

ALUMINUM CONTENT IN EUROPEAN PASSENGER CARS

Prepared for



EUROPEAN ALUMINIUM

- Public Summary -

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ASSESSMENT SCOPE





This assessment of the Aluminum Content in European Passenger Cars encompasses all aluminum applications in a car, includes electric vehicles, and is based on the analysis of a car sample covering nearly 95% of total EU28 production

Scope

-  **Application scope:** Passenger cars
-  **Geographic scope:** EU 28 (production location in EU 28 - CKD not included)
-  **Vehicle sample:** accounts for 94.3% of total EU 28 production
 - Vehicle models have been jointly selected with EA
 - 11 pure BEV models included in the sample:
 - BMW 3 Series EV
 - Mercedes Benz EQC
 - Mercedes Benz EQE Sedan
 - Ford C EV
 - Peugeot 208 EV
 - Renault Zoe ZE
 - Jaguar I-Pace
 - Audi e-tron GT
 - Audi e-tron
 - Porsche Taycan
 - Volkswagen ID.3 (previously called Neo)
-  **Product scope:** aluminum components
 - 11 components groups
 - 38 components in focus (see following page)

Deliverables

-  **CURRENT ALUMINUM CONTENT IN CARS¹ (2019)**
 - Aluminium content by vehicle
 - ✓ Component net weight (for components in focus)
 - ✓ Forming process / Product form (sheet vs. extruded vs. cast vs. forged)
 - ✓ Estimated additional aluminum content by vehicle (subcategories "Other")
 - ✓ [For engine blocks, cylinder heads and steering knuckles only] Share of primary vs. secondary aluminum
 - Average aluminium content per vehicle (after extrapolation to whole EU28 production)
 - ✓ Average component net weight (for components in focus) by vehicle segment
 - ✓ Average net weight of consolidated components in focus segmented by product form
 - ✓ Average additional aluminium content per component group
-  **ALUMINUM CONTENT FORECASTS (2025, 2028²)**
 - Total
 - By component group
 - By forming process
 - By component

^[1] Total market exploration for conventional/hybrid-versions only; only selected EV sample analyzed

^[2] 2028 forecasts are modelled based on 2025 aluminum content data and projected 2028 vehicle production using same CAGR as from 2019 to 2025

ASSESSMENT SCOPE



Aluminum applications are classified into 12 component groups. Within a component group, the focus has been set on select main AL components; remaining applications have been considered in the each sub-category “Other”

Component Group	Component	Approach
Engine	Blocks	Research
	Heads	Research
	Head Covers	Research
	Pistons	Research
	Powertrain Mounts	Research
	Oil Pans	Research
	Other Engine	Modelling
Steering		Research
Chassis & Suspension	Suspension Arms	Research
	Steering Knuckles (Front)	Research
	Wheel Carriers (Rear)	Research
	Front & Rear Subframes	Research
	Other Chassis & Suspension	Modelling
Wheels		Research
Brakes		Research
Trim & Interior	External Trim	Research
	Roof Rails	Research
	Interior Trims	Modelling
	Sun roofs	Modelling
	Pans & Tracks	Modelling
Heat Transfer	Heat Exchangers	Modelling
	Heat Shields	Modelling
	Other Heat Transfer	Modelling

Component Group	Component	Approach
Transmission	Transmission Case	Research
	Differential Case	Research
	Transfer Case	Research
	Driveshaft	Research
	Other Transmission	Modelling
	Body Structure	Complete Body Structures
Shock Towers		Research
Rails		Research
Radiator Supports		Research
Structural Parts		Research
IP Structures		Research
Floor Group		Research
Body Side Panels		Research
Other Body Structure	Modelling	
Closures	Hoods	Research
	Fenders	Research
	Liftgates, Decklids & Tailgates	Research
	Front & Rear Doors	Research
	Roofs	Research
	Other Closures	Modelling
Crash Management	Bumpers & Crash Boxes	Research
Electrification	Battery Boxes	Research
	Electric Motor Housing	Research

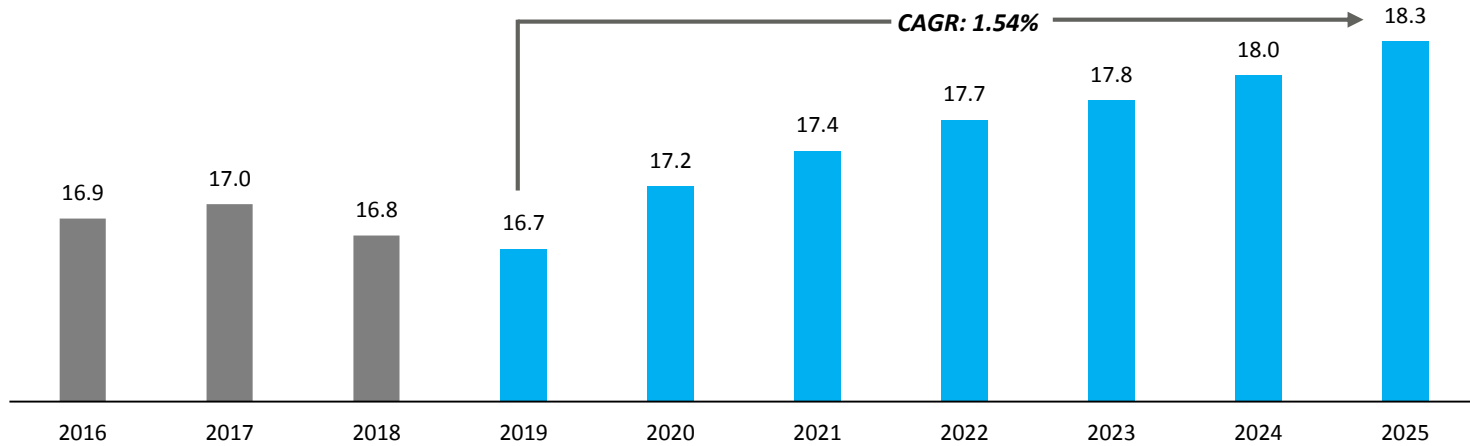
EUROPEAN CAR PRODUCTION



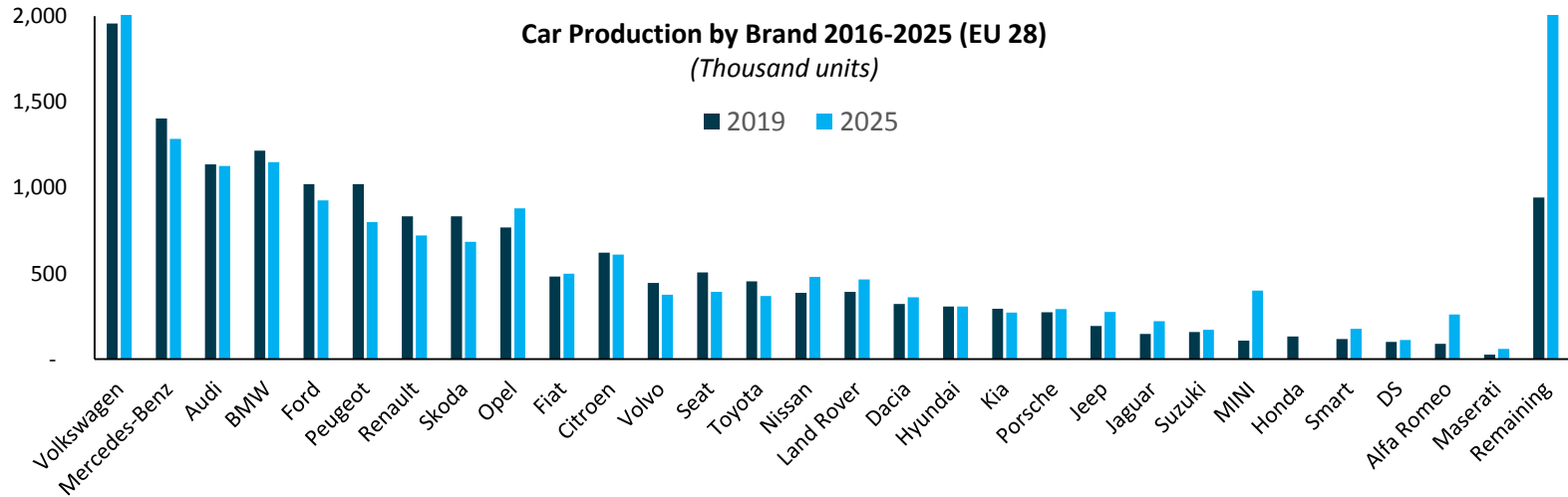
Car production forecasts expect steady growth, with a CAGR of 1.54% from 2019 to 2025.

