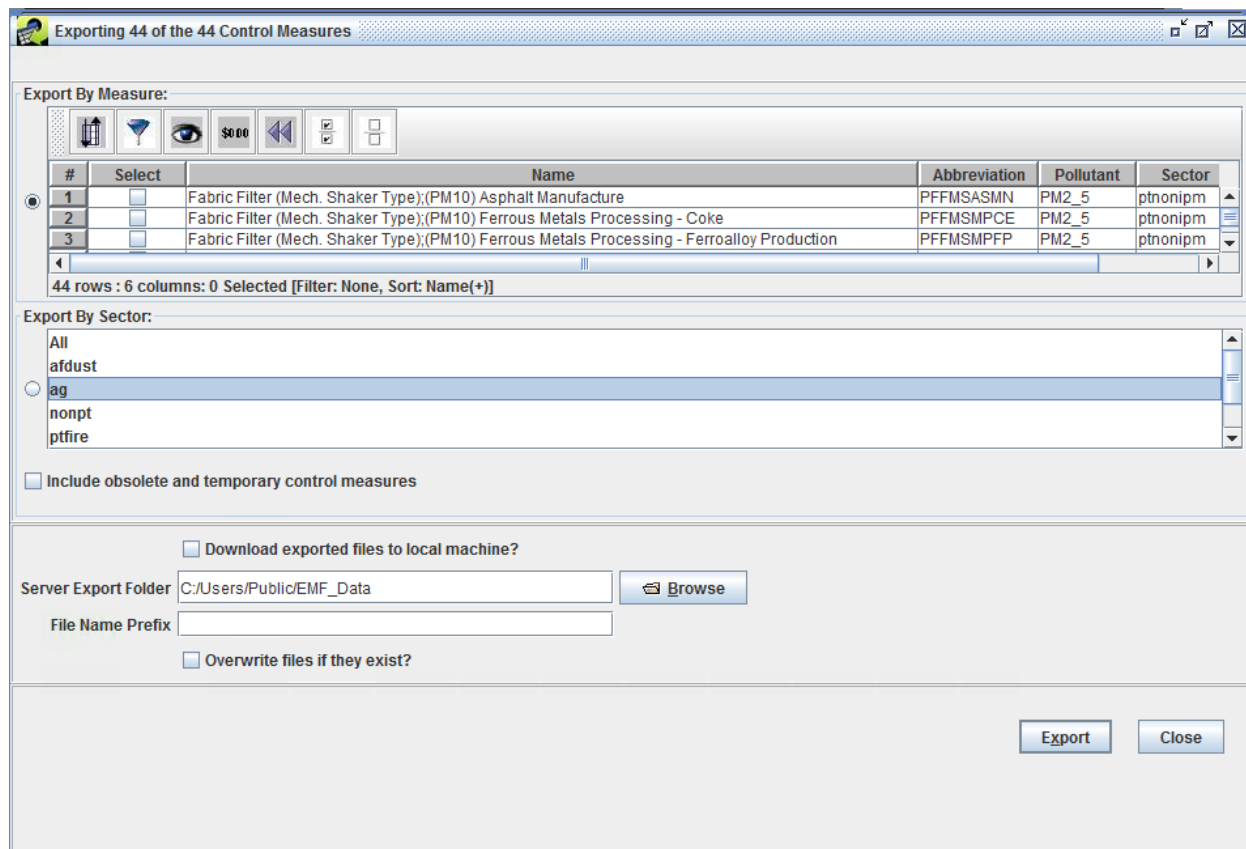


Figure 3.28: Exporting Control Measures Dialog

Manager. Note it's not necessary to click the "Select" checkboxes for these measures, all measures shown in the list will be exported regardless if they are checked or not. To export by inventory sector, select the **Export By Sector** option, then choose the various sectors for which to export control measures.

For this exercise, select **Export By Measure** to export the preselected measures from the Control Measure Manager. To specify the output folder (i.e., directory) into which the CSV files will be written, type the folder name into the **Server Export Folder** text field or use the **Browse** button to bring up a file and directory browser to select the output folder. To specify an export file name prefix for naming the new exported files, type the prefix string into the **File Name Prefix** text field.

Type an export file prefix string (e.g., fabric_filter) into the **File Name Prefix** field of the Exporting Control Measures window. This string will be included at the beginning of the names of the exported CSV files to help identify the types of measures that are included in the files.

After setting the desired output folder and the file name prefix on the Exporting Control Measures window, click the **Export** button. The message at the top of the Export window will state that the export has started and to monitor the **Status** window to track the export request.

The **Status**, or **Downloads**, window is near the bottom of the EMF main window. It will show a message when the export starts and another when it is finished. Monitor the status on demand by clicking the **Refresh** button at the top of the **Status/Downloads** window.

Step 9-2: View the Exported Control Measures. After the export is finished, close the Exporting Control Measures window by clicking **Close**. Use your computer's file browser to view the contents of the folder that you selected for the export. In the example shown above, the files created in the selected folder are: **fabric_filter_summary.csv**, **fabric_filter_efficiencies.csv**, **fabric_filter_SCCs.csv**, **fabric_filter_equations.csv**, **fabric_filter_Props.csv**, and **fabric_filter_Refs.csv**. These files may be opened with standard spreadsheet software. For a complete description of the fields in the files, see "Control Strategy Tool (CoST) Control Measures Database (CMDB) Documentation."

3.9.2 Importing Control Measures

Files in the exported format can also be imported into the CMDB. Control measures can only be imported to CoST/EMF by an Administrator.

Step 9-3: Import Control Measures. If logged in as Administrator, click the **Import** button on the Control Measure Manager to start importing measures. In the **Import Control Measures** window that appears (Figure 3-28), type or paste the name of the import **Folder**. You may also use the **Browse** button to browse to a folder containing the files to be imported and select the files directly from the browser. Alternatively, enter the folder name and then type in a **pattern** to specify the files, then click **Apply Pattern**. When using a pattern, an asterisk (*) will be expanded to the available file names.

After selecting the files to import, click the **Import** button. Information about the status of the import will be shown in the **Status** section of the window. To see updates to the status of the import, click the **Refresh Import Status** button. Once the imports are complete, click the **Done** button. If the measures already existed in the database, the new data will replace the existing data.

Note that as there will be no warning before the CMDB data are replaced, use the import feature with caution.

It is possible to purge existing measures from the CMDB by sector. This feature will remove all measures associated with the sectors chosen in the **Purge Existing Measures By Sectors** list. The user must also click the **Purge** checkbox to allow the measures to be purged. The measures will be purged when the **Import** button is clicked.

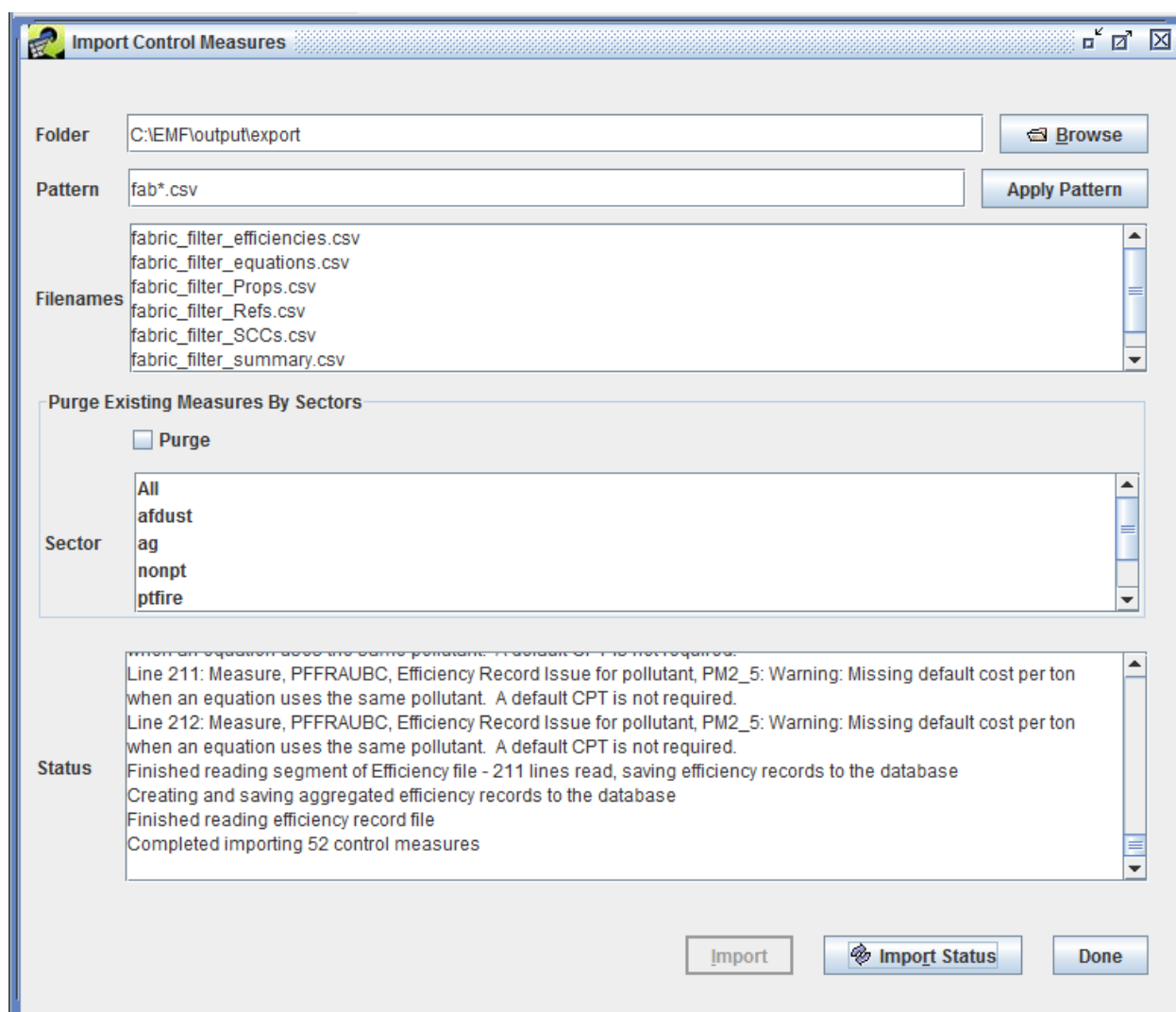


Figure 3.29: Import Control Measures Dialog

Chapter 4

Control Strategy Manager

4.1 Introduction

This chapter demonstrates the features of the Control Strategy Manager. The Control Strategy Manager allows control strategies to be created, edited, copied, and removed. **A control strategy is a set of control measures applied to emissions inventory sources (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. In this chapter, you will learn how to:

- View, sort, and filter a list of control strategies from the *Control Strategy Manager* window
- Create control strategies
- Edit control strategies to specify their inputs and parameters
- Run control strategies
- Copy control strategies
- Remove control strategies
- Analyze and summarize outputs from control strategies

This chapter is presented as a series of steps so that it may be used as part of a training class or as a tutorial on how to use CoST. The numbered steps are the ones you are expected to perform, while other material is provided for documentation purposes.

4.1.1 Introduction to Control Strategies

CoST automates the key steps for preparing control strategies. The purpose of developing control strategies is to answer questions about which sources can be controlled and how much the application of those controls might reduce emissions and how much it might cost. For example, if the goal is to reduce NO_x emissions for the Southeast U.S. in 2030 by 100,000 tons per year, CoST can help answer questions related to this goal, such as:

- What is the **maximum emissions reduction** achievable for NO_x (i.e., is my reduction goal less than the maximum possible reduction?), and what set of controls will achieve this reduction?
- What set of controls can achieve the goal at the **least cost**?
- What does the **cost curve** look like for other levels of reduction?
- What **emissions reductions** for the target pollutant would be achieved?
- What are the emission reductions or increases for **other pollutants** of interest?
- What are the **engineering costs** of applying the controls for a specific strategy?
- What **control measures** are available for specific source categories and pollutants, how much reduction does each one provide, and at what cost?

A future goal for CoST is to be able to answer this question: What is the optimum method for achieving simultaneously targeted reductions for **multiple pollutants**?

CoST can help answer the above questions when users set up and run one or more control strategies. A diagram of the basic steps for running a control strategy is shown in Figure 4.1. As illustrated in the figure, 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 (that have already been loaded into the EMF)
- filters to limit the sources included from those datasets
- filters to limit which control measures are to be included in the strategy analysis
- constraints that limit the application of measures to specific sources based on the resulting costs or emissions reductions achieved

After a control strategy run is complete, several outputs are associated with the strategy. The main CoST output for each control strategy is a table called the “**Strategy Detailed Result**.” This table consists of emissions source-control measure pairings, each of which contains information about the cost and emissions reductions that would be achieved if the measure were to be applied to the source. If multiple inventories were processed by the strategy, then there will be one Strategy DetailedResult for *each* input inventory, unless the inventories were merged for a least cost run (as indicated in the ‘Multiple Inventories’ column Table 4.1). Also, there will be at least one Strategy Detailed Result for each of the least cost iterations performed as part of a Least Cost Curve run. In addition to the Strategy Detailed Result, two other outputs are produced for each strategy run: the Strategy County Summary (which includes uncontrolled and controlled emissions), and the Strategy Measure Summary (which summarizes how control measures were applied for each sector-county-SCC-Pollutant combination). These three outputs are referred to in Table 4.1 as the ‘Standard’ outputs.

The Strategy Detailed Result table itself can be summarized in many ways using predefined summary queries (e.g., by state, by county, by control technology). Users familiar with SQL can also define their own custom queries. The Strategy Detailed Result table can also be merged with the original input inventory, in an automated manner, to produce a *controlled emissions inventory* that reflects implementation of the strategy. The controlled emissions inventory includes information about the measures that have been applied to the controlled

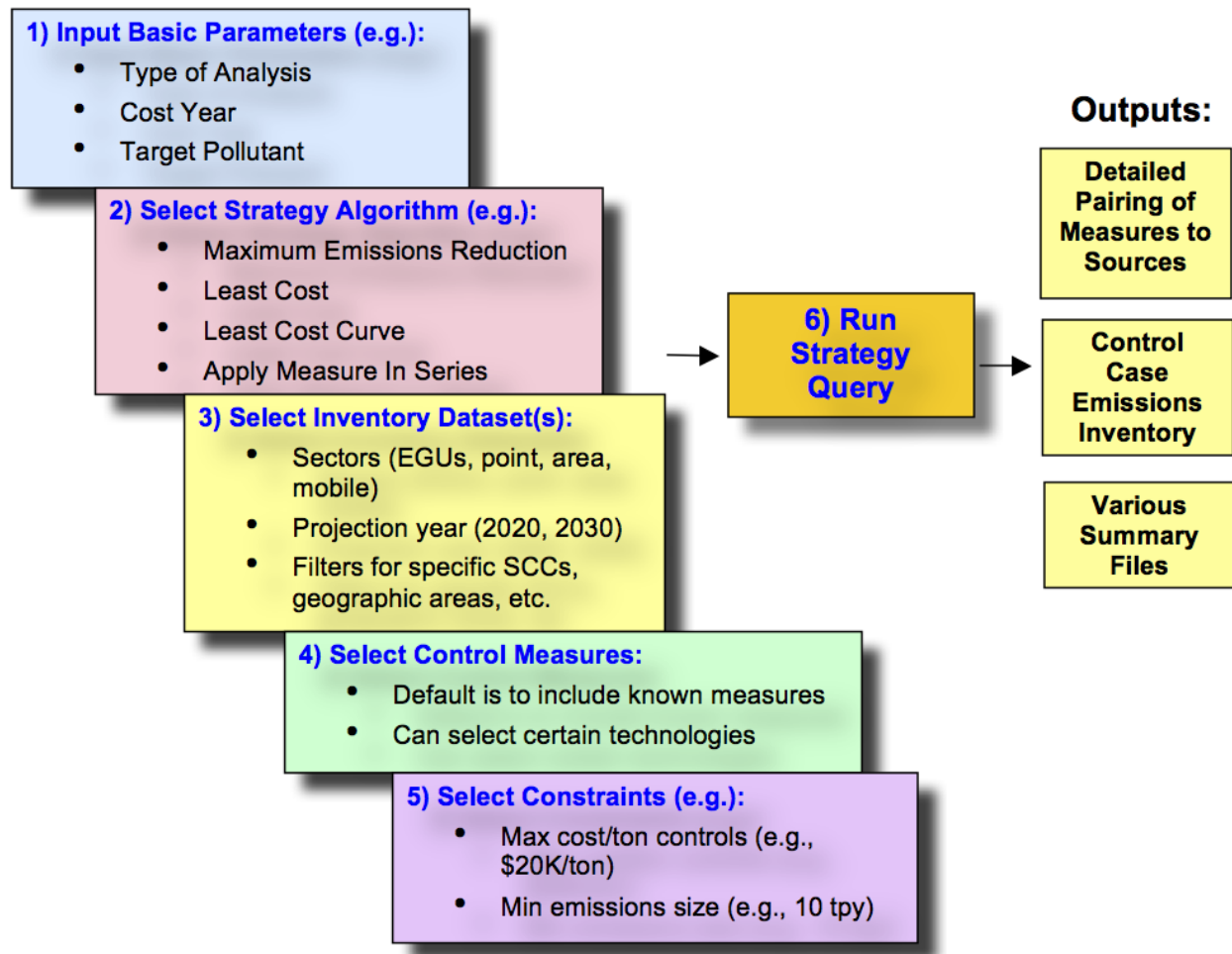


Figure 4.1: Basic Steps for Running a Control Strategy

sources and can be directly input to the SMOKE modeling system to prepare air quality model-ready emissions data. Comments are placed at the top of the inventory file to indicate the strategy that produced it and the settings of the high-level parameters that were used to run the strategy.

Detailed information on the types of control strategy algorithms is provided in [Section 2](#). [Section 3](#) describes how to set up and manage control strategies. [Section 4](#) details the inputs to control strategies, including adding inventories, control measures, and constraints to a strategy. Running a strategy and accessing its outputs are discussed in [Section 5](#). Documentation for the various types of strategy outputs is given in [Section 6](#) and information about summaries of strategy inputs and outputs is given in [Section 7](#).

4.2 CoST Control Strategy Algorithms

Once the inputs have been defined, the strategy can be run on the EMF server. The method by which the measures are associated with the strategies depends on the algorithm that has been selected for the strategy. At this time, six algorithms are available to determine how measures are assigned to sources:

- **Annotate Inventory:** assigns control measures to the inventory based on the control efficiency specified for each source, and can be used to fill in control measure information for inventory sources that are missing these details but have a control efficiency assigned.
- **Apply Measures in Series:** assigns all control measures that can be used for a source in the specified order; this is often used for mobile sources, for which the control measures are typically independent of one another.
- **Least Cost:** each source can be assigned only a single measure to achieve a specified percent or absolute reduction for the sources included in the strategy run, 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.
- **Maximum Emissions Reduction:** assigns to each source the single measure (if a measure is available for the source) that provides the maximum reduction to the target pollutant, regardless of cost.
- **Multi-Pollutant Maximum Emissions Reduction:** assigns all control measures that can be used for a source based on a specific target pollutant order (e.g., NO_x first, PM₁₀-PRI second, VOC third, and SO₂ last). Each source target pollutant can be assigned only a single measure, and it must be the one that provides the maximum reduction, regardless of cost. If a source's target pollutant was already controlled by a measure applied during a previous target pollutant iteration, then no additional control will be chosen for that specific source's target pollutant (e.g., if a NO_x measure also controlled VOC, during the VOC iteration no measure would be attempted for this source, since it was already controlled).

Some of the key aspects of each of the strategy types are summarized in Table 4.1, and some additional information on each strategy type is provided in the following subsections.

Table 4.1: Control Strategy Algorithms.

Strategy Type	Multiple Inventories	Typical Sectors	Measure Assignment	Outputs
Annotate Inventory	Processed independently	Area, nonpoint	One per source	Standard
Apply Measures in Series	Processed independently	Mobile: Onroad, nonroad	Multiple per source	Standard
Least Cost	Will be merged	Area, nonpoint	One per source	Standard, Least Cost Control Measure Worksheet
Least Cost Curve	Will be merged	Area, nonpoint	One per source	Standard, Least Cost Control Measure Worksheet, Least Cost Curve Summary
Maximum Emissions Reduction	Processed independently	Area, nonpoint	One per source, to achieve maximum reduction of target pollutant	Standard

Strategy Type	Multiple Inventories	Typical Sectors	Measure Assignment	Outputs
Multi-Pollutant Maximum Emissions Reduction	Processed independently	Area, nonpoint	One per source target pollutant; based on specified target pollutant order; could be multiple per source	Standard

4.2.1 Maximum Emissions Reduction Control Strategy

The Maximum Emissions Reduction control strategy is the simplest of the strategy algorithms. It assigns to each source the single control measure that provides the maximum reduction to the target pollutant, regardless of cost. The strategy produces the three standard types of strategy outputs, including a Strategy Detailed Result for each input inventory.

4.2.2 Apply Measures in Series Control Strategy

The Apply Measures in Series control strategy applies all relevant controls to a source, as opposed to the Maximum Emissions Reduction strategy, where only the most relevant measure (with the best possible reduction) is applied to the source. The Apply Measures in Series strategy is typically used for mobile sources, for which the input inventories are often average day inventories specific to a given month, and for which there are often multiple independent controls available for each source. Therefore, the measures are applied to the source in series, one after the other. The order of application is based on the user-specified “apply order,” but the system also considers the lowest cost and greatest control efficiency. Thus, the cost factor in terms of dollars per ton of pollutant reduced is used to calculate the annualized cost of the control measure when applied to a specific source.

The three standard types of outputs are generated after a successful strategy run: a Strategy Detailed Result *for each input inventory*, a single Strategy Measure Summary, and a single Strategy County Summary. Note that when input inventories contain average-day emissions data for a month, the corresponding Strategy Detailed Result datasets will specify total monthly emissions as opposed to average day emissions for each source; otherwise they will specify annual emissions. The total monthly emissions are calculated by multiplying the average day emissions by the number of days in the month. Regarding the two types of summary outputs, if the input datasets have data for each of the 12 months, the summaries will provide annual emissions.

4.2.3 Least Cost Control Strategy

The Least Cost control strategy type assigns measures to emissions sources to achieve a specified percent reduction or absolute reduction of a target pollutant for sources in a specified geographic region while incurring the minimum possible annualized cost. This algorithm is similar to the maximum emissions reduction control strategy in that only a single measure is applied to each source. For example, one measure might be selected for a source when trying to reduce the target pollutant by 20%. However, if you were trying to obtain a 40% reduction of the target pollutant, another more expensive measure that achieves a higher level of control might be selected for the same source to meet the targeted level of reduction. If multiple inventories are specified as inputs to a Least Cost control strategy, they are automatically merged into one EMF dataset as an ORL Merged dataset type. This allows the multiple inventory sectors to be considered simultaneously during a single Least Cost run. Note that the merged inventory dataset will be truncated and repopulated at the start of each strategy run, to ensure that the most up-to-date inventory data are included in the run.

The Least Cost control strategy automatically creates the same three standard output datasets, but it also creates an additional output dataset called the Least Cost Control Measure Worksheet. This output is a table of all possible emissions source-control measure pairings (for sources and measures that meet the respective filters specified for the strategy), each of which contains information about the cost and emissions reductions achieved if the measure was to be applied to the source. Examples of these tables are given in [Section 6](#). This dataset will be used to help generate *a single* Strategy Detailed Result (no matter how many input inventories were processed) once the optimization process has been performed to achieve the desired reduction. This dataset has the all of the same columns as the Strategy Detailed Result (see [Table 4.9](#)), in addition to the following columns:

- **marginal:** This column stores the marginal cost (dollars are given based on the specified cost year) for the source-measure record. This is calculated according to the following equation:

$$\text{marginal cost} = \text{annual cost (for specified cost year)} / \text{emissions reductions (tons)}$$

Note that cost equations are used to compute the annual cost, when applicable and all required input data are available. For target pollutant source-control pair records, the annual cost will be the total of the annual costs for the target pollutant and any costs associated with co-pollutant reductions.

- **status:** This column contains a flag that helps determine which source-control records should be actively considered during the strategy run.
- **cum_annual_cost:** This column contains the cumulative annual cost for the source and all preceding sources that have been included in the strategy (i.e., for which status is null). This is only specified for target pollutant sources, but it also includes costs associated with co-pollutant reductions.

- **cum_emis_reduction:** This column contains the cumulative emissions reductions for the source and all preceding sources that have been included in the strategy (i.e., for which status is null). This is only calculated for target pollutant sources. The emissions reductions are cumulated by following the `apply_order` in an ascending order.

If multiple input inventories are used for the least cost control strategy run and the user requests to create controlled inventories, there will be one controlled inventory created for each of the input inventories.

4.2.4 Least Cost Curve Control Strategy

The purpose of the Least Cost Curve control strategy type is to iteratively run Least Cost control strategies so that a cost curve can be generated. In such cost curves, the cost per ton of emissions reductions increases as the level of desired emissions reductions increase. The input inventories are treated in the same way as the least cost run in that the data from the inventories will be put together into an ORL Merged inventory prior to performing any of the runs. The inventory filters and measure filters work in the same way as they do for the other strategy types, as do the constraints that apply to all strategy types. The main difference between the Least Cost and Least Cost Curve control strategy types is in the specification of constraints. Instead of specifying a single percent reduction or absolute emissions reduction, three new constraints are used to control the run:

- **Domain-wide Percent Reduction Start (%):** Specifies a percent reduction to be used for the first Least Cost control strategy to be run.
- **Domain-wide Percent Reduction End (%):** Specifies a percent reduction to be used for the last Least Cost control strategy to be run.
- **Domain-wide Percent Reduction Increment (%):** Specifies a percentage increment on percentages to use between the first and last runs (e.g., if 25% is specified, runs will be performed for 25, 50, 75, and 100% reduction).

Additional runs can be added to a least cost curve control strategy if you do not delete the previous results when you rerun the strategy. Suppose that you generate a coarse cost curve (default increment is 25%) and you find an area of interest that bears further examination. You can then go back and specify different start, end, and increment percent reductions to obtain more information (e.g., start=80%, end=90%, increment=2%) about that portion of the curve.

The types of outputs for a Least Cost Curve control strategy are the following:

- **Strategy Detailed Result** datasets for each targeted percent reduction. Note that several results could have the same actual percent reduction if the targeted reduction exceeds the maximum available reduction. As with a Least Cost control strategy, the actual percent reduction may not exactly match the targeted reduction due to the discrete nature of applying specific controls to specific sources. CoST will ensure that each actual reduction is equal to or greater than the corresponding targeted reduction.

