

Manufacturing of Battery Electric Vehicles: Discussion on Global Trends and Pakistan

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Overview

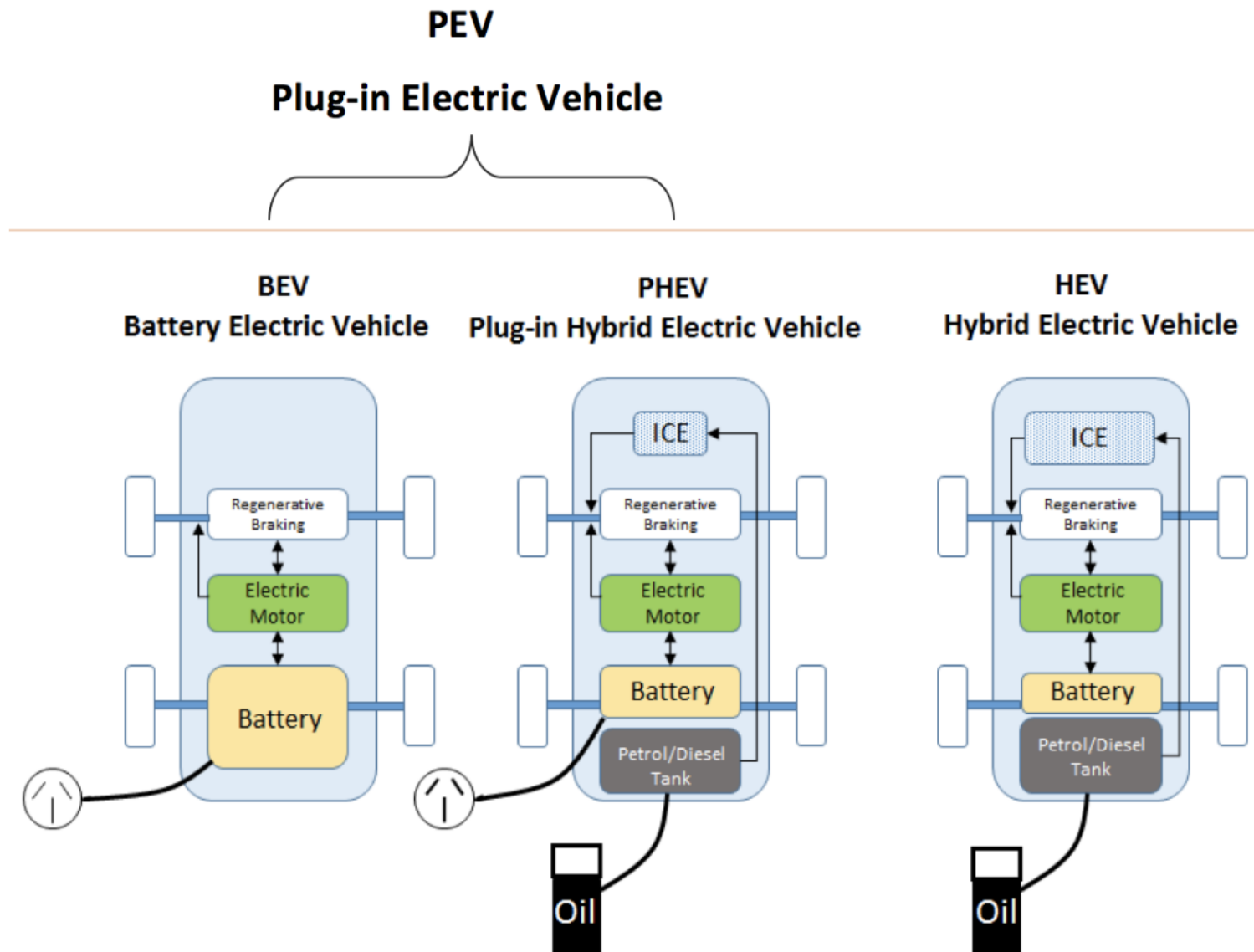
- Appreciating various types of electric vehicles
- Global trends in manufacturing and adoption of battery electric vehicles (BEVs)
- Manufacturing value chain of battery electric vehicles (BEVs) in Pakistan
- Future outlook in Pakistan

Electric Vehicle Types

1. Battery Electric Vehicles (BEVs) or All-Electric Vehicles
2. Plug-In Hybrid Electric Vehicles (PHEVs)
3. Hybrid Electric Vehicles (HEVs)

Why is it important to differentiate?

