Engineers' Welfare Forum
WBPDCL
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POWER GENXT

Volume 11

Published on the day of
11th National Seminar
on

BATTERY TECHNOLOGIES THAT COULD POWER THE FUTURE : A LOOK FORWARD TO IN YEARS TO COME

12th February, 2023

ENGINEERS' WELFARE FORUM

THE WEST BENGAL POWER DEVELOPMENT CORPORATION LIMITED

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THE WEST BENGAL POWER DEVELOPMENT CORPORATION LIMITED

(Recognised by WBPDCL Vide Letter No. : PDCL/CORP./HR/305/1495, Dated 3.3.2012)

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February 09, 2023

MESSAGE

Engineers' Welfare Forum of WBPDCL is going to organize a national seminar on **"Battery Technology That Could Power The Future: A Look Forward To In Years to Come"** on 12th February, 2023 at WBPDCL Corporate Auditorium. I convey my best wishes for the grand success of the Programme and the initiative of publishing the technical journal **POWER GENXT(Vol-11)**.

AROOP BISWAS

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No. 32-ACS(P)/2023

February 9, 2023

MESSAGE

It gives me great pleasure to learn that Engineers' Welfare Forum of West Bengal Power Development Corporation Limited (WBPDCL) is going to organise its 11th National Seminar on **"Battery technologies that could power the future: A look forward to in years to come"** at 10.00 am onwards on February 12, 2023 at WBPDCL Auditorium, *Bidyut Unnayan Bhavan,* Salt Lake, Kolkata–700 106 and a *Souvenir* would be brought out on this auspicious occasion.

I pray for their further prosperity and convey my heartfelt thanks to all of them on this occasion.

(S. Suresh Kumar)

Shri Soumen Das
General Secretary
Engineers' Welfare Forum
West Bengal Power Development Corporation Limited
Bidyut Unnayan Bhavan
Bidhannagar
Kolkata – 700 106.

Dr. P. B. Salim, IAS
Chairman & Managing Director

WBPDCL

Date:

Message

I am very glad to know that Engineers' Welfare Forum of The West Bengal Power Development Corporation Ltd. is going to organize the 11th National Seminar on ***"Battery Technologies That Could Power The Future: A Look Forward To In Years To Come"*** *at the auditorium of Corporate Office, WBPDCL, Kolkata – 700 106 on 12th February, 2023 and a Technical journal* ***POWER GENXT (Vol. – XI)*** *will be published to mark the occasion.*

My heartiest wishes and congratulations are due to the members of the Forum.

10/2/23
(Dr. P. B. Salim)

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Applications of Battery Energy Storage System in Electricity Utility System

✍ **Rajib Kumar Das**

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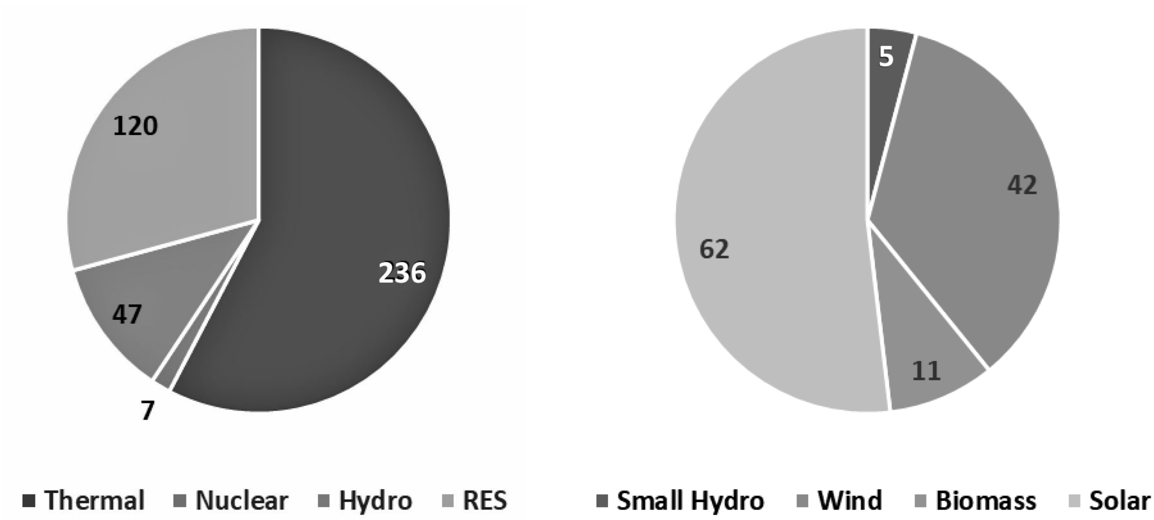
Kolkata

❑ **Summary:**

India has achieved 120 GW of Renewable Energy (RE) generation capacity as on date. Our country is committed to reduce emission and aims to achieve about 50% of its energy requirements from non-fossil fuel-based energy sources by the year 2030. India has an ambitious target of 500 GW Renewable Energy (RE) generation capacity by 2030. Majority of such sources are intermittent in nature. To provide stability of power supply with large intermittent RE sources into the grid, there are energy storage technologies like – pumped hydro and compressed air energy storage facilities as well as flywheels, capacitors, and superconducting magnetic storage etc. At present, Battery Energy Storage System (BESS) appears to be most viable solution with declining cost and improving technology day-by-day. Reports suggest that 27 GW with 4-hour storage capacity is required in India by 2030, in view the challenge of RE integration due to its inherent nature of being variable and intermittent and to fulfil the demand at every instance of time. BESS has several other applications and use cases, including frequency regulation, peak shaving, microgrids, and black start capability etc.

❑ Introduction

At present, India has total power generation capacity 410 GW. Thermal contributes 236 GW and Renewable Energy (RE) generation capacity is 120 GW.



In RE sector, Solar and Wind contributes 90% (104 GW)

Due to large scale development of RE technologies, the costs of RE power has reduced to a great extent in last few years and this trend is expected to continue.

At the same time, there is need to be climate resilient by reducing carbon foot print. Government of India has committed to reduce carbon emission and set a target of 500 GW RE capacity by 2030.

Both Wind and Solar generation is intermittent and integration of such large scale RE capacity into the Grid is a major challenge for stable operation.

Load is generally uncontrolled, as there is no control on load of consumers. Supply & Demand is balanced by controlling the generation side. With more and more intermittent generation, both Supply & Demand side would be uncontrollable. Balancing electrical Supply & Demand which has always been a prime concern for a power utility will be more complex than ever before. Energy Storage System can play a role in managing Supply & Demand.

Increasing needs for system flexibility have enabled BESS to play a significant role in the power system in recent years. While many technologies have been developed for large-scale energy storage purposes such as pumped hydro and compressed air energy storage facilities as well as flywheels, capacitors, and superconducting magnetic storage, many are limited in their site dependence, capacity, or response capabilities. Electrochemical energy storage devices offer the flexibility in capacity, siting, and rapid response required to meet application demands over a much wider range of functions than many other types of storage. There is a long history of integrating batteries into grid applications, and while battery energy storage systems (BESSs) currently account for only a small portion of energy storage within the grid, they have seen great growth recently due to their versatility, high energy density, and efficiency.

BESSs can react to grid demands nearly instantaneously, but also have the capacity to function over longer durations and have a wide range of storage and power capacities. Due to its technological maturity, lead-acid chemistry has seen the most widespread use among large-scale BESSs. However, significant advancement in newer battery chemistries has allowed for a wide range of battery options for new storage applications and has increased the robustness and functionality of batteries within the electric grid.

Compared to other high-quality rechargeable battery technologies (nickel-cadmium or nickel-metal-hydride), Li-ion batteries have a number of advantages i.e. high energy density, low self-discharge, less toxic element, low maintenance, can deliver large amount of current for high power application etc. Large-scale Lithium-ion Battery Energy Storage Systems are gradually playing a very relevant role within electric networks in Europe, the Middle East and Africa. The high energy density of Li-ion based batteries in combination with a remarkable round-trip efficiency and constant decrease in the levelled cost of storage have led to the recent boom of the technology.

❑ Key Characteristics of BESS

A battery energy storage system (BESS) is an electrochemical device that charges (or collects energy) from the grid or a power plant and then discharges that energy at a later time to provide electricity or other grid services when needed. A BESS is characterized by many features related to its electrical capacity, Round-trip efficiency, Self-charge/discharge behaviour, lifetime and cost.

a) **Rated power capacity** is the total possible instantaneous discharge capability (in kilowatts [kW] or megawatts [MW]) of the BESS, or the maximum rate of discharge that the BESS can achieve, starting from a fully charged state.

b) **Energy capacity** is the maximum amount of stored energy (in kilowatt-hours [kWh] or megawatt-hours [MWh])

c) **Storage duration** is the amount of time storage can discharge at its power capacity before depleting its energy capacity. For example, a battery with 1 MW of power capacity and 4 MWh of usable energy capacity will have a storage duration of four hours.

d) **Cycle life/lifetime** is the amount of time or cycles a battery storage system can provide regular charging and discharging before failure or significant degradation.

