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Evolution of Aluminum Usage in Electric Vehicle Context in Europe and North America

Aluminium Business Summit 2021 - Düsseldorf -

September 29, 2021

PRESENTED BY:
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Insightful Advice and Support for Advantage

Passenger Vehicle Production Trends by 2028 – Covid & Semiconductor Shortage Impact

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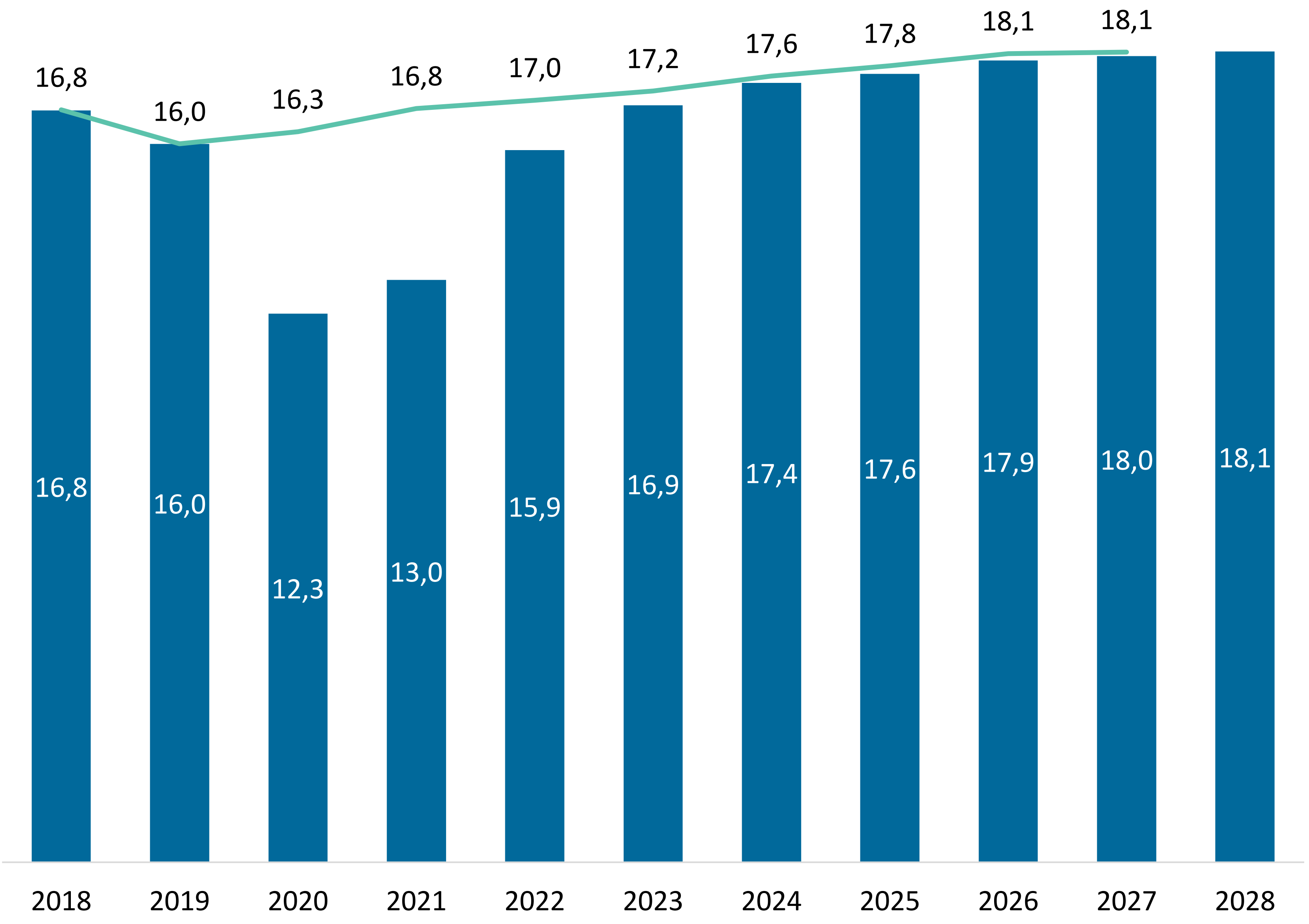
EU27+UK Passenger Vehicle (PV) Production Forecast

Millions of vehicles

Q3- 2021 (Sept) Q1-2020

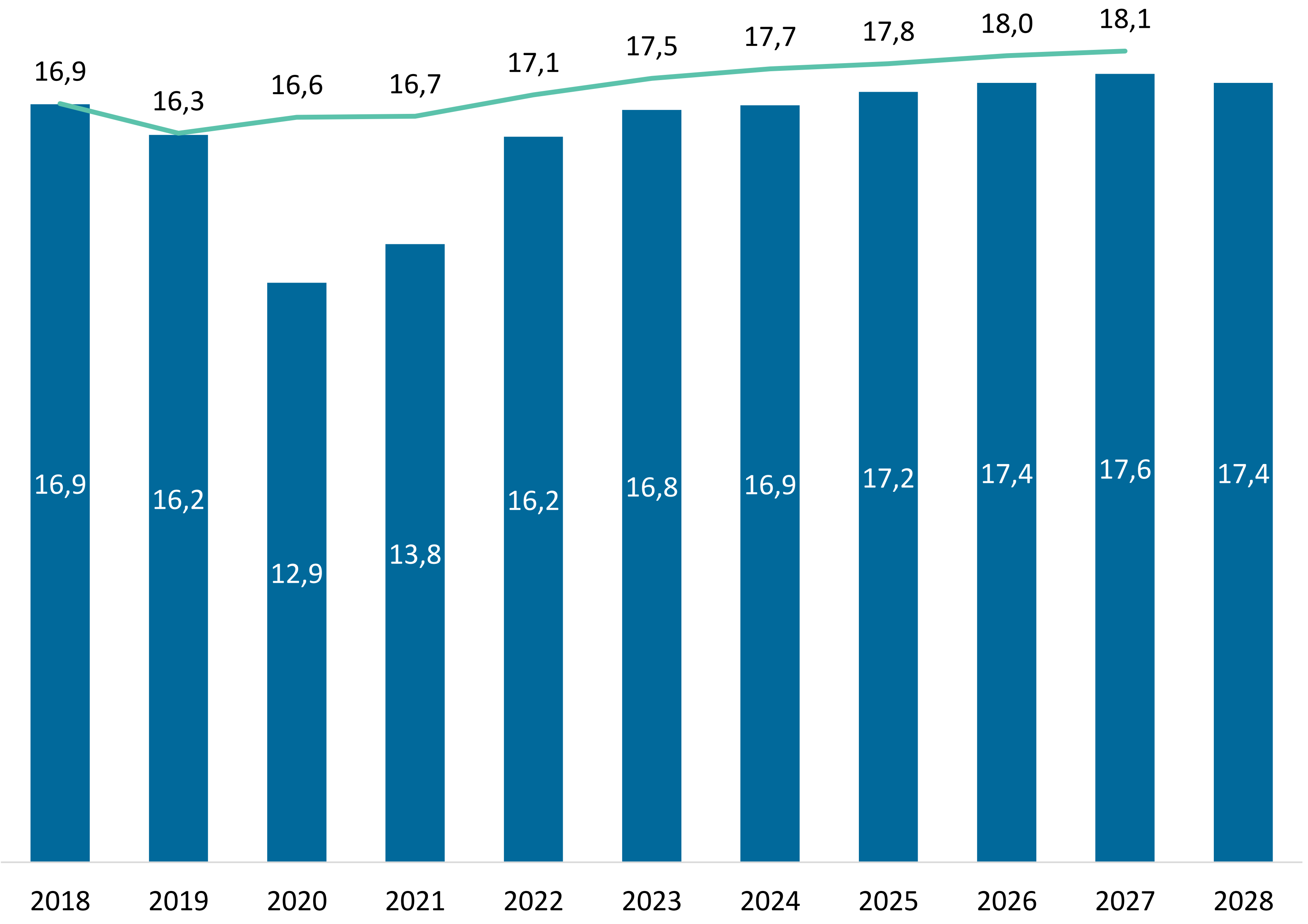


2021-2027 CAGR	EU	NA
Q1-2020 data	1.2%	1.4%
Q2-2021 data	4.0%	2.7%
CAGR 21-28	4.8%	3.4%

NA Light Vehicle (LV) Production Forecast

Millions of vehicles

Q3- 2021 (Sept) Q1-2020



Sources: Ducker, LMC Automotive

Semiconductor Shortage Timeline

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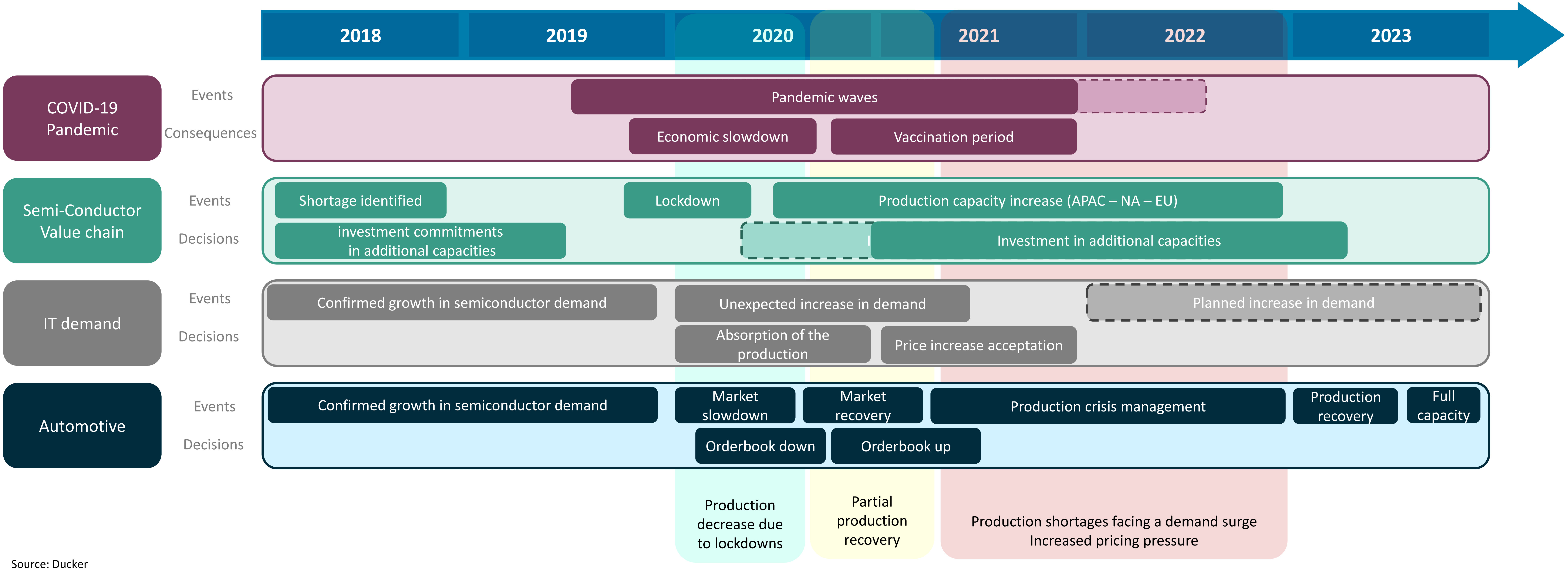
- Initial semiconductor shortage was identified for 2022/2023
- Demand for semiconductors soared during COVID lockdown while productions went down
- New factories (Intel, TSMC, TI, etc.) won't hit full production capacity before 2023



