RIVIAN

Gen 2 R1S Carbon Footprint

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Introduction

At Rivian, we create innovative and technologically advanced products that are designed to excel at work and play with the goal of accelerating the global transition to low-carbon transportation and energy. A central part of our approach includes striving to lead the industry in environmental sustainability by minimizing our use of virgin resources and decarbonizing all stages of the product life cycle.

Introduction

In January of 2024, Rivian published our first Impact and Vehicle Carbon Footprint reports, in which we committed to launch a product by 2030 with half the life cycle carbon footprint compared with our R1 Launch Edition vehicles. Life cycle assessment (LCA) is one of the many tools we use to inform our decarbonization strategies and track progress towards this goal.

Our Vehicle Carbon Footprint reports concluded with a pledge to "continue improving our understanding of our vehicle footprints and [...] share updates." We believe in sharing this data so our customers and stakeholders understand the sustainability benefits of purchasing a Rivian—and so they can track our progress as we keep improving.

This report describes the carbon footprints of the 2025 model year Gen 2 R1S vehicle line. Rivian's 2025 R1S lineup includes new combinations of batteries, drive units, wheels and tires, and other packages. We focus on two variants: the 2025 R1S Dual-Motor with Max Pack (R1S-DM-Max) and Dual-Motor with Standard Pack (R1S-DM-Std).

Our carbon footprints consider the cradle-to-grave greenhouse gas (GHG) emissions of the vehicle, which capture the materials and supply chain, onsite production and logistics, charging and service, and, ultimately, decommissioning phases. This means evaluating thousands of individual parts and dozens of electricity grids and conducting numerous discussions with our engineering, design, procurement, and other teams to develop footprints that accurately reflect our vehicles. Our LCA methodology is evolving as we continue to learn and improve our processes. We believe our carbon footprint studies set the bar for depth and comprehensiveness for electric vehicles.

This report, coupled with the latest version of our Carbon Footprint Methodology Report,[1] conforms with ISO 14040 and 14044[2] standards. We use an attributional carbon footprinting approach and assess a single midpoint impact category: global warming potential (GWP) over a 100-year time frame. The characterization factors for greenhouse gases are established by the sixth assessment report (AR6) from the Intergovernmental Panel on Climate Change (IPCC), which includes climate-carbon feedbacks.

The functional unit is a Rivian R1S driven 155,000 miles over a 10-year period. The results are presented in grams of carbon dioxide equivalents per mile (g CO_2e/mi).

We believe in sharing this data so our customers and stakeholders understand the sustainability benefits of purchasing a Rivian—and so they can track our progress as we keep improving.

[1]Rivian Carbon Footprint Methodology Report v1.1.

[2]ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines" and ISO 14040:2006 "Environmental management – Life cycle assessment – Principles and framework".

R1S Carbon Footprint

The 2025 Gen 2 R1S Dual-Motor variants with the Max Pack (R1S-DM-Max) and Standard Pack (R1S-DM-Std) have a life cycle carbon footprint of 359 g CO_2e/mi over 155,000 miles when charged with electricity from the grid. This is a 16% reduction compared with the R1S Launch Edition.[3]

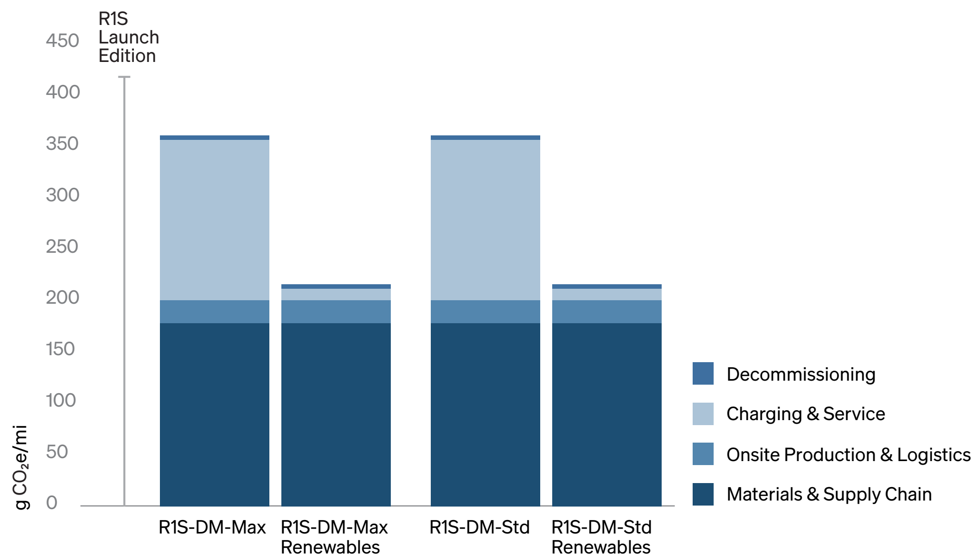
[3]More information about Rivian's previous carbon footprint reports can be found at https://rivian.com/sustainability.

R1S Carbon Footprint

The reductions are driven by significant and purposeful design and production improvements, such as increased vehicle energy efficiency, simplified electrical architecture, more efficient onsite production and supply chain logistics, and other improvements. For context, the entire life cycle carbon footprint of the R1S is 19% lower than the tailpipe and fuel production alone of an average internal combustion (ICE) SUV (444 g CO_2e/mi)[4]—while offering a larger track footprint[5] and more than twice the horsepower.

Figure 1 shows the carbon footprints for the R1S broken down by life cycle phase, as well as scenarios where customers charge their vehicles using renewable energy (e.g., by using residential photovoltaics). The source of charging electricity is a major driver of the life cycle carbon footprint, with renewable energy reducing the footprint by approximately 40%.

Figure 1
Carbon footprint overview of the latest variants for two charging scenarios: grid electricity and renewable electricity



Beyond charging, using renewable energy is a significant decarbonization lever for other stages of the life cycle, such as manufacturing and upstream material production. Rivian's 2022 Impact Report and Goals Update Report laid out our climate goals, many of which focus on increasing access and use of renewable energy:[6]

- Normal, IL manufacturing plant to run on 100% renewable energy on an annual basis and over 90% hourly carbon-free electricity by 2030
- All other non-manufacturing facilities (service centers, offices, etc.) to run on 100% renewable electricity by 2030
- Rivian charging networks to run on 100% renewable energy (continuation of our commitment since launch)
- Support 2 GW of high-impact renewable energy by 2030 to support customer charging
- Launch a product by 2030 with half the life cycle carbon footprint as 2022 R1 products.

The footprint for the R1S life cycle stages is discussed in the following sections of this report. For simplicity, the results in these sections focus on the R1S-DM-Max. More information for the R1S-DM-Std can be found in the appendix.

[4] ICE data from *The 2023 EPA Automotive Trends Report* and accompanying website. Estimated upstream gasoline production emissions of 100 g CO_2e/mi.
[5] Track footprint is defined in the Trends report as the area enclosed by the center point of all four tires. R1S has a track footprint of 60 ft² and minimum 553 horsepower.
[6] More information about Rivian's climate and other sustainability goals can be found at https://rivian.com/sustainability.

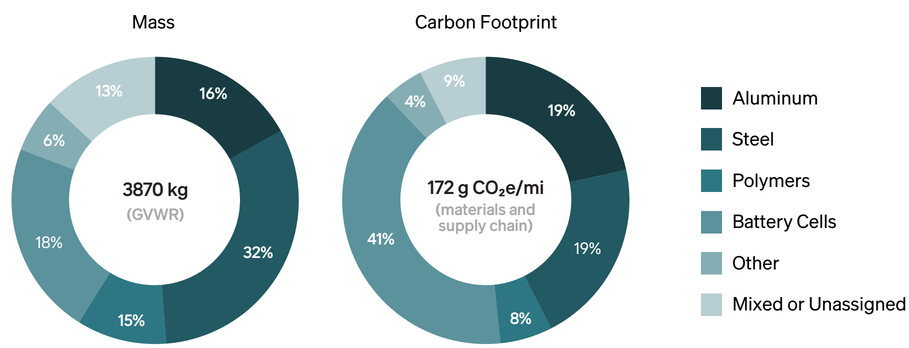
2.1 Materials and Supply Chain

The carbon footprint of the materials and supply chain phase includes resource mining/extraction and refining as well as upstream manufacturing.

