Control Strategy Tool (CoST) "Project Future Year Inventory" Development Document

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Prepared for:
Alison Eyth
U.S. Environmental Protection Agency
C439-02
Research Triangle Park, NC 27711

Prepared by:
Darin Del Vecchio
Institute for the Environment
The University of North Carolina at Chapel Hill
137 E. Franklin St., CB 6116
Chapel Hill, NC 27599-6116

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Acronyms

CE .....Control Efficiency
CMAQ.....Community Multiscale Air Quality model
CMAS .....Community Modeling and Analysis System
CoST .....Control Strategy Tool
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
FGD.....Flue Gas Desulfurizer
FIPS.....Federal Information Processing Standards
GDP.....Gross Domestic Product
GIS .....Geographic information system
HEID .....Health and Environmental Impacts Division
IE.....Institute for the Environment (UNC)
LNB.....Low NOx 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
PR.....Percent Reduction
RE .....Rule Effectiveness
RP.....Rule Penetration
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

1 Introduction

1.1 Background

In the air quality modeling arena, emissions modeling is the process by which emissions inventories and other related information are converted to hourly, gridded, chemically speciated emissions estimates that are suitable for input to an air quality model such as the Community Multiscale Air Quality (CMAQ) model. The Emissions Modeling Framework (EMF) is a software system currently being used by EPA to solve many of the long-standing complexities of emissions modeling [Houyoux, 2008]. 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 modeling system (SMOKE), which is used by EPA to prepare emissions inputs for performing air quality modeling with CMAQ. It provides integrated quality control processes to foster high quality of emissions results, data handling, organization of data, tracking of emissions modeling efforts, and real-time accessibility of information. The EMF has been developed under a multiyear contract between the U.S. EPA and the University of North Carolina at Chapel Hill's Institute for the Environment (UNC-IE).

One of the modules within the EMF system is the Control Strategy Tool (CoST) module. A control strategy is a set of control programs applied to emissions inventory sources in a specified geographic region (in addition to any controls that are already in place) to accomplish a projection of inventories to a future year. Control programs are sets of control measures and other adjustments (e.g., projection factors) that are used to estimate the effects of implementing a regulation that is "on the books." The control programs therefore are considered when projecting a base-year emissions inventory to a future-year base emissions inventory.

The CoST module is used to estimate the emission reductions and costs associated with future-year control scenarios, and then to generate emission inventories with the control scenarios applied. 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. CoST supports analyses for projecting inventories to future years and data transparency, and provides a wide array of options for developing other types of control strategies. It automates the key steps for applying control programs (Plant Closures, Projections, Controls, Caps, and Replacements) when running the control strategy analysis.

The result of a CoST control strategy run contains information that specifies the adjusted inventory emissions and emissions reductions achieved for each combination of control program and emission source. Control strategy results can be exported to comma-separated-values (CSV) files, Google Earth-compatible (.kmz) files, or Shapefiles. The results can also be viewed in a graphical table that supports sorting, filtering, and plotting. The Strategy Detailed Result tables that are output from a strategy can also be merged with the original inventory to create controlled emissions inventories that can be exported to files that can be input to SMOKE.

1.2 Purpose and Intended Audience for this Document

This document is a software development document that provides technical descriptions regarding how CoST computes the "Project Future Year Inventory" (PFYI) type of control strategy. Information is given on the input parameters to strategies, on how the computations of

the strategies are performed, and on the outputs from the strategies. This document is intended for use by readers who are already familiar with emissions modeling and extensive control strategy development. It is not intended as a user's guide.

For additional information on other aspects of the EMF and CoST, please see the following independent documents:

- CoST User's Guide
- CoST Control Measures Database Document

These documents, and additional information about CoST, can be found at: http://www.epa.gov/ttn/ecas/cost.htm. A glossary of terms is included as an appendix to this document.

2 Concepts General to the PFYI Control Strategy

2.1 Introduction to the PFYI Control Strategy

A "Project Future Year Inventory" control strategy is a set of control programs that applies control factors, growth factors, caps, and replacement to sources, as would be needed to project a base-year inventory to a future-year inventory. CoST automates the key steps needed to prepare control strategies.

The inputs to this type of control strategy consist of:

- a set of parameters that control how the strategy is run,
- one or more emissions inventory datasets,
- filters that determine which sources from those datasets are to be included in the run; and
- one or more control programs.

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

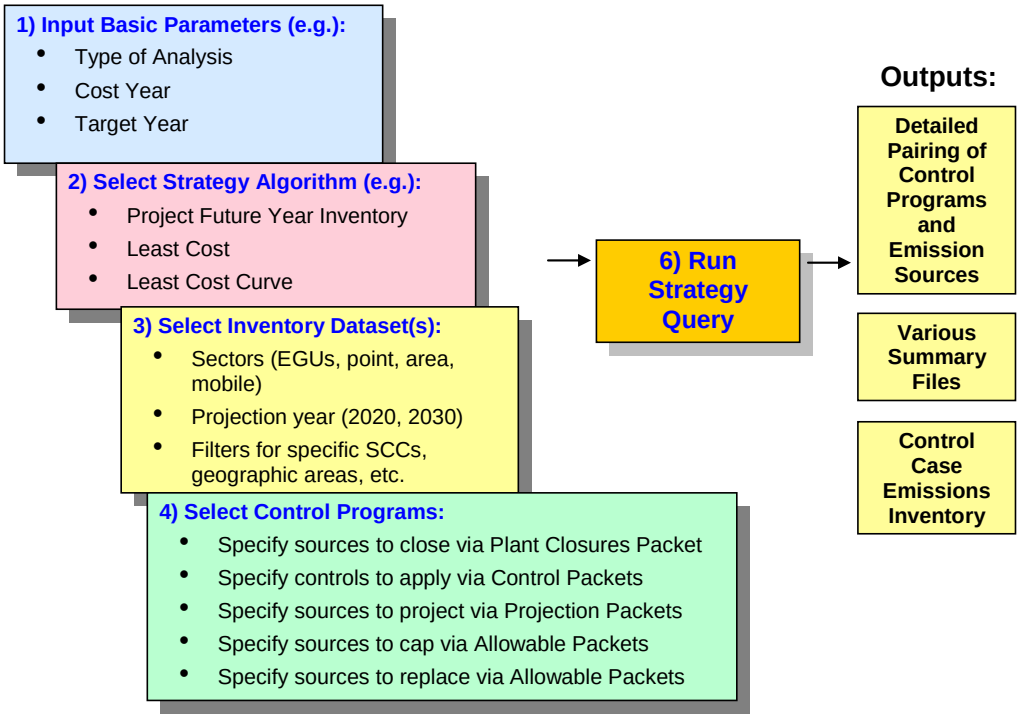

Figure 1. Basic Steps for Running a PFYI Control Strategy

The main output for each control strategy is a table called the "Strategy Detailed Result." This consists of pairings of emission sources and control programs, each of which contains information about the emission adjustment that would be achieved if the control program were to be applied to the source, along with the cost of application. The Strategy Detailed Result table can be used with the original input inventory to produce, in an automated manner, a controlled emissions inventory that reflects implementation of the strategy; this inventory includes information about the control programs 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.

More detailed information on the inputs to and outputs from control strategies is located in the Control Strategy Tool (CoST) Development Document in Sections 2.2 (inputs) through 2.6 (outputs). Section 2 in the Control Strategy Tool (CoST) Development Document also addresses inventories and inventory filtering (Section 2.3) and summaries of strategy inputs and outputs (Section 2.7). Rather than repeating a lot of that information in this document, Sections 2.2 and 2.3 below instead provide details on how the PFYI strategy differs from other types of control strategies in terms of inputs and outputs. Section 2.4 addresses the costing of control measures.

2.2 Inputs to the PFYI Control Strategy

All types of control strategies have fields that can be specified by the user prior to running the strategy. This section describes these how the fields are used differently in a PFYI strategy than in other strategy types.

2.2.1 Summary Information

See the Control Strategy Tool (CoST) Development Document, Section 2.2, for detailed information on the Summary Information fields. The following input fields are used in a different manner than in other CoST strategy types:

- Type of Analysis: The type of algorithm used to match the control program packet records with sources. Must be specified as the "Project Future Year Inventory" strategy type.
- Target Year: The target year represents the future year to which you are projecting the inventory. The target year is used when building the various cutoff dates (control compliance and plant closure effective dates) when evaluating whether or not certain control programs are applied to an inventory.
- Target Pollutant: The target pollutant is not required for this strategy type and so is left blank.

2.2.2 Inventories

See the Control Strategy Tool (CoST) Development Document, Section 2.2.2, for detailed information on how inventories are handled by CoST. The inventories to process for this strategy type includes not just the one-record-per-line (ORL) types but also the newer Flat File 2010 dataset format:

- Inventories to Process: The emissions inventories for which the control strategy will be run. The inventories must already have been loaded into the EMF and be one of the following EMF dataset types: Flat File 2010 Point, Flat File 2010 Nonpoint, ORL point, ORL nonpoint, ORL nonroad, or ORL onroad. Multiple inventories can be processed for a strategy. Note that multiple versions of the inventories may be available, and the appropriate version of each inventory must be selected prior to running a control strategy.

2.2.3 Control Programs

The PFYI strategy type supports four different types of control programs:

- Programs to Include: A list of specific control programs to use for the run.
  - Plant Closure: This control program targets sources to close
  - Control: This control program specifies source control factors
  - Projection: This control program specifies source projection adjustments
  - Allowable: This control program specifies source cap or replacement emissions

As much as possible, the Control Program datasets are designed to be compatible with SMOKE. The Projection, Control, and Allowable datasets are fully compatible with SMOKE. The Plant Closure Packet and the new Projection, Control, and Allowable Extended dataset types, however, are not compatible with SMOKE; these dataset types are CSV-based files that must contain certain columns. The format of these dataset formats will defined in detail in Section 3.2.

2.2.4 Input Constraints

The following settings for the strategy are known as "constraints." If the constraint values are not satisfied for a particular combination of control measure and source, 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): Not used for this strategy type.
- Minimum Control Efficiency (%): Not used for this strategy type.
- Maximum Cost per Ton ($/ton): Not used for this strategy type.
- Maximum Annualized Cost ($/yr): Not used for this strategy type.
- Minimum Percent Reduction Difference for Replacement Control (%): Not used for this strategy type
- Minimum Percent Reduction Difference for Predicting Controls (%): This required constraint determines whether a predicted control measure has a similar percent reduction to the percent reduction specified in the Control Program Control Packet. The following formula defines the calculation used during the constraint validation:

  [ABS(control packet percent reduction - control measure percent reduction) / control packet percent reduction] x 100
  ≥ Minimum Percent Reduction Difference for Predicting Controls (%)

  where

  control packet percent reduction = see percent_reduction column definition in Table 1 for a detailed definition on how this is calculated

  control measure percent reduction

  = control efficiency (%) x (rule penetration (%) / 100) x (rule effectiveness (%) / 100)

2.3 Strategy Outputs

CoST automatically generates two main outputs after each successful strategy run for the PFYI strategy type:

- Strategy Detailed Result (one for each input inventory), discussed in Section 2.3.1
- Strategy Messages (only one for all input inventories) , addressed in Section 2.3.2

Each of these outputs is created as an EMF Dataset. Also discussed in this section is the controlled emissions inventory output (Section 2.3.3).

2.3.1 Strategy Detailed Result

The Strategy Detailed Result is the primary output from the control strategy. It is a table of emission-source–control-program pairings, each of which contains information about the emission adjustment achieved after a control program is applied to a source. The contents of this table are described later in this section.

The columns in the Strategy Detailed Result table are described in Table 1. Although this table format is discussed in detail in the CoST Development Document, the PFYI strategy's use of the table is different enough that a full description needs to be given here. An example of the PFYI Detailed Result is discussed in detail in Sections 3.

