

Energy Usage and Emissions Associated with Electric Energy
Consumption as Part of a Solid Waste Management
Life Cycle Inventory Model

Revision 2

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1. Introduction

Management of municipal solid waste (MSW) through the unit operations of collection, transfer, separation, remanufacturing, combustion and landfilling forms a complex interrelationship of mass flows with associated costs, energy consumption, solid waste production and airborne and waterborne emissions. To examine these interrelationships and identify potential optimal mass flows and beneficial synergies among unit operations, it is necessary to quantify the costs and energy consumption and emissions associated with each unit operation of interest.

The work described here is a part of a larger project that will examine these life cycle inventory (LCI) parameters for a large number of possible unit operations for 48 distinct components of MSW. The ultimate objective of this larger project is the development of a computer-based decision support system (DSS) to allow a user to examine interrelationships among LCI parameters and to explore optimal MSW management strategies regarding minimization of selected parameters such as CO₂ emissions or energy consumption. Additional objectives are to develop a database to support the DSS and to apply the DSS to case studies. The LCI model and the associated energy implications are discussed in Section 2.

In a smaller related research project, spreadsheets were developed to account for the total energy usage and emissions (pre-combustion and combustion) resulting from the use of electric energy, as well as the transportation energy and process energy used in the virgin manufacturing and remanufacturing processes for corrugated boxes, newsprint and aluminum cans. (Ultimately, this effort will be expanded to include all 28 recyclable components designated for the waste stream as a part of the overall project.) Two separate spreadsheets were developed: one to address energy usage and emissions associated with electric energy consumption and one to address energy usage and emissions associated with remanufacturing processes. This report addresses the electric energy spreadsheet.

The electric energy spreadsheet includes default as well as user definable regional and national electric generation fuel mixes to provide accurate accounting of the energy usage and emissions related to consumption of a kilo-watt hour (kWh) of electricity based on the relative proportion of each fuel type used to generate that kWh. Energy usage and emissions offset values are calculated for use with the combustion spreadsheet developed as another part of the overall project. Similarly, offset values will be calculated for other processes from which energy is recovered (refuse-derived fuel, anaerobic digestion, landfill gas) as these process models are written. These offsets will be used in conjunction with the energy usage and emissions associated with MSW combustion and electric generation to provide net energy usage and emissions from MSW combustion. These offsets were developed by displacing 1 kWh of regional base-loaded generation for each kWh of MSW combustion generation. The energy and emissions offsets are calculated based on displacement of the most expensive base-loaded generation fuel types (coal and natural gas) with MSW combustion generation. Section 3 provides a detailed discussion of the electrical energy spreadsheet and its related calculations. Discussions of MSW combustion offsets and their use in the LCI model are provided in Section 3.3.7, Section 3.3.8 and in Appendix A.

Throughout this document, many tables contain entries labeled “variable name.” These variable names are the names by which that particular table entry is referenced by other spreadsheets and by the LCI model.

2. The Solid Waste Management LCI Model

2.1 Model Overview

The ultimate objective of the overall project is the development of a user friendly decision-making tool that allows users to perform cost and LCI optimization modeling of their existing solid waste management system, entirely new systems or some combination of both. The processes that can be modeled include waste generation, collection and transfer, separation (material recovery facilities—MRFs and drop-off facilities), treatment (including composting, anaerobic digestion, combustion and refuse-derived fuel production) and disposal (landfill or enhanced bio-reactor).

Figure 2-1 provides an overview of potential mass flows through a solid waste management system. As can be seen from this figure, upstream decisions can affect the viability of implementing various downstream processes. For example, aggressive upstream recycling of paper would affect the viability of a downstream combustion facility. Because of the large number of mass flow interrelationships, effective evaluation of alternatives, in the absence of a modeling tool, would be a daunting task for a solid waste planner.

The DSS being developed under this project will allow the user to perform cost and LCI analysis and optimization based on user-specified data on MSW generation. Existing facilities and/or equipment can be incorporated as model constraints to ensure that previous capital expenditures are not negated by the model solution.

As shown in Figure 2-2, the DSS consists of several components including process models, an optimization module and a graphic user interface (GUI). The process models consist of a set of spreadsheets developed in Microsoft Excel. These spreadsheets use a combination of default and user supplied data to calculate the cost and life cycle coefficients on a per unit mass basis for each of the 48 MSW components being modeled for each solid waste management unit process (collection, transfer, etc.). For example, in

the electric energy spreadsheet, the user is asked to specify the fuel mix used to generate electricity in the geographic region of interest. Based on this design information and the emissions associated with generating electricity from each fuel type, the spreadsheet calculates coefficients for emissions related to the use of a kilo-watt hour of electricity. These emissions are then assigned to waste stream components on a mass basis for any facility that uses electricity and through which the mass flows. For example, MRFs use electricity for conveyors and lighting. The emissions associated with electricity generation would be assigned to the mass that flowed through that facility. To the extent possible, the ability for the user to override default data has been incorporated.

The optimization module is implemented using the CPLEX linear programming solver. The model is constrained by mass flow equations. These mass flow constraints preclude impossible or nonsensical model solutions. For example, these mass flow constraints will exclude the possibility of removing aluminum from the waste stream via a mixed waste MRF and then sending the aluminum to a landfill. The user can identify the objective as minimizing total cost or any LCI parameter (Particulate matter, NO_x , SO_x , CO , CO_2 , and CH_4). The optimization module uses linear programming techniques to determine the optimum solution consistent with the user-specified objective and mass flow and user-specified constraints. Examples of user-specified constraints are the use of existing equipment/facilities and a minimum recycling percentage requirement.

The GUI consists of Microsoft visual basic for applications routines that act to pull all components of the model together to allow easy user manipulation of the spreadsheet models and the optimization module. It allows additional user constraints to be specified and provides a graphical representation of the solid waste management alternatives resulting from the optimization.

The various process model spreadsheets can be used in a stand alone fashion to examine issues such as the total energy consumption associated with a given generation fuel mix. However, the ultimate intent of the DSS is that the existence of these spreadsheets be transparent to the user and that all user interaction take place through the

DSS GUI depicted in Figure 2-2. Also, the decision support system can be used as an accounting tool for existing solid waste management systems. When used in this mode, no optimization is performed; rather, the cost and LCI values for user-specified management strategies are evaluated.

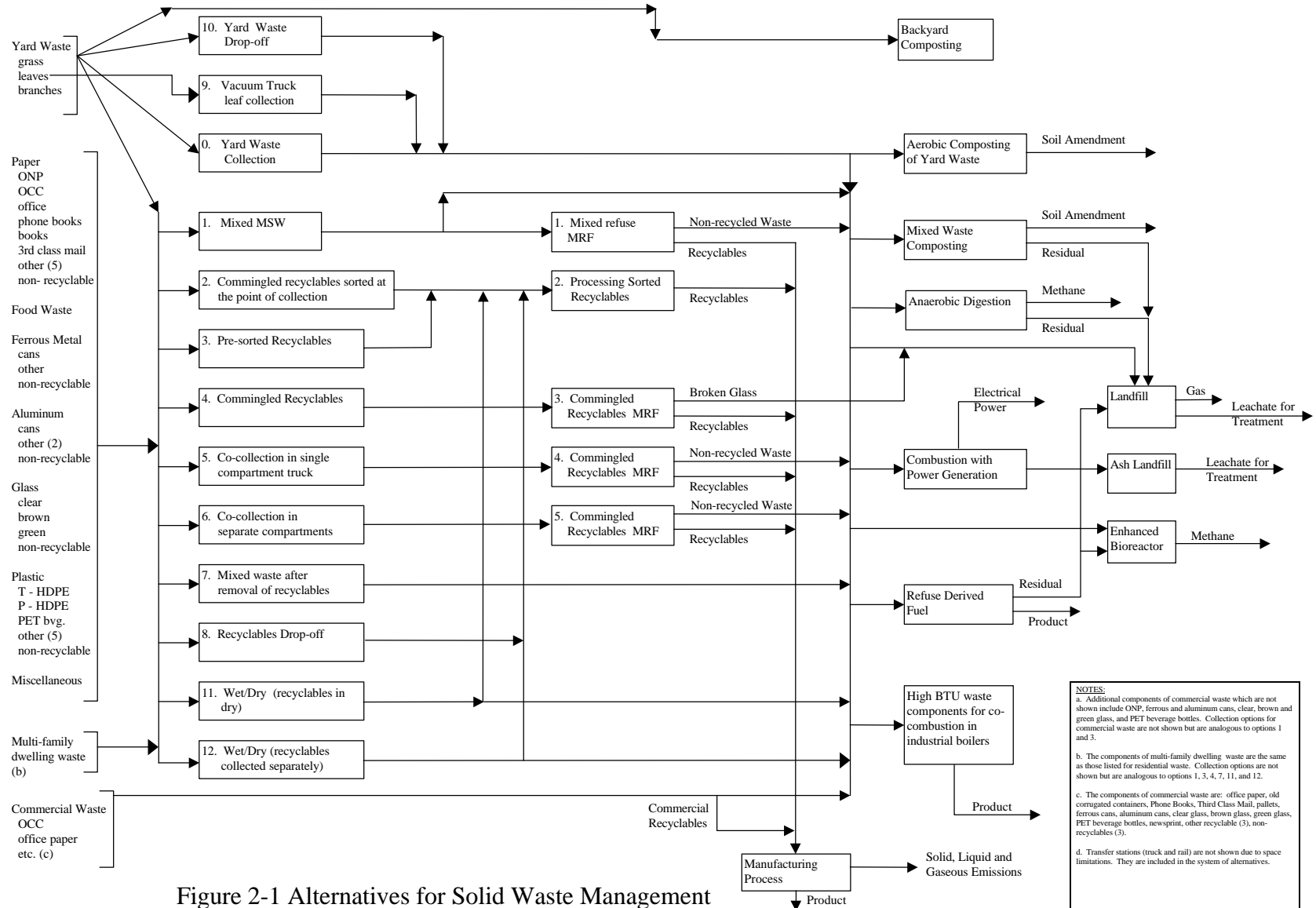


Figure 2-1 Alternatives for Solid Waste Management

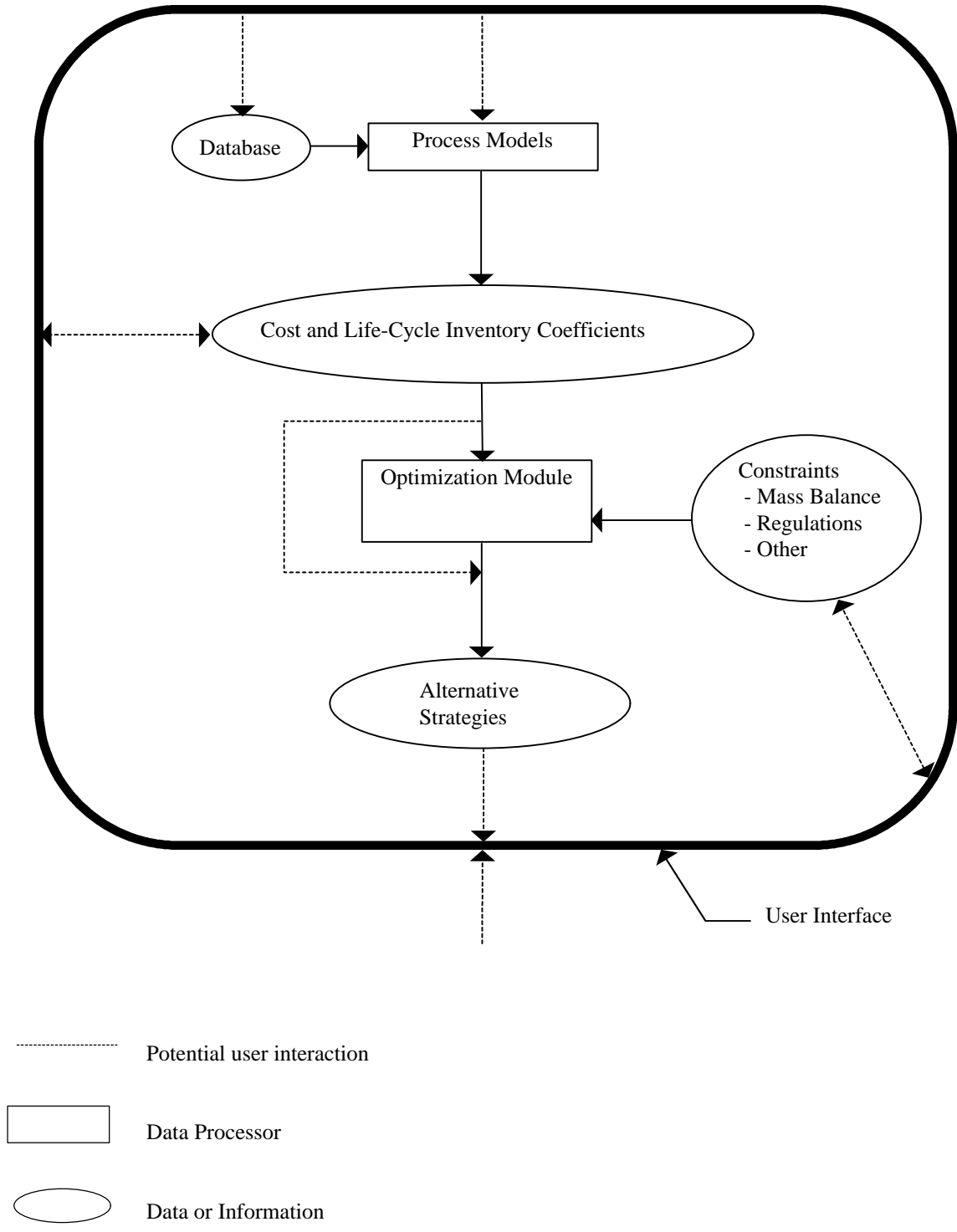


Figure 2-2 Relationship Between the Decision Support System and the User

2.2 Electric Energy Implications

Any life cycle evaluation in which electric energy is consumed must consider the energy and emissions associated with the production of that electric energy. Regarding a life cycle evaluation of MSW that includes recycling, it is important that the differences in fuel mixes used on a regional and national basis be considered. For example, when considering a local MSW strategy, energy and emissions associated with electricity usage in a MRF should be based on the regional electric generation fuel mix. However, materials that are recovered in a MRF may be reprocessed outside that region (i.e., paper and aluminum) such that the energy and emissions associated with their reprocessing are best represented by using national electric grid factors. These considerations are discussed in detail in Section 3.

3. Electric Energy Process Model Design

3.1 Introduction

The electric energy model provides an accounting of the total energy consumption and emissions resulting from the use of electric energy. Pre-combustion and combustion energy consumption and emissions on a per unit fuel basis are used in conjunction with unit efficiencies, transmission and distribution line losses, and electric generation fuel usage percentages to allocate energy consumption and emissions to the usage of an electric kilo-watt hour (kWh) based on the contribution to the generation of that kWh by each fuel type. Emissions and energy consumption per kWh are calculated for the national grid fuel mix as well as for the nine major electrical generating regions in the United States. Default values for parameters used in these calculations are provided with optional user enterable override capability for the majority of these parameters. The assumption adopted for the energy process model, as well as other aspects of the overall LCI model, is that emissions and energy consumption associated with facility construction are negligible.

Energy usage and emissions offset values are calculated for use with the MSW combustion model developed as another part of the overall project. These offsets will be used in conjunction with the energy consumption and emissions associated with MSW combustion and electric generation to provide net energy consumption and emissions for MSW combustion. These offsets are based on the displacement of 1 kWh regional base-loaded generation for each kWh of MSW combustion generation (after reduction for house load). The energy and emissions offsets are calculated based on displacement of the base-loaded unit types currently being constructed (coal and natural gas by default) with MSW combustion generation, since MSW combustors are typically operated as base-loaded units.

As discussed in Section 2.1, the energy process model results are used by spreadsheet models for other unit operations to obtain the total energy consumption and emissions

related to electric energy usage in those unit operations. For example, energy is consumed and emissions result for each kWh of electricity used to operate a baler in a MRF. For each kWh consumed, the electrical energy process model provides the total energy consumed and the resulting emissions (pre-combustion and combustion).

