

# Electric Vehicle (EE60082)

---

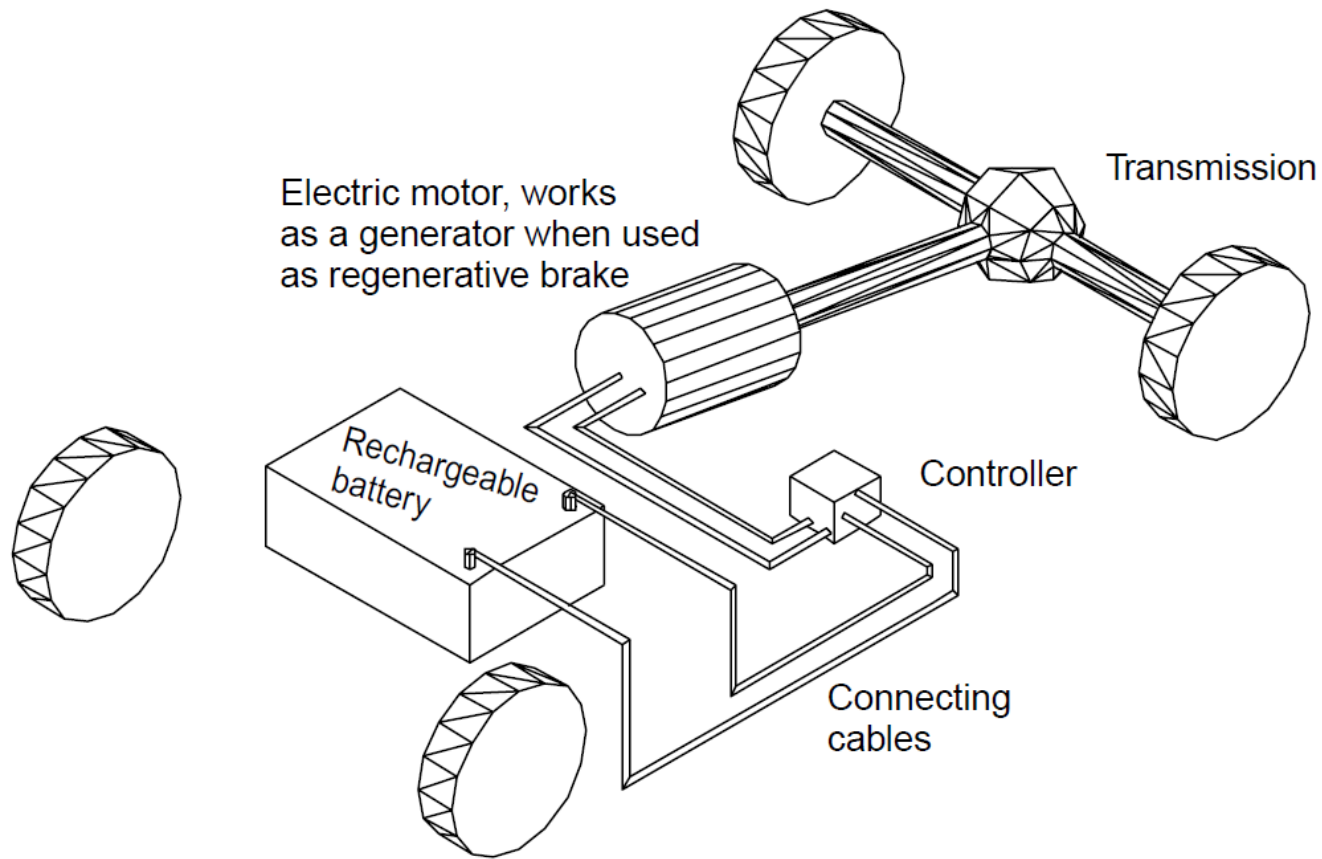
## *Lecture 1: Introduction to Electric Vehicles*

DR. SHIMUL K. DAM

ASSISTANT PROFESSOR,  
DEPARTMENT OF ELECTRICAL ENGINEERING,  
INDIAN INSTITUTE OF TECHNOLOGY (IIT), KHARAGPUR.



