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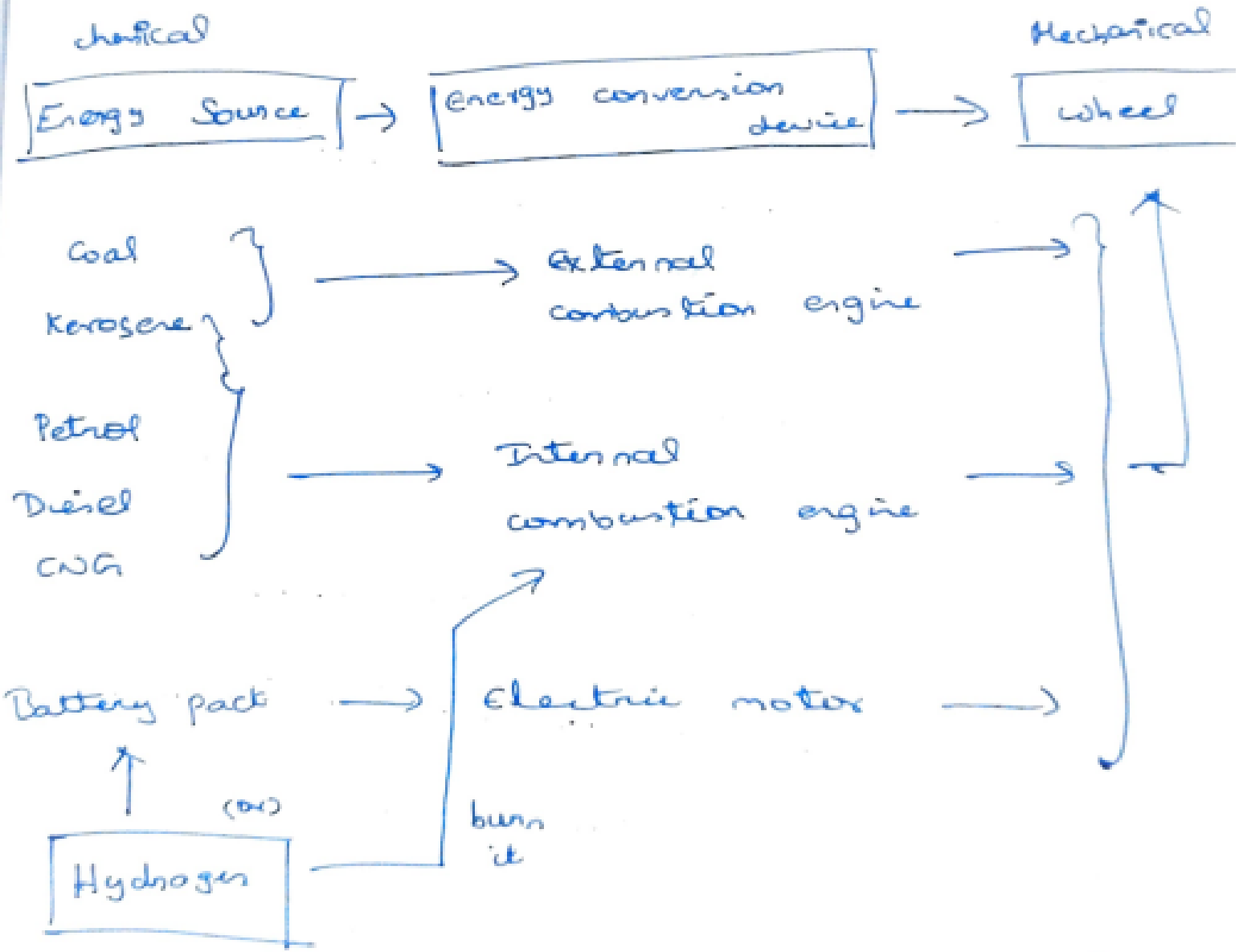
Automobile :

A vehicle which can propel itself from one location to another.

Basic requirements :

- Energy source (basic source is chemical energy)



Steam engine vehicle → Nicolas Cugnot
(or)

First ICE → Issac de Revaz (1806)

vehicle

Fuel - Hydrogen gas

Electric motor → Anyos Zedlik (1826)

(Toy car)

Project - London Underground (1865)
and
Electric Tram Birmingam

Thomas Parker supplied parts

In 1886, he built first EV to undergo production

— × — × —

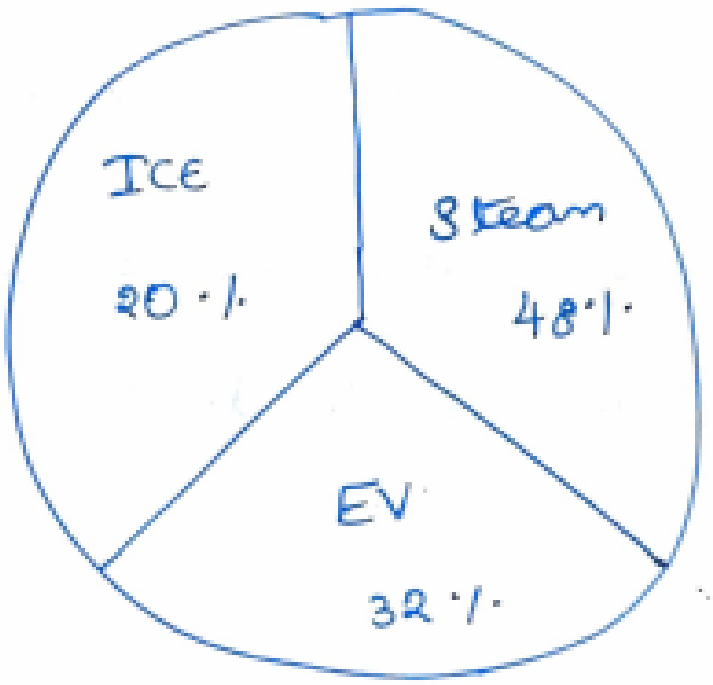
In 1884, Carl Berg also built EV

Morrison Carriage - Project USA

It is a multi speed vehicle. It has 4 speed control (12V / 24V / 48V / 58V)

In 1906, EV has 100 miles range in single charge. Top speed is 45-50 kmph. This vehicle has driven 1800 miles to prove the 100 mile range.