- **Least Cost Control Measure Worksheet:** this output is the same as the worksheet produced for a regular Least Cost control strategy run. Note that the same worksheet is used for all targeted percent reductions and only the status column is updated to specify when measure-source combinations are included in the current strategy.
- **Least Cost Curve Summary:** this output dataset contains a row with cost and emissions reductions information for each of the runs that was performed for the strategy. Rows are added to this output if additional strategy runs are performed (e.g., to examine different sections of the curve). The columns of this summary are: Poll, Uncontroll_Emis (tons), Total_Emis_Reduction (tons), Target_Percent_Reduction, Actual_Percent_Reduction, Total_Annual_Cost, Average_Ann_Cost_per_Ton, Total_Annual_Oper_Maint_Cost, Total_Annualized_Capital_Cost, Total_Capital_Cost. Here, the Uncontroll_Emis column contains the emissions from the original input inventory with all existing controls backed out so that it represents the uncontrolled emissions. The columns starting with Total are computed by summing all of the values of the corresponding column in the Strategy Detailed Result for the pollutant specified in the Poll column. Examples of Least Cost Curve Summaries are given in Figure 4.28 and Table {tbl:summary_of_strategy_algorithms_table}.
- **Controlled Inventories:** these output datasets may optionally be created based on any of the Strategy Detailed Results that are available for the strategy. Thus, results corresponding to any of the targeted reductions may be processed by SMOKE and the resulting data used as an input to an air quality model. Note that for each targeted reduction, individual controlled inventories will be created for each of the input inventories.

4.2.5 Annotate Inventory Control Strategy

The purpose of the Annotate Inventory strategy type is to specify what measures are likely to have been used to achieve specified percent reductions in input inventories. The input inventories are treated in the same way as the Maximum Emissions Reduction runs in that each inventory is processed separately and individual results are created for each one. The inventory filters and measure filters work in the same way as they do for the other strategy types. Note that the selected target pollutant is important because only records for that pollutant will be annotated, but CoST may be changed in the future to consider all inventory pollutants. Constraints are applicable in that if the controlled source does not satisfy the specified constraints, it will not be included in the result and another measure that does satisfy the constraints will be sought.

The outputs from the Annotate Inventory strategy type are an Annotated Inventory for each of the input inventories. The annotated inventories have the same dataset types as the input inventories. All of the source records for the specified target pollutant with nonzero control efficiencies in the input inventory will appear in the annotated inventory and the control measures column will be filled in for sources for which a matching measure has been found. Note that the originally specified control efficiency fields and the emissions in the inventory are not changed, even if the inventory efficiency differed from the efficiency specified for the control measure. Once an annotated inventory has been created, a controlled inventory can

be created from the annotated inventory. Unlike the annotated inventory, the controlled inventory will have all records found in the input inventory and can therefore be used as an input to SMOKE.

One of the goals for CoST that has not yet been met is for the tool to be able to intelligently make use of control measures that can be applied in addition to other controls (also known as ‘add-on’ controls). In order for the software to meet this goal, it is important for it to first be able to determine whether there are any existing control measures on the emissions source and the type of control device(s) used by the existing measures. Currently, a data gap exists in this area for both the base year emissions inventories and the future year emissions inventories that may be used as inputs to a control strategy run. The NEI contains data fields to store this information, and there is a limited amount of existing control efficiency and control device code data in the base year NEI. However, these fields are not always populated in the base year inventory for sectors other than the EGU point sources, and the fields are less well populated in the future year modeling inventories. In addition, the control device codes that are stored in the NEI are a lot less specific than the control measure abbreviations that CoST uses. Therefore, even if the control device codes were well populated, these codes would need to be translated into the CoST control measure abbreviations for CoST to really have the information it needs to properly apply add-on controls.

To address the issue of unspecified control measures in inventories that can be an input to CoST, several steps have been taken. First, when CoST creates a controlled inventory, in addition to filling in the information in the CEFF, REFF, and RPEN columns, CoST populates the Control Measures, Pct Reduction, Current Cost, and Total Cost columns in the FF10 or ORL inventory to specify information about measures that it has applied. In this way, the controlled inventories created by CoST always specify the relevant information about the measures that have been applied as a result of a CoST control strategy. The Annotate Inventory strategy type is a second step that has been taken to provide more information about existing control measures.

When an Annotate Inventory strategy is run, CoST looks at the percent reduction specified by the CEFF, REFF, and RPEN columns and uses the available control measures in the database to try to determine what control measure has the closest percent reduction to the one specified in the inventory. It then fills in the control measures column with the measure that was found. Note that the originally specified control efficiency fields and the emissions in the inventory are not changed, even if the inventory efficiency differed from the efficiency specified for the control measure. If no measure was found, it leaves the control measure field blank. Once the strategy has been run, a summary report can be generated using the “Compare CoST to NEI measures” query that shows the sources with non-zero CEFF values and the difference between the inventory specified percent reduction and the percent reduction for the control measure that CoST “guessed” had been applied to the source. **It is important for the user to then examine the results of this report to find cases where the specified control efficiency matches were not even close and where no match was found.** Both of these situations can indicate that there is missing or incorrect data in the control measures database, or that the information in the inventory was erroneous. The eventual goal of the Annotate Inventory strategy is to develop a base year inventory

with more complete existing control measure information.

4.2.6 Multi-Pollutant Maximum Emissions Reduction Control Strategy

The Multi-Pollutant Maximum Emissions Reduction control strategy assigns to each source the single measure for each target pollutant that provides the maximum reduction, regardless of cost. This process is performed for each target pollutant in an order specified by the user (e.g., NO_x first, PM₁₀-PRI second, VOC third, and SO₂ last). If a measure would control a pollutant that was already controlled by a previous target pollutant analysis iteration, that measure will be excluded from consideration during the source-measure matching process. For example, if measure ABC controlled NO_x (the first analyzed target pollutant) and VOC, and during the next pollutant iteration (for VOC) measure DEF also controls NO_x and VOC, this measure will not be considered because VOC emissions were already controlled by applying the ABC measure.

The inventory filter and county filter work differently for this control strategy than they do for the other strategy types. The inventory filter and county filter can be specified separately for each target pollutant, whereas for the other strategy types they are defined at the strategy level.

The Multi-Pollutant Maximum Emissions Reduction control strategy produces the three standard types of strategy outputs, including a Strategy Detailed Result for each input inventory.

4.3 Managing Control Strategies

The control strategies currently available within CoST are shown in the Control Strategy Manager. The Control Strategy Manager allows you to see information about control strategies, to create new control strategies, and also to edit, remove, and copy control strategies.

4.3.1 Opening the Control Strategy Manager

Step 3-1: Open Control Strategy Manager. To open the Control Strategy Manager, choose **Control Strategies** from the **Manage** menu on the EMF main window (Figure 4.2) and the Control Strategy Manager will appear (Figure 4.3).

The Control Strategy Manager shows all of the control strategies currently available within the CoST/EMF system in a sortable, filterable window. The columns shown in the window are Select, Name, Last Modified, Is Final, Run Status, Region, Target Pollutant, Total Cost, Reduction (tons), Average Cost Per Ton, Project, Strategy Type, Cost Year, Inventory Year, and Creator. Descriptions of some of the columns are given in Table 4.2. The remaining fields are described in detail in Section 4.

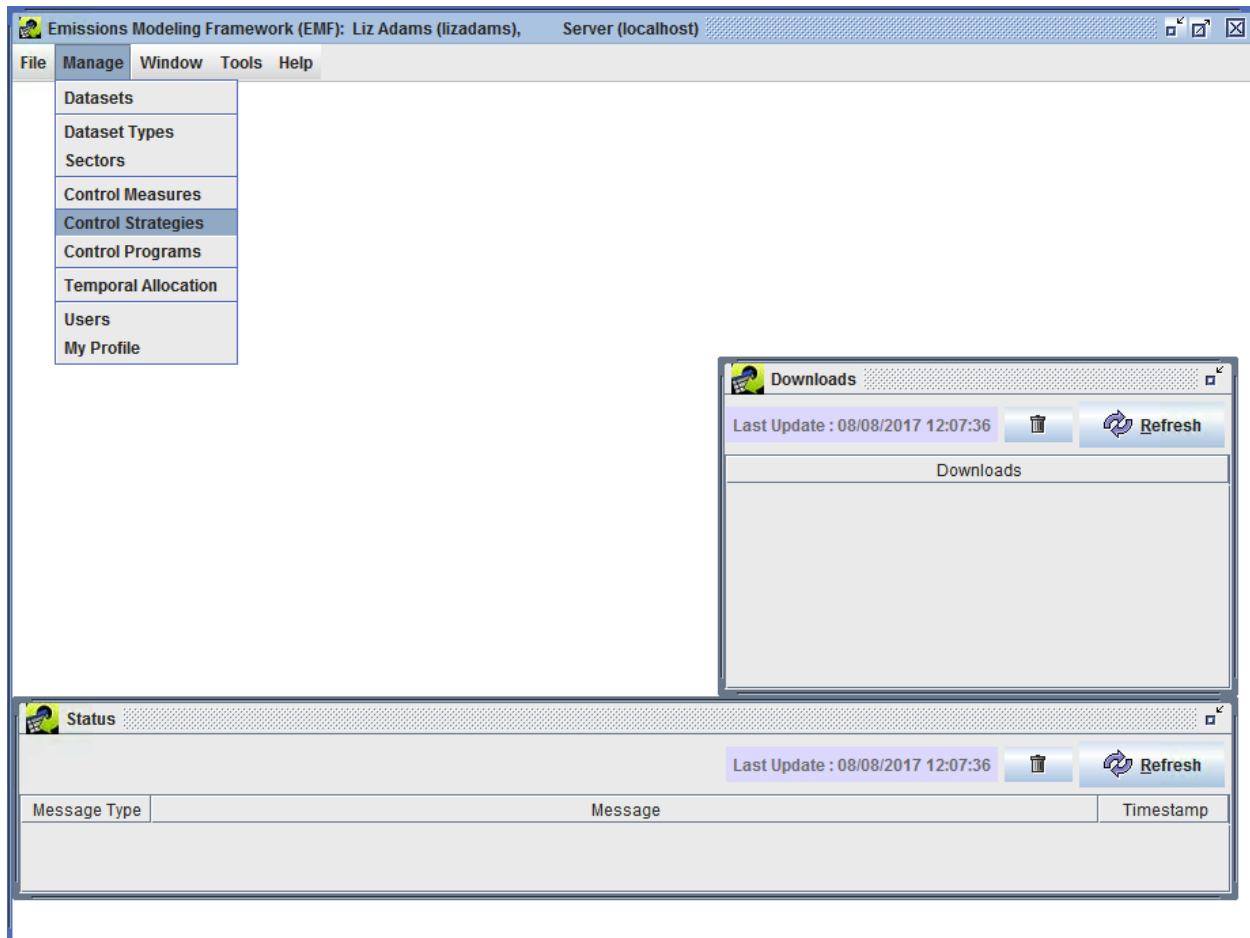


Figure 4.2: Manage Menu of EMF Main Window

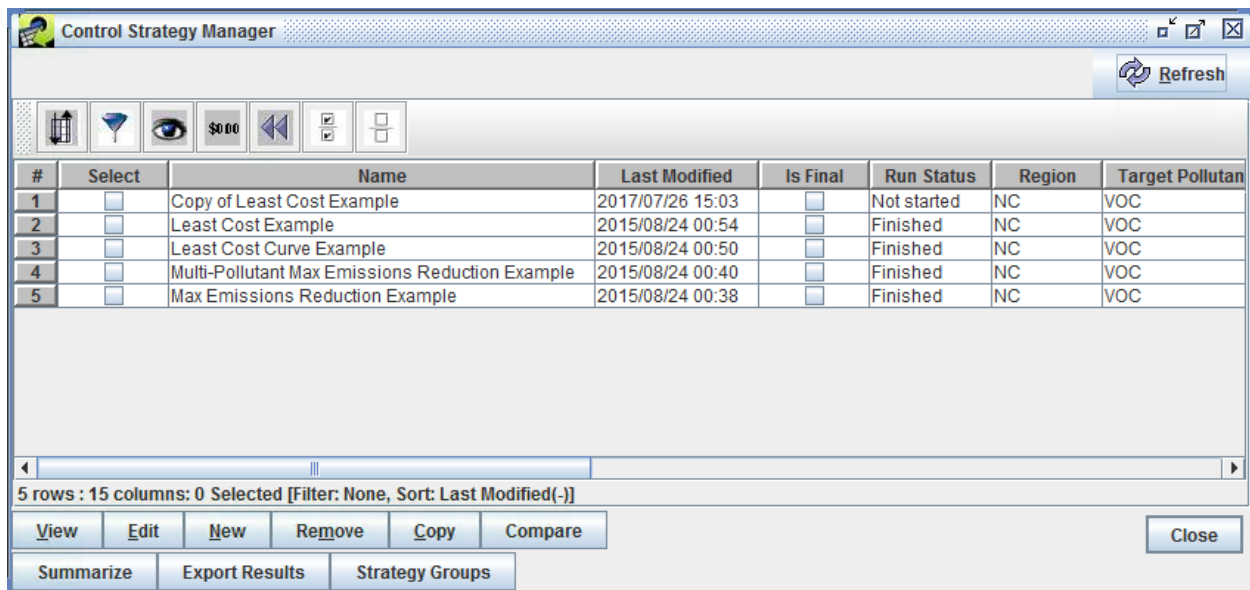


Figure 4.3: Control Strategy Manager Window

Table 4.2: Control Strategy Manager Table.

Column	Description
Name	Shows the name of the control strategy.
Last Modified	Shows the date and time on which the strategy was last changed.
Run Status	Gives information about the strategy run. Possible options are: Not started - the strategy run has never been started; Waiting - a run has been requested, but it is waiting because other strategies are running; Running - the strategy is currently running; Finished - the strategy run completed successfully; Failed - the strategy run started, but failed due to a problem.
Inv Year	Shows the year of the emissions inventory that the strategy will process.

4.3.2 Sorting and Filtering Control Strategies

By default, the strategies are shown using a descending sort on the last modified date and time, so that the most recently modified strategies appear at the top of the list.

Step 3-2: Sort Control Strategies. To sort the control strategies on the total cost of the strategy, click on the heading of the **Total Cost** column and the rows will re-sort so that the most expensive strategies will be shown at the top. Click on the **Total Cost** column header again to reverse the sort.

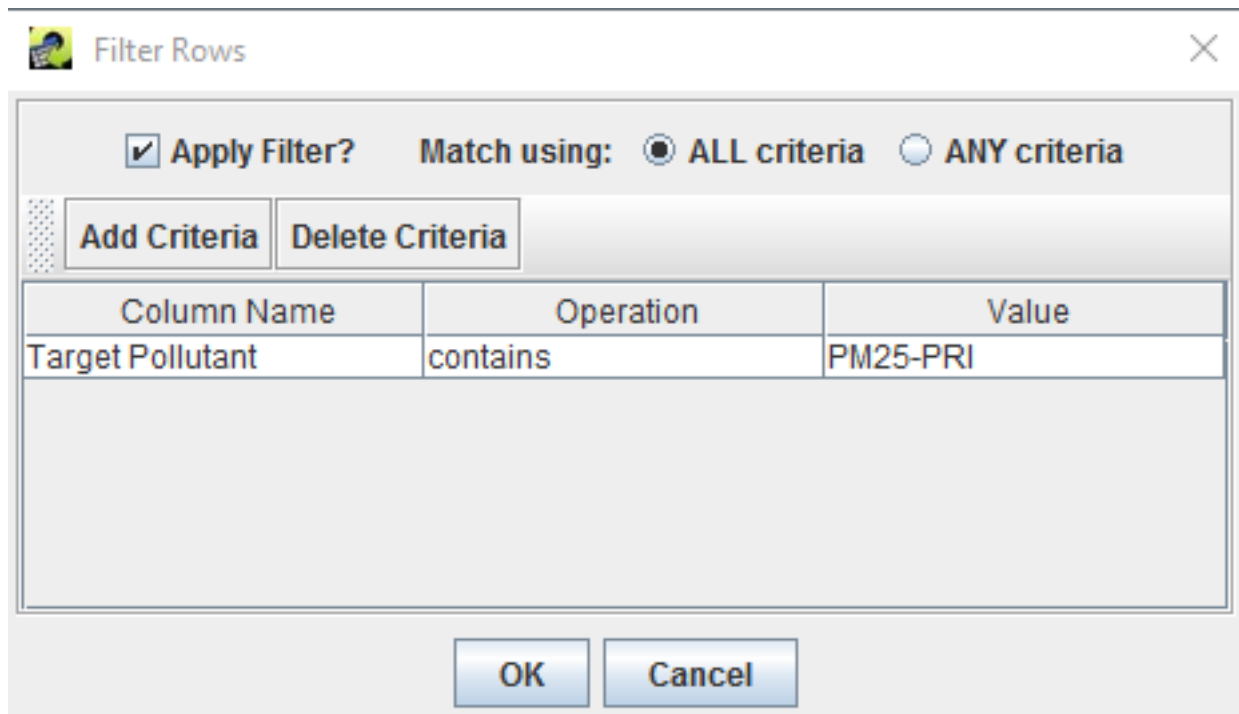
Step 3-3: Filter Control Strategies. To see only strategies that were run with a specific target pollutant, click the **Filter** button on the Control Strategy Manager toolbar. When the **Filter Rows** window appears enter a criterion for the filter by clicking **Add Criteria**. Click in the cell under **Column Name** and choose **Target Pollutant**. Change the operation by clicking in the cell under **Operation**. For this example select **contains** as the desired **Operation**. Enter the pollutant of interest in the **Value** cell. Enter **PM25-PRI** in the **Value** cell for this example.

Note that the filter values are case-sensitive (e.g., “NOx” will not match a filter value of “NOX”). After applying the filter criterion above, the **Filter Rows** window will look like Figure 4.4.

Click **OK** and the Control Strategy Manager will show only strategies that targeted PM25-PRI.

After reviewing the information available on the Control Strategy Manager for PM25-PRI measures, click the **Reset** button to remove the filter and sort criteria.

For more information on performing sorting, filtering, formatting, and other operations on the table that shows the control strategies used for the Control Strategy Manager, refer to the [Introduction to the Control Measure Manager](#).



The image shows a 'Filter Rows' dialog box. At the top, there is a title bar with a small icon and the text 'Filter Rows' and a close button. Below the title bar, there is a section with a checked checkbox labeled 'Apply Filter?' and a 'Match using:' label followed by two radio buttons: 'ALL criteria' (selected) and 'ANY criteria'. Below this, there are two buttons: 'Add Criteria' and 'Delete Criteria'. Underneath these buttons is a table with three columns: 'Column Name', 'Operation', and 'Value'. The table contains one row with the values 'Target Pollutant', 'contains', and 'PM25-PRI'. At the bottom of the dialog box, there are two buttons: 'OK' and 'Cancel'.

Column Name	Operation	Value
Target Pollutant	contains	PM25-PRI

Figure 4.4: Filter Rows to Show Only Strategies Targeting PM25-PRI

4.3.3 Copying Control Strategies

Existing strategies can be copied to create new control strategies, regardless of whether they have been run. If you copy a strategy and then edit the newly created strategy, you will not be changing any settings for the original strategy, so this is a safe way to start working with your own strategies. When a strategy is copied, it retains all of the settings from the original strategy except for the information on the Outputs tab, and the output summary information that is shown on the Summary tab.

Step 3-4: Copy Control Strategies. Click the **Select** checkbox next to one of the strategies (e.g., “Least Cost Example”) and then click **Copy**. A new strategy will be added to the Control Strategy Manager with the name “Copy of *original strategy name*.”

Note that multiple strategies can be copied at once by selecting as many strategies as needed before clicking **Copy**.

4.3.4 Removing Control Strategies

A control strategy creator and an EMF Administrator can remove control strategies from CoST. Strategies should be removed with caution, because there is no ‘undo’ for this operation.

Step 3-5: Remove Control Strategies. Click the **Select** checkbox next to one of the strategies and then click **Remove**. As an example, select the strategy you just copied in the previous subsection. When prompted to confirm removal of the control strategy, a pop-up

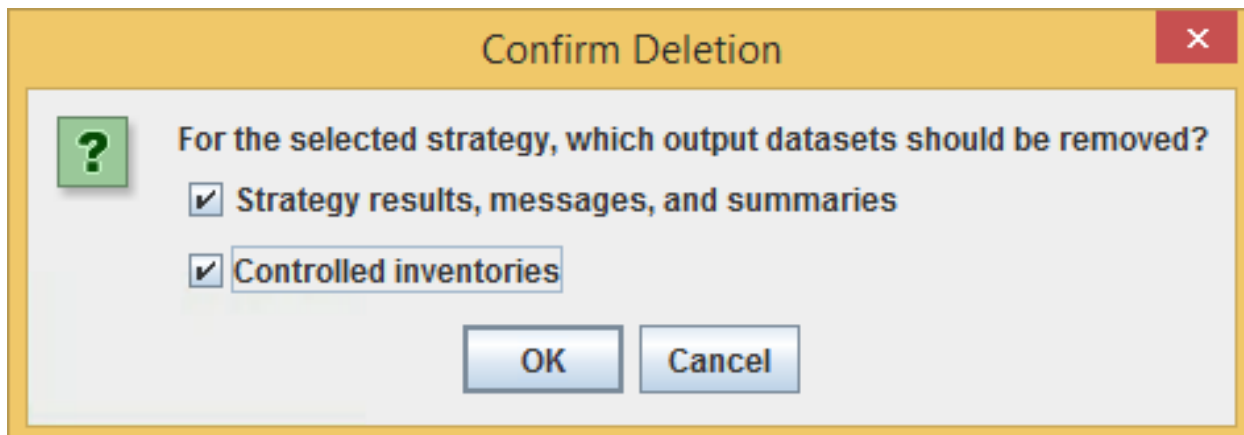


Figure 4.5: Confirm Strategy Deletion

menu will appear in Figure 4.5 where the user can select whether to remove output datasets associated with the strategy that they would like to remove. The first check box is to remove the following output data: Strategy results, messages, and summaries associated with the control strategy that is being deleted. The second check box is to remove the Controlled inventories associated with the control strategy that is being deleted. Check both check boxes, so that all datasets created by the control strategy are cleaned up when the strategy is deleted. The selected strategy and output datasets will be removed from the table of strategies in the Control Strategy Manager.

*Note that if you select more than one control strategy before clicking **Remove**, all of the selected strategies will be removed.*

4.3.5 Creating a New Control Strategy

Step 3-6: Create New Control Strategies. To create a new control strategy, click the **New** button in the Control Strategy Manager. The **Create New Control Strategy** window will appear with a text box to name the new strategy. Enter a name that is different from any of the existing control strategies (e.g., **Least Cost 2017 NOx Example**) and then click OK.

An **Edit Control Strategy** window for your newly created strategy will appear in Figure {@fig:edit_control_strategy_window}. The window has five tabs: Summary, Inventories, Measures, Constraints, and Outputs. This window and how to fill in the information on these tabs is discussed in more detail in Section 4.

Edit Control Strategy: Least Cost 2017 NOx for Training

Summary | Inventories | Measures | Constraints | Outputs

Name: Least Cost 2017 NOx for Training

Description:

Project: ▼ Project Notes

Creator: Liz Adams Last Modified Date: 08/08/2017 12:26

Type of Analysis: Choose a strategy type ▼ Copied From:

Is Final: ☐

Parameters

Cost Year: 2013 ▼

Target Year:

Region: ▼

Target Pollutant: ▼

Discount Rate (%): 7.0

Use Cost Equations: ☒ Include Measures with No Cost Data: ☒

Apply CAP measures on HAP Pollutants: ☐ Major Pollutant must match Target: ☒

Results

Start Date: Not started

Completion Date: Not started

Running User:

Total Annualized Cost:

Target Poll. Reduction (tons):

Save Close Run Refresh Stop

{fig:edit_cont

For this example, edit the following fields in the **Edit Control Strategy** window:

- Set Target Year to **2017**
- Set Type of Analysis to **Least Cost**
- Set Target Pollutant to **NOX**

Click **Save** to save the new strategy and click **Close** to close the **Edit Control Strategy** window.

If the new strategy does not appear in the Control Strategy Manager, first click the **Reset** button on the toolbar to remove any filters that have been applied to the strategies. If the strategy still does not appear, click **Refresh** at the top right of the Control Strategy Manager to obtain new data from the server.

4.3.6 Editing Control Strategies

Step 3-7: Edit Control Strategies. Click the **Select** checkbox next to the new strategy (i.e., the strategy created in Step 3-6) and then click **Edit**. If you have permission to edit

the strategy (i.e., you are its creator or an Administrator), the **Edit Control Strategy** window will appear with the **Summary** tab visible (Figure 4.6). Note that if you had selected multiple control strategies before clicking **Edit**, they each would have opened in their own window. The tabs on the Edit Control Strategy window are listed in Table 4.3. The contents of these tabs are described in detail in Section 4.

Table 4.3: Control Strategy Manager Summary Tab.

Tab	Description
Summary	Shows you high-level information about the strategy, such as its Name and the Target Pollutant.
Inventories	From which you can specify the emissions inventories to use as input to the strategy and filters for those inventories.
Measures	Allows you to specify the classes of measures to include in the strategy, or select specific measures to include.
Constraints	Allows you to specify constraints for the strategy, such as a maximum cost per ton.
Outputs	Shows the results from the strategy after it has been run.

4.4 Inputs to Control Strategies

Control strategies are defined by a series of fields that must be set prior to running the strategy. These fields are described in this section.

4.4.1 Inputs on the Summary Tab

Along with the name and description of the strategy, the Control Strategy **Summary** tab defines the type of analysis to use for the strategy, spatial-temporal parameters, the target pollutant, and the interest rate. To set the fields for the strategy on the **Summary** tab (see Figure 4.6), follow the steps below. Note that the fields on the Summary tab missing from this list are automatically set by CoST, and are discussed in **Fields Automatically Set by CoST Section**. *Fields that are contained within boxes with either white backgrounds or that are pull-down menus are editable; fields that are not contained within boxes are set by the software and cannot be changed by the user.*

Step 4-1: Set the Control Strategy Name and Description. If one has not already been specified, enter a unique and descriptive **Name** for the control strategy. For this example set Name to **Least Cost 2017 NOx Example**. Enter a **Description** of the purpose for the control strategy, and any other information relevant and useful to describe the strategy.

