# Update of Vehicle Material Compositions in the GREET® Model

by

J.C. Kelly, and O. Winjobi

Systems Assessment Group

Energy Systems Division

Argonne National Laboratory

October 1, 2020

## CONTENTS



## TABLES

## ACRONYMS

| | |
|---|---|
| BEV | battery electric vehicle |
| BIW | body-in-white |
| EV | electric vehicle |
| FCEV | fuel cell electric vehicle |
| HEV | hybrid electric vehicle |
| ICEV | internal combustion engine vehicle |
| PHEV | plug-in hybrid vehicle |
| PUT | pickup truck |
| SUV | sports utility vehicle |

*This page intentionally left blank.*

# Update of Vehicle Material Compositions in the GREET® Model

Jarod C. Kelly and Olumide Winjobi

Systems Assessment Group

Energy Systems Division

Argonne National Laboratory

October 1, 2020

This memo documents updates in the GREET® model for the material composition of vehicle systems for Conventional Type 1 vehicles including the midsize sedan (Car), small sport-utility vehicle (SUV), and pickup truck (PUT). The data for the updates are based on an aggregation of vehicles from the A2Mac1 dataset for internal combustion engine vehicles (ICEVs) Cars, SUVs, and PUTs which reflects the current state of the vehicle market. We also used the dataset to update aspects of the hybrid electric vehicle (HEVs), plug-in electric vehicle (PHEV), battery electric vehicle (BEV), and fuel cell electric vehicle (FCEV) component systems.

## 1. UPDATED VEHICLE MATERIAL COMPOSITION

The material composition of vehicle systems, components and parts significantly influences vehicle weight. This update reports updated material compositions for Conventional Type 1 vehicles, including Car, sports utility vehicle (SUV), and Pickup Trucks (PUT) in GREET. The data for these updates come from the A2Mac1 data-set. From this data-set, we chose three midsize cars, four small SUVs, and three pickup trucks that serve has high market share exemplars of the US light duty fleet. We provide an average of their material compositions here.

While this update is based on new data analyzed for ICEV Cars, SUV and Pickup Trucks, we use that data to also update aspects of the HEV, PHEV, BEV, and FCEV powertrain. We do this by utilizing prior work from Argonne (Burnham, 2012) and the GREET 2019 model (Argonne, 2019) to augment the mass and composition of the vehicle. Specifically, in Burnham 2012, the Body and the Chassis systems of all vehicles within the same class (Car, SUV, or Truck) are constant, we thus use that to inform the sizing of our updates. We have defined ICEV, HEV, PHEV, BEV, and FCEV to share a common Body and Chassis, but since the masses of these vehicles in GREET vary from the masses of the vehicles in our analysis this update is focused on

the mass relationships between both the systems within the vehicle and the material compositions within those systems.

For the Transmission systems, we use the previous modeling efforts presented in GREET 2019 to retain the prior the transmission mass for the HEV, PHEV, BEV, and FCEV because those are systems designed on a required power basis. However, we update the ICEV transmission mass based on current data since that is a specifically designed set of vehicles. Furthermore, we retain the previously assumed material composition for HEV, PHEV, BEV, and FCEV while updating the transmission composition for the ICEV. We do this for each vehicle type.

For the Powertrain systems, we again use the previous modeling efforts presented in GREET 2019 to retain the prior powertrain mass of the HEV, PHEV, BEV, and FCEV, while updating the ICEVs mass based on the new data. Furthermore, we retain the previously assumed material composition for HEV, PHEV, BEV, and FCEV while updating the transmission composition for the ICEV. We do this for each vehicle type.

For the Generator, Motor, Controller/Inverter, and Fuel cell auxiliaries, we use the prior mass data for the HEV, PHEV, BEV, and FCEV, as appropriate. Note that this was done for each vehicle type, Car, SUV and Truck. Furthermore, we retained the material compositions of each of those systems as previously reported in the GREET model (Argonne, 2019) and Argonne's update in 2012 (Burnham, 2012).

This update keeps the previous mass of each vehicle type since those are based on model simulations. The change in the vehicles are related to material composition and the relationship of one system to another.

This update will present a detailed representation of the materials on a component basis for each of the ICEV (Car, SUV, and Pickup) for future reference at the disaggregate level. However, for implementation within GREET, we scale these to meet the assumed vehicle mass of the GREET vehicle. Further, we use the ICEV body and chassis as the basis for the other vehicle types, and we must scale them to match the total mass of the predefined vehicle mass in GREET 2019. So, for the HEV, PHEV, BEV, and FCEV, we use the known mass of the associated GREET vehicle, the mass of the GREET-based Transmission, Powertrain, Generator, Motor, Controller/Inverter, and Fuel cell auxiliaries (as appropriate) along with the known mass of the A2Mac1-based aggregate vehicle, body and chassis. With this, we scale the body and chassis of the A2Mac1-based vehicle proportionally by the ratio of sum of the A2Mac1-based body and chassis against the sum of the GREET-based vehicle body and chassis. The vehicle material component contribution to vehicle mass for the Car, SUV, and PUT categories are shown in the Tables 1, 2, and 3 respectively.

