Selecting Battery Chemistry For Electric Vehicle Batteries

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Pendahuluan

Tujuan:

Memahami faktor faktor penting dalam memilih jenis bahan kimia untuk digunakan dalam manufaktur baterai untuk Electric Vehicle (EV).

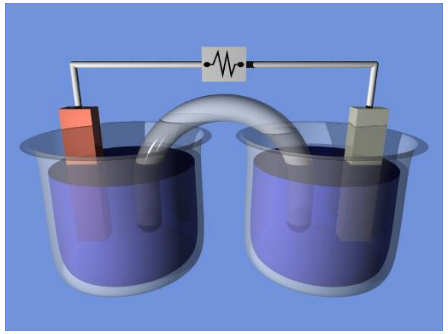
Gambaran Umum:

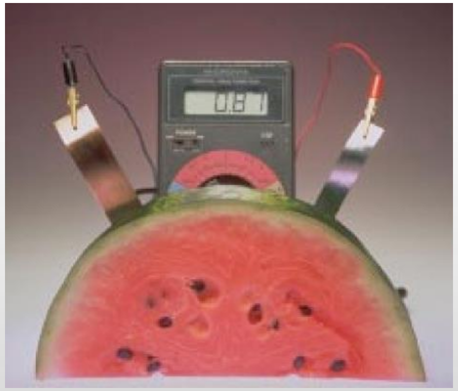
Presentasi ini akan membahas bagaimana energi listrik dapat diperoleh melalui reaksi kimia, melihat jenis “bahan” kimia baterai yang tersedia untuk baterai EV, mengeksplorasi faktor faktor dalam memilih bahan kimia untuk baterai EV, melihat potensi/faktor untuk menuju pemanfaatan baterai EV agar menjadi lebih ramah lingkungan.

