



Users Guide: Minnesota Infrastructure Carbon Estimator version 2.0

December 30, 2019

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MICE Quick-Start Guide

When first opening MICE, enable macros (the tool won't work without them)

- **Step 1:** Select the location (MN) and lifetime (years) on the *Project Inputs* tab.
- **Step 2:** Select Planning operating mode for your analysis.
- **Step 3:** Select all types of infrastructure associated with your project, and select Vehicle Operations if your project affects traffic volumes and/or speeds.
- **Step 4:** Enter information in the comment boxes per MnDOT policy—District #, Highway #, State Project ID, analyst name and date.
- **Step 5:** The selections in Step 3 open up additional tables below the comment boxes; input all relevant data using information from the project you want to analyze. Blue and gray cells display fixed values and results; do not change the information in these cells.
- **Step 6:** Apply any applicable mitigation measures on the *Mitigation Strategies* tab.
- **Step 7:** View summary outputs for the Build scenario on the *Summary Results* tab.
- **Step 8:** For Build/No-Build vehicle operating emissions and roadway resurfacing/reconstruction projects, view results on the *Vehicle_Ops* and *Roadway_Rehab* tabs.

The remainder of this user guide provides a more detailed walk-through of the process, and Minnesota-specific guidance on the inputs for the various infrastructure types and vehicle operating emissions, as well as how to obtain customized vehicle operating emissions output to meet MnDOT guidance requirements.

User's Guide

1.1 How to Use MICE (or ICE)

The Infrastructure Carbon Estimator (ICE) is a spreadsheet tool that estimates the lifecycle energy and greenhouse gas (GHG) emissions from the construction and maintenance of transportation facilities. The ICE tool was created to solve the problem of “planning level” estimation of embodied carbon emissions in transportation infrastructure. Without the need for any engineering studies, ICE helps answer this question: How much carbon will be embodied in the building, modification, and/or maintenance of this transportation project (or group of projects)?

MICE is the Minnesota-specific version of ICE. It is different from ICE in the following ways:

- It incorporates Minnesota-specific motor vehicle emissions factors for calculating exhaust emissions from vehicles
- It provides for Build/No-Build analysis of projects
- It includes Minnesota-specific inputs and changes related to mitigation, lighting, lane widths, and other aspects of the tool.

Most of the content in *this* user guide is pulled directly from the user guide for ICE. Where this user guide references ICE, the information applies to either ICE or MICE. Information that is specific to MICE is identified in text boxes like this one.

The inputs to ICE are designed to be as simple as possible to source and input while still producing a reasonable analysis. The primary inputs required by the tool are metrics that should be readily available, such as roadway lane miles, rail track miles, or number of bridges, signs, or lights.

Note that MICE (and ICE) are designed to provide ballpark estimates of the emissions impacts of projects, not detailed engineering estimates. Some simplifications are applied to ensure that users will have information available at the NEPA stage in order to estimate emissions. To give one example, ICE and MICE are “pavement-neutral;” the roadway-related emissions factors are based on an average mix of asphalt and concrete for all roadways, rather than separate factors for each--at the NEPA stage, planners usually do not know what type of pavement will be used on a future roadway. MnDOT guidance requires use of MICE for *planning documents*, including CEs, EAs, EAWs, and EISs; it is not required for detailed engineering analysis, or post-construction reporting.

ICE is designed to be self-explanatory. ICE includes detailed instructions and explanations of key input parameters in the tool itself. These are included as text in the tool as well as using Excel's comment windows to populate “pop-up” windows with useful information.

Any use of ICE will follow the same basic steps. Those are:

- **Step 1:** Select the location (MN) and lifetime (years) on the *Project Inputs* tab.

- **Step 2:** Select Planning operating mode for your analysis.
- **Step 3:** Select all types of infrastructure associated with your project, and select Vehicle Operations if your project affects traffic volumes and/or speeds.
- **Step 4:** Enter information in the comment boxes per MnDOT policy—District #, Highway #, State Project ID, analyst name and date.
- **Step 5:** The selections in Step 3 open up additional tables below the comment boxes; input all relevant data using information from the project you want to analyze. Blue and gray cells display fixed values and results; do not change the information in these cells.
- **Step 6:** Apply any applicable mitigation measures on the *Mitigation Strategies* tab.
- **Step 7:** View summary outputs for the Build scenario on the *Summary Results* tab.
- **Step 8:** For Build/No-Build vehicle operating emissions and roadway resurfacing/reconstruction projects, view results on the *Vehicle_Ops* and *Roadway_Rehab* tabs.

Factors and assumptions incorporated in the tool are summarized in Section 4 of the ICE User Guide. Additional details are provided in the Appendix of the ICE User Guide. For security purposes, the tool itself is locked and assumptions are hidden.

When using the tool, keep in mind that:

- MICE and ICE are Excel spreadsheets that use macros. When first opening MICE, enable macros if prompted to do so (click on “Enable Content”). The tool will not operate without macros enabled.
- To conduct an accurate analysis, entering information on all project activities is more important than ensuring that all activities are sorted into precise categories. That is, it is most important to ensure that all lane miles and track miles of construction and rehabilitation activity are included.
- Users should make reasonable assumptions based on their knowledge of the project area in order to fill any data gaps.
- If desired, a more detailed analysis may be conducted on certain projects individually using the Project mode once additional information is known.

MnDOT recommends that you retain a “Master” copy of MICE, and for each analysis, save a new copy with a project-specific filename and edit that copy. That way, each analysis will start with a fresh version of MICE that does not contain any inputs from previous analyses.

1.2 Color Scheme

ICE uses a consistent color scheme to illustrate the function of each cell. This includes descriptive cells, computed value cells, cells whose value is irrelevant for the current calculations (e.g., is not applicable, N/A), as well as action cells and buttons. Figure 1 illustrates the cell-specific color scheme used throughout the tool.

Figure 1. Cell-Specific Color Scheme in ICE

Description Cells
Computed Value Cells
Cell value is not relevant (Cell is NA)
Data Entry cells
Action Cell
Command button - on
Command button - off
Command button - disabled

1.3 Tabs and Navigating the Tool

ICE is Microsoft Excel based. It relies on Excel's worksheet-based approach for functionality. This sorts all tool actions, inputs, outputs, and controls into individual worksheets, or tabs. ICE consists of three primary user-facing sheets:

1. A **Project Inputs** sheet where users enter baseline information on the transportation network and information on their project.
2. A **Mitigation Inputs** sheet where users enter information on the current and planned use of strategies that can reduce energy use and GHG emissions.
3. A **Summary Results** sheet that displays estimates of mitigated and unmitigated energy use and GHG emissions under the project, as well as the total amount of materials and fuel that will be used in the construction and maintenance of the project.

At any time, the user can view overall results in the *Summary Results* tab or enter a custom mitigation approach for energy and GHG emissions in the *Mitigation Strategies* tab. The user can switch directly between Excel tabs at any time.

There are also secondary, special purpose sheets:

4. The **Introduction** sheet provides a summary of user instructions and tool functionality.
5. The **Print Results** sheet pulls results from the Summary Results sheet into a formatted output that may be printed to paper or electronic format for archiving and post-model comparison of results.

*MICE users: As a results of the way ICE is designed, the **Summary Results** and **Print Results** sheets do not include results for some types of projects, or Build/No Build traffic emissions comparisons. This is described in more detail later in this guide.*

There are individual tabs for each of the thirteen infrastructure types included in ICE. These are named for the infrastructure category they represent. If selected, there is a special sheet for including renewable portfolio standards (RPS) or other mitigation policy effects on electricity emission factors ([this feature is not used in MICE](#)). Users can navigate between all these sheets

using the buttons that are embedded throughout the tool or the tabs at the bottom of the Excel window. The following subsections describe each of these tabs.

1.3.1 Project Inputs Tab

MICE opens to the *Project Inputs* tab. The user will first enter a state and project analysis lifespan in years before the rest of the Tool is displayed.

The *Project Inputs* tab includes two main sections.

- A General Information section providing instructions and where the user sets basic parameters for the simulation, such as location and the types of infrastructure included.
- An input section where the user enters specific parameters for the simulation for each of the selected infrastructure types.

