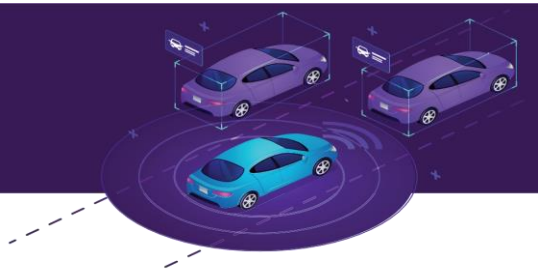
# Electric vehicle Innovation Intelligence

The most comprehensive global guide to innovations in eMobility

January 2021

From EVNext, A division of Energy Alternatives India



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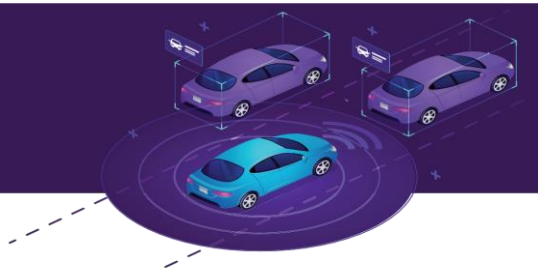

# Foreword

E-mobility is all the rage today. There's hardly a day in any part of the world during which there isn't some announcement about electric vehicles.

But electric vehicles still contribute less than 1% of total automobiles on the road, and e-mobility currently contributes only in a small way to the world's transportation.

But all these could change quite fast. Once the world starts the post COVID recovery, climate change and environmental protection are likely to become even more dominant themes than what they were prior to the pandemic.

2022 is likely to be the landmark year when electric mobility gets into a much higher growth orbit, and a significant shift starts in the transport sector with e-mobility at the core.

Such a shift, which could continue for a decade or even longer, will be propelled mainly by innovation. Innovation across the entire e-mobility value chain.

This is why our research at EVNext has been dedicated to this topic. The main thrust of EVNext's work is to understand electric mobility innovation across all its dimensions.

EVI$^2$ is our flagship intelligence guide on e-mobility innovation. By providing the results of comprehensive research and analyses of e-mobility innovation happening across the world, and across the entire e-mobility value chain, in one place, EVI2 can provide significant benefits to all stakeholders' keen on investing in e-mobility.

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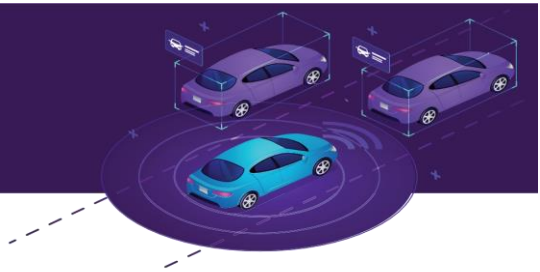


# Imperatives for EV innovations

The role of innovation is critical in accelerating e-mobility.

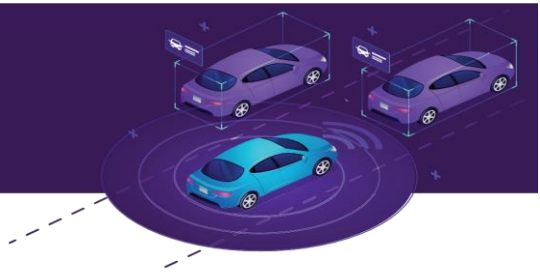
Consider the following:

- EVs cost almost 50% higher than their equivalent ICE counterparts
- The EV battery can travel only 3% of the distance of gasoline or diesel for the same weight (put another way, EV battery energy density is only about 3% that of liquid fossil fuels).
- Most battery charging takes at least an hour, against a couple of minutes for filling gasoline or diesel.
- EVs use significant amounts of Lithium and Cobalt, both scarce metals and some present in conflict prone geographies.
- Production and storing hydrogen still pose significant challenges in economies, operations and safety.

For EVs to play a comprehensive and vital role in the emerging sustainable transport ecosystem, it is imperative that all these challenges are overcome within the next few years.

This is no mean task. If it is to be achieved, a significant number of innovations need to happen across many points in the e-mobility value chain, and perhaps in some related sectors even outside the e-mobility value chain.

And the innovations need to span multiple genres - not just technical, engineering and scientific, but also in business models, government policies, and even in the way companies communicate and market their products and solutions.



# Why will investing in innovations be critical for all EV stakeholders?

E-mobility is attracting the attention of investors from a multitude of stakeholder segments.

Some of these stakeholders are obvious: The auto OEMs and auto component manufacturers and battery makers. But the expected size of the e-mobility transformation is so vast and all pervasive that we at EVNext expect that investments are likely to happen from over 25 different industry and business sectors, some far removed from transport.

For all these stakeholder segments, one of the key reasons to invest is because they are keen to be a winning part of the future transport ecosystem.

The e-mobility sectors, opportunities and ideas that win in future - be it the short term or long-term future - will be those built on powerful innovations. Innovations based on well-thought-out concepts and technologies. Innovations built with a long-term future in mind. And innovations that are aligned to a future world that is a combination of sustainability and technology prowess.

This is why it is important for any stakeholder keen on the e-mobility sector to get a deeper understanding of the innovations driving value addition in the part of e-mobility that is of interest to them. Having this understanding will enable them to invest their time, money and resources on ideas or solutions that are strongly supported by innovations which in turn can provide their business with a long-term competitive advantage.

# How EVI2 was prepared

This comprehensive expert guide EVI2 (Electric Vehicle Innovation Intelligence) was developed by EVNext to fill a gap in the market - while almost every stakeholder knows that innovation is the key to success, they do not have a clear idea and blueprint on how to undertake such innovation.

While an effective innovation for any company or stakeholder will be customised and fine-tuned to many aspects that are specific to the stakeholder - size of business, geography, product, target market segment, company aspirations - there are also aspects of innovations common for specific stakeholders.

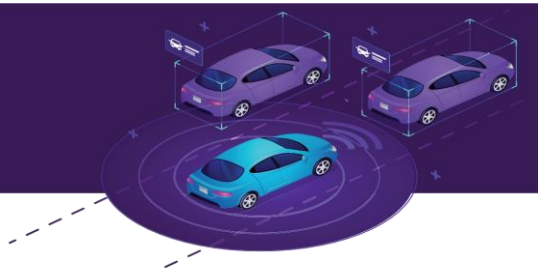
Since the e-mobility movement started around 2016, thousands of companies, startups, research organizations and innovators have undertaken valuable research and innovation efforts. Some of these are highly technical, some innovations are based on concepts and business models, and many others are based on valuable incremental innovations and tweaks to existing solutions.

Acquiring knowledge of these innovations - which run into thousands - in a format that enables stakeholders to relate these innovations to their own ecosystem can be a powerful way for these stakeholders to come up with far superior products or solutions that will dramatically enhance the chances of their success in the marketplace.

EVI2 will enable many different EV industry stakeholders to acquire such focussed intelligence from the global e-mobility ecosystem. Our approach to identifying innovations and analysing them for the stakeholders' benefit include the following aspects:

| | |
|---|---|
| **IDENTIFY**<br><br>A large focus of EVI2 has been to provide stakeholders with effective examples of innovations. The guide contains over 1500 innovations in all! | **EVALUATE**<br><br>Every innovation that has been included in EVI2 has been evaluated on a few basic parameters to ensure that there is significant strategic value in the innovation, and not just cosmetic value. |
| **RELATE**<br><br>We appreciate that even the best technical innovation could fail in the market if there is no innovation on the business front. We have hence made every effort to provide innovations that different stakeholder segments all along the EV value chain can relate to and find value in. | **HIGHLIGHT**<br><br>Our team's senior members have put in significant time and efforts to find out the relevant and powerful insights behind each innovation and highlighted them such that these insights can be utilized by relevant stakeholders |

Our emphasis on the above four aspects all through the EVI2 guide will ensure that readers will benefit immensely from the global e-mobility innovations in ways that make most sense to their business.

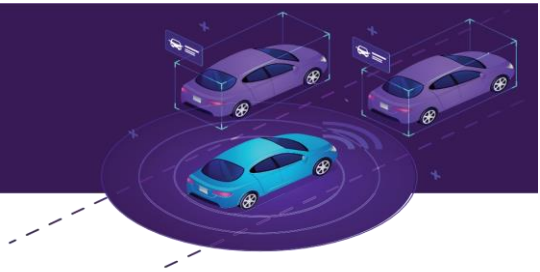


## EV Innovations in Three Key Dimensions

Comprehensive inputs and insights on innovations on three key dimensions are provided for electric mobility:

- By EV products
- By country
- By EV use in different industries

| Dimension | Item | Number of categories | Number of innovations |
|---|---|---|---|
| **Products** | OEMs | 19 | 128 |
| | Battery & BMS | 7 | 28 |
| | Lithium Battery Recycling | 3 | 15 |
| | Raw Materials | 2 | 15 |
| | Other Energy Storage Technologies | 2 | 25 |
| | Battery Charging & Swapping | 3 | 21 |
| | Testing, Training & Design | 2 | 14 |
| | Safety | 1 | 4 |
| | Fleets, Leasing and Rentals | 4 | 25 |
| | Others | 7 | 34 |
| | | | |
| **Country** | Australia | 7 | 11 |
| | Canada | 9 | 24 |
| | France | 13 | 30 |
| | Germany | 4 | 14 |
| | India | 10 | 31 |



| | | | |
|---|---|---|---|
| | Israel | 6 | 11 |
| | Italy | 11 | 29 |
| | Japan | 9 | 17 |
| | Mexico | 6 | 8 |
| | Norway | 9 | 21 |
| | South Korea | 6 | 12 |
| | Taiwan | 6 | 15 |
| | UK | 9 | 19 |
| | | | |
| **Industries** | Food & Beverages | 2 | 13 |
| | Textiles | 1 | 13 |
| | Agriculture & Farming | 1 | 20 |
| | Retail | 1 | 20 |
| | Logistics | 1 | 6 |
| | Construction | 1 | 27 |
| | Hospitality & Tourism | 2 | 25 |
| | Medical & Healthcare | 1 | 15 |
| | Mass Transport Infrastructure | 2 | 11 |
| | Residential Communities | 1 | 3 |
| | Various Sports | 9 | 23 |
| | Oil & Natural Gas | 1 | 7 |
| | City & Local Administrations | 2 | 16 |
| | Armed Forces | 3 | 5 |
| | Smart Grid | 1 | 3 |
| | IT | 5 | 23 |

| | | | |
|---|---|---|---|
| | Circular Economy | 1 | 4 |
| | Materials | 4 | 20 |

**Country specific innovations - takeaways**

Analyses of the innovations across 15 countries show how these are aligned to not just the aspirations of the end use market for electric vehicles in these countries, but also to the strengths and assets for the countries. For instance, countries such as Canada and Australia are investing in innovation at the Li and nickel mining, as both countries - especially Australia - are well endowed with mineral assets.

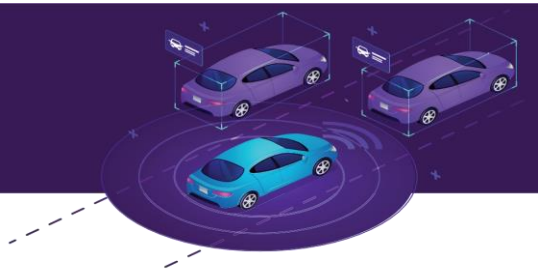
**Product specific innovations - takeaways**

The real breadth of innovations is seen in the electric vehicle products - and by products, we mean more than electric vehicles, we also refer to the other components of the value chain - batteries, charging stations, financial products to spur EV adoption, EV design and more.

Different products are seeing different stakeholders and different approaches to innovation - for instance, while capital intensive sectors such as battery cell producing are seeing deep tech innovation by companies with deep pockets, products such as electric scooter production that require relatively much less capital are seeing exciting young startups willing to experiment some unique ideas to succeed.

**Industry specific innovations - takeaways**

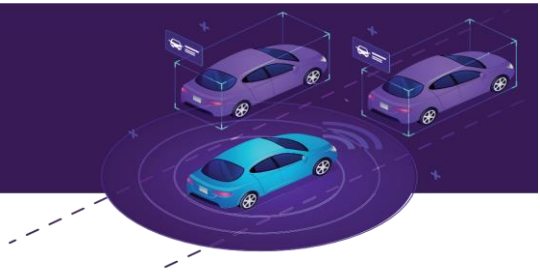
What is not well recognized is that many of the EV taking place are customized to specific industries. With the B2B segment being the prime driver of electric vehicles in many countries, many entrepreneurs and innovators are trying to remodel and custom-build electric vehicles. Such customizations or innovations are not only technology-based. For instance, in many countries, electric LCVs are offered to businesses for their short-distance, intra-city logistics on a pay per use, or electric vehicle as a service model. This makes it easier for the businesses to shift electric vehicles while at the same time reducing the carbon footprint of their logistics operations.



## Eye-opening EV innovation insights and facts

**Insights and facts that will open your eyes to a comprehensive list of innovations taking place in the e-mobility sector**

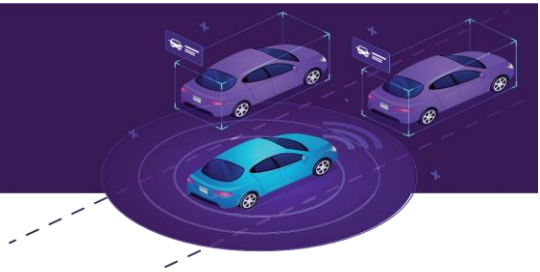
| | | |
|---|---|---|
| **TESLA**<br>Innovation strategies & approaches that made Tesla a $700 billion car company | **TOP OEMs**<br>How the top 50 auto OEMs and auto component companies are using acquisition of start-ups as a key approach in their innovation strategies | **HYDROGEN/FUEL CELLS**<br>Why commercialization of innovation around hydrogen and fuel cells could happen far sooner than expected |
| **LOW TECH**<br>Why low-tech EV innovation could win over high-tech in developing and underdeveloped countries | **STARTUPS**<br>How smart start-ups are crossing the chasm of death on the way to commercializing their innovations | **UNIVERSITIES**<br>How the world's top universities are forging partnerships with industry to leverage their research expertise in e-mobility |
| **INVESTORS**<br>Evaluation strategy used by top financial investors (VCs, PEs and corporate investors) in choosing the right innovations to back | **END USE BUSINESSES**<br>How select business end use sectors such as logistics and business fleets are innovating around attractive business models for EV adoption | **AUTO COMPONENT COS**<br>How all tiers of auto ancillary companies worldwide are strategizing around innovation in their efforts to diversify into electric mobility |
| **CHINA**<br>Why China's EV innovation strategy is different from the growth strategies it adopted for other industries | **SOLAR POWER**<br>How innovations around use of solar power are being used as a strong differentiator for EV OEMs targeting select markets | **GOVERNMENTS**<br>How some of the large corporates are enabling their respective local and national governments to provide support to the right kind of innovation that will be a win-win for many different stakeholders including themselves |
| **NICHES**<br>What are the various micro niches - and micro niche categories - available for start-ups and investors alike in the e-mobility ecosystem? | **MARKET INSIGHTS**<br>How smart companies worldwide are using unique insights of market needs to come up with low-investment, but high potential innovations | **BATTERIES**<br>How different companies are innovating differently at different components of the battery value chain |



## Valuable innovation insights for 100+ different EV product categories

| Product/solution category | Sub-categories for which innovation insights are provided |
|---|---|
| **OEMs** | • Electric cars - mass market<br>• High-end electric cars - luxury and sports cars<br>• Electric scooters<br>• Electric 3 wheelers<br>• Electric trucks<br>• Electric buses<br>• Electric vans<br>• Electric LCVs<br>• Electric motorbike<br>• Electric tractors<br>• Electric aircraft<br>• Electric boats<br>• Electric golf carts for use in micro-mobility<br>• Electric drones<br>• Flying electric cars/taxis<br>• Electric submarines<br>• Electric shipping<br>• Fuel cell based electric trains<br>• Fully electric bicycle<br>• Hybrid electric bicycle<br>• Hybrid electric LCVs<br>• Autonomous EVs<br>• Fuel cells based EVs<br>• Retrofit electric buses<br>• Retrofit electric trucks<br>• Retrofit electric cars<br>• Retrofit electric 3 wheelers |
| **Battery & BMS** | • Li-ion batteries<br>• Lead acid batteries<br>• Li-ion battery BMS<br>• Li-ion battery cathode<br>• Li-ion battery cell making machinery<br>• Li-ion battery electrolyte<br>• Li-ion battery anode<br>• Battery range extension solutions<br>• Battery weight reduction solutions |

| | |
|---|---|
| | • Battery diagnostics<br>• Battery thermal management<br>• Capacitor based storage for EVs |
| **Lithium battery recycling and second life** | • Li-ion battery recycling<br>• Li-ion battery refurbishing for life extension<br>• Use of second-hand Li-ion batteries |
| **Raw materials** | • Lithium mining/sourcing<br>• Sourcing of other materials such as cobalt, nickel etc.<br>• Lightweight materials for EVs |
| **Other energy storage technologies** | • Emerging EV battery technologies<br>• Flow batteries<br>• Solid state batteries<br>• Hydrogen fuel cells<br>• Other emerging storage and charging solutions for EVs (flywheel based etc.) |
| **Battery charging and swapping** | • AC charging stations<br>• DC fast charging stations<br>• Power electronics for AC/DC charging stations<br>• Components for EV battery swapping stations - robots etc.<br>• Battery as a service<br>• Software used in EV charging operations<br>• Wireless/inductive charging |
| **EV testing, training and certifications** | • Testing and simulation solutions for battery design and production<br>• E-mobility training and education |
| **EV design, safety & related** | • EV design solutions<br>• EV safety solutions for use in emergencies such as fire and accidents |
| **EV fleets, lease and rentals** | • EV leasing<br>• EV renting / ride sharing<br>• EV subscriptions<br>• EV fleet management solutions<br>• B2B electric fleets |
| | • Power converters in powertrain<br>• AC motors |

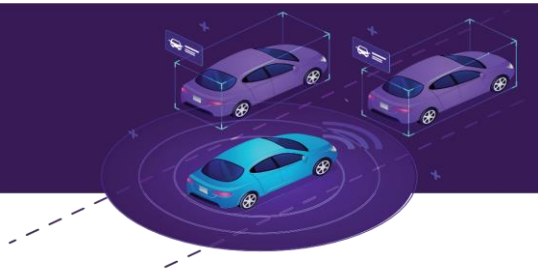


| | |
|---|---|
| **Electricals** | • DC motors<br>• EV motor components<br>• Motor controllers<br>• Cables, wires and connectors for EVs<br>• Electricals, cables and connectors for EV charging and swapping stations<br>• Regenerative braking solutions |
| **Production machinery/equipment** | • Li-ion cell making equipment<br>• Li-ion pack making equipment<br>• EV motor making machinery |
| **IT for E-mobility** | • Big Data/AI/Analytics<br>• IoT, wireless, mobile and cloud<br>• Blockchain<br>• Simulation software for EV design<br>• Simulation software for EV testing<br>• Simulation software for battery testing<br>• Software for EV charging station design<br>• Software for integrating EV with grid (V2G)<br>• Payment solutions<br>• EV charging station location solutions<br>• Software for connected EVs<br>• Software for autonomous EVs<br>• Software for optimizing all EV powertrain operations |
| **Others** | • EV service and maintenance<br>• Telematics for EVs<br>• EV as a service for B2B logistics<br>• EV sales<br>• EV recycling<br>• Eco-friendly seats, dashboards etc for EVs<br>• Use of solar power in EVs<br>• EV financing & insurance<br>• Custom wheels and tyres for EVs |

## EV Start-up Database

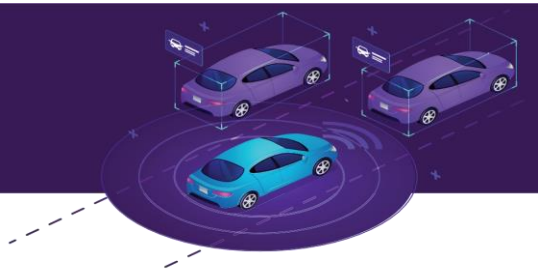
Profiles and innovation inputs for 200 global EV start-ups are provided.

| Dimension | Number/Value |
|---|---|
| Total Number of start-ups | 200 |
| Number of start-ups for which detailed profiles and analyses provided | 100 |
| Number of countries to which the start-ups belong | 17 |
| Number of start-ups in the following product categories | Batteries - 21<br>OEMs - 25<br>Non-Battery Powertrain - 3<br>EV as a Service - 5<br>Recycling - 5<br>EV design - 4<br>Charging/Swapping - 15 |
| Number of start-ups in deep tech innovations | 12 |
| Number of start-ups with business model/commercial innovations | 11 |
| Number of start-ups with OTHER (WHAT) innovations | 8 |
| Number of start-ups in pilot stage | 9 |
| Number of start-ups in early commercial stage | 7 |
| Number of start-ups in commercial stage | 24 |
| Number of start-ups that are university research based | 4 |
| Number of start-ups started by industry professionals | 10 |



## Key takeaways from the start-ups database

- Start-up innovations for electric vehicles, for batteries and for battery charging/swapping contribute to a large share of innovations (almost ⅔ rd. of the prominent innovations we identified).
- While over half the countries worldwide are seeing start-ups working in the e-mobility space, a large part of the start-up activity is focussed around 15 countries, with most of them belonging to the developed economies. Except in rare cases, most well-regarded deep tech start-ups belong to the developed economies.
- A good proportion of start-ups (close to 20% in our list) offer innovations that are neither technical or product oriented - these could hence be business model innovations, or market support innovations etc. This is an exciting trend as it implies that the e-mobility field offers innovation opportunities to a wide range of entrepreneurs and stakeholders.