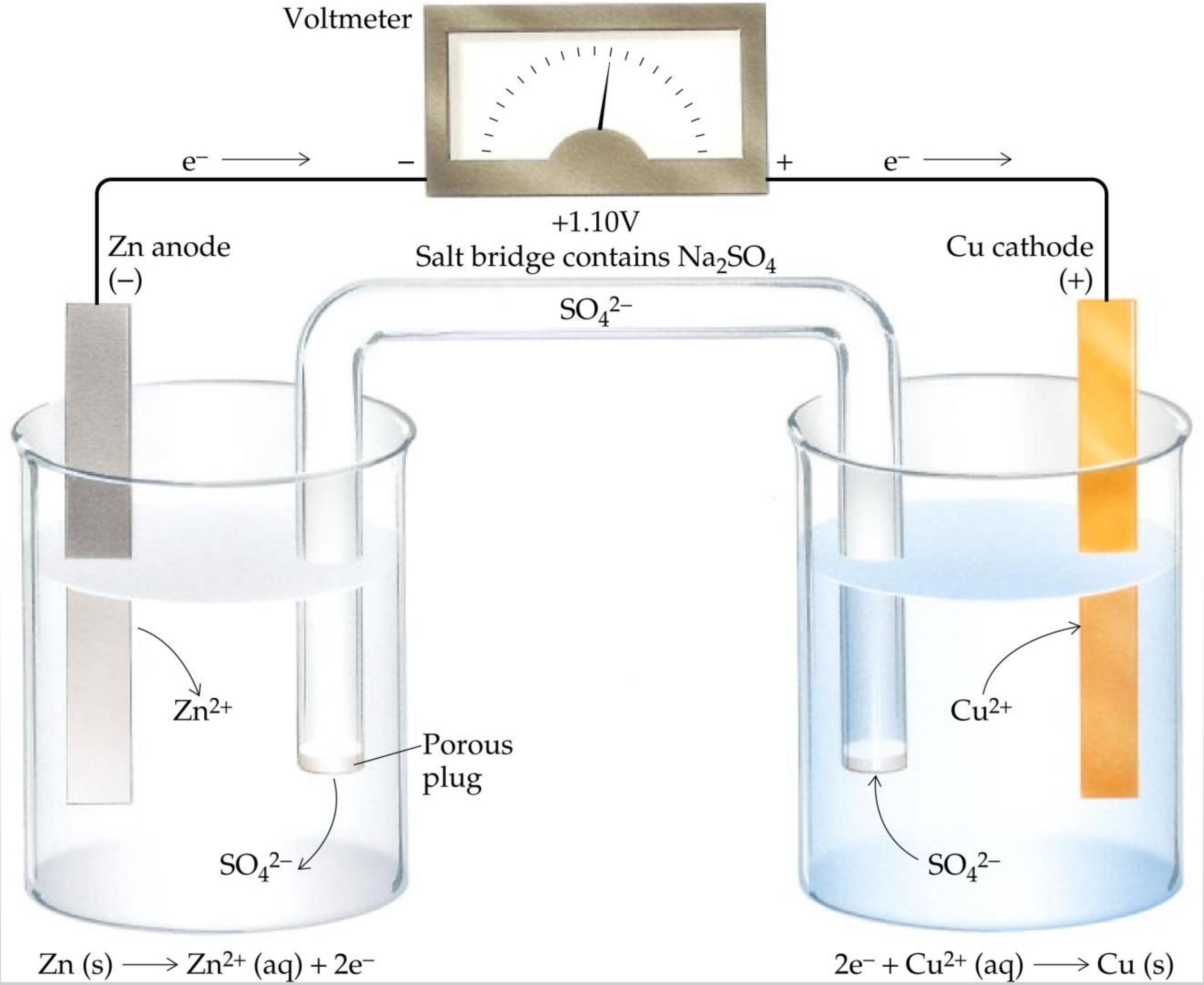
Apa itu battery

- Perangkat yang dapat mengkonversi/ merubah **energi kimia** menjadi **energi listrik**.
- Baterai adalah Sel Volta yang dihubungkan secara seri dan/atau parallel.
- Arus listrik dihasilkan melalui reaksi Reduksi-Oksidasi dari elektroda dalam sel baterai.
- Reaksi Reduksi : Reaksi menerima elektron.
- Reaksi Oksidasi: Reaksi melepas elektron

