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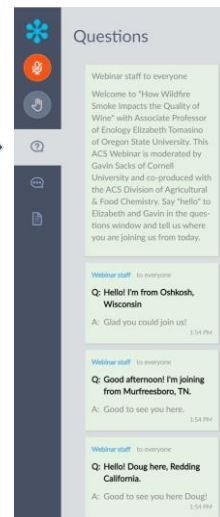
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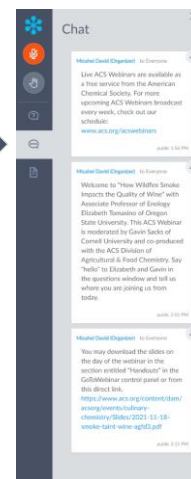


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Announcements and hyperlinks from our team



2

2

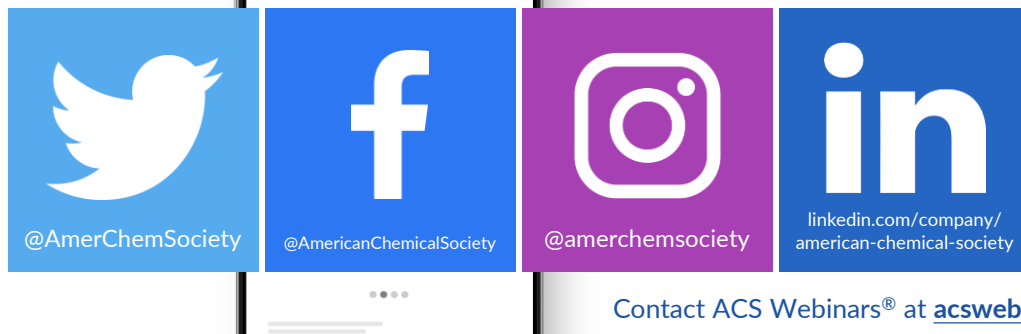


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4



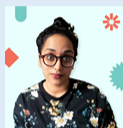
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6

## A Career Planning Tool For Chemical Scientists



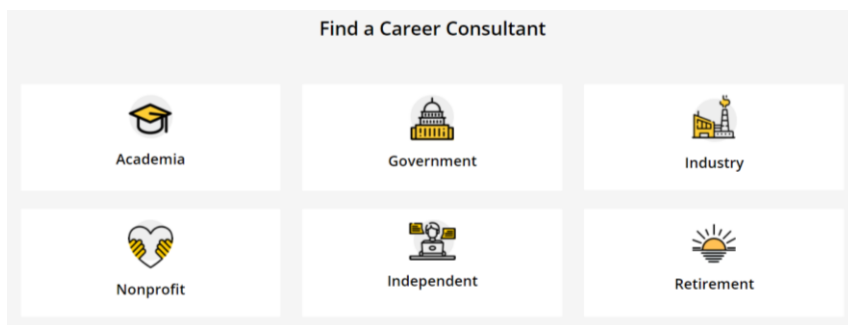
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7

7

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8

8



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10

10



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11

11

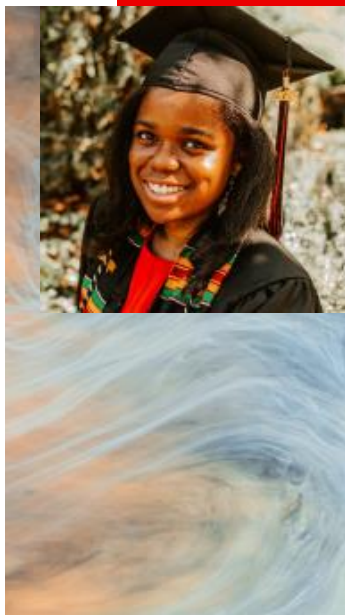
## ACS Scholar Adunoluwa Obisesan

BS, Massachusetts Institute of Technology, June 2021  
(Chemical-biological Engineering, Computer Science & Molecular Biology)

*"The ACS Scholars Program provided me with monetary support as well as a valuable network of peers and mentors who have transformed my life and will help me in my future endeavors. The program enabled me to achieve more than I could have ever dreamed. Thank you so much!"*

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12

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\*\*Adapted from definitions from the Ford Foundation Center for Social Justice:

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13

13

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15

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## More Than an Oil Change: Industrial Lubricants and Electric Vehicles



