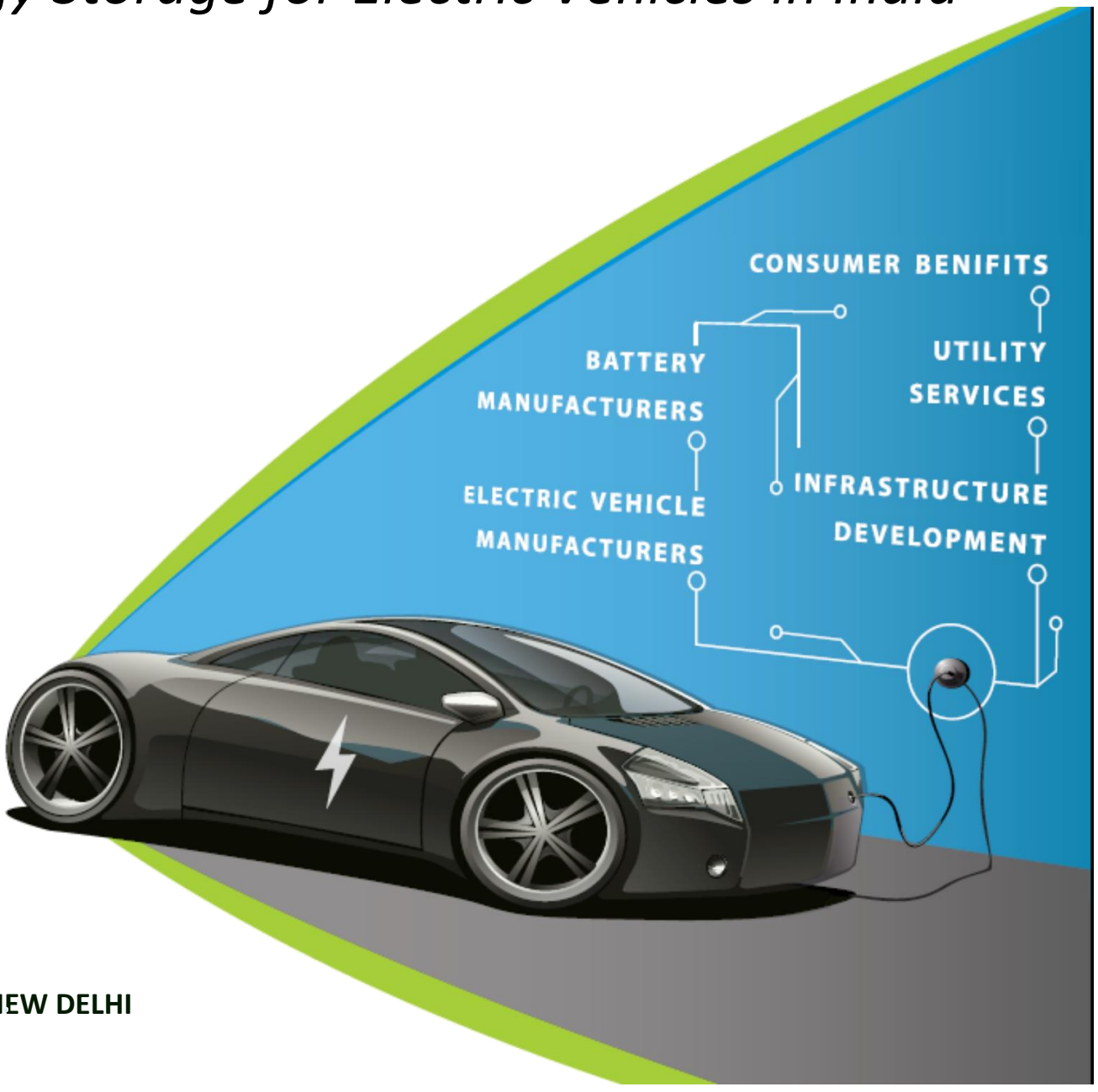
India Energy Storage Alliance

IESA Knowledge Paper

On

"Energy Storage for Electric Vehicles in India"



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India Energy Storage Alliance (IESA):

The India Energy Storage Alliance (IESA) is a membership driven alliance launched in 2012 by Customized Energy Solutions to promote energy storage & micro grid technologies and their applications in India. IESA's vision to make India a global leader in energy storage & microgrid technology adoption and hub for manufacturing of these emerging technologies by 2020. IESA's mission is to make energy sector in India more competitive and efficient by creating awareness among various stakeholders in the industry and by promoting information exchange with the end users. IESA also provides insights to technology developers, original equipment manufacturers, policymakers, renewable players and system integrators on the policy landscape and business opportunities in India through frequent interaction with all key stakeholders. As estimated by IESA, the Indian energy storage market is expected to grow to 70 GW by 2022.

