إِنَّا كُلَّ شَيْءٍ خَلَقْنَٰهُ بِقَدَرٍ

The Pakistan Academy of Engineering

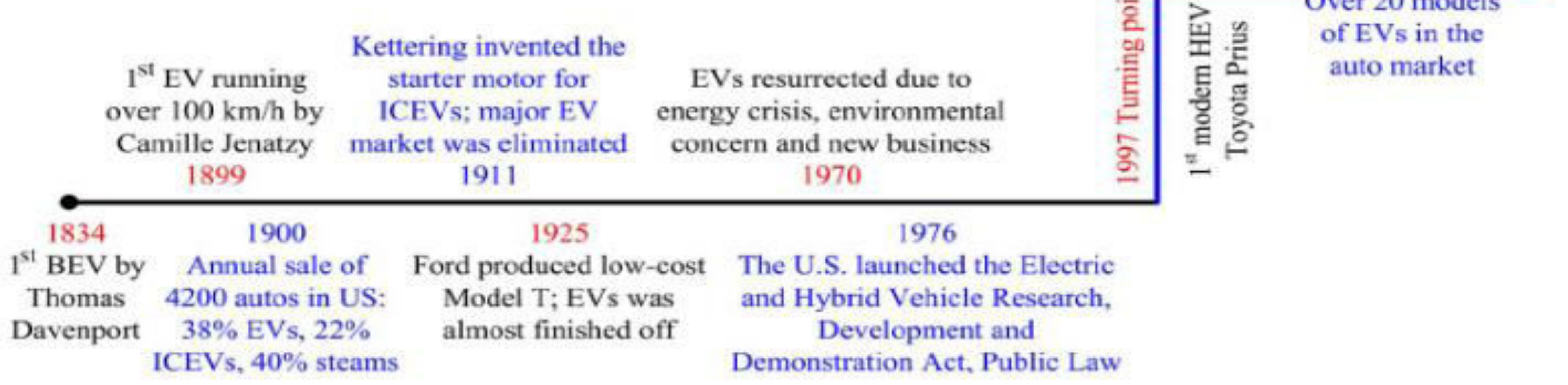
Electric Vehicle Prospects in Pakistan

Introduction

In Pakistan, under the guidance and patronage of Respected Prof. Dr-Ing. Jameel Ahmad Khan (Ex-Vice Chancellor, N.E.D. University of Engineering and Technology), the first solar powered electric car was made in the late 1980's

Detroit Electric Brand
- Image courtesy of 'thehenryford.org – Digital Collections

Lightyear 0
'-Lightyear one'



EV developmental milestones.

3

Global Trend

Global trends indicate two streams of Electric Vehicle development.

Tesla Model Y – Image courtesy TESLA

Battery Electric Vehicle viz. (BEV)

USA Sales reported by Experian (via *Automotive News*), some **378,466** electric vehicles were registered from January to October 2021, which is **94% more** than in 2020 at this point. That's about **2.9%** of the total market, compared to 1.7% a year ago.

Most registered all-electric models reveals the continued domination of Tesla, which has two models - Model Y (134,504 (up 182%; 35.5% of all BEVs) and Model 3 (112,314 (up 39%; 29.7% of all BEVs) and 117,534 non-Tesla.

Fuel Cell Electric Vehicle viz. (FCEV)

USA Sales in 2021 (Mirai and NEXO sales as reported by the manufacturers):

Toyota Mirai - **2,629** (up 427% from 499)

Hyundai NEXO - **430** (up 107% from 208)

other models - 282 (up 23% from 230)

Total: about 3,341 (up 257%, from 937)

Toyota Mirai – image courtesy of Toyota Motor Corporation

Global Trend (*Interesting trend in China*)

Battery Electric Vehicle viz. (BEV)

- The total sales volume was 1.737 million vehicles, a month-on-month decrease of 31.4% and a year-on-year increase of 18.7%, with passenger vehicles accounting for 1.487 million units, down 32% month-on-month and up 27.8% year-on-year.

(Source:https://carnewschina.com/2022/03/23/top-10-best-selling-electric-vehicles-in-china-in-february-2022/)

Fuel Cell Electric Vehicle viz. (FCEV)

- Worldwide sales of hydrogen fuel cell vehicles (HFCVs) amounted to around 17,000 units last year according to the China Association of Automobile Manufacturers, with China accounting for just 1,586 of these.
- The Chinese government is stepping up its hydrogen drive with a new policy calls for 50,000 fuel-cell vehicles to be in use in the country by 2025
- The commission has set a hydrogen production target from renewable sources of between 100,000 and 200,000 tons annually by 2025
- Hyundai is scheduled to begin FCEV production in China later this year with an initial annual capacity of 6,500 heavy trucks ahead of plans to target light vehicle segments starting with the Nexo FCEV.

(Source: https://www.just-auto.com/news/china-raises-hydrogen-fuel-cell-targets/)

Top 3 Electric Vehicles sold in China (Source:https://carnewschina.com/2022/03/23/top-10-best-selling-electric-vehicles-in-china-in-february-2022/)

