ENERCON Excellence—Every project. Every day.	CALCULATION COVER SHEET	CALC. NO. ENTGWF090-CALC-002 REV. 2 PAGE NO. 1 of 20

Title:	**Calculation to Support Section 7.1, Alternatives to the Proposed Action, of the WF3 License Renewal Environmental Report**	**Client:**	**Entergy Louisiana, LLC (WF3)**
		Project:	**ENTGWF094**

Item	Cover Sheet Items	Yes	No
1	Does this calculation contain any open assumptions that require confirmation? (If **YES**, Identify the assumptions)		X
2	Does this calculation serve as an "Alternate Calculation"? (If **YES**, Identify the design verified calculation.) **Design Verified Calculation No.**		X
3	Does this calculation Supersede an existing Calculation? (If **YES**, identify the superseded calculation.) **Superseded Calculation No.**		X

Scope of Revision:

The client revised the existing Waterford 3 (WF3) nuclear power unit generating capacity to 1,188 MWe from 1,235 MWe. The WF3 generating capacity is the amount of power that the range of power alternatives analyzed in WF3's License Renewal Application Environmental Report must match.

Revision Impact on Results:

Revision of generating capacity needs, land requirements, air emission estimates, and waste estimates based on the revised WF3 generating capacity of 1,188 MWe.

Study Calculation	☐	**Final Calculation**	X
Safety-Related	☐	**Non-Safety Related**	X

(Print Name and Sign)

Originator:	Mary N. Hoganson *Mary N Hoganson*	**Date:** 12/9/15
Design Verifier: **SURESH RAJA**	*Suresh Raja*	**Date:** 12/09/2015
Approver:	*[signature]*	**Date:** 12/10/2015

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0	09/032014	Original Issue
1	12/04/2014	Revised Issue
2	12/10/2015	Revised Issue

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
0	0		
Various	1		
Various	2		

APPENDIX REVISION STATUS

APPENDIX NO.	PAGE NO.	REVISION NO.	APPENDIX NO.	PAGE NO.	REVISION NO.
NA					

Calculation Design Verification Plan:

ENERCON used capacity and emissions factors and inputs as detailed in the WF3 License Renewal Application Environmental Report Section 7.0 that were prepared or adopted by federal agencies for approximate estimates of land use requirements, feedstock requirements, environmental emissions, and energy input demands. The calculations were used for relative comparison of alternatives. Calculation inputs were verified by checking the documented input with the source references and verifying that equations used were applicable based on references cited. The validity of references were checked for their intended use and all assumptions were evaluated and verified to be based on sound emissions calculation principles and practices. Calculation results were verified by checking all equations for each type of fuel source. The methodology, results and conclusions were also verified.

(Print Name and Sign for Approval – mark "N/A" if not required)

Approver:	**Date** 12/10/2015

Calculation Design Verification Summary:

All assumptions and data sources were verified. Calculated values are correct.

Based On The Above Summary, The Calculation Is Determined To Be Acceptable.

(Print Name and Sign)

Design Verifier: Suresh Raja	**Date:** 12/09/2015
Others:	**Date:**

Item	CHECKLIST ITEMS	Yes	No	N/A
1	**Design Inputs** - Were the design inputs correctly selected, referenced (latest revision), consistent with the design basis and incorporated in the calculation?	X		
2	**Assumptions** – Were the assumptions reasonable and adequately described, justified and/or verified, and documented?	X		
3	**Quality Assurance** – Were the appropriate QA classification and requirements assigned to the calculation?			X
4	**Codes, Standard and Regulatory Requirements** – Were the applicable codes, standards and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied?			X
5	**Construction and Operating Experience** – Have applicable construction and operating experience been considered?			X
6	**Interfaces** – Have the design interface requirements been satisfied, including interactions with other calculations?			X
7	**Methods** – Was the calculation methodology appropriate and properly applied to satisfy the calculation objective?	X		
8	**Design Outputs** – Was the conclusion of the calculation clearly stated, did it correspond directly with the objectives and are the results reasonable compared to the inputs?	X		
9	**Radiation Exposure** – Has the calculation properly considered radiation exposure to the public and plant personnel?			X
10	**Acceptance Criteria** – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished?			X
11	**Computer Software** – Is a computer program or software used, and if so, are the requirements of CSP 3.02 met?			X