Optionally, use the **Project** pull-down menu to select a project for which this strategy run was performed (e.g., Ozone NAAQS Final 2008). Projects are set in the EMF and are used as a means of grouping related strategies that were performed in support of a common goal.

The screenshot shows a software window titled "Edit Control Strategy: Least Cost 2017 NOx for Training". The window has a tabbed interface with the following tabs: Summary, Inventories, Measures, Constraints, and Outputs. The "Summary" tab is currently selected.

Summary Tab Fields:

- Name:** Least Cost 2017 NOx for Training
- Description:** (Empty text box)
- Project:** (Dropdown menu) **Project Notes** (Button)
- Creator:** Liz Adams **Last Modified Date:** 08/08/2017 12:58
- Type of Analysis:** Least Cost (Dropdown menu) **Copied From:** (Empty text box)
- Is Final:** ☐

Parameters Section:

- Cost Year:** 2013 (Dropdown menu)
- Target Year:** 2017 (Text box)
- Region:** (Dropdown menu)
- Target Pollutant:** NOX (Dropdown menu)
- Discount Rate (%):** 7.0 (Text box)
- Use Cost Equations:** ☒ **Include Measures with No Cost Data:** ☒
- Apply CAP measures on HAP Pollutants:** ☐ **Major Pollutant must match Target:** ☒

Results Section:

- Start Date:** Not started
- Completion Date:** Not started
- Running User:** (Empty text box)
- Total Annualized Cost:** (Empty text box)
- Target Poll. Reduction (tons):** (Empty text box)

Buttons: Save, Close, Run, Refresh, Stop

Figure 4.6: Summary Tab of Edit Control Strategy Window

Step 4-2: Set Strategy Type. Use the **Type of Analysis** pull-down menu to set the type of algorithm used to match the control measures with sources (e.g., Maximum Emissions Reduction, Least Cost). For this example, select **Least Cost** as the analysis type.

Optionally specify whether the strategy **Is Final** to finalize and archive the strategy. Once marked as final, a strategy may not be rerun. For this exercise, do not check the **Is Final** checkbox.

Step 4-3: Set the Cost Year. Use the **Cost Year** pull-down menu to set the year to use for estimating the costs of a strategy. For this exercise, set **Cost Year** to **2013**. All cost data specified for the control measures will be converted to this year using the Gross Domestic Product (GDP): Implicit Price Deflator (IPD), issued by the U.S. Department of Commerce, Bureau of Economic Analysis. Details of the computation used are given in the [Control Strategy Tool \(CoST\) Development Document](#). The **Cost Year** cannot be set to the current year because the economic data necessary is not made available until after the end of each calendar year.

Step 4-4: Set the Target Year. The target year should correspond to the input inventory or inventories (e.g., 2020, 2030). For control measure efficiency records to be considered for a strategy, the specified effective date for the record must be equal to or earlier than the target year. Note that any control measure efficiency records that come into effect *after* the target year will not be considered for use in the strategy. For this example set **Target Year** to **2017**.

Optionally set the name of the geographic **Region** to which the strategy is to be applied. This setting is informational only and does not impact the strategy results. **Region** is different from the concept of “locale” used in the control measure efficiency records to indicate the state or county code to which the record applies. For this example, set **Region** to **NC**.

Step 4-5: Set the Target Pollutant. The target pollutant is the pollutant of primary interest for emissions reductions from the control strategy. The Least Cost and Maximum Emissions Reduction algorithms will apply reductions to the target pollutant. For the Multi-Pollutant Maximum Emissions Reduction strategy, one or more pollutants must be selected from the **Target Pollutant** pull-down menu.

Note that reductions of pollutants other than the selected target pollutant (e.g., PM10-PRI, PM2.5-PRI, elemental carbon [EC], organic carbon [OC]) will be included in strategy results if those pollutants both appear in the inventories input to the strategy and they are affected by measures applied as part of the strategy. These pollutants are sometimes referred to as “co-impact pollutants”, because the impact on the emissions could be either a reduction (i.e., a benefit) or an increase (i.e., a disbenefit).

If **Multi-Pollutant Maximum Emissions Reduction** is selected from the **Type of Analysis** pull-down menu, set the **Target Pollutant** using the **Set** button next to this field to select from a list of pollutants to use for the strategy. Select the pollutants to include in the strategy from the pollutant list using Control-Click.

For this Least Cost example, use the pull-down menu to set **Target Pollutant** to VOC.

Step 4-6: Set the Interest Rate. The Interest Rate is used in the calculation of the

annualized capital cost for control measures when appropriate data are available. For this example, set the **Interest Rate** to **7.0**. Note that the interest rate typically does not affect strategies for area or mobile sources.

Step 4-7: Use Cost Equations. When the **Use Cost Equations** checkbox is checked, cost equations will be included in the strategy run; otherwise only cost per ton-related (CPT) cost estimates will be used. For this exercise, leave **Use Cost Equations** checked to use the Least Cost equations selected as the **Type of Analysis** in Step 2-9.

Step 4-8: Apply CAP measures on HAP Pollutants. When the **Apply CAP measures on HAP Pollutants** checkbox is checked, a CAP-to-HAP pollutant mapping is used to apply CAP reductions to the corresponding HAP pollutants at the same emission reduction percentage. For this exercise, leave **Apply CAP measures on HAP Pollutants** unchecked so that HAP pollutant controls will not be used.

Step 4-9: Include Measures with No Cost Data. When the **Include Measures with No Cost Data** checkbox is checked, measures with control efficiencies but without cost data are included in the strategy run; otherwise they are not included. These are typically measures with no cost data specified or measures that use a cost equation to compute cost, but for which there is not enough data for the source in the inventory to fill in the equations variables. For this exercise, leave **Include Measures with No Cost Data** checked.

Step 4-10: Specify whether Major Pollutant must match Target. When the checkbox is checked, then the major pollutant must be the same as the target. For this exercise, leave **Major Pollutant must match Target** checked.

4.4.2 Fields Automatically Set by CoST

Some fields of a control strategy that appear on the **Summary** tab are set automatically by the CoST software and are not specified by the user. Note that some of these summarize the results of the strategy analysis, so information for them is not available until after the strategy has been run. The automatically set fields are described in Table 4.4.

Table 4.4: Fields Automatically Set by CoST.

Field	Description
Creator	The name of the person who created the strategy.
Last Modified Date	The date and time when the strategy was last modified.
Copied From	The name of the strategy that this strategy was copied from, if any.
Start Date	The date and time on which the strategy run was most recently started, or “Not started” if the strategy has never been run.
Completion Date	The date and time on which the strategy run was most recently completed. If the run has not completed, this field shows the run status of either “Not started”, “Running”, “Waiting”, “Completed”, or “Failed”.

Field	Description
Running User	The name of the user who most recently ran the strategy.
Total Annualized Cost	The total annualized cost of applying the strategy.
Target Poll. Reduction (tons)	The absolute emissions reduction achieved for the target pollutant, in tons.

4.4.3 Inputs on the Inventories Tab

This section describes how to set the inventory inputs for a Control Strategy on the Edit Control Strategy window **Inventories** tab (Figure 4.7). Click on the **Inventories** tab. The **Inventories to Process** table near the top of the tab lists the emissions inventories for which the control strategy will be run. A control strategy can have one or more emissions inventories as input. Before inventories can be selected for use in the strategy, they must already have been imported into the EMF using either the **Import** item on the **File** menu of the EMF Main Window or through the Dataset Manager. The CoST application comes preloaded with several example inventories for training purposes.

CoST/EMF supports both one-record-per-line (ORL) and flat file (FF10) inventory formats. Point source inventories have information about emissions sources with specific locations, which are specified using latitude and longitude. Nonpoint, nonroad, and onroad inventories contain data aggregated to the county level. *Note that IDA inventories are not supported by CoST and need to be converted to ORL or FF10 prior to use with CoST.* The EMF database stores the data for the emissions inventories along with metadata about the inventories in its PostgreSQL (<http://www.postgresql.org>) database.

Step 4-11: Add an Inventory to Control Strategy. To add one or more inventories to the **Inventories to Process** table for the control strategy, click the **Add** button on the **Inventories** tab. From the **Select Datasets** window that appears, use the **Choose a dataset** type pull-down menu to select the type of inventory to add (e.g., Flat File 2010 Nonpoint). The file browser will display the inventories of the specified type (Figure 4.8). If there are many inventories in the list, narrow down the list (e.g., to find inventories for 2017) by entering a search string in the **Dataset name contains** field and pressing the **Enter** key on your keyboard.

To select an inventory to use for the strategy from the **Select Datasets** window, click on the name of the inventory in the table. For this exercise, after choosing **Flat File 2010 Nonpoint** from the **Choose a dataset** type pull-down menu, select **2017eh_from_nonpoint_2011NEIv2_NONPOINT_20141108_09mar2015_v0_FIPS_37** and then click **OK**. The inventory file will then be displayed in the **Inventories to Process** window of the **Inventories** tab.

Step 4-12: Add a Second Inventory to Control Strategy. Click the **Add** button to add a second inventory to the control strategy. Select **Flat File 2010 Point** from the **Choose a dataset** type pull-down menu and add **2017eh_from_ptnonipm_2011NEIv2_POINT_20140913**.

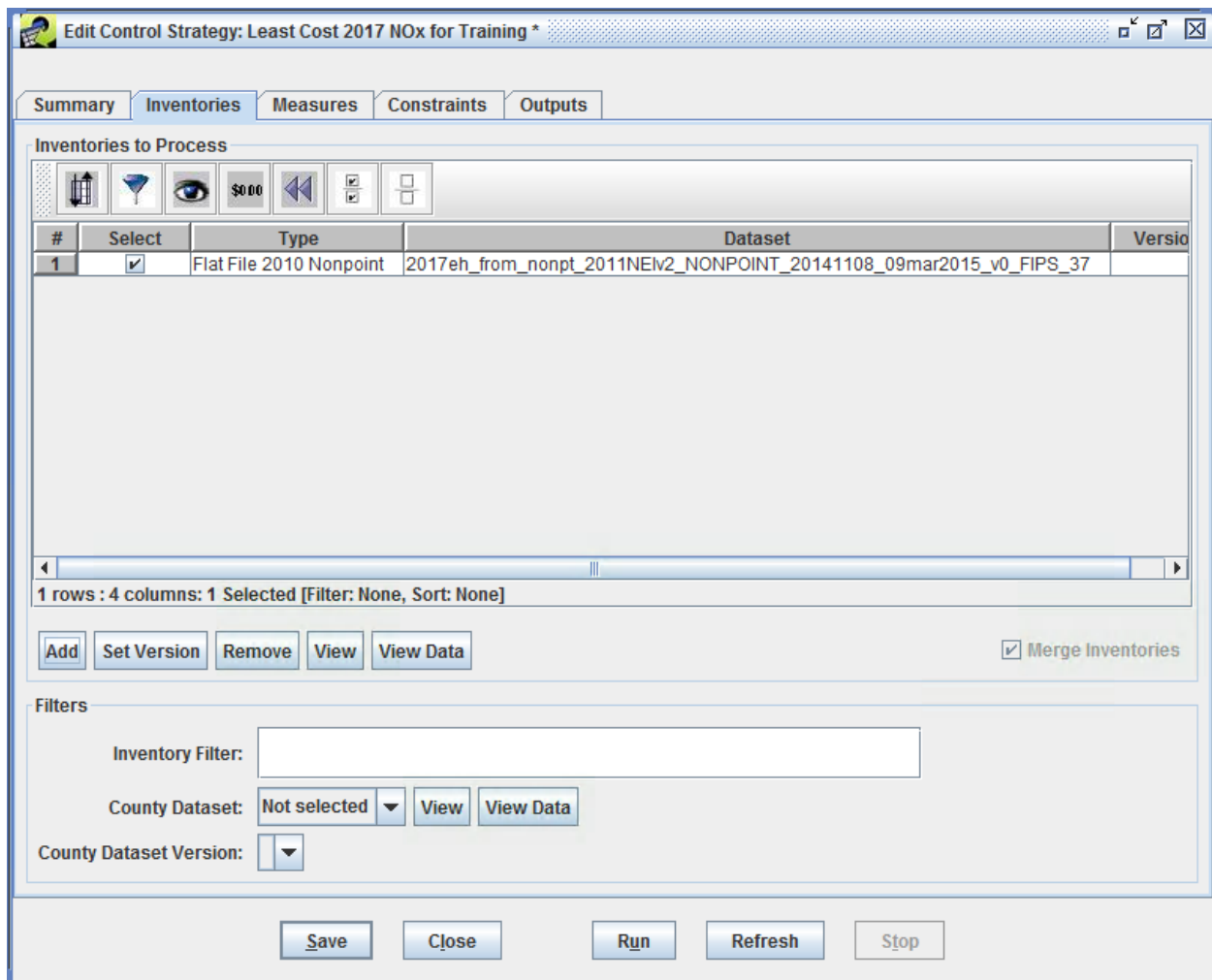


Figure 4.7: Inventories Tab of Edit Control Strategy Window

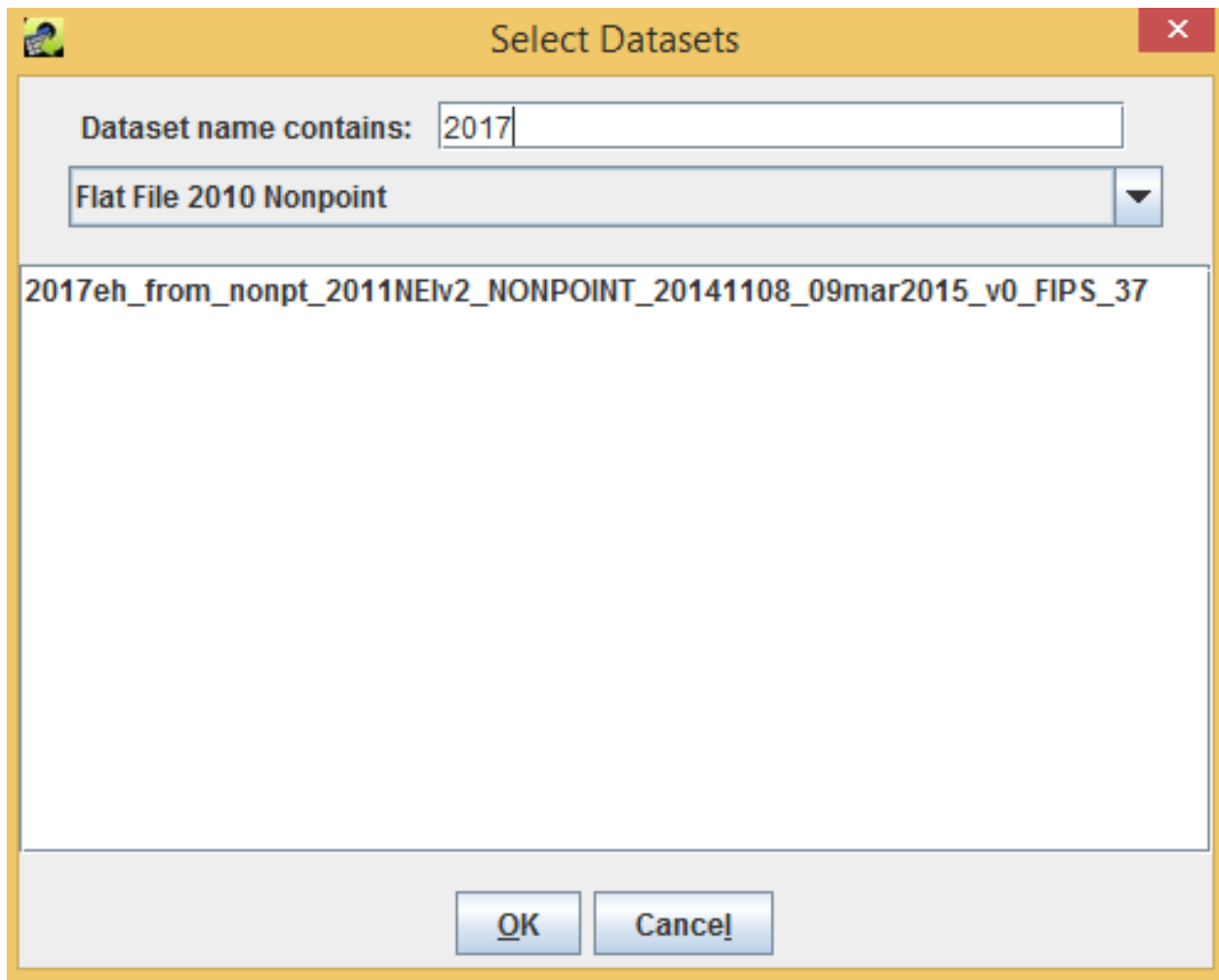


Figure 4.8: Selecting Inventory Datasets for a Control Strategy

Note: To select multiple inventories, hold down the control key while clicking the additional inventories.

Step 4-13: Remove an Inventory from a Control Strategy. To remove inventories from a control strategy, click the **Select** checkbox next to the inventory to remove and click the **Remove** button below the **Inventories to Process** table (Figure 4.7). Click **Yes** to confirm deletion of the selected inventories. There is no need to remove either of the inventories for this example strategy.

Step 4-14: Set Dataset Versions. Note that multiple versions of the inventories may be available within the EMF. The EMF supports dataset versioning to facilitate reproducibility of historical runs. To specify which version of an inventory to use, check the **Select** checkbox next to a single inventory file in the **Inventories to Process** table and then click the **Set Version** button. A window will appear with a pull-down menu that lists the versions available for the selected inventory. Choose the desired version from the menu and then click the **OK** button to set the version to use for the strategy. You will then see the version number in the **Version** column of the **Inventories to Process** table. Note that the initial version of a dataset is always version **0**. There is no need to change the inventory versions for the example exercises.

Step 4-15: View Dataset Properties. To see the properties (i.e., metadata) for an inventory dataset, click the checkbox in the **Select** column of the **Inventories to Process** table and then click **View**. The **Dataset Properties View** window will appear (Figure 4.9). The **Dataset Properties View** window provides information about the selected inventory dataset and has multiple tabs as described in Table 4.5.

Table 4.5: Dataset Properties View Window Tabs.

Tab	Description
Summary	Shows high-level properties of the dataset
Data	Provides access to the actual inventory data so that you can view the data that will be used in the control strategy
Keywords	Shows additional types of metadata not found on the Summary tab
Notes	Shows comments that users have made about the dataset and questions they may have
Revisions	Shows the revisions that have been made to the dataset
History	Shows how the dataset has been used in the past
Sources	Shows where the data came from and where it is stored in the database, if applicable
QA	Shows QA summaries that have been made of the dataset (e.g., state summaries, county summaries)

In addition to the different tabs, there are buttons at the bottom of the Data Properties window. The **Edit Properties** button displays the **Dataset Properties Editor** for *changing* (as opposed to viewing) the properties of the Dataset. The **Edit Data** button displays the **Dataset Versions Editor** for editing the actual data of the dataset by adding new versions.

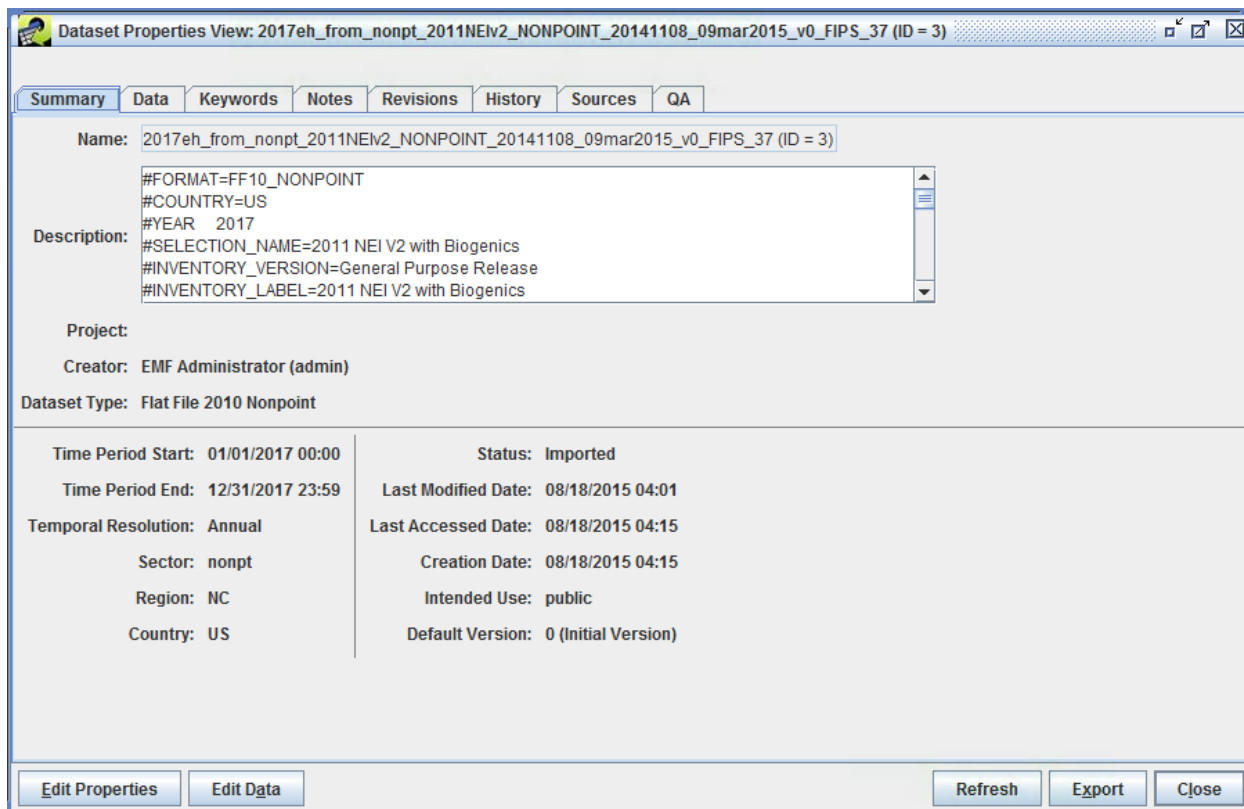


Figure 4.9: Dataset Properties View Window for an Emissions Inventory

The **Refresh** button updates the data on the **Dataset Properties View** window with the latest information available from the server. The **Export** button exports the dataset data to a file. The **Close** button closes the **Dataset Properties View** window.

Close the **Dataset Properties View** window by clicking **Close**.

Step 4-16: View Inventory Data. To view the inventory data itself (as opposed to just the metadata), check the **Select** checkbox next to an inventory file in the **Inventories to Process** table in the **Inventories** tab of the **Edit Control Strategy** window and click the **View Data** button. A Data Viewer window will appear that shows the actual data for the selected inventory (Figure 4.10). The data shown here are different from the metadata in the Dataset Properties View window. *Note that the View Data button is a shortcut. The Data Viewer can also be brought up from the Data tab of the Dataset Properties Viewer.*

Inventories can contain a lot of data, so only the first 300 rows of an inventory are transferred from the server to the Data Viewer by default. The fields in the upper right corner of the window in the area labeled “**Current**” provide information about how many rows the inventory has, and which rows are currently visible. The **Data Viewer** works similarly to a web search engine that shows the results in pages, and the pagination arrows near the upper right corner of the window facilitate moving between pages of data. Use the pagination arrows in the upper right corner of the window to see how they work. Go to first record, go to previous page, give a specific record, go to next page, and go to last record.

Data Viewer [Dataset:2017eh_from_nonpt_2011NElv2_NONPOINT_20141108_09mar2015_v0_FIPS_37, Version: Initial Version, Table: DS_2017eh_from_n...

Sort Order: Apply

Row Filter:

Current: 1 - 300 Filtered: 93866 of 93866

Decimal Places: 4 ☒ Show Commas Format ☐ Reset View

COUNTRY_CD String(4)	REGION_CD String(6)	TRIBAL_CODE String(3)	CENSUS_TRACT_CD String(20)	SHAPE_ID String(20)	SCC String(12)	EMIS_TYPE String(10)	POLL String(20)	ANN_VALUE Double
US	37017				2610030000		118741	
US	37017				2810060100		7440020	
US	37017				2610030000		129000	
US	37017				2610030000		1336363	
US	37017				2610030000		193395	
US	37017				2501055120		1330207	
US	37017				2501050120		98828	
US	37017				2610030000		85018	
US	37017				2810060100		7440382	
US	37017				2810060100		VOC	
US	37077				2102004000		PM10-FIL	
US	37077				2102004000		NH3	
US	37077				2103007000		CO	
US	37077				2104002000		193395	
US	37077				2103004000		85018	
US	37077				2302003200		PM10-PRI	
US	37077				2102011000		PM-CON	
US	37077				2104006000		PM10-PRI	
US	37077				2302002100		71432	
US	37077				2610000100		100425	

Add Note Close

Figure 4.10: Data Viewer for an Emissions Inventory

The data sorting can be controlled by entering a comma-separated list of columns in the **Sort Order** field and then clicking **Apply**. Note that a descending sort order can be specified by following the column name with “desc” (e.g., “ANN_VALUE desc, REGION_CD” will sort by decreasing annual emissions and then by county).

If you enter a **Row Filter**, and then click **Apply**, the **Data Viewer** will find rows that meet the specified criteria. Examples of the syntax for row filters are given in Table 4.6. See Chapter 6 for additional row filter examples.

Table 4.6: Row Filter Examples.

Filter Purpose	SQL Where Clause
Filter on a particular set of SCCs	<code>scc like '246%' or scc like '261%'</code>
Filter on a particular set of pollutants	<code>poll in ('PM10-PRI', 'PM25-PRI') or POLL = 'PM10-PRI' or POLL = 'PM25-PRI'</code> Filter sources only in NC (REGION_CD = 37); note that REGION_CD column format is State + County FIPS code (e.g., 37017) <code>substring(REGION_CD,1,2) in ('37')</code> or <code>REGION_CD like '371'</code> for only sources in NC with a county FIPS code that starts with 1. Filter sources only in NC (37) and include only NOx and VOC <code>pollutants substring(REGION_CD,1,2) = '37' and poll in ('NOX', 'VOC') *or* REGION_CD like '37%' and (poll = 'NOX' or poll = 'VOC')</code>

Click **Close** to close the **Data Viewer** window.

The next few paragraphs provide information on how the options at the lower portion of the **Inventories** tab work.