# Answers to critical questions

## 1. What are the strategic and operational partnerships that 2-wheeler and 4-wheeler OEMs can explore to build strong competitive advantages for the B2C market?

*Insights and innovative approaches provided for the following types of partnerships*

- Partnerships with EV charging or swapping station service providers
- Investing in start-ups
- Strong alliances with specialized online marketing and e-commerce platforms
- Partnerships for better design, aesthetics and ergonomics
- Value added services using advances in IT and electronics
- Partnerships with financing companies

*Number of innovation examples provided for this question:* 25

## 2. How can an entrepreneur or business identify attractive niche EV OEM segments?

*Innovation strategies provided for entrepreneurs on the following aspects:*

- Undertaking a comprehensive review of all product and service opportunities
- Provide public EV chargers through platform business model
- Partner with EV charging stations to provide one stop centre for ‘Charge & Chill’ experience
- Provide battery disposal services
- Learn from start-ups
- Opportunities and challenges in EV localization
- Thinking niche
- Thinking B2B
- Thinking not just innovation in products or services, but also in business models
- Thinking not just innovation in products or services, but also in business models
- Thinking beyond pure EV - also hybrids and retrofits

*Number of innovation examples provided for this question:* 28

## 3. What are the key learnings on best of breed approaches from the e-mobility strategies of prominent OEMs?

*Learnings on innovation provided for the following dimensions:*

- Timing

- Partnerships (including with other OEMs)
- Cultural transformation
- Investments and acquisitions
- Supply chain strategy
- Their strategies to leverage the key mobility trends - shared, connected and autonomous
- Efforts to become a market maker instead of market taker
- Optimal R&D strategy
- Their efforts to develop an extended e-mobility ecosystem that will be a win-win for all stakeholders

*Number of innovation examples provided for this question:* 33

## 4 Which of the two - battery charging or swapping - will dominate in the future?

*Analyses done on the following themes:*

- The key government initiatives and policies that can drive charging or swapping
- Key challenges expected for battery swapping
- Both could co-exist with equal dominance
- Timelines we expect for different types of charging (AC, DC fast charge, flash charge) to evolve
- Could depend on how quickly ultra-fast DC charging becomes technically and commercially feasible
- National policies could determine region specific growth of one or the other
- Could depend on LIB remaining (or not remaining) as the dominant standard in EV battery technology
- Could depend on which can evolve into a low carbon footprint solution faster

*Number of innovation examples provided for this question:* 28

## 5. How can a manufacturer of components for the ICE best strategize to pivot to the electric vehicle sector?

*Innovation strategies provided for the following aspects:*

- Getting an understanding of the complete opportunity spectrum available
- Look at opportunities in the non-ICE components
- Look at becoming a maker of components for the electric powertrain
- Explore if there could be synergistic partnerships through which they can provide offerings to the e-mobility sector
- Study the hybrid electric vehicle market for opportunities
- Consider investing in fuel cells or emerging battery technologies
- What strategic start-up acquisitions or investments could give them a head start?

*Number of innovation examples provided for this question:* 39

## 6. For OEMs, what innovative design paradigms will lead to valuable differentiation?

*Design specific innovation inputs provided for the following aspects:*

- Optimizing on space
- Innovative powertrain design
- The platform (instead of product) paradigm
- Design for materials
- Design for sustainability
- Design for future-proofing the vehicle
- Designing for a smart world
- Designing for the future of mobility

*Number of innovation examples provided for this question:* 29

## 7. What are the attractive business opportunities available for software and information technology professionals in the emerging e-mobility landscape - especially using technologies such as Big Data/AI/ML/IoT?

*Insights on innovative opportunities presented for the following categories:*

- IT + Battery/BMS
- IT + Autonomous EVs
- IT+ EV charging/swapping
- IT + EV fleets
- IT + EMAAS (E-mobility as a service & shared EV economy)
- IT + EV design
- IT + EV telematics
- IT + smart & connected EVs
- Developing EV operating systems?

*Number of innovation examples provided for this question:* 37

## 8. How can Li-ion battery pack makers differentiate their offerings to the OEM market?

*Differentiation strategies along with examples provided for the following dimensions:*

- BMS is the key
- Long-lasting OEM partnerships
- Aligning with battery charging trends

- Increase overall battery pack efficiency
- Providing bespoke battery packs tailored to specific OEM segments
- Innovations that can reduce both the weight and volume of the pack
- Also provide battery as a service (thru an opex model or a lease model)
- Provide a range of battery solutions to OEMs (this could require partnerships)

*Number of innovation examples provided for this question:* 35

## 9. How can some of the key trends in industrial technology and mobility (additive manufacturing, automation/robotics, shared/connected/autonomous mobility) be leveraged by companies keen on providing differentiated offerings in the e-mobility space?

*Innovation insights provided in the intersection of EV and the following technology trends:*

- Additive manufacturing
- Robotics
- Autonomous operations
- Sensors & IoT
- Blockchain

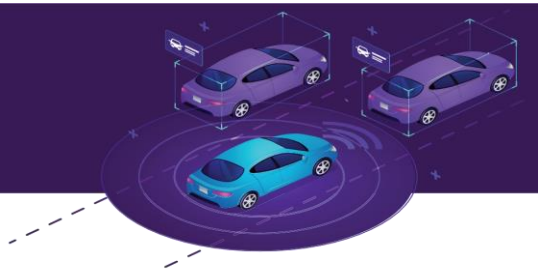
*Number of innovation examples provided for this question:* 25

## 10 What innovative opportunities does the e-mobility sector provide to companies in the renewable energy sector, specifically solar energy sector?

*Insights on innovative opportunities provided for the following intersections:*

- Solar + EVs
- Smart grid + EVs

*Number of innovation examples provided for this question:* 11

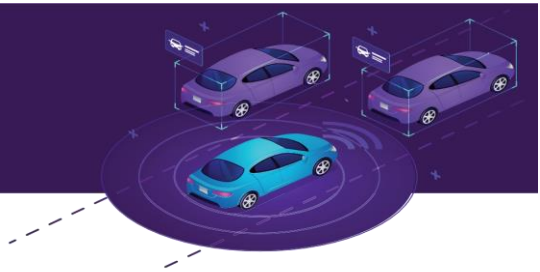


## EV innovation recommendations for all components of value chain

*Recommendations on innovation strategy provided for the following solution categories:*

- Lithium and other battery materials processing
- Battery cell making
- Battery pack making
- EV powertrain components (other than battery)
- EV non-powertrain components
- EV design
- OEMs
- EV charging and battery swapping
- EV maintenance (including battery maintenance and life extensions)
- EV end of life

*Total Number of innovation examples provided for this section:* 169

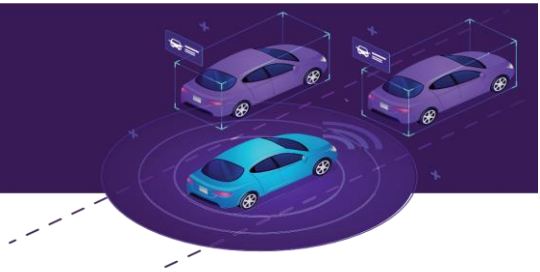


## EV innovations recommendations for key stakeholders

*Recommendations on innovation strategy provided for the following stakeholder categories:*

- EV & conventional automotive OEMs
- EV & component makers for conventional vehicles
- Makers of batteries and battery components - including BMS
- EV charging station or battery swapping service providers
- Business and consumer fleet operators
- Financial investors
- Entrepreneurs keen on investing in innovative (rather than commodity) areas within e-mobility
- IT industry, with a special focus on software companies in select IT domains such as Artificial Intelligence, IoT, Cloud computing, Wireless computing, Imaging & digital security solutions providers, Digital payment solutions providers
- E-mobility researchers & innovators - both corporate and university research
- Federal & regional governments and policymakers

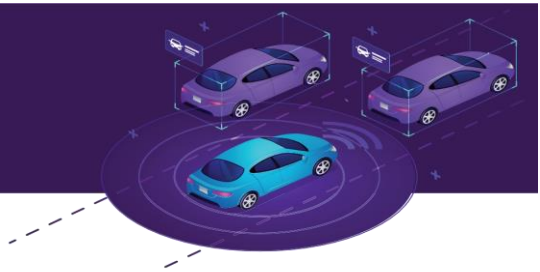
*Total Number of innovation examples provided for this section:* 95



## Inputs & insights for 15 different aspects of innovation

**Innovations in the e-mobility spectrum are happening in multiple aspects. The EVI2 team has identified 15 such aspects and provided examples and insights for each of these.**

- ***Product*** - innovations for 50+ different product categories are provided, across vehicles, batteries, charging and other components.
- ***Value chain component*** - Our team identified 10 different components of the e-mobility value chain, and focussed on identifying powerful innovations in each of these components.
- ***Geography*** - Innovations for 25 different countries have been provided, with a special emphasis on the top 10 countries
- ***Technology***
    - *Deep tech* - Deep tech innovations are provided for batteries, motors, power electronics, and autonomous vehicles.
    - *Incremental tech* - The report covers over 250 innovations that are incremental but at the same time effective in providing differentiated value to the end user.
- ***Business***
    - *Financial or commercial* - Diverse innovations that belong to financial and commercial domains provided on vehicle financing, insurance, renting/leasing etc.
    - *Partnership* - Over 100 examples of innovative e-mobility business partnerships from around the world
    - *Marketing/sales* - Innovations for both offline and online marketing efforts; innovations in sales to both B2B and B2C segments; innovative sales and marketing business models such as the subscription model, value added services model, are provided
- ***End use business/industry sectors*** - Innovative applications of electric vehicles in over 20 different industries
- ***End use consumer sectors*** - Over 50 examples of how customizations and innovations have been implemented in a range of EV products for different consumer segments such as premium market, families with small children, seniors, working professionals etc.
- ***Stakeholder categories*** - Almost every category of stakeholder interested in electric vehicles and e-mobility will benefit from EVI2, as innovations are provided for over 20 different stakeholder categories, with a special emphasis on the top 10 stakeholders (OEMs, battery makers, component makers, power electronics companies, renewable energy companies, electrical firms, financial



investors, logistics/transport firms, power generation and distribution companies, oil & gas companies)

- ***Stage of innovations*** - Innovations belonging to the following stages are provided added emphasis in EVI2: Pilot stage, early commercial, fast growth stage
- ***Strategic intent*** - This aspect of innovation is a fairly unique one that has been analysed in EVI2. We have provided insights on the strategic intent for the innovations in over 100 relevant cases. In these, beyond the obvious value of the innovation, the founders/companies were able to envision a larger potential for the innovation in the future.
- ***Type/background of innovators*** - Successful innovators with over 25 different backgrounds have been identified in EVI2, enabling entrepreneurs with different backgrounds to appreciate the opportunities available to them better.
- ***Micro-niches*** - In order to assist start-ups and entrepreneurs, the EVI2 team invested special efforts to identify over 50 attractive micro-niches along the entire value chain and product categories.

# INNOVATION ANALYSES FOR 16 CATEGORIES

| | Start-up | Small enterprise | Medium scale enterprise | Large, multinational firm |
|---|---|---|---|---|
| **OEM** | I | II | III | IV |
| **Core ancillaries and solutions** | V | VI | VII | VIII |
| **Supporting solutions and services** | IX | X | XI | XII |
| **End users** | XIII | XIV | XV | CATEGORY XVI |

Analyses and recommendations on innovation strategies, along with examples, are provided for each of the above 16 categories of stakeholders.

**Examples of innovations for each of the 16 categories**

| Category | Innovation Examples |
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| I | 1. Lightyear One - long range solar powered car with 5sq. Metres of solar panels on the car<br>2. REE - Ready to construct EV platforms of various specs for use by second party OEMs.<br>3. XEV - small, low speed cars manufactured using additive manufacturing processes.<br>4. Volocopter - Electric passenger aircrafts and entire supporting ecosystem (airports, maintenance, reservations, etc)<br>5. Ono - Pedal assisted intercity goods transportation vehicle with swappable battery. |
| II | 1. ETF Mining equipment largest trucks, connected trains for lease<br>2. TuSimple - Level 4 autonomous trucks with the ability to drive by itself from one depot to another. Vehicle is offered as a transportation/cargo service.<br>3. Arrival - Autonomous city passenger vehicle fleet services. |
| III | 1. Rivian - Autonomous delivery vehicles custom built for amazon and personal off-road vehicles with in-built motors and independent torque vectoring. |

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| | 2. Fisker - The company claims its Ocean to be the most sustainable vehicle in the world with electric powertrain. Almost all components and parts are developed from clean, sustainable sources. materials made from recycled, abandoned fishing nets & plastics from the ocean are used in the environmentally-conscious interior.<br>3. Rimac Automobili - Electric hypercar and its systems and components at house. |
| IV | 1. Researchers at Stanford, working together with MIT & Toyota have developed a machine learning algorithm and method which could supercharge battery development for electric vehicles.<br>2. Mercedes-Benz is working with startups Hydro-Quebec and QuantumScape to develop solid-state batteries for use in its future vehicles.<br>3. BMW is using Blockchain to track the sources of its materials and components to ensure legal and ethical supply chain.<br>4. Nissan e-power technology is a tiny ICE which supports the battery in Nissan Leaf's by recharging them using conventional fuel during emergencies.<br>5. Hyundai and Kia turn up EV efficiency with new heat pump technology. The heat pump is a heat management innovation that maximizes the distance that Hyundai and Kia EVs can travel on a single charge, scavenging waste heat to warm the cabin. It enables EV drivers to heat their car's cabin in cold weather without significantly impacting electric driving range. |
| V | 1. Turntide Technologies - IoT controlled motors which work with 30% greater efficiency than any other motor.<br>2. Aquarius engines - very compact Linear ICEs with 16kWh capacity which can be installed in hybrid vehicles.<br>3. Carbon Three Sixty - designs, develops and tests composite light-weight wheels for electric vehicles and others which require low-weight components. It uses an innovative tailored fibre placement method of manufacture which enables combining fibres and lacing them in different ways to develop the best material for various purposes.<br>4. Lithium werks - Cobalt free, Lithium-ion (LiFePO4) cells where the conventional commercial chemicals are replaced by their proprietary 'Nanophosphate' technology. The company manufactures 18650 and 26650 cells which are further developed into modules and larger systems. |
| VI | 1. Equipmake, and 3D printing specialist Hieta would weigh about 10 kilograms while giving a peak output of 295bhp. The partnership is targeting a peak power of 220kW at 30,000 RPM while weighing under 10 kg leading to a power density of about 20kW per kilogram. By comparison, even the best standard permanent magnet motors would struggle to muster 5kW per kg. |

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| | 2. Transition one - They offer to retrofit some of the most popular car models. For $5,600 (including a government subsidy—it's around $9,000 without), a more efficient electric engine, batteries, and a connected dashboard will be incorporated into the car. This compares favourably with the $22,000 price tag for the cheapest brand-new electric car—and the whole process can be completed in less than a day.<br>3. Oxis Energy - Develops Li-S based battery chemistry with its own anode, cathode and electrolyte which can be supplied to battery manufacturers on-demand. The company has achieved specific energy density of 471 Wh/kg and has targeted to reach 500 Wh/kg energy density. It is also trying to develop fully solid-state Li-S batteries which would increase the energy capacity to 600 Wh/kg and even up to 800 Wh/kg. |
| VII | 1. Yasa - Customizable motors manufactured in separate segments ideally suited to mass manufacture with minimal application engineering. The topology is ideally suited to series production, providing a smaller, lighter, lower cost motor in volume than any conventional motors in the class.<br>2. In-wheel motors, also known as hub motors, give drivers improved torque response, enhanced handling, faster acceleration, less charging and greater range. Ready for volume application in passenger cars, light commercial vehicles, modern last-mile transportation solutions and autonomous mobility pods, Protean Electric's in-wheel motors remove efficiency losses associated with gear, differential and CV joints situated around the vehicle.<br>3. The new technology concept unveiled by tire manufacturer Falken, called Energy Harvester, features two layers of rubber each covered in an electrode, along with a negatively charged film that interfaces with a positively charged film. When fixed to the inside of a conventional tire it generates electricity as the tire deforms during rotation, in a process known as frictional charging. |
| VIII | 1. ZF has introduced a new 2-speed electric drive for passenger cars that integrates an advanced electric motor with shift element and appropriate power electronics. The improvement in energy conversion efficiency compared to previous e-drives extends the driving range for each battery charge.<br>2. BorgWarner has developed an innovative torque vectoring system for electric vehicles which enables the use of just one electric motor instead of the traditional two that are typically found on electric vehicles. This solution is cost-effective and features a compact design, significantly reducing the vehicle space needed as well as the weight of the system. Leveraging its all-wheel drive (AWD) and coupling expertise and portfolio, BorgWarner created the Torque-Vectoring Dual-Clutch unit, which features two clutches—one inner and one outer—that replace the conventional differential in an electric driveline.<br>3. Bosch, the world's largest automotive supplier is introducing silicon carbide (SiC) chips to help boost EV efficiency by about 6%. The addition of carbon atoms to the silicon normally used for semiconductors increases the conductivity of microcircuits on each chip. For the PEM, |