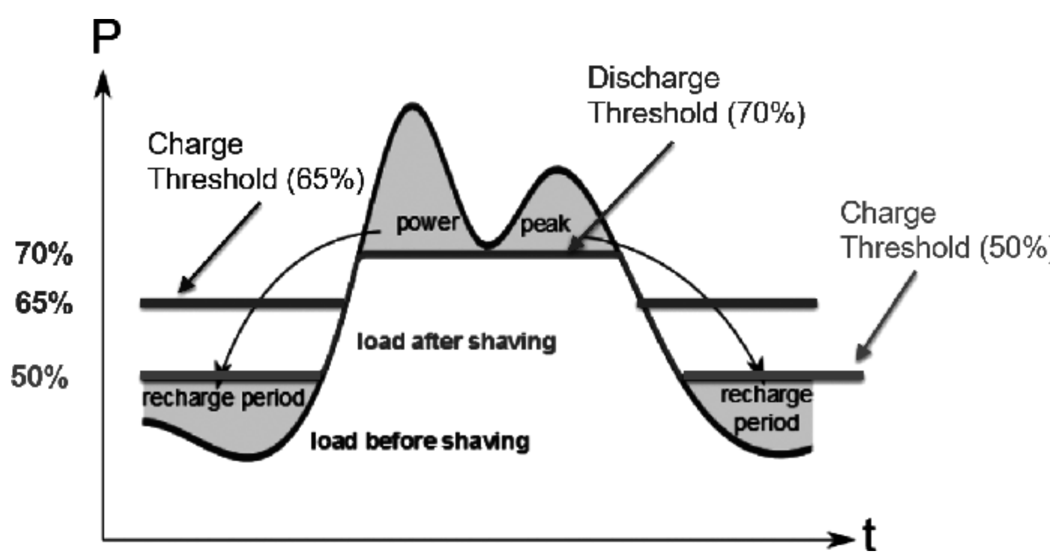
e) **Self-discharge** occurs when the stored charge (or energy) of the battery is reduced through internal chemical reactions, or without being discharged to perform work for the grid or a customer. Self-discharge, expressed as a percentage of charge lost over a certain period, reduces the amount of energy available for discharge and is an important parameter to consider in batteries intended for longer-duration applications.

f) **State of charge**, expressed as a percentage, represents the battery's present level of charge and ranges from completely discharged to fully charged. The state of charge influences a battery's ability to provide energy or ancillary services to the grid at any given time.

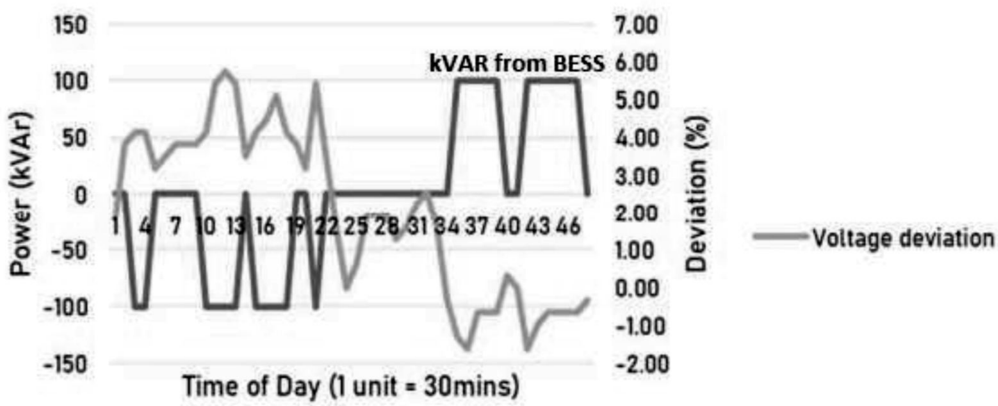
g) **Round-trip efficiency**, measured as a percentage, is a ratio of the energy charged to the battery to the energy discharged from the battery. It can represent the total DC-DC or AC-AC efficiency of the battery system, including losses from self-discharge and other electrical losses. Although battery manufacturers often refer to the DC-DC efficiency, AC-AC efficiency is typically more important to utilities, as they only see the battery's charging and discharging from the point of interconnection to the power system, which uses AC.

❑ Applications of BESS in Power System

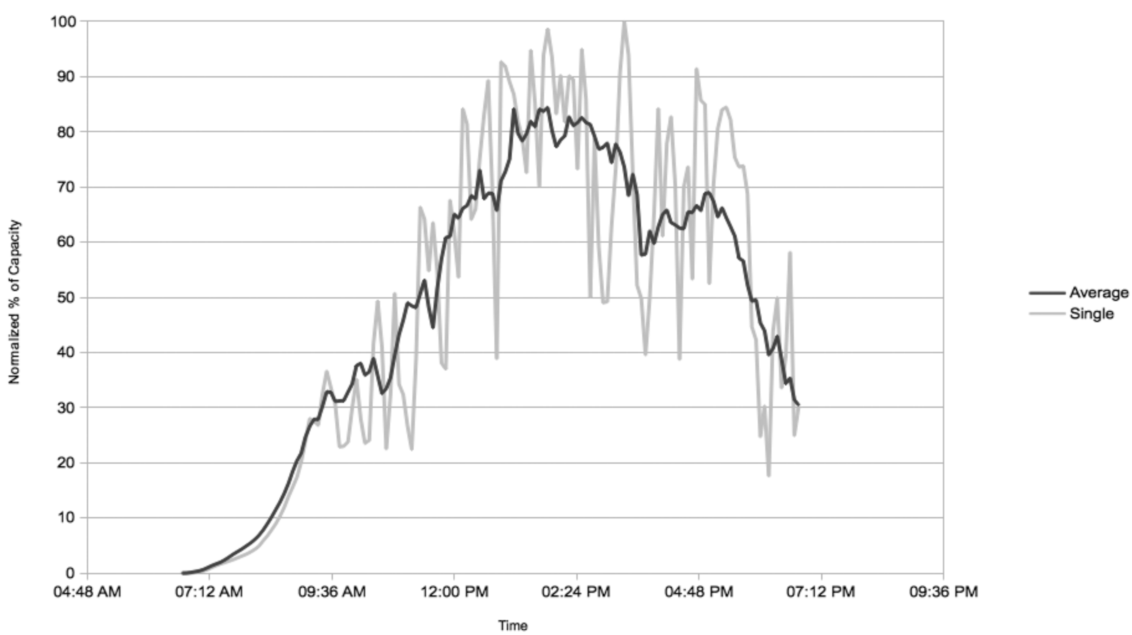
a) Deferrals of Investments towards Transmission and Distribution Upgrade: Deploying BESS can help defer the need for new grid investments by meeting peak demand with energy stored from lower-demand periods, thereby reducing congestion and improving overall transmission and distribution asset utilization.



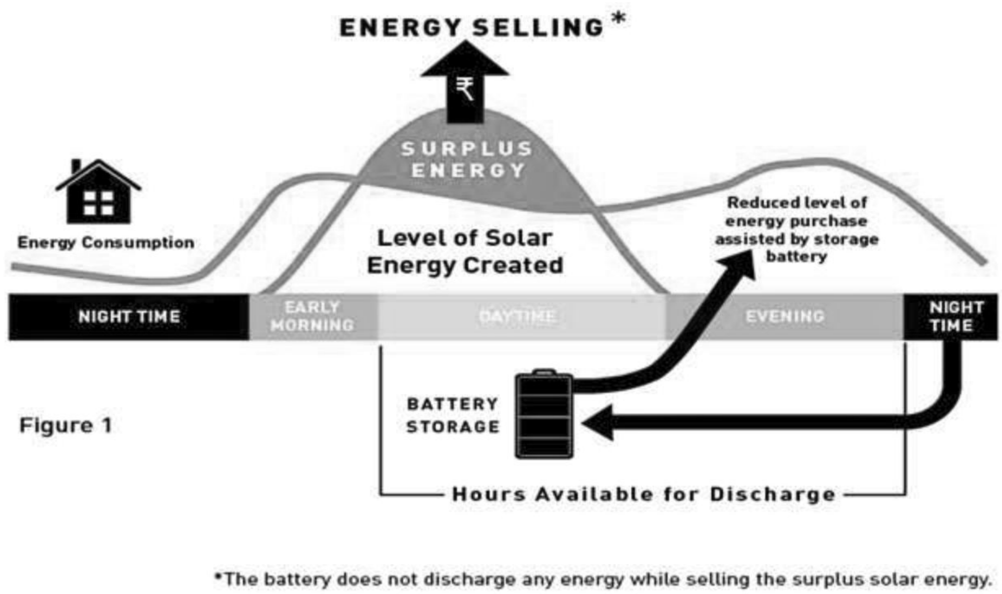
b) Voltage Regulation: A predefined reactive power shall be fed to or drawn from the grid to demonstrate the applicability of BESS for compensation of voltage fluctuation due to intermittency of inductive loads in the circuit.