Source: Ducker

Semiconductors in the Auto industry

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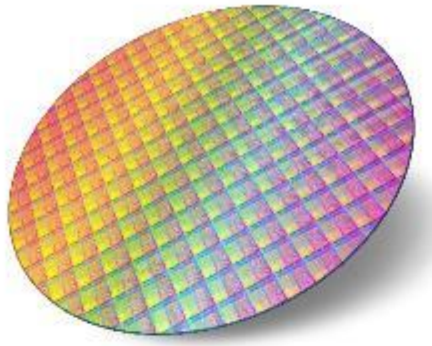
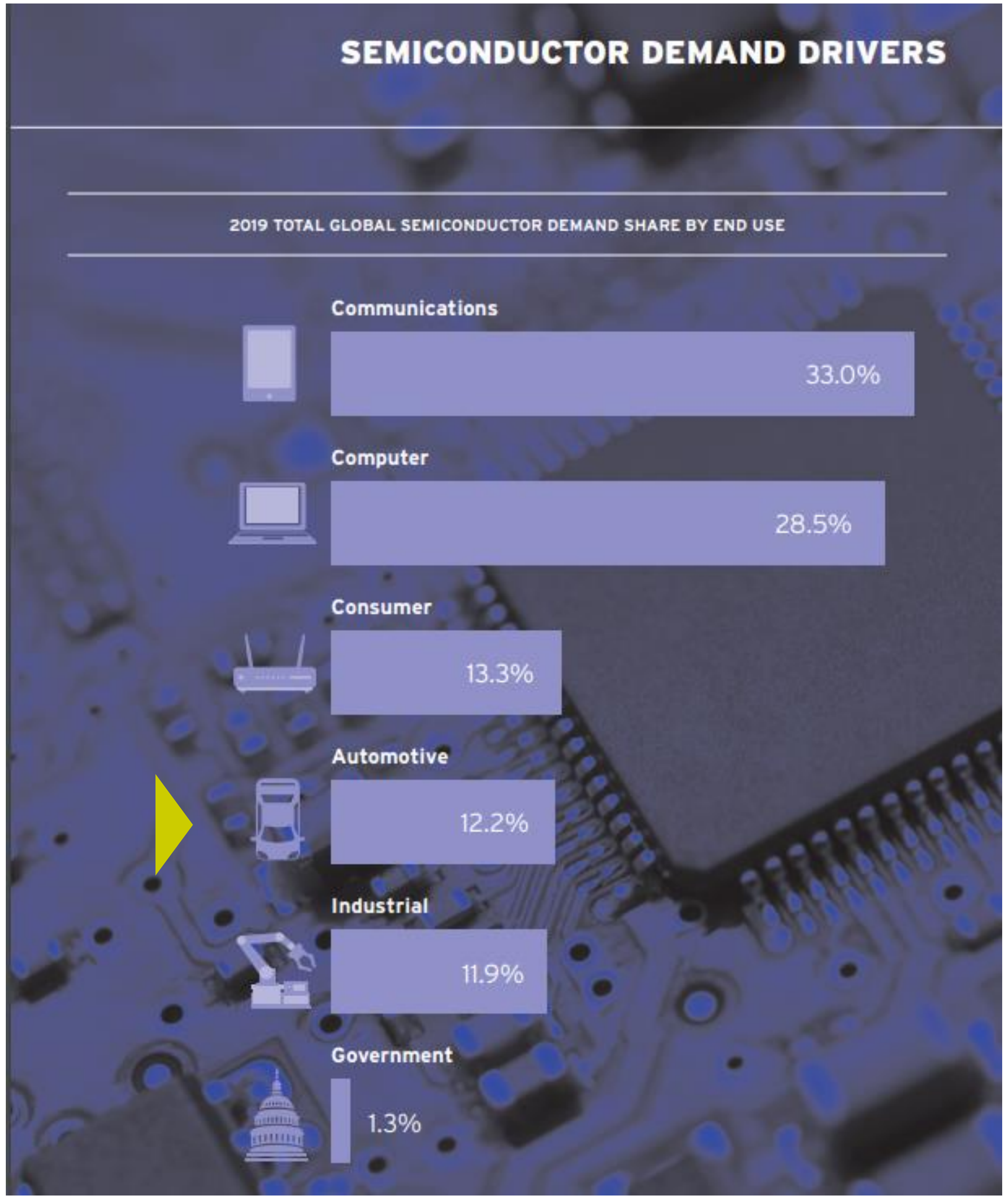
- As of 2020, light vehicles include on average about 1,400 microchips, representing an average content value of $330
- The average content is expected to rise to $600 by 2022/2023 due to the electrification of powertrains, ADAS systems and connectivity
- Hybrid vehicles have over 3,500 microchips for a total value of $1,000 due to the electrified powertrain
- Semiconductor producers are raising prices by 25%, justifying the price increase by capacity investments



Silicon Wafer

Microcontrollers



Source: Ducker, SIA (Semiconductor Industry Association)

Road Toward Emission-Free Cars in the EU

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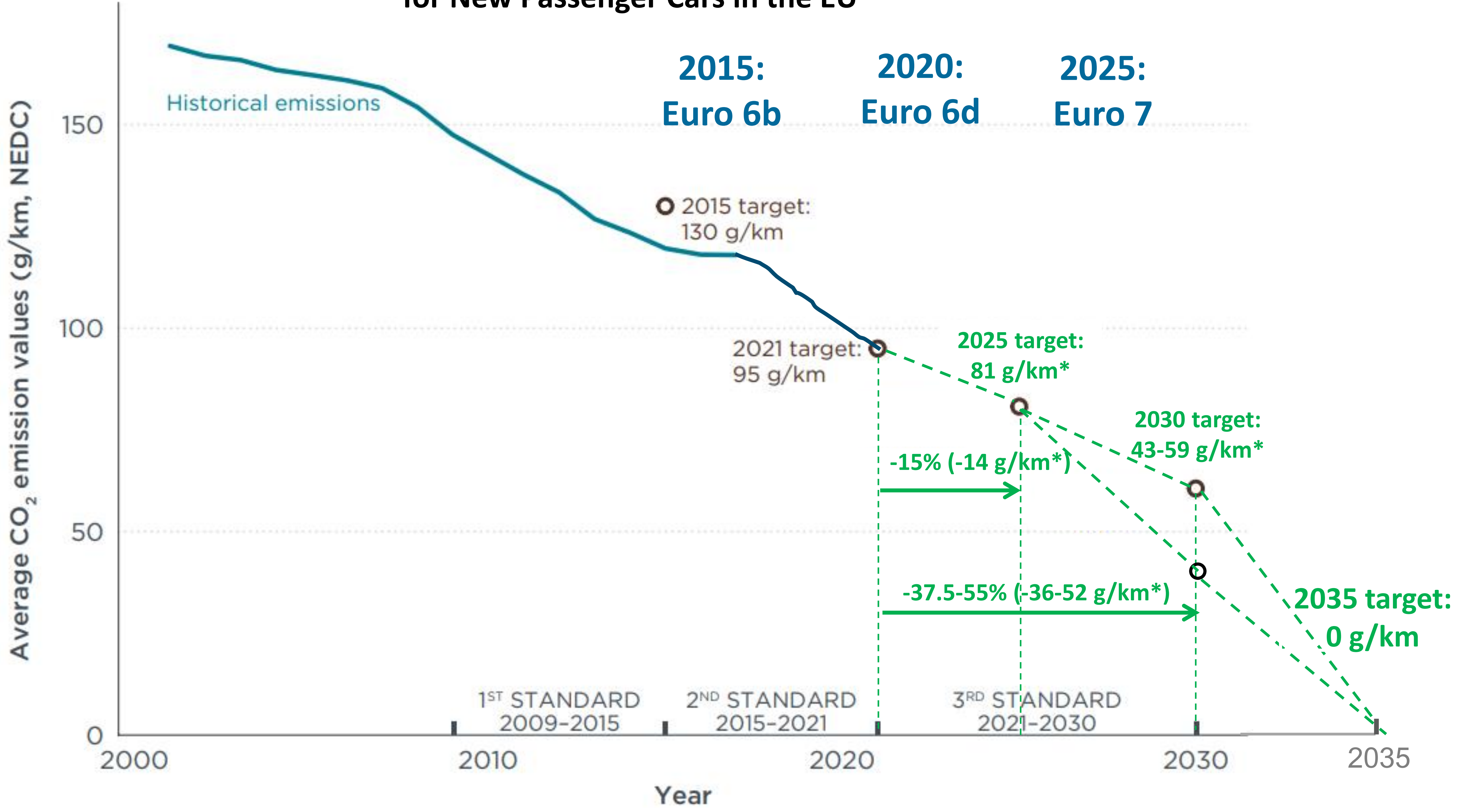
Average Historical CO2 Emission Values and Adopted CO2 Standards for New Passenger Cars in the EU



* Estimated CO2 emission targets in g/km for 2025 and 2030 are based in these calculations on NEDC (New European Driving Cycle) measurements, while future targets to be released will be using WLTP (Worldwide harmonized Light-duty Test Procedure)

Current CO2 emission targets for passenger cars (as compared to 95g/km in 2021):

- 2025: 15% reduction
- 2030: 37.5% reduction – or 55% as proposed by the EU in July 2021 with 'Fit for 55' strategy
- 2035: 100% of new cars emission-free

Future Euro 7 norm: in preparation

- To be presented in Q4 2021
- To be voted in 2022
- To come into effect in 2025 (or later)