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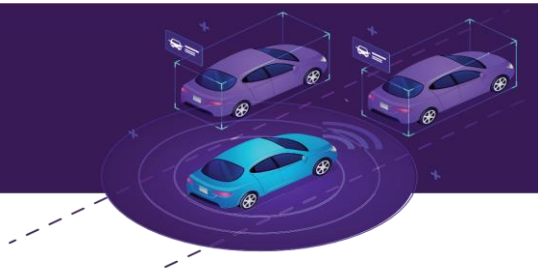
| | these chips are used for switching the current polarity for the DC to AC and AC to DC conversion. SiC allows for higher switching frequencies and a 50% reduction in heat dissipation resulting in more power and less energy loss. The bottom line is 6% more driving range from the same battery charge. That means drivers can either go further, or go the same distance with a smaller, lighter, cheaper battery.<br>4. Panasonic's modular SPACe_C EV concept vehicle supports interchangeable bodiesIt allows the cabin or cargo hold to be completely separate from the drivetrain, and it opens up the potential for a fully modular transporter With no complex mechanical steering and transmission inputs needed to interface between the top and bottom layers, it's possible to make them totally separate units, enabling a click-on, click-off architecture that lets one drivetrain unit perform a variety of different jobs depending on what's sitting on its back. Panasonic has been working on this kind of modular vehicle platform for some time now, the e-Torta has been refined from its previous versions with a new 48-volt powertrain that's modular in its own right, incorporating a nicely integrated block that brings together the charger, inverter and 18-kW (24-hp) motor.<br>5. Continental begins series production of new integrated electric axle drive. Highly integrated means that the new high-voltage drive combines electric motor, power electronics and reduction gear in a single housing. This makes the Continental Powertrain division one of very few system suppliers to offer a complete, electrified powertrain from a single source. Powertrain engineers were able to further improve the interaction between the individual components, consisting of the electric motor, power electronics and transmission, and synchronize them optimally—and also optimize installation space and weight. |
| IX | 1. Duesenfeld, developed a solution which decentralizes battery recycling, reducing logistics and supply chain problems. The start-up deploys mobile recycling centres/vehicles which are equipped with sufficient technology to disassemble and recycle the materials to a certain extent.<br>2. Akkurate - studies all batteries of different specifications from different manufacturers in a centralized diagnostic centre all through the battery's life and provides cell level safety and performance information. It also ensures effective battery recycling and repurposing by indicating the reusable cells/parts of the spent battery.<br>3. EP Tender - Tow-along range extension device with 1 51kWh battery within. The device is offered as a service.<br>4. Ottopia - Teleoperation device which enables the vehicle to be remotely controlled from a distant location giving the vehicle semi-autonomous functioning.<br>5. Electreon - Dynamic wireless charging technology (electromagnetic coils) which can charge a moving vehicle wirelessly. |
| X | 1. ZapGo Battery manufacturer and AS Green Cube Innovation announced a new joint venture to commercialize ultra-fast charging stations with |



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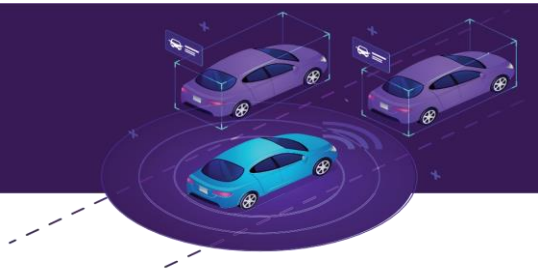
| | ZapGo's Carbon-Ion (C-Ion) ESS in Norway. The idea is to build charging stations for various vehicles, from 350 kW (cars) to 1.2 MW (trucks, buses or ferries) without the need for public infrastructure investments.<br>2. Paramatters software - The software is a fully autonomous designing facility which enables additive manufacturing involving various materials topology with varying physical load and thermal load capabilities to instantly manufacture intricate and complicated components.<br>3. SunMobility - Swappable smart batteries service for two and three wheelers<br>4. Chargetrip - Routing technology for electric vehicles comes with a need to reduce range anxiety. The navigation should provide an optimum path with amenities such as charging and precise mapping based on the driving range available for the vehicle depending on its characteristics, manufacturer, usage and many other parameters. Chargetrip's navigation engine evaluates such factors to provide a safe route. |
| XI | 1. Skeleton technologies - Li based Ultracapacitors which can supplement EV batteries by charging up instantly and gradually charge up batteries unfiormly. This allows the vehicles to be ultrafast charged.<br>2. Valvoline, a supplier of premium branded lubricants and automotive services, revealed the first of its electric vehicle-specific product and service offerings with the introduction of Valvoline EV Performance Fluids. The global production line includes, Valvoline EV Heat Transfer Fluid, Valvoline EV Drive System Fluid, Valvoline EV Brake Fluid and Valvoline EV Grease. Valvoline's new product line works to solve common EV issues surrounding battery temperature variations, powertrain performance and both brake system corrosion and seal bearing failure, among others.<br>3. Otonomo - A cloud-based automotive data collection, processing and distribution technology which takes data from many electric vehicles or OEMs and redistributes it to the OEMs, other manufacturers, charging station providers and other companies which makes applications for various EV services. |
| XII | 1. Bosch developed a battery range extension service which digitally increases battery efficiency by cloud connectivity and continuous monitoring.<br>2. ABB developed chargers for electric buses called TOSA which give out up to 600kW power to a battery in a few seconds (15-20 s) at bus stations to the buses.<br>3. Nissan is enabling all Leafs to be compatible with V2G charging to power up homes during emergencies.<br>4. Hyundai's app allows for adjusting seven different car settings, including maximum motor torque, "responsiveness," the amount of regenerative braking used and even how much energy is used to power the climate control. The app can also suggest specific settings, whether to help conserve battery power for the remainder of a journey or to spice up the car's sportiness for a bit more fun. Hyundai said it also might offer |



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| | different recommended settings for, say, mountainous versus urban roads. |
| XIII | 1. Recurrent - provides battery usage data and lifetime scenarios of a battery to facilitate easier buying of used EVs.<br>2. Dox - a drive-in battery maintenance workshop where the battery is inspected, made healthier and certified.<br>3. Lilium aviation - to and fro commute between the airport and other ports in key areas of the city. |
| XIV | 1. Electriphi - Designs a suitable fleet operation method depending on various factors by running simulations using a software. Also, offers backend support by maintaining the data and generates future servicing maintenance and other practices using the simulations.<br>2. Meshcrafts - The company creates a complete ecosystem where energy utilization is managed effectively to reduce any form of waste at any level. It monitors chargers, used electricity, available energy so that all businesses involved with charging stations receive economic benefits.<br>3. Ossiaco's 'Dcbel' is a bi-directional home EV charger which allows V2X charging during blackouts and emergencies. In addition, the charger also integrates any available solar panel installation into the charging system to power the vehicle creating a complete backup system during emergencies while fast charging an EV during normal days. |
| XV | 1. Arrival - Autonomous vans and buses for public transport within cities.<br>2. The Octopus Electric Vehicles Fleet Solution brings together service providers to create a 'transition bundle' to enable greener driving. The bundle provides full access to the Ohme Fleet Dashboard and Fleetcor AllStar One Electric - giving access to an integrated network of charging at home, work and on the go. It requires an upfront set-up cost and ongoing monthly payment thereafter. Octopus Electric Vehicles provides advice on the range of electric vehicles and works closely with businesses to plan their electric transition based on the business' unique needs.<br>3. UPS, started tests of an all-electric Gaussin Trailer and Swap Body Movers (TSBM), known in the logistics industry as "shifters". This special EV will be used for on-property movements of semi-trailers and containers in the UPS's advanced-technology London Hub in the UK. In addition to being completely electric, the Gaussin TSBM, also has autonomous driving capability, which is yet to be tested. |
| XVI | 1. BMW is manufacturing electric two wheelers and offering them only as a fleet service in London. The vehicle is equipped with advanced telemetry, information and comfort accessories and technology.<br>2. ZF Japan has announced that the company has developed an electric light commercial vehicle specifically for the Japanese market. The company has been electrifying a wide range of systems not only for passenger cars and commercial vehicles but also for industrial machines. The prototype vehicle has been developed by ZF Japan's |

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| | engineering team at their Tech Center in Yokohama, collaborating with a team in ZF HQ in Germany in order to satisfy Japan's unique requirements.<br>3. Bosch developed an IoT shuttle which includes a complete ecosystem of networked mobility services, such as reservation and sharing platforms for consumers as well as solutions for car manufacturers and mobility service providers who wish to use autonomous shuttles to offer on-demand mobility,"<br>4. Groupe Renault announces the launch of Mobility Consulting by Renault to support businesses as they move their fleets towards lower-carbon mobility and introduce their recharging ecosystems, while considering switching to shared mobility services as well. |

## Innovations by global top Automobile & EV industry companies

| OEMS | |
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| **Tesla** | 1. Tesla is working on a whole new wiring architecture for future vehicle platforms and they aim to bring it down to just 100 meters starting with the Model Y, in a new patent application that recently became public.<br>2. Tesla has invented a technique for increasing its all-electric vehicles' power and torque by simply adjusting the shape of some of its electric motor's components. Electric current flow becomes concentrated in different spots on the motor depending on the 'geometry' of these parts, thus an opportunity to limit any losses has presented itself by controlling where the concentrations happen. Tesla has filed this application to protect the process ('method') of building a motor with the geometry knowledge made part of the design and testing.<br>3. Tesla's new patent describes a "tabless electrode" that does away with the tabs that connect the positive and negative terminals of a jelly-roll battery. The goal is to reduce resistance and manufacturing costs. The tab-less electrode technology negates the use of a tab to make the positive-negative connection by instead using two substrates, one of which has a conductive edge.<br>4. Tesla's software measures how well each of the tires are gripping the road and adjusts torque in the front and rear independently hundreds of times per second to ensure the tires are constantly achieving maximum grip and propelling the car forward. And, also, Tesla uses a tire with a tread pattern specifically developed to maximize contact with the ground. |

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| **Toyota** | 1. Together with Stanford Toyota developed a machine learning algorithm which can test and validate batteries much sooner (by nearly 15-fold).<br>2. Toyota announced a special research and development project. With Sharp and the New Energy and Industrial Technology Development Organization (NEDO), it has put a special test vehicle together that uses solar panels to generate almost 1 kW of energy during daylight hours, whether the vehicle is driving or sitting.<br>3. As part of its transition from a transportation company to a mobility company, Toyota has announced its intent to build the Woven City, at a 175-acre site at the base of Mt. Fuji in Japan. In addition to the featured display, Toyota is showcasing two additional technology offerings. The first, Toyota AI Ventures, which is Toyota's US-based venture capital firm, is issuing a "Call for Innovation" for startups to apply for funding. The second is Toyota IP Solutions, a new patent licensing program, that offers access to Toyota's impressive array of intellectual properties in a variety of areas, including: bio-active materials, nanoparticle processing, multi-dimensional paints and electronics thermal management. |
| **FCA** | 1. FCA (Fiat Chrysler Automotive) ENGIE Eps and Terna have presented (in September 2020), within the FCA's premises in Turin, the pilot project Vehicle-to-Grid (V2G) of electric mobility, which once totally completed, will become the biggest of its kind globally.<br>a. The V2G plant at Mirafiori is a project "100% made in Italy". On the one hand, it is a significant opportunity for the Italian industrial system to take a leading role in the development of the future of sustainable mobility. On the other, it is the result of the joint effort of three companies that lead their sectors. In their use of such an innovative technology, their experiments are now beginning on a bidirectional charging solution that benefits from physical aggregation in a single point of interconnection with the power grid, capable of interacting with the other energy resources on site.<br>2. Fiat's Centoventi is an endlessly customizable car that makes sure you never have to trade it in. Named after the Italian automaker's 120th anniversary, the Centoventi allows customers to choose from four different roofs, four bumpers, four-wheel covers, and four paint wraps.<br>a. Once those have been chosen, there are 114 different accessories provided by the courtesy of fellow Fiat Chrysler company, Mopar, such as seat cushions or |

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| | bottle holders. The company even indicates that it could possibly 3D print parts at home.<br>b. Even the Centoventi's battery is configurable. The car comes with a small 100 km range battery pack but features a sliding rail system that leaves room for others. Customers could then buy or even rent extra packs to get up to 500km of range. |
| **GM** | 1. With its new Ultium battery technology, GM is on track to cut the battery cell costs - the single greatest expense in electric vehicles - to less than $100 per kilowatt-hour from about $140 now. The new batteries are unique because of the “large-format, pouch-style cells,” compared to cylindrical cells, which GM says enables them to be stacked vertically or horizontally inside the battery pack. These batteries will offer power ranging from 50 to 200 kWh, which could allow for a driving range up to “400 miles or more.” Motors designed in-house will support front-wheel drive, rear-wheel drive, all-wheel drive, and performance all-wheel drive applications.<br>2. General Motors just introduced a new electronic platform for its vehicles that it says can carry 4.5 terabytes of processing power per hour, five times what the current system can carry.The company says the system will be necessary to meet its goal of building cars that can support a world with "zero accidents, zero emissions, and zero congestion."<br>3. GM Marine unveiled their first electric pontoon boat. Called the Forward Marine First, the electric boat is based off of technology developed for the Chevy Bolt EV.<br>4. GM unveils its wireless battery management tech, will power next-gen EVs with Ultium batteries. The automaker claims that the wBMS technology reduces wires within the batteries by up to 90 percent — resulting in either lighter or more energy-dense battery packs.<br>5. GM has announced that it is purchasing 200 megawatts of wind energy from wind farms in Ohio and Illinois, and that once the turbines are online next year, 20% of the company's global electricity usage will be powered by renewables. The electricity generated will supply seven plants, including those that make the Chevrolet Cruze and Silverado and GMC Sierra light-duty pickups.GM announced last year that it intends to source all electricity needs at its facilities worldwide with renewable energy by 2050. |

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| **Ford** | 1. Ford Patents Solar Charging Cocoon for Its Electric Car. When it is deployed, flexible solar panels extend towards the ground in all directions in the car – front, sides, and rear. The storage compartment where the cocoon is kept also shows solar cells when it is opened. The patent informs us that, when the owner finally decides to drive, the structure automatically retracts back in the storage compartment, which looks like a roof cargo box.<br>2. Ford had acquired a majority stake in a company Argo AI which develops autonomous systems for vehicles as an avenue to launch Autonomous EVs in future. Ford and Volkswagen would share this technology on the latter's MEB EV platform.<br>3. Ford is developing an all-electric version of its Mustang from scratch with a human-centric design that caters to passenger safety and comforts with adaptive sensors, AI, etc<br>4. Ford is trying to do its part to combat climate change by recycling old coffee waste from McDonald's into car parts. The automaker will be taking food waste from the fast-food giant, diverting it from a landfill to its laboratory, where it will be engineered into bioplastics, Ford said. In addition to reducing food waste, the effort will make car parts lighter, use less petroleum, and lower CO2 emissions. |
| **Tata** | 1. Tata Motors revealed a new modular powertrain "Ziptron" that will be deployed in the range of upcoming car models of the company. The Ziptron is a 300-watts powertrain with a range of over 250 kms, 8 years of battery warranty and adherences to the IP67 standards.<br>2. IOC and Tata Motors launched the country's first hydrogen fuel cell bus. The project is being executed with partial financial support from the Department of Science & Industrial Research, MNRE and Ministry of Science & Technology.<br>3. Tata with its many automobile verticals is poising to manufacture its own Li-ion batteries, BMS, motors, powertrains, power electronics, components, interiors, Telematics & communications and even battery recycling. |
| **Daimler** | 1. Daimler researchers used a quantum computer to model the dipole moment of three lithium-containing molecules, which brings us one step closer to the next-generation lithium sulphur (Li-S) batteries that would be more powerful, longer lasting and cheaper than today's widely used lithium-ion batteries. Researchers at Daimler hope that quantum computers will help them design next-generation lithium-sulphur batteries, because they have the potential to compute and precisely simulate their fundamental behaviour.<br>2. Mercedes-Benz has agreed on a sustainability partnership with Farasis Energy Co Ltd(battery Manufacturer) to take a holistic approach along the entire value chain. The supplier network |

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| | contributes a significant part of the value creation and is thus of vital importance for the decarbonisation goals. To ensure responsible sourcing of cobalt, third-party audit company RCS Global was assigned as part of the aforementioned sustainability partnership to inspect the entire cobalt supply chain and in particular the smelters for compliance with the OECD standards.<br>3. Daimler AG has acquired a minority equity stake in U.S. battery material specialist Sila Nanotechnologies Inc. (Sila Nano) as part of its research and development activities. The company replaces conventional graphite electrodes entirely with its proprietary silicon-dominant composite materials that enable high energy density and high cycle life, which translates to more powerful, longer-range and enduring sources of power for electric vehicles. These materials easily drop into existing Li-ion factories, making it possible to deploy efficiently and at scale.<br>4. Daimler Trucks North America(DTNA), as a part of its experiment engaging customers in its development activities, launched the Freightliner Customer Experience (CX) Fleet for its electric truck program. The fleet of all-electric trucks includes six heavy-duty Freightliner eCascadias and two medium-duty eM2-106 trucks. This fleet would add to the Freightliner Electric Innovation Fleet, which started operation in late 2018 to provide feedback and data on the integration of battery-electric trucks in large-scale fleet operations.<br>5. Daimler is hiring computer programmers to create games that encourage electric and hybrid vehicle owners to drive more efficiently. Mercedes vehicles have enough graphics processing power from their use of stereo cameras to also power sophisticated graphics. The Mercedes interface displays a floating ball that needs to be kept within a circle. Aggressive acceleration results in the ball moving off target and a lower score. |
| **Porsche** | 1. Porsche Taycan uses Chargemap's routing system in its vehicle which provides an optimum path with amenities such as charging and precise mapping based on the driving range available for the vehicle depending on its characteristics, manufacturer, usage and many other parameters. Chargetrip's navigation engine evaluates such factors to provide safe routes.<br>2. Porsche has produced its first complete housing for an electric drive using 3D printing. The engine-gearbox unit produced using the additive laser fusion process passed all the quality and stress tests without any problems.<br>3. The new Porsche Cayenne Turbo S E-Hybrid is not only the fastest and most powerful Cayenne of all time—it also offers a new dimension of transverse dynamic capabilities. The interplay of all chassis innovations makes it particularly fast and agile— |

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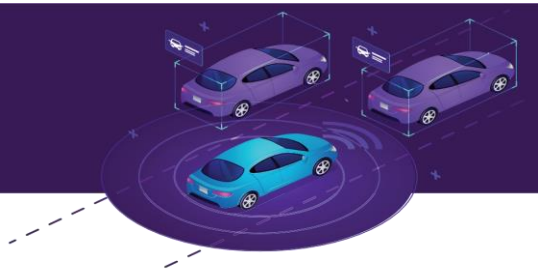
| | performance electrified. A drive in the new Cayenne Turbo S E-Hybrid is breathtaking—with a system output of 500 kW (680 hp) (Cayenne Turbo S E-Hybrid: Fuel consumption combined 3.9 – 3.7 l/100 km; CO2 emissions 90 – 85 g/km; electricity consumption (combined) 19.6 – 18.7 kWh/100 km) and a maximum system torque of 900 Nm, it accelerates from 0 to 100 kmh in 3.8 seconds, reaching a top speed of 295 kmh. |
| **Volkswagen** | 1. Volkswagen launched two new modular powertrain systems for trucks and buses which will be used in the OEMs future heavy commercial vehicle interests. The vehicle would be battery powered but would also house a generator, as powerful as the VW golf engine which would charge the battery. In a unique way not just gasoline but ethanol and also in some versions of natural gas and biomethane can be used to run the generator owing to sustainable reasons.<br>2. Volkswagen recently announced a joint venture with Ford that will focus on autonomous and electric vehicles. Volkswagen will provide Ford with access to its MEB platform – which anchors the ID.3, the first long-range all-electric VW model – as well as a range of other products. In addition, Volkswagen will invest an amount “in the billions” in Argo AI, a Pittsburgh-based research firm specializing in autonomous vehicle development in which Ford became a lead investor two years ago.<br>3. Volkswagen Financial Services Fleet has launched its EV4-ME tool to help company car drivers assess whether electric vehicles are suitable for them. The tool guides drivers through a series of simple questions about their vehicle and needs, covering issues from charge point availability to daily journey needs. The site then gives advice on which fuel type could work best for them, whether that’s diesel, petrol, plug-in hybrid or fully electric vehicle.<br>4. Volkswagen, Tesco and Pod Point teamed up to provide the largest free retail charging network for electric vehicle (EV) owners across the UK. The groundbreaking partnership has now(July, 2020) hit the landmark 200th store after four EV points were installed at the Tesco superstore in Chester. So far, enough renewable energy has been given away to power the homes in a city the size of Chester for a whole day. |
| **Honda** | 1. Honda is trying to develop not just vehicles but a larger ecosystem for PHEVs, BEVs and FCEVs. It would manufacture wall mount chargers and remote hydrogen generators to power its future vehicles.<br>2. Honda has already displayed the ‘Clarity' fuel cell electric vehicle.<br>3. The Honda Mobile Power Pack is a portable and swappable battery that stores electricity generated by renewable energy, for |