Top 1: Wuling Hongguang Mini EV

26,100 units sold in Feb 2022

22,800 units sold in Feb 2022

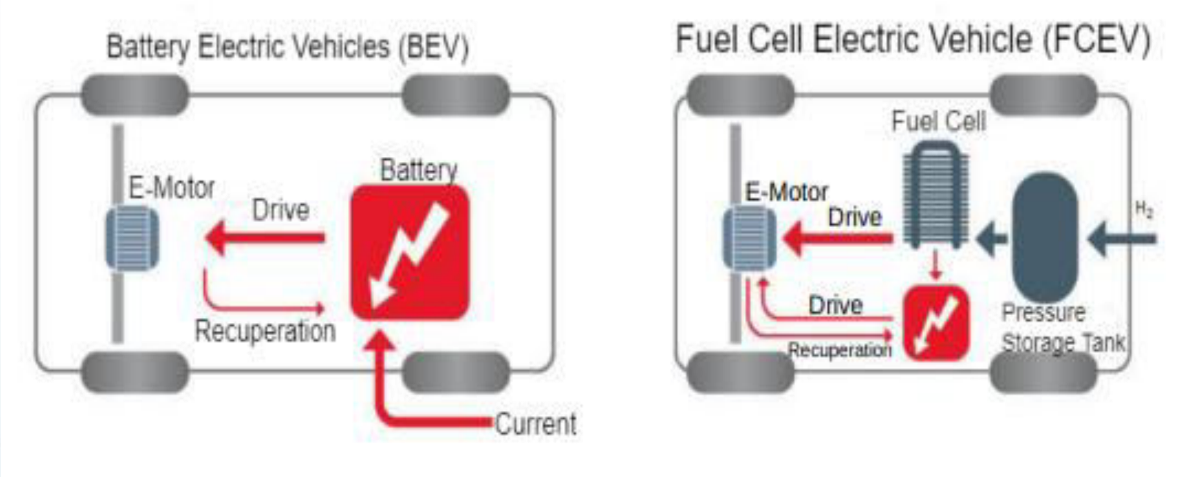
Top 2: BYD Song Plus

22,500 units sold in Feb 2022

Top 3: BYD Qin Plus

The vehicle comes in two battery/range options: 120 km range with 9.3 kWh battery and 170 km range with 13.9 kWh battery. Top speed of 100 km/h or 62 mph. (395,451 units sold in 2021)

Basic Structure of BEV and FCEV



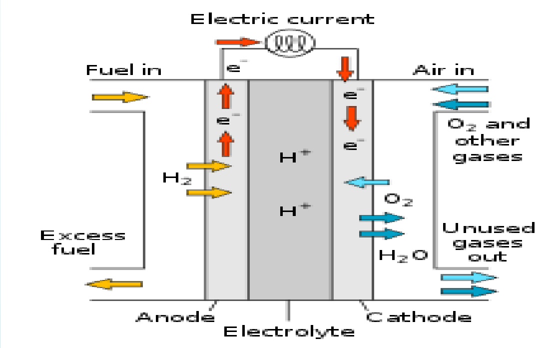
Principle of BEV (left) and FCEV (right) (Source: Forschungszentrum Julich)

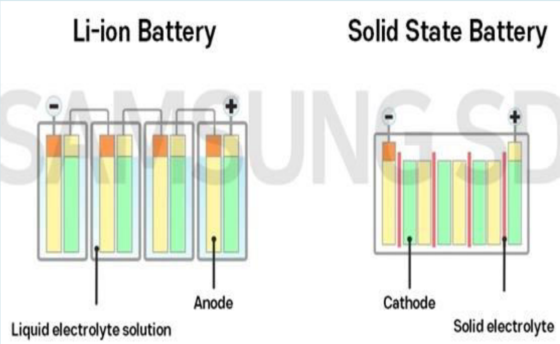
Generally speaking, today BEVs have advantages in the short-distance area, while FCEVs are particularly recommended for payloads and long-distance travel.

Fuel Cell vs Battery

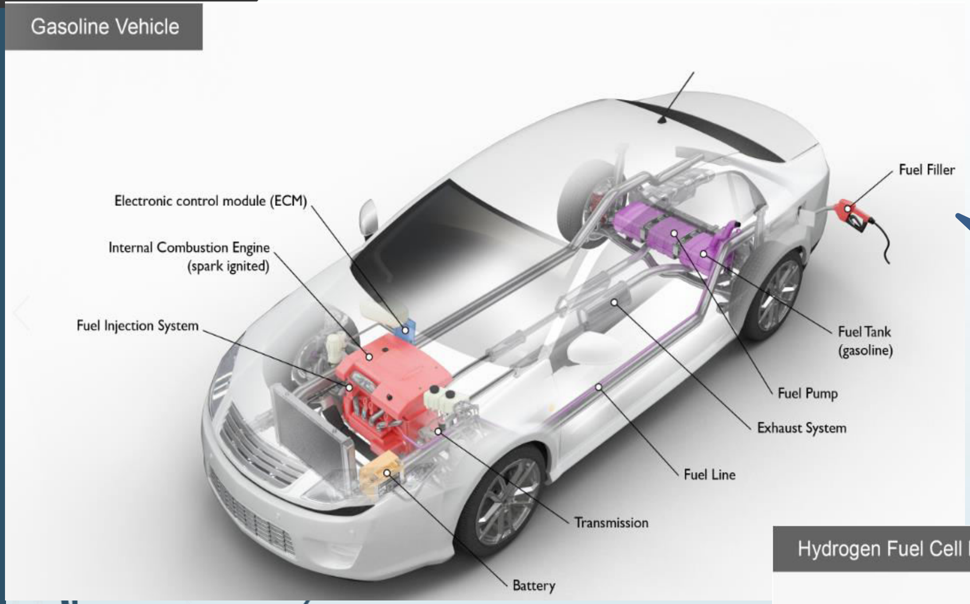
- A fuel cell is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions.
- Fuel cells are different from most batteries in requiring a continuous source of fuel and oxygen (usually from air) to sustain the chemical reaction, whereas in a battery the chemical energy usually comes from substances that are already present in the battery.
- Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.

