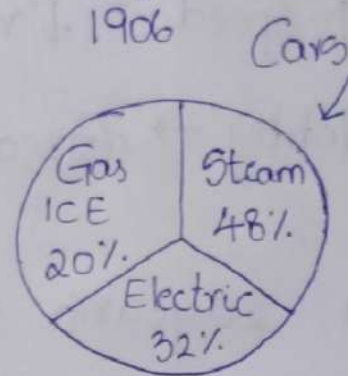


Unit 1 - EV industry

1906 year

100 miles range (1 charge)

top speed $\rightarrow$ 40-50kmph



Why EV gained popularity?

1. No emission
2. Efficient
3. low cost
4. Easy start

Steam engine 45 mins to start
Gas engine 15 mins to start

1906-1910 $\rightarrow$ Golden era of EV. [EV faster than ICE]

Why did EV decline after 1910?

1. Henry Ford $\rightarrow$ assembly line production
ICE engine had 30% reduction every year.
2. Chevrolet $\rightarrow$ 1912 (self start mechanism)
3. World War $\rightarrow$ Range
Charging time } effected & non reliable.
fuel can be carried / but not electricity.

"Harley Davidson became popular of world war".

EV $\rightarrow$ $\uparrow$ speed $\downarrow$ range

4. Oil lobby $\rightarrow$ Great depression of USA.

Within 20 years $\rightarrow$ ICE engines are harmful for environment.

Event : the great smog [5/12 - 9/12 1950]

in London for 4 days, smog was thick and dense.
due to pollution - 12000 deaths.

In 1960's

California - 600 cases per day $\rightarrow$ some diseases caused
by pollution [each day]

48% pollution $\rightarrow$ automobiles

CARB $\rightarrow$ California Air Resources board (1970's)

$\hookrightarrow$ independent of central govt (US).

$\hookrightarrow$ 1st to release emission regulations

India $\rightarrow$ 2003 $\rightarrow$ emission regulations.
2004

1970 - 2003 [control pollution by 80%].

1991 → low emission vehicle 1 (1993-2003) [LEV1]

- mandatory for all manufacturers to provide an EV alternative to market

EV → ZEV (zero emission vehicle).

GM EV1, RangeRover EV, Toyota Prius, etc.

[GM → general motors]

↳ lease agreement only / rent for duration (2yrs min)

1996 → people filed a case against CARB led by MG E1 Range Rover.

1999 → won the case, CARB has pulled [LEV1]

2003 → LEV 2 program → CARB

- LEV (low emission vehicle). 10-15% ↓
 - hybrid • ULEV (ultra low emission vehicle). 70-80% ↓
 - PZEV (pure zero emission vehicle). 0% ↓
- } emission

2006 → Santa monica auto expo
tesla roadster displayed in people went crazy.
↳ [180kmph] [150miles].

PHEV → plug in hybrid EV | BEV → battery EV

2008 → tesla displayed its 1st vehicle.

2010 → Nissan leaf → "1st affordable 5 door hatchback EV" → family vehicle

Range - 110 miles

Speed - 130kmph

tesla roadstar & nissan leaf flipped the EV market.

Bloomberg NEF → Yearly statistic data

2011 → 40000 Sales

2012 → 100000 Sales

2015 → 2017 → 50% growth

2017 → 2018 → 80% growth

2018 → 2019 → 10% growth (drop).

in 2015 Chinese govt provided subsidy for EV

in 2017 subsidy was increased by 15% for 2yrs.

2019 aug ↓ subsidy by 20%. (drop in sales)
govt.

Sales ↓ 80%. immediatly.

dec 2020 → 600000 EV were sold globally.

Germany → 200↑

(i). Govt subsidy ↑ 30% (during pandemic)

(ii). intro to green credit → low interest rate

for individual

→ every charge → 20% refund in cash.

[100kwh → 20kwh refund]

max production

for industry: 80% less production credit score for every vehicle helped in govt. contracts.