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| | use as a power source for small-sized electric mobility, or for the household. |
| **Hyundai** | 1. Hyundai's app allows for adjusting seven different car settings, including maximum motor torque, "responsiveness," the amount of regenerative braking used and even how much energy is used to power the climate control. The app can also suggest specific settings, whether to help conserve battery power for the remainder of a journey or to spice up the car's sportiness for a bit more fun. Hyundai said it also might offer different recommended settings for, say, mountainous versus urban roads.<br>2. Hyundai and Kia turn up EV efficiency with new heat pump technology. The heat pump is a heat management innovation that maximizes the distance that Hyundai and Kia EVs can travel on a single charge, scavenging waste heat to warm the cabin. It enables EV drivers to heat their car's cabin in cold weather without significantly impacting electric driving range.<br>3. Hyundai has unveiled a new concept electric vehicle controlled by a joystick instead of a steering wheel. The car is called Prophecy and is inspired by the company's 'Sensuous Sportiness' design philosophy. The electric car features an ultra-aerodynamic profile and "perfect proportions." Its wheels are set far in the corners to give more space to the interior. The interior features a pillar-to-pillar display, a joystick instead of a steering wheel and plenty of buttons for a variety of features. The car is also made of eco-friendly materials.<br>4. The redesigned 2020 IONIQ Electric delivers 170 miles of range, technology and advanced standard safety features at a starting price of $33,045 for the well-equipped SE model. The new IONIQ Electric's battery has been upgraded from 28 kWh to 38.3 kWh, meaning drivers can go even further between charges. It boasts 36% additional energy storage capacity, offering a total of 170 miles of estimated range. Its e-motor delivers 134 horsepower and 218 lb.-ft. of torque and is fitted standard with a 7.2-kW on-board charger - an upgrade from current 6.6-kW – for Type 2 AC charging. Using a 100-kW fast-charging station, the battery can reach 80% charge in as little as 54 minutes.<br>5. Hyundai Motor Company is showing its smart mobility ecosystem model which includes integration of its Urban Air Mobility (UAM), Purpose Built Vehicles (PBV) and Hub (Mobility Transit Base) smart mobility solutions as part of a dynamic human-centered future cityscape. The UAM is shown with its rotors tilting, enabling vertical take-off and landing and rotating horizontally for flight. On the ground, PBVs can be seen running on the road, traveling around the Hub, becoming part of the building when connecting to the Hub's docking station. The Hub is not only a space that connects UAM and PBVs, but also serves as a new concept for connecting people, which Hyundai says reflects its |

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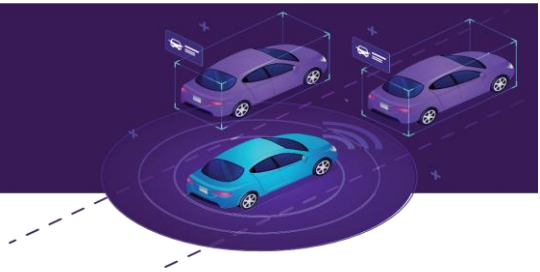
| | determination to give people more quality time while providing seamless freedom of movement and the opportunity to enjoy diverse experiences. |
| **Renault - Nissan** | 1. Nissan, in partnership with the Tokyo Fire Department and the Tokyo Metropolitan Government, recently deployed an all-electric ambulance based on the Nissan NV400 van. This first of its kind zero-emission ambulance in Tokyo is equipped with two lithium-ion battery packs - the main 33 kWh traction battery and an auxiliary 8 kWh for on-board electrical equipment and the air-conditioning system, while the electric motor is 55 kW and 220 Nm (peak).<br>2. Japanese automotive giant Nissan and French electric utility EDF Group will work together to accelerate the adoption of electric vehicles across Europe, which will focus primarily on developing smart charging solutions – such as vehicle to grid (V2G) services – by bringing together technologies which both companies have individually developed and mastered.<br>3. Nissan e-power technology is a tiny ICE which supports the battery in Nissan Leaf's by recharging them using conventional fuel during emergencies.<br>4. Nissan is continuing to innovate the electric vehicle market with its reveal of the innovative e-4ORCE tech at CES 2020 in Las Vegas. Designed to propel immediate torque to all four wheels, the new twin-motor all-wheel-control system delivers sporty performance and a fun-to-drive attitude in the vehicles it powers. The e-4ORCE twin-motor all-wheel control technology offers precise handling and stability, enabling excellent cornering performance and traction on slippery surfaces and comfortable ride for all passengers.<br>5. Roads which use contactless induction technology to charge electric vehicles (EV) on-the-move are part of a two-year Groupe Renault project to trial a series of innovative charging solutions. The French carmaker's INCIT-EV project aims to encourage the development of electromobility in Europe through field experiments and will trial seven innovative EV charging technologies in Estonia, France, Italy, the Netherlands and Spain in 2020 - 2022. |
| **BYD** | 1. Chinese electric vehicle maker BYD has opened a global design center at the company's headquarters in Shenzhen, bringing its designers from around the world under one roof to build better cars.The center spans 12,600 sq. meters and can accommodate 300 in-house designers and 100 external staffers. It contains an area dedicated to creating clay models of the cars. The site also will be used to design monorails, as BYD seeks inroads in that field domestically and abroad.<br>2. BYD officially announced the launch of the Blade Battery at an online launch event themed "The Blade Battery – Unsheathed to |



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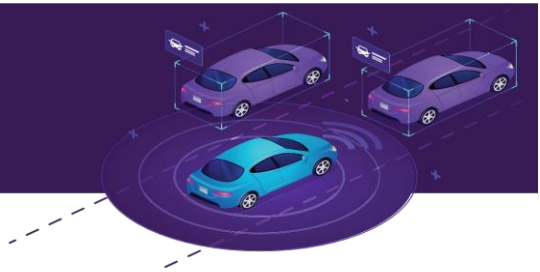
| | Safeguard the World". While undergoing nail penetration tests, the Blade Battery emitted neither smoke nor fire after being penetrated, and its surface temperature only reached 30 to 60°C. Under the same conditions, a ternary lithium battery exceeded 500°C and violently burned, and while a conventional lithium iron phosphate block battery did not openly emit flames or smoke, its surface temperature reached dangerous temperatures of 200 to 400°C. This implies that EVs equipped with the Blade Battery would be far less susceptible to catching fire – even when they are severely damaged.<br>3. BYD, “Build Your Dreams”, announced(november, 2020) the City of Hyattsville, Md. has purchased a BYD 6R Class 6 refuse truck, which will be the first battery-electric, zero-emission vehicle of its kind in the state of Maryland. The BYD 6R has a 221-kWh battery system and is capable of working an entire shift without recharging. With its short wheelbase, this truck is more compact allowing for excellent manoeuvrability on urban streets where space is limited.<br>4. BYD electric buses are used in ‘world’s largest vehicle-to-grid’ project, in London, for energy storage and carriage. |
| **Battery makers** | |
| **LG** | 1. LG Chem has partnered with Georgia Power and PulteGroup to provide sustainable, energy efficient home battery technology to the Smart Neighbourhood™ project. - Smart Neighbourhood™ aims to provide homeowners with new innovative and creative solutions. Each of the 46 technology-enhanced town homes in the Georgia Power Smart Neighbourhood will be served by Georgia Power with power supplemented by individual rooftop solar installations and in-home battery energy storage. LG Chem is supplying two home battery systems to each of the town homes in Atlanta. The latest residential energy technologies will deliver innovative and creative solutions to Georgia Power's customers to more efficiently manage their energy needs.<br>2. LG in partnership with Mahindra in India, is launching a battery manufacturing unit at which LG will design a new cell chemistry based on NMC unique and favourable to the Indian vehicles in their climate and operations.<br>3. LG Chem's Battery Research Center performs research on battery materials such as electrode materials, separators and electrolytes based on the extensive technologies in the fields of electrochemistry, organic/inorganic materials, metals, polymers, |



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| | etc. Based on the research results, the center develops high-capacity/high-output batteries and systems used for mobile devices, electric vehicles and energy storage systems. |
| **Panasonic** | 1. Panasonic's modular SPACe_C EV concept vehicle supports interchangeable bodiesIt allows the cabin or cargo hold to be completely separate from the drivetrain, and it opens up the potential for a fully modular transporter With no complex mechanical steering and transmission inputs needed to interface between the top and bottom layers, it's possible to make them totally separate units, enabling a click-on, click-off architecture that lets one drivetrain unit perform a variety of different jobs depending on what's sitting on its back. Panasonic has been working on this kind of modular vehicle platform for some time now, the e-Torta has been refined from its previous versions with a new 48-volt powertrain that's modular in its own right, incorporating a nicely integrated block that brings together the charger, inverter and 18-kW (24-hp) motor.<br>2. Panasonic, a diversified technology company, launched urban microgrids, hybrid Energy Storage Systems (ESS) with end-to-end solutions for Indian market. The integrated solar power microgrids feature efficient, reliable and intelligent power storage solutions to power up urban residential and commercial areas. The solution allows grid interaction, remote monitoring and data analytics that helps in optimizing the energy usage. Microgrids would enable uninterrupted power supply and enhance operational flexibility for distribution utilities, which are facing challenges in coping up with the increasing demand and network stress, poor power quality and losses, etc.<br>3. Panasonic Corporation has developed a Flexible Lithium-ion Battery with a thickness of only 0.55mm, or about 0.022 inches. Suitable for use in card-type and wearable devices, this rechargeable battery can retain its characteristics even after repeatedly bent into a radius of 25mm or twisted to an angle of 25 degrees.<br>4. AI is crucial to the development of better electric vehicle (EV) batteries, according to research by the Wall Street Journal. Now unprecedented advances are being made in the field that will be crucial to making EVs attractive to mainstream consumers. And they are being led by AI. Panasonic, which makes batteries for Tesla and Ford, has managed to reduce testing times for charge cycles to around six months in some cases. Without AI, the batteries would have been charged and discharged over a period of three years. |

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| **CATL** | 1. Tesla's deal with battery supplier Contemporary Amperex Technology Co Ltd (CATL) for its Made-in-China Model 3 is a strategic move that will deepen the company's roots in the world's largest automotive market.<br>a. CATL is expected to supply a "zero cobalt" prismatic lithium iron phosphate (LFP) battery that the carmaker would use in its Model 3 sedan for the domestic market. The LFP batteries are expected to be cheaper by a "double-digit percent" compared to the existing batteries Tesla is using for its locally-produced Model 3.<br>b. Benchmark Mineral Intelligence, a price reporting agency that specializes in lithium-ion batteries for EVs, estimates that Tesla will save more than 25% in cost compared to what the carmaker spends for batteries used for Model 3s in the United States. CATL will use its cell-to-pack (CTP) technology to improve the energy density and safety of the zero-cobalt batteries. Using the technology that involves more than 70 core patents, CATL can up the mass-energy density of the LFP batteries by 10 to 15 percent, reduce the number of parts of battery packs by around 40 percent, and improve volume utilization efficiency by 15 to 20 percent.<br>2. Mercedes has partnered with CATL in which the OEM will use CATL's cell-to-pack manufacturing technology. The CTP technology simplifies the module structure, the volume utilization rate of a battery pack is increased by 15–20%, the number of parts in a battery pack is reduced by 40%, and production efficiency is increased by 50%.<br>3. CATL uses bionic self-repairing electrolyte. This kind of electrolyte automatically repairs SEI to ensure SEI's integrity and stability. Its self-adaptive protection ability can further improve the cycling and storage performance of battery cells.<br>4. CATL's early warning model of parametric fault and risk developed on the basis of big data ensures a timely response of the battery system in extreme circumstances. It automatically lets the vehicle initiate a cooling strategy, and diagnose and solve problems quickly.<br>5. Aircraft-level thermal insulation material with a strong heat conductivity and its unique Nano pore structure can inhibit heat conduction by air convection and radiation, avoiding the thermal runaway caused by quick heat transfer and the subsequent sudden temperature rise of adjacent batteries. |
| **Electrical & electronics** | |
| **ABB** | 1. ABB has developed a flash charging technology for the buses without having a negative impact on the grid. As opposed to the typical electric buses which use approximately 300kWh batteries |

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| | for their daily commute, the TOSA(Trolleybus Optimisation Système Alimentation) will charge a smaller battery(about 50kW) but at multiple stages as a burst of electricity of up to 600kW which will top-up charge the bus at every station.<br>2. ABB's ModulFlex system, for example, provides precise, modular and scalable assembly and has extensive experience in body-in-white applications. Robots can also apply TIM onto cold plates, with ABB's Integrated Dispensing Function Package (IDFP) offering high speed and high path accuracy. Additionally, robots can be used to connect the battery pack to high-voltage busbars, eliminating the need for human workers to be exposed to medium- and high-voltage currents. Finally, robot installation of magnets in e-motors is more flexible than a dedicated press fixture, which can only accommodate one size of motor, parts in certain angles, etc. ABB's Integrated Force Control automates complex tasks and is suited to e-motor assembly. Furthermore, if changes are required within a manufacturer's facilities, ABB can handle full installation and accommodate new production methods adapted to the EV market.<br>3. ABB is the title partner of the ABB FIA Formula E Championship series – a class of motorsport that uses only electric-powered cars. The series provides a powerful platform upon which to test mobility electrification and digitalization technologies while showcasing their potential to a much wider audience. Fast battery charging for Formula E cars provides one good example of this innovation in action. |
| **Schneider** | 1. The 'Lithium-Ion vs VRLA Trade-off Tool', created by Schneider Electric's Data Centre Science Centre, details the costs incurred when deploying Lithium-ion (Li-ion) batteries over VRLA in UPS applications, taking into account several factors including the source location, the associated energy costs, the UPS capacity, service life, backup time, replacement period and cost of real estate to house the cells. Using data-driven algorithms, the tool analyses the cumulative cost of selecting Li-ion vs. VRLA energy storage approaches and calculates long-term figures, detailing the total cost of ownership (TCO) benefits of Li-ion.<br>2. Schneider's EcoStruxure for eMobility, which is the only end-to-end solution to cover the entire EV charging infrastructure ecosystem. The ecosystem includes key components, such as Fast charge solutions, wallbox, smartwallbox, parking etc.<br>3. The solution, under the umbrella of IoT platform and architecture, improves visibility, cost control, efficiency and resilience, while reducing energy consumption. Ecostruxure of e-mobility includes<br>● Consulting services to help customers strategize, plan, design, install and maintain smart EV charging systems that are safe, reliable and efficient |

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| | • Energy and Microgrid Management to optimize the energy consumption of EV charging units thanks to software that increases the efficiency of usage and cost by forecasting the optimum time to consume, produce, store or sell energy.<br>• Built-in Battery Storage that optimizes grid use and allows for better management of renewable energy<br>• IoT Predictive Maintenance and Operations Management, combined with data analytics, that minimize OpEx and help eliminate downtime<br>• EVlink Charging Stations offer an easy user experience and can be deployed at scale |
| **Bosch** | 1. Bosch, the world's largest automotive supplier is introducing silicon carbide (SiC) chips to help boost EV efficiency by about 6%. The addition of carbon atoms to the silicon normally used for semiconductors increases the conductivity of microcircuits on each chip. For the PEM, these chips are used for switching the current polarity for the DC to AC and AC to DC conversion. SiC allows for higher switching frequencies and a 50% reduction in heat dissipation resulting in more power and less energy loss. The bottom line is 6% more driving range from the same battery charge. That means drivers can either go further, or go the same distance with a smaller, lighter, cheaper battery.<br>2. Bosch developed a battery range extension service which digitally increases battery efficiency by cloud connectivity and continuous monitoring.<br>3. Bosch developed an IoT shuttle which includes a complete ecosystem of networked mobility services, such as reservation and sharing platforms for consumers as well as solutions for car manufacturers and mobility service providers who wish to use autonomous shuttles to offer on-demand mobility," |
| **Component makers** | |
| **ZF** | 1. ZF Japan has announced that the company has developed an electric light commercial vehicle specifically for the Japanese market. The company has been electrifying a wide range of systems not only for passenger cars and commercial vehicles but also for industrial machines. The prototype vehicle has been developed by ZF Japan's engineering team at their Tech Center in Yokohama, collaborating with a team in ZF HQ in Germany in order to satisfy Japan's unique requirements.<br>2. ZF has introduced a new 2-speed electric drive for passenger cars that integrates an advanced electric motor with a shift element and appropriate power electronics. The improvement in energy conversion efficiency compared to previous e-drives extends the driving range for each battery charge. |

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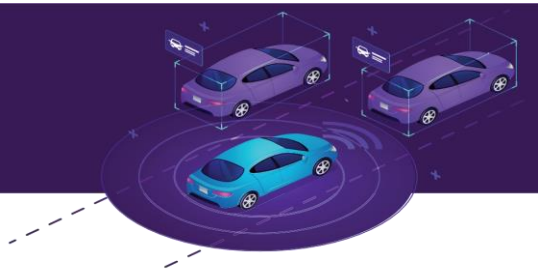
| | 3. ZF has developed the Dual-cam two-lens camera specifically designed for the commercial truck market and to be used in concert with other ZF ADAS technologies. The camera features ZF's longitudinal and lateral vehicle control expertise combined with Mobileye's advanced EyeQ4 processor. Having a second lens also enables redundancy for Level2+ functions—if one lens becomes blinded or non-functional the second lens helps ensure the camera can still operate due to multiple optical paths.<br>4. ZF introduced power electronics on a silicon carbide basis for the Formula E drivetrain, which will be used in volume production in the near future to increase the efficiency and range of electric drives. |
| **Continental** | 1. Continental begins series production of new integrated electric axle drive. Highly integrated means that the new high-voltage drive combines electric motor, power electronics and reduction gear in a single housing. This makes the Continental Powertrain division one of very few system suppliers to offer a complete, electrified powertrain from a single source.Powertrain engineers were able to further improve the interaction between the individual components, consisting of the electric motor, power electronics and transmission, and synchronize them optimally—and also optimize installation space and weight.<br>2. Continental offers vehicle manufacturers the components and systems they need to gradually bring tailor-made electrification to the roads, from start/stop technologies as well as 48-volt and hybrid components to systems for purely electric vehicles. |
| **Software** | |
| **IBM** | 1. IBM unveiled a new battery for EVs, consumer devices, and electric grid storage that it says could be built from minerals and compounds found in seawater. The battery is also touted as being non-flammable and able to recharge 80 percent of its capacity in five minutes. IBM has partnered with Mercedes Benz R&D North America, as well as a Japanese chemical company - Central Glass to refine the battery's electrolyte, and a Silicon Valley battery startup -Sidus to test the battery.<br>2. Researchers at Daimler hope that quantum computers will help them design next-generation lithium-sulfur batteries, because they have the potential to compute and precisely simulate their fundamental behavior. To make sure their calculations on the hardware were accurate, they also performed them on a classical computer using the IBM quantum simulator. Then,they ran these calculations on IBM Q Valencia, and compared the results. Despite working with noisy qubits, the researchers were still able to extract sufficiently precise results. |