Table 1. Car: Vehicle Material Composition

| Component System | ICEV | HEV | PHEV10 | PHEV20 | PHEV30 | PHEV40 | EV100 | EV300 | FCEV |
|---|---|---|---|---|---|---|---|---|---|
| Powertrain System (including BOP) | 15.3% | 22.5% | 22.8% | 23.0% | 23.8% | 23.9% | 4.8% | 4.5% | 8.3% |
| Transmission System | 6.3% | 5.0% | 5.0% | 5.0% | 4.8% | 4.7% | 5.7% | 5.6% | 2.8% |
| Chassis (w/o battery) | 25.4% | 21.6% | 21.5% | 21.4% | 20.6% | 20.5% | 24.8% | 24.2% | 23.5% |
| Traction Motor | - | 2.1% | 2.1% | 2.1% | 3.0% | 3.2% | 7.2% | 9.3% | 4.2% |
| Generator | - | 2.1% | 2.1% | 2.1% | 3.0% | 3.2% | - | - | - |
| Electronic Controller | - | 1.8% | 1.8% | 1.8% | 1.8% | 1.8% | 5.9% | 5.9% | 3.7% |
| Fuel Cell Onboard Storage | - | - | - | - | - | - | - | - | 8.7% |
| Body: BIW, interior, exterior, and glass | 52.9% | 44.9% | 44.7% | 44.6% | 43.0% | 42.6% | 51.6% | 50.4% | 48.9% |

Table 2. SUV: Vehicle Material Composition

| Component System | ICEV | HEV | PHEV10 | PHEV20 | PHEV30 | PHEV40 | EV100 | EV300 | FCEV |
|---|---|---|---|---|---|---|---|---|---|
| Powertrain System (including BOP) | 14.4% | 20.6% | 20.6% | 21.0% | 21.8% | 21.9% | 3.1% | 2.8% | 8.0% |
| Transmission System | 5.9% | 4.1% | 4.1% | 4.1% | 3.9% | 3.9% | 4.7% | 4.6% | 2.9% |
| Chassis (w/o battery) | 26.9% | 23.2% | 23.2% | 23.1% | 22.2% | 22.1% | 26.6% | 25.8% | 29.9% |
| Traction Motor | - | 2.3% | 2.3% | 2.3% | 3.3% | 3.4% | 7.2% | 10.1% | 4.5% |
| Generator | - | 2.3% | 2.3% | 2.3% | 3.3% | 3.4% | - | - | - |
| Electronic Controller | - | 1.8% | 1.8% | 1.8% | 1.8% | 1.8% | 5.9% | 5.9% | 3.9% |
| Fuel Cell Onboard Storage | - | - | - | - | - | - | - | - | 8.9% |
| Body: BIW, interior, exterior, and glass | 52.9% | 45.7% | 45.7% | 45.4% | 43.7% | 43.4% | 52.4% | 50.8% | 41.9% |

Table 3. PUT: Vehicle Material Composition

| Component System | ICEV | HEV | PHEV10 | PHEV20 | PHEV30 | PHEV40 | EV100 | EV300 | FCEV |
|---|---|---|---|---|---|---|---|---|---|
| Powertrain System (including BOP) | 15.4% | 19.0% | 19.3% | 19.5% | 20.4% | 20.5% | 1.8% | 1.6% | 7.9% |
| Transmission System | 5.5% | 3.5% | 3.5% | 3.5% | 3.4% | 3.3% | 4.0% | 3.9% | 2.9% |
| Chassis (w/o battery) | 36.6% | 32.9% | 32.8% | 32.6% | 31.3% | 31.0% | 37.4% | 36.1% | 30.6% |
| Traction Motor | - | 2.3% | 2.3% | 2.4% | 3.4% | 3.7% | 7.4% | 10.7% | 4.4% |
| Generator | - | 2.3% | 2.3% | 2.4% | 3.4% | 3.7% | - | - | - |
| Electronic Controller | - | 1.8% | 1.8% | 1.8% | 1.8% | 1.8% | 5.9% | 5.9% | 3.8% |
| Fuel Cell Onboard Storage | - | - | - | - | - | - | - | - | 8.9% |
| Body: BIW, interior, exterior, and glass | 42.4% | 38.1% | 38.0% | 37.7% | 36.3% | 36.0% | 43.4% | 41.8% | 41.5% |

The material composition for the different vehicle components in GREET are shown in Tables 4, 5, and 6 for the Car, SUV, and PUT categories below:

