Technical Appendix

GHG Measure: Clean Electricity

Cuyahoga County Solar Measure Analysis

Project Background

As part of the Cleveland MSA CPRG Phase II Grant proposal, Power a Clean Future Ohio (PCFO) assessed the potential impacts from the development of several solar photovoltaic (PV) facilities. The following facilities were included:

Project	MW	Classification
Kolthoff Landfill	7.0	Utility Scale
Brooklyn Landfill	5.3	Utility Scale
Harvard Run (North)	6.3	Utility Scale
Harvard Run (South)	3.5	Utility Scale
Garfield Heights	2.8	Rooftop
West 11th	3.2	Utility Scale

This assessment included estimating carbon-equivalent reductions, pollution reductions, and health benefits.

The processes for estimating these values and their results follow. An Excel workbook (***GHGcalcs_CuyahogaCounty.xlsx***) providing sources, input values, calculations, and model outputs is submitted as an attachment to the grant proposal.

Method Documentation

The analysis employed the following process. Worktabs for Cuyahoga County have the label "CC" in front of the Tab name.

1. Workbook Tab 0.1 Background Data
    a. Estimate expected grid decarbonization using US EIA Annual Energy Outlook 2023[1] Reference Case East North Central (subtab 18.3), from a baseline year of 2024 to serve as a modifier for emission, pollution, and health impacts.
    b. Acquire AR5 emission weighting from EPA Emission Factor Hub[2] to develop carbon dioxide equivalents (CO2e) as needed.
2. Workbook Tab 0.2 Project Classification
    a. Collect project information from county.
    b. Classify for Utility Scale or Rooftop.
    c. Sum MW capacity by classification.
3. Workbook Tab 0.3 Solar AVERT Results
    a. Employing the web version of US EPA's *Avoided Emissions and Generation Tool*[3] (AVERT) run 25.3MW utility-scale solar and 2.8MW rooftop solar in Midwest region scenario.
    b. Acquire output files to be used as inputs in US EPA's *Co-Benefits Risk Assessment Health Impacts Screening Tool*[4] (COBRA).
    c. Enter results in workbook.

[1] US EIA. Annual Energy Outlook 2023. https://www.eia.gov/outlooks/aeo/. Accessed 03 Mar 2024.
[2] US EPA. GHG Emission Factor Hub. https://www.epa.gov/climateleadership/ghg-emission-factors-hub. Accessed 06 Mar 2024.
[3] US EPA. EPA's Avoided Emissions and Generation Tool (AVERT). https://www.epa.gov/avert. Accessed 03 Mar 2024.
[4] US EPA. Co-Benefits Risk Assessment Health Impacts Screening Tool (COBRA). https://www.epa.gov/cobra. Accessed 03 Mar 2024.

4. Workbook Tab 0.4 COBRA Results
    a. Using the desktop version of COBRA:
        i. Upload AVERT output file.
        ii. Analysis year: 2028
        iii. Discount Rate: 3%
    b. Tally results by MSA and Rest of Country.
    c. Enter results into Tab.
5. Workbook Tab 1.0 Emissions
    a. Calculate cumulative CO2e reductions by year for 2025 through 2050 using a 25-year lifetime for PV.
    b. Reduce emission reductions based on modeled grid decarbonization for the Midwest.
    c. Convert CO2 to CO2e
        i. Calculate CO2 percent of CO2e output emissions rate percent using 2022 values for Reliability First Corporation West subregion from US EPA's *Emissions & Generation resource Integrated Database*[5] (eGRID).
        ii. Apply percent factor to cumulative CO2 output calculated.
    d. Sum annual values for 2025 through 2030, and for 2025 through 2050.
6. Workbook Tab 2.0 Pollution
    a. Calculate cumulative reductions by year for 2025 through 2050 using a 25-year lifetime for PV:
        i. Avoided SO2 Emissions
        ii. Avoided NOx Emissions
        iii. Avoided PM2.5 Emissions
        iv. Avoided VOC Emissions
        v. Avoided NH3 Emissions
    b. Reduce emission reductions based on modeled grid decarbonization for the Midwest.
    c. Sum annual values for 2025 through 2030, and for 2025 through 2050.
7. Workbook Tab 3.0 Health
    a. Pull in COBRA results from Tab 0.3b.
    b. Calculate impacts by year for 2025 through 2050.
    c. Reduce health benefits based on modeled grid decarbonization for the Midwest.
    d. Sum annual values for 2025 through 2030, and for 2025 through 2050.