Sources: ICCT, Ducker – All CO2 values refer to New European Driving Cycle (NEDC) measurements. Vehicle weight is retained as the underlying utility parameter, i.e., the heavier a manufacturer's car fleet, the higher that manufacturer's CO2 emission target will be under the regulation. Until 2024, a factor of 0.0333 will be used, meaning that for every 100 kilograms (kg) by which a manufacturer's average vehicle weight exceeds the average EU fleet mass, 3.33 g/km higher CO2 emissions will be allowed

OEMs' Carbon-Neutrality Roadmap in Europe

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REUTERS

World Business Legal Markets Breakingviews Technology Investigations

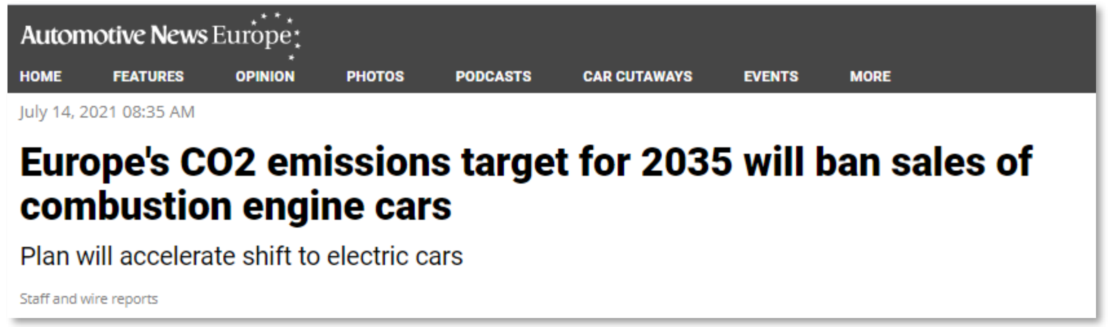
July 14, 2021
10:59 AM EDT
Last Updated 2 months ago

Retail & Consumer

EU proposes effective ban for new fossil-fuel cars from 2035

5 minute read

By Nick Carey and Christoph Steitz


Automotive News Europe

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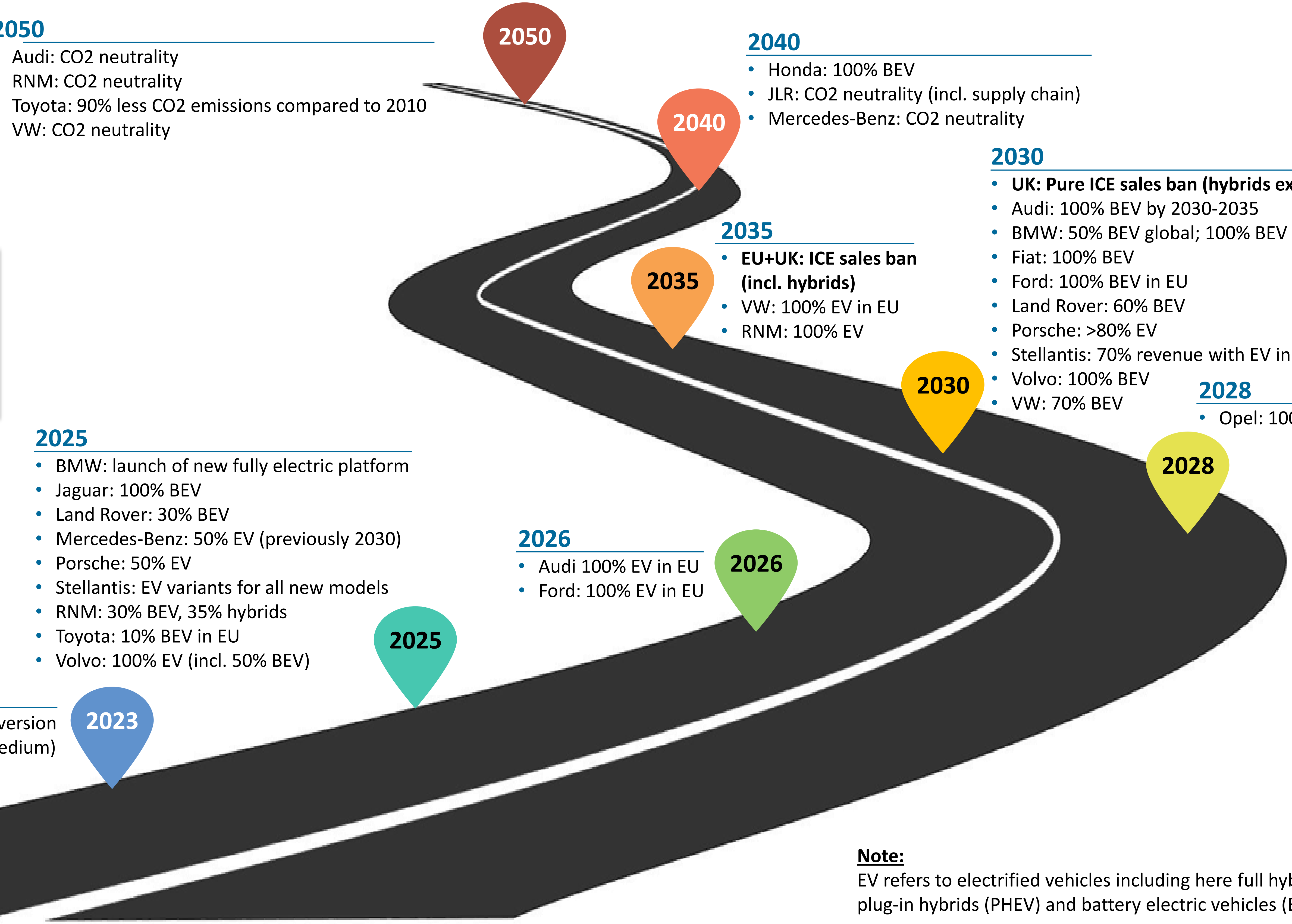
July 14, 2021 08:35 AM

Europe's CO2 emissions target for 2035 will ban sales of combustion engine cars

Plan will accelerate shift to electric cars

Staff and wire reports



2021
- BMW: 20% EV in EU
- Toyota: 60% EV in EU

2023
- BMW: 90% of models with at least one BEV version
- Stellantis: launch of eVMP platform (STLA medium)

2025
- BMW: launch of new fully electric platform
- Jaguar: 100% BEV
- Land Rover: 30% BEV
- Mercedes-Benz: 50% EV (previously 2030)
- Porsche: 50% EV
- Stellantis: EV variants for all new models
- RNM: 30% BEV, 35% hybrids
- Toyota: 10% BEV in EU
- Volvo: 100% EV (incl. 50% BEV)

2026
- Audi 100% EV in EU
- Ford: 100% EV in EU

2028
- Opel: 100% EV in EU

2030
- **UK: Pure ICE sales ban (hybrids excluded)**
- Audi: 100% BEV by 2030-2035
- BMW: 50% BEV global; 100% BEV for Mini
- Fiat: 100% BEV
- Ford: 100% BEV in EU
- Land Rover: 60% BEV
- Porsche: >80% EV
- Stellantis: 70% revenue with EV in EU
- Volvo: 100% BEV
- VW: 70% BEV

2035
- **EU+UK: ICE sales ban (incl. hybrids)**
- VW: 100% EV in EU
- RNM: 100% EV

2040
- Honda: 100% BEV
- JLR: CO2 neutrality (incl. supply chain)
- Mercedes-Benz: CO2 neutrality

2050
- Audi: CO2 neutrality
- RNM: CO2 neutrality
- Toyota: 90% less CO2 emissions compared to 2010
- VW: CO2 neutrality

Note:
EV refers to electrified vehicles including here full hybrids (FHEV), plug-in hybrids (PHEV) and battery electric vehicles (BEV)

Sources: Ducker

The Evolution of US Emission Standards

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Automotive News
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EPA proposes stronger-than-expected vehicle emissions rules

The proposed rules would mandate fleet-wide vehicle mileage of 52 mpg by 2026, up from 40 mpg this year.

August 05, 2021 06:41 PM


President Biden
@POTUS
United States government official

The future of the auto industry is electric — and made in America.

Today I'm signing an executive order with a goal to make 50% of new vehicles sold by 2030 zero-emission — and unveiling steps to reverse the previous administration's short-sighted rollback of vehicle standards.

8:15 AM · Aug 5, 2021 · The White House

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September 23, 2020 01:57 PM

California plans to ban sale of new gasoline-powered passenger vehicles in 2035

DAVID SHEPARDSON and NICHOLA GROOM

Reuters

Targets

- 2030: voluntary goal of 50% new vehicles zero-emission capable (incl. PHEV)
- 2035: carbon-neutral transportation
- 2050: carbon-neutral economy

Strategy

Largely R&D-focused, aiming to create jobs and strong manufacturing capabilities before strongly incentivizing the demand

- Over $46 billion investment approved for ZEV technologies (mainly BEV and FCEV), including investment in charging infrastructure (over 500,000 level 2 and level 3 public charging stations)
- 647,000 jobs anticipated to be created through investment in manufacturing based on grants and tax incentives

Demand incentive

- increased tax credit program from $7,500 to $12,500 for new EV purchase

Source: Ducker, CARB, DOE

Acceleration of Electrification in Europe

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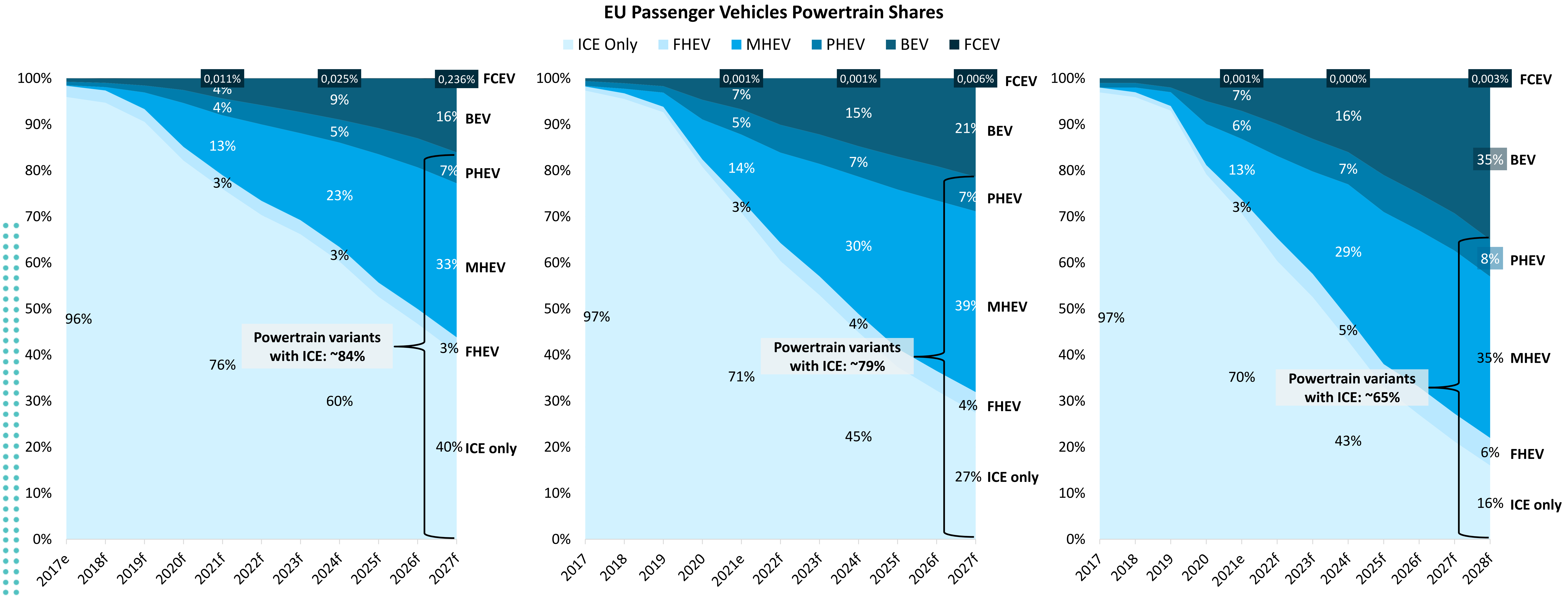
Forecast from Q2-2018	Forecast from Q4-2020	Forecast from Q2-2021
2027: 16% BEV	2027: 21% BEV	2027/2028: 29%/35% BEV