Table 4. Composition of Vehicle Components in GREET (%): Car

| Component System | ICEV | HEV | PHEV | EV | FCV |
|---|---|---|---|---|---|
| **Body** | | | | | |
| Steel | **65.3%** | **65.3%** | **65.3%** | **65.3%** | **65.3%** |
| Wrought Aluminum | **3.1%** | **3.1%** | **3.1%** | **3.1%** | **3.1%** |
| Cast Aluminum | **0.2%** | **0.2%** | **0.2%** | **0.2%** | **0.2%** |
| Copper/Brass | **1.9%** | **1.9%** | **1.9%** | **1.9%** | **1.9%** |
| Zinc | **-** | **-** | **-** | **-** | **-** |
| Magnesium | **-** | **-** | **-** | **-** | **-** |
| Glass Fiber-Reinforced Plastic | **0.8%** | **0.8%** | **0.8%** | **0.8%** | **0.8%** |
| Glass | **4.4%** | **4.4%** | **4.4%** | **4.4%** | **4.4%** |
| Carbon Fiber-Reinforced Plastic | **-** | **-** | **-** | **-** | **-** |
| Average Plastic | **21.7%** | **21.7%** | **21.7%** | **21.7%** | **21.7%** |
| Rubber | **1.8%** | **1.8%** | **1.8%** | **1.8%** | **1.8%** |
| Others | **0.9%** | **0.9%** | **0.9%** | **0.9%** | **0.9%** |
| **Powertrain System (including BOP)** | | | | | |
| Steel | **42.4%** | 48.4% | 50.2% | 5- | 18.7% |
| Stainless Steel | **-** | - | - | - | 31.3% |
| Cast iron | **-** | 24.0% | 22.8% | - | 0.1% |
| Wrought Aluminum | **4.8%** | - | - | - | 16.8% |
| Cast Aluminum | **22.3%** | 14.4% | 13.7% | - | - |
| Copper/Brass | **6.8%** | 2.6% | 2.8% | 20.5% | 1.7% |
| Magnesium | **-** | - | - | - | - |
| Glass Fiber-Reinforced Plastic | **2.5%** | - | - | - | 2.6% |
| Average Plastic | **19.0%** | 8.4% | 8.4% | 29.5% | 16.6% |
| Rubber | **2.2%** | 2.2% | 2.1% | - | 6.5% |
| Carbon Fiber-Reinforced Plastic | **-** | - | - | - | - |
| PFSA | **-** | - | - | - | 0.6% |
| Carbon Paper | **-** | - | - | - | 2.1% |
| PTFE | **-** | - | - | - | 2.6% |
| Carbon & PFSA Suspension | **-** | - | - | - | - |
| Platinum | **0.003%** | 0.002% | 0.002% | - | 0.002% |
| Carbon | **-** | - | - | - | 0.3% |
| Nickel | **-** | - | - | - | 0.002% |
| Silicon | **-** | - | - | - | 0.1% |
| Others | - | - | - | - | - |
| **Chassis (w/o battery)** | | | | | |
| Steel | **66.8%** | **66.8%** | **66.8%** | **66.8%** | **66.8%** |
| Cast Iron | **-** | **-** | **-** | **-** | **-** |
| Wrought Aluminum | **1.5%** | **1.5%** | **1.5%** | **1.5%** | **1.5%** |
| Cast Aluminum | **18.6%** | **18.6%** | **18.6%** | **18.6%** | **18.6%** |
| Copper/Brass | **1.3%** | **1.3%** | **1.3%** | **1.3%** | **1.3%** |
| Zinc | **-** | **-** | **-** | **-** | **-** |
| Magnesium | **0.1%** | **0.1%** | **0.1%** | **0.1%** | **0.1%** |
| Glass Fiber-Reinforced Plastic | **0.2%** | **0.2%** | **0.2%** | **0.2%** | **0.2%** |
| Average Plastic | **2.3%** | **2.3%** | **2.3%** | **2.3%** | **2.3%** |
| Rubber | **9.2%** | **9.2%** | **9.2%** | **9.2%** | **9.2%** |
| Others | **-** | **-** | **-** | **-** | **-** |