Indian Scenario: JMK Research

EV due to petrol rise

EV consumption ↑ due to petrol ↑ } petrol prices

2Wheeler ✓

3W

busses ✓

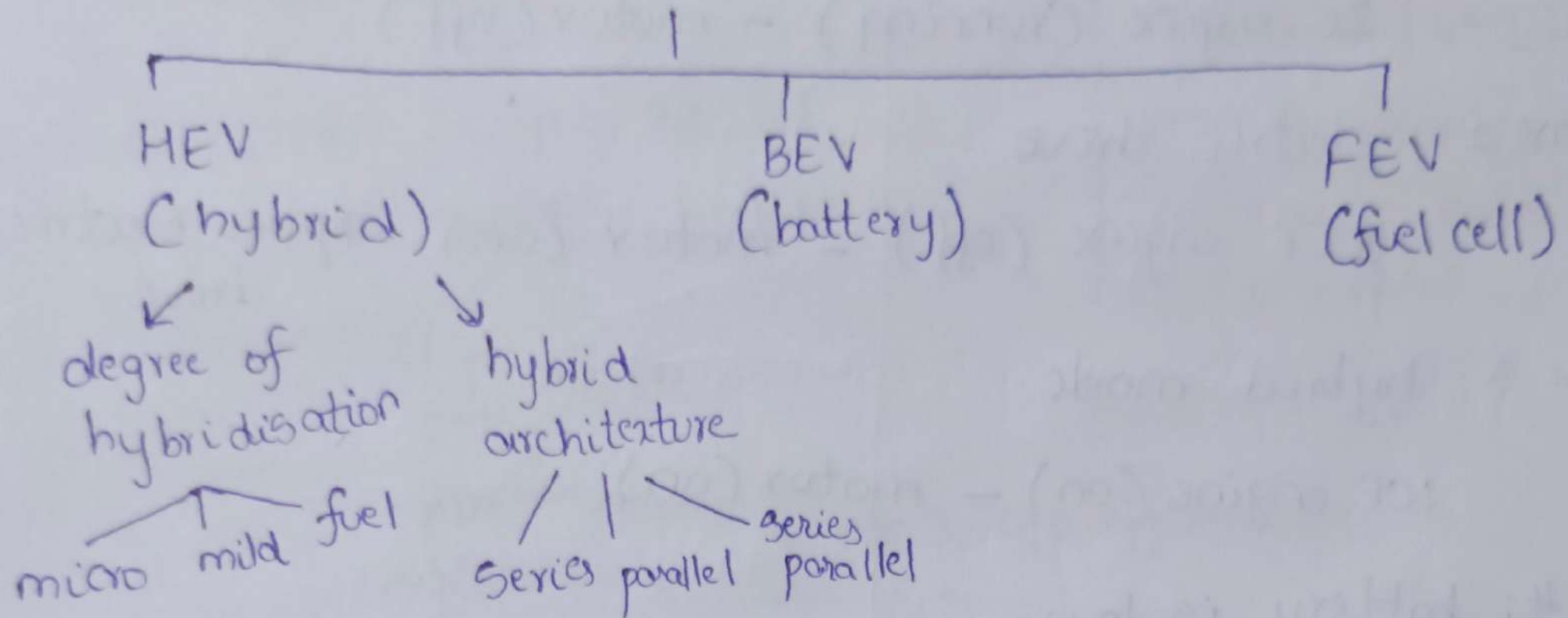
Commercial vehicle } demand in India.

Atter, Revolt & Ampere ✓✓

heroelectric high demand for basic commodities.

→ Parallel hybrid EV:

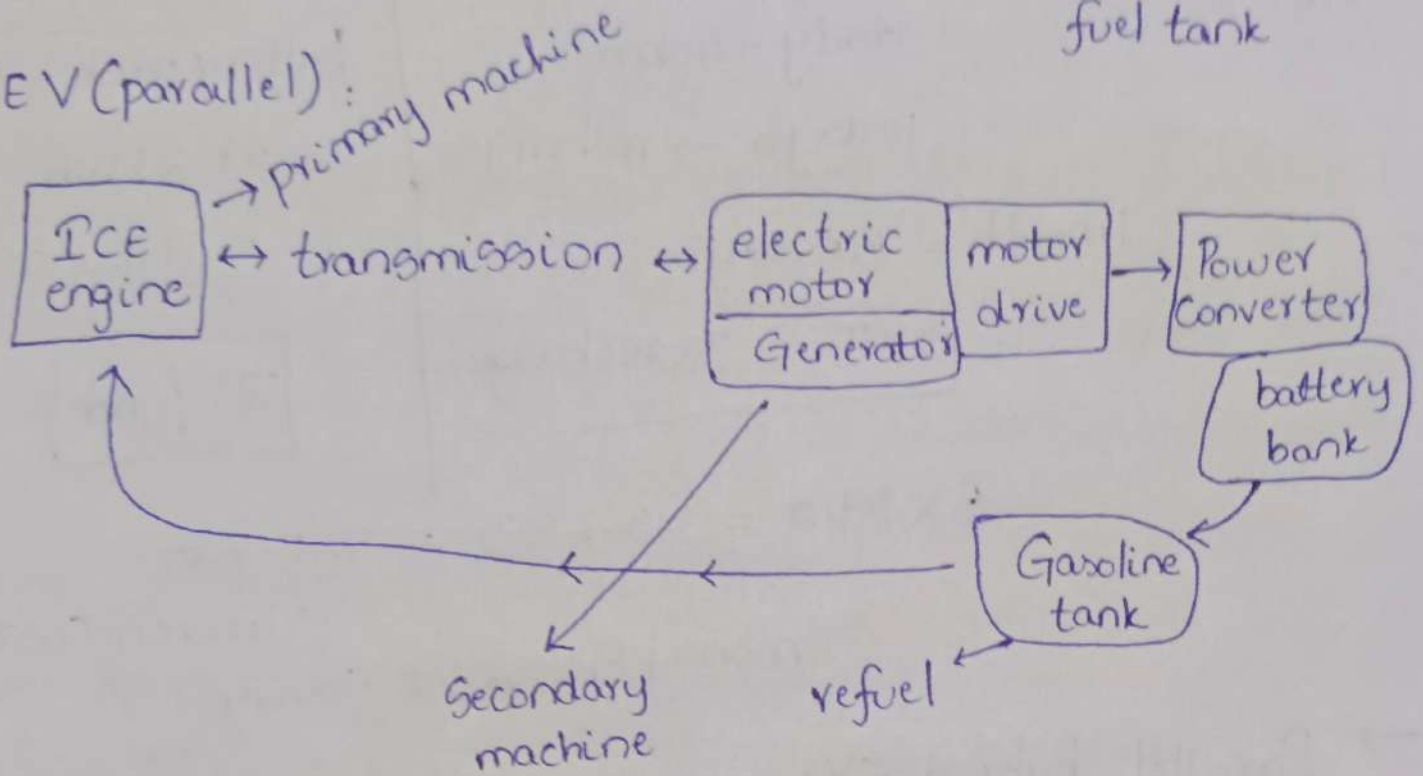
types of EV



ICE car:

ICE engine → transmission → Gasoline tank
↓
fuel tank

HEV (parallel):



Case 1: ICE engine drive

ICE engine (running) - motor (off)

Case 2: electric drive

ICE engine (off) - motor (on) → pure electric drive

Case 3: hybrid mode

ICE engine (on) - motor (on)

Case 4: battery is low

ICE engine → vehicle

↳ battery charging

case 5: Regenerative braking

ICE engine (on) $\rightarrow$ motor as generator

Case study

BMW I8: 2L inline V3 engine

BMW in a hybrid mode

4wheel drive $\left\{ \begin{array}{l} \text{motor} - \text{front wheels} \checkmark \\ \text{engine} - \text{rear wheels} \checkmark \end{array} \right.$

twin power turbo

o/p $\rightarrow$ 231 HP

torque $\rightarrow$ 320 N/m

BMW in electric driving

$\left. \begin{array}{l} \text{motor} - \text{front wheel (on)} \\ \text{engine} - \text{rear wheel (off)} \end{array} \right\} \text{front wheel drive}$

less range $\nearrow$

Combined o/p : 362 HP

top speed = 350 kmph

2.5 km / 100 km

max performance

minimal consumption

$\downarrow$

hybrid mode

BMW in sport mode:

$\left. \begin{array}{l} \text{motor} - \checkmark \\ \text{engine} - \checkmark \end{array} \right\} \text{max o/p efficiency} \\ \text{E speed}$

and also charging the battery pack while breaking (motor changes to generator).