3.2 Energy Conversion Processes

The vast majority of electrical energy in the United States is derived from seven major sources: coal, natural gas, residual oil, distillate oil, uranium, hydroelectric and wood [4]. Insignificant contributions are made by sources such as solar, wind, geothermal and other emerging technologies. Therefore, the seven major fuel types are addressed by the electric energy model with provision for the model user to include one 'other' fuel type.

Pre-combustion energy and emissions for coal are associated with surface and underground mining operations, size reduction, cleaning and transportation. Use of coal as a fuel consists of burning it in a boiler to produce steam that is then used to generate electricity or is used for other process operations [4,10].

Pre-combustion energy and emissions for natural gas are associated with oil well operations, pipeline pumping, transportation and fugitive emissions from pumping and production facilities. Use of natural gas as a fuel consists of burning it in several types of combustion facilities including gas turbines and combined cycle units to produce steam that is then used to generate electricity or is used for other process operations [4,10].

Pre-combustion energy and emissions for residual and distillate oils are associated with oil well operations, refining (process and fugitive emissions) and transportation. Use of residual and distillate oils as fuels consists of burning them in boilers to produce steam that is then used to generate electricity or is used for other process operations [4,10].

Pre-combustion energy and emissions for nuclear fuel are associated with surface and underground mining operations, refining (process and fugitive emissions) and

transportation. Use of nuclear fuel consists of reacting it in a nuclear reactor to produce steam that is then used to generate electricity [4,10].

As discussed in Section 3.3.5, there are no pre-combustion energy and emissions associated with hydroelectric power generation, as a default. Use of hydraulic fuel usually consists of damming a river and using the potential energy of the entrained water to generate electricity by passing it through a water turbine-generator [10].

Since wood fuel is usually a by-product of other wood processing operations and is usually burned on site for self-generated electricity, there are no pre-combustion emissions associated with wood fuel, as a default. Use of wood as a fuel consists of burning it in a boiler to produce steam that is then used to generate electricity or is used for other process operations [4].

3.3 Model Data and Calculations

3.3.1 Electric Grid Definitions

As discussed in Section 2.1, to provide the appropriate emissions and energy usage values to the various model components, it was necessary to define fuel usage by type for national and regional grids.

Table 3-1 shows the regional grid definitions that have been adopted [7]. The geographic locations of these grids are defined in Table 3-2 [1]. These grid definitions were adopted since they represent the vast majority of the United States, the area to which the model will most likely be applied. However, a “user-defined” region has been included to allow the model user to define a region with unique characteristics not available in the Table 3-1 default regions.

Table 3-1 Electric Region Definitions

Control Area Name	Control Area Description
ECAR	East Central Area Reliability Coordination Agreement
ERCOT	Electric Reliability Council of Texas
MAAC	Mid-Atlantic Area Council
MAIN	Mid-America Interconnected Network
MAPP	Mid-Continent Area Power Pool
NPCC	Northeast Power Coordinating Council
SERC	Southeastern Electric Reliability Council
SPP	Southwest Power Pool
WSCC	Western Systems Coordinating Council
User Defined	User Defined Electric Region

Table 3-2 Electric Region Locations

Control Area Name	Location
ECAR	Michigan, Indiana, Ohio, Kentucky, West Virginia
ERCOT	Texas
MAAC	Pennsylvania, New Jersey, Maryland, Delaware
MAIN	Illinois, Missouri (east) Wisconsin (excluding north west)
MAPP	North Dakota, South Dakota, Nebraska, Minnesota, Wisconsin (east)
NPCC	New York, Vermont, Connecticut, Maine, Rhode Island, New Hampshire
SERC	North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Mississippi
SPP	Kansas, Oklahoma, Arkansas, Louisiana, Mississippi (west) Missouri (west)
WSCC	Washington, Oregon, Colorado, California, Nevada, Montana, Idaho, Wyoming, Utah, Arizona, New Mexico

3.3.2 Electric Generation Fuel Usage

The national generation weighted usage for each fuel type was calculated from North American Electric Reliability Council (NERC) regional databases submitted to the Energy Information Administration (EIA) for 1994 [5,6]. These databases include several thousand generating units from the nine NERC regions in the continental United States and represent the vast majority of the U.S. generating capacity. The percentage of national generation derived from each fuel type was calculated as :

$$F_i = \frac{\sum_{j=1}^m \sum_{k=1}^n E_{i,j,k}}{\sum_{i=1}^l \sum_{j=1}^m \sum_{k=1}^n E_{i,j,k}} \times 100$$

Where: F_i = National generation derived from fuel type i (%).

$E_{i,j,k}$ = Yearly generation from fuel type i in region j by unit k (MWhr).

Because a large number of EIA database records were used to perform this calculation, the input data have not been included here but are available in references 5 and 6. Table 3-3 and Figure 3-1 reflect the resulting national default generation percentages by fuel type. These default national generation percentages by fuel type are selected by the model from Table 3-3 unless these percentages are overridden by the user.

The regional generation weighted usage for each generating region and fuel type were also calculated using EIA data [5,6]. The percentage of regional generation derived from each fuel type was calculated as:

$$F_{i,j} = \frac{\sum_{k=1}^n E_{i,j,k}}{\sum_{i=1}^l \sum_{k=1}^n E_{i,j,k}} \times 100$$

Where: $F_{i,j}$ = Generation derived from fuel type i (%) in region j .

$E_{i,j,k}$ = Yearly generation from fuel type i in region j by unit k (MWhr).

Again, because a large number of EIA database records were used to perform this calculation, the input have not been included here but are available in references 5 and 6.

Table 3-4 reflects the resulting regional default generation percentages by fuel type for the nine NERC regions provided. Figure 3-2 graphically shows the resulting Southeastern Electric Reliability Council (SERC) regional default generation percentages by fuel type. North Carolina State University is located in the SERC region; therefore, only data for the SERC have been included in this section. Detailed LCI data for all nine default regions have not been included here because of the large number of tables that would be required. However, these data are included in Appendix B.

The default regional generation percentages by fuel type are selected by the model from Table 3-4 based on the user-selected electric generating region unless these percentages are overridden by the user.

Table 3-3 National Electric Generation by Fuel Type

National Grid Power Generation Split	default % splits	variable name
Fuel Type		nat. grid table
Coal	56.45	c_n_pct
Natural Gas	9.75	ng_n_pct
Residual Oil	2.62	ro_n_pct
Distillate Oil	0.23	do_n_pct
Nuclear	22.13	u_n_pct
Hydro	8.59	h_n_pct
Wood	0.24	w_n_pct
Other		o_n_pct
TOTAL	100.00	

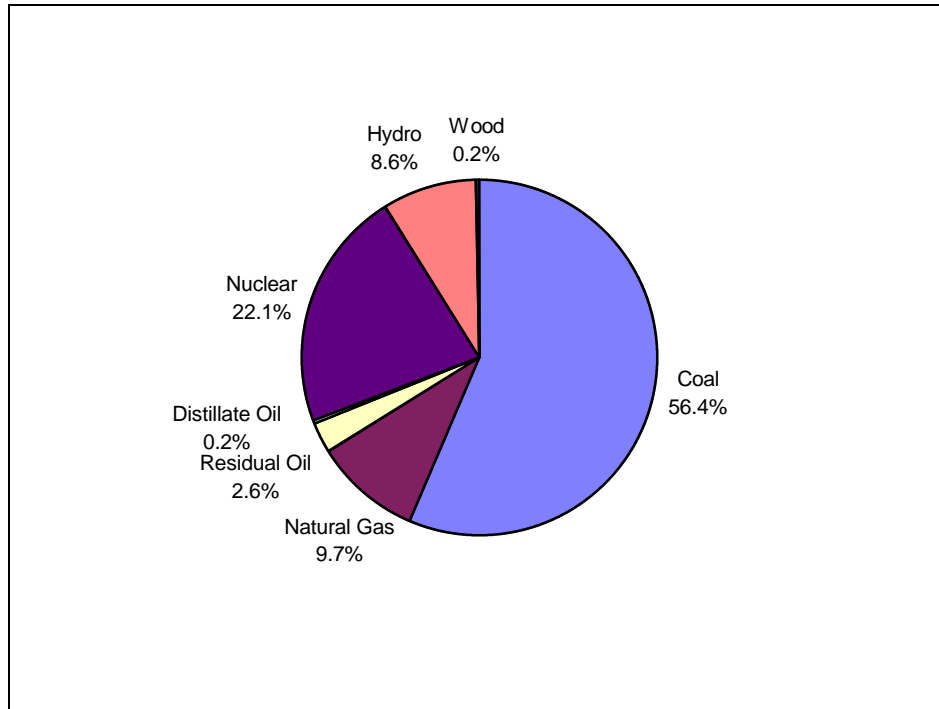


Figure 3-1 National Electric Generation by Fuel Type

Table 3-4 Regional Electric Generation by Fuel Type

Regional Grid Power Generation Splits	ECAR - East Central Area Reliability Coordination Agreement	ERCOT - Electric Reliability Council of Texas	MAAC - Mid Atlantic Area Council	MAIN - Mid-America Interconnected Network	MAPP - Mid-Continent Area Power Pool	NPCC - Northeast Power Coordinating Council	SERC - Southeastern Electric Reliability Council	SPP - Southwest Power Pool	WSCC - Western Systems Coordinating Council
Fuel Type	region 1	region 2	region 3	region 4	region 5	region 6	region 7	region 8	region 9
Coal	90.91	46.87	46.61	54.02	75.96	19.55	56.80	53.31	41.09
Natural Gas	0.34	38.62	3.76	1.36	0.68	11.83	2.94	26.90	14.83
Residual Oil	0.12	0.09	5.11	0.42	0.00	13.58	5.26	0.48	0.41
Distillate Oil	0.24	0.05	0.75	0.19	0.18	0.41	0.27	0.10	0.05
Nuclear	7.72	14.03	41.74	42.49	15.44	37.86	28.70	16.29	12.80
Hydro	0.68	0.34	2.03	1.51	7.47	16.73	6.03	2.89	29.54
Wood	0.00	0.00	0.00	0.00	0.26	0.04	0.00	0.03	1.29
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

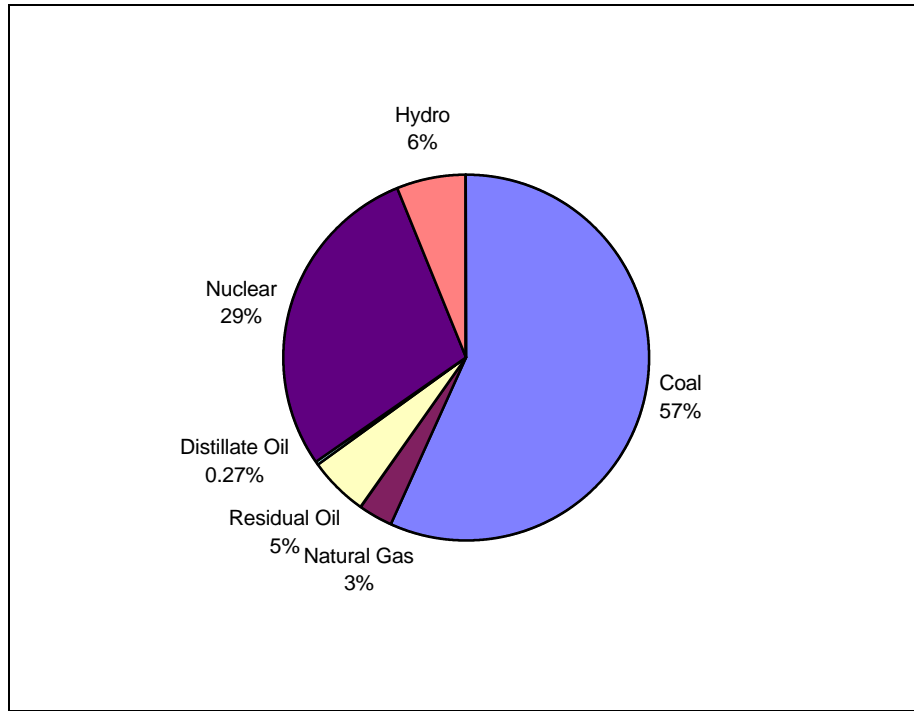


Figure 3-2 SERC Electric Generation by Fuel Type

3.3.3 Generation Efficiencies

Generation weighted national efficiencies for each fuel type are based on EIA data [5,6]. The generation weighted national efficiency for each fuel type was calculated as :

$$h_i = 0.96 \times \left\{ \sum_{j=1}^m \left(\frac{\sum_{k=1}^n E_{i,j,k}}{\sum_{j=1}^m \sum_{k=1}^n E_{i,j,k}} \left(\sum_{k=1}^n \left(\frac{E_{i,j,k}}{\sum_{k=1}^n E_{i,j,k}} \left(\frac{3413}{HR_{i,j,k}} \right) \right) \right) \right) \right\}$$

Where: h_i = Generating efficiency for fuel type i .

0.96 = Factor to convert efficiency to an “as delivered” basis.

$E_{i,j,k}$ = Yearly generation for fuel type i in region j by unit k (MWhr).

3413 = Btu/elec. kWh.

$HR_{i,j,k}$ = Heat rate for fuel type i in region j for unit k (Btu/elec. kWh).

Table 3-5 reflects the resulting default electrical generation efficiencies by fuel type on a national basis. The default national generating efficiencies by fuel type are selected by the model from this table unless these efficiencies are overridden by the user.

It should be noted that the referenced national efficiencies were on an “as generated basis.” These efficiencies were multiplied by 0.96 to account for the typical 4% transmission and distribution line losses [8] such that the resulting efficiencies are on an “as delivered basis.” Often, large industrial facilities receive electrical input to their facility substations at high voltage (115 kV or higher) and are, therefore, subject to line losses closer to 2% [8,3]. If this type of effect is to be included, the user can increase generating efficiencies to reflect a 2% loss instead of the default 4%. Efficiencies for wood and “other” generation were set to the national value for coal generation.

The default generation efficiency for hydroelectric power has been set to 1.0. The reasoning for this, from an LCI standpoint, is that the energy associated with river flow is “lost” on a continuous basis as a part of the natural evaporation-rain cycle. Therefore, even the losses associated with the mechanical to electrical energy conversion process and transmission line losses represent no incremental losses over those that would be incurred as a part of the natural cycle. However, should the model user disagree with this approach, the hydro generation efficiency can be decreased from its default value of 1.0 to account for additional energy consumption. The emissions and energy consumption associated with facility construction are neglected.

Table 3-5 National Grid Generation Efficiencies

National Grid Generation Efficiencies	default national unit efficiency	variable name
Fuel Type		nat. eff.
Coal	0.325	c_n_eff
Natural Gas	0.311	ng_n_eff
Residual Oil	0.326	ro_n_eff
Distillate Oil	0.260	do_n_eff
Nuclear	0.314	u_n_eff
Hydro	1.000	h_n_eff
Wood	0.325	w_n_eff
Other	0.325	o_n_eff

Generating efficiencies for each of the nine NERC generating regions are based on EIA data [5,6]. These data represent 109 nuclear generating units, 373 coal fired units, 93 residual oil fired units, 857 distillate oil fired units and 742 natural gas fired units. The generation weighted efficiency for each fuel type in each generating region was calculated as:

$$h_{i,j} = 0.96 \times \left\{ \sum_{k=1}^n \left(\frac{E_{i,j,k}}{\sum_{k=1}^n E_{i,j,k}} \left(\frac{3413}{HR_{i,j,k}} \right) \right) \right\}$$

Where: $h_{i,j}$ = Generating efficiency for fuel type i in region j .

0.96 = Factor to convert efficiency to an “as delivered” basis.

$E_{i,j,k}$ = Yearly generation for fuel type i in region j by unit k (MWhr).

3413 = Btu/elec. kWh.

$HR_{i,j,k}$ = Heat rate for fuel type i in region j for unit k (Btu/elec. kWh).

Table 3-6 reflects the resulting default electrical generation efficiencies by fuel type for each of the nine NERC generating regions. The default regional generating efficiencies by fuel type are selected by the model from this table based on the user-selected electric generating region unless these efficiencies are overridden by the user.

Residual oil generating efficiency data for the ERCOT and MAPP regions and generating efficiency data for wood for all regions were not available. Therefore, these generating efficiencies were set to national average values. As discussed for national efficiencies, the generating efficiency for hydroelectric power has been set to 1.0.

