

## Technical Appendix

### GHG Reduction Estimate Method

The City of Grand Rapids has utilized engineering estimates to develop the GHG reductions that are presented in this grant application. These have been developed by its internal team supported by third party engineers assisting in the development of the project. The following is a breakdown of the estimates, input data and calculations:

- **Measure 1 – Primary Circuit:** The City has an electrical distribution system that serves various municipal loads throughout Grand Rapids. This distribution system is known as the Grand Rapids Primary Circuit (PC). The interconnection of solar generation directly to the PC will directly reduce carbon emissions generated by the purchase of electricity from Consumers Energy. The following is a breakdown of the calculation methodology:
  - Total PC Annual load profile: 19.285 million KWh
  - Total installed capacity at the Butterworth Landfill tied to the PC: 2MW
  - Total estimated solar electric generation consumed by PC: 3,500 MWhr
  - Current GHG emissions per MWhr of Consumers Grid: 0.49797 MT GHG/MWhr
  - Section A Emissions reduction = Solar Generation \* GHG Emission Rate
    - $3,500\text{MWhr} * 0.49797\text{GHG/MWhr} = \text{Annual Reduction } 1,743 \text{ Tons of GHGs}$
- **Measure 2 – Community Solar:** The Butterworth Landfill will house 5MW of solar PV generation dedicated to the generation of renewable energy that will be provided to low income and disadvantaged communities within the city of Grand Rapids through the Consumers Energy Solar Gardens program (or privately developed community solar if legislation is passed). The total energy generated will directly reduce the emission of these communities by offsetting energy generation from GHG emitting sources:
  - Total Installed capacity of Community Solar: 5MW
  - Total estimated solar electric generation of Community Solar Array: 8,800 MWh
  - Fisher, Sheehan, & Colton, 2019, [Home Energy Affordability Gap, Michigan 2019](#)
  - Current GHG emission per MWhr of the Consumers Grid: 0.49797 MT GHG/MWh
  - Section B Emission reduction = Solar Generation \* GHG Emission Rate
    - $8,800\text{MWhr} * 0.49797\text{GHG/MWhr} = \text{Annual Reduction } 4,282 \text{ Tons of GHGs}$
- **Measure 3 – Vicinity Energy eSteam:** The City, in partnership with Vicinity, plans to distribute solar generated electricity from Butterworth Landfill to Vicinity's district energy system that generates heating for approximately 120 facilities through Grand Rapids downtown urban core. These facilities include municipal complexes, hospitals, residential buildings, civic infrastructure, churches, non-profit organizations, museums, commercial office buildings, etc. The use of electricity generated at the Butterworth Landfill to generate steam at the Vicinity Energy Plant will directly offset Vicinity's use of natural gas for the production of steam that serves these facilities. The following is the savings methodology for the Section C emissions savings:
  - Total installed Capacity to serve Vicinity Energy: 8MW
  - Total estimated electric generation by the proposed field: 27,100 Gwh
  - Electric Boiler efficiency: 98%
  - eSteam generation: 39,945 Mlbs

- Natural Gas consumption to be eliminated: 53,038 MMBTU
- GHG Emission of Natural Gas: 117 lbs/ MMBTU or 0.0531 MTCO<sub>2</sub>/ MMBTU
- GHG Savings = Natural Gas Consumption \* Natural Gas Emission Rate
  - 53,038MMBTU \* .0531GHG/MMBTU = Annual Reduction 2,815 Tons of GHGs

### **Models/ Tools Used**

The team developed its GHG reduction estimates using engineering modeling. This was based upon data and estimations collected from various sources and compiled in the GHG Calculation Spreadsheet (GHGCalcs\_CityofGrandRapids). The developer of the model was a collaborative team of engineers and project specialists for the City of Grand Rapids and its partners on the Butterworth project. Contributors include Vicinity Energy, Consumers Energy, Foresight Engineering, USGBC as well as information provided by 16 independent solar developers that provided responses to the City's Request for Information/Request for Qualifications for Butterworth Solar (most using Aurora HelioScope modeling tools).

