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Nurturing Innovations - Fostering Business

IMPROVEMENTS IN BATTERY COOLING TECHNOLOGIES

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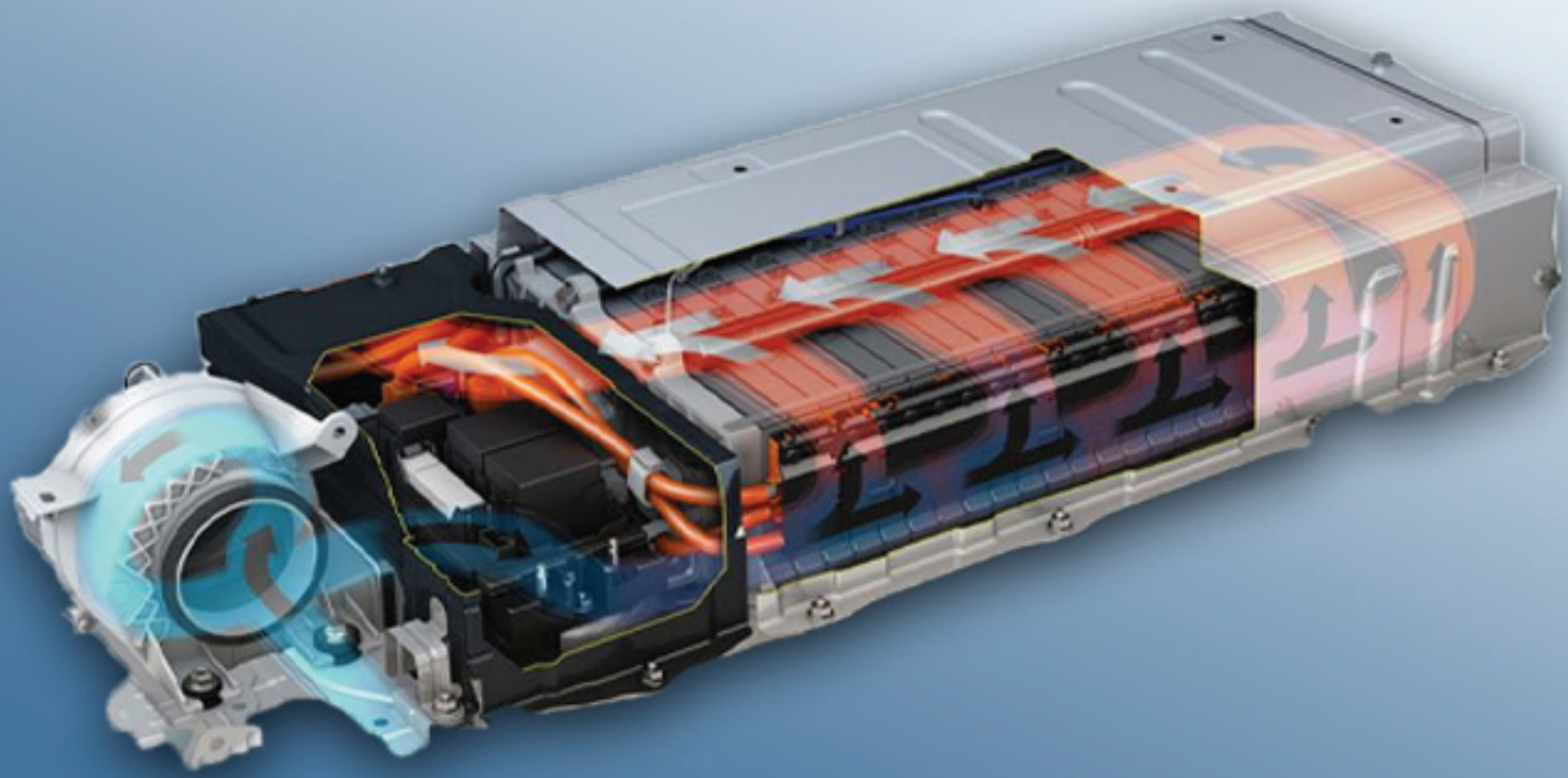

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Introduction

IMPORTANCE OF BATTERY COOLING

Modern electric cars are provided with latest technologies that are capable of being charged at very fast rates which are expected to reach even higher rates with future vehicle models and better charging infrastructure models.

A downside of these charging rates is that they cause the battery to heat up significantly.

High temperatures are inversely proportional to the lifespan of lithium-ion batteries and the risk of thermal runaway in batteries is also increased.

High-density batteries being developed are also prone to rapid heating as they have closely packed electric charges.

Hence, Efficient Cooling is a major requirement to manage the temperature of batteries during fast charging and high-density batteries.

Cooling during charging increases the efficiency of charge transfer and reduces degradation of the battery, allowing the battery to retain capacity over its lifetime so that maximum EV range can be maintained.

High efficiency cooling systems can increase EV reliability and the overall EV adoption rate globally.

A few of the approaches being taken to increase cooling efficiency of EV batteries are explained in Section 2.

APPROACHES IN COOLING TECHNIQUES

1. NEW BATTERY HOUSING DESIGNS

One of the approaches to provide efficient battery cooling within the battery pack is by designing optimized housing of the battery packs.

