CONTROL STRATEGY TOOL

COST EQUATIONS DOCUMENTATION

Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contacts: David Misenheimer, Larry Sorrels, Darryl Weatherhead

Last Updated
June 9, 2010

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1 Introduction

The purpose of EPA's Control Strategy Tool (CoST) is to model the emission reductions and costs associated with control strategies applied to sources of air pollution. The tool overlays a detailed control measure database on EPA emissions inventories to compute source- and pollutant-specific emission reductions and associated costs at various geographic levels (national, regional, local, and/or source). It contains a database of control measure and cost information for reducing the emissions of criteria pollutants (e.g., NO_x, SO_2, VOC, PM_{10}, $PM_{2.5}$, NH_3) as well as CO and Hg from point source emissions from electric utilities mapped to the Integrated Planning Model (ptipm), point sources not matched to the ptipm sector (ptnonipm), non-point sources (nonpt), and mobile sources (onroad and nonroad)[1]. The Control Strategy Tool was developed as a replacement to EPA's AirControlNET (ACN) software tool.

The Control Strategy Tool costs emission control technologies in 2 ways; cost equations are used to determine engineering costs that take into account several variables for the source when those variables are available, if the data is 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. Cost equations are used for some point sources (ptipm and ptnonipm sources), they are not used for non-point (nonpt) sources. This document describes the cost equations used in CoST.

This document provides a list of equations and associated variables assigned to specific control measures in the Control Strategy Tool. The application of these equations is based on the individual emissions inventory record to which they are applied and the specific characteristics of that record. For example, Equation Type 1 calculates capital cost largely on the unit's capacity expressed in units of megawatts (MW) and is scaled based on the original control cost calculations. It is applicable to NO_x and SO_2 emissions at ptipm sources. Variable and fixed operating and maintenance (O&M) costs are estimated in most of the equation types listed in this document. Typically, each equation type is applied either to a pollutant-major source combination or to a more general grouping of pollutant-source group. The scaling factors, additional variables, and cross-references by control measure and equation type are detailed in this document.

[1] Emissions inventory definitions obtained from "Technical Support Document: Preparation of Emissions Inventories for the Version 4, 2005-based Platform". Available at : ftp://ftp.epa.gov/EmisInventory/2005v4/2005_emissions_tsd_draft_11may2010.pdf

2 NO_x Control Cost Equations

2.1 Non-IPM Sector (ptnonipm) NO_x Control Cost Equations

Control costs for some Non-IPM sector (ptnonipm) point source emission reductions are estimated using a boiler capacity variable from the input emissions inventory, as well as, a scaling component that is based on the original Alternative Control Technology or Control Technology Guidelines (ACT/CTG) analyses used to derive these estimates.

Equation based costs are estimated for units that have a positive boiler capacity value which does not exceed 2,000 million Btu per hour (mmBtu/hr). For those sources not meeting the boiler capacity threshold, default cost per ton values are used. Furthermore, a size classification is applied for other ptnonipm sources based on the ozone season daily emissions value. Following the definition included in the NO_x SIP call program, a daily emissions value of less than one ton NO_x per day designates the source as small and applies control cost parameters consistent with this classification. Sources that emit one ton or more per day are considered large, and the appropriate parameters for large sources are applied.

If a NO_x control is already in place from the input inventory, control can only be applied incrementally. The control costs associated with incremental controls are based on alternate default cost per ton or alternate control cost variables. These alternate values take into account the incremental ineffectiveness of applying controls to units which already have a level of control assigned. CoST currently does not apply these incremental controls, but this improvement is currently being coded, and will be included in a June 2010 release.

Table 1 provides a list of the control cost parameters and variables as assigned during the application of Cost Equation Type 2 to NO_x controls applied to ptnonipm sources. The O&M costs are calculated as a subtraction of the annualized costs minus the capital costs × capital recovery factor (CRF). The CRF is included in the current Control Measures Database (CMDB). This value is recalculated in CoST using the equipment life and interest rate of the specific measure, when available. If equipment life is unavailable for the measure then the CRF provided in the CMDB is used.

When the equation based methods do not apply, default cost per ton values are assigned and applied to the annual emission reduction achieved by the applied control measure. In these applications, a capital to annual cost ratio is applied to estimate the capital cost associated with the control, and as before, the O&M costs are calculated using a subtraction of the capital cost × CRF. The variables used in the default cost per ton equations are provided in Table 2.

2.1.1 Equation Type 2

2.1.1.1 Capital Cost Equation

$$Capital\ Cost = Capital\ Cost\ Multiplier \times DESIGN\_CAPACITY^{\ Capital\ Cost\ Exponent}$$

where *Capital Cost Multiplier* and *Capital Cost Exponent* are control measure specific; *DESIGN_CAPACITY* is the capacity in mmBTU/hr obtained from the emissions inventory.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$

2.1.1.2 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Annual\ Cost\ Multiplier\ \times DESIGN\_CAPACITY^{Annual\ Cost\ Exponent}$$

where *Annual Cost Multiplier* and *Annual Cost Exponent* are control measure specific; *DESIGN_CAPACITY* is obtained from the emissions inventory.

2.1.1.3 Operation and Maintenance Equation

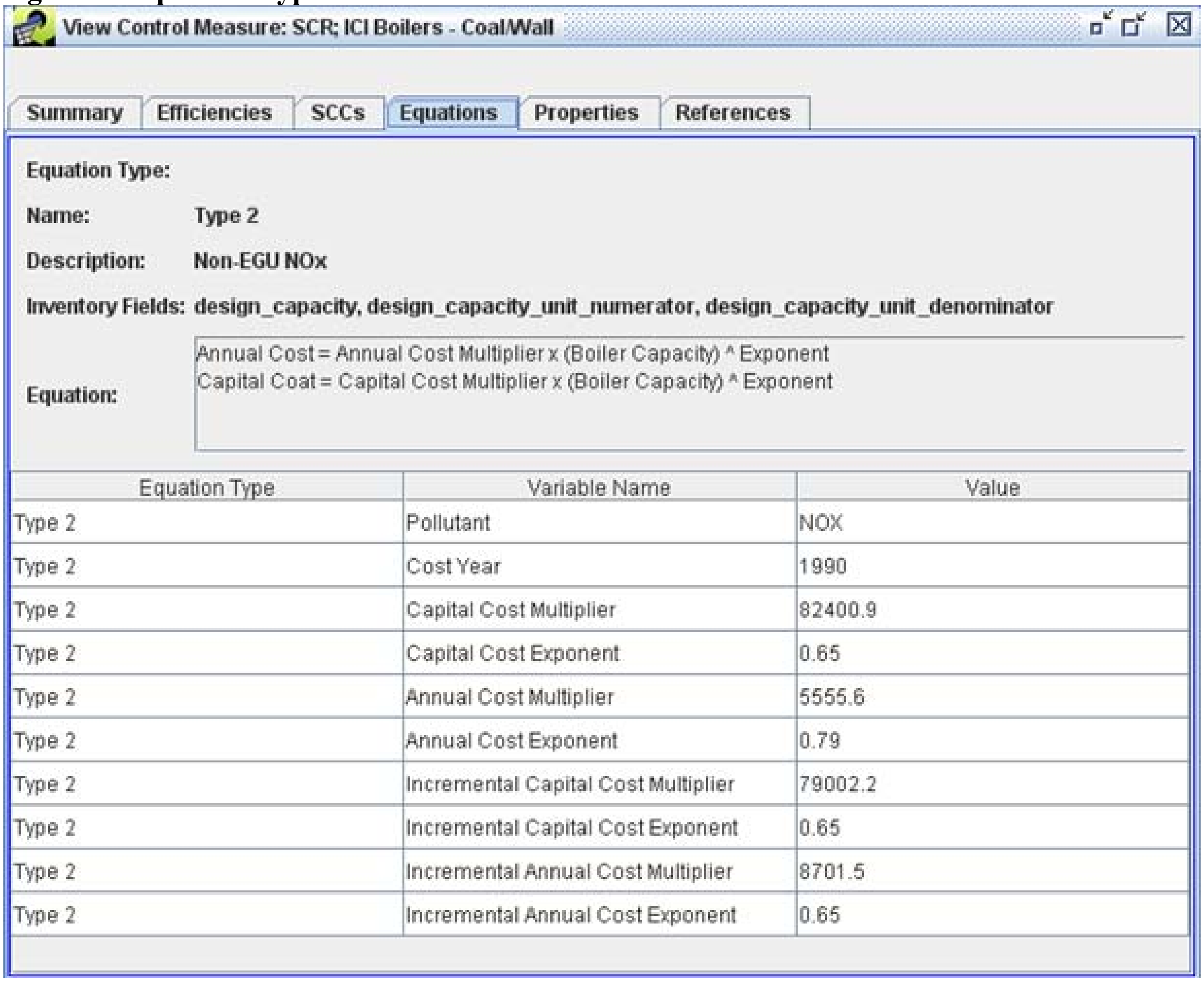
$$O\&M\ Cost = Total\ Annualized\ Cost - Capital\ Cost$$

2.1.2 Equation Type 2 Example

2.1.2.1 Example Equation Variables

Additional Information:
DESIGN_CAPACITY = 301.0 mmBTU/hr (from emissions inventory)
Equipment Life = 20 years (from the summary tab of the control measure data)

Figure 1: Equation Type 2 CoST Screenshot


View Control Measure: SCR; ICI Boilers - Coal/Wall

Summary | Efficiencies | SCCs | Equations | Properties | References

Equation Type:

Name: Type 2

Description: Non-EGU NOx

Inventory Fields: design_capacity, design_capacity_unit_numerator, design_capacity_unit_denominator

Equation:
Annual Cost = Annual Cost Multiplier x (Boiler Capacity) ^ Exponent
Capital Coat = Capital Cost Multiplier x (Boiler Capacity) ^ Exponent

Equation Type	Variable Name	Value
Type 2	Pollutant	NOX
Type 2	Cost Year	1990
Type 2	Capital Cost Multiplier	82400.9
Type 2	Capital Cost Exponent	0.65
Type 2	Annual Cost Multiplier	5555.6
Type 2	Annual Cost Exponent	0.79
Type 2	Incremental Capital Cost Multiplier	79002.2
Type 2	Incremental Capital Cost Exponent	0.65
Type 2	Incremental Annual Cost Multiplier	8701.5
Type 2	Incremental Annual Cost Exponent	0.65

2.1.2.2 When No Control is Currently in Place for the Source

2.1.2.2.1 Capital Cost Equations

$$Capital\ Cost = Capital\ Cost\ Multiplier \times DESIGN\_CAPACITY^{\ Capital\ Cost\ Exponent}$$
$$Capital\ Cost = \$82{,}400 \times 301.0^{0.65}$$
$$Capital\ Cost = \$3{,}365{,}117\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$
$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{20\ years}}{(1 + 0.07)^{20\ years} - 1}$$
$$Capital\ Recovery\ Factor = 0.094393$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$3{,}365{,}117 \times 0.0944$$
$$Annualized\ Capital\ Cost = \$317{,}643\ (1990\$)$$

2.1.2.2.2 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Annual\ Cost\ Multiplier\ \times DESIGN\_CAPACITY^{Annual\ Cost\ Exponent}$$
$$Total\ Annualized\ Cost = \$5{,}555.60 \times 301.0^{\,0.79}$$
$$Total\ Annualized\ Cost = \$504{,}427\ (1990\$)$$

2.1.2.2.3 Operation and Maintenance Equation

$$O\&M\ Cost = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$
$$O\&M\ Cost = \$504{,}427 - \$317{,}643$$
$$O\&M\ Cost = \$186{,}784\ (1990\$)$$

2.1.2.3 When Control is Applied Incrementally to the Source

Note: CoST is currently being updated to apply this equation type incrementally. Release is expected in June 2010.

2.1.2.3.1 Capital Cost Equations

$$Capital\ Cost = Incremental\ Capital\ Cost\ Multiplier \times DESIGN\_CAPACITY^{\ Incremental\ Capital\ Cost\ Exponent}$$
$$Capital\ Cost = \$79{,}002.20 \times 301.0^{0.65}$$
$$Capital\ Cost = \$3{,}226{,}319\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$
$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{20\ years}}{(1 + 0.07)^{20\ years} - 1}$$
$$Capital\ Recovery\ Factor = 0.094393$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$3{,}226{,}319 \times 0.0944$$
$$Annualized\ Capital\ Cost = \$304{,}564\ (1990\$)$$

2.1.2.3.2 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Incremental\ Annual\ Cost\ Multiplier \times DESIGN\_CAPACITY^{Incremental\ Annual\ Cost\ Exponent}$$
$$Total\ Annualized\ Cost = \$8{,}701.50\ \times 301.0^{0.65}$$
$$Total\ Annualized\ Cost = \$355{,}354 (1990\$)$$

2.1.2.3.3 Operation and Maintenance Equation

$$O\&M\ Cost = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$
$$O\&M\ Cost = \ \$355{,}354 - \ \$304{,}564$$
$$O\&M\ Cost = \$50{,}791\ (1990\$)$$

2.1.3 Type 2 Equation CoST code

```
--------------------------------------------------------------------------------------------------------------------------

-- plpgsql script code funneling to Type 2 cost equations...

converted_design_capacity := public.convert_design_capacity_to_mw(design_capacity, design_capacity_unit_numerator,
design_capacity_unit_denominator);
-- convert design capacity to mmBtu/hr
converted_design_capacity := 3.412 * converted_design_capacity;

IF coalesce(converted_design_capacity, 0) <> 0 THEN
-- design capacity must be less than or equal to 2000 MMBTU/hr (or 586.1665 MW/hr))
	IF (converted_design_capacity <= 2000.0) THEN
		select costs.annual_cost,
			costs.capital_cost,
			costs.operation_maintenance_cost,
			costs.annualized_capital_cost,
			costs.computed_cost_per_ton
		from public.get_type2_equation_costs(control_measure_id,
			discount_rate,
			equipment_life,
			capital_recovery_factor,
			emis_reduction,
			converted_design_capacity,
			variable_coefficient1,
			variable_coefficient2,
			variable_coefficient3,
			variable_coefficient4) as costs
		into annual_cost,
			capital_cost,
			operation_maintenance_cost,
			annualized_capital_cost,
			computed_cost_per_ton;
		IF annual_cost is not null THEN
			valid_cost := true;
			actual_equation_type := 'Type 2';
		ELSE
			valid_cost := false;
			actual_equation_type := '-Type 2';
		END IF;
		-- adjust costs to the reference cost year
		annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
		capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
		operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
		annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
		computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
		return;
	END IF;
END IF;
valid_cost := false;
actual_equation_type := '-Type 2';

-- Next the code will call the default CPT approach

--------------------------------------------------------------------------------------------------------------------------

-- Type 2
CREATE OR REPLACE FUNCTION public.get_type2_equation_costs(
	control_measure_id integer,
	discount_rate double precision,
```

```
	equipment_life double precision,
	capital_recovery_factor double precision,
	emis_reduction double precision,
	design_capacity double precision,
	capital_cost_multiplier double precision,
	capital_cost_exponent double precision,
	annual_cost_multiplier double precision,
	annual_cost_exponent double precision,
	OUT annual_cost double precision,
	OUT capital_cost double precision,
	OUT operation_maintenance_cost double precision,
	OUT annualized_capital_cost double precision,
	OUT computed_cost_per_ton double precision)  AS $$
DECLARE
	cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
	-- NOTES:
	-- design capacity must in the units mmBtu/hr

	-- get capital recovery factor, caculate if it wasn't passed in...
	IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
		cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
	END IF;

	-- calculate capital cost
	capital_cost := capital_cost_multiplier * (design_capacity ^ capital_cost_exponent);

	-- calculate annualized capital cost
	annualized_capital_cost := capital_cost * cap_recovery_factor;

	-- calculate annual cost
	annual_cost := annual_cost_multiplier * design_capacity ^ annual_cost_exponent;

	-- calculate operation maintenance cost
	operation_maintenance_cost := annual_cost - annualized_capital_cost;

	-- calculate computed cost per ton
	computed_cost_per_ton :=
		case
			when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
			else null
		end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;

CREATE OR REPLACE FUNCTION public.convert_design_capacity_to_mw(design_capacity double precision,
design_capacity_unit_numerator character varying,
	design_capacity_unit_denominator character varying) returns double precision AS $$
DECLARE
	converted_design_capacity double precision;
	unit_numerator character varying;
	unit_denominator character varying;
BEGIN

	--default if not known
	unit_numerator := coalesce(trim(upper(design_capacity_unit_numerator)), '');
	unit_denominator := coalesce(trim(upper(design_capacity_unit_denominator)), '');

	 --if you don't know the units then you assume units are MW
	IF length(unit_numerator) = 0 THEN
		return converted_design_capacity;
```

```
        END IF;


/* FROM Larry Sorrels at the EPA
    1) E6BTU does mean mmBTU.

    2)  1 MW = 3.412 million BTU/hr (or mmBTU/hr).   And conversely, 1
    mmBTU/hr = 1/3.412 (or 0.2931) MW.

    3)  All of the units listed below are convertible, but some of the
    conversions will be more difficult than others.  The ft3, lb, and ton
    will require some additional conversions to translate mass or volume
    into an energy term such as MW or mmBTU/hr.  Applying some density
    measure (which is mass/volume) will likely be necessary.   Let me know
    if you need help with the conversions.
*/

    --capacity is already in the right units...
    --no conversion is necessary, these are the expected units.
        IF (unit_numerator = 'MW' and unit_denominator = '') THEN
                return design_capacity;
        END IF;

    IF (unit_numerator = 'MMBTU'
       or unit_numerator = 'E6BTU'
       or unit_numerator = 'BTU'
       or unit_numerator = 'HP'
       or unit_numerator = 'BLRHP') THEN

                --convert numerator unit
                IF (unit_numerator = 'MMBTU'
                   or unit_numerator = 'E6BTU') THEN
                        converted_design_capacity := design_capacity / 3.412;
                END IF;
                IF (unit_numerator = 'BTU') THEN
                        converted_design_capacity := design_capacity / 3.412 / 1000000.0;
                END IF;
                IF (unit_numerator = 'HP') THEN
                        converted_design_capacity := design_capacity * 0.000746;
                END IF;
                IF (unit_numerator = 'BLRHP') THEN
                        converted_design_capacity := design_capacity * 0.000981;
                END IF;

                --convert denominator unit, if missing ASSUME per hr
                IF (unit_denominator = '' or unit_denominator = 'HR'
                   or unit_denominator = 'H') THEN
                        return converted_design_capacity;
                END IF;
                IF (unit_denominator = 'D' or unit_denominator = 'DAY') THEN
                        return converted_design_capacity * 24.0;
                END IF;
                IF (unit_denominator = 'M' or unit_denominator = 'MIN') THEN
                        return converted_design_capacity / 60.0;
                END IF;
                IF (unit_denominator = 'S' or unit_denominator = 'SEC') THEN
                        return converted_design_capacity / 3600.0;
                END IF;
        END IF;
        return null;
END;
```

$$ LANGUAGE plpgsql IMMUTABLE;

2.1.4 Non-IPM Sector (ptnonipm) NO_x Control Cost per Ton Calculations

2.1.4.1 Total Annualized Cost

When no control is currently in place for the source:

$$Total\ Annualized\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton$$

where emission reduction is calculated by CoST and *Default Cost per Ton* is control measure specific.

When control is applied incrementally to the source:

$$Total\ Annualized\ Cost = Emission\ Reduction \times Incremental\ Cost\ Per\ Ton$$

where emission reduction is calculated by CoST and *Incremental Cost per Ton* is control measure specific.

2.1.4.2 Capital Cost

$$Capital\ Cost = Total\ Annualized\ Cost \times Capital\ to\ Annual\ Ratio$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

2.1.4.3 Operation and Maintenance Cost

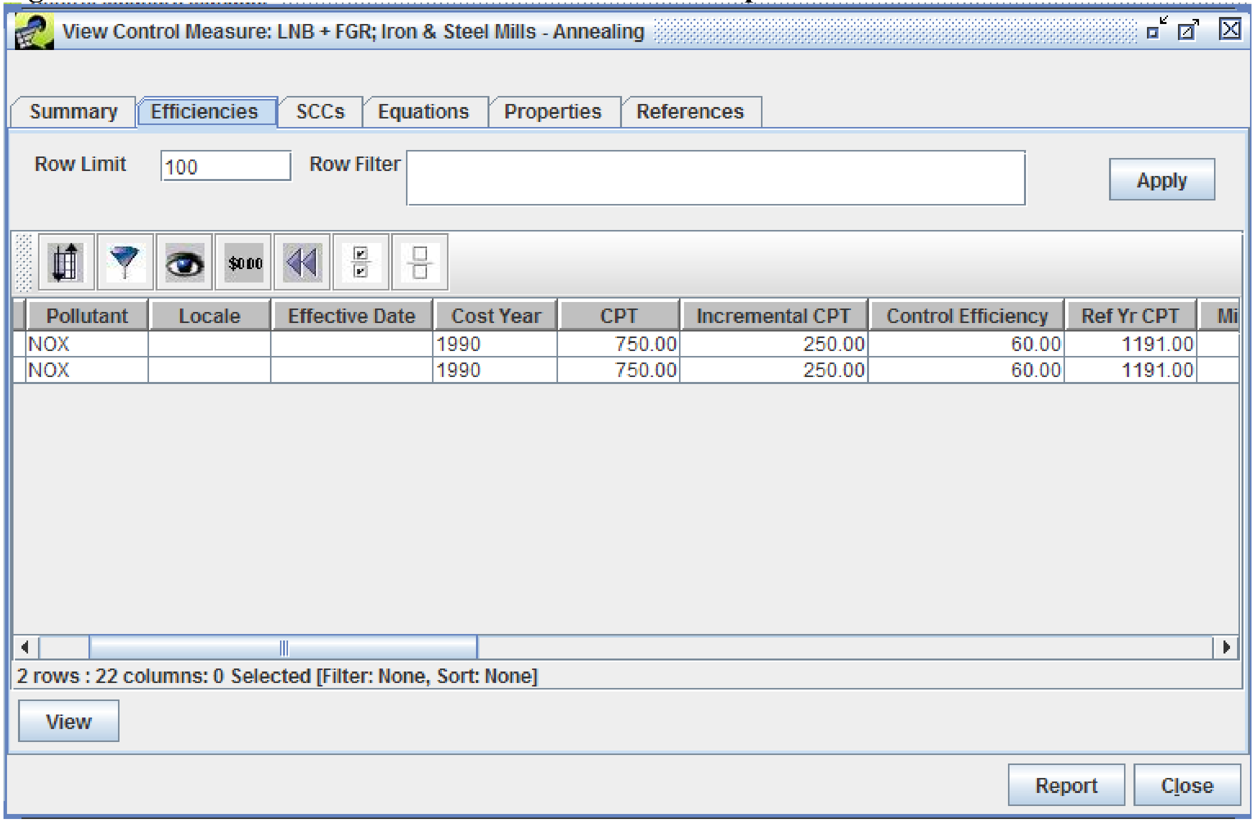
$$Total\ O\&M = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$

2.1.5 Non-IPM Sector (ptnonipm) NO_x Control Cost per Ton Example

2.1.5.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
NO_x Emission Reduction = 125 tons/year
Equipment Life = 10 years (from Summary Tab)
Capital to Annual Ratio = 7.0 (from Efficiencies Tab)

Figure 2: Non-IPM Sector NO_x Control Measure Cost per Ton Screenshot



2.1.5.2 When no Control Measure is currently in Place for the Source

2.1.5.2.1 Total Annualized Cost

$$Total\ Annualized\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton$$
$$Total\ Annualized\ Cost = 125 \times \$750$$
$$Total\ Annualized\ Cost = \$93{,}750\ (1990\$)$$

2.1.5.2.2 Capital Cost

When no control measure is currently in place for the source:

$$Capital\ Cost = Total\ Annualized\ Cost \times Capital\ to\ Annual\ Ratio$$
$$Capital\ Cost = \$93{,}750 \times 7.0$$
$$Capital\ Cost = \$656{,}250\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{10}}{[(1 + 0.07)^{10}\ - 1]}$$
$$Capital\ Recovery\ Factor = 0.1424$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$656{,}250 \times 0.1424$$
$$Annualized\ Capital\ Cost = \$93{,}435\ (1990\$)$$

2.1.5.2.3 Operation and Maintenance Cost

$$Total\ O\&M\ Cost = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$
$$Total\ O\&M\ Cost = \$93{,}750 - \$93{,}435$$
$$Total\ O\&M\ Cost = \$315\ (1990\$)$$

2.1.5.3 When Control Measure is Applied Incrementally to the Source

2.1.5.3.1 Total Annualized Cost

$$Total\ Annualized\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton$$
$$Total\ Annualized\ Cost = 125 \times \$250$$
$$Total\ Annualized\ Cost = \$31{,}250\ (1990\$)$$

2.1.5.3.2 Capital Cost

When no control measure is currently in place for the source:

$$Capital\ Cost = Total\ Annualized\ Cost \times Capital\ to\ Annual\ Ratio$$
$$Capital\ Cost = \$31{,}250 \times 7.0$$
$$Capital\ Cost = \$218{,}750\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{10}}{[(1 + 0.07)^{10}\ - 1]}$$
$$Capital\ Recovery\ Factor = 0.14$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$218{,}750 \times 0.14$$
$$Annualized\ Capital\ Cost = \$30{,}625\ (1990\$)$$

2.1.5.3.3 Operation and Maintenance Cost

$$Total\ O\&M\ Cost = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$
$$Total\ O\&M\ Cost = \$31{,}250 - \$30{,}625$$
$$Total\ O\&M\ Cost = \$625\ (1990\$)$$