A bill of materials (BoM) is extracted automatically from our product lifecycle management (PLM) system through a script that allocates thousands of material designations into roughly 60 material types, such as polyamides, hot-rolled steel, copper, and many others. Several material types are aggregations of mixed or unassigned materials, which are common among complex parts and/or complex supply chains. Parts with mixed and unassigned materials that are greater than 0.1% of the total vehicle mass are investigated individually through discussions with design teams, reviews of engineering drawings, and other efforts to gather more specific material information. Generally, our target is to reduce the mixed and unassigned materials to less than 15% of the overall vehicle mass, with an aim to reduce this threshold as our data improves. For mixed and unassigned materials, a weighted average of the known materials (excluding battery cells) is used to estimate the composition and apply the corresponding carbon intensity factors.

Figure 2 shows the material composition and GHG emissions of the R1S broken into major material categories.

Figure 2
R1S-DM-Max mass and carbon footprint breakdown for the materials and supply chain stage of the life cycle



Materials and Supply Chain (Excluding Battery Cells)

Excluding battery cells, the total emissions of the materials and supply chain phase are 102 g CO_2e/mi.

As shown in Figure 2, steel and aluminum contribute the most to the carbon footprint of the material and supply chain stages of the R1S-DM-Max. Based on feedback from our suppliers, we estimate the recycled content in our sheet aluminum and steel is 33% and 35%, respectively.[7] This is an improvement from our starting estimate for the Launch Edition model, which was 18% and 23%.

Other types of steel are assumed to have a recycled content of 12%. This is aligned with the average recycled content in cold-rolled coil, per Worldsteel[8] data in the Sphera Managed LCA Content (Sphera MLC)[9] database. This is also expected to be a minimum, as all steel will likely contain some recycled content. For cast and extruded aluminum, we assume 40% and 35% recycled content, respectively,

[7] We gather data recycled content information from our suppliers using direct communications facilitated through our supply chain teams.
[8] Life Cycle Inventory (LCI) Study: 2020 Data Release. World Steel Association. 2021.
[9] Sphera MLC is accessed through the LCA for Experts software version 10.7.

which is half of the average recycled content for these semi-fabricated products in North America, as reported by the Aluminum Association.[10] For all other aluminum, we assume 18% recycled content, which is consistent with previous reports. In practice, steel and aluminum will likely have higher recycled content than the amounts included in this R1S study, as demonstrated by both the Aluminum Association and the American Iron and Steel Institute.[11] Rivian uses conservative assumptions to ensure that we are not accounting for lower-carbon materials until we are confident about their presence in our supply chains. Tracking and increasing the amount of recycled content in our vehicles is a core sustainability strategy at Rivian. As outlined in our 2022 Impact Report, we are aiming to reach a minimum of 70% recycled content in steel and aluminum by 2030. The improvements in our Gen 2 R1 lineup represent a significant step toward achieving this goal.

Tracking and increasing the amount of recycled content in our vehicles is a core sustainability strategy at Rivian.

Battery Cells

Battery cells are explored independently of other parts in the BoM due to their complexity and importance with respect to the R1S vehicle footprint. Rivian has created a custom battery model that allows us to integrate relevant details for the cells used in the R1S. The battery model is described in more detail in the Rivian Carbon Footprint Methodology Report. Table 1 shows the carbon footprint of the battery by major contribution source. The total carbon footprint of the battery cells for R1S-DM-Max is 71 g CO_2e/mi.[12] Due to the highly technical nature of the materials in battery cells, the activities associated with the mining and refining of cell materials are the largest drivers of the battery cell footprint.

Table 1
Carbon footprint of the R1S-DM-Max battery cells materials and supply chain

Source	Carbon Footprint (g CO_2e/mi)
Raw cell materials mining and refining	43
Powder production	13
Cell manufacturing[13]	14
Upstream transportation	1

Battery materials are sensitive to changes in carbon intensity due to rapidly evolving technologies, supply chains, geopolitics, and other influences. This report uses recently published data for synthetic graphite, which is more than double that of previous estimates. The implications of this change are discussed in the Scenario Analysis section of this report.

Following mining and refining of battery cell materials, cell manufacturing activities also make up a considerable portion of the emissions from battery cell production. The GHG emissions from these activities are driven by energy consumption.

Summary of Materials and Supply Chain

The carbon footprint for R1S-DM-Max materials and supply chain is 172 g CO_2e/mi, as shown in Table 2. This represents nearly half of the total R1S-DM-Max carbon footprint. The carbon footprint from the materials and supply chain (excluding battery cells) is the largest contributor, with 28% of the total R1S-DM-Max footprint.

Table 2
Carbon footprint of the materials and supply chain

Source	Carbon Footprint (g CO_2e/mi)
Materials and supply chain (excluding battery cells)	102
Battery cell materials and supply chain	71

[10] The Environmental Footprint of Semi-Fabricated Aluminum Products in North America: A Life Cycle Assessment Report. The Aluminum Association. 2022.
[11] Life Cycle Inventories of North American Steel Products. American Iron and Steel Institute. 2020.
[12] Totals in relevant tables may not add up due to rounding.
[13] Cell manufacturing energy data for the Max Pack is obtained from supplier data. Cell manufacturing energy for the Standard Pack is scaled from data published by Degen and Schütte (2022) at: https://doi.org/10.1016/j.jclepro.2021.129798.

2.2 Production and Logistics

GHG emissions from onsite production and logistics account for 28 g CO_2e/mi per R1S, which is 8% of the total vehicle emissions. This is a 45% reduction from the annual carbon footprint per vehicle for onsite production in 2022. This reduction stems from an increase in the throughput of our production which lowers the energy overhead required per vehicle, efficiencies in our logistics network as volumes have increased, and our generation of nearly 2 million kWh of on-site renewable energy at our Normal, IL plant.

The primary contributor to these GHG emissions is the electricity used for onsite production. The breakdown is shown in Table 3.

Table 3
Carbon footprint of onsite production and logistics

Source	Carbon Footprint (g CO_2e/mi)
Onsite production - scope 1 and 2	17
Onsite production - scope 3[14]	2
Logistics - inbound	7
Logistics - outbound	2

Onsite Production

Production of the latest R1S variants occurs at the Rivian production plant in Normal, IL. Much of the GHG emissions from the production plant are from electricity and natural gas, with minor contributions from propane- and diesel-powered equipment and refrigerants. 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 number of vehicles produced in 2023. Our Normal, IL production plant lies in the eGRID subregion SRMW; the 2021 eGRID-based Sphera MLC grid mix dataset is used as the carbon intensity for all electricity pulled from the grid. The plant is equipped with onsite solar and a wind turbine, which supplied a portion of the electricity used in 2023.[15] This reduced the total electricity procured from the grid and therefore reduced the carbon footprint from onsite production.

Rivian has already witnessed significantly lower per-vehicle production energy in 2023 compared with 2022.

We expect that the carbon footprint of onsite production will continue to improve in future years as factory ramp-up leads to higher annual vehicle volumes. Rivian has already witnessed significantly lower per-vehicle production energy in 2023 compared with 2022. In addition, Rivian plans to increase renewable energy procurement for our production facility, which will further reduce the GHG emissions associated with onsite production.

Logistics

Inbound logistics includes the transportation of the parts and materials from suppliers into the Rivian onsite production facilities. GHG emissions from inbound logistics include all incoming freight for materials and parts related to production at the Rivian production plant. The GHG emissions from inbound logistics are divided evenly across all vehicles produced at the plant in 2023. The GHG emissions per vehicle are expected to continue to decrease as Rivian production volume increases and we move towards steady-state operations, thus decreasing logistics associated with production ramp. Additionally, carbon factors from the Global Logistics Emissions Council (GLEC) are used when mass and distance data are reported in the Transportation Management System (TMS). 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. When 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.

