RIVIAN

Version 1.0

# Carbon Footprint Methodology Report

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# Introduction

**Today, the transportation sector relies mostly on fossil fuels—the accumulation of prehistoric plant- and animal-based carbon. If we stay on our current path, we will quickly exhaust this stored energy and, in the process, carbonize our atmosphere to such a degree that life as we know it will not be possible. If we want the planet to continue to sustain life and foster future generations, we must change now.**

## Introduction

Rivian exists to create products and services that help our planet transition to carbon-free energy and transportation. Responding effectively to climate change requires collective action and urgency. We believe we have a responsibility and opportunity to play a role in the global transition to a low- or zero-carbon economy. To make the necessary changes, we must develop a deep understanding of our environmental impact and take action. At Rivian, we believe that our vehicles and other products are key parts of the climate solution, but we also understand that making, using, and recovering them requires inherently carbon-emitting activities.

This report is part of Rivian's mission to drive toward a more sustainable future in a transparent way. In the following chapters, we detail our methodology to create carbon footprints for our vehicles. This is an open report that walks through the key points of Rivian's carbon footprinting process.

Our vehicle carbon footprints follow the methodology described in this report. These show the life cycle greenhouse gas (GHG) emissions of our vehicles, key scenarios, and other information, which allow our customers to understand where we are doing well and where we can do better. We use the same methodology for each vehicle to maintain a consistent and repeatable approach that we hope others in the industry will follow. Rivian believes that reducing the transportation sector's footprint requires transparency and, ultimately, alignment on methods across the industry.

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# Method

**Rivian follows ISO 14040 and ISO 14044[1] standards for conducting life cycle assessments (LCA). These standards help us align with best practices in the industry while characterizing GHG emissions in the most meaningful way for Rivian. Additionally, we adopt principles from ISO 14067[2] for specific topics, including selection of grid mixes and treatment of GHG emissions and removals from renewable energy. We chose not to fully conform to ISO 14067 because we felt that the use of a single global warming potential (GWP) metric most clearly communicates the carbon footprint of our products.**

[1] ISO 14044:2006 "Environmental management – Life cycle assessment – Requirements and guidelines" and ISO 14040:2006 "Environmental management – Life cycle assessment – Principles and framework"
[2] ISO 14067:2018 "Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification"

While these standards provide the necessary foundation for our analyses, there are myriad decisions that still need to be made: where we gather our data, how best to integrate real-world information, the best way to model an incredibly complex supply chain, and many more. This report provides details about how and why we make many of those decisions.

## 2.1 Goal and Scope

The goal of this report is to establish the carbon footprint method for Rivian commercial and consumer vehicles. The methodology serves multiple purposes, such as providing data for internal and external communication of product carbon footprints and strategic insights into potential decarbonization enablers. To do so effectively, the methodology is repeatable, comprehensive, and consistent with ISO 14040 and ISO 14044. It supports deeper transparency into how Rivian assesses carbon footprints and can be used by multiple audiences, including Rivian customers, research institutes, investors, and others.

Rivian employs an attributional carbon footprinting approach and assesses the midpoint impact category—global warming potential over a 100-year time frame. The characterization factors for greenhouse gases (GHG) are established by the sixth assessment report (AR6) from the Intergovernmental Panel on Climate Change (IPCC), which includes climate-carbon feedbacks. It is important to note that GWP represents relative potential impact and does not necessarily predict actual impacts on climate change.

The characterization factors for our selected material types include land use change and exclude $CO_2$ that is biogenic, meaning produced or brought about by living organisms, unless otherwise specified in the vehicle report. The GHGs included in this impact category are carbon dioxide, methane, nitrous oxide, and any other greenhouse gases characterized by the IPCC. The resulting unit is $CO_2$-equivalents or $CO_2e$.

Part of our sustainability strategy involves using high-quality bio-based feedstocks in place of petroleum-based materials. It is important to us that any biogenic carbon emissions or removals that are a result of sustainability initiatives are discernable. To do so, while most of our materials will be assessed with characterization factors that exclude biogenic carbon, our vehicle reports may include biogenic carbon for specific bio-based polymers. The vehicle reports will state any instances where biogenic carbon is included.

The vehicle reports that follow this methodology are not intended to support ISO-conformant comparative assertions without additional analyses and documentation. Differences in data choices, system boundaries, and methodology decisions may result in large discrepancies between carbon footprints generated by different organizations. We encourage all audiences to recognize those differences when drawing any conclusions regarding the carbon footprint of Rivian vehicles versus other vehicles.