The Volkswagen brand leads the European market, accounting alone for approx. 2 million cars produced in the EU28

10-year European Car Production 2016-2025 (EU 28)
(Million Units)



Car Production by Brand 2016-2025 (EU 28)
(Thousand units)



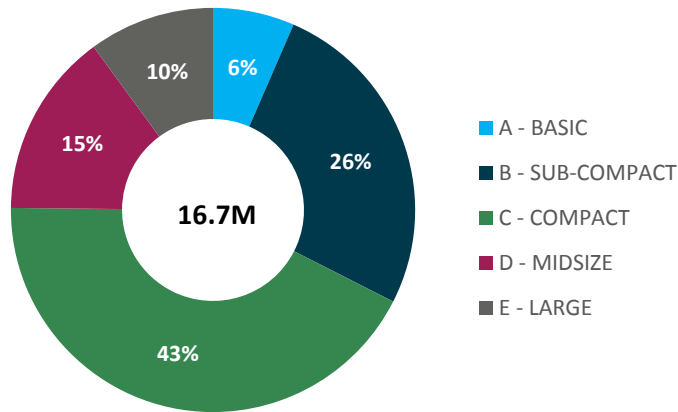
Source: LMCA Database Q1 2019 + Ducker Frontier estimates

EUROPEAN CAR PRODUCTION

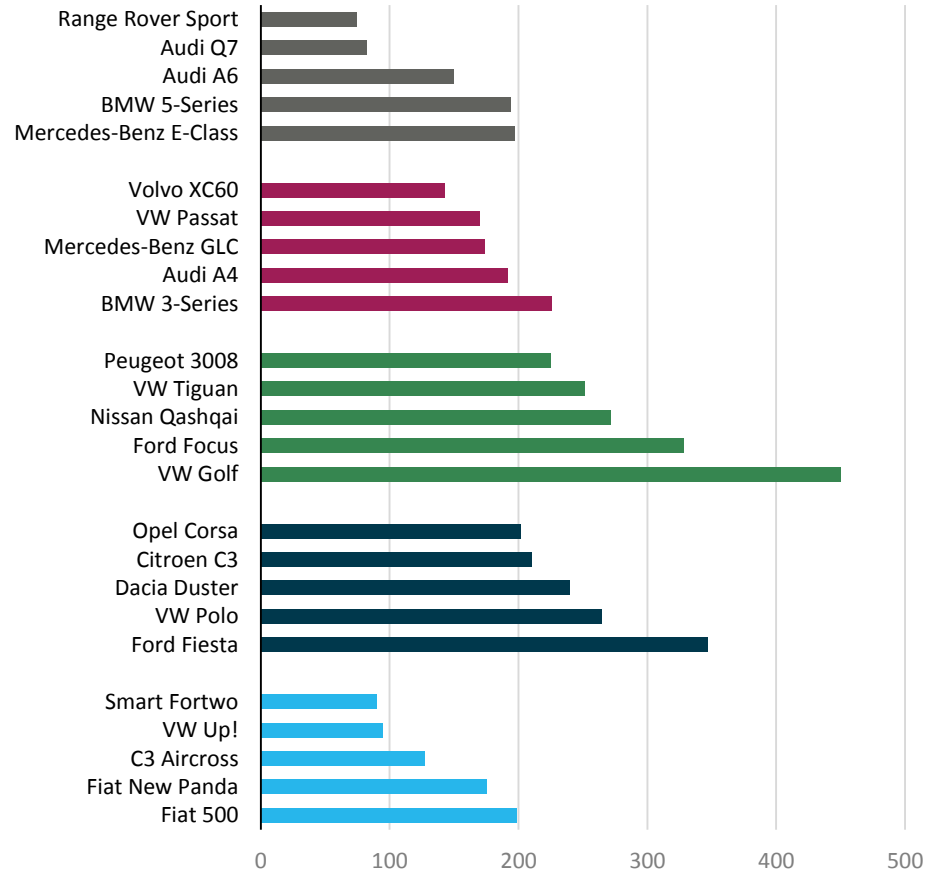


C-Compact vehicles (e.g. VW Golf, Ford Focus, etc.) make up the majority of the car production (43%). Segment split is expected to remain similar till 2025, though with stronger growth from B-segment and a decrease of A-segment

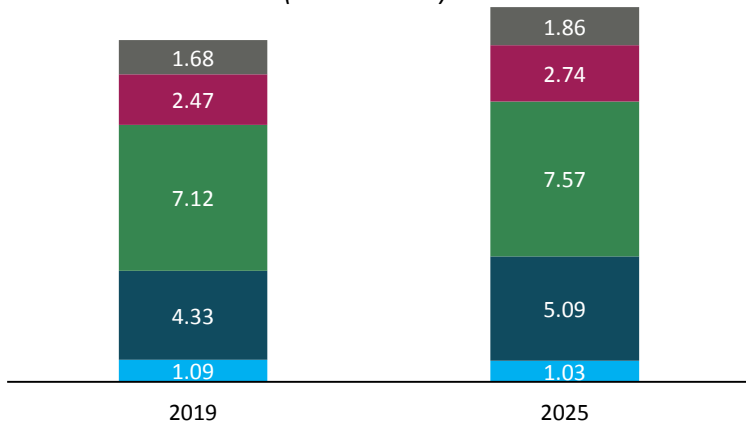
2019 Car Production by Segment



Highest Production Programs by Segment
(2019, Thousand Units)



2019 vs. 2025 Car Production by Segment
(Million units)



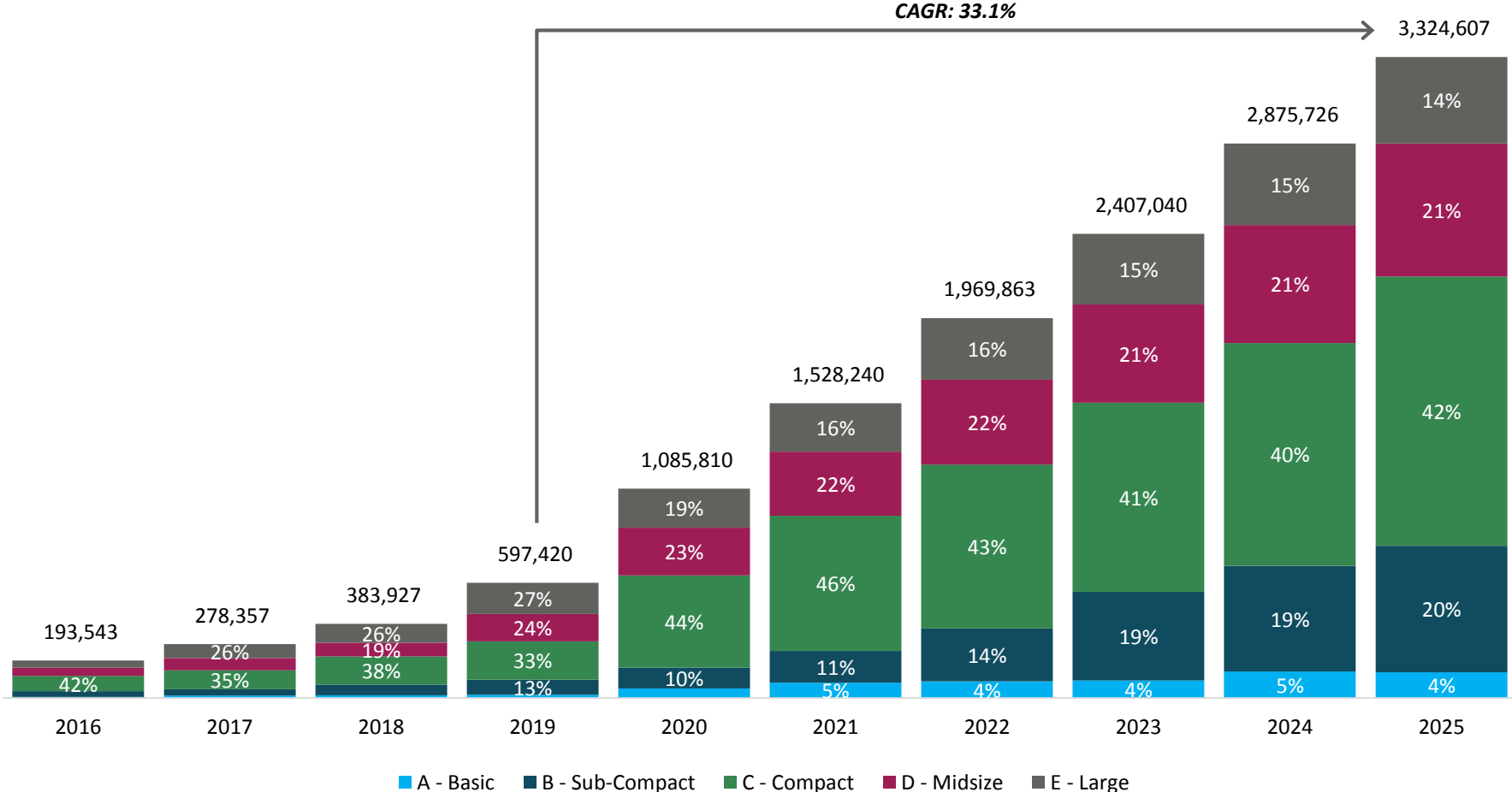
Source: LMCA Database Q1 2019 + Ducker Frontier estimates

EUROPEAN ELECTRIC VEHICLE PRODUCTION



Electric vehicle production (BEV and PHEV combined) is expected to rapidly ramp-up, with a CAGR of over 30% between 2019 and 2025

