An Introduction to Batteries

1

What is a cell?

Electrode:

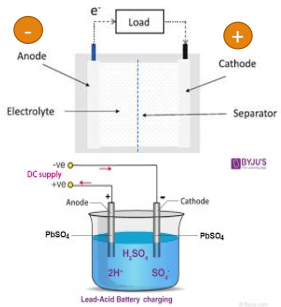
- Material in which electrons are the mobile species
- Usually metallic (sometimes a semiconductors)
- Conductivity on the order of 10^2 to 10^4 S/cm

Electrolyte:

- Mobile species are ions; overall electroneutral
- Free movement of electrons blocked
- Include: molten salts, dissolved salts in solution, some ionic solids
- Conductivity on the order of 10^-4 to 10^-1 S/cm

Separator:

- installed between the anode and the cathode to prevent an electrical short
- Separators are typically an inert, nonconductive polymer material
- The electrodes, together with the separator, are immersed in the electrolyte.



2

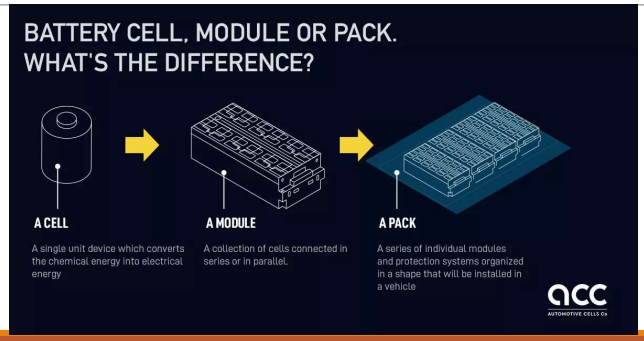
What is a Battery?

A battery is **a device that stores chemical energy and converts it to electrical energy**. An electric battery is **a source of electric power** consisting of one or more electrochemical cells with external connections for powering electrical devices.

Lithium Metal	Alkaline	Carbon Zinc	Silver Oxide	Zinc Air
Lithium - ion	Nickel Cadmium	Nickel Metal Hydride	Lead Acid	Rechargeable Alkaline

3

What is a battery pack?



4

Commonly used parameters in industry

Capacity: The entire energy in a battery is measured here, and it is usually expressed in ampere-hours (Ah). It provides information on how much charge the battery can deliver at a particular discharge rate.

Energy Density and Power Density: The quantity of energy stored per unit of mass or volume is measured by the energy density (Wh/kg or Wh/L). How much power can be delivered per unit of mass or volume is indicated by the power density (W/kg or W/L). In particular, these factors are crucial for portable and mobile apps.

State of Charge (SOC): This displays the battery's current charge level as a percentage of its capacity. It's a crucial variable for determining how much energy is still there in the battery.

Depth of Discharge (DOD): The depth of discharge or DoD is defined as the amount of used energy of a cell. In other words, when the cell is fully charged, DoD = 0, and when the cell is fully discharged, we have DoD = 1. By this definition we have

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Commonly used parameters in industry

State of Health (SOH): SOH is a measurement that depicts a battery's overall health and how long it has left to live in comparison to a brand-new battery. It considers elements including the number of cycles, capacity fading, and changes in internal resistance.

Nominal Voltage: It is the typical voltage at which the battery functions while charged and when subjected to typical operating circumstances.

Internal Resistance: The amount of energy lost as heat during operation depends on this characteristic, which is essential. Increased energy loss caused by a high internal resistance might potentially cause heating and safety problems.

Cycle Life: This indicates how many full charge/discharge cycles a battery may experience before its capacity drops below a specific percentage of its initial capacity.

C-rate: It shows how quickly a battery is losing capacity in relation to its maximum. A 1C rate indicates that the battery will be completely discharged in an hour by the discharge current.

6

Commonly used parameters in industry

Open circuit voltage (OCV): is the difference of electrical potential between two terminals of a device when disconnected from the circuit and in the absence of external load and current flow.

The cut-off voltage : is the voltage at which a battery can be considered a fully discharged battery, beyond which further discharge could cause harm.