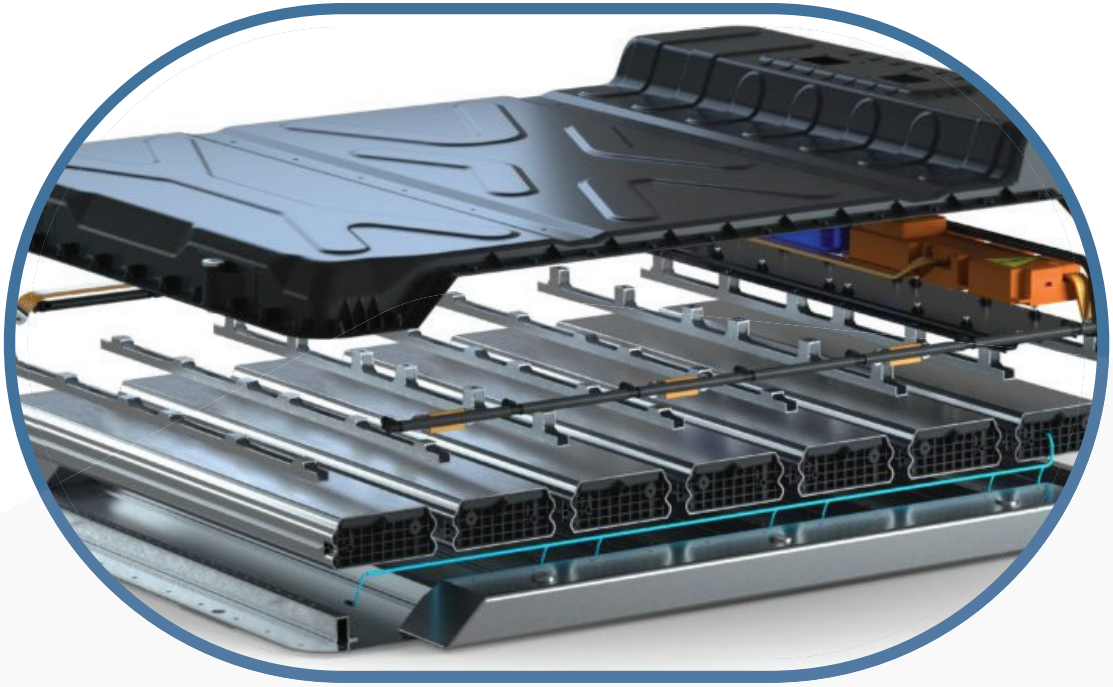
The battery packs are designed in such a way that the coolant flows with least flow resistance possible through the cooling circuit. An improved design can also mitigate the risk of coolant leakage and damage to the cells.

New materials are also a key aspect in designing new battery modules to further increase cooling efficiency of the system as materials enabling better heat rejection to environment lead to better cooling performance.

For Example:

A consortium consisting formed by Lorenz Kunststofftechnik, Forward Engineering, Evonik, LION Smart, Vestaro, and Minth has developed a battery pack for electric vehicles having lightweight construction.

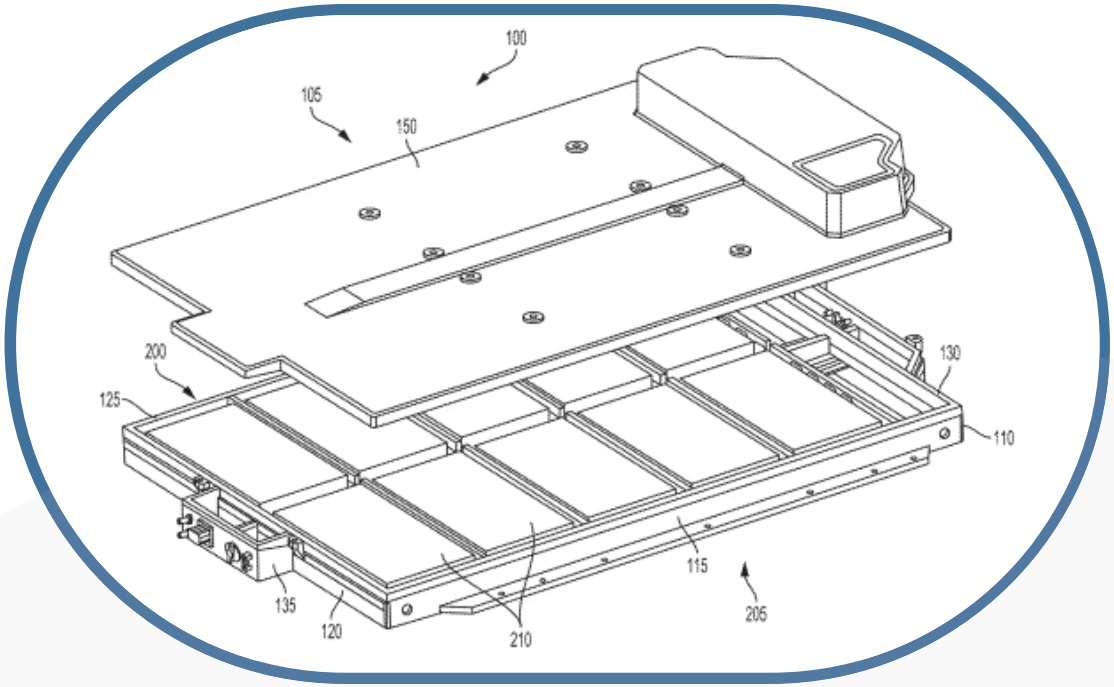
The design uses Glass Fiber-reinforced Epoxy Sheet Molding Compound which is more than 10% lighter than commonly used materials. The material meets all fire resistance requirements and can be molded easily and is safe even under extreme conditions.



For Example:

SF motors received a patent related to a battery housing comprising a bottom panel including a top surface and a bottom surface. A battery module is mounted within a cavity of the housing for the battery pack and supported by a second side wall. A cold plate outlet is coupled with an outlet port to release the coolant from the cold plate. A distribution plate is mounted along the bottom surface of the bottom panel which includes a main channel to convey the coolant from the conduit to the cold plate by an inlet port of the bottom panel and the cold plate inlet.

The main advantage of this design is reduced risk of coolant leakage within the battery pack.



2. NEW COOLANTS

Standard EV batteries packs use air cooling or cold plate cooling using water/ethylene glycol or a refrigerant. Such thermal management systems limit the charging rates or the number of fast charge cycles that can be carried out.

Other challenges that arise while using these fluid is that they can lead to corrosion if they leak and require a secondary cooling system to reject heat to environment.

Major players in the domain are countering these challenges by developing innovative coolants to be used for battery cooling systems in the electric vehicles.

