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Solutions for electric vehicle fluid requirements

Michael Toohey
Market Development Lead
ExxonMobil Product Solutions Company

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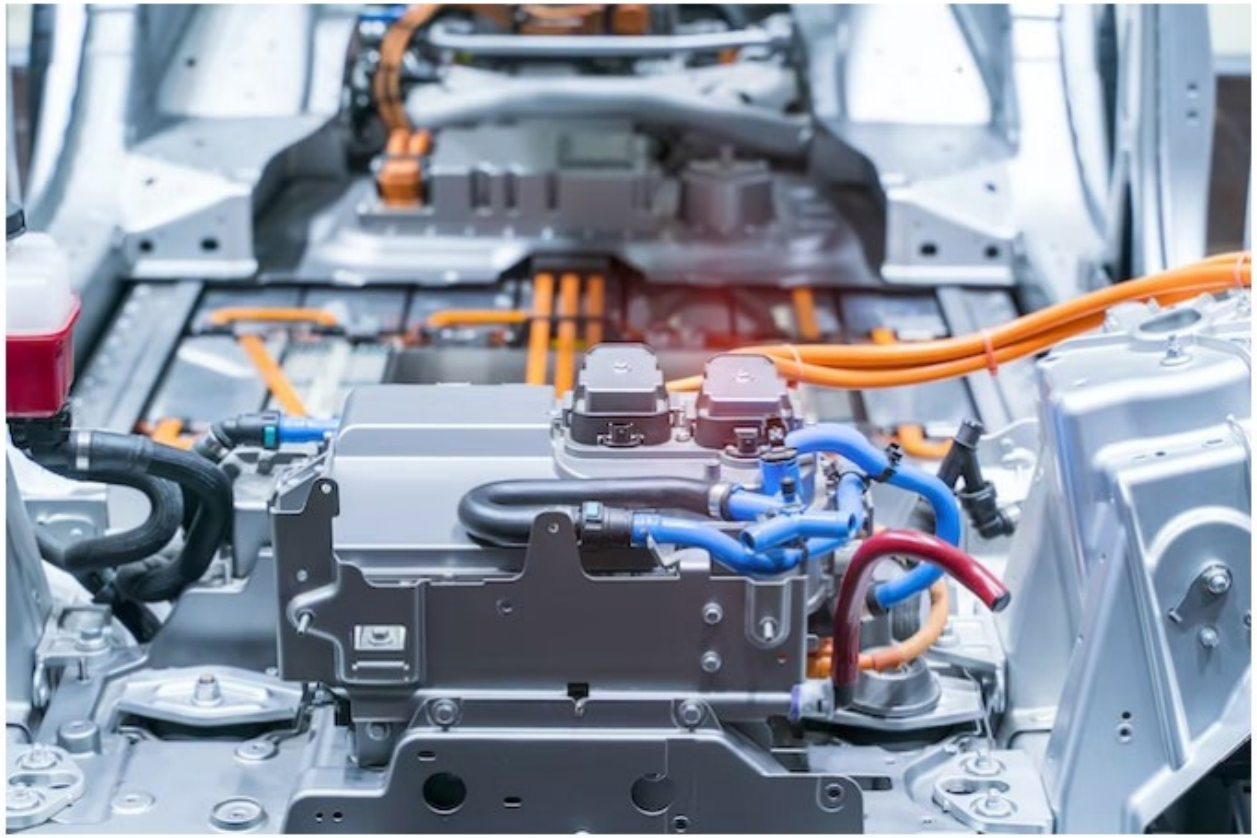
Agenda

- EV OEM targets are evolving
- New fluid applications
- E-axle market key insights and implications
- Novel basestock solutions
- Executive summary



EV OEM* targets are evolving

2022
One third of sales to be fully electric by 2026 and 50% by 2030 with all electric sales in Europe by 2030

2021
All-electric vehicles to exceed 70% of European and 50% of Chinese & US sales by 2030 – by 2040 nearly 100% to be ZEV's