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5. BASIC CHARACTERISTICS

5.1 Capacity（25±5℃）	Nominal Capacity：2600mAh (0.52A Discharge，2.75V) Typical Capacity：2550mAh（0.52A Discharge，2.75V） Minimum Capacity：2500mAh (0.52A Discharge，2.75V)
5.2 Nominal Voltage	3.7V
5.3 Internal Impedance	≤ 70mΩ
5.4 Discharge Cut-off Voltage	3.0V
5.5 Max Charge Voltage	4.20±0.05V
5.6 Standard Charge Current	0.52A
5.7 Rapid Charge Current	1.3A
5.8 Standard Discharge Current	0.52A
5.9 Rapid Discharge Current	1.3A
5.10 Max Pulse Discharge Current	2.6A
5.11 Weight	46.5±1g
5.12 Max. Dimension	Diameter(Ø): 18.4mm Height (H): 65.2mm
5.13 Operating Temperature	Charge: 0 ~ 45℃ Discharge: -20 ~ 60℃
5.14 Storage Temperature	During 1 month: -5 ~ 35℃ During 6 months: 0 ~ 35℃

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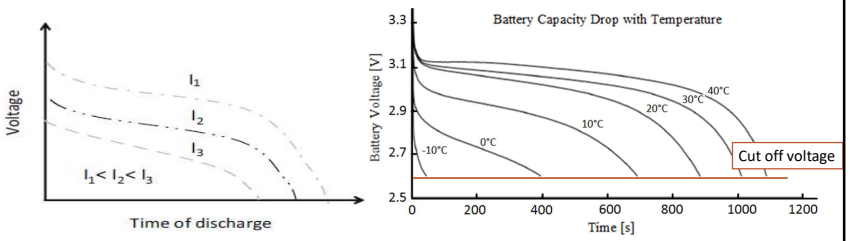
Voltage curve during discharge



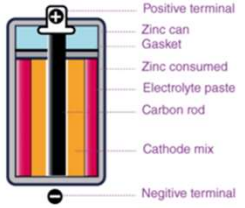
Primary Battery

A primary battery is designed to be used once and is discarded, and cannot be recharged with electricity

The electrochemical reaction occurring in the cell is not reversible, rendering the cell un-rechargeable

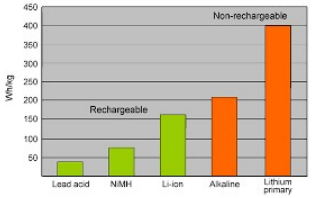
Some Examples :

- ✓ zinc–carbon cell or so-called dry cell
- ✓ magnesium and aluminum batteries
- ✓ alkaline manganese dioxide
- ✓ mercuric oxide and silver oxide
- ✓ zinc–air and lithium batteries.



Primary Battery

- A primary cell is usually alkaline.
- A primary cell is in-expensive and easy to get.
- A primary cell is perfect for low voltage applications due the way they are designed.
- A primary cell contains mercury and therefore should be recycled.
- A primary cell is considered hazardous waste and should not be discarded with regular garbage.
- high energy content per weight and volume, long shelf lives

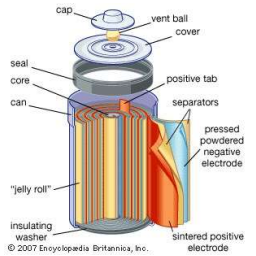


Secondary Battery

A secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times

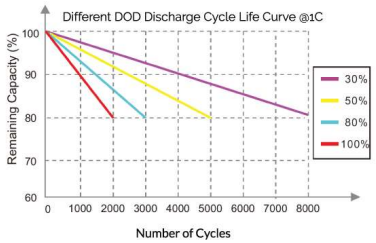
Some Examples :

- ✓ lead-acid
- ✓ Nickel-cadmium (Ni-Cd)
- ✓ nickel-metal hydride (NiMH)
- ✓ lithium-ion (Li-ion)
- ✓ lithium-ion polymer (Li-ion polymer)



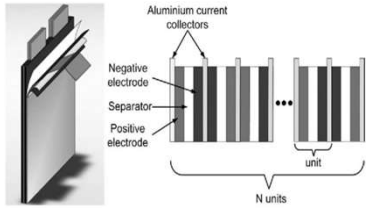
Secondary Batteries

- A secondary cell initially is more costly than a primary cell
- A secondary cell is versatile because they may come in various sizes, shapes, voltages, capacities etc.
- A secondary cell is used for devices which demand more power than that of what the primary cells can provide.
- Over time, secondary cells lose their ability to hold a charge.(They age)
- Secondary cells prone to explode or catch fire, if not handled properly therefore handle them with care.