For Example:

Castrol has commercialized an advanced direct battery e-thermal fluid that enables upcoming EVs to charge more rapidly and offer increased performance, protection, and sustainability.

The Castrol ON e-thermal fluid is an innovative dielectric fluid formulation specifically for 'direct' cooling, where the fluid circulates within the module and in direct contact with individual battery cells.

3. NEW IMMERSION COOLED BATTERIES

Standard EV batteries packs use air cooling or cold plate cooling using water/ethylene glycol or a refrigerant. Such thermal management systems limit the charging rates or the number of fast charge cycles that can be carried out.

Other challenges that arises while using these fluid is that they can lead to corrosion if they leak and require a secondary cooling system to reject heat to environment.

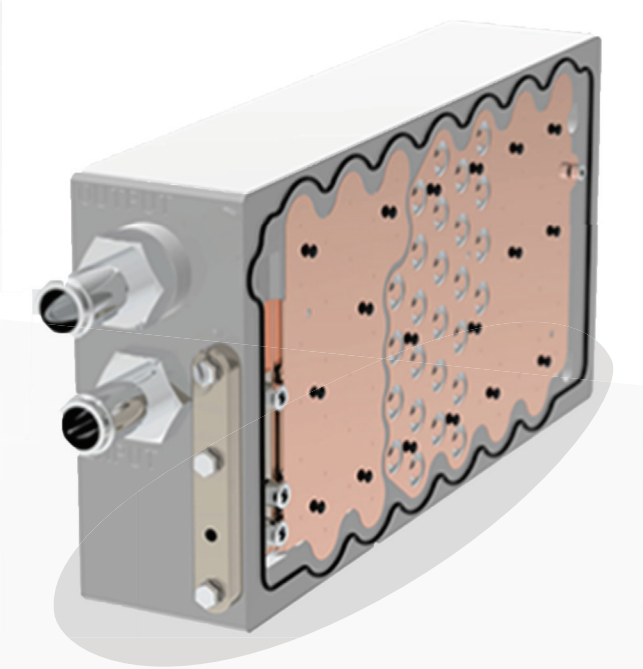
Major players in the domain are countering these challenges by developing innovative Immersion cooled batteries for electric vehicles.

For Example:

M&I Materials, WMG and Ricardo are collaborating in a project called i-CoBat to develop and to demonstrate a new type of EV battery cooling system based on cell immersion cooling using a dielectric fluid.

This collaboration is aimed at improved power output and cell longevity, faster charging rates and low costs of production.

Dielectric fluids are non-conductive and can come into direct contact with battery cells. This means that heat transfer from the cells do not require a secondary indirect cooling system. Direct liquid immersion cooling enables a simpler thermal management solution and simple battery pack design.

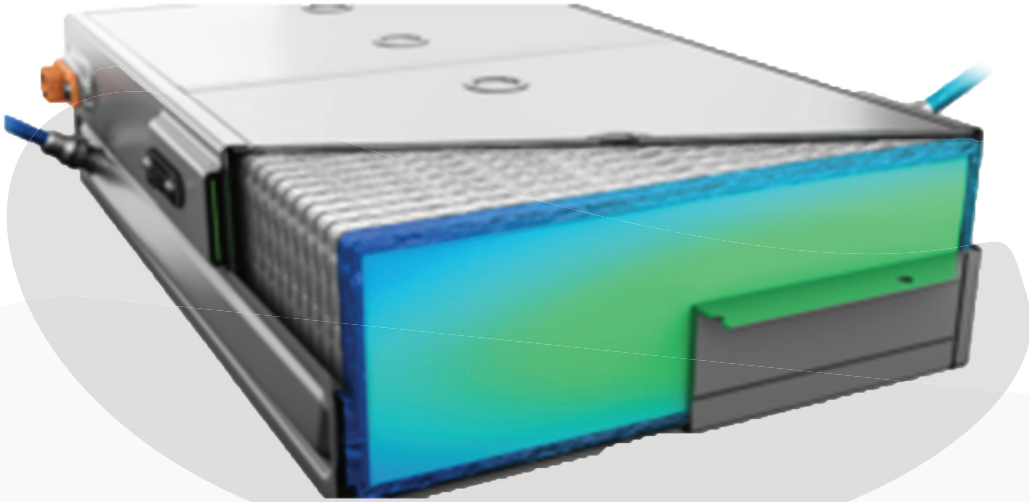


For Example:

MAHLE has developed a new cooling system for batteries.

A non-conductive coolant flows around the cells to cool them down significantly during charging and the overall temperature is distributed gradually.

The battery is presented in a compact form factor that can make electric cars cheaper and efficient.



4. NEW THERMAL INTERFACE MATERIALS

Thermal interface materials are placed between the heat-generating electrical and electronic components and the heatsinks that dissipate the heat into the environment. The main purpose of the TIMs is to improve the thermal contact between hot and cold surfaces and to maximize the heat transfer.

Currently, the most widely used TIMs are composite materials consisting of an organic paste-like or liquid polymer combined with with thermally conductive fillers materials such as aluminum oxide, aluminum nitride, graphite, or metal particles.

These materials have less than desired durability and thermal resistance for high density and fast charging components. So, new materials are being implemented to achieve these properties and reducing the manufacturing and processing cost of the existing (and newly developed) TIMs.