Please find more information on IESA at http://www.indiaesa.info/

Intoduction

Electric Vehicles were invented in mid 19th century and enjoyed dominance till early 20th century, before giving way to age of gasoline powered vehicles that have dominated transport sector for almost 100 years. Past decade has seen renewed focus on electric vehicles from various stake holders around the globe. The desire for rapid adoption of EVs stems from need for reducing dependance on fossile fuels for transportation sector for improving national energy security as well as desire for cleaner air. One of the hurdles for mass adption of EVs was cost effective energy storage that can compete with the coveneince provided by gasoline fueled vehicles. Rapid advances in technology development as well as significant investments in scaling up manufacturing of energy storage technologies has brought us to an inflexion point, where with the right policy support we can start witnessing rapid adoption of EVs around the globe.

Global EV Market Overview:

The global EV market is rapidly gaining momentum towards the target set by Electric Vehicle initiative (EVI) of global deployment of 20 million electric vehicles by 2020. EVI was launched by Clean Energy Ministarial with US and China taking lead. Since 2014, the sale of EV's have more than the doubled. In the year 2015, we had seen the electric cars cross the global threshold of 1 million electric cars on the roads. The market share of electric cars rose above 1% in seven countries in 2015: Norway, Netherlands, Sweden, Denmark, France, China and United Kingdom. The United States was overtaken by China as the largest market for electric cars in 2015 with over 200,000 new registrations.

Currently, China is the biggest market for electric vehicles across the globe. China has registered around 3,52,000 new electric cars registration in 2016 as compared to 1,59,000 cars registered in US. China has a massive target of putting 5 million plug-in cars on road by 2020.

Apart from the electric cars, China is also the biggest market for electric two wheelers and electric buses and sold around more than 30 million electric two wheelers and more than 100,000 electric buses in 2016. Restrictions on the sales of conventional vehicles in urban areas and huge subsidy by the government are the key reasons for the rapid growth of EV market in China. To further accelerate the growth of EV's in the country, China has planned to spend a large amount of money towards development of charging infrastructure. As per a Chinese state news agency, the government will install 100,000 public charging stations in 2017. Currently China has around 150,000 public charging stations.

EV market in the United States, has seen sales of electric cars increased by 37% in 2016. More than half of all EV sales took place in California, driven by the State's zero-emission vehicle mandate. California has a goal to put 1.5 million zero-emission vehicles on the state's road by 2025. Along with the zero-emission vehicle mandate, tax credits and several regulations are key policies promoted by the Federal and State governments in the United States to promote electric and alternate fuel vehicles.

The sales of electric vehicles in Europe has reached over 3% of the total car sales in 2016. As per the recent report published by European Federation for Transport & Environment, more than 5,00,000 electric vehicles are currently running on Europe's roads. Netherlands and the Norway are leading in terms of new electric vehicle registrations and both have already announced their plans of phasing out petrol and diesel vehicle by 2025. In January 2017, Norway

has recorded the highest market share of 37% sales of Plug-in electric vehicles in the country's passenger car market. Incentives such as 25% VAT exemption, no purchase and import taxes, access to bus lanes, free parking in city centers, and no road tolls are playing a significant role in the growth of sales of EV's in the country.

Furthermore, UK, Germany, Italy, Spain and France are the major car markets of Europe. Policies like mandatory emission reduction targets set by EU legislation for new cars and incentives provided by several European countries will further play a significant role in the increase in sales of EV's in the continent.

India EV Market Overview:

The EV Industry in India is at a nascent stage. As of March 2016, 400-500,000 EV's had been sold in the country – around 0.1% of the global market share. Now, the EV Industry has started gaining momentum once again towards the target set under National Electric Mobility Mission Plan (NEMMP) 2020 of 6-7 million sales of EV's by 2020. Government of India has indicated a desire that by 2030 all new vehicles should be EVs. The EV Industry had noticed an increase of 37.5% in the sales of electric vehicles in FY 2015-16 and sold around 22,000 units in that year as compared to 16,000 units in FY 2014-15.

The EV Industry is currently dominated by electric two wheelers. More than 95% of the electric vehicles on Indian roads are low speed electric vehicles. If we talk about the sales trend of electric two wheelers in India, the EV industry noticed the highest sales (100000 units) in FY 2011-12. After that, there was a continuous drop in the sales of two wheelers due to the removal of AFSTP scheme by MNRE. The sales of electric two wheelers has started increasing once again with the introduction of FAME Scheme by DHI in 2015. As per the estimation done by IESA, 5 to 6 lakh electric two wheelers would be sold till 2022.

