



CONTROL STRATEGY TOOL (CoST) CONTROL MEASURES DATABASE (CMDDB) DOCUMENTATION

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Contents

Tables	iv
Figures.....	iv
Acronyms	v
1 Introduction.....	1
2 Control Measures.....	2
2.1 Origins and Status of the Control Measures Database.....	2
2.2 Costs Associated with Control Measures	4
2.3 Developing New Control Measure Information	4
3 Control Measures Database Data Elements.....	5
3.1 Summary Table.....	6
3.2 Efficiency Records Table.....	7
3.3 SCCs Table	10
3.4 Equations Table	10
3.5 References Table.....	11
3.6 Examples of Control Measure Data Tables	12
4 Using the CMDDB to Develop Control Strategies.....	19
4.1 Summary of the Strategy Development Process.....	19
4.2 Strategy Inputs Relevant to Control Measures	21
4.3 Control Measure Filtering and Custom Overrides.....	22
5 References.....	23

Tables

Table 1. Summary Information Table Format	6
Table 2. Efficiency Records Table Format	7
Table 3. Excerpt from the gdplev Table Used to Convert Data between Cost Years.....	9
Table 4. SCCs Table Format.....	10
Table 5. Equations Table Format.....	11
Table 6. References Table Format	12
Table 7. Summary Table Example*.....	13
Table 8. Efficiency Records Table Example*	14
Table 9. SCCs Table Example	15
Table 10. Cost Equations Table Example.....	16
Table 11. References Table Example	17

Figures

Figure 1. Basic Steps for Running a Control Strategy Using CoST.....	20
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Acronyms

CAP	criteria air pollutant
CE	control efficiency
CAMD	Clean Air Markets Division (EPA)
CARB	California Air Resources Board
CMAQ	Community Multiscale Air Quality modeling system
CMAS	Community Modeling and Analysis System
CMDB	Control Measures Database
CoST	Control Strategy Tool
CRF	capital recovery factor
CSV	comma-separated values
EC	elemental carbon
EMF	Emissions Modeling Framework
EPA	U.S. Environmental Protection Agency
FGD	flue gas desulfurization
FGR	flue gas recirculation
FIPS	Federal Information Processing Standards
GDP	Gross Domestic Product
GHG	greenhouse gas
GIS	geographic information system
GUI	graphical user interface
HAP	hazardous air pollutant
HEID	Health and Environmental Impacts Division (EPA)
IE	Institute for the Environment (UNC)
IPM	Integrated Planning Model
LNB	low NO _x burner
MOVES	MOtor Vehicle Emission Simulator
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
OTAQ	Office of Transportation and Air Quality (EPA)
OTC	Ozone Transport Commission
PM	particulate matter
PR	percent reduction
RE	rule effectiveness
RP	rule penetration
RPO	regional planning organization
SCC	Source Classification Code
SIC	Standard Industrial Classification
SNCR	selective non-catalytic reduction
SQL	Structured Query Language
SMOKE	Sparse Matrix Operator Kernel Emissions modeling system
tpy	tons per year
UNC	University of North Carolina

VOCvolatile organic compound(s)

1 Introduction

The U.S. Environmental Protection Agency (EPA) Health and Environmental Impacts Division (HEID) is developing the Control Strategy Tool (CoST) to support national- and regional-scale multipollutant air quality modeling analyses. CoST allows users to estimate the emission reductions and costs associated with future-year emission control strategies, and then to generate emission inventories that reflect the effects of applying the control strategies [Misenheimer, 2007; Eyth, 2008]. The emissions reductions achieved by control strategies are due to the application of control measures to emission sources. Control measures are devices, techniques, or practices that reduce emissions for at least one pollutant of interest for a particular group of emission sources. CoST tracks information about control measures, their costs, and the types of emission sources to which they apply. This tool helps users develop control strategies that match control measures to emission sources using the available algorithms such as “Maximum Emissions Reduction”, “Least Cost”, and “Apply Measures in Series” (these terms are explained in Section 4.1)

CoST is a component of the Emissions Modeling Framework (EMF), which is currently being used by 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 to an air quality model such as EPA’s Community Multiscale Air Quality (CMAQ) modeling system (Byun, 2006). The EMF supports the management and quality assurance of emissions inventories and emissions modeling related data, and also the running of the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system to develop CMAQ inputs. Providing CoST as a tool integrated within the EMF facilitates a level of collaboration between control strategy developers and emissions inventory modelers that was not previously possible. CoST supports multipollutant analyses and data transparency, and provides a wide array of options for developing control strategies. CoST has been developed to replace the older AirControlNET software (discussed in Section 2.1).

CoST has been developed to provide an extensible software system for developing control strategies. The tool uses EPA HEID’s Control Measures Database (CMDB) to develop control strategies, and provides a user interface to that database. The CMDB is a relational database that contains information on an extensive set of control measures for point sources (ptipm and ptnonipm sectors), non-point (nonpt), and mobile sources (onroad and nonroad). Information contained in the database includes descriptions of the measures, control efficiencies for the pollutants affected, costs of control, and the types of sources or processes to which the control measures can be applied. The CMDB currently resides in the EMF as a set of tables in PostgreSQL (<http://www.postgresql.org>).

The information in the CMDB can be imported into and exported from CoST. For many of the control measures in the CMDB, a simple cost factor in terms of dollars per ton of pollutant reduced is used to calculate the cost of the control measure when applied to a specific source. However, a few control measures use more robust cost equations to determine engineering costs that take into account several variables for the source, when values for those variables are available. These equations are described in “Documentation of Cost Equations in EPA’s Control Strategy Tool” (<http://www.epa.gov/ttn/ecas/cost.htm>).

Analyses have been performed by EPA HEID to compare the results of CoST to results of independently developed strategies for criteria air pollutants (CAPs) for point, nonpoint, and mobile sources. It was determined that CoST could reproduce these strategies if the inputs to the independently developed strategies were consistent with those given to CoST. The tool has not yet been used for hazardous air pollutants (HAPs), but it has been used in some limited analyses for greenhouse gases (GHGs). The main limiting factors in using CoST for greenhouse gas analyses are the availability of GHG emissions inventories at an appropriate level of detail, and the availability of control measure data in the CMDB for greenhouse gases.