COMMENTS:

(Print Name and Sign)

Design Verifier: **Suresh Raja** Suresh Raja	**Date:** 12/09/2015
Others:	**Date:**

Table of Contents

1.0 PURPOSE AND SCOPE

The purpose of the following analyses is to support assessments of Section 7.1, Alternatives of the WF3 License Renewal Application Environmental Report. Section 7.1 presents analysis of which of various electricity generating and non-generating options are reasonable for replacement of WF3's generating capacity, which is given as 1,188 MWe in Section 2.2.1.1 of the License Renewal Application Environmental Report and provides detailed discussions of the impacts of reasonable alternatives.

- Estimates of generating capacity needed to replace WF3 for reasonable alternatives listed below
  - a) Natural gas.
  - b) Coal with carbon capture sequestration.
  - c) New nuclear.
  - d) Combination of natural gas and biomass.
- Land use requirements of solar generating facilities, natural gas discrete and combination alternatives, and coal-fired alternative.
- Feedstock estimate for forest residues available in Louisiana in the area of WF3.
- Feedstock estimate for municipal solid waste fired alternative.
- Energy input estimates for natural gas-fired and coal-fired alternatives.
- Annual air emissions for natural gas-fired, coal-fired alternatives, and municipal solid waste (MSW) burning biomass units of combination alternative.
- Annual waste and byproduct estimates for coal-fired alternative.

2.0 SUMMARY OF RESULTS AND CONCLUSIONS

The results of the calculations are presented in the following tables. The calculation results were incorporated as appropriate into Section 7.1, Alternatives to the Proposed Action, of the WF3 License Renewal Environmental Report. The land use requirements for a solar replacement facility and feedstock estimates for a forest residue-fired and MSW- fired replacement facility were used to support that these facilities are unreasonable alternatives to replace WF3. Generating capacity calculations were used to determine the size of a plant that would be needed to replace the generating capacity of WF3. The emissions and waste estimates and land use requirements for the natural gas-fired and coal-fired alternatives were incorporated in Section 7.1 to describe their impacts and contrast them with those of the proposed action, continued operation of WF3. The emissions for a biomass component of the Combination Alternative were used to generally characterize the potential emissions from the biomass units in the absence of precise specifications of feedstock.

Estimates of Generating Capacity Needed for Reasonable Alternatives to Replace WF3

	Natural Gas	Coal w/CCS	Nuclear	Biomass	DSM
Capacity factors	0.87	0.85	0.9	0.83	
Discrete alternative MWe	1,366	1,398	1,320	NA	NA
Combination alternative configuration	668	NA	NA	200	441
Combination alternative MWe yield	581	NA	NA	166	441

Notes: Capacity factors from EIA 2013a. CCS = carbon capture sequestration; DSM = demand side management.

The Combination Alternative configuration was derived by (1) assigning the DSM value of 441 which was projected in an Entergy review of DSM programs (Entergy 2014) to bring the energy capacity needing to be filled by generation to 794 (1188-441 = 747), (2) selection of 4-50 MWe biomass units to provide generation from a renewable resource to provide approximately 20 to 25 percent of the generation capacity, (50-MWe sized biomass units were a component of the Combination Alternative devised by NRC for replacement of the Grand Gulf Nuclear Station in its license renewal EIS (NRC 2014), and (3) selection of a 668 MWe natural gas facility to make up the balance for the needed replacement energy capacity.

Land Use Requirements for Concentrated Solar Power (CSP) and Photovoltaic (PV) Solar Facilities

CSP land use 1.5 acre/GWh/year	15,600 acres
CSP land use 5.3 acre/GWh/year	55,200 acres
PV land use 1.6 acre/GWh/year	16,700 acres
PV land use 5.8 acre/GWh/year	60,400 acres

Notes: Land use factors from NREL 2013.

Land Use Requirements for Natural Gas Alternative

	Discrete Alternative	Combination Alternative
Land for plant (acres)	59.1	28.9
Land for gas wells (acres)	4920	2400

Notes: Land use factor for plant from NETL 2010a and for gas wells from NRC 1996.

Land Use Requirements for Coal-Fired Alternative

Land for plant (acres)	115
Land for mining (acres)	1,350 to 30,700

Notes: Land use factor for plant from NETL 2010b and for mining from NRC 1996 and NETL 2010b.