### **Measure Implementation Assumptions**

Data used in the development of this application was developed and obtained by the City of Grand Rapids from City staff, third party developer partners, RFI/RFQ responders and publicly available information with references provided to primary data sources. The following is a list of primary data references:

- US Energy Information Administration – Michigan Energy Profile 2022: [Michigan Electricity Profile 2022 - U.S. Energy Information Administration \(EIA\)](#)
- [AR5 Synthesis Report - Climate Change 2014 \(ipcc.ch\)](#)
- EGLE, 2023, [Partnering to Reduce Energy Burden](#)
- Housing Next, 2022, [Housing Needs Assessment](#)
- Fisher, Sheehan, & Colton, 2019, [Home Energy Affordability Gap, Michigan 2019](#)
- IREC, 2022, [12<sup>th</sup> Annual National Solar Jobs Census](#)
- [City of Grand Rapids Strategic Plan](#)
- [Distributed Generation | Consumers Energy, Net Metering.pdf \(michigan.gov\)](#)
- [Distributed Generation | Consumers Energy](#)
- U.S. Census Bureau, 2020
- [Home Energy Affordability Gap, Michigan 2019](#)

Implementation milestones: The proposed project is anticipated to be completed over the next few years assuming adequate funding is acquired. Implementation milestone assumptions were based on similar projects, and the information derived from the developer responses solicited by the city. The city's engineering department also assisted in structuring the milestone schedule based on their experience with similar capital projects.

Measure lifetime: The anticipated measures utilizing solar to support the PC, community solar, and generation of eSteam to support heating of downtown commercial buildings, is anticipated to have a minimum life span of 30 years with appropriate operations and maintenance. This 30-year time span has been used for project analysis and review. The team, however, expects that with appropriate

operations and maintenance and prudent capital refurbishment at appropriate points in the system lifecycle, that the proposed measures will continue to have impact beyond the initial 30-year performance period. As a matter of practice, capital maintenance and replacement schedules for the PC component will be factored into the City's long-term capital planning and investment schedule.

Capital cost assumptions: Capital cost assumptions have been developed based upon RFI/RFQ responses submitted by 16 solar developers to the City of Grand Rapids in December 2023. Additional and supplemental project cost estimates have been provided by engineering and technical support for the City's internal estimating teams, as well as third-party engineering and development partners supporting the project.

## **GHG Reduction Estimate Assumptions**

### Emission rates/ emission factors

- Grid Emissions Rate – Data obtained from US Energy Information Administration – Michigan Energy Profile 2022: [Michigan Electricity Profile 2022 - U.S. Energy Information Administration \(EIA\)](#)
  - 2022 – Total Annual Electricity Generation for the State of Michigan: 117,497,052 MWh
  - 2022 – Total CO2 Emissions from Electric Generation: 58,510,000 Metric Tons
    - Electric Emissions Rate (2022) Reference Year: 0.49797 Metric Tons of CO2 (MTCO2)/ MWh
- EGrid emissions estimate: [https://www.epa.gov/system/files/documents/2024-01/egrid2022\\_summary\\_tables.pdf](https://www.epa.gov/system/files/documents/2024-01/egrid2022_summary_tables.pdf)
  - 2022 – Total annual emission output rate for Michigan: 1,015.7 lb/MWh of CO2e
    - 1,015.7 lb = 0.4607 metric tons
  - Michigan Nameplate Capacity: 35,383MW
  - Michigan 2022 estimated net generation: 116,615,131 MWh
- Natural Gas Emission Rate: 117 lbs CO2e/MMBTU
  - [Sources of Greenhouse Gas Emissions | US EPA](#)

### Input assumptions: Cost, performance data, energy prices

- Primary Circuit
  - 19,285,000 kWh in 2022
  - Power requirement
    - Daytime: 1.09MW (average), 0.77MW-1.63MW (range)
    - Nighttime: 2.95MW (average), 3.6MW (maximum)
- Community Solar
  - LIDAC Housing Needs – 7,452 kWh per household annually
  - Approximately - 12,000 LIDAC households in Grand Rapids
- Vicinity eSteam
  - Total Annual Steam Load: 560,000 Mlbs (2022 actual)
  - eBoiler capacity range: 1MW – 9 MW: Project Design value in Range 8MW
  - eBoiler output at 8MW: 22,800 lbs/hr
  - Vicinity baseload: 28,000 lbs/hr

- Existing plant efficiency: 92% (2022 annual average)
- Energy Rates
  - Grid Electricity Rate:
    - Primary Circuit: \$0.08/kWh
    - LIDAC Residential Rate: \$0.16/kWh
  - Natural Gas Rate: \$4.25/ MMBTU

### **Reference Case Scenario (GHG Emissions or Activity Level):**

The Reference Case Scenario is based upon 2022 actual energy consumption profiles. The Butterworth Solar project in all sections is anticipated to provide solar energy input to cover base load power (or portion of base load power) for each associated section. In addition, based upon the scale of power generation and continued anticipated growth of the city of Grand Rapids, it is anticipated that the base load of the city will not diminish. Therefore, the reference case scenario base year of 2022 is a conservative estimate and the full solar field energy will be easily absorbed by the community and provide for direct displacement of the fossil fuel base energy that is currently utilized.