2.1.6 NO_x Ptnonipm CoST Code

```
-----------------------------------------------------------------------------------------------------------------------------

CREATE OR REPLACE FUNCTION public.get_default_costs(
		discount_rate double precision,
		equipment_life double precision,
		capital_annualized_ratio double precision,
		capital_recovery_factor double precision,
		ref_yr_cost_per_ton double precision,
		emis_reduction double precision,
		OUT annual_cost double precision,
		OUT capital_cost double precision,
		OUT operation_maintenance_cost double precision,
		OUT annualized_capital_cost double precision,
		OUT computed_cost_per_ton double precision)  AS $$
DECLARE
```

```
	cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
	-- get capital recovery factor, caculate if it wasn't passed in...
	IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
		cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
	END IF;

	-- calculate annual cost
	annual_cost := emis_reduction * ref_yr_cost_per_ton;
	-- calculate capital cost
	capital_cost := annual_cost  * capital_annualized_ratio;
	-- calculate annualized capital cost
	annualized_capital_cost := capital_cost * cap_recovery_factor;
	-- calculate operation maintenance cost
	operation_maintenance_cost := annual_cost - coalesce(annualized_capital_cost, 0);
	-- calculate computed cost per ton
	computed_cost_per_ton :=
		case
			when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
			else null
		end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

Table 1. Non-IPM Sector NO_x Control Cost Parameters (Equation Type 2)

CoST CMAbbreviation	Source Group	Control Technology	CE	CRF	Control Cost Equation Application Parameters								Cost Year ($ Year)	Emissions Cutoff (Tons/year)
					Default Application				Incremental Application					
					Capital Cost Variables		Annual Cost Variables		Capital Cost Variables		Annual Cost Variables			
					Multiplier	Exponent	Multiplier	Exponent	Multiplier	Exponent	Multiplier	Exponent		
NLNBUGTNG	Gas Turbines - Natural Gas	LNB	68	0.1098	71281.1	0.51	7826.3	0.51	71281.1	0.51	7826.3	0.51	1990	< 365
NLNBUGTNG	Gas Turbines - Natural Gas	LNB	84	0.1098	71281.1	0.51	7826.3	0.51	71281.1	0.51	7826.3	0.51	1990	> 365
NLNBUIBCW	ICI Boilers - Coal/Wall	LNB	50	0.1424	53868.7	0.6	11861.1	0.6	53868.7	0.6	11861.1	0.6	1990	> 365
NLNBUIBCW	ICI Boilers - Coal/Wall	LNB	50	0.1424	53868.7	0.6	11861.1	0.6	53868.7	0.6	11861.1	0.6	1990	< 365
NSCRIBCW	ICI Boilers - Coal/Wall	SCR	90	0.0944	82400.9	0.65	5555.6	0.79	79002.2	0.65	8701.5	0.65	1990	> 365
NSCRIBCW	ICI Boilers - Coal/Wall	SCR	90	0.0944	82400.9	0.65	5555.6	0.79	79002.2	0.65	8701.5	0.65	1990	< 365
NSCRIBDO	ICI Boilers - Distillate Oil	SCR	80	0.0944	33206.3	0.65	2498.1	0.73	40891.3	0.65	4481.5	0.65	1999	> 365
NSCRIBDO	ICI Boilers - Distillate Oil	SCR	90	0.0944	33206.3	0.65	2498.1	0.73	40891.3	0.65	4481.5	0.65	1999	< 365
NSCRIBNG	ICI Boilers - Natural Gas	SCR	90	0.0944	33206.3	0.65	2498.1	0.73	40891.3	0.65	4481.5	0.65	1999	< 365
NSCRIBNG	ICI Boilers - Natural Gas	SCR	90	0.0944	33206.3	0.65	2498.1	0.73	40891.3	0.65	4481.5	0.65	1999	> 365
NSCRLGTNG	Gas Turbines - Natural Gas	SCR + LNB	94	0.1098	86461.8	0.64	19916.7	0.66	33203.7	0.73	13920	0.69	1990	> 365
NSCRLGTNG	Gas Turbines - Natural Gas	SCR + LNB	94	0.1098	86461.8	0.64	19916.7	0.66	33203.7	0.73	13920	0.69	1990	< 365
NSCRSGTNG	Gas Turbines - Natural Gas	SCR + Steam Injection	95	0.1098	90606.2	0.67	25936.7	0.69	15278.8	0.85	5477.9	0.84	1990	< 365
NSCRSGTNG	Gas Turbines - Natural Gas	SCR + Steam Injection	95	0.1098	90606.2	0.67	25936.7	0.69	15278.8	0.85	5477.9	0.84	1990	> 365
NSCRWGTNG	Gas Turbines - Natural Gas	SCR + Water Injection	95	0.1098	121119	0.59	36298.9	0.63	18026.5	0.82	7607	0.78	1990	< 365
NSCRWGTNG	Gas Turbines - Natural Gas	SCR + Water Injection	95	0.1098	121119	0.59	36298.9	0.63	18026.5	0.82	7607	0.78	1990	> 365
NSCRWGTOL	Gas Turbines - Oil	SCR + Water Injection	90	0.1098	123980.2	0.59	36100.2	0.66	70538.9	0.61	28972.5	0.58	1990	> 365
NSCRWGTOL	Gas Turbines - Oil	SCR + Water Injection	90	0.1098	123980.2	0.59	36100.2	0.66	70538.9	0.61	28972.5	0.58	1990	< 365
NSNCRIBCF	ICI Boilers - Coal/FBC	SNCR - Urea	75	0.0944	15972.8	0.6	4970.5	0.6	15972.8	0.6	3059.2	0.6	1990	> 365
NSNCRIBCF	ICI Boilers - Coal/FBC	SNCR - Urea	75	0.0944	15972.8	0.6	4970.5	0.6	15972.8	0.6	3059.2	0.6	1990	< 365
NSNCRIBCS	ICI Boilers - Coal/Stoker	SNCR	40	0.0944	110487.6	0.42	3440.9	0.73	67093.8	0.42	7514.2	0.42	1990	> 365
NSNCRIBCS	ICI Boilers - Coal/Stoker	SNCR	40	0.0944	110487.6	0.42	3440.9	0.73	67093.8	0.42	7514.2	0.42	1990	< 365
NSNCRIBCW	ICI Boilers - Coal/Wall	SNCR	40	0.0944	110487.6	0.42	3440.9	0.73	67093.8	0.42	7514.2	0.42	1990	> 365
NSNCRIBCW	ICI Boilers - Coal/Wall	SNCR	40	0.0944	110487.6	0.42	3440.9	0.73	67093.8	0.42	7514.2	0.42	1990	< 365
NSNCRIBDO	ICI Boilers - Distillate Oil	SNCR	50	0.0944	62148.8	0.42	2012.4	0.72	48002.6	0.42	5244.4	0.42	1990	< 365
NSNCRIBDO	ICI Boilers - Distillate Oil	SNCR	50	0.0944	62148.8	0.42	2012.4	0.72	48002.6	0.42	5244.4	0.42	1990	> 365
NSNCRIBNG	ICI Boilers - Natural Gas	SNCR	50	0.0944	62148.8	0.42	2012.4	0.72	48002.6	0.42	5244.4	0.42	1990	< 365
NSNCRIBNG	ICI Boilers - Natural Gas	SNCR	50	0.0944	62148.8	0.42	2012.4	0.72	48002.6	0.42	5244.4	0.42	1990	> 365
NSNCRIBRO	ICI Boilers - Residual Oil	SNCR	50	0.0944	62148.8	0.42	2012.4	0.72	48002.6	0.42	5244.4	0.42	1990	> 365
NSNCRIBRO	ICI Boilers - Residual Oil	SNCR	50	0.0944	62148.8	0.42	2012.4	0.72	48002.6	0.42	5244.4	0.42	1990	< 365
NSNCRIBWF	ICI Boilers - Wood/Bark/FBC	SNCR - Ammonia	55	0.0944	9855.6	0.6	4185.4	0.6	9855.6	0.6	4185.4	0.6	1990	> 365
NSNCRIBWF	ICI Boilers - Wood/Bark/FBC	SNCR - Ammonia	55	0.0944	9855.6	0.6	4185.4	0.6	9855.6	0.6	4185.4	0.6	1990	< 365
NSNCRIBWS	ICI Boilers - Wood/Bark/Stoker	SNCR - Urea	55	0.0944	65820.1	0.36	17777.1	0.35	65820.1	0.36	17777.1	0.35	1990	> 365
NSNCRIBWS	ICI Boilers - Wood/Bark/Stoker	SNCR - Urea	55	0.0944	65820.1	0.36	17777.1	0.35	65820.1	0.36	17777.1	0.35	1990	< 365
NSTINGTNG	Gas Turbines - Natural Gas	Steam Injection	80	0.1098	9693.1	0.92	764.3	1.15	9693.1	0.92	764.3	1.15	1990	< 365
NSTINGTNG	Gas Turbines - Natural Gas	Steam Injection	80	0.1098	9693.1	0.92	764.3	1.15	9693.1	0.92	764.3	1.15	1990	> 365
NWTINGTNG	Gas Turbines - Natural Gas	Water Injection	76	0.1098	4284.2	1.01	145.7	1.47	4284.2	1.01	145.7	1.47	1990	> 365
NWTINGTNG	Gas Turbines - Natural Gas	Water Injection	76	0.1098	4284.2	1.01	145.7	1.47	4284.2	1.01	145.7	1.47	1990	< 365
NWTINGTOL	Gas Turbines - Oil	Water Injection	68	0.1098	54453.5	0.57	9687.9	0.76	54453.5	0.57	9687.9	0.76	1990	< 365
NWTINGTOL	Gas Turbines - Oil	Water Injection	68	0.1098	54453.5	0.57	9687.9	0.76	54453.5	0.57	9687.9	0.76	1990	> 365

Table 2. NO_x Ptnonipm Default Cost per Ton Values

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost per Ton ($/ton reduced)		Capital /Annual Cost Ratio	CRF	Cost Year ($Year)	Emissions Cutoff (tons/year)
				Default	Incremental				
NAFRICGS	Internal Combustion Engines - Gas	AF RATIO	20	380	380	1.5	0.1098	1990	> 365
NAFRICGS	Internal Combustion Engines - Gas	AF RATIO	20	1570	1570	2.8	0.1098	1990	< 365
NAFRIICGS	Internal Combustion Engines - Gas	AF + IR	30	460	150	1.2	0.1098	1990	> 365
NAFRIICGS	Internal Combustion Engines - Gas	AF + IR	30	1440	270	2.6	0.1098	1990	< 365
NBINTCEMK	Cement Kilns	Biosolid Injection Technology	23	310		7.3	0.1098	1997	
NCLPTGMCN	Glass Manufacturing - Container	Cullet Preheat	25	940	940	4.5	0.1424	1990	> 365
NCLPTGMCN	Glass Manufacturing - Container	Cullet Preheat	25	940	940	4.5	0.1424	1990	< 365
NCLRBIBCC	ICI Boilers - Coal/Cyclone	Coal Reburn	50	300	300	2	0.0944	1990	> 365
NCLRBIBCC	ICI Boilers - Coal/Cyclone	Coal Reburn	50	1570	1570	2	0.0944	1990	< 365
NCUPHGMPD	Glass Manufacturing - Pressed	Cullet Preheat	25	810	810	4.5	0.1424	1990	> 365
NCUPHGMPD	Glass Manufacturing - Pressed	Cullet Preheat	25	810	810	4.5	0.1424	1990	< 365
NDOXYFGMG	Glass Manufacturing - General	OXY-Firing	85	4277				1999	
NDSCRBCCK	In-Process; Bituminous Coal; Cement Kiln	SCR	90	2119				1999	
NDSCRBCGN	In-Process Fuel Use;Bituminous Coal; Gen	SCR	90	3027				1999	
NDSCRBCLK	In-Process; Bituminous Coal; Lime Kiln	SCR	90	2119				1999	
NDSCRCMDY	Cement Manufacturing - Dry	SCR	90	4636				1999	
NDSCRCMWT	Cement Manufacturing - Wet	SCR	90	3962				1999	
NDSCRFEP	Taconite Iron Ore Processing - Induration - Coal or Gas	SCR	90	5269				1999	
NDSCRFFCCU	Fluid Cat Cracking Units; Cracking Unit	SCR	90	3457				1999	
NDSCRFPGCO	In-Process; Process Gas; Coke Oven Gas	SCR	90	6371				1999	
NDSCRIBCF	ICI Boilers - Coal/FBC	SCR	90	1159				1999	
NDSCRIBCK	ICI Boilers - Coke	SCR	90	1610				1999	
NDSCRIBCS	ICI Boilers - Coal/Stoker	SCR	90	2531				1999	
NDSCRIBLP	ICI Boilers - LPG	SCR	90	2958				1990	
NDSCRIBLW	ICI Boilers - Liquid Waste	SCR	90	1568				1999	
NDSCRIBPG	ICI Boilers - Process Gas	SCR	90	2366				1999	
NDSCRIBW	ICI Boilers - Wood/Bark/Waste	SCR	90	3274				1999	
NDSCRIDIN	Indust. Incinerators	SCR	90	3109				1999	
NDSCRISAN	Iron & Steel Mills - Annealing	SCR	90	5269				1999	
NDSCRNAMF	Nitric Acid Manufacturing	SCR	90	812				1999	
NDSCRPPNG	Pulp and Paper - Natural Gas - Incinerators	SCR	90	3109				1999	
NDSCRSPRF	Sulfate Pulping - Recovery Furnaces	SCR	90	2366				1999	
NDSCRSPRF	Sulfate Pulping - Recovery Furnaces	SCR	80	1720				1990	
NDSCRSWIN	Solid Waste Disp;Gov;Other Incin;Sludge	SCR	90	3109				1999	
NDSCRUNGGN	In-Process Fuel Use; Natural Gas; Gen	SCR	90	4953				1999	
NDSCRUPGCO	In-Process; Process Gas; Coke Oven Gas2	SCR	90	4953				1999	
NDSCRUROGN	In-Process Fuel Use; Residual Oil; Gen	SCR	90	4458				1999	
NELBOGMCN	Glass Manufacturing - Container	Electric Boost	10	7150	7150	0	0.1424	1990	> 365
NELBOGMCN	Glass Manufacturing - Container	Electric Boost	10	7150	7150	0	0.1424	1990	< 365
NELBOGMFT	Glass Manufacturing - Flat	Electric Boost	10	2320	2320	0	0.1424	1990	> 365
NELBOGMFT	Glass Manufacturing - Flat	Electric Boost	10	2320	2320	0	0.1424	1990	< 365
NELBOGMPD	Glass Manufacturing - Pressed	Electric Boost	10	8760	8760	0	0.1424	1990	> 365
NELBOGMPD	Glass Manufacturing - Pressed	Electric Boost	10	2320	8760	0	0.1424	1990	< 365
NEPABURN96	Agricultural Burning	Seasonal Ban (Ozone Season Daily Only)	100	0				1990	
NEPOBRUN96	Open Burning	Episodic Ban (Daily Only)	100	0				1990	
NEXABADMF	Adipic Acid Manufacturing	Extended Absorption	86	90	90	6.7	0.1424	1990	> 365
NEXABADMF	Adipic Acid Manufacturing	Extended Absorption	86	90	90	6.7	0.1424	1990	< 365
NEXABNAMF	Nitric Acid Manufacturing	Extended Absorption	95	480	480	8.1	0.1424	1990	> 365
NEXABNAMF	Nitric Acid Manufacturing	Extended Absorption	95	480	480	8.1	0.1424	1990	< 365
NIRICGD	IC Engines - Gas/ Diesel/ LPG	IR	25	490	490	0.6	0.1098	1990	> 365
NIRICGD	IC Engines - Gas/ Diesel/ LPG	IR	25	770	770	1.1	0.1098	1990	< 365
NIRICGS	Internal Combustion Engines - Gas	IR	20	550	550	0.7	0.1098	1990	> 365
NIRICGS	Internal Combustion Engines - Gas	IR	20	1020	1020	1.2	0.1098	1990	< 365
NIRICOL	Internal Combustion Engines - Oil	IR	25	490	490	0.6	0.1098	1990	> 365
NIRICOL	Internal Combustion Engines - Oil	IR	25	770	770	1.1	0.1098	1990	< 365

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost per Ton ($/ton reduced)		Capital /Annual Cost Ratio	CRF	Cost Year ($Year)	Emissions Cutoff (tons/year)
				Default	Incremental				
NIRRICOIL	Reciprocating IC Engines - Oil	IR	25	770		1.1		1999	
NLEAISRH	Iron & Steel Mills - Reheating	LEA	13	1320	1320	3.8	0.1424	1990	> 365
NLEAISRH	Iron & Steel Mills - Reheating	LEA	13	1320	1320	3.8	0.1424	1990	< 365
NLECICEGAS	Lean Burn IC Engine - Gas	Low Emission Combustion	87	422		2.3		1993	
NLECINGIC2	Industrial NG ICE, 2cycle (lean)	Low Emission Combustion	87	521				1999	
NLELSICGS	Internal Combustion Engines - Gas	L-E (Low Speed)	87	630			0.1098	1990	> 365
NLELSICGS	Internal Combustion Engines - Gas	L-E (Low Speed)	87	1680			0.1098	1990	< 365
NLEMSICGS	Internal Combustion Engines - Gas	L-E (Medium Speed)	87	380			0.1098	1990	> 365
NLEMSICGS	Internal Combustion Engines - Gas	L-E (Medium Speed)	87	380			0.1098	1990	< 365
NLNBFAPFD	Ammonia Prod; Feedstock Desulfurization	LNB + FGR	60	590	280	7.5	0.1424	1990	> 365
NLNBFAPFD	Ammonia Prod; Feedstock Desulfurization	LNB + FGR	60	2560	2470	5.9	0.1424	1990	< 365
NLNBFCOBF	In-Proc;Process Gas;Coke Oven/Blast Furn	LNB + FGR	55	2470	830	6.8	0.1098	1990	> 365
NLNBFCOBF	In-Proc;Process Gas;Coke Oven/Blast Furn	LNB + FGR	55	3190	1430	6.9	0.1098	1990	< 365
NLNBFCSRS	Pri Cop Smel; Reverb Smelt Furn	LNB + FGR	60	750	250	7	0.1424	1990	> 365
NLNBFCSRS	Pri Cop Smel; Reverb Smelt Furn	LNB + FGR	60	750	250	7	0.1424	1990	< 365
NLNBFFCCU	Fluid Cat Cracking Units; Cracking Unit	LNB + FGR	55	2470	830	6.8	0.1098	1990	> 365
NLNBFFCCU	Fluid Cat Cracking Units; Cracking Unit	LNB + FGR	55	3190	1430	6.9	0.1098	1990	< 365
NLNBFFPHP	Fuel Fired Equip; Process Htrs; Pro Gas	LNB + FGR	55	2470	830	6.8	0.1098	1990	> 365
NLNBFFPHP	Fuel Fired Equip; Process Htrs; Pro Gas	LNB + FGR	55	3190	1430	6.9	0.1098	1990	< 365
NLNBFFRNG	Ammonia - NG-Fired Reformers	LNB + FGR	60	590	280	7.5	0.1424	1990	> 365
NLNBFFRNG	Ammonia - NG-Fired Reformers	LNB + FGR	60	2560	2470	5.9	0.1424	1990	< 365
NLNBFFROL	Ammonia - Oil-Fired Reformers	LNB + FGR	60	390	190	7.5	0.1424	1990	> 365
NLNBFFROL	Ammonia - Oil-Fired Reformers	LNB + FGR	60	1120	1080	5.9	0.1424	1990	< 365
NLNBFGROFA	ICI Boilers - Gas	LNB + FGR + Over Fire Air	80	368		7.8		2003	> 365
NLNBFGROFA	ICI Boilers - Gas	LNB + FGR + Over Fire Air	80	1278		7.8		2003	< 365
NLNBFGRPH	Fuel Fired Equip/ Process Heaters	LNB + FGR	50	570		7.3	0.1098	1990	
NLNBFIBDO	ICI Boilers - Distillate Oil	LNB + FGR	60	760	370	7.5	0.1424	1990	> 365
NLNBFIBDO	ICI Boilers - Distillate Oil	LNB + FGR	60	2490	1090	5.9	0.1424	1990	< 365
NLNBFIBLP	ICI Boilers - LPG	LNB + FGR	60	760	370	7.5	0.1424	1990	> 365
NLNBFIBLP	ICI Boilers - LPG	LNB + FGR	60	2490	1090	5.9	0.1424	1990	< 365
NLNBFIBLW	ICI Boilers - Liquid Waste	LNB + FGR	60	390	190	7.5	0.1424	1990	> 365
NLNBFIBLW	ICI Boilers - Liquid Waste	LNB + FGR	60	1120	1080	5.9	0.1424	1990	< 365
NLNBFIBNG	ICI Boilers - Natural Gas	LNB + FGR	60	590	280	7.5	0.1424	1990	> 365
NLNBFIBNG	ICI Boilers - Natural Gas	LNB + FGR	60	2560	2470	5.9	0.1424	1990	< 365
NLNBFIBPG	ICI Boilers - Process Gas	LNB + FGR	60	590	280	7.5	0.1424	1990	> 365
NLNBFIBPG	ICI Boilers - Process Gas	LNB + FGR	60	2560	2470	5.9	0.1424	1990	< 365
NLNBFIBRO	ICI Boilers - Residual Oil	LNB + FGR	60	390	190	7.5	0.1424	1990	> 365
NLNBFIBRO	ICI Boilers - Residual Oil	LNB + FGR	60	1120	1080	5.9	0.1424	1990	< 365
NLNBFIPBH	Iron Prod; Blast Furn; Blast Htg Stoves	LNB + FGR	77	380	150	4.1	0.2439	1990	> 365
NLNBFIPBH	Iron Prod; Blast Furn; Blast Htg Stoves	LNB + FGR	77	380	150	4.1	0.2439	1990	< 365
NLNBFISAN	Iron & Steel Mills - Annealing	LNB + FGR	60	750	250	7	0.1424	1990	> 365
NLNBFISAN	Iron & Steel Mills - Annealing	LNB + FGR	60	750	250	7	0.1424	1990	< 365
NLNBFISGV	Iron & Steel Mills - Galvanizing	LNB + FGR	60	580	190	6.5	0.1535 0001	1990	> 365
NLNBFISGV	Iron & Steel Mills - Galvanizing	LNB + FGR	60	580	190	6.5	0.1535 0001	1990	< 365
NLNBFISRH	Iron & Steel Mills - Reheating	LNB + FGR	77	380	150	4.1	0.2439	1990	> 365
NLNBFISRH	Iron & Steel Mills - Reheating	LNB + FGR	77	380	150	4.1	0.2439	1990	< 365
NLNBFPHDO	Process Heaters - Distillate Oil	LNB + FGR	48	1680	16680	6.8	0.1098	1990	> 365
NLNBFPHDO	Process Heaters - Distillate Oil	LNB + FGR	48	4250	19540	7.1	0.1098	1990	< 365
NLNBFPHLG	Process Heaters - LPG	LNB + FGR	55	3200		7.1	0.1098	1990	> 365
NLNBFPHLG	Process Heaters - LPG	LNB + FGR	48	4200		7.1	0.1098	1990	< 365
NLNBFPHLP	Process Heaters - LPG	LNB + FGR	48	1680	16680	6.8	0.1098	1990	> 365
NLNBFPHLP	Process Heaters - LPG	LNB + FGR	48	4250	19540	7.1	0.1098	1990	< 365
NLNBFPHNG	Process Heaters - Natural Gas	LNB + FGR	55	3200	9160	6.8	0.1098	1990	> 365
NLNBFPHNG	Process Heaters - Natural Gas	LNB + FGR	55	4200	15580	6.9	0.1098	1990	< 365
NLNBFPHOF	Process Heaters - Other Fuel	LNB + FGR	34	1380	1380	6.8	0.1098	1990	> 365

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost per Ton ($/ton reduced)		Capital /Annual Cost Ratio	CRF	Cost Year ($Year)	Emissions Cutoff (tons/year)
				Default	Incremental				
NLNBFPHOF	Process Heaters - Other Fuel	LNB + FGR	34	3490	3490	7.1	0.1098	1990	< 365
NLNBFPHPG	Process Heaters - Process Gas	LNB + FGR	55	3200	9160	6.8	0.1098	1990	> 365
NLNBFPHPG	Process Heaters - Process Gas	LNB + FGR	55	4200	15580	6.9	0.1098	1990	< 365
NLNBFPHRO	Process Heaters - Residual Oil	LNB + FGR	34	1380	1380	6.8	0.1098	1990	> 365
NLNBFPHRO	Process Heaters - Residual Oil	LNB + FGR	34	3490	3490	7.1	0.1098	1990	< 365
NLNBFPPAR	Plastics Prod-Specific; (ABS) Resin	LNB + FGR	55	2470	830	6.8	0.1098	1990	> 365
NLNBFPPAR	Plastics Prod-Specific; (ABS) Resin	LNB + FGR	55	3190	1430	6.9	0.1098	1990	< 365
NLNBFSGDR	Sand/Gravel; Dryer	LNB + FGR	55	2470	830	6.8	0.1098	1990	> 365
NLNBFSGDR	Sand/Gravel; Dryer	LNB + FGR	55	3190	1430	6.9	0.1098	1990	< 365
NLNBFSHDO	Space Heaters - Distillate Oil	LNB + FGR	60	760	370	7.5	0.1424	1990	> 365
NLNBFSHDO	Space Heaters - Distillate Oil	LNB + FGR	60	2500	1090	5.9	0.1424	1990	< 365
NLNBFSHNG	Space Heaters - Natural Gas	LNB + FGR	60	590	280	7.5	0.1424	1990	> 365
NLNBFSHNG	Space Heaters - Natural Gas	LNB + FGR	60	2650	2470	5.9	0.1424	1990	< 365
NLNBFSMCO	Starch Mfg; Combined Operations	LNB + FGR	55	2470	830	6.8	0.1098	1990	> 365
NLNBFSMCO	Starch Mfg; Combined Operations	LNB + FGR	55	3190	1430	6.9	0.1098	1990	< 365
NLNBFSPRF	Sulfate Pulping - Recovery Furnaces	LNB + FGR	60	590	280	7.5	0.1424	1990	> 365
NLNBFSPRF	Sulfate Pulping - Recovery Furnaces	LNB + FGR	60	2560	2470	5.9	0.1424	1990	< 365
NLNBFSPSP	Steel Prod; Soaking Pits	LNB + FGR	60	750	250	7	0.1424	1990	> 365
NLNBFSPSP	Steel Prod; Soaking Pits	LNB + FGR	60	750	250	7	0.1424	1990	< 365
NLNBICB	ICI Boilers - Coal/ subbituminous	LNB	51	256		4.5		2003	> 365
NLNBICB	ICI Boilers - Coal/ subbituminous	LNB	51	850		4.5		2003	< 365
NLNBICISWH	ICI Space and Water Heaters	LNB	7	1230		5.5		1990	
NLNBNISAN	Iron & Steel Mills - Annealing	LNB + SNCR	80	1720	1320	3.7	0.1424	1990	> 365
NLNBNISAN	Iron & Steel Mills - Annealing	LNB + SNCR	80	1720	1320	3.7	0.1424	1990	< 365
NLNBNPHDO	Process Heaters - Distillate Oil	LNB + SNCR	78	1880	3150	5.9	0.1098	1990	> 365
NLNBNPHDO	Process Heaters - Distillate Oil	LNB + SNCR	78	3620	3830	6.5	0.1098	1990	< 365
NLNBNPHLP	Process Heaters - LPG	LNB + SNCR	78	1880	3150	5.9	0.1098	1990	> 365
NLNBNPHLP	Process Heaters - LPG	LNB + SNCR	78	3620	3830	6.5	0.1098	1990	< 365
NLNBNPHNG	Process Heaters - Natural Gas	LNB + SNCR	80	2590	3900	6.4	0.1098	1990	> 365
NLNBNPHNG	Process Heaters - Natural Gas	LNB + SNCR	80	3520	6600	6.7	0.1098	1990	< 365
NLNBNPHOF	Process Heaters - Other Fuel	LNB + SNCR	75	1240	1760	5.5	0.1098	1990	> 365
NLNBNPHOF	Process Heaters - Other Fuel	LNB + SNCR	75	2300	2080	6.4	0.1098	1990	< 365
NLNBNPHPG	Process Heaters - Process Gas	LNB + SNCR	80	2590	3900	6.4	0.1098	1990	> 365
NLNBNPHPG	Process Heaters - Process Gas	LNB + SNCR	80	3520	6600	6.7	0.1098	1990	< 365
NLNBNPHRO	Process Heaters - Distillate & Residual Oil	LNB + SNCR	75	1240	1760	5.5	0.1098	1990	> 365
NLNBNPHRO	Process Heaters - Distillate & Residual Oil	LNB + SNCR	75	2300	2080	6.4	0.1098	1990	< 365
NLNBOAICBG	ICI Boilers - Gas	LNB + Over Fire Air	60	280		2.7		2003	> 365
NLNBOAICBG	ICI Boilers - Gas	LNB + Over Fire Air	60	1052		2.7		2003	< 365
NLNBOAICBO	ICI Boilers - Oil	LNB + Over Fire Air	50	306		2.9		2003	> 365
NLNBOAICBO	ICI Boilers - Oil	LNB + Over Fire Air	30	1052		2.9		2003	< 365
NLNBOFAICB	ICI Boilers - Coal/ bituminous	LNB + Over Fire Air	51	392		3.3		2003	> 365
NLNBOFAICB	ICI Boilers - Coal/ bituminous	LNB + Over Fire Air	51	1239		3.3		2003	< 365
NLNBOFAICS	ICI Boilers - Coal/ subbituminous	LNB + Over Fire Air	65	306		3.1		2003	> 365
NLNBOFAICS	ICI Boilers - Coal/ subbituminous	LNB + Over Fire Air	65	972		3.1		2003	< 365
NLNBPHLP	Process Heaters - LPG	LNB	45	970	970	7.3	0.1098	1990	> 365
NLNBPHLP	Process Heaters - LPG	LNB	45	3470	3470	7.3	0.1098	1990	< 365
NLNBSASF	Sec Alum Prod; Smelting Furn/Reverb	LNB	50	570	570	7	0.1424	1990	> 365
NLNBSASF	Sec Alum Prod; Smelting Furn/Reverb	LNB	50	570	570	7	0.1424	1990	< 365
NLNBSISAN	Iron & Steel Mills - Annealing	LNB + SCR	90	4080	3720	5.1	0.1424	1990	> 365
NLNBSISAN	Iron & Steel Mills - Annealing	LNB + SCR	90	4080	3720	5.1	0.1424	1990	< 365
NLNBSPHDO	Process Heaters - Distillate Oil	LNB + SCR	90	8687	8687	7	0.1098	1999	
NLNBSPHLP	Process Heaters - LPG	LNB + SCR	92	9120	9430	7	0.1098	1990	> 365
NLNBSPHLP	Process Heaters - LPG	LNB + SCR	92	11500	15350	6.5	0.1098	1990	< 365
NLNBSPHNG	Process Heaters - Natural Gas	LNB + SCR	80	12378	12378	6.8	0.11	1999	> 365
NLNBSPHNG	Process Heaters - Natural Gas	LNB + SCR	90	12378	12378	6.8	0.1098	1999	< 365
NLNBSPHOF	Process Heaters - Other Fuel	LNB + SCR	91	3160	4840	7	0.1098	1990	> 365
NLNBSPHOF	Process Heaters - Other Fuel	LNB + SCR	91	5420	7680	6.6	0.1098	1990	< 365

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				Default	Incremental				
NLNBSPHPG	Process Heaters - Process Gas	LNB + SCR	90	12378	12378	6.4	0.1098	1999	> 365
NLNBSPHPG	Process Heaters - Process Gas	LNB + SCR	90	12378	12378	6.8	0.1098	1999	< 365
NLNBSPHRO	Process Heaters - Residual Oil	LNB + SCR	90	5240	5240	6.6	0.1098	1999	< 365
NLNBSPWHNG	Water Heater, Space Heater - Natural Gas	LNB	7	770				1999	
NLNBUACCP	Asphaltic Conc; Rotary Dryer; Conv Plant	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUACCP	Asphaltic Conc; Rotary Dryer; Conv Plant	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUCCAB	Conv Coating of Prod; Acid Cleaning Bath	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUCCAB	Conv Coating of Prod; Acid Cleaning Bath	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUCCFB	Coal Cleaning-Thrml Dryer; Fluidized Bed	LNB	50	200	1090	4.5	0.1424	2003	> 365
NLNBUCCFB	Coal Cleaning-Thrml Dryer; Fluidized Bed	LNB	50	1000	1460	4.5	0.1424	2003	< 365
NLNBUCCMD	Ceramic Clay Mfg; Drying	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUCCMD	Ceramic Clay Mfg; Drying	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUCHNG	Surf Coat Oper;Coating Oven Htr;Nat Gas	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUCHNG	Surf Coat Oper;Coating Oven Htr;Nat Gas	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUCMDY	Cement Manufacturing - Dry	LNB	25	440	440	5	0.1098	1997	> 365
NLNBUCMDY	Cement Manufacturing - Dry	LNB	25	440	440	5	0.1098	1997	< 365
NLNBUCMWT	Cement Manufacturing - Wet	LNB	25	440	440	5	0.1098	1997	> 365
NLNBUCMWT	Cement Manufacturing - Wet	LNB	25	440	440	5	0.1098	1997	< 365
NLNBUFFNG	Fuel Fired Equip; Furnaces; Natural Gas	LNB	50	570	570	7	0.1424	1990	> 365
NLNBUFFNG	Fuel Fired Equip; Furnaces; Natural Gas	LNB	50	570	570	7	0.1424	1990	< 365
NLNBUFMTF	Fbrglass Mfg; Txtle-Type Fbr; Recup Furn	LNB	40	1690	1690	2.2	0.3811	1990	> 365
NLNBUFMTF	Fbrglass Mfg; Txtle-Type Fbr; Recup Furn	LNB	40	1690	1690	2.2	0.3811	1990	< 365
NLNBUFRNG	Ammonia - NG-Fired Reformers	LNB	50	650	650	5.5	0.1424	1990	> 365
NLNBUFRNG	Ammonia - NG-Fired Reformers	LNB	50	820	820	5.5	0.1424	1990	< 365
NLNBUFROL	Ammonia - Oil-Fired Reformers	LNB	50	430	430	5.5	0.1424	1990	> 365
NLNBUFROL	Ammonia - Oil-Fired Reformers	LNB	50	400	400	5.5	0.1424	1990	< 365
NLNBUGMCN	Glass Manufacturing - Container	LNB	40	700	1690	2.2	0.1424	1990	> 365
NLNBUGMCN	Glass Manufacturing - Container	LNB	40	700	1690	2.2	0.1424	1990	< 365
NLNBUGMFT	Glass Manufacturing - Flat	LNB	40	700	700	2.2	0.3811	1990	> 365
NLNBUGMFT	Glass Manufacturing - Flat	LNB	40	700	700	2.2	0.3811	1990	< 365
NLNBUGMPD	Glass Manufacturing - Pressed	LNB	40	1500	1500	2.2	0.1424	1990	> 365
NLNBUGMPD	Glass Manufacturing - Pressed	LNB	40	1500	1500	2.2	0.1424	1990	< 365
NLNBUIBCK	ICI Boilers - Coke	LNB	50	1090	1090	4.5	0.1424	1990	> 365
NLNBUIBCK	ICI Boilers - Coke	LNB	50	1460	1460	4.5	0.1424	1990	< 365
NLNBUIBDO	ICI Boilers - Distillate Oil	LNB	50	2070	2070	5.5	0.1424	1990	> 365
NLNBUIBDO	ICI Boilers - Distillate Oil	LNB	50	1180	1180	5.5	0.1424	1990	< 365
NLNBUIBLP	ICI Boilers - LPG	LNB	50	2070	2070	5.5	0.1424	1990	> 365
NLNBUIBLP	ICI Boilers - LPG	LNB	50	1180	1180	5.5	0.1424	1990	< 365
NLNBUIBLW	ICI Boilers - Liquid Waste	LNB	50	430	430	5.5	0.1424	1990	> 365
NLNBUIBLW	ICI Boilers - Liquid Waste	LNB	50	400	400	5.5	0.1424	1990	< 365
NLNBUIBNG	ICI Boilers - Natural Gas	LNB	50	650	650	5.5	0.1424	1990	> 365
NLNBUIBNG	ICI Boilers - Natural Gas	LNB	50	820	820	5.5	0.1424	1990	< 365
NLNBUIBPG	ICI Boilers - Process Gas	LNB	50	650	650	5.5	0.1424	1990	> 365
NLNBUIBPG	ICI Boilers - Process Gas	LNB	50	820	820	5.5	0.1424	1990	< 365
NLNBUIBRO	ICI Boilers - Residual Oil	LNB	50	430	430	5.5	0.1424	1990	> 365
NLNBUIBRO	ICI Boilers - Residual Oil	LNB	50	400	400	5.5	0.1424	1990	< 365
NLNBUISAN	Iron & Steel Mills - Annealing	LNB	50	570	570	7	0.1424	1990	> 365
NLNBUISAN	Iron & Steel Mills - Annealing	LNB	50	570	570	7	0.1424	1990	< 365
NLNBUISGV	Iron & Steel Mills - Galvanizing	LNB	50	490	490	6.5	0.1535	1990	> 365
NLNBUISGV	Iron & Steel Mills - Galvanizing	LNB	50	490	490	6.5	0.1535	1990	< 365
NLNBUISRH	Iron & Steel Mills - Reheating	LNB	66	300	300	4.1	0.2439	1990	> 365
NLNBUISRH	Iron & Steel Mills - Reheating	LNB	66	300	300	4.1	0.2439	1990	< 365
NLNBULMKN	Lime Kilns	LNB	30	560	560	5	0.1098	1990	> 365
NLNBULMKN	Lime Kilns	LNB	30	560	560	5	0.1098	1990	< 365
NLNBUNGGN	In-Process Fuel Use; Natural Gas; Gen	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUNGGN	In-Process Fuel Use; Natural Gas; Gen	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUPGCO	In-Process; Process Gas; Coke Oven Gas	LNB	50	1800	1800	7.3	0.1098	1990	> 365

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NLNBUPGCO	In-Process; Process Gas; Coke Oven Gas	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUPHDO	Process Heaters - Distillate Oil	LNB	45	970	970	7.3	0.1098	1990	> 365
NLNBUPHDO	Process Heaters - Distillate Oil	LNB	45	3470	3470	7.3	0.1098	1990	< 365
NLNBUPHLG	Process Heaters - LPG	LNB	50	3740		2	0.1098	1990	
NLNBUPHNG	Process Heaters - Natural Gas	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUPHNG	Process Heaters - Natural Gas	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUPHOF	Process Heaters - Other Fuel	LNB	37	710	710	7.3	0.1098	1990	> 365
NLNBUPHOF	Process Heaters - Other Fuel	LNB	37	2520	2520	7.3	0.1098	1990	< 365
NLNBUPHPG	Process Heaters - Process Gas	LNB	50	1800	1800	7.3	0.1098	1990	> 365
NLNBUPHPG	Process Heaters - Process Gas	LNB	50	2200	2200	7.3	0.1098	1990	< 365
NLNBUPHRO	Process Heaters - Residual Oil	LNB	37	710	710	7.3	0.1098	1990	> 365
NLNBUPHRO	Process Heaters - Residual Oil	LNB	37	2520	2520	7.3	0.1098	1990	< 365
NLNBUROGN	In-Process Fuel Use; Residual Oil; Gen	LNB	37	710	710	7.3	0.1098	1990	> 365
NLNBUROGN	In-Process Fuel Use; Residual Oil; Gen	LNB	37	2520	2520	7.3	0.1098	1990	< 365
NLNBUSFHT	Steel Foundries; Heat Treating Furn	LNB	50	570	570	7	0.1424	1990	> 365
NLNBUSFHT	Steel Foundries; Heat Treating Furn	LNB	50	570	570	7	0.1424	1990	< 365
NLNBUSHDO	Space Heaters - Distillate Oil	LNB	50	2070	2070	5.5	0.1424	1990	> 365
NLNBUSHDO	Space Heaters - Distillate Oil	LNB	50	1180	1180	5.5	0.1424	1990	< 365
NLNBUSHNG	Space Heaters - Natural Gas	LNB	50	650	650	5.5	0.1424	1990	> 365
NLNBUSHNG	Space Heaters - Natural Gas	LNB	50	820	820	5.5	0.1424	1990	< 365
NLNBUSPRF	Sulfate Pulping - Recovery Furnaces	LNB	50	650	650	5.5	0.1424	1990	> 365
NLNBUSPRF	Sulfate Pulping - Recovery Furnaces	LNB	50	820	820	5.5	0.1424	1990	< 365
NLNCMNGC03	Commercial/Institutional - NG	LNB (1997 AQMD)	75	595				1990	
NLNCMNGC03	Commercial/Institutional - NG	LNB (1997 AQMD)	75	595				1990	
NLNCMNGC03	Commercial/Institutional - NG	LNB (1997 AQMD)	75	595				1990	
NLNCMNGC03	Commercial/Institutional - NG	LNB (1997 AQMD)	75	595				1990	
NLNCMNGC03	Commercial/Institutional - NG	LNB (1997 AQMD)	75	595				1990	
NLNCMNGC03	Commercial/Institutional - NG	LNB (1997 AQMD)	75	595				1990	
NLNRSNGC03	Residential NG	LNB (1997 AQMD)	75	595				1990	
NLNRSNGC03	Residential NG	LNB (1997 AQMD)	75	595				1990	
NLNRSNGC03	Residential NG	LNB (1997 AQMD)	75	595				1990	
NLNRSNGC03	Residential NG	LNB (1997 AQMD)	75	595				1990	
NLNRSNGC03	Residential NG	LNB (1997 AQMD)	75	595				1990	
NLNRSNGC03	Residential NG	LNB (1997 AQMD)	75	595				1990	
NMKFRCMDY	Cement Manufacturing - Dry	Mid-Kiln Firing	30	55	55	3.4	0.1098	1997	> 365
NMKFRCMDY	Cement Manufacturing - Dry	Mid-Kiln Firing	30	55	55	3.4	0.1098	1997	< 365
NMKFRCMWT	Cement Manufacturing - Wet	Mid-Kiln Firing	30	55	55	3.6	0.1098	1997	> 365
NMKFRCMWT	Cement Manufacturing - Wet	Mid-Kiln Firing	30	55	55	3.6	0.1098	1997	< 365
NNGRIBCC	ICI Boilers - Coal/Cyclone	NGR	55	300	300	2	0.0944	1990	> 365
NNGRIBCC	ICI Boilers - Coal/Cyclone	NGR	55	1570	1570	2	0.0944	1990	< 365
NNSCRNAMF	Nitric Acid Manufacturing	NSCR	98	550	550	2.4	0.1424	1990	> 365
NNSCRNAMF	Nitric Acid Manufacturing	NSCR	98	550	550	2.4	0.1424	1990	< 365
NNSCRRBGD	Rich Burn IC Engines - Gas/ Diesel/ LPG	NSCR	90	342	342	2	0.1098	1999	> 365
NNSCRRBGD	Rich Burn IC Engines - Gas/ Diesel/ LPG	NSCR	90	342	342	2	0.1098	1999	< 365
NNSCRRBIC	Rich Burn Internal Combustion Engines - Diesel	NSCR	90	342			0.1098	1990	> 365
NNSCRRBIC	Rich Burn Internal Combustion Engines - Diesel	NSCR	90	342	342	2	0.1098	1990	< 365
NNSCRRBIC2	Rich Burn Internal Combustion Engines - Nat. Gas	NSCR	90	521		3.4	0.1098	1999	
NOTWIFRNG	Ammonia - NG-Fired Reformers	OT + WI	65	320	320	2.9	0.1424	1990	> 365
NOTWIFRNG	Ammonia - NG-Fired Reformers	OT + WI	65	680	680	2.9	0.1424	1990	< 365
NOTWIIBNG	ICI Boilers - Natural Gas	OT + WI	65	320	320	2.9	0.1424	1990	> 365
NOTWIIBNG	ICI Boilers - Natural Gas	OT + WI	65	680	680	2.9	0.1424	1990	< 365
NOTWIIBPG	ICI Boilers - Process Gas	OT + WI	65	320	320	2.9	0.1424	1990	> 365
NOTWIIBPG	ICI Boilers - Process Gas	OT + WI	65	680	680	2.9	0.1424	1990	< 365
NOTWISHNG	Space Heaters - Natural Gas	OT + WI	65	320	320	2.9	0.1424	1990	> 365
NOTWISHNG	Space Heaters - Natural Gas	OT + WI	65	680	680	2.9	0.1424	1990	< 365
NOTWISPRF	Sulfate Pulping - Recovery Furnaces	OT + WI	65	320	320	2.9	0.1424	1990	> 365
NOTWISPRF	Sulfate Pulping - Recovery Furnaces	OT + WI	65	680	680	2.9	0.1424	1990	< 365

