Technical Appendix – Missouri Department of Natural Resources CPRG Implementation Application

GHG Priority Measure 1: Renewable Energy (pages 9-11 Missouri Plan for Environmental Improvement Grants)

Calculating Emissions Associated with Utility and Building Solar Energy Production

To calculate emissions of CO_2 equivalent GHG emissions reductions due to the investment in solar power generation, EPA's AVoided Emissions and geneRation Tool (AVERT) - Web Edition was used. AVERT evaluates how energy policies and programs such as energy efficiency, renewable energy, and electric vehicles lead to changes in emissions of particulate matter ($PM_{2.5}$), nitrogen oxides (NO_X), sulfur dioxide (SO_2), carbon dioxide (CO_2), volatile organic compounds (VOCs), and ammonia (NH_3) from electric power plants at a county, state, or regional level. Midwest and Central region data was used to determine energy and emissions reductions for each specific project proposed. For building-scale solar projects of 1 MW or less, AVERT 2022 Emission Rates for Distributed PV were used. See Industrial Solar, Building Solar, FMDC Solar and State Parks tabs of Technical Appendix Spreadsheet

The magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050

According to the Department of Energy, the estimated operational lifespan of a PV module is about 30-35 years, although some may produce power much longer. However, solar panels slowly degrade over time and produce less electricity from the same amount of sunlight. This is due to external factors such as microcracks forming through thermal cycling, flexing due to strong winds and degradation due to extreme cold and hot weather, humidity and snow and ice. For projecting emissions reductions to years beyond the initial installment, it is assumed that efficiency of solar installations projects will degrade by 1% per year in operation. See Industrial Solar tab of Technical Appendix Spreadsheet.

Measure 2: Electric Conversions (pages 12-15 and 21-22 Missouri Plan for Environmental Improvement Grants)

Measure 2.1: Electric Vehicle Fleet Conversion

Emissions reductions of CO2e due to conversion of conventional gasoline vehicles to electric were determined using the U.S. Department of Energy's Alternative Fuels Data Center (AFDC). For the state of Missouri, the CO_2 emissions reduction for replacing one gasoline vehicle with one electric vehicle, according to AFDC is 4.7 tons/year.[1] Emissions reductions other pollutants of concern were determined using EPA's Avoided Emissions and Generation Tool (AVERT). Because AVERT does not accurately analyze small changes in fleets, for projects replacing fewer than 10 vehicles, 100 vehicles was assumed in the model and the results were scaled down. See the EV Fleet tab of the Technical Appendix spreadsheet.

Measure 2.2: EV Charging Infrastructure

Several projects include the purchasing of electric vehicles along with private charging stations. These EV chargers were not considered to reduce emissions beyond what is accounted for by the replacement of a gasoline vehicle by the EV. To calculate the emissions reductions from publicly available direct current fast and alternating current chargers, it was determined how the increase in charging infrastructure would affect the number of EVs purchased. 2021 EV registration and charging infrastructure data from the Energy Information Administration (EIA data) was used.[2][3]

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[1] Alternative Fuels Data Center: Emissions from Electric Vehicles (energy.gov)

[2] The United States surpassed two million on-road light-duty electric vehicles in 2021 - U.S. Energy Information Administration (EIA)

[3] Trends in charging infrastructure – Global EV Outlook 2022 – Analysis - IEA

In 2021 there were: 2.13 million total US EV registrations, 65% BEVs (1.385 million) and 35% PHEV (745,000); 22,000 publicly available fast charging points; and 92,000 level 2 charging points. The calculations below assume only BEV (and not PHEV) adoption will increase with more charging stations.

Therefore:

1,385,000 BEVs\114,000 public charging points = 12.149 BEVs per charging point
1,385,000 BEVs\22,000 fast public charging points = 62.954 BEVs per fast charging point
1,385,000\92,000 slow public charging points = 15.054 BEVs per slow charging point

Controlling for double counting:

62.954 BEVs\fast point – 12.149 BEVs\total points = 50.805 BEVs/fast point
15.054 BEVs\slow point – 12.149 BEVs\total points = 2.905 BEVs/slow point

So, Correlation Factors[4] =

- 50.805 BEVs per Public Fast Charging Point
- 2.905 BEVs per Public Level 1 or 2 Charging Point

See the EV Charging tab of the Technical Appendix spreadsheet.