1. Consumer standpoint
2. Infrastructure standpoint
3. Distribution and after-sale service standpoint
4. Manufacturing standpoint
5. Technological transition standpoint
6. Regulatory standpoint



Key Components of BEVs

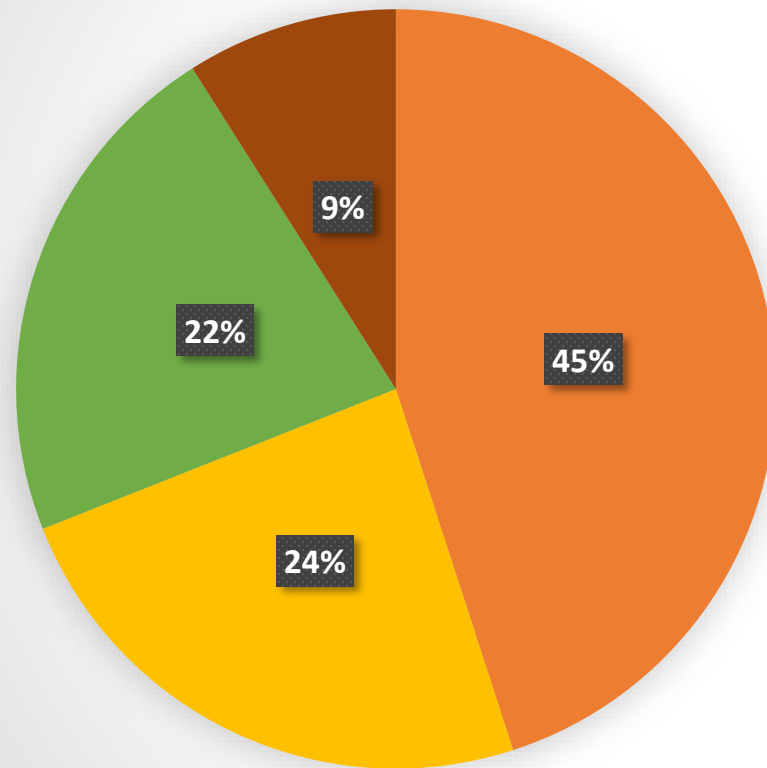
- Battery
 - Lithium-ion
 - Lead Acid
- Battery management system
- Motor
 - DC Series Motor
 - Brushless DC Motor
 - Permanent Magnet Synchronous Motor (PMSM)
 - Three Phase AC Induction Motors
 - Switched Reluctance Motors (SRM)
- Controller
- Cables
- Body

Global Trends

- Electric mobility is expanding at a rapid pace globally.
- In 2018, the global electric car fleet exceeded 5.1 million, up 2 million from the previous year and almost doubling the number of new electric car sales.
- Battery electric vehicles (BEVs) account for 64% of the world's electric car fleet
- The People's Republic of China remains the world's largest electric car market, followed by Europe and the United States.
- Norway is the global leader in terms of electric car market share
- Vision 30 @ 30 – Aims to reach 30% EV market share by 2030. Signatories: China, Japan, Finland, France, Netherlands and Sweden