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NOXYFGMCN	Glass Manufacturing - Container	OXY-Firing	85	4590	4590	2.7	0.1424	1990	> 365
NOXYFGMCN	Glass Manufacturing - Container	OXY-Firing	85	4590	4590	2.7	0.1424	1990	< 365
NOXYFGMFT	Glass Manufacturing - Flat	OXY-Firing	85	1900	1900	2.7	0.1424	1990	> 365
NOXYFGMFT	Glass Manufacturing - Flat	OXY-Firing	85	1900	1900	2.7	0.1424	1990	< 365
NOXYFGMPD	Glass Manufacturing - Pressed	OXY-Firing	85	3900	3900	2.7	0.1424	1990	> 365
NOXYFGMPD	Glass Manufacturing - Pressed	OXY-Firing	85	3900	3900	2.7	0.1424	1990	< 365
NR25COL96	Industrial Coal Combustion	RACT to 25 tpy (LNB)	21	1350				1990	> 25
NR25NGC96	Industrial NG Combustion	RACT to 25 tpy (LNB)	31	770				1990	> 25
NR25OIL96	Industrial Oil Combustion	RACT to 25 tpy (LNB)	36	1180				1990	> 25
NR50COL96	Industrial Coal Combustion	RACT to 50 tpy (LNB)	21	1350				1990	> 50
NR50NGC96	Industrial NG Combustion	RACT to 50 tpy (LNB)	31	770				1990	> 50
NR50OIL96	Industrial Oil Combustion	RACT to 50 tpy (LNB)	36	1180				1990	> 50
NSCRCMDY	Cement Manufacturing - Dry2	SCR	80	3370	3370	4.4	0.1098	1999	> 365
NSCRCMDY	Cement Manufacturing - Dry2	SCR	80	3370	3370	4.4	0.1098	1999	< 365
NSCRFRNG	Ammonia - NG-Fired Reformers2	SCR	90	2366	2366	9.6	0.0944	1999	> 365
NSCRFRNG	Ammonia - NG-Fired Reformers2	SCR	90	2366	2366	10	0.0944	1999	< 365
NSCRFROL	Ammonia - Oil-Fired Reformers	SCR	80	810	940	9.6	0.0944	1990	> 365
NSCRFROL	Ammonia - Oil-Fired Reformers	SCR	80	1480	1910	10	0.0944	1990	< 365
NSCRGMCN	Glass Manufacturing - Container	SCR	75	2200	2200	1.8	0.1424	1990	> 365
NSCRGMCN	Glass Manufacturing - Container	SCR	75	2200	2200	1.8	0.1424	1990	< 365
NSCRGMFT	Glass Manufacturing - Flat	SCR	75	710	710	2.2	0.1424	1990	> 365
NSCRGMFT	Glass Manufacturing - Flat	SCR	75	3370	710	2.2	0.1424	1990	< 365
NSCRGMPD	Glass Manufacturing - Pressed	SCR	75	2530	2530	1.3	0.1424	1990	> 365
NSCRGMPD	Glass Manufacturing - Pressed	SCR	75	2530	2530	1.3	0.1424	1990	< 365
NSCRIBCC	ICI Boilers - Coal/Cyclone	SCR	90	700	700	6.3	0.0944	1990	> 365
NSCRIBCC	ICI Boilers - Coal/Cyclone	SCR	90	820	820	7	0.0944	1990	< 365
NSCRIBCK	ICI Boilers - Coke2	SCR	90	1610	1610	6.5	0.0944	1999	> 365
NSCRIBCK	ICI Boilers - Coke2	SCR	90	1610	1610	7.1	0.0944	1999	< 365
NSCRIBCOAL	ICI Boilers - Coal	SCR	80	876		7		2003	> 365
NSCRIBCOAL	ICI Boilers - Coal	SCR	80	2141		7		2003	< 365
NSCRIBLP	ICI Boilers - LPG2	SCR	90	2958	2958	9.6	0.0944	1999	> 365
NSCRIBLP	ICI Boilers - LPG2	SCR	90	2958	2958	10	0.0944	1999	< 365
NSCRIBLW	ICI Boilers - Liquid Waste2	SCR	90	1568	1568	9.6	0.0944	1999	> 365
NSCRIBLW	ICI Boilers - Liquid Waste2	SCR	90	1568	1568	10	0.0944	1999	< 365
NSCRIBPG	ICI Boilers - Process Gas2	SCR	90	2366	2366	9.6	0.0944	1999	> 365
NSCRIBPG	ICI Boilers - Process Gas2	SCR	90	2366	2366	10	0.0944	1999	< 365
NSCRICBG	ICI Boilers - Gas	SCR	80	986		7		2003	> 365
NSCRICBG	ICI Boilers - Gas	SCR	80	2933		7		2003	< 365
NSCRICBO	ICI Boilers - Oil	SCR	80	760		7		2003	> 365
NSCRICBO	ICI Boilers - Oil	SCR	80	2014		7		2003	< 365
NSCRICGD	IC Engines - Gas/ Diesel/ LPG	SCR	80	920	920	2.2	0.1098	1990	> 365
NSCRICGD	IC Engines - Gas/ Diesel/ LPG	SCR	80	2340	2340	1.8	0.1098	1990	< 365
NSCRICGS	Internal Combustion Engines - Gas	SCR	90	2769		7		1990	
NSCRICOL	Internal Combustion Engines - Oil	SCR	80	920	920	2.2	0.1098	1990	> 365
NSCRICOL	Internal Combustion Engines - Oil	SCR	80	2340	2340	1.8	0.1098	1990	< 365
NSCRISAN	Iron & Steel Mills - Annealing2	SCR	90	5296	5296	5	0.1424	1999	> 365
NSCRISAN	Iron & Steel Mills - Annealing2	SCR	99	5296	5296	5	0.1424	1999	< 365
NSCRNAMF	Nitric Acid Manufacturing2	SCR	90	812	812	2.5	0.1424	1999	> 365
NSCRNAMF	Nitric Acid Manufacturing2	SCR	90	812	812	2.5	0.1424	1999	< 365
NSCRNGCP	Natural Gas Prod; Compressors	SCR	20	533			0.1098	1990	> 365
NSCRNGCP	Natural Gas Prod; Compressors	SCR	20	2769			0.1098	1990	< 365
NSCRPHDO	Process Heaters - Distillate Oil	SCR	75	6030	6030	7	0.1098	1990	> 365
NSCRPHDO	Process Heaters - Distillate Oil	SCR	75	9230	9230	6.4	0.1098	1990	< 365
NSCRPHLP	Process Heaters - LPG	SCR	75	5350	6030	7	0.1098	1990	> 365
NSCRPHLP	Process Heaters - LPG	SCR	75	12040	9230	6.4	0.1098	1990	< 365
NSCRPHNG	Process Heaters - Natural Gas	SCR	75	8160	8160	6.3	0.1098	1990	> 365
NSCRPHNG	Process Heaters - Natural Gas	SCR	75	12040	12040	6.7	0.1098	1990	< 365

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost per Ton ($/ton reduced)		Capital /Annual Cost Ratio	CRF	Cost Year ($Year)	Emissions Cutoff (tons/year)
				Default	Incremental				
NSCRPHOF	Process Heaters - Other Fuel	SCR	75	3590	3590	6.9	0.1098	1990	> 365
NSCRPHOF	Process Heaters - Other Fuel	SCR	75	5350	5350	6.5	0.1098	1990	< 365
NSCRPHPG	Process Heaters - Process Gas	SCR	75	8160	8160	6.3	0.1098	1990	> 365
NSCRPHPG	Process Heaters - Process Gas	SCR	75	12040	12040	6.7	0.1098	1990	< 365
NSCRPHRO	Process Heaters - Residual Oil	SCR	75	3590	3590	6.9	0.1098	1990	> 365
NSCRPHRO	Process Heaters - Residual Oil	SCR	75	5350	5350	6.5	0.1098	1990	< 365
NSCRRICOIL	Reciprocating IC Engines - Oil	SCR	80	1066		7		1993	
NSCRSHDO	Space Heaters - Distillate Oil	SCR	80	1510	1750	9.6	0.0944	1990	> 365
NSCRSHDO	Space Heaters - Distillate Oil	SCR	80	2780	3570	10	0.0944	1990	< 365
NSCRSHNG	Space Heaters - Natural Gas	SCR	80	1210	1410	9.6	0.0944	1990	> 365
NSCRSHNG	Space Heaters - Natural Gas	SCR	80	2860	2860	10	0.0944	1990	< 365
NSCRSPRF	Sulfate Pulping - Recovery Furnaces2	SCR	90	2366	2366	9.6	0.0944	1999	> 365
NSCRSPRF	Sulfate Pulping - Recovery Furnaces2	SCR	90	2366	2366	10	0.0944	1999	< 365
NSCRWGTJF	Gas Turbines - Jet Fuel	SCR + Water Injecti	90	1010	2280	2.3	0.1098	1990	> 365
NSCRWGTJF	Gas Turbines - Jet Fuel	SCR + Water Injecti	90	2300	7850	2.8	0.1098	1990	< 365
NSNCNCMDY	Cement Manufacturing - Dry	SNCR - NH3 Based	50	850	850	3.3	0.1098	1990	> 365
NSNCNCMDY	Cement Manufacturing - Dry	SNCR - NH3 Based	50	850	850	3.3	0.1098	1990	< 365
NSNCRBCCK	In-Process; Bituminous Coal; Cement Kiln	SNCR - urea based	50	770	770	1.6	0.1098	1999	> 365
NSNCRBCCK	In-Process; Bituminous Coal; Cement Kiln	SNCR - urea based	50	770	770	1.6	0.1098	1999	< 365
NSNCRBCGN	In-Process Fuel Use;Bituminous Coal; Gen	SNCR	40	940	940	1.2	0.0944	1990	> 365
NSNCRBCGN	In-Process Fuel Use;Bituminous Coal; Gen	SNCR	40	1260	1260	1.2	0.0944	1990	< 365
NSNCRBCLK	In-Process; Bituminous Coal; Lime Kiln	SNCR - urea based	50	770	770	1.6	0.1098	1990	> 365
NSNCRBCLK	In-Process; Bituminous Coal; Lime Kiln	SNCR - urea based	50	770	770	1.6	0.1098	1990	< 365
NSNCRCIIN	Comm./Inst. Incinerators	SNCR	45	1130	1130	4.1	0.0944	1990	> 365
NSNCRCIIN	Comm./Inst. Incinerators	SNCR	45	1130	1130	4.1	0.0944	1990	< 365
NSNCRCMDY	Cement Manufacturing - Dry	SNCR - Urea Based	50	770	770	2.1	0.1098	1990	> 365
NSNCRCMDY	Cement Manufacturing - Dry	SNCR - Urea Based	50	770	770	2.1	0.1098	1990	< 365
NSNCRCMOU	By-Product Coke Mfg; Oven Underfiring	SNCR	60	1640	1640	2.7	0.1424	1990	> 365
NSNCRCMOU	By-Product Coke Mfg; Oven Underfiring	SNCR	60	1640	1640	2.7	0.1424	1990	< 365
NSNCRFRNG	Ammonia - NG-Fired Reformers	SNCR	50	1570	840	8.2	0.0944	1990	> 365
NSNCRFRNG	Ammonia - NG-Fired Reformers	SNCR	50	3870	2900	9.4	0.0944	1990	< 365
NSNCRFROL	Ammonia - Oil-Fired Reformers	SNCR	50	1050	560	8.2	0.0944	1990	> 365
NSNCRFROL	Ammonia - Oil-Fired Reformers	SNCR	50	2580	1940	9.4	0.0944	1990	< 365
NSNCRGMCN	Glass Manufacturing - Container	SNCR	40	1770	1770	2.4	0.1424	1990	> 365
NSNCRGMCN	Glass Manufacturing - Container	SNCR	40	1770	1770	2.4	0.1424	1990	< 365
NSNCRGMFT	Glass Manufacturing - Flat	SNCR	40	740	740	2.4	0.1424	1990	> 365
NSNCRGMFT	Glass Manufacturing - Flat	SNCR	40	740	740	2.4	0.1424	1990	< 365
NSNCRGMPD	Glass Manufacturing - Pressed	SNCR	40	1640	1640	2.4	0.1424	1990	> 365
NSNCRGMPD	Glass Manufacturing - Pressed	SNCR	40	1640	1640	2.4	0.1424	1990	< 365
NSNCRIBC	ICI Boilers - Coal	SNCR	40	1285		5.8		2003	> 365
NSNCRIBC	ICI Boilers - Coal	SNCR	40	2073		5.8		2003	< 365
NSNCRIBCC	ICI Boilers - Coal/Cyclone	SNCR	35	700	700	6.4	0.0944	1990	> 365
NSNCRIBCC	ICI Boilers - Coal/Cyclone	SNCR	35	840	840	7.5	0.0944	1990	< 365
NSNCRIBCK	ICI Boilers - Coke	SNCR	40	840	260	6.6	0.0944	1990	> 365
NSNCRIBCK	ICI Boilers - Coke	SNCR	40	1040	400	7.7	0.0944	1990	< 365
NSNCRIBGA	ICI Boilers - Bagasse	SNCR - Urea	55	930	930	6.8	0.0944	1990	> 365
NSNCRIBGA	ICI Boilers - Bagasse	SNCR - Urea	55	1440	1440	6.3	0.0944	1990	< 365
NSNCRIBLP	ICI Boilers - LPG	SNCR	50	1890	1010	8.2	0.0944	1990	> 365
NSNCRIBLP	ICI Boilers - LPG	SNCR	50	4640	3470	9.4	0.0944	1990	< 365
NSNCRIBLW	ICI Boilers - Liquid Waste	SNCR	50	1050	560	8.2	0.0944	1990	> 365
NSNCRIBLW	ICI Boilers - Liquid Waste	SNCR	50	2580	1940	9.4	0.0944	1990	< 365
NSNCRIBMS	ICI Boilers - MSW/Stoker	SNCR - Urea	55	1250	1250	6.2	0.0944	1990	> 365
NSNCRIBMS	ICI Boilers - MSW/Stoker	SNCR - Urea	55	1690	1690	6.8	0.0944	1990	< 365
NSNCRICBG	ICI Boilers - Gas	SNCR	40	280		5.2		2003	> 365
NSNCRICBG	ICI Boilers - Gas	SNCR	40	1052		5.2		2003	< 365
NSNCRICBO	ICI Boilers - Oil	SNCR	40	1485		5.5		2003	> 365
NSNCRICBO	ICI Boilers - Oil	SNCR	40	2367		5.5		2003	< 365

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost per Ton ($/ton reduced)		Capital /Annual Cost Ratio	CRF	Cost Year ($Year)	Emissions Cutoff (tons/year)
				Default	Incremental				
NSNCRICGS	Internal Combustion Engines - Gas	SNCR	90	521		4.4	0.1098	1990	
NSNCRIDIN	Indust. Incinerators	SNCR	45	1130	1130	4.1	0.0944	1990	> 365
NSNCRIDIN	Indust. Incinerators	SNCR	45	1130	1130	4.1	0.0944	1990	< 365
NSNCRINGI4	Industrial NG ICE, 4cycle (rich)	SNCR	90	422				1999	
NSNCRISAN	Iron & Steel Mills - Annealing	SNCR	60	1640	1640	2.7	0.1424	1990	> 365
NSNCRISAN	Iron & Steel Mills - Annealing	SNCR	60	1640	1640	2.7	0.1424	1990	< 365
NSNCRMWCB	Municipal Waste Combustors	SNCR	45	1130	1130	4.1	0.0944	1990	> 365
NSNCRMWCB	Municipal Waste Combustors	SNCR	45	1130	1130	4.1	0.0944	1990	< 365
NSNCRMWIN	Medical Waste Incinerators	SNCR	45	4510	4510	4.1	0.0944	1990	> 365
NSNCRMWIN	Medical Waste Incinerators	SNCR	45	4510	4510	4.1	0.0944	1990	< 365
NSNCRPHDO	Process Heaters - Distillate Oil	SNCR	60	1720	1720	5.2	0.1098	1990	> 365
NSNCRPHDO	Process Heaters - Distillate Oil	SNCR	60	3180	3180	6.2	0.1098	1990	< 365
NSNCRPHLP	Process Heaters - LPG	SNCR	60	1720	1720	5.2	0.1098	1990	> 365
NSNCRPHLP	Process Heaters - LPG	SNCR	60	3180	3180	6.2	0.1098	1990	< 365
NSNCRPHNG	Process Heaters - Natural Gas	SNCR	60	1950	1950	5.7	0.1098	1990	> 365
NSNCRPHNG	Process Heaters - Natural Gas	SNCR	60	2850	2850	6.4	0.1098	1990	< 365
NSNCRPHOF	Process Heaters - Other Fuel	SNCR	60	1100	1100	4.8	0.1098	1990	> 365
NSNCRPHOF	Process Heaters - Other Fuel	SNCR	60	1930	1930	6	0.1098	1990	< 365
NSNCRPHPG	Process Heaters - Process Gas	SNCR	60	1950	1950	5.7	0.1098	1990	> 365
NSNCRPHPG	Process Heaters - Process Gas	SNCR	60	2850	2850	6.4	0.1098	1990	< 365
NSNCRPHRO	Process Heaters - Residual Oil	SNCR	60	1100	1100	4.8	0.1098	1990	> 365
NSNCRPHRO	Process Heaters - Residual Oil	SNCR	60	1930	1930	6	0.1098	1990	< 365
NSNCRSHDO	Space Heaters - Distillate Oil	SNCR	50	1890	1010	8.2	0.0944	1990	> 365
NSNCRSHDO	Space Heaters - Distillate Oil	SNCR	50	4640	3470	9.4	0.0944	1990	< 365
NSNCRSHNG	Space Heaters - Natural Gas	SNCR	50	1570	840	8.2	0.0944	1990	> 365
NSNCRSHNG	Space Heaters - Natural Gas	SNCR	50	3870	2900	9.4	0.0944	1990	< 365
NSNCRSPRF	Sulfate Pulping - Recovery Furnaces	SNCR	50	1570	840	8.2	0.0944	1990	> 365
NSNCRSPRF	Sulfate Pulping - Recovery Furnaces	SNCR	50	3870	2900	9.4	0.0944	1990	< 365
NSNCRSWIN	Solid Waste Disp;Gov;Other Incin;Sludge	SNCR	45	1130	1130	4.1	0.0944	1990	> 365
NSNCRSWIN	Solid Waste Disp;Gov;Other Incin;Sludge	SNCR	45	1130	1130	4.1	0.0944	1990	< 365
NTHRDADMF	Adipic Acid Manufacturing	Thermal Reduction	81	420	420	2.3	0.1424	1990	> 365
NTHRDADMF	Adipic Acid Manufacturing	Thermal Reduction	81	420	420	2.3	0.1424	1990	< 365
NULNBPHDO	Process Heaters - Distillate Oil	ULNB	74	610	610	7.3	0.1098	1990	> 365
NULNBPHDO	Process Heaters - Distillate Oil	ULNB	74	2140	2140	7.3	0.1098	1990	< 365
NULNBPHLP	Process Heaters - LPG	ULNB	74	610	610	7.3	0.1098	1990	> 365
NULNBPHLP	Process Heaters - LPG	ULNB	74	2140	2140	7.3	0.1098	1990	< 365
NULNBPHNG	Process Heaters - Natural Gas	ULNB	75	1200	1200	7.3	0.1098	1990	> 365
NULNBPHNG	Process Heaters - Natural Gas	ULNB	75	1500	1500	7.3	0.1098	1990	< 365
NULNBPHOF	Process Heaters - Other Fuel	ULNB	73	360	360	7.3	0.1098	1990	> 365
NULNBPHOF	Process Heaters - Other Fuel	ULNB	73	1290	1290	7.3	0.1098	1990	< 365
NULNBPHPG	Process Heaters - Process Gas	ULNB	75	1200	1200	7.3	0.1098	1990	> 365
NULNBPHPG	Process Heaters - Process Gas	ULNB	75	1500	1500	7.3	0.1098	1990	< 365
NULNBPHRO	Process Heaters - Residual Oil	ULNB	73	360	360	7.3	0.1098	1990	> 365
NULNBPHRO	Process Heaters - Residual Oil	ULNB	73	1290	1290	7.3	0.1098	1990	< 365
NWHCMNGC99	Commercial/Institutional - NG	Water heater replacement	28	0				1990	
NWHCMNGC99	Commercial/Institutional - NG	Water heater replacement	35	0				1990	
NWHCMNGC99	Commercial/Institutional - NG	Water heater replacement	38	0				1990	
NWHCMNGC99	Commercial/Institutional - NG	Water heater replacement	10	0				1990	
NWHCMNGC99	Commercial/Institutional - NG	Water heater replacement	45	0				1990	
NWHCMNGC99	Commercial/Institutional - NG	Water heater replacement	7	0				1990	
NWHRSNGC99	Residential NG	Water heater replacement	38	0				1990	
NWHRSNGC99	Residential NG	Water heater replacement	45	0				1990	
NWHRSNGC99	Residential NG	Water heater replacement	35	0				1990	
NWHRSNGC99	Residential NG	Water heater replacement	28	0				1990	
NWHRSNGC99	Residential NG	Water heater replacement	7	0				1990	
NWHRSNGC99	Residential NG	Water heater replacement	10	0				1990	
NWIGTAGT	Gas Turbines	Water Injection	40	44000		2.8		2005	

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost per Ton ($/ton reduced)		Capital /Annual Cost Ratio	CRF	Cost Year ($Year)	Emissions Cutoff (tons/year)
				Default	Incremental				
NWLCMNGC99	Commercial/Institutional - NG	Water heater + LNB Space heaters	7	1230				1990	
NWLCMNGC99	Commercial/Institutional - NG	Water heater + LNB Space heaters	44	1230				1990	
NWLCMNGC99	Commercial/Institutional - NG	Water heater + LNB Space heaters	38	1230				1990	
NWLCMNGC99	Commercial/Institutional - NG	Water heater + LNB Space heaters	34	1230				1990	
NWLCMNGC99	Commercial/Institutional - NG	Water heater + LNB Space heaters	17	1230				1990	
NWLCMNGC99	Commercial/Institutional - NG	Water heater + LNB Space heaters	27	1230				1990	
NWLRSNGC99	Residential NG	Water heater + LNB Space heaters	17	1230				1990	
NWLRSNGC99	Residential NG	Water heater + LNB Space heaters	27	1230				1990	
NWLRSNGC99	Residential NG	Water heater + LNB Space heaters	34	1230				1990	
NWLRSNGC99	Residential NG	Water heater + LNB Space heaters	38	1230				1990	
NWLRSNGC99	Residential NG	Water heater + LNB Space heaters	44	1230				1990	
NWLRSNGC99	Residential NG	Water heater + LNB Space heaters	7	1230				1990	
NWTINGTJF	Gas Turbines - Jet Fuel	Water Injection	68	650	650	1.6	0.1098	1990	> 365
NWTINGTJF	Gas Turbines - Jet Fuel	Water Injection	68	1290	1290	2.9	0.1098	1990	< 365

2.2 IPM Sector (ptipm) NO_x Control Cost Equations

Please Note: CoST currently does not apply equation Type 1, improvements are planned to incorporate newer equations from IPM and update this equation type.

IPM sector (ptipm) point sources utilizing control measure cost equations for NO_x emission reductions are calculated using Equation Type 1. In this type of equation, model plant capacities are used along with scaling factors and the emission inventory's unit-specific boiler characteristics (boiler capacity, stack parameters) to generate a control cost for an applied technology. Default cost per ton reduced values are not considered in the application of NO_x control measures to ptipm point sources.

This applied equation type involves the application of a scaling factor to adjust the capital cost associated with a control measure to the boiler size (MW). As noted in Table 3, a scaling factor model plant size and exponent are provided for this estimate.

For SCR control measures installed on coal fired ptipm boilers, a scaling factor is applied when the emission inventory source size is less than 500MW. If the unit is greater than or equal to the 500MW threshold, the scaling factor is set to unity (1.0). For other boiler-fuel combinations, the scaling factor is calculated and applied when the inventory boiler size is less than 500MW.

The capital cost associated with these NO_x control measures is then a straightforward calculation of the capital cost multiplier, the unit's boiler capacity (in MW), and the scaling factor (when appropriate).

The fixed O&M component is also based on the unit's capacity while the variable O&M includes an additional estimate for the unit's capacity factor. This factor is the unit's efficiency rating based on existing utilization and operation. A value of 1.00 would represent a completely efficient operation with no losses of production due to heat loss or other factors. A pre-calculated capacity utilization factor of 85% is used for the following utility boiler control measures; LNB, LNBO, LNC1, LNC2, and LNC3. A pre-calculated capacity utilization factor of 85% is used for the following utility boiler control measures; SCR, SNCR, and NGR.

The annualized cost is then estimated using the unit's capital cost times the CRF (derived with the equipment specific interest rate and lifetime expectancy) and the sum of the fixed and variable O&M costs. All of the cost data for ptipm sources is originally from version 3.0 of the Integrated Planning Model (IPM), a model used by EPA's Clean Air Markets Division to estimate the costs of control strategies applied to electric utilities.

2.2.1 Equation Type 1 for NO_x

2.2.1.1 Capital Cost Equations

$$Scaling\ Factor = \left(\frac{Scaling\ Factor\ Model\ Size}{Capacity}\right)^{Scaling\ Factor\ Exponent}$$

where *Scaling Factor Model Size* (the boiler capacity in MW of the model plant) and *Scaling Factor Exponent* are control measure specific; *Capacity* is the boiler capacity in MW obtained from the inventory being processed.

$$Capital\ Cost = Capital\ Cost\ Multiplier\ \times Capacity\ \times Scaling\ Factor\ \times 1{,}000$$

where the *Capital Cost Multiplier* is control measure specific and *Capacity* is obtained from the inventory being processed.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

2.2.1.2 Operation and Maintenance Cost Equations

$$Fixed\ O\&M = Fixed\ O\&M\ Cost\ Multiplier\ \times Capacity\ \times 1{,}000$$

where *Fixed O&M Cost Multiplier* is control measure specific and *Capacity* is specific to each point source and obtained from the emissions inventory being processed.

$$Variable\ O\&M = Variable\ O\&M\ Cost\ Multiplier\ \times Capacity \times Capacity\ Factor\ \times\ 8{,}760$$

where *Variable O&M Cost Multiplier* and *Capacity Factor* are control measure specific, *Capacity* is obtained from the inventory being processed and 8,760 is the number of hours of operation assumed per year.

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$

2.2.1.3 Total Annualized Cost Equation

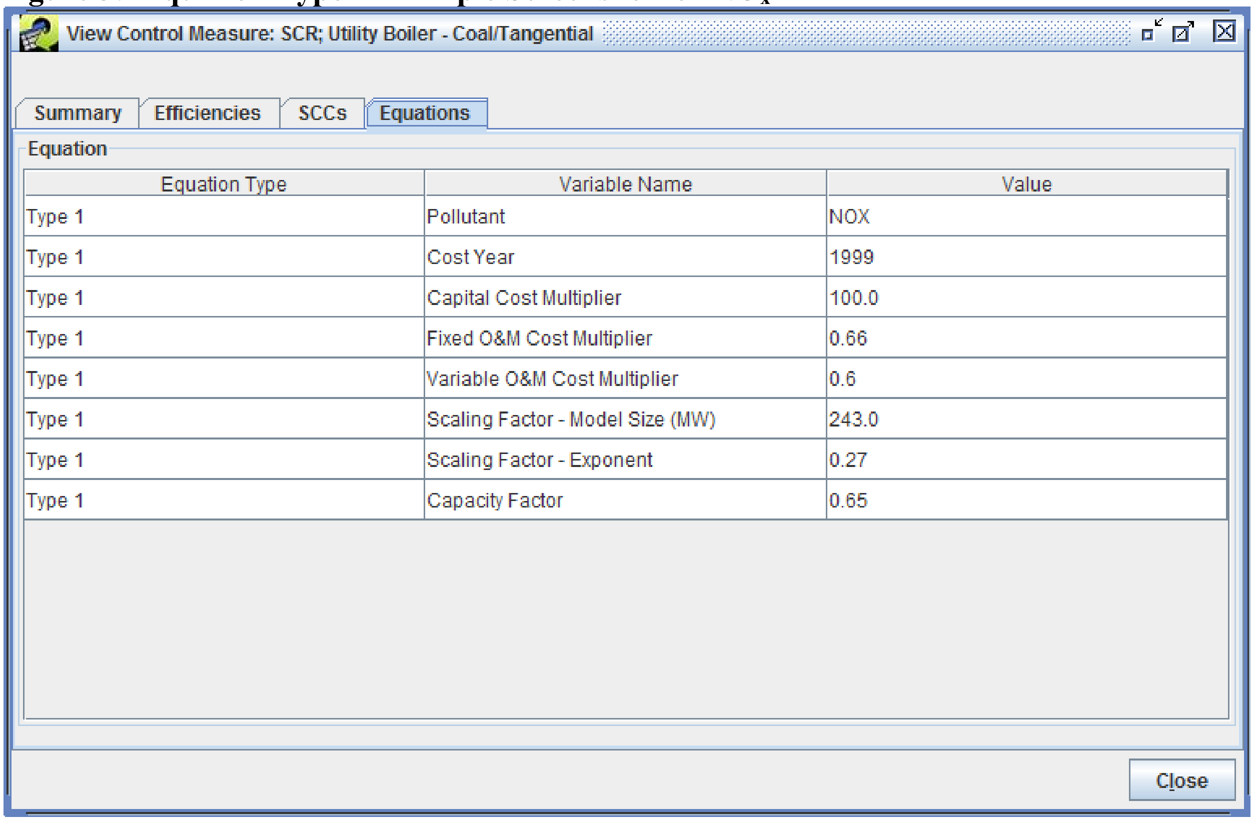
$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

2.2.2 Equation Type 1 Example for NO_x

2.2.2.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 20 years (from summary tab of control measure data)
Capacity = 182.298 MW

Figure 3: Equation Type 1 Example Screenshot for NO_x



Equation Type	Variable Name	Value
Type 1	Pollutant	NOX
Type 1	Cost Year	1999
Type 1	Capital Cost Multiplier	100.0
Type 1	Fixed O&M Cost Multiplier	0.66
Type 1	Variable O&M Cost Multiplier	0.6
Type 1	Scaling Factor - Model Size (MW)	243.0
Type 1	Scaling Factor - Exponent	0.27
Type 1	Capacity Factor	0.65

2.2.2.2 Annualized Capital Cost

$$Scaling\ Factor = \left(\frac{Scaling\ Factor\ Model\ Size}{Capacity}\right)^{Scaling\ Factor\ Exponent}$$

$$Scaling\ Factor = \left(\frac{243.0}{182.298}\right)^{0.27}$$

$$Scaling\ Factor = 1.081$$

$$Capital\ Cost = Capital\ Cost\ Multiplier \times Capacity \times Scaling\ Factor \times 1{,}000$$

$$Capital\ Cost = 100\,\frac{\$}{kW} \times 182.298\ MW \times 1.081 \times 1{,}000\,\frac{kW}{MW}$$

$$Capital\ Cost = \$19{,}700{,}828\ (1999\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life} - 1}$$

$$Capital\ Recovery\ Factor = \frac{0.07 \times (1 + 0.07)^{20\ years}}{(1 + 0.07)^{20\ years} - 1}$$

$$Capital\ Recovery\ Factor = 0.094393$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$19{,}700{,}828 \times 0.094393$$

$$Annualized\ Capital\ Cost = \$1{,}859{,}620\ (1999\$)$$

2.2.2.3 Operation and Maintenance Cost

$$Fixed\ O\&M = Fixed\ O\&M\ Cost\ Multiplier\ \times Capacity\ \times 1{,}000$$
$$Fixed\ O\&M = 0.66\frac{\$}{kW} \times 182.298\ MW \times 1{,}000\frac{kW}{MW}$$
$$Fixed\ O\&M = \$120{,}317$$

$$Variable\ O\&M = Variable\ O\&M\ Cost\ Multiplier\ \left(\frac{\$}{MWh}\right) \times Capacity\ (MW) \times Capacity\ Factor\ \times 8{,}760\ (Hours\ Per\ Year)$$
$$Variable\ O\&M = 0.6\frac{\$}{MWh} \times 182.298\ MW \times 0.65 \times 8{,}760\ Hours$$
$$Variable\ O\&M = \$622{,}803$$

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$
$$O\&M\ Cost = \$120{,}317 + \$622{,}803$$
$$O\&M\ Cost = \$743{,}130\ (1999\$)$$

2.2.2.4 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$1{,}859{,}620 + \$743{,}130\ (1999\$)$$
$$Total\ Annualized\ Cost = \$2{,}602{,}750\ (1999\$)$$

2.2.3 Equation Type 1 CoST code for NO_x

Please Note: CoST currently does not apply equation Type 1, improvements are planned to incorporate newer equations from IPM and update this equation type.

Table 3. IPM Sector NO_x Control Cost Equation Parameters (Equation Type 1)

CoST CMAbbreviation	Source Group	Control Technology	CE	Capital Cost Multiplier	O&M Cost Multiplier Fixed	O&M Cost Multiplier Variable	Scaling Factor Model Size (MW)	Scaling Factor Exponent	Capacity Factor	Interest Rate	Equipment Life	Cost Year ($ Year)
NLNBOUBCW	Utility Boiler - Coal/Wall	LNBO	55.9	23.4	0.36	0.07	300	0.36	0.85	7	15	1999
NLNBOUBCW2	Utility Boiler - Coal/Wall2	LNBO	55.3	23.4	0.36	0.07	300	0.36	0.85	7	15	1999
NLNBUUBCW	Utility Boiler - Coal/Wall	LNB	41	17.3	0.26	0.05	300	0.36	0.85	7	15	1999
NLNBUUBCW2	Utility Boiler - Coal/Wall2	LNB	40.3	17.3	0.26	0.05	300	0.36	0.85	7	15	1999
NLNC1UBCT	Utility Boiler - Coal/Tangential	LNC1	33.1	9.1	0.14	0	300	0.36	0.85	7	15	1999
NLNC1UBCT2	Utility Boiler - Coal/Tangential1	LNC1	43.3	9.1	0.14	0	300	0.36	0.85	7	15	1999
NLNC2UBCT	Utility Boiler - Coal/Tangential	LNC2	12.71	12.7	0.19	0.02	300	0.36	0.85	7	15	1999
NLNC2UBCT2	Utility Boiler - Coal/Tangential2	LNC2	48.3	12.7	0.19	0.02	300	0.36	0.85	7	15	1999
NLNC3UBCT	Utility Boiler - Coal/Tangential	LNC3	53.1	14.5	0.22	0.02	300	0.36	0.85	7	15	1999
NLNC3UBCT2	Utility Boiler - Coal/Tangential3	LNC3	58.3	14.5	0.22	0.02	300	0.36	0.85	7	15	1999
NNGR_UBCT	Utility Boiler - Coal/Tangential	NGR	50	26.9	0.41	0	200	0.35	0.65	7	20	1990
NNGR_UBCW	Utility Boiler - Coal/Wall	NGR	50	26.9	0.41	0	200	0.35	0.65	7	20	1990
NNGR_UBCY	Utility Boiler - Cyclone	NGR	50	26.9	0.41	0	200	0.35	0.65	7	20	1990
NNGR_UBOT	Utility Boiler - Oil-Gas/Tangential	NGR	50	16.4	0.25	0.02	200	0.35	0.65	7	20	1990
NNGR_UBOW	Utility Boiler - Oil-Gas/Wall	NGR	50	16.4	0.25	0.02	200	0.35	0.65	7	20	1990
NSCR_UBCT*	Utility Boiler - Coal/Tangential	SCR	90	100	0.66	0.6	243	0.27	0.65	7	20	1999
NSCR_UBCW*	Utility Boiler - Coal/Wall	SCR	90	100	0.66	0.6	243	0.27	0.65	7	20	1999
NSCR_UBCY	Utility Boiler - Cyclone	SCR	90	90	0.53	0.37	200	0.35	0.65	7	20	1999
NSCR_UBOT	Utility Boiler - Oil-Gas/Tangential	SCR	80	23.3	0.72	0.08	200	0.35	0.65	7	20	1990
NSCR_UBOW	Utility Boiler - Oil-Gas/Wall	SCR	80	23.3	0.72	0.08	200	0.35	0.65	7	20	1990
NSNCRUBCT	Utility Boiler - Coal/Tangential	SNCR	35	15.8	0.24	0.73	100	0.68	0.65	7	20	1990
NSNCRUBCW	Utility Boiler - Coal/Wall	SNCR	35	15.8	0.24	0.73	100	0.68	0.65	7	20	1990
NSNCRUBCY	Utility Boiler - Cyclone	SNCR	35	8	0.12	1.05	100	0.58	0.65	7	20	1990
NSNCRUBOT	Utility Boiler - Oil-Gas/Tangential	SNCR	50	7.8	0.12	0.37	200	0.58	0.65	7	20	1990
NSNCRUBOW	Utility Boiler - Oil-Gas/Wall	SNCR	50	7.8	0.12	0.37	200	0.58	0.65	7	20	1990

* Represents measures that use a scaling factor for units < 600 MW. All other measures use a scaling factor for units <500 MW.

3 SO_2 Control Cost Equations

3.1 Non-IPM Sector (ptnonipm) SO_2 Control Cost Equations

Ptnonipm point sources utilizing control cost equations for SO_2 emission reductions are represented by Equation Types 3 through 7 and 11 and vary by control measure. Each equation uses the source's stack flow rate (in ft^3/min) as the primary variable to estimate cost. For a select set of SO_2 controls, boiler capacity (in mmBTU/hr) is used to assign a default cost per ton reduced which is used to derive the unit's control cost. Cost equations and default cost per ton reduced are taken from the original Alternative Control Technology, Control Technology Guidelines (ACT/CTG), or other EPA analyses used to derive these estimates. Table 4 provides a list of the control cost equations assigned to various ptnonipm control measures

If the unit already has some SO_2 control measure applied in the input inventory, incremental controls are applied only if their control efficiency value exceeds that of the input control. Control costs do not differ in these cases and the costs associated with incremental controls are the same as those applied on uncontrolled sources. This update is currently being coded and will be included in a June 2010 release.

An additional list of control measures are assigned to SO_2 reductions but involve the application of default cost per ton measures to estimate the costs assigned with each control measure. These measures and their cost per ton reduced values (some based on boiler capacity size bins) are presented in Table 5. For the controls that have cost per ton reduced values based on boiler capacity size bins, they will use Equation Type 11 to estimate costs. The controls listed in Table 5 use the Equation Type 11 for estimating costs. A capital to annual cost ratio is applied to estimate the capital cost associated with the control. The O&M costs are calculated by subtracting the capital cost × CRF from the total annualized cost.

3.1.1 Equation Type 3

3.1.1.1 Annualized Capital Costs for Flowrate ≥ 1,028,000 acfm

$$Capital\ Cost = Retrofit\ Factor \times Gas\ Flowrate\ Factor \times Capital\ Cost\ Factor\ \times STKFLOW \times 60$$

where $Gas\ Flow\ rate\ Factor = 0.486$ kW/acfm, $Capital\ Cost\ Factor = \$192/\text{kW}$, $STKFLOW$ is obtained from the emissions inventory (ft^3/s), and 60 is a conversion factor to convert $STKFLOW$ to ft^3/min.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where $Interest\ Rate$ default value is 7.0%, but can be varied by user, and $Equipment\ Life$ is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.1.1.2 Annualized Capital Costs for Flowrate < 1,028,000 acfm

$$Capital\ Cost = \left(\frac{1{,}028{,}000}{Flowrate}\right)^{0.6} \times Retrofit\ Factor \times Gas\ Flow\ Rate\ Factor \times Capital\ Cost\ Factor\ \times STKFLOW \times 60$$

where *Gas Flow Rate Factor* = 0.486 kW/acfm, *Capital Cost Factor* = $192/kW, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.1.1.3 Operation and Maintenance Cost

$$Fixed\ O\&M = Gas\ Flow\ Rate\ Factor\ \times Fixed\ O\&M\ Rate$$

where *Gas Flow Rate Factor* = 0.486 kW/acfm and *Fixed O&M Rate* = $6.9/kW-yr.

$$Variable\ O\&M = Gas\ Flow\ Rate\ Factor \times Variable\ O\&M\ Rate \times Hours\ per\ Year \times STKFLOW \times 60$$

where *Gas Flow Rate Factor* = 0.486 kW/acfs; *Variable O&M Rate* = $0.0015/kWh; *Hours per Year* = 8,736 hours, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$

3.1.1.4 Total Annualized Cost

The following equation applies whether the annualized capital cost is calculated based on the standard (≤1,028,000 acfm) or large (>1,028,000 acfm) size:

$$Total\ Annualized\ Cost = Annualized\ Captial\ Cost + O\&M\ Cost$$

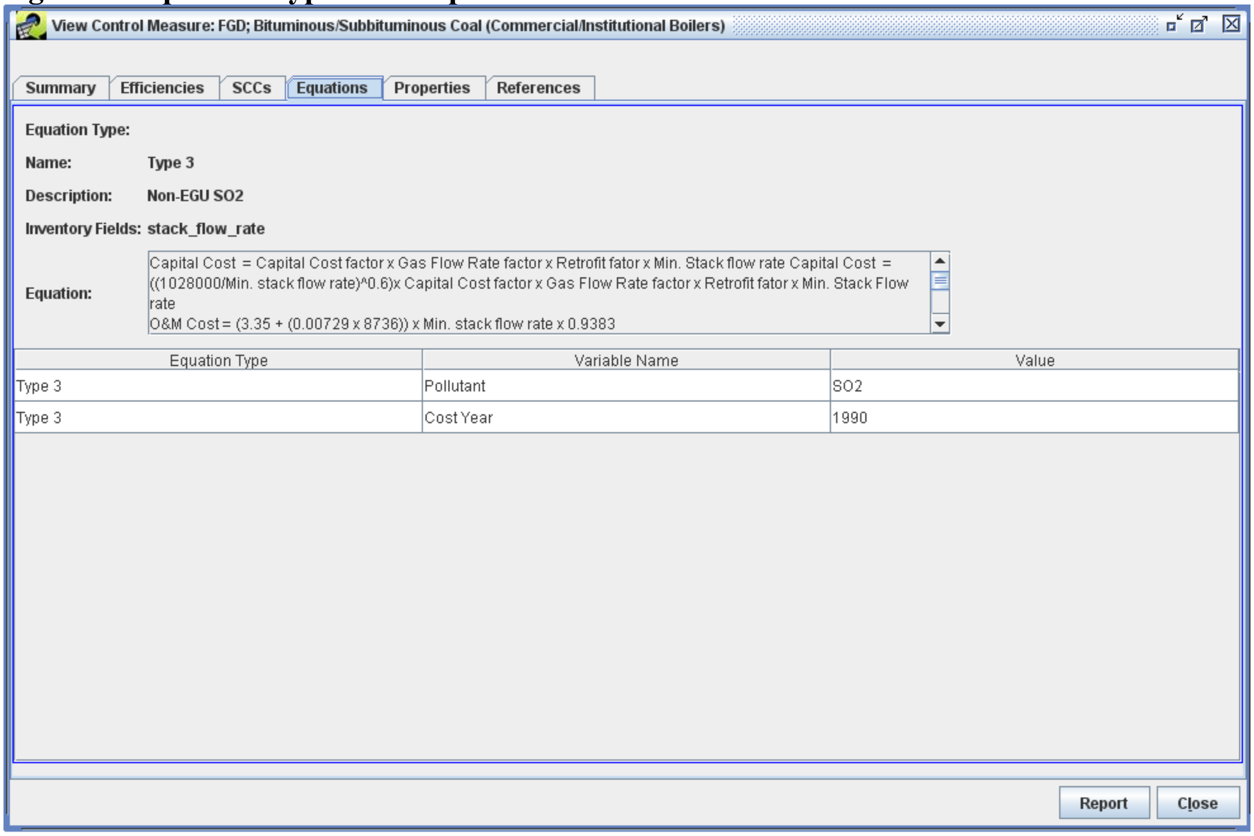
3.1.2 Equation Type 3 Example

3.1.2.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 15 years (from summary tab of control measure data)

$$STKFLOW\ = 1682.7 \frac{ft^3}{sec}$$

Figure 4: Equation Type 3 Example Screenshot



3.1.2.2 Annualized Capital Costs for Flowrate < 1,028,000 acfm

$$Capital\ Cost = \left(\frac{1{,}028{,}000}{Flowrate}\right)^{0.6} \times Retrofit\ Factor \times Gas\ Flow\ Rate\ Factor$$
$$\times\ Capital\ Cost\ Factor\ \times STKFLOW \times 60$$

$$Capital\ Cost = \left(\frac{1{,}028{,}000}{1682.7\frac{ft^3}{sec} \times 60\frac{sec}{min}}\right)^{0.6} \times 1.1 \times 0.486\frac{\text{kW}}{\text{acfm}} \times \frac{\$192}{kW} \times 1682.7\frac{ft^3}{sec} \times 60\frac{sec}{min}$$
$$Capital\ Cost = \$41{,}705{,}106\ (1995\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$
$$Capital\ Recovery\ Factor = \frac{.07\ \times (1 + .07)^{15\ years}}{[(1 + .07)^{15\ years}\ - 1]}$$
$$Capital\ Recovery\ Factor = 0.1098$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost == \$41{,}705{,}106\ \times 0.1098$$
$$Annualized\ Capital\ Cost = \$4{,}578{,}996\ (1990\$)$$

3.1.2.3 Operation and Maintenance Cost

$$Fixed\ O\&M = Gas\ Flow\ Rate\ Factor\ \times Fixed\ O\&M\ Rate$$
$$Fixed\ O\&M = 0.486\ \text{kW/acfm}\ \ \times \$6.9/\text{kW} - \text{yr}$$

$$Fixed\ O\&M = \$3.354$$

$$Variable\ O\&M = Gas\ Flow\ Rate\ Factor \times Variable\ O\&M\ Rate \times Hours\ per\ Year \times STKFLOW \times 60$$

$$Variable\ O\&M = 0.486\frac{\text{kW}}{\text{acf}} \times \frac{\$0.0015}{\text{kWh}} \times 8{,}736\ \text{hours} \times 1682.7\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$Variable\ O\&M = \$642{,}980$$

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$

$$O\&M\ Cost = \$3.354 + \$642{,}980$$

$$O\&M\ Cost = \$642{,}984\ (1990\$)$$

3.1.2.4 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

$$Total\ Annualized\ Cost = \$4{,}578{,}803\ + \$642{,}983$$

$$Total\ Annualized\ Cost = \$5{,}221{,}787\ (1990\$)$$

3.1.3 Equation Type 3 CoST Code