Fuel Cell

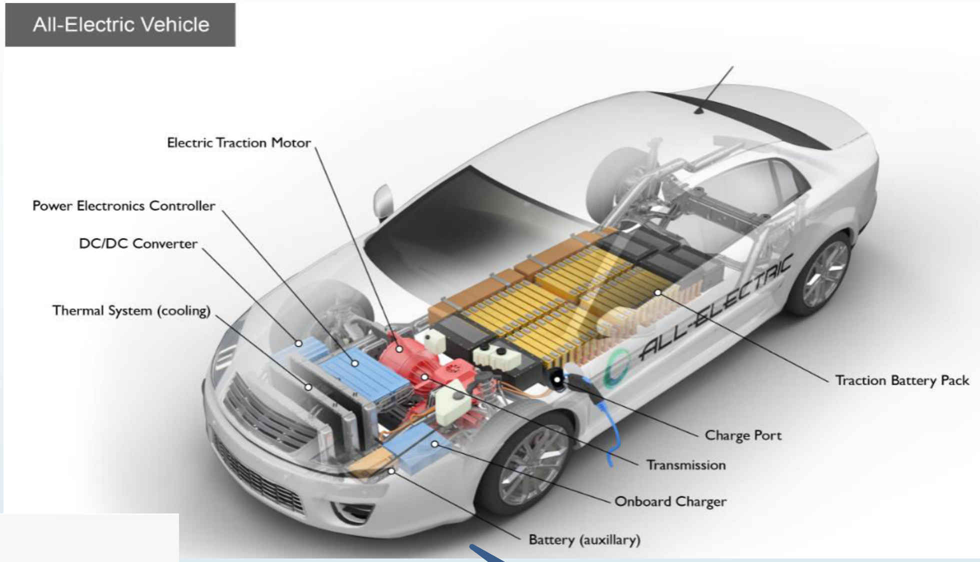




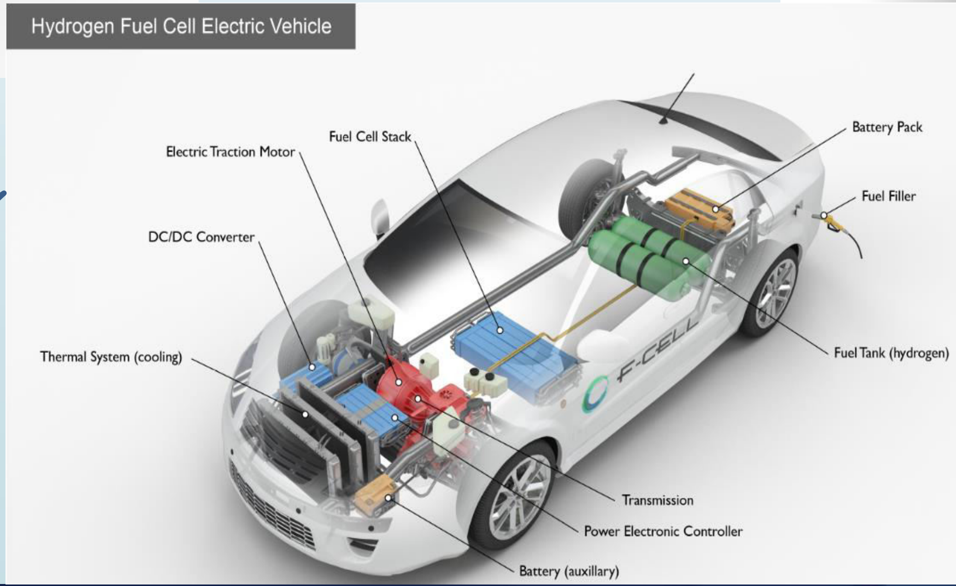
ICE vs BEV vs FCEV – Vehicle Differences



ICE



BEV



FCEV

Images courtesy of afdc.energy.gov

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Technology Trends

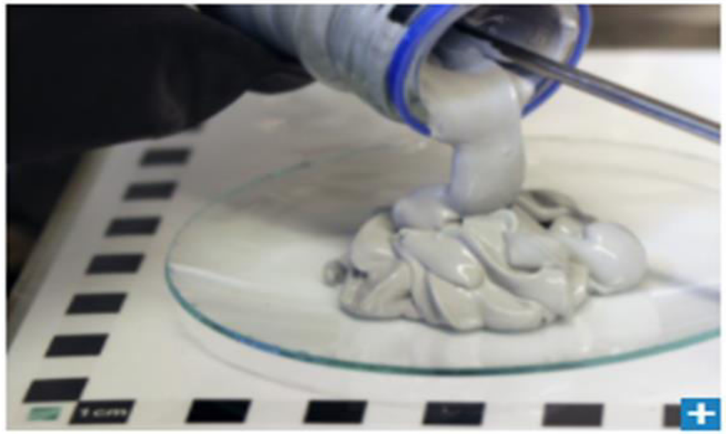
New catalyst for producing Hydrogen for Fuel Cell

- A new sustainable and practical method for producing hydrogen from water has been discovered by a team of researchers at the RIKEN Center for Sustainable Resource Science (CSRS) in Japan led by Ryuhei Nakamura.
- Unlike current methods, the new method does not require rare metals that are expensive or in short supply. Instead, hydrogen for fuel cells and agricultural fertilizers can now be produced using cobalt and manganese, two fairly common metals. The study was published in *Nature Catalysis*.
- The reason for this development is that the catalyst must be very active. If not, the amount of electricity needed for the reaction to produce a given amount of hydrogen soars, and with it, so does the cost.
- The researchers looked at mixed cobalt and manganese oxides. By combining them, the researchers hoped to take advantage of their complementary properties. Eventually, the team overcame these issues by trial and error, and discovered an active and stable catalyst by inserting manganese into the spinel lattice of Co_3O_4, producing the mixed cobalt manganese oxide Co_2MnO_4.
- The new catalyst lasted over two months at a current density of 200 milli-amperes per square centimeter, which could make it effective for practical use. Compared with other non-rare metal catalysts, which typically last only days or weeks at much lower current densities, the new electrocatalyst could be a game changer.

Technology Trends

Hydrogen-powered drives for e-scooters

- Researchers from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Dresden have now come up with a hydrogen-based fuel that is ideal for small vehicles called POWERPASTE, which is based on solid magnesium hydride. "POWERPASTE stores hydrogen in a chemical form at room temperature and atmospheric pressure to be then released on demand," explains Dr. Marcus Vogt, research associate at Fraunhofer IFAM. And given that POWERPASTE only begins to decompose at temperatures of around 250 °C, it remains safe even when an e-scooter stands in the baking sun for hours. Moreover, refueling is extremely simple. Instead of heading to the filling station, riders merely have to replace an empty cartridge with a new one and then refill a tank with mains water. This can be done either at home.



