

Technical Appendix & Optional GHG Emission Reduction Calculations

The following table summarizes the GHG reductions that have been calculated to result from the total scope of work which the grant is requested to fund:

Scope of Work	kWh savings	Therms Savings	GHG annual Savings (Metric Tons CO ₂)	GHG Savings 2025-2030	GHG Savings 2025-2050
Solar - W&WW	6,758,600	0	4,721	23,605	118,025
Solar - Buildings	742,900	0	519	2,595	12,975
LED Lighting	856,546	-812	595	2,975	14,875
Building Automation	102,478	115,11	133	664	3,319
TOTAL	8,460,542	10,699	5,968	29,839	149,194

1. Solar PV Systems - Renewable Energy at the Wastewater and Water Treatment Plants with Microgrid at the Water Treatment Plant

- a. **GHG Reduction Estimate Method:** For each of the two plants that solar PV systems are proposed, the solar electricity production was modeled to determine how much electricity from the utility could be avoided.
- b. **Model/Tools Used:** The tool used for determining the solar production of the selected systems is HelioScope. This model provides the kWh that is expected to be produced by each system. The systems are sized to be able to offset electric use from the utility at the site primarily with a small amount of electricity sent back to the utility grid.
- c. **Measure Implementation Assumptions:**
 - i. The models assume full use of the solar PV systems from the time of installation.
 - ii. It is assumed that the planned systems can be built in the locations identified.
 - iii. The solar PV panels are projected to last for 40 or more years. The inverters serving the panels would be expected to be replaced in about 15 years.
 - iv. The systems are sized to be able to offset electric use from the utility at the site primarily with a small amount of electricity sent back to the utility grid.
 - v. The systems are expected to be able to be installed in about 1 year or less.
- d. **GHG Reduction Estimate Assumptions:**
 - i. The GHG reduction assumes the system is able to produce the modeled production.
 - ii. The greenhouse gas calculation for this measure is taken directly from the EPA's Greenhouse Gas Calculator based on kWh saved. The total of metric tons of CO₂ is calculated as 7 metric tons CO₂ per 10,000 kWh reduced.
- e. **Reference Case Scenario:** the reference scenario in this case would be the use of utility power if these solar PV systems were not available. All of the solar production is viewed as offsetting the environmental impact of buying power from the local utility. At the water treatment plant during the summer months the plant runs generators to reduce

the utility demand and so the GHG savings are likely even greater than calculated. The calculated GHG savings are based on more typical utility produced electricity being avoided. If the grant was not available, the City would apply for the IRA ITC for solar if they were able to identify funds for the balance of the work.

f. Measure-Specific Activity Data:

- i. The solar PV systems at the water and wastewater plants will produce 6,758,600 kWh for one year.

g. GHG Emissions Reduced:

- i. For the Solar – W&WW measure: $6,758,600 \text{ kWh} \times 7 \text{ metric tons CO}_2 / 10,000 \text{ kWh} = 4721 \text{ metric tons CO}_2$

Scope of Work	kWh savings	Therms savings	GHG annual savings (Metric Tons CO ₂)	GHG Savings 2025-2030	GHG Savings 2025-2050
Solar - W&WW	6,758,600	0	4,721	23,605	118,025

Following are screen captures of the Helioscope summary tables for each of the plant solar PV designs. The Helioscope report can be provided in full if requested.

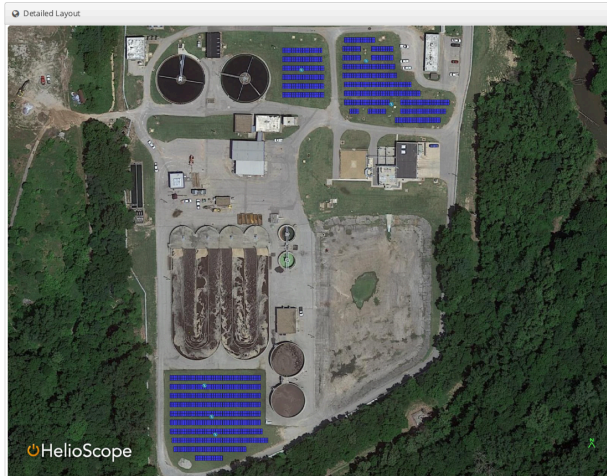
Water Treatment Plant with Microgrid - 5.673 GWh to be saved (equals 5,673,000 kWh to be saved)