```
-------------------------------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--		stack flow rate was converted from cfs to cfm prior to getting here.


-- Type 3
IF equation_type = 'Type 3' THEN
		IF coalesce(STKFLOW, 0) <> 0 THEN
				select costs.annual_cost,
						costs.capital_cost,
						costs.operation_maintenance_cost,
						costs.annualized_capital_cost,
						costs.computed_cost_per_ton
				from public.get_type3_equation_costs(control_measure_id,
						discount_rate,
						equipment_life,
						capital_recovery_factor,
						emis_reduction,
						STKFLOW) as costs
				into annual_cost,
						capital_cost,
						operation_maintenance_cost,
						annualized_capital_cost,
						computed_cost_per_ton;
				IF annual_cost is not null THEN
						valid_cost := true;
						actual_equation_type := 'Type 3';
				ELSE
						valid_cost := false;
						actual_equation_type := '-Type 3';
				END IF;
				-- adjust costs to the reference cost year
				annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
```

```
                capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
                operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
                annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
                computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
                return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 3';
END IF;

-- Next the code will call the default CPT approach

-----------------------------------------------------------------------------------------------------------------------------------------


-- Type 3
CREATE OR REPLACE FUNCTION public.get_type3_equation_costs(
        control_measure_id integer,
        discount_rate double precision,
        equipment_life double precision,
        capital_recovery_factor double precision,
        emis_reduction double precision,
        STKFLOW double precision,
        OUT annual_cost double precision,
        OUT capital_cost double precision,
        OUT operation_maintenance_cost double precision,
        OUT annualized_capital_cost double precision,
        OUT computed_cost_per_ton double precision)  AS $$
DECLARE
        cap_recovery_factor double precision := capital_recovery_factor;
        capital_cost_factor double precision := 192;
        gas_flow_rate_factor double precision := 0.486;
        retrofit_factor double precision := 1.1;
BEGIN
        -- get capital recovery factor, caculate if it wasn't passed in...
        IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
                cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
        END IF;

        -- calculate capital cost
        capital_cost :=
                case
                        when STKFLOW < 1028000 then
                                (1028000/ STKFLOW) ^ 0.6 * capital_cost_factor * gas_flow_rate_factor *
retrofit_factor * STKFLOW
                        else
                                capital_cost_factor * gas_flow_rate_factor * retrofit_factor * STKFLOW
                end;