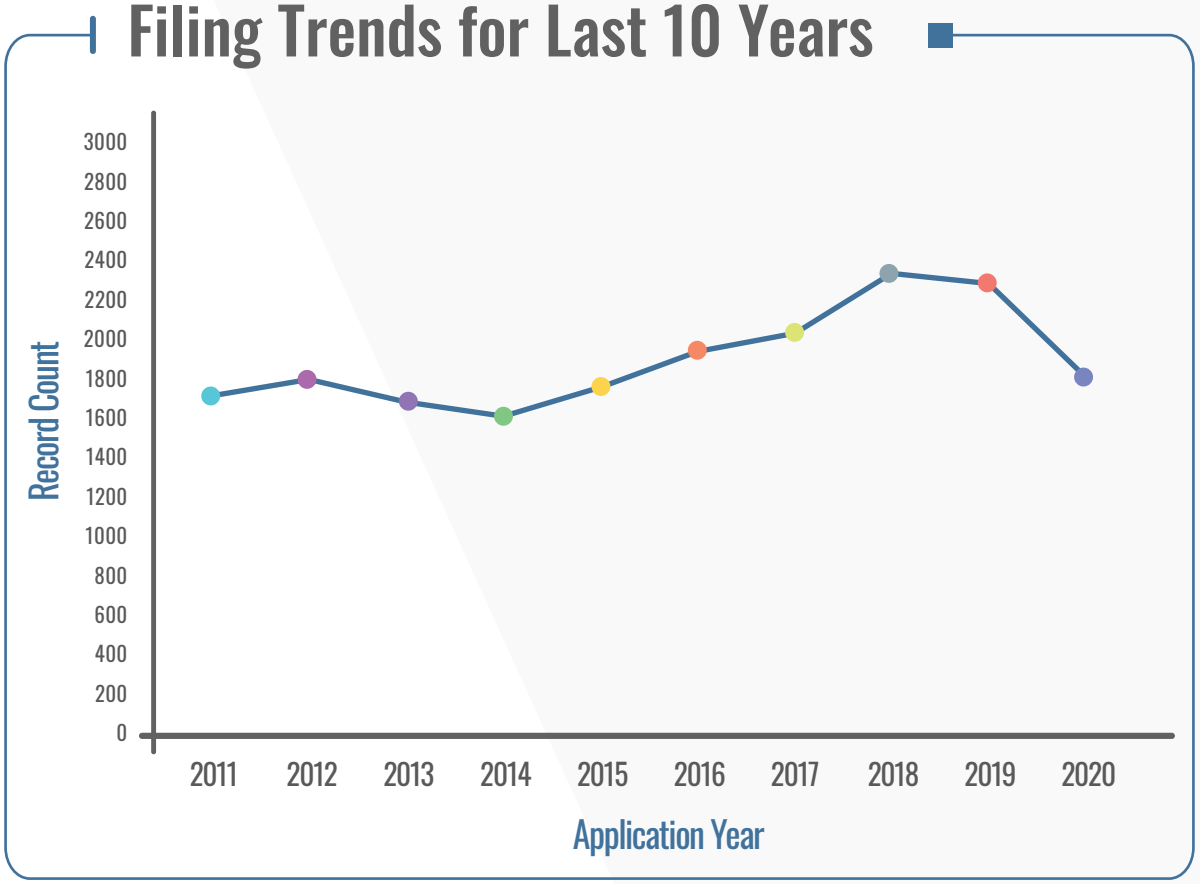
For Example:

Tsinghua University in China and the Georgia Institute of Technology in the USA collaboratively developed a low-cost and high-performance soft porous copper–indium foam-like structure, which exhibits a superior thermal conductivity of 50 Wm−1K−1 while having reduced weight, enhanced durability, and excellent vibration and thermal stress resistance as compared to the traditional TIMs.

PATENT TRENDS

BATTERY THERMAL MANAGEMENT FILING TREND – LAST 10 YEARS

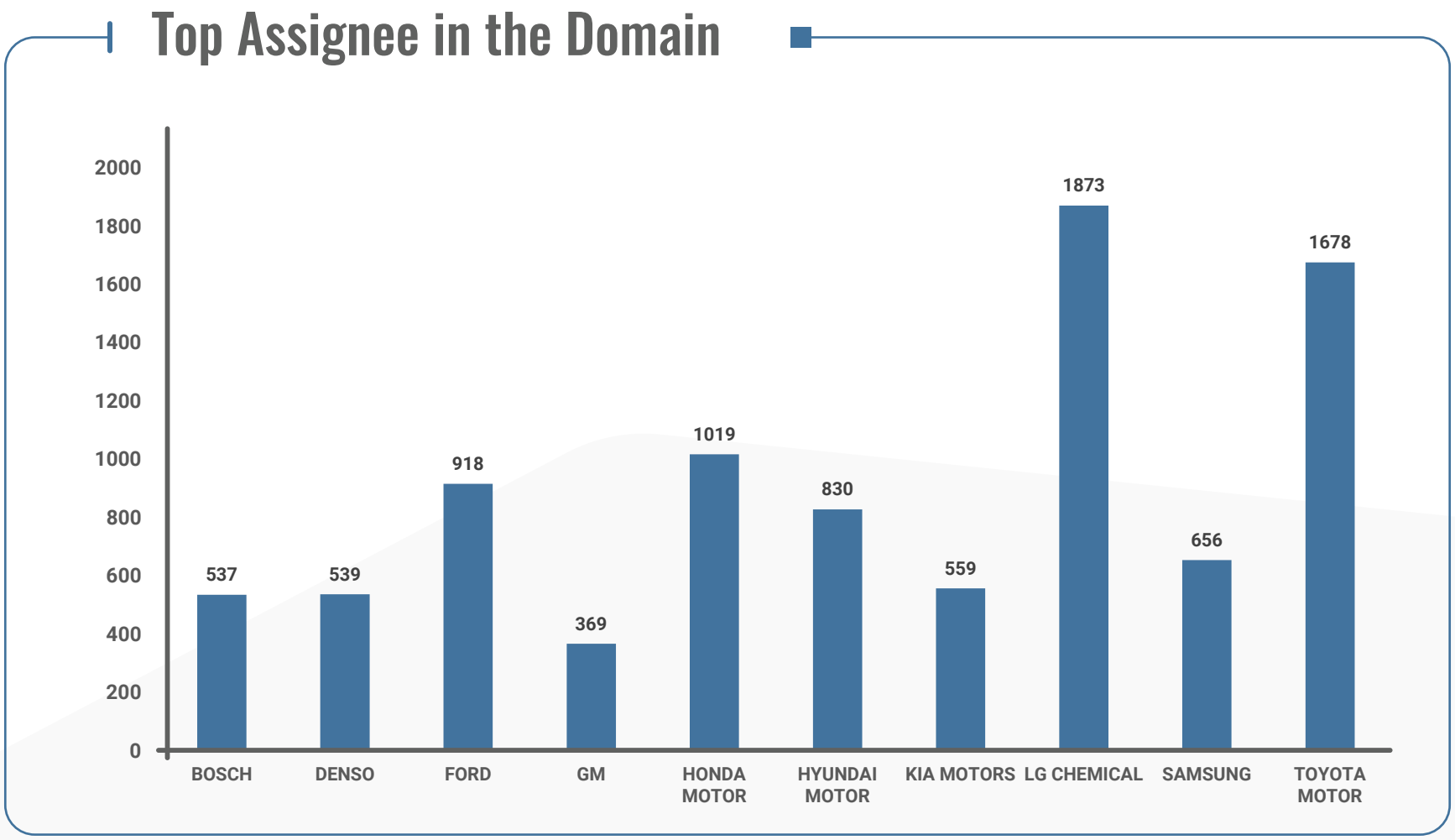
The patent filing trend for last 10 years showcases the increase in patent filings beginning from 2014 (more than 1500 filings)and peaking in 2018 (more than 2800 filings). The trend took a dip in 2019 and 2020 largely due to the COVID-19 pandemic.