Table 5. Composition of Vehicle Components in GREET (%): SUV

| Component System | ICEV | HEV | PHEV | EV | FCV |
|---|---|---|---|---|---|
| **Body** | | | | | |
| Steel | **64.9%** | **64.9%** | **64.9%** | **64.9%** | **64.9%** |
| Wrought Aluminum | **2.9%** | **2.9%** | **2.9%** | **2.9%** | **2.9%** |
| Cast Aluminum | **0.2%** | **0.2%** | **0.2%** | **0.2%** | **0.2%** |
| Copper/Brass | **2.2%** | **2.2%** | **2.2%** | **2.2%** | **2.2%** |
| Zinc | **-** | **-** | **-** | **-** | **-** |
| Magnesium | **-** | **-** | **-** | **-** | **-** |
| Glass Fiber-Reinforced Plastic | **0.9%** | **0.9%** | **0.9%** | **0.9%** | **0.9%** |
| Glass | **4.5%** | **4.5%** | **4.5%** | **4.5%** | **4.5%** |
| Carbon Fiber-Reinforced Plastic | **-** | **-** | **-** | **-** | **-** |
| Average Plastic | **22.2%** | **22.2%** | **22.2%** | **22.2%** | **22.2%** |
| Rubber | **1.8%** | **1.8%** | **1.8%** | **1.8%** | **1.8%** |
| Others | **0.5%** | **0.5%** | **0.5%** | **0.5%** | **0.5%** |
| **Powertrain System (including BOP)** | | | | | |
| Steel | **35.2%** | 48.4% | 50.2% | 5- | 18.7% |
| Stainless Steel | **-** | - | - | - | 31.3% |
| Cast iron | **0.5%** | 24.0% | 22.8% | - | 0.1% |
| Wrought Aluminum | **4.7%** | - | - | - | 16.8% |
| Cast Aluminum | **24.5%** | 14.4% | 13.7% | - | - |
| Copper/Brass | **7.7%** | 2.6% | 2.8% | 20.5% | 1.7% |
| Magnesium | **-** | - | - | - | - |
| Glass Fiber-Reinforced Plastic | **2.5%** | - | - | - | 2.6% |
| Average Plastic | **22.2%** | 8.4% | 8.4% | 29.5% | 16.6% |
| Rubber | **2.6%** | 2.2% | 2.1% | - | 6.5% |
| Carbon Fiber-Reinforced Plastic | **-** | - | - | - | - |
| PFSA | **-** | - | - | - | 0.6% |
| Carbon Paper | **-** | - | - | - | 2.1% |
| PTFE | **-** | - | - | - | 2.6% |
| Carbon & PFSA Suspension | **-** | - | - | - | - |
| Platinum | **-** | 0.002% | 0.002% | - | 0.002% |
| Carbon | **-** | - | - | - | 0.3% |
| Nickel | **-** | - | - | - | 0.002% |
| Silicon | **-** | - | - | - | 0.1% |
| Others | - | - | - | - | - |
| **Chassis (w/o battery)** | | | | | |
| Steel | **66.7%** | **66.7%** | **66.7%** | **66.7%** | **66.7%** |
| Cast Iron | **-** | **-** | **-** | **-** | **-** |
| Wrought Aluminum | **1.7%** | **1.7%** | **1.7%** | **1.7%** | **1.7%** |
| Cast Aluminum | **10.8%** | **10.8%** | **10.8%** | **10.8%** | **10.8%** |
| Copper/Brass | **1.3%** | **1.3%** | **1.3%** | **1.3%** | **1.3%** |
| Zinc | **-** | **-** | **-** | **-** | **-** |
| Magnesium | **0.2%** | **0.2%** | **0.2%** | **0.2%** | **0.2%** |
| Glass Fiber-Reinforced Plastic | **0.7%** | **0.7%** | **0.7%** | **0.7%** | **0.7%** |
| Average Plastic | **3.0%** | **3.0%** | **3.0%** | **3.0%** | **3.0%** |
| Rubber | **15.6%** | **15.6%** | **15.6%** | **15.6%** | **15.6%** |
| Others | **-** | **-** | **-** | **-** | **-** |