10-year EV Production (EU 28) – PHEV & BEV
Units



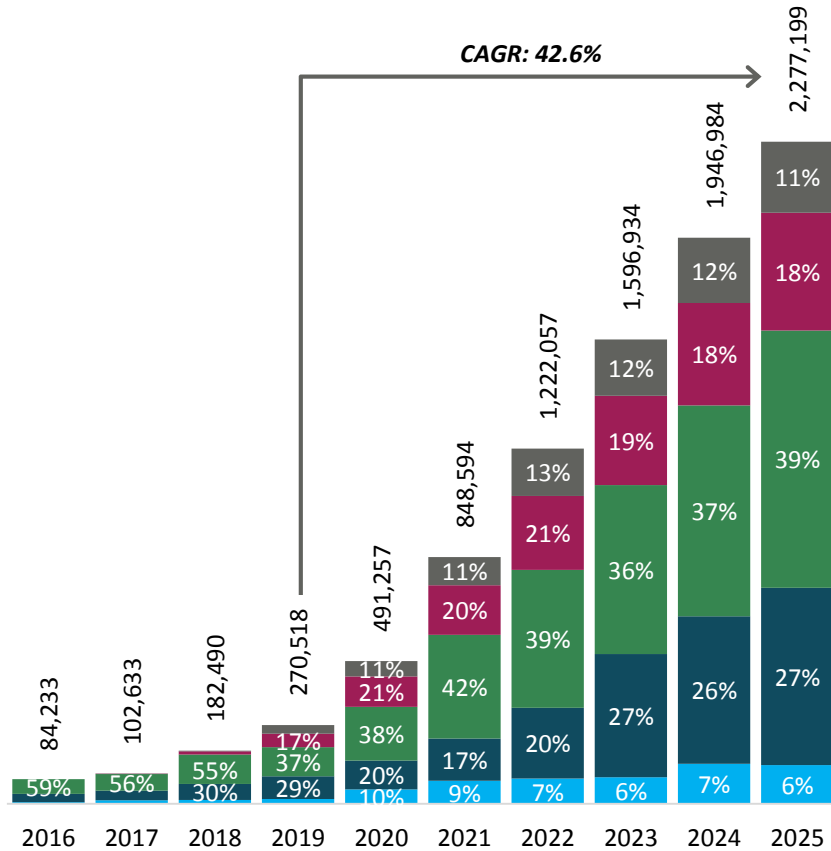
Source: LMCA Database Q1 2019 + Ducker Frontier estimates

EUROPEAN ELECTRIC VEHICLE PRODUCTION

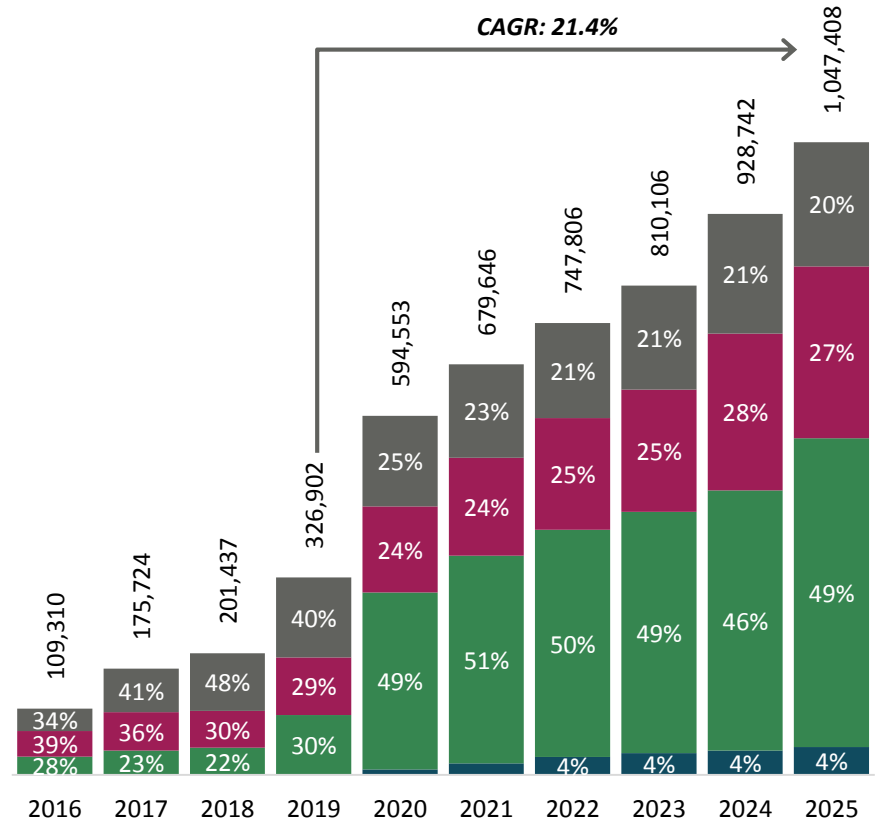


BEVs are forecasted to grow faster than PHEVs. C-segment will continue to be predominant. Smaller PHEVs will be introduced (B-segment) and C-segment to gain shares

10-year BEV Production 2016-2025 (EU 28)



10-year PHEV Production 2016-2025 (EU 28)



■ A - Basic
 ■ B - Sub-Compact
 ■ C - Compact
 ■ D - Midsize
 ■ E - Large

Source: LMCA Database Q1 2019 + Ducker Frontier estimates


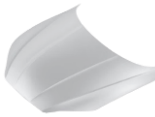


ALUMINUM CONTENT IN CARS (2019)



Average Aluminum Content per Vehicle currently amounts to nearly 179kg and Total Aluminum Content for the whole car market (including electric vehicles) is estimated at 2,989 KT – most of which being aluminum castings

Aluminum Content in Cars (2019)

Net weight

	Average Al Content Per Vehicle	Total Al Content
 Cast	179.2 kg	2,989 KT
 Sheet	116.0 kg	1,936 KT
 Extrusions*	34.0 kg	567 KT
 Forged	19.0 kg	317 KT
	10.2 kg	169 KT

* Extrusions exclude forging stock





ALUMINUM CONTENT IN CARS (2025)



Average AL Content per Vehicle is expected to increase by approx. 20kg to 198.8kg by 2025, bringing the Total AL Content in European cars to 3,635 KT. AL casting is expected to remain the predominant forming process

Aluminum Content in Cars (2025)

Net weight

	Average Al Content Per Vehicle	Total Al Content
 Cast	198.8 kg	3,635 KT
 Sheet	43.2 kg	789 KT
 Extrusions*	26.7 kg	489 KT
 Forged	10.7 kg	196 KT

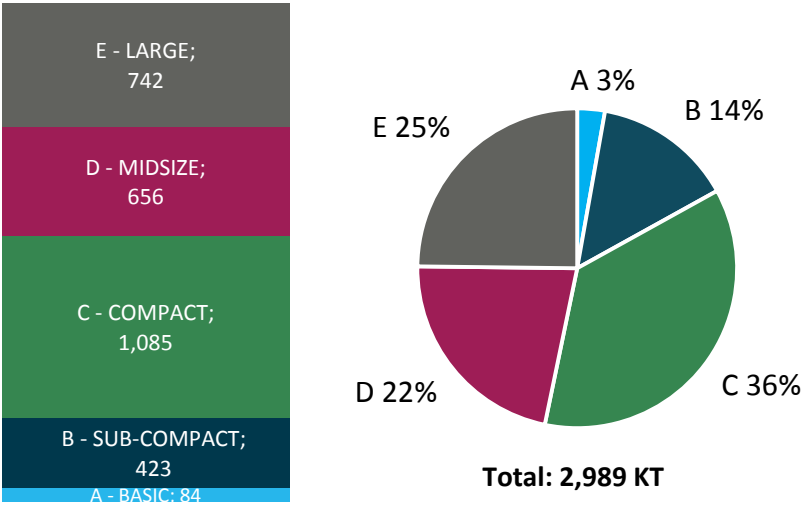
* Extrusions exclude forging stock

ALUMINUM CONTENT BY VEHICLE SEGMENT

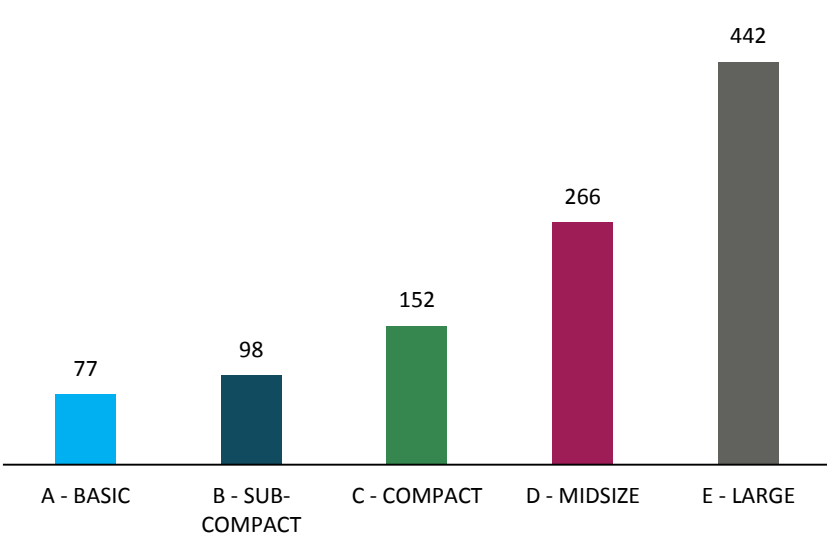


While E-segment vehicles have the highest Average AL Content per Vehicle (442kg), C-segment vehicles capture the largest share (36%) of Total AL demand due to the overall volume of C-segment vehicle production