# Basic EV structure



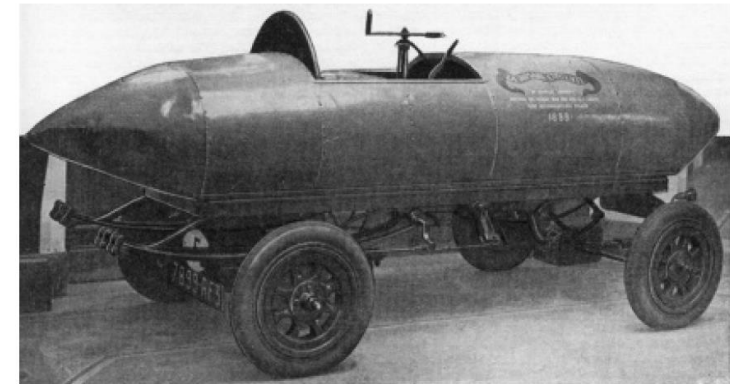
- 1859: lead-acid battery invented by Plante
- 1881: improved lead-acid battery with lead-oxide paste
- 1832: DC motor invented
- 1873: first commercially viable DC motor using a ring armature design

# Evolution of EV

- 1881: The first EV was built by Gustave Trouvé.
  - Tri-cycle driven by DC motor and lead-acid battery
  - not mature enough to compete with horse carriages
- 1894: Electrobat, first commercial EV was Morris and Salom
  - operated as a taxi in New York City
  - Higher initial cost, but more profitable
- 1897: invention of regenerative braking by M. A. Darracq
- 1899: “La Jamais Contente” by Camille Jenatzy, first vehicle to achieve speed over 100 km/h.



Electrobat



La Jamais Contente

# Evolution of Gasoline Vehicles



- 1881: The first EV was built by Gustave Trouvé.
  - Tri-cycle driven by DC motor and lead-acid battery
  - not mature enough to compete with horse carriages
- 1885: Benz Patent-Motorwagen.
  - first practical gasoline-powered automobile
  - It was powered by a single-cylinder four-stroke engine
- 1891: Panhard et Levassor
  - Introduced the "system Panhard" layout: front-engine, rear-wheel drive, and a gearbox
- 1894: Electrobat, first commercial EV was Morris and Salom
  - operated as a taxi in New York City
  - Higher initial cost, but more profitable
- 1896: Duryea Motor Wagon Company
  - first gasoline car manufacturer in the United States
- 1897: invention of regenerative braking by M. A. Darracq
- 1899: "La Jamais Contente" by Camille Jenatzy, first vehicle to achieve speed over 100 km/h.
- 1899: "Daimler-Mercedes" sets record speed of 63 km/h for gasoline automobile.

# HEV timeline



- The first hybrid vehicles reported were shown at the Paris Salon of 1899.
  - to increase range of EVs
  
- Several hybrid vehicles were built during the period 1899–1914.
  
- Dynamic braking by short circuiting or by placing a resistance in the armature of the traction motors
  
- Disadvantages:
  - cost of having an electric motor
  - hazards associated with the lead-acid batteries

# EV disappearance!



- Car sale status in 1900: 4200 automobiles sold:
  - 40% steam powered
  - 38% electric powered
  - 22% gasoline powered
- Next 10 years saw downfall of EV!!
- The last commercially significant EVs were released around 1905

# Causes of EV disappearance

- Rapid development of gasoline vehicle technology
  - 1901: first mass-produced gasoline-powered car
  - 1908: first affordable car for the masses
  - 1911: Introduction of the Electric Starter
  - 1913: Ford Assembly Line – moving assembly line
  
- Cost: Reduction in vehicle cost from \$850 in 1909 to \$260 in 1925. EVs were more expensive.
  