Grid Emissions Rate – Data obtained from US Energy Information Administration – Michigan Energy Profile 2022: [Michigan Electricity Profile 2022 - U.S. Energy Information Administration \(EIA\)](#)

2022 – Total Annual Electricity Generation for the State of Michigan: 117,497,052 MWh

2022 – Total CO2 Emissions from Electric Generation: 58,510,000 Metric Tons

Electric Emissions Rate (2022) Reference Year: 0.49797 Metric Tons of CO2 (MTCO2)/ MWh

### Solar Field Generation

#### Section A: Primary Circuit PV Array

- Installed Capacity: 2MW
- Projected Electric Generation (Annualized): 3,500 MWh/ year
- Total Annual Primary Circuit Load (2022): 19,285 MWh
- Solar PV Array Generation Utilization: 100%
- 2022 Consumers Grid Emissions Rate: 0.49797 MT CO2 per MWh
- Annualized GHG Emission Savings (PV vs. Grid): 1,743 MTCO2e

#### Section B: Community Solar

- Installed Capacity: 5MW
- Project Electric Generation: 8,800 MWh/ year
- Total Annual Community Solar Potential Participation: LIDAC Homes estimated @ 12,000 homes = 90,000 MWh/ year
- Solar PV Array Generation Utilization: 100%
- 2022 Consumers Grid Emissions Rate: 0.49797 MTCO2e per MWh
- Annualized GHG Emission Savings(PV vs. Grid): 4,382 Metric tons of CO2

### Section C: Vicinity Energy eSteam

- Installed Capacity: 8MW
- Project Electric Generation: 13,500 MWh/ year (38,500 Mlbs of Steam)
- Total Annual Energy Input Steam System: 196,000 MWh/yr
- Solar PV arrange Generation Utilization: 100%
- 2022 Natural Gas Emissions: 51,200 MMBTU of Gas avoided @ 117 lbs CO2e/MMBTU
- Annualized GHG Emission Savings (PV vs. Natural Gas): 2,815 Metric Tons CO2e

### GHG Emissions Reduced:

The proposed project has an all-in GHG reduction projected to be 8,839 Metric Tons of CO2e per year. The development cycle anticipated in-service of the field and various components of the project to be online by the end of Q3 – 2026.

- Annual GHG Reductions: Total – 8,940 MT
  - Section A – Primary Circuit – 1,743 MT
  - Section B – Community Solar – 4,382 MT
  - Section C – Vicinity Energy eSteam – 2,815 MT
- Cumulative 2025 – 2030: 29,606 MT reductions
  - Partial 2026, full 2027-2030
- Cumulative 2025 – 2050: 194,410 MT reduction

The projected annual air emissions are based upon the total air emissions generated by Vicinity Energy in the production of steam for the benefit of downtown Grand Rapids. The current air emissions, as actively monitored through a Continuous Emissions Monitoring System (CEMS) and reported as part of Vicinity Energy's air permit, are based upon the utilization of natural gas as the energy source for production. The generation of steam utilizing renewably generated electricity will directly offset use of natural gas. The co-pollutant reduction is based upon the ratio of electric generated steam compared to the total steam generation for the facility (2023 values), and then the reduction of that ratio in the total annual air emission (2023).

Current annual steam production: 535,000 Mlbs

ESteam production (utilizing the 8MW array): 39,945 Mlbs

Ratio of annual eSteam to total production: 7.47%

	tons
CO	32.4001482
NO2 *	38.571605
PM10 - Primary	2.93144198
PM 2.5 - Primary	2.93144198
SO2	0.23142963
VOC	2.121438275

Lead	0.000192858
Ammonia	0.189000865

Emissions reductions 7.47 % due to eSteam direct offset of natural gas combustion

	eSteam Annual Projected Emissions Reductions (Tons)
CO	2.42
NO2 *	2.88
PM10 - Primary	0.22
PM 2.5 - Primary	0.22
SO2	0.02
VOC	0.16
Lead	0.00
Ammonia	0.01