In 1906,



Market

Why its so popular in early stage?

In emission

Why did EV decline after 1910 suddenly ?

- **Henry Ford** came up with Assembly line production. Due to that, ICE vehicle price reduces drastically (30% ↓ per year)
- **Chevenolet** - came up with Self start mechanism for ICE vehicle
- World war - • Range (Non-reliable)
  • charging time
- Bike - Easily usable during war (mainly Harly davidson bike)
- Oil Lobby

After 1950, 48% pollutions are caused by automobiles in USA. So, They started a organization called CARB (California Board) to reduce pollution

Some Acts:

- Low Emission Vehicle (LEV) - I

(1993-2003)

=) All manufacturers to provide an ZEV alternative to market

ZEV - zero emission vehicle

Some car brands manufactured ZEV and they gave it for lease. But, sales are very low. So they filed against CARB. So CARB cancelled LEV - I.

- 2003 - LEV II

=) LEV (Low emission vehicle) - 10-15% ↓

=) VLEV (Very low emission vehicle) - 70-80%

=) ZEV (pure zero emission vehicle) - 0%

HEV :

- It has two complementary drive system
  - a gasoline engine and fuel tank
  - Electric motor, battery and control

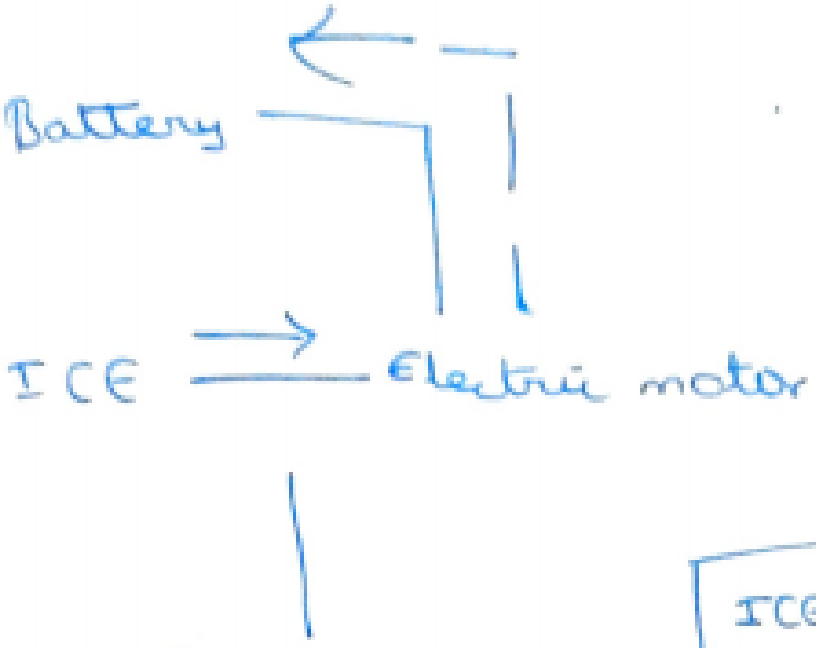
- Engine and motor can simultaneously power the Transmission / wheels.
- HEV cannot be recharged from power grid
- Their energy comes entirely from gasoline and ~~reneg~~ regenerative braking.

Facts :

- Original purchase price is comparable to similar ICE vehicles.
- HEV have advantage over BEV - consumers are already comfortable with gas - or diesel fuelled vehicles.
- HEV offer readily - available fuel for long distance driving and have significantly increased range compared to

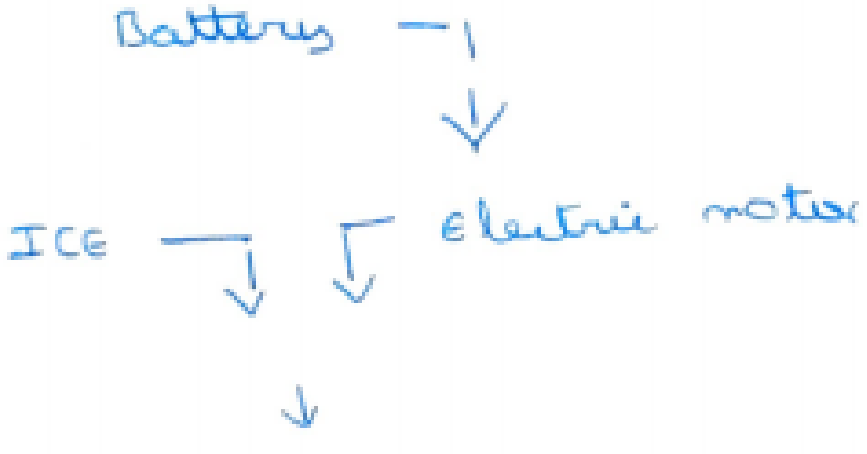
HEV:

Starting



ICE and motor is parallely connected

Pausing :



Types of EV:-

- HEV (Hybrid)
- BEV (Battery)
- FCEV (Fuel cell)

HEV

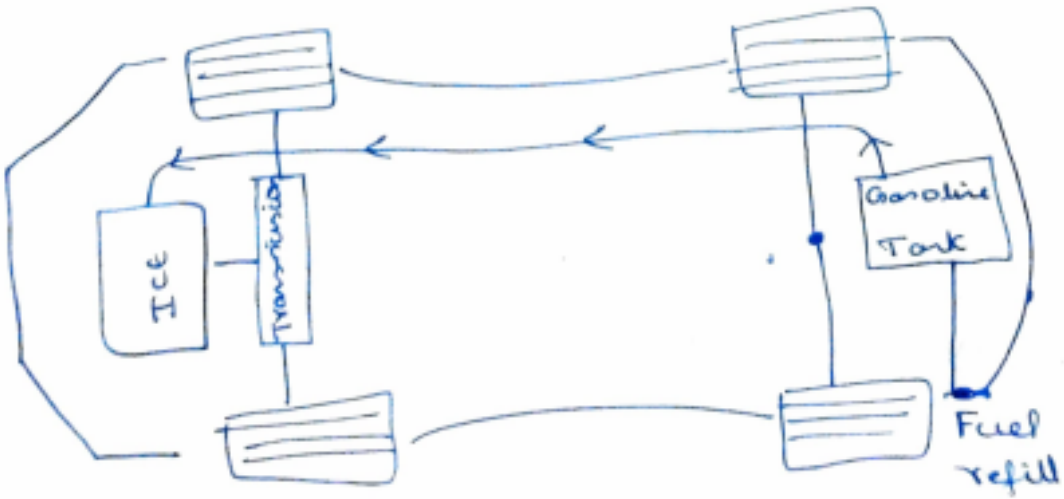
(Based on degree of hybridization)