- Reduction in gasoline cost: discovery of new oil fields such as Spindletop (Texas, 1901)

# Causes of EV disappearance

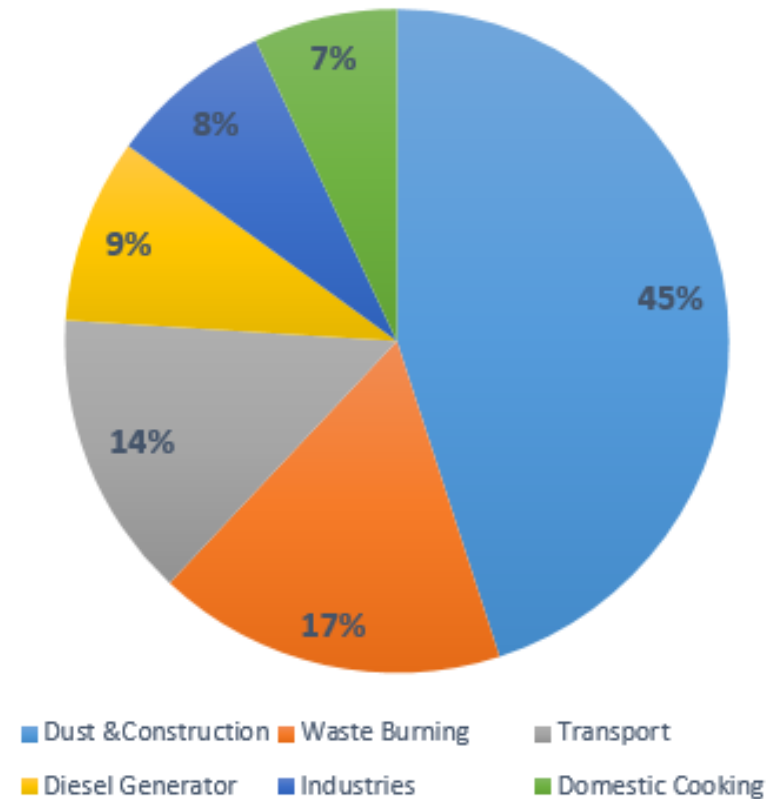
- higher cost
- Infrastructure: Rural areas had very limited access to electricity to charge batteries
- Slow improvement of battery technology
  - Heavy battery
  - Long charging time
  - limited driving range and performance
- Difficulty in motor control
  - controlled by mechanical switches and resistors
  - Limited operating range
  - Very inefficient



# Reappearance of EV – Pollution

- Stringent vehicular emission standards, Bharat Stage VI (BS-VI) in April 2020, similar to Euro VI standards.
- Vehicle Scrappage Policy, Introduced in 2021, mandates the phasing out
  - passenger cars older than 20 years
  - commercial vehicles older than 15 years.
- Incentives for EV adaptation: PM E-DRIVE,
  - subsidies worth 36.79 billion rupees on e-two wheelers, e-three wheelers, e-ambulances and e-trucks
  - Targets to increase EV market share from less than 2% to 30% by 2030.