Table 3-6 Regional Grid Generation Efficiencies

Regional Grid Generation Efficiencies	ECAR - East Central Area Reliability Coordination Agreement	ERCOT - Electric Reliability Council of Texas	MAAC - Mid-Atlantic Area Council	MAIN - Mid-America Interconnected Network	MAPP - Mid-Continent Area Power Pool	NPCC - Northeast Power Coordinating Council	SERC - Southeastern Electric Reliability Council	SPP - Southwest Power Pool	WSCC - Western Systems Coordinating Council
Fuel Type	region 1	region 2	region 3	region 4	region 5	region 6	region 7	region 8	region 9
Coal	0.335	0.309	0.338	0.312	0.291	0.328	0.334	0.316	0.319
Natural Gas	0.247	0.310	0.296	0.303	0.273	0.317	0.299	0.310	0.320
Residual Oil	0.304	0.326	0.314	0.317	0.326	0.325	0.334	0.202	0.339
Distillate Oil	0.274	0.288	0.268	0.243	0.237	0.270	0.241	0.290	0.270
Nuclear	0.310	0.312	0.307	0.312	0.306	0.325	0.315	0.305	0.320
Hydro	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wood	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325
Other	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325

3.3.4 Fuel Heating Values

Tables 3-7 and 3-8 reflect the default fuel heating values by fuel type on a national and regional basis, respectively [4]. The default heating values on a regional basis are set to the national values since these values are regionally dependent (particularly for coal). Heating values for anthracite coal vary from less than 10,000 Btu/lb. to more than 13,000 Btu/lb. depending on the mining region [2]. Desired changes to these default heating values to reflect regional conditions must be entered by the model user. As discussed in Section 3.3.4, hydroelectric power is unique from an LCI standpoint. Therefore, there is no heating value associated with use of hydroelectric power, *per-se*. Rather, the default energy consumption associated with the use of 1 kWh of hydroelectric power is fixed at 3413 Btu/kWh [11]. However, as discussed in Section 3.3.3, this value is divided by the hydro unit efficiency (default value of 1.0) to allow the user to account for additional hydro-related energy consumption if desired.

Table 3-7 National Grid Fuel Heating Values

National Grid Fuel Heating Values	default national heating value (btu/fuel unit)	variable name
Fuel Type (fuel units)		national hv
Coal (lbs)	10,402	c_n_hv
Natural Gas (cuft)	1,022	ng_n_hv
Residual Oil (gal.)	149,700	ro_n_hv
Distillate Oil (gal.)	138,700	do_n_hv
Uranium (lbs)	985,321,000	u_n_hv
Wood (lbs)	10,350	w_n_hv
Other	10,350	o_n_hv

Table 3-8 Regional Grid Fuel Heating Values

Regional Grid Fuel Heating Values	default regional heating value (btu/fuel unit)	variable name
Fuel Type (fuel units)		regional hv
Coal (lbs)	10,402	c_r_hv
Natural Gas (cuft)	1,022	ng_r_hv
Residual Oil (gal.)	149,700	ro_r_hv
Distillate Oil (gal.)	138,700	do_r_hv
Uranium (lbs)	985,321,000	u_r_hv
Wood (lbs)	10,350	w_r_hv
Other	10,350	o_r_hv

3.3.5 Fuel Pre-combustion Energy

Tables 3-9 and 3-10 reflect the default pre-combustion energy by fuel type on a national and regional basis, respectively [4]. Pre-combustion energy is the energy expended in operations required to prepare the fuel for use in an electrical generating facility. Examples of this type of energy would be the gasoline and diesel fuel used in coal mining and transportation.

The default pre-combustion energy values on a regional basis are set to the national values since these values are regionally dependent. For example, in coal mining regions, it is not unusual for generation facilities to be co-located with mining operations (sometimes referred to as “mine-mouth” facilities). For this type of region, the model user may want to decrease the coal pre-combustion energy value to a lower value since there is little transportation energy expended.

Since hydroelectric power is unique from an LCI standpoint, there is no pre-combustion energy associated with the use of hydroelectric power.

Table 3-9 National Grid Fuel Pre-combustion Energy

National Grid Fuel Precombustion Energy	default national pre-combustion energy (btu/fuel unit)	variable name
Fuel Type (fuel units)		nat. pre comb table
Coal (lbs)	264.00	c_n_pc
Natural Gas (cuft)	129.00	ng_n_pc
Residual Oil (gal.)	21,000.00	ro_n_pc
Distillate Oil (gal.)	19,300.00	do_n_pc
Uranium (lbs)	50,600,000.00	u_n_pc
Wood (lbs)	0.00	w_n_pc
Other	0.00	o_n_pc

Table 3-10 Regional Grid Fuel Pre-combustion Energy

Regional Grid Fuel Precombustion Energy	default regional pre-combustion energy (btu/fuel unit)	variable name
Fuel Type (fuel units)		nat. pre comb table
Coal (lbs)	264.00	c_r_pc
Natural Gas (cuft)	129.00	ng_r_pc
Residual Oil (gal.)	21,000.00	ro_r_pc
Distillate Oil (gal.)	19,300.00	do_r_pc
Uranium (lbs)	50,600,000.00	u_r_pc
Wood (lbs)	0.00	w_r_pc
Other	0.00	o_r_pc

3.3.6 Total Fuel Energy

Tables 3-11 and 3-12 reflect the calculated total energy consumed per electric kWh hour delivered by fuel type and fuel usage on a national and regional basis, respectively.

Table 3-11 National Grid Total Fuel Energy by Fuel Type

NATIONAL TOTAL ENERGY BY FUEL TYPE AND USAGE	variable name	pre-comb. btu per fuel unit	comb. btu per fuel unit	total btu per fuel unit consumed	fuel units consumed per electric kwh delivered (fuel unit/kwh elect.)	total btu / electric kwh	total btu / aggregate electric kwh
Fuel Type (fuel units)	nat. energy table	n_pc_btu	n_c_btu	n_btu	n_fuel_per_kwh	n_btu_per_kwh	n_btu_per_ag_kwh
Coal (lbs)	c_n_e	264	10,402	10,666	1.010	10,771	6,079
Natural Gas (cuft)	ng_n_e	129	1,022	1,151	10.723	12,343	1,203
Residual Oil (gal.)	ro_n_e	21,000	149,700	170,700	0.070	11,956	314
Distillate Oil (gal.)	do_n_e	19,300	138,700	158,000	0.094	14,928	34
Uranium (lbs)	u_n_e	50,600,000	985,321,000	1,035,921,000	1.105E-05	11,444	2,533
Hydro	h_n_e	0	3,413	3,413	1.000	3,413	293
Wood (lbs)	w_n_e	0	8,600	8,600	1.221	10,504	25
Other	o_n_e	0	8,600	8,600	1.221	10,504	0
TOTAL							10,481

Note: Slight differences between the values in the following examples calculations and those in the referenced tables are due to the fact that the spreadsheet carries more digits than are printed in the tables.

Using coal as an example, the calculations for Table 3-11 are:

$n_fuel_per_kwh$ = The amount of each fuel required per kWh delivered

For coal,

$$n_fuel_per_kwh = 1.01 \frac{lb - coal}{kwh} = \frac{3413 \frac{Btu}{kwh}}{\left(10,402 \frac{Btu}{lb - coal}\right) \left(0.325 \frac{kwh - electric}{kwh - thermal}\right)}$$

where: $10,402 \frac{Btu}{lb - coal}$ = National grid coal heating value (Table 3-7)

$0.325 \frac{kwh - electric}{kwh - thermal}$ = National grid coal as delivered efficiency (Table 3-5)

$n_btu_per_kwh$ = The total energy consumed per kWh delivered based on each fuel type

For coal,

$$n_btu_per_kwh = 10,771 \frac{Btu}{kwh} = \frac{3413 \frac{Btu}{kwh}}{0.325 \frac{kwh - electric}{kwh - thermal}} + \left(1.01 \frac{lb - coal}{kwh} \right) \left(264 \frac{Btu}{lb - coal} \right)$$

where: $264 \frac{Btu}{lb - coal}$ = National grid coal pre-combustion energy (Table 3-9)

$n_btu_per_ag_kwh$ = The total energy consumed per aggregate kWh delivered

For coal,

$$n_btu_per_ag_kwh = 6,079 \frac{Btu}{kwh} = \left(10,771 \frac{Btu}{kwh} \right) \left(\frac{56.45 \frac{kwh - coal}{kwh}}{100} \right)$$

where: $\frac{56.45 \frac{kwh - coal}{kwh}}{100}$ = National grid coal generation contribution (Table 3-3)

As discussed earlier, these calculations do not apply to hydroelectric generation, which is assigned a value of (3413 Btu/kWh/hydro generating efficiency). The hydro-generating efficiency is set to 1.0 by default; however, the model user can decrease this value to account for additional hydro-related energy consumption, if desired. Summing the last column of Table 3-11 shows that the total energy consumed per kWh delivered on a national basis is 10,481 Btu/kWh.

Table 3-12 SERC Total Fuel Energy by Fuel Type

REGIONAL TOTAL ENERGY BY FUEL TYPE AND USAGE	variable name	pre-comb. btu per fuel unit	comb. btu per fuel unit	total btu per fuel unit consumed	fuel units consumed per electric kw delivered (fuel unit/kw elect.)	total btu / electric kwh	total btu / aggregate electric kwh
Fuel Type (fuel units)	region. energy table	r_pc_btu	r_c_btu	r_btu	r_fuel_per_kwh	r_btu_per_kwh	r_btu_per_ag_kwh
Coal (lbs)	c_r_e	264	10,402	10,666	0.982	10,474	5,950
Natural Gas (cuft)	ng_r_e	129	1,022	1,151	11.160	12,845	378
Residual Oil (gal.)	ro_r_e	21,000	149,700	170,700	0.068	11,644	612
Distillate Oil (gal.)	do_r_e	19,300	138,700	158,000	0.102	16,104	43
Uranium (lbs)	u_r_e	50,600,000	985,321,000	1,035,921,000	0.000	11,401	3,272
Hydro	h_r_e	0	3,413	3,413	1.000	3,413	206
Wood (lbs)	w_r_e	0	10,350	10,350	1.015	10,504	0
Other	o_r_e	0	10,350	10,350	1.015	10,504	0
						TOTAL	10,460

The relationships used to develop the data in Table 3-12 are the same as those discussed above for Table 3-11 except that regional values are used in the calculations.

Summing the last column of Table 3-12 shows that the total energy consumed per kWh delivered in the SERC-generating region is 10,460 Btu/kWh.

3.3.7 Total Fuel Emissions

Appendix C, Tables 1 through 4 reflect the pre-combustion and combustion emissions generated per 1000 fuel units combusted (pounds of coal, cubic feet of natural gas, etc.) on a national and regional basis [4]. The default emissions data for all regions have been set to the values for national generation since data for fuel-related emissions for each of the nine generating regions were not available. Differentiation between national and regional emissions has been included in the model for the reasons discussed in Section 1.

Appendix B, Tables 1 through 21 reflect the calculated emissions generated per electric kWh delivered by fuel usage on a national basis and for each of the nine generating regions.

Using coal-related PM emissions as an example, the calculations for Appendix B, Tables 1 through 21 are:

$a_{pm_n_c}$ = The atmospheric PM emissions (a_{pm}) attributable to national coal (n_c) generation per kWh delivered

For coal,

$$a_{pm_n_c} = \left(1.01 \frac{lb-coal}{kwh} \right) \left(\frac{56.45}{100} \frac{kwh-coal}{kwh} \right) \left(2.87 \frac{lb-PM}{10^3 lb-coal} \right) \left(\frac{10^3 lb-coal}{1000 lb-coal} \right)$$

where: $1.01 \frac{lb-coal}{kwh}$ = National grid coal consumption per kWh delivered (Table 3-11)

$\frac{56.45}{100} \frac{kwh-coal}{kwh}$ = National grid coal generation contribution (Table 3-3)

$2.87 \frac{lb-PM_{10}}{10^3 lb-coal}$ = National grid PM emissions per 10^3 lb. coal combusted

(Appendix C, Table 1)

Appendix B, Tables 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 show the calculated total emissions generated per electric kWh delivered on a national basis and for each of the nine generating regions. These values are simply the summation across each row for each emission for all fuel types.

3.3.8 MSW Combustion Offsets

To account for the energy and emissions savings associated with utility generation that is not required as a result of generating electricity using an MSW combustion facility, it is necessary for the model user to specify the type of utility generation that is being displaced. This would typically be the type of generating unit being constructed in the region by the utility. The majority of units currently being constructed are coal and natural gas fueled [9]. However, the type of fuel that would be displaced depends on the regional base-loaded fuel mix. For example, oil units are often base-loaded in northeast

states while this is rarely the case in southeast states. If a base-loaded MSW combustor came on line in the northeast, the utility might back down an expensive oil-fired unit. Therefore, the definition of displaced fuel types is user definable with the default being coal and natural gas as shown in Table 3-13. The calculations to determine the emissions and energy savings associated with these fuel offsets are discussed in Sections 3.3.9 and 3.3.10, respectively. Appendix A provides a discussion of the model implications of these combustion offsets.

Table 3-13 Combustion Offset Fuel Definitions

Regional Combustion Displacement Fuel Definition	Include In Combustion Offsets (1=Yes, 0=No)	variable name
Fuel Type		offset table
Coal	1	c_offset
Natural Gas	1	ng_offset
Residual Oil		ro_offset
Distillate Oil		do_offset
Nuclear		n_offset
Hydro		hyd_offset
Wood		w_offset
Other		o_offset

3.3.9 MSW Combustion Emission Offsets

Appendix B, Table 21 includes emission offsets based on displacing regional utility generation with MSW combustion as defined in Section 3.3.8 above. These are utility-related emissions that would be avoided if regional electricity were generated from MSW combustion and are credited by the LCI model such that emissions from MSW combustion will be reflected as net emissions

Using PM emissions for the SERC region as an example, the offset calculations for Appendix B, Table 21 are:

$a_pm_comb_offset$ = The atmospheric PM emissions (a_pm) from utility generation that is offset ($comb_offset$) by MSW combustion.

$$a_pm\ off_set = \frac{\sum_{i=1}^n \left(\frac{lbPM\ from\ fueltype\ i}{kwh\ regional\ generation} \right)}{\sum_{i=1}^n \left(\frac{kwh\ from\ fueltype\ i}{kwh\ regional\ generation} \right)}$$

where: $\sum_{i=1}^n \left(\frac{lbPM\ from\ fueltype\ i}{kwh\ regional\ generation} \right)$

= Total regional grid contribution to PM emissions (Appendix B, Tables 3–21) for the n fuel types selected as MSW combustion offset fuels in Table 3-13

$$\sum_{i=1}^n \left(\frac{kwh\ from\ fuel\ type\ i}{kwh\ regional\ generation} \right)$$

= Total regional grid contribution to generation (Table 3-4) for the n fuel types selected as MSW combustion offset fuels in Table 3-13

3.3.10 MSW Combustion Energy Consumption Offsets

The default MSW combustion offset fuel types are coal and natural as shown in Table 3-13. The regional generation contribution and total energy consumption for these fuels are shown in Tables 3-4 and 3-12, respectively. Normalizing these fuel contributions to 100% of the offset generation results in the total energy consumption offset by MSW combustion generation for each generating region shown in Table 3-14.

Table 3-14 MSW Combustion Energy Offsets

Control Area Name	MSW Combustion Energy offset (btu/kwh elect.)
ECAR	10,457
ERCOT	11,814
MAAC	10,547
MAIN	11,265
MAPP	12,044
NPCC	11,205
SERC	10,591
SPP	11,519
WSCC	11,254

3.4 Electric Energy Summary

The default values and calculation methodology discussed in the preceding sections have been implemented in the electrical energy portion of the overall LCI model to ensure that the LCI implications of electrical energy consumption in various unit operations are accounted for. The intent of this implementation is to provide the best available default information. It is also to provide a model that is responsive to macro-level user input values such as electric generating region and generating efficiency by fuel type while allowing for user override of micro-level inputs such as emissions associated with coal combustion should these data become available.