[5] US EPA. Emissions & Generation resource Integrated Database. https://www.epa.gov/egrid. Accessed 03 Mar 2024.

Results

Avoided Emissions

2025 – 2030	**Cumulative** MT CO2e	90,074
2025 – 2030	**Avg. Annual** MT CO2e	15,012
2025 - 2050	**Cumulative** MT CO2e	433,831
2025 - 2050	**Avg. Annual** MT CO2e	16,686

Avoided Pollution

		Avoided SO2 Emissions	Avoided NOx Emissions	Avoided PM2.5 Emissions	Avoided VOC Emissions	Avoided NH3 Emissions
2025 – 2030	**Cumulative** MT	42.8	38.1	5.7	1.4	1.9
2025 – 2030	**Avg. Annual** MT	7.1	6.3	0.9	0.2	0.3
2025 - 2050	**Cumulative** MT	206.2	183.4	27.3	6.5	8.9
2025 - 2050	**Avg. Annual** MT	7.9	7.1	1.1	0.3	0.3

Avoided Health Impacts

		$ Total Health Benefits (low estimate)	$ Total Health Benefits (high estimate)	Minor Restricted Activity Days	Work Loss Days
2025 – 2030	**Total**	$6,122,253	$13,796,956	339	57
2025 – 2030	**Average Annual**	$1,020,375	$2,299,493	56	10
2025 - 2050	**Total**	$20,056,889	$45,199,702	1,109	188
2025 - 2050	**Average Annual**	$771,419	$1,738,450	43	7

Painesville Measure Analysis

Project Background

As part of the Cleveland MSA CPRG Phase II Grant proposal, Power a Clean Future Ohio (PCFO) assessed the potential closure of the Painesville Power Plant and site re-development with 35MW of utility-scale solar photovoltaics, both occurring in 2027.

This assessment included estimating carbon-equivalent reductions, pollution reductions, and health benefits.

The processes for estimating these values and their results follow. An Excel workbook (***GHGcalcs_CuyahogaCounty.xlsx***) providing sources, input values, calculations, and model outputs is submitted as an attachment to the grant proposal.

Method Documentation

The analysis employed the following process. Worktabs for Painesville have the label “P” in front of the Tab name.

1. Workbook Tab 0.1 Background Data
    a. Estimate expected grid decarbonization using US EIA Annual Energy Outlook 2023[6] Reference Case East North Central (subtab 18.3), from a baseline year of 2024 to serve as a modifier for emission, pollution, and health impacts.

[6] US EIA. Annual Energy Outlook 2023. https://www.eia.gov/outlooks/aeo/. Accessed 03 Mar 2024.

    b. Acquire AR5 emission weighting from EPA Emission Factor Hub[7] to develop carbon dioxide equivalents (CO_2e) as needed.
2. Workbook Tab 0.1a Coal-NG Retirement
    a. Acquire last three years (2020-2022) of reported emissions for the Painesville Coal/Natural Gas Power Plant from EPA Greenhouse Gas Reporting Program.
    b. Estimate CO_2e in AR5
    c. Input PCFO estimates of coal and natural gas consumption.
    d. Input PCFO estimates for SOx, NOx, VOC, and PM 2.5.
3. Workbook Tab 0.2 Solar AVERT Results
    a. Employing the web version of US EPA's *Avoided Emissions and Generation Tool*[8] (AVERT) run 35 MW utility-scale solar in Midwest region scenario. Acquire output files to be used as inputs in US EPA's *Co-Benefits Risk Assessment Heath Impacts Screening Tool*[9] (COBRA).
4. Workbook Tab 0.3 COBRA Results
    a. Tally COBRA results for all measures from Tabs 0.3a and 0.3b.
5. Workbook Tab 0.3a Coal-NG Ret Cobra Results
    a. Using the desktop version of COBRA, run two scenarios:
        i. Coal or natural gas pollutant reductions (Tab 0.1a Coal-NG Retirement)
        ii. Analysis year: 2028
        iii. Discount Rate: 3%
    b. Tally results by MSA and Rest of Country.
    c. Enter results into Tab.
6. Workbook Tab 0.3b Solar COBRA Results
    a. Using the desktop version of COBRA, run two scenarios:
        i. Upload AVERT output file.
        ii. Analysis year: 2028
        iii. Discount Rate: 3%
    b. Tally results by MSA and Rest of Country.
    c. Enter results into Tab.
7. Workbook Tab 0.4 Avoided NG Leakage
    a. Estimate natural gas leakage amount using a 0.5% of consumption leakage rate.
    b. Estimate CO_2e based on estimated percentages of CH_4 and CO_2 composition.
8. Workbook Tab 1.0 Total Avd Emissions
    a. Tally estimated avoided emissions for all measures from Tabs 0.4,1.1 and 1.2.
9. Workbook Tab 1.1 Solar Avd Emissions
    a. Calculate cumulative CO_2e reductions by year for 2025 through 2050 using a 25-year lifetime for PV.
    b. Reduce emission reductions based on modeled grid decarbonization for the Midwest.
    c. Convert CO_2 to CO_2e
        i. Calculate CO_2 percent of CO_2e output emissions rate percent using 2022 values for Reliability First Corporation West subregion from US EPA's *Emissions & Generation resource Integrated Database*[10] (eGRID).
        ii. Apply percent factor to cumulative CO_2 output calculated.
    d. Sum annual values for 2025 through 2030, and for 2025 through 2050.
10. Workbook Tab 1.2 Coal-NG Avd Emissions