NEIL CANTER, PhD

Tech Advisor, Society of Tribologists and Lubrication Engineers (STLE)



DAVID CONSTABLE, PhD

Science Director, Green Chemistry Institute, American Chemical Society

*This ACS Webinar<sup>®</sup> is co-produced with ACS Green Chemistry Institute.*

17

17

## Topics

- ▶ **Introduction** – Reasons Automotive Industry is Moving to Electric Vehicles
- ▶ **Presentation Objective**
- ▶ **Manufacturing of Internal Combustion Engine Powered Vehicles (ICEV)**
- ▶ **Manufacturing of Electric Vehicles (EVs)**
  - ▶ Focus on Battery Electric Vehicles (BEVs)
- ▶ **Comparison of the Two Vehicle Types**
- ▶ **Projections for 2040**
- ▶ **New Metalworking Fluid Opportunities**
- ▶ **Summary**

18

18

## Move to Electric Vehicles

- ▶ Simplification of vehicle composition: fewer working parts
- ▶ Fewer parts in general to lubricate
- ▶ Energy efficiency is superior
- ▶ Emissions are lower

19

19

## Move to Electric Vehicles: Improved Efficiency

Parameter	BEV	ICEV
Energy Used	65 megajoules	230 megajoules
Energy Lost	15 megajoules	180 megajoules
% Energy loss	23%	78%

Both cars are driven for 100 kilometers. Both lose 50 megajoules due to rolling, braking and air drag. The BEV is 3.4 times more efficient than the ICEV

20

20

## Move to Electric Vehicles: Reduced Carbon Dioxide Emissions

Source of Emissions	ICEV	BEV – Electricity from Coal	BEV –Electricity from Renewable Energy
Driving	163	0	0
Electricity Generation	0	180	2
Fuel Production	30	0	0
Manufacture	31	48	48
<b>Total</b>	<b>224</b>	<b>228</b>	<b>50</b>

Emissions values in grams per kilometer

BEV using electricity from renewable energy produces 4.5 times fewer emissions than an ICEV.

21

21

## Presentation Objective: Detail the Challenge for Industrial Lubricants in Moving to EVs



- ▶ **Industrial lubricants needed to manufacture the components in an automobile**
  - ▶ Powertrain (Engine + Drivetrain)
  - ▶ Body
- ▶ **Fewer parts required to manufacture EVs than ICE powered automobiles**
  - ▶ ICE Powertrain - >1,000 components
  - ▶ BEV Powertrain – 200 components

Reference: <https://www.bcg.com/publications/2020/transformational-impact-of-electric-vehicles-on-auto-manufacturing>

22

22

## Suppliers Most Affected: Auto Parts Manufacturers



- **Major users of metalworking fluids**
- **Conduct a variety of metal removal and metal forming operations**
- **Shift to electric vehicles:** significant drop in demand for metalworking fluids and associated machine lubricants

23

23

## Auto Parts Suppliers Contribution to Automobiles

- **Internal Combustion Engines:** Parts suppliers contribute 50 – 55% of the value
- **Battery Powered Electric Vehicles:** 35 – 40% of the value
- **Largest impact – metal removal operations**
  - Small chip operations such as honing, lapping and grinding



Reference: <https://www.pwc.com/us/en/industries/industrial-products/library/electric-vehicles-supply-chain.html>

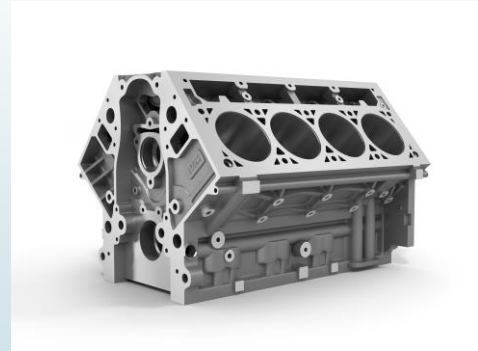
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## Manufacturing of Internal Combustion Powered Automobiles – Engine Parts