Outbound logistics consists of delivering finished R1S vehicles to customers. Like inbound logistics, data are reported by our logistics team and divided across the number of Rivian vehicles produced in 2023 to yield the carbon footprint of outbound logistics per vehicle.

[14] Indirect emissions from onsite energy and refrigerant use.
[15] No energy attributes are sold to the grid (or any other third party). The energy produced onsite is used exclusively by Rivian.

2.3 Charging and Service

Charging and service includes GHG emissions from vehicle usage during the 155,000 mile / 10-year period used for this report.

Charging

The energy used by the R1S is driven principally by propulsion efficiency, but also includes charging efficiency and passive battery drain. We determine the propulsion efficiency using the EPA-reported range and the usable battery energy (UBE) for each vehicle. The EPA-reported range of the R1S-DM-Max is between 370 to 410 miles. This study evaluates the R1S-DM-Max with the 22" Sport wheels and on-road performance tires, which has a range of 410 miles. Over 155,000 miles, R1S-DM-Max is estimated to use roughly 70 megawatt-hours of electricity. This is over a 15% reduction compared with the R1S Launch Edition.

The first charge of each Rivian vehicle off the production line is done with 100% renewable energy. Additionally, all charging done at Rivian charging networks, such as Rivian Adventure Network (RAN) charging stations, which account for approximately 2% of user charging, is matched with 100% renewable energy by Rivian. As such, we assume that both the energy from the first full charge and 2% of the remaining charging energy are powered with 100% renewably sourced electricity. All other energy for charging is assumed to be sourced by grid electricity.

Grid emission factors have significant geographic variation and are expected to change over the life cycle of our vehicles. We estimate the carbon footprint from charging with grid electricity using Rivian specific geographical distribution and a grid projection model. Rivian uses a 3% year-over-year improvement to model the annual carbon intensity of the electricity grid. This improvement is slightly more pessimistic than the most conservative projection from the International Energy Agency (IEA) World Energy Outlook 2021 report,[16] which relies on “stated policies” rather than pledges or other aspirational improvements. From that, the years 2025, 2030, 2040, and 2050 were used to establish the 3% year-over-year improvement rate. All GHG data, including the IEA projections, are based on datasets from Sphera’s MLC database.

Over 155,000 miles, R1S-DM-Max is estimated to use roughly 70 megawatt-hours of electricity. This is over a 15% reduction compared with the R1S Launch Edition.

[16] World Energy Outlook. IEA. 2021.

R1S Carbon Footprint

Rivian believes it is important to use our best understanding of how the electricity grid will change for the base cases of our vehicles. But we also acknowledge that forecasting the GHG emissions from electricity is inherently uncertain. Figure 3 shows the carbon footprint of the R1S-DM-Max across 155,000 miles using different assumptions for the carbon intensity of the grid. The most conservative assumes the R1S-DM-Max is charged in the eGRID subregion with the highest carbon intensity (MROE)[17] and that the grid does not improve relative to 2021 emissions. The most optimistic scenario assumes the R1S-DM-Max is charged using a mix of renewable energy.

Based on the grid projection, Rivian-specific geographical distribution, and renewable matching, the resulting weighted average carbon intensity of the electricity used for charging a Rivian R1S is 344 g CO_2e/kWh. Despite Rivian's renewable matching, our weighted average carbon intensity is largely unchanged from our previous reports. This is due to an increase in the reported US grid carbon intensity between 2020–2021 which is attributed to increased electricity use and accompanying reliance on fossil energy sources across the United States in 2021. This increase in US grid intensity further emphasizes the importance of Rivian's renewable energy goals.

Figure 3
R1S-DM-Max cumulative carbon footprint with different electricity mixes during charging

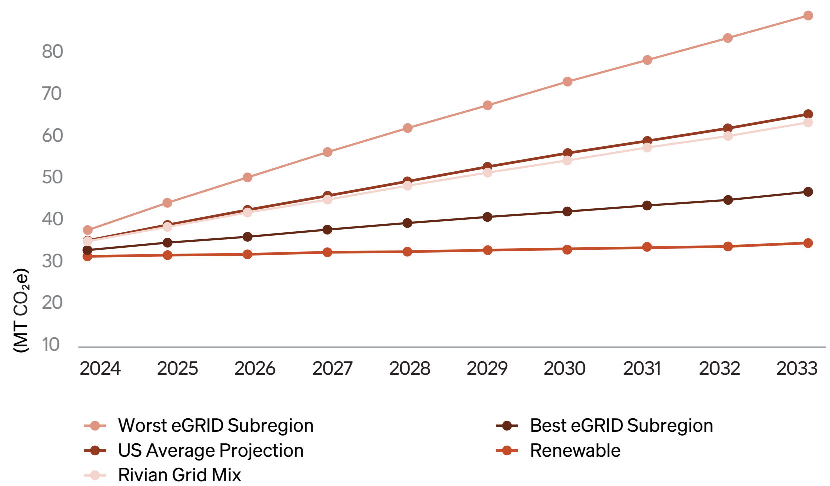


Table 4
Carbon footprint of charging and service

Source	Carbon Footprint (g CO_2e/mi)
Charging	149
Service	7

Service

Service includes GHG emissions from scheduled maintenance activities and other common service items. Scheduled maintenance activities are included based on estimates from our engineering and service teams. For other common service items (e.g., windshield wipers), reasonable assumptions are used. In total, service includes periodic replacement of tires, washer fluid, coolant, brake fluid, cabin filter, and windshield wipers.

Table 4 summarizes the carbon footprint from charging and service activities.

[17] The MROE eGRID subregion covers parts of Wisconsin and Michigan. More information about eGRID subregions can be found on the EPA website at: https://www.epa.gov/egrid/power-profiler#/.

2.4 Decommissioning

Table 5
Carbon footprint of decommissioning

Source	Carbon Footprint (g CO_2e/mi)
Vehicle shredding	0.4
Transportation to recycling	2.0
Landfill	0.2
Incineration	<0.1

Rivian vehicles have not yet been decommissioned under normal operating conditions, so we must make assumptions about the fate of the vehicles and their materials. Rivian has engaged battery recycling companies. As such, our batteries are expected to be recycled when the vehicle is decommissioned. We also assume that wheels and tires would be removed from the vehicle prior to vehicle shredding and sent to recycling facilities. We assume all materials are transported 932 miles (1500 km) by truck to a recycling facility.[18] Under the cut-off allocation approach, the burden from recycling batteries and other materials is not included in the R1S carbon footprint. All other parts of the vehicle are assumed to go through a shredding operation where most of the steel and aluminum are captured for recycling, per industry averages. Most other materials, including mixed and unassigned, are assumed to be classified as automotive shredder residue (ASR) and landfilled. Overall, decommissioning contributes less than 2% to the R1S-DM-Max total carbon footprint.

[18]EPD International. Product Category Rules: UN CPC 49113. PCR: 2024.02. Version 1.0.2

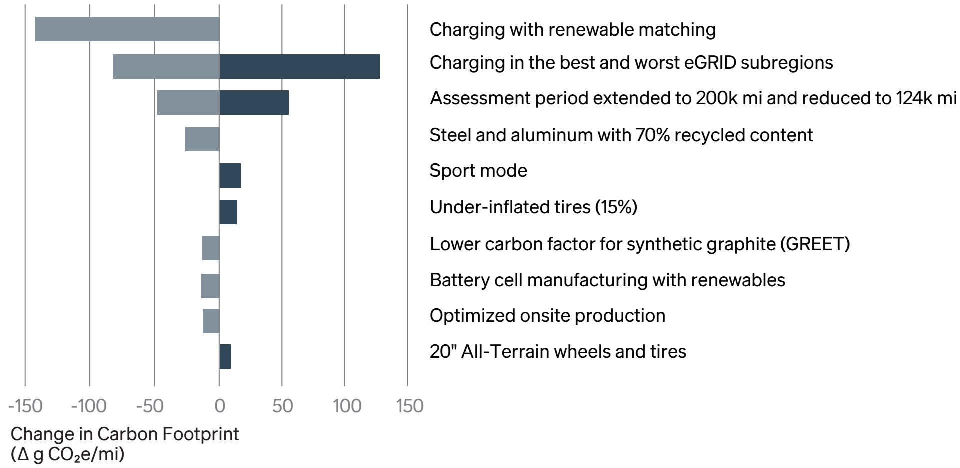
Discussion

The carbon footprints in this report are intended to represent averages. That said, the actual GHG emissions over the life cycle of an individual R1S will vary customer to customer for a plethora of reasons (location, driving style, time of charging, tire inflation, and vehicle lifetime miles—to name a few).