The electric three wheeler market is mainly dominated by e-rickshaws in the country. Approximately 4 to 4.5 lakh e-rickshaws are currently running on Indian roads. Kinetic green, a Pune based company has launched e-rickshaws based on lithium ion battery this year to overcome the limitations of frequent battery replacement and higher charging time of 8 to 10 hours. But again the cost of the lithium ion battery is more than 2 times the cost of lead acid battery used in these e-rickshaws, but this scenario is expected to change fast with global increase in li-ion manufacturing capacity and setting up assembly facilitis for battery pack manufacturing in India in 2017. As per the IESA's estimation, this segment would grow rapidly with a CAGR of 40 to 45% in coming years.

The sales of electric passenger vehicles in India are very low. This segment is continuously lagging in maintaining healthy sales traction due to several barriers associated with these vehicles such as high initial cost, lack of charging infrastructure, higher battery replacement cost, and low driving range. The second biggest problem with this segment is the lack of competition in the market. Other than Mahindra Electric, there are no major players available in the market.

As per Mahindra officials, the company has sold around 1000 to 1200 units of e2O / year. With the launch of new e2o plus and e-verito in the market, the company is expecting further increase in the sales of vehicles. In 2017-18 it is anticipated that number of multinational car manfuacturers will introduce EV models in India. As per the analysis done by IESA, 30,000 to 40,000 cars would be sold till 2022 based on current policy drivers.

India has a tremendous opportunity to leapfrog in EV adoption with commercial vehicle

segments focusing on public transport. Since 2016, pilot projects have been carried out so far in cities such as Bangalore, Delhi and Himachal. High Initial Cost and lack of charging infrastructure are key barriers which are hindering the growth of electric buses in India.

Components of Scheme	2015-16 (INR)	2016-17 (INR)
Technology Platform	70 Crore	120 Crore
Demand Incentives	155 Crore	340 Crore
Charging Infrastructure	10 Crore	20 Crore
Pilot projects	20 Crore	50 Crore
IEC/ Operations	5 Crore	5 Crore
Total	260 Crore	535 Crore
Grand Total	INR 795 Crore	

Table 1: Electric vehicles benefitted by FAME Scheme during 2015-2017

Companies like KPIT, BYD, Ashok Leyland, Tata Motors and JBM Auto in association with Solaris have already launched their electric buses in the market. With the increase in number of players and competition, everybody is expecting the initial cost of these buses to come down further. And as per Hon. Minsiter for Road Transport, Shri. Nitin Gadkari's recent statement, Electric buses would be available soon at a price of INR 95 Lakh by 2018 as compared to INR 2.5 crore earlier.

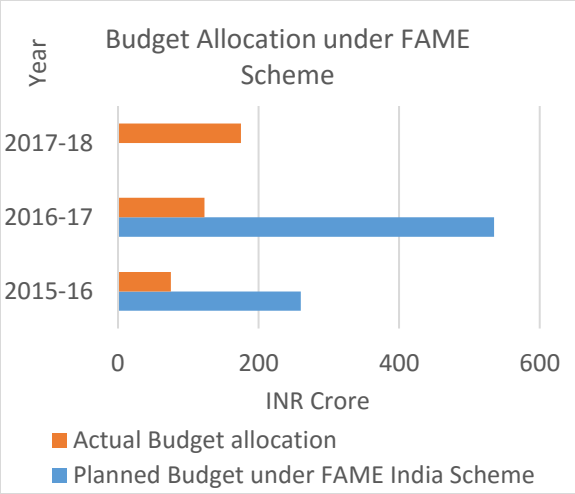
Government is working on a policy where if the buses of the state road transport undertakings are converted into electric, then it is possible to run them with private investment. IESA urges policy makers to set realistic targets by analyzing the traffic patterns and identifying cities and routes that are most suited for introduction of electric buses in India. There is also a need to scale up the rollout target as by lauching 10-25 vehicle pilots, policy makers are sending mixed signals to the industry. By focusing on shorter and pre-defined routes as well as by providing charging stations at multiple lcoations, the cost of the electric buses can be brought down immediately rather than waiting for the cost of storage to drop.

To remove the barrier of lack of charging infrastructure, the government is currently considering an option of battery swapping along with the installations of new charging stations.

This segment has also started gaining momentum slowly as the state government of Himachal has already released a tender to procure 75 electric buses. Bangalore Metropolitan Transport Corporation (BMTC) board has also given the confirmation to procure 150 electric buses for Bangalore City. Pune City has also floated a tender to procure 100 electric buses. And as per the estimation done by IESA, 1500 to 2000 electric buses would be sold till 2022.