Table 1. Columns in the Strategy Detailed Result

Column	Description
SECTOR	The source sector specified for the input inventory dataset.
CM_ABBREV	For Plant Closure Packets, this column will be set to "PLTCLOSURE". For Projection Packets, this column will be set to "PROJECTION". For Control Packets, this column will be set to the abbreviation of the control measure that was applied to the source, if it was explicitly specified in the packet, or it could be the predicted measure abbreviation as found in the CMDB. If no measure can be found, then it will be set to "UNKNOWNMSR". For Allowable Packets, this column will be set to the predicted abbreviation of the control measure that was applied to the source. If no measure can be found, then it will be set "UNKNOWNMSR".
POLL	The pollutant for the source, found in the inventory
SCC	The SCC code 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/facility ID for the source from the inventory.
POINTID	For point sources, the point ID/unit ID for the source from the inventory.
STACKID	For point sources, the stack ID/release point ID for the source from the inventory.
SEGMENT	For point sources, the segment/process ID for the source from the inventory.

Column	Description

ANNUAL_COST ($)	The total annual cost (including both capital and operating and maintenance) required to keep the measure on the source for a year
	
	Default Approach (used when there is no cost equation, or inputs to cost equation are not available):
	Annual Cost = Emission Reduction (tons) x Reference Yr Cost Per Ton ($/tons in 2006 Dollars) x Cost Yr Chained GDP / Reference Yr Chained GDP
	Annual Cost = 11.88 (tons) x 147 ($/ton in 2000 Dollars) x 9817 / 11415.3 = $1,501.85
	
	Using Type 8 Cost Equation:
	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 Factor x Emission Reduction (tons) x Cost Yr Chained GDP / Reference Yr Chained GDP
	Since Stack Flow Rate = 10,500 cfm, use first equation
	Annual Cost = ($11,081 + 0.04 x $117,388 + $99,328) = $115,105
	
	Note that costs are adjusted to the strategy-defined "Cost Year" dollars.

ANN_COST_PER_ TON ($/ton)	The annual cost (both capital and operating and maintenance) to reduce one ton of the pollutant. Ann_Cost_Per_Ton = Annual Cost ($) / Emis Reduction (tons) Default Approach (used when there is no cost equation, or inputs to cost equation are not available): Ann_Cost_Per_Ton = 1,501.85 / 11.88 = $126.42/ton Using Type 8 cost Equation: Ann_Cost_Per_Ton = $115,105 / 11.88 = $9,689/ton Note that costs are adjusted to the strategy-defined "Cost Year" dollars.

Column	Description

ANNUAL_OPER_ MAINT_COST ($)	The annual cost to operate and maintain the measure once it has been installed on the source.
	
	Default Approach (used when there is no cost equation, or inputs to cost equation are not available):
	= (Annual Cost – Annualized Capital Cost)
	= ($1,501.85 - $156) = $1,345.85
	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
	
	Using Type 8 Cost Equation:
	If Stack Flow Rate >= 5.0 cfm Then
	= O&M Control Cost Factor x Stack Flow Rate (cfm) x Cost Yr Chained GDP / Reference Yr Chained GDP
	Else
	= Default O&M Cost Per Ton Factor x Emission Reduction (tons) x Cost Yr Chained GDP / Reference Yr Chained GDP
	Since Stack Flow Rate = 10,500 cfm, use first equation
	= 11.0 x 175 (cfs) x 60 s / 1 min x 9817 / 11415.3 = $99,328
	
	Note that costs are adjusted to the strategy-defined “Cost Year” dollars.

ANNUAL_VARIABLE_ OPER_MAINT_COST ($)	The annual variable cost to operate and maintain the measure once it has been installed on the source. Default Approach (used when there is no cost equation, or inputs to cost equation are not available): = blank (not calculated, no default approach available) Using Type 10 Cost Equation: = variable_operation_maintenance_cost_multiplier x design_capacity x 0.85 x annual_avg_hours_per_year x Cost Yr Chained GDP / Reference Yr Chained GDP = 0.013 x 699 x 0.85 x 8736 x 9817 / 11415.3 = $58,029 Note that costs are adjusted to the strategy-defined “Cost Year” dollars.

Column	Description
ANNUAL_FIXED_ OPER_MAINT_COST ($)	The annual fixed cost to operate and maintain the measure once it has been installed on the source. Default Approach (used when there is no cost equation, or inputs to cost equation are not available): = blank (not calculated, no default approach available) Using Type 10 Cost Equation: = design_capacity x 1000 x fixed_operation_maintenance_cost_multiplier × (250 / design_capacity) ^ fixed_operation_maintenance_cost_exponent x Cost Yr Chained GDP / Reference Yr Chained GDP = 699 x 1000 x 0.31 x (250 / 699) ^ 0.3 x 9817 / 11415.3 = $136,889 Note that costs are adjusted to the strategy-defined "Cost Year" dollars.
ANNUALIZED_ CAPITAL_COST ($)	The annualized cost of installing the measure on the source assuming a particular discount rate and equipment life. Annualized_Capital_Cost = Total Capital Cost x Capital Recovery Factor (CRF) Note: if the CRF is not available for the measure, it is not possible to compute the ACC or the breakdown of costs between capital and O&M costs. CRF = (Discount Rate x (1 + Discount Rate)^Equipment Life) / ((Discount Rate + 1) ^Equipment Life - 1) CRF = (0.07 x (1 + 0.07)^20) / ((0.07 + 1) ^20 - 1) = 0.0944 Default Approach: Annualized_Capital_Cost = 1,652.03 x 0.0944 = $156 Using Type 8 Cost Equation: Annualized_Capital_Cost = $117,388 x 0.0944 = $11,081 Note that costs are adjusted to the strategy-defined "Cost Year" dollars.

Column	Description

TOTAL_CAPITAL_ COST ($)	The total cost to install a measure on a source.
	
	Default Approach (used when there is no cost equation or cost equation inputs are not available):
	TCC = Emission Reduction (tons) x Reference Yr Cost Per Ton ($/tons in 2006 Dollars) x Capital Annualized Ratio x Cost Yr Chained GDP / Reference Yr Chained GDP
	TCC= 11.88 (tons) x 147 ($/tons in 2000 Dollars) x 1.1 x 9817 / 11415.3 = $1,652.03
	
	Using a Type 8 Cost Equation:
	If Stack Flow Rate >= 5.0 cfm Then
	TCC = Capital Control Cost Factor x Stack Flow Rate (cfm) x Cost Yr Chained GDP / Reference Yr Chained GDP
	Else
	TCC = Default Capital Cost Per Ton Factor x Emission Reduction (tons) x Cost Yr Chained GDP / Reference Yr Chained GDP
	Example: Stack Flow Rate = 10,500 cfm, so use first equation = 13.0 x 175 (cfs) x 60 s / 1 min x 9817 / 11415.3 = $117,388
	
	Note that costs are adjusted to the strategy-defined "Cost Year" dollars.

CONTROL_EFF (%)	The control efficiency as specified by the Control Packet or Allowable Packet. For the old Control Packet format, the field is set to the CEFF field. For the new Control Extended Packet format, the field is set to the ANN_PCTRED field for annual emission sources only; if the source happens to have monthly emissions specified, then this field will be calculated based on the following monthly emission and pctred factors: Control Efficiency (%) = $\frac{\left(\frac{jan\_value \times jan\_pctred}{100} + \frac{feb\_value \times feb\_pctred}{100} + \ldots + \frac{dec\_value \times dec\_pctred}{100}\right) \times 100}{(jan\_value + feb\_value + \ldots + dec\_value)}$ This field is null for Plant Closure and Projection Packets.

Column	Description
RULE_PEN (%)	The rule penetration that is specified in the old Control Packet format. For the new Control Extended Packet format, this is set to 100. This field is null for Plant Closure and Projection Packets.
RULE_EFF (%)	The rule effectiveness that is specified in the old Control Packet format. For the new Control Extended Packet format, this is set to 100. This field is null for Plant Closure and Projection Packets.
PERCENT_ REDUCTION (%)	The percent by which the emissions from the source are reduced after the Control Packet has been applied. For the old Control Packet format, the following formula is used: Percent reduction = Control Efficiency (%) x Rule Penetration (%) / 100 x Rule Effectiveness (%) / 100 = 99% x 100% / 100 x 100% / 100 = 99% For the new Control Extended Packet format, the field is set to the ANN_PCTRED field for annual based emission sources only (these sources will have no monthly-based emissions specified in the inventory); if the source is based on monthly emissions (these source will have monthly based emissions specified in the inventory), then this field will be calculated based on the following monthly emission and pctred factors: Percent Reduction (%) = $\frac{\left(\frac{\text{jan\_value}\times\text{jan\_pctred}}{100}+\frac{\text{feb\_value}\times\text{feb\_pctred}}{100}+\ldots+\frac{\text{dec\_value}\times\text{dec\_pctred}}{100}\right)\times 100}{(\text{jan\_value}+\text{feb\_value}+\ldots+\text{dec\_value})}$ This field is null for Plant Closure and Projection Packets.

Column	Description
ADJ_FACTOR	The adjustment factor stores the Projection Packet factor that is applied to the source. This number is stored in a fractional state rather than as a percentage. For the old Projection Packet format, the ann_proj_factor field is used. For the new Projection Extended Packet format, the field is set to the ANN_PROJ_FACTOR field for annual emission sources only; if the source happens to have monthly emissions specified, then this field will be calculated based on the following monthly emission and proj_factor values: Adjust Factor = $\frac{(jan\_value \times jan\_proj\_factor + \ldots + dec\_value \times dec\_proj\_factor)}{(jan\_value + feb\_value + \ldots + dec\_value)}$ This field is null for Plant Closure and Control Packets.
INV_CTRL_EFF (%)	The control efficiency for the existing measure on the source, found in the inventory
INV_RULE_PEN (%)	The rule penetration for the existing measure on the source, found in the inventory
INV_RULE_EFF (%)	The rule effectiveness for the existing measure on the source, found in the inventory
FINAL_EMISSIONS (tons)	The final emissions amount that results from the source's being adjusted by the various Control Program Packets. This is set by subtracting the emis_reduction field by the inv_emissions field. Note that the Strategy Sample discussed in Section 3.5 gives more details on exactly how this field is used.

Column	Description
EMIS_REDUCTION (tons)	This field is used to store the amount by which the emission was reduced for the particular Control Program Packet (Plant Closure, Projection, Control, or Allowable) that is being processed. For example, when applying a Control Packet to a set of sources, some of the sources might already have had Projection Packets applied to them. In the case of the source already being projected, we need to use this adjusted (projected) value as the input emission for the next Packet that is applied instead of using the original inventory emission. In general, the formula for determining this value is as follows: = inv_emissions – final_emissions For Plant Closure Packets, this value would be the original inventory emission, since the plant is being closed and so will not generate any more emissions. For Projection Packets, the value will be the amount by which the emission was adjusted. For example, if the projection factor was 1.5 and the input emission was 10 tons, this value would calculated as follows: = Inventory Emission – (Inventory Emission x Projection Factor) = 10 – (10 x 1.5) = -5.0 tons For Control Packets, the value would be the amount by which the source was reduced by. For example if the control efficiency/percent reduction is 75% and the input emission was 10 tons, this value would calculated as follows: = Input/Inventory Emission – [Input/Inventory Emission x (1 – Control Percent Reduction/100)] = 10 – [10 x (1-75/100)] = 7.5 tons Note that the example above is based on annualized emission inventory, when emissions are monthly based each month will need to be considered separately then summed to give a annualized total. For example when the inventory is monthly based, the Projection calculations would be calculated as follows: = Jan Inv Emis – (Jan Inv Emis x Jan Proj Fac) + Feb Inv Emis – (Feb Inv Emis x Feb Proj Fac) + … + Dec Inv Emis – (Dec Inv Emis x Dec Proj Fac) Note that the Strategy Sample discussed in Section 3.5 gives more details on exactly how this field is used.

Comment [JRE1]: There's a control program packet called "control"? So "control" is used in the umbrella category of "control program packet" and it's also a type contained within the umbrella category? Confusing terminology.

See also my related comment in Sec 2.3.3.