2021
20% of car sales to be electric by 2025

2021
All-newly launched vehicles will be fully electric from 2025

2021
3.5 M annual electric car sales by 2030 and the roll out of 30 BEV models

2021
Become a fully electric car company by 2030

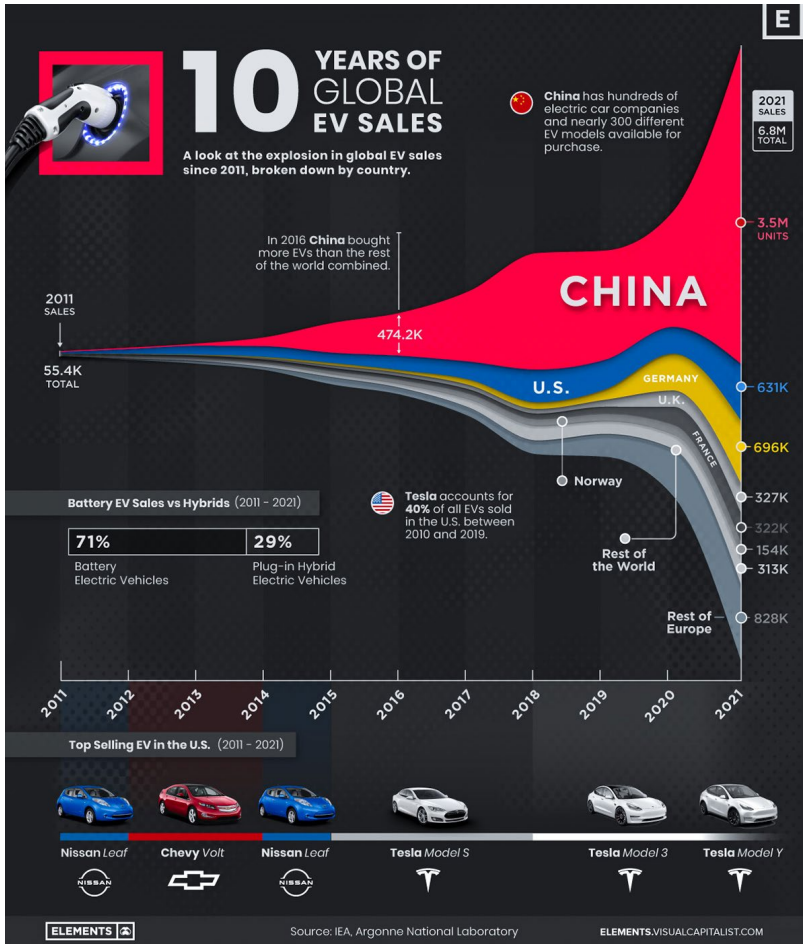
2021
50% of vehicles sold to be fully electric by 2030 or earlier

2022
30 EV models and BEV production capacity of 1 million units in North America by 2025 plus carbon neutrality by 2040

~130-135 Millions

BEV projected population by 2030 according to the latest IEA

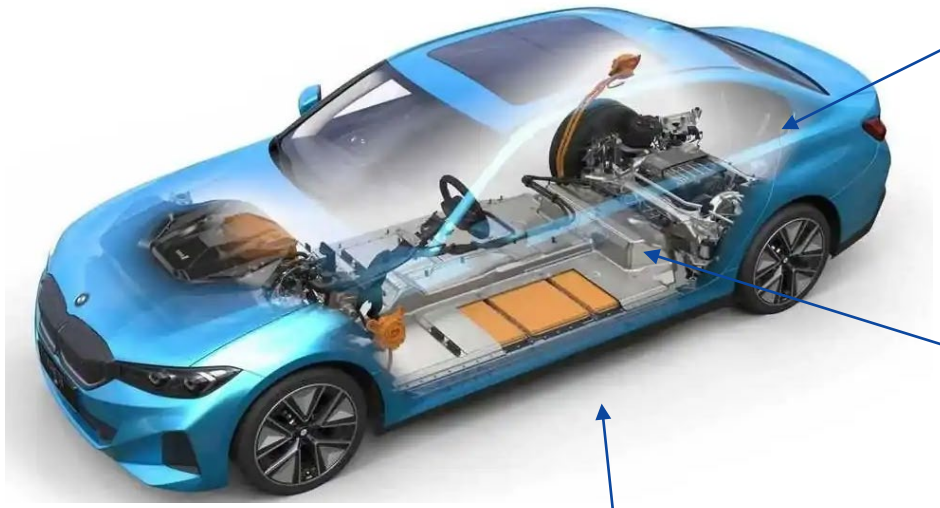
https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer



*Source: IEA 2023 Global EV outlook - https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf

EV fluid applications

Key tribological components of electric vehicles



Electric Motor cooling

Transmission Axle

Battery *Thermal Management*

Various bearing applications (wheels. ..)

