Appendix I
Project Emissions Estimate

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Gopher State Solar, LLC
Gopher State Solar Project
Construction and Operating Emission Calculations
Summary

Emisisons From Construction Equipment	
	Emissions (tons per project)
Description	**Greenhouse Gas (CO_2e)**
Off-Road Engine Emissions	2,154
Construction Worker Vehicles	1,202
Construction Delivery Vehicles	280
Construction Equipment	**3,636**

Operating Emissions	
	Emissions (tons per year)
Description	**Greenhouse Gas (CO_2e)**
Electricity Use - O&M Building	16
Commuter Vehicles - Gasoline	8
Maintenance Trucks - Diesel	0
Total Operating Emissions	**25**

Gopher State Solar, LLC
Gopher State Solar Project
Construction Emission Calculations
Emission Factors for Construction Engines

Off-Road Construction Engines

Equipment	Quantity [a]	Hours per Day	Number of Days	Total Hours Used [b]	Max Power (HP)	Load Factor [c]	Loaded Power (HP)	Emission Factors [d,e] (g/hp hr) CO_2	CH_4	N_2O
ATV	42	8	155	52,080	20	0.5	10	188.262	0.008	0.002
Backhoe	2	8	300	4,800	75	0.8	60	188.262	0.008	0.002
Bulldozer	2	8	50	800	250	1	250	188.262	0.008	0.002
Compactor, Vibratory	4	8	155	4,960	100	1	100	188.262	0.008	0.002
Fork Lift	8	8	155	9,920	120	1	120	188.262	0.008	0.002
Concrete Mixer Truck	6	8	40	1,920	325	1	325	188.262	0.008	0.002
Dump Truck	2	8	75	1,200	325	0.8	260	188.262	0.008	0.002
Excavator	4	8	200	6,400	138	1	138	188.262	0.008	0.002
Front End Loader	3	8	100	2,400	196	1	196	188.262	0.008	0.002
Generator	10	8	155	12,400	250	0.5	125	188.262	0.008	0.002
Pickup Truck	20	8	275	44,000	150	0.25	38	188.262	0.008	0.002
Skid steer loader	4	8	155	4,960	50	1	50	188.262	0.008	0.002
Water truck	4	9	250	9,000	100	0.5	50	188.262	0.008	0.002
Grader	2	8	300	4,800	35	0.8	28	188.262	0.008	0.002
Medium Crane	2	4	40	320	450	0.7	315	188.262	0.008	0.002
Pile Driver	7	8	155	8,680	49	1	49	188.262	0.008	0.002
100 HP Tractor	5	8	200	8,000	100	0.21	100	188.262	0.008	0.002

[a] Equipment counts based on experience with construction of similar projects.
[b] Hours based on estimates from similar projects.
[c] Load Factors from Appendix A of EPA 420_P 04 005, Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling , USEPA, April 2004.
[d] EPA 420 P 04 009, Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling Compression Ignition, USEPA, April 2004 Tier 2 Engines.
[e] GHG emission factors from Title 40 Subchapter C Part 98 Subpart C Table C-1 and C-2 to Subpart C.

Gopher State Solar, LLC
Gopher State Solar Project
Construction Emission Calculations
Emission Estimates from Construction Engines

Equipment	Potential Emissions (ton/yr)			
	CO_2	CH_4	N_2O	CO_2e
ATV	108.08	4.4E-03	8.8E-04	108.45
Backhoe	59.77	2.4E-03	4.8E-04	59.97
Bulldozer	41.50	1.7E-03	3.4E-04	41.65
Compactor, Vibratory	102.93	4.2E-03	8.3E-04	103.28
Fork Lift	247.04	1.0E-02	2.0E-03	247.88
Concrete Mixer Truck	129.49	5.3E-03	1.1E-03	129.94
Dump Truck	64.75	2.6E-03	5.3E-04	64.97
Excavator	183.28	7.4E-03	1.5E-03	183.91
Front End Loader	97.62	4.0E-03	7.9E-04	97.95
Generator	321.66	1.3E-02	2.6E-03	322.76
Pickup Truck	342.41	1.4E-02	2.8E-03	343.59
Skid steer loader	51.47	2.1E-03	4.2E-04	51.64
Water truck	93.39	3.8E-03	7.6E-04	93.71
Grader	27.89	1.1E-03	2.3E-04	27.99
Medium Crane	20.92	8.5E-04	1.7E-04	20.99
Pile Driver	88.26	3.6E-03	7.2E-04	88.57
100 HP Tractor	166.02	6.7E-03	1.3E-03	166.59
TOTAL	**2,146.48**	**8.7E-02**	**1.7E-02**	**2,153.84**

Global Warming Potentials		
CO_2	CH_4	N_2O
1	25	298

Source: Title 40 Part 98 Table A-1.