Total AL Content by Vehicle Segment (2019, Net Weight in KT)



Average AL Content by Vehicle Segment (2019, Net Weight in kg)



Vehicle Programs with the Highest Average AL Content (Net Weight 2019) per Segment

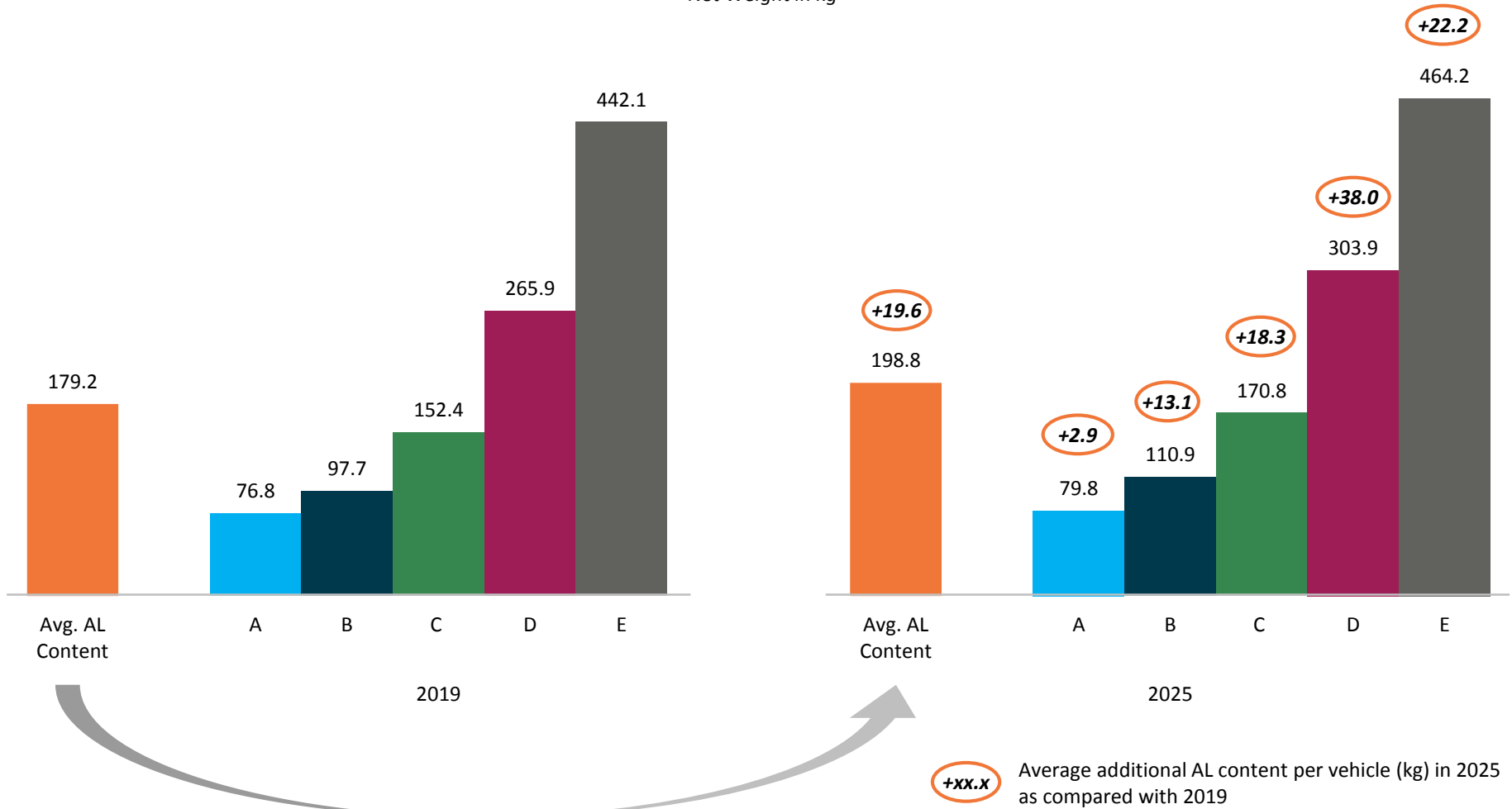
A - Basic	B - Sub-Compact	C - Compact	D - Midsize	E - Large
 <p>Opel Adam</p>	 <p>Audi Q2</p>	 <p>BMW i3</p>	 <p>Jaguar I-Pace</p>	 <p>Audi e-tron</p>
<p>2019 Production: ~27K units Total AL Content 2019: 2.6 KT Avg. AL Content 2019: 110kg</p>	<p>2019 Production: ~82K units Total AL Content 2019: 12.5 KT Avg. AL Content 2019: 164kg</p>	<p>2019 Production: ~40K units Total AL Content 2019: 14.5 KT Avg. AL Content 2019: 367kg</p>	<p>2019 Production: ~21K units Total AL Content 2019: 15.0 KT Avg. AL Content 2019: 704kg</p>	<p>2019 Production: ~29K units Total AL Content 2019: 22.8 KT Avg. AL Content 2019: 804kg</p>

ALUMINUM CONTENT BY VEHICLE SEGMENT



The Average AL Content per Vehicle is forecasted to increase by 19.6kg between 2019 to 2025 - only 2.9kg in A-segment vehicles, but up to 38kg in D-segment vehicles. Growth will come from sheet and extrusions

Average Aluminum Content per Vehicle between 2019-2025 by Segment
Net Weight in kg

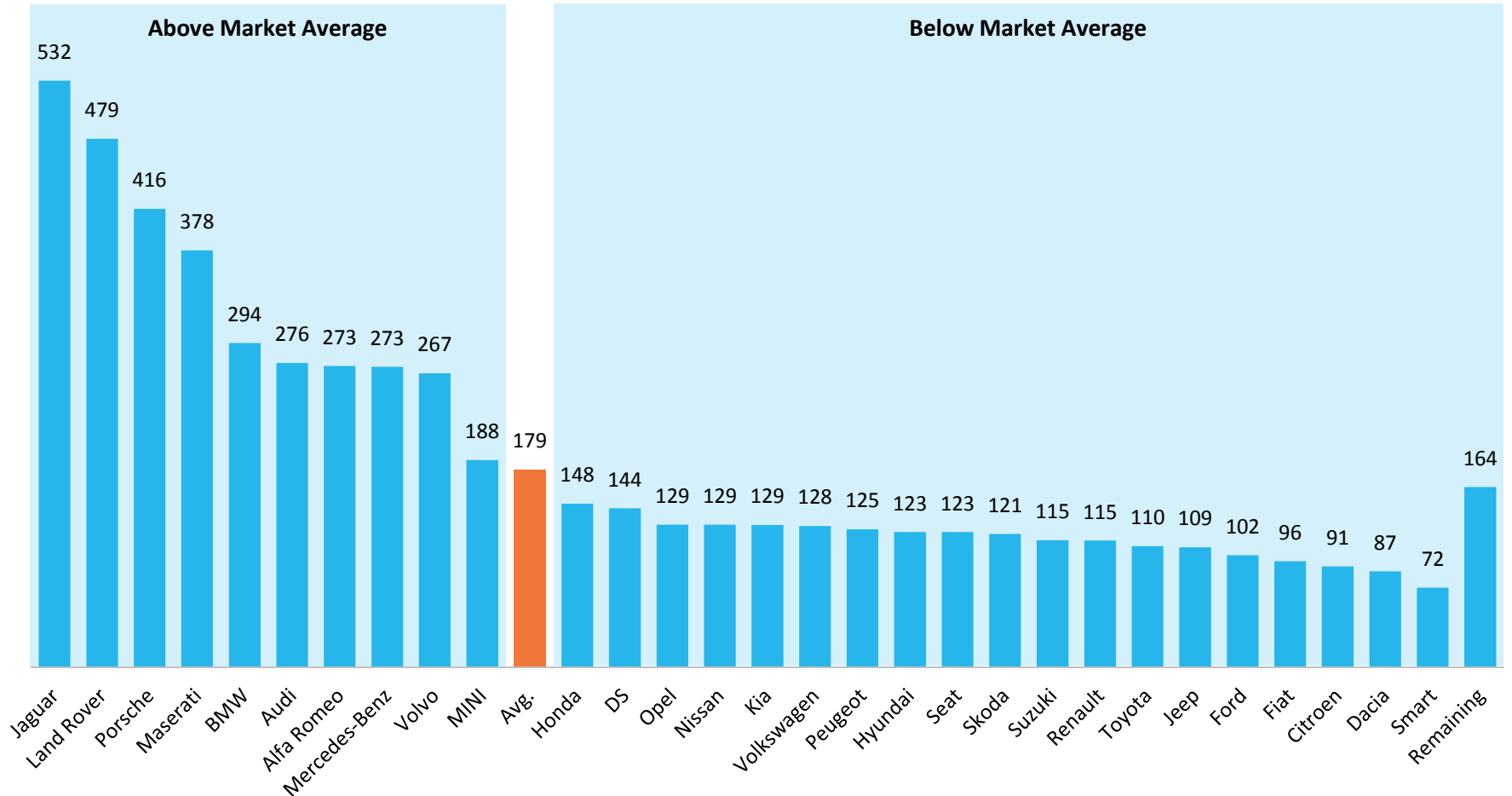


ALUMINUM CONTENT BY VEHICLE BRAND



However, on a per vehicle level, Jaguar Land Rover models have the highest aluminum content. All premium brands are above market average, reversely all volume brands are below average

