Virtual Student Mobility Programme on Water-Energy-Food-Public Health Relationships

Group 4 : Control of Energy Flows in a Hybrid Electric Vehicle

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Problem Statement

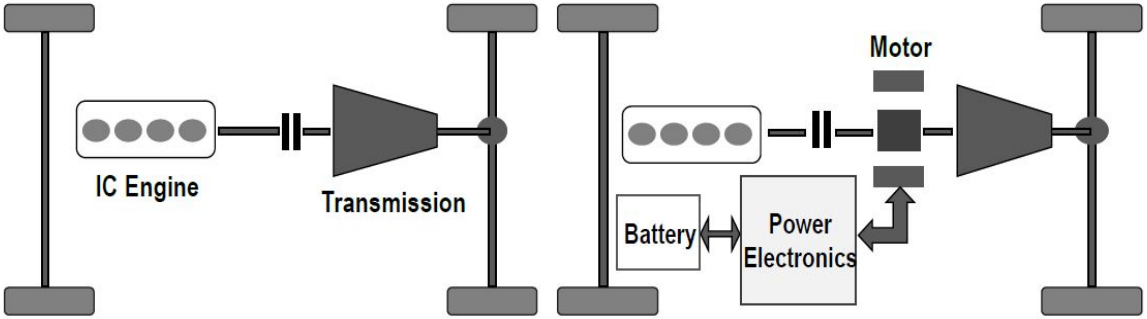
Part A

In a country such as India the focus has been on developing pure EVs rather than HEVs. However, the market share of 4-wheeler EVs in India has remained abysmally low. What is the reason for it? And do you believe focussing on HEVs could be a solution towards increasing the market penetration for electric mobility? Note that market penetration depends on the customer perception of various cost related factors.

Part B

What are the different ways that consumption of energy relates to factors that negatively impact climate change, in the context of HEVs?

Electric Vehicles : Variants and Components



Conventional Vehicle Powertrain

Electric Vehicle Powertrain

Types of Electric Vehicles

1. Battery Electric Vehicles
2. Series Hybrid Electric Vehicles
3. Parallel Hybrid Electric Vehicles

Many Variants

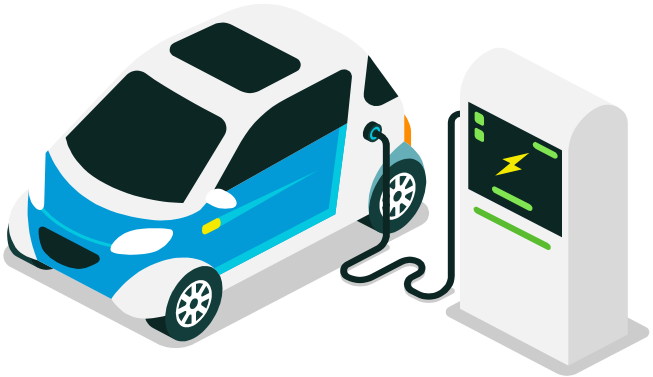
1. Micro, Mild and Strong Hybrids
2. Plug-in Hybrid

Electric Components

1. Motor
2. Battery
3. Power Electronics
4. Charger

Source: Prof. Siddhartha Mukhopadhyay (Department of Electrical Engineering, IIT Kharagpur)

Hybrid Electric Vehicles



Hybrid Electric Vehicles (HEVs) : combination of electric power and petrol/ diesel power

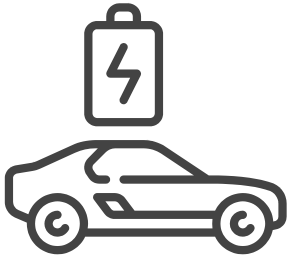
There are two types of HEVs:

- HEVs charged by regenerative braking and the internal combustion engine.
- Plug-in Hybrid Electric Vehicles (PHEV) can also be plugged into a power source

Types of batteries used in HEVs

Lithium-ion

Sodium



Nickel-metal hydride

Hydrogen fuel cells

Current Scenario in India

- The Electric Vehicles market is still in its nascent stage in India
- For higher adoption we require lowering costs for batteries, policy push, and the development of a supporting ecosystem for electric vehicles (EVs) which will lower the total cost of ownership (TCO) (cost of acquisition , running , maintenance)
- Business models such as battery leasing, battery swapping, charging infrastructure, stationary storage, and smart grid solutions are working to make the EV proposition more attractive.
- Sensitivity analysis of TCO for acquisition, running, and maintenance costs suggests that acquisition cost is the most important determiner of viability, making it imperative for OEMs to invest in product design, supplier networks, and the right business models to reduce costs. Battery cost is an important driver of a vehicle's acquisition cost