Some control strategy algorithms (e.g., Apply Measures in Series) are designed to process the inventories iteratively and produce results for each inventory. However, the “Least Cost” and “Least Cost Curve” strategy types can merge the input inventories from multiple sectors together prior to processing them, thereby facilitating cross-sector analyses. The **Merge Inventories** checkbox in the lower right corner of the **Inventories to Process** section of the **Inventories** tab controls whether multiple inventories will be merged together prior to applying the strategy algorithm, such as for Least Cost or Least Cost Curve runs. Otherwise, each inventory will be processed independently to create separate, independent results.

The fields in the **Filters** section of the **Inventories** tab of control whether the entire inventory is processed in the strategy or just a portion of it. The **Inventory Filter** field sets a general filter that can be entered using the same syntax as a Structured Query Language (SQL) “where clause”. Any of the columns in the inventory can be used in the expression. Examples include: “‘SCC like ‘212%’” to limit the analysis to apply only to inventory records for which the SCC code starts with 212, and “‘FIPS like ‘06%’ or FIPS like ‘07%’” to limit the strategy analysis to apply only to inventory records with FIPS numeric state-county codes starting with 06 or 07. Additional examples of filters are shown in Table 4.6.

Note: for the Multi-Pollutant Maximum Emission Reduction control strategy type the **Inventory Filter** has been moved from the **Inventories** tab to the **Constraints** tab. (you are currently viewing the Least Cost Curve Strategy at this point in the exercise, so the **Inventory Filter** is on the **Inventories** tab) For the Multi-Pollutant Maximum Emissions Reduction control strategy it is possible to specify the **Inventory Filter** differently for each target pollutant instead of at the strategy level. Note that within the inventory filter, either upper or lower case may be used to refer to the column names and for the SQL keywords; the specified values within single quotes, however, are case sensitive (e.g., ‘NOx’ is different from ‘NOX’). Adding an inventory filter will not have an effect on the strategy until the strategy is run.

If an inventory filter includes only specific pollutants, then pollutants not specified by the filter will not be considered for the computation of co-impacts from a strategy. In addition, pollutants like EC and OC that are not traditionally included in input inventories will not be included in the results unless the inventory has been preprocessed to include EC and OC.

The **County Dataset** filter allows another way to filter the inventory. This field sets an EMF dataset with a list of counties to which control measures will apply during the strategy run. Control measures will be applied only to counties that are included in this list. The **County Dataset** pull-down menu will show the names of the available CSV datasets in the EMF that have the dataset type ‘List of Counties (CSV)’. Note that CSV files from which these county datasets are created must have at least two columns of data. Also, the first row of the file must be the column names, and one of the columns must have a name that starts with “FIPS”. CoST will assume that this column has the list of FIPS codes that should be controlled. Make sure that leading zeros are present for FIPS codes less than 10000. Note that for the Multi-Pollutant Maximum Emissions Reduction control strategy type the **County Dataset** filter has been moved from the **Inventories** tab to the **Constraints** tab. For the Multi-Pollutant Maximum Emissions Reduction control strategy it’s possible to specify different **County Dataset** filters for each target pollutant instead of at the strategy level.

Note that only the records of the input inventories that pass both the inventory and county filters will be considered for control measure application.

Step 4-17: Set Inventory Filters. For this exercise, set the following on the **Inventories** tab: **Inventory Filter**: REGION_CD in (‘37077’, ‘37017’, ‘37095’). Note that specifying a list of counties using the **Inventory Filter** is an alternative to specifying a county dataset that has a list of counties to consider controlling in the strategy (as shown in the next bullet). To control only a few counties, it is straightforward to use the **Inventory Filter**; to control more than a few counties, the county dataset method is recommended. In addition, many

types of Inventory Filters can be specified using other fields of the inventory depending on the specifications of the control strategy (e.g., SCC like '231%', or ANN_VALUE>5).

Step 4-18: View a County Dataset. Examine the available county datasets by pulling down the **County Dataset** menu and selecting one of the datasets. After selecting a county dataset, examine the dataset properties by clicking **View**. Display the actual county dataset data by clicking **View Data**. Select a version of the dataset using the **County Dataset Version** field, which shows the available versions of the selected dataset. This selection is required because the EMF can store multiple versions of each dataset.

For this example, set the **County Dataset** pull-down menu to **Not selected** before proceeding.

4.4.4 Inputs on the Measures Tab

The **Measures** tab appears on the Edit Control Strategy window for all types of strategies. The **Measures** tab sets the control measures to use in a strategy run. There are two mutually exclusive ways to select control measures for inclusion in the control strategy run. The default is to include measures according to their class (see the top half of Figure 4.11). Currently available classes are **Known** (i.e., already in use), **Emerging** (i.e., realistic, but in an experimental phase), **Hypothetical** (i.e., the specified data are hypothetical), and **Temporary** (controls that are used during the analysis only if the user was the creator of the control measure, therefore other users' temporary measures won't be considered during an analysis). By default, only **Known** measures will be included in the strategy run. The second way to specify measures for inclusion in a strategy run is to select a list of specific measures to consider using for the run. The use of these two methods is described in this section. To select additional classes of measures other than the default 'Known', **hold down the Ctrl key while clicking the desired classes of measures**. To start over with selecting classes, just click on a single class of measure without holding down the Ctrl key. Note that only the measures with the classes selected by the user will be included in the strategy run.

Step 4-19: Select Control Measures by Class. Click on one of the classes in the **Classes to Include** table and click **Save** to include all measures of a given class in a control strategy. To select multiple classes of measures, hold down the Ctrl key while clicking the desired classes of measures. To start over with selecting classes, just click on a single class of measure without holding down the Ctrl key. Note that only the measures with the classes selected by the user will be included in the strategy run.

Step 4-20: Select Specific Control Measures. To select specific measures for inclusion in the strategy, click the **Add** button under the **Measures to Include** table to show the **Select Control Measures** window (Figure 4.12). In this window, set a filter to find all measures with the same control technology. Use the checkboxes in the **Select** column to select the measures to include in a control strategy. To select all of the measures shown in the **Select Control Measures** window, click the **Select All** button in the toolbar. Uncheck measures to exclude from a strategy. For this example, use the **Filter** to select all sources matching the following criteria: **Abbrev contains SNCR**.

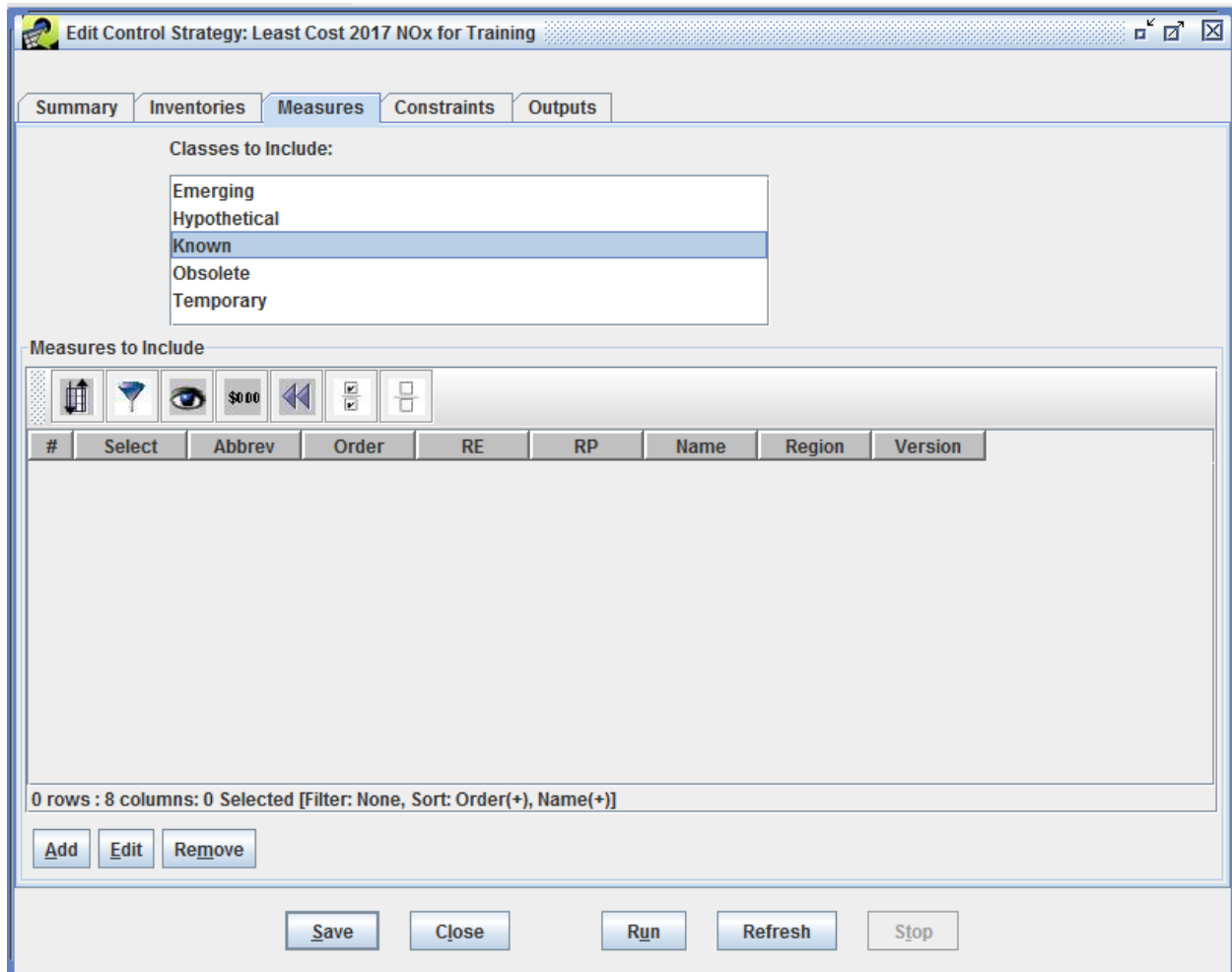


Figure 4.11: Measures Tab of Edit Control Strategy Window

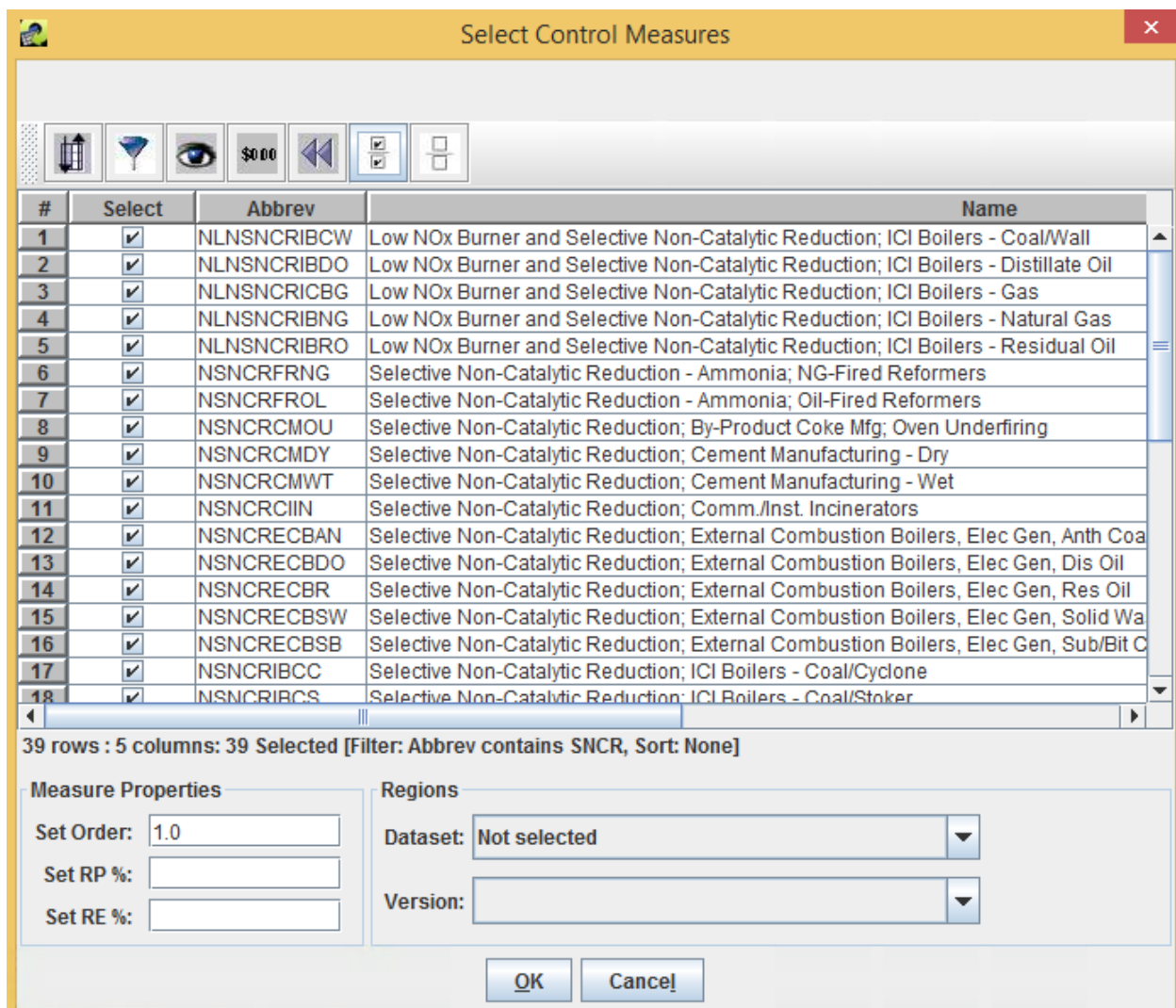


Figure 4.12: Dialog to Add Specific Control Measures to a Strategy

- Specify an **Order** to control the order in which this group of measures is applied as compared to other groups of measures you have selected. This order of application is particularly relevant to the “Apply Measures in Series” strategy type. When running this type of strategy, since multiple measures can be applied to the sources, they will be applied in increasing numerical order (i.e., measures with order set to 1 will be applied before those with order set to 2).
- **Set Order**: Controls the order in which the current group of measures is applied as compared to other groups of measures selected for the control strategy. This order of application is particularly relevant to the “Apply Measures in Series” strategy type. When running this type of strategy, since multiple measures can be applied to the sources, they will be applied in increasing numerical order (i.e., measures with order set to 1 will be applied before those with order set to 2).
- **Set RE%**: Overrides the values of Rule Effectiveness specified in the measure efficiency records.
- **Set RP%**: Overrides the values of Rule Penetration specified in the measure efficiency records. These two settings are useful for assessing the level of emissions reductions achieved assuming different levels of effectiveness and penetration for the measures. For example, setting the rule penetration to 75% assumes that 75% of the sources are applying the measure and would therefore result in 75% of the emissions reductions it would achieve if it was 100%.
- **Regions**: Sets a county dataset from the **Dataset** pull-down menu and a version of that dataset from the **Version** menu. By setting a **Region** the selected measures will only be applied to counties listed in the selected county dataset.

After selecting some the specific measures and overrides using the **Select Control Measures** window, click **OK** to add the measures to the control strategy. The selected measures will appear on the **Measures** tab. The tab will now look similar to that shown in Figure 4.13. Note that only the table of specific measures and their properties is shown, and the **Classes to Include** list is no longer shown. If desired, you may repeat the process of selecting specific measures to add new sets of measures to the list of measures to be used for the strategy. Each new group of measures selected can have different settings for the order, RE, RP, and Region.

Step 4-21: Editing Control Measures List. Specific measures included in a control strategy can be changed by selecting the measure(s) to edit using the checkboxes in the **Select** column of the **Measures to Include** table in the **Measures** tab of the **Edit Control Strategy** window. Select the measures to change and click the **Edit** button. An **Editing Measures** window will appear that supports changes to the measure properties as they apply to the control strategy. Click **OK** to accept the edits or **Cancel** to reject the edits.

Step 4-22: Removing Control Measures from a Strategy. To remove specific measures from the list of measures to be included in a strategy run, check the corresponding **Select**

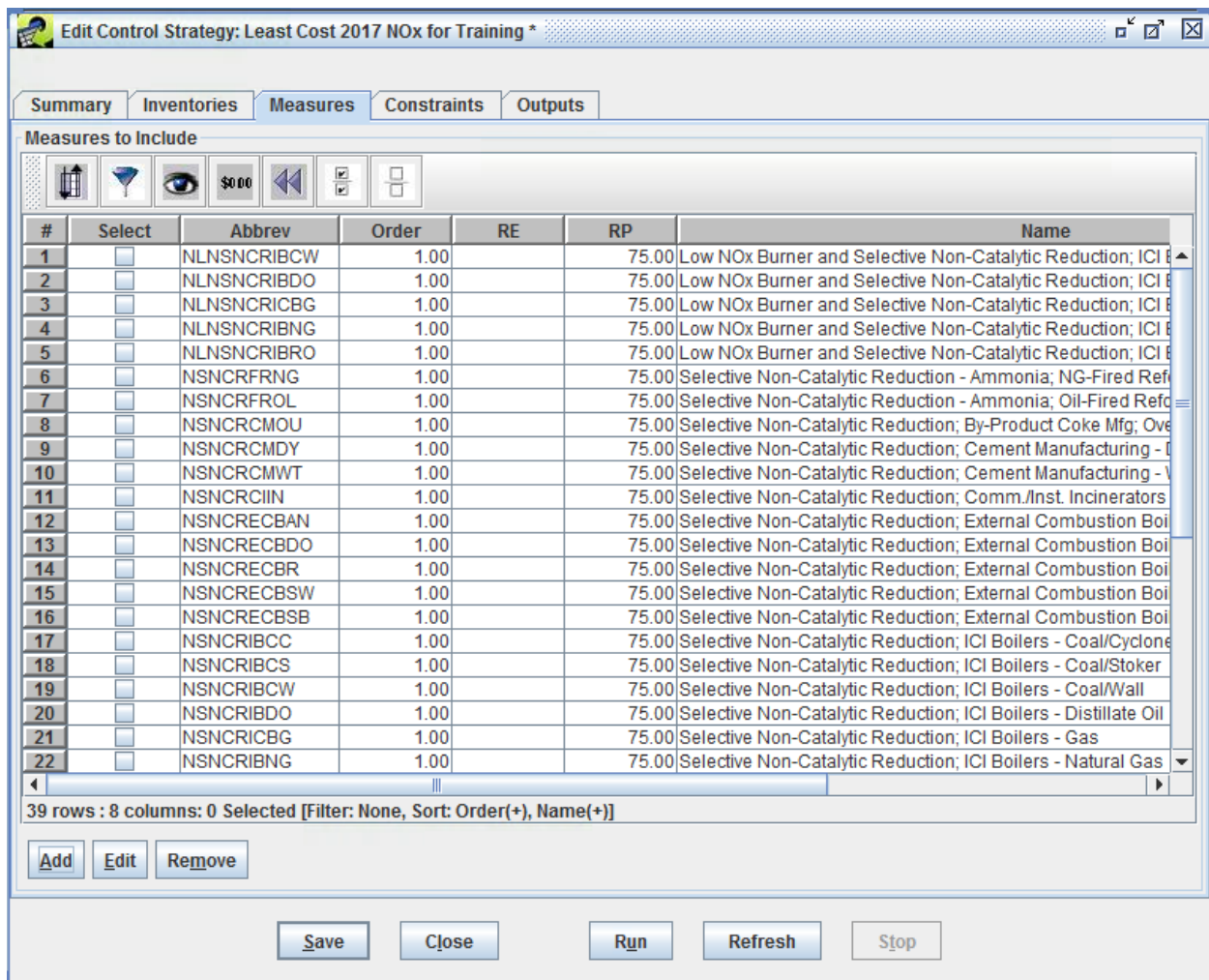


Figure 4.13: Measures Tab Showing Specific Measures to Include

checkboxes and then click **Remove**. Click **Yes** to confirm the removal of the selected measures from the control strategy.

For this example, remove all of the individually selected measures by clicking the **Select All** button on the **Measures** tab toolbar and then clicking **Remove** and **Yes** when prompted. Make sure that **Emerging** and **Known** are both selected in the **Classes to Include** list. The Measures tab will again look like Figure 4.11.

4.4.5 Input on Constraints Tab

The **Constraints** tab (Figure 4.14) of the **Edit Control Strategy** window can be used to specify constraints for a control strategy to limit how control measures are assigned during the strategy run. For example, a strategy could be set up to not use any measures that cost more than \$5,000 per ton (in 2013 dollars) for the target pollutant. Alternatively, a strategy could be defined to only use measures that reduce at least 1 ton of the target pollutant for the source. CoST evaluates the constraints while the source is being matched with the control measures. For example, the emissions reductions achieved by applying a measure to a source are not known until the measure and its control efficiency have been selected. Thus, constraint calculations are dependent on both the inventory source and the measure being considered for application to the source. Note that the term “source” here refers to a single row of the emissions inventory, which for point sources is uniquely determined by FIPS, plant, point, stack, segment, and SCC, and for nonpoint sources is uniquely determined by FIPS and SCC. Sources should not be confused with “plants”, each of which can contain many sources.

Table 4.7 defines the constraints that are applicable to all strategy types. If the constraint values are not satisfied for a particular control measure and source combination, the measure under consideration will not be applied to the source, and CoST will look for another measure that satisfies all of the constraints.

Table 4.7: Constraints Elements Applicable to All Strategy Types.

Constraint Name	Constraint Description
Minimum Emissions Reduction (tons)	If specified, requires each control measure to reduce the target pollutant by at least the specified minimum tonnage for a particular source (down to the plant+point+stack+segment level of specification); if the minimum tonnage reduction is not attainable, the measure will not be applied.
Minimum Control Efficiency (%)	If specified, requires each control measure used in the strategy to have a control efficiency greater than or equal to the specified control efficiency for a particular source and target pollutant.
Maximum 2013 Cost per Ton (\$/ton)	If specified, each control measure must have an annualized cost per ton less than or equal to the specified maximum annualized cost per ton for the target pollutant for each source. This cost is based on 2013 dollars.

Constraint Name	Constraint Description
Maximum 2013 Annualized Cost (\$/yr)	If specified, each control measure must have an annualized cost less than or equal to the specified annualized cost for each source and target pollutant. This cost is based on 2013 dollars.
Minimum Percent Reduction Difference for Replacement Control (%)	If specified, each control measure must have a percent reduction in emissions with the new measure that is greater than or equal to the specified difference for the old control measure to be “replaced by” the new control measure. Incremental controls that add an additional device onto a currently controlled source are not yet supported by CoST except for the Apply Measures in Series strategy type, for which all controls are assumed to be independently applicable. In the event that a combination of two control devices is listed as a control measure (e.g., LNB+FGR) and the combined control efficiency provides an ample increase in the control efficiency over the original efficiency, that combination of the devices can still serve as a replacement control if the source already has a measure applied (e.g., LNB). In the future, instead of requiring an increase in the percent reduction, it may be more useful to specify a minimum additional percent reduction in remaining emissions (e.g., such as one might see when going from a 99% control measure to a 99.5% control measure).

The constraints in Table 4.7 are available in the **All Strategy Types** section of the **Constraints** tab. The **Least Cost** section of the **Constraints** tab is used to specify constraints that are specific to the Least Cost strategy type. These constraints vary based on the type of algorithm selected. Figure 4.14 shows the constraints specific to the Least Cost strategy algorithm.

Details of algorithm-specific constraints for the Least Cost, Least Cost Curve, and Multi-Pollutant Maximum Emissions Reduction follow.

4.4.6 Least Cost Algorithm Constraints

Constraints for the Least Cost algorithm, include *either* a **Domain Wide Emissions Reduction** for the target pollutant in tons or a **Domain Wide Percent Reduction** in emissions of the target pollutant. When the strategy is run, CoST will attempt to satisfy the specified reduction using controls selected with the minimum cost. Note that after the strategy run is complete, CoST will fill in the value for the least cost constraint that was not originally specified.

Step 4-23: Set a Least Cost Constraint. Enter a **Domain Wide Percent Reduction(%)** of **15.0** for the **Least Cost** Constraint. Click **Save** to save the changes made to the strategy. Do not close the Edit Control Strategy window yet.

Order: 1

Pollutant: NOX

Minimum Emissions Reduction (tons) 5.0

Minimum Control Efficiency (%)

Maximum Cost per Ton (\$/ton) [in Strategy Cost Year dollars] 10000.0

Maximum Annualized Cost (\$/yr) [in Strategy Cost Year dollars]

Minimum Percent Reduction Difference for Replacement Control (%) 10.0

Inventory Filter:
(e.g., ANN_EMIS>5000 and SCC like '30300%') ANN_VALUE>25 and REGION_CD='37119'

County Dataset: Not selected

County Dataset Version: ▼

OK Cancel

Figure 4.14: Constraints Tab of Edit Control Strategy Window

Note that if you were to click **Close** without saving the changes, a prompt will ask if you wish to close the window without saving the changes.

4.4.7 Least Cost Curve Algorithm Constraints

When **Least Cost Curve** is selected from the **Type of Analysis** pull-down menu on the **Summary** tab three constraints settings are available in the **Least Cost Curve** section of the **Constraints** tab: **Domain-wide Percent Reduction Increment (%)**: increment for subsequent least cost runs to iterate on until the end percent reduction is reached. **Domain-wide Percent Reduction Start (%)**: target emissions reduction for the first least cost run; and **Domain-wide Percent Reduction End (%)**: final emissions reduction target of the emissions reductions for the incremental least cost runs.

The Least Cost Curve strategy uses all three constraints in an iterative control run. First it will run the least cost strategy with the percent reduction specified as the value of **Domain-wide Percent Reduction Start (%)**. It will then add the **Domain-wide Percent Reduction Increment (%)** to the starting percent value and will run the least cost strategy at that value (i.e., starting value + increment). It will continue running strategies for each increment until it reaches the value of **Domain-wide Percent Reduction End (%)**. Note that it may not be possible to achieve some of the selected percent reductions, in which case CoST will generate the same result for that increment as the Maximum Emissions Reduction control strategy run would generate.