BATTERY THERMAL MANAGEMENT – TOP 10 ASSIGNEE

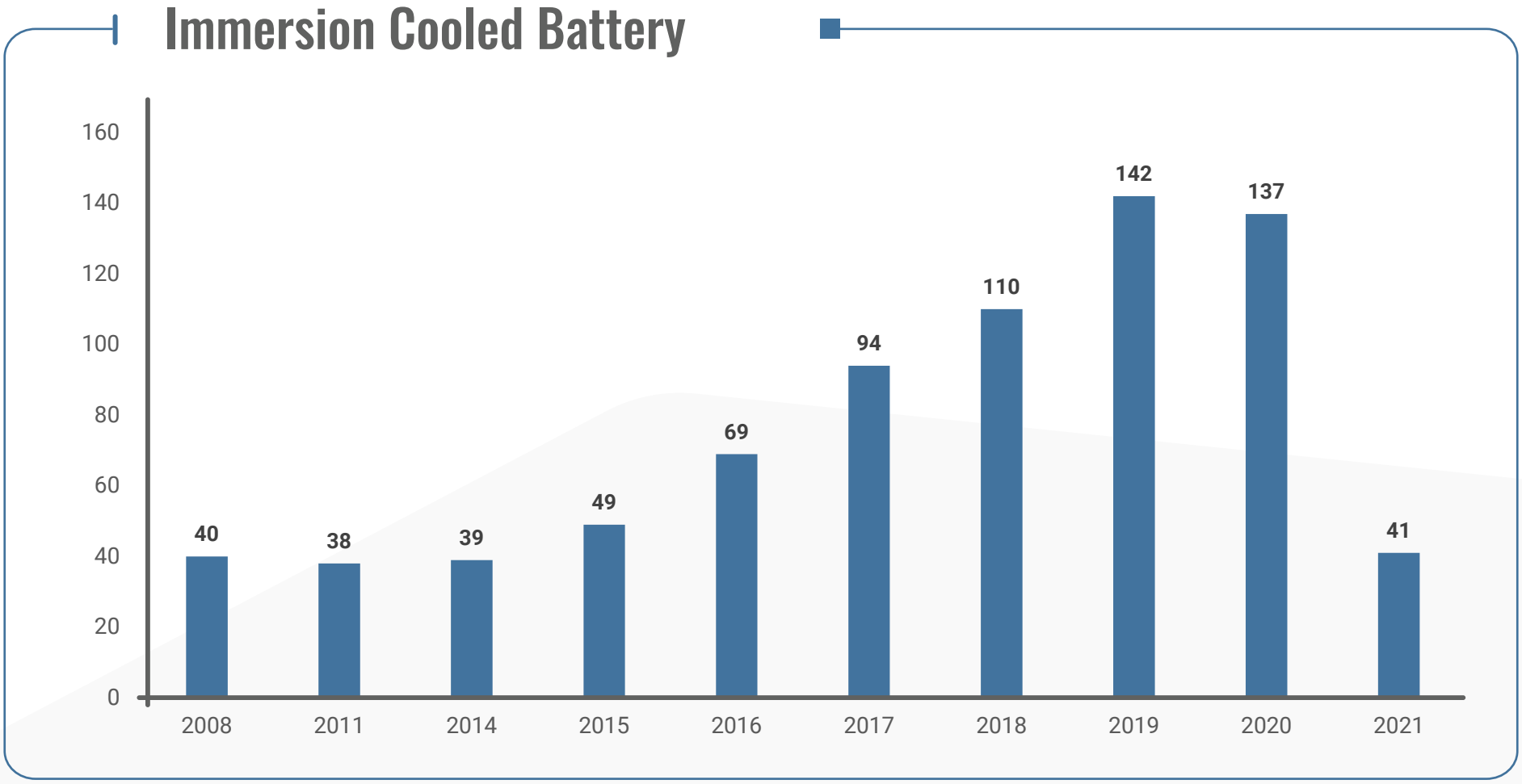
LG Chemical seems to be the strongest player in the domain with over 1,800 publications followed by Toyota Motor with around 1,600 publications.

US based players seem to be lagging behind their Asian counterparts in the domain.