Reaksi kimia menjadi arus listrik



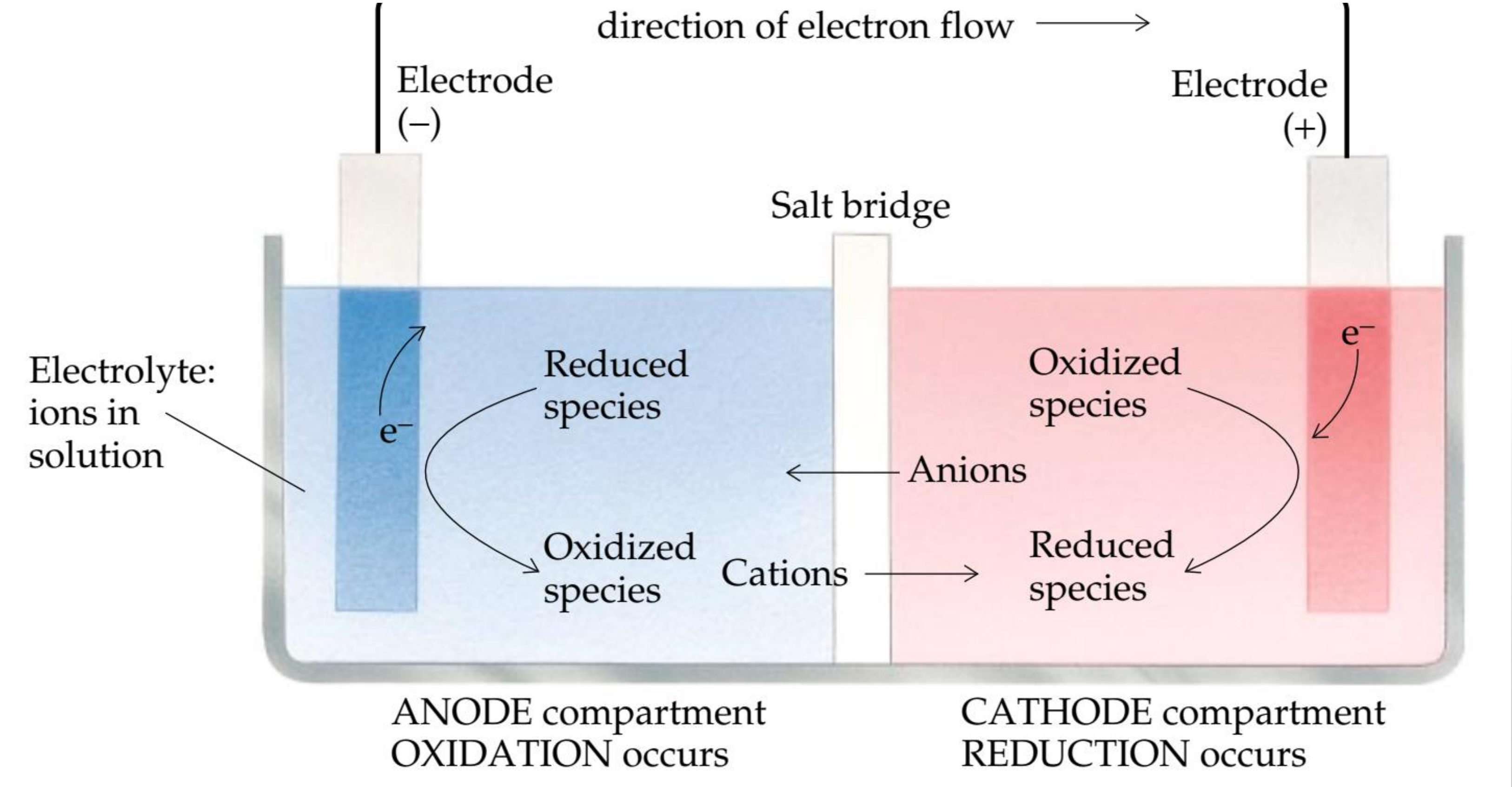




Apa itu battery

Anode, oxidation: $Cd(s) \longrightarrow Cd^{2+}(aq) + 2\,e^-$

Cathode, reduction: $Ni^{2+}(aq) + 2\,e^- \longrightarrow Ni(s)$



Deret potensial elektrokimia

Unsur yang suka reduksi (bertambah elektron)

- *Gold*
- *Mercury*
- *Silver*
- *Copper*
- *Lead*
- *Nickel*
- *Cadmium*

But, there's a reason it's a *sodium* drop

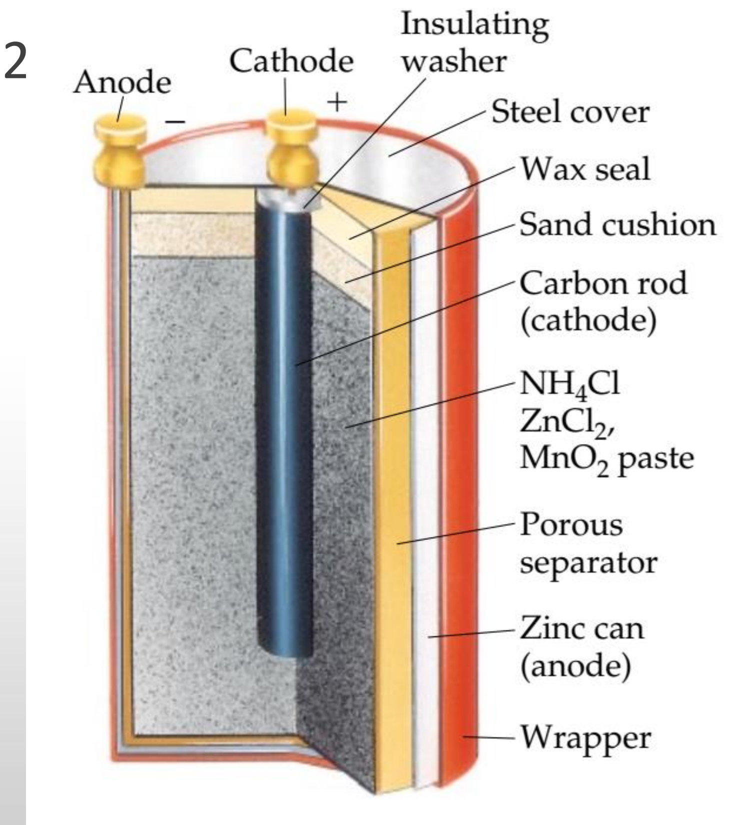
- Iron
- Zinc
- Aluminum
- Magnesium
- Sodium
- Potassium
- ***Lithium***

Unsur yang suka oksidasi (kehilangan elektron)

Jenis Baterai

Berdasarkan jenis bahan kimia (Chemistries) yang digunakan dalam baterai.

- Lechlance Dry Cell: Zn, MnO_2, NH_4Cl, $ZnCl_2$
- Mercury Battery: Zn, HgO, KOH
- NiCd
- NiMn
- Lead Acis Batteries (Aki Mobil)
- Lithium/Lithium Ion
- Sodium Ion
- Fuel Cells



Faktor saat memilih bahan kimia u/ baterai EV

1. **Densitas Energi**:

   Definisi: Jumlah energi yang disimpan per-satuan massa atau volume.

   Pentingnya: Densitas energi yang lebih tinggi berarti jarak tempuh kendaraan yang lebih jauh dengan satu kali pengisian. Ini menentukan seberapa jauh kendaraan dapat melakukan perjalanan dengan satu kali pengisian daya, yang merupakan faktor kritis bagi konsumen dan keberhasilan penetrasi pasar.

2. **Densitas Daya**:

   Definisi: Jumlah keluaran daya per-satuan massa atau volume.

   Pentingnya: Densitas daya yang tinggi memungkinkan akselerasi dan kinerja yang lebih baik. Ini sangat penting untuk responsivitas kendaraan, mempengaruhi dinamika berkendara dan pengalaman pengguna.

Faktor saat memilih bahan kimia u/ baterai EV

3. **Umur Pakai dan Siklus Hidup**:

   Definisi: Jumlah siklus pengisian-pengosongan yang dapat dilakukan baterai sebelum kapasitasnya menurun secara signifikan.