© Fraunhofer IFAM Dresden

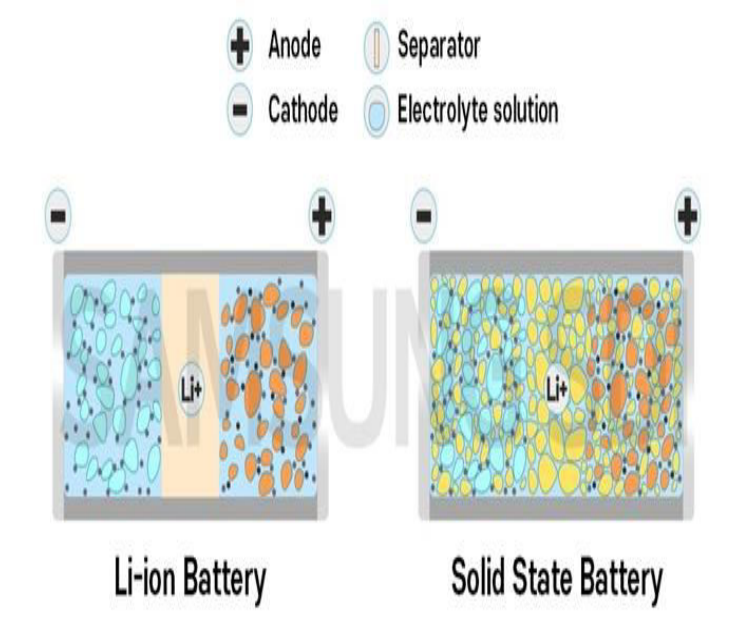
POWERPASTE

- Magnesium powder is combined with hydrogen to form magnesium hydride in a process conducted at 350 °C and five to six times atmospheric pressure. An ester and a metal salt are then added in order to form the finished product. Onboard the vehicle, the POWERPASTE is released from a cartridge by means of a plunger. When water is added from an onboard tank, the ensuing reaction generates hydrogen gas in a quantity dynamically adjusted to the actual requirements of the fuel cell. In fact, only half of the hydrogen originates from the POWERPASTE; the rest comes from the added water.

- Compared to batteries, POWEPASTE has ten times the energy storage density. This means that POWERPASTE offers a range comparable to – or even greater than – gasoline. And it also provides a higher range than compressed hydrogen at a pressure of 700 bar.

Technology Trends

Solid State Battery



[Structure of Li-ion battery(left) and Solid-state battery(right)]
Courtesy SAMSUNG SDI

- Samsung SDI is working on developing the solid-state battery. Samsung Advanced Institute of Technology showed the research result of a solid-state battery that can be charged/discharged over 1,000 times with 800km of mileage on a single charge. The study about the technology that increases life cycle and safety, and reduces the size of a solid-state battery in half was published in the ‘Nature Energy’, a global scientific journal.

- Sakuú has been developing its first generation SSB battery technology alongside its flagship additive manufacturing platform. These first-generation batteries comprise 30 sub-cells, utilize lithium-metal and a proprietary printed ceramic separator. The battery has been designed to use current industry standard cathode materials and can support even higher voltage cathodes in the future that could yield up to 25% more energy. This makes the new battery perfectly suited for consumer, aerospace, mobility, and many other applications given its advantages in safety and energy density.

- In addition to the 800 Wh/L mark, the first-generation lithium-metal battery is demonstrating high energy retention at 97% after 200 cycles. The battery, while remaining dendrite-free, is expected to record 80% retention at 800 cycles once cycling has completed.

Battery Type	Cost $ per Wh	Wh/kg	Wh/liter
Lead-acid	$0.17	41	100
Alkaline long-life	$0.19	110	320
Carbon-zinc	$0.31	36	92
NiMH	$0.99	95	300
NiCad	$1.50	39	140
Lithium-ion	$0.47	128	230

Source: https://sinovoltaics.com/learning-center/storage/energy-density-and-specific-energy-of-battery/

Technology Trends

Solar Cars (smaller battery, lighter car)

- Lightyear 0 solar-assisted car will go into production this year. Company CEO and co-founder Lex Hoefsloot says, "The powertrain is the most efficient in the world," he claims, adding that the car's aerodynamic shape and four in-wheel motors enable a smaller battery to provide the same range.

- That means "the whole car is lighter," he says, "and you get into this positive feedback cycle where everything can become lighter as well. That's how we've been able to get to 1,575 kilograms. If you look at other cars that offer similar range, they're all about 40% heavier."

- Other companies are developing cars with solar panels, but none are ready to hit the market yet. The Sono Sion, slated for production in 2023, promises to provide an average of 10 miles of solar range per day. The Aptera Never Charge is a futuristic-looking three-wheeler that the company claims will collect about 40 miles' worth of solar energy a day. Aptera told CNN that it hopes the car will enter production in 2023, and it already has 24,000 reservations.

- But while the whole concept of the Lightyear 0 may be based around improving efficiency and cutting charging time, it has a maximum speed of just 100 mph, while its 0 to 100 mph time is a sluggish 10 seconds, something that Hoefsloot admits is down to a focus on range.

Practical range
1,000+ km driving range between two charging moments(1)
Battery range - 625 km (WLTP)(2)
Highway range (at 110 km/h) - 560 km(3)
Additional daily solar range - Up to 70 km(4)
Annual solar yield - Up to 11,000 km(4)
Battery pack - 60 kWh

Charging speeds
Amount of range in 1 hour charging

Home charging (regular household plug) - 32 km/h
Public charging - 200 km/h
Fast charging - 520 km/h

1 Based on a 50 km workday commute in Amsterdam in summer. Driving range will vary depending on driving habits, location and season.