        -- calculate annualized capital cost
        annualized_capital_cost := capital_cost * cap_recovery_factor;

        -- calculate operation maintenance cost
        operation_maintenance_cost := (3.35 + (0.000729 * 8736)) * STKFLOW;

        -- calculate annual cost
        annual_cost := annualized_capital_cost + operation_maintenance_cost;

        -- calculate computed cost per ton
        computed_cost_per_ton :=
                case
```

```
                when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
                else null
        end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

3.1.4 Equation Type 4

3.1.4.1 Annualized Capital Cost

$$Capital\ Cost = \$990{,}000 + \$9.836 \times STKFLOW \times 60$$

where \$990,000 is the fixed capital cost and \$9.836 is the scaled capital cost based on model plant data, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.1.4.2 Operation and Maintenance Cost

$$Fixed\ O\&M = \$75{,}800$$

where \$75,800 is the fixed O&M cost based on model plant data

$$Variable\ O\&M = \$12.82 \times STKFLOW \times 60$$

where \$12.82 is the variable O&M cost based on model plant data, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Total\ O\&M = Fixed\ O\&M + Variable\ O\&M$$

3.1.4.3 Total Annualized Cost

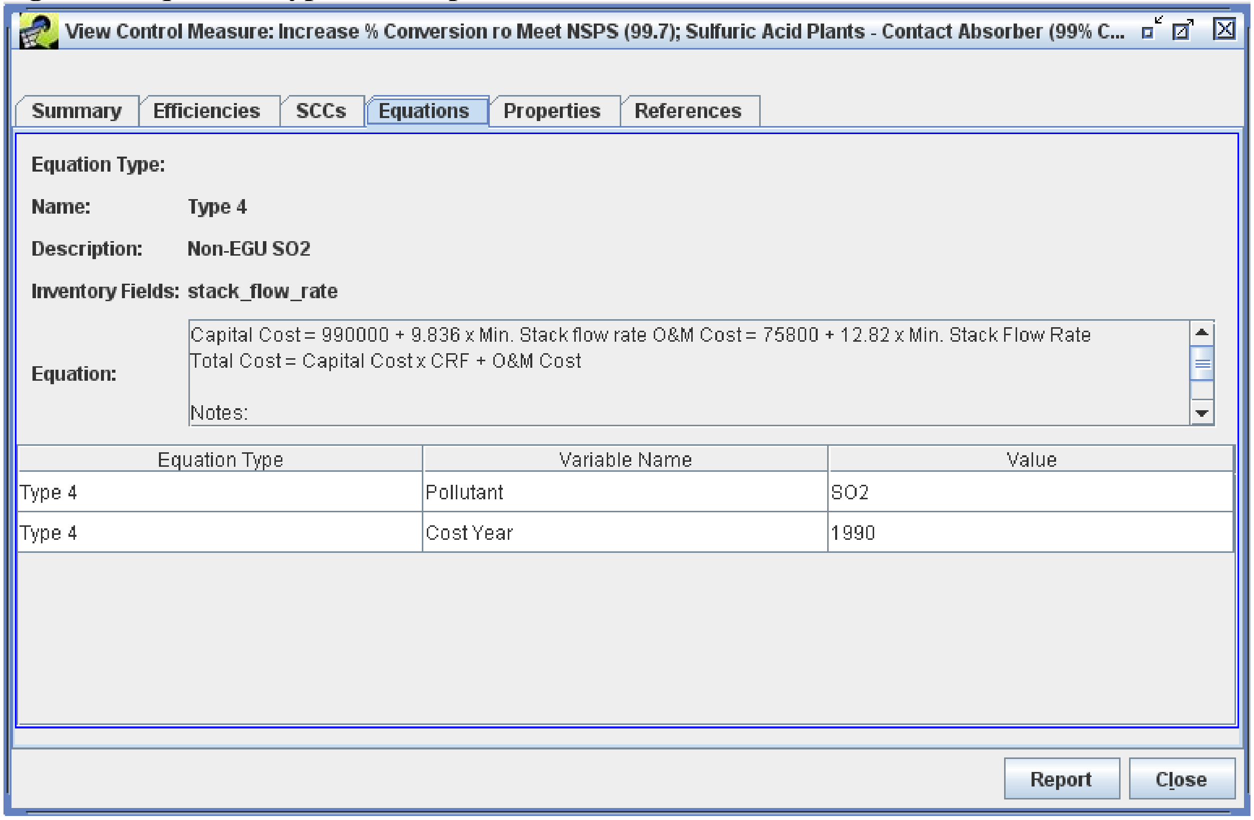
$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

3.1.5 Equation Type 4 Example

3.1.5.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 15 years (from summary tab of control measure data)
$STKFLOW\ = 956.7 \frac{ft^3}{sec}$

Figure 5: Equation Type 4 Example Screenshot



3.1.5.1.1 Annualized Capital Cost

$$Capital\ Cost = \$990{,}000 + \$9.836 \times STKFLOW \times 60$$

$$Capital\ Cost = \$990{,}000 + \$9.836/acfm \times 956.7\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$Capital\ Cost = \$1{,}554{,}606\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{15\ years}}{[(1 + 0.07)^{15\ years}\ - 1]}$$

$$Capital\ Recovery\ Factor = 0.1098$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$1{,}554{,}606\ \times 0.1098$$

$$Annualized\ Capital\ Cost = \$170{,}687\ (1990\$)$$

3.1.5.2 Operation and Maintenance Cost

$$Fixed\ O\&M = \$75{,}800$$

$$Variable\ O\&M = \$12.82 \times STKFLOW \times 60$$

$$Variable\ O\&M = \$12.82/acfm \times 956.7\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$Variable\ O\&M = \$735{,}893$$

$$Total\ O\&M = Fixed\ O\&M + Variable\ O\&M$$
$$Total\ O\&M = \$75{,}800 + \$735{,}894$$
$$Total\ O\&M = \$811{,}694\ (1990\$)$$

3.1.5.3 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$170{,}687 + \$811{,}694$$
$$Total\ Annualized\ Cost = \$982{,}381 (1990\$)$$

3.1.6 Equation Type 4 CoST Code

```
------------------------------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--         stack flow rate was converted from cfs to cfm prior to getting here.


-- Type 4
IF equation_type = 'Type 4' THEN
        IF coalesce(STKFLOW, 0) <> 0 THEN
                select costs.annual_cost,
                        costs.capital_cost,
                        costs.operation_maintenance_cost,
                        costs.annualized_capital_cost,
                        costs.computed_cost_per_ton
                from public.get_type4_equation_costs(control_measure_id,
                        discount_rate,
                        equipment_life,
                        capital_recovery_factor,
                        emis_reduction,
                        STKFLOW) as costs
                into annual_cost,
                        capital_cost,
                        operation_maintenance_cost,
                        annualized_capital_cost,
                        computed_cost_per_ton;
                IF annual_cost is not null THEN
                        valid_cost := true;
                        actual_equation_type := 'Type 4';
                ELSE
                        valid_cost := false;
                        actual_equation_type := '-Type 4';
                END IF;
                -- adjust costs to the reference cost year
                annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
                capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
                operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
                annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
                computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
                return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 4';
END IF;

-- Next the code will call the default CPT approach
```

```
-- Type 4
CREATE OR REPLACE FUNCTION public.get_type4_equation_costs(
		control_measure_id integer,
		discount_rate double precision,
		equipment_life double precision,
		capital_recovery_factor double precision,
		emis_reduction double precision,
		STKFLOW double precision,
		OUT annual_cost double precision,
		OUT capital_cost double precision,
		OUT operation_maintenance_cost double precision,
		OUT annualized_capital_cost double precision,
		OUT computed_cost_per_ton double precision)  AS $$
DECLARE
		cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
		-- get capital recovery factor, caculate if it wasn't passed in...
    IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
        cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
    END IF;

		-- calculate capital cost
		capital_cost := (990000 + 9.836 * STKFLOW);

		-- calculate annualized capital cost
		annualized_capital_cost := capital_cost * cap_recovery_factor;

		-- calculate operation maintenance cost
		operation_maintenance_cost := (75800 + 12.82 * STKFLOW);

		-- calculate annual cost
		annual_cost := annualized_capital_cost + operation_maintenance_cost;

		-- calculate computed cost per ton
		computed_cost_per_ton :=
			case
				when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
				else null
			end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

3.1.7 Equation Type 5

3.1.7.1 Annualized Capital Cost

$$Capital\ Cost = \$2{,}882{,}540 + \$244.74 \times STKFLOW \times 60$$

where \$2,882,540 is the fixed capital cost, \$244.74 is the scaled capital cost based on model plant data, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.1.7.2 Operation and Maintenance Cost

$$Fixed\ O\&M = \$749{,}170$$

where \$749,170 is the fixed O&M cost based on model plant data,

$$Variable\ O\&M = \$148.4 \times STKFLOW \times 60$$

where \$148.4 is the variable O&M data based on model plant data and credit for recovered product, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Total\ O\&M = Fixed\ O\&M + Variable\ O\&M$$

3.1.7.3 Total Annualized Cost

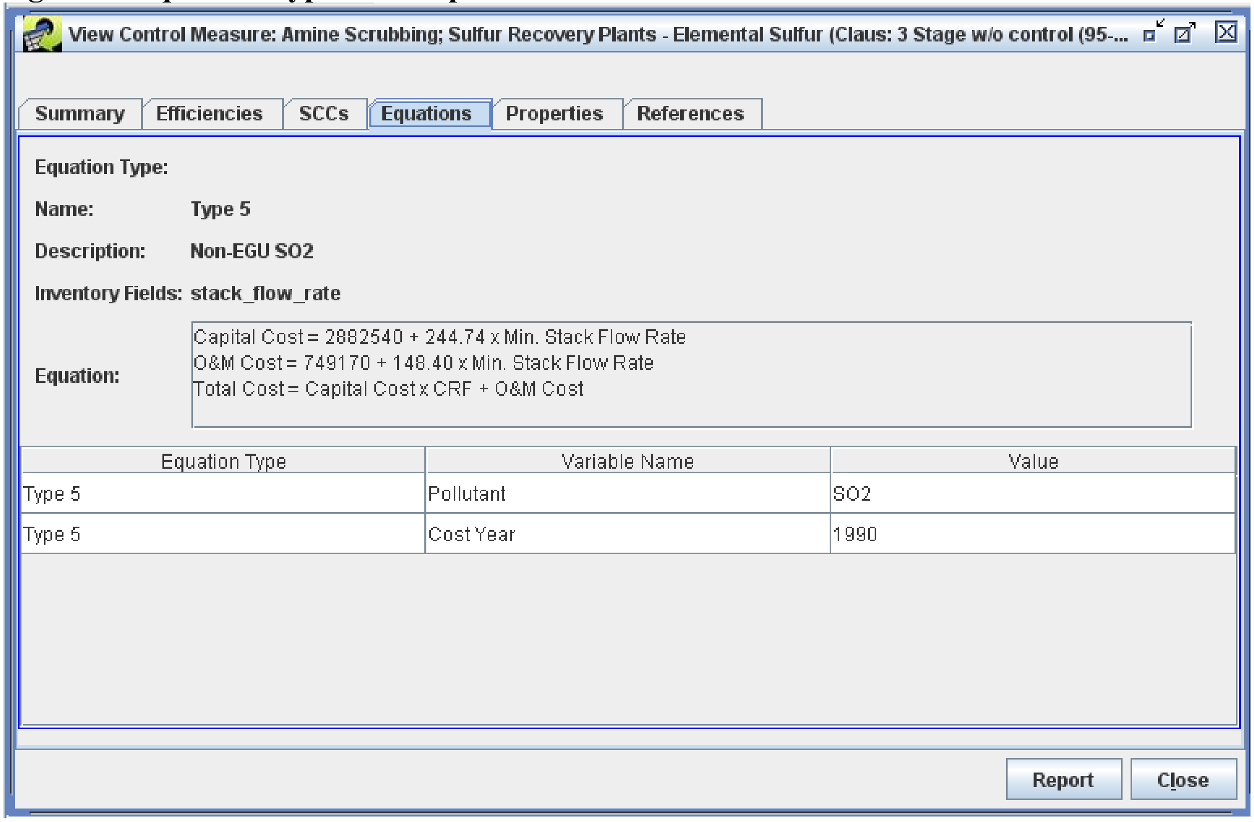
$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

3.1.8 Equation Type 5 Example

3.1.8.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 15 years (from summary tab of the control measure data)
$STKFLOW\ = 541.6 \frac{ft^3}{sec}$

Figure 6: Equation Type 5 Example Screenshot



3.1.8.2 Annualized Capital Cost

$$Capital\ Cost = \$2{,}882{,}540 + \$244.74 \times STKFLOW \times 60$$

$$Capital\ Cost = \$2{,}882{,}540 + \$244.74/acfm \times 541.6\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$Capital\ Cost = \$10{,}835{,}611\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life} - 1]}$$

$$Capital\ Recovery\ Factor = \frac{0.07 \times (1 + 0.07)^{15\ years}}{[(1 + 0.07)^{15\ years} - 1]}$$

$$Capital\ Recovery\ Factor = 0.1098$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$10{,}835{,}611 \times 0.1098$$

$$Annualized\ Capital\ Cost = \$1{,}189{,}750\ (1990\$)$$

3.1.8.3 Operation and Maintenance Cost

$$Fixed\ O\&M = \$749{,}170$$

$$Variable\ O\&M = \$148.4 \times STKFLOW \times 60$$

$$Variable\ O\&M = \$148.4/acfm \times 541.6\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$Variable\ O\&M = \$4{,}822{,}406$$

$$Total\ O\&M = Fixed\ O\&M + Variable\ O\&M$$
$$Total\ O\&M = \$749{,}170 + \$4{,}822{,}406$$
$$Total\ O\&M = \$5{,}571{,}576\ (1990\$)$$

3.1.8.4 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$1{,}189{,}750 + \$5{,}571{,}576$$
$$Total\ Annualized\ Cost = \$6{,}761{,}326\ (1990\$)$$

3.1.9 Equation Type 5 CoST Code

```
------------------------------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--          stack flow rate was converted from cfs to cfm prior to getting here.


-- Type 5
IF equation_type = 'Type 5' THEN
        IF coalesce(STKFLOW, 0) <> 0 THEN
                select costs.annual_cost,
                        costs.capital_cost,
                        costs.operation_maintenance_cost,
                        costs.annualized_capital_cost,
                        costs.computed_cost_per_ton
                from public.get_type5_equation_costs(control_measure_id,
                        discount_rate,
                        equipment_life,
                        capital_recovery_factor,
                        emis_reduction,
                        STKFLOW) as costs
                into annual_cost,
                        capital_cost,
                        operation_maintenance_cost,
                        annualized_capital_cost,
                        computed_cost_per_ton;
                IF annual_cost is not null THEN
                        valid_cost := true;
                        actual_equation_type := 'Type 5';
                ELSE
                        valid_cost := false;
                        actual_equation_type := '-Type 5';
                END IF;
                -- adjust costs to the reference cost year
                annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
                capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
                operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
                annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
                computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
                return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 5';
END IF;

-- Next the code will call the default CPT approach
```

```
-- Type 5
CREATE OR REPLACE FUNCTION public.get_type5_equation_costs(
	control_measure_id integer,
	discount_rate double precision,
	equipment_life double precision,
	capital_recovery_factor double precision,
	emis_reduction double precision,
	STKFLOW double precision,
	OUT annual_cost double precision,
	OUT capital_cost double precision,
	OUT operation_maintenance_cost double precision,
	OUT annualized_capital_cost double precision,
	OUT computed_cost_per_ton double precision)  AS $$
DECLARE
	cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
	-- get capital recovery factor, caculate if it wasn't passed in...
	IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
		cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
	END IF;

	-- calculate capital cost
	capital_cost := (2882540 + 244.74 * STKFLOW);

	-- calculate annualized capital cost
	annualized_capital_cost := capital_cost * cap_recovery_factor;

	-- calculate operation maintenance cost
	operation_maintenance_cost := (749170 + 148.40 * STKFLOW);

	-- calculate annual cost
	annual_cost := annualized_capital_cost + operation_maintenance_cost;

	-- calculate computed cost per ton
	computed_cost_per_ton :=
		case
			when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
			else null
		end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

3.1.10 Equation Type 6

3.1.10.1 Annualized Capital Cost

$$Capital\ Cost = \$3{,}449{,}803 + \$135.86 \times STKFLOW \times 60$$

where $3,449,803 is the fixed capital cost; $135.86 is the scaled capital cost, developed from model plant data, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.1.10.2 Operation and Maintenance Cost

$$Fixed\ O\&M = \$797{,}667$$

where $797,667is the fixed O&M cost derived from model plant data

$$Variable\ O\&M = \$58.84 \times STKFLOW \times 60$$

where $58.84 is the variable O&M cost derived from model plant data, *STKFLOW* is the stack gas flow rate (ft^3/s) from the emissions inventory, and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Total\ O\&M = Fixed\ O\&M + Variable\ O\&M$$

3.1.10.3 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

3.1.11 Equation Type 6 Example

3.1.11.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 15 years (from summary tab of control measure data)
$STKFLOW\ = 5327.45 \frac{ft^3}{sec}$

3.1.11.2 Annualized Capital Cost

$$Capital\ Cost = \$3{,}449{,}803 + \$135.86 \times STKFLOW \times 60$$

$$Capital\ Cost = \$3{,}449{,}803 + \$135.86 \times 5327.45 \frac{ft^3}{sec} \times 60 \frac{sec}{min}$$

$$Capital\ Cost = \$46{,}877{,}044\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{15\ years}}{[(1 + 0.07)^{15\ years}\ - 1]}$$

$$Capital\ Recovery\ Factor = 0.1098$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$46{,}877{,}044\ \times 0.1098$$

$$Annualized\ Capital\ Cost = \$5{,}147{,}099\ (1990\$)$$

3.1.11.3 Operation and Maintenance Cost

$$Fixed\ O\&M = \$797{,}667$$

$$Variable\ O\&M = \$58.84 \times STKFLOW \times 60$$
$$Variable\ O\&M = \$58.84 \times 5327.45\,\frac{ft^3}{sec} \times 60\,\frac{sec}{min}$$
$$Variable\ O\&M = \$18{,}808{,}029$$

$$Total\ O\&M = Fixed\ O\&M + Variable\ O\&M$$
$$Total\ O\&M = \$797{,}667 + \$18{,}808{,}029$$
$$Total\ O\&M = \$19{,}605{,}696\ (1990\$)$$

3.1.11.4 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$5{,}147{,}099 + \$19{,}605{,}696$$
$$Total\ Annualized\ Cost = \$24{,}752{,}705\ (1990\$)$$

3.1.12 Equation Type 6 CoST Code

```
------------------------------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--          stack flow rate was converted from cfs to cfm prior to getting here.


IF equation_type = 'Type 6' THEN
        IF coalesce(STKFLOW, 0) <> 0 THEN
                select costs.annual_cost,
                        costs.capital_cost,
                        costs.operation_maintenance_cost,
                        costs.annualized_capital_cost,
                        costs.computed_cost_per_ton
                from public.get_type6_equation_costs(control_measure_id,
                        discount_rate,
                        equipment_life,
                        capital_recovery_factor,
                        emis_reduction,
                        STKFLOW) as costs
                into annual_cost,
                        capital_cost,
                        operation_maintenance_cost,
                        annualized_capital_cost,
                        computed_cost_per_ton;
                IF annual_cost is not null THEN
                        valid_cost := true;
                        actual_equation_type := 'Type 6';
                ELSE
                        valid_cost := false;
                        actual_equation_type := '-Type 6';
                END IF;
                -- adjust costs to the reference cost year
                annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
                capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
                operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
```

```
            annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
            computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
            return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 6';
END IF;

-- Next the code will call the default CPT approach

-----------------------------------------------------------------------------------------------------------------------------------------



-- Type 6
CREATE OR REPLACE FUNCTION public.get_type6_equation_costs(
        control_measure_id integer,
        discount_rate double precision,
        equipment_life double precision,
        capital_recovery_factor double precision,
        emis_reduction double precision,
        STKFLOW double precision,
        OUT annual_cost double precision,
        OUT capital_cost double precision,
        OUT operation_maintenance_cost double precision,
        OUT annualized_capital_cost double precision,
        OUT computed_cost_per_ton double precision)  AS $$
DECLARE
        cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
        -- get capital recovery factor, caculate if it wasn't passed in...
         IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
            cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
         END IF;

        -- calculate capital cost
        capital_cost := (3449803 + 135.86 * STKFLOW);

        -- calculate annualized capital cost
        annualized_capital_cost := capital_cost * cap_recovery_factor;

        -- calculate operation maintenance cost
        operation_maintenance_cost := (797667 + 58.84 * STKFLOW);

        -- calculate annual cost
        annual_cost := annualized_capital_cost + operation_maintenance_cost;

        -- calculate computed cost per ton
        computed_cost_per_ton :=
            case
                when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
                else null
            end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

3.1.13 Equation Type 11

3.1.13.1 Total Annualized Cost

$$Total\ Annualized\ Cost = Emissions\ Reduction\ \times Default\ Cost\ Per\ Ton$$

where Emissions Reduction is calculated based on the initial emissions from the inventory and the control efficiency, and *Default Cost per Ton* is control measure specific.

3.1.13.2 Total Capital Cost

$$Capital\ Cost = Total\ Annualized\ Cost \times Capital\ to\ Annual\ Ratio$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.1.13.3 Operation and Maintenance Cost

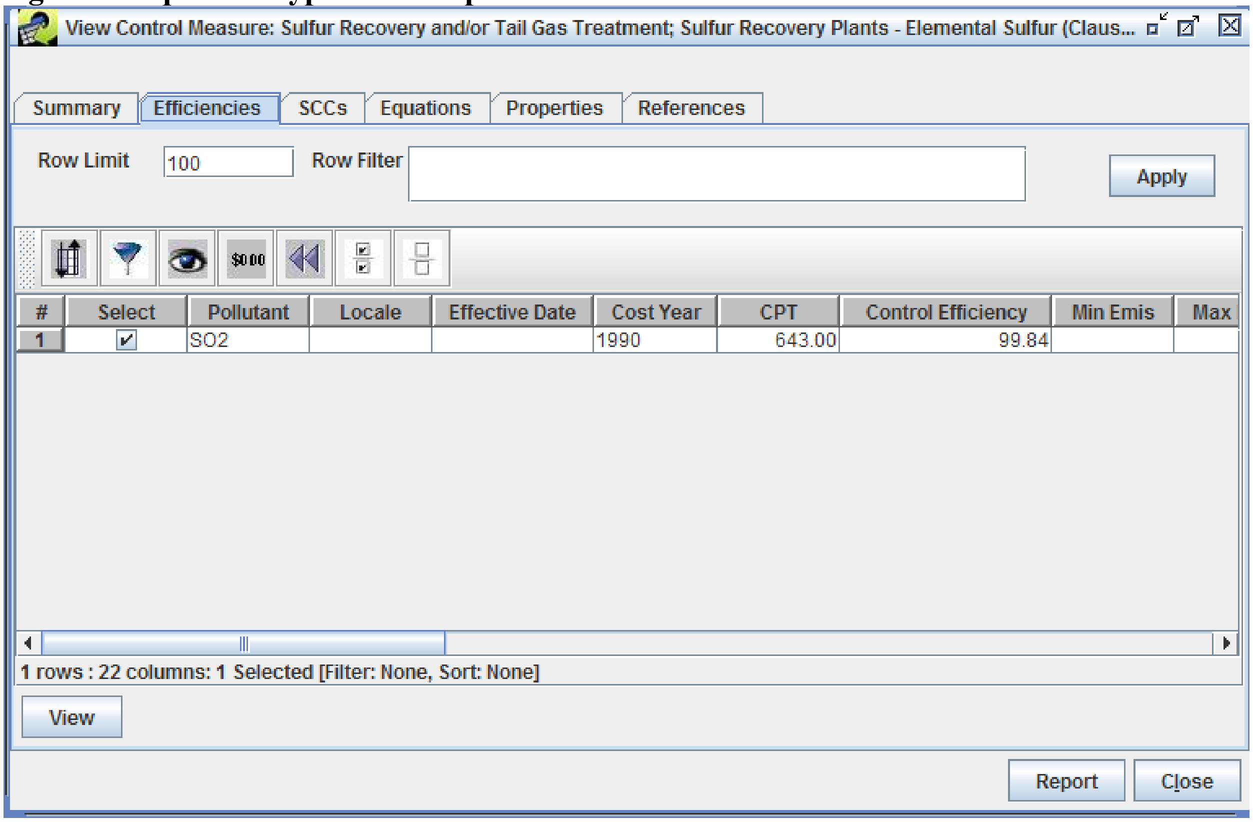
$$Total\ O\&M = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$

3.1.14 Equation Type 11 Example

3.1.14.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 30 years (from summary tab of control measure data)
SO_2 Emissions Reductions = 68.7 tons

Figure 7: Equation Type 11 Example Screenshot



3.1.14.2 Total Annualized Cost

$$Total\ Annualized\ Cost = Emissions\ Reduction\ \times Default\ Cost\ Per\ Ton$$

$$Total\ Annualized\ Cost = 68.7\ Tons\ SO_2\ \times 643\frac{\$}{Ton}$$

$$Total\ Annualized\ Cost = \$44{,}174\ (1990\$)$$

3.1.14.3 Total Capital Cost

$$Capital\ Cost = Total\ Annualized\ Cost \times Capital\ to\ Annual\ Ratio$$

$$Capital\ Cost = \$44{,}174 \times 0$$

$$Capital\ Cost = \$0$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$0\ \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$0$$

3.1.14.4 Operation and Maintenance Cost

$$Total\ O\&M\ Cost = Total\ Annualized\ Cost - Annualized\ Capital\ Cost$$

$$Total\ O\&M\ Cost = \$44{,}174 - \$0$$

$$Total\ O\&M\ Cost = \$44{,}174\ (1990\$)$$

3.1.15 Equation Type 11 CoST Code

```
--------------------------------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--	design_capacity must be in the correct units, MW/hr is assumed if no units are specified


-- Type 11
IF equation_type = 'Type 11' THEN

	-- convert design capacity to mmBTU/hr
	converted_design_capacity := 3.412 * public.convert_design_capacity_to_mw(design_capacity,
design_capacity_unit_numerator, design_capacity_unit_denominator);

	IF coalesce(converted_design_capacity, 0) <> 0 THEN
		select costs.annual_cost,
			costs.capital_cost,
			costs.operation_maintenance_cost,
			costs.annualized_capital_cost,
			costs.computed_cost_per_ton
		from public.get_type11_equation_costs(discount_rate,
			equipment_life,
			capital_recovery_factor,
			capital_annualized_ratio,
			emis_reduction,
			converted_design_capacity,
			variable_coefficient1,
			variable_coefficient2,
			variable_coefficient3,
			variable_coefficient4,
			variable_coefficient5) as costs
		into annual_cost,
			capital_cost,
			operation_maintenance_cost,
			annualized_capital_cost,
			computed_cost_per_ton;
		IF annual_cost is not null THEN
			valid_cost := true;
			actual_equation_type := 'Type 11';
		ELSE
			valid_cost := false;
			actual_equation_type := '-Type 11';
		END IF;
		-- adjust costs to the reference cost year
		annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
		capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
		operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
		annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
		computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
		return;
	END IF;
	valid_cost := false;
	actual_equation_type := '-Type 11';
END IF;

-- Next the code will call the default CPT approach

--------------------------------------------------------------------------------------------------------------------------------------
```

```
-- Type 11 - SO2 Non-IPM Control Equations
CREATE OR REPLACE FUNCTION public.get_type11_equation_costs(
	discount_rate double precision,
	equipment_life double precision,
	capital_recovery_factor double precision,
	capital_annualized_ratio double precision,
	emis_reduction double precision,
	design_capacity double precision, 	-- needs to be in units of mmBTU/hr
	low_default_cost_per_ton double precision,
	low_boiler_capacity_range double precision,
	medium_default_cost_per_ton double precision,
	medium_boiler_capacity_range double precision,
	high_default_cost_per_ton double precision,
	OUT annual_cost double precision,
	OUT capital_cost double precision,
	OUT operation_maintenance_cost double precision,
	OUT annualized_capital_cost double precision,
	OUT computed_cost_per_ton double precision)  AS $$
DECLARE
	cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
	-- get capital recovery factor, caculate if it wasn't passed in...
	 IF coalesce(cap_recovery_factor, 0) = 0 and coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 
THEN
		cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
	END IF;

	-- figure out cost per ton
	computed_cost_per_ton := 
		case 
when design_capacity <= low_boiler_capacity_range then low_default_cost_per_ton
			when design_capacity > low_boiler_capacity_range and design_capacity < 
medium_boiler_capacity_range then medium_default_cost_per_ton
			when design_capacity >= medium_boiler_capacity_range then high_default_cost_per_ton
		end;

	-- calculate annual cost
	annual_cost := emis_reduction * computed_cost_per_ton;
	-- calculate capital cost
	capital_cost := annual_cost  * capital_annualized_ratio;
	-- calculate annualized capital cost
	annualized_capital_cost := capital_cost * cap_recovery_factor;
	-- calculate operation maintenance cost
	operation_maintenance_cost := annual_cost - annualized_capital_cost;

END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

Table 4. Non-IPM Sector SO_2 Control Measure Cost Assignments (Equation Types 3-6)