Sources: Ducker, LMC Automotive

Acceleration of Electrification in North America

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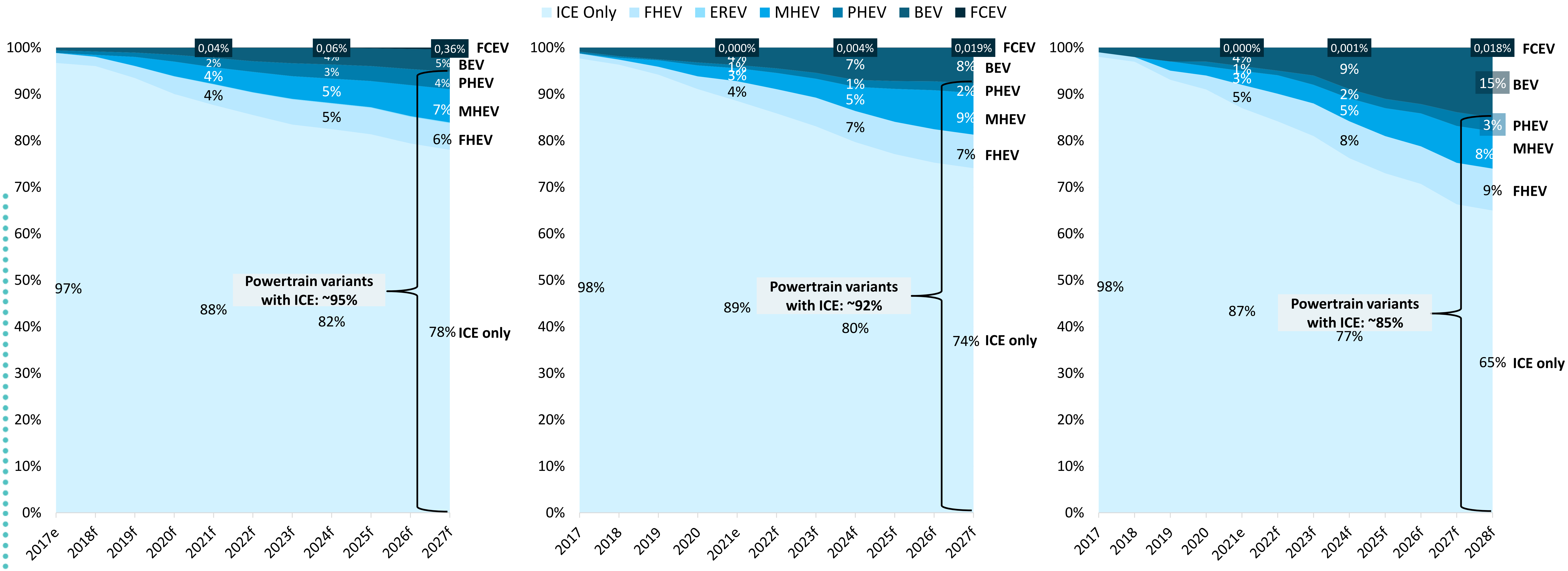
Forecast from Q2-2018 → **Forecast from Q4-2020** → **Forecast from Q2-2021**

2027: 5% BEV | **2027: 8% BEV** | **2027/2028: 14%/15% BEV**

NA Light Vehicles Powertrain Shares



Sources: Ducker, LMC Automotive

Vehicle Aluminum Intensity Continues to Increase - EU

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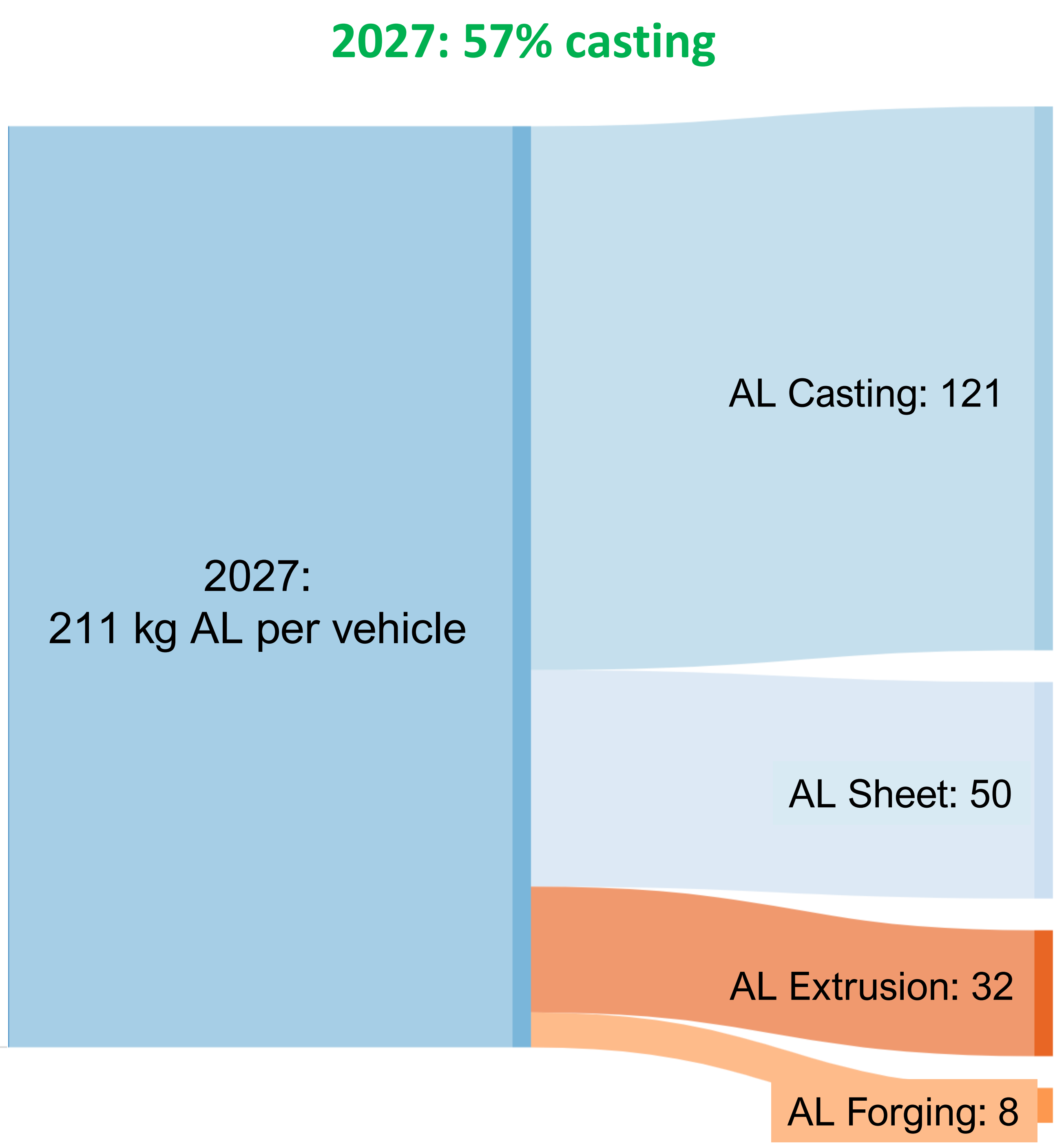
EU Passenger Vehicle Aluminum Content
Net kg per Vehicle