<u>Measure 2.3: Pump and Engine Conversions</u>
The Missouri Department of Conservation (MDC) will replace 4 diesel powered engine pumps and 22 diesel powered engine wells with electric. The pumps run continuously for 4 months per year and the wells run continuously for 5 months per year. The replacement will result in a reduction of 64,800 gallons of diesel fuel burned in these units. CO2e reductions were calculated using 22.45 lb/gallon.[5] See Electric Conversations tab of the Technical Appendix spreadsheet.

Macon and Marshall Municipal Utilities will replace diesel powered peaking generators with 2 – 4 hour electric batteries. The batteries will be charged at off-peak times with renewable sources such as wind which will reduce emissions by 46% or 727 lb/Mwh. With two 4-hour batteries discharging a projected 200 times per year, this will result in 1,163,200 lbs of CO2 avoided annually during the hours when energy has the most coal and natural gas on the grid. See Electric Conversations tab of the Technical Appendix spreadsheet.

St. Louis County Department of Health will deploy a lawn mower replacement program which will remove 1,250 gas-powered lawn mowers with electric mowers. Assuming 22 hours annual usage per mower, 0.5 gallons gasoline per hour, and 17.7 lb CO2 per gallon,[6] this project will reduce CO2 emissions by 121.7 tons/year. State Parks lawnmowers were assumed to run 6 hours per day, 4 days per week for 6 months. Commercial mowers will use on average 1.5 gallons per hour. See Electric Conversations tab of the Technical Appendix spreadsheet.

The magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050
For projecting emissions reductions for EV fleet conversations, the reductions due to the City of Springfield were considered according to the replacement plan they submitted. All other vehicles were

[4] Correlation factors don't attempt to control for any other factors that also impact EV prevalence other than public charging stations, such as policies, tax credits, EV availability, etc.
[5] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis
[6] How to Calculate the Carbon Footprint of Your Lawn Mower | Sciencing

assumed purchased in 2026 and emissions reductions are assumed to remain steady for the life of the vehicle. Each electric vehicle was also presumed to be replacing a gasoline engine powered vehicle.

For projecting emissions reductions due to EV charging infrastructure, it was assumed that emissions reductions would remain steady for the life of the charging points. Although it is likely that greater availability of charging stations would increase EV ownership over time, supporting data is not available.

For projecting emissions reductions for other electric conversation projects are assumed to be fully implemented by 2026 and begin realizing reductions with the annual emissions reductions assumed to remain steady for future years.

Measure 3: Waste Management (pages 18 to 21 of the Missouri Plan for Environmental Improvement Grants)

Measure 3.1: Methane Capture

Calculating Emissions Associated with the Scenarios

To calculate emissions of CO_2 equivalent GHG emissions reductions due to the investment in expanded methane gas to energy projects at landfills and from anaerobic digestors at wastewater treatment plants' baseline emissions were compared to project outcomes on a per project basis, as every project was unique. See Methane Capture tab of the Technical Appendix Spreadsheet.

Project 1: City of Springfield, MO Noble Hill Landfill

This project size is based on the LFG model future flow rate projection at 2,000 scfm, adjusted to 1,795 scfm due to 55.7 percent design methane content.

1,795 scf/min x 60 min/1hour x 8760 hour/year = 943 MMscf/year

1038 MMscf/year x .0238 scm/1 scf = 22.45 MMscm/year

Assume a typical associated gas composition, flare combustion efficiency of 91%[7], a Global Warming Potential for methane of 25, each cubic meter of associated gas flared results in about 2.8 kilograms (6.2 lbs) of CO_2 equivalent emissions, and each ton of non-combusted methane results in 84 tons of equivalent CO2 emissions.[8][9]

22.45 MMscm/year x .09 = 2.02 MMscm methane directly emitted

2.02 MMscm x 1,000,000scm/MMscm x 1.58 lb/1 scm x 1 ton/2000 lb x 84 ton CO2e/1 ton methane = 134,105 ton CO2e

2.45*0.91 MMscm/year x 1,000,000 scm/MMscm x 6.2 lbs CO2e/scm x 1 ton/2000 lbs = 63343 tons CO_2

Total CO2e emissions avoided = 147,518.3 + 69,678.7 = **187,448 tons CO2e**

Project 2: City of Springfield, MO Southwest Wastewater Treatment Plant

At 500 scfm and an expected methane recovery of 97.5 percent, the RNG plant would produce 422 MmBtu/day of RNG at 100 percent design capacity.