→ Regenerative braking is used for all EV's from 1980's.

→ Series Hybrid

```
graph LR; ICE[ICE] --> Trans[trans mission]; Trans --> Motor[motor]; Motor --> MD[motor drive]; MD --> PC1[Power Converter]; PC1 --> Battery[battery]; Battery --> PC2[Power Converter]; PC2 --> Gen[Generator]; Gen --> ICE; ICE --> SS[Secondary Source]; Battery --> PT[Primary Source]; GasTank[Gas tank] --> Refuel[Refuel];
```

motor > ICE [power]

[Commonly seen]

Parallel hybrid [BMW i8]

Series hybrid [BMW i3]

- | | |
|---|---|
| <ul style="list-style-type: none">• ICE vehicle fitted with a powerful electric motor to assist the engine.• [ICE $\rightarrow$ powerful]• battery pack is small | <ul style="list-style-type: none">• EV fitted with ICEngine to recharge battery pack• [motor $\rightarrow$ powerful]• battery pack is larger |
|---|---|

BMW i3 — 1.2L, 2 cylinder engine

(i). electric vehicle

cii. electric vehicle + range extension [cost]

BMW-i8-2L
3cylinder
engine

HEV - Series & parallel

Powersplit is used ✓✓ (Series & Parallel)

Toyota Prius - 1995

motor - generator

IC engine → sun gear

back disc to gear box

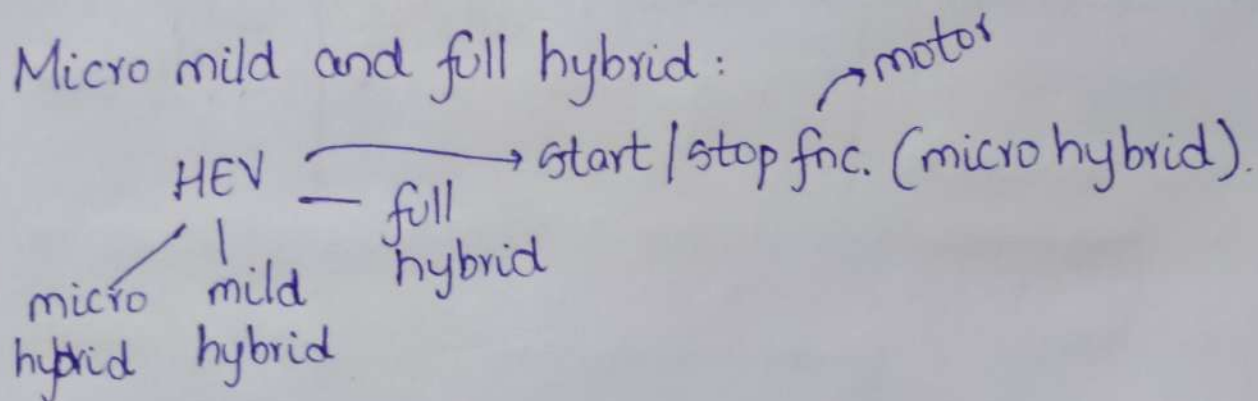
Small generator → generator

→ Fuel cell EV :-

Disadvantage of fuel cell :

1. difficulty to handle H_2 fuel
2. Space of battery in car [less extra space]
3. Cost → high cost.
4. Cost of generation energy per watt.

→ Micro mild and full hybrid :



motor → start stop function + acceleration assist → mild hybrid

motor → start stop fnc + acceleration assist + run vehicle on its own → full hybrid
(BMW i3, i8).

SHVS → smart hybrid vehicle system

↳ ertiga
↳ ciaz
↳ swift } new models.