4. References

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APPENDICES

APPENDIX – A Combustion Offset Discussion

The electric energy process model provides the emissions per kWh of electrical energy consumed. These emissions are based on an aggregate kWh composed of the fractional contributions to emissions depending on the local grid mix. For example, if the local grid is defined as 30% nuclear and 70% coal, the emissions for the use of 1 kWh would be $(0.3)(\text{emissions/nuclear kWh}) + (0.7)(\text{emissions/coal kWh})$. These emissions are used by the LCI model in 2 ways. They are used by the combustion process model to obtain “emissions offset” credits for each kWh output by the combustion facility, thereby displacing the emissions from a kWh that would have been provided by the local utility. They are also used by all other process models (collection, MRF, etc.) to obtain the emissions attributable to use of each kWh (including pre-combustion energy) of waste processing and house load (lighting, etc.).

If a model solution shows 10 mega-watts (MW) of electricity production from combustion, then the grid mix will have changed. It will have changed because the 10 MW produced will displace 10 MW of utility generation from fossil fuel since nuclear and hydroelectric are usually based-loaded. A change in the grid mix would then change the emissions associated with an aggregate kWh. Taking this into account would require an iterative model solution where the new emissions associated with the new grid mix aggregate kWh are used to solve the next model run. This process would then continue until the optimization parameter (say CO₂) stabilizes at some final solution value. This is clearly an undesirable implementation since it would require iteration between the waste flow equation solution and the spreadsheet model.

To evaluate the impact of neglecting changes in the grid mix, the relative magnitude of the possible combustion energy contribution to the grid mix was examined. Assuming all MSW for a population area of 2,000,000 were used for electrical generation, then the maximum generation would be:

$$\text{Maximum MSW Electric generation} = \left(\frac{POP \times GR \times HV \times h}{24 \times (3.413 \times 10^6)} \right) = 161 \text{ MW}$$

Where: *POP* = Population (2,000,000 people)

GR = MSW generation rate (4.4 lb./person-day)

HV = MSW heating value (5000 Btu/lb.)

h = generating efficiency (0.3 electric MW/thermal MW)

24 = hours/day

3.413×10^6 = Btu/MW-hr

Therefore, combustion of all MSW from a city of 2,000,000 could provide, at most, 161 MW of electric generation. Using the Virginia Power total residential customer base of approximately 2,000,000 and their average daily demand of 7,000 MW, this would represent $(161/7000) \times 100 = 2.3\%$ of the total demand.

This value is negligible. Therefore, the emissions charged against each kWh expended in house load for all process models are based on the user-defined electric grid mix neglecting the contribution that might be made by combustion as a part of the model solution. Emission offsets for combustion are based on displacement of fossil emissions without iterating to factor combustion electric generation into the final grid mix.

APPENDIX - B National and Regional Emissions by Fuel Usage

Appendix B – Table 1 National Emissions by Fuel Usage

NATIONAL FUEL RELATED EMISSIONS BY USAGE	variable name	COAL Emissions (lb/kwh elect.)	NATURAL GAS Emissions (lb/kwh elect.)	RESIDUAL OIL Emissions (lb/kwh elect.)	DISTILLATE OIL Emissions (lb/kwh elect.)
		National grid	National grid	National grid	National grid
		56.45%	9.75%	2.62%	0.23%
		emissions table	n_c	n_ng	n_ro
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.64E-03	4.67E-06	6.98E-06	9.59E-07
Nitrogen Oxides	a_no	4.63E-03	5.33E-04	8.12E-05	1.30E-05
Hydrocarbons (non CH ₄)	a_hc	6.84E-05	5.55E-04	1.01E-04	1.10E-05
Sulfur Oxides	a_so	7.83E-03	2.06E-03	3.57E-04	4.45E-05
Carbon Monoxide	a_co	2.74E-04	2.77E-04	2.00E-05	2.34E-06
CO ₂ (biomass)	a_co2_bm	1.71E-04	2.93E-05	1.22E-05	1.31E-06
CO ₂ (non biomass)	a_co2	1.23E+00	1.43E-01	5.19E-02	6.27E-03
Ammonia	a_nh4	1.14E-08	3.15E-06	3.26E-06	8.60E-09
Lead	a_pb	5.45E-08	6.34E-10	1.06E-08	1.08E-09
Methane	a_ch4	2.68E-03	3.97E-04	8.61E-06	9.31E-07
Hydrochloric acid	a_hcl	1.03E-04	1.02E-07	1.30E-06	5.38E-09
Solid Waste					
Solid Waste #1	sw_1	2.42E-01	6.06E-03	3.25E-04	3.57E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.67E-05	3.23E-03	6.96E-05	7.49E-06
Suspended Solids	w_ss	8.78E-04	5.79E-05	4.89E-06	5.57E-07
BOD	w_bod	6.84E-08	3.11E-06	2.57E-07	2.80E-08
COD	w_cod	7.41E-07	4.49E-05	1.74E-06	1.87E-07
Oil	w_oil	8.55E-07	5.64E-05	1.63E-06	1.74E-07
Sulfuric Acid	w_h2s04	1.27E-05	2.19E-08	1.38E-08	6.60E-08
Iron	w_fe	6.84E-05	7.63E-08	3.86E-08	4.09E-09
Ammonia	w_nh4	7.98E-09	6.16E-08	2.76E-08	3.01E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	2.05E-09	1.46E-07	2.57E-09	2.80E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.60E-13	1.15E-11	2.02E-13	2.11E-14
Phosphate	w_po4	6.34E-06	1.15E-08	6.98E-09	3.30E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	2.05E-09	1.46E-07	2.57E-09	2.80E-10
Lead	w_pb	3.25E-12	1.15E-12	2.94E-11	3.23E-12
Zinc	w_zn	7.41E-10	5.02E-08	1.30E-09	1.40E-10

Appendix B – Table 2 National Emissions by Fuel Usage (Continued)

NATIONAL FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR Emissions (lb/kwh elect.)	HYDRO Emissions (lb/kwh elect.)	WOOD Emissions (lb/kwh elect.)	OTHER Emissions (lb/kwh elect.)
		National grid	National grid	National grid	National grid
		emissions table	n_u	n_h	n_w
		22.13%	8.59%	0.24%	0.00%
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.08E-04	0.00E+00	3.66E-06	0.00E+00
Nitrogen Oxides	a_no	1.42E-04	0.00E+00	3.42E-06	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	1.59E-05	0.00E+00	2.56E-06	0.00E+00
Sulfur Oxides	a_so	4.25E-04	0.00E+00	1.83E-07	0.00E+00
Carbon Monoxide	a_co	1.39E-05	0.00E+00	3.17E-05	0.00E+00
CO ₂ (biomass)	a_co2_bm	3.15E-04	0.00E+00	4.32E-03	0.00E+00
CO ₂ (non biomass)	a_co2	1.66E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	7.51E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	8.80E-10	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	3.67E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	1.09E-06	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	1.65E-02	0.00E+00	1.14E-04	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	6.60E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	1.04E-05	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	6.82E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	9.41E-07	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	1.18E-06	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	1.41E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	1.09E-05	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	8.17E-07	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	3.06E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	2.35E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	7.02E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	3.06E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	4.40E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	1.05E-09	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 3 Total National Emissions

TOTAL NATIONAL FUEL RELATED EMISSIONS BY USAGE	variable name	TOTAL Emissions (lb/kwh elect.)
		National grid
	emissions table	100.00%
	n_tot	
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.76E-03
Nitrogen Oxides	a_no	5.41E-03
Hydrocarbons (non CH ₄)	a_hc	7.54E-04
Sulfur Oxides	a_so	1.07E-02
Carbon Monoxide	a_co	6.19E-04
CO ₂ (biomass)	a_co2_bm	4.85E-03
CO ₂ (non biomass)	a_co2	1.45E+00
Ammonia	a_nh4	6.50E-06
Lead	a_pb	6.77E-08
Methane	a_ch4	3.13E-03
Hydrochloric acid	a_hcl	1.06E-04
Solid Waste		
Solid Waste #1	sw_1	2.65E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	3.42E-03
Suspended Solids	w_ss	9.52E-04
BOD	w_bod	3.54E-06
COD	w_cod	4.86E-05
Oil	w_oil	6.03E-05
Sulfuric Acid	w_h2s04	1.29E-05
Iron	w_fe	7.94E-05
Ammonia	w_nh4	9.17E-07
Copper	w_cu	0.00E+00
Cadmium	w_cd	1.54E-07
Arsenic	w_as	0.00E+00
Mercury	w_hg	1.21E-11
Phosphate	w_po4	6.46E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	1.54E-07
Lead	w_pb	3.75E-11
Zinc	w_zn	5.34E-08

Note: Total emissions values are the sum by row of Table 1.

Appendix B – Table 4 ECAR Emissions by Fuel Usage

ECAR FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		90.91%	0.34%	0.12%	0.24%
emissions table	r_c	r_ng	r_ro	r_do	
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	2.55E-03	2.04E-07	3.30E-07	9.66E-07
Nitrogen Oxides	a_no	7.23E-03	2.33E-05	3.84E-06	1.31E-05
Hydrocarbons (non CH4)	a_hc	1.07E-04	2.42E-05	4.78E-06	1.10E-05
Sulfur Oxides	a_so	1.22E-02	8.99E-05	1.69E-05	4.48E-05
Carbon Monoxide	a_co	4.27E-04	1.21E-05	9.47E-07	2.35E-06
CO2 (biomass)	a_co2_bm	2.67E-04	1.28E-06	5.77E-07	1.32E-06
CO2 (non biomass)	a_co2	1.92E+00	6.24E-03	2.46E-03	6.31E-03
Ammonia	a_nh4	1.78E-08	1.37E-07	1.54E-07	8.66E-09
Lead	a_pb	8.51E-08	2.77E-11	5.00E-10	1.09E-09
Methane	a_ch4	4.19E-03	1.73E-05	4.08E-07	9.38E-07
Hydrochloric acid	a_hcl	1.61E-04	4.47E-09	6.14E-08	5.41E-09
Solid Waste					
Solid Waste #1	sw_1	3.77E-01	2.65E-04	1.54E-05	3.59E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	7.30E-05	1.41E-04	3.29E-06	7.53E-06
Suspended Solids	w_ss	1.37E-03	2.53E-06	2.31E-07	5.61E-07
BOD	w_bod	1.07E-07	1.36E-07	1.22E-08	2.81E-08
COD	w_cod	1.16E-06	1.96E-06	8.25E-08	1.88E-07
Oil	w_oil	1.33E-06	2.46E-06	7.73E-08	1.75E-07
Sulfuric Acid	w_h2s04	1.98E-05	9.58E-10	6.52E-10	6.65E-08
Iron	w_fe	1.07E-04	3.33E-09	1.82E-09	4.11E-09
Ammonia	w_nh4	1.25E-08	2.69E-09	1.30E-09	3.03E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	3.20E-09	6.39E-09	1.22E-10	2.81E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	2.49E-13	5.02E-13	9.56E-15	2.12E-14
Phosphate	w_po4	9.89E-06	5.02E-10	3.30E-10	3.32E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	3.20E-09	6.39E-09	1.22E-10	2.81E-10
Lead	w_pb	5.07E-12	5.02E-14	1.39E-12	3.25E-12
Zinc	w_zn	1.16E-09	2.19E-09	6.17E-11	1.41E-10

Appendix B – Table 5 ECAR Emissions by Fuel Usage (Continued)

ECAR FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		7.72%	0.68%	0.00%	0.00%
emissions table	r_u	r_h	r_w	r_o	
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	3.80E-05	0.00E+00	0.00E+00	0.00E+00
Nitrogen Oxides	a_no	5.01E-05	0.00E+00	0.00E+00	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	5.61E-06	0.00E+00	0.00E+00	0.00E+00
Sulfur Oxides	a_so	1.50E-04	0.00E+00	0.00E+00	0.00E+00
Carbon Monoxide	a_co	4.92E-06	0.00E+00	0.00E+00	0.00E+00
CO ₂ (biomass)	a_co2_bm	1.11E-04	0.00E+00	0.00E+00	0.00E+00
CO ₂ (non biomass)	a_co2	5.87E-03	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	2.65E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	3.11E-10	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	1.29E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	3.86E-07	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	5.83E-03	0.00E+00	0.00E+00	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	2.33E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	3.68E-06	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	2.41E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	3.32E-07	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	4.18E-07	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	4.96E-08	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	3.83E-06	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	2.88E-07	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.08E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	8.28E-14	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	2.48E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.08E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	1.55E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	3.71E-10	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 6 Total ECAR Emissions

TOTAL ECAR FUEL RELATED EMISSIONS	variable name	TOTAL Emissions (lb/kwh elect.)
		Regional Grid
		100.00%
	emissions table	r_tot
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	2.59E-03
Nitrogen Oxides	a_no	7.32E-03
Hydrocarbons (non CH ₄)	a_hc	1.52E-04
Sulfur Oxides	a_so	1.25E-02
Carbon Monoxide	a_co	4.47E-04
CO ₂ (biomass)	a_co2_bm	3.81E-04
CO ₂ (non biomass)	a_co2	1.94E+00
Ammonia	a_nh4	3.44E-07
Lead	a_pb	8.71E-08
Methane	a_ch4	4.22E-03
Hydrochloric acid	a_hcl	1.62E-04
Solid Waste		
Solid Waste #1	sw_1	3.83E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	2.48E-04
Suspended Solids	w_ss	1.38E-03
BOD	w_bod	3.07E-07
COD	w_cod	3.72E-06
Oil	w_oil	4.47E-06
Sulfuric Acid	w_h2s04	1.99E-05
Iron	w_fe	1.11E-04
Ammonia	w_nh4	3.08E-07
Copper	w_cu	0.00E+00
Cadmium	w_cd	1.11E-08
Arsenic	w_as	0.00E+00
Mercury	w_hg	8.65E-13
Phosphate	w_po4	9.95E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	1.11E-08
Lead	w_pb	9.91E-12
Zinc	w_zn	3.92E-09

Appendix B – Table 7 ERCOT Emissions by Fuel Usage

ERCOT FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		46.87%	38.62%	0.09%	0.05%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.43E-03	1.86E-05	2.49E-07	1.84E-07
Nitrogen Oxides	a_no	4.05E-03	2.12E-03	2.90E-06	2.49E-06
Hydrocarbons (non CH4)	a_hc	5.98E-05	2.21E-03	3.60E-06	2.10E-06
Sulfur Oxides	a_so	6.84E-03	8.20E-03	1.27E-05	8.53E-06
Carbon Monoxide	a_co	2.39E-04	1.10E-03	7.14E-07	4.48E-07
CO2 (biomass)	a_co2_bm	1.49E-04	1.16E-04	4.35E-07	2.52E-07
CO2 (non biomass)	a_co2	1.08E+00	5.69E-01	1.85E-03	1.20E-03
Ammonia	a_nh4	9.96E-09	1.25E-05	1.16E-07	1.65E-09
Lead	a_pb	4.77E-08	2.53E-09	3.77E-10	2.08E-10
Methane	a_ch4	2.34E-03	1.58E-03	3.07E-07	1.79E-07
Hydrochloric acid	a_hcl	9.02E-05	4.08E-07	4.63E-08	1.03E-09
Solid Waste					
Solid Waste #1	sw_1	2.11E-01	2.41E-02	1.16E-05	6.85E-06
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.08E-05	1.28E-02	2.48E-06	1.44E-06
Suspended Solids	w_ss	7.67E-04	2.30E-04	1.74E-07	1.07E-07
BOD	w_bod	5.98E-08	1.24E-05	9.17E-09	5.36E-09
COD	w_cod	6.47E-07	1.79E-04	6.22E-08	3.59E-08
Oil	w_oil	7.47E-07	2.25E-04	5.83E-08	3.34E-08
Sulfuric Acid	w_h2s04	1.11E-05	8.74E-08	4.91E-10	1.27E-08
Iron	w_fe	5.98E-05	3.04E-07	1.38E-09	7.84E-10
Ammonia	w_nh4	6.97E-09	2.45E-07	9.83E-10	5.77E-10
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.79E-09	5.82E-07	9.17E-11	5.36E-11
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.39E-13	4.58E-11	7.21E-15	4.04E-15
Phosphate	w_po4	5.54E-06	4.58E-08	2.49E-10	6.33E-09
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.79E-09	5.82E-07	9.17E-11	5.36E-11
Lead	w_pb	2.84E-12	4.58E-12	1.05E-12	6.19E-13
Zinc	w_zn	6.47E-10	2.00E-07	4.65E-11	2.68E-11