Report	
Project Name	Midwest - OK - Broken Arrow - Verdigris Water Plant
Project Description	2 Meters. Largest meter annual consumption of 9,848,547 kWh
Project Address	S 360th E Ave, Broken Arrow, OK 74014
Prepared By	Justin Claybrook justin.daybrook@se.com

System Metrics	
Design	240315 - Floating 4x3, 58% Offset
Module DC Nameplate	3.87 MW
Inverter AC Nameplate	3.00 MW Load Ratio: 1.29
Annual Production	5.673 GWh
Performance Ratio	82.3%
kWh/kWp	1,465.6
Weather Dataset	TMY, TULSA, NSRDB (tmy2)
Simulator Version	3fe92129f5-4d3faf5d7a-d23e76a911-5d5de33235

Wastewater Plant Solar PV - 1.086 GWh to be saved (equals 1,086,000 kWh to be saved)



Report	
Project Name	Midwest - OK - Broken Arrow - Waste Water Treatment Plant
Project Address	13803 S 177th E Ave, Broken Arrow, OK
Prepared By	Shawn Hatcher shawn.hatcher@se.com

System Metrics	
Design	231215 - Upsized
Module DC Nameplate	747.0 kW
Inverter AC Nameplate	600.0 kW Load Ratio: 1.25
Annual Production	1.086 GWh
Performance Ratio	79.5%
kWh/kWp	1,453.1
Weather Dataset	TMY, 10km Grid (35.95,-95.75), NREL (prospector)
Simulator Version	2dc402a4ad-affd851c65-47a8314a08-fca490fcc3

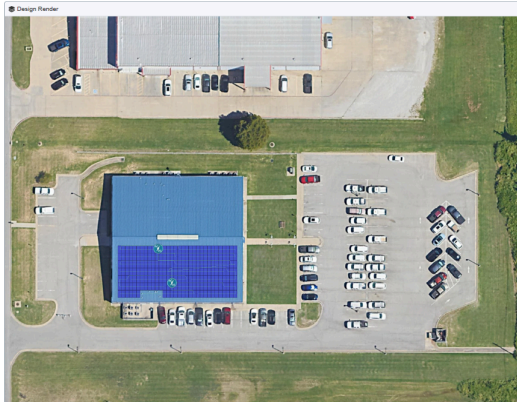
2. Solar PV Systems - Buildings

- a. **GHG Reduction Estimate Method:** For each of the four sites that solar PV systems are proposed, the solar electricity production was modeled to determine how much electricity from the utility could be avoided.
- b. **Model/Tools Used:** the tool used for determining the solar production of the selected systems is HelioScope. This model provides the kWh that is expected to be produced by each system. The systems are sized to be able to offset electric use from the utility at the site primarily with a small amount of electricity sent back to the utility grid.
- c. **Measure Implementation Assumptions:**
 - i. The models assume full use of the solar PV systems from the time of installation.
 - ii. It is assumed that the planned systems can be built in the locations identified.
 - iii. The solar PV panels are projected to last for 40 or more years. The inverters serving the panels would be expected to be replaced in about 15 years.
 - iv. The systems are sized to be able to offset electric use from the utility at the site primarily with a small amount of electricity sent back to the utility grid.
- d. **GHG Reduction Estimate Assumptions:**
 - i. The GHG reduction assumes the system is able to produce the modeled production.
 - ii. The greenhouse gas calculation for this measure is taken directly from the EPA's Greenhouse Gas Calculator based on kWh saved. The total of metric tons of CO₂ is calculated as 7 metric tons CO₂ per 10,000 kWh reduced.
- e. **Reference Case Scenario:** the reference scenario in this case would be the use of utility power if these solar PV systems were not available. All of the solar production is viewed as offsetting the environmental impact of buying power from the local utility. The calculated GHG savings are based on more typical utility produced electricity being avoided. If the grant was not available, the City would apply for the IRA ITC for solar if they were able to identify funds for the balance of the work.
- f. **Measure-Specific Activity Data:**
 - i. The solar production at the four City office buildings will be 742,900 kWh for one year.
- g. **GHG Emissions Reduced:**
 - i. For the Solar – Buildings measure: 742,900 kWh x 7 metric tons CO₂ / 10,000 kWh = 519 metric tons CO₂