   Pentingnya: Umur pakai yang lebih panjang mengurangi frekuensi penggantian baterai, menurunkan biaya total kepemilikan dan meningkatkan keberlanjutan EV

4. **Keamanan**:

   Stabilitas Termal: Kemampuan baterai untuk menahan suhu tinggi tanpa penuruan kinerja atau risiko kebakaran.

   Stabilitas Kimia: Ketahanan terhadap korsleting internal dan reaksi kimia lain yang dapat menyebabkan kebakaran atau ledakan.

   Pentingnya: Keamanan sangat penting untuk melindungi konsumen dan mencegah insiden yang dapat merusak reputasi teknologi EV.

Faktor saat memilih bahan kimia u/ baterai EV

5. **Biaya**:

   Biaya material: Biaya bahan mentah seperti litium, kobalt, nikel, dll.

   Biaya manufaktur: Biaya yang terkait dengan produksi baterai, termasuk tenaga kerja, energi, dan teknologi.

   Pentingnya: Biaya baterai adalah komponen signifikan dari keseluruhan biaya EV. Biaya yang lebih rendah dapat membuat EV lebih terjangkau dan kompetitif dengan kendaraan ICE.

6. **Dampak Lingkungan**:

   Ekstraksi dan pengolahan: Jejak lingkungan dari penambangan dan pemurnian material.

   Daur Ulang dan Pembuangan: Kemudahan dan efisiensi dalam mendaur ulang baterai pada akhir masa pakainya.

   Pentingnya: Praktik berkelanjutan sangat penting untuk mengurangi dampak lingkungan dari EV dan mendukung tujuan iklim global.

Faktor saat memilih bahan kimia u/ baterai EV

7. **Ketersediaan Bahan Mentah**:

   Stabilitas Rantai Pasokan: Keandalan dan faktor geopolitik yang mempengaruhi pasokan bahan penting.

   Skalabilitas: Kemampuan untuk meningkatkan produksi guna memenuhi permintaan yang meningkat.

   Pentingnya: Memastikan pasokan bahan mentah yang stabil dan cukup diperlukan untuk adopsi dan pertumbuhan pasar EV yang luas.

8. **Kematangan Teknologi**:

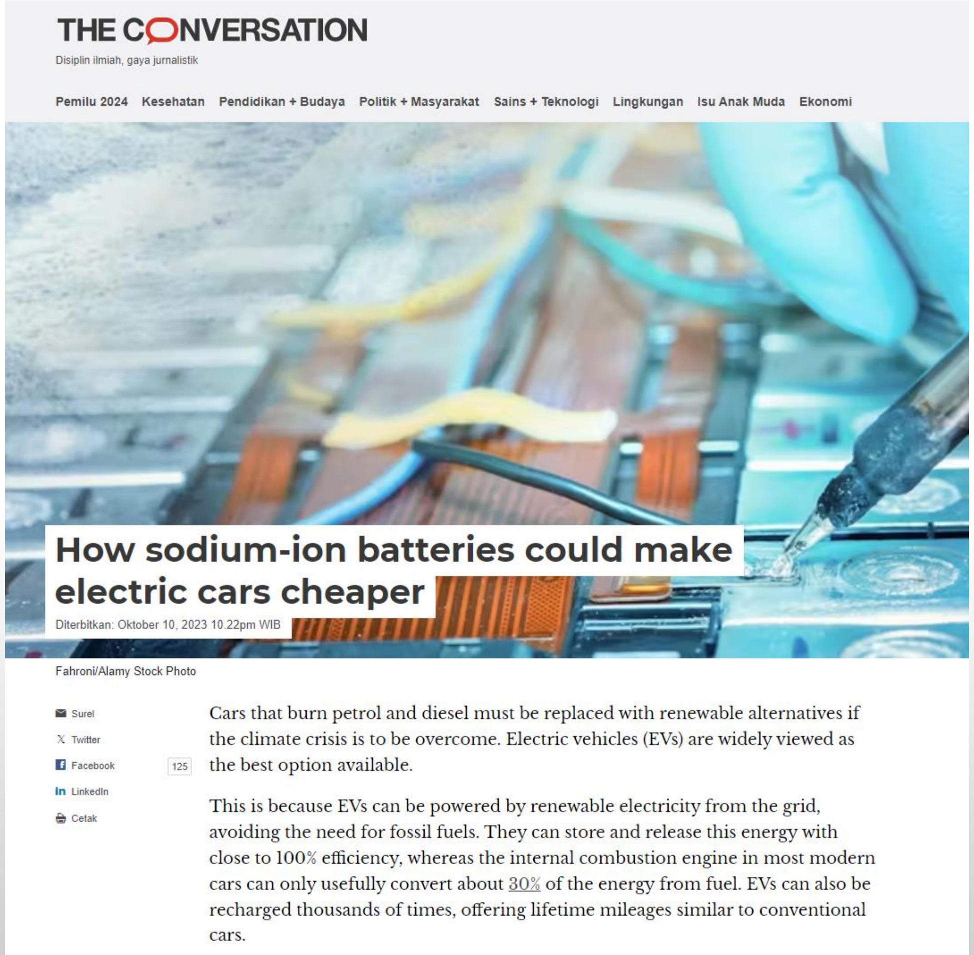
   Stabilitas Rantai Pasokan: Keandalan dan faktor geopolitik yang mempengaruhi pasokan bahan penting.