Appendix B – Table 8 ERCOT Emissions by Fuel Usage (Continued)

ERCOT FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		14.03%	0.34%	0.00%	0.00%
emissions table	r_u	r_h	r_w	r_o	
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	6.86E-05	0.00E+00	0.00E+00	0.00E+00
Nitrogen Oxides	a_no	9.05E-05	0.00E+00	0.00E+00	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	1.01E-05	0.00E+00	0.00E+00	0.00E+00
Sulfur Oxides	a_so	2.71E-04	0.00E+00	0.00E+00	0.00E+00
Carbon Monoxide	a_co	8.89E-06	0.00E+00	0.00E+00	0.00E+00
CO ₂ (biomass)	a_co2_bm	2.01E-04	0.00E+00	0.00E+00	0.00E+00
CO ₂ (non biomass)	a_co2	1.06E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	4.79E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	5.62E-10	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	2.34E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	6.97E-07	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	1.05E-02	0.00E+00	0.00E+00	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.21E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	6.66E-06	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	4.35E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	6.01E-07	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	7.55E-07	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	8.97E-08	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	6.93E-06	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	5.21E-07	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.95E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.50E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	4.48E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.95E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	2.81E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	6.71E-10	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 9 Total ERCOT Emissions

TOTAL ERCOT FUEL RELATED EMISSIONS	variable name	TOTAL
		Emissions (lb/kwh elect.)
		Regional Grid 100.00%
emissions table	r_tot	
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.52E-03
Nitrogen Oxides	a_no	6.27E-03
Hydrocarbons (non CH4)	a_hc	2.29E-03
Sulfur Oxides	a_so	1.53E-02
Carbon Monoxide	a_co	1.35E-03
CO2 (biomass)	a_co2_bm	4.68E-04
CO2 (non biomass)	a_co2	1.66E+00
Ammonia	a_nh4	1.27E-05
Lead	a_pb	5.13E-08
Methane	a_ch4	3.95E-03
Hydrochloric acid	a_hcl	9.13E-05
Solid Waste		
Solid Waste #1	sw_1	2.46E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	1.29E-02
Suspended Solids	w_ss	1.00E-03
BOD	w_bod	1.25E-05
COD	w_cod	1.80E-04
Oil	w_oil	2.26E-04
Sulfuric Acid	w_h2s04	1.13E-05
Iron	w_fe	6.70E-05
Ammonia	w_nh4	7.75E-07
Copper	w_cu	0.00E+00
Cadmium	w_cd	5.86E-07
Arsenic	w_as	0.00E+00
Mercury	w_hg	4.61E-11
Phosphate	w_po4	5.63E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	5.86E-07
Lead	w_pb	9.36E-12
Zinc	w_zn	2.01E-07

Appendix B – Table 10 MAAC Emissions by Fuel Usage

MAAC FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		46.61%	3.76%	5.11%	0.75%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.30E-03	1.90E-06	1.41E-05	3.07E-06
Nitrogen Oxides	a_no	3.68E-03	2.16E-04	1.64E-04	4.17E-05
Hydrocarbons (non CH4)	a_hc	5.43E-05	2.25E-04	2.04E-04	3.51E-05
Sulfur Oxides	a_so	6.21E-03	8.36E-04	7.21E-04	1.43E-04
Carbon Monoxide	a_co	2.17E-04	1.12E-04	4.05E-05	7.48E-06
CO2 (biomass)	a_co2_bm	1.36E-04	1.19E-05	2.47E-05	4.20E-06
CO2 (non biomass)	a_co2	9.77E-01	5.80E-02	1.05E-01	2.01E-02
Ammonia	a_nh4	9.05E-09	1.28E-06	6.59E-06	2.76E-08
Lead	a_pb	4.33E-08	2.57E-10	2.14E-08	3.47E-09
Methane	a_ch4	2.13E-03	1.61E-04	1.74E-05	2.98E-06
Hydrochloric acid	a_hcl	8.19E-05	4.16E-08	2.63E-06	1.72E-08
Solid Waste					
Solid Waste #1	sw_1	1.92E-01	2.46E-03	6.58E-04	1.14E-04
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	3.71E-05	1.31E-03	1.41E-04	2.40E-05
Suspended Solids	w_ss	6.97E-04	2.35E-05	9.88E-06	1.78E-06
BOD	w_bod	5.43E-08	1.26E-06	5.20E-07	8.96E-08
COD	w_cod	5.88E-07	1.82E-05	3.53E-06	6.00E-07
Oil	w_oil	6.79E-07	2.29E-05	3.31E-06	5.58E-07
Sulfuric Acid	w_h2s04	1.01E-05	8.90E-09	2.79E-08	2.11E-07
Iron	w_fe	5.43E-05	3.10E-08	7.80E-08	1.31E-08
Ammonia	w_nh4	6.33E-09	2.50E-08	5.57E-08	9.65E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.63E-09	5.94E-08	5.20E-09	8.96E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.27E-13	4.66E-12	4.09E-13	6.75E-14
Phosphate	w_po4	5.03E-06	4.66E-09	1.41E-08	1.06E-07
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.63E-09	5.94E-08	5.20E-09	8.96E-10
Lead	w_pb	2.58E-12	4.66E-13	5.94E-11	1.03E-11
Zinc	w_zn	5.88E-10	2.04E-08	2.64E-09	4.48E-10

Appendix B – Table 11 MAAC Emissions by Fuel Usage (Continued)

MAAC FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		41.74%	2.03%	0.00%	0.00%
emissions table	r_u	r_h	r_w	r_o	
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	2.07E-04	0.00E+00	0.00E+00	0.00E+00
Nitrogen Oxides	a_no	2.73E-04	0.00E+00	0.00E+00	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	3.06E-05	0.00E+00	0.00E+00	0.00E+00
Sulfur Oxides	a_so	8.19E-04	0.00E+00	0.00E+00	0.00E+00
Carbon Monoxide	a_co	2.68E-05	0.00E+00	0.00E+00	0.00E+00
CO ₂ (biomass)	a_co2_bm	6.07E-04	0.00E+00	0.00E+00	0.00E+00
CO ₂ (non biomass)	a_co2	3.20E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	1.44E-07	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	1.69E-09	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	7.06E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	2.10E-06	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	3.18E-02	0.00E+00	0.00E+00	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	1.27E-04	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	2.01E-05	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	1.31E-07	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	1.81E-06	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	2.28E-06	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	2.71E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	2.09E-05	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	1.57E-06	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	5.88E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	4.52E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	1.35E-07	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	5.88E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	8.47E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	2.02E-09	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 12 Total MAAC Emissions

TOTAL MAAC FUEL RELATED EMISSIONS	variable name	TOTAL
		Emissions (lb/kwh elect.)
		Regional Grid 100.00%
emissions table	r_tot	
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.52E-03
Nitrogen Oxides	a_no	4.37E-03
Hydrocarbons (non CH4)	a_hc	5.50E-04
Sulfur Oxides	a_so	8.73E-03
Carbon Monoxide	a_co	4.04E-04
CO2 (biomass)	a_co2_bm	7.83E-04
CO2 (non biomass)	a_co2	1.19E+00
Ammonia	a_nh4	8.05E-06
Lead	a_pb	7.01E-08
Methane	a_ch4	2.38E-03
Hydrochloric acid	a_hcl	8.67E-05
Solid Waste		
Solid Waste #1	sw_1	2.27E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	1.64E-03
Suspended Solids	w_ss	7.52E-04
BOD	w_bod	2.06E-06
COD	w_cod	2.48E-05
Oil	w_oil	2.97E-05
Sulfuric Acid	w_h2s04	1.06E-05
Iron	w_fe	7.53E-05
Ammonia	w_nh4	1.67E-06
Copper	w_cu	0.00E+00
Cadmium	w_cd	7.30E-08
Arsenic	w_as	0.00E+00
Mercury	w_hg	5.72E-12
Phosphate	w_po4	5.29E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	7.30E-08
Lead	w_pb	7.37E-11
Zinc	w_zn	2.61E-08

Appendix B – Table 13 MAIN Emissions by Fuel Usage

MAIN FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		54.02%	1.36%	0.42%	0.19%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.63E-03	6.70E-07	1.14E-06	8.69E-07
Nitrogen Oxides	a_no	4.62E-03	7.64E-05	1.33E-05	1.18E-05
Hydrocarbons (non CH ₄)	a_hc	6.82E-05	7.96E-05	1.65E-05	9.93E-06
Sulfur Oxides	a_so	7.81E-03	2.95E-04	5.82E-05	4.03E-05
Carbon Monoxide	a_co	2.73E-04	3.97E-05	3.27E-06	2.12E-06
CO ₂ (biomass)	a_co2_bm	1.71E-04	4.19E-06	1.99E-06	1.19E-06
CO ₂ (non biomass)	a_co2	1.23E+00	2.05E-02	8.47E-03	5.67E-03
Ammonia	a_nh4	1.14E-08	4.51E-07	5.32E-07	7.79E-09
Lead	a_pb	5.44E-08	9.09E-11	1.72E-09	9.82E-10
Methane	a_ch4	2.68E-03	5.69E-05	1.41E-06	8.43E-07
Hydrochloric acid	a_hcl	1.03E-04	1.47E-08	2.12E-07	4.87E-09
Solid Waste					
Solid Waste #1	sw_1	2.41E-01	8.69E-04	5.31E-05	3.23E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.66E-05	4.62E-04	1.14E-05	6.78E-06
Suspended Solids	w_ss	8.76E-04	8.30E-06	7.97E-07	5.04E-07
BOD	w_bod	6.82E-08	4.46E-07	4.20E-08	2.53E-08
COD	w_cod	7.39E-07	6.44E-06	2.85E-07	1.69E-07
Oil	w_oil	8.53E-07	8.09E-06	2.67E-07	1.58E-07
Sulfuric Acid	w_h2s04	1.27E-05	3.15E-09	2.25E-09	5.98E-08
Iron	w_fe	6.82E-05	1.09E-08	6.30E-09	3.70E-09
Ammonia	w_nh4	7.96E-09	8.82E-09	4.50E-09	2.73E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	2.05E-09	2.10E-08	4.20E-10	2.53E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.59E-13	1.65E-12	3.30E-14	1.91E-14
Phosphate	w_po4	6.32E-06	1.65E-09	1.14E-09	2.99E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	2.05E-09	2.10E-08	4.20E-10	2.53E-10
Lead	w_pb	3.24E-12	1.65E-13	4.80E-12	2.92E-12
Zinc	w_zn	7.39E-10	7.19E-09	2.13E-10	1.27E-10

Appendix B – Table 14 MAIN Emissions by Fuel Usage (Continued)

MAIN FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		42.49%	1.51%	0.00%	0.00%
	emissions table	r_u	r_h	r_w	r_o
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	2.07E-04	0.00E+00	3.41E-08	0.00E+00
Nitrogen Oxides	a_no	2.73E-04	0.00E+00	3.18E-08	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	3.06E-05	0.00E+00	2.39E-08	0.00E+00
Sulfur Oxides	a_so	8.20E-04	0.00E+00	1.70E-09	0.00E+00
Carbon Monoxide	a_co	2.68E-05	0.00E+00	2.95E-07	0.00E+00
CO2 (biomass)	a_co2_bm	6.08E-04	0.00E+00	4.02E-05	0.00E+00
CO2 (non biomass)	a_co2	3.20E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	1.45E-07	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	1.70E-09	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	7.07E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	2.11E-06	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	3.18E-02	0.00E+00	1.06E-06	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	1.27E-04	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	2.01E-05	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	1.31E-07	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	1.81E-06	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	2.28E-06	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	2.71E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	2.09E-05	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	1.57E-06	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	5.89E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	4.52E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	1.35E-07	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	5.89E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	8.48E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	2.03E-09	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 15 Total MAIN Emissions

TOTAL MAIN FUEL RELATED EMISSIONS	variable name	TOTAL
		Emissions (lb/kwh elect.)
		Regional Grid 100.00%
emissions table	r_tot	
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.84E-03
Nitrogen Oxides	a_no	5.00E-03
Hydrocarbons (non CH4)	a_hc	2.05E-04
Sulfur Oxides	a_so	9.02E-03
Carbon Monoxide	a_co	3.45E-04
CO2 (biomass)	a_co2_bm	8.26E-04
CO2 (non biomass)	a_co2	1.30E+00
Ammonia	a_nh4	1.15E-06
Lead	a_pb	5.89E-08
Methane	a_ch4	2.81E-03
Hydrochloric acid	a_hcl	1.05E-04
Solid Waste		
Solid Waste #1	sw_1	2.74E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	6.54E-04
Suspended Solids	w_ss	9.06E-04
BOD	w_bod	7.13E-07
COD	w_cod	9.45E-06
Oil	w_oil	1.16E-05
Sulfuric Acid	w_h2s04	1.30E-05
Iron	w_fe	8.92E-05
Ammonia	w_nh4	1.60E-06
Copper	w_cu	0.00E+00
Cadmium	w_cd	2.96E-08
Arsenic	w_as	0.00E+00
Mercury	w_hg	2.31E-12
Phosphate	w_po4	6.49E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	2.96E-08
Lead	w_pb	1.20E-11
Zinc	w_zn	1.03E-08

Appendix B – Table 16 MAPP Emissions by Fuel Usage

MAPP FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		75.96%	0.68%	0.00%	0.18%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	2.46E-03	3.73E-07	3.73E-10	8.50E-07
Nitrogen Oxides	a_no	6.96E-03	4.25E-05	4.34E-09	1.15E-05
Hydrocarbons (non CH4)	a_hc	1.03E-04	4.43E-05	5.40E-09	9.72E-06
Sulfur Oxides	a_so	1.18E-02	1.64E-04	1.91E-08	3.94E-05
Carbon Monoxide	a_co	4.11E-04	2.21E-05	1.07E-09	2.07E-06
CO2 (biomass)	a_co2_bm	2.57E-04	2.34E-06	6.52E-10	1.16E-06
CO2 (non biomass)	a_co2	1.85E+00	1.14E-02	2.78E-06	5.55E-03
Ammonia	a_nh4	1.71E-08	2.51E-07	1.74E-10	7.63E-09
Lead	a_pb	8.20E-08	5.06E-11	5.65E-13	9.61E-10
Methane	a_ch4	4.03E-03	3.17E-05	4.61E-10	8.26E-07
Hydrochloric acid	a_hcl	1.55E-04	8.17E-09	6.94E-11	4.77E-09
Solid Waste					
Solid Waste #1	sw_1	3.63E-01	4.84E-04	1.74E-08	3.17E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	7.02E-05	2.57E-04	3.72E-09	6.64E-06
Suspended Solids	w_ss	1.32E-03	4.62E-06	2.61E-10	4.94E-07
BOD	w_bod	1.03E-07	2.49E-07	1.38E-11	2.48E-08
COD	w_cod	1.11E-06	3.59E-06	9.33E-11	1.66E-07
Oil	w_oil	1.28E-06	4.50E-06	8.74E-11	1.54E-07
Sulfuric Acid	w_h2s04	1.91E-05	1.75E-09	7.37E-13	5.85E-08
Iron	w_fe	1.03E-04	6.09E-09	2.06E-12	3.62E-09
Ammonia	w_nh4	1.20E-08	4.91E-09	1.47E-12	2.67E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	3.08E-09	1.17E-08	1.38E-13	2.48E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	2.40E-13	9.18E-13	1.08E-17	1.87E-14
Phosphate	w_po4	9.52E-06	9.18E-10	3.73E-13	2.93E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	3.08E-09	1.17E-08	1.38E-13	2.48E-10
Lead	w_pb	4.88E-12	9.18E-14	1.57E-15	2.86E-12
Zinc	w_zn	1.11E-09	4.00E-09	6.97E-14	1.24E-10

Appendix B – Table 17 MAPP Emissions by Fuel Usage (Continued)