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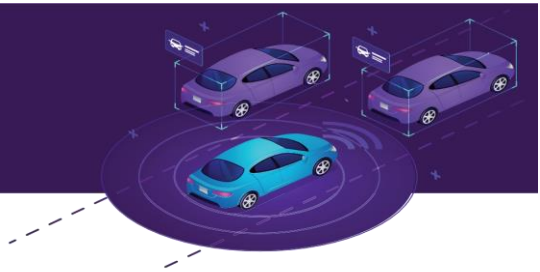
| | 3. IBM has also implemented an artificial intelligence (AI) technique called semantic enrichment to further improve battery performance by identifying safer and higher performance materials. Using machine learning techniques to give human researchers access to insights from millions of data points to inform their hypothesis and next steps, researchers can speed up the pace of innovation in this important field of study. |
| **Microsoft** | 1. ABB and Microsoft Corp. on Tuesday announced the worldwide availability of a new electric vehicle (EV) fast-charging services platform. Combining ABB's leading EV charging stations with Microsoft's Azure cloud-based services will ensure stability, global scalability and advanced management features for ABB customers. The collaboration will also take advantage of machine learning and predictive analytic capabilities to drive future innovations. "Platform performance and stability are critical differentiators for the successful operation of a modern, data-dependent EV charging station. By partnering with Microsoft, ABB will be able to offer best-in-class operations as well as innovative advanced services — what we call the Internet of Things, Services and People,"<br>2. General Motors announced an alliance with Microsoft on its Cruise autonomous driving venture. Microsoft also will provide hardware and software engineering support to GM as part of the alliance, which values Cruise at some $30 billion.<br>3. Tech giant Microsoft has joined hands with Sun Mobility, a provider of energy infrastructure and services for electric vehicles (EVs), to build Smart Network for its EV energy infrastructure. As part of the partnership, Sun Mobility will use Microsoft's IOT technology to connect the 'smart battery' and the Quick Interchange Stations (QIS). QIS are kiosks which would provide swappable smart battery solutions. Sun Mobility will build a network of QIS, which can ready a bus or two and three-wheelers by swapping a battery in five minutes.<br>4. Human Horizons announces its strategic partnership with Microsoft to jointly develop an on-board AI assistant, the HiPhiGo, for HiPhi vehicles. Human Horizons is an innovative mobility company with HiPhi, a subsidiary brand, providing premium smart all-electric vehicles. Supporting the partnership, HiPhi and Microsoft are in discussion to establish a smart computing lab. This will be the latest addition to Human Horizons' '3 Smart' strategic blueprint (Smart Vehicle, Smart Road, and Smart City) enhancing its next-generation connected vehicles. |
| **Google** | 1. Google maps now identifies and displays public ev charging stations along with their real time usage for EV drivers in the UK and USA. |



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| | 2. The polestar2 is powered by google. The vehicle responds to voice commands, infotainment, ensures safety, Navigates and can be used to control all other mechanisms in the vehicle such as air conditioning and seat warming.<br>3. Waymo is an autonomous driving technology developer owned by Alphabet Inc. This technology is integrated with google's solutions to manufacture future vehicles. |
| **Apple** | 1. Apple is trying to develop an electric car with its project 'Titan' incorporated in 2014.<br>2. Electric vehicle charging network ChargePoint that it will team up with Apple Inc to integrate a wide range of EV charging information in Apple's CarPlay infotainment system.<br>a. EV drivers will get hands-free access to such information as the location and status of charging stations on ChargePoint's mobile app on the CarPlay cockpit display screen.<br>b. The app also will enable drivers to navigate to the nearest charging station and start a session, as well as ascertain speed of the charger, cost, availability and plug type. |
| **Amazon** | 1. Amazon has ordered 100,000 autonomous commercial electric vans from Rivin after a 700million USD investment in the OEM startup. |
| **Networking & communications** | |
| **Huawei** | 1. Huawei said that the company will utilise its 5G expertise to develop mm-wave and laser radar using optoelectronic technology to solve the cost and performance problems faced by existing solution providers.<br>2. Instead of trying to be an OEM Huawei will provide solutions such as sophisticated interiors, infotainment devices, payment options, and even small powertrain devices including batteries and motors. |
| **Vodafone** | 1. Vodafone individually adapted the IoT platform to the requirements of intelligent charging management to the Ubitricity(fleet service provider) billing system. The international availability of the Vodafone Managed IoT Connectivity Platform allows Ubitricity to offer and operate its solution not only in Germany but also abroad – which in turn is an important prerequisite for the acceptance of such a mobility concept.<br>2. Vodafone Qatar is supporting an innovative new Qatari start-up, Loop Mobility, with the Internet of Things (IoT) to power its smart scooter sharing service. |

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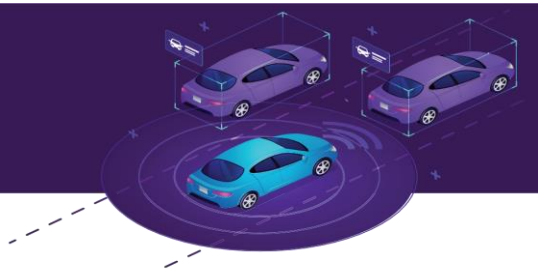
| | a. The company tailor-made the IoT solution to fit Loop's requirements for rolling out hundreds of electric scooters in Doha that are available to anyone.<br>b. Users can enjoy a ride by simply finding a Loop e-Scooter near them in real-time via the Loop mobile app, and after their journey, park it in a safe place. Available currently in West Bay and the Corniche, Loop will help to improve access to public transport by solving Doha's 'first- and last-mile challenge'.<br>c. Preinstalled Vodafone IoT SIM cards ensure that Loop is constantly connected with its fleet of over 500 smart scooters via a web-based dashboard that lets the Loop team track their electric scooters, monitor their condition and batteries, and bring them back to the docking station to be ready for the next ride.<br>d. At the heart of the service is the Vodafone Connectivity Platform, a secure self-service platform that simplifies IoT management, giving Loop full visibility and control of their IoT connected scooters. |
| **Reliance/Jio** | 1. Reliance Jio is running trials of electric vehicle delivery in collaboration with some startups and established vendors.<br>2. Reliance BP Mobility Ltd (RBML), a joint venture of Reliance Industries (RIL) and UK's energy major BP Plc, will set up battery swapping stations at its fuel outlets and spend around ₹3000 crore to expand the fuel retail network, two officials aware of the plans said. RIL and BP, which set up RBML this month, will operate under the Jio-BP brand. BP will pay ₹7,000 crore to RIL for its 49% stake in the venture. |



## Benefits of EVI2 for various EV industry stakeholders

| Stakeholder | How |
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| **Auto OEMs** | Get to know about EV innovations and innovation approaches not by the global top 50 auto OEMs, but also by some of the brightest and nimble entrepreneurs building innovative electric automobiles. |
| **Auto ancillary companies** | Do auto ancillary companies (providing non ICE components) continue supplying to electric vehicles the same way they did to conventional vehicles, or are there innovations possible in even some of the components considered as commodity components. Get to know insightful answers to this question through the dozens of case studies of auto ancillary firms. |
| **Battery makers** | Some of the most exciting innovations are happening in the field of EV batteries. But such dynamic activities also imply that this field carries the most uncertainties. Battery makers can significantly mitigate these uncertainties by getting an excellent overview of battery innovations made around the world, and also innovations in the competing alternative, the hydrogen fuel cell technology. |
| **Charging solutions providers** | Battery charging can be either considered an infrastructure game or a solution in which much needs to be innovated. For companies currently providing or keen on investing in EV charging solutions, EVI2 provides a wide array of innovations and innovation perspectives from leading companies and entrepreneurs around the world. Many of these will show how successful entrepreneurs have built innovative partnerships and collaborations in addition to innovative products. |
| **Logistics & fleet providers** | Logistics providers worldwide are not merely acting as customers or consumers of electric vehicles. Many of them are acting as partners with other stakeholder segments such as OEMs, battery makers and charging solutions providers to evolve and design innovations that can provide significant benefits to all partner stakeholders. |
| **Renewable energy solutions providers** | Renewable energy solutions - especially solar power - hold the key to making electric vehicles a truly low carbon mode |

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| | of transport. This puts RE solution providers in an important position in the e-mobility ecosystem and provides them many opportunities.<br><br>EVI2 shows how many entrepreneurs in the renewable energy domain are innovating to integrate renewable energy in the e-mobility ecosystem. |
| **Electric powertrain component makers (motors, power electronics)** | Powertrain and powertrain component makers can make or break an electric vehicle, such is the importance of the powertrain.<br><br>In addition to innovations at each powertrain component (motors, power electronics etc.), exciting design paradigms are emerging in electric vehicles (in-wheel motors, for instance).<br><br>Companies in the powertrain sector can benefit immensely from EVI2 which has a significant focus on innovations taking place in prominent companies, startups and universities around the electric powertrain. |
| **Financial investors** | Financial investors - be they angel, venture capital or private equity investors - have a critical need to get a comprehensive understanding of effective innovations happening across the entire EV value chain, across the globe. EVI2 is the only compendium that provides such a focussed and powerful intelligence. |
| **Policy makers** | Policies will be one of the key drivers for electric vehicle growth worldwide for the 2020-2030 timeline. But policies need not imply financial support and incentives. A number of innovative non-financial policies and frameworks by federal and regional governments worldwide have made a valuable difference to the growth of e-mobility in their respective regions. Policy makers can get a ringside view of these innovations and insights from EVI2 to help them frame superior policies for their geographies. |
| **University researchers and innovators** | Almost every university worldwide has academic and/or programs for e-mobility. However, most of their offerings and programs can be far superior if they understand how some of the world's top universities are structuring their academic and research programs to align them with the industry's needs for powerful innovations. EVI2 provides over 100 examples of such effective university research efforts. |

# Top management perspectives on EV innovations

Innovations in EVs will come from both the engineers and other executive level stakeholders, as well as from the top management of prominent companies in the ecosystem.

Our analyses of the innovations in the EV ecosystem has shown how the top management of the global automotive leaders will play a critical role in moving the innovation needle in the e-mobility ecosystem. With this in mind, EVI2 lays a special emphasis on innovation perspectives from senior and top management from global leaders in the automotive and E-mobility industry. We have provided over 100 such perspectives.

Here are some samples from the list.

**Elon Musk, Tesla**

Elon Musk is CEO of Tesla

*Building a computer on wheels*

For Elon Musk, his vision of an EV has been to make a computer on wheels. So, a number of features and value-adds in Tesla are guided by this principle - a big screen, a touch interface, over-the-air software update capability etc. For instance, personal computers in the form of desktops and laptops have been doing over-the-air or connected software updates for almost two decades.

The other transformative aspect that Elon Musk is confident in the context of future trends is autonomy - so he foresees an all-electric, all autonomous future.

(Source: https://www.motortrend.com/news/tesla-elon-musk-interview/ )

**Takashi Uehara, Toyota**

Takashi Uehara is Chief Engineer, Powertrain Product Planning Division, Toyota Motor Corporation

*Lithium chemistry and innovations around it are here to stay (at least for a while)*

Takashi feels that given its relatively long history, the Lithium chemistry for batteries is here to stay for a while, but he expects significant innovations to happen within the Lithium chemistry. He also feels that innovations will continue to happen in the use of Li-ion batteries for hybrid electric vehicles.

(Source: http://carindia.in/interview-takashi-uehara-of-toyota-motor-corporation/ )

**Benjamin Boeser - Mercedes Benz**

Benjamin Boeser is the director of open innovation at Mercedes-Benz Research and Development North America - Mercedes

*Mercedes sees big potential for the use of quantum computing to build better EVs and especially EV batteries.*

The company is working with IBM quantum experts. Mercedes-Benz's research and development division are researching how quantum computers could be used to discover new materials for advanced batteries in electric cars within the next decade. Discovering new battery materials could "unlock a billion-dollar opportunity," says Benjamin Boeser. Today, battery development and testing are a physical process that requires experts to build prototypes first because there is no simulation software. A quantum computer could help Mercedes-Benz find new materials or combinations of materials that could result in better electrochemical performance and longer life cycles, but it is still early stages.

A few other prominent automakers such as Ford (use of quantum computing for optimizing driving routes and improving battery structure), and Volkswagen AG (developing quantum-computing-based traffic-management system) are also employing research efforts into quantum computing.

The IBM Q Network program, announced in December 2017, allows companies to access IBM's early-stage quantum-computing systems over the cloud.

(Source: https://www.wsj.com/articles/mercedes-enlists-quantum-computing-to-build-a-better-electric-vehicle-battery-11551134576 )

**BYD**

*BYD has a focus on innovating for battery safety*

For instance, BYD announced in Mar 2020 the launch of the Blade Battery, a development set to mitigate concerns about battery safety in electric vehicles. BYD highlighted a video of the Blade Battery successfully passing a nail penetration test, which is seen as the most rigorous way to test the thermal runaway of batteries due to its sheer difficulty. Due to its optimized battery pack structure, the space utilization of the battery pack is increased by over 50% compared to conventional lithium iron phosphate block batteries.

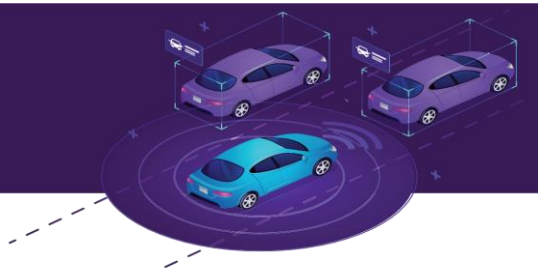
(Source: https://www.prnewswire.com/news-releases/byds-new-blade-battery-set-to-redefine-ev-safety-standards-301031358.html )

**Frank Blome, VW**

Frank Blome is the head of VW's Center of Excellence in Battery Cells

*Innovating to make batteries last longer, much longer*

In 2019, Volkswagen joined Nissan and Tesla as the only automakers to explicitly warranty not just the batteries in its cars but specifically how much life it expects them to retain.



Frank Blome, the head of VW's Center of Excellence in Battery Cells, said that the company expects the battery packs in its upcoming line of ID cars to last "the life of the cars." In this connection, Volkswagen also continues to work with Silicon Valley startup QuantumScape to develop solid-state batteries for its next generation of batteries for electric cars sometime between 2025 and 2030.

(Source:https://www.greencarreports.com/news/1122910_volkswagen-says-ev-batteries-to-last-the-life-of-the-car )

**Saehoon Kim - Hyundai**

Saehoon Kim is the senior vice president and head of Hyundai Motor Co.'s Fuel Cell Center.

*Fuel cells will play a critical role in transport decarbonization*

Hyundai is betting fairly big on innovations around fuel cell technologies. Many senior executives in the company believe that fuel cells will have to play a critical role - in addition to batteries - decarbonizing the transport sector.

The company knows getting the transport sector to a hydrogen economy will not be easy. What makes the hydrogen sector difficult is that the initial expense is very high. With fuel cells, a lot of people think all you need is hydrogen cells but all that gives you is the energy. There are a lot of other components that are needed and you need a fuel tank.

The company eventually wishes to sell its fuel-cell system technology to other OEMs in addition to using them in their own vehicles. In addition to cars, trucks and buses, they also plan to offer their technology to sectors like utilities, shipbuilding and trains.

The company feels that in order to develop fuel cell systems for trucks, it has to be done first with passenger vehicles because you can mass produce. Truck volumes can't come close to volumes of passenger cars.

On economics, their goal is to bring costs for fuel cell vehicles to those of battery-powered cars.

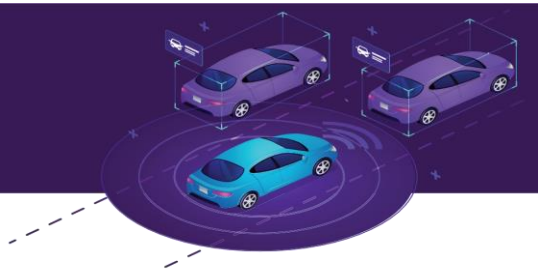
(Source: https://auto.economictimes.indiatimes.com/news/passenger-vehicle/cars/hyundai-hydrogen-chief-on-why-the-company-bet-on-fuel-cells/76302404 )

**Prabhakar Patil - LG Chem Power**

Dr Prabhakar Patil is the CEO of LG Chem Power

*Lithium and innovations around it are here to stay*

He feels that Lithium is one of the best raw material bets for batteries. In his words, "The reason is pretty simple – it's basic chemistry. Lithium is the third-lightest element, and the lightest metal. The only thing



that's lighter is hydrogen, but as a gas it's very difficult to work with because you cannot move it around. And helium is inert. So, lithium is the next best thing for batteries and it will remain lithium in some form for a long time. There could be a future in lithium-metal batteries, like you hear some people talking about, or some other variant. Lithium is very effective in terms of being energy-efficient both from a volume and a mass basis. Right now, there is a lot of focus on improving the cathode, because that's sort of the limiting factor. But as you improve the cathode, the anode sooner or later will become the problem, and that's why people are looking at the silicon type of anode."

(https://chargedevs.com/features/lg-chem-power-ceo-were-the-li-ion-leader-for-pevs-because-of-material-science/ )

**Christoph Schröder - BMW**

*Christoph Schröder is the head of BMW Group Plant Dingolfing*

*Bringing every aspect of electric vehicle production under one roof to accelerate innovation*

"BMW Group Plant Dingolfing is a perfect example of how the automotive industry is transforming itself for e-mobility. We have everything under one roof here: production of batteries, electric motors and electrified vehicles," says Christoph Schröder, head of BMW Group Plant Dingolfing.

(Source: https://www.automotiveworld.com/news-releases/bmw-group-steps-up-electromobility-e-drives-for-half-a-million-electrified-vehicles/ )

**Oliver Zipse - BMW**

Oliver Zipse is Chairman of Board, BMW

*Focus on innovations to decarbonize battery production*

Oliver feels that as e-mobility gains more and more traction, the focus of CO2 reduction will shift to the upstream part of the EV value chain – and, especially, the energy-intensive production of high-voltage batteries as up to 40 percent of a fully-electric vehicle's CO2 emissions come from battery cell production alone. Depending on where they are produced and the electricity mix used there, about a third of these emissions come from power consumption directly at the cell manufacturer. This is a major and very effective lever for reducing CO2 – so that is precisely where we are focusing our efforts.

So, one can expect significant R&D efforts to be focussed on this component.

(Source: https://www.automotiveworld.com/news-releases/interview-with-oliver-zipse-chairman-of-the-board-of-management-of-bmw-ag-we-will-be-taking-sustainability-to-a-whole-new-level/ )

**Frank Muehlon, ABB**

Frank Muehlon is in charge of ABB's global EV infrastructure solutions.

*Innovations to make EV charging more intelligent*

If we were to reach a 100% electrified car fleet, we could expect an increase in total electricity demand of up to 10-20% depending on the country and the level of industrialization. At this stage, the precise schedules and times of charging the vehicle are becoming more important.

ABB feels that by creating intelligent charging hardware which can be digitally controlled, it is possible to optimize charging times and energy flow. In addition, the company is also keen on leveraging the potential which bidirectional charging brings to the sector and how this can support balancing the grid. The company has in its portfolio their bi-directional charging technology and have started working on a Vehicle-To-Grid (V2G) partnership project with DREEV, a joint venture between Électricité de France (EDF) and Nuvve, which specializes in intelligent charging for EVs. In addition to innovations that can be expected on these, expect innovations from ABB to also happen in the Vehicle-To-Home (V2H) domain.

(Source: https://evboosters.com/ev-frontrunners-interview-with-frank-muehlon-abb/ )

**Stefan Hartung - Bosch**

Stefan Hartung is Head - Automotive Business at Bosch

*Bosch sees significant innovations around fuel cells*

Bosch has a partnership with Powercell to mass produce fuel cells.

Why does the company believe now is the right time to invest in the technology?

The company feels that in about 10 years up to 20 percent of all electric vehicles will be charged by fuel cells. It could become a preferred solution for the electrification of medium and heavy commercial vehicles, especially for long range [travel]

The company is not completely writing off the ICEs; it feels that even by 2030, about three-quarters of all vehicles will still have a combustion engine, even if many will be assisted by electrification.

The company also feels innovating for electric mobility will need to also take into account divergent needs of different markets in different geographies, even within the same country. For instance, the U.S. consumers want different vehicles because they have different lifestyles, and you have significant ride-hailing services in cities such as New York, but large fleets of pickups dominate the countryside. And the Chinese and European markets are very different from the US market in terms of customer needs and aspirations,

(Source: https://europe.autonews.com/suppliers/how-bosch-aims-win-electrified-era )

**Dirk Abendroth - Continental**

Dirk Abendroth is the CTO of Continental Automotive

*True innovation will be in combining the big trends in transport*

While the four key trends will continue to gather steam (Connected, Autonomous, Shared & Electric), Dirk feels that the true revolution and innovation will be about combining these trends into a comprehensive, seamless multi-modal mobility service.

Of the four trends, he feels one of the game changers might be autonomous driving.

He also feels that for large companies to succeed in EVs, they will have to strike a balance between the fast innovation of startups and reliability and expertise of large firms.