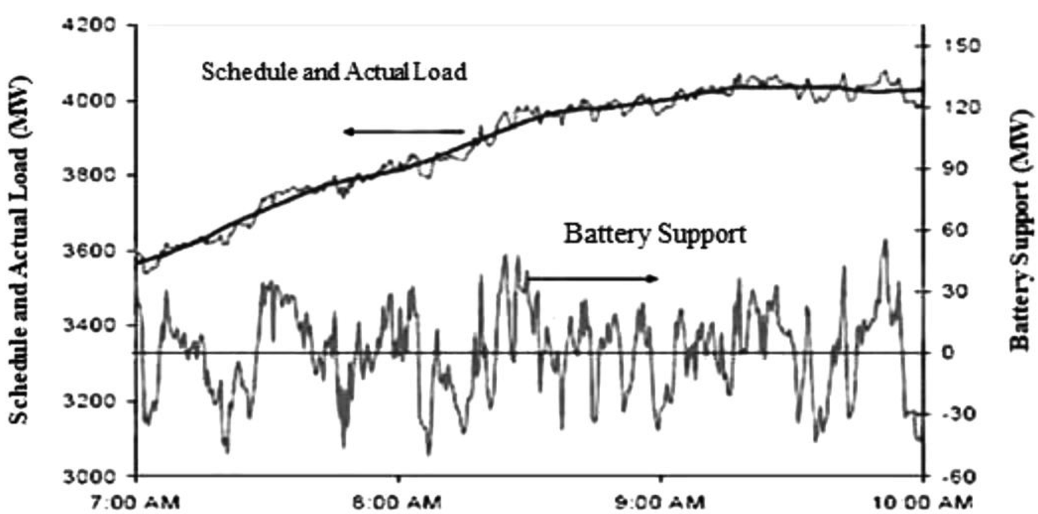
c) **Smoothening of Solar Generation:** BESS helps to mitigate the solar intermittency / variability and reduce power fluctuation in the grid by charging and discharging the battery to maintain a predefined output.



d) Energy Arbitrage: Arbitrage involves charging the battery when energy prices are low and discharging during more expensive peak hours. For the BESS operator, this practice can provide a source of income by taking advantage of electricity prices that may vary throughout the day. One extension of the energy arbitrage service is reducing renewable energy curtailment.

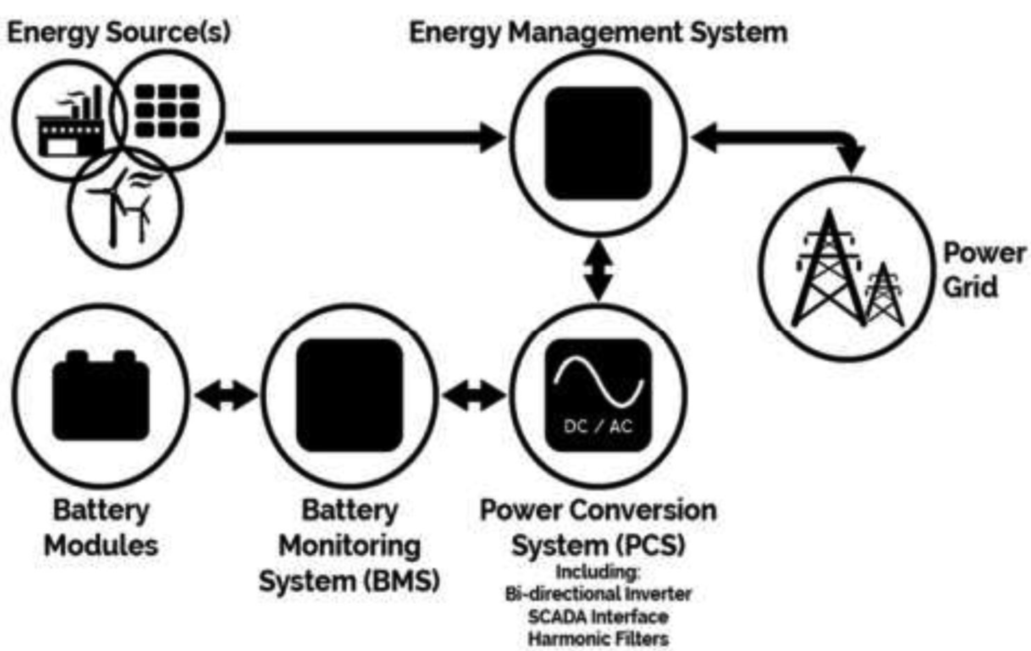


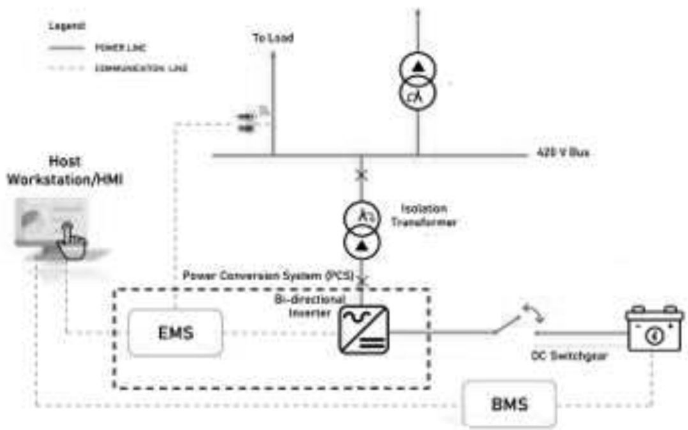
e) **Frequency Response:** BESS can rapidly charge or discharge in a fraction of a second, faster than conventional thermal plants, making them a suitable resource for short-term reliability services, such as PFR (Primary Frequency Response) and Regulation. BESS can help in Deviation Settlement Mechanism (DSM). Deviation Settlement Mechanism is a regulatory mechanism by which grid stability is achieved by imposing penalties and incentives for over drawl/injection or under drawl / injection from the schedule.



f) **Electric supply capacity:** System operators must ensure they have an adequate supply of generation capacity to reliably meet demand during the highest-demand periods in a given year, or the peak demand. This peak demand is typically met with higher-cost generators, such as gas plants; however, depending on the shape of the load curve, BESS can also be used to ensure adequate peaking generation capacity. While DER resources can also be used to meet this requirement, these resources do not typically fully count toward firm capacity, as their generation relies on the availability of fluctuating resources and may not always coincide with peak demand. But system operators can improve DER's ability to contribute to firm capacity requirements through pairing with BESS. Pairing DER resources with BESS can enable these resources to shift their generation to be coincident with peak demand, improving their capacity value and system reliability.

g) **Black Start:** Starting up large generators need an external source of electricity to perform key functions. During normal system conditions, this external electricity can be provided by the grid. After a system failure, however, the grid can no longer provide this power, and generators must be started through an on-site source of electricity. An on-site BESS can also provide this service.





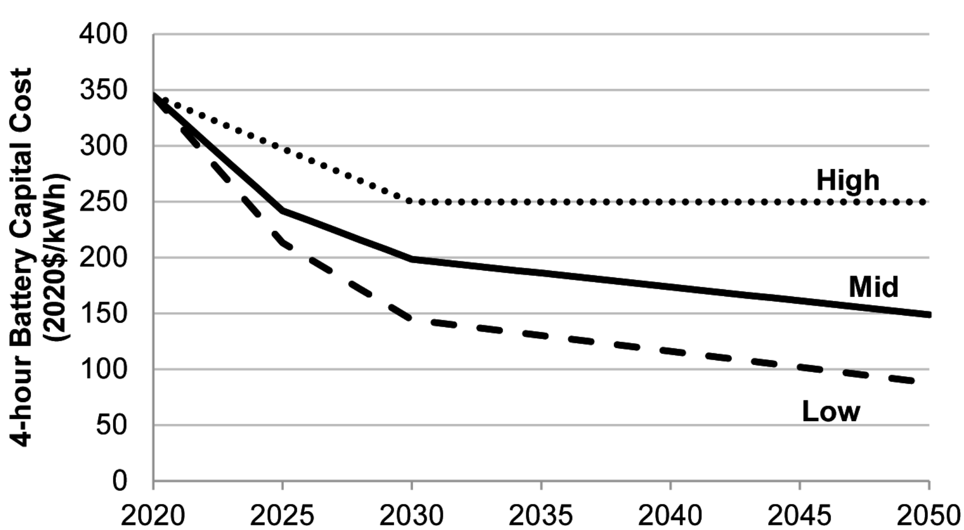
Small capacity BESS connected at Low Voltage System

❑ Challenges

Cost of BESS is presently very high. Major benefits will accrue by avoiding new investment for plant & equipment e.g. transformers, cables, lines etc. and adhering to Deviation Settlement Mechanism.

Another challenge is - "Batteries slowly degrade over time and after a certain number of charge and discharge cycles, the cells are no longer capable of maintaining their nameplate energy rating.

Reports suggest decline in cost of BESS which would make it feasible at all levels of power system. A report from National Renewable Energy Laboratory, for the U.S. Department of Energy (DOE) suggested the following chart for declining cost of battery. The high, mid, and low-cost projections developed in this work are shown as the bolded lines.



❑ Way forward

Energy Storage System has been designated as a Power System element which can be utilized as a Generator, Transmission or Distribution element. Energy Storage Obligation trajectory till 2029-30 has been notified by Ministry of Power vide Order dated 22nd July 2022. States and PSUs are issuing tenders for installation of Grid Scale BESS.

- 10 MWh BESS is in operation at Tata Power Delhi Distribution Ltd.
- 20 MW Solar Power Plant along with 8 MWh BESS is in operation at Andaman.
- Solar Energy Corporation of India (SECI), has recently concluded the bidding process for setting up of Pilot Projects of 500 MW/1000 MWh Standalone BESS under Tariff-Based Competitive Bidding (ESS-I) at Fatehgarh III Substation of Powergrid.
- Hero Future Energies, a Delhi-based renewable energy developer, on Wednesday said it has emerged as a successful bidder in the tender conducted by the Kerala State Electricity Board for construction of a 10 megawatt (MW)-20 MWh , grid-connected energy storage plant in the state
- SUNGROW has agreed to cooperate with Tata Power Solar Systems on the construction of a battery energy storage system (BESS) in the Leh district of the Indian union territory of Ladakh. The BESS will have a capacity of up to 60.56 MWh. The system will be co-located with a 50 MW solar plant in Phyang village, at a high altitude of 3,400 meters above sea level, where the temperature is very low
- NTPC invites bids of energy storage system at power plants
- Gujarat Urja Vikas Nigam Limited (GUVNL) has invited bids to set up pilot projects of 1 GWh (500 MW x 2 hours) standalone battery energy storage systems (BESS)
- The establishment of a 10MW/40MWh five standalone Battery Energy Storage Systems (BESS) in the state of Uttar Pradesh near Vrindavan, Mathura, has been put out to bid by the Uttar Pradesh Power Corporation Ltd. (UPPCL)

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Battery vs Fuel Cell: Which is Better

✍ **Gautam Kumar Das**
(B-Tech. - IIT Kharagpur, MBA – Finance, Marketing & HRD), GM, DCPL

✍ **Ms Nehali Das**
(B-Tech. – MAKAUT), ME, DTPL

Both Fuel Cell and Battery are similar to each other according to the processes that take place inside these devices. Moreover, both these can produce electrical energy using chemical energy. However, there is a distinct difference between fuel cell and battery. The key difference between fuel cell and battery is that a fuel cell can supply electrical energy for a long period of time compared to a normal battery.