Column	Description

INV_EMISSIONS (tons)	This field is used to store the beginning/input emission for the particular Control Program Packet (Plant Closure, Projection, Control, or Allowable) that is being processed. For example, when applying a Control Packet to a set of sources, some of the sources might already have had Projection Packets applied to them. In the case of the source already being projected, we need to use this adjusted (projected) value as the input emission for the next Packet that is applied instead of using the original inventory emission. The following sequence applies:
	
	IF source was projected THEN
	Use final_emissions field from Projection Packet entries in the Strategy Detailed Result Output as input emission
	ELSE
	Use inventory emission as input emission
	END IF
	
	Note that if the starting inventory had average-day emissions, the average-day value is annualized and the resulting value is shown here. If the inventory has monthly-based emissions (FF10 format), the monthly values are summed and the resulting value is shown here.
	
	Note that the Strategy Sample discussed in Section 3.5 gives more details on exactly how this field is used.

APPLY_ORDER	This field stores the Control Program Action Code that is being used on the source. See Table 8 for a list of the action codes. These codes indicate whether the Control Program is applying a Plant Closure, Projection, Control, or Allowable Packet.
INPUT_EMIS (tons)	This field is not used for the strategy type and is left blank/null.
OUTPUT_EMIS (tons)	This field is not used for the strategy type and is left blank/null.
FIPSST	The two-digit FIPS state code.
FIPSCTY	The three-digit FIPS county code.
SIC	The SIC code for the source from the inventory.
NAICS	The NAICS code for the source from the 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).
CS_ID	The numeric ID of the control strategy
CM_ID	This field is not used for the strategy type and is left blank/null.

Column	Description
EQUATION TYPE	The control measure equation that was used during the cost calculations. If a minus sign is in front of the equation type, this indicates that the equation type was missing inputs and the strategy instead used the default approach to estimate costs. Note that this field will be used only when Control Packets are applied, not when any of the other packet types are applied.
ORIGINAL_ DATASET_ID	This field is not used for the strategy type and is left blank/null.
SECTOR	This field is not used for the strategy type and is left blank/null.
CONTROL_PROGRAM	The control program that was applied to produce this record
XLOC	The longitude for the source, found in the 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 inventory for point sources, for nonpoint inventories the county centroid is used. This is useful for mapping purposes.
PLANT	The plant name from the inventory (or county name for nonpoint sources)
REPLACEMENT_ADDON	Indicates whether the Control Packet was applying a replacement or an add-on control packet. A = Add-On Control R = Replacement Control Note that this field will be used only when Control Packets are applied, not when any of the other packet types are applied.
EXISTING_MEASURE_ ABBREVIATION	This field is not used for the strategy type and is left blank/null.
EXISTING_PRIMARY_ DEVICE_TYPE_CODE	This field is not used for the strategy type and is left blank/null.
STRATEGY_NAME	This field is not used for the strategy type and is left blank/null.
CONTROL_TECHNOLOGY	This field is not used for the strategy type and is left blank/null.
SOURCE_GROUP	This field is not used for the strategy type and is left blank/null.
COUNTY_NAME	This field is not used for the strategy type and is left blank/null.
STATE_NAME	This field is not used for the strategy type and is left blank/null.
SCC_L1	This field is not used for the strategy type and is left blank/null.
SCC_L2	This field is not used for the strategy type and is left blank/null.
SCC_L3	This field is not used for the strategy type and is left blank/null.
SCC_L4	This field is not used for the strategy type and is left blank/null.

Column	Description
JAN_FINAL_EMISSIONS	The monthly January final emission that results from the source's being adjusted by the various Control Program Packets. This is set by subtracting the monthly January emission reduction by the monthly January input emission. Note that the Strategy Sample discussed in Section 3.5gives more details on exactly how this field is used. This monthly-related field is populated only when projecting Flat File 2010 inventories.
FEB_FINAL_EMISSIONS	Same as defined for the jan_final_emissions field but for February.
…	…
DEC_FINAL_EMISSIONS	Same as defined for the jan_final_emissions field but for December.
JAN_PCT_RED	The percent by which the source's January monthly emission is reduced after the Control Packet has been applied. For the old Control Packet format, the following formula is used: Percent reduction = Control Efficiency (%) x [Rule Penetration (%) / 100] x [Rule Effectiveness (%) / 100] = 99% x [100% / 100] x [100% / 100] = 99% For the new Control Extended Packet format, the field is set to the Control Packet ANN_PCTRED field for annual based emission sources only (these sources will have no monthly-based emissions specified in the inventory); if the source is based on monthly emissions (these source will have monthly based emissions specified in the inventory), then this field will be set to the Control Packet jan_pctred field. If the jan_pctred field is unknown, then the Control Packet ann_pctred is used. This field is null for Plant Closure and Projection Packets. This monthly-related field is only populated when projecting Flat File 2010 inventories.
FEB_PCT_RED	Same as defined for the jan_pct_red field but for February
…	…
DEC_PCT_RED	Same as defined for the jan_pct_red field but for December
COMMENT	Information about this record and how it was produced; this can be either created automatically by the system or entered by the user.

2.3.2 Strategy Messages

The Strategy Messages output provides useful information that is gathered while the strategy is running. This output can store ERROR and WARNING types of messages. If an ERROR is encountered during the prerun validation process, the strategy run will be canceled and the user can peruse this dataset to see what problems the strategy has (e.g., duplicate packet records).

The columns of the Strategy Messages output are described in Table 2.

Table 2. Columns in the Strategy Messages Result

Column	Description
Fips	The state and county FIPS code for the source, found in the inventory
Scc	The SCC code for the source, found in the inventory
PlantId	For point sources, the plant/facility ID for the source, found in the inventory
PointId	For point sources, the point/unit ID for the source, found in the inventory
StackId	For point sources, the stack/release point ID for the source, found in the inventory
Segment	For point sources, the segment/process ID for the source, found in the inventory
Poll	The pollutant for the source, found in the inventory
Status	The status type. The possible values are listed below: Warning – description Error – description Informational – description
control_program	The control program for the strategy run; this is populated only when using the PFYI strategy type.
message	The text describing the strategy problem.
message_type	Contains a high-level message-type category. Currently this is populated only when using the PFYI strategy type. The possible values are listed below: Inventory Level (or blank) – message has to do specifically with a problem with the inventory Packet Level – message has to do specifically with a problem with the packet record being applied to the inventory
inventory	Identifies the inventory with the problem.
Packet_fips	The state and county FIPS/region code for the source, found in the control program packet
Packet_scc	The SCC code for the source, found in the control program packet
Packet_plantId	For point sources, the plant/facility ID for the source, found in the control program packet
Packet_pointId	For point sources, the point/unit ID for the source, found in the control program packet
Packet_stackId	For point sources, the stack/release point ID for the source, found in the control program packet
Packet_segment	For point sources, the segment/process ID for the source, found in the

Column	Description
	control program packet
Packet_poll	The pollutant for the source, found in the control program packet
Packet_sic	The SIC code for the source, found in the control program packet
Packet_mact	The MACT/regulatory code for the source, found in the control program packet
Packet_naics	The NAICS code for the source, found in the control program packet
Packet_compliance_effective_date	The compliance or effective date, found in the control program packet. The compliance date is used in the Control Packet; the effective date is used in the Plant Closure Packet
Packet_replacement	Indicates whether the packet identifies a replacement versus an add-on control, found in the control program packet
Packet_annual_monthly	Indicates whether the packet is monthly based or annual based

2.3.3 Controlled Emissions Inventory

Another output that can be created is a controlled emissions inventory. 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 EMF/CoST creates a controlled inventory, comments placed at the top of the inventory file indicate the strategy used to produce it and the high-level settings for that strategy.

For ORL Inventories:

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 Packets applied to the sources. The CEFF column is populated differently for a replacement Control Packet record than for an add-on Control Packet record. For a replacement control, the CEFF column is populated with the percent reduction of the replacement control. For an add-on control, the CEFF column is populated with the overall combined percent reduction of the add-on control plus the preexisting control, using the following formula: (1 – {[1 – (existing percent reduction / 100)] x [1 – (add-on percent reduction / 100)]}) x 100. For both types of Control Packet records (add-on or replacement), the REFF and RPEN are defaulted to 100 since the CEFF accounts for any variation in the REFF and RPEN by using the percent reduction instead of solely the CEFF.

Note that only Control Packets (not Plant Closure, Projection, or Allowable packets) will be used to help populate the columns discussed above.

For Flat File 2010 Inventories:

For the sources that were controlled, CoST fills in the annual (ANN_PCT_RED) and monthly percent reduction (JAN_PCT_RED) columns based on the values for the Control Packet that was applied to the sources. The CEFF column is populated differently for a replacement control than for an add-on control. For a replacement control, the CEFF column is populated with the percent reduction of the replacement control. For an add-on control, the CEFF column is populated with the overall combined percent reduction of the add-on control plus the preexisting control, using the following formula: (1 – {[1 – (existing percent reduction / 100)] x [1 – (add-on percent

reduction / 100)]}) x 100. For both types of measures, the REFF and RPEN values are defaulted to 100, because the CEFF accounts for any variation in the REFF or RPEN by using the percent reduction instead of the CEFF.

CoST also populates several additional columns toward the end of the ORL and Flat File 2010 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 × REFF × 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/programs that have been applied as a result of a CoST control strategy.

2.4 Costing Control Measures

The Control Strategy Tool costs out emission control measures in two ways: (1) cost equations are used to determine engineering costs that take into account several variables for the source, when those variables are available; or (2) if those data are not available, 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. The second approach can also utilize a simple incremental cost factor in terms of dollars per ton of pollutant when there is a preexisting control already on the source, as identified in the inventory CEFF field. If the inventory CEFF field is populated and the control measure has an incremental cost per ton factor specified, this cost factor will always be used instead of the normal cost per ton factor. If on the other hand the incremental cost factor is not specified on a control with a preexisting control, than the default cost factor will be used instead.

Currently, cost equations are used only for some EGU and non-EGU source measures. They are not used for area sources.

During a strategy run, if the engineering cost equation was not found to have the appropriate inputs (e.g., missing design capacity), this issue can be identified by looking for a negative sign in front of the equation type in the Strategy Detailed Result equation_type column (e.g., -Type 2 or -Type 8). The sources with this issue will be populated in the Strategy Messages dataset. The associated message will help identify which equation inputs are missing.

See the **Control Strategy Tool (CoST) Development Document** and **Control Strategy Tool Cost Equations Document** for more detailed information on how cost equations are used in CoST.

3 Project Future Year Inventory Control Strategy

3.1 Project Future Year Inventory Background

The inventory projection process involves taking a base-year inventory and projecting it to a future-year base inventory). For the future-year base inventories to have information on existing control measures, it is helpful for the inventory projection process to specify what control measures have been applied to the sources. This can be accomplished in a way that is similar to how the Annotate Inventory strategy analysis works. It can also be accomplished by incorporating the concept of control programs (explained in Section 8.2) into CoST and the EMF. The process of projecting inventories is currently done using a series of SAS programs that take as input data tables collected from various sources. For several years, EPA has wanted to make the process of applying the control programs more explicit and documentable. By incorporating the control programs into CoST and having CoST apply the projection and control factors to create the projected inventory, it will be possible to annotate the inventories as the projection takes place.

To accomplish the application of control programs and projection factors to an inventory, the control programs concept is being incorporated into CoST. For each control program, it will be possible to specify the type of program, the start and end date, and one accompanying dataset that will identify the sources that will be affected by the program (e.g., a list of plants that will close). The types of control programs are expected to include, but not be limited to, the following:

- Planned closures at specific plants
- Planned reductions at specific plants
- Planned growth at specific plants
- Planned replacement control technology at existing plants
- Planned add-on control technology at existing plants
- Caps on emissions at existing plants
- Replacement of emissions at existing plants
- SCC-based reduction programs
- Commuter programs
- Estimated growth for specific sectors

In situations where the desired control measures or technologies for the control program are known, these can be specified as part of the control program. If the control measures are not known, CoST can search for a measure with the desired control efficiency and provide that as the best guess for the applied measure. If a probable measure is found for a source, a cost estimate will also be included as part of the analysis. To implement the process of inventory projection, a new strategy analysis algorithm is being added to CoST, called “Project Future Year Inventory”. The Strategy Detailed Result for this strategy will show the control efficiency (and probable control measure, including costs), growth factor, and cap value or replacement value that was applied to a source. This strategy will also be able to generate a complete inventory for use as

input to SMOKE. It is important to note that there is another important data need: to collect planned control program data (e.g., from SIPs) from states so that future EPA control strategy modeling can incorporate these programs and thereby produce more realistic results than if the planned state-specific programs are ignored.