He also feels that different regions embrace innovations at different rates. For instance, he feels that Chinese customers embrace new technologies and adapt quickly, and as a result both the local industry and the government are pushing for innovation and change at a fast rate.

(Source: https://mag.continental.com/en/interview-with-dr-dirk-abendroth/ )

**Hakan Samuelsson - Volvo**

Hakan Samuelsson is the CEO of Volvo

*Innovating the car sales model*

Hakan believes that customers would like to have mobility in different ways. In the past, this might have meant going to the dealership with a lot of money. What could be very attractive in the future is paying a flat subscription rate for the product. You still get the freedom to move because this car is at your disposal. After three years if you like it you keep it for three or four more years. If you want a bigger one you change to a bigger one. If you don't want it anymore you cancel the contract. This is what the company is trying to achieve with Care by Volvo.

The CEO also feels that achieving significant sustainability along the value chain for automobiles can be achieved if the industry prioritizes it as much as it did for vehicle safety. In his words, “A combination of market forces, technology and international regulations have really driven car safety to improve in the last 50 years. Why shouldn't that also work for sustainability?”

(Source: https://europe.autonews.com/automakers/volvo-ceo-outlines-strategy-electrify-lineup-become-climate-neutral )

**Dr Manfred Braeunl - Porsche**

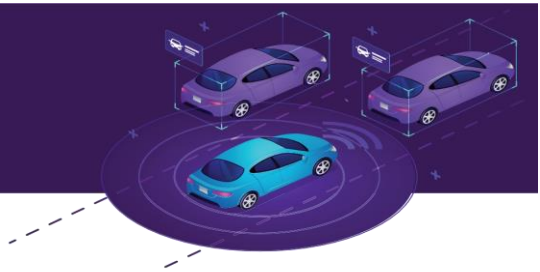
Dr Manfred Braeunl is the CEO - Middle East for Porsche

*Hybrid car innovations can make a different in the short and medium term*

He says that Porsche will continue to build sports cars focusing on three drive technologies: petrol-engine vehicles, hybrids and electric sports cars. There are several advantages to choosing a hybrid model, besides lower fuel consumption and lower CO2 emissions.Hybrid models remain important for the brand's product line-up in the years to come.

Porsche also is clear that their customers value innovations on aspects beyond just the basic and utilitarian aspects of a vehicle. As he puts it, "The future Taycan customer is brand-savvy, committed to responsible use of resources and is a tech fan...status for these customers increasingly derives from conscious actions from an environmental perspective, which makes the question of a brand's sustainability more important. It is also striking that these customers have a strong affinity for new technologies. They want to be among the first to own the latest innovations."

(Source: https://www.tahawultech.com/features/porsches-electric-future-interview-with-middle-east-ceo/ )

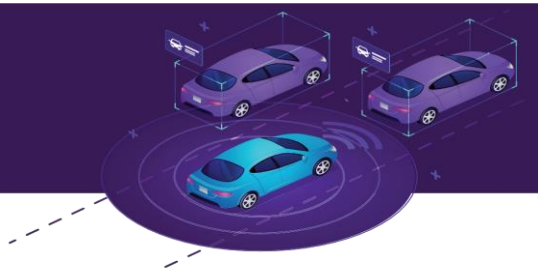


# KEY TAKEAWAYS FROM THE EVI2 GUIDE

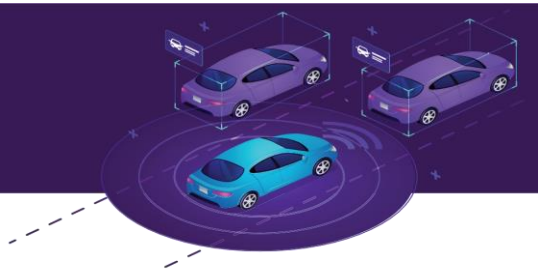
**Key takeaways from EVI2**

Based on the extensive research the EVI2 team undertook to study and analyse EV innovations - which are presented in this comprehensive guide - following are the key takeaways for the e-mobility innovation spectrum:

1. ***Across value chain*** - Innovations are happening across the EV value chain, in every possible component. Even components that are considered commodities (electric cables and connectors, for instance) are seeing significant innovations that are aligned to relevant value propositions.
2. ***Across products*** - In just the past few years (since 2017), electric vehicles have grown too far beyond just electric cars, bikes and scooters - and today , you have electric buses, electric vans, electric trucks and even electric aircraft. As of early 2021, our research counted *no less than 30 different types of vehicles* that have been electrified. Almost all these product categories - and their powertrain components such as batteries, BMS, motors - are seeing significant innovations. Going beyond batteries, hydrogen and fuel cells have also attracted innovator and investor interest. And going beyond just the use phase, innovations are also spurring progress in the end of life of both electric vehicles and batteries - especially in battery recycling, life extension, and in its second use as stationary storage devices.
3. ***Use in multiple industries*** - In addition to the B2C sector, the more visible in the electric vehicle domain, the B2B sector too has started playing an increasingly important role. Electric vehicles are already finding use in over 20 different industries. So high is the interest for EVs in the B2B sector that this sector (rather than B2C) could be the real growth story for electric vehicles during the 2020-2030 period. Diverse innovations are taking place in the B2B EV space, many of which are being supported through large corporate investments in addition to funding from venture capital firms.
4. ***Different genres of innovations*** - Innovations happening in the e-mobility sector are not just technology-oriented. Innovations in strategy, in business models and in financing are seeing exceptional activity as well. For instance, in parallel to technology advances are taking place in battery charging (both AC slow charging & DC fast charging), many startups are also offering unique EV battery swapping solutions, some of which are accompanied by impressive automation through the use of robotics.
5. ***By different stakeholders*** - Transportation touches a wide variety of stakeholders, so it should not be any surprise that EV innovations are being driven by a large and diverse set of stakeholders. In addition to the obvious stakeholder sectors such as the OEMs and auto ancillary companies, our research has identified at least 10 other stakeholder segments significantly driving EV innovations (fleet owners, IT & software firms, solar power companies, venture capital firms etc.), and an additional 10 stakeholder segments who could be providing support for EV innovations in the near future - some of these stakeholders are unique in their diversification efforts and some could be quite surprising - national security and defence organizations, for instance.



6. ***In different stages*** - The e-mobility phenomenon is quite new and is just beginning (EVs still have less than 1% penetration in most product categories), and innovations and inventions driving this sector are in their beginning stages too. A large portion of these innovations - some of which could prove disruptive - are in the pilot and even pre-pilot stages. In the context of EV innovations, one can confidently say that what the commercial world is seeing today is the proverbial tip of the iceberg.
7. ***Strategic intent*** - While some innovations are taking place with specific end applications or unique value propositions in mind, some - especially those by large firms - are driven by long term strategies, and these innovations and their characteristics are quite nuanced.
8. ***Different approaches*** - Depending on the stakeholder segments and their objectives, innovations in the EV space are witnessing different approaches. For instance, while there are hundreds of new startups putting in solo efforts to come up with innovative products, stakeholders such as governments or large auto OEMs are forming a web of diverse partnerships in their innovation efforts. While some of these approaches - OEM partnerships with EV charging networks or acquisition of innovative startups by large firms - are unsurprising, some are innovative and perhaps unique to the e-mobility sector.
9. ***Across countries*** - Most EV innovations that come under the limelight are high-tech ones those developed countries that are auto majors - USA, Germany, Italy, South Korea, China etc. Innovations in the e-mobility spectrum are becoming increasingly commonplace even in underdeveloped countries in Africa. Interestingly, the nature of innovation is significantly different when one compares developed (USA. Germany etc.), developing (India, Kenya, Philippines etc.) and underdeveloped (many African nations) countries. While developed countries have a dominant focus on technology as the key component in their innovation, many underdeveloped countries are in fact *deliberately using low-tech*.to drive innovations.
10. ***Order in chaos*** - If one were to look at the overall innovation spectrum in e-mobility across the globe, it appears chaotic. Large firms seem to be doing everything - acquisitions, partnerships and diversification into seemingly unrelated components of e-mobility. Startups of course are relatively more focussed but there are too many of them seemingly doing too many different things. Seen together, the overall picture appears like a complex maze. But if one looks closely, one will see logical strategies and clearly emerging trends in various stakeholder categories.
11. ***Winning through innovation*** - For companies investing in electric vehicles - whether as a logical extension of their current business or as a diversification - innovation has to be a necessary component of their strategy. But innovation alone is not sufficient. What is also important is a robust approach to innovation. Such an approach will require the firm to review the above aspects and weave the relevant ones into their innovation strategy to create a sustainable competitive advantage.



# Sample Content from The Report

## Startups

## Store Dot

Incorporation: 2012

Location: Herzliya, Israel

Founder: Doron Myersdorf

https://www.store-dot.com/

https://www.linkedin.com/company/storedot/about/

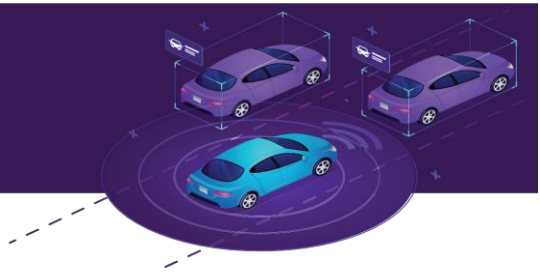
| |
|---|
| **What is the value/product value proposition?**<br>New generation of Li-ion cell design comprising hundreds of EV flash battery cells which enables full charging in less than 10 minutes(flash charging) for electric cars. |
| **Who will benefit from it?**<br>OEMs, BaaS providers |
| **Why is it unique?**<br>The batteries are developed by replacing existing chemical materials and technologies with enhanced electrochemical materials and other proprietary compounds combined with nanomaterials.<br>During their first demonstration in 2019, a two wheeler was charged completely in 5 minutes. |

### Product[1]

A new-generation battery that charges fully in 5 to 10 minutes at a 10C charging rate, providing a range of 300 miles.

Store Dot is developing a new type of electric-car battery consisting of proprietary organic compounds – based on the innovative materials used in its flash battery for mobile devices. The EV flash battery will enable a charging experience which is very similar to fuelling a gasoline car. The EV flash battery enables

[1] https://www.store-dot.com/



full charge in 5 minutes, providing up to 300 miles (480 kms) of driving distance, depending on the model of EV. Store Dot fast charging technology shortens the amount of time drivers have to wait in line to charge their cars, thus also reducing the number of required charging points in a given charging station.

**Innovation**

The batteries are developed by replacing known chemical materials and technologies with enhanced electrochemical materials and other proprietary compounds combined with nanomaterials.

**Charges an electric car in 5 minutes**

EV flash battery's remarkably fast charging rate is achieved due to Store Dot's novel materials and new battery structure. The electric vehicle will have a pack of hundreds of EV flash battery cells that can store enough energy for a full EV range on a 5 minute charge. For a 300 mile car, this translates to 60 miles of travel range on a 1 minute charge.

**EV flash battery cost**

Although the EV flash battery enables the remarkable feature of 5-minute vehicle charging, this will not increase the price of the electric vehicle. As the manufacturing process uses traditional capital equipment, with mostly standard processing, the EV flash battery cost is aligned with Li-ion industry's cost reduction curve over the coming years, and will benefit the expected economies of scale of the industry as a whole.

**Safe and eco-friendly**

EV flash battery architecture is built with a highly stable electrode structure, and contains materials that are far less flammable and more stable at high temperatures than traditional Li-ion technology. Consumer safe, EV flash battery incorporates a multi-layer safety-protection structure. In addition, a flash battery is environmentally safer than a Li-ion battery, utilizing organic compounds and an aquatic based manufacturing process.

Flash

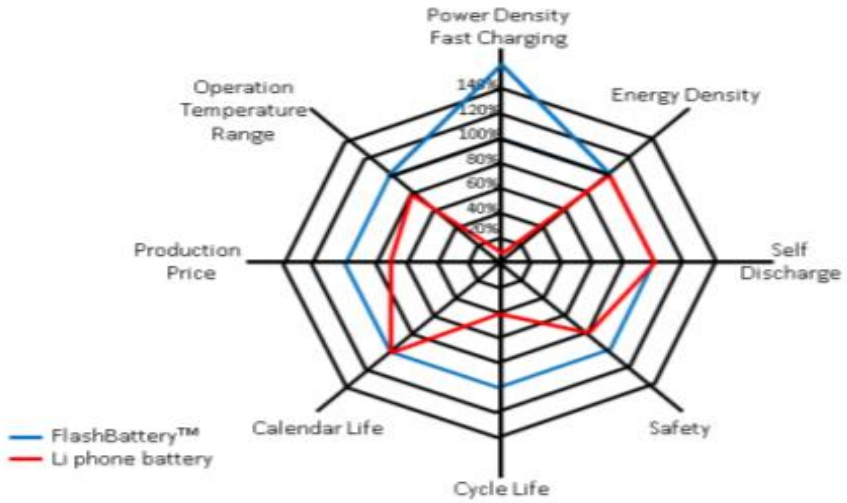
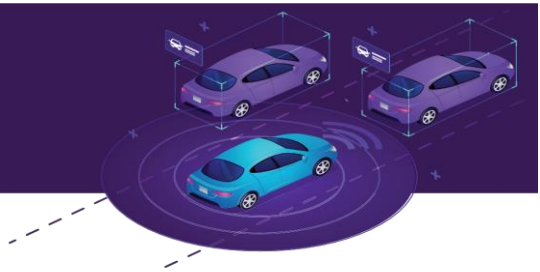



Figure 1: Performance Comparison of Lithium and batteries

Image Source: https://www.store-dot.com/

**Target sector: OEMs**



- Partners include Daimler & British Petroleum
- During the first demonstration in 2019, a two wheeler was charged completely in 5 minutes.

## Future plans[2]

- Has demonstrated its flash charging technology for commercial drones in July, 2020. The company plans to send the batteries to various users across the globe from different industries including medicine, automobile, consumer electronics for reviews.
- The company aims to manufacture its batteries at its own 1 GW factory starting 2022. The facility will have an initial manufacturing capacity of 1 GWh, scalable to 10 GWh.

## Geographical scope

- Store Dot has begun large-scale manufacture of flash batteries in China in partnership with EVE Energy Co.

## Partnership details[3]

**Store Dot signs agreement with new manufacturing partner, EVE Energy Co. Ltd. (Nov, 2018)**

Store Dot, announced the addition of a new manufacturing partner, China based EVE Energy Co. EVE will support the mass production of the first generation of Store Dot's flash battery technology for consumer electronics, enabling a full charge in only 5 minutes. With an initial focus on production for the Chinese market, EVE is also expected to help support a global roll out. This partnership will later extend to the production of Store Dot's second generation FlashBattery™ technology designed for use by electric vehicles (EV).

**Store Dot announces strategic investment from BP (May, 2018)**

Store Dot Ltd, announced a strategic investment in the company from BP. The strategic investment will see Store Dot and its partners join forces with BP to strengthen the ecosystem around the next generation of Electric Vehicle(EV) ultra-fast charging infrastructure.

**Store Dot announces funding and strategic partnership with TDK Corporation (Mar, 2018)**

Store Dot, announced a strategic partnership with the Tokyo based TDK Corporation, an electronic components manufacturer and a Li-ion cell development and manufacturer. The new strategic partnership

[2] https://www.store-dot.com/
[3] https://www.store-dot.com/news

is aimed to commercialize Store Dot's flash battery technology as early as 2019.

**Store Dot completes $60 million funding round with strategic partner Daimler (Sept, 2017)**

Store Dot, announced a third round of financing led by the truck division of top producer of premium cars and commercial vehicles Daimler. The $60 million round also includes Lucian Venture Capital group and participation of financial institutions from Israel and China, as well as existing investors such as Samsung Ventures and Norma Investments, representing Roman Abramovich. In conjunction with the round, Daimler joined as a strategic partner to accelerate the adoption of the flash battery technology to the electric vehicles market.

## Funding[4]

- British Petroleum invested $20 million in a corporate funding round in May 2018 even before Store Dot's first working demonstration.
- Daimler is another lead investor which invested $60 million in August 2017.
- Singulariteam, a Tel Aviv based investment firm, invested a seed capital of $42 million in 2014.
- Samsung Ventures is a non-lead investor with undisclosed amounts for its interest in flash batteries for consumer electronics.

## Intellectual property[5]

- The company has patented a **multifunction electrode** which charges like a capacitor and discharges like a battery. Flash Battery technology is based on the engineering of a proprietary high charging rate and high capacity multifunctional electrode (MFE) to be used as cathode and/or anode in energy storage devices. A combination of both battery like and supercapacitor-like electrode material components is present within the same electrode, thus, composed of organic polymer and Lithium-metal-oxide (LiMO) components.
- Storedot was granted a patent for **composite Lithium borates and/or phosphates and polymer coatings for active-material particles**. This patent granted to Store Dot covers improved anodes and cells, which enable fast charging rates with enhanced safety due to much reduced probability of metallization of lithium on the anode, preventing dendrite growth and related risks of fire or explosion.
- Store dot has 47 patents overall including 'Electrode stack production methods', 'Germanium-containing active material for anodes for lithium-ion devices', etc.[6]

[4] https://www.crunchbase.com/organization/storedot/company_financials
[5] https://www.store-dot.com/news
[6] https://patents.justia.com/assignee/storedot-Ltd

## Global recognition

- 2017: Most disruptive company in the world by Disrupt100.
- BloombergNEF pioneer for 2020.

## Founder's profile

Dr. Doron Myersdorf, CEO. (linkedin.com/in/donush)

- Ex- Sr.Director of marketing and business development at Sandisk
- Ex- CEO of InnerPresence Networks
- Ex- Co-founder of Siftology Inc
- PhD in Industrial Management from the Israel Institute of Technology.

## Factblock

Charge and discharge rates of a battery are governed by **C**-rates. The capacity of a battery is commonly rated at 1C, meaning that a fully charged battery rated at 1Ah should provide 1A for one hour. The same battery discharging at 0.5C should provide 500mA for two hours, and at 2C it delivers 2A for 30 minutes.

Further charging at 5C implies the charging takes place at 1/5th of an hour, i.e, 12 minutes.

StoreDot technology mentions that its batteries can be charged at **10C** rate leading to a full charge within **6 minutes**.

# Lightyear

Incorporation: 2016

Helmond, Netherlands

CEO: Lex Hoefsloot

https://lightyear.one/

https://www.linkedin.com/company/lightyear.one/

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|---|
| **What is the value/product value proposition?**<br>Electric car with self-charging technology |
| **Who will benefit from it?**<br>Premium consumer market |
| **Why is it unique?**<br>Electric car with a solar roof and lining which continuously charges the vehicle under the sun. |

## Product[7]

The Lightyear One is the company's first prototype which scales higher than traditional electric cars, with a roof and hood lined with solar panels.

- Named one of the Top 100 inventions of 2019 by Time magazine, Lightyear One can be charged from an electrical outlet, while the solar panels can charge the car's batteries the equivalent of 7.5 miles of additional range for every hour of charging. The car's solar power capacity means leaving the car outside your workplace on a sunny day would provide you with enough solar power for a standard commute home.
- Five square meters of integrated solar panels are located on the hood and roof of Lightyear One. These panels have a safety glass so strong that an adult can stand on them without causing damage.
- The development of different components based on Lightyear's architecture is being outsourced to specialised partners, as well as production, assembly and most of the testing activities. The only exception is the production of the solar roof which is done in-house.

[7] https://lightyear.one/

- The car company was founded in 2016 by ex-members of Solar Team Eindhoven, a team of engineering students who won the solar-powered World Solar Challenge race in 2013, 2015, and 2017.