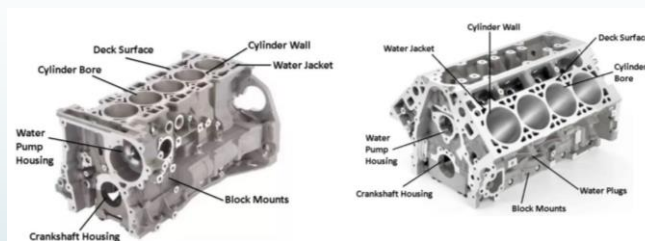
- Cam shafts
- Catalytic converter housings
- Cylinders and cylinder heads – spark plugs
- Exhaust pipes
- Fuel injectors and pumps
- Mufflers
- Oil pumps
- Radiators
- Water pumps



25

25

## Engine Blocks



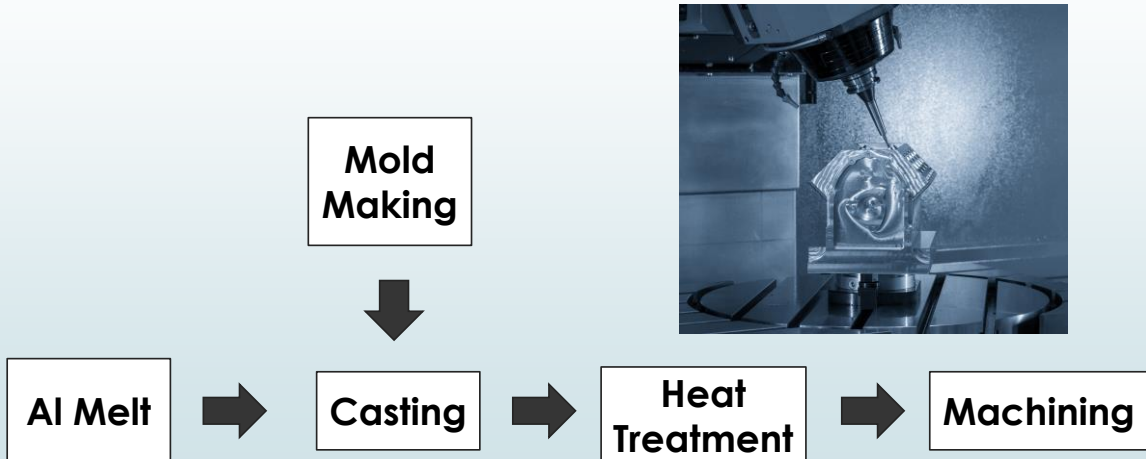
- All engine components are in the engine block
- Generally made from die cast aluminum alloys

**Largest application for metal removal fluids in ICE manufacture**

26

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## Engine Block Manufacturing Process



27

## Engine Block Manufacturing Process

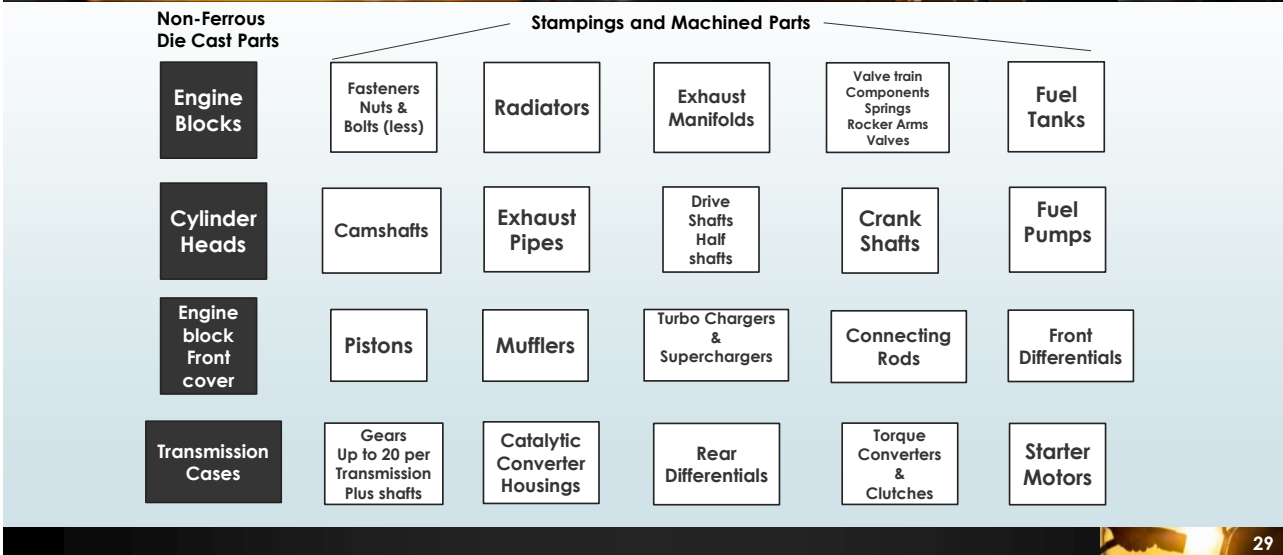


- Engine
- Clutches
- Transmission & Cases (Gears and Gear Sets)
- Drive Shafts
- Differentials (Gear & Gear Sets)
- Axles
- Brakes