3.1 Scenario Analysis

To address some of these alternative use-case scenarios, the results of this study are supplemented with some of the most impactful findings from our scenario analyses.

Figure 4
R1S-DM-Max carbon footprint scenario analyses



While charging with renewable energy substantially decreases the carbon footprint of the R1S, we cannot fully decarbonize the vehicle with this lever alone—we must also continue to increase energy efficiency and decarbonize the materials that we use.

Figure 4 shows that procurement of renewable electricity to cover use phase energy consumption is one of the most effective decarbonization levers. The first scenario in Figure 4 shows that renewable matching across 155,000 miles decreases the carbon footprint by 142 g CO_2e/mi (40%).

While charging with renewable energy substantially decreases the carbon footprint of the R1S, we cannot fully decarbonize the vehicle with this lever alone—we must also continue to increase energy efficiency and decarbonize the materials that we use. Figure 4 also presents scenario analyses with increased recycled content in the steel and aluminum in the R1S-DM-Max. This scenario demonstrates the potential change in the R1S-DM-Max carbon footprint if the recycled content of steel and aluminum were 70%. The analysis shows that introducing more recycled content in our material feedstocks is a significant decarbonization lever.

Synthetic graphite is one of several energy transition materials whose carbon intensity is likely to fluctuate into the future due to further LCA research and other influences.

Synthetic graphite is used in the anode of lithium-ion batteries. Newly published LCA data on synthetic graphite[19] indicates that the carbon intensity of the synthetic graphite grade used in these batteries is much higher than previously reported—notably, more than four times the carbon intensity currently used in the GREET model. Rivian has switched to the latest, higher data, but with the understanding that this study only represents a single source. The choice of graphite data adds 12 g CO_2e/mi to the R1S-DM-Max footprint. Synthetic graphite is one of several energy transition materials whose carbon intensity is likely to fluctuate into the future due to further LCA research and other influences.

We also include scenarios that pertain to the choice of wheels and tires and drive modes. This study focuses on the R1S-DM-Max with 22" Sport wheels and on-road performance tires. The EPA range is based on the All-Purpose drive mode, which switches between all-wheel and front-wheel drive to optimize for range, performance, and safety. This variant, however, can also be operated fully in all-wheel drive (such as in Sport or All-Terrain modes) and is available with alternative wheel and tire configurations: 22" Range wheels and 20" wheels with All-Terrain tires. Both the choice of drive mode and wheel and tire configuration can change the propulsion efficiency of the vehicle. It follows that the annual energy use and carbon footprint vary based on assumed drive mode and wheel and tire choice, as shown in Figure 4.

[19]Carrère et al. (2024). Carbon footprint assessment of manufacturing of synthetic graphite battery anode material for electric mobility applications. Journal of Energy Storage. Vol 24. https://doi.org/10.1016/j.est.2024.112356

3.2 A Note on Industry Standardization

One of the most challenging elements of communicating LCA results for any product is a lack of standardized methods and data. Product category rules (PCRs) have helped establish consistency for some industries, but PCR penetration is still limited and typically finds the most success amongst products with relatively simple life cycles.

LCA methods and data in the automotive industry have not yet been harmonized to the extent that would make vehicle comparisons meaningful or equitable.

LCA methods and data in the automotive industry have not yet been harmonized to the extent that would make vehicle comparisons meaningful or equitable. In our internal research, choices in methods and data can change the results of a study by 50% or more. If one of the fundamental purposes of carbon footprints is to provide transparency to the public, it follows that harmonizing methods and data into a standard framework is of paramount importance.

Some standardization efforts are already underway. The high-voltage battery and vehicle BoM each have dedicated workflows focused on standardization. However, these only address a portion of the vehicle life cycle. As demonstrated earlier in Figure 4, the charging electricity mix and analysis period have a significant influence on the life cycle footprint. Scope also has a large effect, with notable differences observed amongst published studies related to manufacturing yields, service, passive drain, and decommissioning. Similarly, range is commonly reported using either US Environmental Protection Agency (EPA) or Worldwide Harmonised Light Vehicles Test Procedure (WLTP) methods, which are not consistent with one another.

Tables 6-8 present a novel approach to providing transparency and reproducibility for vehicle life cycle carbon footprints.

- Table 6 proposes a set of key data, methods, and scenarios that capture the most common choices that are made in vehicle life cycle carbon footprint studies.
- Table 7 presents the results of these scenarios for the R1S-DM-Max, illustrating the footprint using 48 different combinations of methods and data.
- Table 8 provides a summary of inputs and outputs that allow easier reproducibility of the R1S-DM-Max.

Rivian is committed to elevating the transparency of our LCA efforts and collaborating with the automotive community on standardization.

Both the quantity and spread of the footprints presented in Table 7—ranging from 156 to 609 g CO_2e/mi— reinforce the importance of harmonizing methods and data. Rivian is committed to elevating the transparency of our LCA efforts and collaborating with the automotive community on standardization.

Table 6
Key data and method choices for vehicle life cycle carbon footprints

Key data/method	Scenarios	Description
Range method	EPA WLTP	The WLTP method is assumed to produce a 15% longer range estimate than the EPA method.
Charging electricity mix	Rivian mix China grid US grid EU grid Renewables mix	The Rivian mix matches the changing electricity used in this report. The China, US, EU and renewable electricity mixes use the most recent data from the Sphera MLC database and do not include future projections.
Scope	Rivian scope Simplified scope	Rivian scope matches the scope used in this report. The simplified scope is an abridged version of the Rivian scope that excludes part yields, passive drain, service, and decommissioning.
Analysis period	124,274 mi 155,000 mi 200,000 mi	124,274 mi (200,000 km) matches analysis periods used by some European manufacturers. 155,000 mi is used by Rivian in this report. 200,000 mi is used by some US manufacturers and is roughly the life of an average automobile.

Table 7
Transparency matrix for R1S-DM-Max (g CO_2e/mi)

Scope	Range Method	Analysis Period (mi)	Charging Electricity: Rivian	China	US	EU	Renewables
Rivian Scope	EPA	124k	413	609	465	396	268
		155k	359	550	409	342	217
		200k	310	497	359	294	171
	WLTP	124k	395	569	441	380	267
		155k	341	510	386	327	216
		200k	292	457	336	278	170
Simplified Scope	EPA	124k	377	551	423	362	249
		155k	329	502	374	314	200
		200k	285	459	331	270	157
	WLTP	124k	360	511	399	347	248
		155k	311	462	351	298	199
		200k	268	418	307	254	156

Table 8
Key parameters of the R1S-DM-Max Carbon Footprint

Input/Output	Value for R1S-DM-Max
Carbon footprint	359 g CO_2e per mile / 56 MT CO_2e
Variant	R1S Dual-Motor w/ Max Pack and 22" Sport wheels and tires
Life cycle elements	• Raw materials • Upstream manufacturing, utilization, and yield • Battery cell materials and manufacturing • Inbound logistics • Outbound logistics • Onsite production • Vehicle charging (propulsion) • Vehicle charging (passive drain) • Service • Decommissioning
Analysis period	155,000 miles / 10 years
Average carbon intensity of non-battery cell materials	6.1 kg CO_2e/kg
Battery cell carbon intensity	73 kg CO_2e/kWh
Battery cell cathode chemistry	NCA
Usable battery energy (UBE)	140 kWh
Production and logistics footprint	4.4 MT CO_2e per vehicle
EPA range	410 miles
EPA efficiency	347 Wh/mi
Range method	EPA
Average charging electricity carbon intensity	0.34 kg CO_2e/kWh

Final Thoughts

We feel confident that this report represents the deepest and most comprehensive life cycle carbon footprint study possible for Rivian's latest R1S variants as of mid 2024. At the same time, the R1S is designed to operate a decade into the future, so the results of this study are merely snapshots of the product carbon footprints based on our best data available as of report publication.