Figure 10: Lightyear One visiting California and the Bay Area in October 2019.
Source: https://lightyear.one/news/lightyear-solar-impulse/

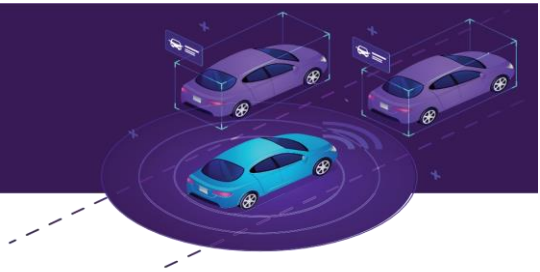
## Partnerships details[8]

**DSM and Lightyear join forces to scale the commercialization of integrated solar roofs for the electric vehicle market (May 2020)**

Lightyear and Royal DSM, a global science-based company in Nutrition, Health and Sustainable Living, have signed an agreement to jointly scale the commercialization of Lightyear's unique solar-powered roof for the electric vehicle market. The partnership aims to integrate solar-powered roofs in a variety of electric vehicles, including cars, vans and buses - thus enabling users to charge their vehicle directly with clean energy. The companies are teaming up to assess the market, starting with pilot projects for customers from the automotive and public transport sector, where the integration of a solar roof could represent a smart investment.

**Deloitte buys 1 million sustainable car kilometres from the Dutch car manufacturer, Lightyear as part of their lease fleet. (September 2019)**

[8] https://lightyear.one/news/



Deloitte and Lightyear have been working together for some time, with the collaboration focussing on the creation of a future-proof organisational structure for Lightyear and building an ecosystem of innovative partners, such as the partnership with LeasePlan Netherlands. Through the reservation of one million sustainable kilometres, Deloitte underlines their confidence in Lightyear's technology and invests in both the future of mobility and energy.

## Funding[9]

Lightyear has raised a total of €27.2 million in funding over 4 rounds. Their latest funding was raised on Sep 20, 2019 from a Convertible Note round. Lightyear is funded by EASME - EU Executive Agency for SMEs.

## Global Recognition[10]

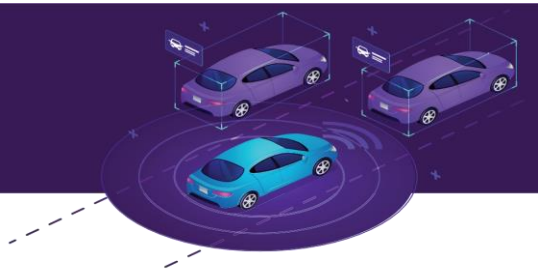
- LinkedIn top Dutch startup 2019.
- The car company was founded in 2016 by ex-members of Solar Team Eindhoven, a team of engineering students who won the solar-powered World Solar Challenge race in 2013, 2015, and 2017.
- October - 2019. Lightyear One sets a new record for most aerodynamic production cars Lightyear's engineering team has performed the first series of validation for the aerodynamic performance of Lightyear One. During a week of testing in a wind tunnel facility in Turin, the Lightyear team was able to validate their simulation models and confirm a drag coefficient (Cd) below 0.20. This means a newly established record in aerodynamics for Lightyear One.
- Lightyear One has been acknowledged as one of the 100 inventions of 2019 TIME magazine.
- Lightyear was accepted by the Solar Impulse Foundation to receive the **Solar Impulse Label**, as one of 1000 efficient solutions aiming to bring about sustainable change.
- The founders were recognized as **Forbes 30 under 30** as young visionary leaders under the technology category for 2020.

## Founder's Profile

Lex Hoefsloot, CEO (linkedin.com/in/lhoefsloot)

- Ex - Cofounder Blue Jay Eindhoven
- Cofounder, Solar Team, Eindhoven
- Master of Science in Engineering, Automotive Technology from Eindhoven University of Technology.

[9] https://lightyear.one/news/
[10] https://lightyear.one/



## Factblock

The Lightyear one can travel 12 kilometres when charged by solar power alone for an hour. 35 kms at 3.7 kW, 209 kms at 22 kW and 570 kms at 60 kW charging, each for an hour.

If a lightyear One is driven in Chennai for a year with an average of 1320kms in a month. 59 days of the year worth of travel would be powered by the sun alone.

## Questions & Answers

# 6.1. What are the strategic and operational partnerships that 2 wheeler and 4 wheeler OEMs can explore to build strong competitive advantages for the B2C market?

Winning in the e-mobility market will not be easy for OEMs especially for those targeting B2C markets. The challenges that EVs comprise currently - high cost and long charging times - along with intense competition necessitates strategic moves to develop sustainable competitive advantages.

One such can be building strong partnerships.

Based on our research and analyses, the EVNext team provides insights on how OEMs can innovate on partnerships to build a successful business.

We discuss seven types of partnership strategies that OEMs can explore:

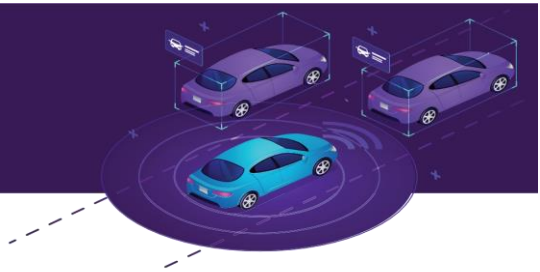
- Partnerships with EV charging or swapping station service providers
- Investing in startups
- Strong alliances with specialized online marketing and e-commerce platforms
- Partnerships for better design, aesthetics and ergonomics
- Value added services using advances in IT and electronics
- Partnerships with financing companies

## Partnerships with EV charging or swapping station service providers

Tesla has had its own charging network - a fairly extensive one in certain regions - for quite a while, giving its users the comfort that help is never far away. While its Supercharger network has helped the automaker differentiate itself and boost sales and is not considered a revenue generator, it certainly has given it a head start in market penetration.

Other EV OEMs are also trying to reach that status and even go beyond that and for that, not all are trying to do it all alone.

Porsche, Mercedes-Benz, BMW, Nissan, General Motors and others are plugging into third-party charging networks, such as EVgo(US), ChargePoint(US) and Electrify America(US). In some cases, automakers have made strategic investments in the businesses.

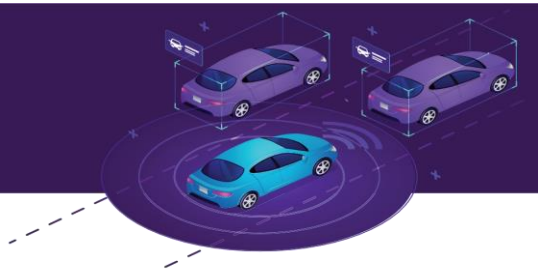


Here are some highlights of how others are planning to expand their EV charging network through partnerships:

- In 2018, GM paid EVgo to develop an exclusive charger network for its Maven Gig car rentals in the US.
- Daimler invested about $82 million in ChargePoint (US) as part of a $125 million funding effort by the charging network in 2017.
- Over a decade, Electrify America plans to invest $2 billion in a public fast-charger network open to customers of all automakers. The company, financed through Volkswagen's settlement over its diesel emissions cheating, will install or have under construction more than 4,800 EV charging stations by June 2019.
- ABB is the title partner of the ABB FIA Formula E Championship series – a class of motorsport that uses only electric-powered cars. The series provides a powerful platform upon which to test mobility electrification and digitalization technologies while showcasing their potential to a much wider audience. Fast battery charging for Formula E cars provides one good example of this innovation in action. (Apr 2019)
- In Australia in Oct 2020, to ensure a premium charging customer experience for its e-tron, Audi has selected to install ABB’s Terra HP high power charger at its main Audi Customer Centres in Melbourne and Sydney. Providing a 175kW DC charging power, the Terra HP can charge a vehicle to 80 percent in 30 minutes and to 100 percent in 45 minutes, enabling a range of 200 kilometers in as little as 8 minute.
- In another partnership with ABB, India’s leading bus maker Ashok Leyland of the Hinduja Group announced in Jan 2020 a pilot electric bus based on ABB's innovative flash-charge technology, TOSA, which tops up the battery in just seconds while passengers get on and off the bus. ABB's TOSA is the world's fastest flash-charging connection technology, which at select passenger stops connects the bus to charging infrastructure and in 15 seconds batteries are charged with a 600-kilowatt power boost.
- In India, SUN Mobility has already partnered vehicle manufacturers and ride-hailing service providers such as Ashok Leyland Ltd, Piaggio Vehicles Pvt Ltd, Uber India, and others to set up battery swapping stations for them in India. (Sep 2020)

## Investing in startups

- Many OEMs like Barath forge, BMW, Damiler, Hyundai, Kia motors, Renault, Nissan and Mitsubishi are investing in startups to adopt new technologies and are trying to accelerate the addition of Ev globally.
- Bharat Forge, one of the world’s largest auto industry suppliers, has acquired a 35% stake in electric truck maker Tevva Motors(UK) for £10 million. The deal is part of a wider round of funding, which has seen £11.8m injected into the Chelmsford-based manufacturer. The launch-pad to develop next generation technology for the UK commercial vehicle sector, and in new geographies too such as China and India, where the government wants to introduce zero emission vehicles by 2030. Tevva delivered 15 7.5-tonne electric trucks to UPS by the summer of 2019. The agreement



will give Bharat Forge a commercial licence to use the Tevva technology within India where it is based. (India - August, 2018)

- Rimac Automobili, the Croatian electric hypercar manufacturer that landed an investment from Porsche in 2018, has again gained the backing of traditional automakers after Hyundai Motor Company and Kia Motors jointly invested €80 million, or around $90 million. Beyond the significant cash infusion, the three parties said the deal includes “a strategic partnership to collaborate on the development of high-performance electric vehicles. (Croatia - May, 2019)
- Smart motor system developer Turntide Technologies, on a mission to replace all of the traditional motors in the world, brought in $33 million in funding to accelerate its strategy. The new investment includes backing from the Amazon Climate Pledge Fund. As of today, the company has raised $103 million since its founding in 2013. That includes a $25 million Series B round in January led by BMW i Ventures. (September, 2020)
- Mercedes-Benz owner Daimler has invested millions in an Israeli start-up whose battery technology can charge electric vehicles in a matter of minutes. Tel-Aviv-based StoreDot announced that the trucking arm of the German automotive giant had led a $60 million funding round, and would partner with the firm to adopt its Flash Battery technology. (September, 2017)
- The alliance of manufacturers Renault, Nissan and Mitsubishi, has invested in the Californian battery startup Enevate via its venture capital subsidiary Alliance Ventures. The amount of the strategic investment is not known. The company currently grants licenses for its silicon-dominant HD-Energy Technology to battery and electric vehicle manufacturers in order to quickly generate production volumes. (November, 2019)

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## Strong alliances with specialized online marketing and e-commerce platforms

- E.ON formed an alliance with ALD Automotive, a full-service leasing and fleet management services company operating across 43 countries. The two companies said the strategic partnership is aimed at jointly developing and marketing digital enhanced mobility, financing and energy services for corporations, municipalities and private customers in Europe. The joint offering will include consultancy and planning, installation, and the operations and maintenance of charging infrastructure. (Germany - February, 2019)

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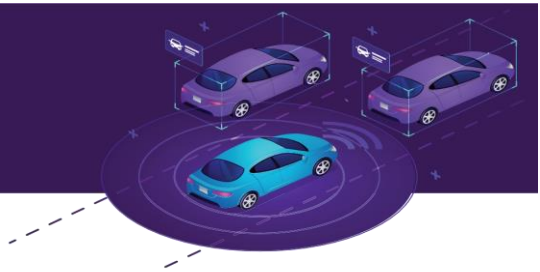
## Partnerships for better design, aesthetics and ergonomics

- 3D printer filament manufacturer Polymaker has partnered with Italian car manufacturer XEV to make 3D printed low-speed electric vehicles (LSEVs). With this process, XEV and Polymaker are planning to change the way the industry makes cars today. Each of the 3D printing machine[s] can extrude 25kg of material per day. This is about 10 times faster than the other industrial 3D printers. (March, 2018)



- Mahindra & Mahindra will collaborate with Israel's REE Automotive to develop and manufacture electric commercial vehicles for global markets. REE's platform technology of integrating powertrain, suspension and steering components in the arch of a vehicle wheel can help Mahindra achieve its goal. REE aims to leverage Mahindra's global presence and engineering expertise to allow them drive their EV technology faster. (August, 2020)
- Bollinger Motors has chosen Optimal Inc. of Plymouth, Michigan to help bring the Bollinger B1 all-electric, all-wheel-drive Sport Utility Truck to production. The two companies finalized the work on the Bollinger B1 by the end of the year 2018, on target for production to start late during the year 2019. (March, 2020)

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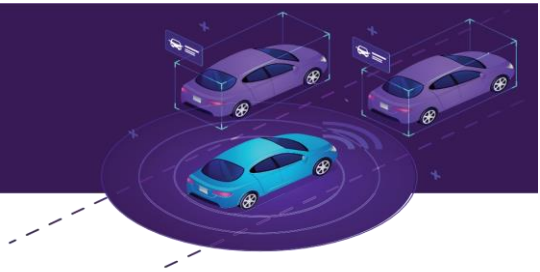
## Value added services using advances in IT and electronics

- BlackBerry Limited and EV startup Canoo(US, Electric vans) announced that the ADAS systems for the company's membership-based semi-autonomous EVs will be powered by the BlackBerry QNX operating system (OS), including radar sensors, parking sensors and cameras. BlackBerry will license its BlackBerry QNX technology to Canoo, including its QNX OS for Safety 2.0 to serve as the safe and secure foundation for the autonomous features within the company's sleek and city-friendly EVs. Canoo aims to bring its first production vehicles to market with advanced level 2 (or level 2+) autonomous features as standard at the end of 2021. (July, 2020)
- Arrival and Charge have chosen connectivity management software provider Cubic Telecom to integrate its intelligent connected car solution to their electric commercial vehicle fleet. The solution will be deployed in selected models from 2020 in the UK, with follow-up plans to roll out to Europe and North America. In addition to powering connectivity for Arrival's fleet of electric commercial vehicles, Cubic Telecom is providing its connectivity solution to Arrival's sister company Charge Automotive for specialist EVs. Charge Automotive expertly develops luxury and high-performance vehicles, redefining classic cars with advanced electric technology. Cubic Telecom's intelligent software and connectivity solution will initially power a fleet of 1960s styled electric Mustangs with telemetry, software updates, multimedia streaming, maps and internet surfing. (December, 2019)
- Volkswagen has reached a deal with Microsoft to cooperate on cloud computing in China and the United States, both the companies announced this during a joint visit to the Volkswagen Digital Lab in Berlin. Volkswagen and Microsoft are also working together on first lighthouse projects for connected vehicle services. Both companies want to deliver communication and navigation solutions as well as personalized services. These will leverage self-learning algorithms facilitating the use of services in the vehicle and offer occupants many extended functions. (Germany - February, 2019)
- Human Horizons announces its strategic partnership with Microsoft to jointly develop an on-board AI assistant, the HiPhiGo, for HiPhi vehicles. This strategic partnership with Microsoft will accelerate the development of our onboard digital AI assistant, HiPhiGo. Using the onboard AI assistant, HiPhi will significantly optimise the connections between its vehicles, cloud-based platform, and user-centric services within the "vehicle-road-city" ecosystem. The HiPhiGo AI



assistant will also allow HiPhi to leverage mobility services across its entire portfolio, providing new services and solutions such as in-car consumer experiences, telematics, and the ability to securely connect data between the car and its occupants. (China - July, 2020)

### Partnerships with financing companies

- Hero Electric recently announced its collaboration with fintech startup Autovert Technologies. Through this partnership, Autovert will be providing Hero Electric customers with subscription-based financing plans starting at INR 2,999 per month. Additionally, Autovert Technologies will also be providing vehicle insurance, service and maintenance benefits, customer loyalty bonuses and attractive upgrade options. Autovert claimed it would be leveraging the internet of things (IoT)-based technology platform 'Autovert Plug' to manage the vehicle throughout the customer lifecycle. (India - July, 2020)
- Northridge Finance, has signed an exclusive agreement with SsangYong Motors UK to provide motor finance products to customers across the brand's UK dealer network. Northridge offers a comprehensive range of lending products for the dealer and intermediary market including; hire purchase, personal contract purchase, leasing and loan products. (UK - July,2019)

## 6.2. How can an entrepreneur or business identify attractive niche EV OEM segments?

**Do a comprehensive review of all product and service opportunities**

- Charging Technology, Battery technology and autonomous driving are the three prominent areas where a lot of research and developments is happening.Improvements in the charging technology will be one of the most exciting trends to watch out for in the EV market. As per a consumer research, range and charging time are two significant challenges compared with ICE vehicles, which are much more convenient for long-distance traveling. Progressions in battery technology have been very slow, and it seems like Lithium-ion is here to stay for some more years. Though, there are improvements under process in the cell chemistry, cathode and anode materials and fabrication process.Globally, many EV companies are already taking a big leap towards autonomous driving to make it a reality in the near future. Autonomous driving technology will not only make long-distance drives more comfortable but also make driving much safer. (January, 2020)
- Some of the New business opportunities in indian EV Industry. (September, 2019)
    - Electric car servicing garage
    - EV Charging Station
    - EV Charging Station Management
    - Electrical workshop for electrical vehicles
    - Home Charging Station Setup Service
    - Charging Station Setup Training Service
    - Spare Parts Manufacturing/selling

- Electric car battery shop
- Mobile Electric Cars Repair Services
- Portable Charging Station
- Solar charging station installation & service centre
- Software maintenance for Autonomous driving vehicles

**Provide public EV chargers through platform business model**

- One of the factors that will lead to the rising of EV will be the availability of EV chargers. The more EV chargers, more electric mobility connectivity, hence more EVs will be sold to market. But, most of the public EV chargers available today are provided for 'FREE'. Some of the chargers are chargeable, but it may not be attractive to the EV users if they can go to the other nearby public charger and get the electric juice for FREE. In a business model that creates value by facilitating exchanges between two or more interdependent groups, usually consumers and producers(Platform Business Model). By providing EV chargers through Platform Business Model, one can protect the customers by preventing them from spending for the electricity. This is a perfect solution for fuel marketers to counter the risk of potential lower gasoline demand due to the rising of EV.

**Partner with EV charging stations to provide one stop center for 'Charge & Chill' experience**

Tesla recently announced their plan to set up Tesla supercharging stations. Their supercharging could be considered as among the advanced technology today. But even that, it took 30 – 40 minutes to fully charge. These charging stations would have up to 40 charge points, a lounge where drivers could sit back and relax, and coffee on-hand (Motoring research, 2017). By providing facilities for the users to "Charge and Chill", this is basically another good business opportunity.

**Provide battery disposal services**

The rising of EV later on will eventually lead to a problem. Current EV battery technology is the same as our smartphone battery – which currently uses Lithium. This is a controlled material and needs proper disposal activity due to environmental concerns. Once the EV battery expires and needs replacement, it needs to be disposed of. Specialized service to dispose of the battery is another business opportunity due to the rise of EV.

**Learn from start-ups**

- Operating from Tacoma, in the northwestern USA, ZEVA Aero have firmly fixed their gaze on the future. They develop electric Vertical Take-Off and Landing (eVTOL) vehicles, with a long-term strategy that extends to 2050. The company envisages that such zero-emission flying vehicles will become ubiquitous by 2030 and personal use eVTOLs by 2050. They have designed a compact landing area and offer a range of 80km (50mi).

- British startup Furo Systems develops all-electric cycles, with the intention of encouraging buyers to commute in environmentally friendly ways. Set up in London, they believe the future of urban mobility is compact, electric, and easily portable vehicles, like their Furo X. The Furo X can be conveniently folded and carried into buses or local trains, helping people with the last-mile connectivity. With a range of 50km (31mi), it can be a useful addition when people start extensively using public transportation.

- Bengaluru based startup Ather Energy is eyeing the massive Indian two-wheeler market by developing fully connected electric scooters. Designed for the Indian road, Ather offers a smart dashboard with navigation, a top speed of 80km (50mi) per hour and a range of 55km-75km (34-46mi). They are also looking to establish a network of charging stations so that buyers can recharge within a 4km radius and operate as they would with non-electric vehicles.

- Based in Vancouver, Canadian startup Electra Meccanica develops the Solo, an all-electric vehicle solution targeting the 100+ million people who drive alone in petrol vehicles every day. The Solo looks like a usual car from the front but there is little else that it has common with traditional cars. It has only 3 wheels, a range of 160km (100mi), and a charging time of just 3 hours all make this vehicle something to keep an eye out for over the coming years.