HEV

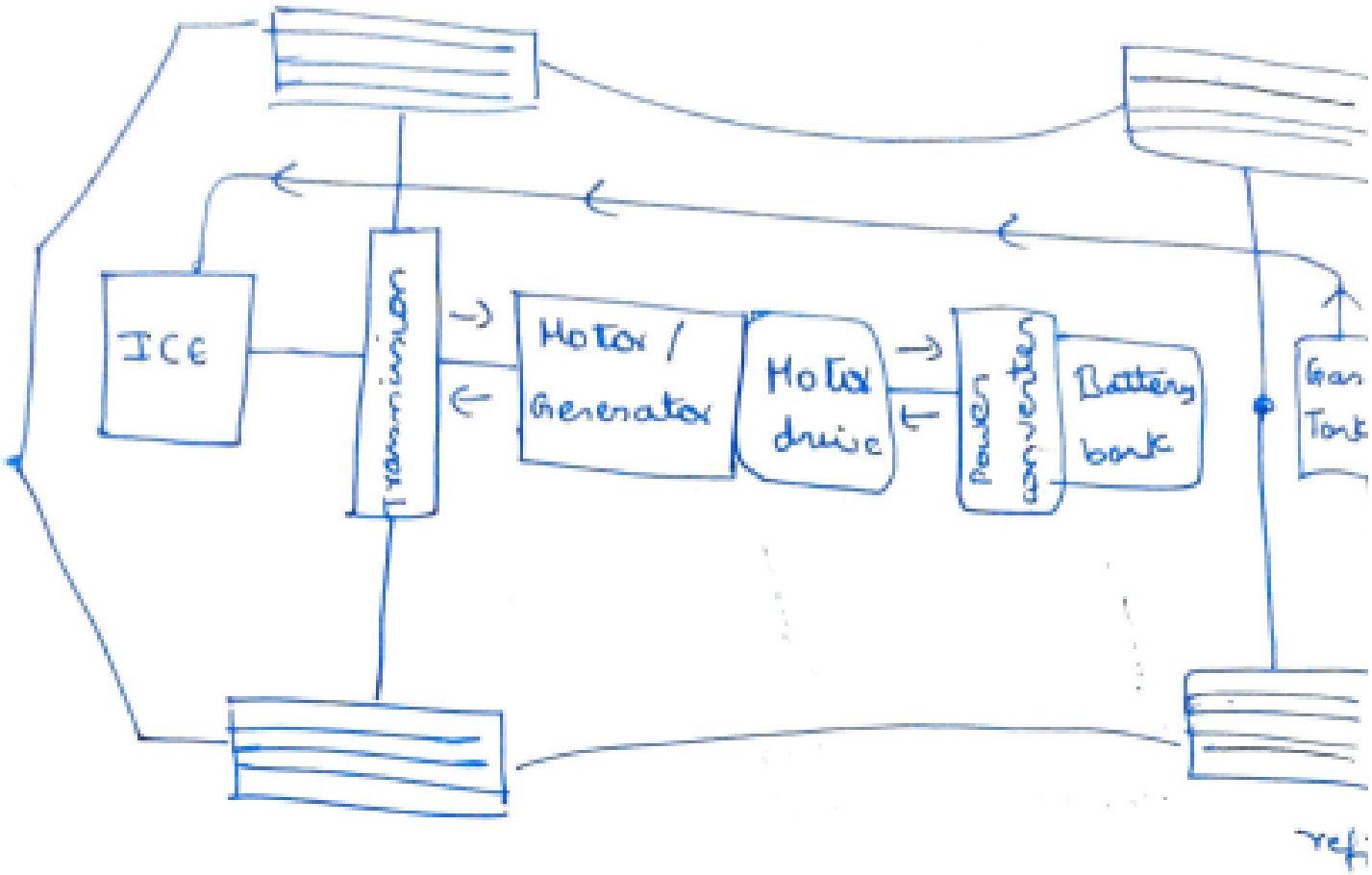
(Based on Hybrid Architecture)

~~ICE~~

Internal combustion engine:



HEV parallel Vehicle :-



Parallel HEV is the most common configuration

In parallel,

- Both Motor and drive are connected togeth
- Both engine and motor powering the Vehi
- ICE is the primary machine
- Electric motor plays a secondary role
- Motor power < ICE power

Case - III

Hybrid mode

→ ICE - ON
→ Motor - ON
} Both

Case - IV

Battery is low

ICE - Running the vehicle as well as charging battery

- Motor act as generator to charge
- ICE will have seperate generator

(Manufacturers choice)

Case - V

Regenerative braking

→ ICE - off

→ Motor - act as generator (while braking)

PHEV - Plug-IN HYBRID ELECTRIC VEHICLE

(BMW I8)

- User parallel setup
- Engine and Motor will not be have same transmission

For BMW, Engine will be in rear (2L inline engine)

Second mode - Electric driving (E-drive mode)

↳ Electric motor will drive the vehicle (which is front wheel drive). Engine will not be operated.