Hydrogen Fuel Cell is a more powerful tool than Batteries. But the batteries are very user-friendly and safest energy storage device.

Hydrogen Fuel Cells are more efficient than batteries and can produce more power for a longer period of time. They also have a longer life span than batteries and require less maintenance. Hydrogen Fuel Cells are also more environment friendly than batteries as they do not produce any harmful emissions and waste. They are also more effective than batteries as they require less energy to produce the same amount of power. Fuel cell technology has the advantage of a quick fill-up time of minutes as opposed to the hours-long charging time that batteries need. Batteries are also relatively safe, as they do not produce any emissions or hazardous waste. But the lack of hydrogen infrastructure alone with trained manpower is still a key hurdle.

Battery-electric cars would be better at cutting carbon emissions, and at a lower cost than fuel cell vehicles, too. That's mainly because hydrogen fueling stations are much more expensive to install than battery-charging stations.

Electric vehicles can run on either rechargeable batteries or fuel cells that convert hydrogen into electricity. Both have zero tailpipe emissions. But when it comes to long-term sustainability, and safe operation, definitely battery operated electric vehicle is the best option as on date. Further the ground reality is the use of Fuel – Cell batteries are not a safe option, even with the specialized trained manpower.

Hydrogen fuel cells can be used to power vehicles, homes, and businesses, and becoming increasingly popular as an alternative to traditional fossil fuels in terms of long life and very less charging time.

But Batteries have a limited range and require frequent recharging. They also have a limited lifespan and can be expensive to replace. Batteries also produce emissions, although these are typically much lower than those produced by traditional combustion engines.

Hydrogen fuel cells also require a large amount of space, compare to the Batteries.

The battery requires fewer safety aids compared to a hydrogen fuel cell. This is because the battery does not require any special containment or venting systems, as the hydrogen fuel cell does. Additionally, the battery does not produce any hazardous byproducts, such as hydrogen gas, which must be safely contained and vented.

Towards E-Mobility

✍ **Er. Joy Chakraborty**
Renewable Energy Professional, Kolkata

✍ **Er. Rima Ghosh**
Software Professional , Kolkata

❑ Abstract:

As India is one of the worst sufferer of climate change, global warming and severe air pollution, it is the task before all of us to ensure cleaning of air of this country .The country has adopted strategies to reduce its Green House Gas (GHG) emissions through enhanced Renewable Energy penetration and phase-wise replacement of the fossil fuel driven transport system by electric vehicles. [2]

In the present article, some unique features like convergence of EV with Solar PV and Information Technology is proposed to ensure more E-Vehicle on road. PV can reduce the cost of charging. App based single window system can help users to take informed decision. AI application for time optimisation of charging exercises for on road e-vehicles can make things easier for users.

Experts and policy makers are busy with exercises to reduce the GDP loss due to climate catastrophes, across the globe. Here it is proposed to flourish EV coupled with Solar PV and IoT, so that after mitigating the climate issuers, India can enhance its GDP through export of de-carbonization and can be in the Driver's Seat in EV in the world.

❑ Introduction

The Covid 19 Pandemic has taught us that at more concentration of suspended pollutant particles (PM 2.5) in the atmosphere, droplets sustain more. It makes Indian Metro cities the worst sufferer of the pandemic. The World Air Quality Report, 2020 shows that 17 lac people in India die every year due to air pollution.

Enhanced penetration of Green House Gases (GHG) in the atmosphere causes the warming. Nearly 200 countries in this planet have agreed to limit the global atmospheric temperature rise within 1.5 degree celcius by 2030.Temperature rise leads to severe climate catastrophes like cloud burst, flood, landslides, super cyclones. The sixth assessment report (August, 2021) of Inter-Governmental Panel on Climate Change (IPCC) records 1.09 degree celcius warming on average in last 10 years in this planet whereas for Kolkata, the recorded temperature hike is 2.66 degree celcius. The 2020 cyclone Amphan which has devastated Kolkata has been identified as the deadliest one in respect of damage of properties and resources in recent past. The Global Climate Risk Index, 2021 has ranked India the seventh worst affected country by weather extremes. Before the Conference of Parties (CoP 26) at Glasgow (Oct-Nov, 2021), the British Prime Minister has appealed before India to upgrade its climate targets.

India's Green House Gas (GHG) emissions reduction strategies are linked with enhanced Renewable Energy and electric vehicles in a time bound manner. Steps are taken for e-bus penetration, e-two wheeler penetration, Performance Based Incentive schemes for indigenous manufacturing of battery, motor in India, developing more road side Charging Stations etc.

As defined in the Paris Climate Accord, 2015; the emission density of GDP of India should be in the range of 33 to 35% by 2030. The structural adjustment cost associated with reducing India's Emission profile is expected to be significant, but the cost of inaction will be creator. In this context, in this article, it is proposed to take an alternative and smarter technology adoption path. Unlike to other countries, accepting the China, India could chart a more prosperous path towards low emission future and can accelerate India's progress to the rest of the world by exporting key technologies, process and know-how. On one hand, it reduce the fossil fuel dependency of Indian Transport sector (the second largest emitter of GHG in India) and on other hand through exporting its de-carbonisation technologies like EV with PV & IoT , India can be the global leader in EV. [8]

❑ Electric Vehicle: The Government policies and initiatives:

The Department of Heavy Industry (DHI), Govt. of India has launched the Faster Adoption and Manufacturing of Electric Vehicle in India (FAME India), Phase-II in order to promote EVs to curve Air Pollution in major cities of India.

To accelerate faster deployment of EVs, the Ministry of Power (MoP), Govt. of India has formulated the Charging Infrastructure for Electric Vehicle : guidelines and standards: 2018 for establishment Public Charging Stations (PCS) in selected cities and highway corridors. The peak power procurement due to increased EV load, suitable revenue models are needed to be worked out to support the network strengthening of Distribution Companies (DISCOMS). The operational management of EV charging is essential for accommodating the impacts on the power network and accessing the associate financial implications. [3]

The Ministry of Housing and Urban Affairs (MoHUA), Govt. of India has amended the Model Building Bye-Laws in order to provide dedicated space for Electric Vehicle Charging Infrastructure (EVCI) in new and existing buildings. This is introduced at different urban bodies like the Kolkata Municipal Corporation.[6]

❑ Possible Electric Vehicle nos in Kolkata in coming days: A forecast

The current penetration of EVs in India is very low. But, in recent past, a number of essential steps have been taken to accelerate the implementation of EVs and public charging stations to attain notable EV roll outs in India by 2030. Based on current conventional vehicles' concentration, the government initiatives, upcoming EV technologies, and potential customer interests; the future EV penetrations for years 2025 and 2030 in Kolkata is estimated. [5]

Serial no	Type of vehicles	Total vehicles on road in 2025	Considered % for EVs	Expected EVs on road in 2025
1.	Two Wheelers	1991219	25	497805
2.	Three Wheelers	47825	15	7174
3.	Commercial Four Wheelers	87322	05	4366
4.	Commercial Heavy Vehicles	265168	05	13258

Table-I: Expected EV by 2025

Serial no	Type of vehicles	Total vehicles on road in 2030	Considered % for EVs	Expected EVs on road in 2030
1.	Two Wheelers	2843382	50	1421691
2.	Three Wheelers	57235	30	17171
3.	Commercial Four Wheelers	106129	10	10631
4.	Commercial Heavy Vehicles	323178	10	32318

Table-II: Expected EV by 2030

❑ **Proposed measures**: [4]

From the so far discussion, the pertaining issues are:

- The peak power procurement modality due to increased EV load is to be fixed up.
- The Standard Operational Protocol (SoP) for operational management of EV charging is to be framed up.
- App based single window system for users to take informed decision, AI application for time optimisation of charging exercises for on road e-vehicles are to be introduced to ensure hassle free, faster charging experiences.
- Introduction of Grid Connected and Off Grid Solar charging stations to reduce dependency on coal based electricity.
- Developing an eco-system for easy availability of spares and post-sale maintenance services.

❑ **Proposed measures**: [4]

As this is a very complicated environment comprising of stakes like Grid Availability of the Distribution Company, availability of charging station, availability of on road e vehicles; a IT based charging solution is needed.

❑ IOT-BASED EV CHARGING APP design APPROACH:

IoT based information systems in communication platforms with associated sensing devices can bring the ultimate of fast-charging solutions that are flexible enough to support the faster charging of all EVs on road.

Salient features of an EV charging app:

An EV charging app must have the following essential features:

- Real-time location detection and providing information about available charging stations.
- Scheduling of charging date and time, setting reminders, getting notifications and tracking usage.
- Real-time updates of the charging status.
- Feedback from users about charging station.
- Payment directly through the app.
- Finding all stations along the road trip route.
- Checking station ratings and description.
- Notification to alert when there’s a charging station nearby.