- Yulu, a Bangalore-based electric bike sharing platform, was started by InMobi Co-founder Amit Gupta in 2017. The startup aims to address traffic problems using the Internet of Things (IoT). At present, it is operational in Bengaluru, Pune, Mumbai, and Bhubaneswar. In November 2019, Yulu raised $8 million in its Series A round, led by leading automobile manufacturer Bajaj Auto Finance. Existing investors invested an additional $2 million. With this funding, the startup plans to build a strong electric vehicle (EV) infrastructure and also fast-track refining its electric scooter, Yulu Miracle. The team is looking to support over 100,000 Yulu Miracles by the end of 2020.

- Based in Hamburg, e-floater develops its eponymous micro-mobility solution of the same name. The three-wheel construction solves some of the stability issues faced by traditional micro-mobility. They aim to offer services where others stop by making a vehicle with a white-label and allowing for very simple recharging. e-floater also ensure their product is transported and distributed without any diesel used, aiming for 100% sustainability within their business.

- Bengaluru-based Ultraviolette was started by Niraj Rajmohan and Narayan Subramaniam in December 2015. In August 2018, TVS Motor Company picked a 15 percent stake in the startup. The company unveiled its first product the F77 in November 2019, which can accelerate from

standstill to 60 kmph in 2.9 seconds. It claims that the motorcycle has a top speed of 140 kmph and has a range of 150 km. Ultraviolette aims to roll this out first in Bengaluru, followed by a national expansion next year.

- Enevate, a US-based lithium-ion battery company, uses silicon-dominant anodes instead of graphite. The startup thereby enables ultrafast charging for electric vehicles, as well as ultrahigh energy density and plug-and-play compatibility with smartphones.

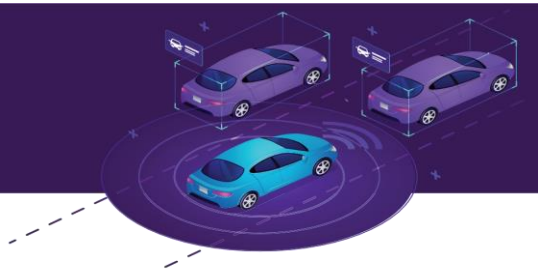
- UK-based Zapinamo develops a charging solution, where instead of battery-to-battery refueling, they are accessing a reservoir of energy. The energy gained in that way enables ultra-fast charging through their patented “power boost” technology.

- Spark Horizon, a French startup, develops EV charging networks across Europe to accelerate the adoption of electric vehicles. The startup creates a reliable infrastructure for e-vehicles by combining free electricity with Artificial Intelligence-based (AI) advertising.

- Dox, a US-based company, provides battery-based predictive analytics to fleet operators to optimize the management of their fleet as well as maintenance processes by enhancing battery usage and reducing battery waste.

**Think niche**

- Segway has revealed its latest self-balancing vehicle, the S-Pod, an egg-shaped rideable chair. Like the original Segway vehicle for upright riding, the S-Pod is self-balancing and has a centre-of-gravity control system that adjusts the speed based on how much it's tilting forward. Unlike that vehicle, the S-Pod doesn't require the rider to lean their body to accelerate. Instead, they turn a knob on a navigation panel while relaxing in their seat. The S-Pod's top speed is 24 miles (38.6 kilometres) per hour.
- Fiat's Centoventi is an endlessly customizable car that makes sure you never have to trade it in. The Centoventi allows customers to choose from four different roofs, four bumpers, four-wheel covers, and four paint wraps. Once those have been chosen, there are 114 different accessories provided by the courtesy of fellow Fiat Chrysler company, Mopar, such as seat cushions or bottle holders. The company even indicates that it could possibly 3D print parts at home. The car comes with a small 100 km range battery pack but features a sliding rail system that leaves room for others. (February - 2020)
- AMAZEA is an agile underwater scooter based on the "catamaran principle" and replicating a dolphin's special body ergonomics that enable faster movement. The underwater scooter, which pulls the diver attached to it forward through the water, is an environmentally friendly, emission-free and low-noise method of exploring marine life without disrupting the ecosystem. An electric BI motor drive powered by two engines (3.1 KW each) and a rechargeable lithium-ion battery set up in the scooter's front, the high-performance scooter offers a maximum speed of 20 km/h (underwater) or 30 km/h (gliding above water) and can be operated up to depths of 18 meters.(Jan, 2020)



**Opportunities and challenges in EV localization**

- Shibulal is Founder of and Director at Micelio,explained that while price would remain a key factor determining the fate of EVs in the country, this also means that localization holds a whole lot of significance. He tells most people that the challenges are the opportunities. The volatility of the China supply chain presents itself as a tremendous opportunity. One can provide incentives for consumers that are purchasing the (electric) vehicle as a subsidy but it will improve adoption in the short run. It is a stop-gap. Ultimately, for long-term adoption, one will have to provide incentives for local innovation. further dipping into a government proposal to offer $4.6 billion in incentives to companies setting up advanced battery manufacturing facilities in India. NITI Aayog is trying to bring that innovation, trying to bring that manufacturing capability to the country because unless one secures the supply chain, there may be a demand for EVs, you may not always be able to cater to it, cater to it at the right price. (Oct, 2020)
- Squad Mobility has unveiled the Squad - (specially developed for urban and shared mobility needs): a 45 km/h, 2-person solar car for daily (sub)urban mobility. The Squad (Solar Quad) is being developed by two ex-Lightyear employees who share a desire to develop an affordable solar car for a large group of consumers. The Squad will be homologated in the L6e category, Light 4-wheeled vehicles. Depending on demand and local legislation, an 80 km/h version will also be offered later. The Squad offers space for two passengers sitting side by side. It combines the practicality of a scooter and the ease of driving a small car. (Nov, 2019)

**Think B2B**

- Electric Vehicle (EV) manufacturer Ampere has announced that it has tied up with e-mobility start-up eBikeGo, and that it has subsequently secured an order for the supply of 2,000 electric scooters. The latest order follows closely behind the 3,000 electric scooters order that the firm secured from Bengaluru-based scooter rental start-up Bounce. (Oct, 2020)
- Hero Electric rolled out various benefits, including a cash discount of up to Rs 5,000, across its range of e-scooters under a limited period festive offer. In addition, the customer can also choose from additional discounts of up to Rs 5,000 on exchange of any two-wheeler or avail interest-free finance at select locations. This e- scooter is specially designed for B2B applications. (Nov, 2020)

**Think not just innovation in products or services, but also in business models**

- Chennai-based startup has developed a personalised wheelchair, and a battery-powered clip-on device that converts the wheelchair into a roadworthy electric vehicle. NeoFly is a wheelchair that can be personalised to each individual’s requirements. From adjusting its height and width, to the kind of wheels, and even colour, NeoFly can be adjusted in 18 different ways to fit each person’s body and environment. The overall size is 30% smaller, which enhances accessibility. Apart from that, the user can customize the colour. (Aug, 2020)

**Think not just innovation in products or services, but also in business models**

- Arrival - OEM and fleet operator for City public

Arrival develops solutions for cities that help them meet sustainability targets and create elevated transportation experiences for their citizens. This Integrated Transportation Ecosystem includes buses, vans, car sharing, taxis, delivery robots, charging infrastructure, Microfactories and digital services. Arrival has invented a unique technology to assemble vehicles in locally placed Microfactories. Each Microfactory can produce any vehicle from Arrival's portfolio. With plans to deploy 1,000 Microfactories globally by 2026, Arrival will regenerate local communities, pay local taxes and retain local talent.

- REE - an ev platform which accelerates OEM’s time of production

Ree’s disruptive technology allows unlimited design capabilities around a completely flat and modular chassis, allowing multiple body configurations on a single platform, increasing volume and efficiency while reducing size and weight along with the time of production and capital. The platform consists of four corners(as the four wheels), each of which can be controlled and altered separately. This provides:

1. Complete freedom for body design.
2. 67% more volume for the highest load carrying capacity.
3. 3 times more space for batteries.
4. Faster launch cycles.
5. Minimal down time. Each corner can be repaired in 20 minutes.

**Think beyond pure EV - also hybrids and retrofits**

- E-trofit - Retrofit for bus, trucks and commercial vehicles. e-troFit represents sustainable mobility. With professional retrofit solutions for diesel vehicles, the company offers solutions for a quick entry into electric mobility e-troFit started as a pilot project of Munich-based development company in-tech. Since 2016, an innovation team at in-tech has been working on the topic of electromobility, also investigating ideas for other industries.
- NAWA Technologies, maker of next-generation ultra-fast energy storage systems, has revealed NAWA Racer, a zero emission motorbike concept which features a world-first in electric powertrains: a 'hybrid' battery. Unlike with a regular fixed battery, the NAWACap pack can also be removed and swapped for different levels of performance, allowing riders to tune their bike's characteristics. As standard, the hub-less rim motor produces 100PS, taking the motorbike from rest to 100km/h in comfortably under three seconds, to a top speed in excess of 160km/h. (Dec, 2019)

# The Wow Section

Electrification brings to automobiles more than sustainability and emission freedom. It opens opportunities for a wide array of business, which would ease the operations and enhance the performance of electric vehicles and mobility as a whole. These opportunities are brilliantly seized by budding and bloomed startups which span across industries to bring solutions to everyone imaginable.

Some of the startups with unique Businesses and business models include

## Electriphi

Running a fleet of electric vehicles involves much more complexity than a fleet of ICEs which can refuel and run at any point. What if there was someone to make an elaborate plan for fleet electrification and its operation?

Electriphi designs a suitable fleet operation method depending on various factors by running simulations using a software. Also, offers backend support by maintaining the data and generates future servicing maintenance and other practices using the simulations.

The company provides software tools, namely

- Fleet electrification planning tool - which develops thousands of simulations considering the various factors of electrification and vehicles used subjected to numerous ‘what if?’ variables.
- EV Fleet Total cost of Ownership - a comprehensive analysis of all the monetary inflow and outflow, for various variables based on vehicle types, electricity consumption, routes, charger type, utility rates, etc.

Further, beyond the autonomous tools the company’s key service lies in comprehensive Fleet and Energy Management. In this Electriphi maintains, studies and optimizes the entire electrification and operation plans of the operator. The company

- Ensures Fleet readiness.
- Optimizes energy costs.
- Controls the data ownership.
- Maximizes reliability.
- Integrates the technology seamlessly via an industrial standard open source platform.
- Plan the transition.

# Twaice

What factors would one assume while choosing batteries for their vehicles? How could one verify that they have chosen the correct battery for their vehicle types. What should be done while using a battery to know if it's healthy? How could one manage the health?

The company first runs physical simulation models of li-ion batteries to help companies choose the right type and configuration of battery they need for their uses. The simulation can be integrated into any research readily. Then the predictive analysis uses deep battery learning, Machine learning and A.I to manage, analyze and optimize the battery operations to increase lifetime and efficiency. The products can also be used individually and independently. This way, Twice provides production, to product, to aftersale services for li-ion batteries.

**TWAICE Predictive Analytics Software**

This platform provides battery analytics solutions across different industries to monitor, analyze and optimize the operation of Li-ion batteries. Based on deep battery knowledge, AI and Machine Learning, the TWAICE Analytics Cloud processes real-life battery data into actionable insights. TWAICE analytics results are accessible intuitively anytime from anywhere via the TWAICE UI or the TWAICE API which smoothly integrates into any battery monitoring and management solution.

**TWAICE Battery Simulation Models**

These are high-precision, physical simulation models of lithium-ion batteries. Mirroring the real battery, they speed up system design and replace lengthy testing cycles.

# Otonomo

Electric vehicle manufacturers need to constantly draw data from the vehicles to analyze their performance, safety and make improvements. The European EV regulations require OEMs to share such data with other OEMs to create a collaborative improvement in safety and development research.

A cloud-based automotive data collection, processing and distribution technology which takes data from many electric vehicles or OEMs and redistributes it to the OEMs, other manufacturers, charging station providers and other companies which makes applications for various EV services.

Otonomo is the first neutral automotive data services platform that simply and securely paves the way for the development of new apps and services for drivers, passengers, municipalities, and transportation companies. The Otonomo platform ingests automotive data from multiple sources, including OEMs and other data providers. It cleanses, normalizes, and aggregates the data and enriches it with third-party datasets in order to meet consumers' privacy expectations, manage compliance, and maximize its value through our global Marketplace.

The Otonomo Automotive Data Services Platform uses patented technology to ingest, secure, cleanse, normalize, aggregate, and enrich car data from 20 million vehicles, tracking 330 billion miles of traveling. It collects more than 4.1 billion data points in a day, which find their uses in various applications for aggregate and personal transportation benefits. The entire information is stored and processed in a 'Neutral Server' made available to many organizations.

# Chargetrip

Routing technology for electric vehicles comes with a need to reduce range anxiety. The navigation should provide an optimum path with amenities such as charging and precise mapping based on the driving range available for the vehicle depending on its characteristics, manufacturer, usage and many other parameters. Chargetrip's navigation engine evaluates such factors to provide safe routes for.

Chargetrip's routing engine uses over fifteen different variables to calculate the real-time range of any electric vehicle. We take into account the outside temperature, weather, charge speed, elevation, rolling resistance, real-time vehicle data, and congestion at charge stations.

The company allows EV users to build queries, mention their vehicles, find suitable charging stations etc with their API(software).

Chargetrip also develops web and mobile applications for various purposes as required by the customer company.

# Ottopia

The company developed a Plug-and-play teleoperation which enables any vehicle to be remotely controlled enabling autonomy to every vehicle irrespective of its other characteristics. This device would make driverless mobility easier, cheaper and safer as it does not involve too many high tech sensors, complex algorithms and the remote driver stays at a distant place controlling the vehicle.

Any vehicle regardless of its class, purpose, size, age can be fitted with this device. It uses sensors and provides 360 degree visibility for the remote driver to work in public roads or industries and even mines and farms.

**In-Vehicle Teleoperation Module**

- Plug and play dedicated hardware that runs proprietary software. Supports all use-cases.
- NetWeave – network bonding and real-time video compression provide a reliable connection between operators and vehicles.
- Advanced Teleoperator Assistance Systems (ATAS™) – algorithm suite that ensures safety at every turn.
- Advanced Teleoperation (ATO™) – APIs for scalable control methods like "Path-Choice" and "Path-Drawing".
- Cyber-security – embedded protection measures, tested against every known attack vector.

**Teleoperation Center**

- Off-the-shelf hardware with specialized software to run your teleoperation center.
- Control tower and shift management tools for a lean operation.
- 360 video stream fused in real-time with vehicle and sensor data.
- Intuitive and thoroughly tested user interfaces that support various methods of control

# EP Tender

Range extender devices combined with a battery-as-a-service business model make the feature of having extra batteries economic.The manufacture does not need to provide any additional real estate in the vehicle for the extender nor does the battery manufacturer. It's a plug and play model which can be integrated to almost every EV.

A 51 kWh tow-along range extension device which can be remotely controlled to attach itself with the vehicle and transmit power when required. The company would establish stations at which an EV can rent an extender and replace for a new one when exhausted. The whole unit acts as a swappable system which can be changed in mere minutes.

The extender can also be connected to external non-EV electronics so that it can supply electricity in remote areas or public uses during outages. Typically, a large UPS which will be towed along by one's vehicle.

# Duesenfeld

Duesenfeld uses a patented method that combines mechanical, thermodynamic and hydrometallurgical processes. This method delivers exceptional material recovery rates despite needing very little energy input. This is only possible because it does not use smelting, which is the technique commonly used in battery recycling.

**Decentralised recycling**

The complex process of transporting hazardous and highly inflammable lithium-ion batteries in battery transport containers generates huge costs. With mobile Duesenfeld recycling containers, lithium-ion batteries are crushed on site at collection points and the electrolyte is extracted with zero emissions. The smallest local preparation unit can fit into two 40-foot containers. The secondary raw materials that are recovered, such as iron and non-ferrous metals, the electrolyte and the black mass, can be transported for further processing safely and efficiently as well as subject to much less stringent requirements and much more cheaply.

# Recurrent

A used electric vehicle should not be bought without knowing the battery statistics, life cycles remaining, state of health, etc. These factors also determine the cost of the vehicle and its feasibility as a whole, helping the buyer understand how efficient or useful the vehicle could be.

With a database formed by country-wide volunteers using electric vehicles, thousands of cars with different battery packs, working under different environmental conditions are studied and analyzed for their battery condition and performance.

The company is further working with data scientists to develop a unique data set to train its predictive algorithms to predict future battery life and range.

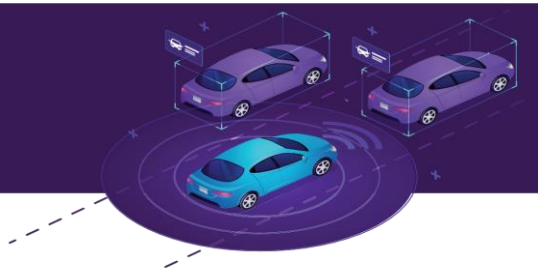
- The data includes information on cars from different manufacturers, with different battery pack configurations, and different operating environments, ages and odometer readings.
- Every volunteer connects to Recurrent's database via a third party data service 'Smart Car'.
- The company's algorithms can then predict future battery life and range, by vehicle identification number, for nearly every used electric vehicle offered for sale
- The vehicle resorts can be availed at used vehicle dealerships or could be requested in the company's website.

# Akkurate

A BMS only provides necessary data to the vehicle or sometimes communicate with the OEM and battery manufacturer. But they do not work collectively nor do they provide information to a third party user. Akkurate diagnoses batteries which are used in fleets or in large numbers and provides their performance, maintenance requirements and end-of-life alerts to the Fleet operator.

Remote battery diagnostics service called the 'Diagnose'.

- Remote monitoring and centralized surveillance - Monitor and manage battery fleet remotely and receive notifications, alerts as well as history data.
- Independent and universal solution - Akkurate's diagnostics calculations are brand independent. Diagnose provides the same diagnostic regardless of battery manufacturer. This allows real comparison between different batteries.
- Improved safety - diagnose monitors that batteries operate under safe conditions and alerts if those are exceeded. It also has a proprietary method to detect nascent internal short circuits early on.
- Realtime warranty monitoring - Customised warranty monitoring collects and stores detailed data throughout the battery lifetime.
- Increased value and readiness for 2nd life - diagnosis offers full battery status and history data to help identify suitable cells for second life application. This means that the batteries don't need to be transported for separate evaluation.



- Better battery performance and lifetime prediction - Follow, compare and optimise the performance and health of your battery fleet. Diagnose provides detailed information on battery health, on Li-ion batteries that have non-linear degradation.

# Lunaz Design

Classics and celebrated cars are a leasing luxury. In time they might become uneconomical and less effective in justifying their purpose. Lunaz design re-engineers the classics into electric vehicles, prolonging their life, making them extremely fun to use.

Lunaz doesn't just retrofit the powertrain or the drivetrain. It changes all the components with new ones of the same design to fit perfectly with the electrification. The vehicle becomes as good as new, with the retro shell/body.

The company began its work with some of the most celebrated classics in history - a 1961 eight-seat Rolls-Royce Phantom V, Rolls Royce Cloud, 1953 Jaguar XK120 and Bentley S2 Flying Spur.

- They source a limited number of such vehicles, some that are no longer functional and create beautiful, clean and usable electric classic cars.
- The cars are fully restored to ensure that all the remaining mechanical components are in excellent working order and of the highest modern safety specifications.
- The company follows the original principle of Rolls Royce to provide customization to the customer to the last stitch.
- The Rolls Royce cars would be powered by a 120kWh battery and can be opted to have a single or dual motor developing a torque of 700Nm or 1400Nm.
- The Jaguar has been fitted with an 80-kWh battery pack and two electric motors which produce 380 hp and 516 lb-ft of torque. Not only does the XK120 offer contemporary levels of performance and reliability but it is also equipped with fast charging capability, a regenerative braking system and the sensitive integration of modern conveniences like traction control and cruise control.