Split of Vehicle Aluminum Content by Product Form
Net kg



Source: Ducker | EA Aluminum Content 2019

Vehicle Aluminum Intensity Continues to Increase - NA

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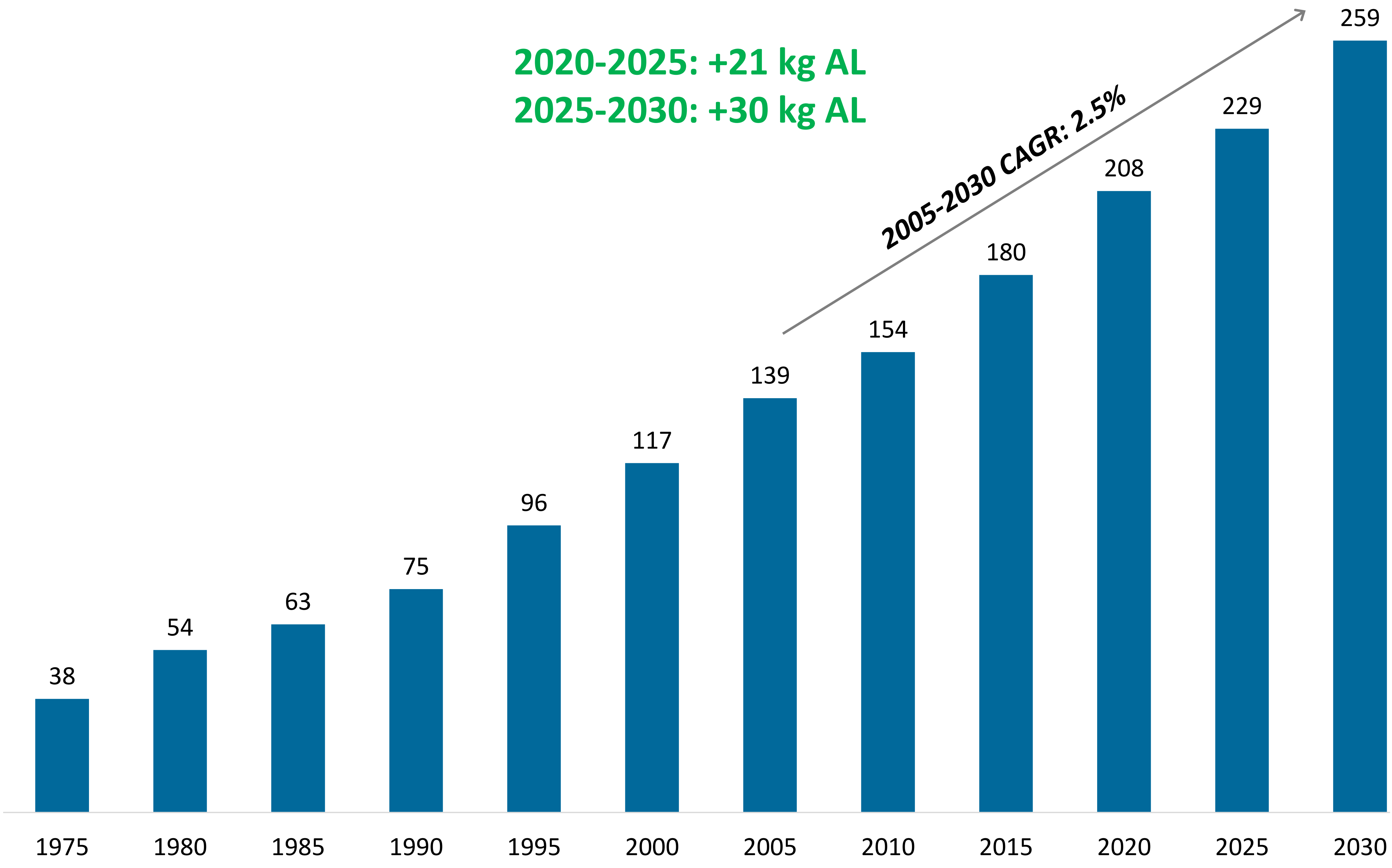
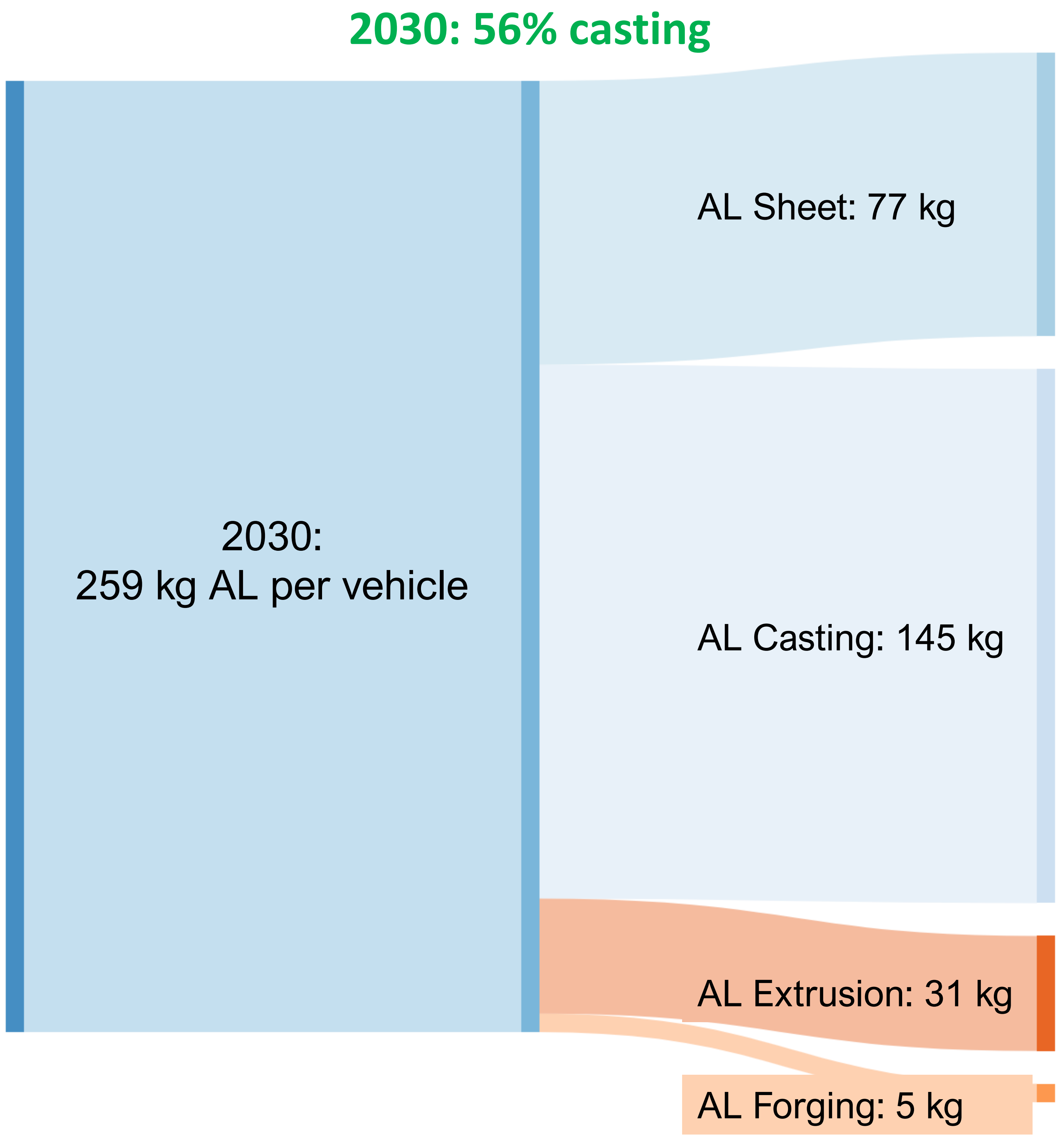
North American Light Vehicle Aluminum Content
Net kg per vehicle



Split of Vehicle Aluminum Content by Product Form
Net kg



Source: Ducker | Aluminum Association 2020 Report

Rolled and Extruded Products Show Dynamic Growth

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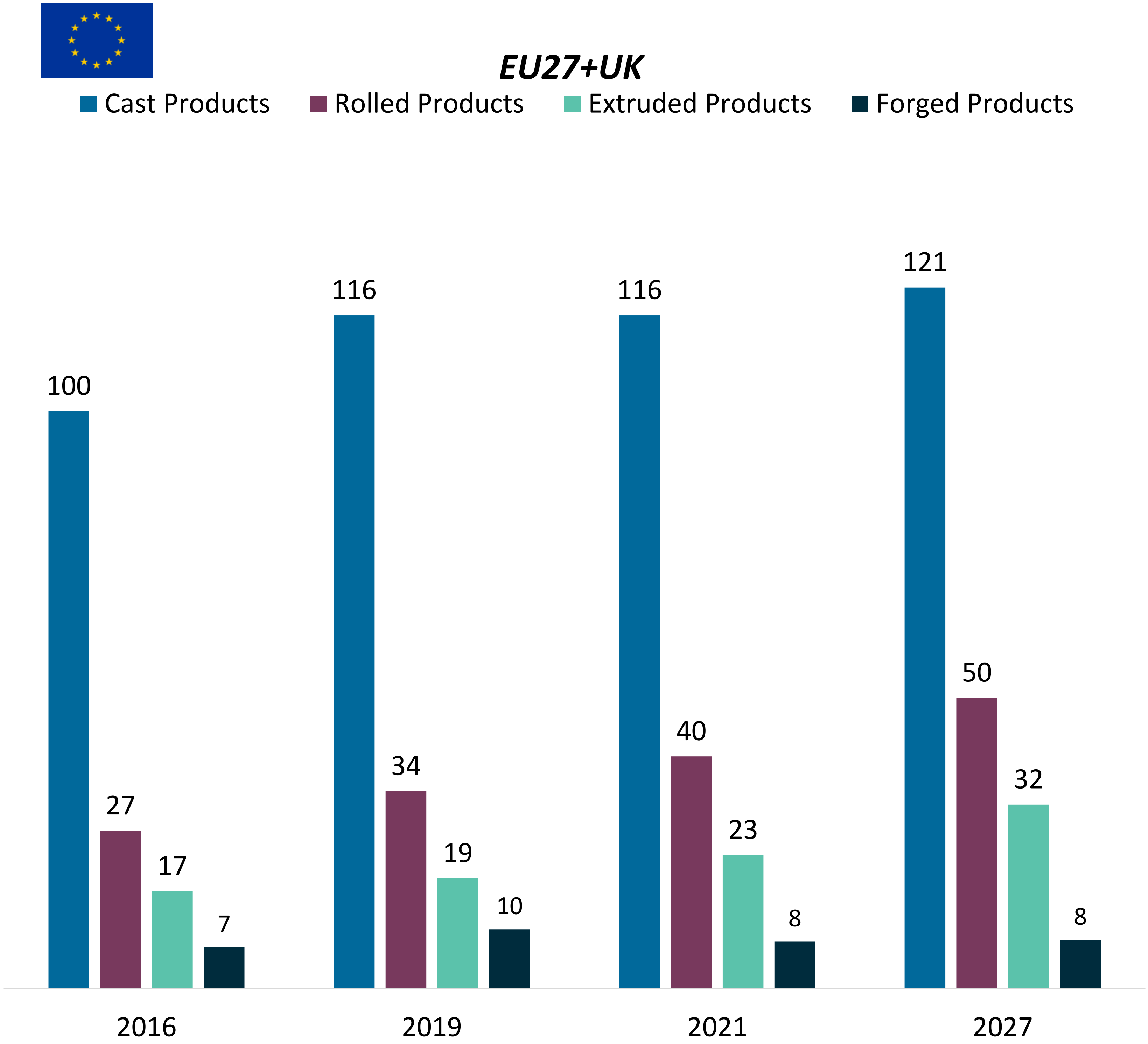
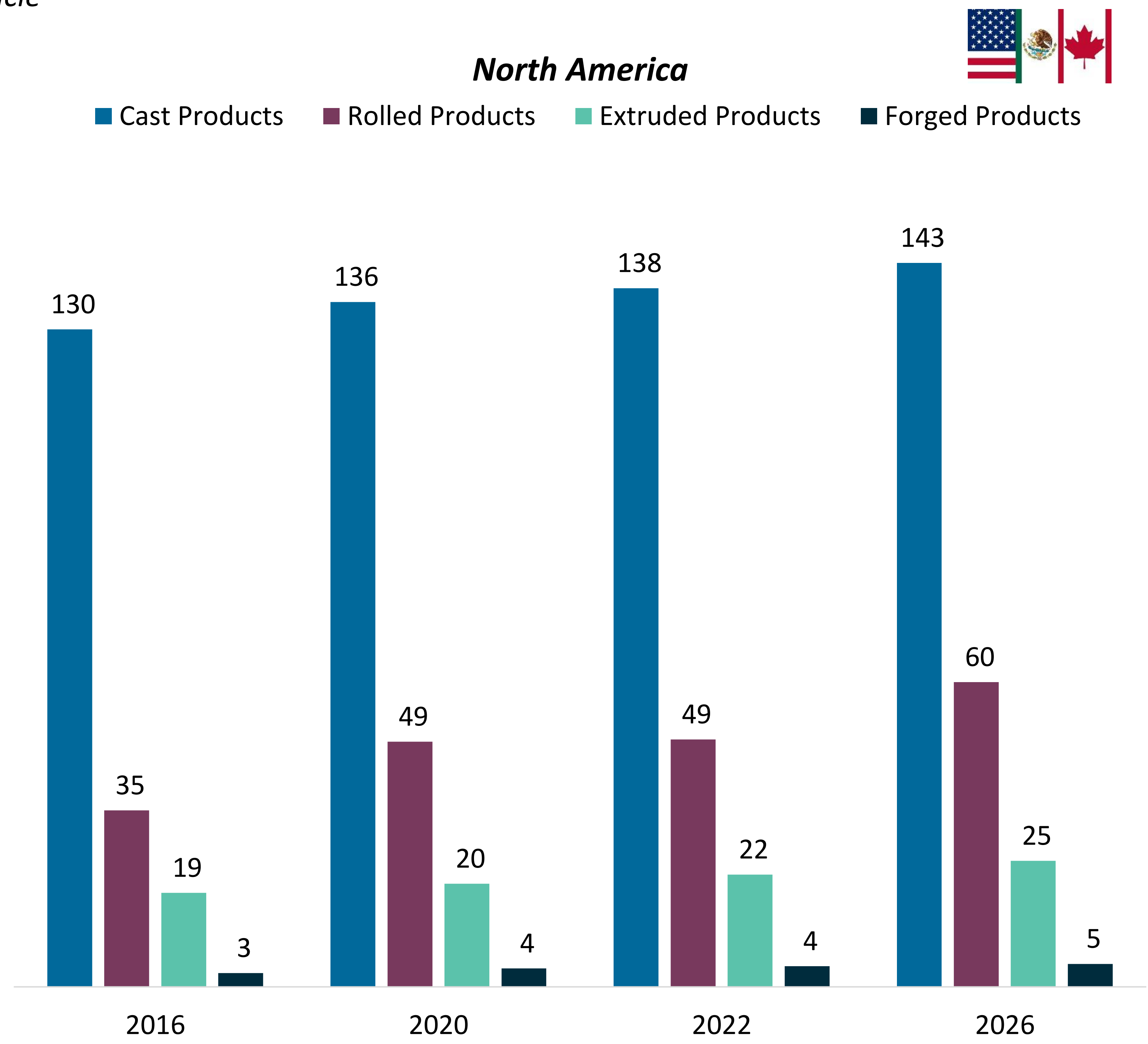
Light Vehicle Aluminum Content by Product Category