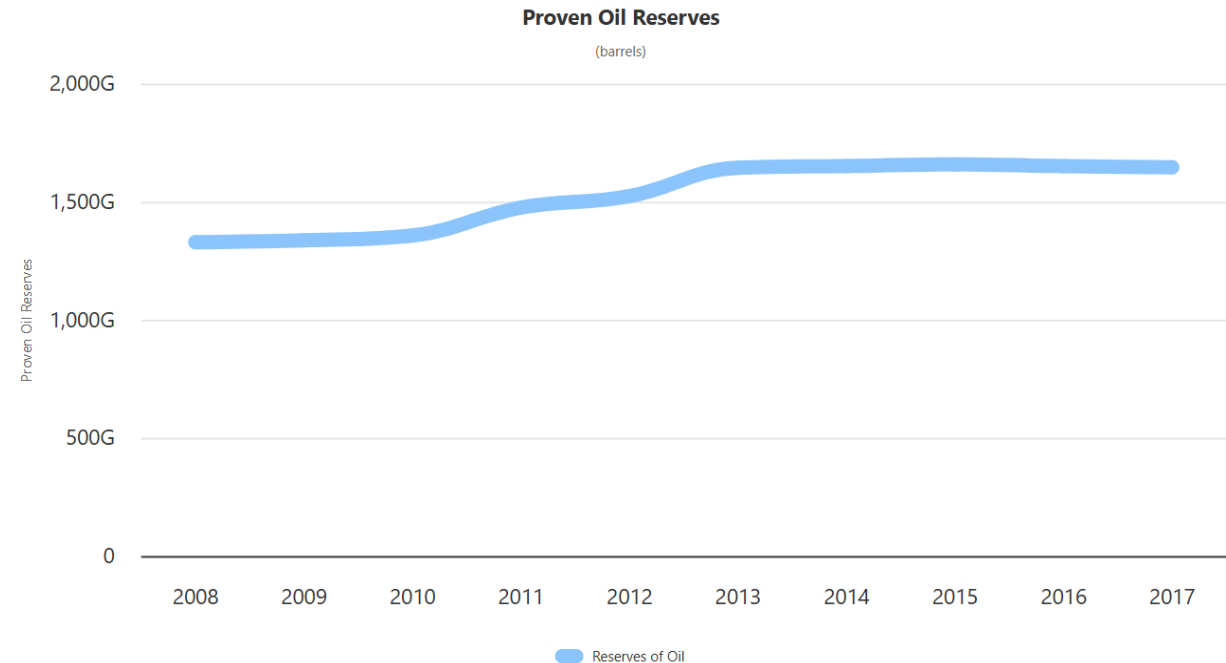
Sources of Air Pollution



[https://en.wikipedia.org/wiki/Air\\_pollution\\_in\\_India](https://en.wikipedia.org/wiki/Air_pollution_in_India)

# Reappearance of EV – Oil Reserve

- Limited oil reserve
- Geopolitical conflicts



OIL RESERVES	
1,650,585,140,000 barrels	
47 years of oil left (at current consumption levels)	

<https://www.worldometers.info/oil/>

# Reappearance of EV - Technology

## Battery technology

- 1970s: Research on Li-ion cells begins
- 1980: Lithium Cobalt Oxide (LCO) Cathode by John Goodenough
- 1991: First Commercial Lithium-Ion Battery by Sony
- 2004: Lithium Iron Phosphate (LFP) Cathode

## Power electronics

- 1947: Invention of the Transistor
- 1956: Invention of Thyristors
- 1975: Invention of IGBT
- 1980s: PWM techniques development
- 1990s: MOSFETs and advanced power converters