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[7] US EPA. GHG Emission Factor Hub. https://www.epa.gov/climateleadership/ghg-emission-factors-hub. Accessed 06 Mar 2024.
[8] US EPA. EPA's Avoided Emissions and Generation Tool (AVERT). https://www.epa.gov/avert. Accessed 03 Mar 2024.
[9] US EPA. Co-Benefits Risk Assessment Heath Impacts Screening Tool (COBRA). https://www.epa.gov/cobra. Accessed 03 Mar 2024.
[10] US EPA. Emissions & Generation resource Integrated Database. https://www.epa.gov/egrid. Accessed 03 Mar 2024.

    a. Pull in emission reduction values from Tab 0.1.
    b. Sum annual values for 2025 through 2030, and for 2025 through 2050.
11. Workbook Tab 2.0 Total Avd Pollution
    a. Tally estimated avoided pollution for all measures from Tabs 2.1 and 2.2.
12. Workbook Tab 2.1 Solar Avd Pollution
    a. Calculate cumulative reductions by year for 2025 through 2050 using a 25-year lifetime for PV:
        i. Avoided SO2 Emissions
        ii. Avoided NOx Emissions
        iii. Avoided PM2.5 Emissions
        iv. Avoided VOC Emissions
        v. Avoided NH3 Emissions
    b. Reduce emission reductions based on modeled grid decarbonization for the Midwest.
    c. Sum annual values for 2025 through 2030, and for 2025 through 2050.
13. Workbook Tab 2.2 Coal-NG Avd Pollution
    a. Pull in pollution reduction values from Tab 0.1.
    b. Sum annual values for 2025 through 2030, and for 2025 through 2050.
14. Workbook Tab 3.0 Total Avd Health
    a. Tally estimated health benefits for all measures from Tabs 3.1 and 3.2.
15. Workbook Tab 3.1 Solar Avd Health
    a. Pull in COBRA results from Tab 0.3b.
    b. Calculate impacts by year for 2025 through 2050 using a 25-year lifetime for PV, for any criteria that returns a significant result (>1).
    c. Reduce health benefits based on modeled grid decarbonization for the Midwest.
    d. Sum annual values for 2025 through 2030, and for 2025 through 2050.
16. Workbook Tab 3.2 Coal-NG Avd Health
    a. Pull in COBRA results from Tab 0.3a.
    b. Calculate impacts by year for 2025 through 2050 for any criteria that returns a significant result (>1).
    c. Reduce health benefits based on modeled grid decarbonization for the Midwest.
    d. Sum annual values for 2025 through 2030, and for 2025 through 2050.