This document describes the history and contents of the CMDB. For additional information on other aspects of CoST, see the following independent documents:

- “Control Strategy Tool (CoST) Training Manual and User’s Guide”
- “Control Strategy Tool (CoST) Development Document”
- “Control Strategy Tool (CoST) Glossary of Terms”
- “Documentation of Cost Equations in EPA’s Control Strategy Tool”

These documents, and additional information about CoST, can be found at: <http://www.epa.gov/ttn/ecas/cost.htm>. If you are unsure of the meaning of terms used in this document, consult the “Control Strategy Tool (CoST) Glossary of Terms”.

2 Control Measures

2.1 Origins and Status of the Control Measures Database

The CMDB began as a collection of point- and nonpoint-source control measures extracted from AirControlNET (for more information on AirControlNET, see <http://www.epa.gov/ttn/ecas/AirControlNET.htm>). The control measures used by AirControlNET were primarily targeted at single-pollutant analyses for studies related to particulate matter (PM) and ozone. Information was included in the database for PM₁₀, PM_{2.5}, NO_x, volatile organic compounds (VOC), NH₃, SO₂, and Hg. Data were extracted from AirControlNET into a set of files in comma separated value (CSV) format that were readable by standard spreadsheet software and could be imported into CoST.

The data in the CMDB are separated into six tables for each control measure:

- 1) summary information about the control measure;
- 2) efficiency records describing the reductions achieved by, and the costs required to apply, the measure for each affected pollutant;
- 3) a list of Source Classification Codes (SCCs) to which the measure applies;
- 4) cost equation information (parameters used to compute the results of cost equations), for measures to which this is applicable;
- 5) references providing additional information on the control measure and how its control efficiency and cost information were derived; and
- 6) additional information that does not fit well within one of the five previous categories, especially parameters that are unique to a single control measure or a subset of control measures.

These tables operate as a relational database and are currently housed within the EMF database as a set of tables within the EMFPostgresSQL database. The tables are described in detail in Section 3.

Control measures are available in the CMDB for point sources, nonpoint sources, and mobile sources (onroad and nonroad). Control measure data in the database are taken from EPA reports and databases, and reflect data from EPA regulatory development and control studies, regional planning organizations (RPOs) such as the Ozone Transport Commission (OTC), and individual State agencies such as the California Air Resources Board (CARB).

- *Point and nonpoint sources:* Most of the control measures in the database for point and nonpoint sources are derived from national average data. This means that the actual results of applying the measures will vary when the devices are applied to specific sources. It is particularly important to keep this in mind if the data are applied to local-scale analyses. The control efficiency records of the CMDB support storing information at several levels of geographic specificity, including national, state, or county level. For example, some data for nonpoint sources are state specific and reflect the varying levels of cost and control for each state. Note that although control measures are available for electricity utility point sources in the CMDB, most analyses involving these are performed using the Integrated Planning Model (IPM), a model employed by EPA's Clean Air Markets Division (CAMD).
- *Mobile sources:* Mobile-source measures are typically derived from data made available by EPA's Office of Transportation and Air Quality (OTAQ) as a result of analyses undertaken using emissions models such as MOBILE6, NONROAD, and MOVES. For example, some mobile-source control measure information in the CMDB was generated by running MOBILE and NONROAD with and without controls. The results were then used to calculate control efficiencies for each pollutant affected, specific to each county. For controls not currently covered in these models, information was obtained from recent studies conducted by OTAQ to identify appropriate control efficiencies, costs, and affected SCCs. Note that the mobile-source measure information currently in the CMDB was derived for particular analyses and is not sharable with external partners (such as State organizations) because it is not broadly applicable. State air agencies and other organizations needing mobile-source control measure information should run the appropriate mobile-source models and consult with OTAQ to obtain control measure information for their particular applications.

There have been several efforts to review and enhance the data in the CMDB. Organizations that have been involved in these efforts include Alpine Geophysics, Research Triangle Institute (RTI), the University of North Carolina at Chapel Hill (UNC), E.H. Pechan & Associates, and various offices within EPA. In its current form, the database primarily supports CAP control strategy analyses and has extensive coverage for NO_x controls for industrial sources. In early 2009, E.H. Pechan & Associates began work for EPA to quality assure, enhance and expand the CMDB, which included the following tasks:

- Resolve inconsistencies with AirControlNET "At-A-Glance" documentation
- Re-evaluate SCCs applicable for each control measure
- Update the control and cost information for several key industries

- Add control measure information for HAPs
- Fill in missing control measure descriptions

2.2 Costs Associated with Control Measures

For many of the control measures in the CMDB, a simple cost factor in terms of “dollars per ton of pollutant reduced” is used to calculate the cost of the control measure when applied to a specific source. These cost-per-ton factors are estimates of the cost of control measures in circumstances where there is limited information on how the engineering control costs vary with respect to variables specific to the source, such as unit size, capacity, and inlet flow rate. These cost-per-ton factors are the primary method of estimating costs for nonpoint-source control measures. They are generated by taking the annualized control costs for a source or set of sources and dividing by the measured or estimated emission reductions for the source(s). It should be noted that these simple cost-per-ton factors may produce results with a high level of uncertainty when applied to a small number of sources in a local-scale analysis.

For a few control measures, a different approach is used: cost equations. These equations calculate engineering costs that take into account several variables specific to the source, when data for those variables are available. Cost equations are most commonly available for point-source control measures. These additional data can sometimes be found in the emissions inventory, but often need to be obtained from other sources. See “Documentation of Cost Equations in EPA’s Control Strategy Tool” (available at <http://www.epa.gov/ttn/ecas/cost.htm>) for more information on cost equations and their inputs.

Note that due to the methods used to obtain the cost data, there are limitations and uncertainties inherent in both the cost-per-ton factors and the cost equation parameters, so caution must be used when applying these approaches for estimating cost, especially for local-scale analyses.

2.3 Developing New Control Measure Information

There is an ongoing need for new and expanded control measure information in the CMDB, for several reasons:

- *New control measures*: New measures are constantly being developed to address various air quality and health-related issues and to achieve greater efficiencies in industrial processes and mobile-source equipment.
- *Co-impacts*: More data are needed on impact of established control measures on pollutants other than the major targeted pollutant, such as the co-impacts of the measure on HAPs and GHGs.
- *Improved characterization*: Some existing control measure data are highly uncertain and need to be improved to reflect latest practices.

Regarding the first bullet above, the general steps for developing new control measure information for the CMDB are as follows:

- 1) Identify and describe the control measure, including other control measures that this measure might replace or be combined with.
- 2) Collect information on the pollutants affected.