3.2 Introduction to Control Programs

A control program is used as an input to a "Project Future Year Inventory" control strategy. A control program contains a control packet type of dataset that will identify the sources that will be affected by the program, a start date and end date, and a list of probable control measure or control technologies to include during the analysis. There are four major types of control programs:

- *Plant Closure* – can identify specific plants to close; can vary the level of closure by targeting specific stacks or by closing whole plants (i.e., all stacks at the plant will be closed)
- *Control* – can apply replacement or add-on controls to inventory emission sources
- *Projection* – can apply projections to inventory emission sources
- *Allowable* – can apply a replacement cap on inventory emission sources or replace inventory emission sources

The Control Program Packet Dataset is used in conjunction with an emission inventory to create a control/projection matrix by matching the control packet to the emission inventory using a hierarchical weighted matching approach. This matching process creates source–control-packet pairings. The matrix is stored in the Strategy Detailed Result. See Table 3 for a complete listing of the matching hierarchy combinations, the inventory types the matching criteria can be used for, and the Control Program Packet Types that can use these criteria.

Table 3. Control Packet Matching Hierarchy

Ranking	Matching Hierarchy	Inventory Types	Control Program Types
1	Country/State/County code, plant ID, point ID, stack ID, segment, 8-digit SCC code, pollutant	point	allowable, control, projection, plant closure
2	Country/State/County code, plant ID, point ID, stack ID, segment, pollutant	point	allowable, control, projection, plant closure
3	Country/State/County code, plant ID, point ID, stack ID, pollutant	point	allowable, control, projection, plant closure
4	Country/State/County code, plant ID, point ID, pollutant	point	allowable, control, projection, plant closure
5	Country/State/County code, plant ID, 8-digit SCC code, pollutant	point	allowable, control, projection, plant closure
6	Country/State/County code, plant ID, MACT code, pollutant	point	control, projection,
7	Country/State/County code, plant ID, pollutant	point	allowable, control, projection, plant closure
8	Country/State/County code, plant ID, point ID, stack ID, segment, 8-digit SCC code	point	allowable, control, projection, plant closure
9	Country/State/County code, plant ID, point ID, stack ID, segment	point	allowable, control, projection, plant closure
10	Country/State/County code, plant ID, point ID, stack ID	point	allowable, control, projection, plant closure
11	Country/State/County code, plant ID, point id	point	allowable, control, projection, plant closure
12	Country/State/County code, plant ID, 8-digit SCC code	point	allowable, control, projection, plant closure

Ranking	Matching Hierarchy	Inventory Types	Control Program Types
13	Country/State/County code, plant ID, MACT code	point	control, projection,
14	Country/State/County code, plant ID	point	allowable, control, projection, plant closure
15	Country/State/County code, MACT code, 8-digit SCC code, pollutant	point, nonpoint	control, projection
16	Country/State/County code, MACT code, pollutant	point, nonpoint	control, projection
17	Country/State code, MACT code, 8-digit SCC code, pollutant	point, nonpoint	control, projection
18	Country/State code, MACT code, pollutant	point, nonpoint	control, projection
19	MACT code, 8-digit SCC code, pollutant	point, nonpoint	control, projection
20	MACT code, pollutant	point, nonpoint	control, projection
21	Country/State/County code, 8-digit SCC code, MACT code	point, nonpoint	control, projection
22	Country/State/County code, MACT code	point, nonpoint	control, projection
23	Country/State code, 8-digit SCC code, MACT code	point, nonpoint	control, projection
24	Country/State code, MACT code	point, nonpoint	control, projection
25	MACT code, 8-digit SCC code	point, nonpoint	control, projection
26	MACT code	point, nonpoint	control, projection
27	Country/State/County code, NAICS code, 8-digit SCC code, pollutant	point, nonpoint	control, projection
28	Country/State/County code, NAICS code, pollutant	point, nonpoint	control, projection
29	Country/State code, NAICS code, 8-digit SCC code, pollutant	point, nonpoint	control, projection
30	Country/State code, NAICS code, pollutant	point, nonpoint	control, projection
31	NAICS code, 8-digit SCC code, pollutant	point, nonpoint	control, projection
32	NAICS code, pollutant	point, nonpoint	control, projection
33	Country/State/County code, NAICS code, 8-digit SCC code	point, nonpoint	control, projection
34	Country/State/County code, NAICS code	point, nonpoint	control, projection
35	Country/State code, NAICS code, 8-digit SCC code	point, nonpoint	control, projection
36	Country/State code, NAICS code	point, nonpoint	control, projection
37	NAICS code, 8-digit SCC code	point, nonpoint	control, projection
38	NAICS code	point, nonpoint	control, projection
39	Country/State/County code, 8-digit SCC code, 4-digit SIC code, pollutant	point, nonpoint	allowable, control, projection
40	Country/State/County code, 4-digit SIC code, pollutant	point, nonpoint	allowable, control, projection
41	Country/State code, 8-digit SCC code, 4-digit SIC code, pollutant	point, nonpoint	allowable, control, projection
42	Country/State code, 4-digit SIC code, pollutant	point, nonpoint	allowable, control, projection
43	4-digit SIC code, SCC code, pollutant	point, nonpoint	allowable, control, projection
44	4-digit SIC code, pollutant	point, nonpoint	allowable, control, projection
45	Country/State/County code, 4-digit SIC code, SCC code	point, nonpoint	allowable, control, projection
46	Country/State/County code, 4-digit SIC code	point, nonpoint	allowable, control, projection
47	Country/State code, 4-digit SIC code, SCC code	point, nonpoint	allowable, control, projection
48	Country/State code, 4-digit SIC code	point, nonpoint	allowable, control, projection
49	4-digit SIC code, SCC code	point, nonpoint	allowable, control, projection
50	4-digit SIC code	point, nonpoint	allowable, control, projection

Ranking	Matching Hierarchy	Inventory Types	Control Program Types
51	Country/State/County code, 8-digit SCC code, pollutant	point, nonpoint, onroad, nonroad	allowable, control, projection
52	Country/State code, 8-digit SCC code, pollutant	point, nonpoint, onroad, nonroad	allowable, control, projection
53	8-digit SCC code, pollutant	point, nonpoint, onroad, nonroad	allowable, control, projection
54	Country/State/County code, 8-digit SCC code	point, nonpoint, onroad, nonroad	allowable, control, projection
55	Country/State code, 8-digit SCC code	point, nonpoint, onroad, nonroad	allowable, control, projection
56	8-digit SCC code	point, nonpoint, onroad, nonroad	allowable, control, projection
57	Country/State/County code, pollutant	point, nonpoint, onroad, nonroad	allowable, control, projection
58	Country/State/County code	point, nonpoint, onroad, nonroad	allowable, control, projection, plant closure
59	Country/State code, pollutant	point, nonpoint, onroad, nonroad	allowable, control, projection
60	Country/State code	point, nonpoint, onroad, nonroad	allowable, control, projection, plant closure
61	Pollutant	point, nonpoint, onroad, nonroad	allowable, control, projection

More than one of the same type of control programs can be added to a strategy. For example, a client could add three Plant Closure Control Programs: Cement Plant Closures, Power Plant Closures, and Boiler Closures. All three of these control programs would be evaluated and a record of the evaluation would be stored in the Strategy Detailed Result. If there happen to be multiple Projection, Control, or Allowable Type Control Programs added to a strategy, packets of the same type are merged into one packet during the matching analysis so that no duplicate source–control-packet pairings are created. Duplicate records will be identified during the run process and the user will be prompted to remove duplicates before the core algorithm performs the projection process.

The Project Future Year Inventory strategy processes Control Programs in the following order:

1. Plant Closure Type Control Programs
2. Projection Type Control Programs
3. Control Type Control Programs
4. Allowable Type Control Programs

The Control analysis is dependent on the Projection analysis; likewise, the Allowable analysis is dependent on the Projection and Control analyses. The adjusted source emission values need to be carried along from each analysis step to make sure each portion of the analysis applies the correct adjustment factor. For example, a source could be projected, and also controlled, in addition to having a cap placed on the source. Or, a source could have a projection or control requirement, or perhaps just a cap or replacement requirement.

As much as possible, the Control Program Packet datasets are designed to be compatible with SMOKE. The Projection, Control, and Allowable Packets are fully compatible with SMOKE. The Plant Closure Packet and the new Projection, Control, and Allowable Packets Extended dataset types, however, are not compatible with SMOKE; these dataset types are CSV-based

files that must contain certain columns. Tables 29 through 36 show the formats (and relevant mappings) of the seven types of control program packets. CoST makes use of some of the SMOKE unused optional columns to further extend the matching hierarchy, as compared to the SMOKE matching hierarchy in cntlmat. These new columns are explained in the Tables 30, 33 and 35 below.

The format of the Control Program Plant Closure Packet (Table 4) is based on the CSV format. The first row of this dataset file must contain the column header definition as defined in Line 1 of Table 4. All the columns specified here must be included in the dataset import file.

Table 4. Table Format for Plant Closure Packet Dataset Type

Line	Position	Description
1	A..H	Column header definition – must contain the following columns: fips,plantid,pointid,stackid,segment,plant,effective_date,reference
2+	A	Country/State/County code, required
	B	Plant Id for point sources, optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	C	Point Id for point sources, optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	D	Stack Id for point sources, , optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	E	Segment for point sources, optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	F	Plant name or description, for point sources, optional, leave blank for nonpoint inventories

Line	Position	Description
	G	Effective Date, the effective date for the plant closure to take place. When the closure effective cutoff is after this effective date, the plant will not be closed. A blank value is assumed to mean that the sources matched from this record will be closed regardless. The strategy target year is the year used in the closure effective cutoff date check. An EMF system-level property (stored in the emf.properties table as COST_PROJECT_FUTURE_YEAR_EFFECTIVE_DATE_CUTOFF_MONTHDAY) is used to store the month and day (e.g., 10/01 for the first day of October) to be used in the closure effective cutoff date check. For example: For a strategy with a target year of 2020 and effective cutoff month/day EMF property of 10/01, the closure effective cutoff date would be 10/01/2020. For a closure record with an effective date of 07/01/2013, this will result in ***all*** matching sources being closed: Is effective date blank/null OR effective date (07/01/2013) < 'effective cutoff month/day'/'strategy target year' true? 07/01/2013 < 10/01/2020 → This is true, so these matching sources would be closed For a closure record with a blank effective date, this will result in ***all*** matching sources being closed: Is effective date blank/null OR effective date < 10/01/2020 true? The effective date is blank → This is true, so these matching sources would be closed For a closure record with an effective date of 11/15/2020, this will result in ***no*** matching sources being closed: Is effective date blank/null OR effective date (11/15/2020) < 10/01/2020 true? 11/15/2020 < 10/01/2020 → This is false, so these matching sources would ***not*** be closed
	H	Reference, contains for the reference information for closing the plant

The format of the Control Program Projection Packet (Table 5) is based on the SMOKE format as defined in the SMOKE user's manual. One modification was made to enhance this packet's use in CoST: the unused SMOKE column at position K is now used to store the NAICS code.