In EVs, regenerative brakes will be used leading to less wear.

28

# Critical Automotive Parts Affected by BEVs— Significant Reductions



29

# Body Parts



- ▶ **Main supporting structure of an automobile**
  - ▶ Bumper
  - ▶ Cabin parts
  - ▶ Frame
  - ▶ Hood

Mainly use metal forming fluids no change in usage anticipated in transitioning to BEVs

30

# Industrial Lubricants Required



- **Metalworking Fluids**
  - Metal Removal Fluids
  - Metal Forming Fluids
  - Metal Treating Fluids
  - Rust Preventives
- **Die release fluids**
- **Machine lubricants**
  - Hydraulic Fluids
    - Straight oil, ester and water glycol
  - Gear Oils
  - Spindle Oils
  - Way Lubricants

31

31



## Audience Survey Question

ANSWER THE QUESTION ON THE INTERACTIVE SCREEN IN ONE MOMENT

**What type of vehicle do you currently drive?**

- Hybrid vehicle
- Internal combustion engine powered vehicle
- Battery electric vehicle
- Do not own or lease a vehicle

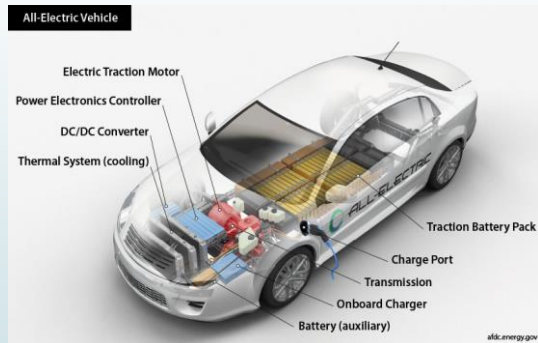
\* If your answer differs greatly from the choices above **tell us in the questions window!**

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# Battery Electric Vehicle Manufacturing



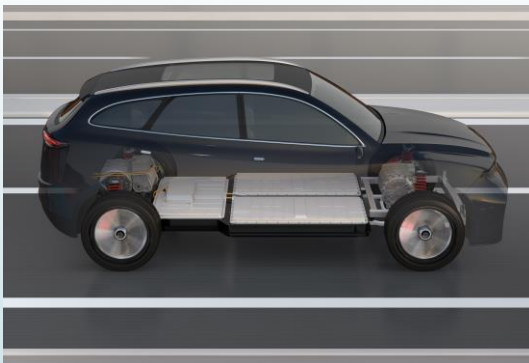
## Components

- Battery Pack
- DC-AC Converter (powertrain electronic control unit)
- Powertrain
- Electric motor
- On-board battery charger
- Additional copper wiring

33

33

# Battery Pack Basic Component – Electrochemical Cell



## For a lithium-ion battery

- **Anode** (typically graphite)
- **Cathode** (various lithium metal oxides)
- **Electrolyte** (organic solvents such as ethylene carbonate)
- **Separator** (polymer based typical polyolefins such as polyethylene)

**Assumption that battery uses liquid electrolyte. Solid state lithium-ion batteries are currently under development**

34

34

## Electrochemical cells organized into modules

Meyer, "Battery-pack of the Nissan Leaf," December 8, 2010, <https://commons.wikimedia.org/wiki/File:BatteryPack-Leaf.jpg>.