Figure 2 shows a screenshot of the upper portion of this tab. For explanation of the color scheme of each cell and control button, see Section 1.2.

Figure 2. Project Inputs Tab

The screenshot displays the 'Project Inputs' tab interface. At the top, there is a 'Hide Instructions' button and a 'No' button. Below this is a large 'INSTRUCTIONS' box containing six numbered steps. To the right of the instructions is a 'Clear All User Data' button. Below the instructions is a 'Tool Use' section with a 'Planning' button and a note: 'MICE users select "Planning" for most applications'. Below this is a grid of infrastructure type buttons: Bridges & Overpasses, Culverts, Lighting, Parking, Roadways, Vehicle Operations, BRT, Light Rail, Heavy Rail, Pathways, Signage, Custom Pavement, and Roadway Rehabilitation. Below the grid are input fields for 'District & Hwy#', 'State Project ID', and 'Analyst & Date'. At the bottom, there is a comment box labeled 'Enter comments and comment titles. These will be displayed on the'.

MICE users: Select “MN” for state, enter the project lifetime, and select “No” for custom electric emissions profile. The project lifetime needs to be consistent with the years entered for traffic data under Vehicle Operations (e.g., if the project base year is 2020 and the design year is 2040, enter “20” here).

MnDOT does not recommend using the “Clear All User Data” function. Among other things, it will clear some of the pre-provided information in the comment boxes. Instead, start each analysis with a fresh copy of MICE, as mentioned above.

In the upper portion of the *Project Inputs* tab the user is asked whether the analysis will be conducted in the project or planning mode. If the project mode is selected from the dropdown the only available inputs here will be to select the infrastructure type and the three input text boxes. When the planning mode is selected, then the buttons for all the various infrastructure types shown in Figure 2 appear, along with the same three input text boxes described above. The user should “turn on” all infrastructure types associated with the project by clicking on the respective buttons.

MnDOT recommends use of Planning mode in MICE. Planning mode is the most efficient, because multiple types of infrastructure and vehicle operating emissions can be analyzed all at once, and emissions from the components of the project will appear in the summary reports. If you use Project mode, you will need a separate version of MICE for each type of infrastructure associated with a project (e.g., for a new urban roadway link, you would need one copy of MICE to analyze the roadway, another for sidewalks, another for lighting, another for signs, another for traffic data, and possibly others if the project also includes bridges and/or culverts.) In addition, most of the extra detail needed for the “Project” mode is not typically available at the CE/EA/EAW/EIS stage of a project. Project mode is not covered in further detail in these Minnesota-specific instructions, but it is covered in the full ICE User Guide (<https://www.fhwa.dot.gov/environment/sustainability/energy/tools/>)

After selecting Planning mode, click the buttons for all the types of infrastructure associated with the project being analyzed. Under MnDOT guidance, if your project impacts vehicle traffic (e.g., it will lead to a change in traffic volumes and/or speeds), you must also select Vehicle Operations.

The projects listed here are the only project types included in ICE. Some types of MnDOT projects are not covered, including traffic signals and signal replacements, variable message signs, noise barriers, guardrails and cable barriers, fencing, and weigh-in-motion or other truck monitoring infrastructure. If a project cannot be analyzed in MICE, it is exempt from GHG analysis under MnDOT guidance.

Three comment boxes allow the user to input descriptive text that will be carried through to the output pages. Enter information in the title boxes per MnDOT policy—District #, Highway #, State Project ID, analyst name and date. The comments boxes themselves can be used to provide project descriptions, notes on assumptions, or other information the analyst may want to include in their report.

The user should then move to the lower portion of this tab. Here, the *Project Inputs* tab allows users to describe the project, including details on each category of infrastructure associated with the project, along with traffic data if the project will impact traffic. For example, users can define the total number of lane miles by classification for a roadway construction project. [The last page of this user guide lists possible sources of data for MICE inputs for various types of infrastructure.](#)

If the project mode has been selected, the required inputs for the one selected infrastructure type are presented. If the planning mode is selected, the required inputs for all selected infrastructure types are presented. The user will populate all necessary inputs.

1.3.2 Mitigation Strategies Tab

In the *Mitigation Strategies* tab, users select from a range of potential mitigation strategies appropriate for their selected infrastructure types. ICE2.0 has the following mitigation categories available, although the mitigation measures displayed are determined by the infrastructure categories considered in the analysis.

- Alternative fuels and vehicle hybridization,
- Vegetation management,
- Snow fencing and removal strategies,
- In place roadway recycling,
- Warm mix asphalt,
- Recycled and reclaimed materials, including use of recycled asphalt, use of industrial byproducts as cement substitutes, and recycled concrete, and
- Pavement Preservation

The primary entry for all but Pavement Preservation is the deployment value as a percentage. This can be thought of as a penetration depth of the strategy, or the extent to which a mitigation strategy is used, as a percentage relative to unmitigated conditions. In ICE2.0 the user now inputs values in the *Mitigation Strategies* tab for both the business as usual (BAU) deployment and the planned deployment.

The BAU deployment is the extent to which the strategy is deployed through standard agency practices. This allows ICE to compute and track separately the impacts of any sustainability practices already implemented by an agency. It may be compared to a Baseline deployment, which here refers to values without any mitigations applied. The Planned deployment represents the extent to which any selected strategy(ies) will be deployed in the project that you are examining.

The Deployment Increase column displays the increase in deployment from implementation of the strategy. Some reduction strategies (e.g., Switch from diesel to Soybean-based BD20 and biodiesel/hybrid maintenance vehicles and equipment) may be incompatible. The user should take care that inputs do not describe a total deployment greater than 100% for overlapping strategies. Logic has been included in ICE2.0 that allows the tool to warn the user if “excess” energy savings from mitigation are predicted. ICE will present a popup “nag window” to warn users of potential incompatible strategy deployment or deployments that exceed 100% when combined and targeting the same reduction category.

MICE Users: Biodiesel values on the Mitigation tab have been pre-populated with Minnesota-specific values to reflect state biofuel requirements.

The last category of strategies is Pavement Preservation. ICE2.0 considers pavement preservation strategies as a broad category of preventative maintenance strategies that reduce the lifecycle emissions and energy associated with roadway infrastructure by extending the life

of the pavement and thus the time required between the major maintenance activities, resurfacing and reconstruction.

MICE Users: Entries for Pavement Preservation are not necessary, because MnDOT guidance requires separate analysis of resurfacing and reconstruction projects. These inputs have been grayed out in MICE. For more information, see the discussion in the text box in section 1.5.5, below.

Figure 3. Mitigation Strategies Tab

Instructions: Follow the steps below to calculate the impact of energy and GHG mitigation strategies:

The user will enter both the business as usual (BAU) deployment (i.e., the extent to which the strategy is deployed through standard agency practices) in Column F and the planned deployment (i.e., the extent to which the strategy will be deployed in the project that you are examining) in Column G. (Baseline refers to values without any mitigations.) For Pavement Preservation strategies, enter both the schedule change and application frequency.

Column H displays the increase in deployment from implementation of the strategy. Some reduction strategies (e.g., Switch from diesel to Soy bean-based B20 and biodiesel/hybrid maintenance vehicles and equipment) may be incompatible. The user should take care that inputs do not describe a total deployment greater than 100% for overlapping strategies. The tool will warn if "excess" energy savings from mitigation are predicted or incompatible strategies are selected.

For a more refined mitigation analysis, please refer to FHWA's upcoming *Pavement LCA Tool*.