- 3) Collect information on the reductions to or increases in emissions of other pollutants as a result of the measure application, either by itself or in addition to other measures. (For example, a measure targeted at NO_x may result in an increase in ammonia emissions.) Identify ranges of reduction that can be achieved and calculate a single value of most likely reduction.
- 4) If possible, generate a cost equation that takes into account the variables that have the greatest impact on cost, in terms of both capital costs and operating and maintenance costs. If it is not possible to generate a cost equation, then calculate a cost-per-ton reduction factor.

3 Control Measures Database Data Elements

As discussed in Section 2.1, the data in the CMDB are separated into five different tables for each control measure:

- 1) **summary** information about the control measure;
- 2) **efficiency records** describing the reductions achieved by, and the **costs** required to apply, the measure for each affected pollutant;
- 3) a list of **SCCs** to which the measure applies;
- 4) cost **equation** information (parameters used to compute the results of cost equations), for measures to which this is applicable;
- 5) **references** providing additional information on the control measure; and
- 6) additional information that does not fit well within one of the five previous categories, especially parameters that are unique to a single control measure or a subset of control measures. The table in which this additional information is managed is called the **properties** table.

These tables are described in Sections 3.1 through 3.5. In the tabular descriptions in these sections, a data type is designated for each data field. The data types are:

- “Char”: Characters or text strings, with the assigned length of the data field shown in parentheses (e.g., Char(128)).
- “Real”: Number fields that use a floating-point representation, which can handle numbers with a fractional part as well as whole numbers.
- “int”: Whole numbers, with the assigned length of the integer field appended to “int” (e.g., int4).
- “Date”: Date in the format mm/dd/yyyy.

Each table has one or more columns that comprise a primary key. A primary key is a column or set of columns whose contents uniquely identify each row in a table. No two distinct rows in the table can have the same value (or combination of values) for the primary key. Section 3.6 then gives an example of each table type.

3.1 Summary Table

The summary table in the CMDB provides high-level information about each control measure. The fields in the summary table of the CMDB import-export format are shown in Table 1. Data provided in the import-export format can be easily read into the database, and conversely subsets of data in the database can be written into files in this format. The primary keys to this table are the CMName and the CMAbbreviation (i.e., each measure must have its own unique name and unique abbreviation); these keys are indicated in **bold**.

An example of a summary table is shown in Table 7 in Section 3.6.

Table 1. Summary Information Table Format

Column Label*	Data Type	Field Description
CMName	Char(255)	A unique name for the control measure that is described in a given row of the summary table. Typically, the name consists of the combined fields "ControlTechnology" and "SourceGroup" (describe in rows 3 and 4 below), separated by a semicolon (e.g., SNCR; Ammonia - Oil-Fired Reformers). This is a unique name that summarizes the control technology and the sources to which it applies.
CMAbbreviation	Char(10)	An acronym-style unique abbreviation for the control measure. The abbreviation is specific to an industry or source category. The first letter typically refers to the major pollutant (i.e., pollutant that the control measure is primarily meant to reduce): A=NH ₃ , N=NO _x , P=PM, S=SO ₂ , V=VOC. The next letters refer to the Control Measure, followed by letters that refer to Source Group or Industry, followed by letters that refer to Fuel Type or additional Industry information.
MajorPoll	Char(128)	Major pollutant: the pollutant most reduced by the control measure. Current pollutant abbreviations include NH ₃ , NO _x , PM ₁₀ , PM _{2.5} , SO ₂ , VOC, etc. This is used only to group related measures, and has no impact on how the measure is assigned to sources in CoST.
ControlTechnology	Char(128)	The method used to reduce emissions (this can represent a device, practice, or process). Note that when editing data for a control measure using the CoST Graphical User Interface (GUI), you can type in a new entry for control technology and this entry then becomes available when making future selections from the control technology pull-down menu.
SourceGroup	Char(128)	The source group or industry sector to which the control measure applies. Note that when editing data for a control measure using the CoST Graphical User Interface (GUI), you can type a new entry for source group and this entry then becomes available when making future selections from the source group pull down menu.
Sector	Char(128)	The emission inventory sector or group of sectors to which the measure applies: PTNONIPM (stationary point sources not covered by IPM), PTIPM (stationary point source covered by IPM, generally some type of utility boiler), NONPT (previously referred to as "area sources"), ONROAD (mobile highway vehicles), NONROAD (mobile nonhighway sources such as construction equipment, and lawn & garden equipment), ALM (airplanes, locomotives, and marine vessels), PTFIRE (fires identified as point sources), AFDUST (area fugitive dust sources), or AG (agricultural).
Class	Char(64)	Characterizes the status of the control measure. Current options are: Known (i.e., already in use), Emerging (i.e., expected to be used in the future), Hypothetical (i.e., the specified data are hypothetical), or Obsolete (i.e., no longer in use).
EquipLife	Real	The expected life of the control measure equipment, in years.

Column Label*	Data Type	Field Description
NEIDeviceCode	int4	The numeric code used in the National Emission Inventory (NEI) to indicate that the measure has been applied to a source. In the NEI, this may be referred to as APC_ID. NEI Control Device Codes are available at: ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/point/augmentation_point/02nei_lkup_states_011907.zip
DateReviewed	Date	Date on which the control measure data were last reviewed (mm/dd/yyyy)
DataSource	Char(128)	A list of numeric codes separated by ' ' (pipes) that refer to items in the references table (see Section 3.5)
Description	Char(un-limited)	Expanded description of the control measure, its applicability, and any other relevant information.

* Unique keys are indicated in bold.

3.2 Efficiency Records Table

The efficiency records in the CMDB provide information about the control efficiency achieved by the control measure, and the cost of applying the measure for each pollutant. The fields in the efficiency records table of the CMDB import-export format are shown in Table 2. The CMAbbreviation field is a “foreign key” that refers to a record in the summary table with the same value for CMAbbreviation. Thus, the control measure name and other summary information associated with the efficiency records can be looked up by finding the entry in the summary table that has the same value as the CMAbbreviation field in the efficiency records table. The fields with the column label in **bold** are used to compose the primary key for the efficiency record. In other words, each unique record in the table must have a unique combination of CMAbbreviation, Pollutant, Locale, Effective Date, ExistingMeasureAbbr, MinEmissions, and MaxEmissions. This also means that you can specify different values for the control efficiency and cost per ton for different pollutants, locales (i.e., states or counties), and source sizes (the latter is done using the MinEmissions and MaxEmissions columns).

An example of an efficiency records table is shown in Table 8 in Section 3.6.