Final Thoughts

As always, we will continue to improve our understanding of our vehicle footprints and share updates as that information improves and our products change. These LCA reports serve not only to promote transparency and provide a step towards greater understanding for the public, but also to inform and drive Rivian's sustainability initiatives and track progress towards our goals.

Below are some of the product sustainability goals we have made notable progress towards since our last carbon footprint report.[20]

- Launch a product by 2030 with half the life cycle carbon footprint as 2022 R1 products.
- Increase percentage of recycled materials in vehicles:

  - Minimum 70% recycled content in steel and aluminum by 2030

  - Minimum 40% recycled and bio-based content in polymers by 2030.

We view our carbon footprints as we do everything else at Rivian: Adventurous Forever.

[20]More detail is available in the Goals Update Report.

Critical Review

Rivian develops the LCA models and reports entirely in-house, led by our Sustainability Science team.

Rivian works with an independent expert to review this report, the underlying Methodology Report, and Supporting Information for conformance with ISO 14044. The review was conducted by Dr. Christoph Koffler, Technical Director Americas, Sustainability Consulting at Sphera in September of 2024.

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Appendix

6.1 Carbon Factors

Table 6.1a outlines the default assumptions and carbon factor datasets for the material types in the refined BoM. The following data are used to find the carbon footprint of the materials and upstream manufacturing processes excluding battery cells. All data from the Sphera Managed LCA Content (MLC) database are from the Sphera LCA for Experts software version 10.7. The derivation of effective carbon intensity is shown below. The following data represents the latest BoM from our product lifecycle management system at the time of assessment (Jul-09-2024). We assume a conservative average part yield of 95%.

$$CI_{\text{weighted average}} = [\%\,RC \times CI_{\text{recylced materials}} + (1\text{-}\%\,RC) \times CI_{\text{virgin materials}}]$$

$$CI_{\text{effective}} = \frac{[CI_{\text{weightedaverage}} / \%\,MU) + CI_{\text{manufacturing process}}]}{\%Y}$$

CI= Carbon Intensity
% RC= Percent Recycled Content
% MU= Percent Material Utilization
% Y= Percent Yield

Table 6.1a also outlines the default assumptions and carbon factor datasets for the activities excluding raw material mining and refining. The following data are critical to assessing the carbon footprint of upstream production processes, on-site production, operation and service, and decommissioning.

Material utilizations are planned scrap losses that occur during manufacturing. These are often very difficult to ascertain, particularly when these steps occur in the supply chain. We use a mix of internal data, industry averages and estimates for material utilizations. In-house stamping utilizations are based on early Rivian data for the R1S. Casting, drawing, and injection molding processes are typically high-utilization processes and are assumed to have 95% utilization. Aluminum extrusion is based on the Aluminum Association data and is 74%. All other processes, including those for mixed and unassigned materials, are assumed to have a 75% utilization. In addition to utilizations, we also include a 95% yield to all parts. This is an assumed value and is used to acknowledge that a certain fraction of all parts will not meet specifications or otherwise are unavailable for the final vehicle.

Table 6.1a
Material types

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
ABS	Polymers	Primary Material: Sphera - DE: Acrylonitrile-butadiene-styrene granulate (ABS) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Adhesive	Polymers	Primary Material: Sphera - DE: Thermoplastic polyurethane (TPU, TPE-U) adhesive Sphera Secondary Material: n/a Process: n/a	100%	95%	0%
Aluminum (other)	Aluminum	Primary Material: Sphera - RNA: Aluminum sheet (0% recycled content) <LC> Secondary Material: Sphera - RNA: Aluminum sheet (100% recycled content) <LC> Process: n/a	75%	95%	33%

Appendix

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
Aluminum casting	Aluminum	Primary Material: Sphera - RNA: Aluminum ingot (0% recycled content + remelting) <LC> Secondary Material: Sphera - RNA: Aluminum ingot (100% recycled content + remelting) <LC> Process: US: Aluminium die-cast part Sphera 5% scrap (plan) <LC>	95%	95%	40%
Aluminum extrusion	Aluminum	Primary Material: Sphera - RNA: Aluminum ingot (0% recycled content + remelting) <LC> Secondary Material: Sphera - RNA: Aluminum ingot (100% recycled content + remelting) <LC> Process: RER: Aluminium extrusion profile - open input aluminium ingot Sphera <p-agg>	74%	95%	35%
Aluminum forging	Aluminum	Primary Material: Sphera - RNA: Aluminum ingot (0% recycled content + remelting) <LC> Secondary Material: Sphera - RNA: Aluminum ingot (100% recycled content + remelting) <LC> Process: US: Drop-forging process Sphera (plan) <LC>	95%	95%	33%
Aluminum sheet	Aluminum	Primary Material: Sphera - RNA: Aluminum sheet (0% recycled content) <LC> Secondary Material: Sphera - RNA: Aluminum sheet (100% recycled content) <LC> Process: US: Aluminum sheet deep drawing <LC>	*confidential*	95%	33%
ASA	Polymers	Primary Material: Calculated - Estimated using ABS Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Assembly	Mixed and unassigned materials	Primary Material: Calculated by vehicle weighted average (excluding battery cells) Secondary Material: n/a Process: n/a	n/a	n/a	n/a
Bamboo	Other materials	Primary Material: Sphera - RNA: Softwood plywood CORRIM <LC> Secondary Material: n/a Process: n/a	75%	95%	0%
Brass	Other metals	Primary Material: Sphera - RER: Brass (CuZn20) Sphera <p-agg> Secondary Material: n/a Process: US: Metal cast part (automotive) process Sphera (plan) <LC>	95%	95%	0%
Bronze	Other metals	Primary Material: Sphera - RER: Brass (CuZn20) Sphera <p-agg> Secondary Material: n/a Process: US: Metal cast part (automotive) process Sphera (plan) <LC>	95%	95%	0%
Carbon fiber	Other materials	Primary Material: Sphera - DE: Carbon Fibre (CF; from PAN; standard strength) Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
Ceramic	Other materials	Primary Material: Sphera - RER: Glass ceramic production Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
Cold rolled steel sheet	Steel	Primary Material: Sphera - RNA: Cold rolled steel coil (HDG, 0% recycled content, AISI) <LC> Secondary Material: Sphera - RNA: Cold rolled steel coil (HDG, 37% recycled content, AISI) <LC> Process: US: Steel sheet deep drawing <LC>	*confidential*	95%	35%

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
Composite	Polymers	Primary Material: Calculated - Carbon Fiber reinforced polyamide Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Copper	Other metals	Primary Material: Sphera - GLO: Copper cathode, 99.99% Cu ICA Secondary Material: n/a Process: US: Copper wire (0.6 mm) process Sphera (plan) <LC>	95%	95%	0%
Cork	Other materials	Primary Material: Sphera - RNA: Softwood plywood CORRIM <LC> Secondary Material: n/a Process: n/a	75%	95%	0%
ECU	Electronics	Primary Material: Supplier - ECU Secondary Material: n/a Process: n/a	100%	95%	0%
Electric steel	Steel	Primary Material: Sphera - GLO: Hot rolled steel coil (HDG, 0% recycled content) <LC> Secondary Material: Sphera - RNA: Hot rolled steel coil (HDG, 48% recycled content, AISI) <LC> Process: US: Steel sheet stamping and bending (5% loss) process Sphera (plan) <LC>	100%	95%	12%
Electronics	Electronics	Primary Material: Supplier - ECU Secondary Material: n/a Process: n/a	75%	95%	0%
EPDM	Polymers	Primary Material: Sphera - DE: Ethylene Propylene Diene Elastomer (EPDM) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
EPP foam	Polymers	Primary Material: Sphera - US: Expanded Polypropylene (EPP) <LC> Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
EVA	Polymers	Primary Material: Sphera - RER: EVA roof sheets (EN15804 A1-A3) Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
Fiberglass	Polymers	Primary Material: Sphera - US: Fiberglass Pipe NAIMA Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Glass	Other materials	Primary Material: Sphera - RER: Float flat glass Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
HDPE	Polymers	Primary Material: Sphera - DE: Polyethylene high density granulate (HDPE/PE-HD) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%