## 2.2 Functional Unit

We assess the carbon footprint of providing transportation services with a Rivian vehicle over the analysis period. The analysis period is aligned with an engineering target that is determined through an internal durability assessment based on the vehicle's intended use and expected reliability. The durability target is reported in both miles and years. These values are determined independently from one another and vary between vehicles depending on the design intent. To normalize results and assist in comparing different vehicles, results are expressed as grams of $CO_2e$ per mile (g $CO_2e$/mi) which is the absolute carbon footprint divided across the analysis period of the vehicle. We use the carbon footprint per mile to capture the potential sustainability benefits of engineering more durable vehicles. The carbon footprint per mile decreases as the total mileage is extended because the total carbon footprint is amortized over a longer period. This creates an incentive for Rivian to design and engineer products that last as long as possible, but this incentive is lost in the absolute carbon footprint (MT $CO_2e$) as it only captures the incremental GHG emissions from operation.

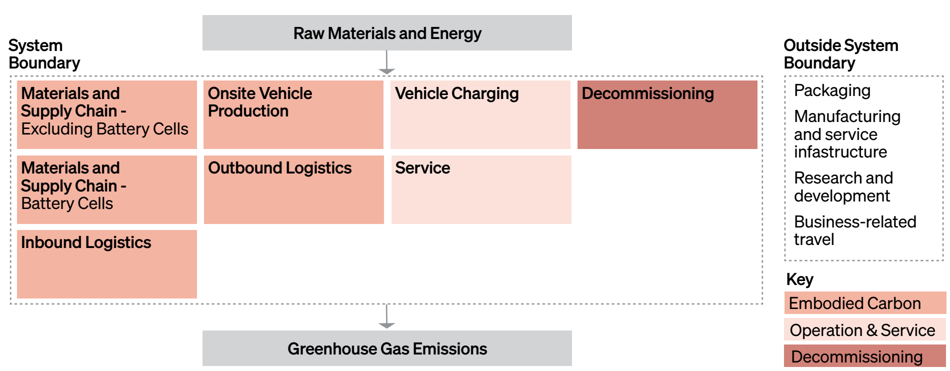
## 2.3 System Boundary

The carbon footprint of a Rivian vehicle includes activities across the life cycle of the vehicle from cradle to grave. This includes extracting resources from nature, turning these into raw materials and intermediate products, manufacturing parts, assembling the vehicle, using the vehicle, and managing the vehicle as it is decommissioned, as well as anything else of relevance in between. The system boundary is drawn to maximize the inclusion of the most relevant processes while acknowledging that certain activities have sufficiently low potential impacts or are otherwise intractably complex to include on a per-vehicle level.

Figure 1 shows the basic system boundary for Rivian's vehicle LCAs. Exclusions include packaging, infrastructure, capital equipment, research and development activities, and business-related travel. This methodology does not define cut-off criteria that are used to exclude materials or energy flows under a certain threshold. The system boundary is defined based on relevance to the goal of the study. For the activities within the system boundary, all available energy and material flow data have been included in the model. Proxy data are used when no matching life cycle inventories are available to represent a flow.

GHG emissions from the supply chain are included in the system boundary but are sometimes difficult to exhaustively capture. The complexity of the supply chain requires assumptions about manufacturing energy, logistics, materials losses, and other factors. Rivian includes estimates for all relevant supply chain activities and uses comprehensive LCA databases to ensure that we use the best available information. However, some activities in the supply chain may not be fully characterized. We are conservative in our assumptions to avoid underestimating GHG emissions from our supply chain.

**Figure 1**
System Boundary



# 2.4 Our Approach to Materials and Supply Chain

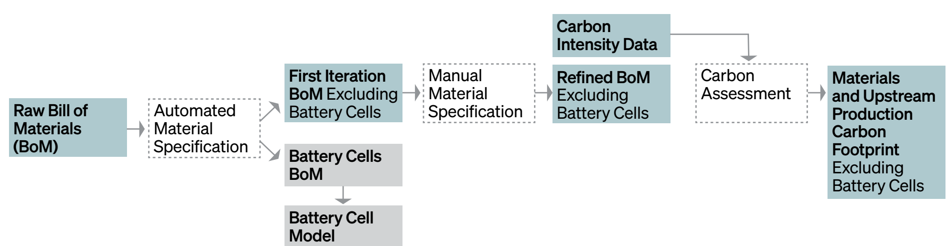
The Bill of Materials (BoM) provides information on the masses and material compositions of the parts and assemblies that make up a vehicle. The first iteration of a BoM for a Rivian vehicle is extracted automatically from our product lifecycle management (PLM) systems. A key step in the script involves categorizing the thousands of materials in our PLM systems into several dozen distinct material types, such as polypropylenes, polyamides, hot-rolled steel, and many others. This first investigation of our BoM, while a step in the right direction, requires further material specification, as it leaves portions of the vehicle with unassigned materials.

The quality of the data in the BoM is essential to the development of a robust life cycle inventory (LCI). To get our BoMs to an adequate state for carbon footprinting, we manually investigate parts with large masses of unassigned materials. This process involves collaborations with internal engineers, supply chain experts, and our upstream suppliers. We conduct part-level assessments until the BoM is categorized to a point that is sufficient for carbon footprinting, with an approximate target of less than 15% by mass of the BoM without specific material designations.