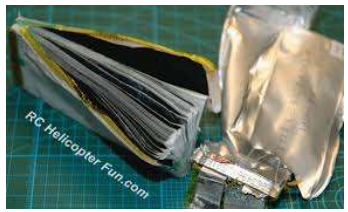


Forms of Battery cells : Pouched Cells

- Simplest form of battery cells
- This cathode-electrolyte-anode sandwich is folded back and forth many times within the pouch to increase the capacity of the battery
- There are no standard sizes for pouch cells
- they are lightweight and cheap to produce
- no exterior protection and thus can be damaged if they aren't enclosed in some form of protective case.
- When a pouch cell ages it can begin to expand. Because pouch cells are entirely sealed, the gas has nowhere to escape and thus creates the puffy, pillow-like appearance.



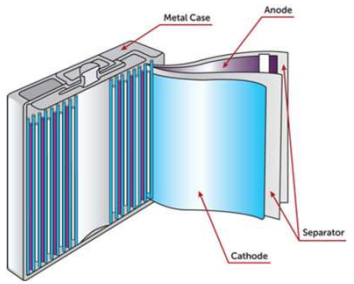
Pouch cells puffed!



Forms of battery cells : Prismatic cells

Prismatic cells are quite similar to pouch cells, except that they have the addition of a rigid rectangular case outside of the cell. Prismatic cells are therefore slightly less space efficient than pouch cells, but are also more durable than pouch cells

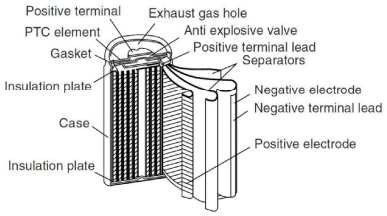
- Unlike pouch cells that have thin tab terminals, prismatic cells often have threaded terminals that allow a nut or bolt to be used for connections.
- There aren't standard dimensions for prismatic cells, but they often come in various capacities with 5 - 10 Ah increments.



Forms of battery cells : Cylindrical cells

Cylindrical cells are produced by rolling up what amounts to the same contents of a pouch cell, then placing it inside of a metallic cylinder with a positive and negative terminal at either end of the cylinder.

- cylindrical cells are produced in standard sizes.
- The most common lithium battery cylindrical cell is the 18650 cell, named for its 18 mm diameter and 65 mm length.



For more information , check and study the attached file (cylindrical cell details.pdf)

Adobe Acrobat Document

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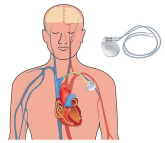
Battery applications

Miniature applications:

- ✓ Low currents
- ✓ Low energy and power
- ✓ Usually coin and button cells
- ✓ Mostly are not rechargeable

Energy :0.1 to 2 Wh
Nominal Voltage :1.35 to 1.5 V

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Battery applications

Portable devices:

- ✓ Cylindrical, prismatic and pouch(cell phones)
- ✓ Rechargeable batteries might get used

Energy :2 to 100 Wh
Nominal Voltage : 1.5 V




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Battery applications

Starting , lighting and ignition (SLI):

- ✓ Ability to provide high power
- ✓ Potential for recycling
- ✓ Low cost
- ✓ Mostly lead-acid batteries

Energy :100 to 1200 Wh
Nominal Voltage : 6 , 12 or 24 V


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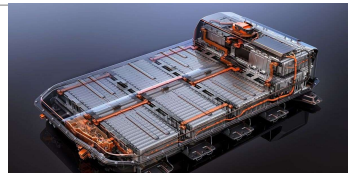
Battery applications

Vehicle traction:

- ✓ Ability to provide high power
- ✓ high energy density
- ✓ high capacity
- ✓ Rechargeable
- ✓ High cyclic life

Energy :20 to 630 kWh
Nominal Voltage : 400-800 V



Battery applications

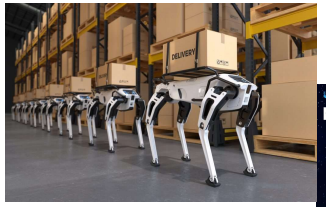
Stationary batteries and energy storage units:

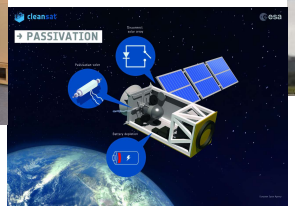
- ✓ Energy storage
- ✓ Difficult thermal management
- ✓ high capacity
- ✓ Rechargeable
- ✓ Requires well-operated control system

Energy :5 MWh and above
Nominal Voltage : 2.15 to 2.23 Volts per cell

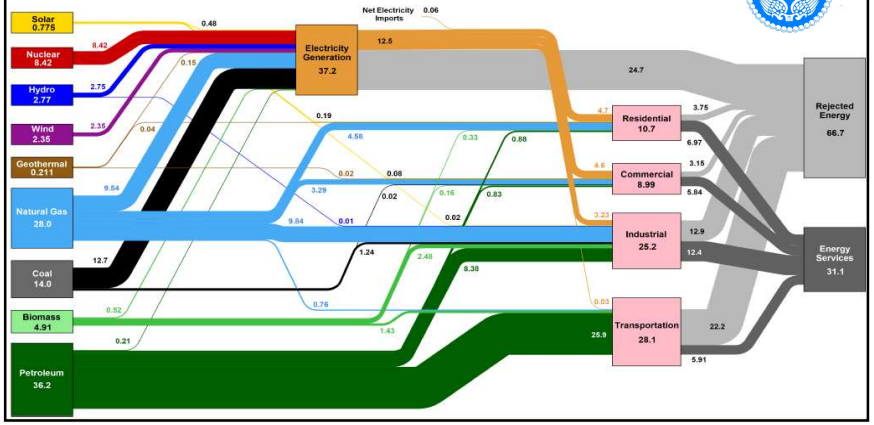
Battery applications

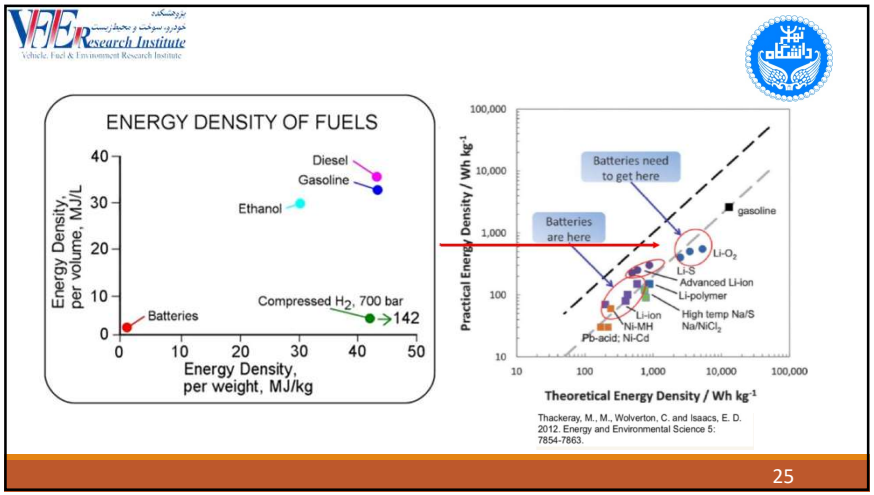
Aerospace and robotics





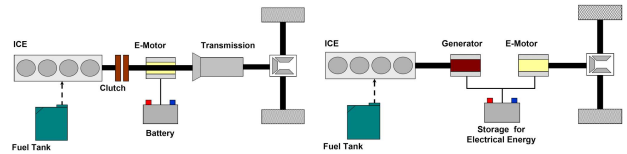
Estimated Energy Consumption in US / 2017