500 scf/min x 60 min/1hour x 8760 hour/year = 262.8 MMscf/year

262.8 MMscf/year x .0238 scm/1 scf = 6.25 MMscm/year

[7] New study finds flaring source of five times more pollution than previously thought (edf.org)

[8] What is Gas Flaring? (worldbank.org)

[9] CO2 equivalents | Climate Change Connection

Assume a typical associated gas composition, flare combustion efficiency of 91%,[10] a Global Warming Potential for methane of 25, each cubic meter of associated gas flared results in about 2.8 kilograms (6.2 lbs) of CO_2 equivalent emissions, and each ton of non-combusted methane results in 84 tons of equivalent CO_2 emissions.[11]

6.25 MMscm/year x .09 = 0.0563 MMscm methane directly emitted

0.0563 MMscm x 1,000,000 scm/MMscm x 1.58 lb/1 scm x 1 ton/2000 lb x 84 ton CO2e/1 ton methane = 37,355.2 ton CO2e

5.69 MMscm/year x 1,000,000 scm/MMscm x 6.2 lbs CO2e/scm x 1 ton/2000 lbs = 17644.3 tons CO_2e

Total CO2e emissions avoided = 37,355.2 + 17,644.3 = **55,499.5 tons CO2e**

Project 3: Lee's Summit Landfill

The Lee's Summit Landfill has an active gas collection and control system that extracts methane gas from the landfill and converts it to carbon dioxide through flaring. The improvements will increase gas collection, which will reduce fugitive methane emissions from the landfill and reduce overall metro GHG emissions. The additional methane collected will be flared, which converts the methane to carbon dioxide, which is a less potent GHG. With these improvements, the site becomes likely to be considered for a landfill gas to energy project. Completing these improvements to the gas collection system will make development of a project at this site more advantageous to a future gas-to-energy development, making clean energy for the surrounding area. Since the system is already largely in place and functional, these additional funds could result in the capture of at least an additional 150 scfm of landfill gas, if not more. This equates to at least 20,000 tons of carbon equivalent GHG tons on a yearly basis.

150 scf/min x 60 min/1hour x 8760 hour/year = 78.84 MMscf/year

78.84 MMscf/year x .0238 scm/1 scf = 1.88MMscm/year

Assume a typical associated gas composition, flare combustion efficiency of 91%,[12] a Global Warming Potential for methane of 25, each cubic meter of associated gas flared results in about 2.8 kilograms (6.2 lbs) of CO_2 equivalent emissions, and each ton of non-combusted methane results in 84 tons of equivalent CO_2 emissions.[13]

1.88 MMscm/year x 0.91 = 1.70 MMscm/year flared

=1.70 MMscm/year x 1,000,000 scm/MMscm x 6.2 lb CO2e/scm x 1 ton/2000 lbs = 5923.3

If not flared:

1.88 MMscm/year x 1,000,000 scm/MMscm x 1.58 lb/1 scm x 1 ton/2000 lb x 84 ton CO2e/1 ton methane = 124,756.8 tons CO2e

Total CO2e emissions reduced by project = 124,756.8 tons – 5923 tons = **119,463.5 tons**

Project 4: Prairie View Landfill

The City of Lamar currently operates a methane to energy generation facility at the Prairie View Landfill. Expanding and adding additional generation equipment to the existing facility will increase the amount of methane consumed and reduce emissions.

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[10] New study finds flaring source of five times more pollution than previously thought (edf.org)

[11] Benefits of Landfill Gas Energy Projects | US EPA

[12] New study finds flaring source of five times more pollution than previously thought (edf.org)

[13] CO2 equivalents | Climate Change Connection

Lamar has the following engines currently installed and operational:

(4) CAT G3520C (1600KW) units = consumes **450 scfm** of methane

(1) GUASCOR (1200KW) units = consumes **380 scfm** of methane

The one Guascor engine is a smaller engine (16-cylinder vs 20-cylinder CAT) and consumes less methane than the CATS. Due to the containments within the methane, one engine is always out-of-service for maintenance. Spark plugs are replaced every 800 hours and the engine heads are replaced every 10,000 hours. So, we essentially only have (4) engines operational at any one time. This project proposed adding (2) CAT Generator sets, fuel scrubbing equipment and building additions. Emissions reductions assume that the installation of the two ne generators will allow the operation of 5 sets continuously and allow one to be down for maintenance.