Table 6. Composition of Vehicle Components in GREET (%): PUT

| Component System | ICEV | HEV | PHEV | EV | FCV |
|---|---|---|---|---|---|
| **Body** | | | | | |
| Steel | **54.7%** | **54.7%** | **54.7%** | **54.7%** | **54.7%** |
| Wrought Aluminum | **13.1%** | **13.1%** | **13.1%** | **13.1%** | **13.1%** |
| Cast Aluminum | **0.4%** | **0.4%** | **0.4%** | **0.4%** | **0.4%** |
| Copper/Brass | **1.9%** | **1.9%** | **1.9%** | **1.9%** | **1.9%** |
| Zinc | **0.1%** | **0.1%** | **0.1%** | **0.1%** | **0.1%** |
| Magnesium | **-** | **-** | **-** | **-** | **-** |
| Glass Fiber-Reinforced Plastic | **1.0%** | **1.0%** | **1.0%** | **1.0%** | **1.0%** |
| Glass | **4.5%** | **4.5%** | **4.5%** | **4.5%** | **4.5%** |
| Carbon Fiber-Reinforced Plastic | **-** | **-** | **-** | **-** | **-** |
| Average Plastic | **21.5%** | **21.5%** | **21.5%** | **21.5%** | **21.5%** |
| Rubber | **1.7%** | **1.7%** | **1.7%** | **1.7%** | **1.7%** |
| Others | **1.0%** | **1.0%** | **1.0%** | **1.0%** | **1.0%** |
| **Powertrain System (including BOP)** | | | | | |
| Steel | **49.9%** | 48.4% | 50.2% | 50.0% | 18.7% |
| Stainless Steel | **-** | - | - | - | 31.3% |
| Cast iron | **4.0%** | 24.0% | 22.8% | - | 0.1% |
| Wrought Aluminum | **4.0%** | - | - | - | 16.8% |
| Cast Aluminum | **15.3%** | 14.4% | 13.7% | - | - |
| Copper/Brass | **5.2%** | 2.6% | 2.8% | 20.5% | 1.7% |
| Magnesium | **-** | - | - | - | - |
| Glass Fiber-Reinforced Plastic | **1.5%** | - | - | - | 2.6% |
| Average Plastic | **18.4%** | 8.4% | 8.4% | 29.5% | 16.6% |
| Rubber | **1.7%** | 2.2% | 2.1% | - | 6.5% |
| Carbon Fiber-Reinforced Plastic | **-** | - | - | - | - |
| PFSA | **-** | - | - | - | 0.6% |
| Carbon Paper | **-** | - | - | - | 2.1% |
| PTFE | **-** | - | - | - | 2.6% |
| Carbon & PFSA Suspension | **-** | - | - | - | - |
| Platinum | **-** | 0.002% | 0.002% | - | 0.002% |
| Carbon | **-** | - | - | - | 0.3% |
| Nickel | **-** | - | - | - | 0.002% |
| Silicon | **-** | - | - | - | 0.1% |
| Others | **0.1%** | - | - | - | - |
| **Chassis (w/o battery)** | | | | | |
| Steel | **76.2%** | **76.2%** | **76.2%** | **76.2%** | **76.2%** |
| Cast Iron | **0.3%** | **0.3%** | **0.3%** | **0.3%** | **0.3%** |
| Wrought Aluminum | **0.9%** | **0.9%** | **0.9%** | **0.9%** | **0.9%** |
| Cast Aluminum | **16.2%** | **16.2%** | **16.2%** | **16.2%** | **16.2%** |
| Copper/Brass | **0.6%** | **0.6%** | **0.6%** | **0.6%** | **0.6%** |
| Zinc | **-** | **-** | **-** | **-** | **-** |
| Magnesium | **0.2%** | **0.2%** | **0.2%** | **0.2%** | **0.2%** |
| Glass Fiber-Reinforced Plastic | **0.2%** | **0.2%** | **0.2%** | **0.2%** | **0.2%** |
| Average Plastic | **1.8%** | **1.8%** | **1.8%** | **1.8%** | **1.8%** |
| Rubber | **3.6%** | **3.6%** | **3.6%** | **3.6%** | **3.6%** |
| Others | **-** | **-** | **-** | **-** | **-** |

A complete breakdown of the vehicle components for the Car, SUV and PUT in GREET for ICEVs are shown in the appendix to enable comparative analysis between this work and other studies.

# ACKNOWLEDGEMENTS

We would like to acknowledge the critical contributions to this effort by Ehsan Islam and Ram Vijayagopal from Argonne National Laboratory.

# REFERENCES

Argonne National Laboratory. GREET Model: The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model. 2019. Available online: **https://greet.es.anl.gov/**

Burnham, A. "Updated vehicle specifications in the GREET vehicle-cycle model." *Argonne National Laboratory* (2012). https://greet.es.anl.gov/publication-update-veh-specs