Material masses and types from the refined BoM are combined with carbon intensity factors (i.e., kg $CO_2$e/kg material) to establish carbon footprints for individual parts. Parts with unassigned materials are given a carbon intensity factor based on the average carbon intensity of the known materials in the vehicle. Carbon intensity data for materials and processes comes from a variety of sources, including the Sphera Managed LCA Content (MLC)[3], ecoinvent[4], industry, and scientific literature. Data choices and preferences are discussed in subsequent sections.

The cells in the high voltage traction battery (battery cells) are evaluated separately from the rest of the vehicle. Rivian has created a custom model dedicated to GHG emissions from the battery cell materials and upstream production activities. This allows us to better adapt to evolving understandings of battery cells and leverage the best information available. Battery cell data and modeling are discussed in more detail in the following chapters.

**Figure 2**
BoM organization and refining



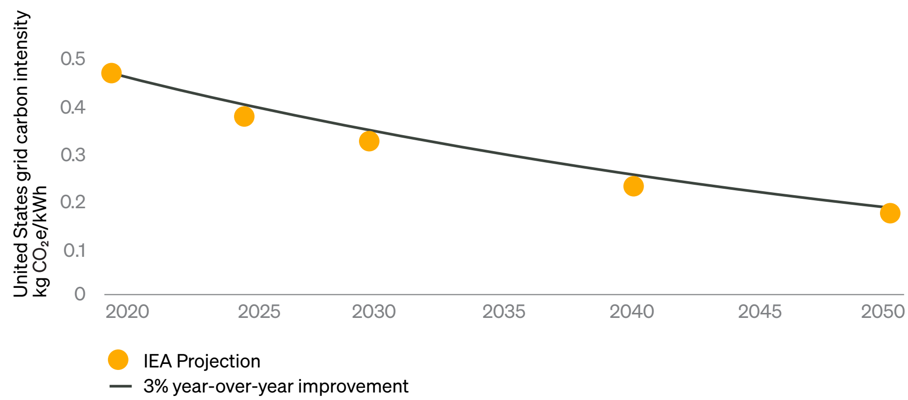

[3]https://sphera.com/life-cycle-assessment-lca-database/
[4]https://ecoinvent.org/

# 2.5 How We Derive Electricity Grid Factors

Grid emission factors have significant temporal and geographic variation. They also have an outsized influence on the carbon footprint of the vehicle. Rivian uses data from Sphera's MLC database at the national level and/or eGRID sub-region[5] for grid carbon intensity factors. Given that Rivian vehicles are expected to stay on the road for up to a decade or more, we can provide a more accurate representation of the carbon footprint of a Rivian vehicle by supplementing historical data with projected emission factors that estimate how electricity grids will change over time.

The International Energy Agency (IEA)[6] provides electricity grid projections through 2050 under different policy scenarios. Rivian uses the most conservative of these, which relies on "stated policies" rather than pledges or other aspirational improvements. Since this projection data are only available at the national level, Rivian selects a year-over-year percentage improvement so that changes for sub-national regions (e.g., the eGRID subregions) can be modeled using the national trend. The year-over-year improvement is selected to be slightly worse than the most conservative projection. Figure 3 shows an example of the IEA data (per Sphera's MLC database) and the Rivian modeled projections using a 3% year-over-year improvement.

**Figure 3**
IEA electricity grid carbon intensity projections compared to 3% year-over-year improvement. Rivian uses a percentage decrease in the grid carbon intensity that is slightly worse than the most conservative projections.




Rivian believes it is important to use our best understanding of how the electricity grid will change for the base cases for our vehicles. But we also acknowledge that forecasting the GHG emissions from electricity is inherently uncertain. Every vehicle carbon footprint includes scenario analyses that test how different projections and grid mixes affect the carbon footprint of the vehicle.

[5] https://www.epa.gov/egrid
[6] https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf

# 2.6 Our Approach to Renewable Energy

Rivian's priority will always be to first minimize the amount of energy that we need to make and operate our vehicles. But even the leanest processes and most efficient vehicles need electricity, so we need to find ways to reduce the resulting GHG emissions. Rivian's approach to this is a renewable energy procurement strategy, and our current efforts in this space are specific to the US grid wherein most of our vehicles are currently used.

**Our renewable energy goals are founded on the core principle of creating the greatest positive impact on the grid, our communities, and the planet.**

Our renewable energy goals are founded on the core principle of creating the greatest positive impact on the grid, our communities, and the planet. To do this, we cannot consider our own energy needs in a vacuum. Instead, we must consider the current makeup of the grid and procure resources to fill in the gaps when grid supply is reliant on fossil fuel generation. This will ensure that we incentivize buildouts at the most beneficial times and better support decarbonization across the grid.