Strategy	BAU deployment	Planned deployment	Deployment increase	Energy reduction factor	GHG reduction factor	BAU Reductions		Planned Reductions	
						Energy reductions	GHG reductions	Energy reductions	GHG reductions
Alternative fuels and vehicle hybridization									
Switch from diesel to Soy bean-based EGO2	60%	60%	0.0%	5%	12%	2.8%	7.0%	2.8%	7.0%
Switch from diesel to Soy bean-based RDM 100			0.0%	-20%	55%	0.0%	0.0%	0.0%	0.0%
Switch from diesel to Forest Residue-based RDM 100			0.0%	-61%	71%	0.0%	0.0%	0.0%	0.0%
Switch from diesel to E-Diesel, Corn			0.0%	-7%	7%	0.0%	0.0%	0.0%	0.0%
Switch from diesel to PHEV, Diesel and Electricity (U.S. Mix)			0.0%	-41%	44%	0.0%	0.0%	0.0%	0.0%
Switch from diesel to CNG, WA NG			0.0%	-4%	11%	0.0%	0.0%	0.0%	0.0%
Switch from diesel to LMO, WA NG			0.0%	-11%	7%	0.0%	0.0%	0.0%	0.0%
Hybrid maintenance vehicles and equipment			0.0%	11%	11%	0.0%	0.0%	0.0%	0.0%
Combined hybridization/SD in maintenance vehicles and equipment			0.0%	1%	27%	0.0%	0.0%	0.0%	0.0%
Hybrid construction vehicles and equipment			0.0%	11%	11%	0.0%	0.0%	0.0%	0.0%
Combined hybridization/SD in construction vehicles and equipment			0.0%	1%	27%	0.0%	0.0%	0.0%	0.0%
Vegetation management									
Alternative vegetation management strategies (hardscaping, alternative mowing, integrated roadway/vegetation management)			NA	25%	29%	0.0%	0.0%	0.0%	0.0%
Snow fencing and removal strategies									
Alternative snow removal strategies (snow fencing, wing plows)			NA	50%	50%	0.0%	0.0%	0.0%	0.0%
In-place roadway recycling									
Cold in-place recycling			0.0%	33%	37%	0.0%	0.0%	0.0%	0.0%
Full depth reclamation			0.0%	66%	69%	0.0%	0.0%	0.0%	0.0%
Warm-mix asphalt									
Warm-mix asphalt			0.0%	37%	37%	0.0%	0.0%	0.0%	0.0%
Recycled and reclaimed materials									
Use recycled asphalt pavement as a substitute for virgin asphalt aggregate			0.0%	12%	12%	0.0%	0.0%	0.0%	0.0%
Use recycled asphalt pavement as a substitute for virgin asphalt subbase			0.0%	44%	44%	0.0%	0.0%	0.0%	0.0%
Use industrial byproducts as substitutes for Portland cement			0.0%	55%	59%	0.0%	0.0%	0.0%	0.0%
Use recycled concrete aggregate as a substitute for base stone			0.0%	55%	59%	0.0%	0.0%	0.0%	0.0%
Pavement preservation									
Pavement preservation extends roadway life by (years)			NA	NA	NA	NA	NA	NA	NA
Pavement preservation frequency (every N years for entire roadway system)			NA	NA	NA	NA	NA	NA	NA

These inputs reflect Minnesota state biodiesel requirements.

Note: Pavement preservation does not apply as a mitigation strategy in MICE.

MnDOT guidance requires separate analysis of resurfacing and reconstruction projects when they occur, so the ICE assumptions regarding future resurfacing and reconstruction have been disabled.

1.3.3 Summary Results Tab

ICE's Summary Results tab is organized in three parts.

The topmost part consists of introductory material. In *Project* mode, this allows the user to view the text input in the text boxes in the *Project Inputs* tab and allows the user to select outputs to view and in which units. There are four available options for display from the "Show" dropdown menu:

- Annualized Greenhouse Gas Emissions,
- Annualized Energy Use,
- Cumulative Greenhouse Gas Emissions, and
- Cumulative Energy Use.

The cumulative impact display is designed to allow better representation of the total environmental impacts of a project. The annualized values consider the impacts on an

annualized basis over the specified project's lifetime. ICE *Summary Results* tab allows display of either emissions or energy use. Finally, there is a dropdown menu to allow selection of reporting units. This is designed to help facilitate the display for cases with small emissions or energy values. The selection of one of the four reporting values and units filters down to the charts and tables sections below.

In *Planning* mode, there are a series of action buttons similar to those shown in the Project Inputs tab. Here the user will select which – any or all – of the infrastructure categories considered in their analysis will be displayed in the charts and tables. Those categories that were not included in the analysis are not available. Those that were included may be turned on or off individually in the display. Figure 4 shows an example of the introductory section of the *Summary Results* tab.

Figure 4. Introduction Section of Summary Results Tab



The second and third sections in the *Summary Results* tab show summary charts and tables, respectively for the selected analysis. The layout of these sections is identical between the Planning and Project modes. However, the values displayed depend on those infrastructure types (multiple types available only for Planning mode) selected for display in the introductory section.

The second section is the “Summary Results – Charts” section. This consists of four charts.

1. Phase – The top left chart breaks down results (annualized or cumulative energy or emissions, as selected above) by phase. This is designed to enhance the educational value of ICE by illustrating the relative contribution of different phases/materials to the overall lifecycle values. Here the resulting total energy and emissions from all infrastructure type(s) are presented by the distinct contributing phases to facilitate in the analysis of upstream versus direct emissions from the project:

- ◆ Materials,
- ◆ Transportation,
- ◆ Construction processes,
- ◆ Operations and maintenance, and
- ◆ Use.

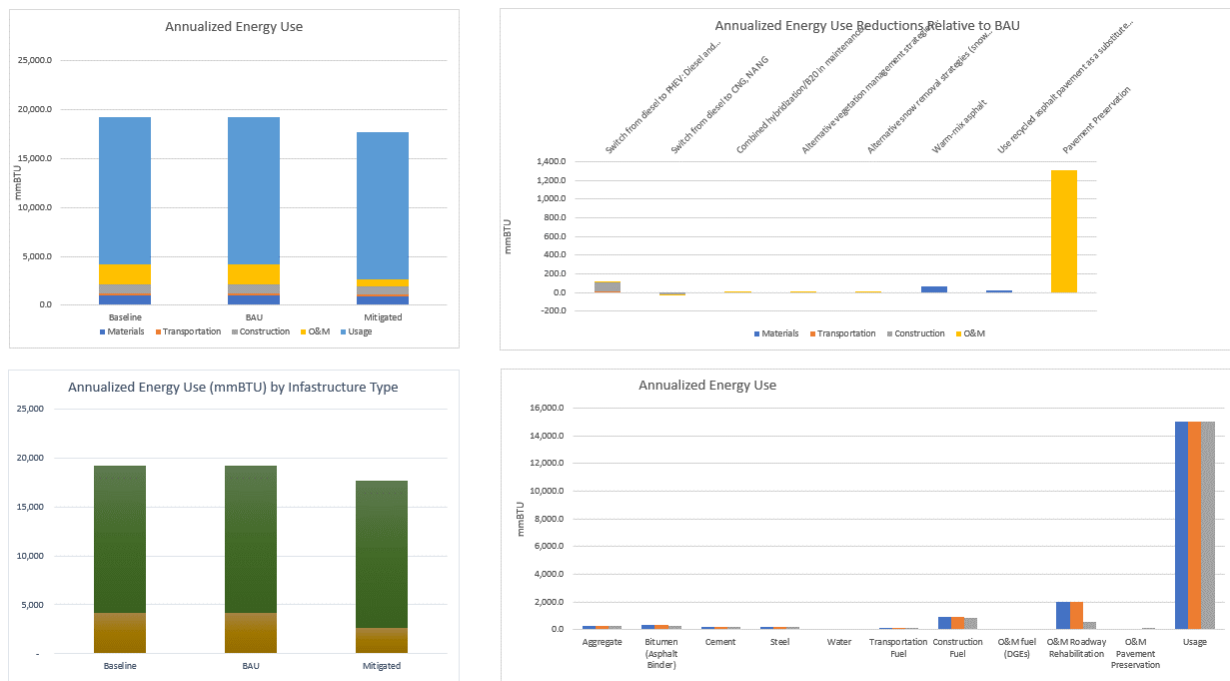
There are three stacked bar charts shown with this breakdown, representing the baseline, BAU, and Planned mitigation deployments. If no or negligible mitigations are applied in any case, the bar charts will be identical.

