

# EVCONNECT

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NEWSLETTER

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### EV Feature

Understanding safety and performance considerations of batteries for electric vehicles  
By *Parveen Kumar and Anusha Chitturi, WRI India*

## FROM THE CEO'S DESK

Dear Friends,

I am pleased to share with you the fifth issue of WRI India's electric mobility newsletter, EV Connect.

Many moves big and small are taking place in electric vehicle policy and markets around the world, and in India as well. The need to respond to the warming climate and degrading air quality is now more important than ever. Take for example, the city of Delhi, where pollution and rising emissions levels are jeopardizing the public health of residents. In this context, adopting electric vehicles is the need of the hour. However, a change in technology will take time and will require a united stand with politicians, industry, academia, and civil society organizations, and of course, our citizens. The transport sector almost entirely relies on fossil fuel, majorly on foreign oil, in India. Electric vehicles offer the opportunity to move away from fossil fuels in a sustainable manner. To achieve this, the critical parameters to be addressed include charging infrastructure, energy storage, and battery technologies in order to integrate renewables into the grid. We need to build awareness about electric vehicles amongst consumers, and promote policies which support technologies that will serve the domestic needs of our cities and the country.

New developments are taking place at a very rapid pace, and it is often difficult to keep up with them. Reported through multiple media channels, these developments are often hard to track. This newsletter seeks to bring together several of these developments into one document. We hope that over time, this curated and compiled content will come handy to those seeking the latest information on electric mobility.

The battery used in an electric vehicle determines its energy efficiency and subsequently, its cost. Hence, this edition of the newsletter includes a conversation with Dr. Judy Jeevarajan who works with Underwriters Laboratories, USA, on battery technologies – prominent chemistries, energy density, and safety aspects, and many other important points. It also features insights on how a sound EV policy for Gurugram, Haryana can be a game changer.

We hope that you find this edition of the newsletter beneficial and share your thoughts on ways to improve it.

Sincerely,



**Dr. OP Agarwal**  
CEO, WRI India



# POWERTALK

**IN CONVERSATION WITH DR. JUDITH JEEVARAJAN**

RESEARCH DIRECTOR, UNDERWRITERS LABORATORIES INC., USA

*Interview taken by Amit Bhatt and Rusha Sen, WRI India*

“ Li-ion recycling facilities have already been established in many countries. You can actually recover a lot of usable material from the Li-ion cell that can be recycled and used again in another new cell. So, I don't think end of life will be a big issue. ”



**WATCH**  
the full interview [here](#)

**Interviewer:** In the short to medium term, do you see Lithium ion continuing? Is there a possibility of new chemistry to emerge in the sector?

**Dr. Judith:** In the short to medium term, I think Li-ion will continue, because it has not been optimized. It has not reached a saturated stage. If you look at Ni-Cad and Metal hydrides and so on, for a decade they were almost constant. They were not improving at all. So, you know that this is the maximum performance that you can get from them. But when you look at Li-ion, they are still inventing new materials, finding new materials that can work as a Li-ion cell with different cathodes anodes, different electrolytes and combinations. So, I don't think at this point I see a big leap or anything out of the box while we are going to look at some big innovative chemistry. And even if someone is discovering it today, it takes 10-15 years to bring it to market, and it takes some more time for it to gain traction. So, right now, I see Li-ion not going away. Probably different forms of Li-ion coming in but not going away for sure.

**Interviewer:** With the introduction of electric vehicles, cities will witness a new kind of solid waste problem which includes batteries. What is the end life of these batteries? Can we manage Lithium ion batteries?

**Dr. Judith:** In many countries, it is a requirement to recycle. So, every manufacturer has to show/ report the percentage of the battery that has been recycled. It is a requirement for battery manufacturers. Li-ion recycling facilities have already been established in many countries. You can actually recover a lot of usable material from the Li-ion cell that can be recycled and used again in another new cell. So, I don't think end of life will be a big issue. Of course it will be expensive to recycle it, but you get the benefit of reusing these materials. So, one should go for recycling rather than just dump it in the waste. If you dump it in the waste, it is also a safety hazard, because if someone crushes it by mistake, that is going to lead to a fire hazard. It has happened in the past where people have mixed Li-ion batteries and lead acid batteries for recycling, and recycling facilities have been burnt to the ground because of that. Because lead acids are crushed for recycling. You can't crush the li-on battery. It goes into flames. So, there are different ways of doing things. They have to be segregated and recycled properly

*Interviewer:* Are fast charging and ultra fast charging Lithium ions potentially hazardous in terms of safety?