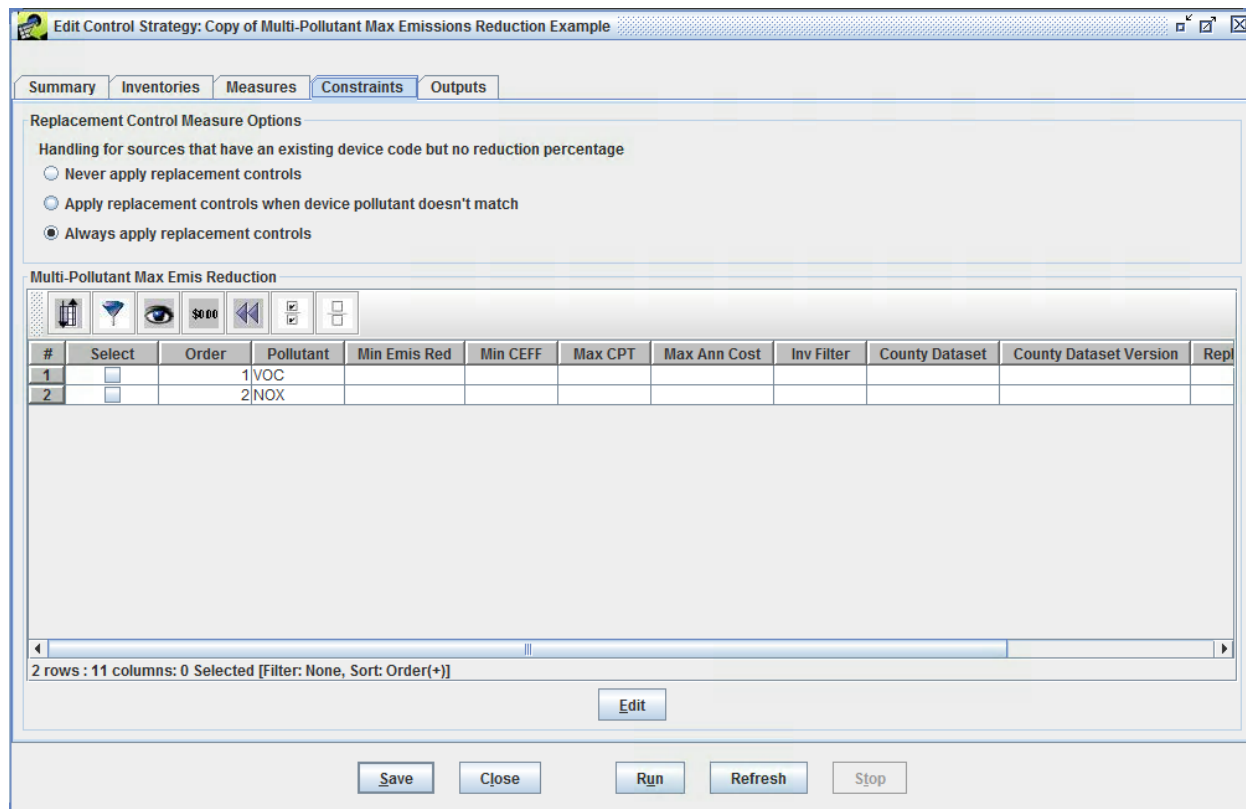


Figure 4.15: Constraints Tab (for Multi-Pollutant Maximum Emission Reduction strategy type) of Edit Control Strategy Window

4.4.8 Multi-Pollutant Maximum Emissions Reduction Algorithm Constraints

The Multi-Pollutant Maximum Emissions Reduction control strategy type presents a different **Constraints** Tab than the other control strategy types. Since this strategy type is running goals on numerous target pollutants (e.g. PM2.5-PRI, NO_x, SO₂), the constraints presented in Table 4.7 are combined with an inventory filtering capability (see the [Section on the Inputs to the Inventory Tab](#)) to allow for pollutant-specific constraints. The Multi-Pollutant control strategy **Constraints** tab interface is shown in Figure 4.15.

The first step in configuring a Multi-Pollutant Maximum Emissions Reduction control strategy is to select the target pollutants from the **Target Pollutant** list on the **Summary** tab. The pollutants selected from this list will appear in the table on the **Constraints** tab. Note that the order the pollutants are added to the **Target Pollutant** list is important because it sets the order by which controls are applied in the multi-pollutant strategy.

To set the constraints and filters for each pollutant, click the checkbox in the **Select** column next to a pollutant on the **Constraints** tab and click **Edit**. The **Edit Control Strategy Target Pollutant** window will appear for setting the constraints and filters to use as the control strategy for the selected pollutant. Figure 4.16 shows an example **Edit Control Strategy Target Pollutant** window. The fields in the Edit Control Strategy Window

include:

- **Minimum Emissions Reduction(tons)**: sets the minimum emissions reduction tonnage for a particular source (down to the plant+point+stack+segment level of specification); only control measures that meet this threshold will be considered for the strategy
- **Minimum Control Efficiency(%)**: requires that control measures used in the strategy have a control efficiency greater than or equal to the specified percentage for a particular source and target pollutant
- **Maximum 2013 Cost per Ton(\$/ton)**: requires that control measures used in the strategy have an annualized cost per ton less than or equal to the specified maximum annualized cost per ton for the target pollutant for each source. This cost is based on 2013 dollars
- **Maximum 2013 Annualized Cost(\$/yr)**: requires that control measures used in the strategy have an annualized cost less than or equal to the specified annualized cost for each source and target pollutant. This cost is based on 2013 dollars
- **Minimum Percent Reduction Difference for Replacement Control(%)**: requires that control measures used in the strategy have a percent reduction of emissions that is greater than or equal to the specified difference in order for an old control measure to be “replaced by” the new control measure
- **Inventory Filter**: sets a general filter that can be entered using the same syntax as a Structured Query Language (SQL) “where clause.” Any of the columns in the inventory can be used in the expression. Examples include: “‘SCC like ‘212%’” to limit the analysis to apply only to inventory records for which the SCC code starts with 212, and “‘FIPS like ‘06%’ or FIPS like ‘07%’” to limit the strategy analysis to apply only to inventory records with FIPS numeric state-county codes starting with 06 or 07.
- **County Dataset/Version**: sets an EMF dataset and version with a list of counties to which control measures will apply during the strategy run. Control measures will be applied only to counties that are included in this list. The County Dataset pull-down menu will show the names of the available CSV datasets in the EMF that have the dataset type ‘List of Counties (CSV)’

See Table 4.7 for an additional description of how these fields are applied in a control strategy.

4.5 Running a Strategy and Accessing Its Outputs

4.5.1 Running a Strategy

Step 5-1: Run Least Cost Example Strategy. After setting all of the example strategy inputs and constraints, as described in Section 4, click the **Run** button in the **Edit Control Strategy** window to start running the strategy. If the strategy was not saved before clicking **Run**, the changes will automatically be saved to the database. Note if the **Edit Control Strategy** window for the “Least Cost 2017 NOx Example” strategy is closed, it can be

Order: 1

Pollutant: NOX

Minimum Emissions Reduction (tons) 5.0

Minimum Control Efficiency (%)

Maximum Cost per Ton (\$/ton) [in Strategy Cost Year dollars] 10000.0

Maximum Annualized Cost (\$/yr) [in Strategy Cost Year dollars]

Minimum Percent Reduction Difference for Replacement Control (%) 10.0

Inventory Filter:
(e.g., ANN_EMIS>5000 and SCC like '30300%') ANN_VALUE>25 and REGION_CD='37119'

County Dataset: Not selected

County Dataset Version:

OK Cancel

Figure 4.16: Edit Target Pollutant Dialog of Edit Control Strategy Window

reopened by selecting the strategy from the list of strategies in the **Control Strategy Manager** and clicking the **Edit** button.

Step 5-2: Monitor a Control Strategy Run Status. After starting a control strategy run, check the **Status** window near the bottom of the EMF GUI to view messages about the run. If all inputs have been properly specified, the status message should show “**Started running control strategy: *your strategy name***”. Click the **Refresh** button on the **Status** window to see immediate status updates; the **Status** window will autoupdate every 1-2 minutes.

If the strategy runs successfully, one message will be displayed for each inventory that completes, such as “**Completed processing control strategy input dataset: *dataset_name***.” When the entire run has finished, the following message will be displayed: “**Completed running control strategy: *your strategy name***” in the **Status** window. Otherwise, message will display stating that the strategy failed with information about why it failed.

4.5.2 List Strategy Outputs

Step 5-3: List Control Strategy Run Outputs. Once the strategy run completes, click on the **Outputs** tab in the **Edit Control Strategy** window and then click **Refresh** at the bottom of the window to see the outputs from the run listed in the **Output Datasets** table (Figure 4.17 and Figure 4.18).

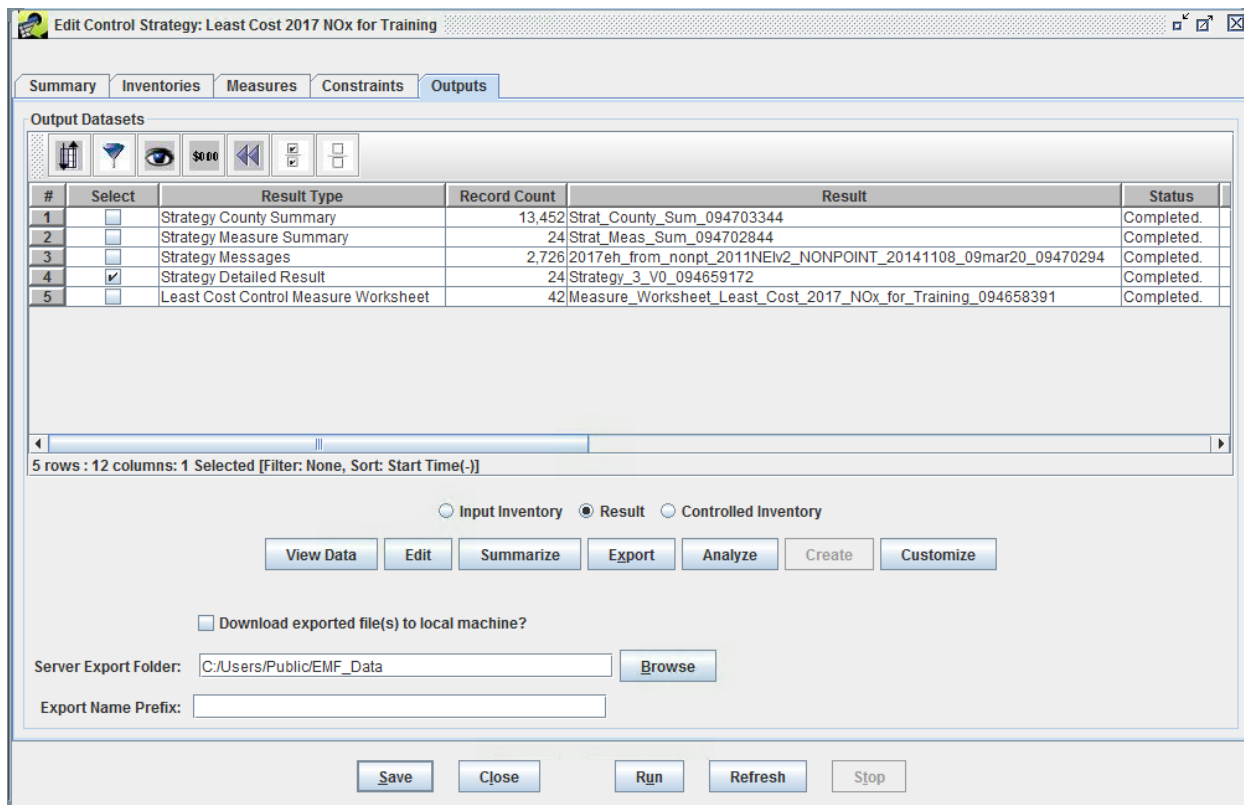


Figure 4.17: Outputs Tab of Edit Control Strategy Window for Least Cost Strategy

CoST automatically generates three main outputs for successful strategy runs: **Strategy Detailed Result**, **Strategy Measure Summary**, and **Strategy County Summary**. Some strategy types also generate a **Strategy Messages** output. Least Cost and Least Cost Curve strategies generate a **Least Cost Control Measure Worksheet** that lists all of the available control measure options for each source in the inventories.

For all types of strategies, CoST can generate a **Controlled Inventory** on-demand for any of the Strategy Detailed Result datasets. The types of outputs are discussed in more detail in [Section 6](#). Note that the output datasets are given unique names that include a timestamp indicating when the strategy was run, including the year, month, day, hour, and minute of the run. A description of how to rename output datasets is provided below.

For additional details on the algorithms that are applied to assign measures to sources as part of a strategy run (other than the descriptions in [Section 1](#)), please see the [Control Strategy Tool \(CoST\) Equations Document](#).

4.5.3 Viewing and Editing Properties of the Strategy Outputs

It is possible to perform a number of operations on the strategy outputs. These operations are described in this subsection and the following subsections.

Step 5-4: View Control Strategy Run Outputs. The most basic operation is to view

Dataset Properties Editor: Strategy_208_V0_111425440 (ID = 209)

Summary | Data | Keywords | Notes | Revisions | History | Sources | QA

Name: Strategy_208_V0_111425440

Description:
#Control strategy detailed result
#Implements control strategy: Least Cost 2017 NOx Example Liz
#Input dataset used: Least_Cost_2017_NOx_Example_Liz_MergedFF10_11142496
#

Project: [Dropdown]

Creator: Liz Adams (lizardams)

Dataset Type: Control Strategy Detailed Result

Time Period Start: [Text Box]	Status: Created by control strategy
Time Period End: [Text Box]	Last Modified Date: 10/19/2017 11:14
Temporal Resolution: Choose a resolution [Dropdown]	Last Accessed Date: 10/19/2017 11:14
Sector: All Sectors [Dropdown]	Creation Date: 10/19/2017 11:14
Region: NC [Dropdown]	Intended Use: public [Dropdown]
Country: Choose a country [Dropdown]	Default Version: 0 (Initial Version) [Dropdown]

Buttons: Refresh | Save | Export | Close

Figure 4.18: Sample Outputs Tab for a Least Cost Curve Strategy

Sort Order: Current: 1 - 24 Filtered: 24 of 24

Row Filter:

Decimal Places: ☒ Show Commas ☐ Reset View

DISABLE Boolean	CM_ABBREV String(20)	POLL String	SCC String(12)	FIPS String(6)	PLANTID String(20)	POINTID String(20)	STACKID String(20)	SEGMENT String(20)	ANNUAL_COST Double	ANN_COST_PER_TON Double
<input type="checkbox"/>	NEPOBURN96	NOX	2610000500	37015						
<input type="checkbox"/>	NEPOBURN96	NOX	2610000100	37017						
<input type="checkbox"/>	NEPOBURN96	NOX	2610000100	37013						
<input type="checkbox"/>	NEPOBURN96	NOX	2610000400	37017						
<input type="checkbox"/>	NEPOBURN96	NOX	2610000400	37013						
<input type="checkbox"/>	NEPOBURN96	NOX	2610000100	37015						
<input type="checkbox"/>	NEPOBURN96	NOX	2610000400	37015						
<input type="checkbox"/>	NLNRSNGC03	NOX	2104007000	37013					10,703.6418	952.67
<input type="checkbox"/>	NWLRSGC99	NOX	2104006000	37013					8,257.8556	1,969.40
<input type="checkbox"/>	NLNRSNGC03	NOX	2104007000	37017					6,824.6519	952.67
<input type="checkbox"/>	NLNCMNGC03	NOX	2103006000	37013					5,112.1834	954.39
<input type="checkbox"/>	NLNRSNGC03	NOX	2104007000	37015					4,222.9579	952.67
<input type="checkbox"/>	NWLRSGC99	NOX	2104006000	37017					2,319.0076	1,969.40
<input type="checkbox"/>	NLNCMNGC03	NOX	2103006000	37017					2,075.6536	954.39
<input type="checkbox"/>	NLNCMNGC03	NOX	2103006000	37015					1,561.0459	954.39
<input type="checkbox"/>	NLNCMNGC03	NOX	2103007000	37013					680.9172	952.67
<input type="checkbox"/>	NWLRSGC99	NOX	2104006000	37015					398.2785	1,969.40
<input type="checkbox"/>	NLNCMNGC03	NOX	2103007000	37017					333.7947	952.67
<input type="checkbox"/>	NLNCMNGC03	NOX	2103007000	37015					251.0390	952.67

Figure 4.19: View Data for Strategy Detailed Result

the data of the output dataset using the **Data Viewer**. To do this, select one of the outputs on the **Outputs** tab, such as the **Strategy Detailed Result**, and then click **View Data**. (Note that the Strategy Detailed Result is the main output on which the Strategy County Summary and Strategy Measure Summary are based.) This will bring up the Data Viewer showing the contents of the Strategy Detailed Result (Figure 4.19).

The **Strategy Detailed Result** shows the abbreviation of the measure matched to each of the sources for all of the controlled sources, along with columns that identify each controlled source, information about the cost of applying the measures to the sources and the emissions reductions that resulted. The information computed includes the cost of application and the emissions reduced as a result. Enter a sort order (e.g., **annual_cost desc**) to have the rows sorted in a particular way.

Clear the entries in the **Sort Order** and **Row Filter** fields on the **Data Viewer** and click **Apply**, all of the data records will be presented in the order in which they appear in the database. More information about the columns included in the detailed result is given in Table 4.9, which is discussed later in the **Strategy Detailed Result Section**.

Click **Close** to exit from the **Data Viewer** when you are finished reviewing the **Strategy Detailed Result**.

Step 5-5: View Control Strategy Run Output Properties. From the Edit Control Strategy **Outputs** tab, access the properties (metadata) of an output dataset (as opposed to the actual data contained in the output), by selecting an output (for this exercise, select the

Dataset Properties Editor: Strategy_3_V0_094659172 (ID = 159)

Summary Data Keywords Notes Revisions History Sources QA

Name: Strategy_3_V0_094659172

Description: #Control strategy detailed result
#Implements control strategy: Least Cost 2017 NOx for Training
#Input dataset used: 2017eh_from_nonpt_2011NEIv2_NONPOINT_20141108_09mar2015_v0_FIPS_37
#

Project: [dropdown]

Creator: Liz Adams (lizadams)

Dataset Type: Control Strategy Detailed Result

Time Period Start: 01/01/2017 00:00

Time Period End: 12/31/2017 23:59

Temporal Resolution: Annual [dropdown]

Sector: nonpt [dropdown]

Region: NC [dropdown]

Country: US [dropdown]

Status: Created by control strategy

Last Modified Date: 08/09/2017 09:46

Last Accessed Date: 08/09/2017 09:46

Creation Date: 08/09/2017 09:46

Intended Use: public [dropdown]

Default Version: 0 (Initial Version) [dropdown]

Refresh Save Export Close

Figure 4.20: Summary Tab of Dataset Properties Editor

Strategy Detailed Result) on the **Outputs** tab of the **Edit Control Strategy** window and clicking the **Edit** button. This will bring up the **Dataset Properties Editor** for the output dataset (Figure 4.20).

Notice that the tabs on the **Dataset Properties Editor** are the same as those on the **Dataset Properties Viewer** shown in Figure 4.9. Editor mode allows many of the fields to be changed, where they could not be changed directly from in the Viewer mode. For example, change the name of the output by replacing the automatically generated name with a more meaningful one (e.g., **Least Cost 2017 VOC for Training Result**) and then click **Save**. Notice that unsaved edits are denoted with an asterisk in the title bar of the window.

Examine the other tabs of the **Dataset Properties Editor** for the **Strategy Detailed Result** output. In particular see the **Keywords** tab, an example of which is shown in Figure 4.21. For the **Strategy Detailed Result**, there are a number of keywords set in the **Keywords Specific to Dataset** section (in the lower part of window). These keywords correspond to the major parameters of the control strategy, such as the **COST_YEAR** and the **STRATEGY_TYPE** as shown in Figure 4.21). There are also keywords for the **UNCONTROLLED_EMISSIONS**, the **TOTAL_EMISSION_REDUCTION**, and the **ACTUAL_PERCENT_REDUCTION**.

The keywords in the **Keywords Specific to Dataset Type** section (the upper part of window in Figure 4.21) typically contain directives on how to export the data or other data

Dataset Properties Editor: Strategy_3_V0_094659172 (ID = 159)

Summary Data **Keywords** Notes Revisions History Sources QA

Keywords Specific to Dataset Type

Keyword	Value
EXPORT_INLINE_COMMENTS	false
EXPORT_HEADER_COMMENTS	false
EXPORT_SUFFIX	.csv

Keywords Specific to Dataset

Select	Keyword	Value
<input type="checkbox"/>	STRATEGY_NAME	Least Cost 2017 NOx for Training
<input type="checkbox"/>	STRATEGY_ID	8
<input type="checkbox"/>	STRATEGY_TYPE	Least Cost
<input type="checkbox"/>	TARGET_POLLUTANT	NOX
<input type="checkbox"/>	COST_YEAR	2013
<input type="checkbox"/>	REGION	Unspecified
<input type="checkbox"/>	MEASURE_CLASSES	Known
<input type="checkbox"/>	DISCOUNT_RATE	7.0%
<input type="checkbox"/>	USE_COST_EQUATION	true
<input type="checkbox"/>	INCLUDE_UNSPECIFIED_COSTS	true
<input type="checkbox"/>	TARGET_YEAR	2017
<input type="checkbox"/>	STRATEGY_INVENTORY_NAME	2017eh_from_nonpt_2011NEN2_NONPOINT_20141108_09mar2015_v0_FIP...
<input type="checkbox"/>	STRATEGY_INVENTORY_VERSION	0

Add Remove

Refresh Save Export Close

Figure 4.21: Keywords Tab of Dataset Properties Editor

values that are the same for all datasets of the same type. Typically FF10 or ORL inventories will have some of these keywords.

Note that when the Dataset Properties Editor is open for a dataset no other users can edit that dataset. Similarly, if a control strategy or control measure is open for *editing*, no other users can edit those items. Users will be able to view these items if the access permissions are set appropriately (see **Intended Use** setting on the **Summary** tab).

After examining the other Dataset Properties tabs, close the **Dataset Properties Editor** by clicking **Save** to save the changes, or **Close** to close without saving changes. For the example exercise, click **Close** and do not save any changes.

4.6 Summarizing the Strategy Outputs

Strategy outputs, particularly **Strategy Detailed Results**, but also the input emissions inventories, can be summarized in many different ways. The ability to prepare summaries is helpful because in many cases there could be thousands of records in a single **Strategy Detailed Result** or emissions inventory. Thus, when the results of a strategy are analyzed or presented to others, it is useful to show the impact of the strategy in a summarized fashion. Frequently, it is helpful to summarize a strategy for each county, state, SCC, and/or control technology. The summaries are prepared using the EMF subsystem that was originally designed to support quality assurance (QA) of emissions inventories and related datasets, for which summaries are also needed. Thus, each summary is stored as the result of a “QA Step” that is created by having CoST run a SQL query. There are many predefined queries stored in the EMF as ‘templates’, circumventing the need for a user of the system to know SQL to create a summary. Summaries can be added from the QA tab of the **Dataset Properties Editor**, although there is a shortcut available on the **Outputs** tab. Summaries are discussed in more detail in [Section 7](#).

Step 5-6: Selecting Control Strategy Summaries. Select **Strategy Detailed Result** on the **Outputs** tab of the **Edit Control Strategy** window and then click **Summarize** to open the **QA** tab of the **Dataset Properties Editor**.

To add a new summary from the list of predefined summary templates, click the **Add from Template** button to see a list of predefined QA Steps ([Figure 4.22](#)). To create summaries of interest, click the mouse button on the summaries to create. For this example, select **Summarize by Control Technology and Pollutant**, **Summarize by County and Pollutant**, **Summarize by Pollutant**. Select multiple summaries (as is illustrated in the figure) using Control-Click. Click **OK** after selecting the summaries and the selected QA templates will be added to the table on the QA tab ([Figure 4.23](#)).

Step 5-7: Running Control Strategy Summaries. To run the QA summaries that are listed on the QA tab, first select the summaries of interest and then click **Edit**. The **Edit QA Step** window will appear ([Figure 4.24](#)). Do not edit anything in this window, just view the properties of the QA summary. Click **Run** at the bottom of the window to start the QA summary processing.