Factors affecting Demand

01
Costs

02
Clean

03
Coverage of public transport

04
Congestion.

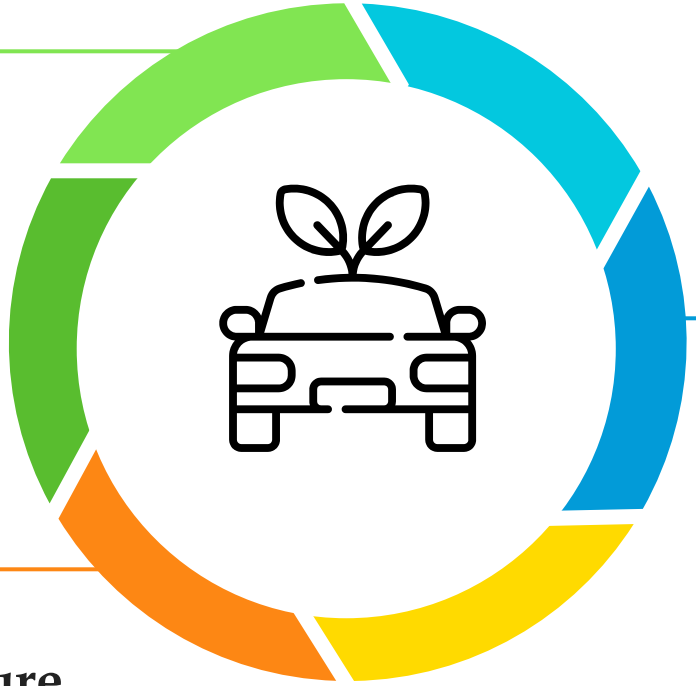
05
Comfort and convenience

06
Country demographics

Factors affecting Supply

01

Lower costs



02

Policy and regulatory frameworks

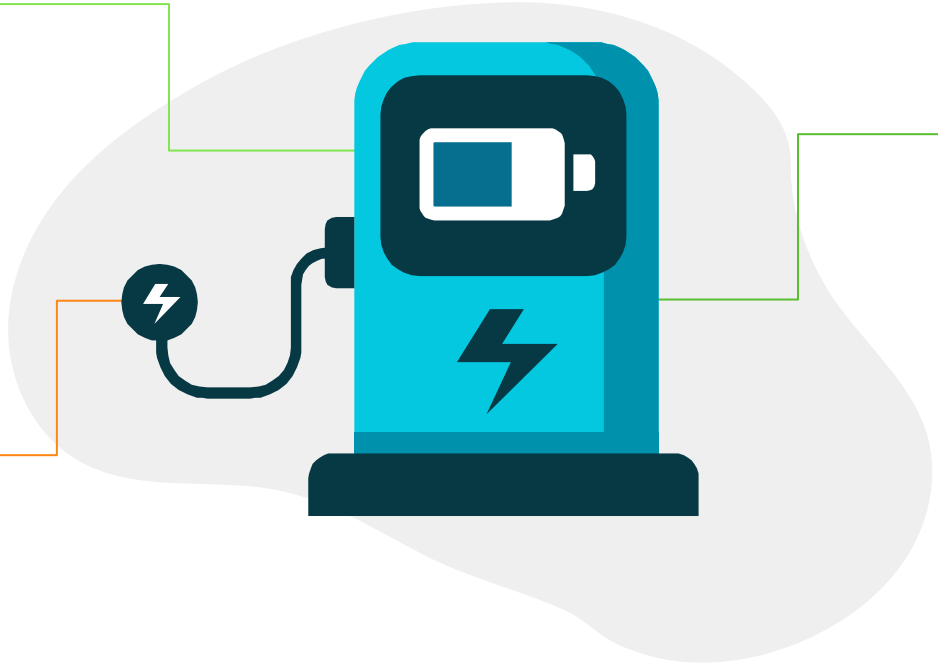
03

A push to develop charging infrastructure

Market Segmentation

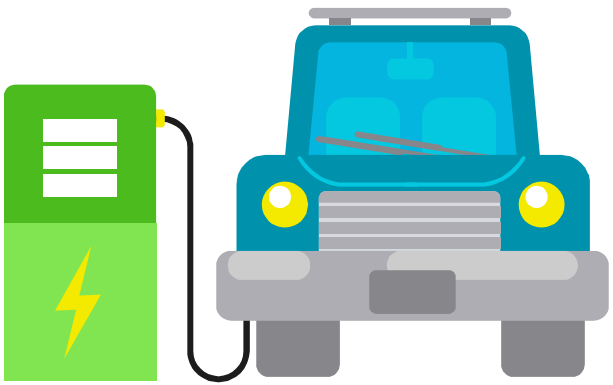
Passenger Vehicles

Commercial Vehicles



Buses

Passenger Vehicles (Personal Use)



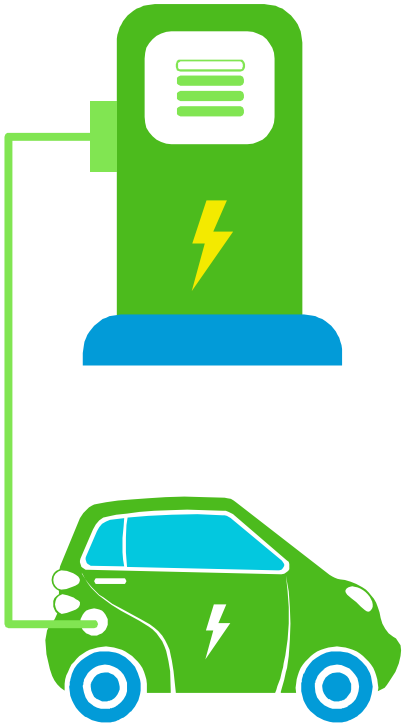
Wider adoption faces several challenges, such as lack of comparable product options, range anxiety, and lack of experience with EV

At current petrol prices, the TCO for electric cars is costlier than for petrol cars with daily running of less than 40 to 45 kilometers

Electric vehicles, however, will still face strong competition from compressed natural gas (CNG) vehicles

Given the current trends in battery pack technology, it would take another three to five years before batteries are available at such price points in India