- Multiple cells in a case with battery terminals attached
- Number of cells used varies by EV manufacturer
- Range from 4 to 444 cells

Reference: Coffin, D. and Horowitz, J. (2018), "Supply Chain for Electric Vehicle Batteries US International Trade Commission - [https://www.usitc.gov/publications/332/journals/the\\_supply\\_chain\\_for\\_electric\\_vehicle\\_batteries.pdf](https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf)

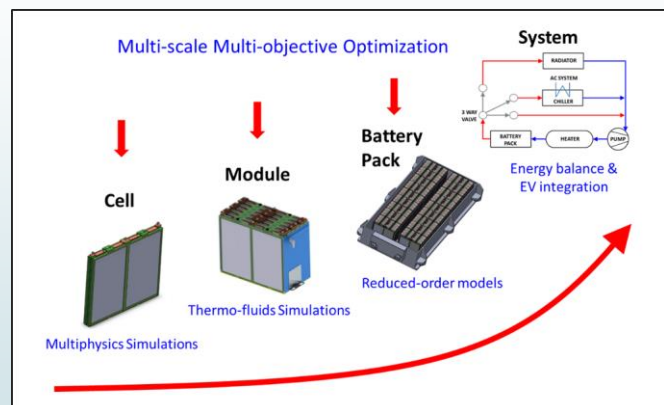
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## Battery modules organized into packs

### Battery packs contain

- Modules
- Electrical connections
- Cooling equipment

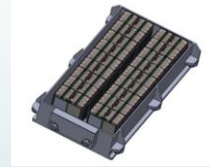
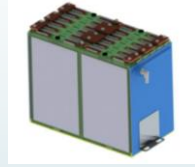


Main operation is stamping so metal forming lubricants are required

36

36

## Battery Pack Manufacture



Electrochemical  
Cell



Module



Pack

37

37

## ICE Powered Automobiles vs. BEVs

- Differences in Production of Both Automobile Types
- Effect on Demand for Industrial Lubricants

38

38

# Critical Automotive Parts Affected by Electric Vehicles

Battery Cases  
Regenerative Brake Systems

Approximately 90% Fewer Parts related to Drive Train Components

Smaller radiators for battery cooling  
Some gears But minimal

Significantly Less Demand for Machined Parts

Copper wire Increase  
Power Management Systems

Significantly Less Demand for Die Cast Parts

Electric Motor Housings From 1 to 4 per vehicle

Significantly Less Demand for Heat Treated Parts



# Fluid Reductions Affected by BEV

## In Manufacturing Plants

- Metal Removal Fluids
- Stamping Fluids
- Way Oils
- Heat Treat Quenching Fluids
- Spindle Oils
- Die Cast Release Fluids
- Hydraulic Oils
- Gear Oils (Machine use)
- Corrosion Protection Fluids (RPs)







## Audience Survey Question

ANSWER THE QUESTION ON THE INTERACTIVE SCREEN IN ONE MOMENT

**What is the single biggest obstacle preventing the rapid move to battery electric vehicles?**

- **A) The cost performance of battery powered electric vehicles is not comparable to internal combustion engine powered vehicles.**
- **B) The electric grid is not sufficiently stable to handle a much higher demand for power during the recharging of batteries.**
- **C) The time it takes to recharge batteries is too long.**
- **D) Batteries used in electric vehicles are not reliable enough.**

\* If your answer differs greatly from the choices above **tell us in the questions window!**

41

41

## Projections for 2040



► **Electric Vehicle Sales**

► **Industrial Lubricant Sales**

Source: <https://www.bloomberg.com/news/articles/2021-08-09/at-least-two-thirds-of-global-car-sales-will-be-electric-by-2040>

42

42

## Projected Increase in Sales of EVs by 2040:

Source Bloomberg NEF\* - Published 8/19/2021

### Analysis covers BEVs and plug-in hybrids

- ▶ More than 2/3 of global car sales will be EVs by 2040
- ▶ 3 million units in 2020 to 66 million in 2040
- ▶ Sales of ICEs peaked in 2018
- ▶ In the EU, battery EVs will be less expensive than ICEs by 2030
- ▶ Battery cost has dropped from \$ 1.20/ kW in 2010 to less than \$0.20/ kW in 2020

Source: <https://www.bloomberg.com/news/articles/2021-08-09/at-least-two-thirds-of-global-car-sales-will-be-electric-by-2040>

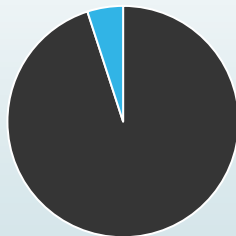
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43