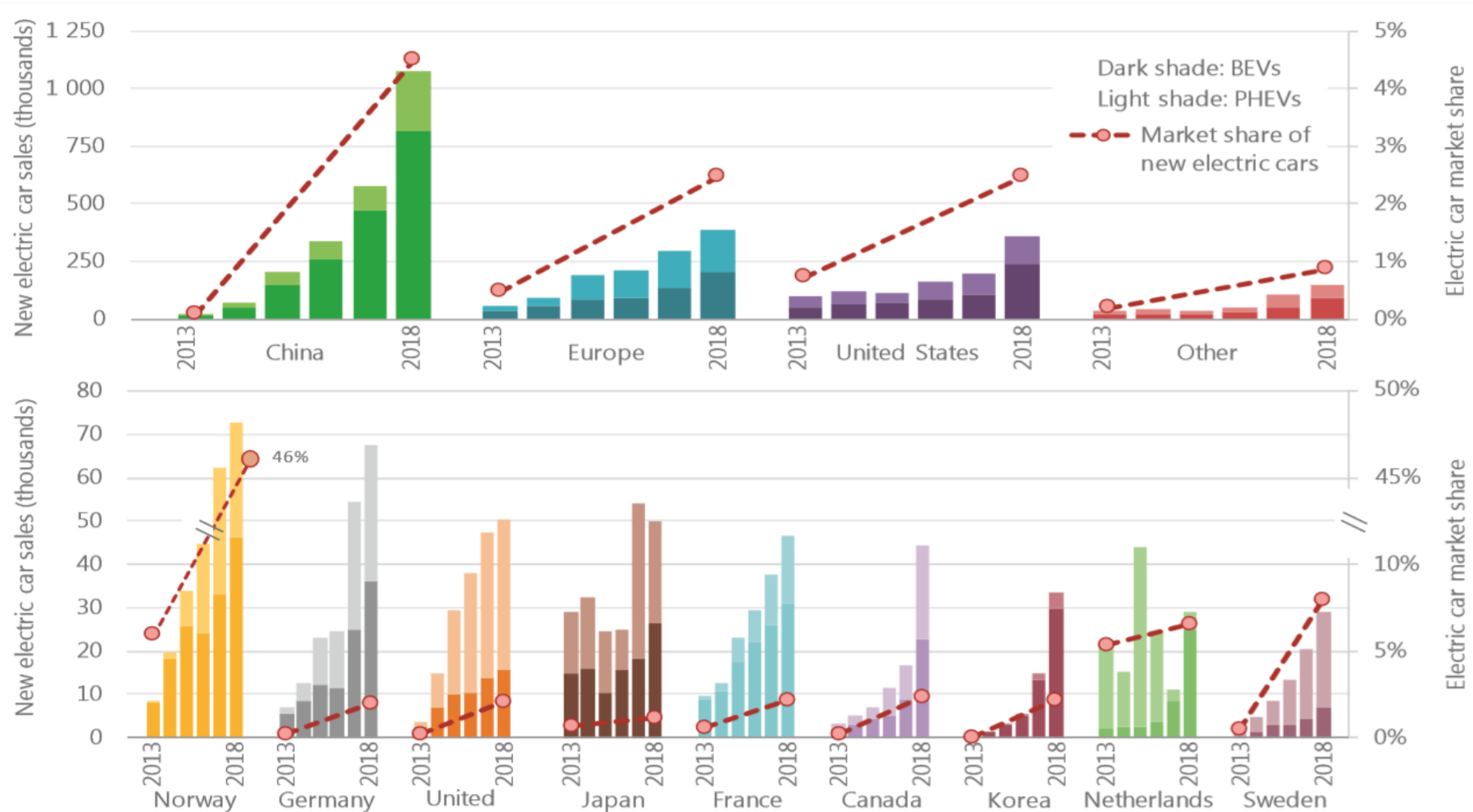
Regional Share in Global Stock of Electric Cars - 2018

Global Stock of Electric Cars (% Share)