2 Pending final verification tests.

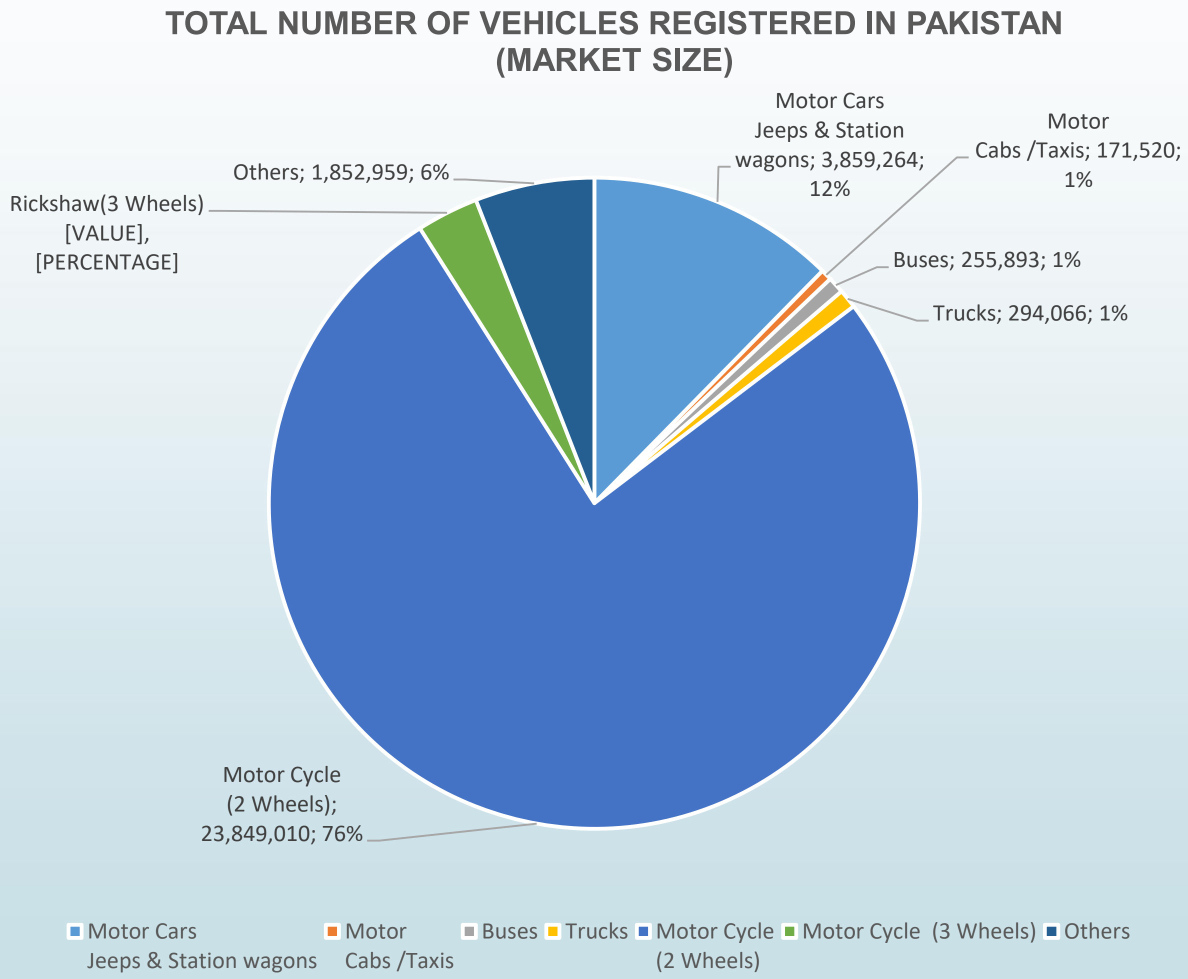
3 Verified by Lightyear Production Intent Vehicle 012 in June 2022.

4 Based on a 35 km workday commute in Southern Spain in spring and summer.

Benefits …

- EV's are cheaper to operate compared to ICE.
- Presumably cheaper to maintain due to less moving parts
  - EV batteries are still very expensive but prices may come down
- Renewable energy utilization
  - Reduce greenhouse gas emissions
  - Recharge EV from solar PV instead of the grid.
- Eco-friendly materials
  - A trend towards more eco-friendly production and materials for EVs.
- Health benefits
  - Reduced harmful exhaust emissions.
  - Quieter than petrol/diesel vehicles; less noise pollution.

Market size in Pakistan



Pakistan's EV projections

EV Penetration Targets	Medium Term Targets (Five Years) Cumulative	Long Term Targets (2030)	Ultimate Targets (2040)
Cars (including Vans, Jeeps and small Trucks)	100,000	30% of New Sales (Approximately 60,000)	90% of New Sales
Two and Three Wheelers Four Wheelers of UNECE 'L' Category	500,000	50% of New Sales (Approximately 900,000)	90% of New Sales
Buses	1000	50% of New Sales	90% of New Sales
Trucks	1000	30% of New Sales	90% of New Sales

Challenges in EV Implementation in Pakistan

- Brand new electric cars are mostly very expensive cars and are not affordable for masses.
- Paradigm shift from ICE based vehicles to Electric vehicles is not easy from average user perspective mainly due to economic reasons.
- Charging time required by the electric vehicles and the driving range they offer.
- Increasing electricity rates and lack of charging infrastructure.
- Lack of related infrastructure for Fuel cell electric vehicles.
- Lack of awareness among vehicle buyers about the advantages of EVs over the combustion engine vehicles.
- Need for local manufacturing of EV’s with resilient supply chain.

Annual Cost Comparison of BEV vs FCEV vs ICE in Germany

	Purchase (in €)	Depreciation (ten years) (in €)	Energy Costs (in €/kWh, for ICE €/litre)	Consumption (in kWh/ 100 km, for ICE litres/100 km)	Energy Costs (10,000 km) in €	Annual Costs (per year in €)
Toyota Mirai	78600	7860	0.285 (H2)	25308 (H2)	722	8582
Toyota Mirai (price reduced)	71999	7200	0.285 (H2)	25308 (H2)	722	7922
Tesla S 75	71999	7200	0.296 (el.)	18500 (el.)	548	7748
BMW 740i [b]	78863	7886	2.011 €/litre [a]	9.26 (lit/100km)	1856	9742

Comparison of annual costs of FCEV and BEV (source: Fraunhofer ISE)

a) Source: https://www.globalpetrolprices.com/Germany/gasoline_prices/

b) Source: https://www.ccarprice.com/de/bmw-740i-2022-price-in-germany-6758

Note: Maintenance costs are not considered due to not enough data available for EV's.

