



Appendix K

Greenhouse Gas Calculations

Boswell Solar Project
GHG Calculations

Project Energy Generation (MWh/year)	eGRID Subregion	CO ₂ Emission Factor ^[1] (lb/MWh)	CH ₄ Emission Factor ^[1] (lb/MWh)	N ₂ O Emission Factor ^[1] (lb/MWh)	CO ₂ (metric tons/year)	CH ₄ (metric tons/year)	N ₂ O (metric tons/year)	CO ₂ e ^[2] (metric tons/year)	CO ₂ e (short tons/year)
166,909	MROW	936.5	0.102	0.015	70,901.17	7.72	1.14	71,418.34	78,725.22

[1] Table 6, Electricity. Emission Factors for Greenhouse Gas Inventories, EPA CCCL. February, 2024. <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>

[2] CO₂e calculated by multiplying the GWP for each pollutant by the potential pollutant emissions. GWPs from EPA CCCL Emission Factors for Greenhouse Gas Inventories, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

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Table 1. Summary of Construction GHG Emissions

Project Area	Fuel Combustion CO ₂ e ^[1] (metric tons)	Land Use Change CO ₂ e ^[1] (metric tons)	Total CO ₂ e ^[1] (metric tons)	Total CO ₂ e (short tons)
Entire Project	465.33	2,677.89	3,143.23	3,464.81

[1] CO₂e calculated by multiplying the GWP for each pollutant by the potential pollutant emissions. GWPs from EPA CCCL Emission Factors for Greenhouse Gas Inventories, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

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Table 2. Summary of Operations GHG Emissions

Project Area	Fuel Combustion CO ₂ e ^[1] (metric tons/yr)	Land Use Change CO ₂ e ^[1] (metric tons/yr)	Total CO ₂ e ^[1] (metric tons/yr)	Total CO ₂ e (short tons/yr)
Entire Project	32.71	457.13	489.84	539.95

[1] CO₂e calculated by multiplying the GWP for each pollutant by the potential pollutant emissions. GWPs from EPA CCCL Emission Factors for Greenhouse Gas Inventories, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

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Table 3. Conversions

Unit	Amount	Unit
ton	2000	lbs
ton	0.907185	metric tons
ton	907.185	kg
ton	907185	grams
lb	0.453592	kg
lb	453.592	grams
MWh	1000	kWh
hectare	2.47105	acres
1 MJ	0.372506136	hp-h
US gallon (diesel) ^[1]	144.945	MJ
US gallon (diesel)	53.9929019	hp-h
US gallon (gasoline) ^[1]	126.833	MJ
US gallon (gasoline)	47.24606261	hp-h
US gallon (jet fuel) ^[1]	142.2	MJ
US gallon (jet fuel)	52.97036342	hp-h

[1] US Energy Information Administration, 2024. <https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php>

[2] [https://www.convertunits.com/from/MJ/to/gallon+\[U.S.\]+of+kerosene+type+jet+fuel](https://www.convertunits.com/from/MJ/to/gallon+[U.S.]+of+kerosene+type+jet+fuel)

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Table 4. Global Warming Potentials

Greenhouse Gas Name	CAS Number	Chemical Formula	Global Warming Potential (100-yr.) [1]
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Table 5. Land Use Change Emission Factor Calculations

Temporary Land Use Change	2022 Net CO ₂ Flux for Converted Land Type ^[1] (M metric tons CO ₂ e)	2022 Total US Land Use Change from Forest Land ^[2] (thousands of hectares)	CO ₂ e Emission Factor (metric tons CO ₂ e/acre)
Forest Land to Grassland	46.8	3,894	4.86
Cropland to Grassland	(12.5)	11,444	(0.44)
Settlement to Grassland	(0.8)	93	(3.48)
Forest Land to Settlement	58.6	440	53.90
Cropland to Settlement	2.9	1,228	0.96
Grassland to Settlement	7.5	1,648	1.84

[1] Net CO2 flux tables for converted land types. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2022. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022>

[2] 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 - 2022. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022>

Table 6. Construction Emissions from Fuel Combustion

Fuel Type ^[1]	Fuel Consumption ^[1] (total gallons)	CO ₂ Emission Factor ^[2] (kg/gal)	CH ₄ Emission Factor ^[3] (g/gal)	N ₂ O Emission Factor ^[3] (g/gal)	CO ₂ (metric tons)	CH ₄ (metric tons)	N ₂ O (metric tons)	CO ₂ e ^[4] (metric tons)	CO ₂ e (short tons)
Diesel	32,200	10.21	1.01	0.94	328.76	3.25E-02	3.03E-02	337.69	372.24
Gasoline	13,800	8.78	2.85	1.47	121.16	3.93E-02	2.03E-02	127.64	140.70
TOTAL	--	--	--	--	449.93	0.07	0.05	465.33	512.94

[1] Fuel consumption estimates obtained from Minnesota Power.