CoST CMAbbreviation	Source Group	Control Technology	CE	Cost Equation Type #	Cost Year ($Year)
SNS99SACA	Sulfuric Acid Plants - Contact Absorber (99% Conversion)	Increase % Conversion to Meet NSPS (99.7)	75	4	1990
SNS98SACA	Sulfuric Acid Plants - Contact Absorber (98% Conversion)	Increase % Conversion to Meet NSPS (99.7)	85	4	1990
SNS97SACA	Sulfuric Acid Plants - Contact Absorber (97% Conversion)	Increase % Conversion to Meet NSPS (99.7)	90	4	1990
SNS93SACA	Sulfuric Acid Plants - Contact Absorber (93% Conversion)	Increase % Conversion to Meet NSPS (99.7)	95	4	1990
SAMSCSRP95	Sulfur Recovery Plants - Elemental Sulfur (Claus: 2 Stage w/o control (92-95% removal))	Amine Scrubbing	98.4	5	1990
SAMSCSRP96	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (95-96% removal))	Amine Scrubbing	97.8	5	1990
SAMSCSRP97	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (96-97% removal))	Amine Scrubbing	97.1	5	1990
SFGDSCMOP	By-Product Coke Manufacturing (Other Processes)	FGD	90	3	1995
SFGDSPHOG	Process Heaters (Oil and Gas Production Industry)	FGD	90	3	1995
SSADPPRMTL	Primary Metals Industry	Sulfuric Acid Plant	70	3	1995
SFGDSMIPR	Mineral Products Industry	FGD	50	3	1995
SFGDSPPSP	Pulp and Paper Industry (Sulfate Pulping)	FGD	90	3	1995
SFGDSPETR	Petroleum Industry	FGD	90	3	1995
SFGDSIBBC	Bituminous/Subbituminous Coal (Industrial Boilers)	FGD	90	3	1995
SFGDSIBRO	Residual Oil (Industrial Boilers)	FGD	90	3	1995
SFGDSCBBCL	Bituminous/Subbituminous Coal (Commercial/Institutional Boilers)	FGD	90	3	1995
SFGDSIPFBC	In-process Fuel Use - Bituminous/Subbituminous Coal	FGD	90	3	1995
SFGDSIBLG	Lignite (Industrial Boilers)	FGD	90	3	1995
SFGDSCBRO	Residual Oil (Commercial/Institutional Boilers)	FGD	90	3	1995
SFGDSSGCO	Steam Generating Unit-Coal/Oil	FGD	90	3	1995
SDLABPLSS	Primary Lead Smelters - Sintering	Dual absorption	99	4	1990
SDLABPZSS	Primary Zinc Smelters - Sintering	Dual absorption	99	4	1990
SCOGDCOP	By-Product Coke Manufacturing (Coke Oven Plants)	Coke Oven Gas Desulfurization	90	6	1990

Table 5. Non-IPM Sector SO_2 Controls Default Cost per Ton Values (Equation Type 11)

CoST CMAbbreviation	Source Group	Control Technology	CE (%)	Boiler Capacity Bin (mmBtu/hr)	Cost Per Ton Reduced ($/ton)	Capital to Annual Ratio	Equipment Life	Interest Rate	Cost Year ($ Year)
SSRBINJICB	ICI Boilers	In-duct Sorbent Injection	40	All Sizes	1069		0		2003
SCHMADDHOM	Residential Nonpoint Source	Chemical Additives to Waste	75	All Sizes	2350		0		2002
SFGDICB	ICI Boilers	Flue Gas Desulfurization	90	All Sizes	1109		0		2003
SLSFICB	ICI Boilers	Low Sulfur Fuel	80	All Sizes	2350		0		1999
SFGDICBOIL	ICI Boilers	Flue Gas Desulfurization	90	All Sizes	2898		0		1999
SFUELSWECB	External Combustion Boilers2	Fuel Switching	75	All Sizes	2350		0		1999
SSCRBPETCK	Petroleum Refinery Catalytic and Thermal Cracking Units	Wet Gas Scrubber	97	All Sizes	665		0		2004
SSCRBPETPH	Petroleum Refinery Process Heaters	Scrubbing	96	All Sizes	26529		0		2004
SFUELSFC	Stationary Source Fuel Combustion	Fuel Switching	75	All Sizes	2350		0		1999
SCATPETCRK	Petroleum Refinery Catalytic and Thermal Cracking Units	Catalyst Additive	43	All Sizes	1493		0		2004
SSCRBCEMKL	Cement Kilns	Wet Gas Scrubber	90	All Sizes	7000		0		2002
SSCRBDRKL	Cement Kilns	Wet Gas Scrubber	90	All Sizes	4000		0		2002
SSCRBPRKL	Cement Kilns	Wet Gas Scrubber	90	All Sizes	35000		0		2002
SSCRBPRPR	Cement Kilns	Wet Gas Scrubber	90	All Sizes	25000		0		2002
SSPRADRKL	Cement Kilns	Spray Dry Absorber	90	All Sizes	4000		0		2002
SSPRAPRPR	Cement Kilns	Spray Dry Absorber	90	All Sizes	25000		0		2002
SSPRAPRKL	Cement Kilns	Spray Dry Absorber	90	All Sizes	35000		0		2002
SSRTGSRP95	Sulfur Recovery Plants - Elemental Sulfur (Claus: 2 Stage w/o control (92-95% removal))	Sulfur Recovery and/or Tail Gas Treatment	99.84	All Sizes	643		15	7	1990
SSRTGSRP96	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (95-96% removal))	Sulfur Recovery and/or Tail Gas Treatment	99.78	All Sizes	643		15	7	1990
SSRTGSRP97	Sulfur Recovery Plants - Elemental Sulfur (Claus: 3 Stage w/o control (96-97% removal))	Sulfur Recovery and/or Tail Gas Treatment	99.71	All Sizes	643		15	7	1990
SIDISIBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	IDIS	40	<100	2107		30	7	1999
SIDISIBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	IDIS	40	100-250	1526		30	7	1999
SIDISIBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	IDIS	40	>250	1110		30	7	1999
SSDA_IBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	SDA	90	<100	1973		30	7	1999
SSDA_IBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	SDA	90	100-250	1341		30	7	1999
SSDA_IBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	SDA	90	>250	804		30	7	1999
SWFGSIBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	Wet FGD	90	<100	1980		30	7	1999
SWFGSIBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	Wet FGD	90	100-250	1535		30	7	1999
SWFGSIBBCL	Bituminous/Subbituminous Coal (Industrial Boilers)	Wet FGD	90	>250	1027		30	7	1999
SIDISIBLG	Lignite (Industrial Boilers)	IDIS	40	<100	2107		30	7	1999
SIDISIBLG	Lignite (Industrial Boilers)	IDIS	40	100-250	1526		30	7	1999
SIDISIBLG	Lignite (Industrial Boilers)	IDIS	40	>250	1110		30	7	1999
SSDA_IBLG	Lignite (Industrial Boilers)	SDA	90	<100	1973		30	7	1999
SSDA_IBLG	Lignite (Industrial Boilers)	SDA	90	100-250	1341		30	7	1999
SSDA_IBLG	Lignite (Industrial Boilers)	SDA	90	>250	804		30	7	1999
SWFGDIBLG	Lignite (Industrial Boilers)	Wet FGD	90	<100	1980		30	7	1999
SWFGDIBLG	Lignite (Industrial Boilers)	Wet FGD	90	100-250	1535		30	7	1999
SWFGDIBLG	Lignite (Industrial Boilers)	Wet FGD	90	>250	1027		30	7	1999
SWFGDIBRO	Residual Oil (Industrial Boilers)	Wet FGD	90	<100	4524		30	7	1999
SWFGDIBRO	Residual Oil (Industrial Boilers)	Wet FGD	90	100-250	3489		30	7	1999
SWFGDIBRO	Residual Oil (Industrial Boilers)	Wet FGD	90	>250	2295		30	7	1999
SLSFRESHET	Residential Heating	Low Sulfur Fuel	75	All Sizes	2350		0		2002

3.2 IPM Sector (ptipm) SO_2 Control Cost Equations

Please Note: CoST currently does not apply equation Type 1, improvements are planned to incorporate newer equations from IPM and update this equation type.

IPM sector (ptipm) point sources utilizing control cost equations for SO_2 emission reductions are limited to Equation Type 1 and to two low sulfur coal switching default cost per ton equation calculations. In Equation Type 1, model plant capacities are used along with scaling factors and the emission inventory's unit-specific boiler characteristics to generate a control cost for an applied technology.

Default cost per ton reduced values are not considered in the application of SO_2 control measures to ptipm point sources with the exception of two low sulfur coal switching options as presented in Table 7.

These two low sulfur coal options are applied based on the emission inventory provided sulfur content of the coal burned. Three classifications of coal are assigned, medium sulfur (<= 2% S by weight), high sulfur (2-3% S by weight), and very high sulfur (>3% S by weight).

Equation Type 1 involves the application of a scaling factor to adjust the capital cost associated with a control measure to the boiler size (MW) based on the original control technologies documentation. As noted in Table 6, a scaling factor model plant size and exponent are provided for this estimate.

For SO_2 controls applied to ptipm sources, a scaling factor is applied when the emission inventory source size is less than the scaling factor model size. If the unit's capacity is greater than or equal to the scaling factor model size, the scaling factor is set to unity (1.0).

Additional restrictions on source size are shown for other controls that use equation type 1. In Table 6, when the Application Restriction lists a minimum and maximum capacity, the control is not applied unless the capacity of the source in the inventory falls within that range.

The capital cost associated with these ptipm SO_2 control measures is then a straightforward calculation of the capital cost multiplier, the unit's boiler capacity (in MW), and the scaling factor (when appropriate).

The fixed O&M component is also based on the unit's capacity while the variable O&M includes an additional estimate for the unit's capacity factor. This factor is the unit's efficiency rating based on existing utilization and operation. A value of 1.00 would represent a completely efficient operation with no losses of production due to heat loss or other factors. Where appropriate, CoST provides a list of pre-calculated capacity factor calculations ranging from 65% to 85% (0.65 to 0.85).

The annualized cost is then estimated using the unit's capital cost times the CRF (derived with the equipment specific interest rate and lifetime expectancy) and the sum of the fixed and variable O&M costs.

3.2.1 Equation Type 1 for SO_2

3.2.1.1 Capital Cost Equations

$$Scaling\ Factor = \left(\frac{Scaling\ Factor\ Model\ Size}{Capacity}\right)^{Scaling\ Factor\ Exponent}$$

where *Scaling Factor Model Size* (the boiler capacity in MW of the model plant) and *Scaling Factor Exponent* are control measure specific; *Capacity* is the boiler capacity in MW obtained from the inventory being processed.

$$Capital\ Cost = Capital\ Cost\ Multiplier\ \times Capacity\ \times Scaling\ Factor\ \times 1{,}000$$

where the *Capital Cost Multiplier* ($/kW) is control measure specific, *Capacity* (MW) is obtained from the inventory being processed, and 1000 is a conversion factor to convert the Capital Cost Multiplier from $/kW to $/MW.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

3.2.1.2 Operation and Maintenance Cost Equations

$$Fixed\ O\&M = Fixed\ O\&M\ Cost\ Multiplier\ \times Capacity\ \times 1{,}000$$

where *Fixed O&M Cost Multiplier* is control measure specific, *Capacity* is obtained from the inventory being processed, and 1000 is a conversion factor to convert the Fixed O&M Cost Multiplier from $/kW to $/MW.

$$Variable\ O\&M = Variable\ O\&M\ Cost\ Multiplier\ \times Capacity \times Capacity\ Factor\ \times\ 8{,}760$$

where *Variable O&M Cost Multiplier* ($/MW-h) and *Capacity Factor* are control measure specific, *Capacity* (MW) is obtained from the inventory being processed, and 8760 is the number of hours the equipment is assumed to operate a year.

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$

3.2.1.3 Total Annualized Cost Equation

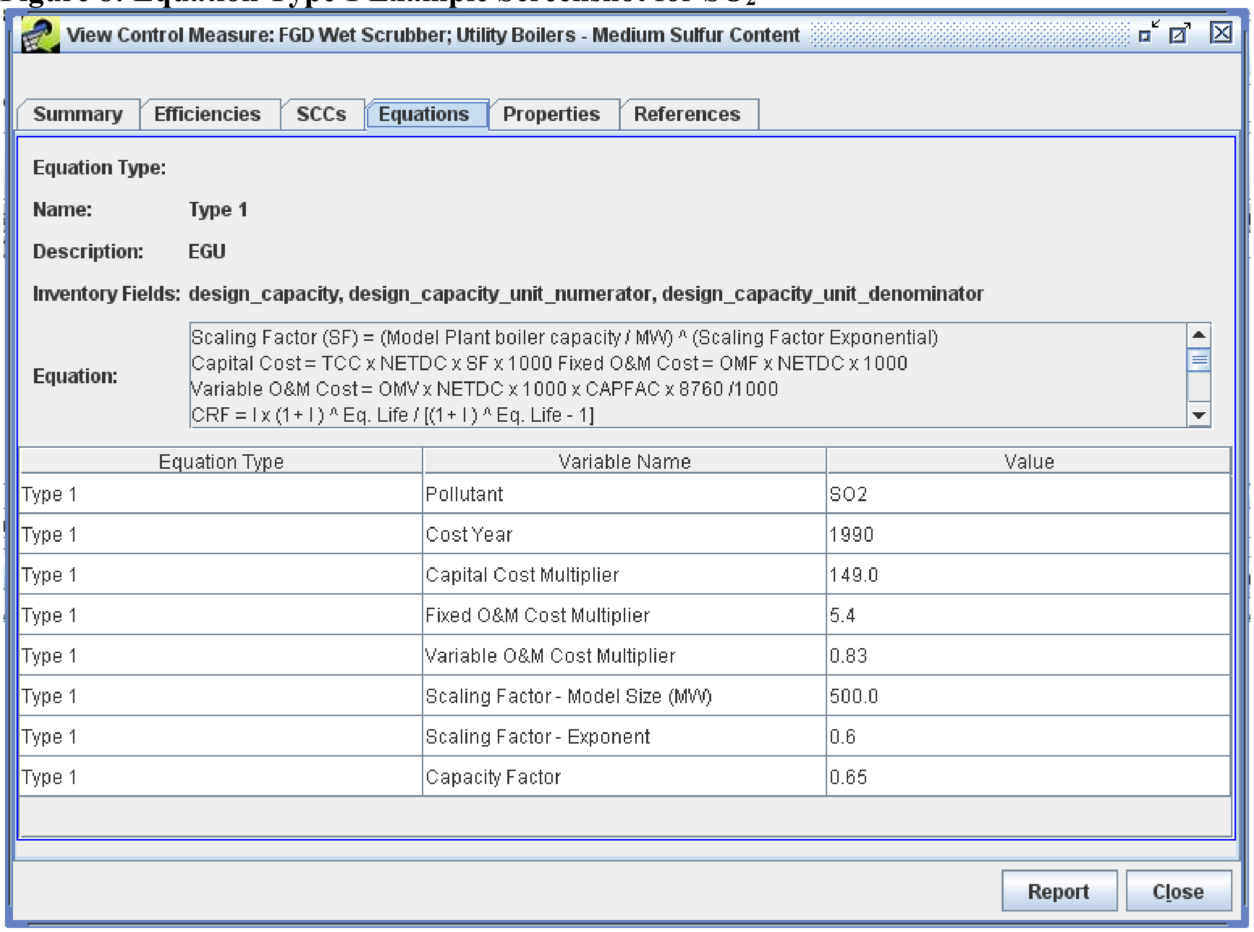
$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

3.2.2 Equation Type 1 Example for SO_2

3.2.2.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 15 years (from summary tab of control measure data)
Capacity = 160.60 MW

Figure 8: Equation Type 1 Example Screenshot for SO_2



View Control Measure: FGD Wet Scrubber; Utility Boilers - Medium Sulfur Content

Summary | Efficiencies | SCCs | Equations | Properties | References

Equation Type:

Name: Type 1

Description: EGU

Inventory Fields: design_capacity, design_capacity_unit_numerator, design_capacity_unit_denominator

Equation:
Scaling Factor (SF) = (Model Plant boiler capacity / MW) ^ (Scaling Factor Exponential)
Capital Cost = TCC x NETDC x SF x 1000 Fixed O&M Cost = OMF x NETDC x 1000
Variable O&M Cost = OMV x NETDC x 1000 x CAPFAC x 8760 /1000
CRF = I x (1 + I) ^ Eq. Life / [(1 + I) ^ Eq. Life - 1]

Equation Type	Variable Name	Value
Type 1	Pollutant	SO2
Type 1	Cost Year	1990
Type 1	Capital Cost Multiplier	149.0
Type 1	Fixed O&M Cost Multiplier	5.4
Type 1	Variable O&M Cost Multiplier	0.83
Type 1	Scaling Factor - Model Size (MW)	500.0
Type 1	Scaling Factor - Exponent	0.6
Type 1	Capacity Factor	0.65

Report | Close

3.2.2.2 Annualized Capital Cost

$$Scaling\ Factor = \left(\frac{Scaling\ Factor\ Model\ Size}{Capacity}\right)^{Scaling\ Factor\ Exponent}$$

$$Scaling\ Factor = \left(\frac{500.0}{160.6}\right)^{0.6}$$

$$Scaling\ Factor = 1.977$$

$$Capital\ Cost = Capital\ Cost\ Multiplier \times Capacity \times Scaling\ Factor \times 1{,}000$$

$$Capital\ Cost = 149\,\frac{\$}{kW} \times 160.6\ MW \times 1.977 \times 1{,}000\,\frac{kW}{MW}$$

$$Capital\ Cost = \$47{,}300{,}582\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$
$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{15}}{(1 + 0.07)^{15} - 1}$$
$$Capital\ Recovery\ Factor = 0.109795$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$47{,}300{,}582 \times 0.109795$$
$$Annualized\ Capital\ Cost = \$5{,}193{,}367 (1990\$)$$

3.2.2.3 Operation and Maintenance Cost

$$Fixed\ O\&M = Fixed\ O\&M\ Cost\ Multiplier\ \left(\frac{\$}{kW}\right) \times Capacity(MW) \times 1{,}000$$
$$Fixed\ O\&M\ = 5.40 \frac{\$}{kW} \times 160.6\ MW \times 1{,}000 \frac{kW}{MW}$$
$$Fixed\ O\&M\ = \$867{,}240$$

$$Variable\ O\&M = Variable\ O\&M\ Cost\ Multiplier\ \left(\frac{\$}{MWh}\right) \times Capacity\ (MW) \times Capacity\ Factor\ \times 8{,}760\ (Hours\ Per\ Year)$$
$$Variable\ O\&M\ = 0.83 \frac{\$}{MWh} \times 160.6\ MW \times 0.65 \times 8{,}760\ Hours$$
$$Variable\ O\&M = \$758{,}998$$

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$
$$O\&M\ Cost = \$867{,}240 + \$758{,}998$$
$$O\&M\ Cost = \$1{,}626{,}238 (1990\$)$$

3.2.2.4 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$5{,}193{,}367 + \$1{,}626{,}238$$
$$Total\ Annualized\ Cost = \$6{,}819{,}605\ (1990\$)$$

3.2.3 Equation Type 1 CoST code for SO_2

Please Note: CoST currently does not apply equation Type 1, improvements are planned to incorporate newer equations from IPM and update this equation type.

Table 6. IPM Sector SO_2 Control Cost Parameters (Equation Type 1)

CoST CMAbbreviation	Source Group	Control Technology	CE (%)	Control Cost Equation Variables: Capital Cost Multiplier	O&M Cost Multiplier: Fixed	O&M Cost Multiplier: Variable	Scaling Factor: Model Size (MW)	Scaling Factor: Exponent	Application Restriction*	Capacity Factor	Interest Rate	Equipment Life	Cost Year ($ Year)
SFGDWUBMS	Utility Boilers - Medium Sulfur Content	FGD Wet Scrubber	90	149	5.4	0.83	500	0.6	%S <=2	0.65	7	15	1990
SFGDWUBHS	Utility Boilers - High Sulfur Content	FGD Wet Scrubber	90	166	6	6.3	500	0.6	2< %S <=3	0.65	7	15	1990
SFGDWUBVHS	Utility Boilers - Very High Sulfur Conte	FGD Wet Scrubber	90	174	6.3	1.8	500	0.6	3< %S	0.65	7	15	1990
SLSDUBC1	Utility Boilers - Bituminous/Subbituminous Coal (100 to 299 MW)	Lime Spray Dryer	95	286	13	2.4	0	0	100≤MW<300	1	7	15	2004
SLSDUBC2	Utility Boilers - Bituminous/Subbituminous Coal (300 to 499 MW)	Lime Spray Dryer	95	155	8	2.4	0	0	300≤MW<500	1	7	15	2004
SLSDUBC3	Utility Boilers - Bituminous/Subbituminous Coal (500 to 699 MW)	Lime Spray Dryer	95	131	6	2.4	0	0	500≤MW<700	1	7	15	2004
SLSDUBC4	Utility Boilers - Bituminous/Subbituminous Coal (700 to 999 MW)	Lime Spray Dryer	95	118	5	2.4	0	0	700≤MW<1000	1	7	15	2004
SLSDUBC5	Utility Boilers - Bituminous/Subbituminous Coal (Over 1000 MW)	Lime Spray Dryer	95	112	4	2.4	0	0	1000≤MW	1	7	15	2004
SLSFOUBC1	Utility Boilers - Bituminous/Subbituminous Coal (100 to 299 MW)	Limestone Forced Oxidation	90	468	19	1.4	0	0	100≤MW<300	1	7	15	2004
SLSFOUBC2	Utility Boilers - Bituminous/Subbituminous Coal (300 to 499 MW)	Limestone Forced Oxidation	90	230	11	1.4	0	0	300≤MW<500	1	7	15	2004
SLSFOUBC3	Utility Boilers - Bituminous/Subbituminous Coal (500 to 699 MW)	Limestone Forced Oxidation	90	174	9	1.4	0	0	500≤MW<700	1	7	15	2004
SLSFOUBC4	Utility Boilers - Bituminous/Subbituminous Coal (700 to 999 MW)	Limestone Forced Oxidation	90	142	8	1.4	0	0	700≤MW<1000	1	7	15	2004
SLSFOUBC5	Utility Boilers - Bituminous/Subbituminous Coal (Over 1000 MW)	Limestone Forced Oxidation	90	120	7	1.4	0	0	1000≤MW	1	7	15	2004

* %S = Sulfur content (%), MW = Boiler Capacity in MW

Table 7. IPM Sector SO_2 Control Cost Parameter for Low Sulfur Coal Fuel Switching Options

CoST CMAbbreviation	Source Group	Control Technology	CE (%)	Applicable Sulfur Content Level	Cost per Ton Reduced ($/ton)	Cost Year($ Year)
SCWSHUBCF	Utility Boilers - Coal Fired	Coal Washing	35	All	320	1997
SFWHLUBHS	Utility Boilers - High Sulfur Content	Fuel Switch - High to Low S Content	60	2< %S	140	1995

4 PM Control Cost Equations

4.1 Non-IPM Sector (ptnonipm) PM Control Cost Equations

Non-IPM point sources utilizing control cost equations for PM emission reductions are limited to Equation Type 8. This equation uses the unit's stack flow rate (in scfm) as the primary variable for control cost calculation. If a unit's stack flow is less than 5 cubic feet per minute (cfm), then the control cost equation is not applied to the specific unit and instead a default cost per ton value calculation is used.

Although applicability and control costs are based on PM_{10} emissions, $PM_{2.5}$ reductions also occur when the above limits are met. A revision is scheduled to change the primary pollutant for all PM control measures from PM_{10} to $PM_{2.5}$ and recalculate all the control costs. This will be available in a future version of the Control Measures Database (CMDB).

If the unit already has PM controls applied in the input inventory, incremental controls are applied only if their control efficiency value exceeds that of the input control. Control costs do not differ in these cases and the cost associated with incremental controls are the same as those applied on uncontrolled sources.

Table 8 provides a list of the control cost equations assigned to various PM control measures. Both the control efficiencies for PM_{10} and $PM_{2.5}$ are provided in this table. Values are representative of typical cost values and low and high cost values are also available in the source tables. These typical costs are presented in terms of $/acfm. Table 9 presents the default cost per ton values used when a unit's stack flow rate is out of the recommended range. Three variables are available for this calculation; a capital cost multiplier, an O&M cost multiplier, and an annualized cost multiplier. These are expressed in terms of $/ton PM-10 reduced.

4.1.1 Equation Type 8

4.1.1.1 Capital Cost Equation

$$Total\ Capital\ Cost = Typical\ Capital\ Cost\ \times STKFLOW \times 60$$

where *Typical Capital Cost* is control measure specific, *STKFLOW* is obtained from the emissions inventory (ft^3/s), and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{[(1 + Interest\ Rate)^{Equipment\ Life}\ - 1]}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

4.1.1.2 Operation and Maintenance Cost Equation

$$O\&M\ Cost = Typical\ O\&M\ Cost\ \times STKFLOW \times 60$$

where *Typical O&M Cost* is control measure specific, *STKFLOW* is obtained from the emissions inventory (ft^3/s), and 60 is a conversion factor to convert *STKFLOW* to ft^3/min.

4.1.1.3 Total Annualized Cost Equation

When stackflow is available and in range,

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + 0.04 \times Capital\ Cost + O\&M\ Cost$$

where 4% of the Total Capital Cost is fixed annual charge for taxes, insurance and administrative costs.

When stackflow is unavailable in the inventory,

$$Total\ Annualized\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton$$

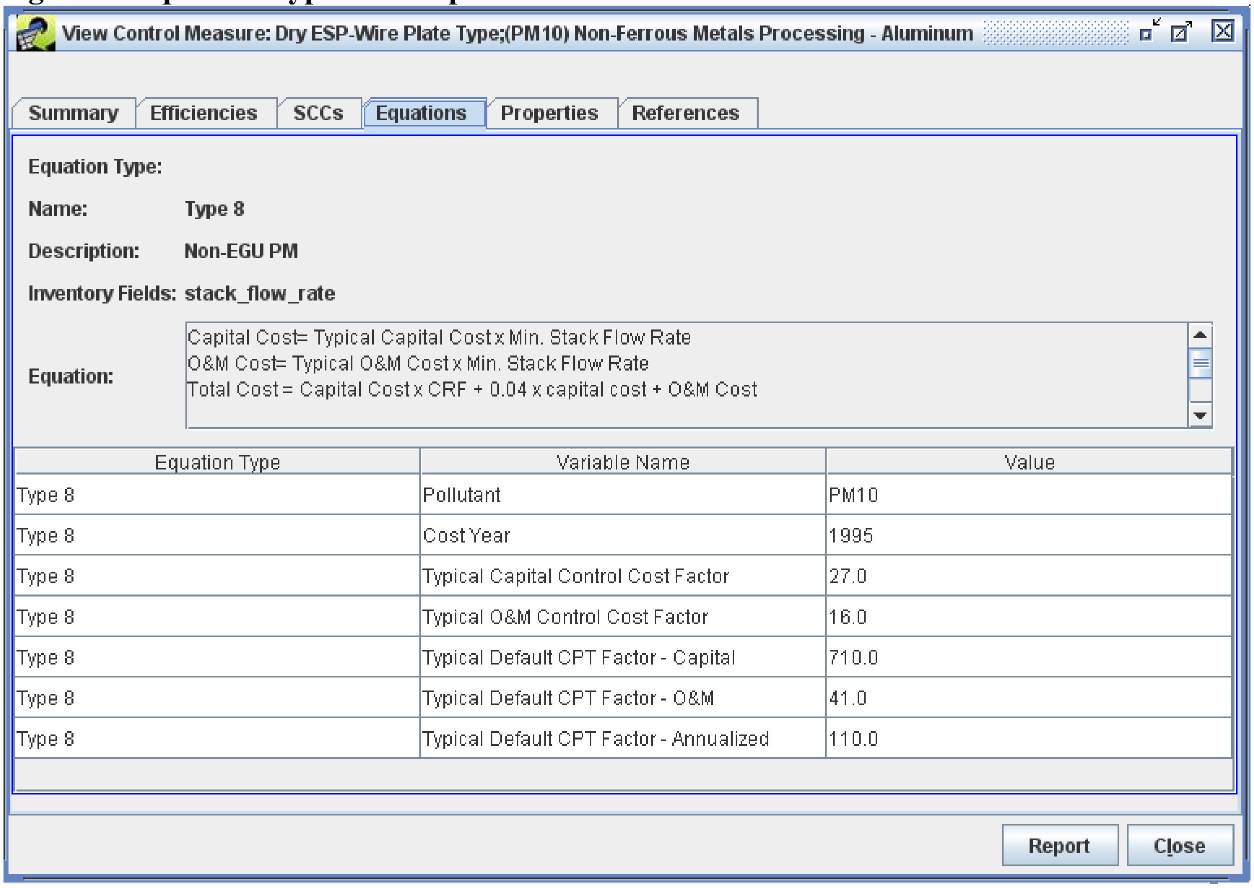
where emission reduction is calculated by CoST and *Default Cost per Ton* is control measure specific.