Government support and Policies:

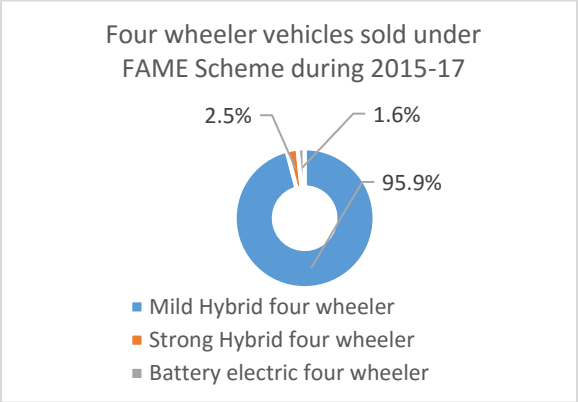
The Department of Heavy Industries (DHI) launched the National Electric Mobility Mission Plan (NEMPP) 2020 in 2013 with a view to sell 6 to 7 million electric & Hybrid vehicles by 2020 to reduce India's dependency on crude oil imports and also to reduce carbon emissions. In 2015, DHI launched the FAME India scheme for faster adoption and manufacturing of electric and hybrid vehicles in India with an approved outlay of Rs. 795 Crore for Phase 1 which was initially for 2 years i.e. FY 2015-16 and FY 2016-17. The outline of the planned scheme was following:



In both years, the actual allocation of the fund was much less than planed allocation and the scheme remained unsuccessful in creating the market at a bigger scale.

Type of Vehicle	No of units sold	Funds allocated (Rs.)
Low speed 2 wheeler with conventional battery	33496	251,220,000
High speed 2 wheeler with conventional battery	1386	13,028,400
Mild Hybrid 4 wheeler	73633	957,229,000
Low speed 2 wheeler with advanced battery	193	3,281,000
Strong Hybrid 4 wheeler	1949	136,430,000
Full electric car	1230	152,520,000
Full electric LCV	10	1,870,000
Total vehicles supported	111897	
Total amount of Claim received		1,515,578,400
Total amount released as on 28/02/2017		1,277,738,200

Secondly, the number of Vehicles supported by FAME scheme during phase 1 was 1,11,897 units. And if we look at the subsidy provided under FAME scheme, Almost 63% of the subsidy was provided to Mild Hybrid cars only.



Out of the total 4 wheelers vehicles sold under FAME Scheme, More than 95% were the Mild Hybrid Vehicles only, whereas strong hybrids and battery electric were merely 2.5% and 1.6%.

IESA analysis of FAME Scheme had found the program defeating the purpose of promoting electric mobility as maximum benefit of the scheme was taken by hybrid segment only. But the government has now removed the mild hybrids from the FAME India subsidy scheme and which is a must step required to achieve the target of sales of 6-7 million electric vehicles by 2020.

Change in Trend:

Earlier when NEMPP 2020 was launched in 2013, the focus of the government was to sell 6-7 million EV's by 2020 to provide a kick start to electric mobility in the country. Then in 2015 during COP 21 summit in Paris, India had committed to bring down its emissions intensity by 33% - 35% by 2030. And after that the government announced its vision to become a 100% electric vehicle nation by 2030 and started working actively towards its goal of achieving 100% electric mobility.

But lack of charging infrastructure, high initial cost, and lack of consumer awareness are the key barriers which are continuously hindering the growth of EV's in India. But the positive sign for the EV industry is that the government has started addressing all these issues and working hard towards bridging the gap.

The government is currently working on various policies to put the electric vehicles at larger front in the country and has already defined a roadmap to convert the public transport into electric in phase 1 and kept the private vehicles the in last phase. As per Niti Aayog's latest policy, Rohtang in Himachal Pradesh had already begun tests for using only electric vehicles for public transport. Five cities, namely Bengaluru and Mysore in Karnataka and Amaravati, Kakinada, and Vishakhapatnam in Andhra Pradesh have been selected further for the implementation of new policy.

Furthermore, the government is also working on a model where electric two wheelers, electric three wheelers, and non-air-conditioned city buses made by automobile companies in India will be sold without batteries as part of the plan thus slashing the initial cost of vehicles up to 70%. The batteries will be leased at a specific cost and can be swapped easily with the recharged ones at stations within a short span of time.

Along with the government, companies like BHEL are also planning to manufacture electric vehicles in the country and has also tied up with ISRO to provide low cost lithium ion batteries for electric vehicles in India. Tata Power Delhi Distribution Ltd (TPDDL) is also planning to install 1000 charging stations across Delhi in next four to five years. PGCIL and NTPC are also exploring opportunities to install charging infrastructure for EV's across the country.

As compared to the earlier scenario, all stakeholders are working more actively towards achieving the goal of 100% electric mobility in the country and currently exploring all possible solutions to counter barriers associated with the use of electric vehicles in the country.