Average AL Content per Vehicle by Brand
2019, Net Weight in KG

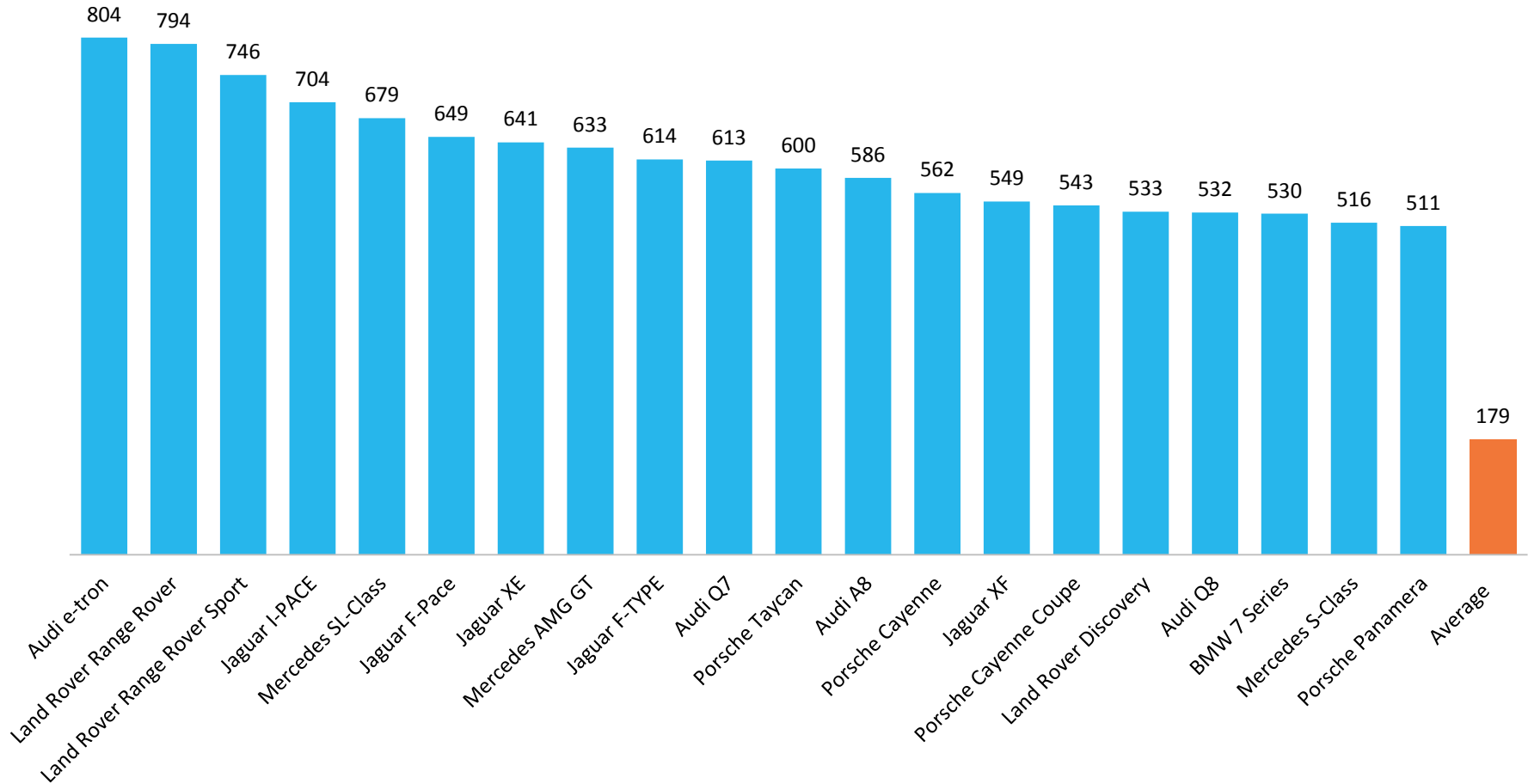


ALUMINUM CONTENT BY VEHICLE MODEL



8 out of the 20 most aluminum-intensive vehicle models belong to the JLR group. The model with the highest AL content however is the Audi e-tron with 804kg AL content (nearly 4.5 times the market average)

Top 20 Vehicle Models with the Highest Average AL Content per Vehicle
2019, Net Weight in kg



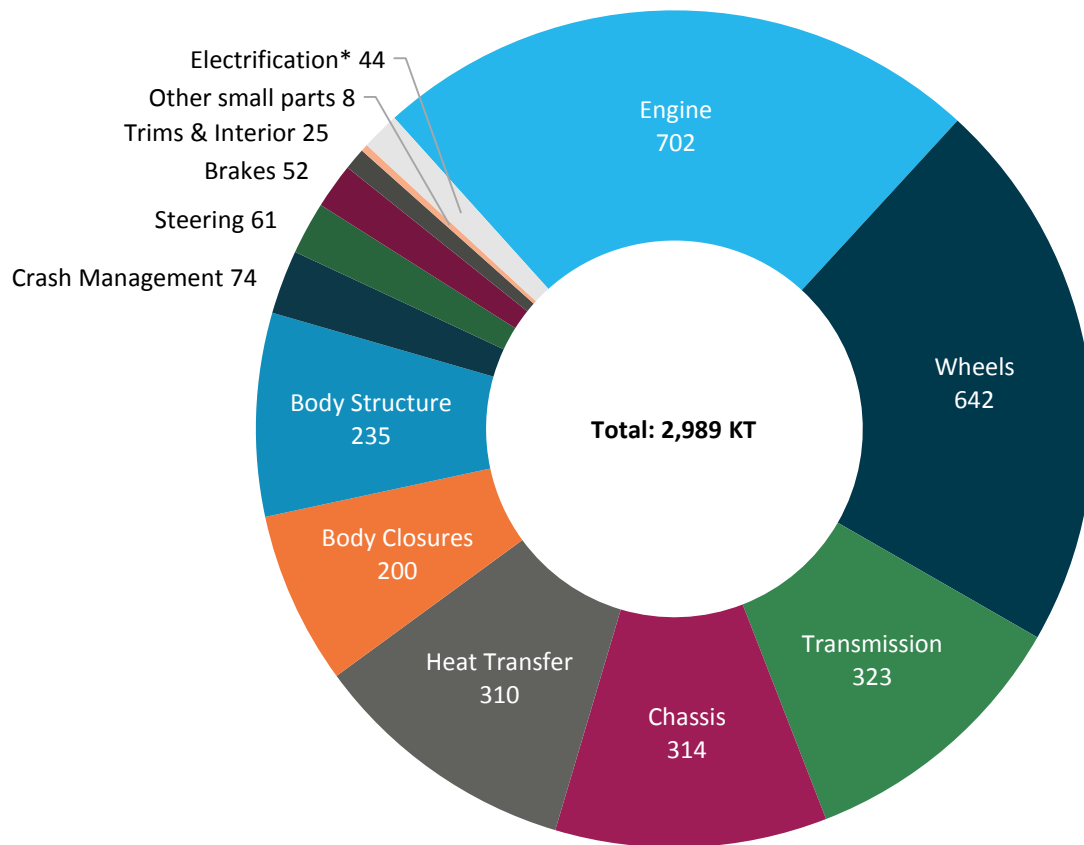
ALUMINUM CONTENT BY COMPONENT GROUP



Engine and Wheels together represent almost half of Total Aluminum Content in cars (~45%)