4.1.2 Equation Type 8 Example with Inventory Stackflow

4.1.2.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 20 years (from summary tab of control measure data)
PM_{10} Emissions Reductions = 162.78 tons
$STKFLOW = 283.69\ ft^3/sec$

Figure 9: Equation Type 8 Example Screenshot



4.1.2.2 Capital Cost Equation

$$Capital\ Cost = Typical\ Capital\ Cost\ \times STKFLOW \times 60$$

$$Capital\ Cost = \$27/acfm\ \times 283.69\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$Capital\ Cost = \$459{,}578\ (1995\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$

$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{20\ years}}{(1 + 0.07)^{20\ years} - 1}$$

$$Capital\ Recovery\ Factor = 0.094393$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$459{,}578 \times 0.094393$$

$$Annualized\ Capital\ Cost = \$43{,}381\ (1995\$)$$

4.1.2.3 Operation and Maintenance Cost Equation

$$O\&M\ Cost = Typical\ O\&M\ Cost\ \times STKFLOW \times 60$$

$$O\&M\ Cost = \$16/acfm\ \times 283.69\frac{ft^3}{sec} \times 60\frac{sec}{min}$$

$$O\&M\ Cost = \$272{,}342\ (\$1995)$$

4.1.2.4 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + 0.04 \times Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$43{,}381 + 0.04 \times \$459{,}578 + \$272{,}342$$
$$Total\ Annualized\ Cost = \$637{,}851\ (1995\$)$$

4.1.3 Equation Type 8 Example without Inventory Stackflow

4.1.3.1 Example Equation Variables

Uncontrolled PM_{10}: 15 tons (from inventory record without stack parameters)
PM_{10} control efficiency: 98% (from efficiencies tab of control measure data)
PM_{10} reduction: 14.7 tons

4.1.3.2 Capital Cost

$$Total\ Capital\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton - Capital$$
$$Total\ Capital\ Cost = 14.7\ tons \times 710\,\frac{\$}{ton}$$
$$Total\ Capital\ Cost = \$10{,}437\ (1995\$)$$

4.1.3.3 Operating and Maintenance Cost

$$Total\ O\&M\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton - O\&M$$
$$Total\ O\&M\ Cost = 14.7\ tons \times 41\,\frac{\$}{ton}$$
$$Total\ O\&M\ Cost = \$603\ (1995\$)$$

4.1.3.4 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Emission\ Reduction \times Default\ Cost\ Per\ Ton - Annualized$$
$$Total\ Annualized\ Cost = 14.7\ tons \times 110\,\frac{\$}{ton}$$
$$Total\ Annualized\ Cost = \$1{,}617\ (1995\$)$$

4.1.4 Equation Type 8 CoST Code

```
------------------------------------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--


-- Type 8
IF equation_type = 'Type 8' THEN
	IF coalesce(STKFLOW, 0) <> 0 THEN
		select costs.annual_cost,
			costs.capital_cost,
			costs.operation_maintenance_cost,
			costs.annualized_capital_cost,
```

```
                costs.computed_cost_per_ton
            from public.get_type8_equation_costs(control_measure_id,
                discount_rate,
                equipment_life,
                capital_recovery_factor,
                emis_reduction,
                STKFLOW,
                variable_coefficient1,
                variable_coefficient2,
                variable_coefficient3,
                variable_coefficient4,
                variable_coefficient5) as costs

            into annual_cost,
                capital_cost,
                operation_maintenance_cost,
                annualized_capital_cost,
                computed_cost_per_ton;
            IF annual_cost is not null THEN
                valid_cost := true;
                actual_equation_type := 'Type 8';
            ELSE
                valid_cost := false;
                actual_equation_type := '-Type 8';
            END IF;
            -- adjust costs to the reference cost year
            annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
            capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
            operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
            annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
            computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
            return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 8';
END IF;

-- Next the code will call the default CPT approach

-----------------------------------------------------------------------------------------------------------------------------------------



-- Type 8
CREATE OR REPLACE FUNCTION public.get_type8_equation_costs(
        control_measure_id integer,
        discount_rate double precision,
        equipment_life double precision,
        capital_recovery_factor double precision,
        emis_reduction double precision,
        STKFLOW double precision,
        capital_control_cost_factor double precision,
        om_control_cost_factor double precision,
        default_capital_cpt_factor double precision,
        default_om_cpt_factor double precision,
        default_annualized_cpt_factor double precision,
        OUT annual_cost double precision,
        OUT capital_cost double precision,
        OUT operation_maintenance_cost double precision,
        OUT annualized_capital_cost double precision,
        OUT computed_cost_per_ton double precision)  AS $$
```

```
DECLARE
	cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
	-- * Comments *




	-- * Comments *

	-- get capital recovery factor, caculate if it wasn't passed in...
	 IF coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0 THEN
		cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
	END IF;

	-- calculate capital cost
	capital_cost :=
		case
			when coalesce(STKFLOW, 0) = 0 then null
			when STKFLOW >= 5.0 then capital_control_cost_factor * STKFLOW
			else default_capital_cpt_factor * emis_reduction
		end;

	-- calculate operation maintenance cost
	operation_maintenance_cost :=
		case
			when coalesce(STKFLOW, 0) = 0 then null
			when STKFLOW >= 5.0 then om_control_cost_factor * STKFLOW
			else default_om_cpt_factor * emis_reduction
		end;

	-- calculate annualized capital cost
	annualized_capital_cost := capital_cost * cap_recovery_factor;

	-- calculate annual cost
	annual_cost :=
		case
			when coalesce(STKFLOW, 0) = 0 then null
			when STKFLOW >= 5.0 then annualized_capital_cost + 0.04 * capital_cost +
operation_maintenance_cost
			else default_annualized_cpt_factor * emis_reduction
		end;

	-- calculate computed cost per ton
	computed_cost_per_ton :=
		case
			when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
			else null
		end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

Table 8. Non-IPM Sector PM Control Cost Equation Factors (Equation Type 8)

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Equipment Life	Typical Control Cost Equation-Based Factors		Cost Year ($ Year)
			PM-10	PM-2.5		Capital	O&M	
PCATFWAT	Beef Cattle Feedlots	Watering	50	25	10			1990
PCHIPHB	Household burning	Substitute chipping for burning		50	0			1999
PCHIPOB	Open burning	Substitute chipping for burning		100	0			1999
PCHRBCAOX	Conveyorized Charbroilers	Catalytic Oxidizer	83	83	10			1990
PCHRBCAOX1	Conveyorized Charbroilers	Catalytic Oxidizer	8.3	8.3	10			1990
PCHRBESP	Conveyorized Charbroilers	ESP for Commercial Cooking	99	99	10			1990
PCHRBESPSM	Commercial Cooking -- large underfired grilling operations	ESP	99	99	10			1990
PCONWATCHM	Construction Activities	Dust Control Plan	62.5	37.5	0			1990
PDESPCIBCL	Commercial Institutional Boilers - Coal	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPCIBOL	Commercial Institutional Boilers - Oil	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPCIBWD	Commercial Institutional Boilers - Wood	Dry ESP-Wire Plate Type	90	90	20	27	16	1995
PDESPIBCL	Industrial Boilers - Coal	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPIBLW	Industrial Boilers - Liquid Waste	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPIBOL	Industrial Boilers - Oil	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPIBWD	Industrial Boilers - Wood	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMICM	Mineral Products - Cement Manufacture	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMIOR	Mineral Products - Other	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMISQ	Mineral Products - Stone Quarrying & Processing	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPAM	Non-Ferrous Metals Processing - Aluminum	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPCR	Non-Ferrous Metals Processing - Copper	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPFP	Ferrous Metals Processing - Ferroalloy Production	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPIS	Ferrous Metals Processing - Iron & Steel Production	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPLD	Non-Ferrous Metals Processing - Lead	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPOR	Non-Ferrous Metals Processing - Other	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMPZC	Non-Ferrous Metals Processing - Zinc	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPMUWI	Municipal Waste Incineration	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDESPWDPP	Wood Pulp & Paper	Dry ESP-Wire Plate Type	98	95	20	27	16	1995
PDIEOXCAT	IC Diesel Engine	Diesel Oxidation Catalyst (DPF infeasible)	20		0			2003
PDIEPRTFIL	IC Diesel Engine	Diesel Particulate Filter	85		0			2003
PDPFICE	Internal Combustion Engines	Diesel Particulate Filter		90	0			1999
PESPOFBOIL	Oil fired boiler	ESP		75	0			1999
PESPPETCRK	Petroleum Refinery Catalytic and Thermal Cracking Units	ESP	95		0			1999
PFFMSASMN	Asphalt Manufacture	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMICC	Mineral Products - Coal Cleaning	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMICM	Mineral Products - Cement Manufacture	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMIOR	Mineral Products - Other	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMISQ	Mineral Products - Stone Quarrying & Processing	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPAM	Non-Ferrous Metals Processing - Aluminum	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPCE	Ferrous Metals Processing - Coke	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPCR	Non-Ferrous Metals Processing - Copper	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPFP	Ferrous Metals Processing - Ferroalloy Production	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPGI	Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPIS	Ferrous Metals Processing - Iron & Steel Production	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPLD	Non-Ferrous Metals Processing - Lead	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPOR	Non-Ferrous Metals Processing - Other	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPSF	Ferrous Metals Processing - Steel Foundries	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFMSMPZC	Non-Ferrous Metals Processing - Zinc	Fabric Filter (Mech. Shaker Type)	99	99	20	29	11	1998
PFFPJASMN	Asphalt Manufacture	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJCIBCL	Commercial Institutional Boilers - Coal	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJCIBWD	Commercial Institutional Boilers - Wood	Fabric Filter (Pulse Jet Type)	80	80	20	13	11	1998
PFFPJGRMG	Grain Milling	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJIBCL	Industrial Boilers - Coal	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJIBWD	Industrial Boilers - Wood	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Equipment Life	Typical Control Cost Equation-Based Factors		Cost Year ($ Year)
			PM-10	PM-2.5		Capital	O&M	
PFFPJMICC	Mineral Products - Coal Cleaning	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJMICM	Mineral Products - Cement Manufacture	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJMIOR	Mineral Products - Other	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJMISQ	Mineral Products - Stone Quarrying & Processing	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJMPIS	Ferrous Metals Processing - Iron & Steel Production	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFPJMPSF	Ferrous Metals Processing - Steel Foundries	Fabric Filter (Pulse Jet Type)	99	99	20	13	11	1998
PFFRAASMN	Asphalt Manufacture	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRACIBCL	Commercial Institutional Boilers - Coal	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRACIBWD	Commercial Institutional Boilers - Wood	Fabric Filter - Reverse-Air Cleaned Type	80	80	20	34	13	1998
PFFRAGRMG	Grain Milling	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAIBCL	Industrial Boilers - Coal	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAIBWD	Industrial Boilers - Wood	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMICC	Mineral Products - Coal Cleaning	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMICM	Mineral Products - Cement Manufacture	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMIOR	Mineral Products - Other	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMISQ	Mineral Products - Stone Quarrying & Processing	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPAM	Non-Ferrous Metals Processing - Aluminum	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPCE	Ferrous Metals Processing - Coke	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPCR	Non-Ferrous Metals Processing - Copper	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPFP	Ferrous Metals Processing - Ferroalloy Production	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPGI	Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPIS	Ferrous Metals Processing - Iron & Steel Production	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPLD	Non-Ferrous Metals Processing - Lead	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPOR	Non-Ferrous Metals Processing - Other	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPSF	Ferrous Metals Processing - Steel Foundries	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFFRAMPZC	Non-Ferrous Metals Processing - Zinc	Fabric Filter - Reverse-Air Cleaned Type	99	99	20	34	13	1998
PFIRINSHH	Home Heating	Fireplace Inserts		98	0			1999
PISCRMPGI	Ferrous Metals Processing - Gray Iron Foundries	Impingement-plate scrubber	64	64	10	7	25	1995
PLNDFILBRN	Open Burning	Substitution of land filling for open burning	75		0			1999
PPFCCASMN	Asphalt Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCFMAB	Fabricated Metal Products - Abrasive Blasting	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCFMMG	Fabricated Metal Products - Machining	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCFMWG	Fabricated Metal Products - Welding	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCGRMG	Grain Milling	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCMICC	Mineral Products - Coal Cleaning	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCMICM	Mineral Products - Cement Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCMIOR	Mineral Products - Other	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPFCCMISQ	Mineral Products - Stone Quarrying & Processing	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	20	9	14	1998
PPRBRNFULM	Prescribed Burning	Increase Fuel Moisture	50	50	0			1990
PRESWDEDAD	Residential Wood Combustion	Education and Advisory Program	50	50	0			1990
PRESWDEDAP	Residential Wood Combustion Generic	Education and Advisory Program	35	35	0			1990
PRESWDSTV1	Residential Wood Combustion	NSPS Compliant Wood Stove	8.2	8.2	0			1990
PRESWDSTV2	Residential Wood Combustion	NSPS Compliant Wood Stove	9.8	9.8	0			1990
PVENTCCU	Catalytic cracking units	Venturi scrubber		90	0			1999
PVESCIBCL	Industrial Boilers - Coal	Venturi Scrubber	82	50	10	11	42	1995
PVESCIBOL	Industrial Boilers - Oil	Venturi Scrubber	92	89	10	11	42	1995
PVESCIBWD	Industrial Boilers - Wood	Venturi Scrubber	93	92	10	11	42	1995
PVSCRMICC	Mineral Products - Coal Cleaning	Venturi Scrubber	99	98	10	11	42	1995
PVSCRMISQ	Mineral Products - Stone Quarrying & Processing	Venturi Scrubber	95	90	10	11	42	1995

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Equipment Life	Typical Control Cost Equation-Based Factors		Cost Year ($ Year)
			PM-10	PM-2.5		Capital	O&M	
PVSCRMPCE	Ferrous Metals Processing - Coke	Venturi Scrubber	93	89	10	11	42	1995
PVSCRMPGI	Ferrous Metals Processing - Gray Iron Foundries	Venturi Scrubber	94	94	10	11	42	1995
PVSCRMPIS	Ferrous Metals Processing - Iron & Steel Production	Venturi Scrubber	73	25	10	11	42	1995
PVSCRMPSF	Ferrous Metals Processing - Steel Foundries	Venturi Scrubber	73	25	10	11	42	1995
PWESPCHMN	Chemical Manufacture	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMIOR	Mineral Products - Other	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMISQ	Mineral Products - Stone Quarrying & Processing	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMPAM	Non-Ferrous Metals Processing - Aluminum	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMPCR	Non-Ferrous Metals Processing - Copper	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMPIS	Ferrous Metals Processing - Iron & Steel Production	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMPLD	Non-Ferrous Metals Processing - Lead	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMPOR	Non-Ferrous Metals Processing - Other	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPMPZC	Non-Ferrous Metals Processing - Zinc	Wet ESP - Wire Plate Type	99	95	20	40	19	1995
PWESPWDPP	Wood Pulp & Paper	Wet ESP - Wire Plate Type	99	95	20	40	19	1995

Table 9. Non-IPM Sector PM Controls Default Cost per Ton Factors (Equation Type 8 or Controls Applied to Non-point Sources)

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Typical Default Cost per Ton Factors			Cost Year ($ Year)
			PM-10	PM-2.5	Capital	O&M	Annualized	
PCATFWAT	Beef Cattle Feedlots	Watering	50	25			307	1990
PCHIPHB	Household burning	Substitute chipping for burning		50				1999
PCHIPOB	Open burning	Substitute chipping for burning		100				1999
PCHRBCAOX	Conveyorized Charbroilers	Catalytic Oxidizer	83	83			2150	1990
PCHRBCAOX1	Conveyorized Charbroilers	Catalytic Oxidizer	8.3	8.3			2150	1990
PCHRBESP	Conveyorized Charbroilers	ESP for Commercial Cooking	99	99			7000	1990
PCHRBESPSM	Commercial Cooking -- large underfired grilling operations	ESP	99	99			7000	1990
PCONWATCHM	Construction Activities	Dust Control Plan	62.5	37.5			3600	1990
PDESPCIBCL	Commercial Institutional Boilers - Coal	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPCIBOL	Commercial Institutional Boilers - Oil	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPCIBWD	Commercial Institutional Boilers - Wood	Dry ESP-Wire Plate Type	90	90	710	41	110	1995
PDESPIBCL	Industrial Boilers - Coal	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPIBLW	Industrial Boilers - Liquid Waste	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPIBOL	Industrial Boilers – Oil	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPIBWD	Industrial Boilers - Wood	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMICM	Mineral Products - Cement Manufacture	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMIOR	Mineral Products - Other	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMISQ	Mineral Products - Stone Quarrying & Processing	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPAM	Non-Ferrous Metals Processing - Aluminum	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPCR	Non-Ferrous Metals Processing - Copper	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPFP	Ferrous Metals Processing - Ferroalloy Production	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPIS	Ferrous Metals Processing - Iron & Steel Production	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPLD	Non-Ferrous Metals Processing - Lead	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPOR	Non-Ferrous Metals Processing - Other	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMPZC	Non-Ferrous Metals Processing - Zinc	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPMUWI	Municipal Waste Incineration	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDESPWDPP	Wood Pulp & Paper	Dry ESP-Wire Plate Type	98	95	710	41	110	1995
PDIEOXCAT	IC Diesel Engine	Diesel Oxidation Catalyst (DPF infeasible)	20				1500	2003
PDIEPRTFIL	IC Diesel Engine	Diesel Particulate Filter	85				10500	2003
PDPFICE	Internal Combustion Engines	Diesel Particulate Filter		90				1999
PESPOFBOIL	Oil fired boiler	ESP		75				1999
PESPPETCRK	Petroleum Refinery Catalytic and Thermal Cracking Units	ESP	95				5050	1999
PFFMSASMN	Asphalt Manufacture	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMICC	Mineral Products - Coal Cleaning	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMICM	Mineral Products - Cement Manufacture	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMIOR	Mineral Products - Other	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMISQ	Mineral Products - Stone Quarrying & Processing	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPAM	Non-Ferrous Metals Processing - Aluminum	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPCE	Ferrous Metals Processing - Coke	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPCR	Non-Ferrous Metals Processing - Copper	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPFP	Ferrous Metals Processing - Ferroalloy Production	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPGI	Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPIS	Ferrous Metals Processing - Iron & Steel Production	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPLD	Non-Ferrous Metals Processing - Lead	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPOR	Non-Ferrous Metals Processing - Other	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPSF	Ferrous Metals Processing - Steel Foundries	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFMSMPZC	Non-Ferrous Metals Processing - Zinc	Fabric Filter (Mech. Shaker Type)	99	99	412	62	126	1998
PFFPJASMN	Asphalt Manufacture	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJCIBCL	Commercial Institutional Boilers - Coal	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJCIBWD	Commercial Institutional Boilers - Wood	Fabric Filter (Pulse Jet Type)	80	80	380	28	117	1998
PFFPJGRMG	Grain Milling	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJIBCL	Industrial Boilers - Coal	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJIBWD	Industrial Boilers - Wood	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJMICC	Mineral Products - Coal Cleaning	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Typical Default Cost per Ton Factors			Cost Year ($ Year)
			PM-10	PM-2.5	Capital	O&M	Annualized	
PFFPJMICM	Mineral Products - Cement Manufacture	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJMIOR	Mineral Products - Other	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJMISQ	Mineral Products - Stone Quarrying & Processing	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJMPIS	Ferrous Metals Processing - Iron & Steel Production	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFPJMPSF	Ferrous Metals Processing - Steel Foundries	Fabric Filter (Pulse Jet Type)	99	99	380	28	117	1998
PFFRAASMN	Asphalt Manufacture	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRACIBCL	Commercial Institutional Boilers - Coal	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRACIBWD	Commercial Institutional Boilers - Wood	Fabric Filter - Reverse-Air Cleaned Type	80	80	0	0	148	1998
PFFRAGRMG	Grain Milling	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAIBCL	Industrial Boilers - Coal	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAIBWD	Industrial Boilers - Wood	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMICC	Mineral Products - Coal Cleaning	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMICM	Mineral Products - Cement Manufacture	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMIOR	Mineral Products - Other	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMISQ	Mineral Products - Stone Quarrying & Processing	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPAM	Non-Ferrous Metals Processing - Aluminum	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPCE	Ferrous Metals Processing - Coke	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPCR	Non-Ferrous Metals Processing - Copper	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPFP	Ferrous Metals Processing - Ferroalloy Production	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPGI	Ferrous Metals Processing - Gray Iron Foundries	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPIS	Ferrous Metals Processing - Iron & Steel Production	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPLD	Non-Ferrous Metals Processing - Lead	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPOR	Non-Ferrous Metals Processing - Other	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPSF	Ferrous Metals Processing - Steel Foundries	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFFRAMPZC	Non-Ferrous Metals Processing - Zinc	Fabric Filter - Reverse-Air Cleaned Type	99	99	0	0	148	1998
PFIRINSHH	Home Heating	Fireplace Inserts		98				1999
PISCRMPGI	Ferrous Metals Processing - Gray Iron Foundries	Impingement-plate scrubber	64	64	87	417	431	1995
PLNDFILBRN	Open Burning	Substitution of land filling for open burning	75				3500	1999
PPFCCASMN	Asphalt Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCFMAB	Fabricated Metal Products - Abrasive Blasting	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCFMMG	Fabricated Metal Products - Machining	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCFMWG	Fabricated Metal Products - Welding	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCGRMG	Grain Milling	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCMICC	Mineral Products - Coal Cleaning	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCMICM	Mineral Products - Cement Manufacture	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCMIOR	Mineral Products - Other	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPFCCMISQ	Mineral Products - Stone Quarrying & Processing	Paper/Nonwoven Filters - Cartridge Collector Type	99	99	0	0	142	1998
PPRBRNFULM	Prescribed Burning	Increase Fuel Moisture	50	50			2617	1990
PRESWDEDAD	Residential Wood Combustion	Education and Advisory Program	50	50			1320	1990
PRESWDEDAP	Residential Wood Combustion Generic	Education and Advisory Program	35	35			1320	1990
PRESWDSTV1	Residential Wood Combustion	NSPS Compliant Wood Stove	8.2	8.2			1454	1990
PRESWDSTV2	Residential Wood Combustion	NSPS Compliant Wood Stove	9.8	9.8			1454	1990
PVENTCCU	Catalytic cracking units	Venturi scrubber		90				1999
PVESCIBCL	Industrial Boilers - Coal	Venturi Scrubber	82	50	189	713	751	1995
PVESCIBOL	Industrial Boilers - Oil	Venturi Scrubber	92	89	189	713	751	1995
PVESCIBWD	Industrial Boilers - Wood	Venturi Scrubber	93	92	189	713	751	1995
PVSCRMICC	Mineral Products - Coal Cleaning	Venturi Scrubber	99	98	189	713	751	1995
PVSCRMISQ	Mineral Products - Stone Quarrying & Processing	Venturi Scrubber	95	90	189	713	751	1995
PVSCRMPCE	Ferrous Metals Processing - Coke	Venturi Scrubber	93	89	189	713	751	1995
PVSCRMPGI	Ferrous Metals Processing - Gray Iron Foundries	Venturi Scrubber	94	94	189	713	751	1995
PVSCRMPIS	Ferrous Metals Processing - Iron & Steel Production	Venturi Scrubber	73	25	189	713	751	1995
PVSCRMPSF	Ferrous Metals Processing - Steel Foundries	Venturi Scrubber	73	25	189	713	751	1995
PWESPCHMN	Chemical Manufacture	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMIOR	Mineral Products - Other	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMISQ	Mineral Products - Stone Quarrying & Processing	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMPAM	Non-Ferrous Metals Processing - Aluminum	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMPCR	Non-Ferrous Metals Processing - Copper	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMPIS	Ferrous Metals Processing - Iron & Steel Production	Wet ESP - Wire Plate Type	99	95	923	135	220	1995

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Typical Default Cost per Ton Factors			Cost Year ($ Year)
			PM-10	PM-2.5	Capital	O&M	Annualized	
PWESPMPLD	Non-Ferrous Metals Processing - Lead	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMPOR	Non-Ferrous Metals Processing - Other	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPMPZC	Non-Ferrous Metals Processing - Zinc	Wet ESP - Wire Plate Type	99	95	923	135	220	1995
PWESPWDPP	Wood Pulp & Paper	Wet ESP - Wire Plate Type	99	95	923	135	220	1995

4.2 IPM Sector (ptipm) PM Control Cost Equations

Three types of equations are utilized in the control cost calculation for IPM sector PM controls. One equation has been described in the non-IPM emissions sector PM section of this report. Equation Type 8 uses the unit's stack flow rate (in acfm) as the primary variable for control cost calculation. If a unit's stack flow is outside of a range of values (15,000 <= stack flow rate (cfm) <= 1,400,000), then the control measure is not applied to the specific unit; instead a default cost per ton value calculation is used. The second equation, Equation Type 9, is referenced in a report prepared by EPA's Office of Research and Development (ORD). This equation also uses a unit's stack flow rate (acfm) with capital and O&M cost factors. The third equation, Equation Type 10, is used for control measures that are upgrades to existing ESPs.

Table 10 provides a list of the control cost equations assigned to various ptipm PM control measures. Both the control efficiencies for PM_{10} and $PM_{2.5}$ are provided in this table. Values are representative of typical cost values and although not provided as options in the CoST output, low and high cost values are also available in the source tables. This table also presents the default cost per ton values used when a unit's stack flow rate is out of the recommended range. Three variables are available for this calculation; a capital cost multiplier, an O&M cost multiplier, and an annualized cost multiplier. Table 11 provides the capital and O&M factors associated with the new equation type described in Equation 9. The new equation application does not appear to have any default cost per ton backup calculation in the event of stack flow rates being outside of the acceptable range, however, it is noted that a description of the control measures utilizing this new equation (Fabric Filter – Mechanical Shaker) is also represented in the Equation Type 8 control measure list.

If the unit already has PM controls applied in the input inventory, incremental controls are applied only if their control efficiency value exceeds that of the input control. Control costs do not differ in these cases and the costs associated with incremental controls are the same as those applied on uncontrolled sources.

In addition to add-on control measures, there are control measures included in CoST that are upgrades to control measures already in operation on a unit. CoST includes control measures that are upgrades to ESPs on ptipm sources. These control measures are costed using Equation Type 10 and the variable values are presented in Table 12.

4.2.1 *Equation Type 8*

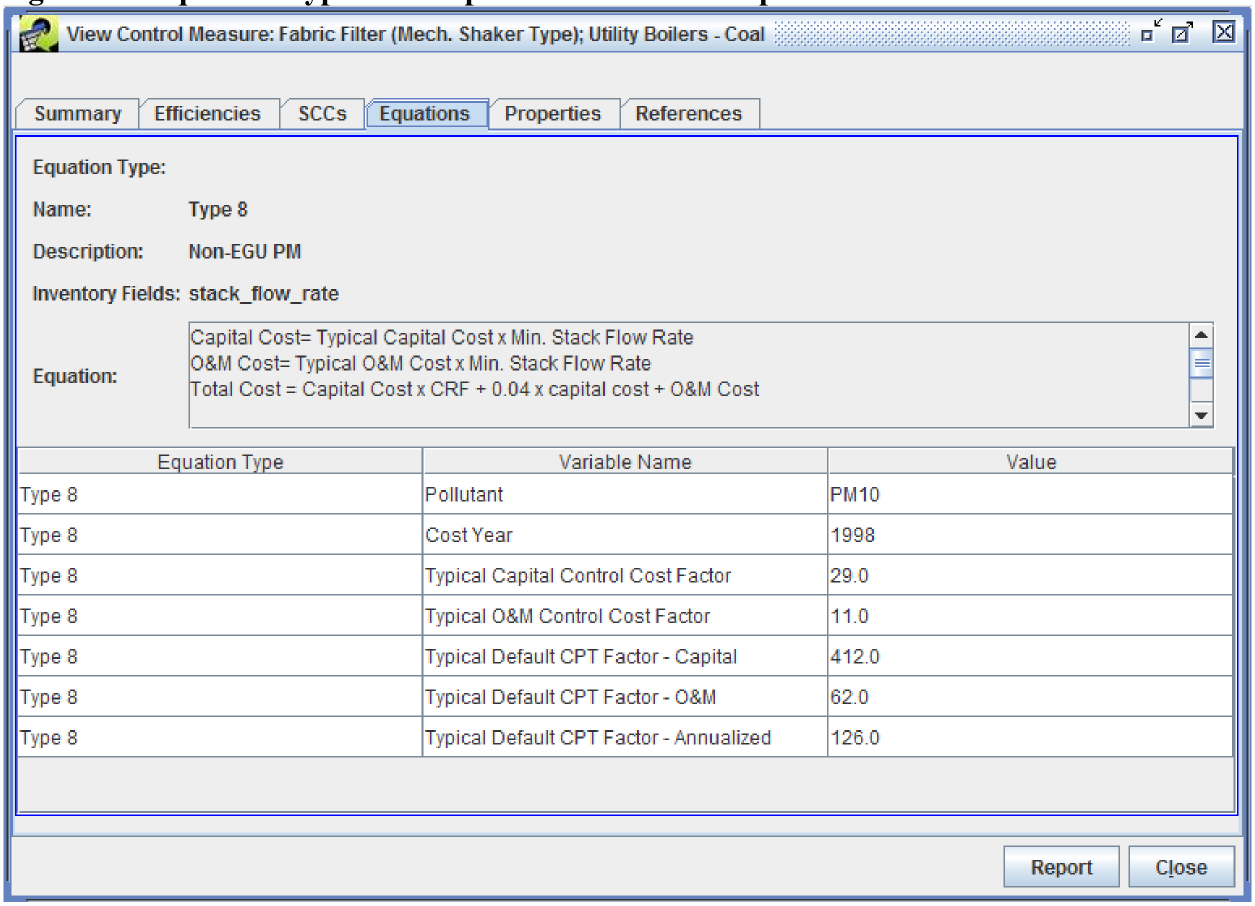
Please refer to section 2.3.1.1 above.

4.2.2 Equation Type 8 Example for IPM Sector Sources

4.2.2.1 Example Equation Variables

$Interest\ Rate = 7\%$ (can be set by user in CoST)
$Equipment\ Life = 20$ years (from summary tab of control measure data)
PM_{10} Emissions Reductions = 135 tons
$STKFLOW = 283.69\ \text{ft}^3/\text{sec}$

Figure 10: Equation Type 8 Example Screenshot for Ptipm Source


View Control Measure: Fabric Filter (Mech. Shaker Type); Utility Boilers - Coal

Summary | Efficiencies | SCCs | Equations | Properties | References

Equation Type:

Name: Type 8

Description: Non-EGU PM

Inventory Fields: stack_flow_rate

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

Equation Type	Variable Name	Value
Type 8	Pollutant	PM10
Type 8	Cost Year	1998
Type 8	Typical Capital Control Cost Factor	29.0
Type 8	Typical O&M Control Cost Factor	11.0
Type 8	Typical Default CPT Factor - Capital	412.0
Type 8	Typical Default CPT Factor - O&M	62.0
Type 8	Typical Default CPT Factor - Annualized	126.0

Report | Close

4.2.2.2 Capital Cost Equation

$$Capital\ Cost = Typical\ Capital\ Cost \times STKFLOW \times 60$$

$$Capital\ Cost = \$29/acfm \times 283.69 \frac{ft^3}{sec} \times 60 \frac{sec}{min}$$

$$Capital\ Cost = \$493{,}621\ (1998\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life} - 1}$$

$$Capital\ Recovery\ Factor = \frac{0.07 \times (1 + 0.07)^{20\ years}}{(1 + 0.07)^{20\ years} - 1}$$

$$Capital\ Recovery\ Factor = 0.094393$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$

$$Annualized\ Capital\ Cost = \$493{,}621 \times 0.094393$$

$$Annualized\ Capital\ Cost = \$46{,}594\ (1998\$)$$

4.2.2.3 Operation and Maintenance Cost Equation

$$O\&M\ Cost = Typical\ O\&M\ Cost\ \times STKFLOW \times 60$$
$$O\&M\ Cost = \$11/acfm\ \times 283.69 \frac{ft^3}{sec} \times 60 \frac{sec}{min}$$
$$O\&M\ Cost = \$187{,}235\ (\$1995)$$

4.2.2.4 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + 0.04 \times Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$46{,}594 + 0.04 \times \$493{,}621 + \$187{,}235$$
$$Total\ Annualized\ Cost = \$253{,}575\ (1995\$)$$

4.2.3 Equation Type 8 CoST Code

Please refer to section 2.3.1.3 above.

4.2.4 Equation Type 9

4.2.4.1 Capital Cost Equations

$$Capital\ Cost = [(Total\ Equipment\ Cost\ Factor\ \times STKFLOW) + Total\ Equipment\ Cost\ Constant\ ]\ \times\ Equipment\ to\ Capital\ Cost\ Multiplier$$

where the *Total Equipment Cost Factor, Total Equipment Cost Constant,* and *Capital Cost Multiplier* are control measure specific, and *STKFLOW* is obtained from the inventory being processed.

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life} - 1}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$

4.2.4.2 Operation and Maintenance Cost Equation

$$O\&M\ Cost = \left(Electricty\ Factor\ \times STKFLOW \left(\frac{ft^3}{min}\right) + Electricity\ Constant\right) + \left(Dust\ Disposal\ Factor \times STKFLOW \left(\frac{ft^3}{min}\right) + Dust\ Disposal\ Constant\right) + \left(Bag\ Replacement\ Factor \times STKFLOW \left(\frac{ft^3}{min}\right) + Bag\ Replacement\ Constant\right)$$

where *Electricity Factor, Electricity Constant, Dust Disposal Factor, Dust Disposal Constant, Bag Replacement Factor*, and *Bag Replacement Constant* are control measure specific, and *STKFLOW* is obtained from the inventory being processed.

4.2.4.3 Total Annualized Cost Equation

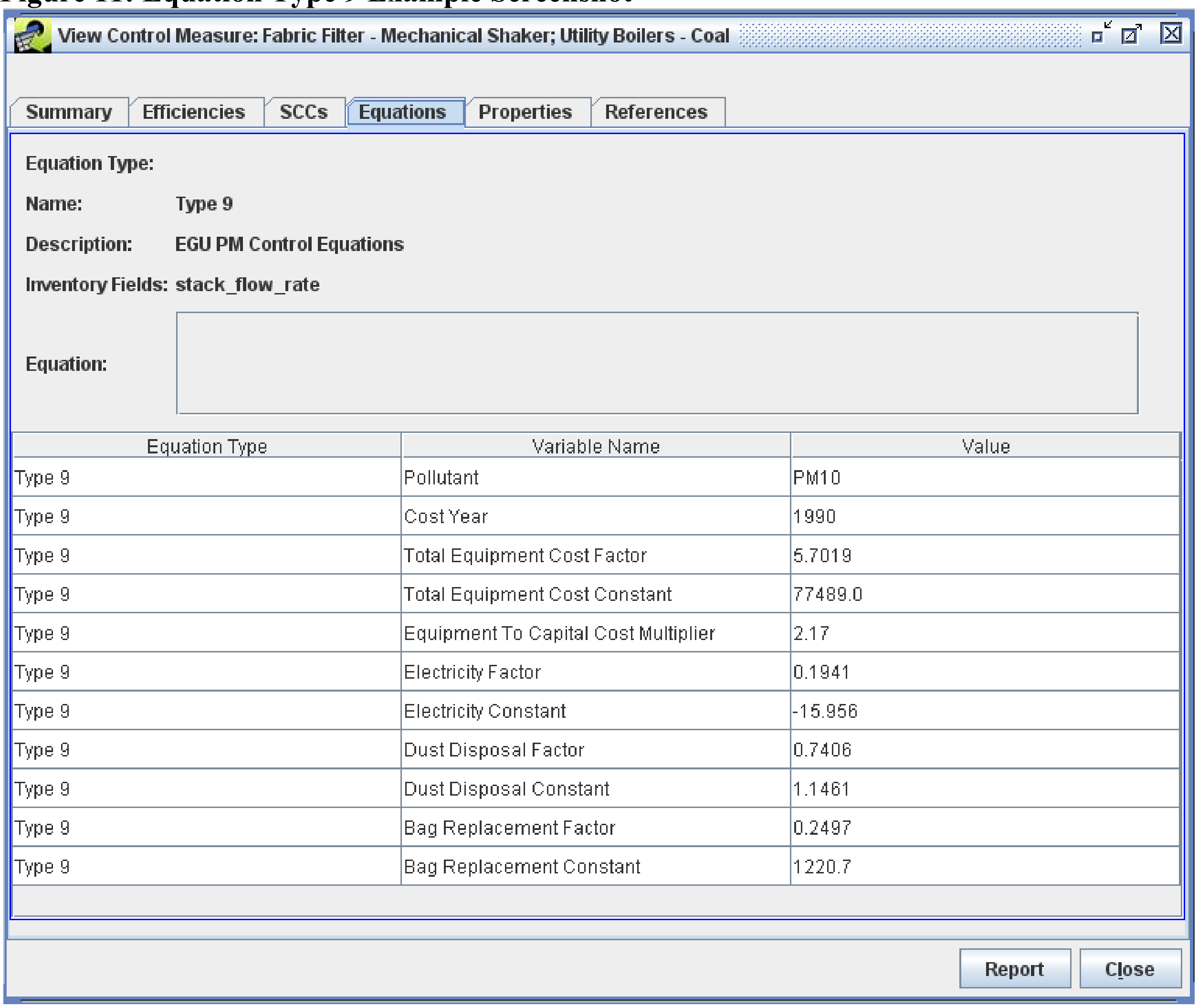
$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$

4.2.5 Equation Type 9 Example

4.2.5.1 Example Equation Variables

Interest Rate = 7% (can be set by user in CoST)
Equipment Life = 20 years (from summary tab of control measure data)
STKFLOW =16,354 ft^3/min

Figure 11: Equation Type 9 Example Screenshot



4.2.5.2 Annualized Capital Cost

$$Capital\ Cost = ((Total\ Equipment\ Cost\ Factor \times STKFLOW \left(\frac{ft^3}{min}\right) + Total\ Equipment\ Cost\ Constant\ ) \times Equipment\ to\ Capital\ Cost\ Multiplier$$

$$Capital\ Cost = \left(\frac{\$5.7019}{acfm} \times 16{,}354\ \left(\frac{\text{ft}^3}{\text{min}}\right) + \$77{,}489\ \right) \times 2.17$$
$$Capital\ Cost = \$370{,}501\ (1990\$)$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$
$$Capital\ Recovery\ Factor = \frac{0.07\ \times (1 + 0.07)^{20\ years}}{(1 + 0.07)^{20\ years} - 1}$$
$$Capital\ Recovery\ Factor = 0.094393$$

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$370{,}504 \times 0.094393$$
$$Annualized\ Capital\ Cost = \$34{,}973\ (1990\$)$$

4.2.5.3 Operation and Maintenance Cost

$$O\&M\ Cost = \left(Electricty\ Factor\ \times STKFLOW\left(\frac{\text{ft}^3}{\text{min}}\right) + Electricity\ Constant\right) + \left(Dust\ Disposal\ Factor \times STKFLOW\left(\frac{\text{ft}^3}{\text{min}}\right) + Dust\ Disposal\ Constant\right) + \left(Bag\ Replacement\ Factor \times STKFLOW\left(\frac{\text{ft}^3}{\text{min}}\right) + Bag\ Replacement\ Constant\right)$$
$$O\&M\ Cost = \left(\frac{\$0.1941}{acfm} \times 16{,}354\left(\frac{\text{ft}^3}{\text{min}}\right) - \$15.956\right) + \left(\$0.7406/acfm \times 16{,}354\left(\frac{\text{ft}^3}{\text{min}}\right) + \$1.1461\right) + \left(\$0.2497/acfm \times 16{,}354\left(\frac{\text{ft}^3}{\text{min}}\right) + \$1220.7\right)$$
$$O\&M\ Cost = \$20{,}576\ (1990\$)$$

4.2.5.4 Total Annualized Cost

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$34{,}973 + \$20{,}576$$
$$Total\ Annualized\ Cost = \$55{,}549\ (1990\$)$$

4.2.6 Equation Type 9 CoST Code