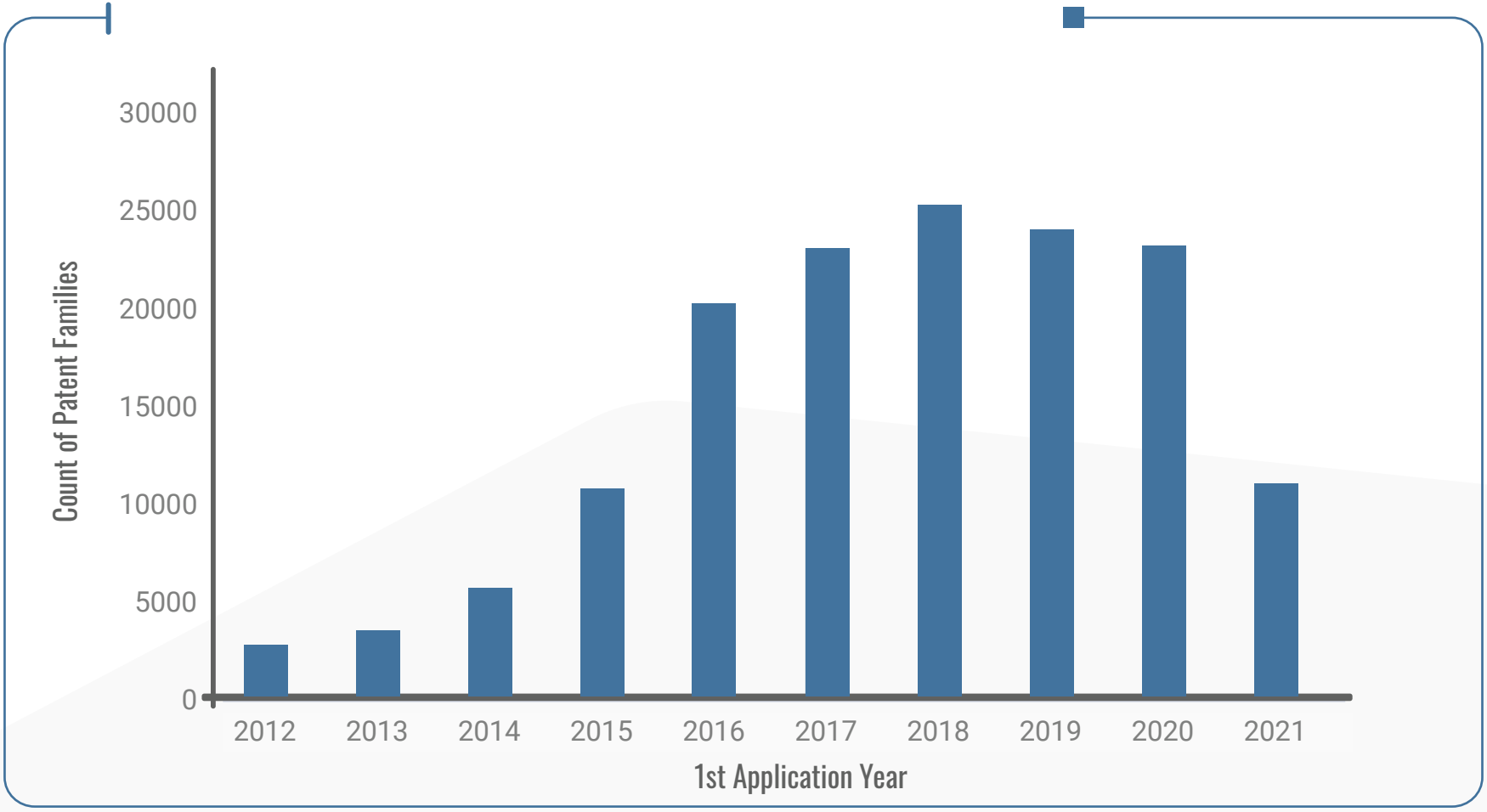
BATTERY THERMAL MANAGEMENT – IMMERSION COOLING FILING TREND

Immersion cooled EV batteries are gaining momentum since last 5 years. Patent filings related to Immersion cooled batteries peaked in 2019 with more than 140 filings and took a huge dip in 2021. This may be due to the fact that manufacturers were focusing on production instead of R & D to cover up losses due to the global pandemic.



OVERALL ELECTRIC VEHICLE FILING TREND – LAST 10 YEARS

Overall filings related to electric vehicles took a sharp turn in 2013 and kept taking giant leaps till 2017. The filings peaked in 2018 but saw a year-on-year dip from 2019 to 2021, owing to the global pandemic. This is due to growing demand and adoption rate of electric vehicles in the last decade. The domain is expected to grow in gradually from 2023-2030 as the industry recovers from the hit of the global pandemic in last 2 years.