Feedstock Estimate for Forest Residues Available Per Parish Surrounding WF3

Forest residue energy content wet Btu/lb	5,140
Forest residue energy content dry Btu/lb	8,570
Dry metric tons (Tonnes) available per year per Louisiana parish	50,000
Tonnes to lb conversion factor	2,205
lbs	110,250,000
Btu/year from forest residue from one parish	9.44843E+11
Btu/hr	107,858,732.9
Watt to Btu/hr conversion factor	3.412142
MWe	31.61027087

Notes: Energy content factors from EPA 2007; dry tonnes available from NREL 2009.

Feedstock Estimate for Municipal Solid Waste (MSW) Fired Alternative

Average energy content of MSW (MWh per ton)	0.482122708
2012 MSW throughput (tons)	30,211,120
2012 MWh (net)	14,565,467
WF3 replacement energy (MWh/year)	10,400,000
Annual quantity (tons) of MSW needed for replacement	5,000,000

Notes: 2012 data from ERC 2014.

2.1 Energy Inputs and Air Emissions for Natural Gas and Coal-Fired Alternatives

Air Emissions from Natural Gas-Fired Alternative

Emission	Discrete Alternative Annual Amount	Combination Alternative Annual Amount
Gas consumption	94.0 Billion ft^3	46.0 Billion ft^3
Sulfur dioxide[a]	164 tons	79.9 tons
Nitrogen oxides[b]	625 tons	306 tons
Carbon monoxide	1,440 tons	705 tons
Particulate matter	317 tons	155 tons
Nitrous oxide	144 tons	70.5 tons
Volatile organic compounds	101 tons	49.4 tons
Carbon dioxide	5.29 million tons	2.59 million tons

a. Assumes sulfur content of 3.4%.
b. Assumes 90 percent conversion in the Selective Catalytic Reduction equipment

Air Emissions from Super-Critical Pulverized Coal Alternative

Parameter	Tons/year
Annual coal consumption	7.84 million
Sulfur oxides	2,670
Nitrogen oxides	1,410
Carbon monoxide	1,960
Filterable particulate matter	524
Particulates less than 10 microns in diameter	121
Carbon dioxide	13.7 million

Air Emission Estimates for Biomass Units Based on MSW-fired Units Average Emissions

Biomass Units of Combination Alternative	Plant Size (MWe)	Annual (MWh)	SO_2	NO_x	CO_2
Emission factors (lb/MWh)	200	1,752,000	1.2	6.7	1,016
Annual emission (tons)			1051.2	5,869.2	890,016

Notes: Emission factors for SO_2 and NO_x from EPA 2013; emission factors for CO_2 from EPA 2014.

2.2 Annual Waste and Byproduct Estimates for Coal-Fired Alternate

Solid Waste from Super-Critical Pulverized Coal Alternative

Parameter	Amount
Annual SO_2 generated subject to removal by scrubbers (excludes the uncontrolled SOx emission)	61,000 tons per year
Annual SO_2 captured	58,000 tons per year
Annual scrubber waste	158,000 tons per year
Annual scrubber waste disposed based on 90 percent recycling	15,800 tons per year
Annual ash generated	523,000 tons per year
Annual ash disposed based on 50 percent recycling	262,000 tons per year
Annual total waste disposed	277,000 tons per year
Waste pile area (40-year period) assuming recycling	167 acres, 30 feet high

3.0 REFERENCES

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4.0 ASSUMPTIONS

- The natural gas-fired alternative would be a natural gas-fired combined-cycle (NGCC) plant, consisting of multiple combustion turbines, heat recovery steam generator, and steam turbine generator assembled in appropriate power train configurations to produce a net electrical power virtually equivalent to the 1,188 net MWe generated by WF3.

- Key inputs for the NGCC alternative are provided in Section 7.0.

- The coal-fired alternative would a super-critical coal-fired generation (SCPC) plant, configured to produce net electrical power virtually equivalent to the 11,188 net MWe generated by WF3.

- Key inputs for the SCPC alternative are provided in Section 7.0.

- The combination alternative involves the implementation of DSM programs for an annual reduction in demand and construction and operation of NGCC units and biomass units at the Waterford site.

