Environment

Battery Research

Purdue University

ElectroChemical Society

Goal:

The use of fossil fuels in cars, industrial machineries increase the carbon di-oxide content of the planet, which contribute to ozone-layer depletion significantly resulting in high UV ray penetration and global warming. Our goal is to decarbonize the world's atmosphere by expanding electric machinery usage and solving critical problems in this field. From a very young age we should be aware of protecting our environment from pollution by boosting renewable energy usage for a sustainable future. In 2021 only 20% of the total energy produced are from renewable energy sources such as solar, wind, hydro etc. which need to be improved to achieve a net zero carbon emission.

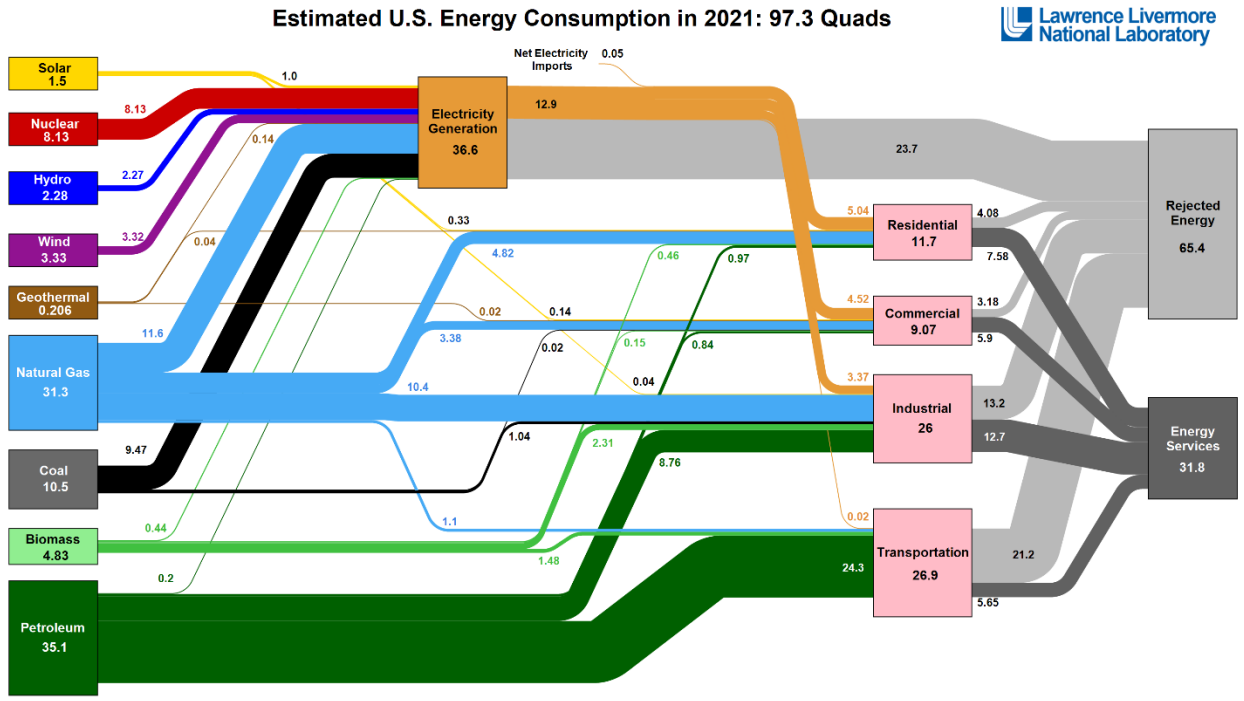

Image: Energy production and consumption flowchart in US in 2021*

Vision:

From a study carried out by Lawrence Livermore National Laboratory in 2021, the sector responsible for most carbon dioxide emissions (37% of 4800 million metric tons) is the transportation sector in the US. So, the primary focus of an all-electric economy should reside in revolutionizing electric vehicles including personal cars, heavy-duty vehicles, and airplanes. Currently, electric cars have a higher up-front price than conventional vehicle due to its new energy technology and low production volume. The primary vision of an all-electric economy will be to produce cost-effective efficient batteries and build an efficient network of public charging stations, utilities, and a supply-chain for electric vehicle supply equipment (EVSEs). The battery used in EVs should be designed to have more capacity and fast charging capabilities. Predictive modeling speculates a battery's life span to be 12 to 15 years in moderate climates and 8 to 10 years in

*Source: https://flowcharts.llnl.gov/

PURDUE UNIVERSITY | Birck Nanotechnology Center

extreme climates**. Experiments and extensive physics-based modeling research need to be done to investigate the underlying science of charge transport and reaction kinetics inside batteries.