Passenger Vehicles (Commercial Use)



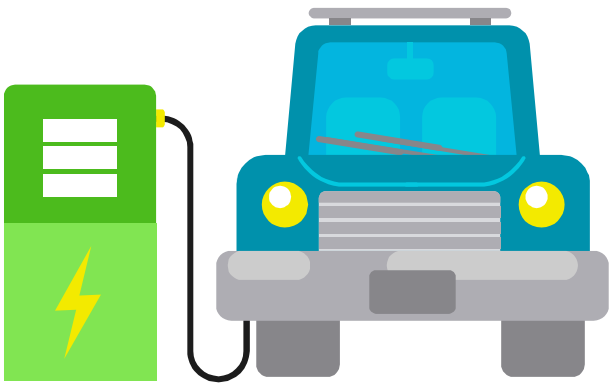
The TCO comparisons for electric and diesel entry level sedans show electric are feasible than diesel over 35 km range.

Since most commercial vehicles require average use of 150-200 km electric cars offer better TCO proposition

Platform providers for ride hailing ,large fleet operators and independent taxi owners can fuel the demand

Offering bundled after sales , partnerships with financiers for large upfront cost can bring down TCO and build consumer confidence

Buses (InterCity)



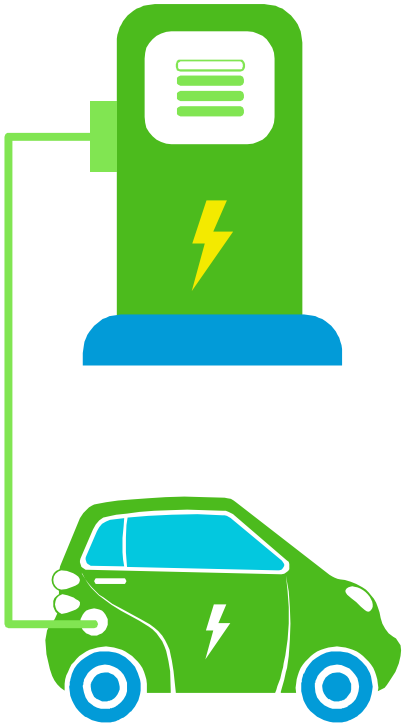
low penetration because of the high acquisition costs , lack of experience , for various stakeholders and lack of charging infrastructure on highways

The TCO for electric buses in intercity coaches is more attractive than diesel buses at daily distances of more than 200 kilometers

Acquisition costs for electric buses are much higher even after subsidies

The full-range luxury AC segment is best suited for electric bus adoption in applications with flexibility to charge higher tariffs.

