How “clean” is an electric car?

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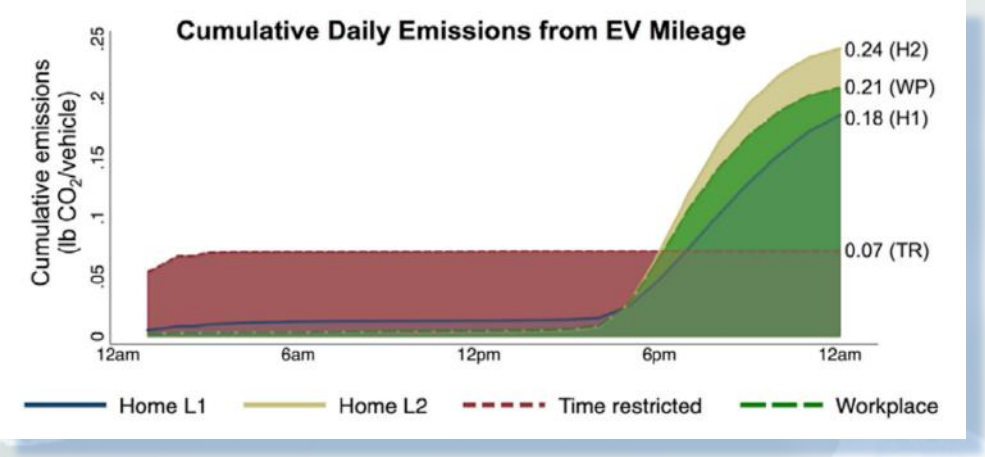
https://www.iea.org/reports/global-ev-outlook-2020
https://library.wwindea.org/global-statistics/
https://www.renewableenergyworld.com/2020/01/10/142-gw-of-solar-capacity-will-be-added-to-the-global-market-in-2020-says-ihs/#gref

Electrified Transportation



Where is the electricity coming from? A high-carbon grid? A low-carbon grid?

Even an all-electric vehicle can still be responsible for carbon emissions

https://afdc.energy.gov/files/u/publication/ev_emissions_impact.pdf

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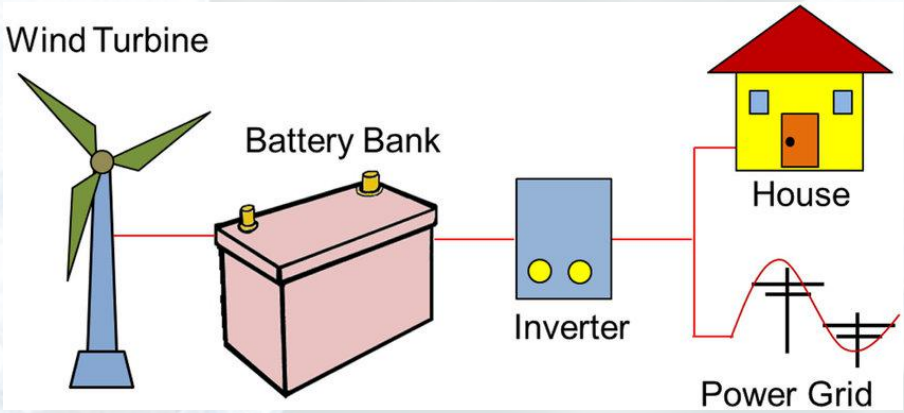
Renewable Solar and Wind Energy



Energy is generated sporadically and intermittently

Batteries help to level the load and shave off peaks in energy demand

Abdalla, A. H.; et al., *IET Digital Library* 2016, p. 1529-1534.

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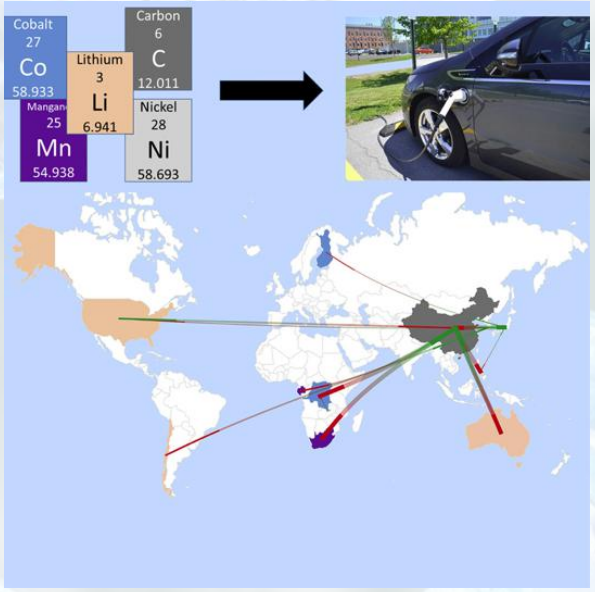
Is the Battery “Clean”?

- How much carbon does it take to manufacture a battery?
  - Battery manufacturing is energy intensive
  - Electricity for manufacturing is main contributor
- Where do the materials come from?
  - Domestic materials security
  - Child labor
  - Sociopolitical consideration



https://www.bruegel.org/2019/05/is-an-electric-car-a-cleaner-car/
Olivetti, E. A. et al. *Joule* **2017,** *1* (2), 229-243.