MAPP FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		15.44%	7.47%	0.26%	0.00%
	emissions table	r_u	r_h	r_w	r_o
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	7.70E-05	0.00E+00	4.03E-06	0.00E+00
Nitrogen Oxides	a_no	1.01E-04	0.00E+00	3.76E-06	0.00E+00
Hydrocarbons (non CH4)	a_hc	1.14E-05	0.00E+00	2.82E-06	0.00E+00
Sulfur Oxides	a_so	3.04E-04	0.00E+00	2.01E-07	0.00E+00
Carbon Monoxide	a_co	9.97E-06	0.00E+00	3.49E-05	0.00E+00
CO2 (biomass)	a_co2_bm	2.26E-04	0.00E+00	4.75E-03	0.00E+00
CO2 (non biomass)	a_co2	1.19E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	5.37E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	6.30E-10	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	2.62E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	7.82E-07	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	1.18E-02	0.00E+00	1.26E-04	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.72E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	7.47E-06	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	4.88E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	6.73E-07	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	8.47E-07	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	1.01E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	7.77E-06	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	5.84E-07	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	2.19E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.68E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	5.02E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	2.19E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	3.15E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	7.52E-10	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 18 Total MAPP Emissions

TOTAL MAPP FUEL RELATED EMISSIONS	variable name	TOTAL Emissions (lb/kwh elect.)
		Regional Grid
		100.00%
	emissions table	r_tot
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	2.54E-03
Nitrogen Oxides	a_no	7.12E-03
Hydrocarbons (non CH ₄)	a_hc	1.71E-04
Sulfur Oxides	a_so	1.23E-02
Carbon Monoxide	a_co	4.80E-04
CO ₂ (biomass)	a_co2_bm	5.24E-03
CO ₂ (non biomass)	a_co2	1.88E+00
Ammonia	a_nh4	3.30E-07
Lead	a_pb	8.36E-08
Methane	a_ch4	4.09E-03
Hydrochloric acid	a_hcl	1.56E-04
Solid Waste		
Solid Waste #1	sw_1	3.76E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	3.82E-04
Suspended Solids	w_ss	1.33E-03
BOD	w_bod	4.25E-07
COD	w_cod	5.54E-06
Oil	w_oil	6.79E-06
Sulfuric Acid	w_h2s04	1.92E-05
Iron	w_fe	1.11E-04
Ammonia	w_nh4	6.04E-07
Copper	w_cu	0.00E+00
Cadmium	w_cd	1.72E-08
Arsenic	w_as	0.00E+00
Mercury	w_hg	1.34E-12
Phosphate	w_po4	9.60E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	1.72E-08
Lead	w_pb	8.15E-12
Zinc	w_zn	5.99E-09

Appendix B – Table 19 NPCC Emissions by Fuel Usage

NPCC FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		19.55%	11.83%	13.58%	0.41%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	5.60E-04	5.56E-06	3.62E-05	1.67E-06
Nitrogen Oxides	a_no	1.59E-03	6.35E-04	4.21E-04	2.26E-05
Hydrocarbons (non CH4)	a_hc	2.34E-05	6.61E-04	5.24E-04	1.91E-05
Sulfur Oxides	a_so	2.68E-03	2.45E-03	1.85E-03	7.74E-05
Carbon Monoxide	a_co	9.37E-05	3.30E-04	1.04E-04	4.07E-06
CO2 (biomass)	a_co2_bm	5.86E-05	3.49E-05	6.33E-05	2.28E-06
CO2 (non biomass)	a_co2	4.22E-01	1.70E-01	2.69E-01	1.09E-02
Ammonia	a_nh4	3.91E-09	3.75E-06	1.69E-05	1.50E-08
Lead	a_pb	1.87E-08	7.56E-10	5.48E-08	1.89E-09
Methane	a_ch4	9.19E-04	4.73E-04	4.47E-05	1.62E-06
Hydrochloric acid	a_hcl	3.54E-05	1.22E-07	6.74E-06	9.36E-09
Solid Waste					
Solid Waste #1	sw_1	8.28E-02	7.22E-03	1.69E-03	6.21E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	1.60E-05	3.84E-03	3.61E-04	1.30E-05
Suspended Solids	w_ss	3.01E-04	6.90E-05	2.54E-05	9.70E-07
BOD	w_bod	2.34E-08	3.71E-06	1.33E-06	4.87E-08
COD	w_cod	2.54E-07	5.35E-05	9.06E-06	3.26E-07
Oil	w_oil	2.93E-07	6.72E-05	8.48E-06	3.03E-07
Sulfuric Acid	w_h2s04	4.34E-06	2.61E-08	7.15E-08	1.15E-07
Iron	w_fe	2.34E-05	9.09E-08	2.00E-07	7.11E-09
Ammonia	w_nh4	2.73E-09	7.33E-08	1.43E-07	5.24E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	7.03E-10	1.74E-07	1.33E-08	4.87E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	5.47E-14	1.37E-11	1.05E-12	3.67E-14
Phosphate	w_po4	2.17E-06	1.37E-08	3.62E-08	5.75E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	7.03E-10	1.74E-07	1.33E-08	4.87E-10
Lead	w_pb	1.11E-12	1.37E-12	1.53E-10	5.62E-12
Zinc	w_zn	2.54E-10	5.97E-08	6.77E-09	2.43E-10

Appendix B – Table 20 NPCC Emissions by Fuel Usage (Continued)

NPCC FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		37.86%	16.73%	0.04%	0.00%
	emissions table	r_u	r_h	r_w	r_o
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.78E-04	0.00E+00	6.75E-07	0.00E+00
Nitrogen Oxides	a_no	2.34E-04	0.00E+00	6.30E-07	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	2.63E-05	0.00E+00	4.73E-07	0.00E+00
Sulfur Oxides	a_so	7.03E-04	0.00E+00	3.38E-08	0.00E+00
Carbon Monoxide	a_co	2.30E-05	0.00E+00	5.85E-06	0.00E+00
CO ₂ (biomass)	a_co2_bm	5.21E-04	0.00E+00	7.96E-04	0.00E+00
CO ₂ (non biomass)	a_co2	2.75E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	1.24E-07	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	1.45E-09	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	6.06E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	1.81E-06	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	2.73E-02	0.00E+00	2.11E-05	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	1.09E-04	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	1.72E-05	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	1.13E-07	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	1.56E-06	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	1.96E-06	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	2.32E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	1.79E-05	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	1.35E-06	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	5.05E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	3.88E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	1.16E-07	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	5.05E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	7.27E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	1.74E-09	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 21 Total NPCC Emissions

TOTAL NPCC FUEL RELATED EMISSIONS	variable name	TOTAL Emissions (lb/kwh elect.)
		Regional Grid
		100.00%
	emissions table	r_tot
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	7.82E-04
Nitrogen Oxides	a_no	2.90E-03
Hydrocarbons (non CH4)	a_hc	1.26E-03
Sulfur Oxides	a_so	7.76E-03
Carbon Monoxide	a_co	5.60E-04
CO2 (biomass)	a_co2_bm	1.48E-03
CO2 (non biomass)	a_co2	9.00E-01
Ammonia	a_nh4	2.08E-05
Lead	a_pb	7.76E-08
Methane	a_ch4	1.50E-03
Hydrochloric acid	a_hcl	4.40E-05
Solid Waste		
Solid Waste #1	sw_1	1.19E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	4.34E-03
Suspended Solids	w_ss	4.13E-04
BOD	w_bod	5.23E-06
COD	w_cod	6.47E-05
Oil	w_oil	7.83E-05
Sulfuric Acid	w_h2s04	4.79E-06
Iron	w_fe	4.17E-05
Ammonia	w_nh4	1.57E-06
Copper	w_cu	0.00E+00
Cadmium	w_cd	1.94E-07
Arsenic	w_as	0.00E+00
Mercury	w_hg	1.52E-11
Phosphate	w_po4	2.39E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	1.94E-07
Lead	w_pb	1.61E-10
Zinc	w_zn	6.88E-08

Appendix B – Table 22 SERC Emissions by Fuel Usage

SERC FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		56.80%	2.94%	5.26%	0.27%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.60E-03	1.47E-06	1.36E-05	1.22E-06
Nitrogen Oxides	a_no	4.54E-03	1.67E-04	1.58E-04	1.65E-05
Hydrocarbons (non CH4)	a_hc	6.69E-05	1.74E-04	1.97E-04	1.39E-05
Sulfur Oxides	a_so	7.66E-03	6.46E-04	6.96E-04	5.65E-05
Carbon Monoxide	a_co	2.68E-04	8.69E-05	3.91E-05	2.97E-06
CO2 (biomass)	a_co2_bm	1.67E-04	9.18E-06	2.38E-05	1.67E-06
CO2 (non biomass)	a_co2	1.21E+00	4.48E-02	1.01E-01	7.96E-03
Ammonia	a_nh4	1.12E-08	9.87E-07	6.36E-06	1.09E-08
Lead	a_pb	5.34E-08	1.99E-10	2.06E-08	1.38E-09
Methane	a_ch4	2.63E-03	1.25E-04	1.68E-05	1.18E-06
Hydrochloric acid	a_hcl	1.01E-04	3.21E-08	2.53E-06	6.83E-09
Solid Waste					
Solid Waste #1	sw_1	2.37E-01	1.90E-03	6.34E-04	4.54E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.57E-05	1.01E-03	1.36E-04	9.51E-06
Suspended Solids	w_ss	8.59E-04	1.82E-05	9.54E-06	7.08E-07
BOD	w_bod	6.69E-08	9.77E-07	5.02E-07	3.55E-08
COD	w_cod	7.25E-07	1.41E-05	3.41E-06	2.38E-07
Oil	w_oil	8.37E-07	1.77E-05	3.19E-06	2.21E-07
Sulfuric Acid	w_h2s04	1.24E-05	6.89E-09	2.69E-08	8.39E-08
Iron	w_fe	6.69E-05	2.39E-08	7.53E-08	5.19E-09
Ammonia	w_nh4	7.81E-09	1.93E-08	5.38E-08	3.83E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	2.01E-09	4.59E-08	5.02E-09	3.55E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.56E-13	3.61E-12	3.94E-13	2.68E-14
Phosphate	w_po4	6.20E-06	3.61E-09	1.36E-08	4.20E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	2.01E-09	4.59E-08	5.02E-09	3.55E-10
Lead	w_pb	3.18E-12	3.61E-13	5.74E-11	4.10E-12
Zinc	w_zn	7.25E-10	1.57E-08	2.55E-09	1.78E-10

Appendix B – Table 23 SERC Emissions by Fuel Usage (Continued)

SERC FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		28.70%	6.03%	0.00%	0.00%
	emissions table	r_u	r_h	r_w	r_o
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.39E-04	0.00E+00	0.00E+00	0.00E+00
Nitrogen Oxides	a_no	1.83E-04	0.00E+00	0.00E+00	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	2.05E-05	0.00E+00	0.00E+00	0.00E+00
Sulfur Oxides	a_so	5.50E-04	0.00E+00	0.00E+00	0.00E+00
Carbon Monoxide	a_co	1.80E-05	0.00E+00	0.00E+00	0.00E+00
CO ₂ (biomass)	a_co2_bm	4.07E-04	0.00E+00	0.00E+00	0.00E+00
CO ₂ (non biomass)	a_co2	2.15E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	9.70E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	1.14E-09	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	4.74E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	1.41E-06	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	2.13E-02	0.00E+00	0.00E+00	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	8.53E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	1.35E-05	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	8.81E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	1.22E-06	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	1.53E-06	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	1.82E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	1.40E-05	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	1.05E-06	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	3.95E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	3.03E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	9.07E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	3.95E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	5.69E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	1.36E-09	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 24 Total SERC Emissions

TOTAL SERC FUEL RELATED EMISSIONS	variable name	TOTAL Emissions (lb/kwh elect.)
		Regional Grid
		100.00%
	emissions table	r_tot
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.76E-03
Nitrogen Oxides	a_no	5.06E-03
Hydrocarbons (non CH ₄)	a_hc	4.73E-04
Sulfur Oxides	a_so	9.61E-03
Carbon Monoxide	a_co	4.15E-04
CO ₂ (biomass)	a_co2_bm	6.09E-04
CO ₂ (non biomass)	a_co2	1.38E+00
Ammonia	a_nh4	7.47E-06
Lead	a_pb	7.67E-08
Methane	a_ch4	2.82E-03
Hydrochloric acid	a_hcl	1.05E-04
Solid Waste		
Solid Waste #1	sw_1	2.60E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	1.29E-03
Suspended Solids	w_ss	9.01E-04
BOD	w_bod	1.67E-06
COD	w_cod	1.97E-05
Oil	w_oil	2.35E-05
Sulfuric Acid	w_h2s04	1.27E-05
Iron	w_fe	8.11E-05
Ammonia	w_nh4	1.14E-06
Copper	w_cu	0.00E+00
Cadmium	w_cd	5.73E-08
Arsenic	w_as	0.00E+00
Mercury	w_hg	4.49E-12
Phosphate	w_po4	6.35E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	5.73E-08
Lead	w_pb	6.56E-11
Zinc	w_zn	2.06E-08

Appendix B – Table 25 SPP Emissions by Fuel Usage

SPP FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		53.31%	26.90%	0.48%	0.10%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.59E-03	1.29E-05	2.04E-06	3.64E-07
Nitrogen Oxides	a_no	4.50E-03	1.48E-03	2.38E-05	4.94E-06
Hydrocarbons (non CH4)	a_hc	6.64E-05	1.54E-03	2.96E-05	4.16E-06
Sulfur Oxides	a_so	7.60E-03	5.71E-03	1.04E-04	1.69E-05
Carbon Monoxide	a_co	2.66E-04	7.67E-04	5.86E-06	8.87E-07
CO2 (biomass)	a_co2_bm	1.66E-04	8.11E-05	3.57E-06	4.98E-07
CO2 (non biomass)	a_co2	1.20E+00	3.96E-01	1.52E-02	2.38E-03
Ammonia	a_nh4	1.11E-08	8.72E-06	9.54E-07	3.27E-09
Lead	a_pb	5.30E-08	1.76E-09	3.09E-09	4.12E-10
Methane	a_ch4	2.61E-03	1.10E-03	2.52E-06	3.54E-07
Hydrochloric acid	a_hcl	1.00E-04	2.84E-07	3.80E-07	2.04E-09
Solid Waste					
Solid Waste #1	sw_1	2.35E-01	1.68E-02	9.52E-05	1.36E-05
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.54E-05	8.94E-03	2.04E-05	2.84E-06
Suspended Solids	w_ss	8.53E-04	1.60E-04	1.43E-06	2.12E-07
BOD	w_bod	6.64E-08	8.63E-06	7.53E-08	1.06E-08
COD	w_cod	7.20E-07	1.25E-04	5.11E-07	7.11E-08
Oil	w_oil	8.31E-07	1.56E-04	4.79E-07	6.62E-08
Sulfuric Acid	w_h2s04	1.23E-05	6.08E-08	4.03E-09	2.51E-08
Iron	w_fe	6.64E-05	2.11E-07	1.13E-08	1.55E-09
Ammonia	w_nh4	7.75E-09	1.71E-07	8.07E-09	1.14E-09
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.99E-09	4.05E-07	7.53E-10	1.06E-10
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.55E-13	3.19E-11	5.92E-14	8.00E-15
Phosphate	w_po4	6.16E-06	3.19E-08	2.04E-09	1.25E-08
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.99E-09	4.05E-07	7.53E-10	1.06E-10
Lead	w_pb	3.16E-12	3.19E-12	8.60E-12	1.23E-12
Zinc	w_zn	7.20E-10	1.39E-07	3.82E-10	5.31E-11

Appendix B – Table 26 SPP Emissions by Fuel Usage (Continued)

SPP FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		16.29%	2.89%	0.03%	0.00%
	emissions table	r_u	r_h	r_w	r_o
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	8.13E-05	0.00E+00	5.12E-07	0.00E+00
Nitrogen Oxides	a_no	1.07E-04	0.00E+00	4.78E-07	0.00E+00
Hydrocarbons (non CH4)	a_hc	1.20E-05	0.00E+00	3.58E-07	0.00E+00
Sulfur Oxides	a_so	3.22E-04	0.00E+00	2.56E-08	0.00E+00
Carbon Monoxide	a_co	1.05E-05	0.00E+00	4.44E-06	0.00E+00
CO2 (biomass)	a_co2_bm	2.38E-04	0.00E+00	6.04E-04	0.00E+00
CO2 (non biomass)	a_co2	1.26E-02	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	5.67E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	6.65E-10	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	2.77E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	8.26E-07	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	1.25E-02	0.00E+00	1.60E-05	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	4.99E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	7.89E-06	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	5.16E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	7.12E-07	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	8.95E-07	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	1.06E-07	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	8.21E-06	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	6.17E-07	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	2.31E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.77E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	5.30E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	2.31E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	3.33E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	7.95E-10	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 27 Total SPP Emissions