*Dr. Judith:* If your electrode is not designed for a fast charge rate (for instance, if the porosity of the electrode is not the correct one), then the Li-ion batteries when you charge them really fast, don't have enough time to intercalate into the anode; instead they will deposit on the anode. So, that is one of the things that could happen. Another thing that could happen when you are charging really fast and your electrolyte does not have the right ionic conductivity, is that you will have the heating up of the electrolyte and decomposition of the electrolyte, which again leads to lithium metal deposition rather than intercalation. Also, the other last part is that your cathode should be able to release the lithium ions fast enough to be able to intercalate into the anode, and that also depends on how the cathode is built. So, there are all these factors that need to be looked into before you can opt for a fast charge/ an ultra fast charge method.

*Interviewer:* Electric movement in vehicle revolution is now kicking in. However, there are questions regarding the safety of batteries. What is your opinion in this field owing to your experience of 21 years?

*Dr. Judith:* Li-Ion has been unsafe for a long time, but I won't say it is completely unsafe. It depends on how you design the battery. If you design it correctly, even a medium performer can be very safe and work like you want it to work. But because of the safety hazards associated with Li-ion, it is taking longer to become prolific.

The other part of it is also that Li-ion has changed so much. First we had Li Cobalt oxide, and then graphite. We have so many combinations of newer cathode materials and newer anode materials. It has not reached the optimum peak performance. So, you will see that there are changes happening in the Li-Ion industry itself, which is also causing changes in how it is used, how it is designed and so on.

The last aspect is size. We have Li-ion batteries that are consumer based as well as ones that are large stationary energy storage batteries and the safety varies with reference to the size also. That is why there is not a full grown acceptance of Li-Ion mainly in the larger sizes. You will see the consumer equipment batteries everywhere, but with the larger batteries, because of the challenges with safety, incomplete understanding of all the different aspects, the different chemistries and the different capabilities with reference to rate, to temperature and so on, it has not caught on as fast and cost is a big factor.



## INTERNATIONAL NEWS

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### **Company leadership on electric vehicles: There is no middle road** | *Market development*

The transport sector became the largest contributor of greenhouse gas (GHG) emissions in the US in 2016, leaving behind the electric power sector. In this context, changes at the policy and corporate levels are necessary. Corporate companies own, operate, and manage the largest share of vehicles in the country. While electric vehicles present a huge opportunity for companies to earn monetary savings on fuel and maintenance, switching to electric vehicles is an equal responsibility that corporates need to work towards, in order to tackle climate change and address the environmental risks from the emissions of conventional vehicles. Many corporate companies in the US have joined coalitions such as Ceres' Commit to Climate Initiative, that works with 130 companies to voice support for the corporate uptake of electric vehicles and the deployment of charging infrastructure. This sheds light on how electric vehicles make good business sense and the existence of private players who have a large appetite for moving to alternative mobility.

*Takeaway for India:* No doubt, India would benefit from the corporate willingness to switch to electric. The bottom-line operations for corporates will also benefit from the move. Creating a network of companies committed to adopting electric vehicles will provide volumes for manufacturers to supply. Corporate fleets will also have a high demonstration value, especially for the employees of the companies, and will likely serve as a tool to build consumer confidence. [Read more](#)

### **A \$6 trillion barrier holds electric cars back** | *Policy and market development*

A study by Goldman Sachs and Co. estimates that world over, electric vehicle infrastructure will need an investment of USD 6 trillion -- this is about 7-8% of the world's Gross Domestic Product (GDP) and excludes the cost of manufacturing the vehicle, in which batteries and their raw materials predominate the costs. Hence, government subsidies and support will be needed to supply this funding. This way companies will be able to strike a balance between profitability and affordability for consumers. Even if not immediately, Internal Combustion Engines (ICE) vehicles are experiencing a decline and electric vehicles are the future. It will take at least an additional five years to adopt electric vehicles, if taxes and subsidies are excluded.

*Takeaway for India:* As India charts the roadmap to move to electric vehicles, the question of whether or not, or

how much to allow as subsidies is a critical one. Spreading a new and clean technology in the Indian context is centered on price sensitivity. While the government can share some of the financial risks for consumers and the producers through subsidies, it must eventually lead to a market that thrives on innovation and highly energy efficient technologies. [Read more](#)

### **Samsung to build electric vehicle battery pack factory in Auburn Hills** | *Policy and market development*

Samsung is investing USD 62 million to create an electric vehicle battery factory in Auburn Hills, Michigan. This will result in 400 new and high skill jobs. This is Samsung America Inc.'s first high-volume automotive battery pack manufacturing facility in the US. The setup of this battery manufacturing facility has led to a highly skilled workforce and resulted in a boost to the local economy, for which the company will receive a USD 10 million Michigan Business Development Program performance-based grant. Other possible support from the local government of Auburn Hills could be in the form of property tax abatements.