# APPENDIX

Table A-1. Average Vehicle component weight based on A2Mac1 in GREET (lbs): Car

| GREET Level | Sub Level | Component | Steel | W. Al | Cast Al | Copper | Mg | GFRP | Glass | Plastic | Rubber | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Body | | Body-in-white | 684.05 | - | - | - | - | - | - | - | - | - | 684.05 |
| Body | | Bumpers | 8.87 | 17.69 | - | 0.04 | - | - | - | 31.48 | 0.31 | 0.00 | 58.39 |
| Body | | Decklid/Fenders | 40.88 | 0.12 | - | 0.27 | - | 0.15 | - | 3.18 | 0.55 | - | 45.15 |
| Body | | Front doors | 80.69 | 0.12 | 0.16 | 1.97 | - | 1.30 | 8.30 | 46.10 | 2.20 | 0.00 | 140.84 |
| Body | | Glass | 0.03 | - | - | - | - | - | 48.23 | 0.34 | 0.26 | - | 48.86 |
| Body | | Hood | 7.89 | 18.85 | - | 0.11 | - | - | - | 1.91 | 0.45 | 0.72 | 29.93 |
| Body | | Rear doors | 61.01 | 0.05 | 0.09 | 0.95 | - | 0.69 | 6.79 | 33.24 | 2.81 | - | 105.63 |
| Body | Exterior | Exterior lighting | 0.41 | - | - | 7.60 | - | 5.02 | - | 12.69 | - | - | 25.73 |
| Body | Exterior | Fascia and trim | 26.73 | 1.88 | 0.20 | 0.27 | - | 1.42 | 8.48 | 29.28 | 1.52 | 0.03 | 69.82 |
| Body | Exterior | Wiper system | 3.58 | 0.67 | - | 0.61 | - | 0.74 | - | 3.21 | 0.46 | - | 9.26 |
| Body | Interior | Entertainment | 8.67 | - | - | 2.40 | - | 0.06 | - | 6.77 | - | - | 17.90 |
| Body | Interior | Front seats | 57.81 | 1.09 | 1.52 | 2.50 | - | 0.81 | - | 26.09 | - | 1.22 | 91.04 |
| Body | Interior | HVAC | 10.51 | 9.14 | 0.68 | 2.75 | - | 0.49 | - | 18.24 | 1.48 | - | 43.31 |
| Body | Interior | Instrument panel | 21.59 | - | - | 3.95 | - | 0.59 | - | 26.78 | 0.01 | 0.06 | 52.99 |
| Body | Interior | Rear seats | 24.41 | - | - | 0.77 | - | 0.11 | - | 23.38 | - | 2.46 | 51.14 |
| Body | Interior | Safety systems | 15.33 | - | - | 4.23 | - | 0.19 | - | 30.60 | 0.05 | 0.00 | 50.40 |
| Body | Interior | Trim & insulation | 2.65 | - | - | 2.28 | - | 2.15 | - | 57.02 | 18.48 | 9.32 | 91.91 |
| Chassis | | Braking system | 101.90 | 2.29 | 0.25 | 3.34 | - | 1.00 | - | 6.91 | 3.24 | 0.00 | 118.93 |
| Chassis | | Drive shaft (no axles) | 49.68 | 1.79 | 4.50 | 1.96 | - | 0.01 | - | 2.82 | 14.12 | - | 74.88 |
| Chassis | | Front suspension | 140.18 | 4.15 | 4.79 | - | - | - | - | 0.25 | 11.33 | - | 160.70 |
| Chassis | | Rear suspension | 125.97 | 2.25 | 3.24 | - | - | - | - | 1.24 | 15.39 | - | 148.09 |
| Chassis | | Steering system | 27.33 | 1.23 | 5.87 | 4.97 | 0.78 | 0.16 | - | 6.81 | 1.19 | - | 48.33 |
| Chassis | | Tires and Wheels | 73.57 | - | 125.74 | - | - | 0.03 | - | 0.20 | 25.80 | 0.06 | 225.40 |
| Powertrain | | Engine | 110.58 | 12.08 | 98.08 | 6.26 | - | 8.18 | - | 13.79 | 4.70 | 0.00 | 253.68 |
| Powertrain | | Engine fuel storage | 11.12 | - | - | 1.27 | - | 0.12 | - | 23.67 | 1.10 | - | 37.29 |
| Powertrain | | Exhaust | 57.75 | 1.54 | 2.22 | 0.17 | - | - | - | 0.25 | 0.79 | 0.00 | 62.72 |
| Powertrain | | Powertrain electrical | 13.21 | 1.86 | 2.06 | 22.16 | - | 0.08 | - | 39.93 | 0.72 | 0.02 | 80.05 |
| Powertrain | | Powertrain thermal | 5.82 | 7.20 | 2.28 | 1.83 | - | 3.25 | - | 11.39 | 3.09 | - | 34.86 |
| Transmission | | Transmission and clutch | 127.85 | 9.92 | 43.83 | 3.18 | - | 1.73 | - | 5.71 | 0.50 | - | 192.72 |