We use a variety of mechanisms to develop or purchase renewable energy, including power purchase agreements (contracts to buy a certain amount of renewable energy at a fixed price for a period of time), onsite and community-based solar and wind projects, and partnerships with utilities. Regardless of the mechanism, our aim is to add renewables to the nation's grid, located where they can drive the greatest benefits. Clean energy is not distributed evenly across geographies and balancing access is a critical step on the path to a more sustainable system.

Renewable energy is used in various parts of the vehicle life cycle. Depending on the vehicle, renewable electricity may be used for the electricity consumed at Rivian facilities; charging vehicles using Rivian charging equipment (including Rivian Adventure Network (RAN) and Rivian Waypoints networks); charging vehicles using non-Rivian charging equipment; and other applications. In each case, the goal is to prioritize where Rivian can most positively contribute to grid decarbonization.

Currently, and in our future strategy, we have renewable energy procurements that correspond to the electricity consumed while charging Rivian vehicles with Rivian equipment. Conservatively, we do not account for future renewables in our baseline carbon footprints. We also have onsite renewables at our production facility in Normal, Illinois. Because the energy production of existing renewables is historically reported in the meter data at Rivian production plants, the emissions from the production and use of these renewable energies are included in our vehicle carbon footprints. Based on our exclusion of all future renewable purchases and developments associated with charging, our expectation is that the actual fraction of renewable electricity in each vehicle's life cycle will likely be larger than that assumed in the analyses. To communicate these benefits, additional scenario analyses may be included in vehicle reports that highlight the predicted impact of our renewable electricity procurements.

The inclusion of renewable energy aligns with ISO 14067, Sections 6.4.9.4.2 and 6.4.9.4.4:

- conveys the information associated with the unit of electricity delivered together with the characteristics of the generator
- is assured with a unique claim
- is tracked and redeemed, retired or cancelled by or on behalf of the reporting entity
- is as close as possible to the period to which the contractual instrument is applied and comprises a corresponding timespan
- is produced within the country, or within the market boundaries where consumption occurs if the grid is interconnected

Detailed information about Rivian's renewable energy strategy and policy can be found on Rivian's website or is available upon request.

## 2.7 Allocations

Rivian uses the cut-off method, indicating that the GHG emissions from disposal are only included for materials that are not reused or recycled into another product life cycle. Scrap material that enters Rivian's supply chain is considered burden-free; all modifications of that scrap after entering Rivian's supply chain (including transportation, remelting, and other improvements) are included in our scope. Following the cut-off method, no credits are applied for any materials once they leave the Rivian system boundaries.

Any GHG emissions associated with the energy used in Rivian production facilities for sorting scrap for recycling or other decommissioning scenarios are accounted for in the footprint of the onsite production processes. All scrap that is landfilled or incinerated is included in the decommissioning stage of this study. Following the cutoff method, this methodology does not account for the burden of recycling processes beyond onsite material disposal sorting.

GHG emissions for systems with multiple co-products are allocated according to the ISO 14044 stepwise procedure. Upstream allocation is often inherently included in the aggregated datasets. The most notable application of co-production allocation may be for onsite production, where multiple vehicles may be assembled in the same facility or even on the same line. In these cases, the GHG emissions from the facility are allocated based on the number of vehicles produced.

## 2.8 Data Quality

Data quality has a significant influence on the results and conclusions of any LCA study. Although most organizations follow similar guidelines for best practices, choosing the best data varies based on many factors, including data availability, intended purpose, supplier relationships, and individual practitioner preference. The quality of data evolves over time and generally increases as internal systems are established, real-world data become available, and the general state-of-the-science is raised across the industry.

Even with these challenges, it is imperative that data quality remains at the forefront and that data are selected using consistent philosophies. Attention to data quality decreases the likelihood of creating biases for our vehicles. In general, the order of preference and ranking for data sources is:

1. Supplier data / Rivian primary data
2. Calculated values based on primary data
3. Sphera managed LCA content (MLC)
4. Literature data / ecoinvent
5. Estimates / proxy data

We use the latest versions of Sphera's MLC database and ecoinvent databases at the time of assessment. Certain materials, such as aluminum, use regional averages or even site-specific carbon intensity data when available and applicable. Many other materials and processes are global averages, which we chose based on the globally diverse supply chain needed to manufacture Rivian vehicles.

## Method

Sphera's MLC database is the primary source of most carbon intensity data. Other sources, including ecoinvent, literature, and industry data, are used to fill gaps in or to better represent Rivian processes and materials. By preferentially selecting data from Sphera's MLC database, Rivian ensures better consistency between datasets.

All carbon intensity data are updated annually or as new information becomes available. Rivian understands that the quality of the data from LCA databases and other sources is constantly improving, and it is important that our analyses use the most recent information.

Data from Rivian systems are also updated frequently. As our systems improve and we learn more about our vehicles, we will update data sources and values to reflect our current state of knowledge.