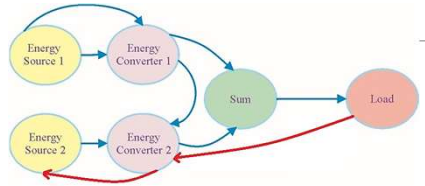


خودروهای هیبرید

- خودروی هیبرید خودرویی است که با بیش از یک منبع توان به‌حرکت در می‌آید و یکی از این منابع توان قابلیت ذخیره‌سازی انرژی را داراست.
- انواع: خودروهای هیبرید الکتریکی، خودروهای هیبرید مکانیکی، خودروهای هیبرید پیل‌سوختی
- دارای دو ساختار کلی سری و موازی:



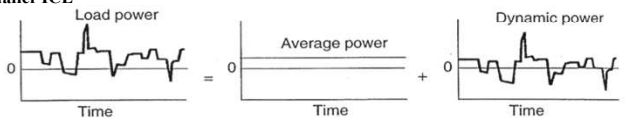
تکنولوژی هیبرید



مودهای کارکرد سامانه انتقال قدرت هیبرید

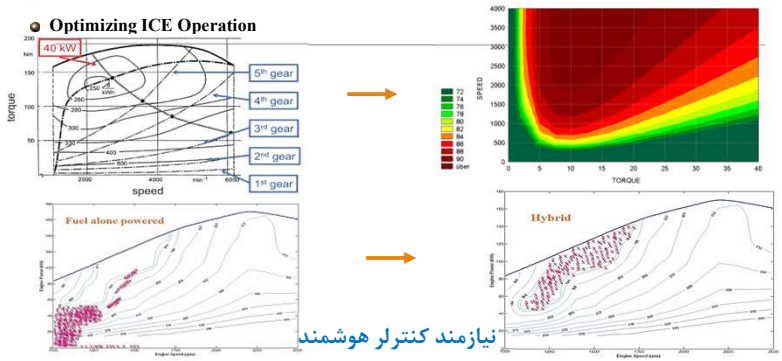
- Smaller ICE

روش ارتقاء مصرف انرژی



تکنولوژی هیبرید

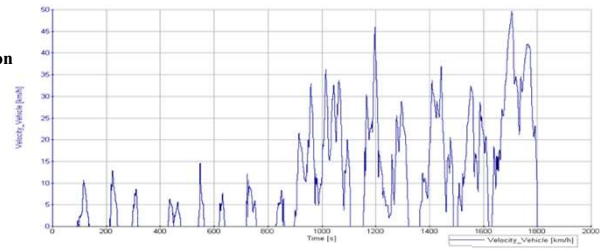
- Smaller ICE
- Optimizing ICE Operation



نیازمند کنترلر هوشمند

تکنولوژی هیبرید

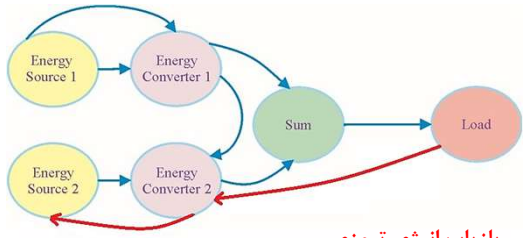
- Smaller ICE
- Optimizing ICE Operation
- Start-Stop Operation



حذف مصرف انرژی در کارکرد درجا

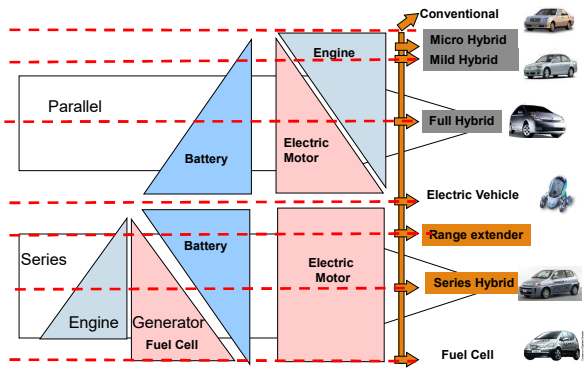
تکنولوژی هیبرید

- Smaller ICE
- Optimizing ICE Operation
- Start-Stop Operation
- Regenerative Braking