- The biomass units of the combination alternative would be capable of using a variety of biomass fuels such as wood waste, crop residues, energy crops, and MSW. The air emissions calculations are based on MWS emissions due to availability of average emissions from EPA publications.

5.0 DESIGN INPUTS

See Section 4.0.

6.0 METHODOLOGY

ENERCON used capacity and emissions factors and inputs as detailed in Section 7.0 that were prepared by or adopted by federal agencies for prepared approximate estimates of environmental emissions and energy input demands. The calculations are used for relative comparison of alternatives. The methodology for preparing the calculations is detailed within Section 7.0.

7.0 CALCULATIONS

7.1 Generating Capacity Estimates for Reasonable Alternatives to Replace WF3 Generating Capacity

Formulas and Inputs

	A	B	C	D	E	F	G
1	WF3 net generating capacity (MWe)			1,188			
2		**Natural Gas**	**Coal w/CCS**	**Nuclear**	**Biomass**	**DSM**	
3	Capacity factors (-)	0.87	0.85	0.9	0.83		
4	Discrete alternative MWe	=$D1/B3	=$D1/C3	=$D1/D3	NA	NA	
5	Combination alternative configuration	722	NA	NA	200	441	**Total**
6	Combined alternative MWe yield	=B5*B3	NA	NA	=E5*E3	441	=B6+E6=F6

Notes: Capacity factors from EIA 2013a. CCS = carbon capture sequestration; DSM = demand side management.

Results

	Natural Gas	Coal w/CCS	Nuclear	Biomass	DSM
Discrete alternative MWe	1,366	1,398	1,320	NA	NA
Combination alternative configuration (MWe)	668	NA	NA	200	441
Combination alternative MWe yield	581	NA	NA	166	441

7.2 Natural Gas Alternative Calculations

7.2.1 Land Use Requirements for Natural Gas Alternative

Formulas and Inputs

	A	B	C
1		**Discrete alternative**	**Combination alternative**
2	Plant size (MWe)	1,366	668
3	Plant land need factor m2 per MWh	0.02	
4	Gas wells land use factor acres/MW	=3,600/1,000	
5	Land for plant (acres)	=(B2*24*365)*B3*.0002471	=(C2*24*365)*B3*.0002471
6	Land for gas wells (acres)	=B2*B4	=C2*B4

Notes: Land use factor for plant land from NETL 2010a and for gas wells from NRC 1996; see Section 7.2.1 for calculation of plant size.

Results

	Discrete Alternative	Combination Alternative
Land for plant (acres)	59.1	28.9
Land for gas wells (acres)	4920	2400

7.2.2 NGCC Annual Air Emissions

Key inputs for NGCC air emissions

Characteristic	Basis
Total size = 1,366 MWe for discrete alternative and 668 MWe for combination alternative	Calculated as replacement for WF3's generating capacity of 1,188 based on 87% capacity factor (EIA 2013). (See Section 7.1 above)
Fuel type = natural gas	
Fuel heating average value = 1,023Btu/ft3	EIA 2014
Heat rate = 8,039 Btu/kWh	EIA 2014
Capacity factor = 0.87%	EIA 2013, Table 1
Air emission factors	EPA 2000, Tables 3.1-1 and 3.1-2a
Btu/kWh = British thermal unit per kilowatt hour **Btu/ft3** = British thermal unit per cubic foot	**CO_2** = carbon dioxide **MMBtu** = million British thermal unit **MWe** = megawatts, electric

Formulas, Emission Factors, Results

Annual gas consumption (ft3)	Plant size in MWe x Heat rate, 8,039 Btu/kWh x 1,000 x (1/ Fuel heating average value = 1,023 Btu/ft3) x hours in a year						
Annual MMBtu	= (annual gas consumption x fuel heating average value)/1,000,000						
	CO_2	**NO_X**	**CO**	**PM**	**SO_2**	**VOC**	**N_2O**
Emission factor for Processed Natural Gas (lbs/MMBtu)	110	0.13	0.03	0.0066	0.0034	.0.0021	0.003
Annual emissions (tons)	= (emission factor) x (annual MMBtu)/2000						

Notes:

CO_2 = carbon dioxide; NO_x = nitrogen oxides; CO = carbon monoxide; PM = total filterable particulates; SO_x = oxides of sulfur; VOC = volatile organic carbon; NO_2 – nitrous oxide.