Table 2. Efficiency Records Table Format

Column Label*	Data Type	Description
CMAbbreviation	Char(10)	Acronym-style unique abbreviation for the control measure. See Table 1 for more information. For the efficiency record to be valid, the value of CMAbbreviation used for the efficiency record must be found in the CMAbbreviation column of the summary table.
Pollutant	Char(128)	The pollutant impacted by the control measure (i.e., emissions of the pollutant are either decreased or increased): PM10, PM2_5, PM_METALS, EC, OC, SO2, VOC, NOx, etc. This can be the major pollutant (see Table 1) or any other pollutant impacted by the measure. New pollutants (e.g., HAPs) may be added as necessary. Eventually, CoST will be updated to support groups of related pollutants that behave similarly, such as 'Organic HAPs', and individual GHGs.

Column Label*	Data Type	Description
Locale	Char(6)	Particular areas of the country for which this record applies. This field can be populated with a two-digit State FIPS code, or a five-digit State/County FIPS code. If this field is empty, then it is assumed that the control measure information applies nationwide. Locale might be included for sources such as Onroad Mobile sources for which the MOBILE model calculates individual control efficiencies for each county in the nation.
Effective Date	Date	Date (mm/dd/yyyy) when a particular efficiency record becomes effective nationwide or in a specific locale (e.g., some measures are phased in over time). The system will find the record with the closest effective date that is less than or equal to the specified target year for the analysis (which is usually the same as the year for which the inventory was constructed). If this field is empty, then the record is assumed to apply to any date.
ExistingMeasureAbbr	Char(10)	This field should be populated when the data for the record 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. (This field is not currently used when assigning sources to measures)
NEIExistingDevCode	int4	This field applies only when the specified measure (per its NEI device code abbreviation) is already applied to the source. (This field is not currently used.)
MinEmissions	Real	This record applies only when the uncontrolled emissions for the inventory source record exceed the specified amount.
MaxEmissions	Real	This record applies only when the uncontrolled emissions for the inventory source record are less than or equal to the specified amount.
ControlEfficiency	Real	The [median] control efficiency (in units of percent reduction, e.g., 99.9% for a 99.9% reduction in emissions) that is achieved when the measure is applied to the source, exclusive of rule effectiveness and rule penetration. <i>Note that there are sometimes disbenefits for certain pollutants as a result of the control measure, so control efficiency can be negative to indicate that the amount of a pollutant actually increased.</i>
CostYear	int4	The year that is the basis for the capital and annual cost estimate.
CostPerTon	Real	The cost to reduce each ton of the specified pollutant.
RuleEff	Real	The rule effectiveness of the measure, which may vary by locale. Rule effectiveness is defined as "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.
RulePen	Real	The rule penetration of the measure, which may vary by locale. Rule penetration is 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. RulePen is typically 100 for measures applied to point sources.
EquationType	Char(128)	"cpton" for Cost per Ton, or give equation type (Type 1, Type 2, etc.). Currently only cpton is used here and other equations are stored separately in the Equations table.
CapRecFactor	Real	The capital recovery factor, based on the interest rate and the equipment life in years.
DiscountRate	Real	The discount/interest rate used to compute annualized capital costs.

Column Label*	Data Type	Description
CapAnnRatio	Real	Ratio of the total capital investment to the total annual costs.
IncrementalCPT	Real	Incremental cost per ton if another control has already been applied. (This is not currently used in computations.)
Details	Char(255)	Text that specifies information about the source of data for this record; or the reason the data for the record was changed.

* Unique keys are indicated in bold.

Regarding the use of CMDB cost data: Cost data obtained by EPA for the CMDB are in terms of a particular year, and that year varies from one control measure to another. To compute the cost results for a control strategy, it is necessary to escalate or de-escalate the costs to a consistent year in order to adjust for inflation and create consistency when adding up costs and comparing costs. This cost escalation is done using the following formula:

$$\text{Cost (\$) for a year of interest} = \frac{\text{Cost for original cost year} \times \text{Chained GDP for cost year}}{\text{Chained GDP for year of interest}}$$

where the chained GDP is the chained Gross Domestic Product available from the United States Department of Commerce Bureau of Economic Analysis spreadsheet at <http://www.bea.gov/national/xls/gdplev.xls>. The current chained GDP table used in the CMDB is dated January 30, 2009. An excerpt of this table is shown in Table 3.

**Table 3. Excerpt from the gdplev Table
Used to Convert Data between Cost Years**

Year	Current_GDP	Chained_GDP
1996	7816.9	8328.9
1997	8304.3	8703.5
1998	8747	9066.9
1999	9268.4	9470.3
2000	9817	9817
2001	10128	9890.7
2002	10469.6	10048.8
2003	10960.8	10301
2004	11712.5	10675.8
2005	12455.8	10989.5
2006	13246.6	11294.8
2007	13807.5	11523.9

To facilitate comparing the costs of control measures with one another, a normalized version of the control measure cost per ton is actually stored within the CMDB and is called the “Reference year cost per ton”. 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 2006. In addition, during the course of a CoST run for a given strategy, the costs are converted (using the above formula) from the reference year to the cost year that is specified by the CoST user as an input to the strategy, and the results of the strategy are therefore presented in terms of the specified cost year.

3.3 SCCs Table

The SCCs table identifies the specific SCCs to which each control measure applies. The CMAbbreviation field is a foreign key that refers to a record in the summary table with the same value for CMAbbreviation. Thus, the control measure name and other summary information associated with the efficiency records can be looked up by finding the entry in the summary table that has the same value as the CMAbbreviation field in the SCCs table. The fields with the column label in **bold** are used to compose the primary key for the SCC record. In other words, each unique record in the table must have a unique combination of CMAbbreviation and SCC.

When CoST runs a control strategy, the control measure is considered for application for any inventory sources that have one of the SCCs specified for the measure. Thus, if the measure can apply to sources with more than one SCC, there should be multiple rows listed in this table with the same value for the CMAbbreviation. Note that CoST requires an explicit list of SCCs to be listed for each measure, and will not expand a general SCC ending in zeros to specific SCCs (e.g., 2310000000 will not expand to 2311011000). However, if it is anticipated that a general SCC (ending in zeros) might appear in the inventory and if the measure should be applied to the source, that SCC should be included in the CMDB.

An example of an SCCs table is shown in Table 9 in Section 3.6.