   Skalabilitas: Kemampuan untuk meningkatkan produksi guna memenuhi permintaan yang meningkat.

   Pentingnya: Memastikan pasokan bahan mentah yang stabil dan cukup diperlukan untuk adopsi dan pertumbuhan pasar EV yang luas

Kimia Baterai EV yang Umum.

- Lead Acid Battery ($Pb/PbSO_4/PbO$)
- Lithium-Ion (Li-ion)
- Nickel-Metal Hydride (NiMH)
- Baterai Solid-State
- Lithium Iron Phosphate (LiFePO4)
- Nickel-Cobalt-Aluminum (NCA)
- Nickel-Manganese-Cobalt (NMC)
- Sodium-Ion Battery



THE CONVERSATION

Disiplin ilmiah, gaya jurnalistik

Pemilu 2024 Kesehatan Pendidikan + Budaya Politik + Masyarakat Sains + Teknologi Lingkungan Isu Anak Muda Ekonomi

How sodium-ion batteries could make electric cars cheaper

Diterbitkan: Oktober 10, 2023 10.22pm WIB

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Cars that burn petrol and diesel must be replaced with renewable alternatives if the climate crisis is to be overcome. Electric vehicles (EVs) are widely viewed as the best option available.

This is because EVs can be powered by renewable electricity from the grid, avoiding the need for fossil fuels. They can store and release this energy with close to 100% efficiency, whereas the internal combustion engine in most modern cars can only usefully convert about 30% of the energy from fuel. EVs can also be recharged thousands of times, offering lifetime mileages similar to conventional cars.

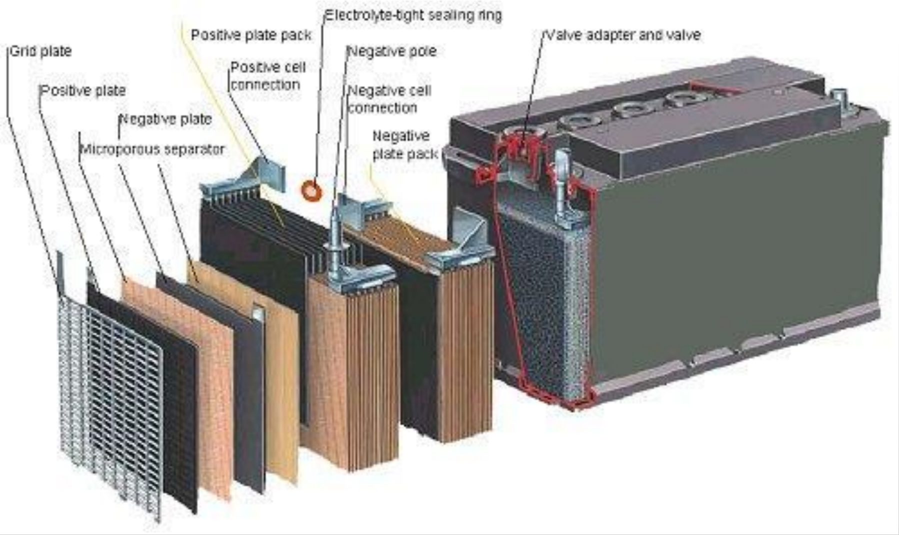
Battery Chemistries – Lead Acid

Lead Acid Batteries = Baterai Asam Timbal (Aki Mobil)

- One of the oldest rechargeable batteries
- Rugged, forgiving if abused, safe, low price
- Usable over a large temperature range

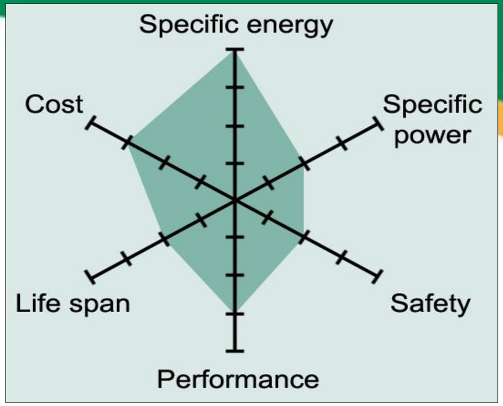
- Has low specific energy
- Limited cycle life, does not like full discharges
- Must be stored with sufficient charge
- Produces gases, needs ventilation