Realistic Value

In order to arrive at 'Realistic Value', various operating cost comparisons were made based on the key figures listed here:

VEHICLE NAME	Motor (in KW)	Tank Volume / Battery	Wt. in Kg	Range (in km - EPA)	Fuel Consumption (KWh/100km)
Toyota Mirai	113	H2: 165 KWhH2 Batt: 1.6 KWhel	1850	502	33.33 KWhH2
Tesla Model S75	235	Batt: 75 KWhel	2108	401	21.12KWh
Nissan Leaf 30	80	Batt: 30 KWhel	1573	172	16.77KWel

Comparison of typical key figures of representative FCEV and BEV (Source: University of Hannover)

Assumptions and data used for the comparisons:

- Used a residential rate of Rs. 25 /kWh
- Since commercial charging in Pakistan is under development stage, therefore, the percentage difference between residential and commercial charging rates for various chargers used in Germany were used (to estimate the commercial charging rate in Pakistan).
- In the case of FCEV, commercial hydrogen rate of 3.5 euro/kg is used (as the commercial hydrogen production from the upcoming green hydrogen "Oracle Power Project" in Pakistan will be less than 1.75 euro/kg).
- Battery charging time for TESLA: (source:https://ev-database.org/car/1071/Tesla-Model-S-75
- Cost per Kg H2 for refueling (Euro/Kg) = 9.5 (source: (https://h2.live/en/ , H2 MOBILITY, Germany))
- 2021 Germany - avg. cost in Euro/kwh - DC >= 50 kW commercial charger = 0.4845 (source:https://www.statista.com/statistics/1167538/electricity-prices-charging-stations-electric-cars-by-provider-germany/)
- 2021 Germany - avg. cost in Euro/kwh - AC = 22 KW commercial charger = 0.4118 (source:https://www.statista.com/statistics/1167538/electricity-prices-charging-stations-electric-cars-by-provider-germany/)
- 2021 Germany - avg. cost in Euro/kwh - Home charging = 0.3193 (source:https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Electricity_price_statistic)
- Germany - gasoline cost (in Euro /litre) = 2.011 (source: https://www.globalpetrolprices.com/Germany/gasoline_prices/)
- 1 Euro = Rs.198.17 (Mar. 2022)

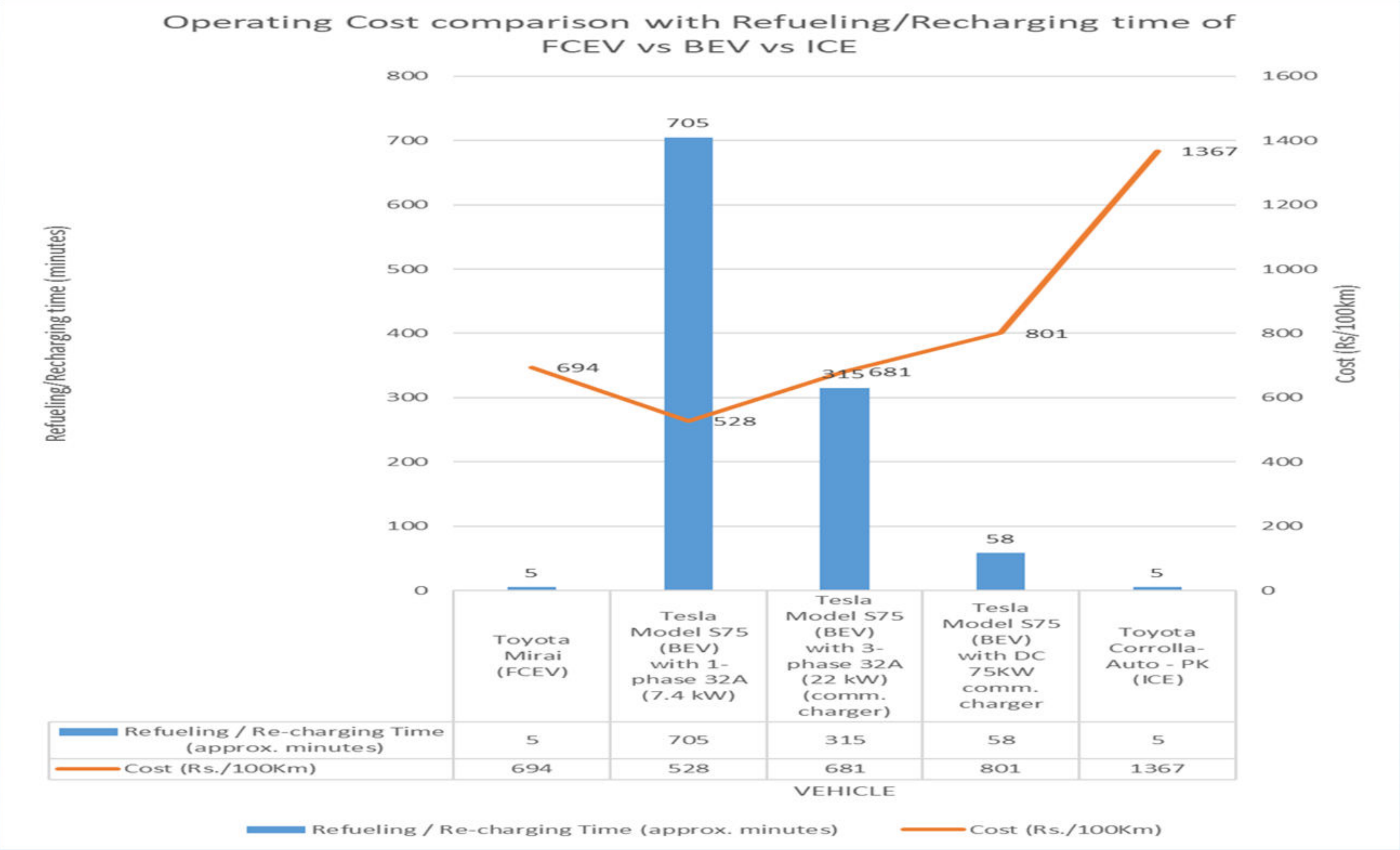
Operating Cost Comparison of BEV vs FCEV vs ICE in Germany (Scenario No.1)

VEHICLE NAME	**Toyota Mirai** (FCEV)	**Tesla Model S75** with 1-phase 32A (7.4 kW)	**Tesla Model S75** with 3-phase 32A (22 kW) (commercial charger)	**Tesla Model S75** with DC 75KW commercial charger	**BMW 740i** (ICE)
Annual Distance travelled (km)	15000	15000	15000	15000	15000
Fuel Economy (FCEV: in 1kgH2/100km, BEV: in KWh/100km, ICE: km/litres)	1kgH2/100km	21.12	21.12	21.12	10.8
(in KWh/100km)	33.33	21.12	21.12	21.12	
Fuel needed per year (Kg of H_2 - FCEV) (KWh - BEV) (litres - ICE)	150	3168	3168	3168	1389
Fuel Cost (FCEV-Euro/kg, V-Euro/KWh, ICE- Euro/litre)	9.5	0.3193	0.4118	0.4845	2.011
Annual Cost of Refueling (Euro)	1425.00	1011.54	1304.58	1534.90	2793.06
Cost in Euro/100km	9.5	6.74	8.70	10.23	18.62
Refueling time /Charging time	3-5 min. (Avg. est.)	11.75 hrs (Avg. est.)	5.25 hrs (Avg. est.)	58 min. (Avg.est)	3-5 min. (Avg. est.)