Table 4. SCCs Table Format

Column Label*	Data Type	Description
CMAbbreviation	Char(10)	Acronym-style unique abbreviation for the control measure. See Table 1 for more information. For the SCC record to be valid, its CMAbbreviation must be found in the summary table.
SCC	Char(10)	Source Classification Code to which the control measure applies: there are 11,000+ SCCs. The SCC is emissions unit specific and often industry specific, but may be applied generically to industries for certain sources, such as Industrial Boilers.
Status	Char(128)	Whether the SCC is Current, Non-existent, or Inactive. (This field is informational and is not considered during any computations.)

* Unique keys are indicated in bold.

3.4 Equations Table

The equations table contains parameters used to compute the results of cost equations. The CMAbbreviation field is a foreign key that refers to a record in the summary table with the same value for CMAbbreviation. Thus, the control measure name and other summary information associated with the cost equations can be looked up by finding the entry in the summary table that has the same value as the CMAbbreviation field in the cost equations table. **Currently, at most a single entry should appear in this table for each CMAbbreviation.** If there is no

applicable equation for the measure, no rows should appear for that CMAbbreviation. There are several types of cost equations, and the variables specified in the Var1 through Var10 data fields differ for each type. More information on these variables and the available cost equations can be found in "Documentation of Cost Equations in EPA's Control Strategy Tool (CoST)" at http://www.epa.gov/ttn/ecas/models/documentation_control_strategy_tool_cost_equations%20.pdf.

An example of an equations table is shown in Table 10 in Section 3.6.

Table 5. Equations Table Format

Column Label*	Data Type	Description
CMAbbreviation	Char(10)	Acronym-style unique abbreviation for the control measure. See Table 1 for more information. For the equation record to be valid, its CMAbbreviation must be found in the summary table.
CMEqnType	Char(128)	Cost equation "type": Type 1, Type 2, Type 3, Type 4, Type 5, Type 6, Type 7, Type 8 equations as specified in "Documentation of Cost Equations in EPA's Control Strategy Tool (CoST)". Each type uses multiple variables to estimate the costs.
Pollutant	Char(128)	The pollutant being reduced for which the equation is computing costs (i.e., emissions of the pollutant are either decreased or increased): PM10, PM2_5, PM_METALS, EC, OC, SO2, VOC, NOx, etc. Typically this is the major pollutant impacted by the measure.
CostYear	int4	The year that is the basis for the capital and annual cost estimate.
Var1	Real	Value for 1st variable in cost equation.
Var2	Real	Value for 2nd variable in cost equation.
Var3	Real	Value for 3rd variable in cost equation.
Var4	Real	Value for 4th variable in cost equation.
Var5	Real	Value for 5th variable in cost equation.
Var6	Real	Value for 6th variable in cost equation.
Var7	Real	Value for 7th variable in cost equation.
Var8	Real	Value for 8th variable in cost equation.
Var9	Real	Value for 9th variable in cost equation.
Var10	Real	Value for 10th variable in cost equation.

* Unique keys are indicated in bold.

3.5 References Table

The references table provides a list of references that are referred to in the DataSource field in the summary tables for all control measures. In the references table, the DataSource column is the key, and multiple control measures may refer to the same data source. The DataSource numeric code in this table relates to the codes list in the DataSource field in the summary table.

An example of a references table is shown in Table 11 in Section 3.6.

Table 6. References Table Format

Column Label*	Data Type	Description
DataSource	Char(128)	Numeric code of the reference or data source for the control information (numbered 1 through xx).
Description	Char(512)	Expanded description of the control measure, its applicability, and any other relevant information.

* Unique keys are indicated in bold.

3.6 Properties Table

The properties table includes fields that are unique to a single or small number of control measures, or that do not fit easily within the previously described tables. Unlike the other CMDB tables, this table does not contain a fixed set of pre-defined fields but instead allows the user to add any number of new fields. This format allows greater flexibility for adding new information to the CMDB that does not readily fit within the existing fields of the previous tables.

3.7 Examples of Control Measure Data Tables

Tables 7 through 12 provide examples of data contained in the CMDB.

Table 7. Summary Table Example*

CMName	CMAbbreviation	Major Poll	Control Technology	SourceGroup	Sector	Class	Equip Life	Date Reviewed	Data Source	Description
AF + IR; Internal Combustion Engines - Gas	NAFRIICGS	NOx	AF + IR	Internal Combustion Engines - Gas	PTNONIPM	Known	15	2006	1 35	N0227
Amine Scrubbing; Sulfur Recovery Plants - Elemental Sulfur (Claus: 2 Stage w/o control (92-95% removal))	SAMSCSRP95	SO2	Amine Scrubbing	Sulfur Recovery Plants - Elemental Sulfur	PTNONIPM	Known	15	2006	1	S0601
Amine Scrubbing; Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (95-96% removal))	SAMSCSRP96	SO2	Amine Scrubbing	Sulfur Recovery Plants - Elemental Sulfur	PTNONIPM	Known	15	2006	1	S0701
Biosolid Injection Technology; Cement Kilns	NBINTCEMK	NOx	Biosolid Injection Technology	Cement Kilns	PTNONIPM	Known	15	2006	1	NCEMK
Biosolid Injection; Cement Manufacturing	NDBIOCM	NOx	Biosolid Injection	Cement Manufacturing	PTNONIPM	Emerging	15		40	
Catalyst Additive; Petroleum Refinery Catalytic and Thermal Cracking Units	SCATPETCRK	SO2	Catalyst Additive	Petroleum Refinery Catalytic and Thermal Cracking Units	PTNONIPM	Known		2006	28 29	
CEM Upgrade and Increased Monitoring of PM Controls; (PM10) Asphalt Manufacture	PCUIMASMN	PM10	CEM Upgrade and Increased Monitoring Frequency of PM Controls	Asphalt Manufacture	PTNONIPM	Known		2006	1	

* The column NEIDeviceCode has been excluded to make the table fit on the page and because there were no data in that column.