Appendix

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
Hot rolled steel sheet	Steel	Primary Material: Sphera - DE: Polyethylene high density granulate (HDPE/PE-HD) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	*confidential*	95%	35%
Iron	Other metals	Primary Material: Sphera - DE: Cast iron component (EN15804 A1-A3) Sphera <p-agg> Secondary Material: n/a Process: n/a	95%	95%	0%
Liquid	Other materials	Primary Material: Sphera - DE: Rinsing-agent (100% solvents) Sphera Secondary Material: n/a Process: n/a	100%	95%	0%
Magnesium	Other metals	Primary Material: Sphera - CN: Magnesium Sphera Secondary Material: n/a Process: US: Magnesium die-cast process Sphera (plan) <LC>	95%	95%	0%
Magnet	Other materials	Primary Material: Sphera - GLO: market for permanent magnet, for electric motor ecoinvent 3.8 Secondary Material: n/a Process: n/a	100%	95%	0%
Mica	Other materials	Primary Material: Sphera - DE: Kaolin Sphera Secondary Material: n/a Process: n/a	95%	95%	0%
Mixed	Mixed and unassigned materials	Primary Material: Calculated by vehicle weighted average (excluding battery cells) Secondary Material: n/a Process: n/a	n/a	n/a	n/a
Nickel	Other metals	Primary Material: Sphera - GLO: Nickel mix Sphera Secondary Material: n/a Process: US: Metal cast part (automotive) process Sphera (plan) <LC>	95%	95%	0%
Other foam	Polymers	Primary Material: Sphera - RER: Polyurethane rigid foam (PU) PlasticsEurope Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PA	Polymers	Primary Material: Sphera - DE: Polyamide 6 granulate (PA 6) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Paint	Other materials	Primary Material: Sphera - RER: Solvent paint white (EN15804 A1-A3) Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
Paper	Other materials	Primary Material: Sphera - EU-25: Graphic Paper Euro-graph/ELCD <LC> Secondary Material: n/a Process: n/a	75%	95%	0%

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
PBT	Polymers	Primary Material: Sphera - DE: Polybutylene terephthalate granulate (PBT) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PC	Polymers	Primary Material: Sphera - DE: Polycarbonate granulate (PC) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PC/ABS	Polymers	Primary Material: Calculated - Average of PC and ABS Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PC/ASA	Polymers	Primary Material: Calculated - Average of PC and ABS Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PET	Polymers	Primary Material: Sphera - DE: Polyethylene terephthalate granulate (PET via DMT) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Plastic	Polymers	Primary Material: Calculated - Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PMMA	Polymers	Primary Material: Sphera - DE: Polymethyl methacrylate granulate (PMMA) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
POM	Polymers	Primary Material: Sphera - DE: Polyoxymethylene granulate (POM) Mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PP	Polymers	Primary Material: Sphera - DE: Polypropylene granulate (PP) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PPA	Polymers	Primary Material: Sphera - DE: Polyphenylene Ether (PPE) Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
PPO	Polymers	Primary Material: Sphera - DE: Polyphenylene Ether (PPE) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PPS	Polymers	Primary Material: Sphera - DE: Polyphenylene sulfide granulate (PPS) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%

Appendix

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
Press hardened steel sheet	Steel	Primary Material: Sphera - RNA: Cold rolled steel coil (HDG, 0% recycled content, AISI) <LC> Secondary Material: Sphera - RNA: Cold rolled steel coil (HDG, 37% recycled content, AISI) <LC> Process: US: Steel sheet deep drawing <LC>	*confidential*	95%	35%
PTFE	Polymers	Primary Material: Sphera - DE: Polytetrafluoroethylene granulate (PTFE) Mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PU	Polymers	Primary Material: Sphera - DE: PUR synthetic leather seat cover (1 kg) Sphera <LC> Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PUR foam	Polymers	Primary Material: Sphera - RER: Polyurethane rigid foam (PU) PlasticsEurope Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
PVC	Polymers	Primary Material: Sphera - DE: Polyvinyl chloride granulate (S-PVC) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Rubber	Polymers	Primary Material: Sphera - DE: Silicone rubber (RTV-2, condensation) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Sheet molding compound	Polymers	Primary Material: Sphera - DE: Sheet Moulding Compound resin mat (SMC) Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
Silicone	Polymers	Primary Material: Sphera - DE: Silicone rubber (RTV-2, condensation) Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Silver	Other metals	Primary Material: Sphera - GLO: Silver mix Sphera Secondary Material: n/a Process: n/a	75%	95%	0%
Stainless steel	Steel	Primary Material: Sphera - RER: Stainless steel cold rolled coil (316) Eurofer <LC> Secondary Material: n/a Process: US: Metal cast part (automotive) process Sphera (plan) <LC>	95%	95%	0%
Steel (other)	Steel	Primary Material: Sphera - RNA: Cold rolled steel coil (HDG, 0% recycled content, AISI) <LC> Secondary Material: Sphera - RNA: Cold rolled steel coil (HDG, 37% recycled content, AISI) <LC> Process: US: Steel sheet stamping and bending (5% loss) process Sphera (plan) <LC>	75%	95%	12%
Titanium	Other metals	Primary Material: Sphera - GLO: Titanium Sphera Secondary Material: n/a Process: n/a	75%	95%	0%

Appendix

Material Type	Material Category	Source/Datasets	Material Utilization	Yield	Recycled Content
TPE	Polymers	Primary Material: Sphera - DE: Polypropylene / ethylene propylene diene elastomer granulate (PP/EPDM, TPO, TPE-O) mix Sphera Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
TPO	Polymers	Primary Material: Calculated - Estimated using TPE Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
TPU	Polymers	Primary Material: Calculated - Secondary Material: n/a Process: n/a	75%	95%	0%
TPV	Polymers	Primary Material: Calculated - Estimated using TPE Secondary Material: n/a Process: US: Plastic compounding + injection moulding (plan) <LC>	95%	95%	0%
Unassigned	Mixed and unassigned materials	Primary Material: Calculated by vehicle weighted average (excluding battery cells) Secondary Material: n/a Process: n/a	n/a	n/a	n/a
Wood	Other materials	Primary Material: Sphera - RNA: Softwood plywood CORRIM <LC> Secondary Material: n/a Process: n/a	50%	95%	0%
Zinc	Other metals	Primary Material: Sphera - GLO: Special high grade zinc only from Zn concentrate IZA <LC> Secondary Material: n/a Process: US: Metal cast part (automotive) process Sphera (plan) <LC>	95%	95%	0%
Standard tire	Polymers	Primary Material: Supplier - Standard Tire Secondary Material: n/a Process: n/a	100%	95%	0%
Sustainable tire	Polymers	Primary Material: Supplier - Sustainable Tire Secondary Material: n/a Process: (included in vendor data)	100%	95%	0%
Washer fluid	Other materials	Primary Material: Sphera - US: Washer Fluid (21% ethyl alcohol / 79% deionized water) (plan) <LC> Secondary Material: n/a Process: n/a	100%	95%	0%

Table 6.1b
Other relevant datasets

Material Category	Datasets
Steel	GLO: Value of scrap worldsteel RNA: Steel hot rolled coil AISI RNA: Steel cold rolled coil AISI Hot dip galvanizing (via AISI report)
Aluminum	RNA: Primary aluminum ingot AA RNA: Recycled aluminum ingot Recycled content mixer <u-so> Remelt and Casting RER Aluminum sheet – open input
Polymers	GLO: Plastic extrusion profile (unspecific) Sphera <u-so> US: Lubricants at refinery Sphera GLO: Compressed air 7 bar (medium power) GLO: Compounding (plastics) Sphera GLO: Plastic injection moulding RER: Tap water from groundwater Sphera

