Implementation of Eco-Friendly Energy Sources in Electric Vehicles

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Abstract: The objective of this paper is to propose an eco friendly approach to energy source used for charging the electric vehicles (EVs). Using a comprehensive analysis, this study analyzed that a majority of the electricity came from coal-fired plants and non-conventional renewable energy sources (RES) which is used to charge EVs across the world. This paper focused on effective use of renewable resources for charging. Also discussed the use of hydrogen fuel cell (FCEV) to generate electricity for powering the motor, generally using oxygen from the air and compressed hydrogen. The proposed approach is capable of achieving the goal of solving the problem of increasing air pollution.

Index Terms: Alternative Fuels, Electric vehicles, Hydrogen fuel cells, Li-ion Battery charging.

I. INTRODUCTION

Now day’s whole world is moving towards an electric vehicle (EV). Generally an electric vehicle is powered by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator. Electric motors are mechanically very simple and often achieve 90% energy conversion efficiency whereas petrol engines achieved 24% over the full range of speeds and power output and can be precisely controlled. Lithium-ion batteries (Li-Ions or LIBs) are used in most electric vehicles. Lithium ion batteries have higher energy capacity, longer service life and higher power efficiency relative to most other practical batteries. Security, longevity, thermal breakdown and cost are all complicating factors. The performance of EVs ‘tank-to-wheels’ is about 3 higher than that of internal combustion engine vehicles. In contrast to internal combustion engines which consume fuel while idling, energy is not consumed while the vehicle is stationary. When not in use for charging, EVs may be plugged into the electric grid. The cost of running an EV varies widely depending on where you are. An EV costs less to drive than a similar gas-powered car in certain parts of the world, as long as the higher initial sales price is not factored in.

EVs do not emit any air contaminants from the tail pipe at the location where they are run. They also typically generate less noise pollution than an internal combustion engine, whether at rest or in motion. Ideally EVs claim to be eco friendly and zero emission to use so that the problem of rising air pollution because of internal combustion engines can be reduced. Using electric vehicles has many advantages over traditional internal combustion engine cars, reducing local air pollution, particularly in cities, as they do not emit harmful tailpipe pollutants such as particulate matter (soot), volatile organic compounds, hydrocarbons, carbon monoxide, ozone, lead, and various oxides. EVs are said to be the future of automobiles. Transport Minister Nitin Gadkari in the year 2017, shocked the automobile industry (and the world) when he announced that he intended for India to move to 100% electric cars by 2030. Many existing manufacturer and few new manufacturer actively developing new models of EVs. Also peoples are preferred EVs. Figure no.1 shows increasing trend of year wise sale of electric vehicles in India.
II. TYPES OF BATTERIES USED FOR ELECTRIC VEHICLES

Because of the high energy density and increased power per mass battery unit, Li-Ion batteries now represent the most used technology in electric vehicles, which reduced weight and dimensions at competitive prices. Electric Vehicle generally used four different types of batteries i.e. Lithium Ion (Li-Ion), Molten Salt (Na-NiCl2), Nickel Metal Hydride (Ni-MH) and Lithium Sulphur (Li-S). [2] High energy density and increased capacity of Li-Ion batteries per mass battery cell that reduced weight and dimensions at competitive prices. Most of the leading manufacturer used Lithium ion batteries in their model (Renault Twizy, Hyundai Ioniq, Nissan Leaf, VW E-Golf, Tesla Model S). This system is the first "charge--" approach that fulfills one of the most important requirements for a battery used in the electric vehicle industry, making it easier for them to substitute Ni- batteries. Another benefit is the lack of memory effect (to slowly lose the full capacity of energy in case of recharge twice, without being fully discharged), resulting in an extended life cycle.