Dis-adv - • low range (because ICE will be prime mover)

• Max. speed will be low

Sport mode :

↳ Both motor and ICE will be work together

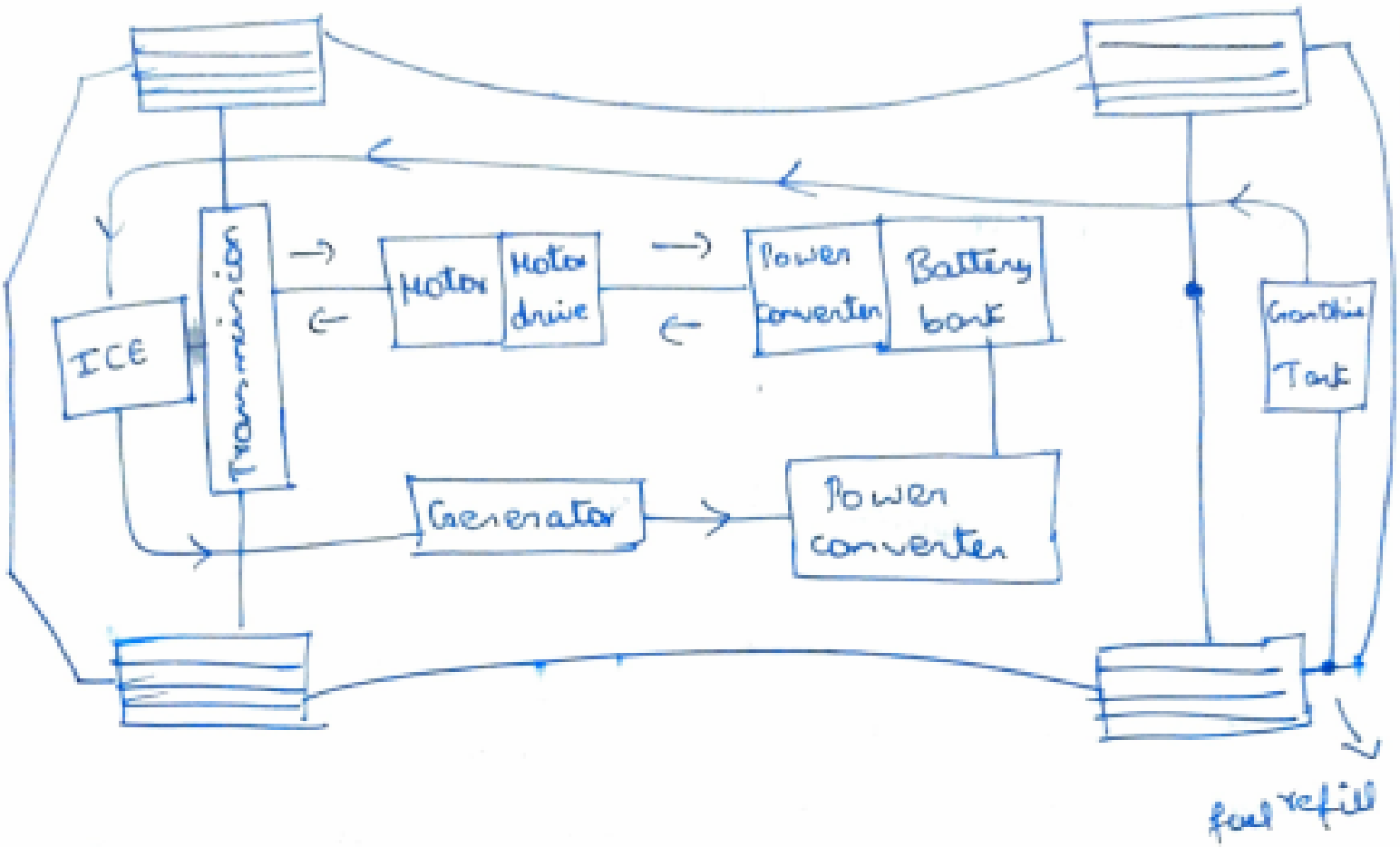
↳ They both work at max. performance.

↳ ICE recharge the battery at the same time

Braking :

• The motor will be act as a generator during braking.

Series Hybrid Electric Vehicle:



In series:

- Motor is connected to transmission and ICE is connected to generator. That generator recharge the battery bank. The motor uses that power to drive the vehicle
- Motor is primary source and ICE is secondary source.

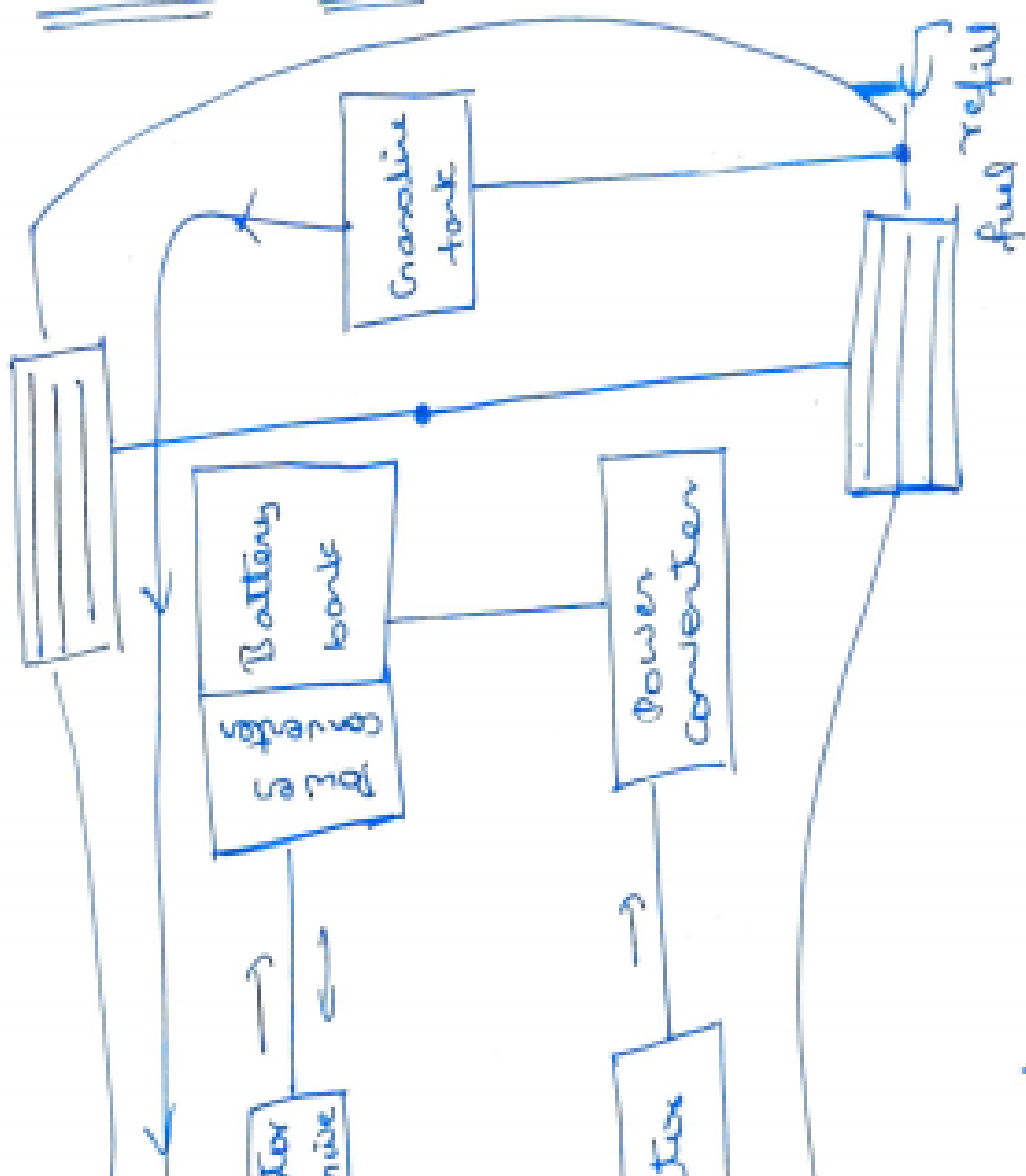
Parallel Hybrid	Series hybrid
ICE engine vehicle fitted with powerful electric motor to assist the engine	Motor vehicle fitted with ICE to recharge the battery bank
ICE has greater power	Motor has greater power.
Battery pack is smaller in size because primary source is ICE	Battery pack will be larger because motor is primary source
BMW i8	BMW i3