Table 1 provides an overview of specific data quality indicators and the assessment for Rivian's models.

**Table 1**
Data quality indicators and assessment for Rivian's models

| Data quality indicator | Assessment for Rivian's models |
|---|---|
| **Time** | Primary data for onsite production, logistics, and material flows are collected for the production year of vehicles. Material and process carbon intensities are selected from the latest versions of LCA databases, industry data, and/or supplier information. Electricity data for operation are projected over the analysis period to estimate anticipated changes to the grid. |
| **Geography** | Rivian has a complex global supply chain with materials and parts sourced from around the world. When choosing data, we use North American datasets when available and applicable. Some material data, including many about plastics, are from global or European datasets. Electricity datasets for operation are specific to the region where the vehicles are expected to be used. |
| **Technology** | All data are modeled to represent the relevant technologies or technology mixes. Some materials may be imperfectly represented or simplified due to lack of available datasets or incomplete understanding of the material details, such as specific alloy compositions or polymer composites. |
| **Precision** | The bill of materials comes from Rivian's engineering systems and represents actual information for the masses and material types in the vehicles. Likewise, onsite production and logistics data are gathered from Rivian systems. Vehicle operation is estimated based on various factors, including EPA ranges, battery capacity, charging efficiencies, and annual mileage. |
| **Completeness** | No data are knowingly omitted from our models. Any data gaps are filled with proxy data or estimates. |
| **Consistency** | Most background data are sourced from Sphera's MLC database to maintain consistency. |
| **Reproducibility** | Reproducibility is supported as much as possible by providing breakdowns of materials, our approach to electricity modeling, and information about our battery modeling. While some details need to remain confidential, we expect that any third party should be able to approximate our results using similar data and methods. |

# Life Cycle Inventory

**The life cycle inventory (LCI) is divided into three stages: Embodied Carbon, Operation and Service, and Decommissioning.**

# 3.1 Embodied Carbon

Embodied carbon comprises the cradle-to-gate life cycle stages of a Rivian vehicle, ending with the distribution of the vehicle to the customer. The bill of materials (BoM), which outlines the mass and material composition of the vehicle parts, is central to the analysis of these stages.

### 3.1.1 Materials and Supply Chain—Excluding Battery Cells

The material types in each vehicle's BoM are assigned material carbon intensities using data from Sphera's MLC database. When necessary, the LCA database from ecoinvent and literature provide supplemental material intensities. For electronic control units (ECUs), we assign a carbon factor based on other average carbon footprints of ECUs in the vehicle, as described in the next section. The material carbon intensities for steel and aluminum are also modeled with more detail due to the increased availability of supplier-specific data on the recycled content and the abundance of these materials in the vehicle.

Each material type is assigned a manufacturing process based on information from the supplier when available and literature as needed. The carbon intensity of each manufacturing process is found in Sphera's MLC database with supplemental information from ecoinvent or literature. At Rivian, most sheet metal stamping is done in-house and, as with other in-house processes, the carbon footprint of stamping is largely included within the onsite production footprint. However, because we cannot assume that all stamping occurs in-house, we conservatively also include the associated GHG emissions in this stage to avoid underestimating the total GHG emissions from material manufacturing.

Like many industries, material utilization and throughput yields are imperfect in the automotive industry. Losses from imperfect material utilization are planned losses associated with manufacturing processes (e.g., forging flash, stamping scrap). When available, we use part-specific material utilization data to account for the material losses. In the absence of part-specific data, this methodology employs default material utilization figures by material category and associated manufacturing processes. Along with losses from material utilization, we include the material losses that occur from imperfect throughput yields. Yield losses are associated with parts that do not meet specifications or are otherwise unfit to be used. Depending on the final stage of production of a part, yield losses can occur upstream or in-house. Although accurate yield data are often difficult to ascertain, we still include estimates since we understand that fallout occurs even in the most well-managed processes.

**Electronic Control Units**

Much of the advanced electronics are housed in electronic control unit (ECU) modules. The GHG emissions of ECUs can vary significantly depending on the size and complexity of the printed circuit board (PCB), onboard electronics, and the housing materials. To better understand the carbon footprint of the low-voltage electronics in our vehicles, Rivian conducted an internal study to determine the carbon footprint of all the ECUs in Rivian vehicles. From this, we derived average carbon intensity factors for our ECUs.