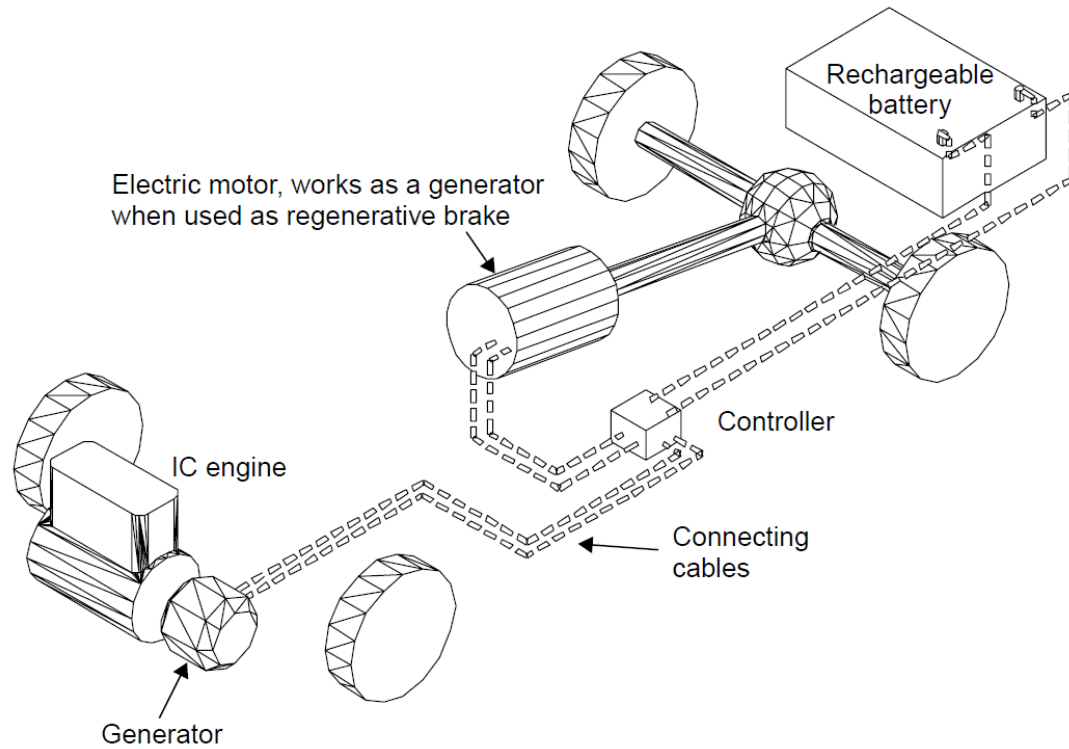
# Adding battery to gasoline vehicle

Hybrid EV – traditional gasoline vehicle with small battery

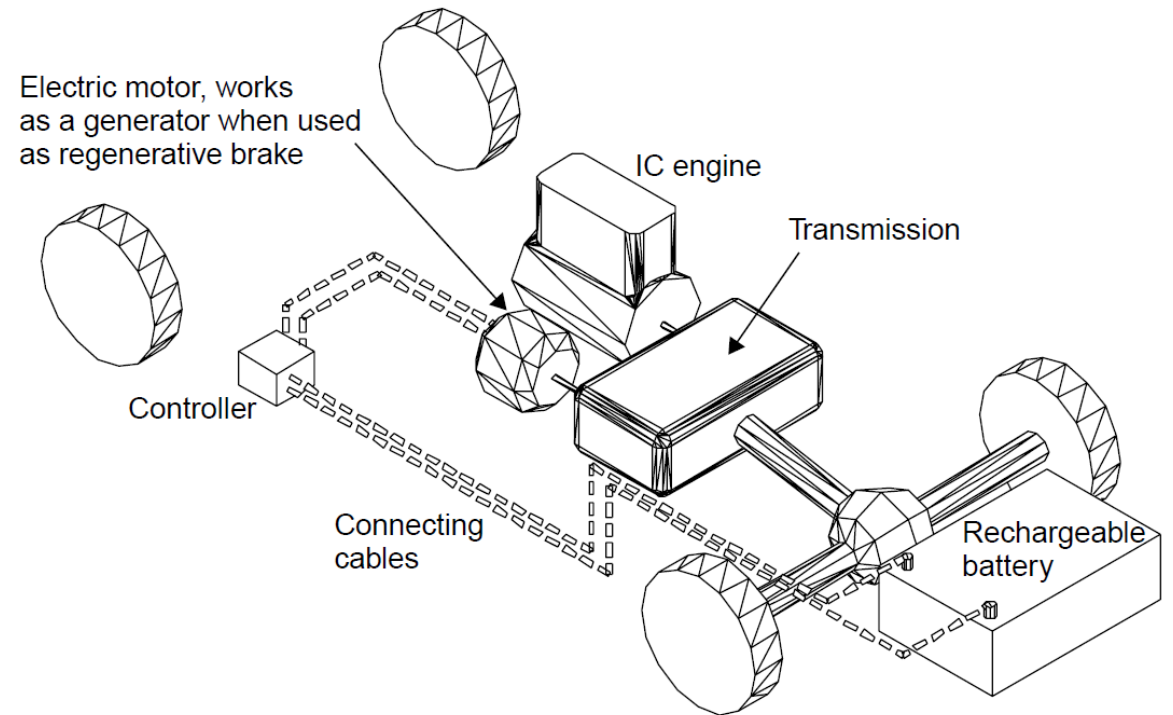
- Optimize the operating point of ICE
- Stop the ICE if not needed (ultra low speed and stops)
- Recover the kinetic energy at braking
- Reduce the size (hp and volume) of ICE