Table 6.1c
Other carbon factors

Transportation	Datasets
Air	GLO: Cargo plane Sphera (plan) <LC>
Rail	US: Rail transport cargo - average, average train, gross tonne weight 1,000t / 726t payload capacity <LC>
Autocarrier	US: Truck - auto carrier (EPA SmartWay) Sphera (plan) <LC>
Truck	US: Truck - dray (EPA SmartWay) Sphera (plan) <LC>

Electricity	Datasets
AZNM	US: Electricity grid mix – AZNM Sphera
CAMX	US: Electricity grid mix – CAMX Sphera
ERCT	US: Electricity grid mix – ERCT Sphera
FRCC	US: Electricity grid mix – FRCC Sphera
MROE	US: Electricity grid mix – MROE Sphera
MROW	US: Electricity grid mix – MROW Sphera
NEWE	US: Electricity grid mix – NEWE Sphera
NWPP	US: Electricity grid mix – NWPP Sphera
NYCW	US: Electricity grid mix – NYCW Sphera
NYLI	US: Electricity grid mix – NYLI Sphera
NYUP	US: Electricity grid mix – NYUP Sphera
RFCE	US: Electricity grid mix – RFCM Sphera
RFCM	US: Electricity grid mix – RFCM Sphera
RFCW	US: Electricity grid mix – RFCW Sphera
RMPA	US: Electricity grid mix – RMPA Sphera
SPNO	US: Electricity grid mix – SPNO Sphera
SPSO	US: Electricity grid mix – SPSO Sphera
SRMV	US: Electricity grid mix – SRMV Sphera
SRMW	US: Electricity grid mix – SRMW Sphera

Electricity	Datasets
SRSO	US: Electricity grid mix – SRSO Sphera
SRTV	US: Electricity grid mix – SRTV Sphera
SRVC	US: Electricity grid mix – SRVC Sphera
US average	US: Electricity grid mix Sphera
US wind	US: Electricity from wind power Sphera
US solar	US: Electricity from photovoltaic Sphera
US coal	US: Electricity from hard coal Sphera
US natural gas	US: Electricity from natural gas Sphera
US generic renewables	US: Green electricity grid mix (production mix) Sphera
China	CN: Electricity grid mix Sphera
Europe	RER: Electricity grid mix Sphera

Other Energy Sources	Datasets
Chinese steam energy	CN: Process steam from natural gas 90% Sphera
Chinese thermal energy	CN: Thermal energy from natural gas Sphera
US steam energy	US: Process steam from natural gas 90% Sphera
US thermal energy	US: Thermal energy from natural gas Sphera
Diesel	US: Diesel mix at filling station Sphera
Premium gasoline	
Regular gasoline	US: Gasoline mix (regular) at filling station Sphera
Liquified petroleum gas	US: Liquefied Petroleum Gas (LPG) (70% propane; 30% butane) Sphera
Heavy fuel oil (3 wt.%)	
Heavy fuel oil (2.5 wt.%)	US: Heavy fuel oil at refinery (2.5wt.% S) Sphera
Light fuel oil	US: Light fuel oil at refinery Sphera
Propane	US: Propane at refinery Sphera

6.1.1 Aluminum

Rivian developed carbon footprint models for aluminum ingot and sheet. The models are based on the Aluminum Association LCA report for semi-fabricated[21] products. Rather than use the information directly from the report or the analogous datasets in the Sphera MLC, Rivian reconstructed these models so that recycled content could be a variable. Any level of recycled content can be evaluated through interpolation between these models. Utilizations and processing steps mirror the information in the Aluminum Association report and use automotive-specific information whenever available.

6.1.2 Steel

Rivian developed carbon footprint models for hot and cold-rolled sheet with varying levels of recycled content. The American Iron and Steel Institute (AISI)[22] for steel sheet assumes a scrap input based on industry averages. By adding the "value of scrap" dataset upstream, the scrap inputs are assigned the burden of primary steel, thus approximating a theoretical steel sheet with 0% recycled content. These models are combined with the standard AISI datasets in Sphera so that any level of recycled content can be evaluated through interpolation and extrapolation. All steel is assumed to be hot-dip galvanized. The hot-dip galvanizing model was developed using data from AISI.

[21] The Environmental Footprint of Semi-Fabricated Aluminum Products in North America. The Aluminum Association. 2022. https://www.aluminum.org/sites/default/files/2022-01/2022_Semi-Fab_LCA_Report.pdf

[22] Life Cycle Inventories of North American Steel Products. American Iron and Steel Institute. 2020.

6.1.3 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 that will be used across all Rivian vehicles until another study is conducted.

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 the datasets shown in Table 6.1a scale by mass, which allows us to use the ECU BoM 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 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. These data are then combined with carbon intensity factors for the appropriate type of PCB.

Determining the GHG emissions of 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. While this estimation is relatively rough, the populated ECUs contribute less than 1% to the life cycle carbon footprint of an R1S. As such, the uncertainty introduced into the overall results is acceptable for the goal of this study.

6.1.4 Other Plans

A variety of other plans were created in Sphera FE to support the modeling. These are marked with an <LC> term in Table 6.1a, per Sphera nomenclature. Many plans are simple scaling functions used to normalize a process to a declared unit of 1 kg. Other plans are processes with upstream energy and operating materials (e.g., lubricants) flows connected using US data (e.g., US average electricity, USthermal energy from natural gas). These types of simple plans reflect the data in unit processes from Sphera's MLC database and are not published here.

For example, the plans for expanded polypropylene (EPP) and plastic injection are slightly more complex and cannot be found directly in Sphera's MLC database. For EPP, no data on this material are available, so an estimate was made using PP granulate and an extrusion unit process. This is a crude estimate, but not expected to have relevant impact on the results.

6.2 Onsite Production

The carbon footprint from onsite production is calculated using site specific data from the Rivian production plant in Normal, IL in 2023. The footprint from the production at Normal is divided evenly across the number of saleable vehicles in 2023. The Normal production plant lies in the eGRID subregion SRMW; the 2021 eGRID data from Sphera's MLC database are used as the carbon intensity for all electricity pulled from the grid.

The production plant in Normal, IL is equipped with an array of rooftop solar panels. At the plant, neither the solar energy produced, nor any renewable energy credits are sold back to the grid (or any other third party). The energy is used exclusively by Rivian onsite. The upstream GHG emissions from the solar energy are less than 1 kg CO_2e / vehicle.

6.3 Logistics

The carbon footprint of inbound logistics is based on the cargo and freight transport that pertains to vehicle production at the Rivian production plant in Normal, IL.

Carbon factors from Sphera's MLC database (as shown in Table 6.1c) are used when freight 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.

The carbon footprint from all incoming freight that consists of materials and parts related to vehicle production is divided across the number of saleable Rivian vehicles produced in 2023 to yield the average carbon footprint of inbound logistics per vehicle.

The carbon footprint of outbound logistics is found using the mode and distance of transportation for all vehicle sales in 2023. These data are divided across the number of saleable Rivian vehicles produced in 2023 to yield the average carbon footprint of outbound logistics per vehicle. The carbon footprint of this is found using the carbon factors outlined in Table 6.1c.

6.4 Charging

We allocate R1S sales data to the respective eGRID subregions using the zip codes that correspond to the sale and the Power Profiler tool from the EPA.[23] We assume each vehicle is driven in the subregion in which it was originally purchased. For a small number of R1S sales, the zip code could either not be determined or was outside of an eGRID subregion; these sales were allocated to US average.

[23]The EPA power profiler tool can be found at: https://www.epa.gov/egrid/power-profiler#/

6.5 Decommissioning

The carbon footprint of decommissioning the materials in an R1S is estimated using the rates of decommissioning scenarios shown in table 6.5. Materials that are not expected to be isolated during decommissioning processing are modeled as automotive shredder residue (ASR) and assumed to be landfilled.