TOTAL SPP FUEL RELATED EMISSIONS	variable name	TOTAL
		Emissions (lb/kwh elect.)
		Regional Grid 100.00%
emissions table	r_tot	
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.69E-03
Nitrogen Oxides	a_no	6.11E-03
Hydrocarbons (non CH4)	a_hc	1.65E-03
Sulfur Oxides	a_so	1.38E-02
Carbon Monoxide	a_co	1.05E-03
CO2 (biomass)	a_co2_bm	1.09E-03
CO2 (non biomass)	a_co2	1.62E+00
Ammonia	a_nh4	9.74E-06
Lead	a_pb	5.89E-08
Methane	a_ch4	3.74E-03
Hydrochloric acid	a_hcl	1.02E-04
Solid Waste		
Solid Waste #1	sw_1	2.64E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	9.06E-03
Suspended Solids	w_ss	1.02E-03
BOD	w_bod	8.83E-06
COD	w_cod	1.27E-04
Oil	w_oil	1.59E-04
Sulfuric Acid	w_h2s04	1.25E-05
Iron	w_fe	7.49E-05
Ammonia	w_nh4	8.05E-07
Copper	w_cu	0.00E+00
Cadmium	w_cd	4.11E-07
Arsenic	w_as	0.00E+00
Mercury	w_hg	3.23E-11
Phosphate	w_po4	6.26E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	4.11E-07
Lead	w_pb	1.65E-11
Zinc	w_zn	1.41E-07

Appendix B – Table 28 WSCC Emissions by Fuel Usage

WSCC FUEL RELATED EMISSIONS BY USAGE	variable name	COAL	NATURAL GAS	RESIDUAL OIL	DISTILLATE OIL
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		41.09%	14.83%	0.41%	0.05%
	emissions table	r_c	r_ng	r_ro	r_do
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	1.21E-03	6.93E-06	1.06E-06	1.87E-07
Nitrogen Oxides	a_no	3.44E-03	7.91E-04	1.23E-05	2.54E-06
Hydrocarbons (non CH ₄)	a_hc	5.07E-05	8.24E-04	1.53E-05	2.14E-06
Sulfur Oxides	a_so	5.80E-03	3.05E-03	5.39E-05	8.69E-06
Carbon Monoxide	a_co	2.03E-04	4.11E-04	3.03E-06	4.56E-07
CO2 (biomass)	a_co2_bm	1.27E-04	4.34E-05	1.84E-06	2.56E-07
CO2 (non biomass)	a_co2	9.13E-01	2.12E-01	7.85E-03	1.22E-03
Ammonia	a_nh4	8.45E-09	4.67E-06	4.93E-07	1.68E-09
Lead	a_pb	4.05E-08	9.41E-10	1.60E-09	2.12E-10
Methane	a_ch4	1.99E-03	5.89E-04	1.30E-06	1.82E-07
Hydrochloric acid	a_hcl	7.66E-05	1.52E-07	1.96E-07	1.05E-09
Solid Waste					
Solid Waste #1	sw_1	1.79E-01	8.99E-03	4.92E-05	6.98E-06
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	3.47E-05	4.79E-03	1.05E-05	1.46E-06
Suspended Solids	w_ss	6.51E-04	8.59E-05	7.39E-07	1.09E-07
BOD	w_bod	5.07E-08	4.62E-06	3.89E-08	5.46E-09
COD	w_cod	5.50E-07	6.67E-05	2.64E-07	3.66E-08
Oil	w_oil	6.34E-07	8.37E-05	2.47E-07	3.40E-08
Sulfuric Acid	w_h2s04	9.41E-06	3.26E-08	2.08E-09	1.29E-08
Iron	w_fe	5.07E-05	1.13E-07	5.83E-09	7.98E-10
Ammonia	w_nh4	5.92E-09	9.13E-08	4.17E-09	5.88E-10
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.52E-09	2.17E-07	3.89E-10	5.46E-11
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.18E-13	1.71E-11	3.06E-14	4.12E-15
Phosphate	w_po4	4.70E-06	1.71E-08	1.06E-09	6.45E-09
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.52E-09	2.17E-07	3.89E-10	5.46E-11
Lead	w_pb	2.41E-12	1.71E-12	4.45E-12	6.30E-13
Zinc	w_zn	5.50E-10	7.44E-08	1.97E-10	2.73E-11

Appendix B – Table 29 WSCC Emissions by Fuel Usage (Continued)

WSCC FUEL RELATED EMISSIONS BY USAGE	variable name	NUCLEAR	HYDRO	WOOD	OTHER
		Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)	Emissions (lb/kwh elect.)
		Regional Grid	Regional Grid	Regional Grid	Regional Grid
		12.80%	29.54%	1.29%	0.00%
emissions table	r_u	r_h	r_w	r_o	
Atmospheric Emissions					
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	6.10E-05	0.00E+00	1.96E-05	0.00E+00
Nitrogen Oxides	a_no	8.05E-05	0.00E+00	1.83E-05	0.00E+00
Hydrocarbons (non CH ₄)	a_hc	9.02E-06	0.00E+00	1.37E-05	0.00E+00
Sulfur Oxides	a_so	2.41E-04	0.00E+00	9.79E-07	0.00E+00
Carbon Monoxide	a_co	7.91E-06	0.00E+00	1.70E-04	0.00E+00
CO ₂ (biomass)	a_co2_bm	1.79E-04	0.00E+00	2.31E-02	0.00E+00
CO ₂ (non biomass)	a_co2	9.43E-03	0.00E+00	0.00E+00	0.00E+00
Ammonia	a_nh4	4.26E-08	0.00E+00	0.00E+00	0.00E+00
Lead	a_pb	4.99E-10	0.00E+00	0.00E+00	0.00E+00
Methane	a_ch4	2.08E-05	0.00E+00	0.00E+00	0.00E+00
Hydrochloric acid	a_hcl	6.20E-07	0.00E+00	0.00E+00	0.00E+00
Solid Waste					
Solid Waste #1	sw_1	9.36E-03	0.00E+00	6.11E-04	0.00E+00
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waterborne Emissions					
Dissolved Solids	w_ds	3.75E-05	0.00E+00	0.00E+00	0.00E+00
Suspended Solids	w_ss	5.92E-06	0.00E+00	0.00E+00	0.00E+00
BOD	w_bod	3.87E-08	0.00E+00	0.00E+00	0.00E+00
COD	w_cod	5.34E-07	0.00E+00	0.00E+00	0.00E+00
Oil	w_oil	6.71E-07	0.00E+00	0.00E+00	0.00E+00
Sulfuric Acid	w_h2s04	7.98E-08	0.00E+00	0.00E+00	0.00E+00
Iron	w_fe	6.16E-06	0.00E+00	0.00E+00	0.00E+00
Ammonia	w_nh4	4.63E-07	0.00E+00	0.00E+00	0.00E+00
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	w_cd	1.73E-09	0.00E+00	0.00E+00	0.00E+00
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	w_hg	1.33E-13	0.00E+00	0.00E+00	0.00E+00
Phosphate	w_po4	3.98E-08	0.00E+00	0.00E+00	0.00E+00
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chromium	w_cr	1.73E-09	0.00E+00	0.00E+00	0.00E+00
Lead	w_pb	2.50E-13	0.00E+00	0.00E+00	0.00E+00
Zinc	w_zn	5.96E-10	0.00E+00	0.00E+00	0.00E+00

Appendix B – Table 30 Total WSCC Emissions

TOTAL WSCC FUEL RELATED EMISSIONS	variable name	TOTAL Emissions (lb/kwh elect.)
		Regional Grid
		100.00%
	emissions table	r_tot
Atmospheric Emissions		
Particulates (PM10)	a_pm_10	0.00E+00
Particulates (non PM10)	a_pm	1.30E-03
Nitrogen Oxides	a_no	4.34E-03
Hydrocarbons (non CH ₄)	a_hc	9.15E-04
Sulfur Oxides	a_so	9.16E-03
Carbon Monoxide	a_co	7.95E-04
CO ₂ (biomass)	a_co2_bm	2.34E-02
CO ₂ (non biomass)	a_co2	1.14E+00
Ammonia	a_nh4	5.21E-06
Lead	a_pb	4.37E-08
Methane	a_ch4	2.60E-03
Hydrochloric acid	a_hcl	7.75E-05
Solid Waste		
Solid Waste #1	sw_1	1.98E-01
Solid Waste #2	sw_2	0.00E+00
Solid Waste #3	sw_3	0.00E+00
Solid Waste #4	sw_4	0.00E+00
Solid Waste #5	sw_5	0.00E+00
Waterborne Emissions		
Dissolved Solids	w_ds	4.87E-03
Suspended Solids	w_ss	7.44E-04
BOD	w_bod	4.75E-06
COD	w_cod	6.80E-05
Oil	w_oil	8.53E-05
Sulfuric Acid	w_h2s04	9.53E-06
Iron	w_fe	5.70E-05
Ammonia	w_nh4	5.65E-07
Copper	w_cu	0.00E+00
Cadmium	w_cd	2.21E-07
Arsenic	w_as	0.00E+00
Mercury	w_hg	1.73E-11
Phosphate	w_po4	4.77E-06
Selenium	w_se	0.00E+00
Chromium	w_cr	2.21E-07
Lead	w_pb	9.44E-12
Zinc	w_zn	7.58E-08

Appendix B – Table 31 MSW Combustion Emissions Offsets by Generating Region

MSW COMBUSTION EMISSIONS OFFSETS BY GENERATING REGION	variable name	MSW Combustion Emission offsets (lb/kwh elect.)									
		ECAR - East Central Area Reliability Coordination Agreement	ERCOT - Electric Reliability Council of Texas	MAAC - Mid-Atlantic Area Council	MAIN - Mid-America Interconnected Network	MAPP - Mid-Continent Area Power Pool	NPCC - Northeast Power Coordinating Council	SERC - Southeastern Electric Reliability Council	SPP - Southwest Power Pool	WSCC - Western Systems Coordinating Council	
Atmospheric Emissions											
Particulates (PM10)	a_pm_10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates (non PM10)	a_pm	2.80E-03	1.69E-03	2.58E-03	2.95E-03	3.21E-03	1.80E-03	2.68E-03	2.00E-03	2.18E-03	
Nitrogen Oxides	a_no	7.95E-03	7.22E-03	7.73E-03	8.49E-03	9.14E-03	7.08E-03	7.87E-03	7.45E-03	7.56E-03	
Hydrocarbons (non CH4)	a_hc	1.44E-04	2.66E-03	5.55E-04	2.67E-04	1.92E-04	2.18E-03	4.04E-04	2.00E-03	1.56E-03	
Sulfur Oxides	a_so	1.35E-02	1.76E-02	1.40E-02	1.46E-02	1.56E-02	1.64E-02	1.39E-02	1.66E-02	1.58E-02	
Carbon Monoxide	a_co	4.81E-04	1.57E-03	6.54E-04	5.65E-04	5.65E-04	1.35E-03	5.94E-04	1.29E-03	1.10E-03	
CO2 (biomass)	a_co2_bm	2.94E-04	3.11E-04	2.93E-04	3.16E-04	3.38E-04	2.98E-04	2.95E-04	3.08E-04	3.04E-04	
CO2 (non biomass)	a_co2	2.11E+00	1.92E+00	2.06E+00	2.26E+00	2.43E+00	1.89E+00	2.09E+00	1.99E+00	2.01E+00	
Ammonia	a_nh4	1.70E-07	1.47E-05	2.55E-06	8.35E-07	3.50E-07	1.20E-05	1.67E-06	1.09E-05	8.36E-06	
Lead	a_pb	9.33E-08	5.87E-08	8.65E-08	9.84E-08	1.07E-07	6.20E-08	8.97E-08	6.83E-08	7.40E-08	
Methane	a_ch4	4.61E-03	4.59E-03	4.55E-03	4.94E-03	5.30E-03	4.44E-03	4.61E-03	4.62E-03	4.61E-03	
Hydrochloric acid	a_hcl	1.77E-04	1.06E-04	1.63E-04	1.86E-04	2.02E-04	1.13E-04	1.69E-04	1.25E-04	1.37E-04	
Solid Waste											
Solid Waste #1	sw_1	4.14E-01	2.75E-01	3.86E-01	4.37E-01	4.74E-01	2.87E-01	3.99E-01	3.14E-01	3.37E-01	
Solid Waste #2	sw_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Solid Waste #3	sw_3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Solid Waste #4	sw_4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Solid Waste #5	sw_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Waterborne Emissions											
Dissolved Solids	w_ds	2.34E-04	1.51E-02	2.67E-03	9.19E-04	4.28E-04	1.23E-02	1.77E-03	1.12E-02	8.62E-03	
Suspended Solids	w_ss	1.50E-03	1.17E-03	1.43E-03	1.60E-03	1.73E-03	1.18E-03	1.47E-03	1.26E-03	1.32E-03	
BOD	w_bod	2.66E-07	1.46E-05	2.62E-06	9.29E-07	4.58E-07	1.19E-05	1.75E-06	1.08E-05	8.35E-06	
COD	w_cod	3.42E-06	2.10E-04	3.74E-05	1.30E-05	6.13E-06	1.71E-04	2.48E-05	1.56E-04	1.20E-04	
Oil	w_oil	4.16E-06	2.64E-04	4.68E-05	1.61E-05	7.55E-06	2.15E-04	3.10E-05	1.96E-04	1.51E-04	
Sulfuric Acid	w_h2s04	2.17E-05	1.31E-05	2.00E-05	2.29E-05	2.49E-05	1.39E-05	2.08E-05	1.54E-05	1.69E-05	
Iron	w_fe	1.17E-04	7.03E-05	1.08E-04	1.23E-04	1.34E-04	7.50E-05	1.12E-04	8.31E-05	9.09E-05	
Ammonia	w_nh4	1.66E-08	2.95E-07	6.22E-08	3.03E-08	2.21E-08	2.42E-07	4.54E-08	2.22E-07	1.74E-07	
Copper	w_cu	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Cadmium	w_cd	1.05E-08	6.83E-07	1.21E-07	4.16E-08	1.93E-08	5.58E-07	8.02E-08	5.08E-07	3.91E-07	
Arsenic	w_as	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Mercury	w_hg	8.23E-13	5.37E-11	9.51E-12	3.26E-12	1.51E-12	4.38E-11	6.30E-12	3.99E-11	3.07E-11	
Phosphate	w_po4	1.08E-05	6.53E-06	1.00E-05	1.14E-05	1.24E-05	6.96E-06	1.04E-05	7.72E-06	8.44E-06	
Selenium	w_se	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Chromium	w_cr	1.05E-08	6.83E-07	1.21E-07	4.16E-08	1.93E-08	5.58E-07	8.02E-08	5.08E-07	3.91E-07	
Lead	w_pb	5.61E-12	8.67E-12	6.04E-12	6.15E-12	6.49E-12	7.91E-12	5.93E-12	7.91E-12	7.36E-12	
Zinc	w_zn	3.67E-09	2.34E-07	4.16E-08	1.43E-08	6.68E-09	1.91E-07	2.76E-08	1.74E-07	1.34E-07	