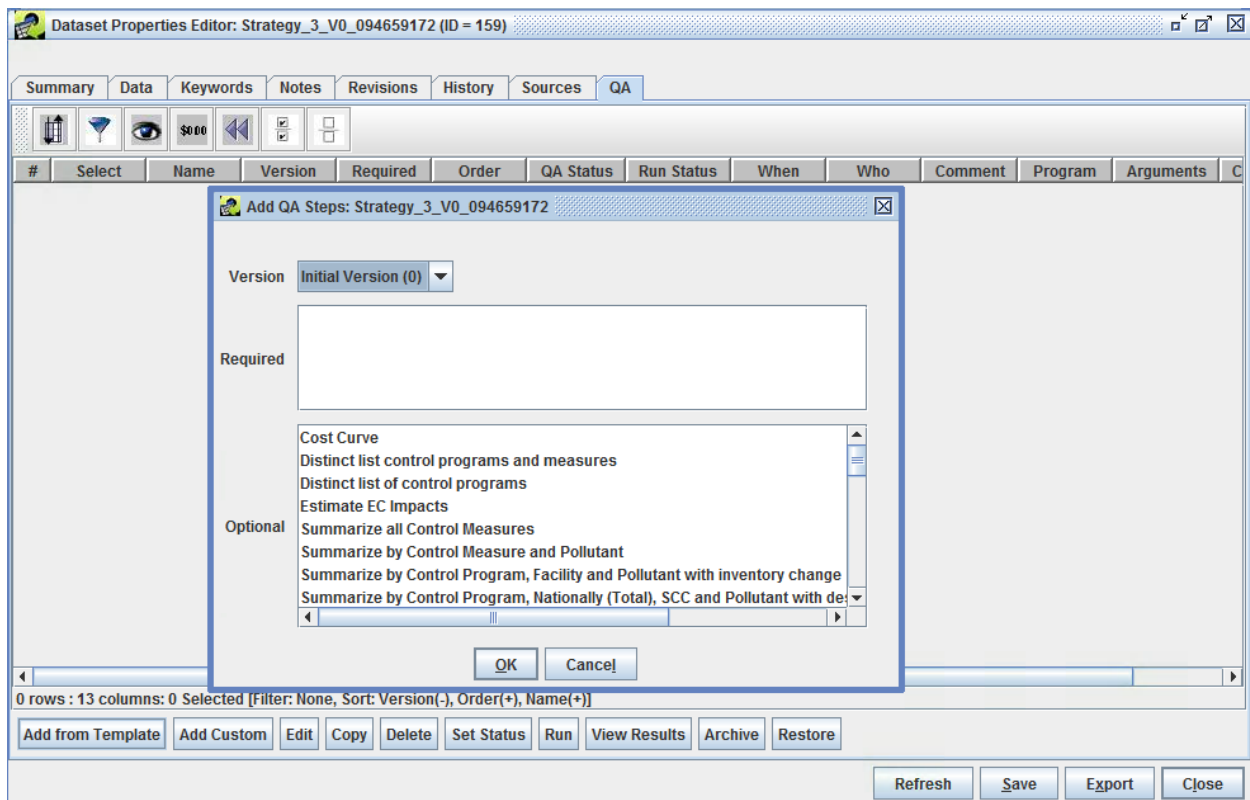


Figure 4.22: Summarizing a Strategy Detailed Result

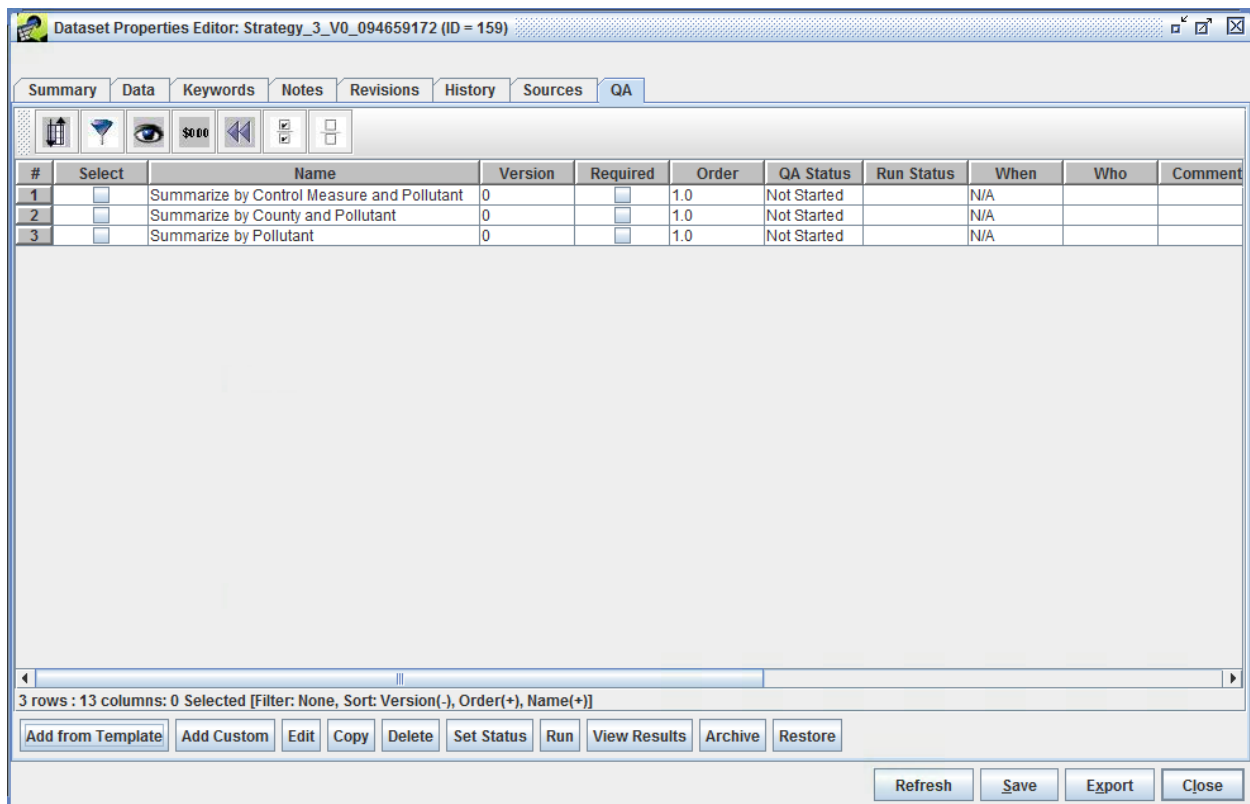


Figure 4.23: Available QA Summaries for a Strategy Detailed Result

Edit QA Step: Summarize by Control Measure and Pollutant - Strategy_3_V0_094659172 (v0)

Name:

Version:

Arguments:

Order: Required? ☐ Arguments same as template? ☒

Description:

QA Status: Output Name:

QA User: Run Status:

QA Date: Run Date:

Current Output? ☐

Configuration:

Comments:

☐ Download result file to local machine?

Export Folder:

Export Name:

☐ Overwrite files if they exist?

Figure 4.24: Edit QA Step Window to Create a Summary

Monitor the progress of the QA step in the **Status** window at the bottom of the EMF main window. Once the run is complete, click the **Refresh** button to populate the **Output Name**, **Run Status**, and **Run Date** fields in the **Edit QA Step** window. *Note: as an alternative to clicking Run on several different windows, you can instead select a few summaries and click Run on the QA tab.*

Step 5-8: Viewing Control Strategy Summaries. To see summarized control strategy output, select a checkbox next to the summary of interest on the **QA** tab and click **View Results** to bring up the **View QA Step Results** window (Figure 4.25). Sort and filter the results in this window in the same way as the **Control Measure Manager** and **Control Strategy Manager**. For example, click on the **avg_cost_per_ton** column header to sort on the cost per ton. You can also show the Top n or Bottom n rows using the second and third from the left toolbar buttons. The colorful toolbar buttons on the right support computing statistics, creating plots (if you have the R software package installed on your

	sector	fips	county	state_name	state_abbr	poll	avg_cost_per_ton	annual_cost	inv_emissions	final_emis
1	nonpt	37013	Beaufort Co	North Carolina	NC	NOX	593.82	24,754.60	66.38	
2	nonpt	37015	Bertie Co	North Carolina	NC	NOX	500.57	6,433.32	19.92	
3	nonpt	37017	Bladen Co	North Carolina	NC	NOX	452.86	11,553.11	38.68	

Figure 4.25: View QA Step Results Window

client machine), and saving the table and plot configurations.

Step 5-9: Export Control Strategy Summary to Google Earth (KMZ). If the summary has longitude and latitude information (e.g., a plant, state, or county summary), the EMF has an interface to create Google Earth-compatible Keyhole Markup Language Zipped (.kmz) files by choosing **Google Earth** from the **File** menu of the **View QA Step Results** window. The interface to create these files is shown in Figure 4.26. Note that the following detailed result summaries have longitude and latitude:

- Summarize by U.S. County and Pollutant
- Summarize by U.S. State and Pollutant
- Summarize by Plant and Pollutant

In the **Create Google Earth file** window, select a **Label Column** that will be used to label the points in the .kmz file. This label will appear when hovering over a point in the Google Earth map. For a plant summary this would typically be `plant_name`, for a county summary this would be `county`, and for a state summary, this would be `state_name`.

Select a **Data Column** to show the value of a point in the .kmz file. This value will appear when hovering over a point in the Google Earth map. (e.g., `total_emissions_reduction`, `total_annual_cost`, or `avg_cost_per_ton`). The mouse over information will have the form:

value from Label column : value from Data Column.

Create Google Earth file: QA_DSID159_V0_1502291088791_1/ Summarize by County... - □ ×

Data File

Properties File

Properties

Title

Subtitle

Title Position ▼

Legend Position ▼

Label Column ▼

Filter Column ▼

Filter Value

Data Column ▼

Discard Blank Data ☒

Maximum Data Cutoff

Zero Cutoff

Minimum Data Cutoff

Difference Plot ☐

Number of Bins ▼

Color Palette ▼

Binning Algorithm ▼

Decimal Places

Icon Scale

Output File

Figure 4.26: KMZ File Generator

For a summary that includes multiple pollutants, specify a filter so that data for only one pollutant is included in the .kmz file. Set the **Filter Column** to poll (e.g., pollutant), and then specify a **Filter Value** for a specific inventory pollutant (e.g., NOX).

Use **Minimum Data Cutoff** to limit the points shown in the .kmz file to include only those that reach a certain size threshold (e.g., do not show small sources or sources with a small amount of reduction). Points will only be created for rows in the summary for which the value in the data column exceeds the value given set by **Minimum Data Cutoff**. For example, if the **Data Column** is set to total_emissions_reduction, you might enter 1.0 as the **Minimum Data Cutoff** to show only plants with at least 1 ton of reduction.

Use **Icon Scale** to control the size of the points displayed in the Google Earth map. The setting of **Icon Scale** is a real number between 0 and 1. Smaller values produce smaller circles and larger values produce larger circles.

Mouse over the fields in this window to see tooltips with information about the field. After specifying the settings (aside from the Properties file) click **Generate** to create the .kmz file using default file name. The name and location of the output file are set by the **Output File** field.

Click **Save** to save the settings of the Google Earth file **Properties** to a file. Load a saved set of properties using the Load button in the **Create Google Earth file** window.

Close the **Create Google Earth file** window by clicking the X at the top right corner.

Step 5-10: Export Control Strategy Summaries to CSV. From the **Edit QA Step** window (Figure 4.24) select a folder to export the results by either typing a directory path in the **Export Folder** field, or by using the **Browse** button to select an output directory. Click the **Export** button and the **Export QA Step Result** will be written to the selected folder on the EMF server.

4.6.1 Exporting the Strategy Outputs

Return to the **Outputs** tab of the **Edit Control Strategy window** (Figure 4.17).

Step 5-11: Export Control Strategy Outputs. To export the strategy output datasets to the EMF server, enter a folder/directory name into the **Server Export Folder** field on the **Outputs** tab. Use the checkboxes to select one or more results files to export from the **Output Datasets** table and click **Export**. The files will be written as ASCII files to the **Server Export Folder**. The resulting CSV files can be imported into a spreadsheet or other database software for analysis. *Note that the dataset must be exported to a location where the EMF application user has read/write access to the folder (e.g., the same directory as specified in the environment variable, EMF_DATA_DIRECTORY, in the EMF installation batch file).*

4.6.2 Analyzing the Strategy Outputs

It is possible to view the strategy results directly from the **Outputs** tab in a sortable, filterable table, similar to the table used by the View QA Step Results window (Figure 4.25).

Analyze Control Strategy: Copy of Least Cost Emissions for NY1

File

Strat_County_Sum_20090608182536828

File Name C:\Documents and Settings\eyth\Local Settings\Temp\EMF1\Strat_County_Sum_20090608182536828.csv

Header #DATASET_NAME=Strat_County_Sum_20090608182536828 #DATASET_VERSION_NUM= dataset.g Full Description

	sector	fips	poll	uncontrolled_emis	emis_reduction	remaining_emis	pct_red	annual_cost
1	nonpt	05001	CO	6252.00		6252.00		
2	nonpt	05001	NH3	3558.00		3558.00		
3	nonpt	05001	NOX	569.90	489.30	80.60	85.86	9103.00
4	nonpt	05001	PM10	2689.00		2689.00		
5	nonpt	05001	PM2_5	1244.00		1244.00		
6	nonpt	05001	SO2	439.20		439.20		
7	nonpt	05001	VOC	1008.00		1008.00		
8	nonpt	05003	CO	1033.00		1033.00		
9	nonpt	05003	NH3	749.60		749.60		
10	nonpt	05003	NOX	309.00	284.30	24.65	92.02	7505.00
11	nonpt	05003	PM10	902.50		902.50		
12	nonpt	05003	PM2_5	286.50		286.50		
13	nonpt	05003	SO2	390.10		390.10		
14	nonpt	05003	VOC	474.60		474.60		
15	nonpt	05005	CO	1297.00		1297.00		
16	nonpt	05005	NH3	683.50		683.50		
17	nonpt	05005	NOX	322.80	273.10	49.74	84.59	18560.00

6783 rows : 13 columns [Filter: None, Sort: None]

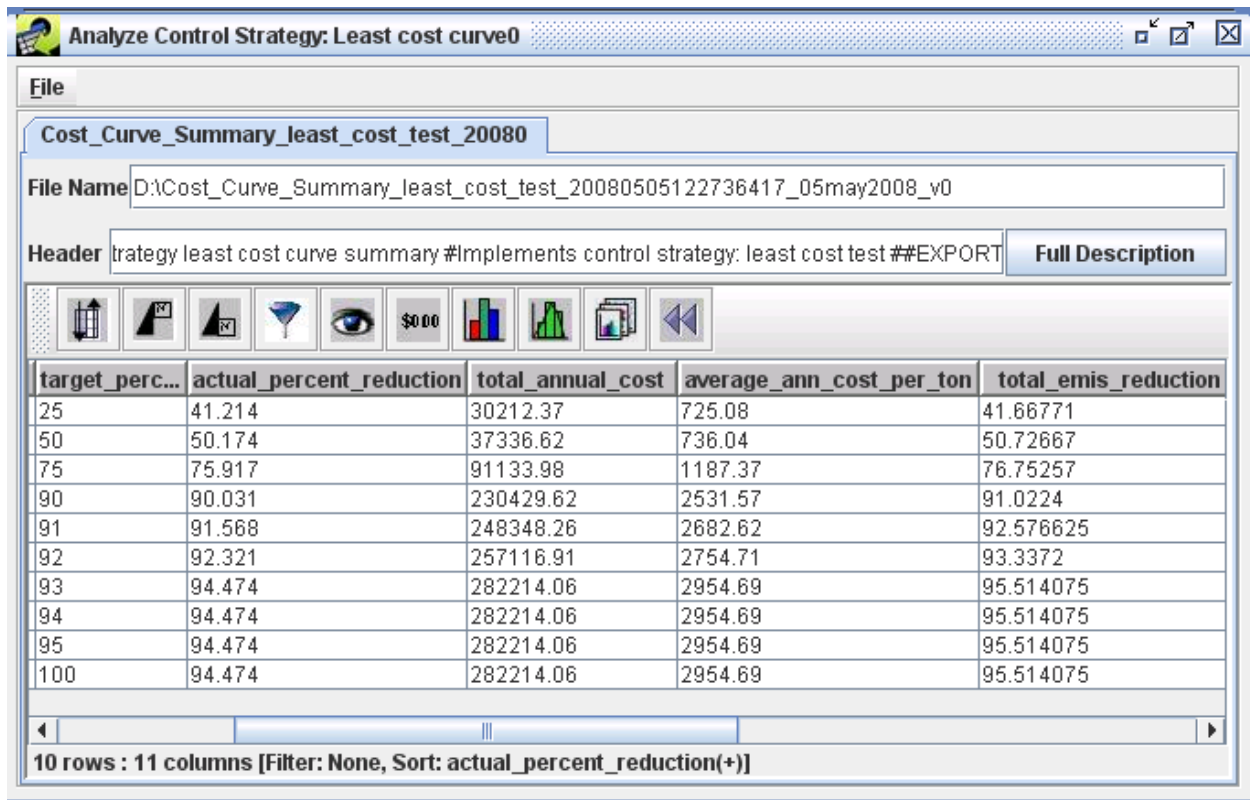
Figure 4.27: Analyze Control Strategy Window

Step 5-12: Analyze Control Strategy Outputs in CoST. Use the checkboxes to select one or more results files to analyze from the **Output Datasets** table and click **Analyze** to show the **Analyze Control Strategy** window for the selected outputs. An example of a Strategy County Summary analysis is shown in Figure 4.27. The results in this window can be sorted, filtered, plotted, and summarized with statistics. An example of a Least Cost Curve Summary is shown in Figure 4.28. Exit from the **Analyze Control Strategy** window using the X at the top of the window.

4.7 Creating a Controlled Emissions Inventory

CoST can create a controlled emissions inventory that reflects the effects of the control strategy by merging the detailed result with the original emissions inventory. Details on controlled inventories are discussed further in the **Controlled Emissions Inventory Section**.

Step 5-13: Creating a Controlled Inventory. To create a controlled inventory, click the **Controlled Inventory** radio button on the **Outputs** tab of the **Edit Control Strategy** window (Figure 4.17) and select the **Strategy Detailed Result** in the **Output Datasets** table to enable the **Create** button. *Note that only creators of a strategy or the Administrator*



Analyze Control Strategy: Least cost curve0

File

Cost_Curve_Summary_least_cost_test_20080

File Name D:\Cost_Curve_Summary_least_cost_test_20080505122736417_05may2008_v0

Header strategy least cost curve summary #Implements control strategy: least cost test ##EXPORT **Full Description**

target_perc...	actual_percent_reduction	total_annual_cost	average_ann_cost_per_ton	total_emis_reduction
25	41.214	30212.37	725.08	41.86771
50	50.174	37336.62	736.04	50.72667
75	75.917	91133.98	1187.37	76.75257
90	90.031	230429.62	2531.57	91.0224
91	91.568	248348.26	2682.62	92.576625
92	92.321	257116.91	2754.71	93.3372
93	94.474	282214.06	2954.69	95.514075
94	94.474	282214.06	2954.69	95.514075
95	94.474	282214.06	2954.69	95.514075
100	94.474	282214.06	2954.69	95.514075

10 rows : 11 columns [Filter: None, Sort: actual_percent_reduction(+)]

Figure 4.28: Analyzing a Least Cost Curve Output

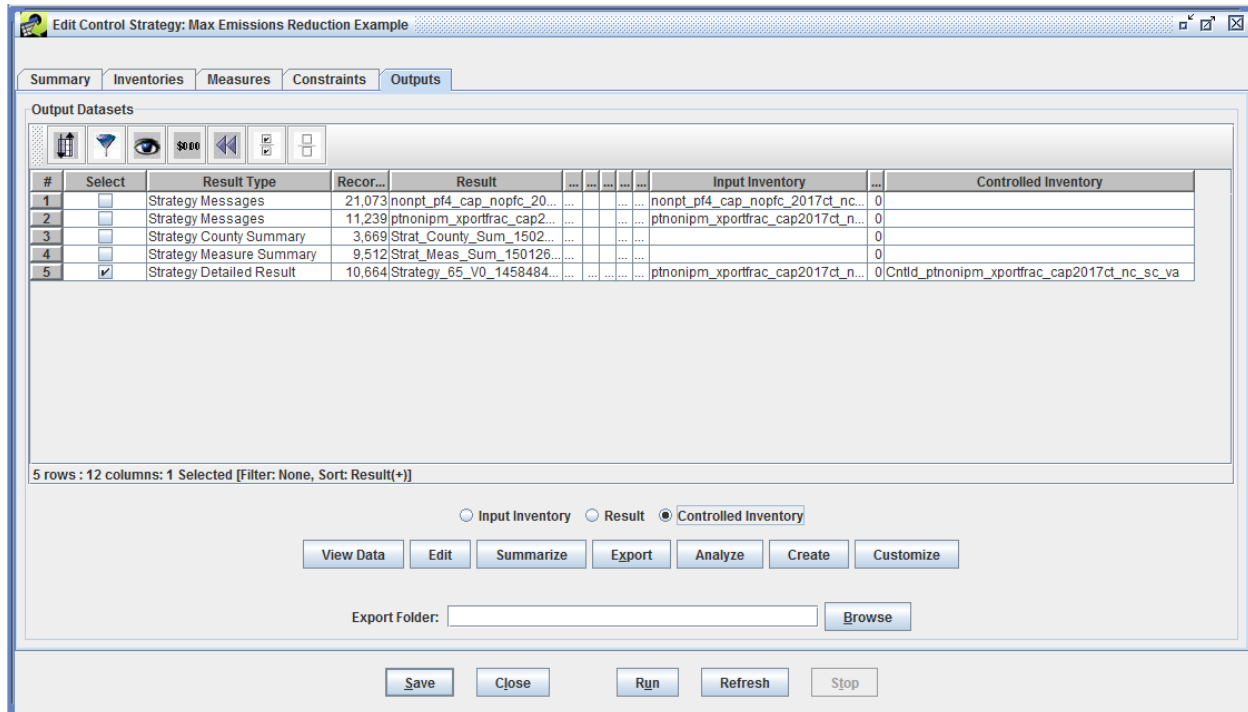


Figure 4.29: Controlled Inventory for Maximum Emissions Reduction Example

can create inventories from a strategy result.

Click **Create** to receive a prompt to **Enter a name prefix for the controlled inventories**; for this exercise, enter **training** and click the OK button. Cancelling this prompt will result in a controlled inventory with no name prefix. The status of the inventory creation will be shown in the Status window. Once the controlled inventory has been successfully created, for all but the Least Cost control strategy types the name of the inventory will appear at the far right of the **Output Datasets** table in the row corresponding to the **Strategy Detailed Result**. For Least Cost control strategy types, the controlled inventory will show up as rows in the **Output Datasets** table under the “Controlled Inventory” **Result Type**. Figure 4.29 shows an example of where the controlled inventory name is located for a Maximum Emissions Reduction control strategy. Figure 4.30 shows an example of where the controlled inventories are located for a Least Cost control strategy.

Step 5-14: Viewing a Controlled Inventory. To view the data for a controlled inventory generated from all but the Least Cost control strategy types, select the **Controlled Inventory** radio button and click **View Data** (Figure 4.29). For Least Cost control strategy types use the checkbox in the **Select** column of the **Output Datasets** table to select a controlled inventory, select the **Result** radio button, and click **View Data** (Figure 4.30). The data for the controlled inventory dataset will appear in the **Data Viewer**.

To view the data for the input inventory that was merged with the **Strategy Detailed Result** to create the controlled inventory, select the **Input Inventory** radio button and click **View Data**.

#	Select	Result Type	Record Count	Result	Status	Total Cost	Total Revenue
1	<input type="checkbox"/>	Controlled Inventory	62,921	least_cost_example_005736292	Completed.		
2	<input type="checkbox"/>	Controlled Inventory	66,092	least_cost_example	Completed.		
3	<input type="checkbox"/>	Strategy County Summary	3,669	Strat_County_Sum_150208687	Completed.		
4	<input type="checkbox"/>	Strategy Measure Summary	9,512	Strat_Meas_Sum_150154497	Completed.		
5	<input type="checkbox"/>	Strategy Messages	32,312	Least_Cost_Example_MergedORL_145707681_strategy_msgs_150124655	Completed.		
6	<input type="checkbox"/>	Strategy Detailed Result	15,294	Strategy_156_V0_145740692	Completed.	2,227,000,000	
7	<input type="checkbox"/>	Least Cost Control Measure Worksheet	45,052	Measure_Worksheet_Least_Cost_Example_145707117	Completed.		

Figure 4.30: Controlled Inventory for Least Cost Curve Example

4.7.1 Creating Custom Strategy Outputs

The **Customize** button on the **Outputs** tab is not frequently used, but can generate special types of outputs related to analyses with a Response Surface Model (RSM). These custom outputs are not discussed here.

The remainder of this chapter provides reference documentation on the outputs of strategies and summaries that can be created with CoST. Additional advanced exercises and examples are available in [Chapter 5](#).

4.8 Outputs of Control Strategies

This section provides details on the contents of each type of CoST output.

4.8.1 Strategy Detailed Result

As noted earlier, the Strategy Detailed Result is the primary output from running a control strategy. It is a table of emission source-control measure pairings, each of which contains information about the costs and emission reduction achieved for measures after they are applied to the sources. The contents of this table are described later in this subsection. When generating the Strategy Detailed Result table, some data are needed for CoST to calculate the values of some columns related to costs, such as:

- **Stack Flow Rate (cfs)**: from the emissions inventory
- **Capital Annual Ratio**: from the control measure efficiency record
- **Equipment Life (yrs)**: from the control measure efficiency record
- **Boiler Capacity (MW)**: from the design capacity column of the inventory; units are obtained from the design_capacity_unit_numerator and design_capacity_unit_denominator columns from the inventory. Note that boiler capacity is often blank in inventories, so special steps may need to be taken to fill in this information.

The stack flow rate provides information on the volume of effluent that requires treatment by the control device. The capital annual ratio is used to calculate the capital costs of a control device from an available O&M cost estimate for that device. The capital costs are the one-time costs to purchase and install the device, while the operating and maintenance (O&M) costs are those required to operate and maintain the device for each year. The interest rate and equipment life are used to compute the annualized capital costs for the device. The interest rate is an annual interest rate used to calculate the cost of borrowing money to purchase and install the control device. The annualized capital cost is computed based on the interest rate, and the costs are spread over the life of the equipment. The algorithms to compute these cost breakdowns vary based on whether the input data required to use a cost equation are available. This topic is described in further detail in Table 4.9, which is given after an introductory discussion of cost concepts, below. The columns of the Strategy Detailed Result are also given in Table 4.9.

When cost data are provided for the control measures, the resulting costs are also specified in terms of a particular year. To compute the cost results for a control strategy, it is necessary to escalate or de-escalate the costs to the same year in order to adjust for inflation and to allow for consistency in comparing control strategy results. This is done with the following formula:

Cost (\$) for a year of interest = (Cost for original cost year x GDP IPD for year of interest)

where the GDP IPD is the Gross Domestic Product.

Implicit Price Deflator (IPD) available from the United States Department of Commerce Bureau of Economic Analysis Table 1.1.9. [Implicit Price Deflators for Gross Domestic Product](#). The current version used is dated November 24, 2015. An excerpt of this version is shown in Table 4.8.

Table 4.8: Excerpt from the Table Used to Convert Data between Cost Years.

Year	GDP IPD	Year	GDP IPD	Year	GDP IPD	Year	GDP IPD
1980	44.377	1990	66.773	2000	81.887	2010	101.221
1981	48.520	1991	68.996	2001	83.754	2011	103.311
1982	51.530	1992	70.569	2002	85.039	2012	105.214
1983	53.565	1993	72.248	2003	86.735	2013	106.929

Year	GDP	IPD	Year	GDP	IPD	Year	GDP	IPD	Year	GDP	IPD
1984	55.466		1994	73.785		2004	89.120		2014	108.686	
1985	57.240		1995	75.324		2005	91.988				
1986	58.395		1996	76.699		2006	94.814				
1987	59.885		1997	78.012		2007	97.337				
1988	61.982		1998	78.859		2008	99.246				
1989	64.392		1999	80.065		2009	100				

To facilitate the comparison of the costs of control measures with one another, a normalized version of the control measure cost per ton is stored within the control measures database. These costs have all been converted to a consistent “reference year” using the above formula, so that the cost of any measure can be compared with any other even if their cost years differ. Currently, the reference year is 2013. In addition, during the course of the strategy run, the costs are converted (using the above formula) from the reference year to the cost year that was specified as an input to the strategy. The results of the strategy are therefore presented in terms of the specified cost year.

As indicated above, Table 4.9 provides details on the columns of the Strategy Detailed Result.

Table 4.9: Columns in the Strategy Detailed Result.