Vehicles, boats, UPS, golf cars, forklift, wheelchairs,

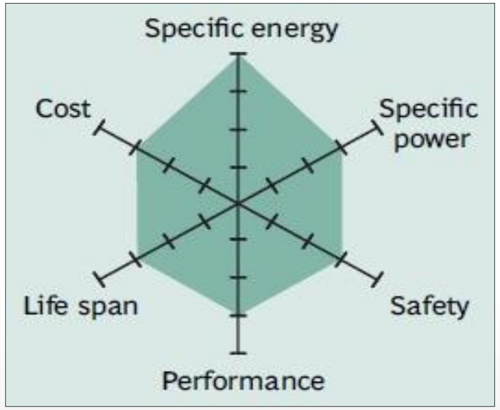


Beberapa jenis Baterai Lithium Ion

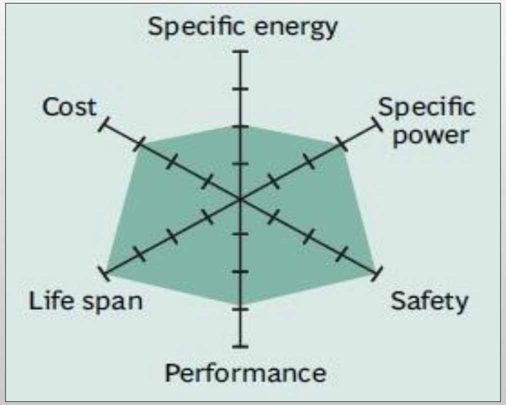
Li-cobalt (LiCoO2)
Available since 1991, replaces NiCd and NiMH. Lighter, longer runtimes.



NMC (nickel-manganese-cobalt)
High specific energy. Power tools, medical instruments, e-bikes, EVs.



Li-phosphate (LiFePO4)
Long cycle life, enhanced safety but has lower specific energy. UPS, EVs



Beberapa Pros and Cons. bbrp jenis Baterai

Battery Chemistry	Pros	Cons
Lead Acid Battery	Teknologi matang Sumber berlimpah	Densitas energi rendah
Baterai Li-Ion, $LiFePO_4$	High energy density, good cycle life, and widespread use	Risk of thermal runaway, higher cost.
Nickel-Metal Hydride (NiMH) Batteries	Better safety profile, lower cost than Li-ion.	Lower energy density, memory effect.
Solid-State Batteries	Higher energy density, improved safety, longer life.	Currently expensive, manufacturing challenges.
Sodium-Ion Battery	Sumber berlimpah	Teknologi masih baru