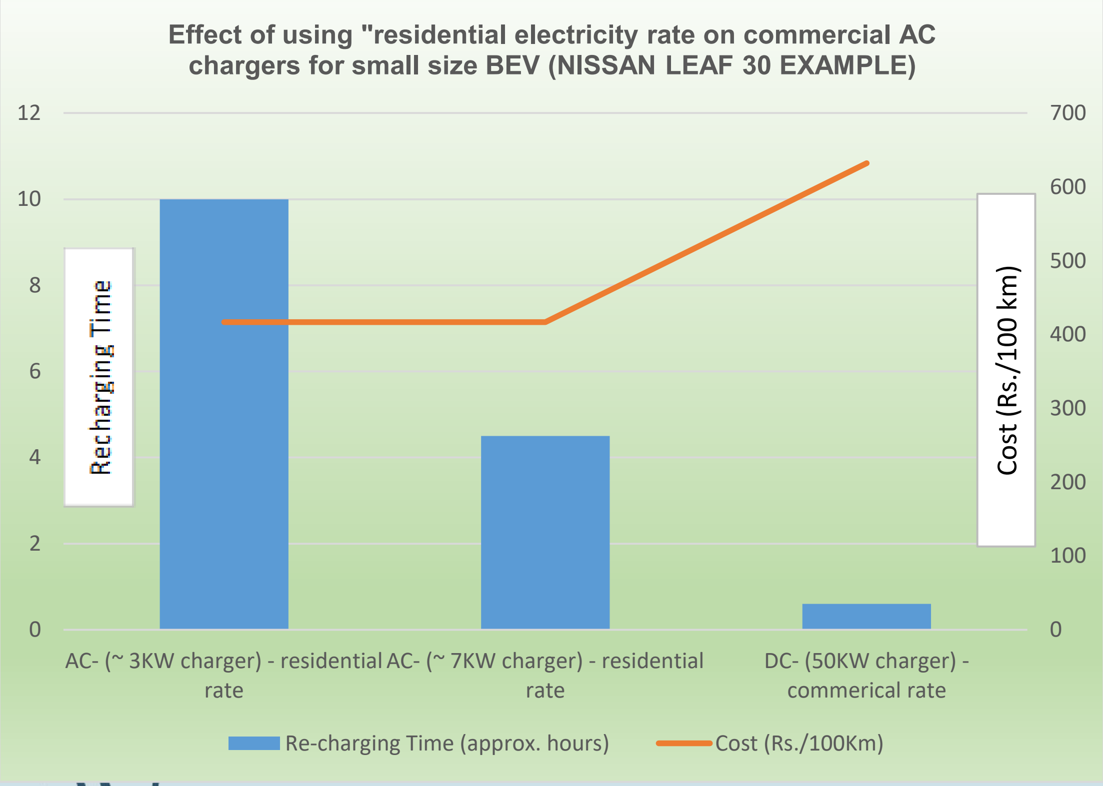
Operating Cost Comparison of BEV vs FCEV vs ICE in Pakistan (Scenario No.2)

VEHICLE NAME	**Toyota Mirai** (FCEV)	**Tesla Model S75** with 1-phase 32A (7.4 kW)	**Tesla Model S75** with 3-phase 32A (22 kW) (commercial charger)	**Tesla Model S75** with DC 75KW commercial charger	**Toyota Corrolla-Automatic (in PK)** (ICE)
Annual Distance travelled (km)	15000	15000	15000	15000	15000
Fuel Economy (FCEV: in 1kgH2/100km, BEV: in KWh/100km, ICE: km/litres)	1kgH2/100km	21.12	21.12	21.12	11
(in KWh/100km)	33.33	21.12	21.12	21.12	
Fuel needed per year (Kg of H_2 - FCEV) (KWh - BEV) (litres - ICE)	150	3168	3168	3168	1364
Fuel Cost (FCEV-Euro/kg, BEV-Euro/KWh, ICE- Euro/litre)	3.5	25	32	38	0.76
Annual Cost of Refueling (Euro)	525.00	400	515	606	1034.58
Cost in Euro/100km	3.5	2.66	3.44	4.04	6.90
Refueling time /Charging time	3-5 min. (Avg. est.)	11.75 hrs (Avg est.)	5.25 hrs (Avg. est.)	58 min. (Avg.est)	3-5 min. (Avg. est.)
Annual Cost of Refueling (PKR)	104039	79200	102144	120178	205023
Cost in Rs/100km	694	528	681	801	1367

Operating Cost Comparison of BEV vs FCEV vs ICE in Pakistan (Scenario No.2)



Operating Cost Comparison based on AC vs DC charging of small BEV using different electricity rates in Pakistan (Scenario No.3)



	NISSAN LEAF 30	with Home charging (~3 KW)	NISSAN LEAF 30	with (7KW charging)	NISSAN LEAF 30	with DC 50KW commercial charger
Annual Distance travelled (km)	15000		15000		15000	
Fuel Economy	16.77		16.77		16.77	
(in Kwh/100km)	16.67		16.67		16.67	
Fuel needed per year	2500.5	KWh	2500.5	KWh	2500.5	KWh
Fuel Cost	25	PKR/kWh	25	PKR/kWh	38	PKR/kWh
Refueling time/Charging time	~10 hrs (Avg est.)		~4.5 hrs (Avg est.)		~30 min (80% charged)-(Avg. est.)	
Annual Cost of Refueling (Rs.)	62513		62513		94856	
Cost in Rs/100km	417		417		632	