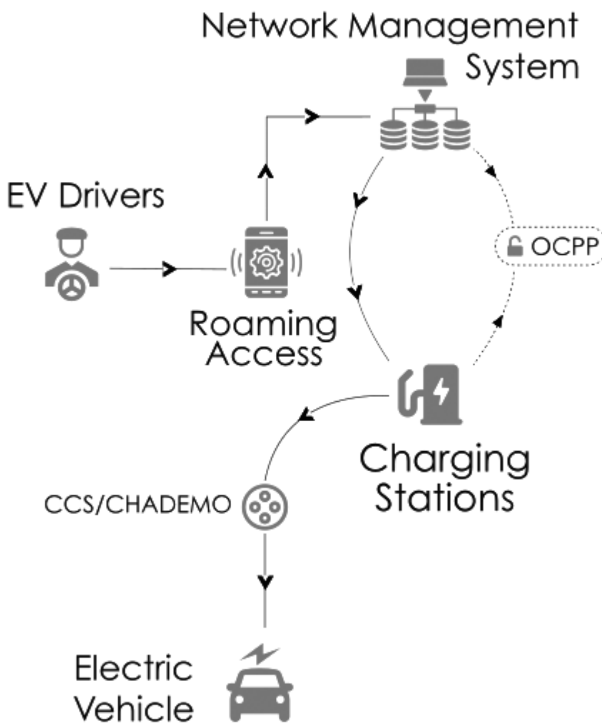
Technology components to develop an EV charging app:

- **Cloud environment:** AWS, Google, Azure
- **Database:** MongoDB, Hbase, MySQL, Cassandra, Mail Chimp Integration, PostgreSQL.
- **Communication Protocol:** OCPP
- **Real-time analytics:** Big Data, Hadoop, Spark, Apache Flink, Cisco.
- **Server:** NGINX
- **Framework:** Laravel
- **Find user location:** Google Places API, Google Maps, Core Location Framework
- **Payments:** Paypal, Braintree, Stripe, EWallets
- **Push Notifications:** Push, Twilio, Amazon SNS, Urban Airship, Firebase Cloud Messaging.
- **MS, Voice and Phone verification:** Twilio, Nexmo
- **Front-end:** ReactJS, HTML, Bootstrap and CSS for web application. Kotlin, Swift, Objective C for mobile applications.
- **Back-end:** Node JS for new micro services and review for existing services, Python and JS

Open Charge Point Protocol (OCPP) for an EV charging station:

It is an application protocol that allows communication between charging stations and their management systems, which is as follows:

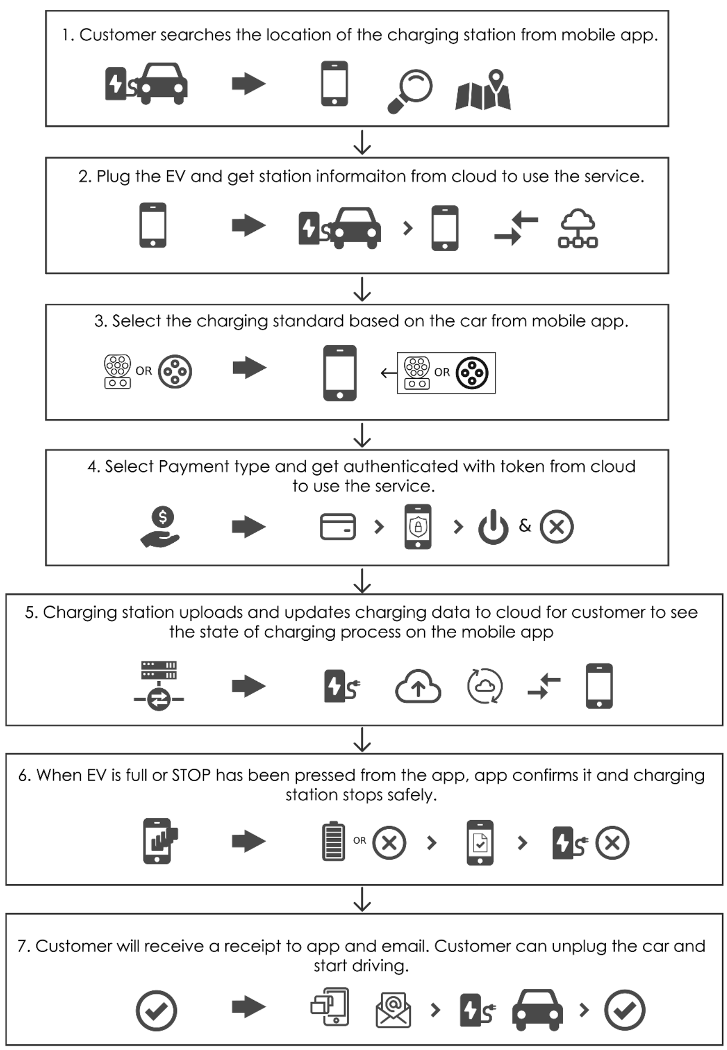
- As soon as, the charging station is turned on, the OCPP tries to connect with the management software. The software verifies the identity of the charging station. After successful verification, the IT backend sends a signal to the EV charging station management system to identify its availability. The station responds by providing its current status with the date and time.
- The authorization process begins when a user requests to start the charging. In response to the request, the power supply nozzle is unlocked and plugged into the e-vehicle to start charging. At this stage, OCPP sends another transaction message denoting that the charging process has begun.
- When the user wants to stop charging, identification verification is required again at the charging station through the mobile app. When the Stop Transaction message is sent to the station, the charging is stopped and the user is ready to leave the charging station.



Standard and Secure EV Charging Process with Background Activities:

1. The customer selects the charging station using the mobile app. The map on the application allows users to locate and check the status of charging stations. Available stations display the details, including charging standards (CCS or CHAdeMO), price per minute, location, address, and charging station power. The mobile application also allows reserving the available charger for a specific duration.
2. At the station, the customer plugs the charging pistol into the EV. Once it recognizes the app interaction, it begins to communicate the next steps through the cloud service back end. The user needs to log in using their credentials to get the receipt of charging.
3. Charging stations may offer either one or both CCS and CHAdeMO standards. The users can select the desired charging standard pistol using the mobile app. Besides, if the station provides only one charging standard, the app indicates the available port by app visualization or environment colouring.
4. Payment options depend on the service provider; however, it must support the most common debit, credit cards and UPIs. The payment service provider uses a tokenization procedure to grant the token to accomplish payment. A valid Token provides customers temporary time-based access to start and stop actions of the app. The app sends the action over API to the cloud and then the updated information is displayed to the customer.

5. It takes approximately 10 to 40 minutes to complete the charging process using fast charging technology. Meanwhile, regular updates are provided to the customer. The charging station sends data to the cloud and forwards it to APIs. The mobile application reads the RESTful API Json data and updates the user interface.
6. When charging is complete, or the stop button has been pressed, the mobile app will send an HTTP API request to the cloud back end apply changes to the controller. The controller will lower the current and voltage and indicate to remove it from the EV safely.
7. When the charging is completed, the user will receive a receipt of the charging. It includes energy displayed in kW/h, price per minute, total amount and duration of charging. The start and stop time of charging is recorded and kept for at least ten years due to law regulations. The authentication token is deleted after the charging process is complete.



❑ Introducing Solar PV charging Station: a WBTC case study:

There are 80 Electric Buses currently in West Bengal Transport Corporation (WBTC) fleet. 75 are running in Kolkata and 5 are running (from Digha depot) within Midnapore. Tata Motors has supplied all the 80 Electric Buses along with 80 nos. grid connected DC EV Chargers in 2018-19.The chargers make Tellus Power from Hyd.There are 60 slow Chargers (60 KW @80A) and 20 Fast Chargers (120KW @160A). [1]

Presently, buses at Depots are charged overnight using Slow Charger (5-6 hrs) and also charged in between trips at Terminuses (and nearest depot) with Fast Chargers [1-2 hrs depending on 'state-of-charging' (SOC)].

Objective of WBTC is to increase frequency of e-Buses trips (150-180 Kms per bus/ day) across Kolkata and suburbs with more Solar powered EV Charging station installations at all terminuses and augment fast Charging facilities at all Depots on Solar. At times when buses are not charging during the day, Depot power requirements may be met with the generated solar power. In case of adverse weather condition, when Solar Power will not be sufficient, power can be drawn from the utility grid. [7]

Costing Solar PV Charging Stations: For a 120KW Fast DC Charger, a solar PV power plant of 150kWp capacity (with 0.8 Power Factor) can meet the purpose. Considering the present benchmark cost of the Govt. of India @Rs.39,080/-per kWp; this cost is applicable for the range of 100kWp to 500kWp PV power plant) comes to Rs.58,62,000/-. The cost of generation of Solar Power is presently in the range of Rs. 1.99 / unit to Rs. 2.49 / unit, which is cheaper than Thermal power. In fact, since the year 2000, Solar Power has become the cheapest source of electricity in India. The RoI is within 4.5years.