Table 5. Table Format for Projection Packet Dataset Type

Line	Position	Description
1	A	/PROJECTION <4-digit from year> <4-digit to year>/
2+	A	# Header entry. Header is defined by the # as the first character on the line
3+	A	Country/State/County code, or Country/state code with blank for county, or zero

Line	Position	Description
		(or blank or -9) for all Country/State/County or Country/state codes
	B	8 or 10-digit SCC, optional, blank, zero, or -9 if not a SCC-specific projection
	C	Projection factor [enter number on fractional basis; e.g., enter 1.2 to increase emissions by 20%]
	D	Pollutant , blank, zero, or -9 if not a pollutant-specific projection
	E	Standard Industrial Category (SIC), optional, blank, zero, or -9 if not a SIC-specific projection
	F	Maximum Achievable Control Technology (MACT) code, optional, blank, zero, or -9 if not a MACT-specific projection
	G	Plant Id for point sources, optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	H	Point Id for point sources, optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	I	Stack Id for point sources, , optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	J	Segment for point sources, optional, blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	K	North American Industry Classification (NAICS) Code, optional, blank, zero, or -9 if not a NAICS-specific projection
	L	Characteristic 5 (blank for ORL inventory input format), optional
3	A	/END/

The format of the Control Program "Projection Packet Extended" (Table 6) is not based on the SMOKE format. It is based on the EMF Flexible File Format, which is based on the CSV-based format. This new format uses column names that are aligned with the Flat File 2010 dataset types in the EMF system. The format also supports monthly projection factors in addition to annual projection factors. For example, instead of using the FIPS code, the new format uses the REGION_CD column, and instead of PLANTID the new format uses FACILITY_ID. The appropriate mapping between the old and new formats is described in Table 7. The new format also contains additional columns that will be used in the future to help further enhance the inventory source matching capabilities, these include COUNTRY_CD, TRIBAL_CODE, CENSUS_TRACT_CD, SHAPE_ID, and EMIS_TYPE.

Table 6. Table Format for Projection Packet Extended Dataset Type

Column	Description
Country_cd	Country code, optional; currently not used in matching process
Region_cd	State/county code, or state code with blank for county, or zero (or blank or -9) for all state/county or state codes
Facility_id	Facility ID (aka Plant ID in ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Unit_id	Unit ID (aka Point ID for ORL format) for point sources, optional; blank, zero,

Column	Description
	or -9 if not specified; leave blank for nonpoint inventories
Rel_point_id	Release Point ID (aka Stack ID in ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Process_id	Process ID (aka Segment on ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Tribal_code	Tribal code, optional; currently not used in matching process
Census_tract_cd	Census tract ID, optional; currently not used in matching process
Shape_id	Shape ID, optional; currently not used in matching process
Emis_type	Emission type, optional; currently not used in matching process
Scc	8- or 10-digit SCC, optional; blank, zero, or -9 if not an SCC-specific control
Poll	Pollutant;, blank, zero, or -9 if not a pollutant-specific control
Reg_code	Regulatory code (aka Maximum Achievable Control Technology code), optional; blank, zero, or -9 if not a regulatory code-specific control
Sic	Standard Industrial Category (SIC), optional; blank, zero, or -9 if not an SIC-specific control
Naics	North American Industry Classification (NAICS) code, optional; blank, zero, or -9 if not a NAICS-specific control
Ann_proj_factor	The annual projection factor used to adjust the annual emission of the inventory. The number is stored as a fraction rather than a percentage; e.g., enter 1.2 to increase emissions by 20% (double precision). The annual projection factor is also used as a default for monthly-specific projection factors when they are not specified. If you do not want to specify a monthly-specific projection factor value, then also make sure not to specify an annual projection factor, which could be used as a default.
Jan_proj_factor	The projection factor used to adjust the monthly January emission of the inventory (the jan_value column of the FF10 inventory). The number is stored as a fraction rather than a percentage; e.g., enter 1.2 to increase emissions by 20% (double precision). If no January projection factor is specified, the annual projection factor value will be used as a default. The monthly-specific projection factor fields are not used on the older ORL inventory formats; only the annual projection factor field will be used on these older formats.
Feb_proj_factor	Analogous to the January projections factor, above.
…	…
Dec_proj_factor	The projection factor used to adjust the monthly December emission of the inventory (the dec_value column of the FF10 inventory). The number is stored as a fraction rather than a percentage; e.g., enter 1.2 to increase emissions by 20% (double precision).

Column	Description
	If no December projection factor is specified, the annual projection factor value will be used as a default. The monthly-specific projection factor fields are not used on the older ORL inventory formats; only the annual projection factor field will be used on these older formats.
Comment	Information about this record and how it was produced and entered by the user.

Table 7 identifies the appropriate mapping between the old (ORL inventories) and new (FF10 inventories) packet formats.

Table 7. Column Mapping between New and Old Control Program Packet Formats

New Extended Format Column "Control Program Extended" DS Type	Old Format Column "Control Program Extended" DS Type	Description
REGION_CD	FIPS	State/county code, or state code
FACILITY_ID	PLANTID	Plant ID for point sources
UNIT_ID	POINTID	Point ID for point sources
REL_POINT_ID	STACKID	Stack ID for point sources
PROCESS_ID	SEGMENT	Segment for point sources
MACT	REG_CD	Maximum Achievable Control Technology (MACT) code

The format of the Control Program Control Packet Dataset Type (Table 8) is based on the SMOKE format as defined in the SMOKE user's manual. Several modifications were made to enhance the packet's use in CoST: (1) The unused SMOKE column at position D is now used to store the primary control measure abbreviation; if one is specified, this measure is used on any source that was matched with those control packet entries. (2) The unused SMOKE column at position P is used to store the compliance date the control can be applied to sources. (3) The unused SMOKE column at position Q is used to store the NAICS code.

Table 8. Table Format for Control Packet Dataset Type

Line	Position	Description
1	A	/CONTROL/
2+	A	# Header entry. Header is indicated by use of "#" as the first character on the line.
3+	A	Country/state/county code, or country/state code with blank for county, or zero (or blank or -9) for all country/state/county or country/state codes
	B	8- or 10-digit SCC, optional; blank, zero, or -9 if not an SCC-specific control
	C	Pollutant; blank, zero, or -9 if not a pollutant-specific control
	D	Primary control measure abbreviation; blank, zero, or -9 applies to all measure in the Control Measure Database
	E	Control efficiency; value should be a percent (e.g., enter 90 for a 90% control

Line	Position	Description
		efficiency)
	F	Rule effectiveness; value should be a percent (e.g., enter 50 for a 50% rule effectiveness)
	G	Rule penetration rate; value should be a percent (e.g., enter 80 for a 80% rule penetration)
	H	Standard Industrial Category (SIC); optional, blank, zero, or -9 if not an SIC-specific control
	I	Maximum Achievable Control Technology (MACT) code; optional, blank, zero, or -9 if not a MACT-specific control
	J	Application control flag: • Y = control is applied to inventory • N = control will not be used
	K	Replacement flag: • A = control is applied in addition to any controls already on source • R = control replaces any controls already on the source
	L	Plant ID for point sources; optional, blank, zero, or -9 if not specified; leave blank for nonpoint inventories
	M	Point ID for point sources; optional, blank, zero, or -9 if not specified; leave blank for nonpoint inventories
	N	Stack ID for point sources; optional, blank, zero, or -9 if not specified; leave blank for nonpoint inventories
	O	Segment for point sources; optional, blank, zero, or -9 if not specified; leave blank for nonpoint inventories
	P	Compliance Date. The compliance date on which a control can be applied to sources; prior to this date, the control will not be applied. A blank value is assumed to mean that the control is within the compliance date and the sources matched from this record will be controlled regardless. The strategy target year is the year that is used in the control compliance cutoff date check. An EMF system-level property (stored in the emf.properties table as COST_PROJECT_FUTURE_YEAR_COMPLIANCE_DATE_CUTOFF_MONTHDAY) is used to store the month and day (e.g., 10/01 for the first day of October) to be used in the control compliance cutoff date check. For example, For a strategy with a target year of 2020 and compliance cutoff month/day EMF property of 10/01, the control compliance cutoff date would be 10/01/2020. For a control record with a compliance date of 07/01/2013, this will result in ***all*** matching sources ***not*** being controlled: Is compliance date blank/null OR compliance date (07/01/2013) > 'compliance cutoff month/day'/'strategy target year' true? 07/01/2013 > 10/01/2020 → This is false, so these sources would not be controlled

Line	Position	Description
		For a control record with a blank compliance date, this will result in ***all*** matching sources being controlled: Is compliance date blank/null OR compliance date > 10/01/2020 true? The compliance date is blank → This is true, so these matching sources would be controlled For a control record with a compliance date of 11/15/2020, this will result in ***all*** matching sources being controlled: Is compliance date blank/null OR compliance date (11/15/2020) > 10/01/2020 true? 11/15/2020 > 10/01/2020 → This is true, so these matching sources would be controlled
	Q	North American Industry Classification (NAICS) Code, optional, blank, zero, or -9 if not a NAICS-specific control
4	A	/END/

The format of the Control Program "Control Packet Extended" (Table 9) is not based on the SMOKE format. It is based on the EMF Flexible File Format, which is based on the CSV-based format. This new format uses column names that are aligned with the Flat File 2010 dataset types in the EMF system. The format also contains additional columns that will be used in the future to help further enhance the inventory source matching capabilities: COUNTRY_CD, TRIBAL_CODE, CENSUS_TRACT_CD, and SHAPE_ID, and EMIS_TYPE.

Table 9. Table Format for Control Packet Extended Dataset Type

Column	Description
Country_cd	Country code, optional; currently not used in matching process
Region_cd	State/county code, or state code with blank for county, or zero (or blank or -9) for all state/county or state codes
Facility_id	Facility ID (aka Plant ID in ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Unit_id	Unit ID (aka Point ID for ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Rel_point_id	Release Point ID (aka Stack ID in ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Process_id	Process ID (aka Segment on ORL format) for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
Tribal_code	Tribal code, optional; currently not used in matching process
Census_tract_id	Census tract ID, optional; currently not used in matching process
Shape_id	Shape ID, optional; currently not used in matching process

Column	Description
Emis_type	Emission type, optional; currently not used in matching process
Scc	8- or 10-digit SCC, optional; blank, zero, or -9 if not an SCC-specific control
Poll	Pollutant;, blank, zero, or -9 if not a pollutant-specific control
Reg_code	Regulatory code (aka Maximum Achievable Control Technology code), optional; blank, zero, or -9 if not a regulatory code-specific control
Sic	Standard Industrial Category (SIC), optional; blank, zero, or -9 if not an SIC-specific control
Naics	North American Industry Classification (NAICS) code, optional; blank, zero, or -9 if not a NAICS-specific control
Compliance_Date	Compliance Date. The compliance date on which a control can be applied to sources; prior to this date, the control will not be applied. A blank value is assumed to mean that the control is within the compliance date and the sources matched from this record will be controlled regardless. The strategy target year is the year used in the control compliance cutoff date check. An EMF system-level property (stored in the emf.properties table as COST_PROJECT_FUTURE_YEAR_COMPLIANCE_DATE_CUTOFF_MONTHDAY) is used to store the month and day (e.g., 10/01 for the first day of October) to be used in the control compliance cutoff date check. For example, For a strategy with a target year of 2020 and compliance cutoff month/day EMF property of 10/01, the control compliance cutoff date would be 10/01/2020. For a control record with a compliance date of 07/01/2013, this will result in ***all*** matching sources ***not*** being controlled: Is compliance date blank/null OR compliance date (07/01/2013) > 'compliance cutoff month/day'/'strategy target year' true? 07/01/2013 > 10/01/2020 → This is false, so these sources would not be controlled For a control record with a blank compliance date, this will result in ***all*** matching sources being controlled: Is compliance date blank/null OR compliance date > 10/01/2020 true? The compliance date is blank → This is true, so these matching sources would be controlled For a control record with a compliance date of 11/15/2020, this will result in ***all*** matching sources being controlled: Is compliance date blank/null OR compliance date (11/15/2020) > 10/01/2020 true? 11/15/2020 > 10/01/2020 → This is true, so these matching sources

Column	Description
	would be controlled
Application_control	Application control flag: • Y = control is applied to inventory • N = control will not be used
Replacement	Replacement flag: • A = control is applied in addition to any controls already on source • R = control replaces any controls already on the source
Pri_cm_abbrev	Primary control measure abbreviation (from the Control Measure Database) that defines the control packet record
Ann_pctred	The percent reduction of the control (value should be a percent; e.g., enter 90 for a 90% percent reduction) to apply to the annual emission factor; the percent reduction can be considered a combination of the control efficiency, rule effectiveness, and rule penetration (CE * RE/100 * RP/100). The annual percent reduction field is used to reduce annual emission of the inventory (the ann_value column of the FF10 inventory formats contains the annual emission value). The annual percent reduction is also used as a default for monthly-specific percent reductions when they are not specified. If you do not want to specify a monthly-specific projection factor value, then also make sure not to specify an annual projection factor, which could be used as a default.
Jan_pctred	The percent reduction of the control to apply to the monthly January emission factor (the jan_value column of the FF10 inventory). If no January percent reduction is specified, the annual percent reduction value will be used as a default. The monthly-specific percent reduction fields are not used on the older ORL inventory formats; only the annual percent reduction field will be used on these older formats.
Feb_pctred	Analogous to the January percent reduction, above.
…	…
Dec_pctred	The percent reduction of the control to apply to the monthly December emission factor (the dec_value column of the FF10 inventory). If no December percent reduction is specified, the annual percent reduction value will be used as a default. The monthly-specific percent reduction fields are not used on the older ORL inventory formats; only the annual percent reduction field will be used on these older formats.
Comment	Information about this record and how it was produced and entered by the user.