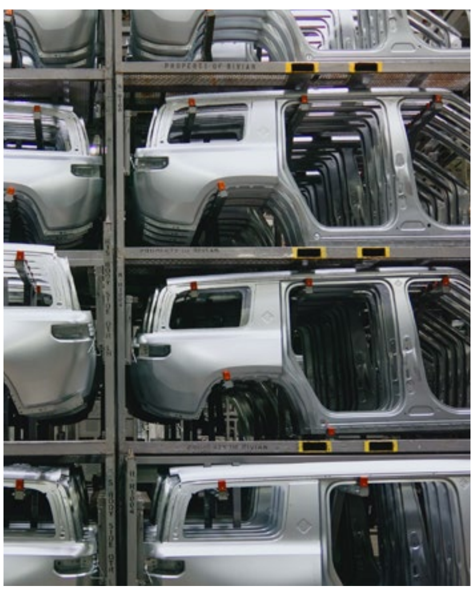
The subcomponents of an ECU can be broken down into two categories: populated PCBs and mechanical parts. The mechanical parts are made up of polymers and metals. As such, the corresponding carbon factors from Sphera's MLC database scale by mass, which allows us to use the BoM of ECU to find the carbon footprint of the mechanical parts.

The GHG emissions for an unpopulated PCB are determined by exploring engineering drawings to determine the rectangular dimensions[7] and number of layers of the PCB. Using rectangular dimensions rather than actual area allows us to approximate losses associated with panelization efficiency during PCB fabrication. This data are then combined with carbon intensity factors for the appropriate type of PCB. Determining the GHG emissions from the onboard electronics (integrated circuits, resistors, capacitors, etc.) is more difficult and has not been researched in detail. For our early models, we estimate that a populated PCB will have approximately double the carbon footprint of an unpopulated PCB based on examination of generic populated PCB data from Sphera's MLC database.

**Aluminum**

Aluminum is used extensively in our vehicles and constitutes a significant portion of the GHG emissions. While Rivian's approach to evaluating the emissions of aluminum parts is not fundamentally different than that of other materials, the data are more carefully scrutinized to improve accuracy and applicability to Rivian's vehicles and supply chain.

We categorize aluminum parts into four distinct material types: extruded, sheet, cast, and forged. We derive carbon intensity factors for aluminum by reconstructing models from the Aluminum Association[8] for North American aluminum products. Reconstruction is required to incorporate Rivian-specific recycled contents (the Aluminum Association assumes industry average recycled contents). We combine primary and secondary ingot data from the Aluminum Association with data from our supply chain recycled contents. We create models for specific aluminum forms by adding downstream fabrication (e.g., sheet rolling, extrusion) and material utilizations that align with the Aluminum Association.



For material types where the form of aluminum cannot be inferred, we use the carbon intensity of aluminum sheet as a proxy. In cases where a mixed material type contains aluminum, we average the carbon intensities of aluminum sheet and the other material.

The vehicle carbon footprint reports contain additional details regarding aluminum modeling for a given vehicle.

**Steel**

Along with increasing the recycled content in our aluminum parts, we also strive to incorporate more recycled content into our steel parts. As with aluminum, steel constitutes a large portion of the GHG emissions from the material and supply chain in Rivian vehicles. In our BoM organization process, steel is divided into the two most common types of steel in our vehicles: hot-rolled and cold-rolled.

[7] Rectangular dimensions: the rectangle that encompasses the surface area of a PCB, regardless of actual PCB shape
[8] https://www.aluminum.org/

Carbon intensity data from the World Steel Association (worldsteel)[9] is available for versions of hot and cold-rolled steels with industry average recycled contents. Additionally, a theoretical 100% primary steel is estimated by applying the worldsteel value of scrap dataset to the upstream scrap input for hot and cold-rolled steels. Using these two datasets — the industry average recycled content and the 100% theoretical primary steel — we can estimate the GHG emissions of steel with any recycled content through interpolation and extrapolation. This is admittedly an estimation, but it is necessary in order for us to develop datasets that can estimate Rivian's supply chain without the need to develop and/or gather other primary data.

For material types where we cannot infer the form of steel, we use the carbon intensity of cold-rolled steel as a proxy. In cases where a mixed material type contains steel, we use an average of the carbon intensities of cold-rolled steel and the other material.

The vehicle carbon footprint reports contain additional details regarding steel modeling for a given vehicle.

### 3.1.2 Materials and Supply Chain – Battery Cells

Rivian has developed a custom model to determine the carbon footprint of the battery cells in the high voltage traction battery. This model includes the raw material inputs, which are documented in a battery cell BoM, and any upstream production processes. We divide the model into two scenarios depending on the location of the module and pack assembly.

1. When the assembly of battery cells into modules and modules into battery packs occurs in Rivian manufacturing facilities, the model includes the extraction of raw materials, powder processing, and cell manufacturing. In this scenario, we assume that the module and pack assembly processes are included in the GHG emissions from onsite production.
2. When the assemblies of the modules and pack are done at the supplier, these assembly processes are included in the battery model along with the activities described in the first scenario.

As shown in Figure 4, in both scenarios, the materials used for the assembly of battery cells into modules and modules into battery packs are captured with the other materials in the vehicle.