Table 8. Efficiency Records Table Example*

CMAbbreviation	Pollutant	Locale	Effective Date	Min Emis sions	Max Emis sions	Control Efficiency	Cost Year	Cost PerTon	RuleEff	Rule Pen	Equation Type	Cap Rec Factor	Cap Ann Ratio	Incre mental CPT
NAFRICGS	NOx			365		20.00%	1990	380	100	100	cpton	0.1098	1.5	380
NAFRICGS	NOx			0	365	20.00%	1990	1570	100	100	cpton	0.1098	2.8	1570
SAMSCSRP95	SO2					98.4%	1990		100	100	5	.1098		
SAMSCSRP96	SO2					97.8%	1990		100	100	5	.1098		
NBINTCEMK	NOx					23.0%	1997	310	100	100	cpton	.1098	7.3	
NDBIOCM	NOx					40.0%	1999	336.7	100	100				
NWTINGTJF	NOx			365		68.00%	1990	650	100	100	cpton	0.1098	1.6	650
SCATPETCRK	SO2					43.00%	2004	1493	100	100	cpton			
NWTINGTNG	NOx			365		76.00%	1990	730	100	100	cpton	0.1098	1.6	730
NWTINGTNG	NOx			0	365	76.00%	1990	1510	100	100	cpton	0.1098	3.1	1510
NWTINGTOL	NOx			0	365	68.00%	1990	1290	100	100	cpton	0.1098	2.9	1290
NWTINGTOL	NOx			365		68.00%	1990	650	100	100	cpton	0.1098	1.6	650
PCUIMASMN	PM10					7.70%	2003	5200	100	100	cpton			
PCUIMASMN	PM10	37	1/1/2010			10.0%	2003	5200	100	100	cpton			
PCUIMASMN	PM2_5					7.70%			100	100				
PCUIMCHMN	PM10					7.70%	2003	5200	100	100	cpton			
PCUIMCHMN	PM2_5					7.70%			100	100				
PCUIMCHMN	PM_METALS					7.70%			100	100				
PCUIMCIBCL	PM2_5					7.70%			100	100				
PCUIMCIBCL	PM10					7.70%	2003	5200	100	100	cpton			
PCUIMCIBLP	PM10					7.70%	2003	5200	100	100	cpton			

* The columns ExistingMeasureAbbr, NEIExistingDevCode, DiscountRate, and Details have been excluded to make the table fit on the page and because there were no data in these columns.

Table 9. SCCs Table Example

CMAbbreviation	SCC	Status
NAFRICGS	20100202	Current
NAFRICGS	20100205	Current
NAFRICGS	20100206	Current
NAFRICGS	20100207	Current
NAFRICGS	20100208	Current
NAFRICGS	20100209	Current
NAFRICGS	20200202	Current
NAFRICGS	20200204	Current
NAFRICGS	20200205	Current
NAFRICGS	20200206	Current
NAFRICGS	20200207	Current
SAMSCSRP95	30103201	Current
SAMSCSRP96	30103202	Current
SAMSCSRP97	30103203	Current
SCATPETCRK	30600201	Current
SCATPETCRK	30600202	Current
SCATPETCRK	30600301	Current
NWTINGTNG	20100201	Current
NWTINGTNG	20100205	Current
NWTINGTNG	20100206	Current
NWTINGTNG	20100207	Current
NWTINGTNG	20100208	Current
NWTINGTNG	20100209	Current
NWTINGTNG	20200201	Current
PCUIMASMN	30500100	Inactive
PCUIMASMN	30500101	Current
PCUIMASMN	30500102	Current
PCUIMASMN	30500103	Current
PCUIMASMN	30500104	Current

Table 10. Cost Equations Table Example

CMAbbreviation	CMEqn Type	Pollutant	Cost Year	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Var9	Var10
NLNBOUBCW	Type 1	NOx	1999	23.4	0.36	0.07	300	0.36	0.85				
NLNBOUBCW2	Type 1	NOx	1999	23.4	0.36	0.07	300	0.36	0.85				
SFGDWUBVHS	Type 1	SO2	1990	174	6.3	1.8	500	0.6	0.65				
SRPNGUBCF	Type 1	SO2	1998	1566	25.44	2.42	500	0.6	0.65				
NLNBUGTNG	Type 2	NOx	1990	71281.1	0.51	7826.3	0.51	71281.1	0.51	7826.3	0.51	0.11	
NLNBUICBW	Type 2	NOx	1990	53868.7	0.6	11861.1	0.6	53868.7	0.6	11861.1	0.6	0.14	
SFGDSPSP	Type 3	SO2	1990										
SFGDSSGCO	Type 3	SO2	1990										
SSADPPRMTL	Type 3	SO2	1990										
SDLABPLSS	Type 4	SO2	1990										
SDLABPZSS	Type 4	SO2	1990										
SNS93SACA	Type 4	SO2	1990										
SAMSCSRP95	Type 5	SO2	1990										
SAMSCSRP96	Type 5	SO2	1990										
SAMSCSRP97	Type 5	SO2	1990										
SFGDSCMOC	Type 6	SO2	1990										
SFGDSECOMP	Type 6	SO2	1990										
PDESCIBCL	Type 8	PM10	1995	27	16	710	41	110					
PDESCIBOL	Type 8	PM10	1995	27	16	710	41	110					
PFFMSASMN	Type 8	PM10	1998	29	11	412	62	126					
PFFMSMICC	Type 8	PM10	1998	29	11	412	62	126					
PWESPMPOR	Type 8	PM10	1995	40	19	923	135	220					
PWESPMPZC	Type 8	PM10	1995	40	19	923	135	220					
PWESPWPPP	Type 8	PM10	1995	40	19	923	135	220					

Table 11. References Table Example

Data Source	Description
1	"AirControlNET Database, May 2006" Prepared for US EPA, OAQPS, RTP, NC 27711. Prepared by Pechan & Associates, Inc., 5528-B Hempstead Way, Springfield, VA 22151. May 2006.
2	"AirControlNET v.4.1 Documentation Report." Prepared for US EPA, OAQPS, RTP, NC 27711. Prepared by Pechan & Associates, Inc., 5528-B Hempstead Way, Springfield, VA 22151. Pechan Report No. 05.09.009/9010.463. September 2005. www.epa.gov/ttnecas1/models/DocumenationReport.pdf
3	Pechan, 1995: E.H. Pechan & Associates, Inc., "Regional Particulate Strategies - Draft Report," prepared for U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Washington, DC, September 1995.
4	Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.
5	Pechan, 1997: E.H. Pechan & Associates, "Additional Control Measure Evaluation for the Integrated Implementation of the Ozone and Particulate Matter National Ambient Air Quality Standards, and Regional Haze Program," prepared for U.S. Environmental Protection Agency, July 1997.
6	SCAQMD, 1996: South Coast Air Quality Management District, "1997 Air Quality Management Plan, Appendix IV-A: Stationary and Mobile Source Control Measures." August 1996.
7	EPA, 1986: U.S. Environmental Protection Agency, Air and Engineering Research Laboratory, Identification, Assessment, and Control of Fugitive Particulate Emissions, EPA/600/8-86/023, prepared by Midwest Research Institute, August 1986.
9	SCAQMD, 1994: South Coast Air Quality Management District, "1994 Air Quality Management Plan, Appendix I-D: Best Available Control Measures PM-10 SIP for the South Coast Air Basin," April 1994.
10	Clapper, 1999: W. Clapper, Sunline Transit Services, personal communication with J. Reisman, E.H. Pechan & Associates, Inc., August 18, 1999.
11	Harrison, 1999: J. Harrison, GCS Western Power, personal communication with J. Reisman, E.H. Pechan & Associates, Inc., August 18, 1999.
12	Pechan, 1999: E.H. Pechan & Associates, Inc., "Control Measure Evaluations: The Control Measure Data Base for the National Emissions Trends Inventory (Control NET)," prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Innovative Strategies and Economics Group, Research Triangle Park, NC, September 1999
13	Pechan, 1998: E.H. Pechan & Associates, Inc., "Clean Air Act Section 812 Prospective Cost Analysis - Draft Report," prepared for Industrial Economics, Inc., Cambridge, MA, September 1998.
14	Peters, 1977: J.A. Peters, and T. R. Blackwood, Monsanto Research Corporation, "Source Assessment: Beef Cattle Feedlots," prepared for U.S. Environmental Agency, Office of Research and Development, Research Triangle Park, NC, June 1977.
15	EPA, 1974: U.S. Environmental Protection Agency, "Investigation of Fugitive Dust, Volume I Sources, Emissions, and Control," EPA-450/3-74-036a. June 1974.