The format of the Control Program Allowable Packet (Table 10) is based on the SMOKE format as defined in the SMOKE user's manual. Two modifications were made to enhance this packet's use in CoST. (1) The unused SMOKE column at position L is now used to store the compliance date that the cap or replacement emission value can be applied to a source. (2) The unused SMOKE column at position M is used to store the NAICS code.

Table 10. Table Format for Control Program Allowable Packet

Line	Position	Description
1	A	/ALLOWABLE/
2+	A	# Header entry. Header is indicated by use of "#" as the first character on the line.
3+	A	Country/state/county code, or country/state code with blank for county, or zero (or blank or -9) for all country/state/county or country/state codes
	B	8- or 10-digit SCC, optional; blank, zero, or -9 if not an SCC-specific cap or replacement
	C	Pollutant;, blank, zero, or -9 if not a pollutant-specific control; in most cases, the cap or replacement value will be a pollutant-specific value, and that pollutant's name needs to be placed in this column
	D	Control factor (no longer used by SMOKE or CoST; enter -9 as placeholder)
	E	Allowable emissions cap value (tons/day) (required if no "replace" emissions are given)
	F	Allowable emissions replacement value (tons/day) (required if no "cap" emissions are given)
	G	Standard Industrial Category (SIC); optional, blank, zero, or -9 if not an SIC-specific cap or replacement
	H	Plant ID for point sources, optional; blank, zero, or -9 if not specified; leave blank for nonpoint inventories
	I	Point ID for point sources, optional; blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	J	Stack ID for point sources, optional; blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	K	Segment for point sources, optional; blank, zero, or -9 if not specified, leave blank for nonpoint inventories
	L	Compliance Date. The compliance date on which a cap or replacement entry can be applied to sources; prior to this date, the cap or replacement will not be applied. A blank value is assumed to mean that the cap or replacement is within the compliance date and is available for analysis. The strategy target year is used to calculate the baseline comparison date to use in the compliance date check. January 1st of the strategy target year will define this baseline compliance date to use in the comparison check (i.e., target year = 2020 → baseline compliance date is 1/1/2020). In order for the compliance date to be met, the following must be true: Packet compliance date ≥ 1/1/'strategy target year'

Line	Position	Description
		For example: For a strategy with a target year of 2020, the baseline compliance date would be 1/1/2020. baseline compliance date = 1/1/'strategy target year' = 1/1/2020 A packet compliance date of 5/1/2020 would pass the compliance check since 5/1/2020 >= 1/1/2020 is true. A packet compliance date of 1/1/2018 would NOT pass the compliance check since 1/1/2018 >= 1/1/2020 is false. A blank compliance date assumes the entry is in compliance and is not subject to the conditional check listed above
	M	North American Industry Classification (NAICS) Code, optional; blank, zero, or -9 if not a NAICS-specific projection
4	A	/END/

3.3 PFYI Inputs and Outputs

The PFYI strategy type assigns projection and control adjustment factors, applies add-on or replacement control measures, and applies a cap or replacement to emissions sources in a specified geographic region. If multiple inventories are specified as inputs to a Project Future Year Inventory strategy, each inventory is processed separately and one Strategy Detailed Result is generated per inventory. Control Programs are assigned to the strategy to drive the Project Future Year Inventory strategy, as described in Section 8.2.

Note that almost all of the strategy parameters for the Project Future Year Inventory strategy have the same meaning and act in the same way as they do for the Maximum Emissions Reduction strategy (see Sections 2.2 and 2.3 of the CoST Development Document), such as cost year, inventory filter, and county dataset. The user does not need to specify a target pollutant for this strategy type. So, if a filter for the inventory is specified, only sources that meet the filter will be considered for control.

Control Program Packet datasets are applied during the Project Future Year Inventory strategy by the Control Programs that are assigned to the strategy. The Control Program contains a packet dataset the will perform various actions on the sources in the emission inventory. The packet dataset contains several key fields that can be used for matching to key source identifiers in the emission inventory. Various combinations can be used when matching between the packet entry and the source. The control packet source matching criteria are defined in Table 3. For example, a control packet could be very specific, identifying a specific plant stack (i.e., fips, plantid, pointid, stackid, and segment are filled in), or the packet could be as broad as specifying all sources that are classified under a certain MACT code. The more specific the match, the higher the ranking is; so, in the example just given, the plant-specific control packet entry would outweigh the MACT-specific packet entry.

The Project Future Year Inventory strategy type uses only one constraint during the strategy run:

- Minimum Percent Reduction Difference for Predicting Controls (%): This required constraint is the minimum percent reduction for predicting the probable control measure that could be applied to the source. The percent difference calculation is based on the probable control measure percent reduction compared to the control percent reduction specified in the control packet.
    - = [(Control Measure Percent Reduction – Control Packet Percent Reduction) / Control Measure Percent Reduction] x 100 ≤ Minimum Percent Reduction Difference for Predicting Controls (%)
    - Old Control Packet Format:

      = {[(CM CEFF x CM RPEN x CM REFF) – (CP CEFF x CP RPEN x CP REFF)] / (CM CEFF x CM RPEN x CM REFF)} x 100 ≤ Minimum Percent Reduction Difference for Predicting Controls (%)
    - New Control Extended Packet Format:

      = {[(CM CEFF x CM RPEN x CM REFF) – (CP PCTRED)] / (CM CEFF x CM RPEN x CM REFF)} x 100 ≤ Minimum Percent Reduction Difference for Predicting Controls (%)

  The control measure with the smallest Percent Reduction Difference will be assigned as the most probable measure by assigning the control measure abbreviation to the cm_abbrev column in the Strategy Detailed Result.

  If the pri_cm_abbrev is populated in the Control Packet, the Minimum Percent Reduction Difference for Predicting Controls constraint is ignored, and the pri_cm_abbrev value is used to fill in the cm_abbrev column in the Strategy Detailed Result.

The Project Future Year Inventory control strategy can assign to each source many Control Program Packet records (e.g., plant closure, future-year projection, or applying an add-on control measure). As noted earlier, this algorithm uses similar inputs to those described in Section 2 of the CoST Development Document: summary parameters, input inventories, inventory filters, and a constraint, but not measures. The algorithm also expects control programs as input. The strategy produces the two standard types of strategy outputs described in Section 2.6: Strategy Detailed Result ***for each input inventory*** and Strategy Messages ***for all input inventories***.

The apply_order column of the Strategy Detailed Result defines what type of action the control packet takes on the inventory source pollutant record. Table 11 contains a list of valid action codes that will be stored in the apply_order column.

Table 11. Control Program Action Codes

Control Program Action Code	Control Program Action	Control Program Type	Control Program Packet Dataset Types
0	Close plants, plants will be removed from strategy controlled inventory	Plant Closure	Plant Closure (CSV)
1	Project inventory source emissions	Projection	Projection Packet or Projection Extended Packet
2	Apply add-on or replacement control to inventory source emissions	Control	Control Packet or Control Extended Packet
3	Cap inventory source emissions	Allowable	Allowable Packet or Allowable Extended Packet
4	Replace inventory source emissions	Allowable	Allowable Packet or Allowable Extended Packet

The control_program column of the Strategy Detailed Result will contain the control program name that created the source–control-packet pair. The cm_abbrev column will contain either the type of Control Program Packet that was applied or, for Control Packets, it could contain the predicted or specified control measure applied to the source.

- For the source–projection-packet pairs, the cm_abbrev column will be set to PROJECTION
- For the source–plant closure-packet pairs, the cm_abbrev column will be set to PLTCLOSURE.
- For pairs of sources and control packets or of sources and allowable packets, the cm_abbrev column will contain either the measure abbreviation specified via the control packet pri_cm_abbrev column, or the probable measure abbreviation (if the constraint discussed above was met), or it will be set to UNKNOWNMSR if no measure was found in the CMDB (or if the constraint was not met).

3.4 PFYI Algorithm

This section provides an overview of the algorithm that matches sources with control measures for a Project Future Year Inventory control strategy. Figure 2 diagrams the process that is used when running this type of strategy. The steps in the source-measure matching algorithm for the Project Future Year Inventory strategy are given below.

1. Process/read the emissions inventory
2. Use inventory filtering (discussed in Section 2.3) to filter the emissions inventory, then compute uncontrolled emissions for later use
    a. Filter by SQL WHERE Clause (based on contents of the Inventory Filter field), if any
    b. Filter by the counties specified in the selected County Dataset, if any
    c. Compute uncontrolled emissions for controlled sources using one of these formulas:

       ORL Inventories:

unc_emis = ann emis / (1 - CE / 100 × RE / 100 × RP / 100)
unc_emis = avg day emis × days_in_month / (1 - CE / 100 × RE / 100 × RP / 100)

Flat File 2010 Inventories:
unc_emis = ann_value / (1 – ann_pct_red / 100)
unc_emis = jan_value / (1 – jan_pctred / 100)
+ feb_value / (1 – feb_pctred / 100)
…
+ nov_value / (1 – nov_pctred / 100)
+ dec_value / (1 – dec_pctred / 100)

3. Preprocess control program packets by cleaning all packet types (i.e., change -9, 0 (zero), and blank (empty string) column values to null);. The following is a list of the columns that are changed for each control packet:

a. Control Packet: plantid, pointid, stackid, segment, fips, scc, poll, mact, sic, naics, pri_cm_abbrev
b. Control Extended Packet: facility_id, unit_id, rel_point_id, process_id, region_cd, scc, poll, reg_code, sic, naics, pri_cm_abbrev
c. Projection Packet: plantid, pointid, stackid, segment, fips, scc, poll, mact, sic, naics
d. Projection Extended Packet: facility_id, unit_id, rel_point_id, process_id, region_cd, scc, poll, reg_code, sic, naics
e. Allowable Packet: plantid, pointid, stackid, segment, fips, scc, poll, sic, naics
f. Allowable Extended Packet: facility_id, unit_id, rel_point_id, process_id, region_cd, scc, poll, reg_code, sic, naics
g. Plant Closure Packet: plantid, pointid, stackid, segment, fips, effective_date

4. Perform a prerun process that validates the routine. This process evaluates the control program packets for the presence of severe errors that would stop the core algorithm from running. The following severe errors (shown as "Error" in the status column) will be logged in the Strategy Messages Output and would stop the strategy run from proceeding:

a. Plant Closure Packets closure date is not in the correct format (it is stored as string, so format could be incorrect)

b. There are duplicate packet-specific records. To check for this, like packets are merged and then evaluated for duplicates. For example, all "Control packets (even extended types)" will be unioned together and this resulting dataset is evaluated for duplicates.

The information stored in the Strategy Messages Output can be used to help identify and quality-assure the packet records that have "Error" status. Once all "Error" issues are resolved, the Project Strategy run should be able to complete successfully.