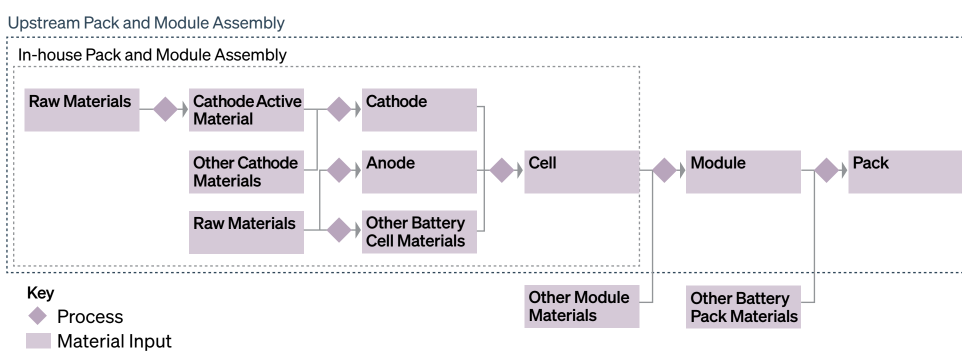



**Figure 4**
Battery Model – System Boundary of Assembly Scenarios

[9]https://worldsteel.org/

We estimate the processing energy required for powder production and cell manufacturing using the GREET[10] model from the Argonne National Laboratory. We apply carbon factors from Sphera's MLC database to the processing energy to estimate the GHG emissions from cell assembly. In scenario 2, the GHG emissions from module and pack assembly are estimated with manufacturing carbon data from Sphera's MLC database. This methodology includes a literature-based value for material utilization and an internal value for throughput yield to estimate battery cell scrap.

To account for the carbon footprint of the raw material inputs in the battery cells, we remove the battery cells from the BoM and assess them separately. We determine the material composition of battery cells using our internal understanding of the chemistry, which we validate and supplement with literature. To increase the granularity of these findings, we estimate the material composition of the cathode active material based on the cell chemistry using the GREET model. We estimate a 1:1 ratio of natural and synthetic graphite in the anode.

The raw material inputs in this stage are not limited to the materials found in the teardown. Ancillary materials used in the production of battery cells are estimated using literature data. To determine the carbon footprint of the raw material inputs, we apply carbon factors from Sphera's MLC database, ecoinvent, and the GREET model to the battery cell BoM.

### 3.1.3 Onsite Production

Rivian conducts a variety of manufacturing and assembly processes in Rivian-owned facilities, such as our plant in Normal, Illinois (United States). Many activities occur at these facilities, such as sheet metal stamping, painting, general assembly, battery pack production, scrap sorting, and drive unit production. The onsite production data are from our corporate greenhouse gas accounting program. The direct and upstream GHG emissions at Rivian onsite production facilities are determined by aggregating the total emissions and dividing it between the individual vehicles based on the total number of units produced in that time frame, typically one year. Most manufacturing scrap is recycled (pre-consumer scrap) without credits, aligned with the cut-off allocation approach.

We report the energy production of onsite renewables at Rivian production facilities along with the annual energy use, including the emissions from these renewable energies and the respective displacement of grid energy. We determine the carbon footprint of our grid electricity use by using the most recent version of the relevant eGRID subregion data available in Sphera's MLC database. For each vehicle assessment, the carbon intensities of the grid electricity are selected for the regional electricity grids in which the production facilities are located.

Rivian's manufacturing plant energy metering system is not equipped with sub-metering, therefore the carbon footprint of this stage conservatively includes business activities outside of production and is divided equally across Rivian vehicles using the total annual number of vehicles produced.

[10]https://greet.es.anl.gov/index.php

### 3.1.4 Inbound Logistics

The carbon footprint of the inbound logistics is from Rivian's corporate greenhouse gas emission accounting efforts. The carbon footprint calculation is found using the following data: mass and cost of the transported parts and materials, distance of transportation, and carbon intensity of the various modes of transportation.

The primary source of the transportation data are provided by suppliers and recorded within Rivian's Transportation Management System (TMS). Inbound logistics data are tracked at the company level and allocated to individual vehicles by the total number of units produced during the timeframe of the logistics dataset, usually a one-year period.

Carbon factors from Sphera's MLC database are used when mass and distance data are reported in the TMS system. In the absence of mass inputs, cost data are used alongside CEDA factors from CEDA Global 4.01 to determine the GHG emissions from these parts. Comparing the mass and cost data for parts with both metrics available, we find the cost-based estimation consistently more conservative. As such, we expect that as our data improve, the GHG emissions from this stage of the product's life cycle will decrease.

Rivian considers the following modes of transportation: truck, air, inland ship, oceanic ship, drayage, cartage, and rail.

### 3.1.5 Outbound Logistics

We calculate the carbon footprint of outbound logistics using the weight of the final product along with the distance and mode of transportation. The distance from the manufacturing plant to the vehicle's final sale location is based on Rivian's outbound transportation management system. The mode of transportation is typically auto carrier or rail. For either mode, we use the corresponding emission factor from Sphera 's MLC database.