Results

Emission	Discrete Alternative Annual Amount	Combination Alternative Annual Amount
Gas consumption	94.0 Billion ft^3	46.0 Billion ft^3
Sulfur dioxide[a]	164 tons	79.9 tons
Nitrogen oxides[b]	625 tons	306 tons
Carbon monoxide	1,440 tons	705 tons
Particulate matter	317 tons	155 tons
Nitrous oxide	144 tons	70.5 tons
Volatile organic compounds	101 tons	49.4 tons
Carbon dioxide	5.29 million tons	2.59 million tons

a. Assumes sulfur content of 3.4%.
b. Assumes 90 percent conversion in the Selective Catalytic Reduction equipment

7.3 Coal-Fired Alternative Calculations

7.3.1 Land Use Requirements for Coal-Fired Alternative

Formulas and Inputs

	A	B	
1	Plant size (Units)	=1,398	
2	Plant land need factor m2 per MWh	=0.038	
3	Mining land use factor	= 0.0000192 m2 per kg coal	=22,000/1,000 acres/MW
4	Land for plant (acres)	=(B1*24*365)*B2*.0002471	
5	Land for mining	=annual coal consumption kg (see Section 7.3.2) X 40 yrs X land use factor X conversion to acres	=B1*B3

Notes: Land use factors from NRC 1996 and NETL 2010b.
Conversion of tons to kg is tons X 907.18486 = kg.
Conversion of m2 to acres is m2 X .0002471 = acres.

Results

Plant size (MWe)	1,398
Plant land need factor m2 per MWh	0.038
Mining and waste disposal land use factor acres/MW	22
Land for plant (acres)	115
Land for mining and waste (acres)	1,350 to 30,700

7.3.2 SCPC Annual Air Emissions

Key Inputs for the SCPC Air Emissions Calculations

Characteristic	Basis
Total size = 1,398 MWe	Calculated as replacement for WF3's generating capacity of 1,188 based on 85% capacity factor (EIA 2013). (See Section 7.1 above.)
Boiler type = pulverized coal, tangentially fired, dry-bottom, New Source Performance Standard	Minimizes nitrogen oxide emissions (EPA 1998, Table 1.1-3)
Fuel type = subbituminous (Powder River Basin) and lignite (Louisiana)	Typical for coal used in Louisiana (EIA 2010, Table 15) Approximately 78% = subbituminous (Powder River Basin) and 22% lignite (Louisiana)
Fuel heating average value = 8,201 Btu/lb	Coal used in LA electricity generation (EIA 2010, Table 15)
Fuel ash content by weight = 6.69 percent	Coal used in LA electricity generation (EIA 2010, Table 15)
Fuel sulfur content by weight = 0.39 percent	Coal used in LA electricity generation (EIA 2010, Table 15)
Uncontrolled SO_x emission = 35S lb/ton Uncontrolled NO_x emission = 7.2 lb/ton Uncontrolled CO emission = 0.5 lb/ton	Typical for pulverized coal, tangentially fired, dry-bottom, new source performance standard (EPA 1998, Table 1.1-3)
Heat rate = 10,498 Btu/kWh	Average operating heat rate for coal (EIA 2013b, Table 8.1)
Capacity factor = 0.85	EIA 2013a
NO_x control = low NO_x burners, overfire air and selective catalytic reduction (95 percent reduction)	Best available (EPA 1998, Table 1.1-2)
Particulate Material, filterable (PM_f) = 10A lb/ton of ash Particulate Material (less than 10 microns) PM_{10} = 2.3A lb/ton of ash	Typical for pulverized coal, tangentially fired, dry-bottom (EPA 1998, Table 1.1-4). "A" represents factor based on fuel ash content by weight.
Particulate control = fabric filters (baghouse - 99.8 percent removal efficiency)	Best available for minimizing particulate emissions (EPA 1998, Table 1.1-6)
SO_x control = Wet scrubber – lime (95 percent removal efficiency)	Best available for minimizing SOx emissions (EPA 1998, Table 1.1-1)
CO_2 emission - average of bituminous and subbituminous coal = 212.7 lb/MMBtu	EIA 2013b, Table A.3
Btu/kWh = British thermal unit per kilowatt hour **Btu/lb** = British thermal unit per pound **CO** = carbon monoxide **CO_2** = carbon dioxide **lb** = pound **MMBtu** = million British thermal unit **MW** = megawatt	**MWe** = megawatts, electric **NO_x** = nitrogen oxides **NSPS** = New Source Performance Standard **PM_f** = total filterable particulates **PM_{10}** = particulates having diameter <10 microns **S** = sulfur **SO_x** = oxides of sulfur