Nowadays, Li-Ion batteries have the largest segment of electric vehicle equipment market. Moderate energy consumption (14.7 kWh/100 km), continuous cost price decrease, advanced production technology, improved cycle life, low weight and high energy storage capacity make Li-Ion batteries an ideal option in this area. Their drawback is reflected by high working temperatures, which can adversely affect their energy efficiency and lifecycle. Both of these pose risks with regard to the vehicle's safe operation. The drawback of Li-Ion batteries is the highly established operating temperature that may impact energetic efficiency, including lifetime and operating health. This technology includes one battery management device to control and regulate the temperature of the internal cells. Besides the drawbacks caused by temperature manipulation, there are also issues related to high manufacturing costs, recycling out - of -use battery power and recharging infrastructure.

III. CHALLENGES IN CHARGING OF ELECTRIC VEHICLE

a. Battery life is less (3-4.5 years)- For this challenge the battery should be designed so that the battery will work effectively, efficiently and any environment.

b. Frequent recharging of battery- For this the battery capacity is to be increased with less space consuming battery should be implement.

c. Recharging time is high (6-8hr)- Existing electric vehicle should be kept 6-8 hr for complete recharging for this challenge the different methods have to obtain for fast charging of battery.

d. Access- Access for recharge is not easily available outside the home For this challenge the government and manufacturer have to provide the charging station like petrol station

d. Energy source for battery charging- As we said electrical vehicles are eco-friendly but in actual case it uses power for charging of batteries which is generated from either coal, gas or hydro. About 55.9% of electricity is generated in India is by Coal power plants. 7.0% amount of electricity is generated by from gas and diesel. Nuclear 1.9%, hydro having 12.40% share and Eco-friendly electricity production amounts to 23.50%. Thus additional power generation is required if electrical vehicles are increased. It means electrical vehicles are indirectly causes pollution. This represents that an increase in electric vehicles will increase the pollution caused because of thermal power plants.

![Fig. 2 Current power generation resources in India](image)

In India air pollution is a severe health issue. The 51% of pollution is caused by the industrial pollution, 27% by vehicles. Air pollution contributes to the premature deaths of 2 million Indians every year. In the mining and processing of lithium, cobalt, and manganese, critical raw materials needed for the manufacture of these batteries, a gigantic amount of energy is used. The manufacturing of an electric car requires more than twice as much energy as a traditional one and the key reason for that is the battery. Contemporary technology battery production requires 350 to 650 Megajoule of energy per kWh, as per a study led by the Swedish Center for Environmental Research (IVL). A typical EV battery pack is also capable of releasing 73 to 98 grams of CO2 into the air per kilometer. Adding to this is the electricity CO2 emissions from power plants that drive these vehicles.
**e. Lithium availability** - India lacks ample reserves of lithium to produce lithium-ion batteries. This may result in a significant shift in the energy security priorities of the country, with the securing of supplies of lithium, a crucial raw material for EV batteries, becoming as critical as purchasing oil and gas fields overseas. Also, major concern is the shortage of battery manufacture in India. There is a need to develop technology to enable a resource-efficient and economically feasible recycling system for lithium-ion batteries and thus assure the future supply of the component materials.

**IV. GENERATION OF ELECTRICITY CAPACITY MIX FOR PERIOD 2021 TO 2030**

It shows that India moves towards eco-friendly renewable energy sources. It will help to fulfill additional electricity requirement arises due to electric vehicle. More amount of solar and wind energy generation expected in future.

![Fig no.3 Generation of electricity capacity mix for period 2021 to 2030](image)

Source-Report on Optimal Generation Capacity Mix for 2029-30 by Govt. of India

**V. SMART CHARGING STRATEGIES**

a. **Network-oriented charging**

Shifting the charging times to low demand periods (e.g. night times) which will helpful for smoothing load patterns. It will avoid network congestions and physical capacity constraints (e.g. overload of lines, voltage drops).

