

TECHNICAL APPENDIX

This appendix explains the methodology and assumptions used for developing the estimated greenhouse gas (GHG) emissions and co-pollutant emissions reduced for the **Accelerating Methane Capture and Renewable Natural Gas Adoption at Wastewater Facilities in Eastern Iowa** measure included in the East Central Iowa Priority Climate Action Plan.

Cedar Rapids Emission Reductions Estimate Methodology

Biogas quantities and quality were developed from plant mass balance, process models and bench scale pilot information. RNG production was developed based on methane capture and uptime of the biogas conditioning equipment. Below is a summary of the biogas production estimates for Phase 1 and Phase 2:

For 759 scfm * 580 BTU/scf * 1440 min/day * 365 day/year * 97% methane capture * 95% uptime = 213,000 MMBTU/year

Annual emission reduction estimates were then developed using the life cycle approach and an assumed carbon intensity score for the renewable natural gas produced. Below is the description of the approach and calculations. No co-pollutant benefits were included.

Lifecycle Approach

A lifecycle accounting methodology utilizes the RNG's carbon intensity (i.e., GHG emissions per unit of energy) which varies substantially between feedstocks and production methods. Carbon intensities include methane emission offsets which reflect the reduced emissions due to a change in production practice or elimination of emission sources like landfill emissions or uncovered farm lagoons. Carbon intensities can also vary by location of production and how the fuel is transported and distributed.

Calculation - *MMBtu of RNG produced (MMBtu/yr) * (CI Reference Target for RNG - Feedstock CI Score)gCO₂e/MJ * 1,055 MJ/MMBtu * 1 MT/1,000,000grams = GHG Emission Reduction (tCO₂e/yr)*

Assuming a CI Score of +30 gCO₂e/MJ (assumed) and a reference CI Score of +94.71 gCO₂e/MJ(diesel)

213,000 * (94.7 – 30) * 1055 * 1 /1,000,000 = 14,539 tCO₂e/year (metric tons)

Models/Tools Used

The estimated biogas production was developed using an plant mass balance model. This spreadsheet-based model was developed by HDR Engineering.

Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Geographic Scope - Biogas production, conditioning, and pipeline injection at the Cedar Rapids Water Pollution Control Facility.
- Implementation measure uptake – The measure will capture 97% of the methane produced in the anaerobic digestion process. The biogas conditioning equipment is also anticipated to have an uptime of 95%.
- Implementation measure milestones – Phase 1 is scheduled to be completed in late 2026 and Phase 2 will be completed in 2031.
- Measure lifetime - 2025 to 2050.
- Capital Cost Assumptions - Cost estimates generated using comparisons to other similar projects recently constructed in the Midwest, the use of RS Means construction cost standards, discussions with major equipment vendors, and utilizing a seasoned contractor to evaluate construction cost and constructability.
- Operational and maintenance cost assumptions – Comparison of other plant process operations, comparison to other facilities in the Midwest, cost of critical spares and parts, and general oversight and administration.

Emission Reduction Estimate Assumptions

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

Below are the major assumptions used to quantify the emissions reductions for this measure.

1. Biogas Quantities – Anticipated biogas production was developed from a plant mass balance and digestion process model. This model assisted with determining the average annual biogas production, in standard cubic feet per minute (scfm), for the Phase 1 project including digestion and biogas conditioning as well as the Phase 2 improvements when the thermal hydrolysis process (THP) is added to improve digester performance.
2. Biogas Quality - Anticipated biogas quality, including a heating value of 580 BTU/cubic foot, was estimated from the anaerobic digestion and THP piloting performed during the study phase of the project.
3. Implementation Costs – Costs were developed from 90% design drawings and vendor quotes. Operation and maintenance costs were developed from energy costs of electricity, labor costs, and material costs from the vendor provided information and similar projects.

4. RNG production - RNG production was estimated using an assumed methane capture of 97% and an equipment uptime of 95% which are the values provided by the biogas conditioning equipment vendor.
5. RNG Carbon Intensity - For the emissions reduction estimates, a carbon intensity of the RNG was assumed to be +30gCO₂e/MJ, which is typical for RNG produced from biogas generated at municipal wastewater treatment plant.

Reference Case Scenario

The reference case scenario of not implementing this measure includes the combustion of the biogas through an on-site waste gas flare which results in a reduction of 0.0 metric tons of carbon dioxide equivalent.

Measure-Specific Activity Data and Implementation Tracking Metrics:

Metrics tracked for estimated emissions reductions for this measure include measuring and monitoring of renewable natural gas (RNG) injected into the MidAmerican Energy (MEC) Pipeline and sold as vehicle fuel in compliance with the EPA Renewable Fuel Standard (RFS) program. Monitoring of RNG quantities will be performed with EPA approved gas flow meters and RNG quality and BTU content will be measured with an EPA and MEC approved gas chromatograph. Additional metrics could include calculation and verification of the RNG carbon intensity CI score produced by the facility, which is estimated to be +30gCO₂e/MJ for this application.

GHG Emissions Reduced:

Implementation of this measure is anticipated to reduce 14,539 metric tons of carbon dioxide equivalents (mtCO₂e) per year from the proposed improvements with 43,617 cumulative mtCO₂e for the period between 2025 – 2030 and 334,398 cumulative mtCO₂e for the period between 2025 – 2050.