Formulas and Inputs

	A	B
8	Average Btu content of coal used in LA per BTU/lb (EIA 2010) sub-biuminous	8,201
9	Power plant heat rate Btu/kWh (EIA 2013, Table 8.1)	10,498
10	Annual coal consumption (tons)	=((((1453*B9*1,000)/B8)*24*365)/2,000)
11	SO_x emissions (tons)	=((B10*0.39*35)/2,000)*((100-95)/100)
12	NO_x emissions (tons)	=((B10*7.2*(1/2,000)*((100-95)/100)))
13	CO emissions (tons)	=(B10*0.5)/2,000
14	CO_2 emissions factor (EIA 2013, Table A.3) (tons)	=((B10*212.7)/1,000,000)*8,201
15	PM filterable (tons)	=(B10*(6.69*10)/2,000)*((100-99.8)/100)
16	PM_{10} (tons)	=(B10*(6.69*2.3)/2,000)*((100-99.8)/100)

Results

Parameter	Tons/year
Annual coal consumption	7.84 million
Sulfur oxides	2,670
Nitrogen oxides	1,410
Carbon monoxide	1,960
Filterable particulate matter	524
Particulates less than 10 microns in diameter	121
Carbon dioxide	13.7 million

7.3.3 SCPC Annual Solid Waste

Formulas and Inputs

	A	B	C
18	**Annual Generation**		**Accounting for Recycling**
19	SO_2 generated	Annual tons coal consumption X fuel sulfur content, 0.39% X (atomic weight of SO2, 64.1/atomic weight of Sulfur, 32.1)	NA
20	SO_2 removed by scrubbers	=Annual SOx generation X sulfur removal efficiency, 95/100)	NA
21	Ash generated	=Annual tons coal consumption X fuel ash content, 6.69% X particulate removal efficiency, 99.8%	=Ash generated X 50% recycling
22	Lime consumption as scrubber media	=Annual SOx generation X (atomic weight CaO, 56.1 / atomic weight of SO2, 64.1)	NA
23	Calcium sulfate	=Annual SOx generation X (atomic weight CaSO 2H O, 172 / atomic weight of SO2, 64.1)	NA
24	Scrubber waste	= Annual Calcium sulfate + scrubbing media carryover calculated as Annual lime consumption X 100% – SOx removal efficiency, 95%)	=Scrubber waste X 10% (90% recycling assumed)
25	Mass of waste disposed	=Ash generated +Scrubber waste	=Ash not recycled + Scrubber waste not recycled
26	Total volume of scrubber waste (ft^3)	$\left[\frac{\text{Scrubber waste (tons/year)} \cdot \text{Time(years)} \cdot 2000\text{(lb/ton)}}{Density(lb/ft3)}\right]$	=Scrubber waste ft3 X 10% (90% recycling assumed)
27	Total volume of ash (ft^3)	$\left[\frac{\text{AshGen(tons/year)} \cdot \text{Time(years)} \cdot 2000\text{(lb/ton)}}{DensityofAsh(lb/ft3)}\right]$	=Ash generated ft3 X 50% recycling
28	Total volume of solid waste (ft^3)	=volume of scrubber waste + volume of ash	=volume of scrubber waste after recycling + volume of ash after recycling
29	Waste pile area (acres)	= (total volume of solid waste in ft3 / 30 ft) X 0.00002296.	= (total volume of solid waste after recycling in ft3 / 30 ft) X 0.00002296.

Notes:

Density of $CaSO_4 \cdot 2H_2O$ is 144.8 lb/ft^3.

Density of ash is based on coal bottom ash, 100 lb/ft^3 (FHA 2000).

Conversion of sq ft to acres is 0.00002296.