Another advantage is that it avoid infrastructural investments.

b. **Renewable energy-oriented charging**

Use of high or surplus renewable energy sources for charging.

c. **Cost-oriented charging**

Charging during low price electricity period helpful for reduction of cost for EV charging.

d. **Lithium-ion battery recycling process development**

Reuse of this rare material will be helpful for reducing pollution created by lithium mining.

e. **Battery swapping**

Battery charging takes more time so already charged batteries during low demand periods can be available at energy station. For this standardization in battery manufacturing is needed.

f. **Solar and wind energy park**

Solar and wind energy park can be installed near to highways where charging facilities and battery swapping facilities may be available.

g. **Use of hydrogen fuel cell**

Use of hydrogen fuel cell (FCEV) for generating electricity to power the motor which is an eco-friendly -zero harmful emission process.
VI. HYDROGEN FUEL CELL AS A BETTER OPTION

A Fuel Cell Vehicle (FCV) or Fuel Cell Electric Vehicle (FCEV) is a type of electric vehicle that uses a fuel cell to power its on-board electric motor instead of a battery, or in conjunction with a battery or super capacitor. For automobiles fuel cells produce energy to power the engine, usually using air oxygen and compressed hydrogen. Many fuel cell vehicles are categorized as zero-emission vehicles which only emit heat and water. Hydrogen vehicles, as opposed to internal combustion engines, centralize emissions at the hydrogen manufacturing site, where hydrogen is usually produced from transformed natural gas. Many fuel cell vehicles are categorized as zero-emission vehicles which only emit heat and water. Hydrogen vehicles, as opposed to internal combustion engines, centralize emissions at the hydrogen manufacturing site, where hydrogen is usually produced from transformed natural gas.

In 2010, a US DOE Well-to-Wheels publication assumed that the efficiency of the single step of compressing hydrogen to 6,250 psi (43.1 MPa) at the refueling station is 94%. A 2016 study by scientists at Stanford University and the Technical University of Munich in the November issue of the journal Energy concluded that, also assuming the output of local hydrogen, “investing in all-electric battery vehicles is a more economical option for reducing carbon dioxide emissions, mainly because of their lower cost and substantially higher energy efficiency.”

Advances in fuel cell technology have high fuel cell electric vehicles capacity, weight and cost. It estimated that the cost of automotive fuel cells had fallen by 80 percent since 2002, and that these fuel cells could theoretically be manufactured for $51/kW, assuming cost savings in high-volume manufacturing. Fuel cell electric vehicles were built with a driving range of more than 250 miles before refueling.” They can be refueled in less than 5 minutes. Deployed fuel cell busses have a fuel economy of 40 per cent higher than diesel busses. The EERE Fuel Cell Technologies System states that as of 2011, fuel cells achieved full-power efficiency of 42 to 53 per cent fuel cell electric vehicles, and a reliability of more than 75,000 miles with less than 10 per cent loss of voltage, double that achieved in 2006. In 2012, Lux Research, Inc. released a study finding that capital costs would restrict adoption by 2030 to a mere 5.9 GW, creating an almost insurmountable obstacle for adoption, even in niche applications. Lux's study concluded that stationary applications for PEM fuel cells would exceed $1 billion by 2030, while the demand for cars, including fuel cell forklifts, would exceed a total of $2 billion.

VII. COMPARISON OF FCEV WITH BEV

a. Vehicle Mass
Extra mass to expand the range of the fuel cell. EV is negligible as hydrogen plus slightly larger tanks to extend the range adds little mass, while the battery EV mass increases considerably with range, as each extra mile requires the addition of heavy battery plates. The non-linear growth in weight with vehicle range is the product of mass compounding, where any extra kilogram of battery to increase range requires extra structural mass, heavier brakes, a larger traction motor, and in effect more batteries to accelerate this extra mass in an insidious feedback cycle.

b. Storage Volume
Together, compressed hydrogen tanks plus the fuel cell device take up less room than batteries per unit of useful energy supplied to the engine. In theory, an EV with an advanced Li-Ion battery could achieve a range of 400 to 480 km (250 to 300 miles), but such batteries would take up 450 to 600 liters of space (equivalent to a 120 to 160 gallon tank!). The fuel cell plus storage tanks of hydrogen will take up about half the space.

c. Greenhouse Gas Pollution (GHG)
Production and charging of batteries depends in large part on the electricity produced from power plants. Currently, electrical power generation plants transform just 32 percent to 36 percent of coal-fired energy into electricity and losses with electrical transmission line losses.

