**Technical Appendix – Demonstration of GHG Reduction Assumptions**

The technical appendix explains the methodology and assumptions used to calculate the GHG emission reductions associated with the measure of reducing production temperatures for asphalt mixtures. This includes a detailed explanation of the following calculations.

1. Baseline Hot Mix Asphalt Calculations
2. CCPR Calculations
3. WMT Calculations

The latest available information from the IPCC Fifth Assessment Report and the EPA Emission Factors for Greenhouse Gas Inventories were used to support the calculations and estimates below.

**Baseline Hot Mix Asphalt Calculations**

According to an industry life cycle assessment, 300,320 BTUs per ton of energy is needed for traditional hot mix asphalt (HMA), with electricity equating to 11,320 BTUs per ton and the burner energy equating to 289,000 BTUs per ton.[[1]](#footnote-2) Using the 2021 National Asphalt Pavement Association survey, approximately 4.4 million tons of HMA were produced in Alabama for Alabama Department of Transportation projects.[[2]](#footnote-3) If asphalt mix tonnage remains consistent over the years, the total energy required is calculated as follows:

Asphalt plants typically use natural gas or recycled fuel oil (RFO). Based on a sample of plants in Alabama, 88% of fuel consumption for the burner is natural gas and the remaining 12% of recycled fuel oil (RFO). Emission factors were gathered from the EPA GHG Emission Factors Hub.[[3]](#footnote-4)

According to the EPA eGRID, we know the state of Alabama falls within the SRSO subregion.[[4]](#footnote-5) SRSO emission factors were gathered from the EPA GHG Emission Factors Hub.3

Therefore, the total estimated GHG emissions for baseline ALDOT asphalt tonnage is 76,673,401 kgCO2eq, or **76,673 MTCO2eq**.

**CCPR Calculations**

The following calculations were used to determine GHG emission reductions during the CCPR pilots outlined in the proposal. To calculate the GHG emissions reduced as a result of using CCPR opposed to the traditional HMA, the GHG emissions of CCPR were estimated and subtracted from the baseline emissions calculation assuming the same tonnage. Using the CCPR trail as a demonstration of the calculations, the estimate tonnage is 37,514 tons of asphalt mixture. If traditional HMA was used, the associated GHG emissions would be approximately 654 MTCO2eq (653,710 kgCO2eq) according to the Baseline Hot Mix Asphalt calculations outlined previously.

CCPR reduces the need for heating at the burner, thus only electricity is needed. If electricity consumption remains the same, the GHG emissions for CCPR would be calculated as follows:

According to the EPA eGRID, we know the state of Alabama falls within the SRSO subregion.4 SRSO emission factors were gathered from the EPA GHG Emission Factors Hub.3

Therefore, our total kgCO2eq savings with CCPR technology compared to traditional HMA is 603,279 kgCO2eq or **603 MTCO2eq (92.3% of the production emissions of asphalt mixtures).**

**WMT Calculations**

The following calculations were used to determine GHG emission associated with WMT. To illustrate the calculations, we used an estimated tonnage of 62,524 tons of asphalt mixture produced at a temperature reduction of 80 degrees Fahrenheit. If the Baseline Hot Mix Asphalt calculations outlined previously were used, the associated GHG emissions would be approximately 1,090 MTCO2eq (1,089,529kgCO2eq) for traditional HMA.

The NCHRP Report 779 found an estimated energy savings of 1,100 Btu/°F per ton of WMT produced.[[5]](#footnote-6)

Asphalt plants typically use natural gas or recycled fuel oil (RFO). Based on a sample of plants in Alabama, 88% of fuel consumption for the burner is natural gas and the remaining 12% of recycled fuel oil (RFO). Emission factors were gathered from the EPA GHG Emission Factors Hub.3

In summary, calculations show that using warm-mix technologies to decrease production temperatures by 80 degrees Fahrenheit can lead to a decrease in emissions of 306,166 kgCO2eq or **306 MTCO2eq (28.1% of the production emission of asphalt mixtures).**