Net Kg Per Vehicle





Source: Ducker | Aluminum Association 2020 | EA Aluminum Content 2019

BEVs Are More Aluminum-Intensive

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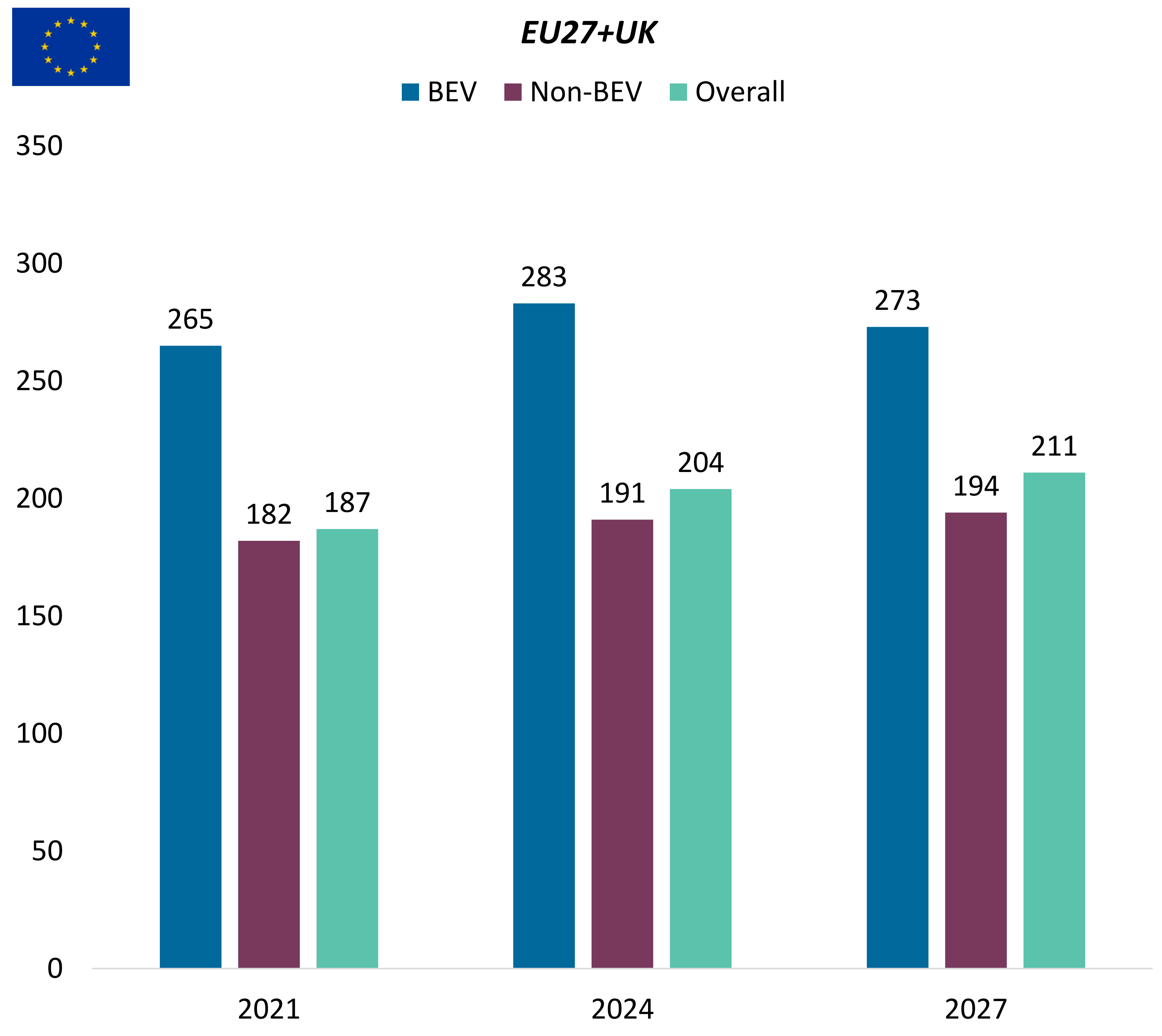
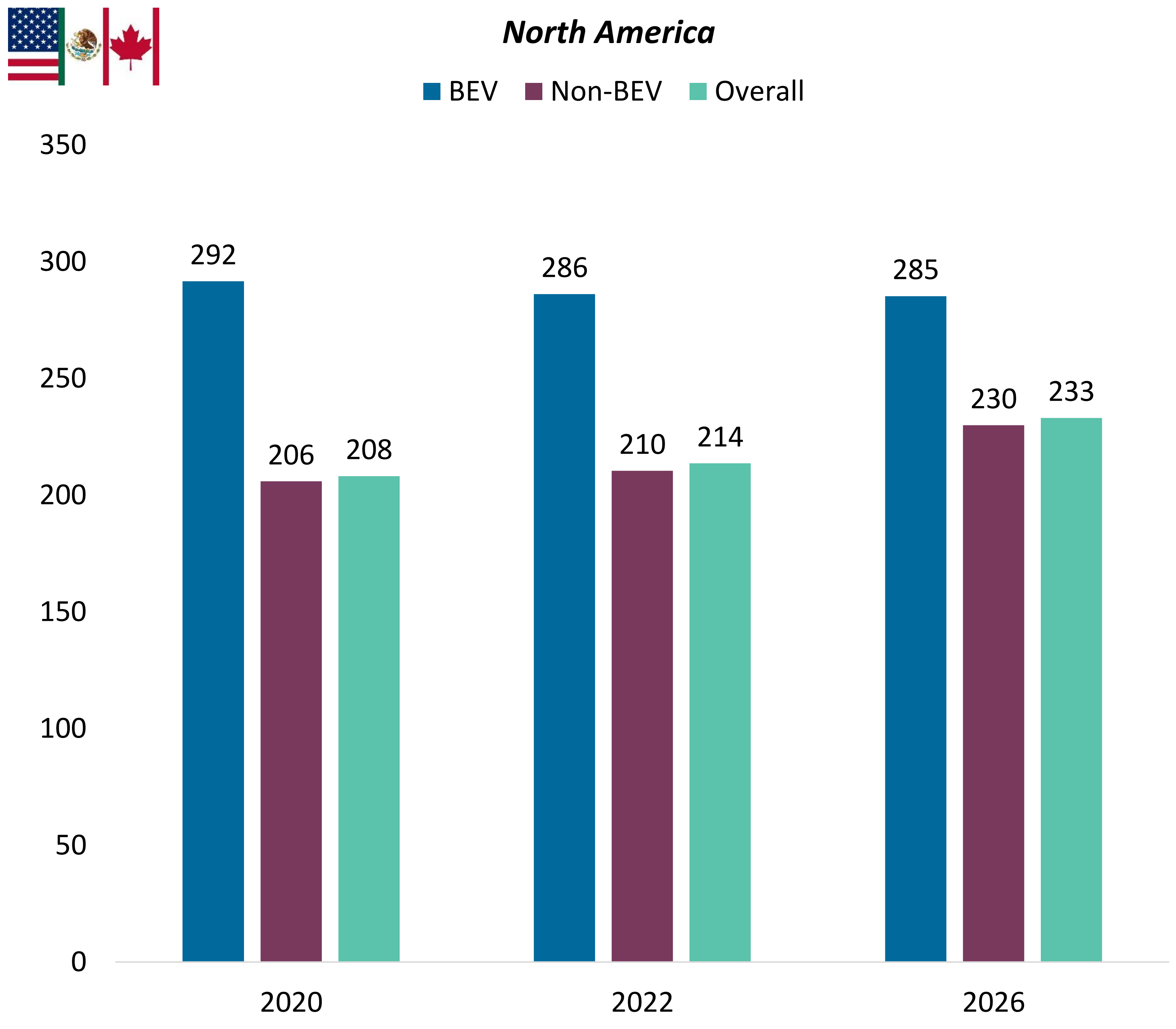
Content per Vehicle - BEV vs. Other