2. **Mitigation Impacts by Phase** – The top right chart breaks down the effects of applied mitigations by phase. This shows the energy or emission (as selected) reductions for each of the selected mitigation strategies individually.
3. **Infrastructure Category** – The bottom left chart breaks down results by selected infrastructure category. For the Planning mode, when multiple infrastructure categories are included, the bar charts show the contribution to the total plan emissions by each of the infrastructure categories included. As with the first chart, there are three stacked bar charts shown with this breakdown, representing the baseline, BAU, and Planned mitigation deployments.
4. **Material** – the bottom right chart breaks down results by material used in the project or plan. Note that some materials are actually pseudo-materials used in ICE calculations, such as usage or operations and maintenance (O&M) pavement preservation. These pseudo materials are used for accounting in ICE but do not correspond to the physical materials in ICE, discussed in Section 4.1 of the ICE User Guide.

Figure 5 shows an example of the four charts in the *Summary Results* tab.

The third section is the “Summary Results – Tables” section. This consists of four tables, corresponding to the four charts listed above.

Figure 5. Summary Results Graphs



MICE users: Data from the Summary Results tab reflect 1) emissions and energy from nearly all construction and maintenance activities, and 2) vehicle operating emissions and energy associated with the project Build scenario only.

Results for Roadway Rehabilitation projects (resurfacing and reconstruction) *do not* appear in the Summary Results (for these projects, ICE does not even open a Summary Results tab). Instead, emissions results for these projects are found starting in row 153 of the Roadway_Rehab tab. If you have a project that combines Roadway Rehab and other activities, the emissions from the other activities will be in the Summary Results tab, and the emissions for the Rehab activities are reported separately on the Roadway_Rehab tab.

Likewise, vehicle operating emissions and energy results for the project base year and No-build scenario do not appear in the Summary Results, but are found in rows 43-50 of the Vehicle_Ops tab. Summary Results only contain vehicle operating emissions and energy results for the project Build scenario.

Note that if the NEPA document for the project also includes an Energy section, the energy outputs from MICE can be included in that discussion.

1.4 Secondary Tabs

1.4.1 Introduction

The Introduction tab provides an overview of the tool and general user instructions. It is referential only, entirely text based, and without any user interaction.

1.4.2 Print Results

The Print Results tab collects the tabular and chart outputs from the Summary Results tab and reformats for printing or archiving. This tab also requires no user interaction unless the user changes the reporting units with the drop-down menu. This tab is designed to provide a simple form for the user to save model results and use after simulations are complete. This could facilitate a comparison of complex simulations involving multiple facility types.

1.5 Infrastructure Type Tabs

Use of the various infrastructure types in ICE2.0 is described here. For more information on the prototypes and calculations for each type, see Section 4 of the ICE User Guide.

Each of the thirteen infrastructure tabs follow the same organization:

- The topmost section provides a text overview of information about or needed for calculations.
- The Specification section typically echoes back key inputs from the Project Inputs tab. It may also request or allow additional inputs depending on the infrastructure type.

- The Baseline Energy Use and GHG Emissions section summarizes the baseline, or unmitigated, energy and emissions calculation results. In the project mode, it also displays material quantities and related values. All values in this section are cumulative over the specified lifetime.
- The Mitigated Results section summarizes the annualized energy use and GHG emissions results for three cases: the baseline (unmitigated), the Business-as-Usual (BAU) (agency standard practice mitigations), and Mitigated (planned mitigations applied to the scenario).
- The Results-Charts section summarizes the results of all calculations in both tables and figures. This includes breakdowns of results by material, phase, and mitigation.

1.5.1 Bridges and Overpasses

1.5.1.1 Overview

ICE estimates the energy and GHG emissions associated with the construction, reconstruction, or lane addition for single span, two-span, and multi-span bridges and overpasses. Bridges and overpasses are treated as being functionally equivalent in ICE.

The Bridges and Overpasses module in ICE applies to the construction of the bridge structure rather than the pavement surface. Bridge paving activities should be entered as part of the Roadway construction activities.

Approximately half of short bridges in the U.S. (less than 1,000 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. The bridge module in ICE is only applicable to bridges shorter than 1,000 feet. Longer bridges are major projects that are characterized by different material and energy intensities than those used to develop these prototypes.

Please note that very large bridges that carry traffic very high or span very deep spaces are unique and likely require additional materials and construction processes that cannot be approximated by ICE.

1.5.1.2 Required Inputs to Use in ICE

The configuration of inputs and outputs for bridges and overpasses is significantly updated in ICE2.0. Figure 6 is a screenshot of inputs for planning level analyses on the *Project Inputs* tab. The inputs are defined below.

The tool model four types of bridge spans:

1. Single-span: A single-span bridge is anchored at each end with no supports in the middle
2. Two-span: A two-span bridge has two sections of bridge structure between supports.
3. Multi-span (over land): This is a bridge crossing over land with more than two sections of structure between supports.
4. Multi-span (over water): This is a bridge crossing over water with more than two sections of structure between supports.

Figure 6. Bridges & Overpasses Inputs for Planning Level Analysis (*Project Inputs* tab)

Bridge/Overpass Structure	Construct New Bridge/Overpass				Reconstruct Bridge/Overpass				Add Lane to Bridge/Overpass			
	Number of bridges & overpasses	Average number of spans per structure	Average number of lanes per structure	Total number of lane-spans	Number of bridges & overpasses	Average number of spans per structure	Average number of lanes per structure	Total number of lane-spans	Number of bridges & overpasses	Average number of spans per structure	Average number of lanes per structure	Total number of lane-spans
Single-Span	↑	1	↑	0	↑	1	↑	0	↑	1	↑	0
Two-Span	↓	2	↓	0	↓	2	↓	0	↓	2	↓	0
Multi-Span (over land)				0				0				0
Multi-Span (over water)				0				0				0

The following list explains each input element in Figure 6:

- Enter the number of newly constructed bridges or overpasses
- For multi-span (over land or water), enter the average number of spans per newly constructed bridge or overpass.
- Enter the average number of lanes per newly constructed bridge or overpass.
- Enter the number of reconstructed bridges or overpasses.
- For multi-span (over land or water), enter the average number of spans per reconstructed bridge or overpass.
- Enter the average number of lanes reconstructed per bridge or overpass.
- Enter the number of bridges or overpasses where a lane addition is occurring.
- Enter the average number of spans for multi-span bridge per bridge or overpass with a lane addition.
- Enter the average number of lanes added per bridge or overpass.

MICE users: Some analyses may require multiple types of infrastructure in order to be complete. Interchanges are one example. While many large projects include new or modified interchanges, ICE does not include a separate Interchange facility type. Since interchanges are a combination of roadways and bridges, the relevant infrastructure can be entered in those tables, including the number and type of bridges involved in each interchange and the type of construction activity involved (e.g., new construction, reconstruction, adding lanes). Large “flyover” bridges can be represented as “Multi-span (over land).”

ICE’s bridge section focuses on construction of bridge structures rather than the construction and maintenance of the roadway surfaces of the bridges. To complete that analysis, the user should also include the roadway surface using the Roadway infrastructure type inputs.

A similar approach would be used in cases where several adjacent culverts are paved over to create a bridge, using the Culvert inputs (below).

1.5.2 Culverts

1.5.2.1 Overview

ICE characterizes single box culverts, double box culverts, and pipe culverts of various sizes and lengths.

Box culverts are typically constructed with reinforced concrete with thickness and size dependent on application. Box culvert designs are based on a maximum fill height of 10 feet. Pipe culverts are smaller drainage structures with common diameters ranging from one to four feet depending on application. Pipe culvert prototypes include corrugated steel pipe and reinforced concrete headwalls on both ends.

In ICE, culvert size follows a small/medium/large classification. Approximate pipe diameter/cell size is shown to illustrate these sizes. Project mode allows for customization of pipe diameter, length, width, etc. by selecting the “custom” culvert size.

1.5.2.2 Required Inputs to use in ICE

Figure 7 is a screenshot of the Planning level inputs for culvert analyses; the inputs are defined below.