Current landfill gas produced (2024) is projected to be 3493 scfm, with 75% captured = 2620 scfm.
Of the 2620 scfm, 1800 scfm will be flared and 820 scfm will be combusted for energy.
The propped engine installations will result in 63 scfm flared and 2630 scfm combusted for energy (2025), resulting in a net difference is -757 scfm flared and +1810 scfm combusted for energy.

Assume a Global Warming Potential for methane of 25, each cubic meter of associated gas flared results in about 2.8 kilograms (6.2 lbs) of CO2 equivalent emissions,

757 scfm x 60 min/hr x 8760 hr/year = 3.98×10^8 scf/year

3.98×10^8 scf/year x 0.0283 scm/1 scf x 6.2 lb CO2e x 1 ton/2000 lb

= **34,905 tons CO2e/year avoided**

The magnitude of GHG reductions from 2025 through 2030

The timeline of these projects is such that they will not be completed until at least half-way through 2026, so emission reductions will not begin to be realized until then. For 2026, 50% of emissions reductions is assumed and each year thereafter, full emissions reductions calculated. Emissions projections through 2030 are cumulative. See the Methane Capture tab of the Technical Appendix Spreadsheet.

The magnitude of GHG reductions from 2025 through 2050

Generally, more recently buried waste (i.e., waste buried less than 10 years) produces more landfill gas through bacterial decomposition, volatilization, and chemical reactions than does older waste (buried more than 10 years). Peak gas production usually occurs from 5 to 7 years after the waste is buried. [14] However, emissions reductions will continue to be realized for each year thereafter the systems are installed as newer waste is introduced to the landfills and operations expand. The Prairie View Landfill has plans to close in 2026, however significant amounts of landfill gas will continue to be produced for at least 20 years, after which it will slow down. Emissions projections through 2050 are cumulative. See the Methane Capture tab of the Technical Appendix Spreadsheet.

Measure 3.2: Waste Reduction and Recycling

Calculating Emissions Associated with the Scenarios

Anticipated waste reduction data was gathered from recycling project applicants and the Perry County Refuse-to-Energy system for input into EPA's Waste Reduction Model (WARM). Recyclables that would have gone to the landfill but were assumed to be recycled include: 2,606 tons of cardboard/paper; 321

[14] ATSDR - Landfill Gas Primer - Chapter 2: Landfill Gas Basics (cdc.gov)

tons of glass; 264 tons of mixed metal; 412 tons of mixed plastics; and 20.4 tons of mixed recyclables. The Refuse-to-Energy project will divert 174,000 tons of mixed solid waste. The City of St. Peters' route optimization software for municipal solid waste pickup will reduce annual VMT by 20% or 35,065. Assuming 3 MPG per vehicle, this will reduce the use of 11,688 gallons of diesel resulting in a 119-ton CO2e annual reduction. See Waste-Recycling tab of the Technical Appendix Spreadsheet.

The magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050
For projecting emissions reductions for recycling projects for City of St. Peters and the rural statewide recycling centers, a 2% annual increase in participation was assumed. The emissions for the Refuse-to-Energy project were assumed to begin in 2028 and remain steady for the life of the system. Emissions reductions due to the route optimization software were also assumed to remain steady for future years. See Waste-Recycling tab of the Technical Appendix Spreadsheet.

Measure 4: Energy Efficiency (pages 7-9 of the Missouri Plan for Environmental Improvement Grants)
Measure 4.1: Weatherization and Building Energy Efficiency Upgrades
Calculating Emissions Associated with the Scenarios
Emissions reductions were calculated using the estimated energy savings per project based on energy audits or data taken from utility bills. Emission factors for CO_2 reductions in natural gas usage were gathered from the EPAs greenhouse gas equivalencies calculator[15] and from eia.gov FAQs[16] for kWh reduced. It was assumed that the offset in energy used was produced from a coal power plant due to Missouri's large reliance on coal as a fuel source of energy production. Energy savings due to the installation of spray foam insulation was estimated from industry standards.[17] Demand response system projects energy savings were considered to grow each year up until 10 years and then level out. Emissions reductions for State Parks and FMDC projects were determined using AVERT with electricity usage reduced as input. For natural gas usage reductions, a factor of 14.42 kg CO_2/MMBtu was used and then converted to tons. See the Energy Efficiency-Weatherization, FMDC Energy Efficiency and State Parks tabs in the Technical Appendix spreadsheet.

The magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050
For projecting emissions reductions for weatherization and energy efficiency upgrades, annual emissions reductions for APCP projects were assumed to begin in 2026 and considered to be stable through 2050, except for demand response system projects, for which energy savings were considered to grow each year up until 10 years and then level out. Projects for FMDC and State Parks are assumed to begin in 2025 and be completed in the third year of the program. See the Energy Efficiency-Weatherization, FMDC Energy Efficiency and State Parks tab in the technical appendix spreadsheet.

Measure 4.2 State Pre-Weatherization program and Weatherization program expansion
Calculating Emissions Associated with the Scenarios
Emissions reductions for funds associated with the expansion of the existing Weatherization program were based on data collected through past years of the program. Energy savings data is collected from energy audits during the upgrade process, as well as information about the cost of upgrades. If a home is rejected from the program, the reason for this rejection is also recorded. The additional average cost of remedial enabling work was applied to the requested CPRG funding to estimate the number of

[15] Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA
[16] Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA)
[17] How Much Does Spray Foam Insulation Save - Save Money With Energy Audits, Air Conditioning Service and Insulation With Green ID (greenintegrateddesign.com)

projects expected to be funded through this expansion. Using program averages for energy savings per project, this number of projects was used to calculate an expected emissions benefit from the magnitude of energy savings using AVERT. Because the Weatherization Assistance Program operates in all areas of the state, and because Missouri is split between the Central and Midwest power grids, the statewide magnitude of energy savings was split in accordance with AVERT's user guide Appendix G to estimate the state's overall emissions reduction. See the State Weatherization Supplement tab of the technical appendix spreadsheet

Magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050
To project emissions reductions for the Pre-Weatherization Program expansion, it was assumed that projects would be equally distributed across years 2-5 of the program (2026-2029). As such, the annual cumulative energy use reduction increases across these years as more projects are assumed to finish and come online. These savings, and the associated emissions reductions, were assumed to be stable year over year for 2030 and beyond.

Measure 5: Land Use (pages 15-18 of the Missouri Plan for Environmental Improvement Grants)
Calculating Emissions Associated with the Scenarios
<u>Measure 5.1: Urban Greening and Afforestation</u>
Emissions reductions resulting from the planting of trees in urban greening and afforestation projects was calculated using information from the US Department of Agriculture (USDA) website[18] and the i-Tree tool.[19] The USDA estimates that in one year a mature tree will absorb more than 48 lbs of carbon dioxide and release oxygen in exchange. Although the type of trees planted will vary, it was assumed that each tree planted was a common maple tree. Co-pollutant emissions reductions were determined using the i-Tree tool. Location data was input into the tool when available with adequate specificity. See Land Use-NS tab in the Technical Appendix spreadsheet.

<u>Measure 5.2: Prairie and Native Plants Cultivation and Restoration</u>
For projects involving restoration or planning of prairie grass and pollinator plots, emissions calculations of CO_2 were determined using information from the Missouri Prairie Foundation, which states than one acre of intact prairie can absorb one ton of carbon in its roots and soil per year.[20] For the cover crop project, the University of Missouri provided research and an extensive analysis of carbon sequestration potential of cover crops, determining that each acre can absorb up to 3 metric tons of CO2e per acre cover crop planted. Supporting information was also found in the Journal of Soil and Water Conservation, article Cover crop impacts on US cropland carbon sequestration. [21] Emissions reduction potential for Missouri State University's propagation of giant cane was calculated utilizing the following research submitted by the applicant and supported by articles submitted.[22][23]
1 acre planted giant canebrake (monoculture) estimated for first 5 years, 10 years and 30 years. From planting to maturity is 10 years (7-10).

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[18] The Power of One Tree - The Very Air We Breathe | USDA
[19] i-Tree Tools - Calculate the benefits of trees! (itreetools.org)
[20] Prairie Facts - Missouri Prairie Foundation (moprairie.org)
[21] Cover crop impacts on US cropland carbon sequestration | Journal of Soil and Water Conservation (jswconline.org)
[22] Propagatio, physiology, and biomass of Giant Cane (Arundinaria gigantea) for conservation and restoration; J. Bamboo Rattan (2023) 22(1):17-29 https://doi.org/10.55899/09734449/jbr022103
[23] Carbon Footprint offset of a managed Bamboo plantation in temperate regions; Sustainable Production and Consumption 40(2023)220-235: www.elsevier.com/locate/spc