Table A-2. Average Vehicle component weight based on A2Mac1 in GREET (lbs): SUV

| GREET Level | Sub Level | Component | Steel | W. Al | Cast Al | Cu | Mg | GFRP | Glass | Plastic | Rubber | Others | Cast Iron | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Body | | Body-in-white | 815.46 | - | - | - | - | - | - | - | - | - | - | 815.46 |
| Body | | Bumpers | 15.81 | 16.50 | - | 0.29 | - | - | - | 40.08 | 0.09 | - | - | 72.78 |
| Body | | Decklid/Fenders | 8.50 | 1.51 | - | - | - | - | - | 3.13 | - | - | - | 13.14 |
| Body | | Front doors | 84.90 | 0.17 | 0.35 | 2.28 | - | 2.89 | 9.69 | 54.36 | 5.49 | 0.01 | - | 160.13 |
| Body | | Glass | 0.02 | - | - | - | - | - | 46.49 | 0.53 | 0.07 | - | - | 47.10 |
| Body | | Hood | 16.31 | 9.54 | - | 0.17 | - | - | - | 2.01 | 0.61 | 0.00 | - | 28.64 |
| Body | | Rear doors | 70.97 | - | 0.16 | 1.56 | - | 0.66 | 7.69 | 44.23 | 3.64 | 0.00 | - | 128.90 |
| Body | | Tailgate | 33.01 | 6.65 | 0.07 | 2.59 | - | 1.19 | 12.31 | 18.12 | 2.47 | 0.01 | - | 76.43 |
| Body | Exterior | Exterior lighting | 0.43 | - | 0.00 | 12.42 | - | - | - | 19.37 | 0.00 | 0.00 | - | 32.23 |
| Body | Exterior | Fascia and trim | 18.36 | 8.26 | 0.15 | 0.29 | - | 5.04 | 10.35 | 25.97 | 1.63 | 0.03 | - | 70.08 |
| Body | Exterior | Wiper system | 5.10 | 2.20 | 0.70 | 1.29 | - | 0.18 | - | 3.58 | 1.05 | 0.00 | - | 14.09 |
| Body | Interior | Entertainment | 9.70 | - | 0.01 | 2.96 | - | 0.41 | - | 7.21 | 0.03 | 0.04 | - | 20.35 |
| Body | Interior | Front seats | 64.37 | - | 1.49 | 2.68 | - | 0.84 | - | 30.43 | 0.02 | 1.30 | - | 101.14 |
| Body | Interior | HVAC | 10.49 | 11.24 | 0.94 | 4.17 | - | 0.36 | - | 24.50 | 1.67 | 0.00 | - | 53.37 |
| Body | Interior | Instrument panel | 25.85 | 0.02 | - | 3.91 | - | 0.10 | - | 31.17 | 0.01 | 0.01 | - | 61.06 |
| Body | Interior | Rear seats | 69.65 | - | 0.07 | 0.24 | - | - | - | 28.74 | 0.01 | 2.43 | - | 101.14 |
| Body | Interior | Safety systems | 17.23 | - | 0.06 | 6.53 | - | 2.21 | - | 24.05 | 0.05 | 0.00 | - | 50.12 |
| Body | Interior | Trim & insulation | 3.93 | 0.04 | - | 1.50 | - | 3.07 | 2.50 | 76.60 | 17.86 | 6.56 | - | 112.08 |
| Chassis | | Braking system | 123.23 | 1.29 | 0.22 | 4.15 | - | 0.79 | - | 9.16 | 4.90 | - | - | 143.75 |
| Chassis | | Drive shaft (no axles) | 117.49 | 2.53 | 28.06 | 1.47 | - | 0.09 | - | 2.09 | 24.18 | - | - | 175.91 |
| Chassis | | Front suspension | 161.93 | 4.29 | - | - | - | - | - | 6.16 | 11.65 | - | - | 184.02 |
| Chassis | | Rear suspension | 141.55 | 6.08 | 2.98 | - | - | - | - | 0.78 | 16.65 | - | - | 168.04 |
| Chassis | | Steering system | 18.90 | 2.36 | 3.18 | 7.73 | 1.88 | 5.82 | - | 11.44 | 1.41 | - | - | 52.72 |
| Chassis | | Tires and Wheels | 100.41 | - | 73.47 | 0.00 | - | 0.06 | - | 0.34 | 96.63 | 0.05 | - | 270.95 |
| Powertrain | | Engine | 107.09 | 12.43 | 113.83 | 9.91 | - | 8.23 | - | 22.47 | 6.72 | 0.03 | 2.75 | 283.47 |
| Powertrain | | Engine fuel storage | 9.01 | 1.35 | 0.00 | 1.52 | - | 0.26 | - | 31.47 | 1.12 | 0.00 | - | 44.73 |
| Powertrain | | Exhaust | 55.64 | 1.26 | 13.40 | 0.21 | - | - | - | 0.43 | 1.00 | - | - | 71.93 |
| Powertrain | | Powertrain electrical | 9.16 | 0.77 | 2.13 | 27.80 | - | 2.26 | - | 48.04 | 0.46 | 0.02 | - | 90.64 |
| Powertrain | | Powertrain thermal | 6.78 | 9.21 | 1.56 | 1.87 | - | 2.75 | - | 16.17 | 4.68 | - | - | 43.04 |
| Transmission | | Transmission and clutch | 144.89 | 7.74 | 44.68 | 6.38 | - | 1.92 | - | 11.10 | 0.86 | 0.01 | - | 217.58 |