APPENDIX – C National and Regional Emissions by Fuel Type

1 National and Regional Fuel Related Emissions by Fuel Type (coal & natural gas)

NATIONAL GRID - FUEL RELATED EMISSIONS BY FUEL TYPE	variable name	COAL			NATURAL GAS		
		pre comb. (lbs emission per 1000 lbs fuel combusted)	combustion (lbs emission per 1000 lbs fuel combusted)	total (lbs emission per 1000 lbs fuel combusted)	pre comb. (lb. emission per 1000 cuft fuel combusted)	combustion (lbs emission per 1000 cuft fuel combusted)	total (lbs emission per 1000 cuft fuel combusted)
		nat. fuel emissions table					
		Emission Type	n_c_pc_e	n_c_c_e	n_c_e_per_k	n_ng_pc_e	n_ng_c_e
Atmospheric Emissions							
Particulates (PM10)	n_a_pm_10						0.000E+00
Particulates (Total)	n_a_pm	2.560E+00	3.100E-01	2.870E+00	3.800E-03	6.700E-04	4.470E-03
Nitrogen Oxides	n_a_no	2.300E-01	7.900E+00	8.130E+00	1.200E-01	3.900E-01	5.100E-01
Hydrocarbons (non CH4)	n_a_hc	8.500E-02	3.500E-02	1.200E-01	5.300E-01	1.400E-03	5.314E-01
Sulfur Oxides	n_a_so	2.300E-01	1.350E+01	1.373E+01	1.970E+00	6.700E-04	1.971E+00
Carbon Monoxide	n_a_co	1.800E-01	3.000E-01	4.800E-01	2.300E-01	3.500E-02	2.650E-01
CO2 (biomass)	n_a_co2_bm	3.000E-01		3.000E-01	2.800E-02		2.800E-02
CO2 (non biomass)	n_a_co2	4.070E+01	2.120E+03	2.161E+03	1.570E+01	1.210E+02	1.367E+02
Ammonia	n_a_nh4	2.000E-05		2.000E-05	9.500E-06	3.000E-03	3.010E-03
Lead	n_a_pb	2.700E-06	9.300E-05	9.570E-05	2.870E-07	3.200E-07	6.070E-07
Methane	n_a_ch4	4.690E+00	1.900E-02	4.709E+00	3.800E-01	3.200E-07	3.800E-01
Hydrochloric acid	n_a_hcl	1.100E-03	1.800E-01	1.811E-01	9.800E-05		9.800E-05
Solid Waste							
Solid Waste #1	n_sw_1	3.450E+02	7.900E+01	4.240E+02	5.800E+00		5.800E+00
Solid Waste #2	n_sw_2						
Solid Waste #3	n_sw_3						
Solid Waste #4	n_sw_4						
Solid Waste #5	n_sw_5						
Waterborne Emissions							
Dissolved Solids	n_w_ds	8.200E-02		8.200E-02	3.040E+00	4.700E-02	3.087E+00
Suspended Solids	n_w_ss	1.410E+00	1.300E-01	1.540E+00	5.400E-03	5.000E-02	5.540E-02
BOD	n_w_bod	1.200E-04		1.200E-04	2.700E-03	2.800E-04	2.980E-03
COD	n_w_cod	1.300E-03		1.300E-03	1.900E-02	2.400E-02	4.300E-02
Oil	n_w_oil	1.500E-03		1.500E-03	5.400E-02		5.400E-02
Sulfuric Acid	n_w_h2so4	2.500E-04	2.200E-02	2.225E-02	2.100E-05		2.100E-05
Iron	n_w_fe	1.200E-01		1.200E-01	7.300E-05		7.300E-05
Ammonia	n_w_nh4	1.400E-05		1.400E-05	4.900E-06	5.400E-05	5.890E-05
Copper	n_w_cu	0.000E+00		0.000E+00	0.000E+00		0.000E+00
Cadmium	n_w_cd	3.600E-06		3.600E-06	1.400E-04		1.400E-04
Arsenic	n_w_as	0.000E+00		0.000E+00			0.000E+00
Mercury	n_w_hg	2.800E-10		2.800E-10	1.100E-08		1.100E-08
Phosphate	n_w_po4	1.200E-04	1.100E-02	1.112E-02	1.100E-05		1.100E-05
Selenium	n_w_se	0.000E+00		0.000E+00			0.000E+00
Chromium	n_w_cr	3.600E-06		3.600E-06	1.400E-04		1.400E-04
Lead	n_w_pb	5.700E-09		5.700E-09	1.100E-09		1.100E-09
Zinc	n_w_zn	1.300E-06		1.300E-06	4.800E-05		4.800E-05

Appendix C – Table 2 National and Regional Fuel Related Emissions by Fuel Type (resid. & dist. oil)

NATIONAL GRID - FUEL RELATED EMISSIONS BY FUEL TYPE	variable name	RESIDUAL OIL			DISTILLATE OIL		
		pre comb. (lbs emission per 1000 gal. fuel combusted)	combustion (lbs emission per 1000 gal. fuel combusted)	total (lbs emission per 1000 gal. fuel combusted)	pre comb. (lbs emission per 1000 gal. fuel combusted)	combustion (lbs emission per 1000 gal. fuel combusted)	total (lbs emission per 1000 gal. fuel combusted)
		n_ro_pc_e	n_ro_c_e	n_ro_e_per_k	n_do_pc_e	n_do_c_e	n_do_e_per_k
Atmospheric Emissions							
Particulates (PM10)	n_a_pm_10			0.000E+00			0.000E+00
Particulates (Total)	n_a_pm	1.800E+00	2.000E+00	3.800E+00	1.660E+00	2.800E+00	4.460E+00
Nitrogen Oxides	n_a_no	9.200E+00	3.500E+01	4.420E+01	8.470E+00	5.200E+01	6.047E+01
Hydrocarbons (non CH4)	n_a_hc	5.500E+01	1.300E-02	5.501E+01	5.020E+01	7.600E-01	5.096E+01
Sulfur Oxides	n_a_so	2.810E+01	1.660E+02	1.941E+02	2.580E+01	1.810E+02	2.068E+02
Carbon Monoxide	n_a_co	6.900E+00	4.000E+00	1.090E+01	6.360E+00	4.500E+00	1.086E+01
CO2 (biomass)	n_a_co2_bm	6.640E+00		6.640E+00	6.100E+00		6.100E+00
CO2 (non biomass)	n_a_co2	2.861E+03	2.540E+04	2.826E+04	2.627E+03	2.650E+04	2.913E+04
Ammonia	n_a_nh4	4.400E-02	1.730E+00	1.774E+00	4.000E-02		4.000E-02
Lead	n_a_pb	1.500E-04	5.600E-03	5.750E-03	1.400E-04	4.900E-03	5.040E-03
Methane	n_a_ch4	4.410E+00	2.800E-01	4.690E+00	4.050E+00	2.800E-01	4.330E+00
Hydrochloric acid	n_a_hcl	2.700E-02	6.800E-01	7.070E-01	2.500E-02		2.500E-02
Solid Waste							
Solid Waste #1	n_sw_1	1.440E+02	3.300E+01	1.770E+02	1.330E+02	3.300E+01	1.660E+02
Solid Waste #2	n_sw_2			0.000E+00			0.000E+00
Solid Waste #3	n_sw_3			0.000E+00			0.000E+00
Solid Waste #4	n_sw_4			0.000E+00			0.000E+00
Solid Waste #5	n_sw_5			0.000E+00			0.000E+00
Waterborne Emissions							
Dissolved Solids	n_w_ds	3.790E+01		3.790E+01	3.480E+01		3.480E+01
Suspended Solids	n_w_ss	8.600E-01	1.800E+00	2.660E+00	7.900E-01	1.800E+00	2.590E+00
BOD	n_w_bod	1.400E-01		1.400E-01	1.300E-01		1.300E-01
COD	n_w_cod	9.500E-01		9.500E-01	8.700E-01		8.700E-01
Oil	n_w_oil	8.900E-01		8.900E-01	8.100E-01		8.100E-01
Sulfuric Acid	n_w_h2so4	7.500E-03		7.500E-03	6.900E-03	3.000E-01	3.069E-01
Iron	n_w_fe	2.100E-02		2.100E-02	1.900E-02		1.900E-02
Ammonia	n_w_nh4	1.500E-02		1.500E-02	1.400E-02		1.400E-02
Copper	n_w_cu	0.000E+00		0.000E+00	0.000E+00		0.000E+00
Cadmium	n_w_cd	1.400E-03		1.400E-03	1.300E-03		1.300E-03
Arsenic	n_w_as			0.000E+00			0.000E+00
Mercury	n_w_hg	1.100E-07		1.100E-07	9.800E-08		9.800E-08
Phosphate	n_w_po4	3.800E-03		3.800E-03	3.500E-03	1.500E-01	1.535E-01
Selenium	n_w_se			0.000E+00			0.000E+00
Chromium	n_w_cr	1.400E-03		1.400E-03	1.300E-03		1.300E-03
Lead	n_w_pb	1.600E-05		1.600E-05	1.500E-05		1.500E-05
Zinc	n_w_zn	7.100E-04		7.100E-04	6.500E-04		6.500E-04

Appendix C – Table 3 National and Regional Fuel Related Emissions by Fuel Type (uranium & hydro)

NATIONAL GRID - FUEL RELATED EMISSIONS BY FUEL TYPE	variable name	URANIUM			HYDRO		
		pre comb. (lbs emission per 1000 lbs fuel combusted)	combustion (lbs emission per 1000 lbs fuel combusted)	total (lbs emission per 1000 lbs fuel combusted)	pre comb. (lbs emission per electric kw delivered)	combustion (lbs emission per electric kw delivered)	total (lbs emission per electric kw delivered)
		n_u_pc_e	n_u_c_e	n_u_e_per_k	n_h_pc_e	n_h_c_e	n_h_e_per_k
Atmospheric Emissions							
Particulates (PM10)	n_a_pm_10			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Particulates (Total)	n_a_pm	4.400E+04		4.400E+04	0.000E+00	0.000E+00	0.000E+00
Nitrogen Oxides	n_a_no	5.800E+04		5.800E+04	0.000E+00	0.000E+00	0.000E+00
Hydrocarbons (non CH4)	n_a_hc	6.500E+03		6.500E+03	0.000E+00	0.000E+00	0.000E+00
Sulfur Oxides	n_a_so	1.740E+05		1.740E+05	0.000E+00	0.000E+00	0.000E+00
Carbon Monoxide	n_a_co	5.700E+03		5.700E+03	0.000E+00	0.000E+00	0.000E+00
CO2 (biomass)	n_a_co2_bm	1.290E+05		1.290E+05	0.000E+00	0.000E+00	0.000E+00
CO2 (non biomass)	n_a_co2	6.800E+06		6.800E+06	0.000E+00	0.000E+00	0.000E+00
Ammonia	n_a_nh4	3.070E+01		3.070E+01	0.000E+00	0.000E+00	0.000E+00
Lead	n_a_pb	3.600E-01		3.600E-01	0.000E+00	0.000E+00	0.000E+00
Methane	n_a_ch4	1.500E+04		1.500E+04	0.000E+00	0.000E+00	0.000E+00
Hydrochloric acid	n_a_hcl	4.470E+02		4.470E+02	0.000E+00	0.000E+00	0.000E+00
Solid Waste							
Solid Waste #1	n_sw_1	6.750E+06		6.750E+06	0.000E+00	0.000E+00	0.000E+00
Solid Waste #2	n_sw_2			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Solid Waste #3	n_sw_3			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Solid Waste #4	n_sw_4			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Solid Waste #5	n_sw_5			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Waterborne Emissions							
Dissolved Solids	n_w_ds	2.700E+04		2.700E+04	0.000E+00	0.000E+00	0.000E+00
Suspended Solids	n_w_ss	4.270E+03		4.270E+03	0.000E+00	0.000E+00	0.000E+00
BOD	n_w_bod	2.790E+01		2.790E+01	0.000E+00	0.000E+00	0.000E+00
COD	n_w_cod	3.850E+02		3.850E+02	0.000E+00	0.000E+00	0.000E+00
Oil	n_w_oil	4.840E+02		4.840E+02	0.000E+00	0.000E+00	0.000E+00
Sulfuric Acid	n_w_h2so4	5.750E+01		5.750E+01	0.000E+00	0.000E+00	0.000E+00
Iron	n_w_fe	4.440E+03		4.440E+03	0.000E+00	0.000E+00	0.000E+00
Ammonia	n_w_nh4	3.340E+02		3.340E+02	0.000E+00	0.000E+00	0.000E+00
Copper	n_w_cu	0.000E+00		0.000E+00	0.000E+00	0.000E+00	0.000E+00
Cadmium	n_w_cd	1.250E+00		1.250E+00	0.000E+00	0.000E+00	0.000E+00
Arsenic	n_w_as			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Mercury	n_w_hg	9.600E-05		9.600E-05	0.000E+00	0.000E+00	0.000E+00
Phosphate	n_w_po4	2.870E+01		2.870E+01	0.000E+00	0.000E+00	0.000E+00
Selenium	n_w_se			0.000E+00	0.000E+00	0.000E+00	0.000E+00
Chromium	n_w_cr	1.250E+00		1.250E+00	0.000E+00	0.000E+00	0.000E+00
Lead	n_w_pb	1.800E-04		1.800E-04	0.000E+00	0.000E+00	0.000E+00
Zinc	n_w_zn	4.300E-01		4.300E-01	0.000E+00	0.000E+00	0.000E+00

Appendix C – Table 4 National and Regional Fuel Related Emissions by Fuel Type (wood & other)

NATIONAL GRID - FUEL RELATED EMISSIONS BY FUEL TYPE	variable name	WOOD			OTHER		
		pre comb. (lbs emission per 1000 lbs fuel combusted)	combustion (lbs emission per 1000 lbs fuel combusted)	total (lbs emission per 1000 lbs fuel combusted)	pre comb. (lb. emission per 1000 fuel units used)	combustion (lbs emission per 1000 fuel units used)	total (lbs emission per 1000 fuel units used)
		nat. fuel emissions table	n_w_pc_e	n_w_c_e	n_w_e_per_k	n_o_pc_e	n_o_c_e
Emission Type							
Atmospheric Emissions							
Particulates (PM10)	n_a_pm_10			0.000E+00		0.000E+00	
Particulates (Total)	n_a_pm		1.500E+00	1.500E+00		0.000E+00	
Nitrogen Oxides	n_a_no		1.400E+00	1.400E+00		0.000E+00	
Hydrocarbons (non CH4)	n_a_hc		1.050E+00	1.050E+00		0.000E+00	
Sulfur Oxides	n_a_so		7.500E-02	7.500E-02		0.000E+00	
Carbon Monoxide	n_a_co		1.300E+01	1.300E+01		0.000E+00	
CO2 (biomass)	n_a_co2_bm		1.769E+03	1.769E+03		0.000E+00	
CO2 (non biomass)	n_a_co2			0.000E+00		0.000E+00	
Ammonia	n_a_nh4			0.000E+00		0.000E+00	
Lead	n_a_pb			0.000E+00		0.000E+00	
Methane	n_a_ch4			0.000E+00		0.000E+00	
Hydrochloric acid	n_a_hcl			0.000E+00		0.000E+00	
Solid Waste							
Solid Waste #1	n_sw_1		4.680E+01	4.680E+01		0.000E+00	
Solid Waste #2	n_sw_2			0.000E+00		0.000E+00	
Solid Waste #3	n_sw_3			0.000E+00		0.000E+00	
Solid Waste #4	n_sw_4			0.000E+00		0.000E+00	
Solid Waste #5	n_sw_5			0.000E+00		0.000E+00	
Waterborne Emissions							
Dissolved Solids	n_w_ds			0.000E+00		0.000E+00	
Suspended Solids	n_w_ss			0.000E+00		0.000E+00	
BOD	n_w_bod			0.000E+00		0.000E+00	
COD	n_w_cod			0.000E+00		0.000E+00	
Oil	n_w_oil			0.000E+00		0.000E+00	
Sulfuric Acid	n_w_h2so4			0.000E+00		0.000E+00	
Iron	n_w_fe			0.000E+00		0.000E+00	
Ammonia	n_w_nh4			0.000E+00		0.000E+00	
Copper	n_w_cu			0.000E+00		0.000E+00	
Cadmium	n_w_cd			0.000E+00		0.000E+00	
Arsenic	n_w_as			0.000E+00		0.000E+00	
Mercury	n_w_hg			0.000E+00		0.000E+00	
Phosphate	n_w_po4			0.000E+00		0.000E+00	
Selenium	n_w_se			0.000E+00		0.000E+00	
Chromium	n_w_cr			0.000E+00		0.000E+00	
Lead	n_w_pb			0.000E+00		0.000E+00	
Zinc	n_w_zn			0.000E+00		0.000E+00	