Results

Parameter	Amount
Annual SO_2 generated	61,000tons per year
Annual SO_2 captured	58,000 tons per year
Annual scrubber waste	158,000 tons per year
Annual scrubber waste disposed based on 90 percent recycling	15,800 tons per year
Annual ash generated	523,000 tons per year
Annual ash disposed based on 50 percent recycling	262,000 tons per year
Annual total waste disposed	277,000 tons per year
Waste pile area (40-year period) assuming recycling	167 acres, 30 feet high

7.4 Calculations for Biomass Alternatives

7.4.1 <u>Feedstock Estimates for Wood Waste Alternative</u>

Formulas and Inputs

	A	B
1	Forest residue energy content wet Btu/lb	5,140
2	Forest residue energy content dry Btu/lb	8,570
3	Dry metric tons (tonnes) available per year per Louisiana parish	50,000
4	Metric tons (Tonnes) to pound conversion factor	2,205
5	Pounds per year	=B3*B4
6	Btu/year from forest residue from one parish	=B5*B2
7	Btu/hr	=B6/(24*365)
8	Watt to Btu/hr conversion factor	3.412142
9	MWe	=(B7/B8)/1,000,000

Notes: Energy content factors from EPA 2007; dry metric tons (tonnes) available from NREL 2009.

Results

Forest residue energy content wet Btu/lb	5,140
Forest residue energy content dry Btu/lb	8,570
Dry metric tons (tonnes) available per year per Louisiana parish	50,000
Metric tons (Tonnes) to lb conversion factor	2,205
Pounds per year	110,250,000
Btu/year from forest residue from one parish	9.44843E+11
Btu/hour	107,858,732.9
Watt to Btu/hour conversion factor	3.412142
MWe	31.61027087

7.4.2 Feedstock Estimates for Municipal Solid Waste (MSW) Fired Alternative

Formulas and Inputs

	A	B
1	Average energy content of MSW (MWh/ton)	=B3/B2
2	2012 MSW throughput (tons)	30,211,120
3	2012 MWh (net)	14,565,467
4	WF3 replacement energy (MWh/yr)	=1188*24*365
5	Annual quantity (tons) of MSW needed for replacement	=B4*B1

Notes: 2012 data from ERC 2014.

Results

Average energy content of MSW (MWh/ton)	0.482122708
2012 MSW throughput (tons)	30211120
2012 MWh (net)	14565467
WF3 replacement energy (MWh/yr)	10406880
Annual quantity (tons) of MSW needed for replacement	5,020

7.4.3 Air Emission Estimates for Biomass Units Based on MSW-Fired Units Average Emissions

Formulas and Inputs

	A	B	C	D	E
9			**SO_2**	**NO_x**	**CO_2**
10	Plant size (MWe)	200			
11	Emission factors (lb/MWh)		1.2	6.7	1,016
12	Annual MWh	=B10*(24*365)			
13	Annual emissions (tons)		=(B12*C11)/2,000	=(D11*B12)/2,000	=(E11*B12)/2,000

Notes: Emission factors for SO2 and NOx from EPA 2013; emission factors for CO_2 from EPA 2014.

CO_2 = carbon dioxide; NO_x = nitrogen oxides; SO_2= sulfur dioxide.

Results

	Plant Size (MWe)	Annual (MWh)	SO_2	NO_x	CO_2
Emission factors (lb/MWh)	200	1,752,000	1.2	6.7	1,016
Annual emissions (tons)			1,051.2	5,869.2	890,016

7.5 Land Use Requirements for Concentrated Power Solar (CSP) and Photovoltaic (PV) Solar Facilities

Formulas and Inputs

	A	B
1	MW to GWh/year	=B2*B3
2	Hours/year	=24*365
3	MW to GW	=1188/1,000
4	CSP land use 1.5 acre/GWh/year	=B1*1.5
5	CSP land use 5.3 acre/GWh/year	=B1*5.3
6	PV land use 1.6 acre/GWh/year	=B1*1.6
7	PV land use 5.8 acre/GWh/year	=B1*5.8

Notes: Land use factors from NREL 2013.

Results

CSP land use 1.5 acre/GWh/year	15,600 acres
CSP land use 5.3 acre/GWh/year	55,200 acres
PV land use 1.6 acre/GWh/year	16,700 acres
PV land use 5.8 acre/GWh/year	60,400 acres

8.0 APPENDICES

None.