*Takeaway for India:* Several states in India have either finalized or are in the process of drafting their electric vehicle policies with an emphasis on local manufacturing of vehicles and job creation. Local fiscal instruments and tax breaks for domestic battery making companies and research and development will foster the field of energy storage systems in India. It is inevitable that India will be sourcing materials and technologies from the global battery market, but a sustainable approach will reduce dependence on foreign players. [Read more](#)

### **Silver cyclers: Stores reveal big surge in over-55s buying electric battery-powered bikes**

| *Market development*

Scotland is witnessing a unique trend: 62 percent of e-bicycle consumers are aged 55 or above. Electric bikes offer ease in cycling for many in this age bracket who otherwise hesitate due to fitness and health reasons. With the additional power that electric motor supplies, cyclists can travel longer distances, take part in adventurous and uphill climbs, and spend more time exercising and gaining health benefits. The Transport Secretary of the region expressed that electric bikes should be made accessible to low-income zip codes, to ensure that the positive health and well-being outcomes are spread beyond upper and middle-income families.

*Takeaway for India:* While there are obvious benefits to electric mobility, it hasn't reached affordable levels yet. India is predominantly a country of two and three wheelers and public buses. Electric mobility should be emphasized in these areas, as opposed to premium and luxury segments. Mass and affordable means of travel are most vulnerable to the adverse impacts of emissions from conventional vehicles. [Read more](#)

### **China is leading the world to an electric car future** | *Policy*

More than 40 percent of the global EV sales take place in China. To make the EV market even stronger, the Chinese government has mandated that all manufacturers should produce – in domestic and export markets – a certain number of New Energy Vehicles (NEVs), i.e. hybrids, all-electric, fuel cell vehicles. The goal is to create an electric-first vehicle manufacturing industry. This is a form of Cap and Trade system. It applies to all the companies that produce or import more than 30000 vehicles annually. All the manufacturers that are unable to produce the required share of NEVs will need to purchase credits from other manufacturers who exceed the portion. This is a serious commitment on part of the Chinese national government to aggressively reduce emissions produced from vehicles, reduce dependence on foreign oil and curtail toxic gases from vehicle exhausts. In the credit system, a high performing car will attain higher credits than a low performer. The Chinese government is aiming for an annual sale of 7 million vehicles by 2025, about 20 percent of its total to be plug-in hybrids or battery powered vehicles. To avoid falling short of the NEV quotas, many domestic and foreign companies are forging partnerships with one another. More details on the credit system are likely to emerge in the coming period.

*Takeaway for India:* China's credit system to encourage manufacturing and import of electric vehicles is a market-based model to spur the domestic market of electric vehicles in the country. To promote localized manufacturing and the export of electric vehicles, India could also explore the creation of a market-based system – balancing the carrots and sticks for auto manufacturers – for an initial period. Another noteworthy point is China's emphasis on vehicles with longer ranges. [Read more](#)



## NATIONAL NEWS

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### **Economics of electric vehicle very good for commercial use** | *Market*

This is an excerpt of a conversation with venture capitalist, Alok Goyal at Stellaris Ventures, who backs electric vehicle start ups in India. The article highlights that while it is premature at present, there is going to be an EV wave in India. The economics of electric vehicles highlights their suitability for commercial use, where the distance to be driven is large. Commercial segment consumers include fleet owners such as delivery companies and e-commerce logistics, and scooter rental companies. The business case is very strong for two wheelers (i.e. scooters for commercial segments and bikes for premium personal use) as compared to cars. Three wheelers, while yet to switch to lithium ion batteries, have a low total cost of ownership, which is what has made them the flag bearer of electric mobility in India. The interviewee also opines that this is the right time to invest in India's growing electric start-up space. [Read more.](#)