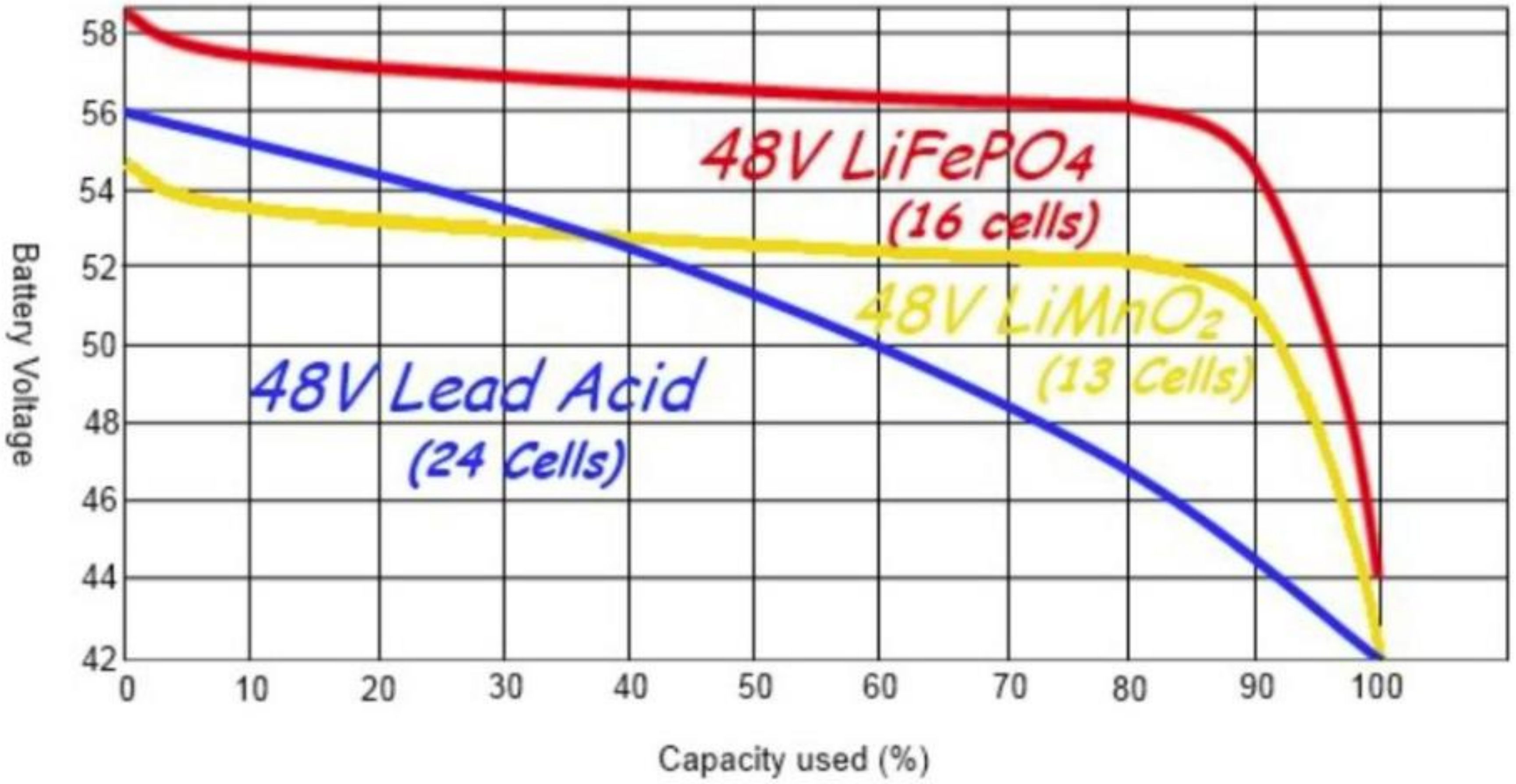
Some Comparative Analysis

- **Energy Density:**
  Li-ion > Solid-State > NCA > NMC > NiMH > $LiFePO_4$
- **Safety:**
  Solid-State > NiMH > $LiFePO_4$ > NMC > NCA > Li-ion
- **Cost:**
  NiMH > $LiFePO_4$ > NMC > NCA > Li-ion > Solid-State
- **Lifespan:**
  Solid-State > $LiFePO_4$ > NMC > NCA > Li-ion > NiMH

Evaluating Battery Performance: Potential - Discharge Curve

$$Fe(s) + Cd^{2+}(aq) \longrightarrow Fe^{2+}(aq) + Cd(s)$$

$$E = E^\circ - \frac{0.0257\ V}{n} \ln \frac{[Fe^{2+}]}{[Cd^{2+}]}$$



Li-ion versus lead acid discharge curves using a 0.2C discharge rate. (Image: ***Off Grid Ham****)*

Sumber listrik yang “hijau” penting !!

- EV ramah lingkungan bila sumber listrik yang digunakan untuk men-charge baterai berasal dari sumber yang ramah lingkungan.
- Setiap konversi energi akan disertai loss of energy

Konversi energi pada sumber pembangkit energi tradisional:

Minyak/Batubara → Energi gerak (Turbin) → Energi listrik → Energi Kimia (Baterai) → Energi Gerak (Motor EV)

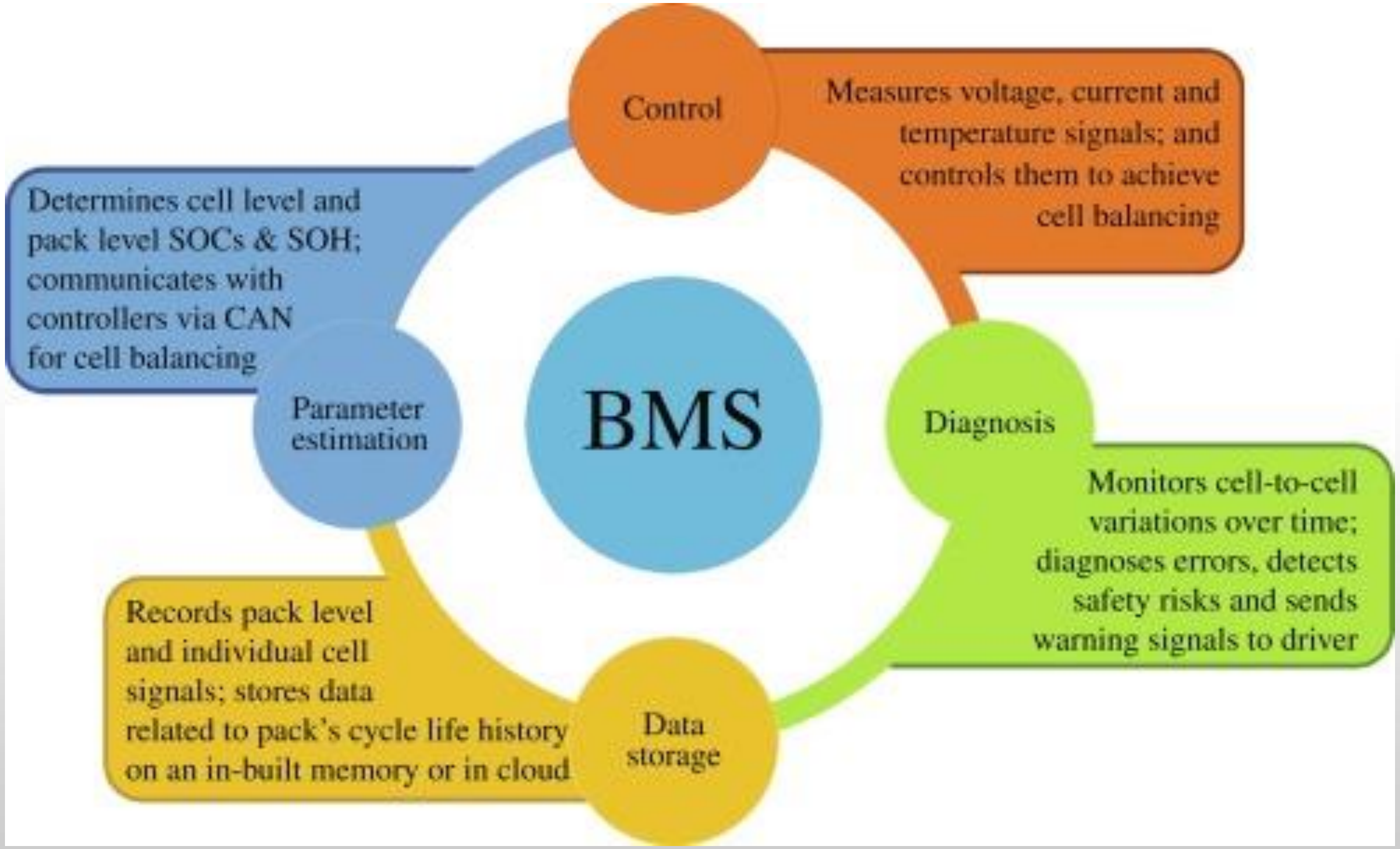
Perlu sumber energi listrik yang ramah lingkungan