Results

Avoided Emissions

2025 – 2030	**Cumulative** MT CO2e	116,203
2025 – 2030	**Avg. Annual** MT CO2e	19,367
2025 - 2050	**Cumulative** MT CO2e	559,679
2025 - 2050	**Avg. Annual** MT CO2e	21,526

Avoided Pollution

		Avoided SO2 Emissions	Avoided NOx Emissions	Avoided PM2.5 Emissions	Avoided VOC Emissions	Avoided NH3 Emissions
2025 – 2030	**Cumulative** MT	62.9	53.2	8.2	1.8	2.3
2025 – 2030	**Avg. Annual** MT	10.5	8.9	1.4	0.3	0.4
2025 - 2050	**Cumulative** MT	293.6	247.9	38.5	8.1	10.9
2025 - 2050	**Avg. Annual** MT	11.3	9.5	1.5	0.3	0.4

Avoided Health Impacts

		$ Total Health Benefits (low estimate)	$ Total Health Benefits (high estimate)	Minor Restricted Activity Days	Work Loss Days
2025 – 2030	**Total**	$5,416,042	$12,205,617	293	50
2025 – 2030	**Average Annual**	$902,674	$2,034,269	49	8
2025 - 2050	**Total**	$25,277,706	$56,965,974	1,366	231
2025 - 2050	**Average Annual**	$972,219	$2,190,999	53	9

Cumulative Emissions Reductions Total of both projects under Clean Electricity GHG measure

Project	Unit	2025-2030	2025-2050
Painesville	MT CO2e	116,202.845	559,679.413
Cuyahoga County Solar	MT CO2e	90,073.650	433,830.754
Total	**MT CO2e**	**206,276.495**	**993,510.167**

GHG Measure: Nature Based Solutions

Cuyahoga County Landfill Sites

Project Background

Cuyahoga County proposes to use the native pollinator seed mix developed by West Creek Conservancy to establish pollinator habitat across each of the landfill solar sites proposed in Cuyahoga County under this CPRG request. 38 total acres will be planted with native pollinator habitat.

Method Documentation

Assumptions include:

- All acres are currently mowed every 3 weeks (21 times per year).
- Once pollinator habitat is established, mowing will occur once every three years.
- Mowing one acre requires an estimated 0.75 gallons of gasoline.

- Pollinator habitat will be established across all sites by 2030.

Tools used:
- Gallons of gasoline used for mowing were converted to metric tons of CO2 equivalent using the EPA's Greenhouse Gas Equivalencies Calculator

GHG Emissions Calculations
GHG Emissions Reduction Calculation for the 38 acres of pollinator habitat to be established by 2030:
- Present emissions scenario: 0.75 gallons gasoline/acre * 38 acres * 21 mowing events/year = 598.5 gallons gasoline/year = 5.3 metric tons CO2 equivalent per year
- Future emissions scenario: 0.75 gallons gasoline/acre * 38 acres * 0.33 mowing event/year = 9.4 gallons gasoline/year = 0.1 metric tons CO2 equivalent per year
- **Reduction of 5.2 metric tons CO2 equivalent per year starting in 2030**

Total GHG Emissions Reduction by 2050:
20 years * (5.2 metric tons CO2 equivalent/year) = **104 metric tons CO2 equivalent reduced by 2050**

Results
- Reduction of 5.2 metric tons CO2 equivalent per year
- 104 metric tons CO2 equivalent reduced by 2050

Painesville Site

Project Background A
Establishment of Native Pollinator Habitat & Reduction of On-Site Mowing
West Creek Conservancy is proposing to establish 400 acres of native pollinator habitat on various sections of the former Diamond Shamrock property in Painesville. This habitat establishment will occur in a phased approach, to coincide both with the anticipated schedule of transfer of site control from Occidental to West Creek Conservancy as well as with the anticipated schedule for installation of the solar. An initial planting of 140 acres on the northern, lakefront portion of the property will occur in 2025; a secondary planting of 100 acres will occur in 2026, and the final 160 acres will be planted by 2028. West Creek Conservancy will work with conservation partners to develop a species mix including native pollinator species and meadow species that are suitable for planting on capped landfills and near solar panels (meaning a shallow root system and shade tolerant).