Table 6.5
Decommissioning fates

Material Type			Source	Carbon Factor Dataset
Aluminum	% Recycled	91%	https://www.aluminum.org/sites/default/files/2021-10/Final-Report-Automotive-Aluminum-Recycling-at-End-of-Life-A-Grave-to-Gate-Analysis.pdf	-
	% Landfilled	9%		RER: Inert matter (Aluminium) on landfill Sphera
	% Incineration	0%		US: Inert waste in waste incineration plant Sphera (plan) <LC>
Steel	% Recycled	96%	https://www.steel.org/wp-content/uploads/2021/08/AISI-and-SMA-Steel-Recycling-Rates-Report-Final-07-27-2021.pdf	-
	% Landfilled	4%		RER: Inert matter (Steel) on landfill Sphera
	% Incineration	0%		US: Inert waste in waste incineration plant Sphera (plan) <LC>
Polymers	% Recycled	0%	assumption	-
	% Landfilled	100%		RER: Plastic waste on landfill Sphera
	% Incineration	0%		US: Plastic packaging in municipal waste incineration plant Sphera <p-agg> <LC>
Electronics	% Recycled	90%	estimate	-
	% Landfilled	5%		Calculated - based on polymers
	% Incineration	5%		US: Populated printed wiring board (after RoHS) in waste incineration plant Sphera <p-agg> <LC>
Other metals	% Recycled	96%	modeled as steel	-
	% Landfilled	4%		Calculated - based on steel
	% Incineration	0%		Calculated - based on steel
Battery cells	% Recycled	100%	assumption	-
	% Landfilled	0%		-
	% Incineration	0%		-
Tires	% Recycled	100%	assumption	-
	% Landfilled	0%		-
	% Incineration	0%		-
Other materials	% Recycled	0%	modeled as ASR	-
	% Landfilled	100%		Calculated - based on polymers
	% Incineration	0%		Calculated - based on polymers
Vehicle shredding				DE: Car shredder Sphera <p-agg>
Transportation to recycling facility				US: Truck - dray (EPA SmartWay) Sphera (plan) <LC>

6.6 Detailed footprint summary

Table 6.6a
Detailed breakdown R1S-DM-Max (MT CO_2e)

		Body system	Chassis system	Interior system	Powertrain system	Other systems	Battery cells	Logistics	Onsite production	Charging	Maintenance	Decommissioning
Materials and upstream production	Aluminum	2.0	1.8	0.1	0.4	0.8						
	Steel	3.5	0.3	0.4	0.4	0.3						
	Polymers	0.5	0.3	0.6	0.0	0.7						
	Other metals	0.0	0.1	0.1	0.0	0.1						
	Other materials	0.1	0.0	0.0	0.0	0.2						
	Electronics	0.0	0.0	0.0	0.0	0.2						
	Mixed or unassigned materials	0.6	0.4	0.8	0.1	0.6						
	Battery cells						10.9					
Logistics	Inbound							1.1				
	Outbound							0.4				
Onsite production	Scope 1 and 2								2.6			
	Scope 3								0.4			
Charging and service	Charging									23.1		
	Service										1.0	
Decommissioning	Shredding											0.1
	Transportation											0.3
	Landfill											0.0
	Incineration											0.0
Total		6.8	3.0	2.0	1.0	3.0	10.9	1.5	2.9	23.1	1.0	0.4

Table 6.6b
Detailed breakdown R1S-DM-Std (MT CO_2e)

		Body system	Chassis system	Interior system	Powertrain system	Other systems	Battery cells	Logistics	Onsite production	Charging	Maintenance	Decommissioning
Materials and upstream production	Aluminum	1.3	1.8	0.1	0.4	1.6						
	Steel	3.3	0.3	0.4	0.4	0.3						
	Polymers	0.5	0.3	0.6	0.0	0.3						
	Other metals	0.0	0.1	0.1	0.0	0.1						
	Other materials	0.1	0.0	0.0	0.0	0.2						
	Electronics	0.0	0.0	0.0	0.0	0.2						
	Mixed or unassigned materials	0.6	0.4	0.8	0.1	0.6						
	Battery cells						11.4					
Logistics	Inbound							1.1				
	Outbound							0.4				
Onsite production	Scope 1 and 2								2.6			
	Scope 3								0.4			
Charging and service	Charging									23.2		
	Service										1.2	
Decommissioning	Shredding											0.1
	Transportation											0.3
	Landfill											0.0
	Incineration											0.0
Total		5.8	3.0	2.0	1.0	3.4	11.4	1.5	2.9	23.2	1.2	0.4

- Critical Review Statement -

Gen 2 R1S Carbon Footprint - Version 1.0

Gen 2 R1S Supporting Information (Confidential) – Version 1.0

Carbon Footprint Methodology Report – Version 1.1

Commissioned by:	Rivian Automotive, Inc. ("Rivian")
Conducted by:	Rivian Automotive, Inc. ("Rivian")
Reviewer:	Christoph Koffler, PhD – Technical Director Americas, Sustainability Consulting
References:	ISO 14044:2006 – Environmental Management – Life Cycle Assessment – Requirements and Guidelines ISO 14067:2018 Greenhouse gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification ISO/TS 14071:2014 — Environmental management — Life cycle assessment — Critical review processes and reviewer competencies:Additional requirements and guidelines to ISO 14044:2006

Scope of the Critical Review

In accordance with ISO 14044:2006, section 6.1, the goal of the Critical Review was toassess whether:

- the methods used to carry out the LCA are consistent with the internationalstandards ISO 14040 and ISO 14044,
- the methods used to carry out the LCA are scientifically and technically valid,
- the data used are appropriate and reasonable in relation to the goal of the study,
- the interpretations reflect the limitations identified and the goal of the study, and
- the study report is transparent and consistent.

As the study is not intended to support comparative assertions intended to be disclosed to the public, the review was performed by single independent expert following ISO 14044:2006, clause 6.2.

This review statement is only valid for the specific reports and version numbers listed in the header of this review statement.

The review was performed exclusively on the above documents. No software models were shared during the review.

The reviewer performed the review in his capacity as an independent expert.

Critical Review process

The review was conducted by exchanging comments and responses using a spreadsheet template based on Annex A of ISO/TS 14071:2014. It was carried out in parallel with the review of the Carbon Footprint Methodology Report (Version 1.1).

The critical review was carried out between June 2024 (submission of first draft reports) and September 2024 (delivery of the final review statement). There were multiple formal rounds of comments on different draft versions of the reports, online meetings to discuss and clarify those comments, as well as several email conversations in-between.

A copy of the final review report containing all written comments and responses has been provided to Rivian along with this review statement.

The overall review was conducted in an equitable and constructive manner. The reviewer would like to highlight the good and constructive collaboration with the authors of the study. All comments were addressed and all open issues resolved. There were no dissenting opinions held by any of the involved parties upon finalization of the review.

General evaluation

The study is well scoped and capable of supporting the goal of the study. It shows a high level of technical knowledge and methodological proficiency. It is based on a multitude of data sources and primary data points covering material composition, in-house manufacturing, and use phase parameters to achieve a high level of data quality.

Its main limitation lies in the complexity of the automotive supply chain and the limited availability of primary supplier data, which is a general issue in the automotive industry and not specific to this study. As such, the study should be understood to represent mostly market-average supply chain emissions based on conservative assumptions and best-available data. Nevertheless, the results are deemed to be sufficiently accurate for external communication as well as for internal use to identify opportunities for further improvement.

Conclusion

Based on the final report documents, it can be concluded that the methods used to carry out the LCA are consistent with the International Standard ISO 14044, that they are scientifically and technically valid, that the data used are appropriate and reasonable in relation to the goal of the study, and that the interpretations reflect the limitations identified and the goal of the study. The report documents are considered sufficiently transparent and consistent.

When communicating results to third parties outside of Rivian, ISO 14044, section 5.2 requires that a third-party report be made available to any such parties. For this specific study, the combination of Summary Report (including Appendix) and Methodology Report shall constitute the third-party report.

Christoph Koffler, PhD

Valid as of 09/06/2024