E-Drives key components

Electric Motor	Power Electronics	Transmission
Converts electrical to mechanical energy	Inverts DC to AC and controls power	Gear set reducing high motor RPM to suitable output

When combined into a compact unit :

E-Axle

Compact system bringing components together
supports integration – control – modularity and weight / space optimization

E-Drive : Are components and systems which convert electricity into power in the drive system of an electric vehicle

E-Axle : Are a compact, cost-attractive electric drive solutions for battery-electric vehicles and hybrid applications. In E-Axles the electric motor, power electronics and transmission are combined in a compact unit directly powering the vehicle's axle.

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E-Axle market key insights and implications

Learning or Confirmation **#1**

Electric vehicle E-Axle market will grow **@ 17.1 % CAGR*** from 2022 to 2029.

*6.3 Millions Units were sold in 2021**

Fluid producers need to develop supply ahead of demand

Learning or Confirmation **#2**

A **PV market** but with potential to development into **CV segments.**

74%*

26%*

Fluid formulators to understand specific application needs

Learning or Confirmation **#3**

E-Axle Technology not mature yet, but development continues to foster BEV mass adoption.

+ Compact
+ Integration
+ Power density

Fluid formulators need to anticipate upcoming changes

*Source : Electric Vehicle E-Axle Market Global Market Analysis, Insights and Forecast, 2022-2029

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E-Axle market key insights and implications

Learning or Confirmation **#3**

E-Axle Technology is not mature yet, but development continues to foster BEV mass adoption

+ Compact
+ Integration
+ Power density

Fluid formulators need to anticipate upcoming changes

Internal combustion engine

- viscosity
- volatility
- protection
- durability
- compatibility

Moving into electric powertrain

Current electric vehicle

- Electrical property
- Cooling perf.
- viscosity
- volatility
- protection
- durability
- compatibility

E-axle cooling + higher power density and fast charging

Next up electric vehicle

- Foaming - Aeration
- Electrical property
- Cooling perf.
- viscosity
- volatility
- protection
- durability
- compatibility

Enhanced | New / critical

What will be the fluid of choice for E-Axle applications ?

- OEM specific / bespoke ?
- Range of viscosity ? (KV100)
- Fluid architecture ? (Base oil, Additives ?
- Increase constraints ? (Power density)

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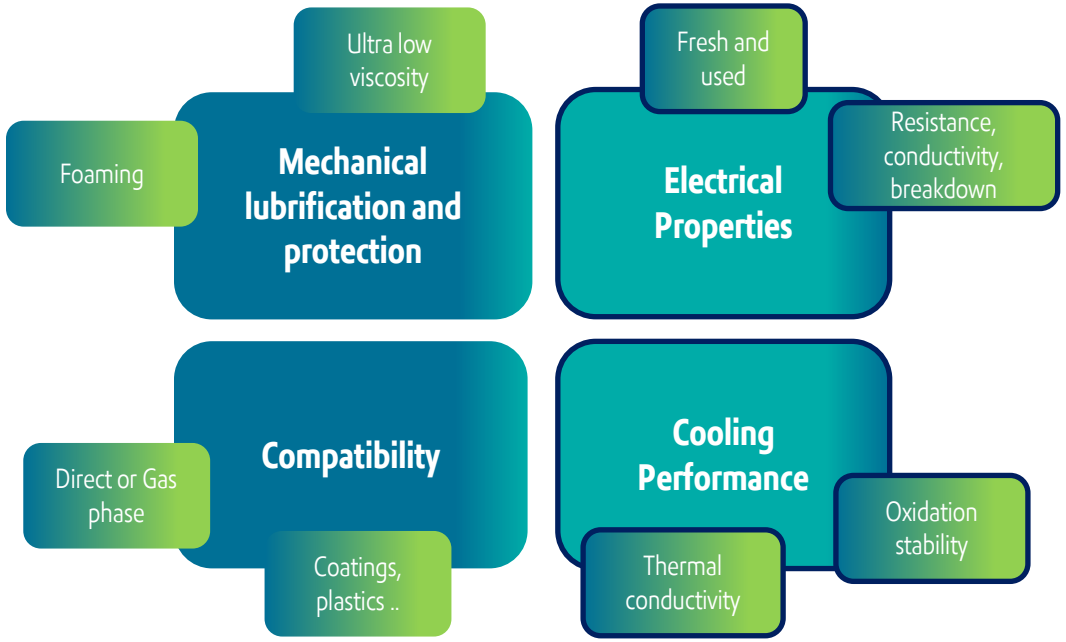
BEV driveline – new requirements for fluids