Battery Technologies for electric Vehicle: Past, Present and Futures

Batteries have come a long way over the last few hundred years although admittedly a lot has changed only in the last fifty years and continues to change at an ever increasing rate. In the beginning of the 20th century the only battery commercially available was lead acid. When Ferdinand Porsche made his first car (an electric car!) it used lead acid batteries and had a range of only 10 kms under ideal conditions. The main challenge then was the reduction of the weight of the batteries. Not much changed until the 1950s when the alkaline batteries were introduced for the first time. We know these batteries most commonly as NiMH or NiCd or Zinc Alkaline batteries. These were much lighter but had a very limited rechargeability which means that their cycle life was very limited. Since they were much lighter a lot of applications such as hand held radio sets became possible but were not really ideal for electric vehicles.

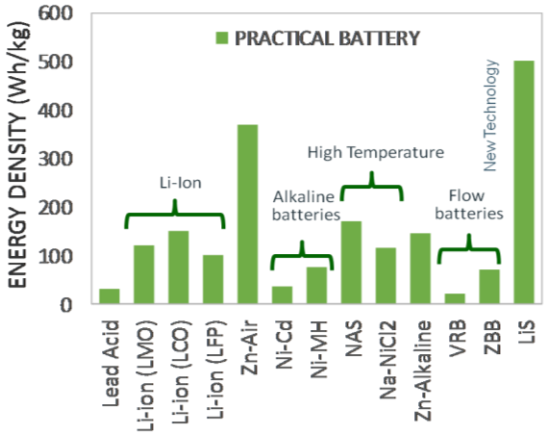


Figure 1: Energy Density of Various Tecnhologies

Undoubtedly the weight and size are the most critical factors when designing a battery for an electric vehicle. A lighter and smaller battery can mean that we can pack additional batteries to give a longer driving range and reduce the 'range anxiety' for the driver. This critical parameter is defined by the energy density of the battery. Simply put it is how much energy (Wh) you can store in 1 kg or 1 L of battery and the unit for this is Wh/kg or Wh/L. If a phone battery which has approximately 10 Wh of stored energy and weighs about 50 grams; the energy density of this battery is 200 Wh/kg. This simple calculation can be used to compare batteries of all types and the comparison is shown in the graph above. In the graph we can quickly see why lead acid batteries are far from ideal for use in electric vehicles; they are simply too heavy. The alkaline batteries (NiCd and NiMH) have a higher energy density compared to lead acid batteries. However, the category that really stands out is the family of Li-ion batteries. Currently, these are the state of the art for use in electric vehicles and are used ubiquitously for this purpose. They have gradually replaced the other battery types in the electric cars.

The first commercial lithium ion cell was introduced by Sony in the year 1991 for their cordless phones. Since the introduction more than three decades ago the technology has made tremendous progress in reducing its size and weight and increasing its cycle life. If we were using the same battery introduced in 1991 then our cell phone battery would last only 8 hours on one charge (assuming it lasts 24 hours now). Similarly an electric car such as Nissan Leaf or Chevy Volt, would only have a driving range of 30 km instead of the 90 km it offers now. There is however a physical limit to how light the

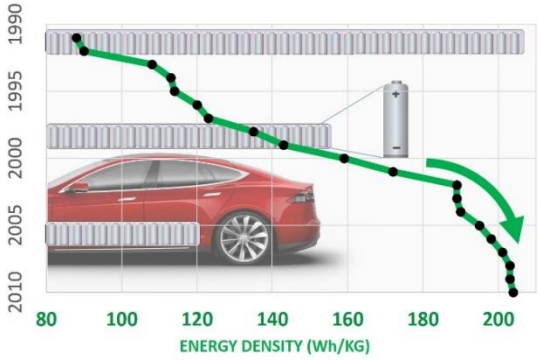


Figure 2: energy Density over the Years

Make	Year Introduced	Type of Battery
Porsche (P1)	1898	Lead acid
GM (EV1)	1996	Lead acid
Toyota RAV4	1997	NiMH
Honda EV Plus	1997	NiMH
GM (EV1 (Gen II))	1998	NiMH
Nissan (Leaf)	2010	Li-ion
Tesla (Model S)	2012	Li-ion
Honda (Fit EV)	2012	Li-ion
BMW (i3)	2014	Li-ion
TESLA		

batteries can become and it looks like the current Lithium ion technology is fast approaching that limit. The energy density of the individual cells has not changed greatly in the past ten years. It seems to be plateauing around

