



Appendix K

Greenhouse Gas Calculations

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AES**Birch Coulee Solar Project****GHG Calculations****Table 1. Summary of Operations GHG Emissions**

Emission Source	CO₂ (metric tons/year)	CH₄ (metric tons/year)	N₂O (metric tons/year)	CO₂e^[1] (metric tons/year)
Direct Sources				
Mobile Combustion	7.63	3.30E-04	6.72E-05	7.66
Land Use Change	--	--	--	1,342.76
Indirect Sources				
Electrical Consumption	19.54	2.10E-03	2.94E-04	19.68
TOTAL - ALL SOURCES	27.18	2.43E-03	3.62E-04	1,370.11

[1] CO₂e calculated by equation A-1 of 40 CFR 98.2, which states the total CO₂e is equal to the GWP for each pollutant multiplied by the potential pollutant emissions. The GWP for CO₂ is 1, CH₄ is 25, and N₂O is 298.

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Table 2. Conversions

Unit	Amount	Unit
1 US ton	2000	lbs
1 US ton	0.907185	metric tons
1 US ton	907.185	kg
1 US ton	907185	grams
1 lb	453.592	grams
1 MWh	1000	kWh
1 hectare	2.47105	acres
1 US gallon of diesel	144.945	MJ
1 MJ	0.372506136	hp-h
1 US gallon of diesel	53.9929019	hp-h
Heating Value of Fuel	137030	Btu/gal
Break-specific fuel consumption	7000	Btu/hp-hr

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Table 3. Global Warming Potentials

Greenhouse Gas Name	CAS Number	Chemical Formula	Global Warming Potential (100-yr.)[1]
Carbon dioxide	124-38-9	CO ₂	1
Methane	74-82-8	CH ₄	25
Nitrous oxide	10024-97-2	N ₂ O	298

[1] Table A-1 to Subpart A of Part 98, Title 40, [https://www.ecfr.gov/current/title-40/part-98/appendix-Table A-1 to Subpart A of Part 98](https://www.ecfr.gov/current/title-40/part-98/appendix-Table%20A-1%20to%20Subpart%20A%20of%20Part%2098)

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Table 4. Operations Emissions from Fuel Combustion Sources

Fuel Type ^[1]	Fuel Consumption ^{[1], [2]} (gallons/year)	CO ₂ Emission Factor ^[2] (kg/gallon)	CH ₄ Emission Factor ^[3] (g/gallon)	N ₂ O Emission Factor ^[3] (g/gallon)	CO ₂ (metric tons/year)	CH ₄ (metric tons/year)	N ₂ O (metric tons/year)	CO ₂ e ^[4] (metric tons/year)
Gasoline	839	8.78	0.38	0.08	7.37	3.19E-04	6.72E-05	7.40
Diesel	30	8.78	0.38	0.08	0.26	1.13E-05	2.38E-06	0.26
TOTAL	--	--	--	--	7.63	3.30E-04	6.95E-05	7.66

[1] Barr estimated based on professional experience with similar project types.
[2] Fuel consumption for the diesel generator was calculated based on a typical emergency generator engine output of 50 Hp, a diesel heating value of 137,030 Btu/gal, conversion of 7,000 Btu/hp-hr, and 12 hours per year of operation.
[3] Table 2, Mobile Combustion CO₂. Emission Factors for Greenhouse Gas Inventories, EPA CCCL. April, 2023. <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>
[4] Table 5, Mobile Combustion CH₄ and N₂O for Non-Road Vehicles. Emission Factors for Greenhouse Gas Inventories, EPA CCCL. April, 2023. <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>
[5] CO₂e calculated by equation A-1 of 40 CFR 98.2, which states the total CO₂e is equal to the GWP for each pollutant multiplied by the potential pollutant emissions. The GWP for CO₂ is 1, CH₄ is 25, and N₂O is 298.

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Table 5. Operations Emissions from Electrical Consumption

Temporary Facility	Energy Consumption ^[1] (kWh/year)	eGRID Subregion	CO ₂ Emission Factor ^[2] (lb/MWh)	CH ₄ Emission Factor ^[2] (lb/MWh)	N ₂ O Emission Factor ^[2] (lb/MWh)	CO ₂ (metric tons/year)	CH ₄ (metric tons/year)	N ₂ O (metric tons/year)	CO ₂ e ^[3] (metric tons/year)
Operations	43269	MROW	995.8	0.107	0.015	19.54	2.10E-03	2.94E-04	19.68
TOTAL	--	--	--	--	--	19.54	2.10E-03	2.94E-04	19.68

[1] Barr estimated based on professional experience with similar project types

[2] Table 6, Electricity. Emission Factors for Greenhouse Gas Inventories, EPA CCCL. April, 2023. <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>

[3] CO₂e calculated by equation A-1 of 40 CFR 98.2, which states the total CO₂e is equal to the GWP for each pollutant multiplied by the potential pollutant emissions. The GWP for CO₂ is 1, CH₄ is 25, and N₂O is 298.

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Table 6. Land Use Change Emissions

Permanent Land Use Change ^[1]	Area of Land Change ^[1] (acres)	2021 Net CO ₂ Flux for Converted Land Type ^{[2][3]} (M metric tons CO ₂ e)	2021 Total US Land Use Change from Forest Land ^[4] (thousands of hectares)	CO ₂ e Emission Factor (metric tons CO ₂ e/acre)	CO ₂ e ^[5] (metric tons/year)
Forest Land to Settlement	-	63.7	456	56.53	-
Cropland to Settlement	768.21	5.9	1,366	1.75	1,342.76
Wetlands to Settlement	-	0.3	14	8.67	-
Grassland to Settlement	-	12.2	1,830	2.70	-
TOTAL	768.21	82.10	3,666.00	69.65	1,342.76

[1] Estimated from development area delineation files and NLCD land cover estimates.

[2] Table 6-129. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2021. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021>

[3] Table 6-44. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2021. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021>

[4] Table 6-5: Land Use and Land-Use Change for the U.S. Managed Land Base for All 50 States, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2021. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021>



Table 7. Avoided GHG Emissions

Temporary Facility	Energy Consumption ^[1] (MWh/year)	eGRID State	CO ₂ Emission Factor ^[2] (lb/MWh)	CH ₄ Emission Factor ^[2] (lb/MWh)	N ₂ O Emission Factor ^[2] (lb/MWh)	CO ₂ (metric tons/year)	CH ₄ (metric tons/year)	N ₂ O (metric tons/year)	CO ₂ e ^[3] (metric tons/year)
Operations	263,684	Minnesota	825.973	0.082	0.012	98,790.57	9.81	1.44	99,463.47
TOTAL	--	--	--	--	--	98,790.57	9.81E+00	1.44E+00	99,463.47

[1] Barr estimated based on professional experience with similar project types
[2] U.S. eGrid Factors, 2023 Update, Total Output Emissions Rates for Minnesota, metric tonne/MWh; <https://www.epa.gov/egrid/download-data>
[3] CO₂e calculated by equation A-1 of 40 CFR 98.2, which states the total CO₂e is equal to the GWP for each pollutant multiplied by the potential pollutant emissions. The GWP for CO₂ is 1, CH₄ is 25, and N₂O is 298.