At maturity a canebrake will have a net positive carbon uptake of 100 tons CO_2/acre (estimated both Sharma and Wait, 2023 with giant cane and Marchi et al. 2023 with Moso bamboo*)
Cumulative totals:

- Year 1: 4,000 rhizomes (24 inches in length) with four 24 inch culms (plants)** attached are initially planted per acre = 1 ton CO_2/acre
- Year 5: 12,000 culms = 375 tons CO_2/acre
- Year 10: 16,000 culms = 800 tons CO_2/acre (this can be maintained with harvest for 30 years = 2,400 tons CO_2/acre)
- Year 30 without harvest: 116,000 culms = 1,600 tons CO_2/acre

The magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050

New trees planted do not absorb as much carbon as a mature tree therefore emission reductions were assumed to be 0 the first year of planting, 5% of 48 lbs the second year of planting and increase 5% each year until assumed maturing at 20 years. Each year thereafter, carbon absorption was assumed to be stable. Several projects involve the planting of up to 3,000 trees each year so cumulative emissions reductions were calculated for these scenarios. Co-pollutant emissions reductions were determined using the i-Tree tool.

CO2e emissions reductions for giant cane propagation were projected to increase 10-fold each year until year 10 and then remain steady. Emissions reductions for other cover crop, native and prairie restoration were assumed to be stable yearly and cumulative totals were calculated. See Land Use -NS tab of the Technical Appendix spreadsheet.

<u>Measure 5.3: Alternative Transportation and Greenways</u>

Emissions reductions due to the construction of trails in conjunction with Interstate-44 improvements in Springfield, MO were calculated using the following equations for Auto VMT reductions, where D = 320; ADT = 7200; L = 3.0; A = 0.0104; and C = 0.0015 (Over 7 activity centers within ½ mile). The new trails were calculated to reduce VMT by 83,166 miles annually.

Equation 1: Auto VMT Reductions (current method)

$$Auto\ VMT\ Reduced = (D) * (ADT) * (A + C) * (L)$$

Where,

			Units
D	=	days of use per year (default is 200 days)	Days
ADT	=	annual average two-way daily vehicular traffic on parallel road (project-specific data, with a maximum of 30,000)	Trips/day
A	=	adjustment factor (table lookup value)	-
C	=	activity center credit (table lookup value)	-
L	=	walking trip length (1.0 miles/trip in one direction)	Miles/trip

To convert VMT to CO2e reductions, EPAs greenhouse gas equivalencies calculator[24] was referenced and a factor of 3.9×10^{-4} metric tons of CO_2e/mile was used. See the Alternative Transportation Tab in the Technical Appendix spreadsheet.

The magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050

For projecting emissions reductions from the I-44 trail project, reductions were assumed to begin by mid-2026, therefore half of the annual emissions reductions was assumed for the first year. It was assumed that usage of the trail would grow by 1% from the 2026-year estimate. See the Alternative Transportation Tab in the technical appendix spreadsheet.

[24] Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA

Measure 6: Sustainable Agriculture Practices (pages 21-22 of the Missouri Plan for Environmental Improvement Grants)

Calculating Emissions Associated with Scenario

Emissions reductions for funds associated with the Agriculture Energy Efficiency Grant Program were estimated based on data from the Energize Missouri Agriculture Program (EMAP). The projects from EMAP were sorted into categories for GPS/guidance systems, solar fences, solar energy generation, farm building energy efficiency (including insulation, lighting, and HVAC projects), farm equipment replacements, and "multiple projects" for applications that funded several types of projects.

Of these categories, farm equipment replacement and multiple project applications were discounted for the purposes of emissions reduction estimation. This is due to the program limitations of EMAP. In the case of farm equipment replacements, EMAP allowed for existing equipment to be refitted to meet Tier 3 standards, and for all other equipment to meet Tier 4 diesel standards. While this more modern equipment doubtless has fuel savings compared to older equipment, and therefore a reduction in greenhouse gas emissions, EMAP did not require this savings to be quantified or collect sufficient data for individual estimations to be possible. Similarly, projects with multiple energy efficiency projects did not have sufficient detail to accurately estimate the project's overall emissions reduction.

To estimate the level of public interest in CPRG funds for similar projects, the total cost of each of the remaining project categories was totaled and the proportion of total funding apportioned to each project category was calculated. Similarly, an average project cost was determined based on cost data associated with each project category. The proportion of EMAP spending associated with each project was then applied to the requested CPRG funding for the proposed grant program to determine the expected public interest (measured in total project dollars for the category), which was then divided by the average project cost to estimate several funded projects. A conservative estimate of 50% grant funding for each project was applied, though the actual program may include higher funding percentages for applicants that meet certain need thresholds or are in disadvantaged communities.