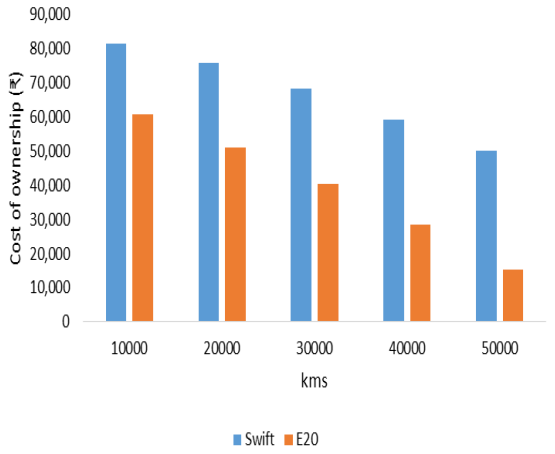
values of 200 Wh/kg which certainly opens door for the next generation of batteries.

Irrespective of all the progress which has already been made, one thing is for sure that the time is just about right for the next technology. We already know that we would like to have a larger driving range (> 600 km) for our electric cars. This is where the next generation lightweight batteries come in. Depending on the technologies these are anywhere between the research, prototype or pilot plant stage just about ready to be commercialized. These new technologies are Lithium Sulphur (LiS), Lithium-Air and zinc air. The achievable energy density of these batteries can be anywhere between 6-8X of the current state of the art lithium ion. An air cathode is the ultimate holy grail in batteries because it does not actually have to contain any cathode material (thus reducing weight); instead it uses the oxygen in the air to produce electricity. For this reason these batteries have often been referred to as breathable batteries. Our car are already ready for these new technologies and now it remains to be seen how long it will take for them to be a part of our lives.

Business Case

EV Adoption in India

A 2016 study[1] conducted across major Indian cities concluded that average Vehicle-Kilometers driven per year by an Indian household was 8817kms. The vehicle usage frequency average was 226 days per year which indicates an average use of 40km/day. Mahindra E20, the passenger Electric Vehicle (EV) claims a range of 110km/charge, yet India has an electric car market share of 0.1%[2]. The lack of EV adoption at the passenger car level could be due to various factors ranging from the Total Cost of Ownership (TCO), lack of policy and infrastructure support or lack of options in the market.



Total Cost of Ownership (TCO)

A preliminary evaluation of TCO was done by

comparing Mahindra E20 with the base model of Maruti Suzuki Swift. The cost of ownership accounted for the interest cost, fuel and maintenance cost. Depreciation and insurance costs were kept out of the analysis. Interest costs were calculated based on the landed cost for Swift and E20 minus the subsidy which is currently ₹1,24,000 under the FAME (Faster Adoption and Manufacturing of Electric Vehicles) scheme. Assuming a maximum run of 10000 km/yr., the equivalent fuel costs were calculated based on the claimed mileages, i.e. km/l for Swift and km/charge for E20. Maintenance cost for E20 are minimal until batteries are replaced post the claim period of 60,000 kms. The prevailing market prices were considered for fuel prices and the average household electricity tariff with annual escalation was considered to calculate the yearly running costs.

Figure 3:Cost of ownership (Up to 5 yrs. /50,000kms)

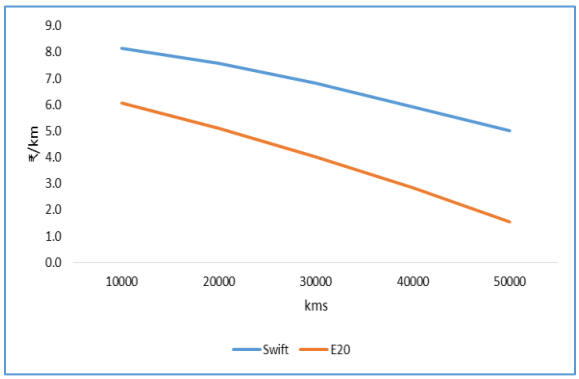
[1] Schievelbein, W., Kockelman, K.M., Bansal, P. and Schauer-West, S., 2017. Indian Vehicle Ownership and Travel Behaviors: A Case Study of Bangalore, Delhi and Kolkata (No. 17-01171).

[2] Global EV outlook, 2016 Cost of ownership (Up to 5 yrs. /50,000kms)

The cost of ownership on a 10 year period in E20 also accounted for the complete battery replacement.

Car	TCO(5 year)	TCO(10 year)
Swift	₹ 3,34,962	₹ 5,66,553
E20	₹ 1,95,895	₹ 3,39,127

The calculated running cost/km for Swift was around ₹ 8.22/km in year 1 as against ₹ 6.1/km for E20 and the costs were at ₹ 5/km and ₹ 1.5/km for Swift and E20 at the end of year 5 respectively assuming a run of 10,000km/yr.



Running cost/km

The 10 year average running cost/km was around ₹ 5.7/km for Swift and ₹ 3.4/km for E20 after assuming the costs for battery replacement in E20 during this period.