BMW i3 :-

- Rear side - Electric motor
- In BMW i3, There is an another model which

ICE size or power will be smaller. Eg:- In bmw i8 (parallel) has 2L 3 cylinder engine. BMW I3 (series) has 1.2L 2 cylinder engine (only for recharging the battery). → Except range extender model.

Series - Parallel HEV :-



Adv :-

cost

In Series - Parallel HEV,

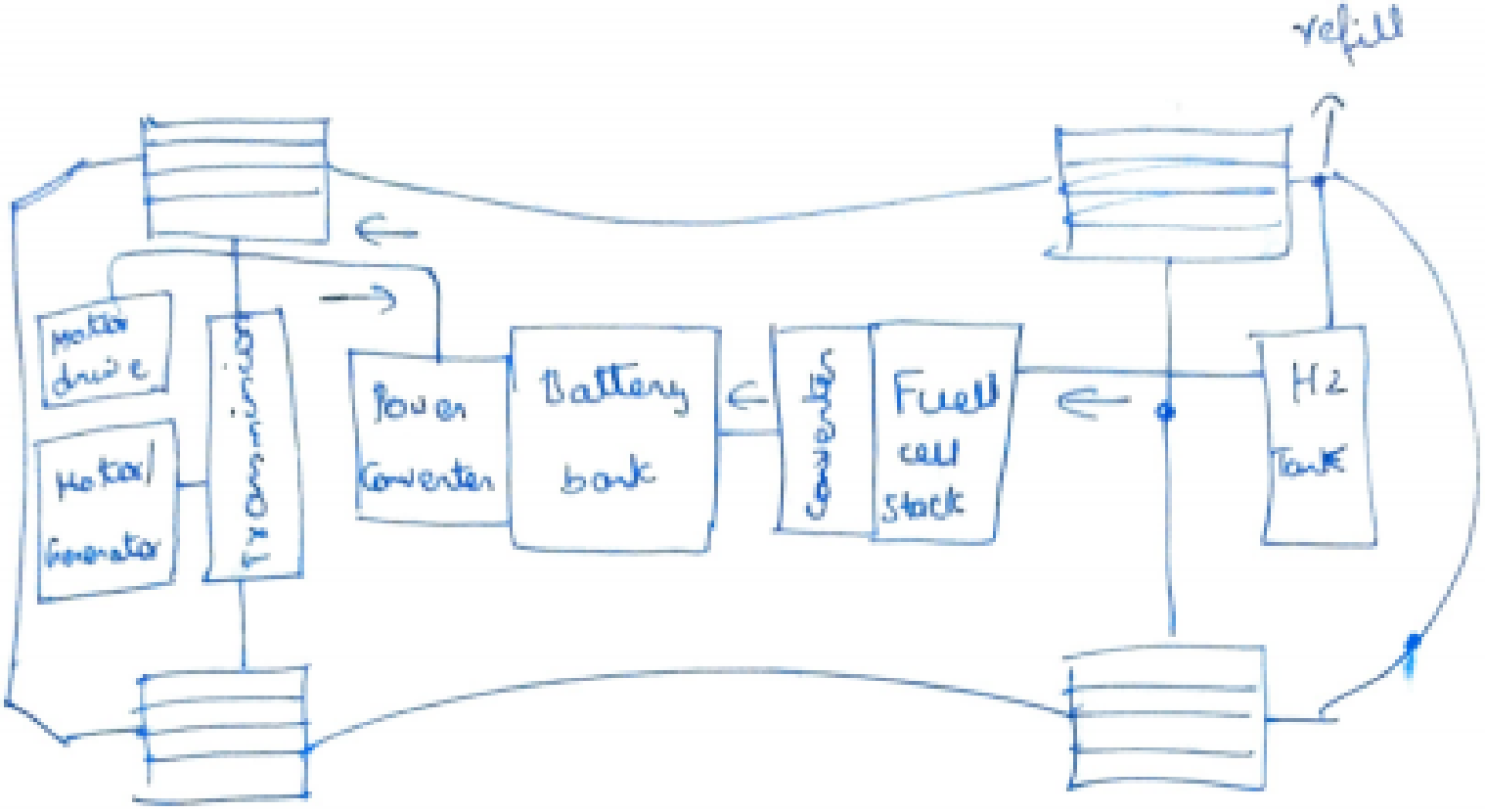
- Powersplit is a device that split the power either to transmision or Generator.
- If a battery bank change is low, the power split direct the power of ICE to Generator to rechange the battery.
- If a battery power is full, The powersplit direct the power of ICE to transmision to drive the vehicle
- We can use either by parallel or Series combination