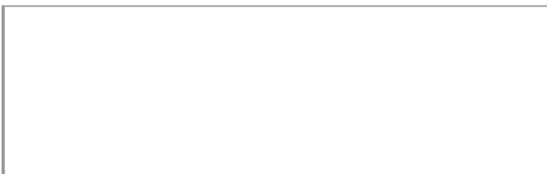
Scope of Work	kWh savings	Therms Savings	GHG annual Savings (Metric Tons CO ₂)	GHG Savings 2025-2030	GHG Savings 2025-2050
Solar - Buildings	742,900	0	519	2,595	12,975

Following are screen captures of the Helioscope summary tables for each of the municipal building solar PV designs. The Helioscope report can be provided in full if requested.

Operations Building Solar PV - 152.7 MWh to be saved (equals 152,700 kWh to be saved)

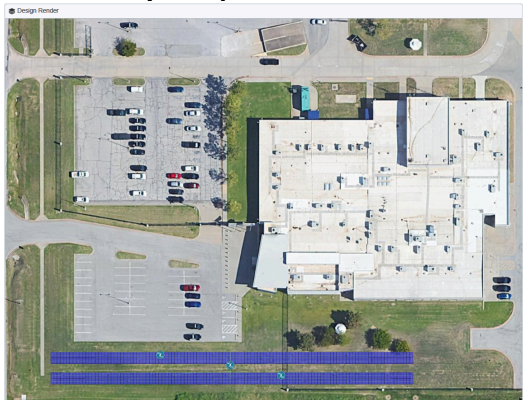


Project Details	
Address	485 N Poplar, Broken Arrow, OK
Owner	Jason Mendenhall
Last Modified	Ben Johnson a minute ago
Location	(36.0562594, -95.8084392) (GMT -6)
Profile	Default Commercial



System Metrics	
Design	Operations Bldg - 202,160 kWh/yr
Module DC Nameplate	109.0 kW
Inverter AC Nameplate	100.0 kW Load Ratio: 1.09
Annual Production	152.7 MWh
Performance Ratio	78.5%
kWh/kWp	1,400.8
Weather Dataset	TMY, 0.04° Grid (36.05,-95.82), NREL (psm3)
Simulator Version	bea0c32975-f7c166ba04-e5790ed422-e085315a86

Public Safety Complex Solar PV - 187.5 MWh to be saved (equals 187,500 kWh to be saved)

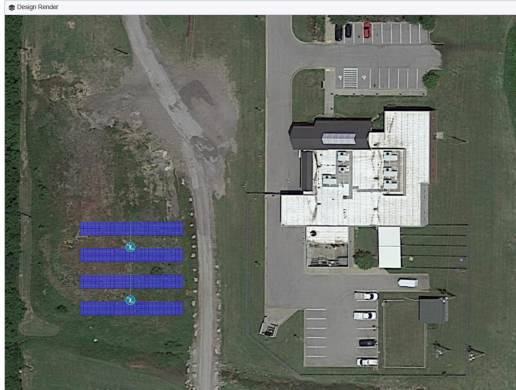


Project Details	
Address	1101 N 6th, Broken Arrow, OK
Owner	Jason Mendenhall
Last Modified	Ben Johnson 10 minutes ago
Location	(36.0628141, -95.7814245) (GMT -6)
Profile	Default Commercial



System Metrics	
Design	Public Safety - 795,900 kWh/yr
Module DC Nameplate	228.0 kW
Inverter AC Nameplate	187.5 kW Load Ratio: 1.22
Annual Production	361.4 MWh
Performance Ratio	82.0%
kWh/kWp	1,585.0
Weather Dataset	TMY, 0.04° Grid (36.05,-95.82), NREL (psm3)
Simulator Version	bea0c32975-f7c166ba04-e5790ed422-e085315a86

Animal Shelter Solar PV - 164.6 MWh to be saved (equals 164,600 kWh to be saved)