The impact of subsidy

The overall analysis could be perceived to favor E20 because of the subsidy on offer. However, the same analysis without subsidy provides a different perspective.

Car	TCO-5 year (Incl. Subsidy)	TCO-5 year (Excl. Subsidy)
E20	₹ 1,95,895	₹ 2,26,565

The difference in the 5 year cost of ownership is ₹ 30,670 and the 5 year average running cost/km works out to be ₹ 6.7/km for Swift and ₹ 4.5/km for E20 without subsidy (₹ 3.9/km with subsidy). The need for subsidy is likely to be questioned but, there is a need to look at the bigger picture. Providing subsidy to promote EV should be weighed against the cost of pollution from vehicles.

Societal cost

The recent crisis across Indian cities over air pollution is well documented. A World Bank study noted that air pollution cost India nearly 8.5% of its GDP in 2013. The permissible emissions under the BS IV regulations is 0.08g/km of Nitrous Oxide (NOX) and 1 g/km of Carbon Monoxide (CO). Electric Vehicles on the other side are emission neutral but even accounting for the carbon emissions of the grid would still favor EVs. For example E20 would have an impact of about 0.08mg/km considering India's grid emission factor of about 0.82kg CO2e/kWh which is nearly 1000 times better than the best possible petrol equivalent. An increasing renewable energy in the grid mix would only lower the grid emission factor and make EVs look even greener. In a recent response[3] in Parliament FAME scheme has claimed to have resulted in 10million liters' of fuel savings and a reduction of 0.03million ton of CO2 reduction since launch.

Lack of adoption

In spite of electric cars out-performing their rivals in terms of Total Cost of Ownership (TCO) and running cost per km their adoption has been very low in India.

Range Anxiety

The widely stated reason for low adoption of EV is the range anxiety. Mahindra E20 claims to have a range of 110km per charge. The impact of declining battery costs and large scale manufacturing have managed to pack in more battery capacity per car thereby increasing the

[3] Rajya Sabha, Apr 12, 2017

range. Tesla model 3 claims a mileage of 346km/charge. The trend will certainly reduce the range anxiety. Equally, having public fast charging infrastructures installed on major routes in cities and highways will help consumers switch to EV sans range anxiety.

EV charging infrastructure

Charging infrastructure is widely classified under Electric Vehicle Supply Equipment (EVSE) that includes connectors, coupling and control devices and power unit. Typically its classified under 3 types, Level 1 for half/one day cycles at 110V AC; Level 2 for 8-hour cycles at 220V AC and Level 3 fast charging based on DC grid.

Figure 4 Charging stations in India (Source: Plugin India)

The total number of electric vehicles sold in India would be around 500,000 of which electric 3 wheelers account for a significant number. On a low side, the total EVs currently running on road could be assumed to be the EVs sold through FAME scheme during Apr'15 to Feb'17 which is close to 120,000. Neglecting the 2 wheeler sales of 35,000 which is mostly charged at private facilities the total vehicle count reduces to 85,000. Currently in India, there are around 300 publicly available charging stations, nearly one-thirds are in Mahindra outlets or its group company owned facilities. The EV-public charging station ratio stands at 283:1. The number is in sharp contrast to China and Japan which is at 30:1. Similarly the ratio is between 60-90 for US and Canada. It clearly illustrates a wide gap in the market.

Policy support for EV charging infrastructure

The National Electric Mobility Mission plan envisaged charging points between 175,000-227,000 by 2020 with fast charging points accounting 10% of the total. The FAME scheme which followed up on this plan envisaged fund allocation in developing the infrastructure but unfortunately it has not taken off as proposed.

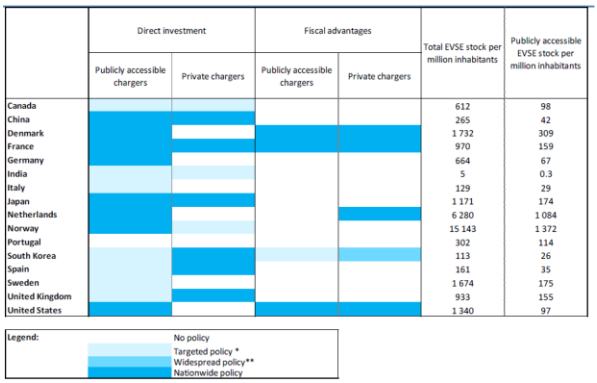


Figure 5 Summary of policy support for EVSE (Source: Global EV outlook, 2016)

Development of charging infrastructure would hinge on

- Regulations that classify energy storage as an asset that could also be traded.
- Standards for charging stations, connectors and hardware protocols. The Automotive Research Association of India (ARAI) has recently released an industry charging standard for AC systems and is likely to release one for DC systems soon.
- Utility's preparedness to witness a surge in demand.
- Incentive to charge vehicles through a time of use/ off-peak charging tariffs.

