The need for electric vehicles

Environment, Ecology

Major revolution is taking place in transport industry with the advent of electric vehicles (EVs). Due to improvements in battery technology and increasing consumer concern for the issue of environmental damage, the adoption of electric vehicles is increasing day by day.

In this report we have discussed about the fundamentals of EV and also done a brief study about the working of BMW i3 produced by the German automaker. Our aim through this project is to understand the underlying technologies that are used in the plugin hybrid electric vehicles (BMW i3) and develop one for an average consumer.

We plan on adding solar panels to our car to act as an alternate source of energy. The batteries can be charged using a plug-in charger also. The electricity produced will be DC which has to be converted into AC by the use of an inverter. Our main inspiration for this idea is Lightyear One: a solar powered electric car with all wheel drive capability.

The energy which will be stored in the lithium ion batteries will be used to run the AC electric motor. The batteries will be placed along the wheelbase of the car and provide low center of gravity and improved driving capability.

Vast majority of vehicles work on conventional fuels like petroleum which in return causes air pollution by emitting harmful gases such as oxides of carbon, nitrogen. Since the resource does not replenish itself hence is not sustainable. Hence traditional fuels are degenerate for the environment and cannot fulfil the future needs of transportation and energy. The next era of vehicles should be based on renewable energy resources and available readily to be harnessed. This is the major reason to develop electric vehicles.

They not only cause almost negligible harm to the environment locally but also eliminate the dependency on conventional fuels.[1] The fig. 1 below provides information about CO2 emissions by various sectors.

The transportation sector is a major contributor of CO2 in the atmosphere. With the ever-increasing number of vehicles on road this number is only going to increase. Furthermore, we have limited petroleum resources and our rate of consumption is much greater than rate of replenishment in nature which is unsustainable. Therefore, there is an urgent need for highly efficient, clean and safe transportation.

“ Electric vehicles (EVs) have a battery instead of a gasoline tank, and an electric motor instead of an internal combustion engine.” Main types of EVs:

- Hybrid EV: “ A vehicle with both internal combustion and electric powertrains, but that cannot be charged from the grid and requires refuelling using gasoline or other fuel.”
- Pure EV: “ A vehicle that is solely powered by an electric powertrain recharged from the electric grid.”
- Plug-in Hybrid EV: “ A Hybrid Electric Vehicle that can be recharged from the electric grid, typically with the ability to travel significant distances without burning fuel, but with a combustion powertrain that can enable longer distances and faster acceleration.”
- Fuel Cell EV: “ A vehicle with an electric powertrain which may include a battery but primarily relies on a hydrogen fuel cell for power, and which can only be refueled with hydrogen.”

Hybrid Electric Vehicles (HEV) Architectures:

Parallel HEV architecture

In parallel architecture the vehicle can be powered by either electric motor or the Internal Combustion Engine or both depending upon on requirement. There is a need for complex electronic control system to manage the design. The major advantage of parallel HEV over series HEV is the freedom of choosing between electric power and combustion engine power which help in overcoming the fear of drive range in some consumers. The figure below provides the schematic view of parallel HEV architecture.

Series HEV architecture:

In series HEV architecture, the ICE and the transmission are separate units. Current produced by the generator gets stored in the battery and is further used by the electric motor to propel the vehicle. The advantage of series HEV is that the engine operates at peak efficiency. There are some energy loses because of conversion of energy first from mechanical-electrical-mechanical.

Electric vehicles with solar power

According to Mike Tinskey, Director Vehicle Electrification and Infrastructure at Ford Motor Company, “ PV+EV (photovoltaic + electric vehicle) is a good combination”.

Solar panel: The environmental benefits of electric vehicles increases if they are powered from sustainable energy resources like sun’s energy rather than electrical energy generated from conventional methods.

A single panel consists of a number of cells which capture the energy of sunlight and produce current. More is the concentration of sunlight on the cells, more is the energy generated. Functioning of a solar cell is shown Fig. 5 below.

Some electric cars that use solar panels are listed below:

Fisker Karma Revero:

Fisker Karma Revero is an Extended Range Electric Vehicle (EREV) with a solar panel roof. It has a 200W solar panel which is mainly used to power the infotainment and air conditioning. It has 50 miles of all electric range and make use of lithium ion battery of 21 kWh battery capacity.

Lightyear One

Another product in development is Lightyear One

The prototype won the prestigious Climate Change Award at the Consumer Electronics Show (CES). According to the company the advantage of solar powered electric vehicles is that there will not be any need to wait for charging infrastructure to be built to run the solar powered vehicles. The company states that with the combination of optimized aerodynamics , light weight structure and use of solar energy to power the vehicle their vehicle will have range of about 400 to 800 km depending upon battery configuration. The vehicle will also have option of plug-in charging.

Ford C Max Solar Energi

A concept introduced in 2014, 300 Watt curved solar panel on the roof of the vehicle. The solar cells cover roof area of 1. 5 sq. meter. The PV cells have been developed by SunPower. After an ideal sunny day charge the company

claims a range of 21 miles. Another technique they are using to maximize the functioning is by using a charging infrastructure consisting of lenses that will concentrate the sunlight on the solar roof and increase it by a factor of eight. Also, the lenses will be able to move to get the maximum concentrated sunlight at all times.

According to a website the best electric vehicles of 2018 are:

- Tesla Model 3: because of the overall package
- Nissan leaf: most affordable
- Chevrolet Bolt EV: offers the best driving range
- Tesla Model S: offers high performance
- BMW i3: as a high-end EV

The thing that is common among all these vehicles is that the use of Lithium based battery pack. Traditionally, the ICE based vehicles have Lead-acid batteries which provide ignition to start the engine. These batteries are used because they provide high current, easy to manufacture and are cheap. The disadvantages of these batteries are low life span, heavy weight, environmental damage. Following are the reasons why lithium-ion battery packs are the preferred choice of EV manufacturers:

1. High Energy Density
2. Lighter weight
3. More Charge-Discharge cycles

BMW i3 (2017)

BMW is a German automobile giant which produces luxury automobiles and motorcycles. The company has always been at the forefront of innovation. It has a number of sub-brands. From 1928 to 2013 the company has produced a number of vehicles from hatchback to sportscars which were majorly powered by Internal Combustion (IC) engines. It was in 2013 that BMW launched its first electric vehicle, BMW i3 under the BMW i sub brand as a step towards greener vehicles. Our aim through this project is to understand the underlying technologies that are used in the plugin hybrid electric vehicles (BMW i3) and develop one for an average consumer.

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The energy which will be stored in the lithium ion batteries will be used to run the AC electric motor. The batteries will be placed along the wheelbase of the car and provide low center of gravity and improved driving capability.

The vehicle is based on BMW’s LifeDrive concept [19] which consist of two separate units:

1. Life Module: “ The Life-module primarily consists of carbon fiber-reinforced plastic”
2. Drive Module: “ Structural support, high voltage battery, electric motor”

There are also Range Extender versions of BMW i3 on offer in which an engine acts as a generator to charge the batteries. For this project we will be focusing only on the full battery version. The specification of the BMW i3 provide by BMW USA are as follows. BMW i3 2018 is offered with a 33kWh battery. The size of the battery staying the same. The range offered by the vehicle is of 114 miles on full charge under ideal conditions. The driving dynamics of the vehicle is also good because of symmetric weight distribution and reduced center of gravity. The figures below provide the physical dimensions of BMW i3. To calculate the area of the roof suitable for putting solar panel we took approximate values.