-X- This combination is brought and used by Toyota (model is Prius)

Drawback - bulky or heavy

- to ring gear

FCEV - Fuel cell Electric Vehicle :



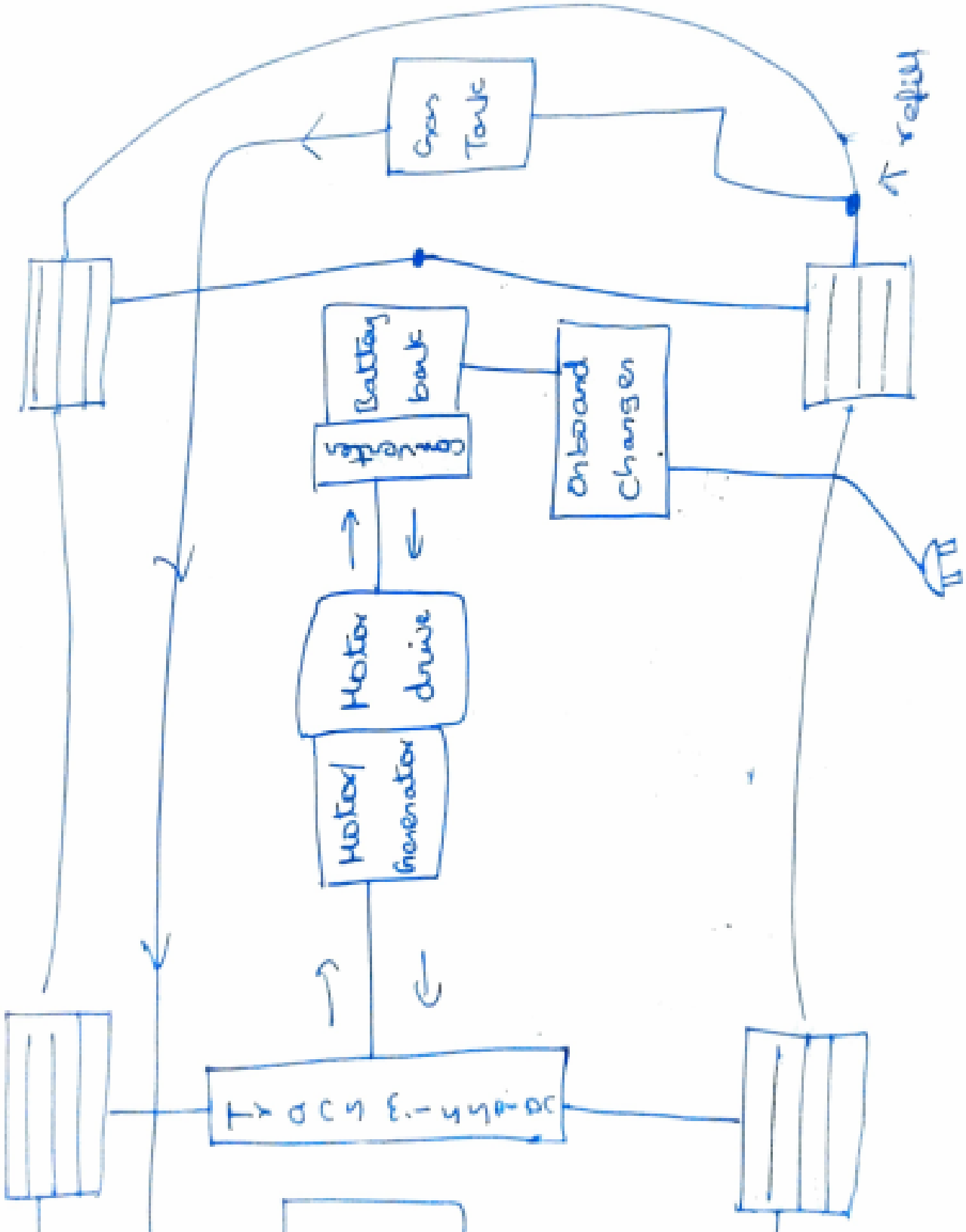
Hydrogen tank will be provide to fuel cell stack which generates energy. The power will be provide to battery bank. The power directs to the motor to drive the vehicle. Eg- Hyundai Nexo

Dis-adv :