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Solutions to Making Batteries “Cleaner”

- Power battery manufacturing with renewable energy

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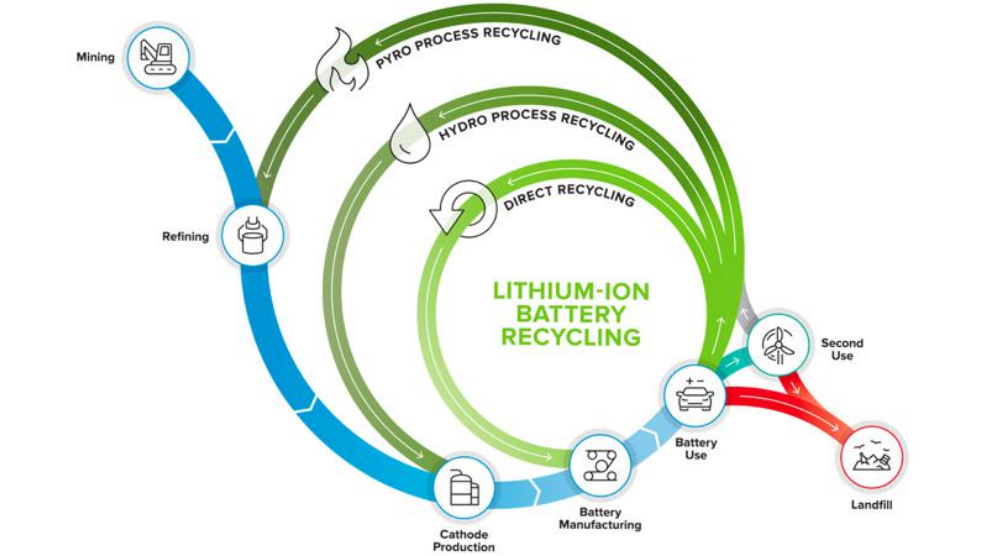
Solutions to Making Batteries “Cleaner”

- Power battery manufacturing with renewable energy
- Recycling and repurposing



https://www.anl.gov/article/doe-launches-its-first-lithiumion-battery-recycling-rd-center-recell
https://www.waste360.com/e-waste/department-energy-commits-ramping-lithium-ion-battery-recycling
Nature Energy 2019, 4 (4), 253-253

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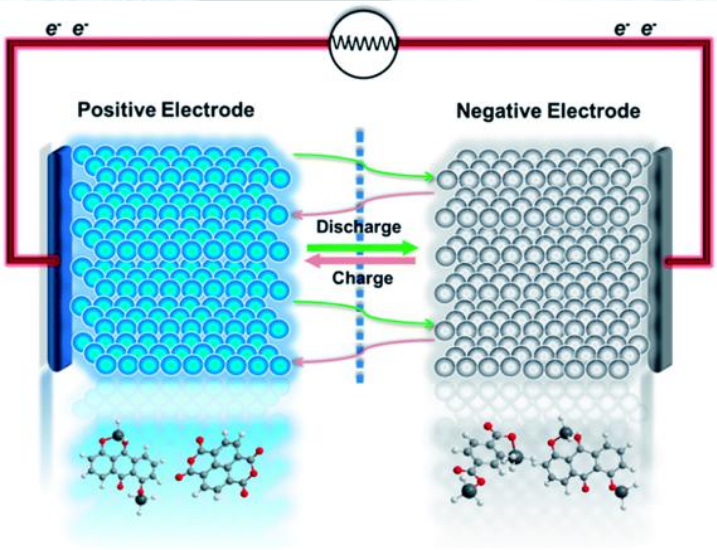
Solutions to Making Batteries “Cleaner”

- Power battery manufacturing with renewable energy
- Recycling and repurposing
- Low-cobalt or no-cobalt chemistries
- Metal-free chemistries



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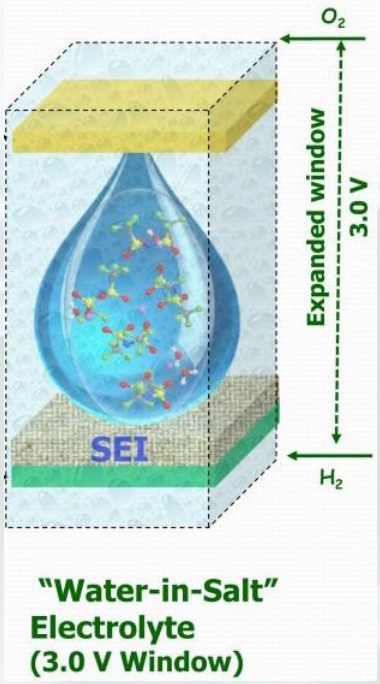
- Aqueous electrolytes



Suo et al. *Science* 2015, 350, 938-943
https://www.greencarcongress.com/2015/11/umdusarl-team-develops-water-in-salt-electrolyte-enabling-high-voltage-aqueous-li-ion-chemistries.html

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“Decarbonization of energy necessitates that we take a hard look at the carbon footprint of battery manufacturing and battery charging”

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