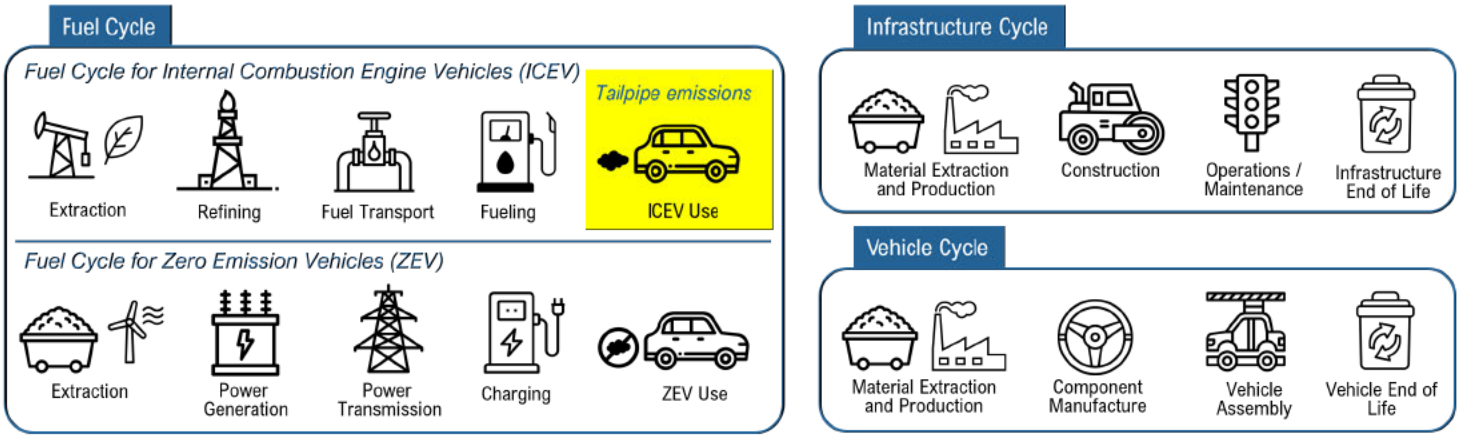
Addressing Life-cycle GHG Emissions in Transportation Planning

Life-cycle greenhouse gas (GHG) emissions include both direct and indirect emissions associated with the transportation system. Traditionally, transportation plans have analyzed GHG emissions by quantifying the direct, or tailpipe, GHG emissions from roadway users (highlighted in the figure below). However, transportation is responsible for GHG emissions from other processes related to fuels, infrastructure, and vehicles.



Fuel cycle, includes the production, transportation, and use of transportation fuels including the electricity used by electric vehicles. Quantifying emissions from all these processes is often referred to as well-to-wheels analysis.

Infrastructure cycle, includes the extraction, production and transport of raw materials, along with the construction, operation, maintenance, and disposal of infrastructure. GHG emissions from these processes are also known as embodied emissions.

Vehicle cycle, includes the extraction, production and transport of raw materials, component fabrication, vehicle assembly, and vehicle disposal.

Note that there is some overlap across fuel, infrastructure, and vehicle cycles. For instance, the infrastructure and vehicle cycles require on-road vehicle activity to transport materials, and some of this activity may be captured in the analysis of vehicle use emissions associated with the fuel cycle. When evaluating the GHG 'footprint" of transportation, it can be useful to identify areas of overlap to avoid double-counting GHG emissions from certain processes.

WHY SHOULD PLANS CONSIDER LIFE-CYCLE EMISSIONS?

GHG emissions such as carbon dioxide (CO_2) can remain in the earth's atmosphere for generations regardless of when and where they are released. Accordingly, it can be valuable to quantify both direct and indirect GHG emissions to understand the overall impact of transportation decisions. This type of analysis will be important as agencies consider the effect of electric vehicles, renewable energy, infrastructure, and agency operations on overall GHG emissions. This FHWA Every Day Counts initiative will produce resources to help practitioners understand and quantify these effects.