Total Aluminum Content by Component Group

2019, Net Weight in KT



***Electrification components** includes Battery Box, Battery Cooling and Electric Motor Housing

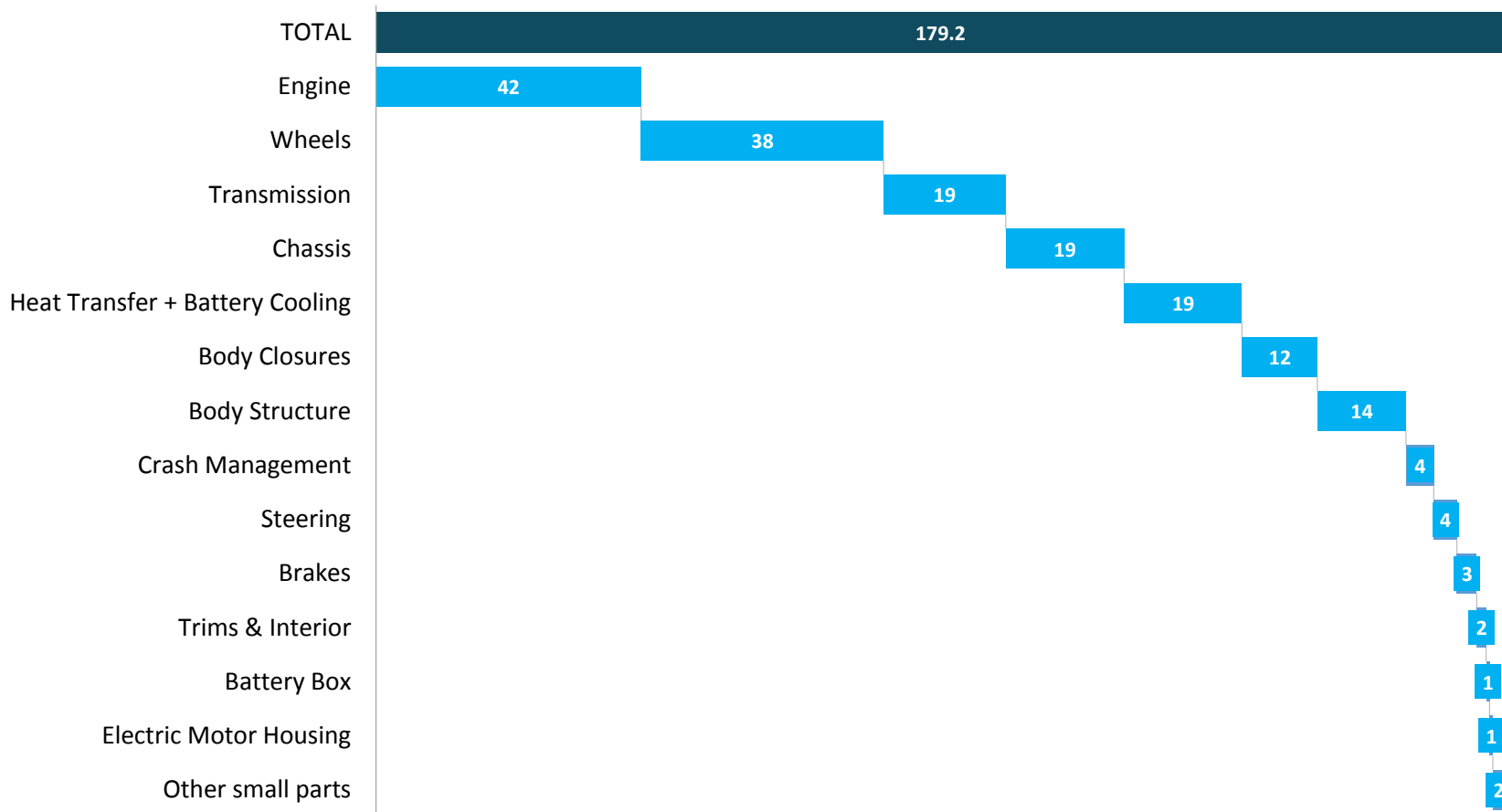
ALUMINUM CONTENT BY COMPONENT GROUP



Engine components and Wheels are by far the largest aluminum contributors. Average AL Content per Vehicle related to Battery Box and Electric Motor Housing will grow fast with the expected accelerated production of EVs

2019 Average Aluminum Content per Vehicle by Component Group

Incl. all powertrain types, Net Weight in kg

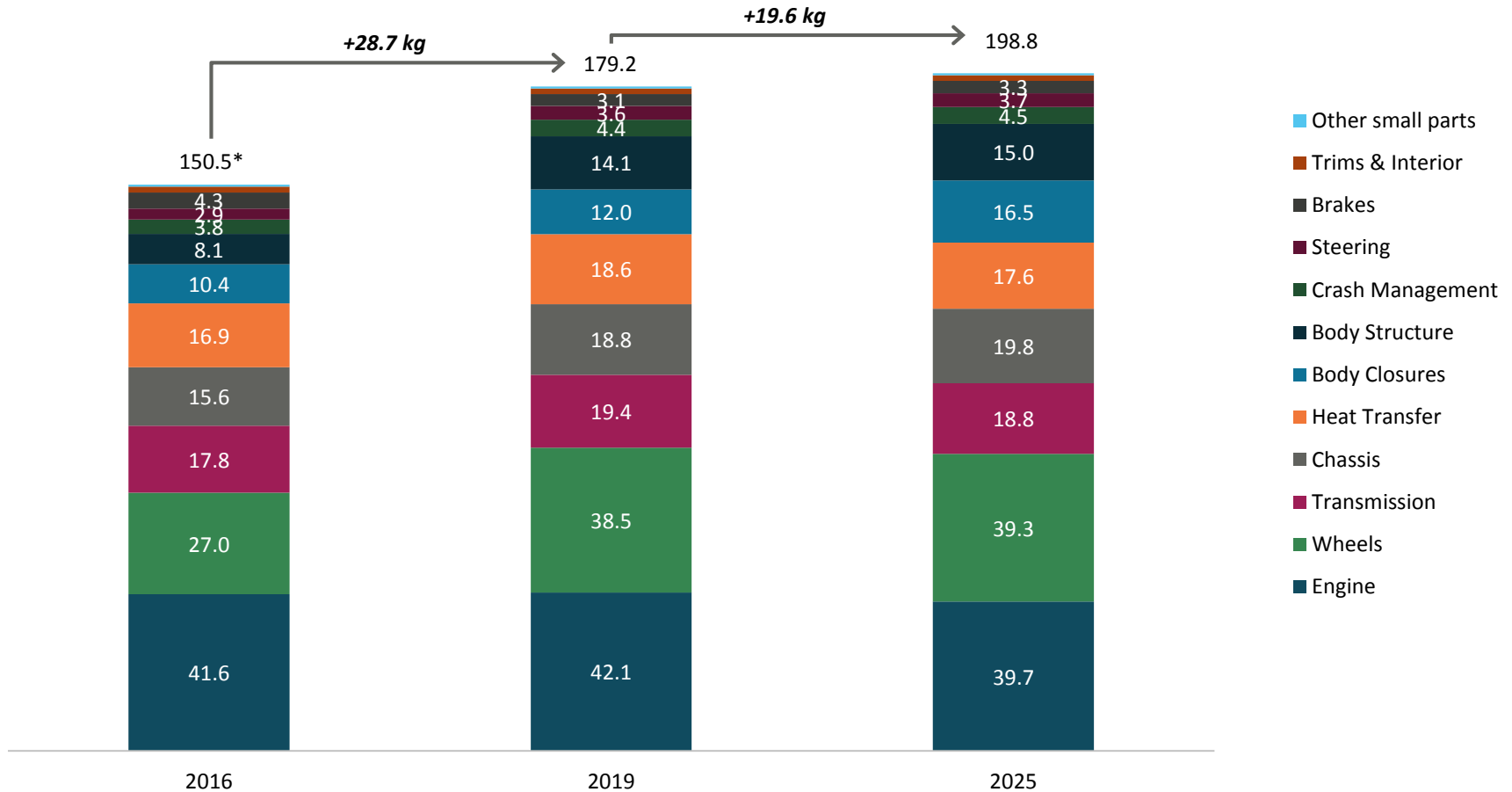


ALUMINUM CONTENT BY COMPONENT GROUP



Electrification components will be the main growth area by 2025, together with Body Closures.
 Alone Battery Boxes account for nearly 2/3 of the Average AL Content increase to come

Avg. Aluminum Content Evolution 2016-2025 by Component Group
 Net Weight in kg



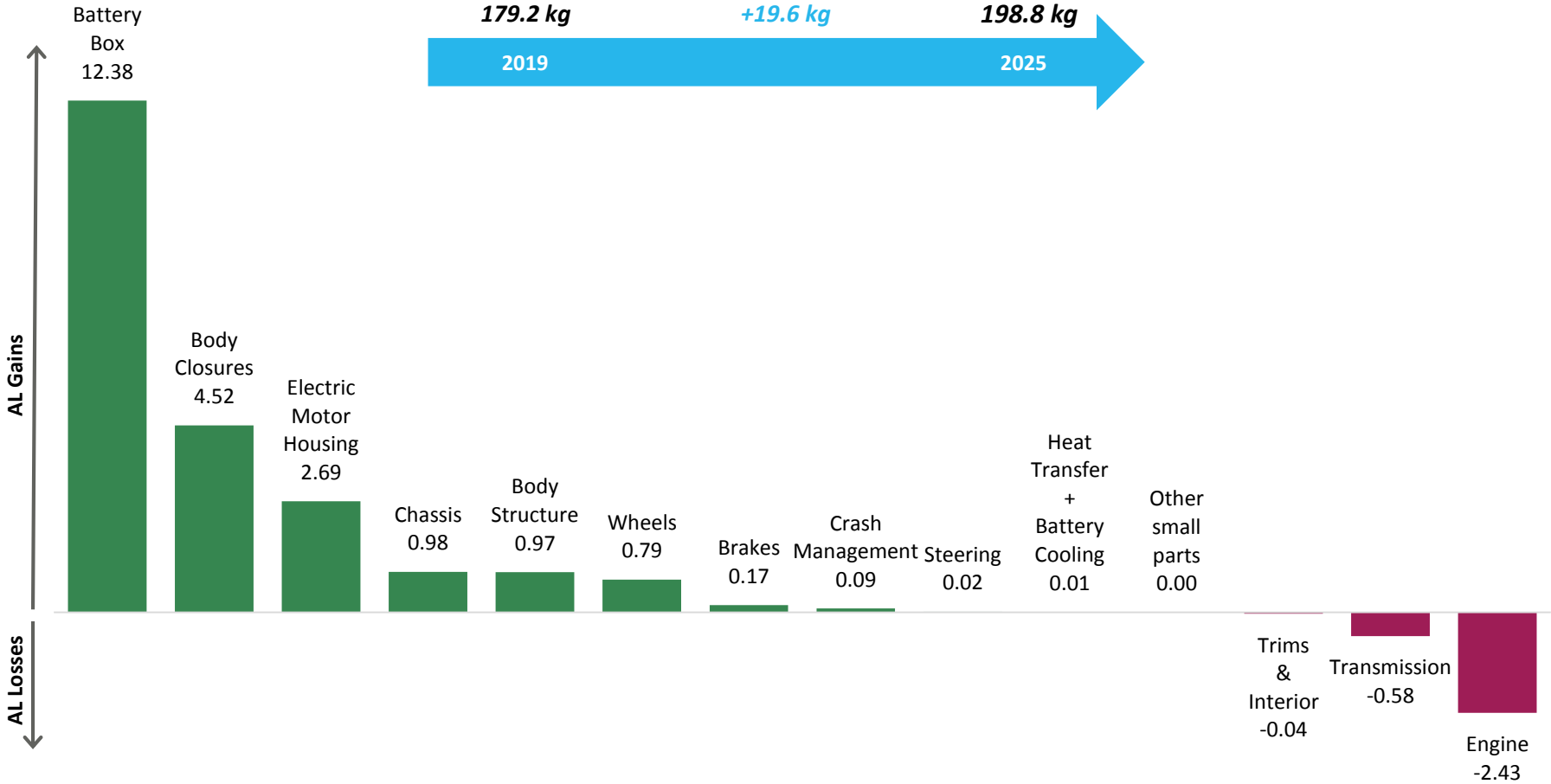
* 2016 numbers do not include Electrification components (i.e. Battery Boxes, Battery Cooling and Electric Motor Housings), and are based on a limited sample of 60 vehicles that has been extrapolated to the whole market. 2016 numbers do also not include the second set of OE wheels that is purchased at the same time as the vehicle