- China
- Europe
- United States
- Rest of the World

Global electric car sales and market share, 2013-18

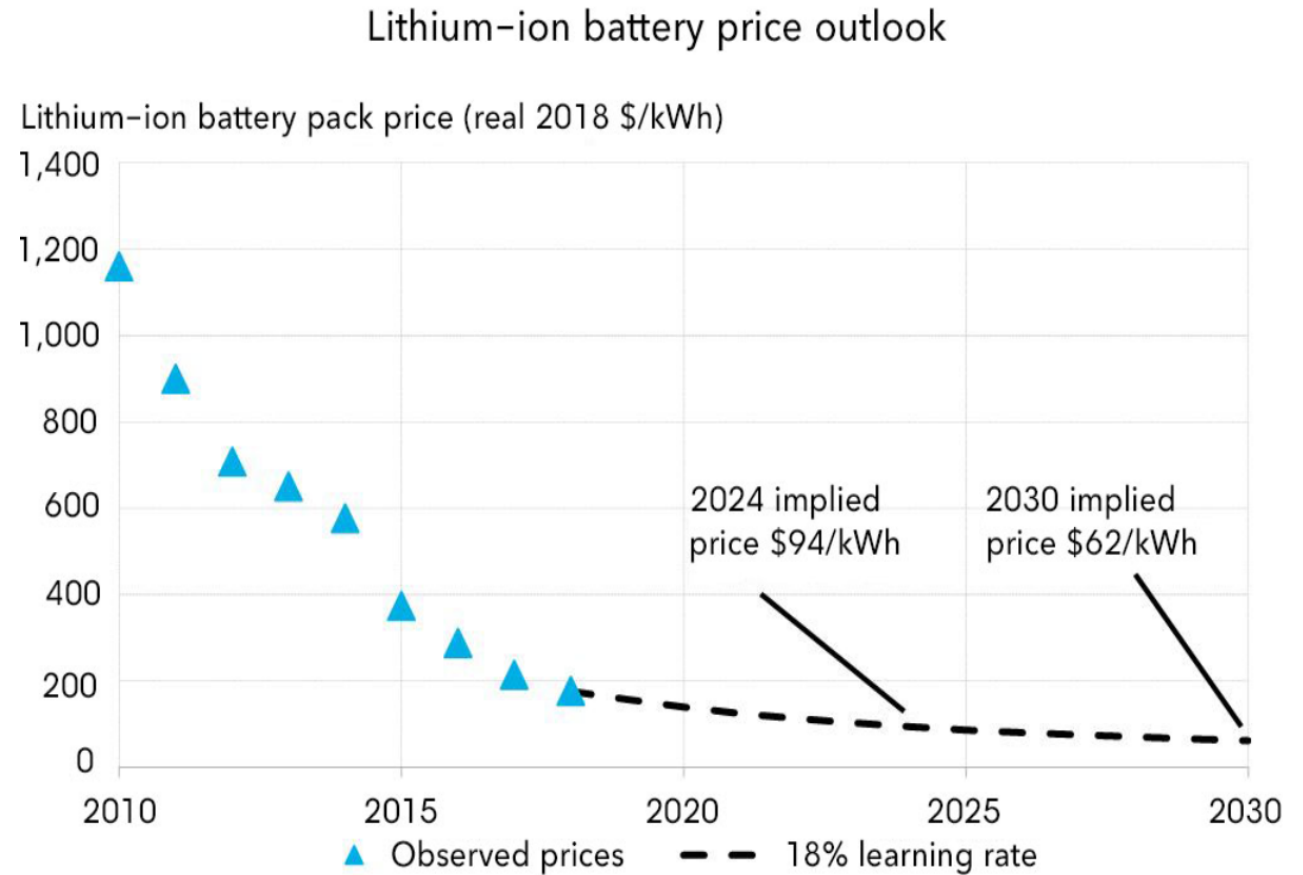


Drivers of BEV Mass Adoption

- Energy efficiency: EVs are three-to-five times more energy efficient than conventional internal combustion engine (ICE) vehicles.
- Energy security: BEVs reduce reliance on oil-based fuels and can reduce dependence on oil imports for many countries.
- Air pollution: BEVs have zero tailpipe emissions and can address pollution issues, especially in urban areas and along road networks
- Green House Gas emissions: BEVs can deliver significant reductions in GHG emissions especially from road transport relative to ICE vehicles.
- Noise reduction: EVs are quieter than ICE vehicles and hence contribute to less noise pollution, especially in the two/three-wheeler category.