Column	Description
DISABLE	A true-false value that determines whether to disable the control represented on this line during the creation of a controlled inventory.
CM_ABBREV	The abbreviation for the control measure that was applied to the source.
POLL	The pollutant for the source, found in the inventory.
SCC	The SCC for the source, found in the inventory.
FIPS	The state and county FIPS code for the source, found in the inventory.
PLANTID	For point sources, the plant ID for the source from the inventory.
POINTID	For point sources, the point ID for the source from the inventory.
STACKID	For point sources, the stack ID for the source from the inventory.
SEGMENT	For point sources, the segment for the source from the inventory.
ANNUAL_COST (\$)	Total annual cost (including both capital and O&M) required to keep the measure on the source for a year. <i>a. Default Approach (used when there is no cost equation, or when inputs to cost equation are not available):</i> $\text{Annual Cost} = \text{Emissions Reductions (tons)} \times \text{Reference Yr Cost Per Ton (\$/tons in 2013 Dollars)} \times \text{Cost Yr GDP IPD} / \text{Reference Yr GDP IPD}.$ <i>b. Approach when Using Type 8 Cost Equation:</i> If Stack Flow Rate ≥ 5.0 cfm Then Annual Cost = (Annualized Capital Cost + 0.04 x Capital Cost + O&M Cost) Else Annual Cost = Default Annualized Cost Per Ton x Emissions Reductions (tons) x Cost Yr GDP IPD / Reference Yr GDP IPD
ANN_COST_PER_TON (\$/ton)	The annual cost (both capital and O&M) to reduce one ton of the pollutant. $\text{Ann_Cost_Per_Ton} = \text{Annual Cost (\$)} / \text{Emissions Reductions (tons)}$

Column	Description
ANNUAL_O&M_COST (\$)	Operate and maintain the measure once it has been installed on the source. <i>a. Default Approach (used when there is no cost equation, or inputs to cost equation are not available):</i> (Annual Cost - Annualized Capital Cost) Note: if the capital recovery factor was not specified for the measure, it would not be possible to compute Annualized Capital Cost or Annual O&M Costs. <i>b. Approach when Using Type 8 Cost Equation:</i> If Stack Flow Rate ≥ 5.0 cfm Then = O&M Control Cost Factor x Stack Flow Rate (cfm) x Cost Yr GDP IPD / Reference Yr GDP IPD Else = Default O&M Cost Per Ton Factor x Emissions Reductions (tons) x Cost Yr GDP IPD / Reference Yr GDP IPD
ANNUAL_VARIABLE_O&M_COST (\$)	Operate and maintain the measure once it has been installed on the source. <i>a. Default Approach (used when there is no cost equation, or inputs to cost equation are not available):</i> = blank (not calculated, no default approach available). <i>b. Approach when Using Type 10 Cost Equation:</i> = variable_operation_maintenance_cost_multiplier x design_capacity x 0.85 x annual_avg_hours_per_year x Cost Yr GDP IPD / Reference Yr GDP IPD
ANNUAL_FIXED_O&M_COST (\$)	Operate and maintain the measure once it has been installed on the source. <i>a. Default Approach (used when there is no cost equation, or inputs to cost equation are not available):</i> = blank (not calculated, no default approach available) <i>b. Approach when Using Type 10 Cost Equation:</i> * = design_capacity x 1000 x fixed_operation_maintenance_cost_multiplier x (250 / design_capacity) ^ fixed_operation_maintenance_cost_exponent x Cost Yr GDP IPD / Reference Yr GDP IPD
ANNUALIZED_CAPITAL_COST (\$)	If installing the measure on the source assuming a particular interest rate and equipment life. Annualized_Capital_Cost = Total Capital Cost x Capital Recovery Factor (CRF) Note: if the CRF can not be calculated for the measure, it is not possible to compute the ACC or the breakdown of costs between capital and O&M costs. CRF = (Interest Rate x (1 + Interest Rate)^Equipment Life) / ((Interest Rate + 1) ^Equipment Life - 1)
TOTAL_CAPITAL_COST (\$)	To install a measure on a source. <i>a. Default Approach (used when there is no cost equation or cost equation inputs are not available):</i> TCC = Emissions Reductions (tons) x Reference Yr Cost Per Ton (\$/tons in 2013 Dollars) x Capital Annualized Ratio x Cost Yr GDP IPD / Reference Yr GDP IPD <i>b. Approach when Using Type 8 Cost Equation:</i> If Stack Flow Rate ≥ 5.0 cfm Then TCC = Capital Control Cost Factor x Stack Flow Rate (cfm) x Cost Yr GDP IPD / Reference Yr GDP IPD Else TCC = Default Capital Cost Per Ton x Emissions Reductions (tons) x Cost Yr GDP IPD / Reference Yr GDP IPD
CONTROL EFF (%)	The control efficiency of the measure being applied, stored in the measure efficiency record.

Column	Description
RULE_PEN (%)	The rule penetration of the measure being applied, stored in the measure efficiency record, but could be overridden as a strategy setting (see the Section on the Inputs to the Measures Tab).
RULE_EFF (%)	The rule effectiveness of the measure being applied, stored in the measure efficiency record, but could be overridden as a strategy setting (see the Section on the Inputs to the Measures Tab).
PERCENT_REDUCTION (%)	The percent by which the emissions from the source are reduced after the control measure has been applied. Percent reduction = Control Efficiency (%) x Rule Penetration (%) / 100 x Rule Effectiveness (%) / 100
ADJ_FACTOR	The factor that was applied by a control program to adjust the emissions to the target year.
INV_CTRL_EFF (%)	The control efficiency for the existing measure on the source, found in the emissions inventory.
INV_RULE_PEN (%)	The rule penetration for the existing measure on the source, found in the emissions inventory.
INV_RULE_EFF (%)	The rule effectiveness for the existing measure on the source, found in the emissions inventory.
FINAL_EMISSIONS (tons)	Annual emissions that result from the source being controlled. = Annual Emissions (tons) - Emissions Reductions (tons)
EMIS_REDUCTION (tons)	Emissions reduced (in tons) as a result of applying the control measure to the source. Emissions reductions = Annual Emission (tons) x Percent Reduction (%) / 100
INV_EMISSIONS (tons)	Annual emissions, found in the emissions inventory. Note that if the starting inventory had average-day emissions, the average-day value is annualized and the resulting value is shown here. This is necessary to properly compute the costs of the measure.
APPLY_ORDER	When multiple measures are applied to the same source, this is a numeric value noting the order of application for this specific control measure. The first control to be applied will have a value of 1 for this field, the second will have a value of 2, and so on.
INPUT_EMITS (tons)	The emissions that still exist for the source after prior control measures have been applied. Usually this is the same as INV_EMISSIONS (see above), but for the “Apply Measures In Series” strategy type, in which multiple measures are applied to the same source, this is the emissions from the source after all prior control measures have been applied.
OUTPUT_EMITS (tons)	Emissions that still exist for the source after the current and all prior control measures have been applied. Usually this is the same as FINAL_EMISSIONS (see above), but for the “Apply Measures In Series” strategy type, in which multiple measures are applied to the same source, this is the emissions from the source after the current and all prior control measures have been applied.
FIPST	The two-digit FIPS state code.
FIPSCTY	The three-digit FIPS county code.

Column	Description
SIC	The Standard Industrial Classification (SIC) code for the source from the emissions inventory.
NAICS	The North American Industry Classification System (NAICS) code for the source from the emissions inventory.
SOURCE_ID	The record number from the input inventory for this source.
INPUT_DS_ID	The numeric ID of the input inventory dataset (for bookkeeping purposes). If multiple inventories were merged to create the inventory (as can be done for Least Cost control strategies), this ID is that of the merged inventory.
CS_ID	The numeric ID of the control strategy.
CM_ID	The numeric ID of the control measure.
EQUATION	The control measure equation that was used during the cost calculations.
TYPE	
ORIGINAL_DS_ID	The numeric ID of the original input inventory dataset, even if a merged inventory was used for the computation of the strategy, as can be done for Least Cost control strategies.
SECTOR	The emissions inventory sector specified for the input inventory (text, not an ID number; e.g., ptnonipm for the point non-IPM sector)
CONTROL_PROGRAM	The program that was applied to produce this record.
XLOC	The longitude for the source, found in the emissions inventory for point sources; for nonpoint inventories the county centroid is used. This is useful for mapping purposes.
YLOC	The latitude for the source, found in the emissions inventory for point sources; for nonpoint inventories the county centroid is used. This is useful for mapping purposes.
PLANT	The plant name from the emissions inventory (or county name for nonpoint sources).
REPLACEMENT_ADDON	Indicates whether the measure was a replacement or an add-on control. A = Add-On Control, R = Replacement Control
EXISTING_MEASURE_ABBREVIATION	Indicates whether an Add-On Control was applied to a source; it indicates the existing control measure abbreviation that was on the source.
EXISTING_PRIMARY_DEVICE_TYPE_CODE	Indicates whether a Replacement Control was applied to a source; it indicates the existing control measure primary device type code that was on the source.
STRATEGY_NAME	The name of the control strategy that produced the detailed result.
CONTROL_TECHNOLOGY	The control technology of the control measure.
SOURCE_GROUP	Indicates the source group of the control measure.
COMMENT	Information about this record and how it was produced; this information is either created automatically by the system or entered by the user.
RECORD_ID	System specific columns used for tracking primary key and versioning of data
VERSION	
DELETE_VERSIONS	

4.8.2 Strategy Measure Summary

The Strategy Measure Summary output dataset is a table of emissions reductions and cost values aggregated by the emissions sector (i.e., an emissions inventory sector), state/county FIPS code, SCC, pollutant, and control measure. This table contains information only for sources that were controlled during the strategy run. It is generated by running a SQL statement that aggregates the data from the Strategy Detailed Result according to the five categories just listed. The annual cost and emissions reductions are calculated by summing all costs and emissions reductions for the specified grouping (sector, FIPS, SCC, pollutant, and control measure). The average annual cost per ton is calculated by dividing the total annual costs by the total emissions reductions for each measure. The columns contained in this summary and the formulas used to compute their values are shown in Table 4.10. An example Strategy Measure Summary is shown in Table 4.14.

Table 4.10: Columns in the Strategy Measure Summary.

Column	Description
SECTOR	The emissions inventory sector for the source (e.g., ptnonipm for the point non-IPM sector)
FIPS	The state and county FIPS code for the source
SCC	The SCC for the source
POLL	The pollutant for the source
CONTROL_MEASURE_ABBREV	Control measure abbreviation
CONTROL_MEASURE	Control measure name
CONTROL_TECHNOLOGY	Technology that is used for the measure (e.g., Low NOx burner, Onroad Retrofit).
SOURCE_GROUP	Group of sources to which the measure applies (e.g., Fabricated Metal Products - Welding).
ANNUAL_COST	The total annual cost for all sources that use this measure. This is calculated by summing all source annual costs that use this measure
AVG_ANN_COST_PER_TON	The average annual cost per ton (\$/ton). This is calculated by dividing the total annual cost by the total emissions reductions for all sources for this measure
INPUT_EMIS	The total of emissions from all sources entering the control measure. This is calculated by summing the input emissions for all sources that were controlled by this measure
EMIS_REDUCTION	Total reduction in emissions in tons for all sources for this control measure
PCT_RED	The percent reduction (%) for all sources controlled by this measure. This is calculated by dividing the total emissions reductions by the total input emissions.
RECORD_ID	System specific columns used for tracking primary key and versioning of data
VERSION	
DELETE_VERSIONS	

4.8.3 Strategy County Summary

The Strategy County Summary output dataset is a table of emissions reductions and cost values aggregated by emissions sector, county, and pollutant. This dataset includes all of the emissions inventory sources regardless of whether they were controlled. If there is more than one inventory included in the control strategy inputs, then all inventories and their associated Strategy Detailed Results are merged and aggregated in this summary. The columns that compose this summary are shown in Table 4.11. An example Strategy County Summary is shown in Table 4.15.

Table 4.11: Columns in the Strategy County Summary.

Column	Description
SECTOR	The emissions inventory sector for the source (i.e., ptnonipm for the point non-IPM emissions sector)
FIPS	The state and county FIPS code for the source
POLL	The pollutant for the source
UNCONTROLLED_EMIS	The original inventory emissions for the county (in tons)
EMIS_REDUCTION	The total emissions reductions for the county (in tons)
REMAINING_EMIS	The remaining emissions after being controlled (in tons)
PCT_RED	The percent reduction for the pollutant
ANNUAL_COST	The total annual cost for the county. This is calculated by summing the annual costs for the county
ANNUAL_OPER_MAINT_COST	The total annual O&M costs for the county. This is calculated by summing the annual O&M costs for the county
ANNUALIZED_CAPITAL_COST	The total annualized capital costs for the county. This is calculated by summing the annualized capital costs for the county
TOTAL_CAPITAL_COST	The total capital costs for the county. This is calculated by summing the total capital costs for the county
AVG_ANN_COST_PER_TON	The average annual cost per ton (\$/ton). This is calculated by dividing the total annual cost by the total emission reduction for the county.
RECORD_ID_VERSIONS_DELETE_VERSIONS	System-specific versions used for tracking primary key and versioning of data

4.8.4 Controlled Emissions Inventory

Another output that can be created is a controlled emissions inventory (introduced earlier in the [Creating a Controlled Emissions Inventory Section](#)). This dataset is not automatically created during a strategy run; instead, a user can choose to create it after the strategy run has completed successfully. When CoST creates a controlled inventory, comments are placed at the top of the inventory file that indicate the strategy that produced it and the high-level

settings for that strategy. For the sources that were controlled, CoST fills in the CEFF (control efficiency), REFF (rule effectiveness), and RPEN (rule penetration) columns based on the control measures applied to the sources. It also populates several additional columns toward the end of the ORL inventory rows that specify information about measures that it has applied. These columns are:

- **CONTROL MEASURES:** An ampersand-separated list of control measure abbreviations that correspond to the control measures that have been applied to the given source.
- **PCT REDUCTION:** An ampersand-separated list of percent reductions that have been applied to the source, where percent reduction = CEFF x REFF x RPEN.
- **CURRENT COST:** The annualized cost for that source for the most recent control strategy that was applied to the source.
- **TOTAL COST:** The total cost for the source across all measures that have been applied to the source.

In this way, the controlled inventories created by CoST always specify the relevant information about the measures that have been applied as a result of a CoST control strategy.

4.8.5 Strategy Messages

The Strategy Messages output provides information gathered while the strategy is running that is helpful to the user. The Strategy Messages output is currently created by the following strategy types:

- Project Future Year Inventory
- Maximum Emissions Reduction
- Least Cost (but not Least Cost Curve)

The columns of the Strategy Messages output are described in Table 4.12. An example Strategy Messages output is shown in Table 4.13.

Table 4.12: Columns in the Strategy Messages Output.

Column	Description
FIPS	The state and county FIPS code for the source, found in the emissions inventory
SCC	The SCC code for the source, found in the emissions inventory
PLANTID	For point sources, the plant ID for the source from the emissions inventory.
POINTID	For point sources, the point ID for the source from the emissions inventory.
STACKID	For point sources, the stack ID for the source from the emissions inventory.

Column	Description
SEGMENT	For point sources, the segment for the source from the emissions inventory.
POLL	The pollutant for the source, found in the emissions inventory
STATUS	The status type of the message. The possible values: Warning - a possible issue has been detected, but processing did not stop; Error - a problem occurred that caused the processing to stop; or Informational - it was desirable to communicate information to the user.
CONTROL_PROGRAM	The control program for the strategy run; this is populated only when using the “Project Future Year Inventory” strategy type.
MESSAGE	Text describing the strategy issue.
MESSAGE_TYPE	Reserved columns used for another strategy type that was not part of this training exercise.
INVENTORY	
PACKET_FIPS	
PACKET_SCC	
PACKET_PLANTID	
PACKET_POINTID	
PACKET_STACKID	
PACKET_SEGMENT	
PACKET_POLL	
PACKET_SIC	
PACKET_MACT	
PACKET_NAICS	
PACKET_COMPLIANCE_DATE	
RECORD_ID	System specific columns used for tracking primary key and versioning of data
VERSION	
DELETE_VERSIONS	

Table 4.13: Example of Strategy Messages Output.

fips	scc	plantid	pointid	stackid	segment	poll	status	control_program	message
42049	30900201	420490009	942	S942	1	PM25-PRI	Warning		Negative emission reduction (-1693.9)

Table 4.14: Example of Strategy Measure Summary Data.

SECTOR	CHPS	SCC	POL	ABBRE	CONTROL MEASURE	CONTROL TECHNOLOGY	SOURCE GROUP	ANNUAL COST	AVG ANN COST	PER EMIS REDUCTION
ptnonip	37001	10200906	PM10	PFFPJ	Boiler Filter (Pulse Jet Type);(PM10) Industrial Boilers - Wood	Fabric Filter (Pulse Jet Type)	Industrial Boilers - Wood	\$119,294	\$12,862	2.6007
ptnonip	37001	10200906	PM2.5	PFFPJ	Boiler Filter (Pulse Jet Type);(PM10) Industrial Boilers - Wood	Fabric Filter (Pulse Jet Type)	Industrial Boilers - Wood			19.5426
ptnonip	37001	3050031	PM10	PFFPJ	Mineral Filter (Pulse Jet Type);(PM10) Mineral Products - Other	Fabric Filter (Pulse Jet Type)	Mineral Products - Other	\$446,026	\$3,379	9.3494
ptnonip	37001	3050031	PM2.5	PFFPJ	Mineral Filter (Pulse Jet Type);(PM10) Mineral Products - Other	Fabric Filter (Pulse Jet Type)	Mineral Products - Other			2.0939
ptnonip	37001	30501110	PM10	PFFPJ	Mineral Filter (Pulse Jet Type);(PM10) Mineral Products - Other	Fabric Filter (Pulse Jet Type)	Mineral Products - Other	\$110	\$147	0.7498
ptnonip	37001	30501110	PM2.5	PFFPJ	Mineral Filter (Pulse Jet Type);(PM10) Mineral Products - Other	Fabric Filter (Pulse Jet Type)	Mineral Products - Other			0.2605

Table 4.15: Example of Strategy County Summary Data.

SECTOR	FIPS	POLLUTANT	INPUT EMISSIONS	REMOVED EMISSIONS	POINT SOURCE ANNUAL COST	ANNUAL MAINT COST	ANNUAL OPER- ATING COST	ANNUAL CAP- ITAL COST	ANNUAL TOTAL COST	AVG PER TON
ptnonipn	37001	VOC	313.8724	313.8724						
ptnonipn	37001	PM25	33.4717	33.2505	2212	99.3391				
		PRI								
ptnonipn	37001	NH3	6.9128	6.9128						
ptnonipn	37001	NOX	146.2904	146.2904						
ptnonipn	37001	PM10	51.0928	50.7009	3909	99.2349	\$865,430	\$746,831	\$83,300	\$882,489
		PRI								
ptnonipn	37001	SO2	54.3864	54.3864						\$22,363

4.9 Summaries of Strategy Inputs and Outputs

The EMF/CoST system can prepare summaries of the datasets that are loaded into the system, including both the emissions inventory datasets and the Strategy Detailed Result outputs. The ability to prepare summaries is helpful because in many cases there could be thousands of records in a single Strategy Detailed Result. Thus, when the results of a strategy are analyzed or presented to others, it is useful to show the impact of the strategy in a summarized fashion. Frequently, it is helpful to summarize a strategy for each county, state, SCC, or control technology. The power of the PostgreSQL relational database that contains the system data is used to develop these summaries. Currently, they are prepared using the EMF subsystem that was designed to support quality assurance of emissions inventories and related datasets. Recall that the creation of summaries for strategy outputs was discussed in the [Summarizing Strategy Outputs Section](#).

Each summary is stored as the result of a “QA Step” that is created by asking CoST to run a SQL query. Summaries can be added to inventory or Strategy Detailed Result datasets by editing the dataset properties, going to the QA tab, and using the available buttons to add and edit QA steps. For more details on how to create summaries, see [Summarizing Strategy Outputs Section](#). Examples of the types of summary templates available for Point Source Inventories (the type with the most templates due to the larger number of columns in that inventory type) are:

- “Summarize by Pollutant with Descriptions”
- “Summarize by Pollutant”
- “Summarize by SCC and Pollutant with Descriptions”
- “Summarize by SCC and Pollutant”

- “Summarize by U.S. State and Pollutant with Descriptions”
- “Summarize by U.S. State and Pollutant”
- “Summarize by U.S. County and Pollutant with Descriptions”
- “Summarize by MACT Code, U.S. State and Pollutant with Descriptions”
- “Summarize by Data Source Code, U.S. State and Pollutant with Descriptions”
- “Summarize by U.S. State, SCC and Pollutant with Descriptions”
- “Compare CoST to NEI measures”
- “Roll Up CoST and NEI measures”
- “Summarize by Plant and Pollutant”

Note that the summaries “with Descriptions” have more information than the ones without. For example, the “Summarize by SCC and Pollutant with Descriptions” summary includes the SCC description in addition to the pollutant description. The disadvantage to include the descriptions is that they are a bit slower to generate because information has to be brought in from additional tables than just the table being summarized.

Each of the summaries is created using a customized SQL syntax that is very similar to standard SQL, except that it includes some EMF-specific concepts that allow the queries to be defined generally and then applied to specific datasets as needed. An example of the customized syntax for the “Summarize by SCC and Pollutant” query is:

```
select SCC, POLL, sum(ann_emis) as ann_emis from $TABLE[1] e group by SCC, POLL order by
```

Notice that the only difference between this and standard SQL is the use of the \$TABLE[1] syntax. When this query is run, the \$TABLE[1] portion of the query is replaced with the table name used to contain the data in the EMF. Note that most datasets have their own tables in the EMF schema, so you do not normally need to worry about selecting only the records for the specific dataset of interest. The customized syntax also has extensions to refer to another dataset and to refer to specific versions of other datasets using tokens other than \$TABLE. For the purposes of this discussion, it is sufficient to note that these other extensions exist.

Some of the summaries are constructed using more complex queries that join information from other tables, such as the SCC descriptions, the pollutant descriptions (which are particularly useful for HAPs), and to account for any missing descriptions. For example, the syntax for the “Summarize by SCC and Pollutant with Descriptions” query is:

```
select e.SCC, coalesce(s.scc_description, 'AN UNSPECIFIED DESCRIPTION')::character varyin
```

This query is quite a bit more complex, but is still supported by the EMF QA step processing system. In addition to summaries of the inventories, there are many summaries available for the Strategy Detailed Results output by control strategy runs and for some of the other CoST-related dataset types. Some of the summaries available for Strategy Detailed Results are as follows:

- “Summarize by Pollutant”
- “Summarize by County and Pollutant”
- “Summarize by SCC and Pollutant”
- “Summarize by Control Technology and Pollutant”
- “Summarize by Control Measure and Pollutant”
- “Summarize by Source Group and Pollutant”
- “Summarize by U.S. State and Pollutant”
- “Summarize by State, SCC, and Control Technology”
- “Summarize by Control Technology, FIPS, and SCC”
- “Summarize by Control Program, U.S. State and Pollutant”
- “Summarize by Plant and Pollutant”
- “Summarize all Control Measures”
- “Summarize by Sector and Pollutant with Descriptions”
- “Summarize by Sector, U.S. State, and Pollutant”
- “Summarize by U.S. State and SMOKE Pollutant Name”
- “Cost Curve”

A plot created based on the output of a Summarize by Control Technology and Pollutant summary is shown in Figure 4.31.

When multiple datasets need to be considered in a summary (e.g., to compare two emissions inventories), the EMF “QA Program” mechanism is used. The QA programs each have customized user interfaces that allow users to select the datasets to be used in the query. Some of the following QA programs may prove useful to CoST users:

- **Multi-inventory sum:** takes multiple inventories as input and reports the sum of emissions from all inventories
- **Multi-inventory column report:** takes multiple inventories as input and shows the emissions from each inventory in separate columns
- **Multi-inventory difference report:** takes two sets of inventories as input, sums each inventory, and then computes the difference between the two sums
- **Compare Control Strategies:** compares the data available in the Strategy Detailed Result datasets output from two control strategies

Summaries can be mapped with geographic information systems (GIS), mapping tools, and Google Earth. To facilitate this mapping, many of the summaries that have “with Descriptions” in their names include latitude and longitude information. For plant-level summaries, the latitude and longitude provided are the average of all the values given for the specific combination of FIPS and PLANT_ID. For county- and state-level summaries, the latitude and longitude are the centroid of the county or state specified in the fips table of the EMF reference schema.

It is useful to note that after the summaries have been created, they can be exported to CSV files. By clicking **View Results**, the summary results can be viewed in a table called the Analysis Engine that does sorting, filtering, and plotting. From the **File** menu of the

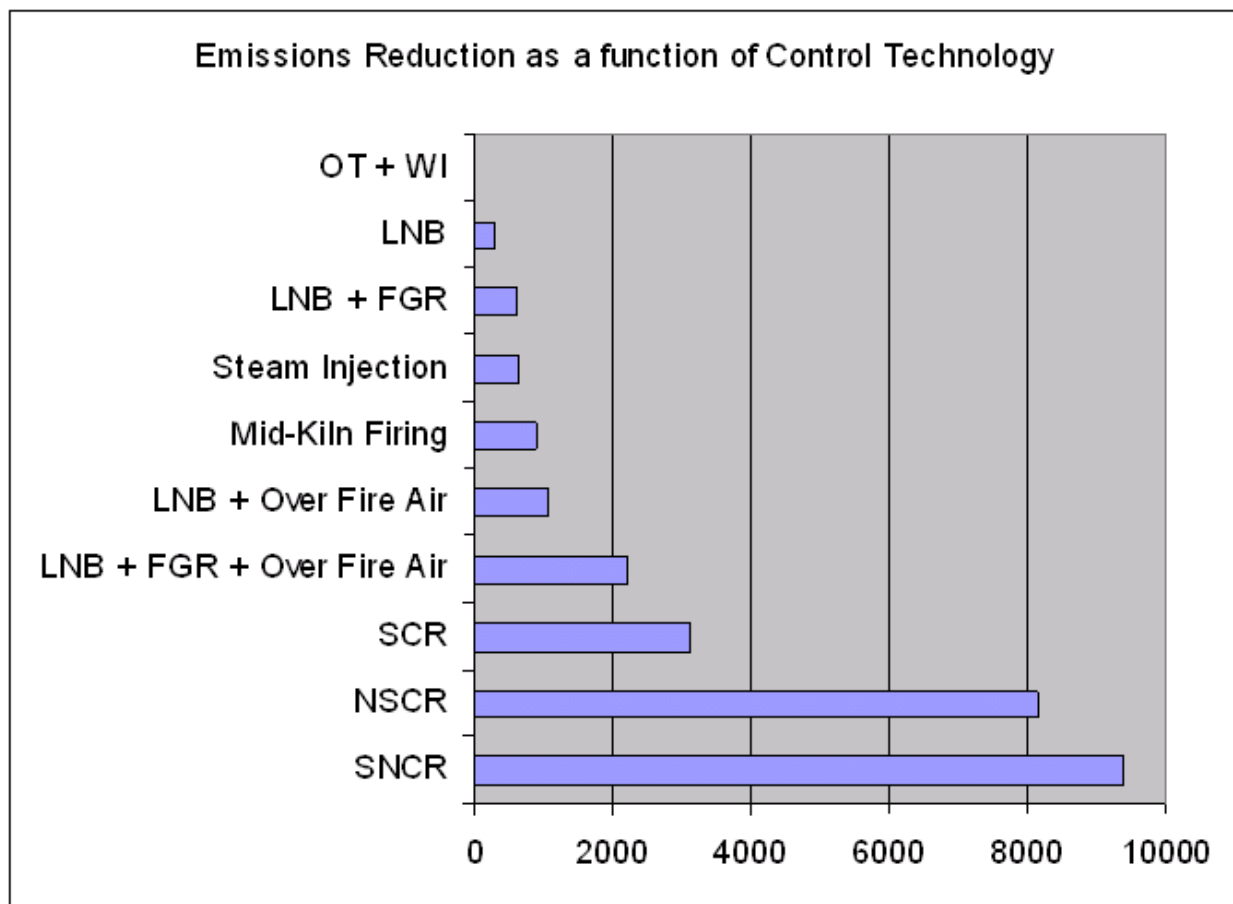


Figure 4.31: Control Technologies used within a Least Cost Analysis

Analysis Engine window, a compressed .kmz file can be created and subsequently loaded into Google Earth. Note that each KMZ file is currently provided with a single latitude and longitude coordinate representing its centroid, even for geographic shapes like counties.