2Wheeler and 3Wheeler EV Operating Cost in Pakistan

	2W- Motor bike - Electric	2W- Motor bike (ICE)
Annual distance travelled	14600	14600
Fuel consumption rate (For BEV - in Km/ KWh, For ICE in Km/ liter)	40	40
Fuel Cost (For BEV - in Rs./KWh, For ICE - in Rs./liter)	25	150
Annual Fuel required (For BEV -in KWh, For ICE - in liters)	365	365
Annual Cost of refueling (Rs.)	9125	54878

Vehicle Type	Average Vehicle Consumption			
	Average Annual Distance	Electricity	Petrol	Diesel
	km	km/kWh	km/liter	km/liter
2 W Motorbikes	14,600	40	40	–
3 W - rickshaw	45,000	20	20	–
4W Sedan, SUVs LDV	12,000	6	11	17
Buses	75,000	1.3	3	4
Trucks	75,000	1	2.5	3.2

Assumption for average annual distance travelled & fuel consumption by vehicle type [1]

	3W- Rickshaw - Electric	3W-Rickshaw (ICE)
Annual distance travelled	45000	45000
Fuel consumption rate (For BEV - in Km/ KWh, For ICE in Km/ liter)	20	20
Fuel Cost (For BEV - in Rs./KWh, For ICE - in Rs./liter)	25	150
Annual Fuel required (For BEV -in KWh, For ICE - in liters)	2250	2250
Annual Cost of refueling (Rs.)	56250	338288

Using the above-mentioned assumptions by utilizing Petrol rate = Rs. 150.35 / liter and Electricity rate = Rs. 25 / kWh, following operating cost comparisons were made:

[1] Khalil Raza, Scaling Up Electric Mobility in Pakistan, *UNDP NDC Support Programme*, (October 2021).

PAE

Conclusions

- Operating cost ‘scenario no.1’ highlights the fact that by considering ‘higher outreach/range’ and ‘comparing refueling time of ICE vehicle’ and ‘recharging times of BEV’ with an FCEV in terms of ‘Cost/100 km’, FCEV vehicle is a better choice.
- Operating cost ‘scenario no.2’ further strengthens ‘scenario no.1’ outcome of FCEV as a better choice and highlights the fact that if the hydrogen availability at the hydrogen pumping stations is within the assumed commercial availability rates, then an FCEV will be the vehicle of choice for a majority of four wheel vehicles.
- The focus on sustainable green hydrogen production and its availability at hydrogen stations (similar to current petrol pumps in Pakistan) at a commercially viable rates holds the key to this success.
- The smaller battery size results in lower battery charging times coupled with lower infrastructure costs. Therefore, battery electric vehicles offer advantages in “shorter range /outreach” due to smaller size battery, better re-charging time, low operating cost and low infrastructure costs in smaller size vehicles.
- The operating cost ‘scenario no.3’ shows that by keeping the commercial AC charging rates low (i.e. equal to residential electricity rates), especially in the case of 2 wheeler motor bikes, 3 wheeler rickshaws and the smaller size 4 wheel cars (by virtue of their smaller battery sizes), the end user will see a bigger benefit in using BEVs and can result in rapid ramp-up of EVs in Pakistan.
- Average consumer need to understand the difference between “claimed versus actual reality” so that the they can make informed decisions before expensive purchases.
- While the per kilometer operating cost of electric vehicles seems relatively lower given their lower fuel consumption, but the upfront cost of ownership and the expensive parts dilutes this advantage.
- The price premiums of battery-driven electric vehicles over ICE vehicles are very high and they vary (mainly due to their larger battery size).
- Developed countries or those with a higher renewable energy mix could afford to subsidize electric vehicles, making their upfront cost lower.

Conclusions

- Price of EV can be brought down by local manufacturing of its parts and accessories for local assembly, as well as local manufacturing / assembly of any other associated equipment such as Batteries, Chargers, Electrolyzers etc. However, this has to be done with the careful and constant monitoring and evaluation of upfront EV purchase cost, the latest EV component manufacturing techniques and technology trends that suit Pakistan’s actual needs (not the wish list).
- Regional export market development while catering the needs of local market
  - ➢ Manufacture export oriented electric vehicle parts / assemblies

    (Electric vehicle motors and its associated parts, controller, charging systems and its associated parts, solid state batteries and its management system, Components of thermal management system (e.g.) Coolant proportional valve, Electric coolant pump, Refrigerant switch valve, Refrigerant expansion valve. In the case of FCEV; Fuel cells, hydrogen fuel tanks, membranes etc. are few of the critical export oriented parts and systems which can be exported initially to North America, Australia, European countries, China and Japan)
  - ➢ Export 2 wheeler (motor cycles) / 3 wheelers (rickshaws) electric vehicles

    (countries like Afghanistan, Cambodia, Sri Lanka, Turkey, Iran and African countries can be a good market initially for the export of 2 wheeler (motor cycles) / 3 wheelers (rickshaws) electric vehicles)
- Research and development in line with new technology trends in EV market need to be promoted in Pakistan to help in localization of components and related equipment.
- After sales service / robust maintenance model need to be in place (i.e., Dealerships as well as Road side workshop personnel need to be properly trained).
- Due to rising cost of living in Pakistan, lack of infrastructure, lingering threat of power shortfall, non-fixing of power tariffs etc., it is a difficult decision for an average consumer to opt for an Electric Vehicle.
- Recently launched Rinco Aria, which runs on a lithium iron phosphate battery, has come forward as a cheaper alternative to big brands. At Rs2.4 million, the car is more affordable than other electric vehicles. However, it is too early to tell whether it will offer more value for money or not.
- Sazgar Engineering has launched Electric Rickshaw (3 wheelers) and Sunra electric bike (2 wheelers) has been launched in Pakistan.
- Costs of solar panels / solar systems should be reduced and provide subsidies (if possible) to promote local manufacturing. This will be a big incentive for rapid adoption of electric vehicles in Pakistan as well as for the electricity needs of every household.