HOW ARE AGENCIES USING LIFE-CYCLE ANALYSIS TO INFORM DECISIONS?

Virginia Statewide GHG Planning Analysis. The Virginia Department of Transportation evaluated GHG emissions from both the build and no-build scenarios from its 2040 long range transportation plan and compared the tailpipe and embodied emissions for two hypothetical projects to test methodologies for statewide evaluation of major projects.

Oregon Statewide Transportation Improvement Program (STIP) Analysis. The Oregon Department of Transportation conducted a pilot evaluation of both tailpipe and embodied GHG emissions for its 2024-2027 STIP. The evaluation identified the types of projects that can potentially increase emissions and established a baseline GHG emissions level to compare to future investment programs.

Minnesota Department of Transportation Evaluation of Agency Construction Projects. The Minnesota Department of Transportation uses a state-specific version of FHWA's Infrastructure Carbon Estimator (ICE) Tool to calculate GHG emissions estimates from planned projects. These estimates inform mitigation planning to ensure the state meets GHG reduction targets.

Integrating Greenhouse Gas Assessment and Reduction Targets in Transportation Planning

U.S. Department of Transportation
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DIFFERENCES BETWEEN TAILPIPE AND LIFE-CYCLE APPROACHES

Tailpipe GHG analysis quantifies the fuel use and emissions directly associated with operating vehicles. Life-cycle analysis quantifies a broader set of processes required for a vehicle to be able to move.[1] Transportation agencies may determine which processes to include based on the purpose of the analysis. For instance, an agency may estimate tailpipe GHG emissions to track progress toward a state-level goal that specifically addresses direct tailpipe GHG emissions from transportation sources. However, the same agency could also quantify the "upstream" fuel emissions from electricity and fuel production, transport, and use in vehicles to better understand the overall GHG emissions from the vehicle fleet and the impact of strategies to promote electrification. Likewise, an agency could compare the tailpipe emissions from a transit project to that of the vehicles it displaces, but a more complete analysis would include the full life-cycle emissions – construction, operations, maintenance, fuel, and use – of the different projects. The below table provides more information on the differences between tailpipe and life-cycle analyses.

CHARACTERISTIC	TAILPIPE APPROACH	LIFE-CYCLE APPROACH
Scope of Analysis	Emissions directly associated with the **operation of vehicles.**	Tailpipe emissions, ***along with*** processes required to support the use of vehicles. Depending on purpose of analysis, these may include the production of energy, the construction and maintenance of infrastructure, and the manufacture of vehicles.
Timeframe	Typically short term, such as results for single or a selected few **calendar year(s).**	**Less time-dependent than the tailpipe approach.** May address cumulative or individual years of emissions over the lifetime of a transportation project or plan.
Analysis Tools	• **Environmental Protection Agency's MOVES model** • **California's EMFAC model**	• **FHWA's ICE tool** • **Environmental Protection Agency's eGRID tool** • **Argonne National Laboratory's GREET model**
Application	• **Monitoring and reporting** of tailpipe GHG emissions from transportation sources. • **Evaluating changes** in tailpipe GHG emissions from transportation decisions. • Setting and reporting against **GHG targets.**	**Systems perspective on direct and indirect impacts** of transportation decisions intended to reduce GHG emissions. Typically, these will answer questions requiring more detail than a tailpipe analysis, such as: • The life-cycle impact of electric vehicle adoption. • Changes in the carbon footprint associated with different decisions. • The payback period for operational improvements to offset construction GHG emissions. • The benefits of sustainable procurement relative to conventional practices.

[1] "Life-Cycle Assessment for Transportation Decision-making", Mikhail Chester, Juan Matute, Paul Bunje, William Eisenstein, Stephanie Pincetl, Zoe Elizabeth, and Connery Cepeda.

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https://www.planning.dot.gov/planning/topic_GHG.aspx