Recall that in addition to the datasets output for control strategies, many types of summaries of these datasets can be created in CoST. Figure 4.31 shows a plot summarizing a Least Cost Strategy Detailed Result using the “Summarize by Control Technology and Pollutant” query. Some of the technologies used in this run were Low NOx burners (LNB), Low NOx burners with Flue Gas Recovery (LNB + FGD), Non-Selective Catalytic Reduction (NSCR), and Selective Non-catalytic Reduction (SNCR). Note that Figure 4.31 was generated by plotting data output from CoST with spreadsheet software, and not by CoST itself. CoST does have some plotting capabilities, but they are not discussed in this document.

Chapter 5

Advanced Control Strategy Exercises

This chapter includes advanced exercises for learning how to use different features of CoST. Users should complete the exercises in [Chapter 3](#) and [Chapter 4](#) before attempting the exercises in this chapter.

5.1 Exercise 1. Importing an Emissions Inventory (or County List File)

1. Choose **Datasets** from the **Manage** menu of the main EMF window.

In many cases, it will be necessary to import an emissions inventory into the EMF for use with CoST. Before it can be imported, the inventory must be in one of these FF10 or ORL formats: Point, Onroad, Nonroad, or Nonpoint. For more information on these formats, see https://www.cmascenter.org/smoke/documentation/4.5/html/ch08s02.html#sect_input_inventory_format. Try importing an inventory using the following steps:

2. Select an inventory format from **Show Datasets of Type** menu to the type that represents the inventory to import (e.g., FF10 Nonpoint Inventory).
3. Click the **Import** button to show the **Import Datasets** window.
4. Click the **Browse** button and browse to the location of the inventory to import on the EMF server computer (e.g., C:\Users\Public\EMF_Data\inventories).
5. Select the checkbox that corresponds to the inventory (e.g., 2017eh_from_nonpt_2011NEIv2_NONPO) and then click **OK**.
6. Specify a unique, descriptive name for the new dataset in the **Dataset Name** dialog box.

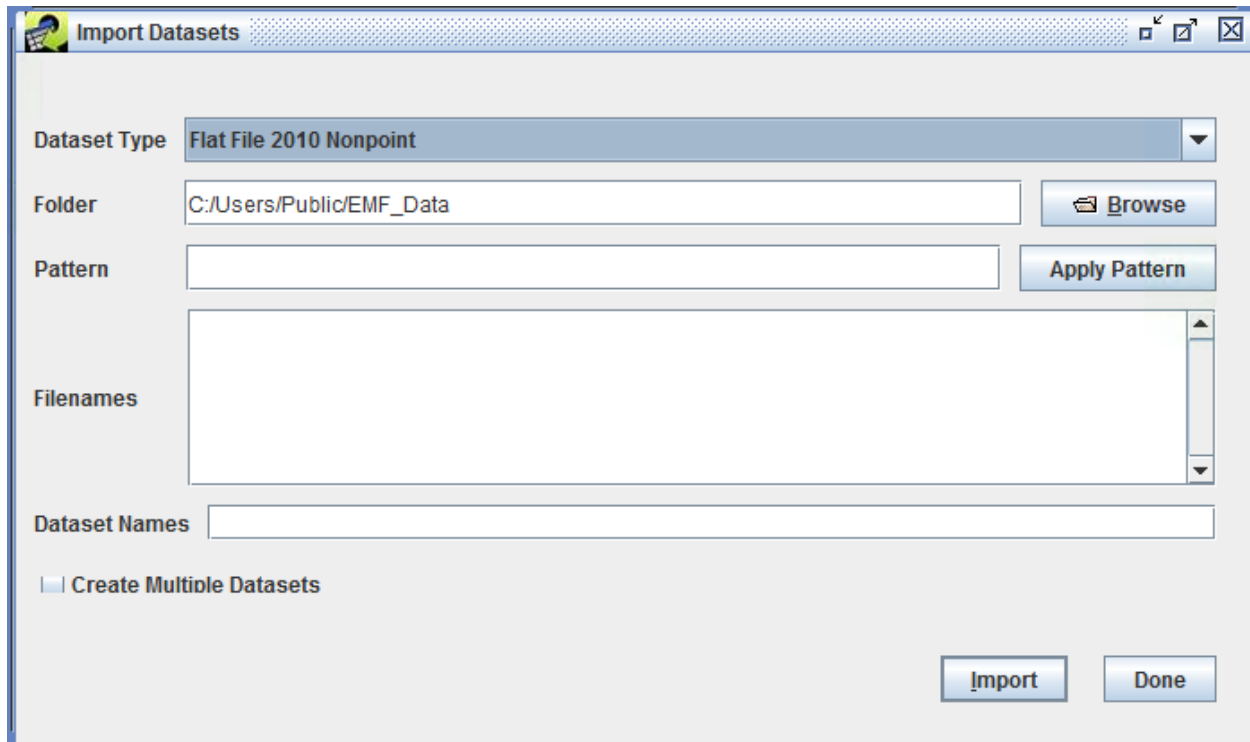


Figure 5.1: Import Dataset Window

7. Click the **Import** button. Monitor the **Status** window for the status of the import.
8. Click **Done** on the Import Datasets window.
9. After the Status window messages indicates that the import has completed, click **Refresh** on the **Dataset Manager** to see the newly imported inventory dataset. The dataset could now be used as an input to a control strategy.
10. To import a list of counties to limit the counties used for a strategy analysis, set the **Show Datasets** of **Type** menu to **List of Counties** and then import the file following steps 3 through 9 above. Be sure that the list of counties file has at least two columns, with one of them labeled FIPS.

The Dataset Manager includes the following controls:

- **View** opens the Dataset Properties Viewer
- **Edit Properties** opens the Dataset Properties Editor
- **Edit Data** creates new versions of the dataset
- **Remove** removes the dataset
- **Import** imports new datasets
- **Export** exports the data to a file on the EMF server
- **Purge** purges datasets that were removed from the system
- **Close** closes the **Dataset Manager Window**

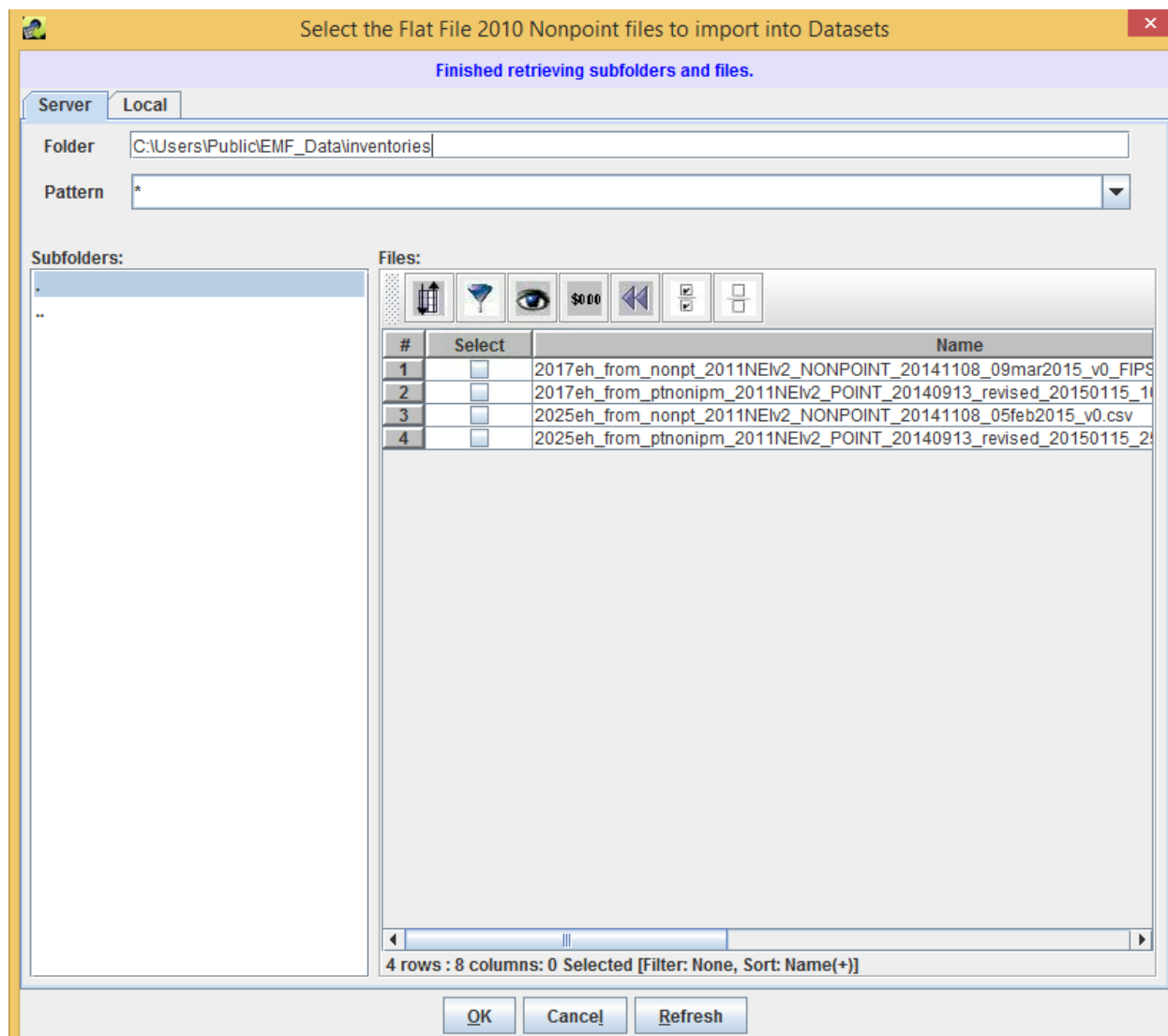


Figure 5.2: Import Browse Window

Export: 2017eh_from_nonpt_2011NElv2_NONPOINT_20141108_09mar2015_v0_FIPS_37

Datasets

2017eh_from_nonpt_2011NElv2_NONPOINT_20141108_09mar2015_v0_FIPS_37

☐ Download files to local machine?

Folder C:/Users/Public/EMF_Data

☐ Overwrite files if they exist?

File Name Prefix

Version 0 (Initial Version) ▼

Row Filter

Filter Dataset

Filter Dataset Join Condition

Purpose

Figure 5.3: Export Window

5.2 Exercise 2. Running a Maximum Emissions Reduction Strategy

For this exercise, an existing Least Cost Strategy will be modified to create a Maximum Emissions Reductions strategy.

1. From the Control Strategy Manager **Copy** the least cost strategy created in **Chapter 4** to a new strategy.
2. **Edit** the strategy and set the Type of Analysis to **Max Emissions Reduction**.
3. Run the new strategy and answer the following questions once it completes.
 - Did the Maximum Emissions Reduction strategy run slower or faster than the Least Cost?
 - How many more emissions reductions were achieved over the 50% level of reduction set in the Least Cost run in **Chapter 4**?
 - How do the Average Cost per Ton and Total Cost differ between the 50% Least Cost control reduction strategy and the Maximum Emissions Reduction available?

*Hint: use the following columns of the **Control Strategy Manager** to answer this question.*

Least Cost Strategy Total Cost: Least Cost Strategy Average CPT:

Max. Emissions Red Total Cost: Max. Emissions Red Average CPT:

- What are some of the SCCs for sources that had control measures applied in the result, but had a control efficiency of less than 90%? [It is important to note these because they may provide opportunities for controls...] *Hint: Examine the Strategy Detailed Result and apply a filter for CONTROL_EFF<90 to find the applicable rows:*

SCCs with CE < 90%:

5.3 Exercise 3. Running a Strategy with a Hypothetical Measure

For this exercise, create a new control measure and then see what impact it has on the strategy results.

1. From the **Control Strategy Manager** create a **New** control measure. Set the Major Pollutant to **NOX** and set the Class to **Hypothetical**.

2. For the new measure enter an **Efficiency** record for **NOX** with a control efficiency of **95%**, a **Cost per Ton** of **3000**, and a **Cost Year** of **2006**.
3. For your new measure, add all SCCs **starting with 102** (there should be about 78 of these). *Hint: you do not have to click 78 checkboxes to do this - remember to filter and Select All.*
4. **Copy** the Maximum Emissions Reduction strategy from the previous exercise to a new strategy.
5. Set the new strategy to include **Hypothetical** measures in addition to **Known** measures.
6. **Run** the new strategy.

Based on the results of this strategy, **how many additional emissions reductions** were realized over the previous maximum reduction result if there was a control measure with a 95% CE available for sources with SCCs starting with 102?

5.4 Exercise 4. Examining Co-benefits of a Control Strategy

For this exercise, run a control strategy that produces co-benefits for multiple pollutants.

1. Set up a new control strategy.
2. Set the **Target Year** to **2020** and the **Strategy Type** to **Maximum Emissions Reduction**.
3. Set the inventory to use to be the **Nonpoint** inventory imported in [Exercise 1](#).
4. Set the **Target Pollutant** to **PM25-PRI**, then **Run** the strategy.
5. Once the run completes, summarize the **Strategy Detailed Result** by **Control Technology and Pollutant**.
6. Once the summary has completed running, **View the Strategy Detailed Result**
 - Does this result show more than one pollutant?
 - What is the typical cost per ton for the strategy?
7. Try setting a **Maximum Cost per Ton** constraint less than the typical cost per ton in the result just generated and rerun the strategy. How does the constraint impact the results?

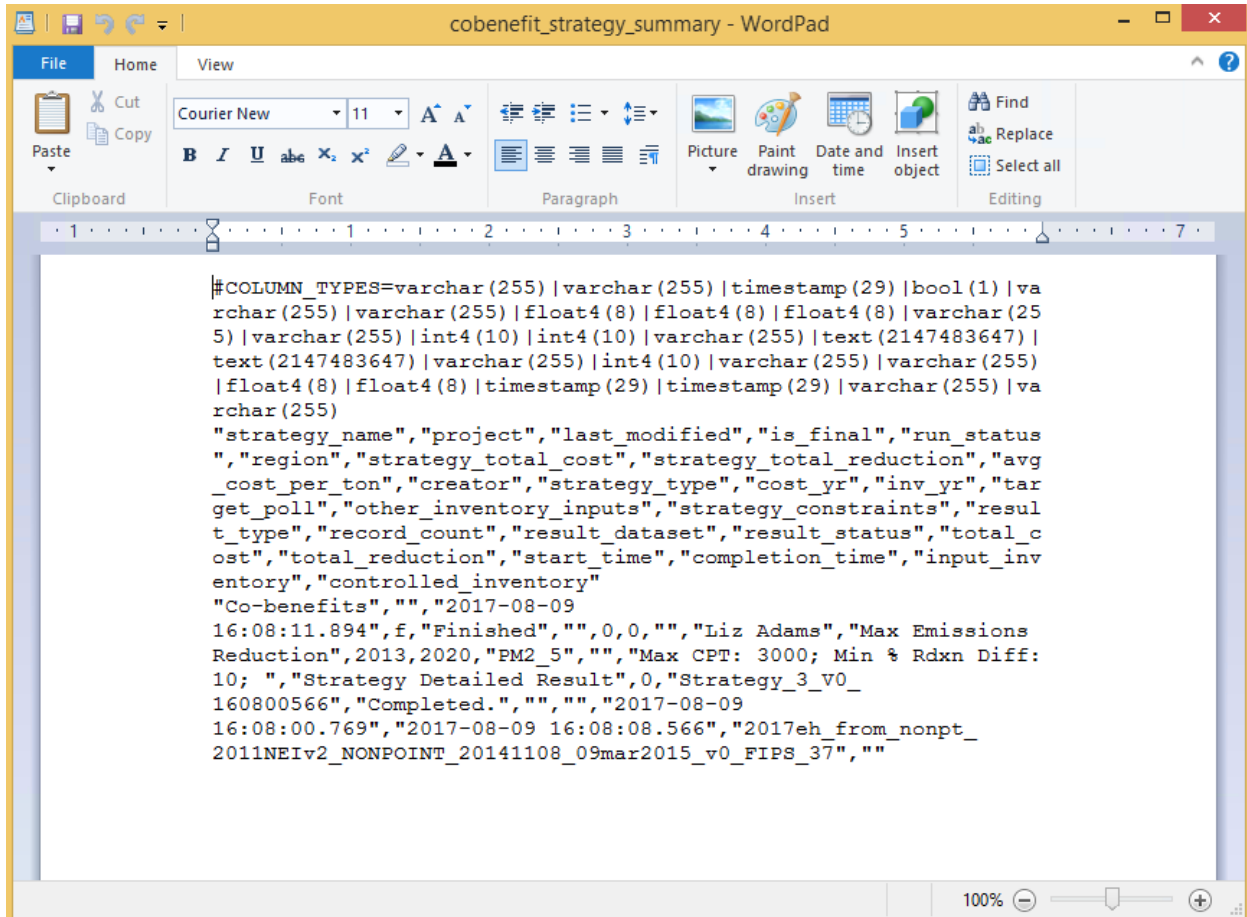


Figure 5.4: Summary Spreadsheet

8. Use the Cost Control Summary Function in the Control Strategy Manager Window to create a local spreadsheet summarizing the selected control strategies, including name, strategy type, and constraints, emission reductions and strategy costs.
9. Note that the summary spreadsheet with constraints was for a cost per ton value of 3000. The result was that no controls were applied, as they all cost more than that. For the summary spreadsheet with no constraints, the cost of the controls is listed after the status (Completed), for a total value of \$3,679,355 and a total emission reduction of 331.2 tons of PM2.5.

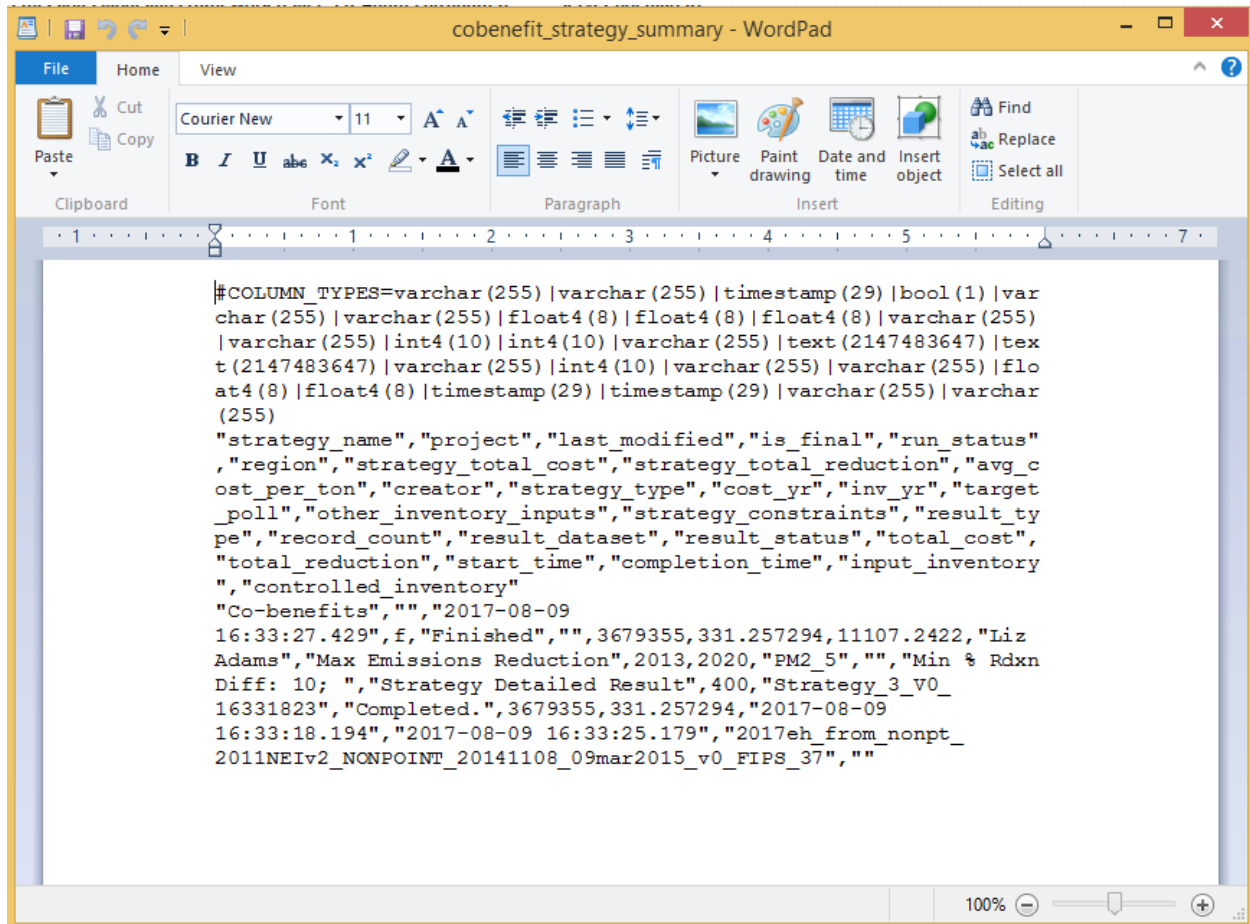


Figure 5.5: Summary Spreadsheet No Constraints

Chapter 6

Example SQL Statements for Creating Row Filters

Table 6.1 provides some examples of row filters that can be applied to inventory filters to target specific sources for use during strategy analyses.

Table 6.1: Examples of Row Filters (Data Viewer window) and Inventory Filters (Inventories tab of the Edit Control Strategy window.

Filter Purpose	SQL Where Clause
Filter on a particular set of SCCs	<code>scc like '101%' or scc like '102%'</code>
Filter on a particular set of pollutants	<code>poll in ('PM10-PRI', 'PM25-PRI') or POLL = 'PM10-PRI' or POLL = 'PM25-PRI'</code>
Filter sources only in NC (State FIPS = 37), SC (45), and VA (51);note that FIPS column format is State + County FIPS code (e.g., 37001)	<code>substring(FIPS,1,2) in ('37', '45', '51')</code>
Filter sources only in CA (06) and include only NOx and VOC pollutants	<code>substring(fips,1,2) = '06' and poll in ('NOX', 'VOC') or fips like '06%' and (poll = 'NOX' or poll = 'VOC')</code>

Chapter 7

References

Eyth, A.M., D. Del Vecchio, D. Yang, D. Misenheimer, D. Weatherhead, L. Sorrels, “Recent Applications of the Control Strategy Tool (CoST) within the Emissions Modeling Framework”, 17th Annual Emissions Inventory Conference, Portland, OR, 2008.

Houyoux, M.R., M. Strum, R. Mason, A. Eyth, A. Zubrow, C. Allen, “Using SMOKE from the Emissions Modeling Framework”, 17th Annual Emissions Inventory Conference, Portland, OR, 2008.

Misenheimer, D.C., “A New Tool for Integrated Emissions and Controls Strategies Analysis”, 16th Annual Emissions Inventory Conference, Raleigh, NC, 2007.

Chapter 8

Acronyms

Abbreviation	Definition
AQM	Air Quality Model
CE	Control Efficiency
CMAQ	Community Multiscale Air Quality model
CMAS	Community Modeling and Analysis System
CoST	Control Strategy Tool
CPT	Cost per Ton
CRF	Capital Recovery Factor
CSV	Comma-separated values
DBF	D-base Format
EC	Elemental Carbon
EMF	Emissions Modeling Framework
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute (creators of ArcGIS software)
FGD	Flue Gas Desulfurization
FGR	Flue gas recirculation
FIPS	Federal Information Processing Standards
GDP	Gross Domestic Product
GIS	Geographic information system
GUI	Graphical User Interface
HEID	Health and Environmental Impacts Division (of EPA)
IE	Institute for the Environment (University of North Carolina)
IPD	Implicit Price Deflator
LNB	Low NO _x Burner
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NSCR	Non-Selective Catalytic Reduction
OC	Organic Carbon
O&M	Operating and Maintenance
ORL	One record per line

Abbreviation	Definition
PM10-PRI	Particulate matter with a diameter of 10 micrometers or less
PM25-PRI	Particulate matter with a diameter of 2.5 micrometers or less
PR	Percent Reduction
RE	Rule Effectiveness
RP	Rule Penetration
SCC	Source Classification Code
SCR	Selective Catalytic Reduction
SIC	Standard Industrial Classification
SNCR	Selective Noncatalytic Reduction
SQL	Structured Query Language
SMOKE	Sparse Matrix Operator Kernel Emissions modeling system
tpy	Tons per year
UNC	University of North Carolina