Falling Battery Prices

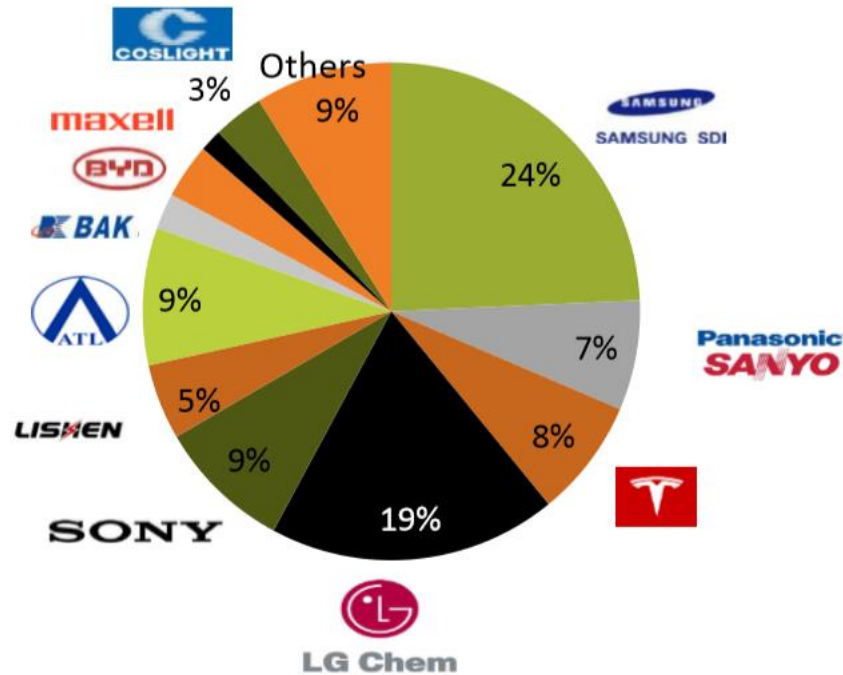
- Battery price >\$1000/kWh in 2010
- By 2025 batteries will increasingly use cathode chemistries that are less dependent on cobalt, such as NMC 811 (80% nickel, 10% manganese, and 10% cobalt) or advanced NCA batteries
- Graphene Technology
- Supercapacitor (SC)