5. Match the Inventory Sources to Control Program Packets using the Control Packet Matching Hierarchy (see Table 3). Merge like Control Program Types (i.e., all Control Program Control Packets) to ensure that no duplicate source-control packet records are handled during the analysis. Ensure Control Program start and end dates lie within the strategy Target Year; if so, include in analysis. Process the Control Programs in the following order:

a. Plant Closure Type Control Program

b. Projection Type Control Program; uses the results from the Plant Closure Packet analysis to ensure the closed sources are excluded from the analysis
c. Control Type Control Program; uses the results from the Plant Closure Packet and Projection Packet analyses to ensure that the unclosed sources are projected before the sources are controlled
d. Allowable Type Control Program; uses the results from the Plant Closure, Control, and Projection Packet analyses to ensure that the unclosed sources are projected and/or controlled before the sources have a cap or replacement applied

6. *For Control Program Control Packet analysis only:* Filter the Control Measures to consider during the Control Program Control Packet analysis
a. By the selected Specific Control Measures as specified in the Control Program, AND/OR
b. By the selected Specific Control Technologies as specified in the Control Program

7. *For Control Program Control Packet analysis only:* Predict Probable Measure for Inventory Sources
a. Of the remaining measures, find the ones that apply to the SCC of the source (as specified by the SCCs listed as applicable to each measure)
b. Match on FIPS (data could be available at the National, State, or County level)
c. Match on Inventory Pollutant
d. Match on Measure Effective Date (the target year must be equal to or later than the effective date for the measure to be included)
e. Match on measure's Minimum and Maximum Emissions (inventory source must have greater than or equal to the minimum emissions and less than the maximum emissions)

8. *For Control Program Control Packet analysis only:* Evaluate Minimum Percent Reduction Difference for Predicting Controls Constraint while the source is being matched with Control Program Control Packet. This Constraint calculation is dependent on both the inventory source and the Control Packet. The Minimum Percent Reduction Difference constraint is used to help predict when a measure is the most likely to match the control specified in the Control Packet.

9. *For Control Program Control Packet analysis only:* If multiple measures are available for a source, then the best measure is chosen according to the following criteria:
a. Closest Locale (matching both FIPS state and county is best, then FIPS-state, followed by national)
b. Closest Percent Reduction (choose the measure that has the minimum percent reduction difference between the Control Packet specified percent reduction and the measures efficiency record percent reduction).
c. Cheapest annual cost

10. Perform a postrun process that looks for unused control programs, packet records that were not used in all inventories, and packet records that were not used at all during the analysis. This information will be logged as a "Warning" in the Strategy Messages Output. The information stored in this output can be used to help identify and quality-assure the packet records that have problems.

11. Compute the Strategy Detailed Result to include the source–control-packet pairs obtained from the algorithms shown in 5, 6, 7, 8, and 9.

12. After completing the computation of Strategy Detailed Results for all input inventories, prepare the summary outputs (described in Section 2.6) along with any controlled inventories upon user request.

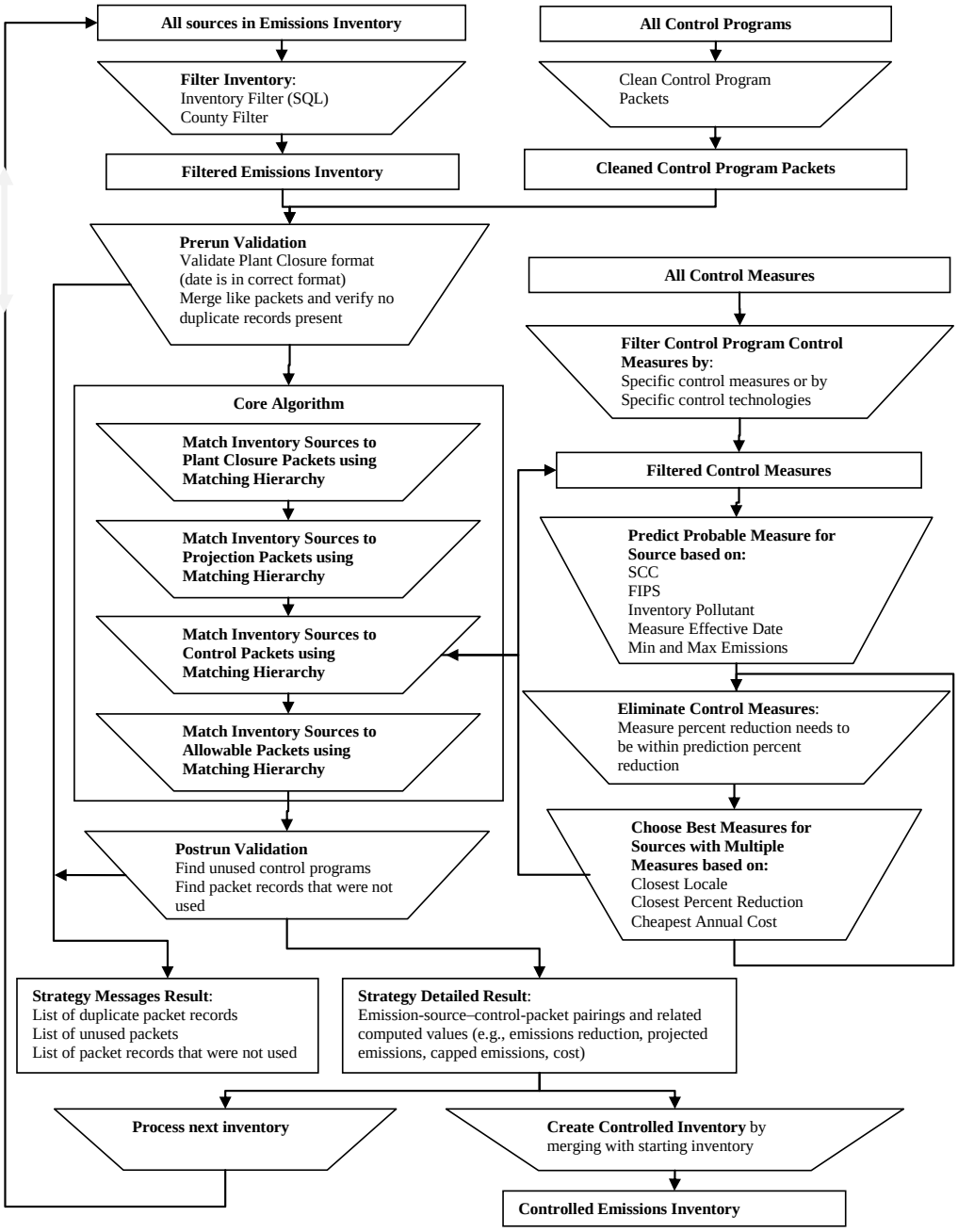

Figure 2. The Process for Running Project Future Year Inventory Control Strategy

3.5 PFYI Strategy Example

In Section 2.1 there was a brief description of how the PFYI strategy algorithm works. The current section provides much more detail using a specific example, including what the inputs to the strategy are, what the source–measure pairings are, and what the outputs look like. Note that in this and the following sections describing the strategy algorithms, only the inputs that actually affect the results are included; ones that are just informational may be left out (e.g., Project, Region). This example incorporates as many use-case scenarios as possible that a user might encounter when using this process: annual-only emissions, annual- and monthly-based emissions, and monthly-only emissions.

Strategy Inputs:
Name: Project Future Year Strategy Sample
Type of Analysis: Project Future Year Inventory
Cost Year: 2006
Target Year: 2017
Discount Rate: 7%
Use Cost Equations: Yes
Inventories: Flat File 2010 Point Dataset, ptinv_ptnonipm_2008, version 1
Programs:
- Plant Closure Packet Sample
- Control Packet Sample
- Projection Packet Sample

Minimum Percent Reduction Difference for Predicting Controls (%): 10%

Table 12 shows the inventory sources to be used in this example. It was created based on data from an ORL point EMF dataset. The information in the brackets for the Source column helps define the key structure for a source.

Table 13 contains the data for the sample Plant Closure packet.

Table 14 contains the data for the sample Projection packet.

Table 15 contains the data for the sample Control packet.

Table 16(a+b) contains detailed data from the Detailed Result output that is created during the projection process. Table 16b is just a continuation of Table 16a. The Detailed Result contains many table columns and only a subset of the important columns is reported in these tables. The comments column from these two tables contains information that will identify key steps as related to that inventory source-control program pairing projection matching process.

Table 12. Inventory Records

No.	Source [Source Id→Facility Id, Unit Id, Release Point Id, Process Id]	Region Code	SCC	Pollutant	Annual Emission (tons)	Monthly Emissions (tons)											
						JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	ABC Lumber Co [1→7787611, 2867713, 69288012, 18363114]	37001	10200906	CO	12.6	1.1	1.0	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1	1.0	1.1
2	ABC Lumber Co [1]	37001	10200906	NOX	15.5	1.3	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
3	ABC Lumber Co [1]	37001	10200906	PM10	11.2	1.0	0.9	1.0	0.9	1.0	0.9	1.0	1.0	0.9	1.0	0.9	1.0
4	ABC Lumber Co [1]	37001	10200906	PM2_5	9.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
5	ABC Lumber Co [1]	37001	10200906	SO2	1.8	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.2
6	ABC Lumber Co [1]	37001	10200906	VOC	1.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	DEF Brick Co [2→7811311, 73960213, 68790812, 101177114]	37007	30500311	CO	23.8	2.0	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
8	DEF Brick Co [2]	37007	30500311	NOX	5.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
9	DEF Brick Co [2]	37007	30500311	PM10	2.8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	DEF Brick Co [2]	37007	30500311	PM2_5	2.8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
11	DEF Brick Co [2]	37007	30500311	SO2	12.4	1.1	0.9	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1	1.0	1.1
12	DEF Brick Co [2]	37007	30500311	VOC	2.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
13	GHI Steam Electric Plant [3→8392811, 1654113, 1569412, 17761914]	37021	10100202	CO	127.2	10.8	9.8	10.8	10.5	10.8	10.5	10.8	10.8	10.5	10.8	10.5	10.8
14	GHI Steam Electric Plant [3]	37021	10100202	NOX	382.3	32.5	29.3	32.5	31.4	32.5	31.4	32.5	32.5	31.4	32.5	31.4	32.5
15	GHI Steam Electric Plant [3]	37021	10100202	PM10	403.5	34.3	31.0	34.3	33.2	34.3	33.2	34.3	34.3	33.2	34.3	33.2	34.3
16	GHI Steam Electric Plant [3]	37021	10100202	PM2_5	242.7	20.6	18.6	20.6	19.9	20.6	19.9	20.6	20.6	19.9	20.6	19.9	20.6
17	GHI Steam Electric Plant [3]	37021	10100202	SO2	316.1	26.8	24.2	26.8	26.0	26.8	26.0	26.8	26.8	26.0	26.8	26.0	26.8
18	GHI Steam Electric Plant [3]	37021	10100202	VOC	15.2	1.3	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
19	JKL Steam Station [4→8370411, 408113, 69507212, 17773814]	37035	10100202	CO	1115.6	94.7	85.6	94.7	91.7	94.7	91.7	94.7	94.7	91.7	94.7	91.7	94.7
20	JKL Steam Station [4]	37035	10100202	NOX	4380.0	372.0	336.0	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0
21	JKL Steam Station [4]	37035	10100202	PM10	2313.6	196.5	177.5	196.5	190.2	196.5	190.2	196.5	196.5	190.2	196.5	190.2	196.5
22	JKL Steam Station [4]	37035	10100202	PM2_5	2286.5	194.2	175.4	194.2	187.9	194.2	187.9	194.2	194.2	187.9	194.2	187.9	194.2
23	JKL Steam Station [4]	37035	10100202	SO2	2014.9	171.1	154.6	171.1	165.6	171.1	165.6	171.1	171.1	165.6	171.1	165.6	171.1
24	JKL Steam Station [4]	37035	10100202	VOC	49.4	4.2	3.8	4.2	4.1	4.2	4.1	4.2	4.2	4.1	4.2	4.1	4.2
25	MNO Die Casting [5→13452811, 74890413, 69265812, 101400314]	37081	30405001	CO	1.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
26	MNO Die Casting [5]	37081	30405001	NOX	1.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
27	MNO Die Casting [5]	37081	30405001	PM10	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	MNO Die Casting [5]	37081	30405001	PM2_5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	MNO Die Casting [5]	37081	30405001	SO2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	MNO Die Casting [5]	37081	30405001	VOC	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 13. Plant Closure Packet