Model	City FE Gain	Hwy FE Gain	Note
Honda Civic	66%	24%	EPA Cycle
Honda Accord	43%	23%	EPA MPG
Toyota Prius	100%	34%	Compared w/ Corolla
Ford Escape	80%	24%	EPA MPG
GM Silverado	10~15%	10~15%	Cycle unknown

# Hybrid EV



Series configuration

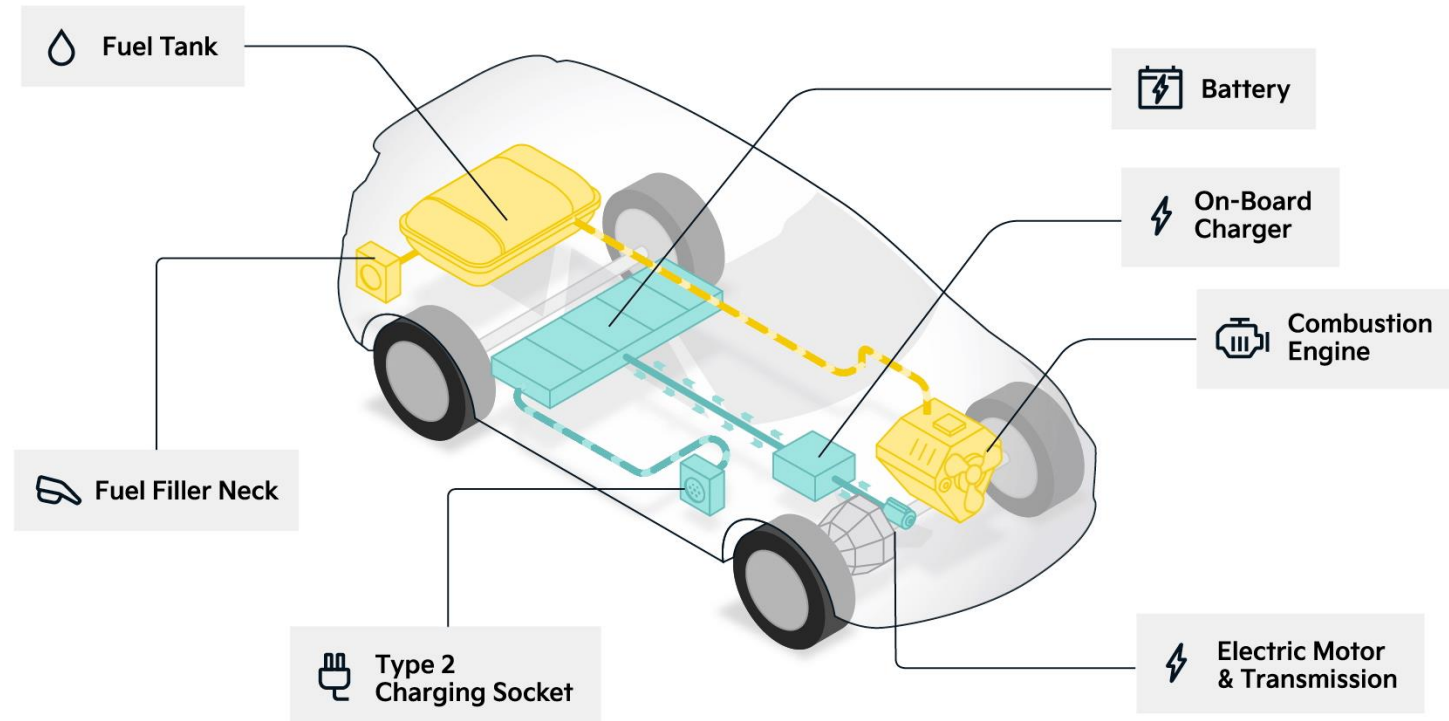