Example calculations:

CO_2 (ton/yr) = [Total hours] * [Loaded Power (hp)] * [188.262 g CO_2 / hp-hr] * [1 lb / 453.5924 g] * [1 ton / 2000 lb]

CH_4 (ton/yr) = [Total hours] * [Loaded Power (hp)] * [0.008 g CH_4 / hp-hr] * [1 lb / 453.5924 g] * [1 ton / 2000 lb]

N_2O (ton/yr) = [Total hours] * [Loaded Power (hp)] * [0.002 g N_2O / hp-hr] * [1 lb / 453.5924 g] * [1 ton / 2000 lb]

CO_2e (ton/yr) = [CO_2 ton/yr * 1] + [CH_4 ton/yr * 25] + [N_2O ton/yr * 298]

Gopher State Solar, LLC
Gopher State Solar Project
Operating Emission Calculations
Emissions Estimates for Construction Commuters and Delivery Vehicles

On-Road Vehicles					
	Vehicles per day	**Miles per vehicle**	**Number of Days**	**Gallons Used per Project**	**CO_2 Emissions Tons**
Commuter Vehicles - Gasoline [b]	150	60	300	122,727	1,202
Delivery Trucks - Diesel [c]	18	60	150	24,923	280

[a] Assumes 1 gallon of gasoline = 8,887 grams CO_2 and 1 gallon of diesel = 10,180 g CO_2, per US EPA's "Greenhouse Gas Emissions from a Typical Passenger Vehicle," available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YT.pdf

[b] Assumes commuters travel 30 miles each way (60 miles round trip) per day, with a fuel economy of 22.0 miles per gallon, per US EPA and US Department of Energy Fuel Economy data for combined city and highway driving in 2023, available online at: https://www.fueleconomy.gov/feg/download.shtml.

[c] Assumes delivery trucks travel 30 miles each way (60 miles round trip) per day, with a fuel economy of 6.5 miles per gallon, industry average.

1 short ton =	907,185	grams
1 gal gasoline =	8,887	g CO_2
1 gal diesel =	10,182	g CO_2

Gopher State Solar, LLC
Gopher State Solar Project
Operating Emission Calculations
Emissions from Facility Operation

	kWh / month	kWh / year	GHG Emissions [a] tons CO_2e / year
Electricity Use - O&M Building	1,688	20,250	15.8

[a] Greenhouse gas emissions calculated using US EPA's Greenhouse Gas Equivalencies Calculator, available online at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

	Vehicles per week	Fuel Usage gal/vehicle/week	Fuel Usage gal/year	GHG Emissions [a] tons CO_2e / year
Commuter Vehicles - Gasoline [b]	6	16	851	8.3
Maintenance Trucks - Diesel [c]	2	0.8	42	0.5

[a] Assumes 1 gallon of gasoline = 8,887 grams CO_2 and 1 gallon of diesel = 10,180 g CO_2, per US EPA's "Greenhouse Gas Emissions from a Typical Passenger Vehicle," available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YT.pdf

[b] Assumes six commuters travel 30 miles each way (60 miles round trip) per week, with a fuel economy of 22.0 miles per gallon, per US EPA's "Greenhouse Gas Emissions from a Typical Passenger Vehicle," available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YT.pdf

[c] Assumes two trucks travel 10 miles on site each week, with a fuel economy of 24.64 miles per gallon (1 gallon of low sulfur diesel is equivalent to 1.12 gallons of gasoline), per US Department of Energy Alternative Fuels Data Center Fuel Propoerties Comparison, available online at: https://afdc.energy.gov/files/u/publication/fuel_comparison_chart.pdf.