بازیاب انرژی ترمزی

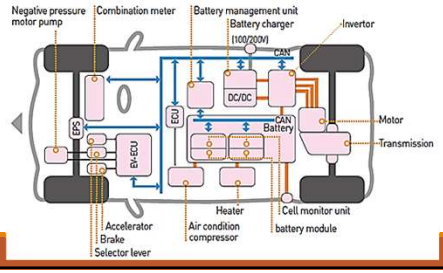
درصد هیبریدسازی خودرو



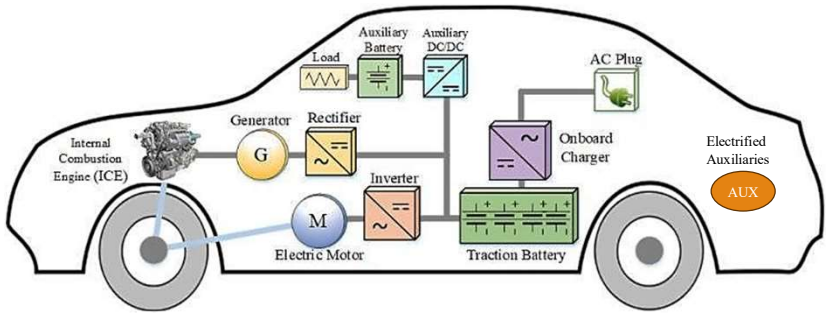
معرفی کلی سیستم و اجزای آن

اجزاء اصلی خودروهای الکتریکی

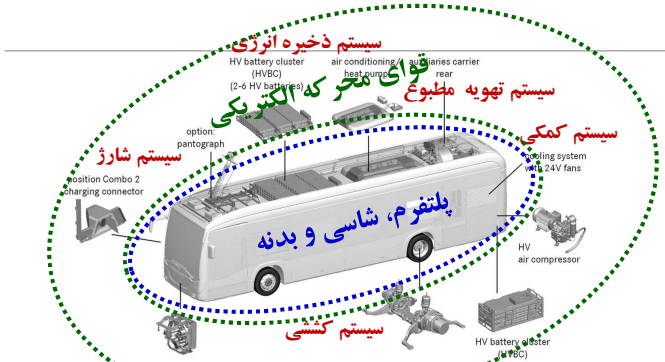
- *Electric Drive Motor*
- *Power Inverter Module (converts DC power to AC for the drive unit)*
- *On Board Charger*
- *Electric Climate Control System Compressor*
- *Battery Cells and Pack*
- *High Power Distribution Module (manages the flow of high voltage to various components)*
- *Battery Heater*
- *Accessory Power Module (maintains low-voltage power delivery to accessories)*
- *Power Line Communication Module (manages communication between vehicle and a DC charging station)*
- *Instrument Cluster*
- *Infotainment System*



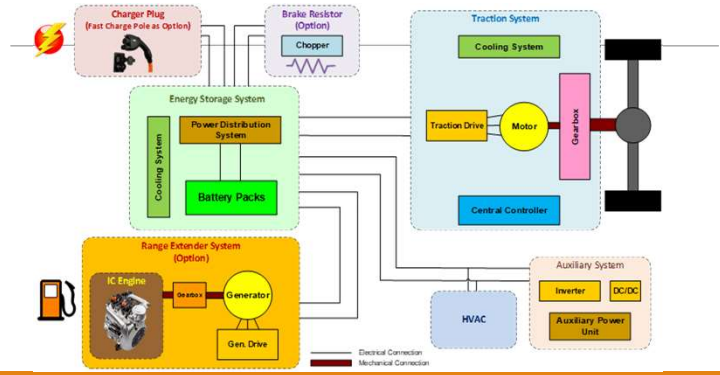
قوای محرکه خودروهای برقی‌سازی‌شده



قوای محرکه خودروهای برقی‌سازی شده



قوای محرکه خودروهای برقی‌سازی شده



Why EVs?