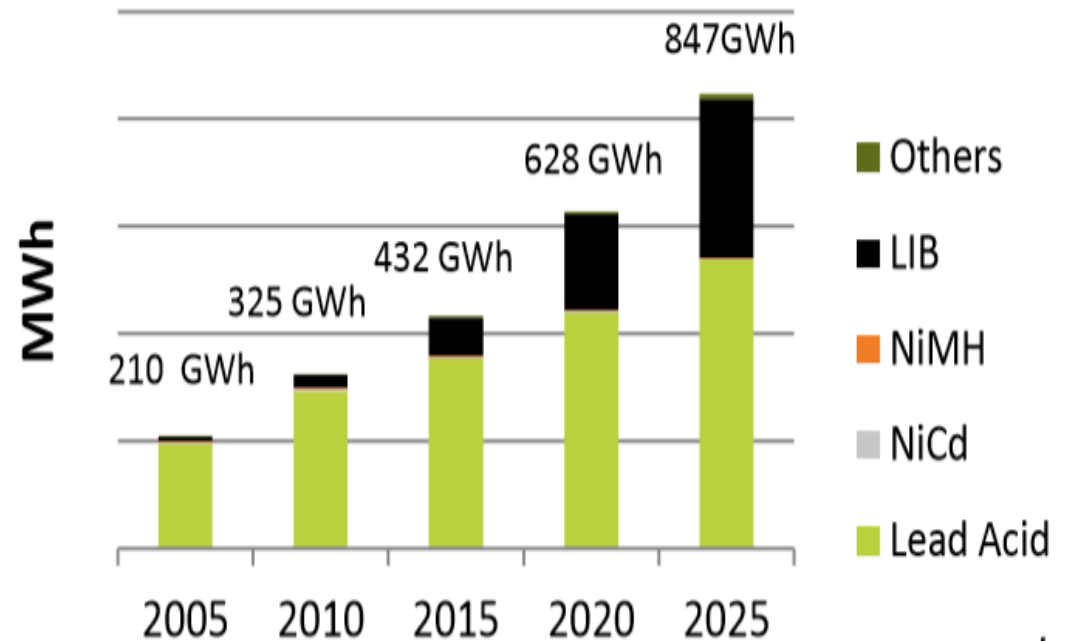
Source: BloombergNEF

Global Battery Market

- Global Lithium Ion Battery Market Share



- Lead acid batteries have a higher market share but LIBs have a higher growth rate
- Automotive applications accounted for over 70% of total lithium-ion battery shipments in 2018, compared to just 43% in 2015 and 6% in 2010



Government Policies

- Critical policy measures used by leading countries:
 - **Fuel economy standards** (e.g. Corporate Average Fuel Economy, ZEV mandate etc.): used in U.S.A, China, Japan, Canada and EU
 - **Fiscal Incentives** for zero- and low-emissions vehicles (e.g. tax credits, subsidies to manufacturers and consumers)
 - **Economic Instruments** - To boost the value proposition of EVs and help bridge the total cost of ownership gap between electric and conventional vehicles (e.g. free registration or license plates, lower toll or parking fees, access to bus lanes etc.)
- Globally policy support is being used to address the strategic importance of the **battery technology value chain**.

Government Policies

- **Procurement Programs** – To stimulate demand for electric vehicles and to enable an initial roll-out of publicly accessible charging infrastructure.
 - In the city of Shenzhen, government mandated operators to go electric, 16 000 electric buses operate, the largest-scale electric bus transition observed in a city.
 - Largest electric bus fleet procurement in Europe: 100 electric buses on routes in the Schiphol Airport area in the Netherlands
- **Infrastructure Support Policies:** Minimum requirements to ensure EV readiness in new or refurbished buildings and parking lots, and the roll-out of publicly accessible chargers in cities and on highway networks.
- **Adoption of standards** to facilitate inter-operability of various types of charging infrastructure.

CHINA – Adoption Trends

- Target of 5 million EVs by 2020 including 4.6 million passenger light-duty vehicles (PLDVs).
- New electric vehicle (NEV) mandate: 12% NEV credit sales in passenger cars. NEVs get between two and six credits depending upon their range. OEMs must earn enough credit to match 12% of their output.
- Roadmap for NEV sales share: 7-10% by 2020, 15-20% by 2025 and 40-50% by 2030.
- Proposal for tightened fuel economy standard for cars (4 L/100 km by 2025).
- Current fuel economy standard to be used till 2020

CHINA – Adoption Trends

- China is both the biggest manufacturer and the biggest market for cars globally.
- Buys more than half of the world's new electric cars.
- China's electric car market is 3 times larger than the US electric car market. In 2018, China had 1.26 million electric cars to 361,000 electric cars in the US.
- China has the largest volume of EV in absolute terms. But relatively, EVs still account only for a small fraction of the market.

CHINA – Manufacturing Trends

- Uses the term New Energy Vehicles which includes BEVs, hybrids and plug-in hybrids.
- Built a complete value chain with a high percentage of locally produced components being incorporated into foreign cars produced in China
- Foreign automotive vehicle & components manufacturers must form joint ventures with local firms to enter the Chinese market
- China leads the electric two-wheeler market: produced 26 million units and had an estimated stock of 250 million units (1/4th of the global stock) in 2018
- Domestic OEMs have a 94% market sales share of the Chinese EV market
- Incentives being phased out in recent years as industry matures and cost of production falls.
- China remains the global leader in the production of both mined rare earth products and refined rare earth compounds, with Chinese production accounting for 86% of global refined production in 2017. Rare earths are a key raw material in permanent magnets which are used in electric motor for EVs.
- Research focus on Graphene Technology - China International Graphene Industry Union (CIGIU) for industrial development of Graphene.