Table 12. Properties Table Example

CMAbbreviation	Name	Category	Units	Data_Type	DB_FieldName	Value
SDLABPLSS	ADMIN_PCT	No category	%	double precision	ADMIN_PCT	0
NLBNPHDO	APPLICATION	No category		text	APPLICATION	<p>This control is the use of low NOx burner (LNB) technology and selective non catalytic reduction (SNCR) to reduce NOx emissions. LNBs reduce the amount of NOx created from reaction between fuel nitrogen and oxygen by lowering the temperature of one combustion zone and reducing the amount of oxygen available in another. SNCR controls are post-combustion control technologies based on the chemical reduction of nitrogen oxides (NOx) into molecular nitrogen (N2) and water vapor (H2O).</p> <p>This control is applicable to small (40 to 174 MMBtu/hr) distillate oil-fired process heaters with uncontrolled NOx emissions greater than 10 tons per year.</p>

4 Using the CMDB to Develop Control Strategies

This section provides an overview of how the control measure data are used in developing control strategies, to provide some context regarding how the fields in the database are used.

4.1 Summary of the Strategy Development Process

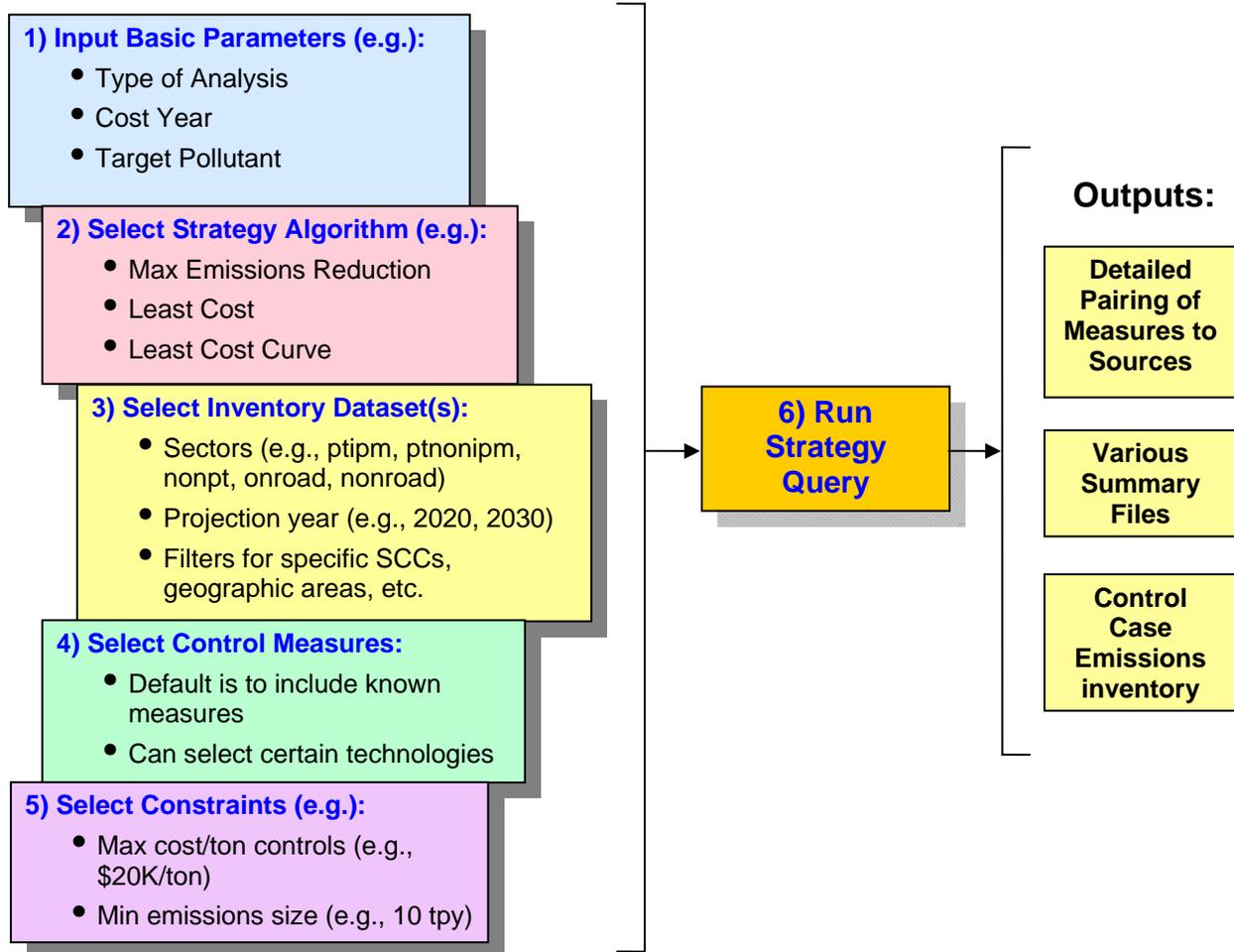
A control strategy applies a set of control measures to emissions inventory sources in a specified geographic region (in addition to any controls that are already in place) to accomplish an emissions reduction goal. Such goals are usually set to improve air quality and/or to reduce risks to human health. CoST automates the key steps for preparing and running control strategies designed to estimate emissions reductions and their associated costs.