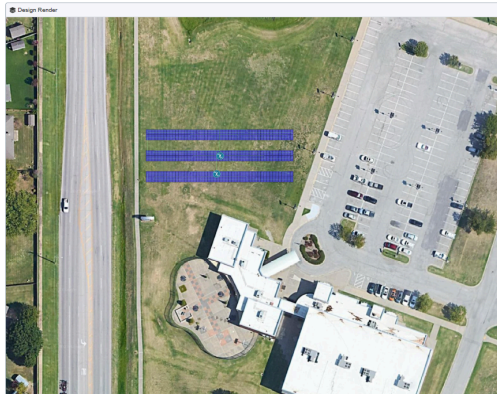
Project Details

Address	4142 E Omaha St, Broken Arrow, OK 74012, USA
Owner	Ben Johnson
Last Modified	Ben Johnson a minute ago
Location	(36.0899094, -95.7368614) (GMT -6)
Profile	Default Commercial

System Metrics

Design	Animal Shelter - 273,760 kWh
Module DC Nameplate	108.0 kW
Inverter AC Nameplate	100.0 kW Load Ratio: 1.08
Annual Production	164.6 MWh
Performance Ratio	77.9%
kWh/kWp	1,524.5
Weather Dataset	TMY, 0.04° Grid (36.09,-95.74), NREL (psm3)
Simulator Version	bea0c32975-f7c166ba04-e5790ed422-e085315a86

Nienhuis Park Solar PV - 238.1 MWh to be saved (equals 238,100 kWh to be saved)



Project Details	
Address	3201 N 9th, Broken Arrow, OK
Owner	Jason Mendenhall
Last Modified	Ben Johnson 19 hours ago
Location	(36.0853355902, -95.7787798131) (GMT -8)
Profile	Default Commercial

System Metrics	
Design	Nienhuis Park - 268,320 kWh/yr
Module DC Nameplate	150.0 kW
Inverter AC Nameplate	125.0 kW Load Ratio: 1.20
Annual Production	238.1 MWh
Performance Ratio	81.5%
kWh/kWp	1,587.2
Weather Dataset	TMY, 0.04° Grid (36.09,-95.82), NREL (psm3)
Simulator Version	bea0c32975-f7c186ba04-e5790ed422-e085315a88

3. LED Lighting

- GHG Reduction Estimate Method:** A detailed survey was done of the facilities to understand the current lighting in each space. After identifying the lighting in each space currently, a spreadsheet was used to enter the current watts each light uses and then a retrofit chosen and the post retrofit watts that it would use.
- Model/Tools Used:** spreadsheet-based tools are used to inventory and analyze the current lighting systems as well as the impact of the proposed LED lighting upgrades.
- Measure Implementation Assumptions:**
 - The retrofits are expected to be able to be installed in about 9 months or less.
 - The new LED lighting should typically last without replacement for 15 years based on the number of hours the spaces are occupied and require lighting.
- GHG Reduction Estimate Assumptions:**
 - Published data for demand (watts) used for each existing fixture as well as the retrofits proposed.
 - The building survey documented the amount of time that each space was used to calculate the annual hours that each light fixture was on ("burn hours"). Using these annual hours multiplied by the difference in current watts used minus the new watts used, the annual kWh savings were determined.

Multiplying this by the number of fixtures for each type of retrofit in each space allowed us to come up with a total kWh saved.

- iii. kWh saved = # of fixtures x (pre retrofit watts – post retrofit watts) x hours of use x 1000 watts/kW
- iv. The total sum of the kWh from all the different retrofits in all the spaces was used.
- v. The greenhouse gas calculation for this measure is taken directly from the EPA's Greenhouse Gas Calculator based on kWh saved. The total of metric tons of CO₂ is calculated as 7 metric tons CO₂ per 10,000 kWh reduced. The heating penalty is calculated at 5.3 metric tons CO₂ per 1000 therms of natural gas required.

e. Reference Case Scenario:

- i. The alternative to being able to do the LED upgrade through the CPRG grant is the City upgrading lights one at a time as they fail. This process would take up to 10 years to complete based on that approach.
- ii. Currently there are some relatively small utility incentives for upgrading lighting to LED. If the City was not able to fund the LED lighting through the CPRG grant, then it would seek to recoup some funds from replacing the lighting individually with the utility incentives.

