# Electric Vehicles

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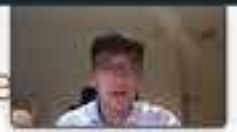
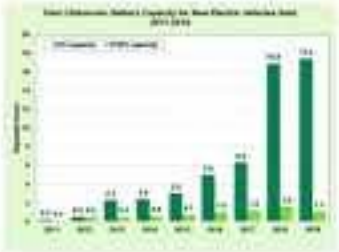
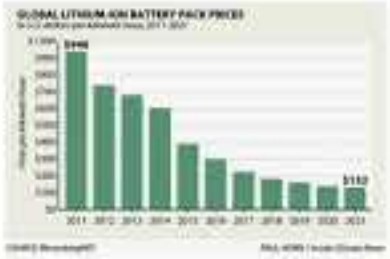
# The History and Composition of EVs

# Construction of EVs (Lithium Ion Batte



- Type of rechargeable battery that uses the reversible reduction of lithium ions to store energy
- Four main components: cathode, anode, electrolyte, and separator
- Three steps to producing batteries: electrode manufacturing, cell assembly, and cell finishing
  - Currently an emissions heavy process; for every 1 tonne of mined lithium, 15 tonnes of $CO_2$ are emitted into the air
- Price of batteries is getting cheaper, and overall capacities are increasing





# History of EVs

- Two distinct turning points that spa
    1. Toyota Prius became w
    2. Establishment of Tesla I
- The 2009 Recovery Act created nati
- Paris-Agreement is established and
- European Battery Alliance founded

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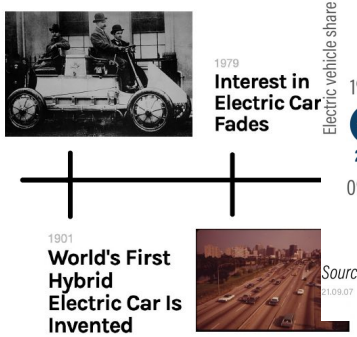