No	fips	plantid	pointid	stackid	segment	plant	effective_date	reference
1	37021	8392811	1654113				07/01/2018	
2	37035	8370411					01/01/2015	

Table 14. Projection Packet (Extended Format)

												Monthly Projection Factor											
No	region_cd	facility_id	unit_id	rel_point_id	process_id	Scc	poll	reg_code	sic	naics	Annual Projection Factor	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	37001	1				10200906	PM10				0.90												
2						30405001	CO				0.17	0.17	0.18			0.20		0.22		0.18	0.17		
3						30500311	PM10				0.61												
4						10100202	PM10					0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
5	37001	1				10200906	PM2_5				0.90												
6						30500311	PM2_5				0.61												
7						10100202	PM2_5				0.88												

Table 15. Control Packet (Extended Format)

																Monthly Percent Reduction											
No	region_cd	facility_id	unit_id	rel_point_id	process_id	scc	poll	reg_code	sic	naics	Compliance Date	Application Control	replacement	Primary Control Measure Abbreviation	Annual Percent Reduction	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	37001	1				10200906	PM10					Y	R		90												
2						30405001	CO					Y	R		17	17	18			20		22		18	17		
3						30500311	PM10					Y	R		61												
4						10100202	PM10					Y	A			88	88	88	88	88	88	88	88	88	88	88	88
5	37001	1				10200906	PM2_5					Y	R		90												
6						30500311	PM2_5					Y	R		61												
7						10100202	PM2_5					Y	A		88												

Table 16. Detailed Result Records (first part of table)

Source [Source Id=Facility Id, Unit Id, Release Point Id, Process Id, Region Cd, Scc, Pollutant]	CM Abbrev	Apply Order or Action Code	Control Efficiency	Percent Reduction	Replacement Addon	Adjustment Factor	Final Emissions	Emission Reduction	Inventory Emissions	Comments
JKL Steam Station [8370411, 408113, 69507212, 17773814, 37035, 10100202, CO]	PLTCLOSURE	0					0.00	1115.60	1115.60	The apply order, 0, indicates a "Plant Closure" packet has been applied. The Plant Closure packet record No. 2 from Table 13 was applied by matching on fips, plantid, and effective date.
JKL Steam Station [8370411, 408113, 69507212, 17773814, 37035, 10100202, NOX]	PLTCLOSURE	0					0.00	4380.00	4380.00	The Plant Closure packet record No. 2 from Table 13 was applied by matching on fips, plantid, and effective date. Note how the Final Emission is zero indicating the plant generates zero emissions.
JKL Steam Station [8370411, 408113, 69507212, 17773814, 37035, 10100202, PM10]	PLTCLOSURE	0					0.00	2313.60	2313.60	The Plant Closure packet record No. 2 from Table 13 was applied by matching on fips, plantid, and effective date. Note how the Emission Reduction column has the same value as in the Inventory Emissions showing full emission reduction.
MNO Die Casting [13452811, 74890413, 69265812, 101400314, 37081, 30405001, CO]	PROJECTION	1				0.18	0.23	1.07	1.30	The apply order, 1, indicates a "Projection" packet has been applied. The Projection packet record No. 2 from Table 14 was applied by matching on scc and pollutant. Note how the adjustment factor is only being used for "Projection" packets. The projection factor is fraction and not percentage based.
GHI Steam Electric Plant [8392811, 1654113, 1569412, 17761914, 37021, 10100202, PM2_5]	PROJECTION	1				0.88	213.57	29.12	242.69	The Projection packet record No. 7 from Table 14 was applied by matching on scc and pollutant. Here are the projection calculations for an annual based source: Final Emission = Inventory Emission x Projection Factor = 242.69 x 0.88 = 213.57 Emission Reduction = Inventory Emission - Final Emission = 242.69 - 213.57 = 29.12
GHI Steam Electric Plant [8392811, 1654113, 1569412, 17761914, 37021, 10100202, PM10]	PROJECTION	1				0.88	355.05	48.42	403.47	The Projection packet record No. 4 from Table 14 was applied by matching on scc and pollutant. Here are the projection calculations for a monthly based source: Final Emission = Jan Inv Emis x Jan Projection Factor + Feb Inv Emis x Feb Projection Factor + ... + Dec Inv Emis x Dec Projection Factor = 34.3 x 0.88 + 31.0 x 0.88 + ... + 34.3 x 0.88 = 355.05 Emission Reduction = Inventory Emission - Final Emission = (Jan Inv Emis + Feb Inv Emis + ... + Dec Inv Emis) - Final Emission = (34.3 + 31.0 + ... + 34.3) - 355.05 = 48.42
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM2_5]	PROJECTION	1				0.61	1.73	1.11	2.84	The Projection packet record No. 6 from Table 14 was applied by matching on scc and pollutant.
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM10]	PROJECTION	1				0.61	1.73	1.11	2.84	The Projection packet record No. 3 from Table 14 was applied by matching on scc and pollutant.
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM10]	UNKNOWNMSR	2	61.0	61.0	R		0.68	1.06	1.73	The apply order, 2, indicates a "Control" packet has been applied. The Control packet record No. 3 from Table 15 was applied by matching on scc and pollutant. Note how the control efficiency and percent reduction are being used but the adjustment factor is not being used. Also these fields are percentage and not fraction based. The Replacement Addon field is set to R, indicating a replacement control will be applied and not an Addon control. Since, this source was projected in the previous table row, the emission to be controlled will be based on the projected emissions. Note how the emissions, 1.73 tons, comes from the Final Emissions field during the projection process
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM2_5]	UNKNOWNMSR	2	61.0	61.0	R		0.68	1.06	1.73	The Control packet record No. 6 from Table 15 was applied by matching on scc and pollutant. Here are "Replacement" control calculations for an annual based source: Emission Reduction = Uncontrolled Inv Emission – [Uncontrolled Inv Emission x (1 – Percent Reduction/100)] = 1.73 - (1.73 x (1 - 61/100)) = 1.06 where the Uncontrolled Inv Emission is calculating by "backing out" existing controls as specified in the inventory control efficiency field. Final Emission = Inventory Emission - Emis Red = 1.73 - 1.06 = 0.68

Source [Source Id=Facility Id, Unit Id, Release Point Id, Process Id, Region Cd, Scc, Pollutant]	CM Abbrev	Apply Order or Action Code	Control Efficiency	Percent Reduction	Replacement Addon	Adjustment Factor	Final Emissions	Emission Reduction	Inventory Emissions	Comments
GHI Steam Electric Plant [8392811, 1654113, 1569412, 17761914, 37021, 10100202, PM10]	UNKNOWNMSR	2	88.0	88.0	A		42.61	312.45	355.05	The Control packet record No. 4 from Table 15 was applied by matching on scc and pollutant. Here are""Addon" control calculations for a monthly based source: Emission Reduction = Jan Inv Emission x Jan Percent Reduction/100 + Feb Inv Emission x Feb Percent Reduction/100 + ... + Dec Inv Emission x Dec Percent Reduction/100 where existing controls are NOT "backed out" the control is assumed to add on to the existing control Final Emission = (Jan Inv Emis + Feb Inv Emis + ... + Dec Inv Emis) - Emission Reduction

Table 17. Detailed Result Records (continuation of

Table 13. Plant Closure Packet

No	fips	plantid	pointid	stackid	segment	plant	effective_date	reference
1	37021	8392811	1654113				07/01/2018	
2	37035	8370411					01/01/2015	

Table 14. Projection Packet (Extended Format)

												Monthly Projection Factor											
No	region_cd	facility_id	unit_id	rel_point_id	process_id	Scc	poll	reg_code	sic	naics	Annual Projection Factor	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	37001	1				10200906	PM10				0.90												
2						30405001	CO				0.17	0.17	0.18			0.20		0.22		0.18	0.17		
3						30500311	PM10				0.61												
4						10100202	PM10					0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
5	37001	1				10200906	PM2_5				0.90												
6						30500311	PM2_5				0.61												
7						10100202	PM2_5				0.88												

Table 15. Control Packet (Extended Format)

																Monthly Percent Reduction											
No	region_cd	facility_id	unit_id	rel_point_id	process_id	scc	poll	reg_code	sic	naics	Compliance Date	Application Control	replacement	Primary Control Measure Abbreviation	Annual Percent Reduction	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	37001	1				10200906	PM10					Y	R		90												
2						30405001	CO					Y	R		17	17	18			20		22		18	17		
3						30500311	PM10					Y	R		61												
4						10100202	PM10					Y	A			88	88	88	88	88	88	88	88	88	88	88	88
5	37001	1				10200906	PM2_5					Y	R		90												
6						30500311	PM2_5					Y	R		61												
7						10100202	PM2_5					Y	A		88												

Table 16)

		Final Emissions												Percent Reduction (%)												
Source [Source Id=Facility Id, Unit Id, Release Point Id, Process Id, Region Cd, Scc, Pollutant]	**Apply Order or Action Code**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Comments**
JKL Steam Station [8370411, 408113, 69507212, 17773814, 37035, 10100202, CO]	0																									The apply order, 0, indicates a "Plant Closure" packet has been applied.
JKL Steam Station [8370411, 408113, 69507212, 17773814, 37035, 10100202, NOX]	0																									Note how the monthly specific columns are not populated "Plant Closure" packet has been applied
JKL Steam Station [8370411, 408113, 69507212, 17773814, 37035, 10100202, PM10]	0																									
MNO Die Casting [13452811, 74890413, 69265812, 101400314, 37081, 30405001, CO]	1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02													The apply order, 1, indicates a "Projection" packet has been applied.
GHI Steam Electric Plant [8392811, 1654113, 1569412, 17761914, 37021, 10100202, PM2_5]	1	18.14	16.38	18.14	17.55	18.14	17.55	18.14	18.14	17.55	18.14	17.55	18.14													If monthly based emissions are specified then the monthly based final emissions column is populated
GHI Steam Electric Plant [8392811, 1654113, 1569412, 17761914, 37021, 10100202, PM10]	1	30.16	27.24	30.16	29.18	30.16	29.18	30.16	30.16	29.18	30.16	29.18	30.16													Here is a projection calculation for monthly based source: Jan Final Emission = Jan Inv Emis x Jan Projection Factor = 34.3 x 0.88 = 30.16
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM2_5]	1	0.15	0.13	0.15	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.14	0.15													
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM10]	1	0.15	0.13	0.15	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.14	0.15													
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM10]	2	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	61	61	61	61	61	61	61	61	61	61	61	61	The apply order, 2, indicates a "Control" packet has been applied.
DEF Brick Co [7811311, 73960213, 68790812, 101177114, 37007, 30500311, PM2_5]	2	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	61	61	61	61	61	61	61	61	61	61	61	61	If monthly based emissions are specified then the monthly based final emissions and percent reduction_columns are populated
GHI Steam Electric Plant [8392811, 1654113, 1569412, 17761914, 37021, 10100202, PM10]	2	3.62	3.27	3.62	3.50	3.62	3.50	3.62	3.62	3.50	3.62	3.50	3.62	88	88	88	88	88	88	88	88	88	88	88	88	Here is a "Addon" control calculation for a monthly based source: Jan Final Emission = Jan Inv Emis - Jan Inv Emission x Jan Percent Reduction/100

4 Potential Future Updates

This section describes updates that may be made to the CoST algorithms in the future. Reviewing these may also make the reader more aware of some of the nuances involved with applying the current version of CoST.

The following updates could be supported in future versions of the software:

1) Update Control Program Allowable Packet processing algorithm to be based on monthly and annual values instead of daily-based values.
2) Include more thorough warning messages in the Strategy Messages about Control Program Packet usage and trends during the analysis.

5 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.

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