f. Measure-Specific Activity Data:

- i. The LED lighting scope will result in reduced electricity use due to the new lighting requiring significantly less power (watts) to produce the same amount of light as the current fluorescent and other lighting.
- ii. There is also an additional impact on the HVAC systems for interior lighting. Additional kWh savings are captured during the cooling season but heating penalties of natural gas therms (or in some cases kWh where electric heat is in use) were also considered as additional heat would need to be supplied due to the loss of heat produced by the current lighting.
- iii. Total energy impact = direct lighting kWh saved + indirect HVAC kWh saved – indirect HVAC heating therms required

g. GHG Emissions Reduced:

- i. The LED lighting scope savings will be 856,546 kWh for one year.
- ii. There is an estimated heating penalty of 810 therms (natural gas)
- iii. 856,546 kWh saved x 7 metric tons CO₂ / 10,000 kWh – 812 therms x 5.3 metric tons CO₂ / 1000 therms = 595 metric tons CO₂ (net)

Scope of Work	kWh savings	Therms Savings	GHG annual Savings (Metric Tons CO ₂)	GHG Savings 2025-2030	GHG Savings 2025-2050
LED Lighting	856,546	-812	595	2,975	14,875

4. Building Automation Program

- a. **GHG Reduction Estimate Method:** A detailed survey of the facilities was performed, and occupants were interviewed to determine the current use of the spaces. Also identified were the heating and cooling loads, typical thermostat setpoints and other related factors that impact the amount of cooling and heating energy required currently.
- b. **Model/Tools Used:** A spreadsheet model of the annual energy use was built to compare how the buildings are currently using energy and comparing that to how an energy-efficient building should be using energy with a functional BAS.
- c. **Measure Implementation Assumptions:**
 - i. The BAS systems are expected to be installed in 9 to 14 months.
 - ii. The new systems should last a minimum of 15 years with proper maintenance.
- d. **GHG Reduction Estimate Assumptions:**
 - i. The BAS is assumed to only reduce the HVAC energy use in the building.
 - ii. Load factors of the buildings before and after savings calculations were evaluated to ensure reasonableness of savings projections.
 - iii. Final building consumption projections were compared to Federal database information to ensure reasonableness of expected operating parameters.
 - iv. The greenhouse gas calculation for this measure is taken directly from the EPA's Greenhouse Gas Calculator based on kWh saved. The total of metric tons of CO₂ is calculated as 7 metric tons CO₂ per 10,000 kWh reduced. The heating savings is calculated at 5.3 metric tons CO₂ per 1000 therms of natural gas avoided.
- e. **Reference Case Scenario:** if the City does not implement these BAS systems, they will continue to operate most of these facilities with standalone programmable or non programmable thermostats. Even though many are programmable currently, it was found during the building survey that many of those did not have a schedule in place or the clock had the wrong time. As a result, the buildings were not being scheduled properly. There are no alternative funding sources identified for this scope of work.
- f. **Measure-Specific Activity Data:**
 - i. With the new BAS systems the City will be able to schedule their facilities according to occupancy and use. Heating and cooling setpoints will be able to be set at appropriate levels and maintained through remote monitoring.
 - ii. Electrical energy will be saved by reducing the runtime of fans and A/C compressors and related equipment.
 - iii. Natural gas will be saved by reducing the heating due to not heating the spaces when occupants are gone at night or on weekends.
- g. **GHG Emissions Reduced:**
 - i. The BAS scope electrical savings will be 102,478 kWh for one year.
 - ii. The BAS scope natural gas savings will be 11,511 therms.
 - iii. $102,478 \text{ kWh saved} \times 7 \text{ metric tons CO}_2 / 10,000 \text{ kWh} + 11,511 \text{ therms} \times 5.3 \text{ metric tons CO}_2 / 1000 \text{ therms} = 133 \text{ metric tons CO}_2$

Scope of Work	kWh savings	Therms savings	GHG annual savings (Metric Tons CO ₂)	GHG Savings 2025-2030	GHG Savings 2025-2050
BAS	102,478	11,511	133	664	3,319