Angin/Hidro/ Pasang Surut Nuklir → Energi gerak (Turbin) → Energi listrik → Energi Kimia (Baterai) → Energi Gerak (Motor EV)

Matahari → Energi listrik → Energi Kimia (Baterai) → Energi Gerak (Motor EV)

Battery Management System (BMS)

The main goal of BMS is to keep the battery within the safety operation region in terms of voltage, current, and temperature during the charge, the discharge, and in certain cases at open circuit.



Baterry Afterlife ....

Disposal and Recycling

- In general, the life span of a lithium-ion battery is 3 to 10 years depending on the number of recharge cycles.
- Estimated between 200 million and 500 million tons of spent battery wastes are generated annually by 2020.
- They contain toxic metals like cobalt, dumping them in the landfill is not an option. Plus, these batteries have valuable metals, so there is also a financial incentive to recycle them.
- Steven Athwal, managing director of The Big Phone Store, a UK mobile refurbishment brand, said the real issue of recycling batteries is how cheaply it can be done. “Currently, buying recycled lithium is much more expensive than mining it straight from the ground. That needs to change,” he said. “By scaling up our current battery recycling, those costs will go down.

Peran ITB dalam pengembangan Batery

- 2012-2015 Program MOLINA (Mobil Listrik Nasional).
- Tim Pengembangan Mobil Listrik Nasional :
  Tim Pengembangan Sistem Penyediaan Energi Listrik
  - Prodi Teknik Kimia : Fuel Cell
  - Prodi Teknik Elektro : Super Capasitor
  - Prodi Fisika : Elektroda baterai
  - Prodi Kimia : Elektrolit baterai
  - Prodi Teknik Fisika : Battery Manajemen System

Peran ITB dalam pengembangan Batery

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Dimana ITB dapat berperan pengembangan battery EV

- **Improved sourcing:** The current method of mining is antiquated, dangerous, polluting, and time-consuming. It is ripe for innovation and improvement to have less environmental impact when removing lithium from the ground.
- **Improved battery design:** R&D in battery life has been going on since it was invented. But the needs to be continued investment in creating batteries with longer lifespans, higher energy density, and faster charging capabilities..
- **Material substitution:** While lithium-ion batteries are the best option at the moment, alternatives can always come to the market. One alternative design uses sodium instead of lithium but it is in the very early stages. More environmentally friendly alternatives need to be explored.
- **Battery recycling:** No lithium-ion battery should ever go to a landfill. It should go to a reputable recycling company, one that is heavily audited for environmental compliance and not using child labor as is often the case in some countries.
- **Public awareness and education:** businesses tend to be more environmentally conscious about recycling dead and exhausted lithium-ion batteries than consumers. It needs to be more consumer awareness about the importance of recycling dead batteries and not just throwing them in the trash.
- **Source of Electricity:** Clean and renewable electric generator should be developed. No matter clean and environmental friendly EV, it will not great for environmental if the source of electricity is not “green”.

Terima Kasih