What to consider ?

- Direct **Fluid contact** with Electronic components
- **High speed** (up to 20.000 rotation per minute)
- Incorporation **of new materials** / chemicals
- **Cooling system integration** with Lubrication
- Industry trend to move to **Ultra Low Viscosities**

FLUID BECOMES CRITICAL TO ENSURE Durable and optimized E-Axle operations



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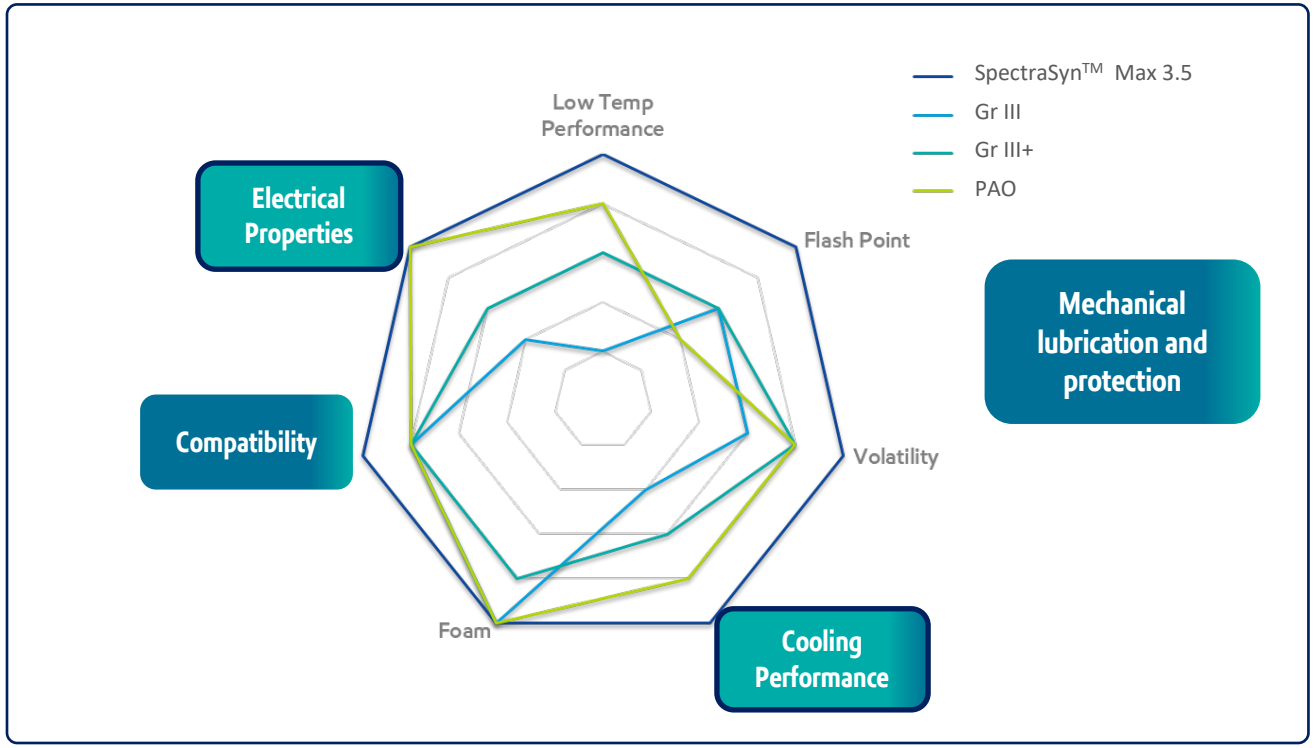
Novel basestock solutions and performance using the KV100 test