Figure 7. Culvert Inputs for Planning Level Analysis

	Single Box Culverts		Double Box Culverts		Pipe Culverts	
	Number of culverts	Average culvert length (ft)	Number of culverts	Average culvert length (ft)	Number of culverts	Average culvert length (ft)
Small (e.g., 6'x6' cell or 12" pipe)	↑	↑	↑	↑	↑	↑
Medium (e.g., 8'x8' cell or 24" pipe)	A	B	C	D	E	F
Large (e.g., 12'x12' cell or 48" pipe)	↓	↓	↓	↓	↓	↓

The following list explains each input element in **Figure 7** for a planning level analysis:

- A. Enter the number of single box culverts (by size).
- B. Enter the average box culvert length (by size).
- C. Enter the number of double box culverts (by size).
- D. Enter the average double box culvert length (by size).
- E. Enter the number of pipe culverts (by size).
- F. Enter the average pipe culvert length (by size).

1.5.3 Custom Pavement

1.5.3.1 Overview

ICE is designed to be “pavement material-neutral” regarding pavement surfaces. That is, mix design and proportions of asphalt and concrete used as pavement surfaces are derived from the representative sample of projects, represent a typical mix of asphalt and concrete surfaces, and remain fixed in all ICE calculations. ICE is also prescriptive for most operations and maintenance activities.

MICE Users: At the moment, the Custom Pavement input is not used in MICE; however, in the future, Minnesota-specific inputs may be available, especially to reflect different types of overlay projects.

1.5.4 Rail, Bus, Bicycle, and Pedestrian Facilities

1.5.4.1 Overview

In ICE1.0, these facility types were collected into a single input group. In ICE2.0, each has been treated as its own separate facility.

- *BRT* analyzes construction or conversion of bus rapid transit facilities. This is characterized in terms of roadway lanes dedicated to bus transit and not shared with general traffic.
- *Heavy Rail* analyzes projects including four new construction project types for heavy rail lines: underground – hard rock; underground – soft soil; elevated; or at grade. ICE also allows for assessing the impacts of building new underground, elevated, or at grade stations for heavy rail.
- *Light Rail* projects include five categories of new construction project types for light rail lines: underground – hard rock; underground – soft soil; elevated; at grade; or converted/upgraded existing facilities. ICE also allows for assessing the impacts of building new underground, elevated, or at grade light rail stations.
- The *Pathways* facility category characterizes the new construction, resurfacing, and restriping of off-street bicycle or pedestrian paths, on-street bicycle lanes, and on-street pedestrian sidewalks.

In the *Pathways* category, on-street bicycle lanes apply where new roadway service is constructed for a bicycle lane. Roadway resurfacing of existing surfaces to create a bicycle lane should be included under ‘Resurfacing’. Bicycle lanes created by restriping existing roadway space should be entered under ‘Restriping’. However, restriping will not affect the energy and GHG estimates of the tool, since energy expended in restriping is negligible compared to energy expended in resurfacing or new construction. Pedestrian facilities include the construction and resurfacing of new off-street paths and the construction of new on-street sidewalk miles. **Note that sidewalk construction must be entered in this table, as roadway projects are assumed to include no sidewalks.** For example, plans that include sidewalks on all newly constructed roads should multiply centerline miles of roadway by two to calculate construction of new on-street sidewalk miles. Only new construction of sidewalks is included in the tool because property owners are typically responsible for maintenance and repair of sidewalks.

Note that vehicle use phase emissions are currently incompatible with all of these infrastructure types.

1.5.4.2 Required Inputs to use in ICE

Figure 8 is a screenshot of inputs for a heavy rail infrastructure analysis; the inputs are defined below. Please note that heavy rail inputs are the same for a Planning and Project level analysis. However, the *Heavy_Rail* tab in the Project mode allows for customization of many parameters, including materials, fuels, hauling distance, use of steel plates, and use of galvanized materials.

Figure 8. Heavy Rail Inputs

Heavy Rail Infrastructure	
Total existing track miles of heavy rail	A

Heavy Rail construction	
Project Type	Heavy rail
New construction (at grade) - track miles	B
New construction (elevated) - track miles	C
New construction (underground - hard rock) - track miles	D
New construction (underground - soft soil) - track miles	E
New rail station (at grade) - stations	F
New rail station (elevated) - stations	G
New rail station (underground) - stations	H

The following list explains each input element in **Figure 8**:

- A. Enter the total existing track miles of the heavy rail system being analyzed.
- B. Enter the total number of newly constructed, at grade, heavy rail track miles.
- C. Enter the total number of newly constructed, elevated, heavy rail track miles.
- D. Enter the total number of newly constructed, underground – hard rock, heavy rail track miles.
- E. Enter the total number of newly constructed, underground – soft soil, heavy rail track miles.
- F. Enter the total number of, at grade, new heavy rail stations
- G. Enter the total number of, elevated, new heavy rail stations
- H. Enter the total number of, underground, new heavy rail stations

Figure 9 is a screenshot of inputs for a light rail infrastructure analysis; the inputs are defined below. Please note that light rail inputs are the same for a Planning and Project level analysis. However, the Project mode allows customization of the same parameters listed for Heavy Rail.

Figure 9. Light Rail Inputs

Light Rail Infrastructure	
Total existing track miles of light rail	<input type="text" value="A"/>

Light Rail construction	
Project Type	Light rail
New construction (at grade) - track miles	<input type="text" value="B"/>
New construction (elevated) - track miles	<input type="text" value="C"/>
New construction (underground - hard rock) - track miles	<input type="text" value="D"/>
New construction (underground - soft soil) - track miles	<input type="text" value="E"/>
Converted or upgraded existing facility - track miles	<input type="text" value="E"/>
New rail station (at grade) - stations	<input type="text" value="G"/>
New rail station (elevated) - stations	<input type="text" value="H"/>
New rail station (underground) - stations	<input type="text" value="I"/>

The following list explains each input element in **Figure 9**:

- A. Enter the total existing track miles of the light rail system being analyzed.
- B. Enter the total number of newly constructed, at grade, light rail track miles.
- C. Enter the total number of newly constructed, elevated, light rail track miles.
- D. Enter the total number of newly constructed, underground – hard rock, light rail track miles.
- E. Enter the total number of newly constructed, underground – soft soil, light rail track miles.
- F. Enter the total number of, at grade, new light rail stations
- G. Enter the total number of, elevated, new light rail stations
- H. Enter the total number of, underground, new light rail stations

Figure 10 is a screenshot of inputs for a bicycle and pedestrian facility analysis under Pathways; the inputs are defined below. Please note that bicycle and pedestrian inputs are the same for a Planning and Project level analysis. Like rail facilities, the Project mode allows customization of material amounts, hauling distance, and galvanized materials if known.

Figure 10. Bicycle and Pedestrian Facility Inputs

Bicycle and Pedestrian Facilities		
Project Type	New Construction	Resurfacing
Off-Street Bicycle or Pedestrian Path - miles	<input type="text" value="A"/>	<input type="text" value="B"/>
On-Street Bicycle Lane - lane miles	<input type="text" value="C"/>	<input type="text" value="D"/>
On-Street Sidewalk - miles	<input type="text" value="E"/>	N/A

The following list explains each input element in **Figure 10**:

- A. Enter the number of newly constructed off-street bicycle or pedestrian path miles
- B. Enter the number of off-street bicycle or pedestrian path miles to be resurfaced
- C. Enter the number of newly constructed on-street bicycle lane miles
- D. Enter the number of on-street bicycle lane miles to be resurfaced
- E. Enter the number of newly constructed miles of sidewalk

1.5.5 Roadways

1.5.5.1 Overview

Roadways may be the most complicated feature included in ICE and also the most common application. MICE accounts for the full roadway lifespan of both new and existing road networks through the *Roadways* tab. This includes both construction and routine maintenance.

Emissions and energy associated with routine maintenance (sweeping, striping, bridge deck repair, litter pickup, and maintenance of appurtenances) and roadway rehabilitation is automatically estimated per lane mile of both new and existing roadways associated with a project. (Vehicle use-phase emissions are estimated via the Vehicle Operations tab.)

Note that roadway projects do not include sidewalks. If your project or plan includes constructing sidewalks, they should be entered separately in the Rail, Bus, Bicycle, and Pedestrian Facilities section of the tool.