Buses (IntraCity)



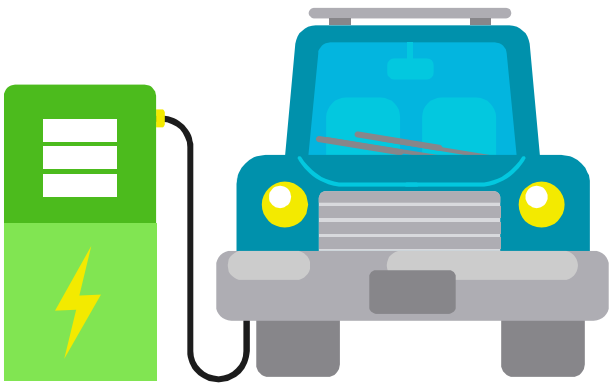
With the subsidy on acquisition costs, electric buses have TCO parity with diesel buses at current levels of daily usage of 200 kilometers or more

Possible increase in diesel prices, higher daily usage, or better subsidies and incentives will impact the TCO in favor of electric buses.

CNG buses are a strong competition to electric buses because of their lower acquisition and running costs.

Electric buses should therefore be positioned in cities that do not have an evolved CNG network

Commercial Vehicles



Small commercial vehicles (SCVs) are expected to be the early adopters, eventually propelling other segments

Electric SCVs have a TCO that is comparable with diesel vehicles only above daily usage of 170 to 180 kilometers

CNG SCVs are the most efficient, with 30 to 40 percent lower running costs at a similar acquisition cost compared with diesel

Since electric SCVs will have a comparable TCO only at daily usage of 450 kilometers

Sensitivity Analysis of Different Segments

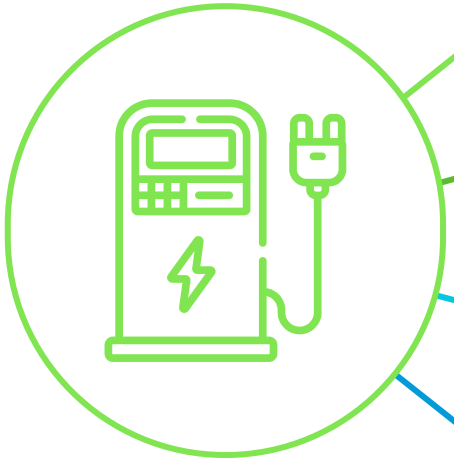
Sensitivity of TCO to individual EV components

Vehicle segments	Sensitivity		
	Acquisition cost	Fuel cost per kilometer	Maintenance cost
Passenger vehicles (personal)			
Intra-city buses			
Small commercial vehicles			

High sensitivity Low sensitivity

Sources : Kearney Mobility Report

Viable Business Solution



01 Vehicle Leasing

02 Battery Leasing

03 Battery Swapping

04 Vehicle Sharing

Viable Business Solution

Models	Segments			Suitable players
	Passenger vehicles	Buses	Commercial vehicles	
Vehicle leasing	●	○	●	– OEMs with financing partners or their own financing arms – Independent lease business operators
Battery leasing	●	●	○	– Vehicle and battery OEMs with a financing partner or their own financing arms – Battery OEMs in collaboration with independent players
Battery swapping	◐	○	●	– OEMs in collaboration with an utility player – OEMs in partnership with independent players – Professional charging operator
Vehicle sharing	◐			– Independent players