The inputs to a control strategy consist of:

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

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

Figure 1. Basic Steps for Running a Control Strategy Using CoST



At this time, six algorithms are available in CoST to control how measures are assigned to sources:

1. **Annotate Inventory:** Assigns control measures to the inventory based on the specified control efficiency for each source. This algorithm can also be used to fill in control measure information for inventory sources that are missing details on the actual control measures used, but have a control efficiency assigned. (It could be applied to either a base- or future-year inventory.)
2. **Apply Measures in Series:** Assigns all control measures that can be used for a source to that source in the specified order. This is often used for mobile sources, for which the control measures are typically independent of one another.
3. **Least Cost:** Each source is assigned a single measure to achieve a specified percentage or absolute reduction in a region with the minimum possible annualized cost.

4. **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.
5. **Maximum Emissions Reduction:** Assigns to each source the single measure that provides the maximum reduction for the target pollutant, regardless of cost.
6. **Project Future-Year Inventory:** Applies control programs and growth factors to sources, as would be needed to project a base-year inventory to a future-year inventory.

The main CoST output for each control strategy is a table called the “Strategy Detailed Result”. This table consists of emission source-control measure pairings, each of which contains information about the cost and emission reduction that would be achieved if the measure were applied to the source. Some columns available in the Strategy Detailed Result are:

CM_Abbrev, POLL, SCC, FIPS, Plant_ID, Annual_cost, Ann_cost_per_ton, control_efficiency, final_emissions, emis_reduction, inv_emissions, SIC, NAICS, equation_type, ...

For examples of Strategy Detailed Result tables, please see the “CoST Development Document” or the “CoST Training Manual and User’s Guide”. The Strategy Detailed Result table can be combined, in an automated manner, with the original input inventory to produce a controlled emissions inventory that reflects implementation of the strategy; this inventory includes information about the measures that have been applied to the controlled sources. The controlled inventory can then be directly input to the SMOKE modeling system to prepare air quality model-ready emissions data. In addition, 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.

4.2 Strategy Inputs Relevant to Control Measures

All types of control strategies have fields for which the user can specify values prior to running the strategy. For a complete listing of the fields, see the “CoST Development Document” (<http://www.epa.gov/ttn/ecas/cost.htm>). The following fields are particularly relevant to how control measure efficiency records are selected and applied to emissions inventory sources:

- **Target Year:** This is the target year for the strategy run. Typically, this is the year represented by the input inventory(ies). For the “Project Future-Year Inventory” analysis type, the target year represents the future year to which you are projecting the inventory. 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, or the effective date may be unspecified to indicate that it is relevant to any year.
- **Target Pollutant:** The pollutant that is targeted as the primary interest for reduction in this control strategy. The ‘Least Cost’ and ‘Maximum Emissions Reduction’ algorithms will consider reductions of this pollutant when performing their computations. Note that reductions of pollutants other than the selected target pollutant (e.g., PM₁₀, PM_{2.5}, EC, OC) will be included in strategy results if (1) they appear in the inventories that are input to the strategy and (2) they are reduced by measures applied as part of the strategy. These pollutants are sometimes referred to as “co-impact pollutants.”, and the impact on the emissions can either be a reduction (i.e., a benefit) or an increase (i.e., a disbenefit).

The following settings for the strategy are known as “constraints”. 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.

- Minimum Emissions Reduction (tons): If specified, requires each control measure to reduce the target pollutant by 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 attained when applying a measure to the source, that measure will not be applied and another that meets the constraint will be selected, if possible.
- Minimum Control Efficiency (%): If specified, requires each control measure used in the strategy to have a control efficiency greater than the specified control efficiency for a particular source and target pollutant.
- Maximum Cost per Ton (\$/ton): If specified, each control measure must have an annualized cost per ton less than the specified maximum annualized cost per ton for the target pollutant for each source. If the maximum cost per ton is exceeded when applying a measure to the source, that measure will not be applied and another that meets the constraint will be selected, if possible. This cost is based on 2006 dollars.
- Maximum Annualized Cost (\$/yr): If specified, each control measure must have an annualized cost less than the specified annualized cost for the target pollutant for each source. If the maximum annualized cost is exceeded when applying a measure to the source, that measure will not be applied and another that meets the constraint will be selected, if possible. This cost is based on 2006 dollars.
- Minimum Percent Reduction Difference for Replacement Control (%): If specified, each control measure must cause a percent reduction in emissions greater than the specified value in order for the old control measure to be “replaced by” the new control measure, according to the formula:

$$(\text{original emissions} - \text{new emissions}) * 100 / \text{original emissions} > \text{min. percent red. diff.}$$

By expressing the requirement in this way, it would allow a control with 99.9% efficiency to replace one with 99% efficiency, for example. Note that incremental controls that add an additional device onto a previously 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., low NO_x burner [LNB] + flue gas recirculation [FGR]) and provides an appropriate level of emissions reduction, that combination control measure can serve as a replacement control for the original measure.

4.3 Control Measure Filtering and Custom Overrides

For all strategy types except “Project Future-Year Inventory”, the measures used during an analysis can be filtered either by measure class (see field 7 in Table 1) or by specifying specific measures to consider for the strategy run.

- *Measure class*: By default, only measures with the class set to “Known” are included in a strategy run. Measures with other classes — Emerging, Hypothetical, or Obsolete — may be selected for inclusion in a strategy. Note that only the measures with the classes selected by the user will be included in the strategy run.
- *Specific measures*: As an alternative to selecting the classes of measures to include, users can select specific measures to include in the strategy. Values for rule penetration and rule effectiveness can be overridden for the specified measures. Note that in the CMDB the geographic extent for individual measures can be limited to certain sets of counties by specifying a region dataset for the measure from one of the available datasets with the “List of Counties (CSV)” dataset type. For algorithms that support the application of multiple measures to sources, such as “Apply Measures in Series”, an order of application can be specified for the selected measures and they will be applied in ascending order. For example, a mobile-source strategy may have the following specified for each measure: an order of application, a geographic region, and a rule penetration override.

Control measure filtering and custom overrides are not available for the “Project Future Year Inventory” strategy type. Instead, the user may select from a list of available control *programs*. Control programs are described in more detail in the “Control Strategy Tool (CoST) Training Manual and User’s Guide”.

5 References

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