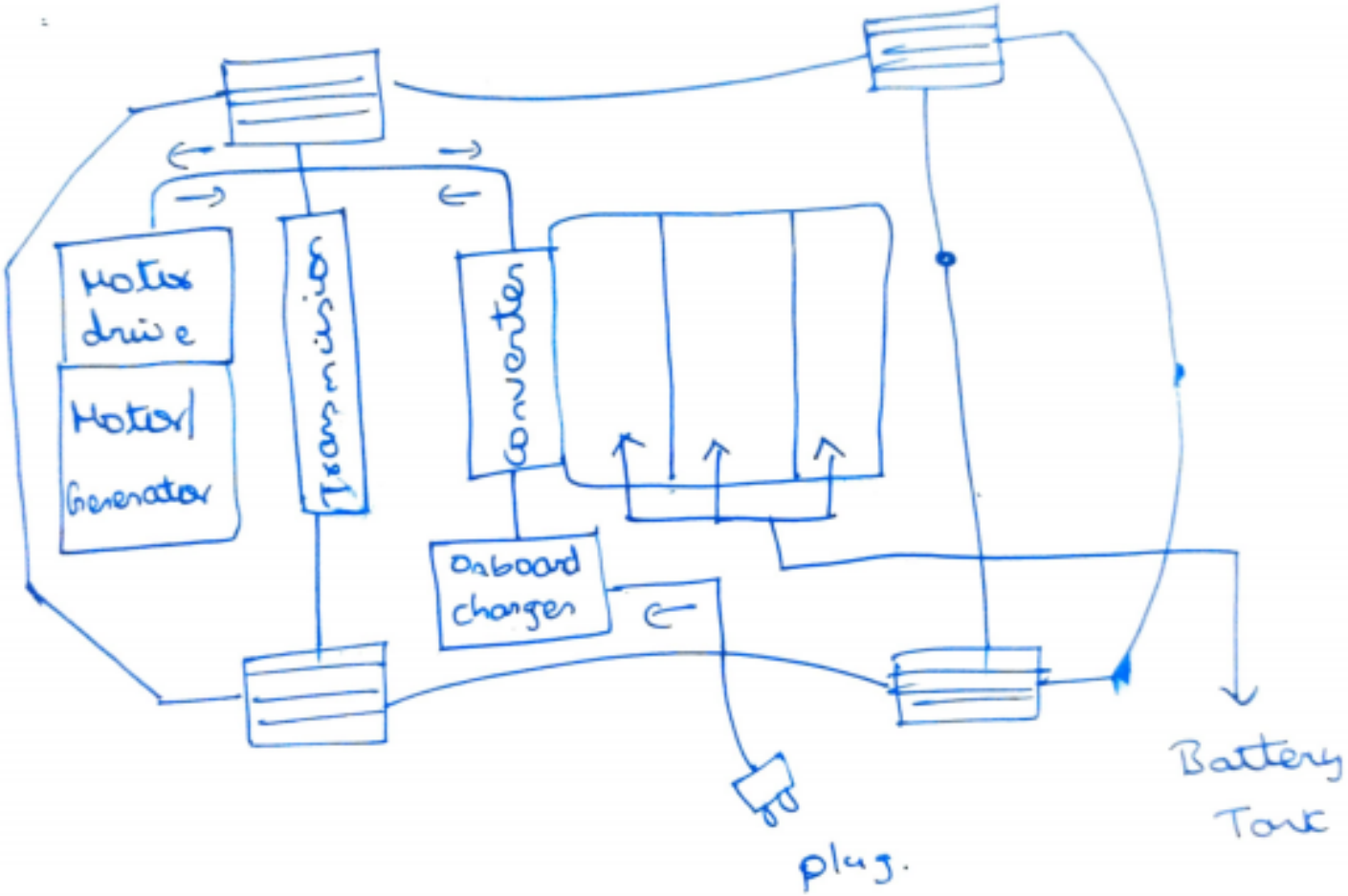
- Difficulty in handling the hydrogen fuel bz explosive in nature.

PHEV ⇒ Plug-In Hybrid Electric Vehicle

Similar to HEV. Battery can be externally charged using onboard charger.



Battery Electric Vehicle



Electric Vehicle Configuration :-

Motor : (Electrical to Mechanical)

	DC	AC	AC
Motors	BLDC (brushless DC)	Induction motor (IM)	PMSM (permanent magnet synchronous motor)
Efficiency	$\eta_{max} = 95\%$ $\eta_{min} = 35\%$	$\eta_{max} = 90\%$ $\eta_{min} = 65\%$	$\eta_{max} = 98\%$ $\eta_{min} = 75\%$
Cost	X x 3	Cheapest (let x be IM)	X x 2
Weight	0.3 - 0.4 X	Heaviest (let x kg)	0.5 - 0.8 x
Application	2W, 3W ~ 15KW	Heavy truck	Passenger cars, Bus..

Motor

- DC
  - DC series
  - BLDC
- AC
  - Induction
  - Synchronous
    - PMSM (Permanent magnet)
    - IMSM (Interna magnet

Motor

(in term of design or architecture)

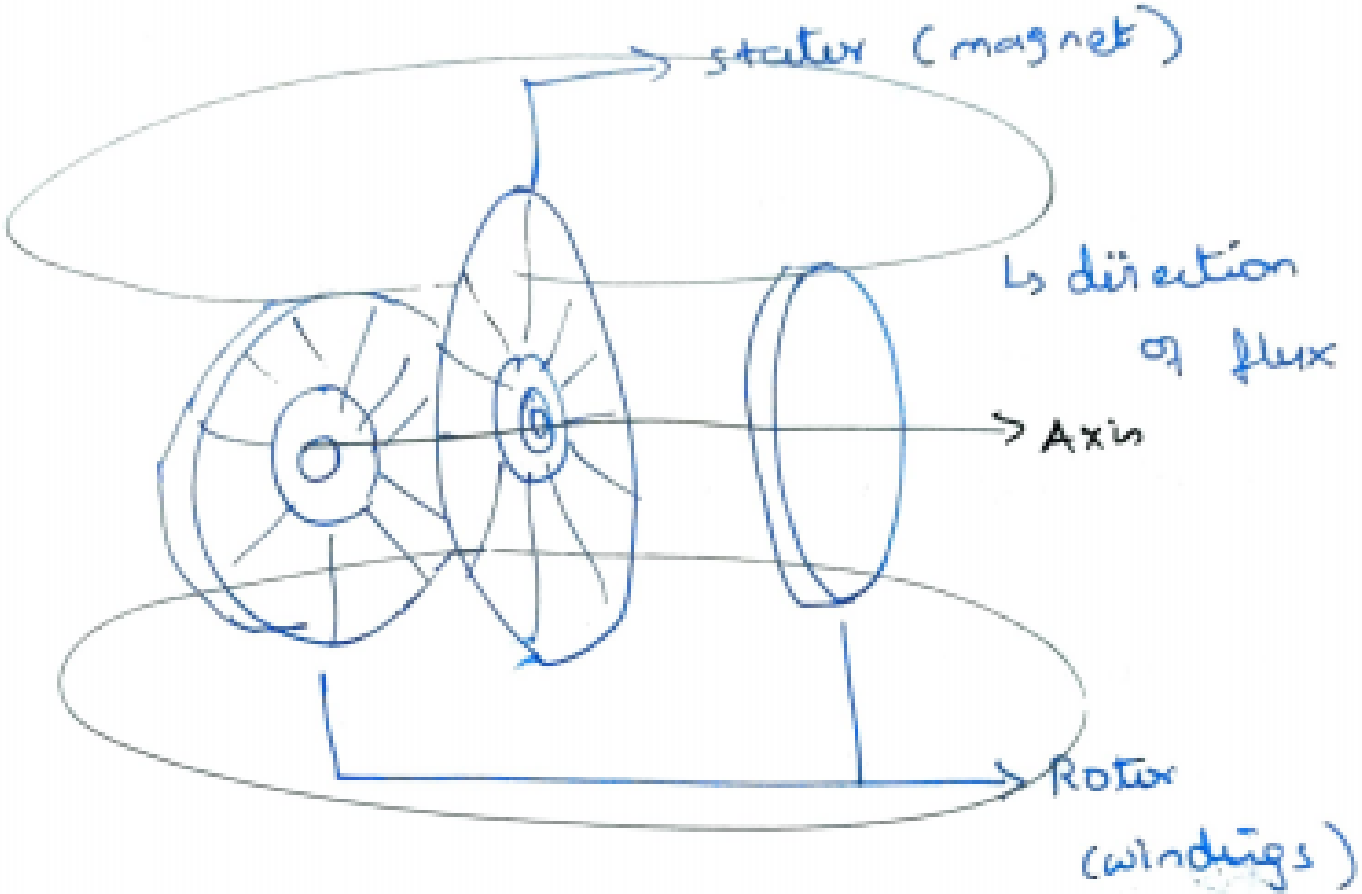
- Radial Flux
- Axial Flux.