Parallel configuration

# Plugged-in HEV (PHEV)

Plugged-in Hybrid EV –  
traditional gasoline vehicle  
with bigger battery

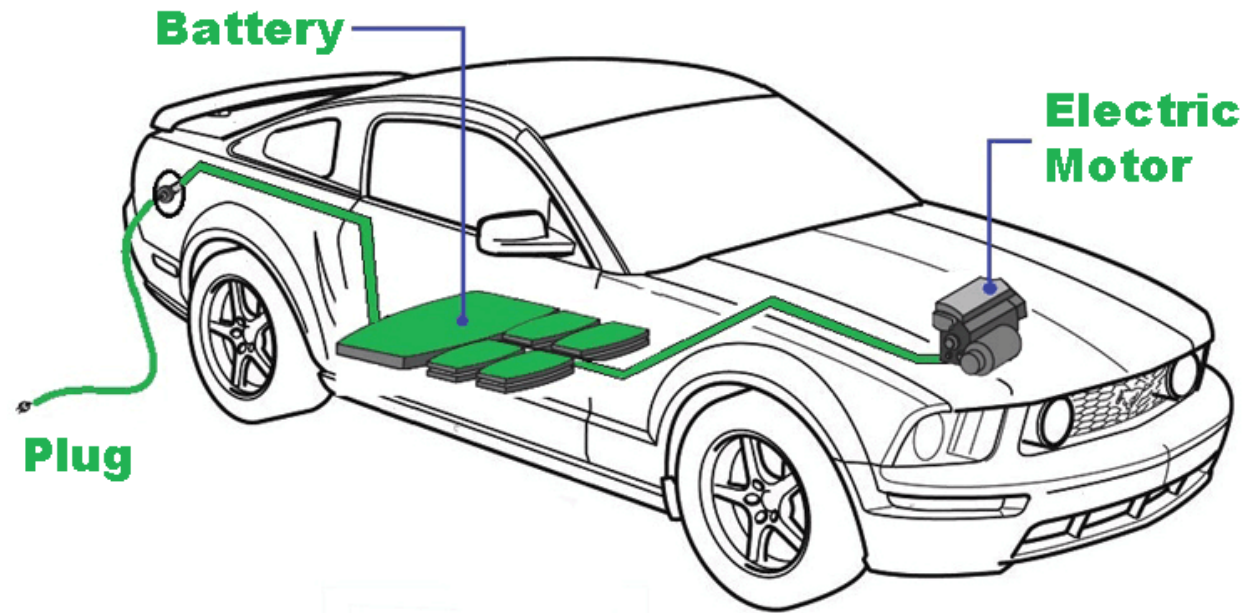
- Partially support the propulsion power
- Reduce IC engine size
- Reduce gasoline consumption
- Avoid range anxiety using IC engine