ICE also does not intrinsically allow customized pavement configurations. Most analyses should use this Roadway tab and ICE's internal pavement configuration. The Custom Pavement analysis relies on external data rather than ICE's calculations to estimate lifecycle values for different configurations. Please see the Custom Pavement tab for more information. Users should not enter both Roadway and Custom Pavement values for the same project.

Standalone rehabilitation projects, such as one-time resurfacing, are analyzed with the Roadway Rehabilitation project type and may not be combined with other project types.

In *Project* mode for roadways, ICE2.0 asks for some additional inputs. First, the user has the option to input custom lane widths for each roadway type. [MICE is populated with default lane widths for Minnesota, which appear on the Roadways tab. If you wish to use a different lane width, you will need to model the roadway in Project mode. Also note that if you enter non-default lane widths, the "Total Lane Miles" listed under Roadway System on the Roadways tab will be adjusted compared to the inputs of the Project Inputs tab. In Project mode, the user is also allowed to specify the material hauling distance.](#)

The definition of the seven roadway types modeled in ICE2.0 are as follows:

- *Rural Interstate*: Interstates are limited-access, high-speed, divided roadways that accommodate long-distance travel.
- *Rural Principal Arterials*: Principal arterials move high volumes of traffic at high speeds over long distances between major destinations.
- *Rural Minor Arterials*: Minor arterials move high volumes of traffic at high speeds over shorter distances and connect destinations to each other or connect collectors to larger roads.

- *Rural Collector*: Collectors are low- to medium-capacity roads that connect local roads to higher-volume arterial roads
- *Urban Interstates/ Expressways*: Interstates and expressways are limited-access, high-speed, divided roadways that accommodate long-distance travel.
- *Urban Principal Arterials*: Principal arterials move high volumes of traffic at high speeds over long distances between major destinations.
- *Urban Minor Arterials/Collectors*: Minor arterials move high volumes of traffic at high speeds over shorter distances and connect destinations to each other or connect collectors to larger roads. Collectors are low- to medium-capacity roads that connect local roads to higher-volume arterial roads.

Roundabouts: MICE does not explicitly model roundabouts, but they can be modeled as roadways, with the applicable functional class selected and a distance calculated based on the average circumference of the roundabout lane(s). For example, for a roundabout with an overall radius of 50' and two 12' lanes, the equivalent roadway distance would be:

$$\begin{aligned}\text{Distance} &= 2\pi(\text{average radius outside lane} + \text{average radius inside lane}) \\ &= 2\pi(46+32) \\ &= 477.5 \text{ feet or } .0904 \text{ lane miles}\end{aligned}$$

1.5.5.2 Required Inputs to Use in ICE

Figure 11 is a screenshot of inputs for roadway analyses. The inputs are defined below. Please note that Roadway inputs for a Planning and Project level analysis on the *Project Inputs* tab are the same. However additional specifications are available in the *Roadways* tab as discussed above.

Figure 11. Roadway System Inputs (Project and Planning Mode)

Roadway System						
Total existing centerline miles						
Total newly constructed centerline miles						

Roadway Projects						
Facility type	Roadway System	Roadway Construction				
	Existing Roadway (lane miles)	New Roadway (lane miles)	Construct Additional Lane (lane miles)	Realignment (lane miles)	Lane Widening (lane miles)	Shoulder Improvement (centerline miles)
Rural Interstates						
Rural Principal Arterials						
Rural Minor Arterials						
Rural Collectors						
Urban Interstates / Expressways						
Urban Principal Arterials						
Urban Minor Arterials / Collectors						

Include roadway rehabilitation activities (reconstruct and resurface)	No	For Minnesota, this box should always read <u>No</u> .
---	----	--

% roadway construction on rocky / mountainous terrain	
---	--

The following list explains each input element in Figure 11:

- A. Enter the total centerline miles for the existing roadway network (if applicable-enter “0” or leave blank when analyzing totally new roadways).
- B. Enter the total newly constructed centerline miles for the proposed project analysis (if applicable).
- C. Enter the total lane miles, of each roadway type, for the existing roadway network (if applicable)
 - ◆ (Note: A should sum to the same amount of lane miles as C).
- D. Enter the total lane miles of new roadway for the project.
- E. Enter the number of lane miles when adding additional lanes to an existing roadway.
- F. Enter the total lane miles when analyzing roadway realignment.
 - ◆ These are projects in which there is a change to the horizontal and/or vertical alignment of a portion of an existing roadway.
- G. Enter the total lane miles when analyzing lane widening.
 - ◆ These are projects in which there is a reconstruction with lanes wider than the replaced section of roadway.
- H. Enter the total centerline miles of a shoulder improvement project.
 - ◆ These are projects in which there is a widening of shoulders to design standards or the complete reconstruction of shoulders to provide additional strength.

- I. Estimate the percentage of the project area that is in hilly or mountainous terrain. The energy and emissions impacts are higher for projects in these terrains because of higher energy intensity of construction activities such as cut and fill in rocky soils and longer hauls of materials and equipment for projects located in mountainous areas.

The last roadway input on the *Project Inputs* tab is incorporating roadway rehabilitation activities. **MICE users should always select “No” (see discussion below).**

Note that, in the mitigation breakdown in the last Results-Charts section of the *Roadways* tab the mitigations for “Cold In-place recycling” and “Full depth reclamation” do not appear as line items in the table or charts. However, if selected, they are included in the calculations through impacts on Roadway Rehabilitation activities.

Understanding how ICE handles roadway rehabilitation

There are three separate sets of inputs in the *ICE* tool (not MICE) that influence roadway rehabilitation activities. *MICE significantly modifies these functions (see below).*

First, ICE includes a default schedule for resurfacing and reconstruction of newly-constructed roads; roads are assumed to be resurfaced after 15 years, and fully reconstructed after 30 years. ICE will account for these activities automatically, but the extent depends on what is entered under Project Lifetime on the Project Inputs page. (If a new roadway is modeled with a project lifetime of 20 years, ICE will automatically include emissions associated with one resurfacing event, but not reconstruction.)

Second, ICE includes a Roadway Rehabilitation project type. This is for stand-alone resurfacing and reconstruction projects of existing roadways. For these projects, ICE only estimates emissions for that activity, and does not apply the 15/30 year schedule used for new roads. As noted above, ICE reports emissions for these projects separately (on the Roadway_Rehab tab) and does not include them in the lifecycle results reported in the Summary Results tab.

Finally, under Mitigation Strategies, ICE has an option for Pavement Preservation. Here, the user can specify 1) how long the strategies extend the life of the roadway surface, and 2) how often the strategies are applied. These inputs are used by ICE to adjust the default 15/30 year rehabilitation schedule so that rehabilitation strategies are pushed off into the future (and possibly beyond the specified project lifetime).

MICE users: MnDOT guidance requires separate modeling of roadway rehabilitation projects as they occur. Therefore, in MICE, the functions that automatically calculate emissions for these activities during the lifetime of a new roadway have been disabled. Likewise, the Pavement Preservation mitigation strategies have also been disabled, since they only affect the frequency of automatically-applied rehabilitation projects in ICE. Notes to this effect have been added throughout the MICE tool as reminders.

1.5.6 Roadway Lighting

1.5.6.1 Overview

Roadway lighting projects can be a significant contributor to the annual energy use and GHG emissions of many transportation agencies. *This function of the ICE tool has been specifically customized in MICE to reflect MnDOT lighting practices.*

ICE estimates the energy and GHG emissions associated with lighting projects. ICE evaluates the impacts of two of the most common lighting technologies: High Pressure Sodium (HPS) & Light Emitting Diode (LED). However, since MnDOT does not use HPS lighting, MICE only accepts inputs for LED lights.

To estimate the energy and GHG emissions associated with lighting use projects, ICE pairs annual energy consumption with state-specific energy emission factors to determine GHG emissions.

1.5.6.2 Required Inputs to Use in MICE

Figure 12 is a screenshot of inputs for a roadway lighting analysis; the inputs are defined below. Please note that roadway lighting inputs for a Planning and Project level analysis are the same. However, in the *Lighting* tab in the Project mode, the user can input customize hauling distance and use of galvanized materials.