Science background:

Batteries as an energy storage unit don't have any carbon-dioxide emission during operation which make them a viable solution towards decarbonizing our environment. We can store energy, use it according to our need, and charge the battery when necessary. A battery has three components: two **electrodes** (**Cathode** & **Anode**) at the boundaries and one **electrolyte** in the middle, a sandwich structure. In a lithium-ion battery, the electrolyte is a liquid which helps to carry the '**ions**' produced at the electrode.

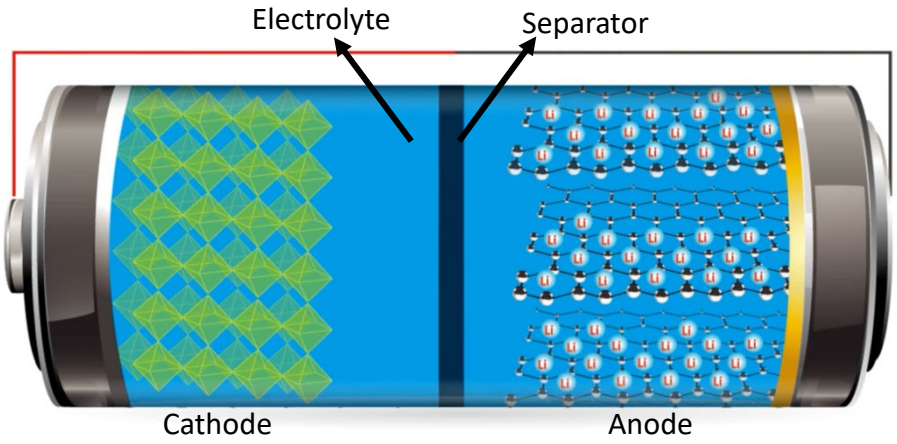

Image: Schematic of Lithium ion-battery at a complete charged state***

Challenges:

There are many existing challenges present to make a battery more efficient and suitable for the current world's need. To mention a few,

1. We need fast charging and high-capacity batteries for electric vehicle applications to substitute high mileage efficient conventional Internal Combustion (IC) engines in cars. Current existing batteries are unable to provide both together due to its internal chemical limitations.
2. Dendrite formation inside the battery can short-circuit the battery from inside which produce high heat and waste the battery. It's called **thermal runaway** of battery.
3. Thermal runway of a single battery in a car battery-pack can damage other batteries from the outside resulting in car destruction.

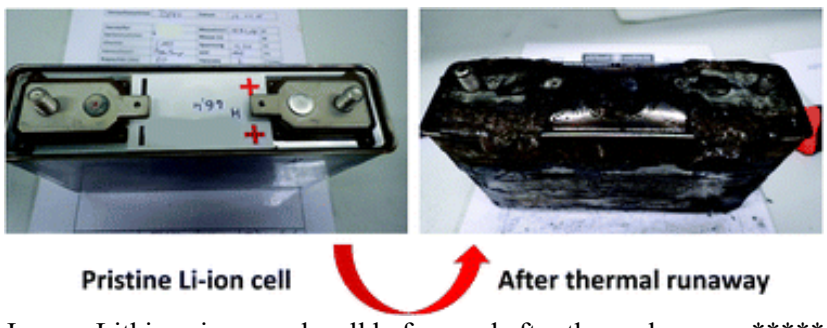

Image: Lithium-ion pouch cell before and after thermal runway*****

Want to learn more?

**Source: https://afdc.energy.gov/fuels/electricity_benefits.html
***Source: https://www.energy.gov/energysaver/articles/how-does-lithium-ion-battery-work
****Source: https://doi.org/10.1039/C8RA06458J