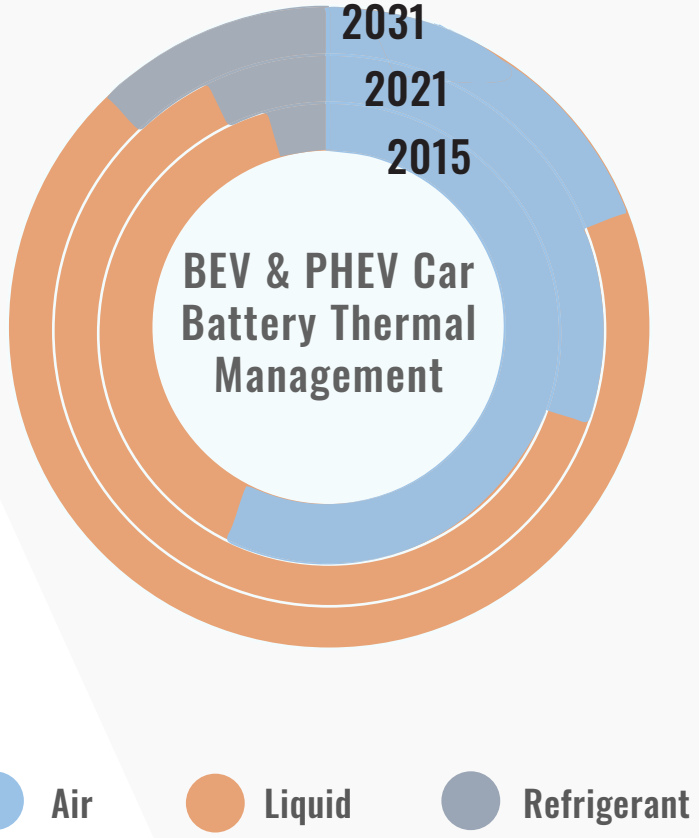


MARKET ANALYSIS – A GLIMPSE

MARKET DISTRIBUTION BASED ON TYPE OF COOLANT USED

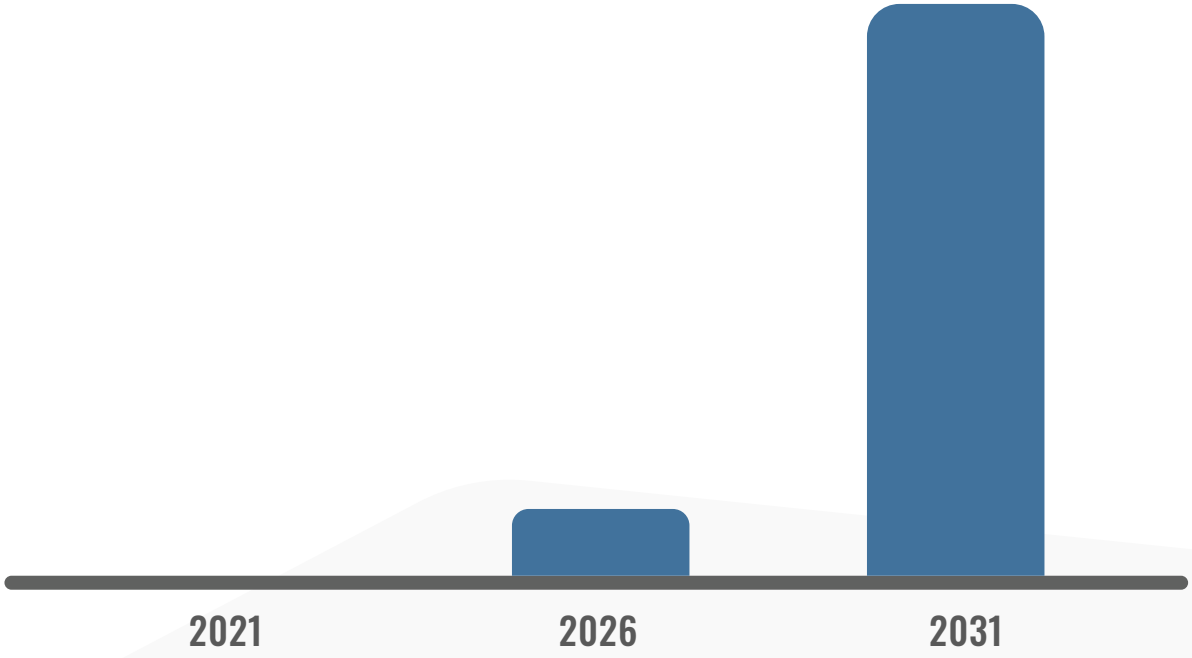
Market share of the liquid coolant-based battery thermal management systems have grown rapidly and will continue to do so in the next 10 years.

On the other hand, the market share for passively cooled battery thermal management systems is decreasing as they are no more viable for new fast charging techniques.



RISE IN DEMAND FOR DI-ELECTRIC FLUIDS

With the rise in adoption of immersion cooled batteries in modern electric vehicles, the demand for Di-Electric fluids is expected to grow at an un-precedented rate.