❑ Benefits:

With the present charging arrangement, buses are charged through conventional electricity and so at somewhere coal is burnt. Charging through Solar power can be an emission less transport system where both at the point of travel and at the point of charging source, emission is nil. The financial benefits are as following:

Type of Bus	Type of fuel used	Cost (Rs. /km)
Non-A.C	Diesel	35
A.C	Diesel	50
A.C EV	Conventional Electricity	25
AC : EV + PV	Solar	16

Table III: Cost Comparison

❑ Conclusions:

Worldwide countries are fighting for climate mitigation exercises because climate induced calamities correspond to loss of G.D.P. On part of India, it can be an unique opportunity to enhance its G.D.P in the name of aggressive and planned intervention in PV & EV through Export of de Carbonizationto the world. India can act now to prevent the country 35T$ in economic potential of damage in next 50 years due to unlimited climate change. So, more and effective penetration of E-Vehicles with PV Charging and IoT based infrastructure management mechanism will not only reduce fossil fuel dependency, but also , it will lead India's transition towards a Green Economy which can export de-carbonization through technologies like PV,EV and PV-EV combined. Other than organised sector employment, an eco-system for ancillary, maintenance services can also be developed like what has happened for India's top car maker Maruti. India has a distinct opportunity to become the global leader in the upcoming electric vehicle revolution. This will reduce the GHG emissions, enhance EV penetration and will provide new scope of employment to the youth of this country. Converging EV with PV, IT &IoT can ensure best possible penetration for EV in India and India can be the Global Leader in EV in coming days.

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Electric Vehicles & Charging Infrastructure – The Need

✍ **Mr. Amartya Jyoti Chanda**
EV professional , Kolkata

❑ Introduction

Air pollution from fossil fuel combustion poses a grave threat to human health world-wide. Pollution is already contributing to a rise in the Earth's surface temperature, changing our weather patterns causing glaciers to disintegrate, ice in the poles to melt and raise the ocean level. Recent studies have predicted that changes in global temperatures will also account for introduction of new infectious diseases, enterprising certain species of animals to become extinct, intensifying storms, incrementing the likelihood of droughts and floods.

Study reveals a significant contribution of air pollution in urban areas comes from motor vehicle emissions. Most of the developed countries have made great improvements in reducing the use of leaded fuels; however, highway emission of lead remains a persistent air quality problem in the developing countries. It is indicative that motor vehicles are also a major or primary source of other toxic air pollutants including 1.3-butadiene, benzene and a number of carcinogens associated with particulate matter.

As the vehicle fleet continues to grow, motor vehicle emissions and the products of their transformation in the atmosphere become increasingly important contributors to nearly every major air pollution problem that the world faces today. In urban areas, where more than 70% of the population dwells, levels of motor-vehicle related pollutants frequently exceed internationally agreed air quality guidelines.

The Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) clearly states that human activity is causing unprecedented, and sometimes irreversible, climate change. According to the World Health Organisation (WHO), India has the world's worst air quality. In 2020, even during the Covid crisis with national and state lockdowns, 36 cities out of 50 cities which had unhealthy levels of air quality were from India. The vehicular pollution arising from the increasing stock of private vehicles, especially internal combustion engines (ICE) has contributed significantly to deterioration of air quality in Indian cities. The increase in ICE vehicles stock has led to India becoming the third-highest oil consuming and greenhouse gas (GHG) emitting country worldwide. Additionally, nearly two-thirds of deaths in India can be attributed to emissions coming from ICE (diesel) vehicles.

For the addressal of these issues the Central & State Ministry announced a goal to transition from new sales of ICE (Petrol & Diesel) vehicles to 100% plug-in electric vehicles (EV) by 2030.

❑ Abstract

Electric vehicles have strong potential sustainability. Owing to their beneficial effect on the environment in urban traffic, electric vehicles are an important factor in the improvement of traffic and more particularly in developing a healthier living environment. They ought to be supplied with clean and sustainable electric energy, for which charging infrastructure is need of the hour.

❑ Technical Facet

➤ Charging power levels of EV

AC (Slow) Charging

Trickle Charge (Charging through on-board charger – Level 1 charging)

- Facilitates charging through a standard (three prong) 220V Plug that comes with the EV. Another end is plugged in directly to the EV
- No additional charging equipment is required
- Can deliver 13-16 km range per hour of charging
- Charging speed :approx 65 kms of range in 5 hours / 200 km in 14 hours
- Recommended only in urgent cases when the EV is having low battery charge to drive to a nearby public charging station or access an AC wallbox at home.

AC Household Charging (Level 2 charging)

- Simplify Charging through 230V outlet which @ 3-4 times faster than Trickle Charger depending on the acceptance rate of the EV model and the charger
- Useful when the EV owner has the opportunity and time to charge the

vehicle overnight. It takes around 6-7 hours to energize the batteries to the full extent.

AC (Slow) Charging

Public Charging (Level 3 charging)

- Quick and elegant way of charging
- Expediting charging power >50kW through voltage >450V and current >125A
- Capable of charging from 20 to 80% of charge in approx. 40 minutes
- Utilizes GB/T, Combined Charging System (CCS) protocols

➤ Charging Standards

Currently, there are three dominant standards for fast charging: CHAdeMO, CCS and GB/T. These standards are partially compliant with IEC 61851 standard, or with an equivalent standard as the GB/T 18487. They differ from one another in the connector cable employed, communication protocol, or security procedures. Nevertheless, maintaining the general requirements for a DC charger.

Output Power Level Classification for DC Chargers w.r.t CHAdeMO and CCS Standards

	Version / Power Class	Output Power (kW)
CHAdeMO	1.0	62.5 (500V x 125 A)
	1.2	200 (500V x 400 A)
	2.0	400 (1kV x 400 A)
CCS	DC5	5 (500V x 10 A)
	DC10	10 (500V x 20 A)
	DC20	20 (500V x 40 A)
	FC50	50 (500V x 100 A)
	HPC150	150 (500V x 300 A,920Vx163A)
	HPC250	250 (500V x 500 A,920Vx271A)
	HPC350	350 (500V x 500 A,920Vx380A)

➤ **EV Charging Sockets**

Current Type	Region				
	Japan	America	Europe (EU), rest of the world	China	All markets except EU
AC					
Plug name	J1772 (Type1)	J1772 (Type1)	Mennekes (Type 2)	GB/T	
DC					
Plug Name	CHAdeMO	CC1	CCS2	GB/T	TESLA

➤ **Implementation of EV Charging**

With the rising demand of Electric Vehicle, Smart charging can be implemented at scale through widespread public charging networks, where many hundreds or even thousands of charging points are deployed and operated.

This allows the aggregated energy consumption profiles to be forecast with greater accuracy. Combined with smart charging, it then means that real consumption aligns with the forecasts, positively impacting the energy price as a result of this greater control of consumption.

This is only possible if the smart charging service is large-scale-ready, which may seem obvious, but is not in the current scenario though Government of India has already taken strong initiatives to enacting the same.

➤ **Grid Impact of residential & public charging**

EV integration into the electricity grid comes with many positive effects, such as power management and V/f regulation. The coordinated charging and discharging of EVs can improve the voltage profile and reduces power transmission loss. The marginal cost is lower than the original power supply cost of the grid. The low cost thus benefits from difference in the load curve.

However, it has negative impacts also. Electric charging stations must supply the load with continuous power at the desired time and in the dispersed locations; therefore, they are not favorable for utility companies as utilities try to have a homogenous load profile, and otherwise, they will face future issues implied on the grid, such as local power shortages. Thus, a high share of EVs that use Smart charging method (smart) could be beneficial in the network. EVs have the most impact on the distribution grid, and it can also negatively affect the reliability of the network. So, in that case, a controlled charging strategy for EVs to minimize the network's daily power losses considering operation constraints. Due to EV's dynamic characteristics, they have a natural effect on the grid's power quality, such as harmonics, sag, swell, voltage, and phase imbalance. However, companies follow power quality standards while manufacturing EVs to prevent devastating impacts on the grid.

❍ **Solutions to compensate negative impacts of EV charging stations on the grid**

- ✓ Hybrid Energy Storages
- ✓ Battery
- ✓ Fuel Cell
- ✓ Ultra Capacitor
- ✓ Distributed Generation
- ✓ Investments on new infrastructure for charging stations
- ✓ Investments on distribution systems, transmission systems and power plants etc.

➤ **Interaction of EV Charging with renewable energy supply**

Concerning the rapid increase of EV demand and EV charging, many research centers, and energy supplying companies began thinking seriously about reducing the pressure on local electricity networks because of the increasing number of electric vehicle charging points. Renewable energy sources such as wind and solar are some of the most effective solutions to bridge this deficit faced by local electricity networks, potentially supporting the EV charging infrastructure.

After the announcement of the rapid development of the EV at the turn of the millennium, Renewable Energy-Based Charging Infrastructure (RCI) research began with the effort of wind and solar charging infrastructure. It envisioned a charging facility that could match EV demand with renewables and direct current (DC) to improve shortcomings of conventional charging infrastructure. The traditional charging stations affect the grid's stability with issues such as harmonics, fluctuations, and voltage outages. By contrast, the RCI has several advantages, such as high efficiency, low system cost, and simple arrangement. Besides, it requires less power conversion levels than those in alternating current (AC)-based facilities. The RCI can contribute significantly to reducing carbon emissions and expanding the energy domain's penetration of renewable energy sources. Moreover, RCI has the potential to lower the cost of EV charging. However, uncertainties of the renewable sources (e.g., seasonal variations in wind speed and sun irradiance and daily randomness in cloud coverage for solar panels) and load characteristics of EVs (e.g., battery capacity, number and types of EVs, stop time, charging start time, and the initial state of charge) are serious challenges in implementing the RCI.

Currently, there is an ongoing considerable research work on the aforementioned topics. At the same time, other researchers are working on various aspects of implementation and operation of RCI, such as optimal planning, controlling and sizing, pricing approaches, and examination of the key factors influencing the linking of EV load directly with the RCI.