# Battery Electric Vehicle (BEV)

Battery EV – gasoline engine replaced

- Large battery pack
- No emission
- Low noise
- Low maintenance



# Energy efficiency of EV

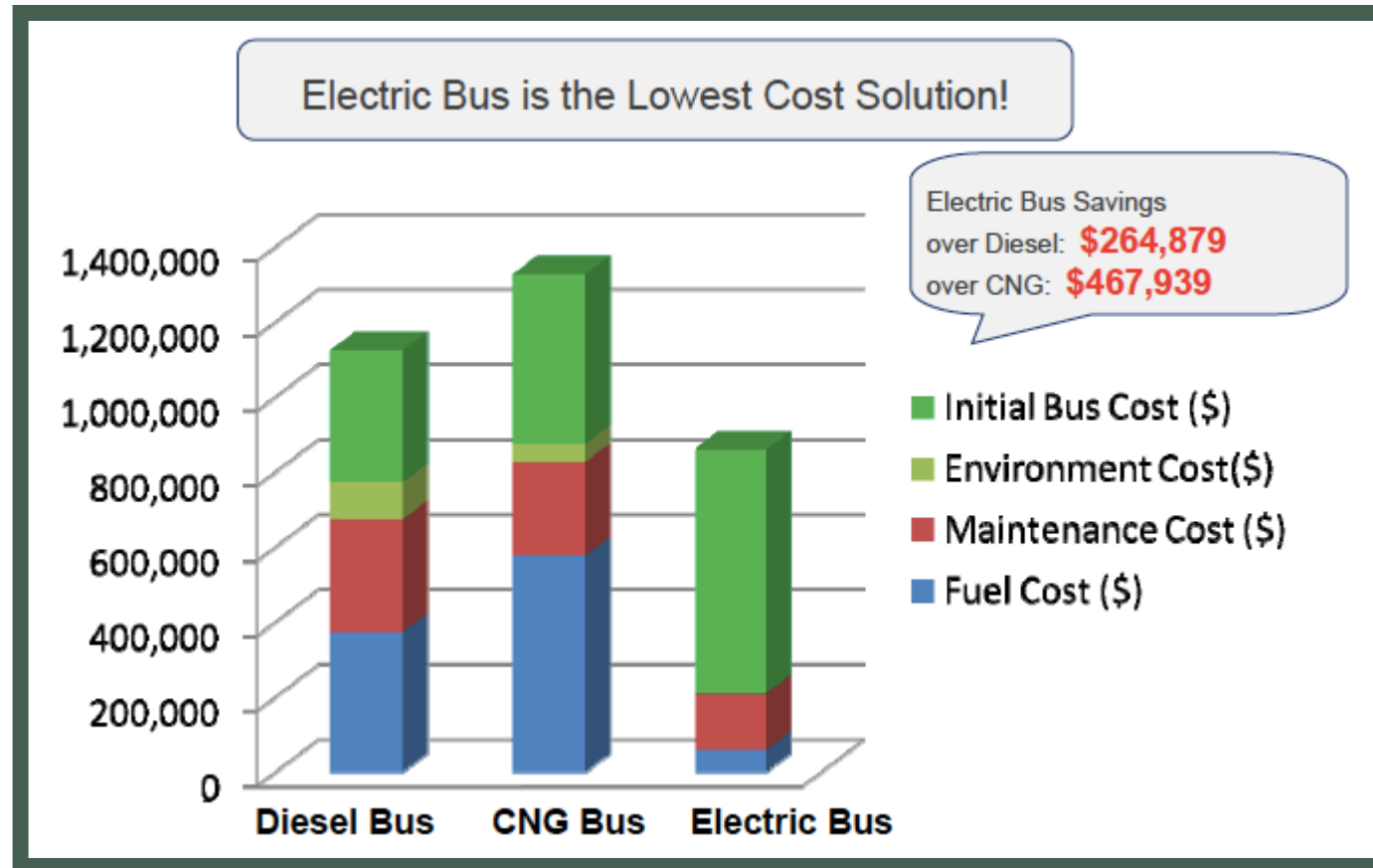


## VEHICLE EFFICIENCY WELL-TO-WHEELS

- Oil – Gasoline – Mechanical Drive Wheel  
✓ *Efficiency of 11% to 13%*
- Coal – Electricity – Electric Drive Wheel  
✓ *Efficiency of 19% to 32%*
- Natural Gas – Electricity – Electric Drive Wheel  
✓ *Efficiency of 27% to 42%*
- Solar Energy – Electricity – Electric Drive Wheel  
✓ *Efficiency ???*



# Cost Savings of EV



<https://www.byd.com>

# Disadvantages of EV



- Higher cost
- Range anxiety
- Limited battery pack life
- Lack of charging infrastructure
- Slow charging

# Other challenges

- Poor battery performance in extreme environment
- Rare-earth material in battery and lack of recycling technology
- Grid strain – added power demand on existing grid
- Geo-political risks

# Thank you!