- Kg per vehicle -





Source: Ducker April 2020 data, Aluminum Association 2020 Report | EA Aluminum Content Study 2019

BEV Battery Housings Drive Strong Increase of Aluminum Content in Vehicle

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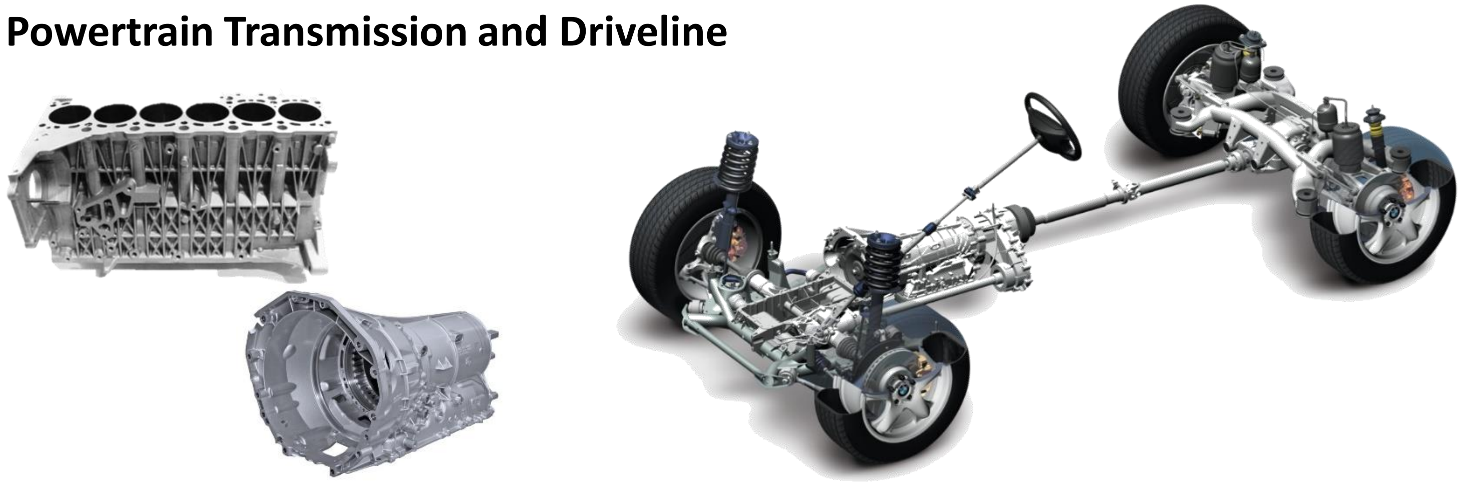
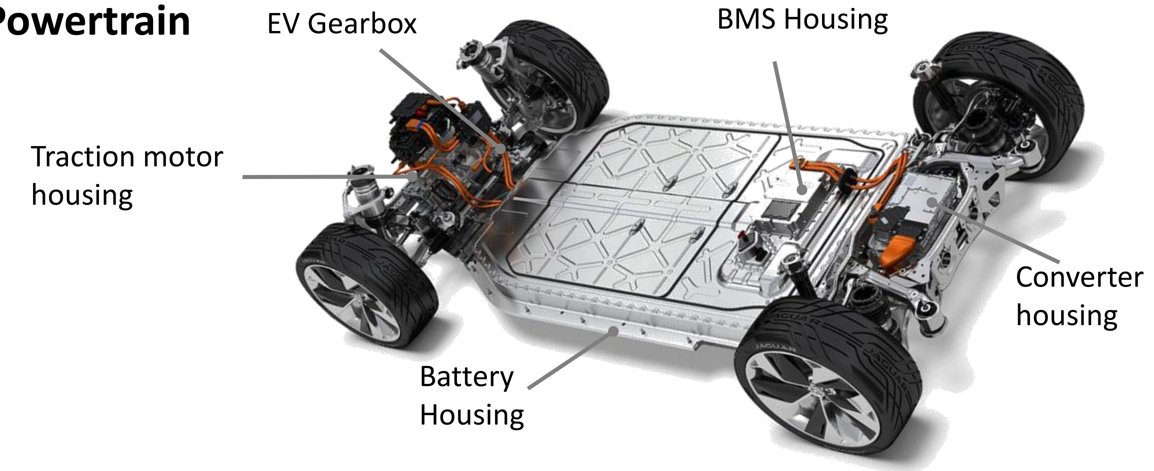
Eliminated ICE Parts