Figure 12. Roadway Lighting Inputs

Number of roadway miles				
Lighting Structures				
MnDOT Luminaire Type	Typical Lumens	Ave. number of HPS lights per roadway mile	Ave. number of LED lights per roadway mile	Typical wattage of LED lights in this lumen range
Roadway Use 40' Mount 250 W HPS Replacement	15,450			120
Roadway Use 49' Mount 400 W HPS Replacement	18,120			147
Roadway Underpass Use 250 W HPS Replacement	10,320			100
High Mast Luminaire - Asymmetrical	43,300			322
High Mast Luminaire - Symmetrical	85,300			629
Roadway Luminaire - 5 Lane Shoulder	43,264			325
Roadway Luminaire - 5 Lane Median	31,341			226
Rest Area Parking Lot Luminaire	15,850			130
Rest Area Walkway Luminaire	4,150			35
Other (specify wattage in Column G)				

The following list explains each input element in **Figure 12**:

- Enter the number of roadway miles where roadway lighting is being applied.
- Enter the average number of light-emitting diode (LED) roadway lights (by structure type) being applied to the roadway system (note that the inputs for HPS lights have been grayed out, since MnDOT does not use these). MICE has been pre-populated with the typical wattages for these types of lights.

- C. If you are using a type of luminaire not covered in the default list, enter both the number of LED lights per mile, and the wattage of these lights.

Instead of using the roadway miles and number of lights to calculate lights per mile, you can also just enter “1” for the number of roadway miles and enter the total number of lights of each type.

1.5.7 Roadway Rehabilitation

1.5.7.1 Overview

The Roadway Rehabilitation facility type is designed for isolated, standalone projects involving resurfacing and reconstructing pavements on existing facilities.

The lifecycle assessment for Roadway Rehabilitation analyses is more limited than for other infrastructure types. Roadway Rehabilitation applies only to standalone roadway maintenance for existing roadways. It does not cover the full lifetime of other projects (although all factors for fuels and materials used do include cradle to gate lifecycle) and thus may not be combined with other types of analyses in ICE. Because of this, roadway rehabilitation analysis types in the tool do not activate ICE's Print Results and Summary Results tabs. Results for these activities must be viewed in the Roadway Rehabilitation tab itself.

1.5.7.2 Required Inputs to Use in ICE

Figure 13 is a screenshot of inputs for roadway analyses; the inputs are defined below. All inputs for roadway rehabilitation projects are the same in both the Planning and Project modes. However, additional inputs are available in the Roadway_Rehab tab in the Project mode for custom lane width, galvanized material, and hauling distance.

Figure 13. Roadway Rehabilitation Inputs

Roadway System for Road Rehabilitation		
Facility type	Resurface (lane miles)	Reconstruct (lane miles)
Rural Interstates	A	B
Rural Principal Arterials		
Rural Minor Arterials		
Rural Collectors		
Urban Interstates / Expressways	B	C
Urban Principal Arterials		
Urban Minor Arterials / Collectors		

% roadway construction on rocky / mountainous terrain

The following list explains each input element in Figure 13:

- A. Enter the total lane miles of roadway resurfacing for each roadway type.
- B. Enter the total lane miles of roadway reconstruction for each roadway type.

- C. Enter an estimate (percentage) of the project area that is in hilly or mountainous terrain. The energy and emissions impacts are higher for projects in these terrains because of higher energy intensity of construction activities such as cut and fill in rocky soils and longer hauls of materials and equipment for projects located in mountainous areas.

1.5.8 Roadway Signage

1.5.8.1 Overview

Signage infrastructure is a combination of aluminum sheet metal, and directly embedded or concrete encased steel or wood supports. The signage category was divided into small, medium, and large structures representing the three most common types of roadway signs.

ICE divides the signage category is divided into small, medium, and large structures representing the three most common types of roadway signs. Small and medium sized signs are typically regulatory and warning signs supported by a single post. Large signs include overhead guidance highway signs, typically supported by two posts or hung overhead on large steel cantilever arms.

1.5.8.2 Required Inputs to Use in ICE

Figure 14 is a screenshot of inputs for a roadway signage analysis; the inputs are defined below.

Figure 14. Roadway Signage Inputs

Number of roadway miles	
Signage Structures	Avg. number of signs per roadway mile
Small (3'x3') - 14 Gauge Steel Post	
Medium (6'x6') - 14 Gauge Wood Post	
Large (10'x14') - 8 Gauge Cantilever Arm	

The following list explains each input element in Figure 14:

- Enter the number of roadway miles where roadway signage is being applied.
- Enter the average number of roadway signs (by size) on the roadway system.

Instead of using the roadway miles and number of signs to calculate signs per mile, you can also just enter "1" for the number of roadway miles and enter the total number of signs of each type.

Emissions from signage are typically very low. If you don't have data on the number of signs, MnDOT recommends either making an educated guess, or disregarding this source of emissions altogether. The emissions are too low to justify any additional effort to gather input data.

1.5.9 Parking

1.5.9.1 Overview

ICE2.0 estimates energy and emissions associated with two types of parking facilities: surface lots and parking structures. Both are characterized in terms of the number of spaces. Parking structures are treated generically and may also be characterized in terms of their total area.

1.5.9.2 Required Inputs to Use in ICE

Figure 15 is a screenshot of inputs for a parking structure analysis; the inputs are defined below. Please note that parking inputs for a Planning and Project level analysis are the same in the *Project Inputs* tab. However, in the *Parking* tab, additional inputs are available in the Project mode. These allow customization of hauling distance, galvanized materials, and the share of steel that is structural versus fencing.

Figure 15. Parking Structure Inputs

	Spaces
Surface Parking	A
Structured Parking	B

The following list explains each input element in **Figure 15**:

- A. Enter the number of surface level parking spaces.
- B. Enter the number of parking structure parking spaces.

1.5.10 Vehicle Operations

1.5.10.1 Overview

The Vehicle Operations project category estimates emissions associated with a Minnesota vehicle fleet using the facility for the specified lifetime (operating emissions), and/or the additional vehicle emissions associated with construction delay. Both are intended 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.

ICE estimates the vehicle operations impact of infrastructure projects from two distinct effects:

- Vehicle operating emissions – The user enters the years, average daily traffic (AADVMT), and average speed for the base and design years for the project. MICE computes the cumulative operating emissions over on the project's lifetime, and the difference between Build and No Build.
- Construction delay emissions – The user enters the years, average daily traffic (AADVMT), and average speed for the year construction starts and a baseline year for comparison (typically the year before construction starts), along with the construction timeframe in months. MICE computes the additional energy and GHG emissions due to vehicle delay during construction. Construction delay only applies for projects where speeds are reduced in the work zone during construction. [Under MnDOT's GHG](#)

guidance, construction delay does not need to be considered for projects where construction lasts less than one year.

Note that mitigation strategies are not applicable for vehicle operating emissions. Also, the calculations reflect a standard automobile fleet. They should not be used to estimate bus emissions on BRT or train emissions from Light- or Heavy-Rail.

1.5.10.2 Required Inputs to use in MICE

Figure 16 is a screenshot of inputs for a vehicle operations analysis; the inputs are defined below. Please note that vehicle operations inputs are the same for a Planning and Project level analysis.

Figure 16. Vehicle Operations Inputs in MICE (example)

Vehicle Operating Emissions				
	Year		Avg Daily VMT on project	Average Daily (Congested) Speed (mph) (or NA)
	Default	Custom		
Project Base Year	2019	2020	10000	55
Project Design Year/No Build	2050	2040	10000	40
Project Design Year/Build	2040	2040	10000	70

Construction Delay, Additional Emissions				
	Year		Avg Daily VMT impacted by project	Average Daily (Congested) Speed (mph) (or NA)
	Default	Custom		
Construction start year	2019	2022	10000	35
Pre-construction (baseline) year	2018	2020	10000	55
Project Base Year				
Construction timeframe (months)	N/A	18		

The following list explains each input element in Figure 16:

- Enter in a custom base and project design/horizon year for vehicle emissions. The interval between the base year and design year (in this example, 20 years) must be consistent with the “project lifetime” entered on the Project Inputs page.
- Enter the average daily vehicle miles traveled for the base year, design year no build, and design year build. This is the total VMT for all road segments associated with the project.
- Enter the average daily (congested) speed for the base year, design year no build, and design year build. **If unknown, enter “NA” (in capital letters).**
- If estimating emissions from construction delay (see note below), enter in the construction start year and a preconstruction year (representing an uncongested situation prior to lane closings). Enter the construction timeframe in months.
- Enter the average daily vehicle miles traveled for the start and preconstruction years.