Table A-3. Average Vehicle component weight based on A2Mac1 in GREET (lbs): PUT

| GREET Level | Sub Level | Component | Steel | W. Al | Cast Al | Cu | Zinc | Mg | GFRP | Glass | Plastic | Rubber | Others | Cast Iron | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Body | | Body-in-white | 325.79 | 110.22 | - | - | - | - | - | - | - | - | 0.04 | - | 436.04 |
| Body | | Bumpers | 64.23 | - | - | 0.53 | - | - | 1.25 | - | 32.14 | - | 0.00 | - | 98.16 |
| Body | | Decklid/Fenders | 23.40 | 2.78 | - | - | - | - | - | - | 4.51 | - | - | - | 30.70 |
| Body | | Front doors | 87.16 | 9.23 | 0.55 | 2.86 | 2.07 | - | 2.01 | 9.82 | 46.67 | 4.79 | 0.04 | - | 165.19 |
| Body | | Glass | 0.79 | - | 0.39 | 0.30 | - | - | 0.02 | 48.90 | 0.15 | 0.29 | - | - | 50.83 |
| Body | | Hood | 8.50 | 16.59 | - | 0.14 | - | - | 0.56 | - | 2.17 | 0.67 | - | - | 28.62 |
| Body | | Rear doors | 60.25 | 6.78 | 0.29 | 1.59 | - | - | 0.65 | 8.61 | 43.59 | 4.46 | - | - | 126.23 |
| Body | | Tailgate | 31.36 | 12.58 | 0.02 | 0.37 | - | - | 0.31 | - | 9.57 | 0.31 | - | - | 54.52 |
| Body | Exterior | Exterior lighting | 0.86 | - | 0.01 | 10.07 | - | - | - | - | 17.71 | - | 0.03 | - | 28.68 |
| Body | Exterior | Fascia and trim | 167.46 | 69.15 | 1.34 | 2.08 | - | - | 6.44 | 15.02 | 30.07 | 2.23 | 0.03 | - | 293.80 |
| Body | Exterior | Wiper system | 3.80 | 1.84 | 0.81 | 0.67 | - | - | - | - | 1.35 | 0.31 | - | - | 8.78 |
| Body | Interior | Entertainment | 45.41 | 0.32 | 0.00 | 5.62 | - | - | 0.24 | - | 12.97 | 0.01 | 0.03 | - | 64.61 |
| Body | Interior | Front seats | 52.05 | - | 2.02 | 2.91 | - | - | 0.55 | - | 31.31 | 0.02 | 5.96 | - | 94.82 |
| Body | Interior | HVAC | 14.98 | 10.45 | 0.87 | 0.94 | - | - | 0.52 | - | 18.19 | 2.43 | 0.00 | - | 48.39 |
| Body | Interior | Instrument panel | 24.03 | 0.29 | - | 3.14 | - | - | 2.39 | - | 27.87 | 0.09 | 0.00 | - | 57.82 |
| Body | Interior | Rear seats | 59.07 | - | - | 0.25 | - | - | 0.40 | - | 17.87 | - | 8.77 | - | 86.35 |
| Body | Interior | Safety systems | 19.94 | - | 0.70 | 1.91 | - | - | 2.47 | - | 23.38 | 0.00 | - | - | 48.40 |
| Body | Interior | Trim & insulation | 11.56 | 0.18 | 0.05 | 2.06 | - | - | 1.16 | - | 74.06 | 14.98 | 4.20 | - | 108.25 |
| Chassis | | Braking system | 158.84 | 4.58 | 1.22 | 2.60 | - | - | 0.61 | - | 7.26 | 1.00 | 0.01 | - | 176.12 |
| Chassis | | Drive shaft (no axles) | 191.48 | 0.02 | 25.94 | 1.15 | - | - | - | - | 6.29 | 5.32 | - | - | 230.20 |
| Chassis | | Front suspension | 561.00 | 6.67 | 5.30 | 1.31 | - | - | 2.77 | - | 2.32 | 13.85 | 0.44 | 4.73 | 598.39 |
| Chassis | | Rear suspension | 189.31 | 0.66 | 3.41 | 0.80 | - | - | 0.15 | - | 5.17 | 6.60 | - | - | 206.09 |
| Chassis | | Steering system | 36.24 | 1.72 | 3.75 | 4.12 | - | 3.39 | 0.10 | - | 6.77 | 1.74 | 0.03 | - | 57.85 |
| Chassis | | Tires and Wheels | 66.12 | - | 215.54 | 0.01 | - | - | - | - | 0.58 | 28.28 | - | - | 310.52 |
| Powertrain | | Engine | 216.18 | 9.80 | 94.36 | 4.37 | - | - | 6.20 | - | 20.08 | 5.05 | 0.04 | 26.32 | 382.40 |
| Powertrain | | Engine fuel storage | 10.01 | 0.06 | - | 0.99 | - | - | 0.19 | - | 30.40 | 0.82 | - | - | 42.48 |
| Powertrain | | Exhaust | 91.46 | 0.95 | 2.23 | 0.27 | - | - | - | - | 0.47 | 0.82 | 0.59 | - | 96.79 |
| Powertrain | | Powertrain electrical | 6.47 | 0.54 | 1.50 | 27.54 | - | - | 1.94 | - | 55.58 | 0.40 | - | - | 93.98 |
| Powertrain | | Powertrain thermal | 8.06 | 14.93 | 3.76 | 1.36 | - | - | 1.59 | - | 15.72 | 3.96 | - | - | 49.39 |
| Transmission | | Transmission and clutch | 166.70 | 5.64 | 54.36 | 2.38 | - | - | 2.29 | - | 6.04 | 1.20 | - | - | 238.62 |