Method Documentation
Assumptions include:
- All but 40 acres are currently mowed every 3 weeks (21 times per year). 40 acres are currently maintained as meadow habitat and mowed once per year.
- Once pollinator habitat is established, mowing will occur once every three years.
- Mowing one acre requires an estimated 0.75 gallons of gasoline

Tools used:
- Gallons of gasoline used for mowing were converted to metric tons of CO2 equivalent using the EPA's Greenhouse Gas Equivalencies Calculator

GHG Emissions Calculations
Establishment of Native Pollinator Habitat & Reduction of On-Site Mowing

GHG Emissions Reduction Calculation for the 140 acres to be established in 2025:

- Present emissions scenario: (0.75 gallons gasoline/acre * 100 acres * 21 mowing events/year) + (0.75 gallons/acre * 40 acres * 1 mowing event/year) = 1605 gallons gasoline/year = 14.3 metric tons CO2 equivalent per year
- Future emissions scenario: 0.75 gallons gasoline/acre * 140 acres * 0.33 mowing event/year = 34.65 gallons gasoline/year = 0.3 metric tons CO2 equivalent per year
- **Reduction of 14 metric tons CO2 equivalent per year starting in 2025**

GHG Emissions Reduction Calculation for the 100 acres to be established in 2026:
- Present emissions scenario: 0.75 gallons gasoline/acre * 100 acres * 21 mowing events/year = 1,575 gallons gasoline/year = 14 metric tons CO2 equivalent per year
- Future emissions scenario: 0.75 gallons gasoline/acre * 100 acres * 0.33 mowing event/year = 25 gallons gasoline/year = 0.2 metric tons CO2 equivalent per year
- **Reduction of 13.8 metric tons CO2 equivalent per year starting in 2026**

GHG Emissions Reduction Calculation for the 160 acres to be established in 2028:
- Present emissions scenario: 0.75 gallons gasoline/acre * 160 acres * 21 mowing events/year = 2,520 gallons gasoline/year = 22.4 metric tons CO2 equivalent per year
- Future emissions scenario: 0.75 gallons gasoline/acre * 160 acres * 0.33 mowing event/year = 39.6 gallons gasoline/year = 0.4 metric tons CO2 equivalent per year
- **Reduction of 22 metric tons CO2 equivalent per year starting in 2028**

GHG Emissions Reductions 2025-2030:
(5 years * 14 metric tons CO2 equivalent/year) + (4 years * 13.8 metric tons CO2 equivalent/year) + (2 years * 22 metric tons CO2 equivalent/year) = **169.2 metric tons CO2 equivalent reduced by 2030**

GHG Emissions Reductions 2030-2050:
20 years * (49.8 metric tons CO2 equivalent/year) = **996 metric tons CO2 equivalent reduced from 2030-2050**

Total GHG Emissions Reduction by 2050:
169.2 + 996 = **1,165.2 metric tons CO2 equivalent reduced by 2050**

Project Background B
Reforestation of 80 Acres of Riparian Area in the Grand River Valley
West Creek Conservancy proposes to reforest degraded riparian areas along the 2 miles of Grand River frontage that run through the former Diamond Shamrock property. Approximately 4,000 1" caliper trees will be planted, with species including sycamore, cottonwood, red maple, silver maple, sugar maple, northern red oak, white oak, American basswood, black willow, sandbar willow, and dogwood. The planting is anticipated to be complete by 2030.

Method Documentation
Assumptions include:
- Annual mortality rate of 10% for 20 years given the unknown soil conditions and slope of the river valley
- Trees are in good condition when planted and receive full sun

Tools used:
- CO2 sequestration and other ecological benefits of the tree planting were calculated using the USDA Forest Service's iTree Planting software (Version 2.7.0)

Results:
- **Total GHG Emissions Reduction by 2050: 540.3 metric tons of CO2**

Results

Project A and B at Painesville Site

- 2025-2030: 169.2 metric tons CO2e reduced
- 2025-2050: 1,705.5 metric tons CO2e reduced

Cumulative Emissions Reductions Total of both projects under Nature Based Solutions Measure

- 2025-2030: 169.2 metric tons CO2e reduced
- 2025-2050: 1,809.5 metric tons CO2e reduced

Cumulative Emissions Reductions Total for both GHG measures

- **2025-2030: 206,445.695 MT CO2e**
- **2025-2050: 995,319.667 MT CO2e**

Project	Unit	2025-2030	2025-2050
Painesville	MT CO2e	116,202.845	559,679.413
Cuyahoga County Solar	MT CO2e	90,073.650	433,830.754
Nature Based Solutions	MT CO2e	169.200	1809.500
Total	**MT CO2e**	**206,445.695**	**995,319.667**