[m-Hawk engine] → mahindra

↳ mild hybrid

[e-Hawk engine] ↑

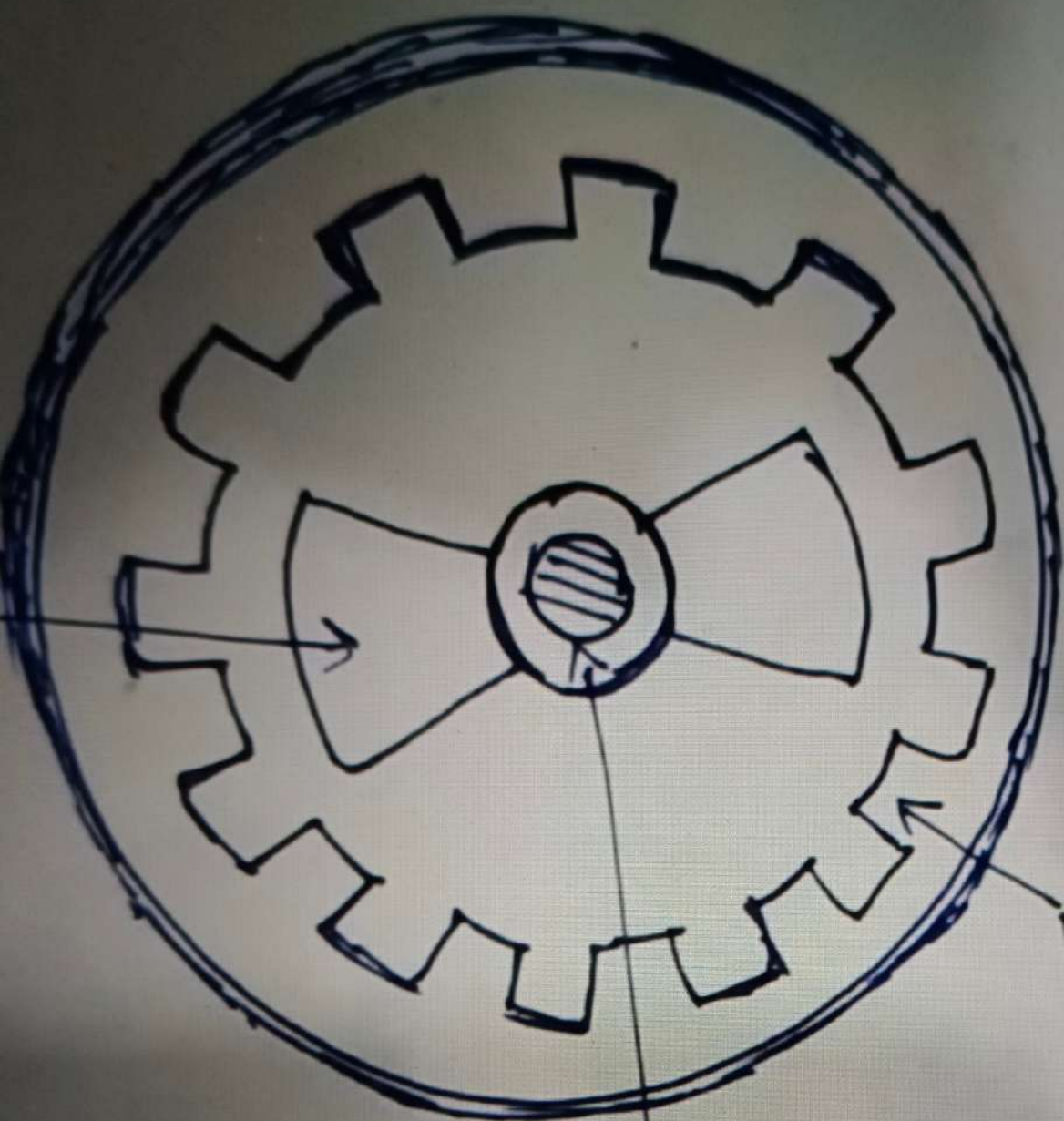
R15 - VVT - Variable valve technology → in budget.

ISG - integrate Starter generator.

↓ ↳ conventional converter/alternator.
to restart the engine.

Regenerative braking system.

Construction of Brushless DC motor:



stator
with winding

shaft

permanent magnet