ALUMINUM CONTENT BY COMPONENT GROUP



By 2025, Battery Box and Body Closures appear to be the component groups that will most benefit from the Average Aluminum Content growth. On the contrary, aluminum demand for traditional powertrain components will decrease

Expected AL Gains & Losses within Average AL Content per Vehicle
 For the time period 2019 to 2025 (Net Weight in kg)

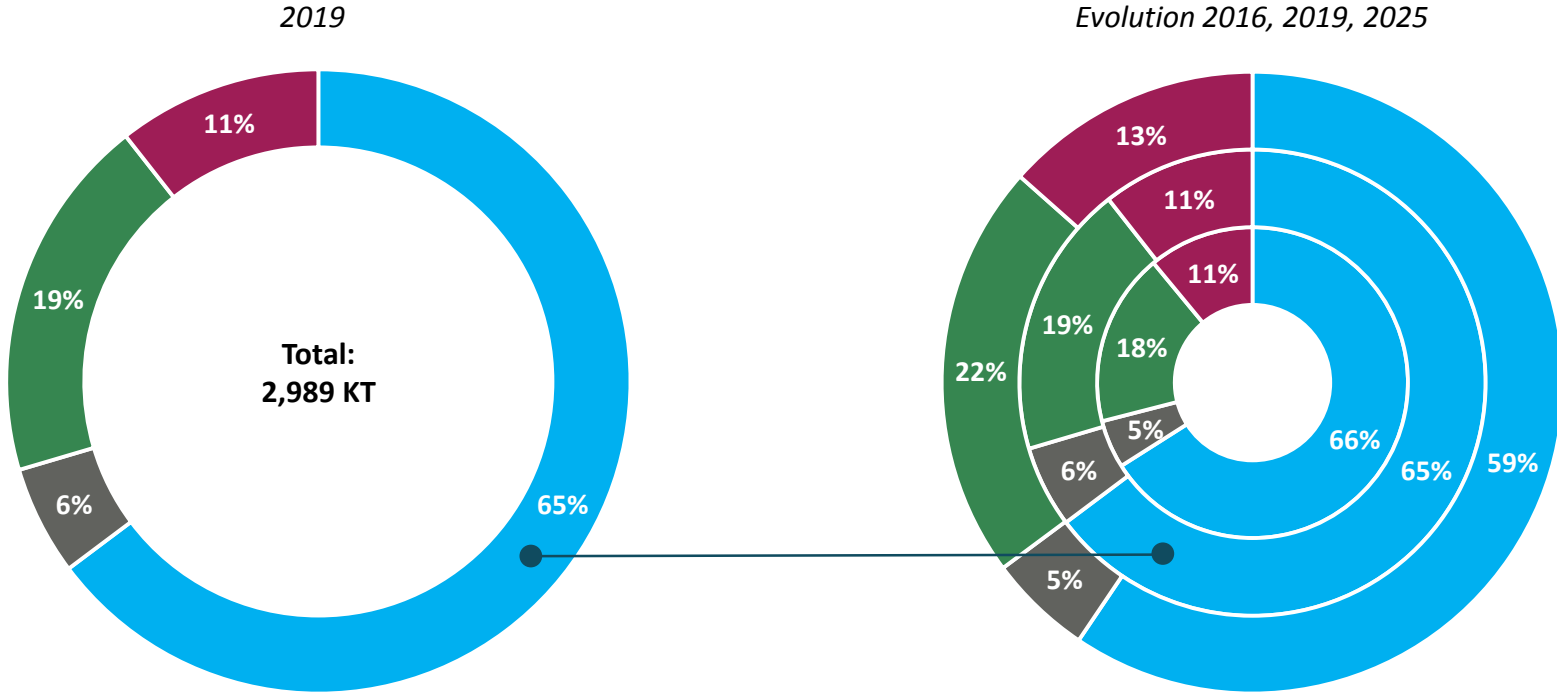


ALUMINUM CONTENT BY FORMING PROCESS



Cast aluminum represents the large majority of the Total Aluminum Content (in 2016, 2019 as well as in 2025). Extrusions and Sheet will win shares by 2025, mainly driven by demand for Electrification components and Closures

Forming Process Split of Total AL Content (Net Weight in KT)



Innermost ring: 2016 (2,620 KT)
 Middle Ring: 2019 (2,989 KT)
 Outer Ring: 2025 (3,635 KT)

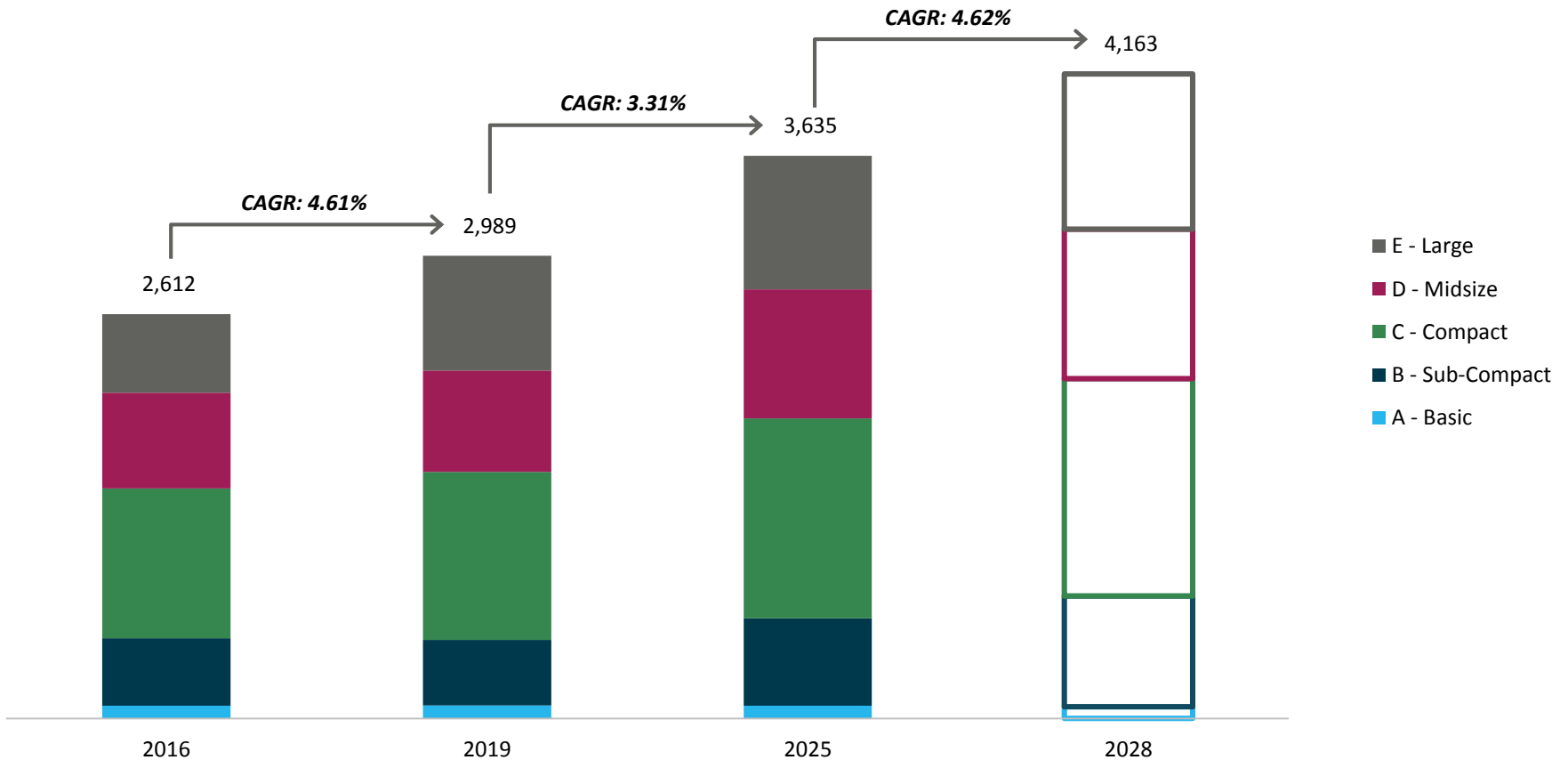
■ Cast ■ Forged ■ Sheet ■ Extrusion

ALUMINUM CONTENT EVOLUTION (2016-2028)