d. Fueling Time
Testing of 140 FCEVs reveals that it takes just 3.3 minutes to refill hydrogen gas fueling systems at high speed. The key challenge in case of battery quick charging currents without overheating the battery cells or disturbing the tension balance between cell banks is. So charging takes 36 minutes to 1.4 hours or more.

e. Vehicle Cost
According to the analysis of Kromer and Heywood at the MIT, an advanced battery EV with a range of 320 km (200 miles) would cost around $10,200 more than a traditional vehicle, whereas an FCEV with a range of 560 km (350 miles) would cost just $3,600 more in mass production.

f. Fuel Cost
For a FCEV owner, the owner of BEV with an off-peak rate of 6 cents / kWh would be around half the cost of hydrogen fuel per mile. Yet once the FCEV network supply is set this cost would go down.

g. Fueling Infrastructure Cost
The cost of each FCEV vehicle is greater. Although there is less time to refill. That way it can be used at its optimal point.
VIII. APPLICATIONS OF FCEV

a. Buses
Fuel cell busses have a fuel economy that is 30-141 percent higher than diesel busses and gas busses.

b. Forklifts
PEM fuel-cell-powered forklifts offer major advantages over forklifts powered by petroleum, as they do not emit any local emissions. Fuel-cell forklifts can operate on a single tank of hydrogen for a complete 8-hour cycle, can be refueled in 3 minutes, and have an 8–10 year life. Fuel cell-powered forklifts are commonly used in refrigerated warehouses, as lower temperatures do not degrade their performance.

c. Motorcycles and bicycles
The motorcycle carries enough fuel to run for four hours and travel at a top speed of 80 km/h (50 mph) 160 km (100 mi) in an urban environment.

d. Airplanes
The motorcycle carries enough fuel to run for four hours and ride 160 km (100 mi) in an urban area at 80 km/h (50 mph) top speed.

e. Boats
The world's first HYDRA Fuel Cell Boat used an AFC configuration with net outputs of 6.5 kW. The average outboard engine produces 140 times fewer hydrocarbons produced by the average modern vehicle for every liter of fuel consumed. Fuel cell engines have higher energy efficiencies than combustion engines, providing greater range and substantially lower emissions.

f. Submarines
The German Type 212 submarine [24] is the first submersible use of fuel cells. Each Type 212 contains nine PEM fuel cells, which are distributed across the ship and provide between 30 and 50 kW of electrical power each. It allows for a longer submergence of the Type 212 and makes it easier to identify them. Submarines powered by fuel cells are also simpler to build, manufacture and maintain than submarines powered by nuclear power.

g. Trains
In 2016, Alstom unveiled a commuter train powered by hydrogen fuel cells in the Coradia iLint. It was planned to reach 140 km/h (87 mph) and fly 600–800 km (370–500 mi) on a full hydrogen tank. In 2018 the train entered service in Germany and is scheduled to be tested in the Netherlands starting in 2019.

IX. CONCLUSION
Advantages of Fuel cell electric vehicles over advanced lithium ion full function battery electric vehicles.

a. Takes up less space on the vehicle
b. Less Greenhouse gases generation
c. Costs less (lower vehicle costs and life-cycle costs)
d. Requires less well-to-wheels natural gas or biomass energy
e. Less refueling time.

Battery electric vehicles (BEV) have three advantages compared to fuel cell evs:

a. Lower fuel cost per kilometer
b. Less well-to-wheels wind or solar energy per kilometer
c. Greater access to fueling capability initially

Electric vehicles are the necessity of today’s world to reduce CO2 emission. It shows that for successful implantation of electric vehicles Li-ion batteries as well as hydrogen fuel cell are required. The versatility of hydrogen can be a big catalyst for the renewable energy, oil and gas, automotive, rail, public infrastructure and advanced materials industries in India. India is one of the major methane emitters, and a waste source. But both technologies required dedicated research development in the area of hydrogen conversion, hydrogen storage, fast and safe charging technique of Li-Ion batteries, Lithium recycling.

References