**GHG Emission Reduction Estimates for 2025-2030**

Using the calculations outlined above, it can be estimated that the 2025-2030 cumulative reductions of GHG emissions would be 66,564 MTCO2eq as compared to if traditional HMA was used, which is approximately a 14% reduction. The table below summarizes the annual and cumulative GHG Emission Reduction Estimates for 2025-2030. This table can also be found in *Section 2.a*. of the *Workplan*. This includes one pilot project for CCPR per year in 2025 and 2026. Additionally, it is also expected that 35% of ALDOT’s tonnage will utilize WMT with reduced temperatures in 2025 and increasing to 45% in 2026. Specifications will be developed and refined with incentives to scale the use of these technologies following the pilot projects. It is further anticipated that 60% of ALDOT’s tonnage will be produced using WMT technology with temperature reductions from 2027 through 2030. Since CCPR must be used in lane widening, reconstruction or new construction projects, it is anticipated that two CCPR projects will be let per year during 2027 and 2028.

| **Year** | **Alabama Tonnage (Short Ton)** | **AL Total GHG Emissions (MTCO2eq)** | **Pilot Tonnage (Short Ton)** | **Total GHG Emissions (MTCO2eq)** | **Pilot GHG Reductions (MTCO2eq)** | **% Reductions (MTCO2eq)** |
| --- | --- | --- | --- | --- | --- | --- |
| 2025 | 4,400,000 | 76,673 | 1,577,514 | 27,487 | 8,145 | 11% |
| 2026 | 4,400,000 | 76,673 | 2,017,514 | 35,153 | 9,954 | 13% |
| 2027 | 4,400,000 | 76,673 | 2,715,028 | 47,307 | 12,167 | 16% |
| 2028 | 4,400,000 | 76,673 | 2,715,028 | 47,307 | 12,167 | 16% |
| 2029 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2030 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| **Total** | **26,400,00** | **460,040** | **14,305,084** | **249,254** | **66,564** | **14%** |

**GHG Emission Reduction Estimates for 2025-2050**

Assuming the successful implementation and transition, 60% of ALDOT’s tonnage will continue to be produced using WMT with temperature reductions from 2030 through 2050, as stated under *Section 1.a., Description of GHG Reduction Measures* of the workplan. In addition, one CCPR project will be let every three years, starting in 2031, as a result of the specification change. According to these estimates, the total reduction in GHG emissions during this period will be 312,102 MTCO2e. This represents a 16% decrease compared to the emissions that would have been produced if conventional HMA had been used. The table below summarizes the annual and cumulative GHG Emission Reduction Estimates for 2025-2050. This table can also be found in *Section 2.a*. of the *Workplan*.

| **Year** | **Alabama Tonnage (Short Ton)** | **AL Total GHG Emissions (MTCO2eq)** | **Pilot Tonnage (Short Ton)** | **Total GHG Emissions (MTCO2eq)** | **Pilot GHG Reductions (MTCO2eq)** | **% Reductions (MTCO2eq)** |
| --- | --- | --- | --- | --- | --- | --- |
| 2025 | 4,400,000 | 76,673 | 1,577,514 | 27,487 | 8,145 | 11% |
| 2026 | 4,400,000 | 76,673 | 2,017,514 | 35,153 | 9,954 | 13% |
| 2027 | 4,400,000 | 76,673 | 2,715,028 | 47,307 | 12,167 | 16% |
| 2028 | 4,400,000 | 76,673 | 2,715,028 | 47,307 | 12,167 | 16% |
| 2029 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2030 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2031 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2032 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2033 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2034 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2035 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2036 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2037 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2038 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2039 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2040 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2041 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2042 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2043 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2044 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2045 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2046 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2047 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2048 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| 2049 | 4,400,000 | 76,673 | 2,677,514 | 46,653 | 12,669 | 17% |
| 2050 | 4,400,000 | 76,673 | 2,640,000 | 46,000 | 12,066 | 16% |
| **Total** | **114,400,000** | **1,993,508** | **67,367,682** | **1,173,823** | **312,102** | **16%** |

**Cost Effectiveness**

As outlined in the CPRG NOFO, the cost effectiveness of the GHG reductions anticipated from the measure included in the proposal can be calculated using the following calculation.[[6]](#footnote-7)

Therefore, we can use the equation and plug in the known values from our estimates above and from the budgeted outlined in the Budget Narrative.

Using the 2021 National Asphalt Pavement Association survey, approximately 4.4 million tons of HMA were produced in Alabama for Alabama Department of Transportation projects and 1.5 million tons of HMA were produced in Alabama for other agencies.2 Assuming that the technology and transition is successful, we can assume that other agencies will adopt the use of WMT with reduced temperatures from 2028 through 2030. The table below outlines the GHG reductions and cost effectiveness of this scenario.

| **Year** | **Alabama Tonnage (Short Ton)** | **AL Total GHG Emissions (MTCO2eq)** | **Pilot Tonnage (Short Ton)** | **Total GHG Emissions (MTCO2eq)** | **Pilot GHG Reductions (MTCO2eq)** | **% Reductions (MTCO2eq)** |
| --- | --- | --- | --- | --- | --- | --- |
| 2025 | 4,400,000 | 76,673 | 1,577,514 | 27,487 | 8,145 | 11% |
| 2026 | 4,400,000 | 76,673 | 2,017,514 | 35,153 | 9,954 | 13% |
| 2027 | 4,400,000 | 76,673 | 2,715,028 | 47,307 | 12,167 | 16% |
| 2028 | 5,900,000 | 102,802 | 3,615,028 | 62,989 | 18,542 | 18% |
| 2029 | 5,900,000 | 102,802 | 3,540,000 | 61,681 | 17,335 | 17% |
| 2030 | 5,900,000 | 102,802 | 3,540,000 | 61,681 | 17,335 | 17% |
| **Total** | **30,900,000** | **538,427** | **17,005,084** | **296,299** | **83,477** | **16%** |

Using the 2021 National Asphalt Pavement Association survey, approximately 432.4 million tons of HMA were produced in Alabama.2 Assuming that the technology and transition is successful, we can assume the use of WMT with reduced temperatures from 2028 through 2030 will be further adopted state-wide. The table below outlines the GHG reductions and cost effectiveness of this scenario.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Alabama Tonnage (Short Ton)** | **AL Total GHG Emissions (MTCO2eq)** | **Pilot Tonnage (Short Ton)** | **Total GHG Emissions (MTCO2eq)** | **Pilot GHG Reductions (MTCO2eq)** | **% Reductions (MTCO2eq)** |
| 2025 | 4,400,000 | 76,673 | 1,577,514 | 27,487 | 8,145 | 11% |
| 2026 | 4,400,000 | 76,673 | 2,017,514 | 35,153 | 9,954 | 13% |
| 2027 | 4,400,000 | 76,673 | 2,715,028 | 47,307 | 12,167 | 16% |
| 2028 | 432,400,000 | 7,534,188 | 259,515,028 | 4,521,821 | 1,271,660 | 17% |
| 2029 | 432,400,000 | 7,534,188 | 259,440,000 | 4,520,513 | 1,270,454 | 17% |
| 2030 | 432,400,000 | 7,534,188 | 259,440,000 | 4,520,513 | 1,270,454 | 17% |
| **Total** | **1,310,400,000** | **22,832,586** | **784,705,084** | **13,672,794** | **3,842,833** | **17%** |

1. Michigan Technological University (2021). Update to the Life Cycle Assessment for Asphalt Mixtures in Support of the Emerald Eco Label Environmental Product Declaration Program. Available online at: [LCA\_Asphalt\_Mixtures\_07\_29\_2021.pdf (asphaltpavement.org)](https://www.asphaltpavement.org/uploads/documents/Programs/Emerald_Eco-Label_EPD_Program/PCR_Public_Comment_Period/LCA_Asphalt_Mixtures_07_29_2021.pdf) [↑](#footnote-ref-2)
2. National Asphalt Paving Association (2021). Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage 2021. Available online at: [NAPA > Shop > Product Catalog > Product Details (asphaltpavement.org)](https://member.asphaltpavement.org/Shop/Product-Catalog/Product-Details?productid=%7bBDAB6C1D-7D96-ED11-AAD1-0022482A4988%7d) [↑](#footnote-ref-3)
3. Environmental Protection Agency (2024). GHG Emission Factors Hub. Available online at: [GHG Emission Factors Hub | US EPA](https://www.epa.gov/climateleadership/ghg-emission-factors-hub) [↑](#footnote-ref-4)
4. Environmental Protection Agency (2021). Power Profiler. Available online at: [Power Profiler | US EPA](https://www.epa.gov/egrid/power-profiler#/) [↑](#footnote-ref-5)
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6. Environmental Protection Agency (2024). Climate Pollution Reduction Grants Program: Implementation Grants – General Competition Notice of Funding Opportunity. Available online at: [cprg-general-competition-correction.pdf (epa.gov)](https://www.epa.gov/system/files/documents/2024-01/cprg-general-competition-correction.pdf) [↑](#footnote-ref-7)