The servicing requirements for electric vehicles are lesser than the conventional petrol or diesel vehicles. Therefore, the yearly cost of running an electric vehicle is significantly low.

Easy to use :

1- Charging at home

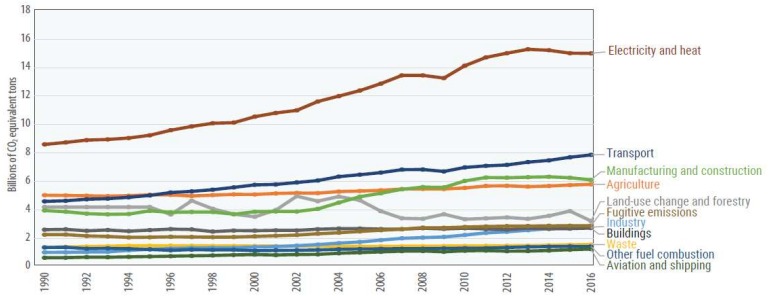
2- No noise pollution

Why EVs?

zero tailpipe emissions, but even when electricity production is taken into account, petrol or diesel vehicles emit almost 3 times more carbon dioxide than the average EV.

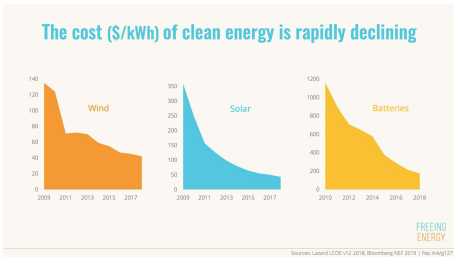
Regenerative systems can be applied for brakes and wearing parts

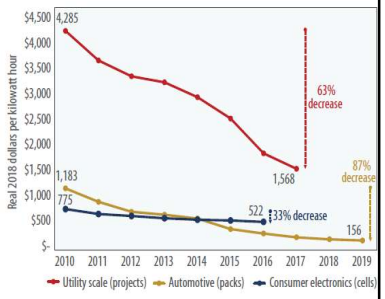
Why EVs?



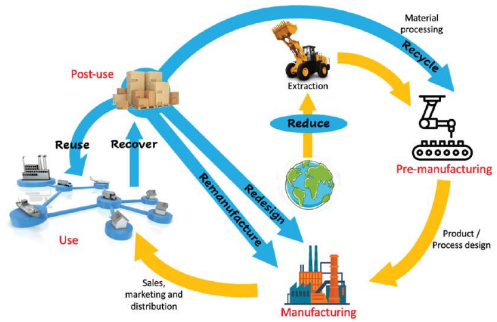
Courtesy of Department of Economic and Social Affairs (United Nations)
Article title : Frontier Technology Issues: Lithium-ion batteries: a pillar for a fossil fuel-free economy?

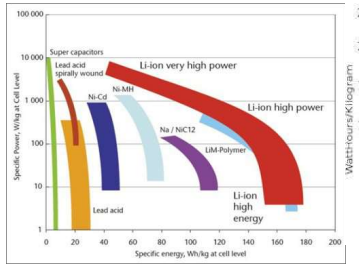
Why EVs?

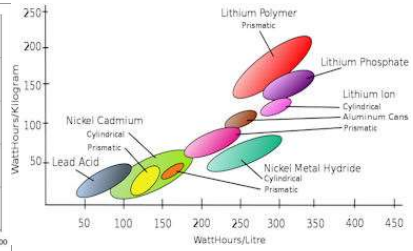




Why EVs?




Super capacitors
Lead acid spirally wound
Li-ion very high power
Ni-Cd
Ni-MH
Na / NiC12
Li-ion high power
LiM-Polymer
Lead acid
Li-ion high energy
Specific Power, W/kg at Cell Level
Specific energy, Wh/kg at cell level


Lithium Polymer
Prismatic
Lithium Phosphate
Lithium Ion
Cylindrical
Aluminum Cans
Prismatic
Nickel Cadmium
Cylindrical
Prismatic
Lead Acid
Nickel Metal Hydride
Cylindrical
Prismatic
WattHours/Kilogram
WattHours/Litre

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