2027 – 2029 = 14,539 mtCO₂e/yr * 3 yrs = 43,617 mtCO₂e cumulative

2030 – 2050 = 14,539 mtCO₂e/yr * 20 yrs = 290,781 mtCO₂e cumulative

Total GHG Emissions Reductions for Cedar Rapids WWTF Upgrades:

2025 – 2050 = 43,617 mtCO₂e + 290,781 mtCO₂e = 334,398 mtCO₂e

Iowa City Emission Reductions Estimate Methodology

Biogas quantities and quality were developed from existing plant data, including digester gas production data, sludge loading data and mass balances, and estimates of additional digester gas production in the future as a result of codigestion of hauled in industrial wastes. RNG

production was developed based on the RNG manufacturer's estimates related to methane capture and uptime of the biogas conditioning equipment.

Biogas amounts are projected to increase over time, both as a result of community growth and as a result of hauled waste additions to the digestion facilities for additional gas production.

The gas flow estimates are provided below:

Near Term (through 2030): 52,100 million British thermal units (MMBtu)/year

Long-Term (2030-2050): 54,600 MMBtu/year

Annual emission reduction estimates were then developed using the life cycle approach and an assumed carbon intensity (CI) score for the RNG produced. The assumed CI scores are based on related EPA documents and engineering experience. Below is the description of the approach and calculations. No co-pollutant benefits were included.

Emission Reduction Estimate Assumptions

1. **Biogas Quantities:** Anticipated biogas production was developed from the plant's historical gas production data, as well as from estimates of future growth and experience with co-digestion operations elsewhere.
2. **Biogas Quality:** Anticipated biogas quality, including a heating value of 600 BTU/cubic foot, was estimated based on gas sampling and comparable projects.
3. **Implementation Costs:** Costs were developed from conceptual design layouts, vendor quotations, and discussions with the local gas utility. design drawings and vendor quotes. Operation and maintenance costs were developed from energy costs of electricity, labor costs, and material costs from the vendor provided information and similar projects.
4. **RNG Production:** RNG production was estimated using an assumed methane capture of 99% and an equipment uptime of 95%, which are the values provided by the biogas conditioning equipment vendor.
5. **RNG Carbon Intensity:** For the emissions reduction estimates, a CI of the RNG was assumed to be +30gCO₂e/MJ, which is typical for RNG produced from biogas generated at municipal wastewater treatment plants.

Models and Tools Used

The estimated biogas production was developed using the existing Iowa City biogas production data, as well as future digestion loading projections and future hauled waste volumes and loadings. This spreadsheet-based model was developed by Strand Associates, Inc.

Measure Implementation Assumptions

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure.

- Geographic Scope: Biogas production, conditioning, and pipeline injection at the Iowa City South Wastewater Treatment Facility.
- Implementation Measure Uptake: The measure will capture 99% of the methane produced in the anaerobic digestion process. The biogas conditioning equipment is anticipated to have an uptime of 95%.
- Implementation Measure Milestones: The RNG and hauled waste acceptance facilities are projected to be on-line by January 1, 2028.
- Measure Lifetime: 2025 to 2050.
- Capital Cost Assumptions: Capital cost opinions were developed as part of conceptual design project for the RNG facilities during the summer of 2023. Manufacturer proposals were solicited to inform the equipment costs, and the local gas utility was consulted for connection locations and utility charges for the project. The overall capital costs are based on +/- 30% estimating value. Approximately 30 million dollars.
- Operational and Maintenance Cost Assumptions:
 - RNG plant O&M (\$175,000) Technology vendor service contract + media replacement and disposal
 - RNG transmission (\$123,000) Injection, balancing and transmission charges.
 - MEC annual charge (\$54,000) Basic service charge + quality monitoring + O&M
 - NG charges (\$210,000) NG demand in boilers in lieu of digester gas
 - Power charges (\$86,500) Additional power demand for RNG plant
 - Reporting/compliance(\$50,000) Third party RIN verification process
 - RIN sales support (\$385,000) 20% Broker/off-taker fee
 - Additional staffing (\$40,000) 0.5 FTE
 - Total (\$1,123,5

Lifecycle Calculations

2028 - 2030: $52,100 * (94.7 - 30) * 1055 / 1,000,000 = 3,667 \text{ MTCO}_2\text{e/year} = 11,000 \text{ MTCO}_2\text{e}$

2031-2050: $54,600 * (94.7 - 30) * 1055 / 1,000,000 = 3,700 \text{ MTCO}_2\text{e/year} = 74,000 \text{ MTCO}_2\text{e}$

Total GHG Emissions Reduced

2028 – 2030: $52,100 * (94.7 - 30) * 1055 / 1,000,000 = 3,667 \text{ MTCO}_2\text{e/year}$

= 11,000 MTCO₂e

2031 – 2050: $54,600 * (94.7 - 30) * 1055 / 1,000,000 = 3,700 \text{ MTCO}_2\text{e/year}$

= 74,000 MTCO₂e

2025 – 2050: 11,000 + 74,000 = 85,000 MTCO₂e