[2] CO₂ emissions calculated using the EPA CCCL emission factors for mobile combustion, Table 2: Mobile Combustion CO₂, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

Fuel Type	CO ₂ Emission Factor (kg/gal)
Diesel Fuel	10.21
Motor Gasoline	8.78

[3] CH₄ and N₂O emissions calculated using the EPA CCCL emission factors for construction/mining equipment, Table 5: Mobile Combustion CH₄ and N₂O for Non-Road Vehicles, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

Vehicle Type	Fuel Type	CH4 Emission Factor (g/gal)	N ₂ O Emission Factor (g/gal)
Construction/Mining Equipment	Diesel Equipment	1.01	0.94
Construction/Mining Equipment	Gasoline (4 stroke)	2.85	1.47

[4] CO₂e calculated by multiplying the GWP for each pollutant by the potential pollutant emissions. GWPs from EPA CCCL Emission Factors for Greenhouse Gas Inventories, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

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Table 7. Construction Emissions from Land Use Change

Project Area	Temporary Land Use Change from Forest Land to Settlement ^[1] (acres)	Temporary Land Use Change from Cropland to Settlement ^[1] (acres)	Temporary Land Use Change from Grassland to Settlement ^[1] (acres)	CO ₂ e ^{[2][3]} (metric tons)	CO ₂ e (short tons)
Solar Facility	278.85	509.13	160.49	2,599.10	2,865.02
Gen-Tie Line	8.08	24.23	11.22	78.79	86.85
TOTAL	286.93	533.36	171.71	2,677.89	2,951.87

[1] Land use areas obtained from the National Land Cover Database for Project Area.
[2] See land use change emission factors calculation table.
[3] Emissions are calculated for an assumed 60-day duration of temporary disturabance.

Table 8. Operation Emissions from Fuel Combustion

Equipment Type ^[1]	Fuel Type ^[1]	Fuel Consumption ^[1] (gal/yr)	CO ₂ Emission Factor ^[2] (kg/gal)	CH ₄ Emission Factor ^[3] (g/gal)	N ₂ O Emission Factor ^[3] (g/gal)	CO ₂ (metric tons/yr)	CH ₄ (metric tons/yr)	N ₂ O (metric tons/yr)	CO ₂ e ^[4] (metric tons/yr)	CO ₂ e (short tons/yr)
Rental Front-End Loader - Snow Removal	Diesel	1,000	10.21	0.42	0.60	10.21	4.20E-04	6.00E-04	10.38	11.44
Compact Track Loader	Diesel	500	10.21	0.42	0.60	5.11	2.10E-04	3.00E-04	5.19	5.72
1 ton 3500 Pickup	Gasoline	700	8.78	2.74	1.54	6.15	1.92E-03	1.08E-03	6.49	7.15
¾ ton 2500 Pickup	Gasoline	700	8.78	2.74	1.54	6.15	1.92E-03	1.08E-03	6.49	7.15
UTV	Gasoline	300	8.78	2.72	1.48	2.63	8.16E-04	4.44E-04	2.77	3.06
Commercial Mower	Gasoline	150	8.78	2.74	1.54	1.32	4.11E-04	2.31E-04	1.39	1.53
TOTAL	--	--	--	--	--	31.56	5.69E-03	3.73E-03	32.71	36.05

[1] Equipment type and fuel consumption estimates obtained from Minnesota Power.

[2] CO₂ emissions calculated using the EPA CCCL emission factors for mobile combustion, Table 2: Mobile Combustion CO₂, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

Fuel Type	CO ₂ Emission Factor (kg/gal)
Diesel Fuel	10.21
Motor Gasoline	8.78

[3] CH₄ and N₂O emissions calculated using the EPA CCCL emission factors for industrial/commercial equipment, Table 5: Mobile Combustion CH₄ and N₂O for Non-Road Vehicles, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

Vehicle Type	Fuel Type	CH4 Emission Factor (g/gal)	N ₂ O Emission Factor (g/gal)
Industrial/Commercial Equipment	Diesel	0.42	0.60
Industrial/Commercial Equipment	Gasoline (4 stroke)	2.74	1.54
Recreational Equipment	Gasoline (4 stroke)	2.72	1.48

[4] CO₂e calculated by multiplying the GWP for each pollutant by the potential pollutant emissions. GWPs from EPA CCCL Emission Factors for Greenhouse Gas Inventories, 2024. <https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf>

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Table 9. Operation Emissions from Land Use Change

Project Area	Land Use Change from Forest Land to Grassland ^[1] (acres)	Land Use Change from Cropland to Grassland ^[1] (acres)	Land Use Change from Settlement to Grassland ^[1] (acres)	CO ₂ e ^{[2][3]} (metric tons/yr)	CO ₂ e (short tons/yr)
Solar Facility	279	509	160	572.49	631.06
Gen-Tie Line	8.08	24.23	41	(115.36)	(127.16)
TOTAL	286.93	533.36	201.84	457.13	503.90

[1] Land use areas obtained from the National Land Cover Database for Project Area.
[2] See land use change emission factors calculation table.