## Bloomberg NEF Current and Projected New Passenger Car Sales

### 2020

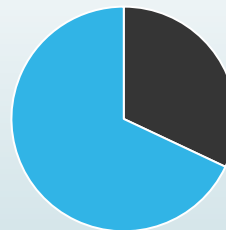
Passenger Car Sales



■ ICEs ■ EVs

### 2040 Projection

Passenger Car Sales



■ ICEs ■ EVs

Source: <https://www.bloomberg.com/news/articles/2021-08-09/at-least-two-thirds-of-global-car-sales-will-be-electric-by-2040>

44

44

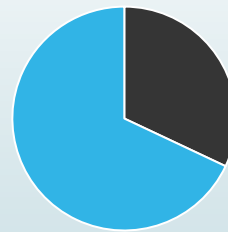
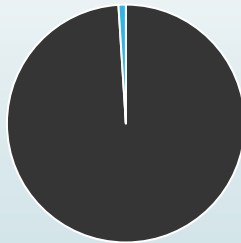
# Bloomberg NEF Current and Projected Light Commercial Vehicles (Pickup Trucks and Vans)

2020

2040 Projection

Light Commercial Vehicle Sales

Light Commercial Vehicle Sales



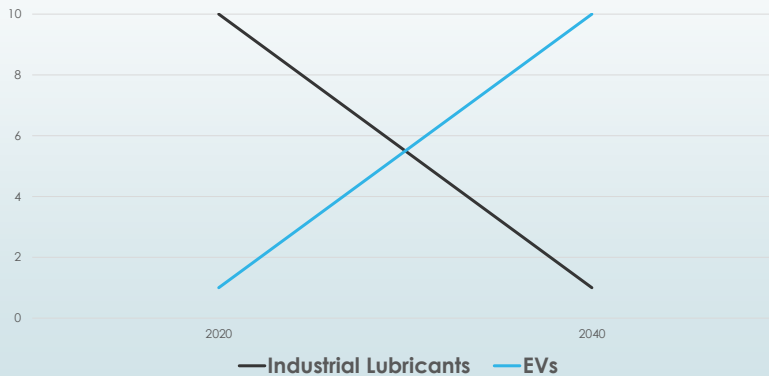
■ ICEs ■ EVs

■ ICEs ■ EVs

Source: <https://www.bloomberg.com/news/articles/2021-08-09/at-least-two-thirds-of-global-car-sales-will-be-electric-by-2040>

# Electric Vehicle Sales Vs Industrial Lubricant Sales: "X" Marks the Spot

Sales Trends: 2020 - 2040



— Industrial Lubricants — EVs

Source: <https://www.bloomberg.com/news/articles/2021-08-09/at-least-two-thirds-of-global-car-sales-will-be-electric-by-2040>

# New Metalworking Fluid Opportunities

- ▶ **Battery Casing:** Primarily produced using metal forming operations (bending, blanking, drawing, embossing)
- ▶ **Electric motor housing manufacture:** Die casting (typically aluminum)
- ▶ **Increased demand for copper wire:** wire drawing – a metal forming operation

Source: <https://www.bloomberg.com/news/articles/2021-08-09/at-least-two-thirds-of-global-car-sales-will-be-electric-by-2040>

47

47



## Audience Survey Question

ANSWER THE QUESTION ON THE INTERACTIVE SCREEN IN ONE MOMENT

**What is the most difficult issue a consumer has with transitioning from driving an internal combustion engine powered vehicle to a battery powered electric vehicle?**

- The car makes too little noise in use.
- Finding a suitable charging station.
- Uncertainty about how to handle the new electronic equipment in the car.
- Concern about how far the car will travel before needing to be recharged.

\* If your answer differs greatly from the choices above **tell us in the questions window!**

48

48

## Summary

- ▶ **Industrial lubricant use will decline significantly!**
- ▶ **Growth of EVs will impact manufacturing initially**
- ▶ **Fluids to decline include metalworking fluids** (specifically metal removal fluids), **hydraulic fluids, gear oils, way lubricants, heat treat** (quenching) **fluids and die caste fluids**
- ▶ **Demand for metal forming fluids used to manufacture battery casings and copper wire will increase**

49

49

## How rapidly will this transition take place?



- ▶ Corporate sustainability
- ▶ Governmental regulations
- ▶ Battery Development
- ▶ Consumer acceptance?
- ▶ Infrastructure!
  - ▶ Supply chain!

50

50



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51

51

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52

52



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53

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54



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56

56



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57