### **Mahindra to invest ₹1,000 Crore by 2020 for electric vehicles** | *OEM development*

Mahindra Electric, a subsidiary of Mahindra, is going to create a facility in Karnataka focusing on electric vehicles – sports utility vehicles and tractors. With an investment of INR 1000 crores, the aim is to have an annual capacity of 70000 vehicles by 2020. The company is looking to make Bengaluru its local center for manufacturing various components. Other companies will also be able to purchase parts of electric vehicles from this facility. For batteries, Mahindra has already partnered with LG Chemicals. In addition, Mahindra Electric is planning to launch an EV costing 300,000 Euros with its Italian subsidiary Pininfarina. [Read more.](#)

### **NTPC signs MoUs with seven vehicle aggregators like Ola, Zoom Car** | *Policy and Market development*

The National Thermal Power Corporation (NTPC), is partnering with vehicle aggregators such as Ola, Shuttl, Lithium, Zoom Car, Bixxie, and others to develop and utilize public charging infrastructure. These aggregators have presence all over the country and will allow NTPC to avail the demand created by these companies and fully use the charging stations to attain a timely break even. NTPC is in talks with state commissioners to create public charging stations for public transport and has entered into agreements with Jabalpur, Navi Mumbai. NTPC will further create charging locations for two, three wheelers and public buses. [Read more.](#)

## EV infra policy soon; individual can set up charging station for commercial use: R K Singh | *Policy*

The ministry of power will be coming out with a charging infrastructure policy soon. Recently, at the INSPIRE conference, the Minister of Power and Renewables confirmed that no licenses are needed for individuals interested in setting up commercial charging facilities. This is intended to create a widespread network of charging infrastructure in the country. Moreover, the Ministry of Power is chalking out a plan with the Ministry of Oil to set up charging points at petrol pumps. [Read more.](#)

## Exclusive: Meet India's first startup that can switch your car from fossil fuel to electric! | *Technology*

E-Trio is a Hyderabad based start-up that converts conventional vehicles into electric. It has received official sanction from Automotive Research Association of India (ARAI). E-Trio buys old cars, refurbishes them, removes petrol and diesel engines and installs a Retrofitted Electric Kit (REK) that comprises of a motor, controller and a lithium ion battery. Charging for five hours can allow the car to run for 150 kilometers. A prototype with 250 km per charge is under testing. E-Trio, incorporated in 2015, is looking at business-to-business sales – targeting cab companies whose cars travel longer distances. At present, installing REK in a car costs INR 7-8 lacs, but this price will come down with large orders. The company will begin sales from next month as it is currently smoothening out its supply chain management and also doing extensive outreach with the government to understand the charging infrastructure. [Read more.](#)



## EV @ WRI

### A sound policy regarding electric vehicles can be a game changer | *Amit Bhatt, WRI India*

Introducing electric vehicles in the state will not only improve the air quality, but also create more employment opportunities and foster innovation in the transportation sector. [Read more](#)

*This post first appeared in Hindustan Times*

# EV FEATURE

## UNDERSTANDING SAFETY AND PERFORMANCE CONSIDERATIONS OF BATTERIES FOR ELECTRIC VEHICLES

By Parveen Kumar and Anusha Chitturi, WRI India

The high capital cost of EVs, where battery accounts for a significant share (~50 %) of the total EV cost, is one of the major challenges in their large scale adoption. While Lithium-ion batteries (LIB) are the most preferred energy storage option for EVs primarily due to their performance, they come with a limitation of high cost. At present, fast charging and battery swapping systems emerge as two popular alternatives available to address the issues related to drive range anxiety and long charging time. Therefore, as these systems show promise of being widely adopted in the interim before alternative battery technologies emerge, there is a need to understand their safety and performance implications.

WRI recently organized a round table discussion in collaboration with a leading safety science organization, Underwriters Laboratories Inc. (UL), to review the current available battery technologies from the vantage point of safety and performance. The closed group discussion saw participation from diverse stakeholders such as public fleet operators, electric vehicle manufacturers, battery manufacturers, and electric vehicle start-ups. Specifically, it was attended by representatives from BMTCL, Ather Energy, Cell Propulsion, UITP India, and Next Drive Electric.

Below are the key safety and performance considerations of EV batteries:

### **A trade-off between drive range and cost is vital**

Energy density, which is the amount of energy stored per unit volume, of batteries are lower than that of a gasoline. Currently, the commercially available Li-ion batteries can only offer ~2% of the energy density of gasoline. Therefore, keeping in mind the drive range needs of the electric vehicles and battery cost, the size of the battery packs should be optimized. For on-ground applications of stationary storage, the weight of the battery does not matter, but in a moving vehicle, any extra weight is not good as it impacts the center of gravity and fuel efficiency. Therefore, to address the limitation of low energy density of batteries, the size of the battery pack requires a trade-off between drive range and cost.