Electric Mobility: A Ready Reckoner

✍ **Er Shreya Karmakar**
Renewable Energy Professional
UAE

Barriers

- High cost of EV as compared to IC Engine based vehicles.
- Increase in Battery price.
- Lack of appropriate charging infrastructure.
- Battery blast.

On Going Activities

- Awareness & sensitization.
- Production Linked Incentive (PLI) in manufacturing.
- Capital subsidy on purchase.
- Developing public EV charging infrastructure.
- Time bound adaptation of open access (from DISCOM) for charging stations, conducive tariff, access to easy finance for entrepreneurs.

Present Trend

- There exists 10 million Electric vehicles in the globe at present.
- In India, still Battery Rickshaw and EV Two Wheelers are more than 90% of total EV penetration.
- In last three years, EV penetration rate is higher than that of CNG penetration.
- Local manufacturing and maintenance ecosystem generates employment.

Advantage

- Technology is becoming more and more efficient which reduces the cost of manufacturing of Electric Vehicles and its operation – maintenance cost.
- There is a huge potential of short range (i.r.o. kilometer) traveling in Indian cities and suburbs which fits for EV.
- More Charging Stations are now available and it is increasing day by day.
- DISCOMs are allowing faster connection to Charging Stations with conductive tariff and open access.

Future of EV in India

- In early days of 2000, Scooters India Ltd. and Mahindra manufactured Electric Vehicles in India which were used across the country including Kolkata.
- Then Electrotherm, Hero Electric etc. have started manufacturing EV Two Wheelers.
- From 2014, some local assemblers have started manufacturing /assembling of E Rickshaw, which was initially plying at and around New Delhi railway Station. During 2014 to 2016, in the same fashion (through local assembling and maintenance) E Rickshaws have reached every nuke and corner of this country. Prof. Amartya Sen has called it 'Local Skill Based Revolution' which ultimately serves the comparatively lower income group people of this country (who are not poor and not rich also at the same time) who drive these vehicles and who are also passengers of these vehicles.
- The operational management of EV charging is essential for determining the impacts on the Power Supply Network and related financial implications. So, a detailed study is needed on analysing the impacts of coordinated EV charging on network management for a DISCOM which should include the network congestion, local transformer loading, EV charging tariff with or without ToD tariff etc.
- The future is charging with Renewable Energy and application of IT & IoT, which will reduce charging hassles and the cost of charging.
- Since Kolkata is one of the most vulnerable city i.r.o. temperature rise, polluted air; EV penetration is more urgently needed here and in this juncture, the West Bengal Transport Corporation is playing a very progressive role with one of the highest Electric Bus penetration in India, here.
- Since India has skill in Automobile Manufacturing and IT; with the Government push of Policies and Initiatives, reciprocated by our entrepreneurs; India can be the Global Leader in Electric Vehicles.

Electric Car

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SgTPP, WBPDCL

❑ Abstract:

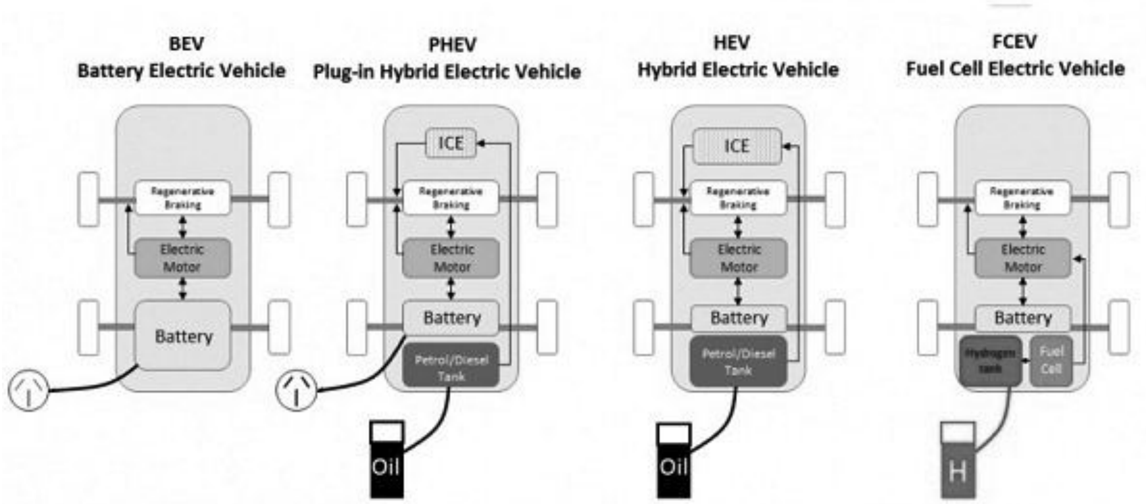
We all know that, fossil fuel is demolishing day by day so, we have a great challenge to find alternative way to overcome this issue. Now, our main focus is our Automobile sector, the recent development and technology changes this sector very dramatically. The one is Electric vehicle (EV), the main aim of paper is to explain the importance of electric vehicle and how we are reducing greenhouse gas emission from the Environment. This Paper deals with basic concept of electric vehicle and also explained all possible type of electric vehicle. At last we have given a brief description of electric vehicle (BEV).

An electric car is a vehicle that is fully or partially propelled electric motors, using energy stored in rechargeable batteries. The first practical electric cars were produced in the 1880s.Electric cars were popular in the late 19 th century and early 20 th century. Innovation & advanced development in internal combustion engine (ICE)and mass production of cheaper gasoline vehicle have led to decline in the use of electric vehicle.

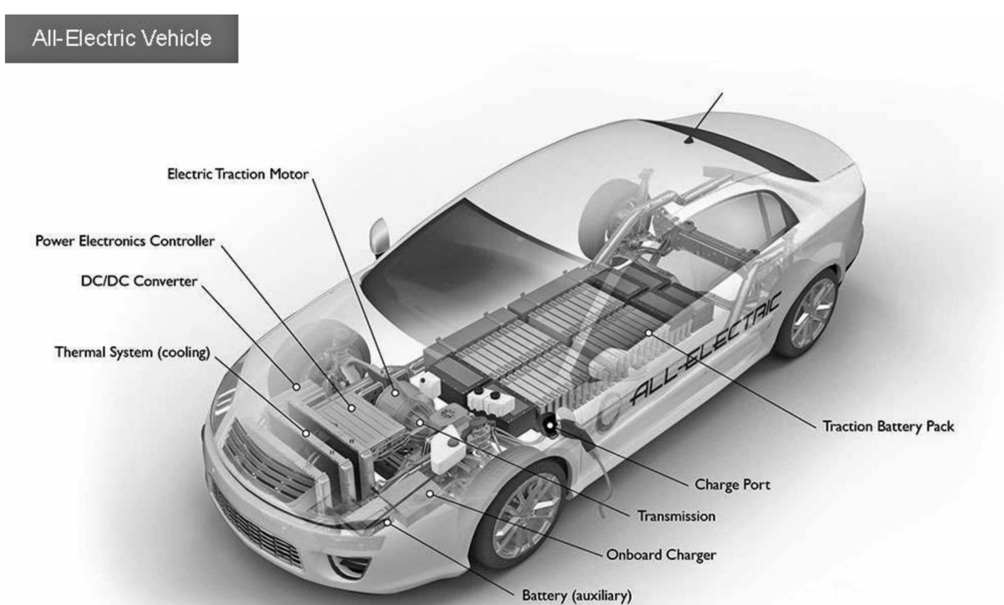
❑ Types of electric Car

There are 4 types of electric cars, with the following out lines.

1. Battery electric Vehicle (BEV).
2. Hybrid Electric Vehicle (HEV).
3. Plug-in Hybrid Electric Vehicle (PHEV).
4. Fuel Cell Electric Vehicle (FCEV)



1. **Battery Electric Vehicle**: A battery electric (BEV) also called all electric vehicle (AEV), runs entirely on a battery and electric drive train. This types of electric car do not have an IC Engine. Electricity is stored in a large battery pack that is charged by plugging in to the electricity grid. The battery pack, in turn provided power to one or more electric motors to run the electric car. All-electric vehicles also referred to as battery electric vehicles (BEVs), have an electric motor instead of an internal combustion engine. The vehicle uses a large traction battery pack to power the electric motor and must be plugged in to a wall outlet or charging equipment, also called electric vehicle supply equipment (EVSE). Because it runs on electricity, the vehicle emits no exhaust from a tail pipe and does not contain the typical liquid fuel components, such as a fuel pump, fuel line, or fuel tank. Learn more about electric vehicles.



Key Components of an All-Electric Car

- **Battery (all-electric auxiliary):** In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.
- **Charge port:** The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.
- **DC/DC converter:** This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
- **Electric traction motor:** Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.
- **Onboard charger:** Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.
- **Power electronics controller:** This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
- **Thermal system (cooling):** This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
- **Traction battery pack:** Stores electricity for use by the electric traction motor.
- **Transmission (electric):** The transmission transfers mechanical power from the electric traction motor to drive the wheels.

Why Lithum-ion Battery:

Lithium-ion batteries are currently used in most portable consumer electronics such as cell phones and laptops because of their high energy per unit mass relative to other electrical energy storage systems. They also have a high power-to-weight ratio, high energy efficiency, good high-temperature performance, and low self-discharge. Most components of lithium-ion batteries can be recycled, but the cost of material recovery remains a challenge for the industry. The U.S. Department of Energy is also supporting the Lithium-Ion Battery Recycling Prize to develop and demonstrate profitable solutions for collecting, sorting, storing, and transporting spent and discarded lithium-ion batteries for eventual recycling and materials recovery. Most of today's all-electric vehicles and PHEVs use lithium-ion batteries, though the exact chemistry often varies from that of consumer electronics batteries. Research and development are ongoing to reduce their relatively high cost, extend their useful life, and address safety concerns in regard to overheating.