● High applicability ◐ Medium applicability ○ Low applicability

Sources : Kearney Mobility Report

Establishing Supply Chain

01 **Availability of Technology**

02 **Access to Technology**

03 **Demand Visibility and Standardization**

Establishing Supply Chain

	OEMs	Suppliers	Government bodies
Availability of components	— Partner with other players (supplier and OEMs) to locally manufacture powertrain components at scale, given that individual OEM volume may remain small. — Collaborate with the government to invest in building a supplier base.	— Identify high value-add parts and the best OEMs to partner with, in line with existing capabilities. — Identify carryover components, and create a first-mover advantage.	— Exempt duties on capital equipment to incentivize local production. — Offer grants suitable for large-scale investments. — Create a tax holiday for OEMs and component suppliers to incentivize greenfield or brownfield investments.
Access to technology	— Support ICE suppliers in developing capabilities for EV components. — Collaborate with suppliers, providing technical and financial support for R&D.	— Procure production-ready technology to reduce rejections. — Invest in development of lower-cost alternatives suitable in the Indian market.	— Invest in R&D to develop EV technologies, and tailor them to meet local needs. — Create scientific panels for collaboration on technology development. — Public-private partnerships can play an active role in researching new and upcoming technologies.
Demand visibility and standardization	— Include suppliers in product planning for cost efficiencies in the design phase.	— Standardize components across multiple OEMs to achieve scale.	— Support standardization of technologies by adopting common standards for better asset utilization and scale.

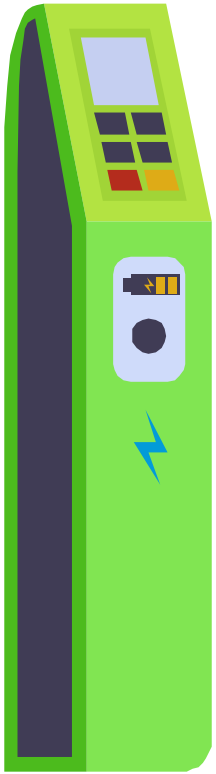
Sources : Kearney Mobility Report

Supporting Infrastructure

01 Limited Garage Space

02 High Downtime

03 Limited Depot infrastructure



04 Charging Standards

05 Power Production

06 Last Mile infrastructure

Shareholders and Roles

Industry Bodies

Government

OEM

Citizens

Negative Environmental Impacts of Hybrid Vehicles

Issues related to Batteries –

- Lithium-ion-based batteries (most common) – high sensitivity to external environment
- Nickel-hydride batteries - human carcinogen , improperly disposing can pose an environmental hazard.
- Mining for heavy metals used in batteries (nickel, copper)

Underground mining contributes to air emissions of various metals and sulfuric acid.

Open pit mining involves stripping of surface trees and dirt to unearth the deposits of minerals.

Emission -

- Hybrid cars reduce smog-forming emissions in the environment, but it may not be by as much as we think.
- According the report by the Connecticut General Assembly emissions only reduced by approximately 10 percent.

Dirty energy sources –

- Most city's or state's power grid are fuelled with coal or oil, may end up emitting as much or more pollution.

Production stage -

- Extraction and processing of materials used for HEVs creates environmental pollution. The bigger the mass of raw materials (e.g metal, plastic, rubber, glass) used in production of car accessories, the bigger the pollutant emissions

Operation stage -

- CO, NO_x and CO_2 are main emissions from exhausts during fuel combustion

Utilisation stage -

- Emissions from processing and neutralisation of hazardous materials such as rubber.

Looking at Alternatives

Smart City
MISSION TRANSFORM-NATION

Technological Alternatives

1. Lithium Sulfur Batteries
2. Zinc Ion Batteries
3. Aluminum Air Batteries

Solar-powered batteries

Power/charging

- Solar energy from solar panels can be stored and used to power HEVs and EVs
- Home charger unit and unit converter required

Storage

- Power is stored in a solar battery (seen in Tesla and EDF cars)
- Batteries provide backup power without creating greenhouse gas emissions

Costs

- Installation of solar panels are expensive
- Batteries usually cost more than standard diesel generators

Factors affecting charge time

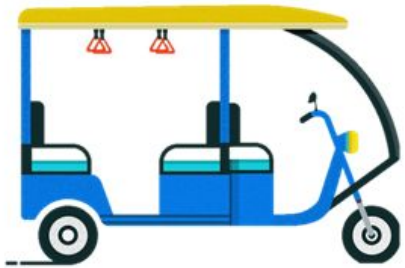
- Temperature
- Angle of solar panel to sun
- Presence of haze or clouds

Public Transportation

Indian bus market represents a significant portion of the 430,000 buses above 6 tonne sold globally.

By 2025, “India will account for more than 10% of the total annual demand for electric buses globally, which is more than Europe and North America combined”

For the market’s potential to be realised, however, clarity on subsidies is necessary and timings must be communicated.



Different state govts of india are focusing on converting the autorickshaws into the electric ones, they are providing subsidies too to the affording people and manufacturing companies as well.

The driving range per full charge of three hours will be 100 km which Will cost around 40-50 indian rupees for electric vehicles but for The same range it would cost 350-400 india rupees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Thank You!