Normally,

Magnetic field is along the radial line R

So, Radial flux motor.

Axial flux:



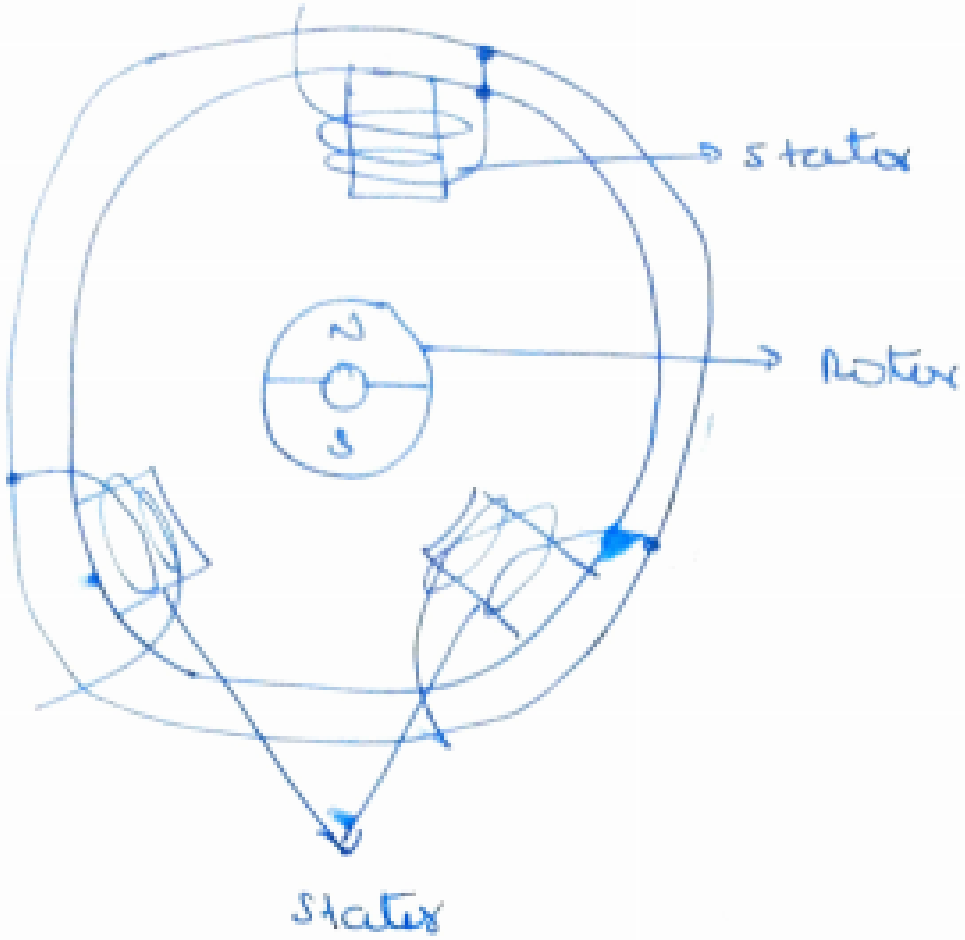
The flux direction is parallel to rotational axis, so its called axial flux motor.

The research on this going on because of its advantages,

- Better flux density
- Better efficiency than radial flux

BLDC Motor :

DC motor that does not have brushes. The controller provides pulses of current to motor windings which control the speed and torque of synchronous motor. BLDC motor works on the principle similar to conventional DC motor, ie lorentz force law which states whenever a current carrying conductor placed in magnetic field it experience a force. As a consequence of reaction force, the magnet will experience an equal and opposite force



Types :-

Inner rotor design :

Rotor is located in the centre of the motor and stator windings surrounds the motor. As rotor located in the core rotor magnets do not insulate heat inside and heat gets dissipated easily. Due to this reason, inner rotor designed motor produce large amount of torque.

Battery Pack :

- Energy Source of EV
- Controller will communicate with the pack to draw the power, to modulate the V, I and F

Li-ION cells :

- NMC (622) - common model
- NMC (811) - upgraded version
- NCA - Tesla researching on this model

N - Nickel
M - Manganese
C - Cobalt

Cost of 48V 150Ah model of Li-ion cell :-

90-50K

Adv :

- Energy density of Li-ion is 6 times higher in Li-ion cell.

Cell Architecture in EV :

- EV Battery is composed of cell → module → Pack.

Battery cell :

Basic unit of Li-ion battery made by inserting cathode, anode, seperator and electrolyte into rectangular aluminium case.

(5000 - 10000 cells in EV)

Battery module :

Battery assembly put into a frame by combining fixed number of cells to protect from external shocks, heat.

- In simple terms, battery cells are arranged in series or parallel combinations.

Battery packs :

Final shape of battery pack.

Composed of battery module and various controls or protection system including BMS, cooling system, etc...

EV battery voltage and Capacity spec :

- A common pack is composed of blocks of 18-30 parallel cells in series to achieve a desired voltage.

- Battery capacity ranges :

What happens if we use lower voltage in EV?

- If voltage is lower means current will be higher
- If current higher, voltage drop, I^2R losses will be more.

Components of EV battery :

- Battery pack
- BMS
- Battery Heating / cooling system
- On-board charger (OBC)

Battery Management System :

System that protects and manages rechargeable batteries.

Characteristics :