The evolution of Total AL Content is expected to continue on a positive trajectory, with further dynamic growth. The 2028 demand is currently forecasted at approximately 4,160 KT (net weight)

Total Aluminum Content Evolution 2016-2028 (Net Weight in KT)
by Vehicle Segment



COMPARISON OF ALUMINUM CONTENT BY POWERTRAIN TYPE

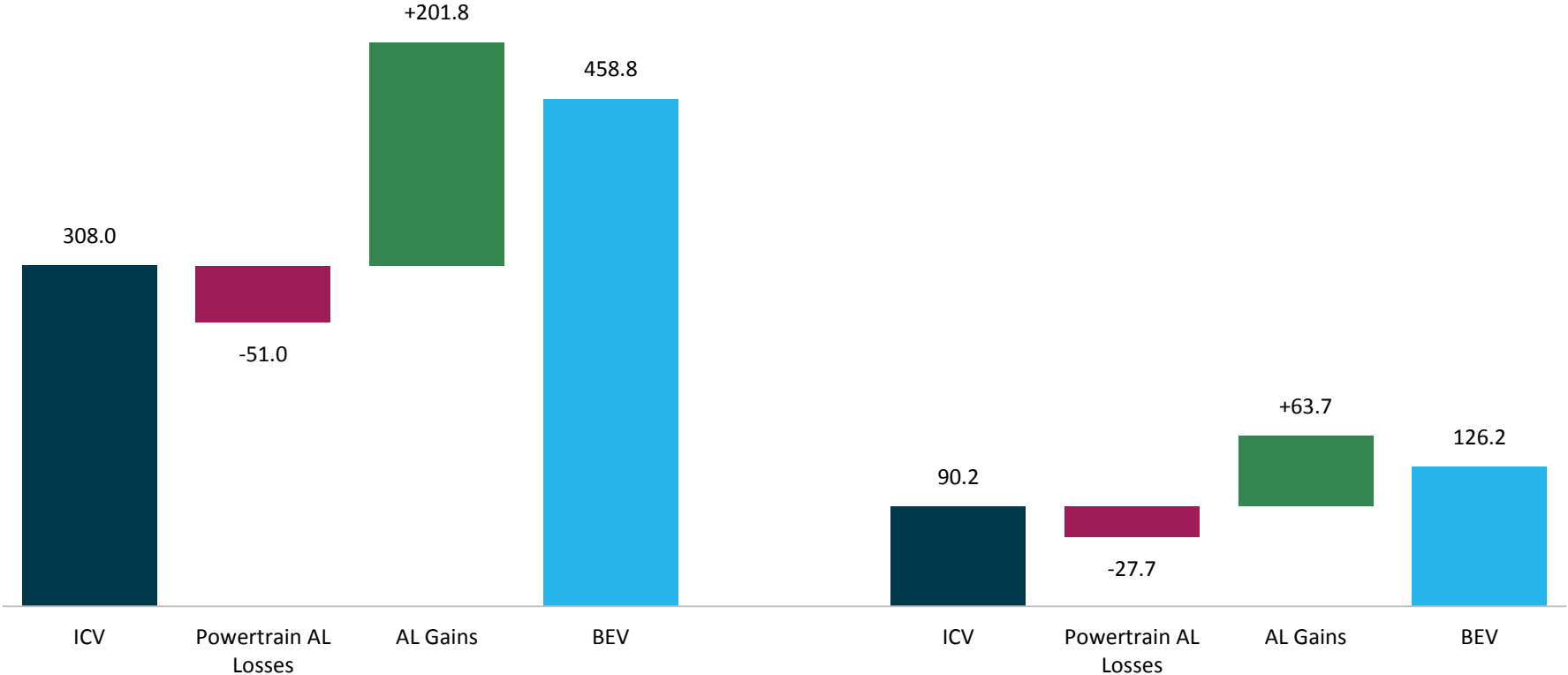


BEVs have significantly higher AL Content than their ICE variant, primarily due to the aluminum used for the Battery Box. Overall, the higher the car segment, the larger the difference in AL Content between BEV and ICE variants

Avg. AL Content per Vehicle for ICE vs. BEV variant
2019, Net Weight kg

D-Midsize Vehicle from Premium Brand with ICV and BEV Variants

B-Sub-Compact Vehicle from Volume Brand with ICV and BEV Variants

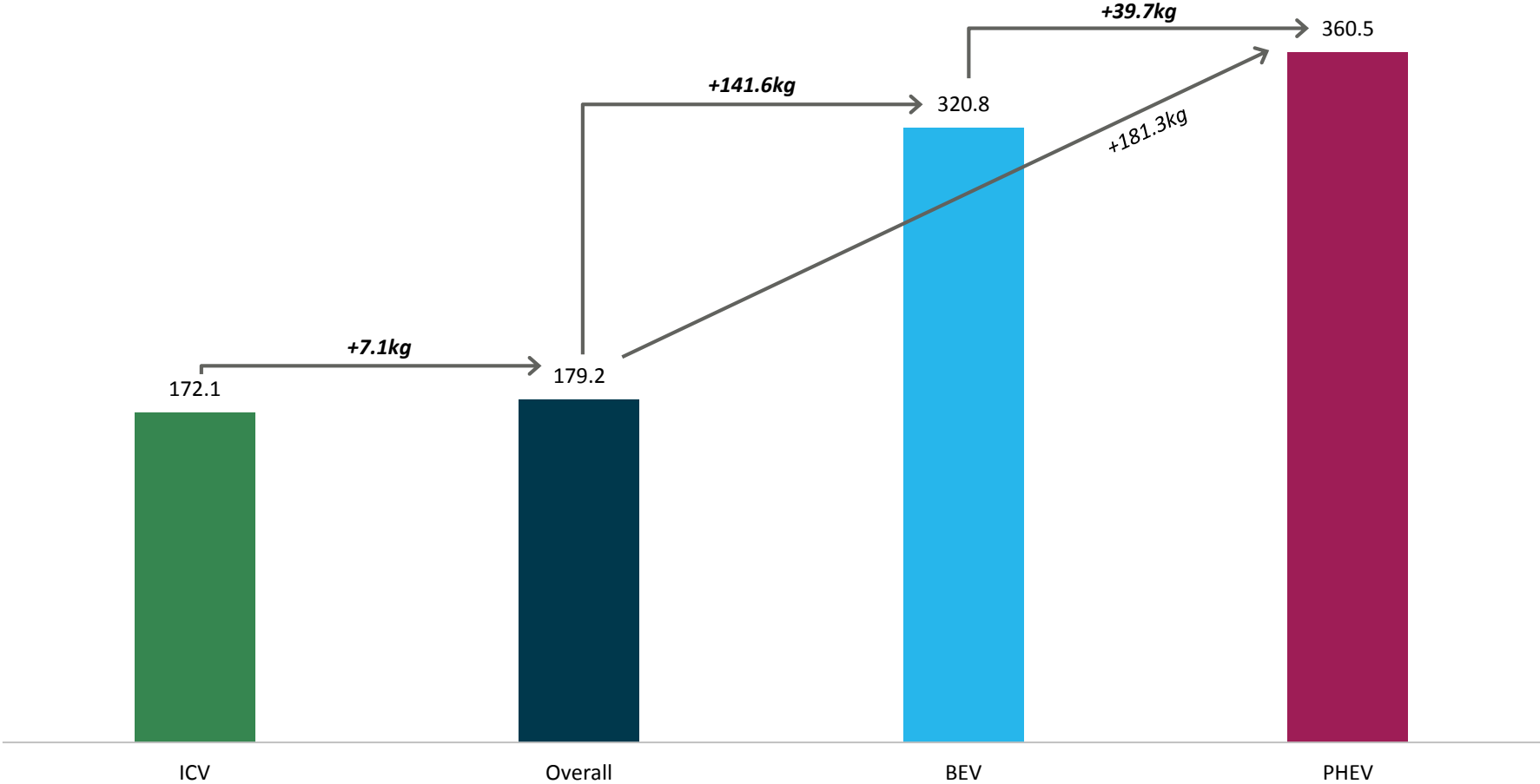


COMPARISON OF ALUMINUM CONTENT BY POWERTRAIN TYPE



Large batteries for BEV & PHEV, as well as doubled powertrain components for PHEV, are strong drivers for high Average Aluminum Content. Electric vehicle growth will foster a further increase of the Average Aluminum Content per Vehicle

Average Aluminum Content per Vehicle
Comparison by Powertrain Variant (2019, Net Weight in kg)



THANK YOU

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