BEVs Value Chain in Pakistan

Entrepreneurial ventures

- Power Electronics Pakistan (PEP), Lahore
- Jolta, Lahore
- S. Zia ul Haq & Sons (SZS), Karachi
- InerZ, Islamabad

Existing automobile manufacturers (Perspectives)

- Nishat Hyundai
- Atlas Group
- Sazgar Engineering
- Omega Industries (Road Prince)

Component manufacturers (Current Situation)

- Battery
 - Treet Daewoo (Lead acid: deep cycle and maintenance free batteries)
 - Atlas (Lead acid)
 - Pakistan's battery industry seems to be lead acid based manufacturing
 - Some effort towards importing and assembling Li ion cells is happening
 - LUMS School of Science and Engineering (Assembly of Li ion using imported cells)
 - Challenge is optimization of energy density, charging time, price, temperature, efficiency (temperature sensitive), weight, life cycle, ...
 - Graphene based technology and ultra capacitors: globally battery constraints seem coming down sharply
- Motor manufacturing
 - Gujranwala (Golden pumps, Diamond Motors, Akhlas Motors,..)
 - Various types of motors though mostly AC motors
 - Sophistication and export orientation is lacking
 - Mostly from recycled material (electric sheets: majority recovered from international scrap; copper wire: original requires scale so second hand used; bearing: several levels of quality ABCD..)
 - Key facilities for research and development such as for testing for international standards lacking
 - Efficiency and temperature relationship
 - Can possibly reverse engineer over time (5-7 years) and designing might take longer
 - Possible role of fan manufacturing industry

Component manufacturers (Current situation)

- Cables
 - Fast Cables
 - Two items: conductor (almost constant) and insulator (varies)
 - Current automobile market size is too small for large companies
 - BEVs can bring opportunities in 4 wheelers
 - In BEVs, unlike ICE based vehicles, temperatures not very high
 - Though lab equipment is missing it can quickly catch up
- Controller
 - Could not find a specific company
 - Companies like Jolta and InerZ are working to develop their own

Universities and R&D Institutions

- LUMS School of Science and Engineering
 - Student projects on electric vehicles and international competitions
- NED Karachi
 - Student projects
 - Working with Mehran fans to develop motors
- UET Lahore
 - Test beds of electric motors
- UET Peshawar
- LUMS Energy Institute
 - Working with federal government to provide intellectual support in the development of BEVs encouraging policies

International players

- Interested in:
 - Pakistan's market
 - Manufacturing for global markets
- Integrated electric kits providing combination of:
 - Battery packs
 - Battery management system
 - Motor
 - Controller
 - Battery swapping system

Economic sense of BEVs

- Upfront cost
 - Battery is the major cost in BEVs (approximately 30-50% in Li ion based BEVs)
 - Cost goes very high with Li ion battery
 - Affordable price with lead acid but issues of lead acid
 - Li ion is the way to go – for now
- Companies in Pakistan are targeting some design innovations to bring the upfront cost down e.g., SZS (4 wheeler) and InerZ (2 wheeler)
- Operating cost attractive

Regulatory framework

- Current Auto Development Policy 2016-21 does not have needed focus on BEVs
- Recently government has announced an electric vehicles policy
- Policy making in conflicting objectives: new players, existing players, climate change, localization
- Pakistan hoping to become a signatory of International Energy Agency's 30%@2030 initiative
- Green banking regulations of State Bank of Pakistan (mainly focus on solar energy)
- Energy supply in Pakistan is surplus in next ten years (LUMS Energy Institute)
- Energy infrastructure and business models

Future Outlook - Pakistan

- Key components
 - EV kits: Seem a transition for aspirant 2/3 wheelers
 - Battery (Li ion and or lead acid) – Reducing cost: step wise localization beginning from assembly of cells
 - Battery management system: critical for Pakistani environment
 - Motor: leverage the existing knowledge to localize in 5-7 years
 - Controller: some companies are working on it
 - Body: requires innovation to bring the cost down
 - Cables: seem quite ready
- Financing (high upfront cost)
 - Loans for BEVs
 - Battery leasing models: Cars and batteries
- Starting target markets: Two/three wheelers, commercial vehicles, institutional customers
- Policy (Enhancing demand versus enhancing demand as well as localization)

Thank you.

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