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Solutions for electric vehicle fluid requirements

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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



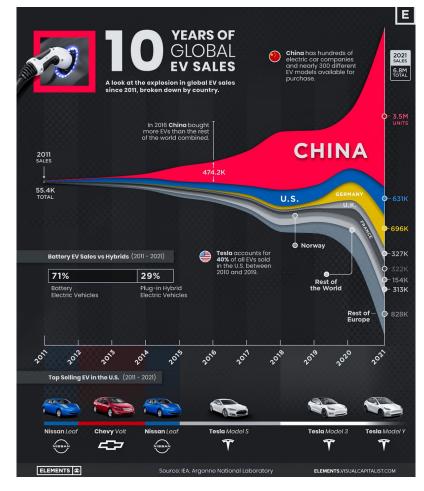
2022

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

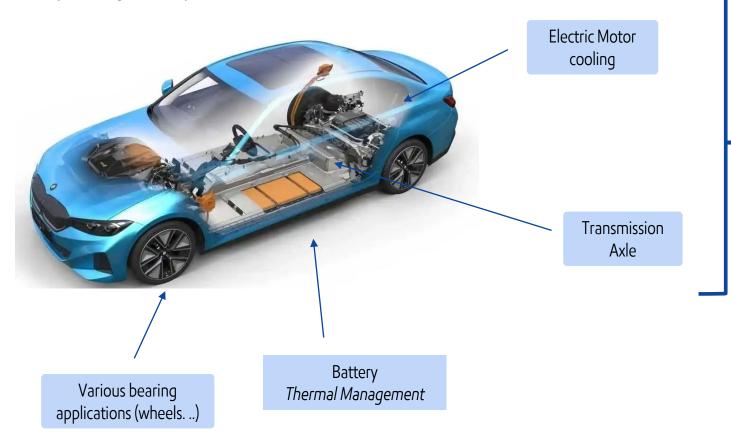
https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer





EV fluid applications

Key tribological components of electric vehicles



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.



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.

- + Integration
- + Power density

Fluid formulators need to anticipate upcoming changes



⁺ Compact

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

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

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)



BEV driveline – new requirements for fluids

What to consider?

Direct **Fluid contact** with Electronic components

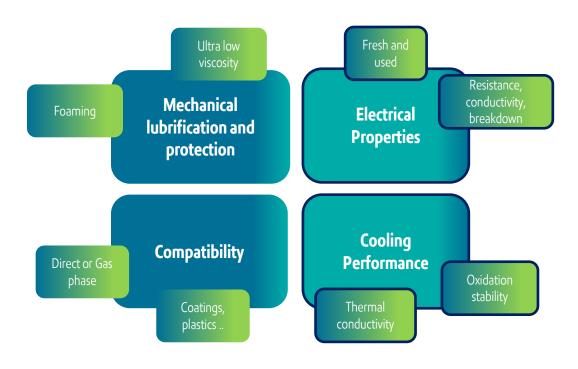
High speed (up to 20.000 rotation per minute)

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

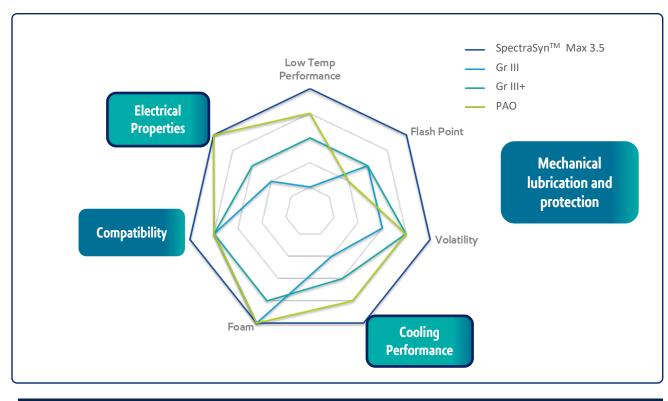




Novel basestock solutions and performance using the KV100 test

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 MaXTM 3.5 provides superior performance compared to other basestocks



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

	Test ref.	PAO 2.X	PAO 2	Gr II+	GrII
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

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

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

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



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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