- F. Enter the average daily speed for the construction period (congested) and pre-construction (before construction delay effects are observed). If the congested speed during construction is unknown, enter “NA”. (If the user does not enter a construction-delayed speed it is assumed to be half of the pre-construction speed. If the user does not know the pre-construction speed, they should enter the speed limit.)

MICE Users: This feature of ICE has been extensively modified in MICE to meet MnDOT needs. For vehicle operating emissions, rather than entering information in ICE for an opening year, interim year, and design year, MICE allows entry of data for a base year, design year No Build, and design year Build. This allows for Build/No-Build comparisons of vehicle emissions.

Results for Base Year and No Build do not appear in the Summary Reports produced by ICE. The “Usage” results in the Summary Report represent emissions for the Build scenario only (including construction delay), either total lifetime emissions or annual average emissions. (While not required by MnDOT guidance, if you request annual average vehicle emissions, this value reflects the average between base year and design year levels.) To see Base Year and No-Build vehicle emissions estimates, go to the Vehicle Ops tab. The build and no build CO₂e (and energy) results appear in rows 43-50 and can be copied into your NEPA document. Construction delay emissions appear in row 68 of this tab.

Build/No Build Results

Annual		Emissions CO ₂ e (MT/year)	LCA Energy, Mbtu/year
Project Base Year	2020	19,167	251,594
Project Design Year/No Build	2040	16,673	217,890
Project Design Year/Build	2040	15,979	208,811
Difference Between Build and No Build		(695)	(9,079)
Cumulative Difference Over Project Lifetime		(6,947)	(90,787)
Project Total (Build)	20	351,454	4,604,054

A note on speeds: ICE is designed to use either daily average speed inputs, or no speed inputs (“NA”). Users with more refined speed input data for their project have a couple of options. First, the Vehicle Operations function of MICE can be rerun multiple times, with inputs of VMT and speed applicable to each available time period (e.g., peak and off-peak, or AM peak/midday/PM peak/overnight). Alternatively, the VMT and speed data for each time period can be used to calculate a daily average speed for input to MICE. (Calculate VHT for each time period, and then total daily VMT divided by total daily VHT will provide an estimate of daily average speed.) The first approach will produce a more refined estimate of vehicle emissions than the second, and would be especially appropriate for congestion relief projects, to capture the GHG emissions benefits of congestion relief.

1.6 Unique Issues in Using MICE/ICE

1.6.1 Matching very Specific Projects to ICE Prototypes

Cases have been reported where users have attempted to match very specific roadway rehabilitation projects, such as milling, overlaying, slope stabilization, or bituminous shoulder replacement, to the general categories included in ICE, such as resurfacing and reconstructing pavement.

ICE is built on aggregated project data, and ICE will not accurately represent energy or emissions from projects more finely resolved than the prototypes on which ICE calculations are made. *MnDOT guidance does not require GHG analysis of any project types not covered by ICE.*

1.6.2 Projects with More Than One Build Alternative

ICE and MICE are designed to analyze the construction and operational impacts of one project. If you are analyzing a project with multiple proposed alternatives, you will need a separate version of MICE for each alternative. One version can include the No-Build traffic information and the traffic and construction information for Build alternative A; the next would include the No-Build traffic information and the traffic and construction information for Build alternative B; and so on.

Likewise, MICE assumes that the No Build scenario involves no construction. It can accommodate Build/No-Build traffic data, but not Build/No-Build construction inputs. If your No Build scenario does include some construction activities (e.g., resurfacing, or replacing a bridge that needs to be replaced regardless), you will need a separate version of MICE to reflect both the vehicle operation and construction activities associated with No Build.

If your No Build scenario includes some existing infrastructure (e.g., you are adding a lane to an existing roadway), your No Build scenario may still include maintenance emissions even if it doesn't include any construction activity. MICE calculates maintenance emissions on the existing system for Bus Rapid Transit, rail projects, and roadways. To address this, you can either populate a separate "No Build" version of MICE to account for only the existing infrastructure, or you can populate MICE with the existing infrastructure first, record the results for maintenance, and then add the new infrastructure to reflect the Build scenario.

1.6.3 Native Units and Reporting Results

ICE calculates lifecycle energy use and greenhouse gas (GHG) emissions. To do this, ICE requests the analysis timeframe (in years) from the user. It produces lifecycle (to end-of-life) estimates of energy use and/or GHG emissions. Both values can be reported on an annualized or total lifespan basis. ICE includes the building, modification, maintenance, and/or use of a transportation project or group of projects in its analysis.

The standard reporting unit for energy is "mmBTU", or millions of British Thermal Units. The standard reporting unit for GHG emissions is "MT CO₂e", or metric tons of CO₂-equivalent gases. 1 metric ton equals 1,000 kg. CO₂ equivalency is defined on a 100-year global-warming potential basis. Material factors are defined as cradle-to-gate. Operations and maintenance

activities and operational (use-phase) emissions are determined by integrating over the specified project lifetime.

The final units presented in outputs are user-selectable in the output tabs. This allows reporting in units different from the native units and avoids cases with insufficient resolution in the reported values. Reported values may be reported in MICE on an annualized basis, or cumulative values integrated over the project's specified lifespan.

MICE Users: MnDOT's GHG guidance requires reporting of total (cumulative) construction emissions, along with annual vehicle operating emissions for the project base year, design year No Build, and design year Build scenarios. The MICE Summary Results include tables of total emissions (see example screenshot below). Total Greenhouse Gas Emissions results are obtained by choosing this reporting option in the dropdown menu at the top of the Summary Results tab. The total construction emissions for MnDOT reporting purposes include Materials, Transportation (of construction materials), Construction, and O&M (maintenance) (see box in red below). As noted earlier, the "Usage" emissions in the Summary Results tables represents total lifetime (or annual average) emissions of the Build scenario only, and are reported in MnDOT NEPA documents separately from construction emissions.

If you are modeling construction delay, these emissions are *not* included in the MICE "construction" total; they are found in row 68 of the *Vehicle_Ops* tab. For MnDOT reporting purposes, add these emissions to the Construction total for the Build alternative.

Summary Results - Tables			
Total Greenhouse Gas Emissions			
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Materials	1,132	1,132	1,132
Transportation	151	141	141
Construction	1,031	958	958
Maintenance	430	409	409
Usage	351,454	351,454	351,454
Total	354,197	354,093	354,093

Additional emissions attributable to construction delay		
Years	Emissions CO2 (MT)	LCA Energy, Mbtu
1.166666667	2,150	28,078

1.6.4 Possible Sources of MICE Input Data

Infrastructure Type	Sources of Data
Bridges and Overpasses	Project Design Documents Size of existing bridge (for replacements)
Bus Rapid Transit	Project Design Documents
Culverts	Project Design Documents Size of existing culverts (for replacements)
Light and Heavy Rail	Project Design Documents
Lighting	Project Design Documents Lighting present on similar road sections
Parking	Project Design Documents
Pathways (trails & sidewalks)	Project Design Documents
Roadways	Project Design Documents
Roadway Resurfacing and Reconstruction	Planned lane miles for project(s)
Signage	Project Design Documents Signage present on similar road sections Disregard this source if no data available
Vehicle Operations (only required for projects that impact traffic volumes and/or speeds)	Project Design Documents and/or traffic report MPO transportation modeling (urban areas) Existing traffic counts & expected growth rate Speed limits/work zone speed limits MnDOT traffic forecasting web site: mndotgis.dot.state.mn.us