The location of Battery bank in the EV is just above the chassis as the weight of the battery is quite higher and its gives the dynamic stability of the vehicle. Basically this battery are similar types of battery used in laptop, mobile are similar types but the number and size is bigger. Around 7000-7500 cell are considered with EV. The battery bank all are connected with Nickel strip, due to corrosion problem and increasing internal resistance problem Copper is not used here.

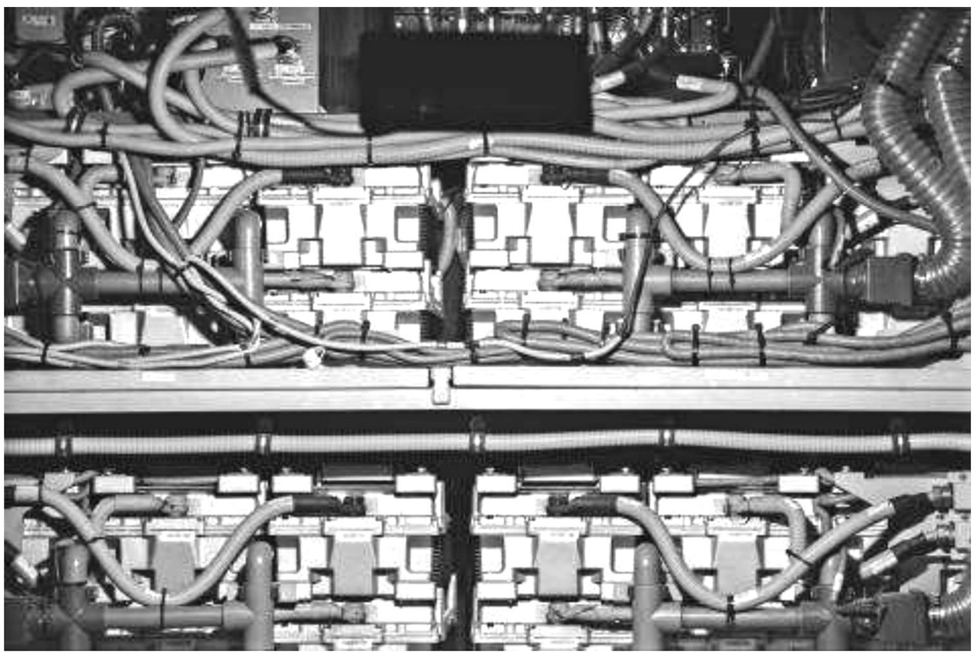
The main parts of those battery prepared by Lithium. So it is clear that the Nickel &Lithium is the main component of these types of battery. The expected life of the EV's Battery bank is 3 to 4 years but after that it will be recycled and used other area also. The main advantages of the EV's are their compact size.In conventional CAR's operate by IC Engine which may be positioned in the front or sometimes in rare positions but in Electrically operated car's there is no need of IC engines, Only a Motor & AC to DC converter is sufficient to powered the CARs which create the simplicity of the machines,better space utilization and smoothservice life.

BATTERY USED IN EVs

Work principle:

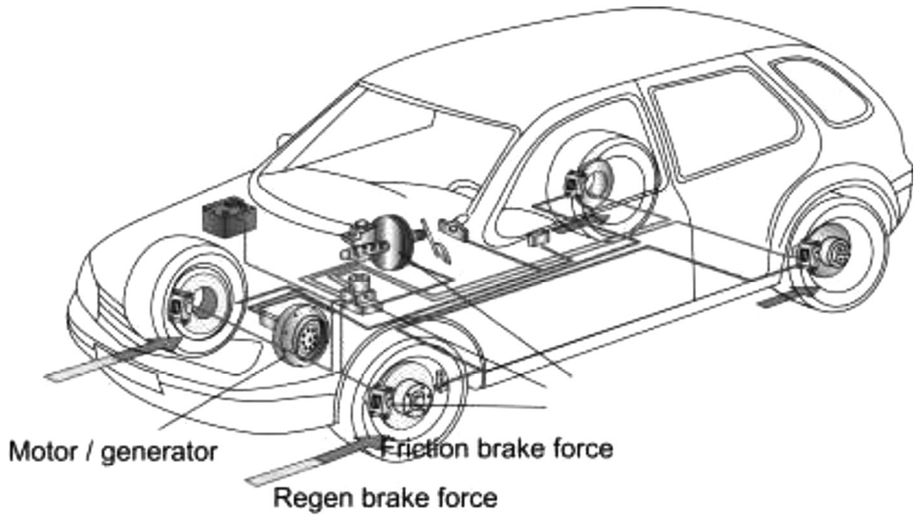
Mainly the supply DC power coming from the 7000 battery cell pack and it fed to the DC toAC converter and converts the DC to AC Power, which powered the traction motor. AC motor or alternating current motor is a three-phase motor that is powered by 240 volts of alternating current are widely used by EV manufacturers, particularly for high-performance vehicles. The main problem of the system is utilization of the power from the battery bank throughout its running cycle so a system called BMS battery management system was developed as continuous power is obtained from the entire cycle of the battery. Normally 300 Max Km is ruined this types of developed EV's and after that it required charged. At the time of charging it is require Min 30 minutes in case of recently developed super charger (made by TESLA).

Like every system to manage the heating problem here also a great concern. Similar technique is used to cool an EV's battery, which involves the use of cooling pipes around the battery. The coolant flows through these pipes and helps to cool down the battery in much the same way as in a traditional car, where the coolant is eventually sent to a radiator. The battery thermal management in electric vehicles uses cooling loops that contain liquid coolants such as ethylene glycol. An electric pump and compressor circulates the coolant through the batteries. Radiators are included in the cooling loop to release the heat to the ambient.



BATTERY CONNECTION WITHPIPE COOLING ARRRANGEMENT

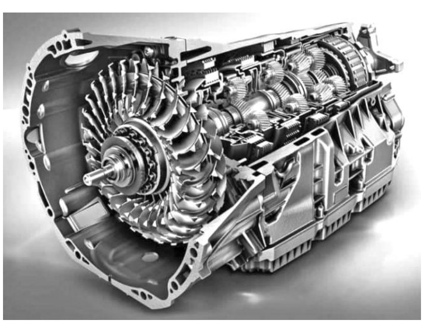
Speed control is easier and regenerative braking is used. In case of conventional vehicles at the time of breaking a large amount of fuel are burned but here at the time of braking battery got charged. Regenerative brakes work by reversing electric motors that propel a car. It works like a generator and feeds energy back into the hybrid or electric system to help replenish a little bit of range. These small boosts in battery range can accumulate and improve efficiency over time when used regularly. Regenerative braking systems aim to recover, store and reuse some of the vehicle's braking energy to improve fuel efficiency or boost the range of electric and hybrid vehicles (FEV/HEV). Energy storage media include electric batteries and/or ultra capacitors, flywheels and hydraulic accumulators.

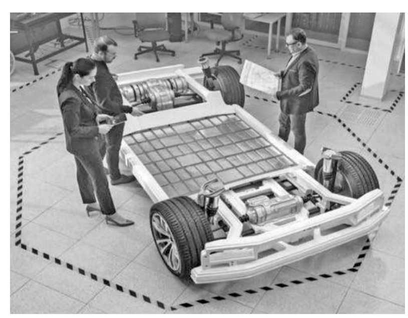


Converter

Traction Motor used in AEV

Gearbox & Chassis





❑ Advantages of Electric Vehicles:

1. Smooth Speed Control & Used AUTO Control
2. Efficiency higher.
3. Green energy, minimum pollution.
4. Better used in CAR space, better design.
5. Used Regenerative Braking.
6. Less Maintenance.
7. It generates high starting torque.
8. Noise free operation

❑ Disadvantages of Electric Vehicles:

It is important to consider both sides of the equation when deciding if an EV is right for you. Despite the massive push in this country to move to a greater number of electric vehicles, there remain several potential disadvantages or cons of owning and operating an electric car. These disadvantages include finding charging stations, charging times, higher initial costs, limited driving range, and battery packs can be expensive to replace. There is no doubt that the future is electric and as both the adoption rate of EVs increase and the underlying technology mature these downsides will become less and less of a factor.

❑ Present Senerio:

1. Finding a charging station – EV charging stations are fewer and further between gas station.
2. Charging takes longer.
3. The driving range on a full charge.
4. Higher initial purchase cost.
5. Replacing the batteries is expansive.

❑ ELECTRIC VECHICLE FUTURE IN INDIA AND THE WORLD :

- Global EV marketing is growing at a staggering CAGR of 21.7%
- A whopping 4.19 lakh EVs have already sold in India in 2022. This number stood at a mere 1.19 lakhs in 2020.

❑ STEPS TOWARDS ELECTRIC VECHICLE IN INDIA :

1. Reduced CO2 emission & sustainability.
2. Cheaper to buy and drive.
3. Charging made easy.
4. Enjoyable drive experience.
5. Improving diplomatic relationship of raw materials for battery i,e lithium Nickel reach countries like Argentina ,Chilly , Bolivia Australia for Lithium and for Nickel it is Indonesia. Side by side India also formed the KABIL (Khanij Bidesh India ltd)for strategic minerals like Nickel,Lirhum.