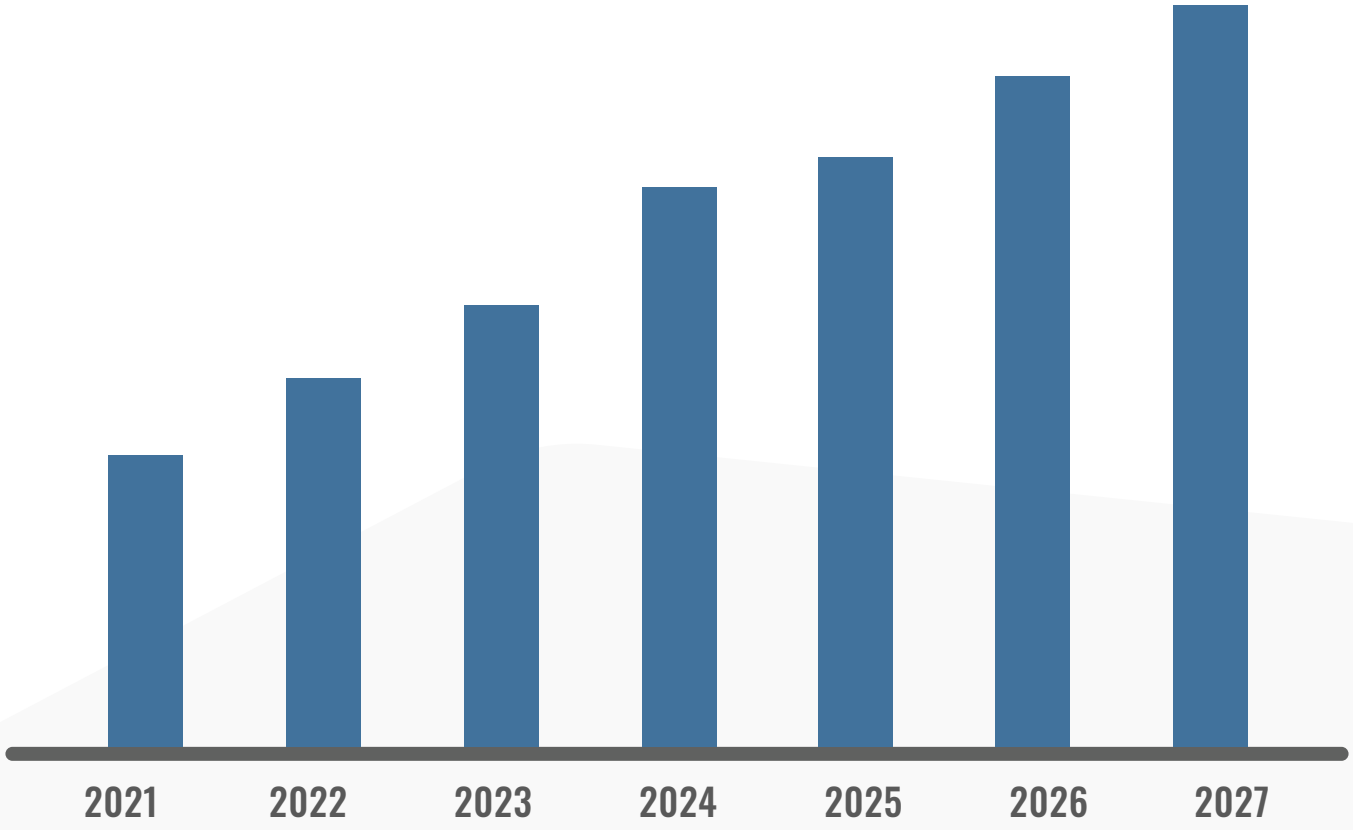


GROWING DEMAND FOR EVs

Electric vehicle battery market is expected to grow at a CAGR of 18.0% over the forecast period.

The expected market size of electric vehicle batteries is USD 120 billion by 2027.

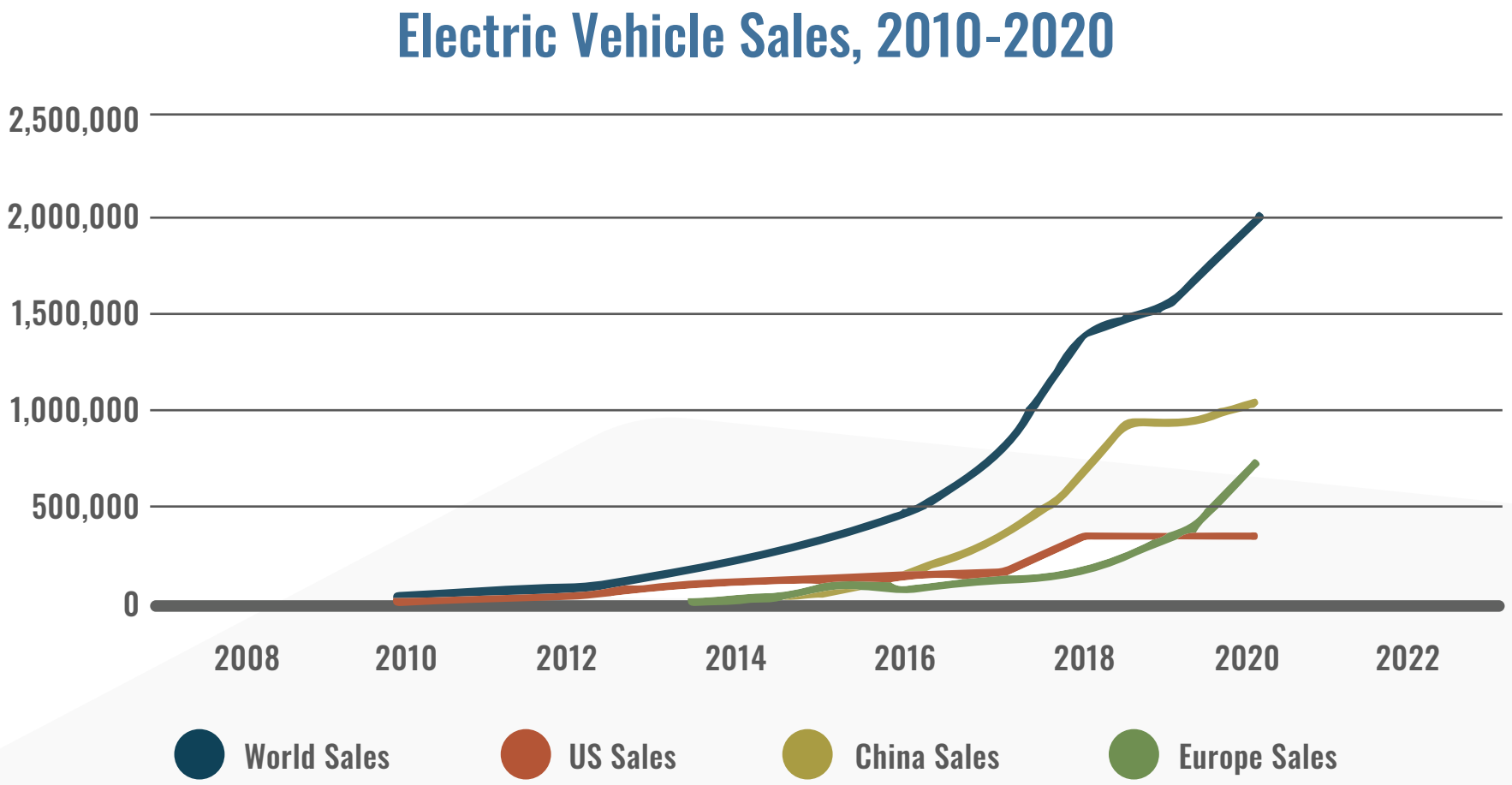
This is largely due to growing concerns about the environment and hence an increase in EV adoption rate.



INCREASING ADOPTION RATE OF EVs

The growing concerns about the environment and increasing viability factors related to EVs such as fast charging, long ranges and charging infrastructures are all leading to an increase in global EV adoption at a very high rate.

China is leading the trend followed by Europe.



CONCLUSION - OPPORTUNITIES

Electric vehicle market, especially the battery and thermal management segments are taking off in a huge wave.

This presents all stakeholders with a ripe opportunity to focus on **battery and battery cooling related R & D** to standardize high efficiency, low cost and easy to manage battery technologies and take full advantage of this growth over the next decade.

With major countries focusing on environmental concerns and growing consumer demand for electric vehicles, early strategic moves will provide long term advantage.

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