For each project category, the estimated number of projects was split across years 2-5 of the grant program. Per-project rates of energy or fuel savings were assumed for each project category. For GPS and guidance systems, a value of 1,756.5 liters of fuel savings was assumed based on a study of farming practices in rural North Dakota[25]. Annual per-project emissions reductions associated with GPS and guidance system projects were quantified using EPA's Diesel Emissions Quantifier with the simplifying assumption that the fuel savings were realized by a Tier 3, 2006 engine model year agricultural equipment that operates roughly equivalent to the default assumptions built into the quantifier other than the fuel savings from the upgrade project. While the population and usage specifics of the actual fleet of agricultural equipment in the state is not known, this simplifying assumption is expected to be conservative regarding the actual fleet of agricultural equipment.

For energy efficiency projects related to farm buildings, such as insulation, HVAC, and lighting, the University of Missouri estimates that the average farm in Missouri can achieve an annual savings of 1469[26] kWh by implementing energy savings upgrades and practices. For energy savings related to solar generation, EMAP limited installed solar arrays to 5kW maximum size. While this same limitation may not be carried over into the proposed grant program, this maximum size was used to estimate energy

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[25] Bora, G.C., Nowatzki, J.F. & Roberts, D.C. Energy savings by adopting precision agriculture in rural USA. *Energ Sustain Soc* **2**, 22 (2012). https://doi.org/10.1186/2192-0567-2-22

[26] https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pub/pdf/agguides/agengin/g01978.pdf

savings from solar generation projects. Finally, energy savings from solar-powered electric fences were estimated based on energy use of a standard 250W, 25-mile electric fence that operates 24 hours a day, year-round. AVERT was used to turn each project type's energy savings into a magnitude of emissions reduction. Because Missouri is modeled in AVERT as partially in both the Central and Midwest grids, and because this grant program will operate statewide, the magnitude of energy savings was split proportionally between these two grids as described in the AVERT User Guide Appendix G. See the Agricultural Program tab of the technical appendix spreadsheet.

Magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050
To project emissions reductions for the Agriculture Energy Efficiency Grant Program, it was assumed that projects and project types would be equally distributed across years 2-5 of the program (2026-2029). As such, the annual cumulative energy and fuel use reductions increases across these years as more projects are assumed to finish and come online. These energy and fuel savings, and the associated emissions reductions, were assumed to be stable year over year for a period of 20 years across all project categories as these technologies are robust and have long expected lifetimes.

Due to the nature of the simplifying assumptions made to predict the performance of this program, these results are expected to be very conservative. One project category that will likely be considered for the proposed grant program is electrification of agricultural equipment. This type of project was not available to applicants of EMAP, due in part to the other programmatic restrictions of the funding, but also due to the relatively small amount available to the grant program. Electrification of farm equipment has the potential to eliminate greenhouse gas emissions from fuel use at farms, but the available data from EMAP was insufficient to estimate this addition to the proposed grant program.

Measure 7: Decarbonization in Cement Manufacturing (pages 22-24 of the Missouri Plan for Environmental Improvement Grants)
Calculating Emissions Associated with the Scenarios
Emissions reductions for funds associated with the implementation of converting the Holcim cement kiln to low-carbon fuels were determined by comparing the baseline scenario to the fuel upgrade. Currently the plant does not have access to a natural gas pipeline, so coal and petroleum coke serve as the primary fuel source along with some use of liquid fuels. The goal of the current alternative fuels project is to allow the use of natural gas and low carbon engineered fuels as permissible fuels. The plant does not currently have storage or handling equipment in place to accommodate these fuels to allow them to be fed to the kiln system in lieu of coal and petroleum coke. Reductions were estimated using emission factors from the US Energy Information Administration website.[27] See the Cement tab in the Technical Appendix spreadsheet.

Magnitude of GHG reductions from 2025 through 2030 and from 2025 through 2050
To project emissions reductions for this project, it is assumed that construction will begin in 2025 and that fuel switching would begin near mid-2026. Therefore, half of the annual potential emissions reductions will be realized starting in 2026. For future years thereafter emissions reductions are assumed to remain stable.

[27] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis