

APPENDIX G

Greenhouse Gas Emissions

Project Inputs

Mitigation Inputs

Results Summary

Impacts on Vehicle Operation

- Instructions:**
1. Using information from the project or plan you want to analyze, complete the inputs on this page and on the Mitigation Inputs page by entering information in the cells that are shaded orange. Gray cells display results; do not change the information in these cells. (The tool uses the term “project” not just to refer to individual projects, but also to long-range transportation plans or other plans that consist of a suite of projects.)
 2. Click on the gray buttons at the top of the page to navigate between input pages, the results page, and the impacts on vehicle operation page.
 3. For further instructions, refer to the accompanying user guide for detailed descriptions of factors and assumptions used in this tool.

Key to Cell Colors

User Input

Results Automatically Calculated

General Information

| | |
|---------------------------------|----|
| Infrastructure location (state) | SC |
| Analysis timeframe (years) | 25 |

| | |
|---|--------|
| Average daily traffic per lane mile - for facilities that will be reconstructed or resurfaced | 10,500 |
|---|--------|

Roadway System

| | |
|--|--------|
| Total existing centerline miles | 22.8 |
| Total existing lane miles | 45.6 |
| Total newly-constructed centerline miles | 11.405 |
| Total newly-constructed lane miles | 45.62 |

Rail, Bus, and Bicycle Infrastructure

| | |
|---|---|
| Total existing track miles of light rail | 0 |
| Total existing track miles of heavy rail | 0 |
| Total newly-constructed track miles of rail | 0 |
| Total existing lane miles of bus rapid transit | 0 |
| Total newly-constructed lane miles of bus rapid transit | 0 |
| Total existing lane miles of bicycle lanes | 0 |
| Total newly-constructed lane miles of bicycle lanes | 0 |

Roadways

| Roadway Projects | | | | | | | |
|------------------------------------|-----------------------------|---|------------------------------|-------------------------------|--|--|---------------------------------------|
| Facility type | Roadway Construction | | | | | Roadway Rehabilitation | |
| | New Roadway (lane miles) | Construct Additional Lane (lane miles) | Re-Alignment (lane miles) | Lane Widening (lane miles) | Shoulder Improvement (centerline miles) | Re-construct Pavement (lane miles) | Resurface Pavement (lane miles) |
| Rural Interstates | 20 | 20 | 0 | 20 | 20 | 0 | 60 |
| Rural Principal Arterials | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Minor Arterials | 1.65 | 1.65 | 0 | 1.65 | 0 | 0 | 1.65 |
| Rural Collectors | 1.16 | 1.16 | 0 | 1.16 | 0 | 0 | 1.16 |
| Urban Interstates / Expressways | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Principal Arterials | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Minor Arterials / Collectors | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Parking | |
|-----------------------------|---|
| Surface Parking (spaces) | 0 |
| Structured Parking (spaces) | 0 |

| Options | |
|---|----|
| % roadway construction on rocky / mountainous terrain | 0% |

Accounting for the Full Roadway Lifespan

The estimator tool accounts for construction, rehabilitation, routine maintenance, and preventive maintenance in different ways:

- **New Construction (user provided):** The user enters lane miles of construction projects.
- **Rehabilitation (user provided):** The user enters expected reconstruction and resurfacing projects on all existing and new roadways for the length of the analysis period. As a general rule of thumb, new roadways require resurfacing after 15 years and reconstruction after 30 years.
- **Routine Maintenance (automatically estimated):** The tool automatically estimates routine maintenance activity, such as sweeping, striping, bridge deck repair, litter pickup, and maintenance of appurtenances, per lane mile of existing and new roadway.
- **Preventive Maintenance (user provided):** The user has the option to specify a preventive maintenance program as a mitigation strategy (in the Mitigation Inputs tab). Preventive maintenance techniques include crack sealing, patching, chip seals, and micro-surfacing.

Example: The user enters new construction of 10 lane miles of new freeway, with an analysis period of 40 years. Assuming that all construction takes place in year 1, the user enters 10 lane miles of freeway resurfacing (assumed to take place in year 15) and 10 lane miles of freeway reconstruction (assumed to take place in year 30). The tool automatically includes routine maintenance of the 10 newly constructed lane miles. The user has the option of specifying a preventive maintenance strategy, which will increase the longevity of the pavement surface and therefore reduce the amount of energy and emissions associated with resurfacing and rehabilitation.

Bridge Structures

| Bridge Structure | Construct New Bridge | | | | Reconstruct Bridge | | | | Add Lane to Bridge | | | |
|-------------------------|----------------------|---|---|-------------------------------|----------------------|---|---|-------------------------------|----------------------|---|---|-------------------------------|
| | Number of bridges | Average number of spans per bridge | Average number of lanes per bridge | Total number of lane-spans | Number of bridges | Average number of spans per bridge | Average number of lanes per bridge | Total number of lane-spans | Number of bridges | Average number of spans per bridge | Average number of new lanes per bridge | Total number of lane-spans |
| Single-Span | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Two-Span | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 |
| Multi-Span (over land) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Multi-Span (over water) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

How Many Bridge Spans?

Approximately half of short bridges in the U.S. (less than 1000 feet long) are single-span or double-span. If information about number of spans is not available, it is reasonable to assume a mix of single-span and two-span bridges. Note that the number of spans is an important factor in energy use and GHG emissions. You may want to test a few different assumptions to see the effects. Longer bridges (more than 1000 feet) can't be reliably estimated in the tool.

Rail, bus, bicycle, and pedestrian facilities

| Rail construction | | |
|--|------------|------------|
| Project Type | Light rail | Heavy rail |
| New construction (underground - hard rock) - track miles | 0 | 0 |
| New construction (underground - soft soil) - track miles | 0 | 0 |
| New construction (elevated) - track miles | 0 | 0 |
| New construction (at grade) - track miles | 0 | 0 |
| Converted or upgraded existing facility - track miles | 0 | N/A |
| New rail station (underground) - stations | 0 | 0 |
| New rail station (elevated) - stations | 0 | 0 |
| New rail station (at grade) - stations | 0 | 0 |

| Bus rapid transit construction | |
|--|---|
| New lane or right-of-way - lane miles | 0 |
| Converted or upgraded lane/facility - lane miles | 0 |
| New BRT Stations | 0 |

| Bicycle and Pedestrian Facilities | | | |
|---|------------------|-------------|------------|
| Project Type | New Construction | Resurfacing | Restriping |
| Off-Street Bicycle or Pedestrian Path - miles | 0 | 0 | N/A |
| On-Street Bicycle Lane - lane miles | 0 | 0 | 0 |
| On-Street Sidewalk - miles | 0 | N/A | N/A |

Construction - Delay

| | |
|---|--------|
| Total project-days of lane closure | 2,190 |
| Average daily traffic per directional segment for facilities requiring lane closure | 11,450 |
| Percentage of facility lanes closed during construction | <50% |

Impacts on Vehicle Operation

Estimating Project-Days of Lane Closure

Estimates of project-days of lane closure may be available from project documents. The tool assumes that lane closures occur in one-mile increments. Average values for construction schedules (e.g., daytime versus overnight) are incorporated in the calculations. Estimates of emissions from construction delay are meant to provide a rough sense of the scale of emissions relative to the construction processes themselves, and are not meant to replace estimates derived from traffic modeling software. Planned construction projects that will result in significant lane closures on high volume roads should be evaluated using traffic modeling software.

Results Summary

Project Inputs

Mitigation Inputs

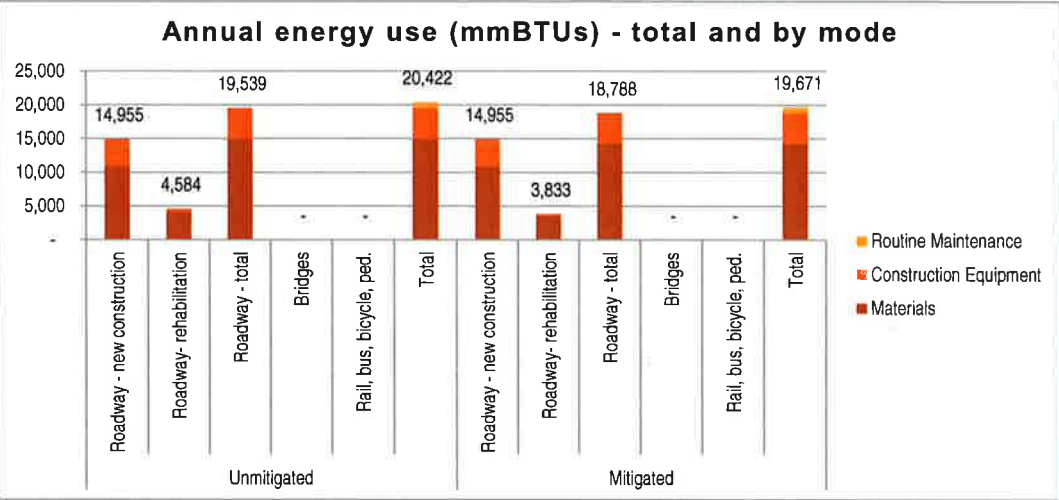
Impacts on Vehicle Operation

| | Annualized energy use (mmBTUs), per year over 25 years | | | | | | | | | | | |
|--------------------------------------|--|------------------------|-----------------|---------|--------------------------|--------|----------------------------|------------------------|-----------------|---------|--------------------------|--------|
| | Unmitigated | | | | | | Mitigated | | | | | |
| | Roadway - new construction | Roadway-rehabilitation | Roadway - total | Bridges | Rail, bus, bicycle, ped. | Total | Roadway - new construction | Roadway-rehabilitation | Roadway - total | Bridges | Rail, bus, bicycle, ped. | Total |
| Upstream Energy Materials | 10,859 | 4,109 | 14,968 | - | - | 14,968 | 10,859 | 3,436 | 14,295 | - | - | 14,295 |
| Direct Energy Construction Equipment | 4,096 | 475 | 4,571 | - | - | 4,571 | 4,096 | 397 | 4,493 | - | - | 4,493 |
| Routine Maintenance | | | 883 | | | 883 | | | | | | 883 |
| Total | 14,955 | 4,584 | 19,539 | - | - | 20,422 | 14,955 | 3,833 | 18,788 | - | - | 19,671 |

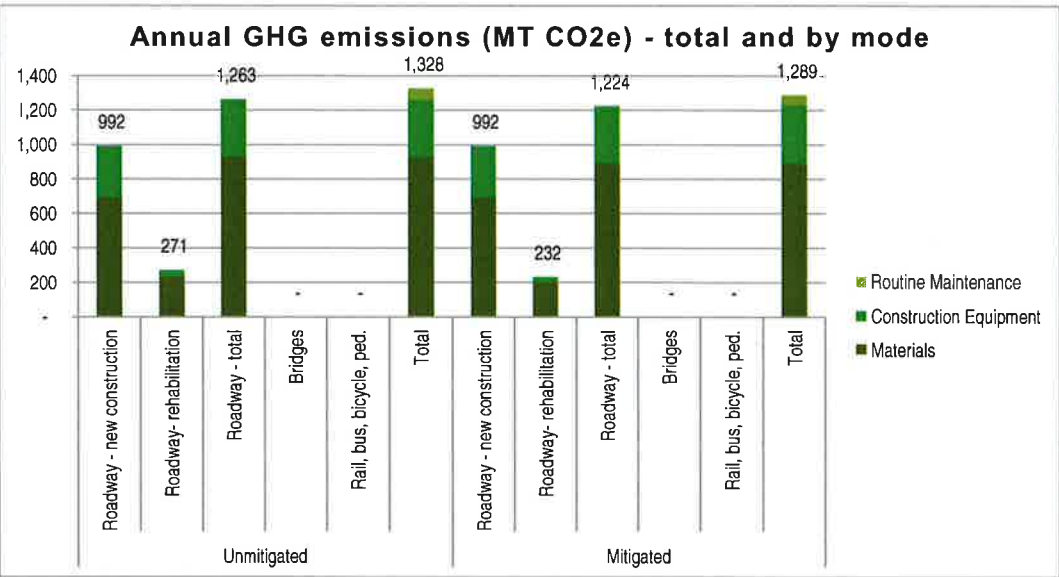
Note: To convert mmbTU to the equivalent gallons of US conventional diesel, use the conversion factor of 7.785 gallons of diesel / mmbTU. Please keep in mind that this conversion represents the equivalent amount of energy required, which can be useful for informational purposes, but it does not necessarily represent actual gallons of diesel required.

| | Annual GHG emissions (MT CO2e), per year over 25 years | | | | | | | | | | | |
|------------------------|--|------------------------|-----------------|---------|--------------------------|-------|----------------------------|------------------------|-----------------|---------|--------------------------|-------|
| | Unmitigated | | | | | | Mitigated | | | | | |
| | Roadway - new construction | Roadway-rehabilitation | Roadway - total | Bridges | Rail, bus, bicycle, ped. | Total | Roadway - new construction | Roadway-rehabilitation | Roadway - total | Bridges | Rail, bus, bicycle, ped. | Total |
| Upstream Emissions | | | | | | | | | | | | |
| Materials | 693 | 236 | 929 | - | - | 929 | 693 | 202 | 895 | - | - | 895 |
| Direct Emissions | | | | | | | | | | | | |
| Construction Equipment | 299 | 35 | 334 | - | - | 334 | 299 | 30 | 329 | - | - | 329 |
| Routine Maintenance | | | | | | 65 | | | | | | 65 |
| Total | 992 | 271 | 1,263 | - | - | 1,328 | 992 | 232 | 1,224 | - | - | 1,289 |

Annualized over 25 Years



Annualized over 25 Years



Impacts on Vehicle Operation

Project Inputs

Mitigation Inputs

Results Summary

Note: In addition to increasing energy use and GHG emissions associated with constructions and maintenance vehicles and materials, transportation projects can also affect the energy use and emissions associated with vehicles using the roadway. This module estimates energy and GHG emissions impacts due to vehicle delay associated with construction projects and increased pavement smoothness following resurfacing and reconstruction projects. However, these results are not comparable with those shown in the other modules of the tool because they come from a different source - roadway vehicles - rather than the construction materials and construction and maintenance vehicles that are the focus of the other modules in the tool. The results shown in this sheet should be considered in the context of a comprehensive evaluation of a plan or project's impact on roadway vehicles, including not only delay and pavement smoothness, but also travel patterns and demand.

| Construction delay | Result | Energy use (mmBTUs) | GHG emissions (MT CO2e) |
|--|--------|------------------------|-------------------------------|
| Total project-days of construction/lane closure | 2,190 | | |
| Project lifetime (years) | 25 | | |
| Additional energy use / emissions due to delay (per project-day) | | 12.1 | 1.1 |
| Total energy use / GHG emissions due to construction delay | | 26,564 | 2,365 |
| Annual energy use / GHG emissions due to construction delay, per year | | 1,062.6 | 94.6 |

| Pavement smoothness | Result | Energy use (mmBTUs) | GHG emissions (MT CO2e) |
|---|--------|------------------------|-------------------------------|
| Total lane miles of roadway reconstruction / resurfacing | 63 | | |
| Project lifetime (years) | 25 | | |
| Reduced Energy use / GHG emissions due to smooth pavement | | 1,832 | 134 |
| Annual energy / emissions savings due to pavement smoothness | | 73.3 | 5.4 |

Note: Energy and emission savings from pavement smoothness are automatically calculated for all resurfacing and reconstruction projects. Savings accrue after project completion.

| Total | Energy use (mmBTUs) | GHG emissions (MT CO2e) |
|--|------------------------|-------------------------------|
| Total Annualized Delay and Pavement Smoothness Impacts | 989.3 | 89.2 |

GHG Running Exhaust and Fuel Cycle Emissions (CO₂e)

| Year | Emission Factor (g/ml) | ADT | Length (miles) | Grams/day | MY CO ₂ E/day | MT CO ₂ E/year |
|---------------|------------------------|--------|----------------|-------------|--------------------------|---------------------------|
| 2015 Existing | 599.779 | 45,800 | 10 | 274,698,782 | 274.69 | 100,261.85 |
| 2040 No Build | 421.504 | 63,000 | 10 | 265,547,520 | 265.54 | 96,922.00 |
| 2040 Build* | 421.504 | 63,000 | 11.50 | 305,379,648 | 305.38 | 111,463.00 |

*2040 Build includes new cross-road mileage at all four interchanges

I-85 Widening

ICE Tool Assumptions for GHG Analysis of Construction Maintenance

- Analysis timeframe – 25 years (to include through design year of 2040)
- Rural Interstate, speed limit 70mph
- 2040 ADT – 63,000 (highest among segments in corridor, using as most conservative estimate).
- Total improvements: Centerline 22.8 miles
- Timeframe:
 - Construction completion in 3 years
 - Year 15 – Resurface entire roadway
- Total Project-days of lane closure: Construction – assume three years for widening and interchange improvements. Two lane closures per night to allow access to median work area. Lane closures 50 percent of time. Total days: 1095.
- Mitigation Inputs – 50% planned deployment of preventative maintenance