Powertrain Transmission and Driveline



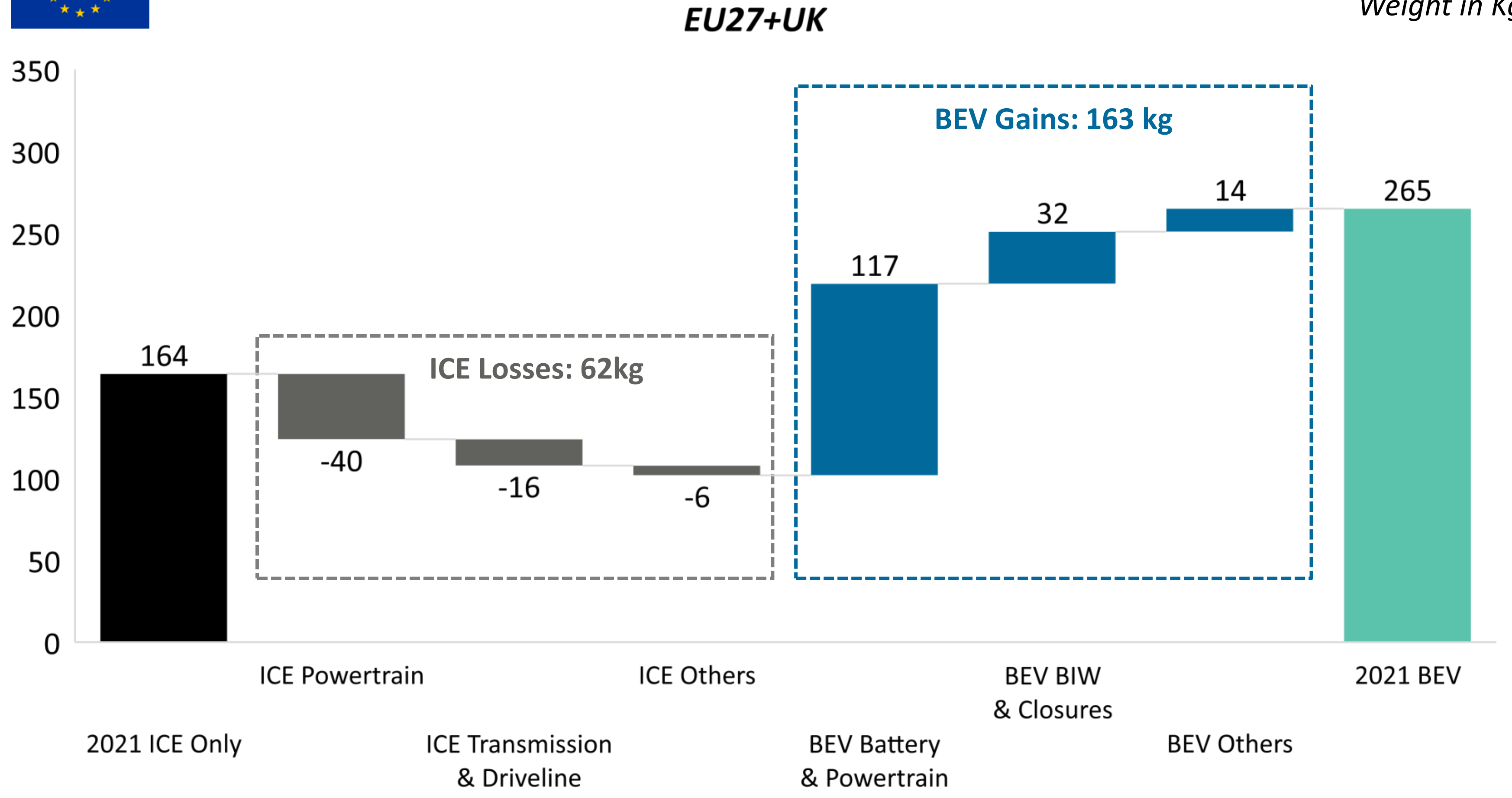
Added BEV Parts

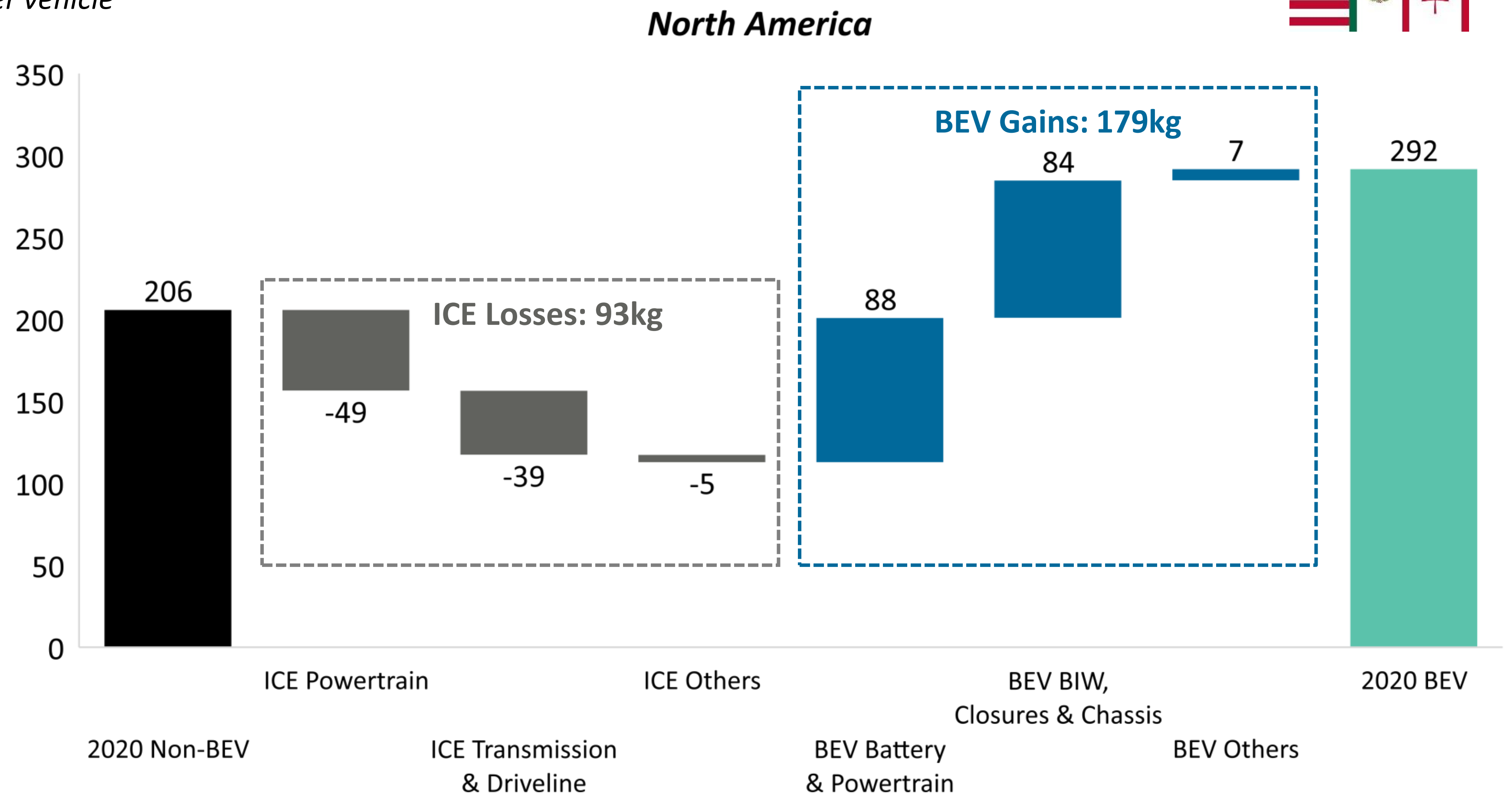
BEV Platform and Powertrain



From ICE to BEV: Aluminum Content Change

Weight in Kg per vehicle





Source: Ducker April 2020 data, Aluminum Association 2020 Report

EV Platform & Battery Housing Design Diversity

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EV Platforms

Platform	Traditional Versatile Platform ICE, MHEV, FHEV, PHEV, FCEV, BEV	Traditional Dedicated EV Platform BEV and FCEV	Skateboard Platform (dedicated) BEV only
Description	• Highly scalable and low cost • Existing manufacturing capabilities • Battery not structural	• EV integrated architectures • Battery can be structural • Cost efficiency and weight reduction	• EV native platforms • Battery is structural • Threatened by solid-state technology
Example	 Hyundai 3rd Generation PF	 2020 Nissan Leaf	 Volkswagen MEB

Battery Housing Design Types

Tray Design

Audi e-tron battery housing

+

Simple and efficient sealing with tight tray/lid

Greater serviceability than assembled design

–

Tray generates additional weight in the housing

Low scalability; one tool set for one size

Frame Design

+

Better use of space

Highly scalable

–

Complex joining and sealing processes

Lower serviceability (maintenance cost)

Sources: Ducker, Audi

Solid-State Batteries Expected to Support Further Penetration of EV

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Solid-state seems closer…

Solid-state batteries enable higher safety

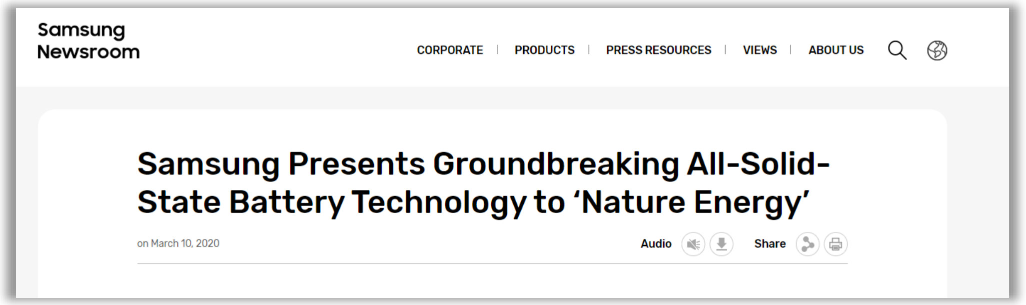
- Doubling energy density, mostly based on LFP technology so far
- Increased safety with lower chances of runaway cells, enabling the possibility to charge at higher speeds due to better thermal management
- Batteries are expected to keep their sizes for the first generation of solid-state applications (keeping range slightly above but close to current NMC and NCA based technologies)
- All in all, solid-state batteries is ultimately expected to further accelerate EV acceptation and adoption

Progress in development of all-solid-state batteries

June 2020

August 2020

Obtained license plate registration in August 2020 and conducted test drives



Samsung Newsroom

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Samsung Presents Groundbreaking All-Solid-State Battery Technology to 'Nature Energy'

on March 10, 2020

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Fisker Inc. has 'completely dropped' solid-state batteries

"SOLID-STATE BATTERIES ARE STILL VERY, VERY FAR OUT"

… but still has to overcome major challenges

Solid-state batteries are years out

- Scaling up solid-state batteries to reach the necessary size for automotive grade and mobile utilization is a big challenge
- From the first prototype to large scale validation, testing, calibration, and industrialization, the automotive industry requires cycles that are usually of at least 5 to 10 years
- In the best-case scenario, the first solid-state application on a production vehicle is 5 years ahead; more and more industry participants are targeting a potential launch to 10 years from now
- Solid-state batteries will help slowing down the need for raw materials, but it won't stop the raw material price increase as demand will rise and require more expensive mining, deeper digging, leading to potentially more carbon emissions from battery manufacturing over time

Sources: Ducker, Samsung SDI, TheVerge, Toyota

Mix of Net-Zero Solutions to Meet Carbon-Neutrality Targets

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CCU solutions lead to net-zero carbon solutions as they mitigate the increase in CO2…

…by utilizing carbon in a closed-loop reducing GHG (Green House Gas) increase, the net-zero solution

Carbon Capture & Utilization can benefit to 2 major technologies in the automotive industry:

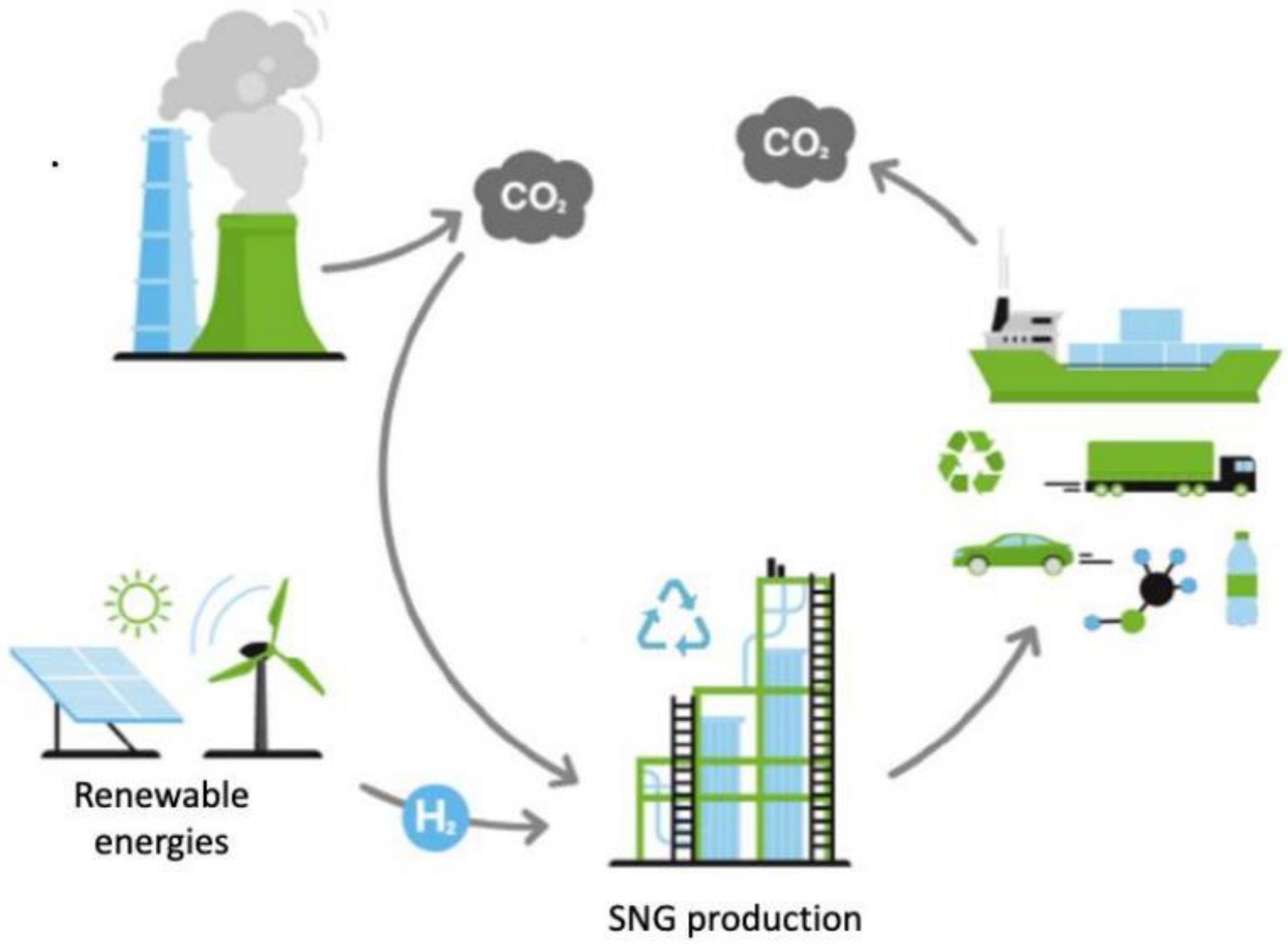
H2 for FCEV

Low-carbon hydrogen, coupled with on-site production capabilities, would help the deployment of FCEVs by:

- solving the infrastructure cost issue linked to electrification
- and reducing charging time to a matter of minutes (avoiding waste of time and queueing while refueling/charging)

E-fuels

Carbon capture could lead to the production of synthetic fuels that would be drop-in, which means dropped in the tank of ICE vehicles without major investments from the distribution or technology perspectives and no impact on carbon concentration in the atmosphere (closed loop)



Sources: Ducker, European Commission

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