The performance of ExxonMobil's SpectraSyn™ MaX 3.5 was directly compared to other base stocks blended to the same viscosity

	Test ref.	SpectraSyn™ MaX 3.5	Gr III	Gr III+	PAO
KV100, cSt	ASTM D445	3.51	3.43	3.49	3.48
KV40, cSt	ASTM D445	14.2	14.4	14.4	14.4
VI		**128**	114	122	120
Brookfield viscosity -40 °C, mPa·s	ASTM D2983	**1458**	Too viscous to be measured	5300	1700
Pourpoint, °C	ASTM D97	**-78**	-24	-51	-60
Noack at 250 °C, 1 hour	ASTM D5800	**12.5**	33.4	26.4	28.0
Flash point (CoC), °C	ASTM D92	**225**	201	210	203
Fire point (CoC), °C	ASTM D92	**261**	226	236	219



SpectraSyn MaX™ 3.5 provides superior performance compared to other basestocks

Source: ExxonMobil internal data & Analysis of publicly available data

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PAO 2.X achieves low viscosity, while improving or maintaining other key properties

	Test ref.	PAO 2.X	PAO 2	Gr II+	Gr II
Kinematic Viscosity @ 100°C, cSt	D445	**2.27**	1.68	3.03	2.67
Noack Volatility @ 200°C, wt%	D5800	**8.8**	34.7	7.6	7.4
Pour Point, °C	D5950**	**-78**	-87	-36	-42
Brookfield Viscosity @ -40°C, cP	D2893	**942.0**	239.9	3869	1760
Cold Cranking Simulator @ -35C, mPa·s	D5293	**286**	238	1051	525
Flash Point COC, °C	D92	**187**	163	196	200

Source: ExxonMobil internal data & analysis of publicly available data; **ASTM method D5950 only covers up to -66 °C

Customer interest in high-performance, lower viscosity base oil.

Experimental PAO 2.X may enable lower viscosity formulations for EV applications.

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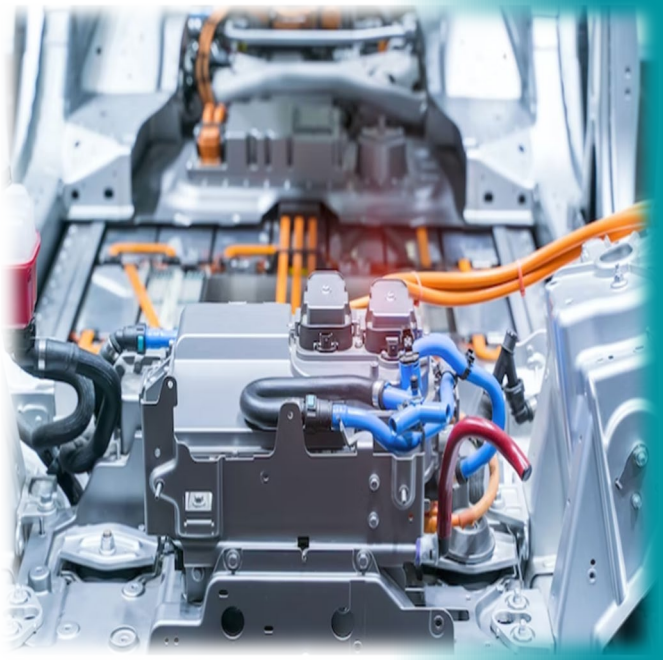
Executive summary



- The electric vehicle E-Axle market will experience a **significant growth** in the upcoming years – primarily in Passenger car segment, but also in Commercial vehicles.
- Fluids with **new 'performance' attributes** will be required in large quantities in order to be able to meet each novel OEM designed approach.
- The ExxonMobil Synthetics Business Unit will continue **to innovate** new **Low Viscosity-Low Volatility (LVLV)** products and solutions which will enable our customers to win in these new and challenging applications.
- We are looking **forward to work with you** to help you evaluate how you could extract value from our existing and new basestock offerings.

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