Challenges and Road Ahead:

There are a lot of challenges associated with electric vehicles which need to be addressed first before the adoption of EV's at a larger scale:

The first issue is what should be the appropriate EV Charging infrastructure model for the urban areas, highways and rural India. Lots of discussions are already going on regarding what type of charging infrastructure should be deployed in different areas. But no concrete model has been finalised yet. As per IESA recommendation, Type 1 chargers are most suitable for residential townships and workplaces. Type 1 charger takes around 8 to 10 hours for complete charging and people generally spend around 8 to 10 hours at their workplaces where they can charge their vehicles easily. Type 2, which takes around 3 to 4 hours for complete charging, is most suitable for the commercial purpose such as Malls, Parking lots etc. For highways and other places where fast charging is required throughout, Type 3 chargers should be considered. Additionally a combination of type 1 and type 2 should be installed in petrol pumps and auto stands.

The next issue is what the right tariff for the charging of electric vehicles should be – whether we choose commercial rates/promotional rates for the promotion of EV's in India or consider Time of day (ToD) requirements for the grid. As per IESA recommendations, it could be dependent on the customer usage such as residential users may be able to charge at residential rates while the commercial users or the public charging spaces paying at commercial rates. ToD aspect should be considered as well as incentives should be available for Vehicle to grid (V2G) for providing ancillary services and demand response to grid.

The next biggest challenge is to find out the appropriate battery technology for the electric vehicles whether it should be lead acid or the lithium ion. Also the technology should be environment friendly. Currently, most of the EV manufacturers are shifting towards lithium ion batteries but considering advanced lead acid could also be a suitable option. Lead acid batteries will have an advantage in terms of recycling and also will not have dependency on other countries for importing lead acid batteries as we have a well-established in-house facility in the country. For other technologies, we need to develop the recycling unit first along with the development of infrastructure and technology.

Apart from these major issues, there are various other issues as well, such as:

- What would be the impact of EV charging over grid?
- Who will operate the EV charging stations?
- What kind of incentives should be provided for the faster adoption of electric vehicles?

IESA Initiatives in Electric Vehicle Segment

India Energy storage Alliance (IESA) has been actively involved in development of Electric Vehicle market in India since inception in various capacities.

- In IESA's Annual International Conference and Expo "Energy Storage India", IESA created a special track on Electric Mobility and transportation since 2013. The conference and expo has brought together key policy makers, researchers, technology developers and automotive manufactuers each year since then.

- IESA was actively involved in Smart Utility Group (SUG) created by ISGF on providing inputs to Department of Heavy Industries (DHI) on "Effect of Electric Vehicle Penetration on Electric Grid and charging Infrastructure" during 2015-16.
- IESA organised an open webinar on "Indian Electric Vehicle (& Hybrid Vehicle) Market" in July 2015. The presenters include Mr. Robert (Bob) Galyon, CTO, CATL, Mr. Basant Vaishya, Sr. Vice President and Yo–Bikes, ELECTROTHERM, Mr. Maheshwar Babu, Sales & Marketing Head, Firefly Batteries and Sumit Dhanuka, VP & Lead- Private Investments, Sar Group, LivGuard Batteries.
- IESA supported as an Association Partner and also presented on energy storage requirement for the electric vehicle at the "Energy Conclave on Electric Vehicle" organized by IIT Bombay in August 2016.
- IESA has provided inputs to Department of Science and Technology (DST) on battery module standardisation efforts.
- IESA submitted a paper to NITI Aayog on advanced energy storage manufacturing policy for India, which will boost Electric Vehicle manufacturing in India in 2016.
- IESA team presented its view on energy storage requirement for e-rickshaws at EV Expo 2016
- IESA organised its regional event on energy storage for Electric Vehicle at Pune in October 2016. The conference saw participation from Tata Motors, Go Green BoV, CECRI, ARAI, Octilion Power Systems, and CMET.
- IESA team created and released an Industry landscape report on Indian Electric Vehicle Market Overview 2017.
- IESA participated in the Strategy development workshop organized by The International Council on Clean Transportation (ICCT) in association with the Shakti Sustainable Energy Foundation to promote electric vehicles in India in January 2017. IESA provided its inputs to overcome the barriers associated with the electric vehicles in India.
- IESA is founding member of Transportation Electrification Special Interest Group being created by IEEE and IET in 2017. TESIG will focus on pollution control by EV adaptation, Employment generation adopting Make in India for EV and India's Energy Security.

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