### **Safety implications of alternatives should be looked at**

While fast charging options are emerging as a popular alternative to circumvent the high charging time of a lithium-ion battery, it is important to ensure that the battery design and chemistry supports this. If the battery isn't designed for fast charging, side reactions can happen due to metal depositions on the electrode; this impacts the safety of the battery. On the other hand, battery swapping needs central swapping with good management. The staff managing the system should be technically aware of the battery chemistry and employ state-of-the-art IoT to manage the life of the battery.

### **Managing operational conditions can extend battery life**

Operational conditions such as ambient temperature, road gradient, type of charging, and total load can impact the life of the batteries. Li-ion batteries can be used anywhere from 4-5 years for EV applications. But the life of these batteries can be extended up to 10 years, depending on how they are used. Thermal gradient (external or internal) is one of the main factors and keeping the battery cool goes a long way in ensuring long battery life. At the end of 5 years, capacity checks can be run on batteries to assess their remaining life. If the capacity is still suitable for EV operation, the life can be extended further for a certain number of years.

### **Battery hazards are varied and multicausal**

Overcharging is a very common hazard; in very cold temperatures, the internal resistance goes up so much that the lithium metal starts getting deposited on the electrodes. Over discharging a battery causes copper dissolution and deposition which can cover the surface of the cathode, anode and separator leading to loss of intercalation paths resulting in lithium metal deposition instead of intercalation which can eventually lead to a thermal runaway.

External shorts are of two types - High impedance and Low impedance. High impedance can be more severe than low impedance and leads to drain on the battery. For example, when there is a pinching of the wire, the battery discharges constantly and it leads to heating of the battery and other risks. Similar issue was found in Boeing 787 incident with the primary lithium batteries. During the safety testing of the 787 Li-ion batteries under high impedance shorts, thermal runaway and heavy smoke was observed (but no fire) but that was overlooked.

Internal shorts are caused due to manufacturing defects or misuse in the field. Usage of inexpensive cells of low quality and counterfeit cells are some examples of manufacturing defects which can sometimes escape a screening process if it is not stringent. Misuse in the field-- using batteries out of its range of use-- can also lead to internal shorts, which can be catastrophic.

### **An effective Battery Management System (BMS) can help maintain a safe thermal gradient**

Thermal gradient should always be very low for safe battery operation. A faulty battery design can cause localized heating in different parts of the battery. This can be seen as strain on the rivets. It is best to keep the thermal gradient very low- 'between 2-3 degrees Celsius'. Anything higher than that could be managed by using a good BMS.

### **EV fires, though infrequent, could be catastrophic**

A Li-ion battery, when it catches fire, leads to an explosion. This is because Li-ion batteries have a very compact design, and a battery fire will result in release of combustible gases in a confined space. This is bound to result in an explosion. Extinguishing Li-ion fires is not an easy task. To control the fire effectively, the starting point of the fire has to be identified and put out to prevent reignition. And when you have a sealed system, you can't get to the source easily. Water is the best hydrant to extinguish Li-ion fires.

### **Accessible batteries can mitigate the risk of a failure**

Today, the batteries are placed on the underside of the car to maintain the center of gravity and hence are not easily accessible in the event of a failure. Essentially, an EV should be designed in such a way that the batteries are easily accessible in the event of a catastrophic failure. There is also a need to display some instructions on the vehicle for firefighters. One of the things that can be done is display the vehicle design to easily locate the battery.

### **Safety testing up-front would greatly reduce investigation costs**

While performance testing is usually done on batteries, safety testing is neglected. Screening each and every cell before assembling the batteries is important. It is important to note that tests on individual cells don't translate to battery testing. In the same manner, testing the battery does not translate to cell-level testing as some of the safety features internal to cells can be the cause of a failure at the battery level. A post-failure investigation in the field will probably cost 10 times more than the up-front safety testing. Therefore, it is important to invest up-front in safety testing.

Currently, Li-ion battery variants are most preferred choice for EV application due to high energy density and high cycle life (> 1000 cycles) compared to nickel cadmium (Ni-Cd), nickel metal hydride (Ni-MH) and lead acid battery (Pb-acid). While there is an evolving field of research to develop high energy-density batteries, in the interim, using Li-ion batteries looks like the most feasible option. Focusing on improving safety and performance of the Li-ion batteries will not only ensure public safety, but will also help to effectively manage the life and cost of the battery.

## COURTESY FOR THE ARTICLES

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