```
-------------------------------------------------------------------------------------------------------------

-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--

-- Type 9
IF equation_type = 'Type 9' THEN
        IF coalesce(STKFLOW, 0) <> 0 THEN
```

```
            select costs.annual_cost,
                costs.capital_cost,
                costs.operation_maintenance_cost,
                costs.annualized_capital_cost,
                costs.computed_cost_per_ton
            from public.get_type9_equation_costs(control_measure_id,
                discount_rate,
                equipment_life,
                capital_recovery_factor,
                emis_reduction,
                STKFLOW,
                variable_coefficient1,
                variable_coefficient2,
                variable_coefficient3,
                variable_coefficient4,
                variable_coefficient5,
                variable_coefficient6,
                variable_coefficient7,
                variable_coefficient8,
                variable_coefficient9) as costs
            into annual_cost,
                capital_cost,
                operation_maintenance_cost,
                annualized_capital_cost,
                computed_cost_per_ton;
            IF annual_cost is not null THEN
                valid_cost := true;
                actual_equation_type := 'Type 9';
            ELSE
                valid_cost := false;
                actual_equation_type := '-Type 9';
            END IF;
            -- adjust costs to the reference cost year
            annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
            capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
            operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
            annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
            computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
            return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 9';
END IF;

-- Next the code will call the default CPT approach

------------------------------------------------------------------------------------------------------------------------------------

-- Type 9 - ptipm PM Control Equations
CREATE OR REPLACE FUNCTION public.get_type9_equation_costs(
        control_measure_id integer,
        discount_rate double precision,
        equipment_life double precision,
        capital_recovery_factor double precision,
        emis_reduction double precision,
        STKFLOW double precision, -- in cfm
        total_equipment_cost_factor double precision,
        total_equipment_cost_constant double precision,
        equipment_to_capital_cost_multiplier double precision,
        electricity_factor double precision,
        electricity_constant double precision,
```

```
        dust_disposal_factor double precision,
        dust_disposal_constant double precision,
        bag_replacement_factor double precision,
        bag_replacement_constant double precision,
        OUT annual_cost double precision,
        OUT capital_cost double precision,
        OUT operation_maintenance_cost double precision,
        OUT annualized_capital_cost double precision,
        OUT computed_cost_per_ton double precision)  AS $$
DECLARE
        cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
        -- * Comments *



        -- * Comments *

        -- get capital recovery factor, caculate if it wasn't passed in...
        IF coalesce(cap_recovery_factor, 0) = 0 and coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0
THEN
                cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
        END IF;

        -- calculate capital cost
        capital_cost := ((total_equipment_cost_factor * STKFLOW) + total_equipment_cost_constant) *
equipment_to_capital_cost_multiplier;

        -- calculate operation maintenance cost
        operation_maintenance_cost :=
                ((electricity_factor * STKFLOW) + electricity_constant) + ((dust_disposal_factor * STKFLOW) +
dust_disposal_constant) + ((bag_replacement_factor * STKFLOW) + bag_replacement_constant);

        -- calculate annualized capital cost
        annualized_capital_cost := capital_cost * cap_recovery_factor;

        -- calculate annual cost
        annual_cost :=  annualized_capital_cost + operation_maintenance_cost;

        -- calculate computed cost per ton
        computed_cost_per_ton :=
                case
                        when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
                        else null
                end;
END;
$$ LANGUAGE plpgsql IMMUTABLE;
```

4.2.7 Equation Type 10

4.2.7.1 Capital Cost Equations

$$Capital\ Cost\ Scaling\ Factor = \left(\frac{250\ MW}{Capacity}\right)^{Capital\ Scaling\ Factor\ Exponent}$$

where *Capital Scaling Factor Exponent* is control measure specific; *Capacity* is the boiler capacity in MW obtained from the inventory being processed.

$$Capital\ Cost = Capital\ Cost\ Multiplier\ \times Capacity\ \times Capital\ Cost\ Scaling\ Factor\ \times 1{,}000$$

where the *Capital Cost Multiplier* is control measure specific, *Capacity* is obtained from the inventory being processed, and 1000 is a conversion factor to match the Capital Cost Multiplier ($/kW) with the Capacity (MW).

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$

where *Interest Rate* default value is 7.0%, but can be varied by user, and *Equipment Life* is control measure specific.

$$Annualized\ Capital\ Cost = Capital\ Cost\ \times Capital\ Recovery\ Factor + Capital\ Cost\ \times$$

4.2.7.2 Operation and Maintenance Cost Equations

$$Fixed\ O\&M\ Cost\ Scaling\ Factor = \left(\frac{250\ MW}{Capacity}\right)^{Fixed\ O\&M\ Scaling\ Factor\ Exponent}$$

Where *Fixed O&M Scaling Factor Exponent* is control measure specific; *Capacity* is the boiler capacity in MW obtained from the inventory being processed.

$$Fixed\ O\&M = Fixed\ O\&M\ Cost\ Scaling\ Factor \times Fixed\ O\&M\ Cost\ Multiplier\ \times Capacity \times 1{,}000$$

where *Fixed O&M Cost Multiplier* is control measure specific, *Capacity* is obtained from the inventory being processed, and 1000 is a conversion factor to match the Fixed O&M Cost Multiplier ($/kW) with the Capacity (MW).

$$Variable\ O\&M = Variable\ O\&M\ Cost\ Multiplier\ \times Capacity \times Capacity\ Factor \times\ Annual\ Operating\ Hours$$

where *Variable O&M Cost Multiplier* and *Capacity Factor* are control measure specific, *Capacity* is obtained from the inventory being processed, and *Annual Operating Hours* is obtained from the inventory being processed.

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$

4.2.7.3 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + .04\ \times Total\ Capital\ Cost + O\&M\ Cost$$

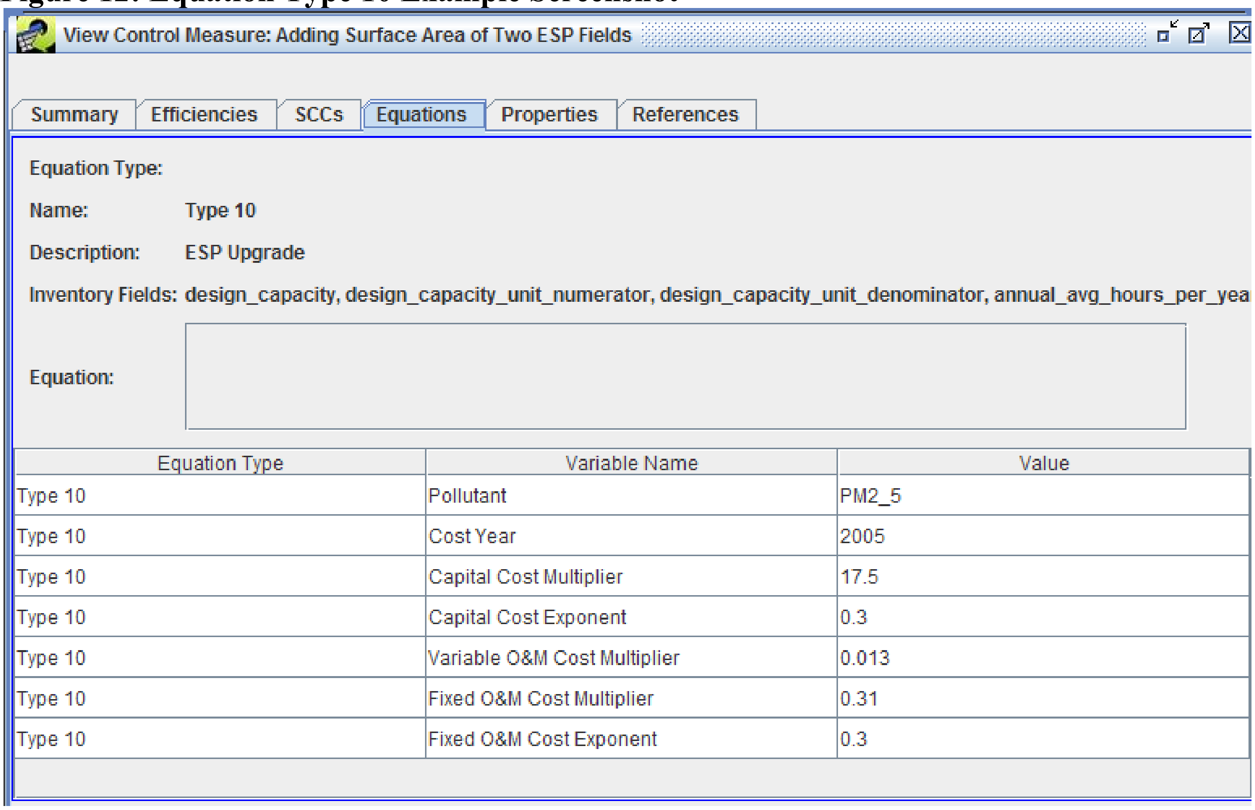
where 4% of the Total Capital Cost is fixed annual charge for taxes, insurance and administrative costs.

4.2.8 Equation Type 10 Example

4.2.8.1 Example Equation Variables

Capacity = 58.068 MW
Interest Rate = 7%(can be set by user in CoST)
$Equipment\ Life$ = 5 years (from summary tab of control measure data)

Figure 12: Equation Type 10 Example Screenshot


View Control Measure: Adding Surface Area of Two ESP Fields

Summary | Efficiencies | SCCs | Equations | Properties | References

Equation Type:
Name: Type 10
Description: ESP Upgrade
Inventory Fields: design_capacity, design_capacity_unit_numerator, design_capacity_unit_denominator, annual_avg_hours_per_yea
Equation:

Equation Type	Variable Name	Value
Type 10	Pollutant	PM2_5
Type 10	Cost Year	2005
Type 10	Capital Cost Multiplier	17.5
Type 10	Capital Cost Exponent	0.3
Type 10	Variable O&M Cost Multiplier	0.013
Type 10	Fixed O&M Cost Multiplier	0.31
Type 10	Fixed O&M Cost Exponent	0.3

4.2.8.2 Capital Cost Equations

$$Capital\ Cost\ Scaling\ Factor = \left(\frac{250\ MW}{Capacity}\right)^{Capital\ Scaling\ Factor\ Exponent}$$

$$Capital\ Cost\ Scaling\ Factor = \left(\frac{250\ MW}{58.068\ MW}\right)^{0.3}$$

$$Capital\ Cost\ Scaling\ Factor = 1.55$$

$$Capital\ Cost = Capital\ Cost\ Multiplier\ \times Capacity\ \times Capital\ Cost\ Scaling\ Factor\ \times 1{,}000$$

$$Capital\ Cost = \frac{\$17.50}{kW} \times 58.068\ MW\ \times 1.55\ \times 1{,}000\ \frac{kW}{MW}$$

$$Capital\ Cost = \$1{,}575{,}095$$

$$Capital\ Recovery\ Factor = \frac{Interest\ Rate\ \times (1 + Interest\ Rate)^{Equipment\ Life}}{(1 + Interest\ Rate)^{Equipment\ Life}\ - 1}$$

$$Capital\ Recovery\ Factor = \frac{0.07 \times (1+0.07)^{5\ Years}}{(1+0.07)^{5\ Years} - 1}$$
$$Capital\ Recovery\ Factor = 0.2439$$

$$Annualized\ Capital\ Cost = Capital\ Cost \times Capital\ Recovery\ Factor$$
$$Annualized\ Capital\ Cost = \$1{,}575{,}095 \times 0.2439$$
$$Annualized\ Capital\ Cost = \$384{,}166\ (2005\$)$$

4.2.8.3 Operation and Maintenance Cost Equations

$$Fixed\ O\&M\ Cost\ Scaling\ Factor = \left(\frac{250\ MW}{Capacity}\right)^{Fixed\ O\&M\ Scaling\ Factor\ Exponent}$$
$$Fixed\ O\&M\ Cost\ Scaling\ Factor = \left(\frac{250\ MW}{58.068\ MW}\right)^{0.3}$$
$$Fixed\ O\&M\ Cost\ Scaling\ Factor = 1.55$$

$$Fixed\ O\&M = Fixed\ O\&M\ Cost\ Scaling\ Factor \times Fixed\ O\&M\ Cost\ Multiplier \times Capacity \times 1{,}000$$
$$Fixed\ O\&M = 1.55 \times \$0.31 \frac{\$}{kW\text{-}year} \times 58.068\ MW \times 1{,}000 \frac{kW}{MW}$$
$$Fixed\ O\&M = \$27{,}901$$

$$Variable\ O\&M = Variable\ O\&M\ Cost\ Multiplier \times Capacity \times Capacity\ Factor \times Annual\ Operating\ Hours$$
$$Variable\ O\&M = \$0.013 \frac{\$}{kWh} \times 58.068\ MW \times 0.85 \times 8{,}760 \frac{Hours}{Year}$$
$$Variable\ O\&M = \$5{,}620$$

$$O\&M\ Cost = Fixed\ O\&M + Variable\ O\&M$$
$$O\&M\ Cost = \$27{,}901 + \$5{,}620$$
$$O\&M\ Cost = \$33{,}522\ (2005\$)$$

4.2.8.4 Total Annualized Cost Equation

$$Total\ Annualized\ Cost = Annualized\ Capital\ Cost + .04 \times Total\ Capital\ Cost + O\&M\ Cost$$
$$Total\ Annualized\ Cost = \$384{,}166 + .04 \times \$1{,}575{,}095 + \$33{,}522$$
$$Total\ Annualized\ Cost = \$480{,}692\ (2005\$)$$

4.2.9 Equation Type 10 CoST Code

```
----------------------------------------------------------------------------------------------------------------------------------
-- Code that funnels the source to the correct control measure cost equations.

-- NOTES:
--

-- Type 10
IF equation_type = 'Type 10' THEN
        --default units numerator to MW
        converted_design_capacity :=
                public.convert_design_capacity_to_mw(design_capacity,
                case
```

```
                    when length(coalesce(design_capacity_unit_numerator, '')) = 0 then
        'MW'::character varying
                    else
                        design_capacity_unit_numerator
                end
                , design_capacity_unit_denominator);


        IF coalesce(design_capacity, 0) <> 0 THEN
                select costs.annual_cost,
                    costs.capital_cost,
                    costs.variable_operation_maintenance_cost,
                    costs.fixed_operation_maintenance_cost,
                    costs.operation_maintenance_cost,
                    costs.annualized_capital_cost,
                    costs.computed_cost_per_ton
                from public.get_type10_equation_costs(
                    discount_rate,
                    equipment_life,
                    capital_recovery_factor,
                    emis_reduction,
                    converted_design_capacity,
                    annual_avg_hours_per_year,
                    variable_coefficient1,
                    variable_coefficient2,
                    variable_coefficient3,
                    variable_coefficient4,
                    variable_coefficient5) as costs
                into annual_cost,
                    capital_cost,
                    variable_operation_maintenance_cost,
                    fixed_operation_maintenance_cost,
                    operation_maintenance_cost,
                    annualized_capital_cost,
                    computed_cost_per_ton;
                IF annual_cost is not null THEN
                    valid_cost := true;
                    actual_equation_type := 'Type 10';
                ELSE
                    valid_cost := false;
                    actual_equation_type := '-Type 10';
                END IF;
                -- adjust costs to the reference cost year
                annual_cost := ref_yr_chained_gdp_adjustment_factor * annual_cost;
                capital_cost := ref_yr_chained_gdp_adjustment_factor * capital_cost;
                variable_operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor *
variable_operation_maintenance_cost;
                fixed_operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor *
fixed_operation_maintenance_cost;
                operation_maintenance_cost := ref_yr_chained_gdp_adjustment_factor * operation_maintenance_cost;
                annualized_capital_cost := ref_yr_chained_gdp_adjustment_factor * annualized_capital_cost;
                computed_cost_per_ton := ref_yr_chained_gdp_adjustment_factor * computed_cost_per_ton;
                return;
        END IF;
        valid_cost := false;
        actual_equation_type := '-Type 10';
END IF;

-- Next the code will call the default CPT approach
--------------------------------------------------------------------------------------------------------------------------------
```

```
-- Type 10
CREATE OR REPLACE FUNCTION public.get_type10_equation_costs(
	discount_rate double precision,
	equipment_life double precision,
	capital_recovery_factor double precision,
	emis_reduction double precision,
	design_capacity double precision,
	annual_avg_hours_per_year double precision,
	capital_cost_multiplier double precision,
	capital_cost_exponent double precision,
	variable_operation_maintenance_cost_multiplier double precision,
	fixed_operation_maintenance_cost_multiplier double precision,
	fixed_operation_maintenance_cost_exponent double precision,
	OUT annual_cost double precision,
	OUT capital_cost double precision,
	OUT variable_operation_maintenance_cost double precision,
	OUT fixed_operation_maintenance_cost double precision,
	OUT operation_maintenance_cost double precision,
	OUT annualized_capital_cost double precision,
	OUT computed_cost_per_ton double precision)  AS $$
DECLARE
	cap_recovery_factor double precision := capital_recovery_factor;
BEGIN
	-- NOTES:
	-- design capacity must be in the units, MW

	-- get capital recovery factor, caculate if it wasn't passed in...
	 IF coalesce(cap_recovery_factor, 0) = 0 and coalesce(discount_rate, 0) != 0 and coalesce(equipment_life, 0) != 0
THEN
		cap_recovery_factor := public.calculate_capital_recovery_factor(discount_rate, equipment_life);
	END IF;

	-- calculate capital cost
	capital_cost := design_capacity * capital_cost_multiplier * 1000 * (250.0 / design_capacity) ^
capital_cost_exponent;

	-- calculate annualized capital cost
	annualized_capital_cost := capital_cost * cap_recovery_factor;


	-- calculate variable_operation_maintenance_cost
	variable_operation_maintenance_cost := variable_operation_maintenance_cost_multiplier * design_capacity *
0.85 * annual_avg_hours_per_year;

	-- calculate fixed_operation_maintenance_cost
	fixed_operation_maintenance_cost := design_capacity * 1000 * fixed_operation_maintenance_cost_multiplier *
(250 / design_capacity) ^ fixed_operation_maintenance_cost_exponent;

	-- calculate operation maintenance cost
	operation_maintenance_cost := variable_operation_maintenance_cost + fixed_operation_maintenance_cost;

	-- calculate annual cost
	annual_cost := annualized_capital_cost + operation_maintenance_cost;

	-- calculate computed cost per ton
	computed_cost_per_ton :=
		case
			when coalesce(emis_reduction, 0) <> 0 then annual_cost / emis_reduction
			else null
		end;
END;
```

```
$$ LANGUAGE plpgsql IMMUTABLE;
```

Table 10. IPM Sector PM Control Cost Equation Factors (Equation Type 8)

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Typical Control Cost Equation-Based Factors		Typical Default Cost per Ton Factors			Cost Year ($ Year)
			PM-10	PM-2.5	Capital	O&M	Capital	O&M	Annualized	
PFFMSUBC	Utility Boilers - Coal	Fabric Filter (Mech. Shaker Type)	99	99	29	11	412	62	126	1998
PFFPJUBC	Utility Boilers - Coal	Fabric Filter (Pulse Jet Type)	99	99	13	11	380	28	117	1998
PFFRAUBC	Utility Boilers - Coal	Fabric Filter (Reverse-Air Cleaned Type)	99	99	34	13	0	0	148	1998
PDESPWPUBC	Utility Boilers - Coal	Dry ESP-Wire Plate Type	98	95	27	16	710	41	110	1995
PDESPWPUBO	Utility Boilers - Oil	Dry ESP-Wire Plate Type	98	95	27	16	710	41	110	1995

Table 11. IPM Sector PM Control Cost Equation Factors (Equation Type 9)

CoST CMAbbreviation	Source Group	Control Technology	Control Efficiency (%)		Capital Cost Variables			O&M Cost Variables						Cost Year ($ Year)
			PM-10	PM-2.5	tecs	teci	ec to cc	els	eli	dds	ddi	brs	bri	
PFFMSUBC2	Utility Boilers – Coal	Fabric Filter - Mechanical Shaker	99	99	5.702	77489	2.17	0.194	-15.96	0.7406	1.146	0.25	1221	1990
PFFMSUBG	Utility Boilers - Gas/Oil	Fabric Filter - Mechanical Shaker	95	95	5.702	77489	2.17	0.188	-19.58	0.0007	0.19	0.241	1224	1990

Table 12. IPM Sector PM Control Cost Equation Factors (Equation Type 10)

CoST CMAbbreviation	Source Group	Control Technology	Pollutant	Capital Cost		Variable O&M	Fixed O&M		Cost Year ($ Year)
				Multiplier	Exponent	Multiplier	Multiplier	Exponent	
PDESPMAGG	Utility Boilers – Coal	Agglomerator	PM2.5	8.0	0.3	0.021	0.0	0.0	2005
PDESPM1FLD	Utility Boilers – Coal	Adding Surface Area of One ESP Field	PM2.5	13.75	0.3	0.0090	0.24	0.3	2005
PDESPM2FLD	Utility Boilers – Coal	Adding Surface Area of Two ESP Fields	PM2.5	17.5	0.3	0.013	0.31	0.3	2005
PDESPM2FAF	Utility Boilers – Coal	Adding Surface Area of Two ESP Fields, an Agglomerator, and ID Fans	PM2.5	37.2	0.3	0.042	0.53	0.3	2005