## 3.2 Operation and Service

### 3.2.1 Operation

Operation includes the GHG emissions from electricity consumed by Rivian vehicles over the analysis period. Most of the electricity is used for propulsion, but also includes losses from charging efficiency and passive battery drain.

We determine the propulsion electricity using the EPA-reported range and the usable battery energy (UBE) for each vehicle. We use EPA-reported range because it establishes a repeatable method that is publicly available for different vehicles. Charging is broken down into the source and type of charging. Different charging modes — Level 1[11], Level 2[12], direct current fast charging (DCFC)[13] — may have different charging efficiencies. Rivian uses vehicle analytics to determine the share of each charging mode and applies the relevant charging efficiency. When better data are not available, charging efficiencies are assumed to align with EPA-reported efficiencies.

[11] Level 1 charging is the lowest voltage and slowest charging method. It uses a standard residential voltage AC outlet.
[12] Level 2 charging uses higher voltage and is faster than level 1 charging. It is available residentially and commercially.
[13] DCFC (level 3) charging is only commercially available and is the highest voltage and fastest charging option.

Along with charging losses, all electric vehicles consume electricity while not in use. Rivian uses internal data to estimate this passive battery drain and includes the emissions alongside other operation sources.

Charging location plays an important role in a vehicle's GHG emissions during operation. When data are available, we consider the region in which each Rivian vehicle is driven. Data sources for this information include vehicle analytics, fleet data, and consumer sales data. We determine the GHG emissions using the Rivian electricity grid projection (3% year-over-year improvement) for each relevant grid region.

Renewable energy for operation is included when it aligns with the ISO 14067 requirements. Renewable energy that is beyond 14067 requirements — including intended purchases for future emissions — is addressed via scenario analyses.

The operation of Rivian vehicles is the single largest source of GHG emissions. Vehicle reports include scenario analyses to assess how different data decisions or prediction models may affect the GHG emissions during operation.

### 3.2.2 Service

Service includes scheduled maintenance of the vehicle and its parts. Scheduled maintenance is consumable parts that will need to be replaced over the analysis period, most notably tires. Service parts are replaced at intervals based on their anticipated replacement rates. The replacement parts are modeled using the data found in the BoM for that part.

## 3.3 Decommissioning

Decommissioning includes vehicle dismantling and material disposal. Rivian vehicles have only recently been produced in mass and have not been decommissioned in meaningful numbers. This methodology assumes a decommissioning phase that includes generic vehicle shredding and material disposal. Batteries, wheels, and tires are removed from the vehicle prior to shredding and are therefore not considered in the GHG emissions from vehicle shredding.

For material disposal, Rivian considers three decommissioning scenarios: landfill, incineration, and recycling. Following the cut-off approach, burdens from recycling the post-consumer scrap beyond the sorting processes are excluded. Effectively, the GHG emissions are from the portion of materials in the product that are landfilled or incinerated. Following the cut-off approach, no credits are given for any usable energy that may be generated from landfill or incineration activities.

The fraction of materials that are landfilled, incinerated, or recycled is estimated with literature values when primary data are unavailable. Battery cells, tires (including tire-derived fuel), and most metals are recycled when the vehicle is decommissioned. The carbon footprint of decommissioning after generic vehicle shredding is found using carbon intensities of incineration and landfilling processes by material type.

# A Note on Carbon Footprints

**At Rivian, we believe that one of the first steps toward decarbonization is understanding your carbon footprint. This enables companies, as well as individuals, to take informed actions. Decarbonization of the transportation sector must be a collective effort; however, comparing LCA studies undertaken by different practitioners can be difficult because of differing underlying assumptions.**

## A Note on Carbon Footprints

As suggested in the introduction, the vehicle reports that follow this methodology are not intended to support ISO-conformant comparative assertions without additional analyses and documentation. This methodology document provides guidelines for Rivian's LCAs in a way that can be consistently applied to a variety of vehicles.

Rivian wants to be transparent about our processes and that our data are constantly evolving and improving. We hope that by us providing full transparency, the industry can move toward a more standardized methodology for LCA reporting, so we can identify common improvement opportunities and come together to decarbonize the sector.

Our vehicles are designed to operate for many years, but the carbon footprints of all life cycle stages are evaluated at a single point in time. The result is a snapshot of the predicted life cycle carbon footprint based on our best data and estimations when the analysis is conducted. We employ a multitude of assumptions throughout the methodology and use conservative values whenever possible to avoid underestimating potential GHG emissions. Ultimately, the vehicle carbon footprint summaries that follow this methodology are living documents, and we will periodically update this document with the latest information. As Rivian matures, our goal will always be to ensure that our LCA methods and data mature along with us.

# Critical Review

This methodology was reviewed for conformance with ISO 14040 and ISO 14044 by Dr. Christoph Koffler, Technical Director Americas, Sustainability Consulting at Sphera in November of 2023.