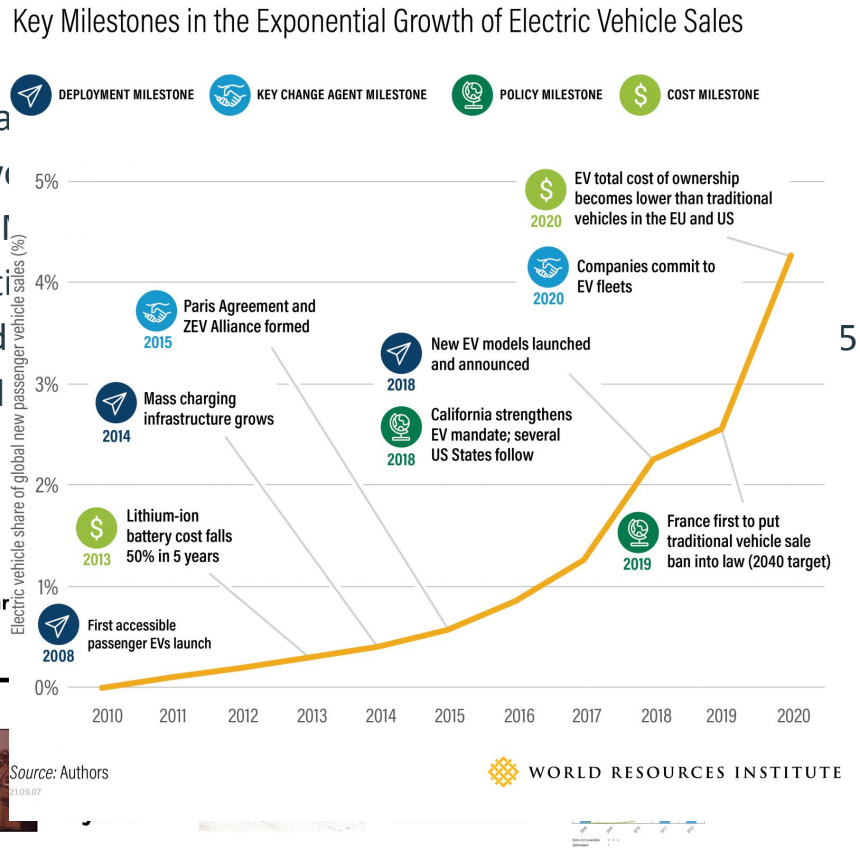

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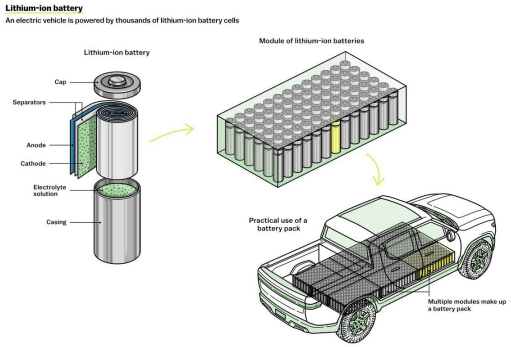
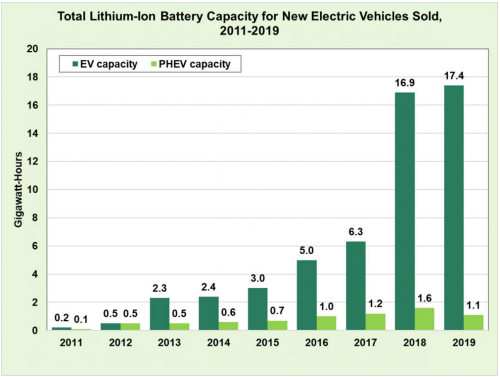
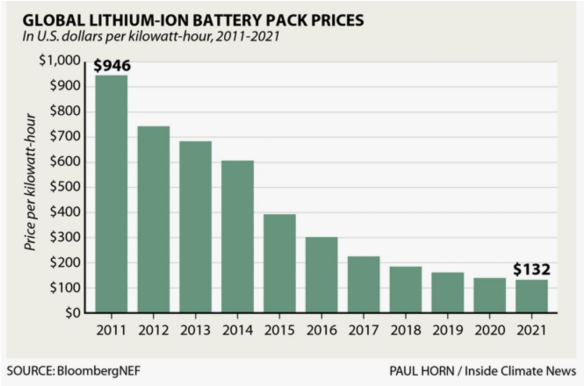


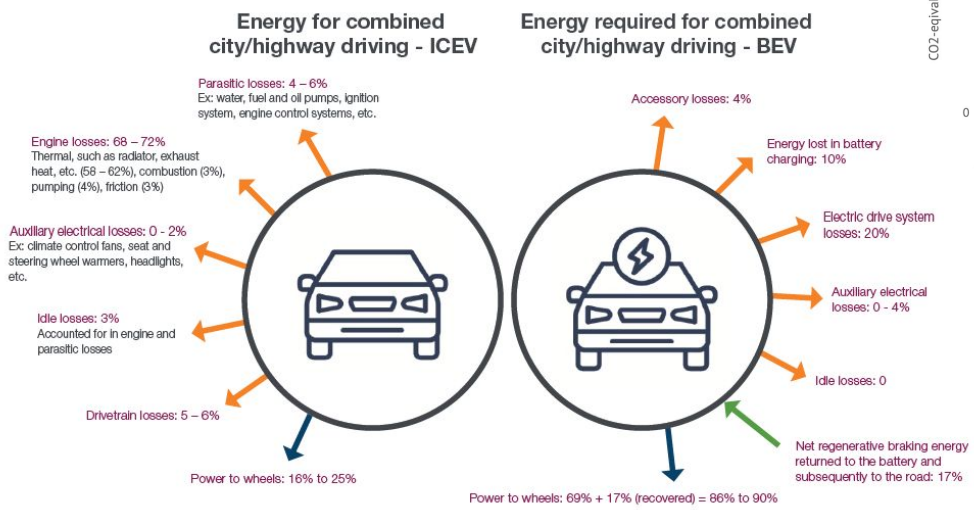



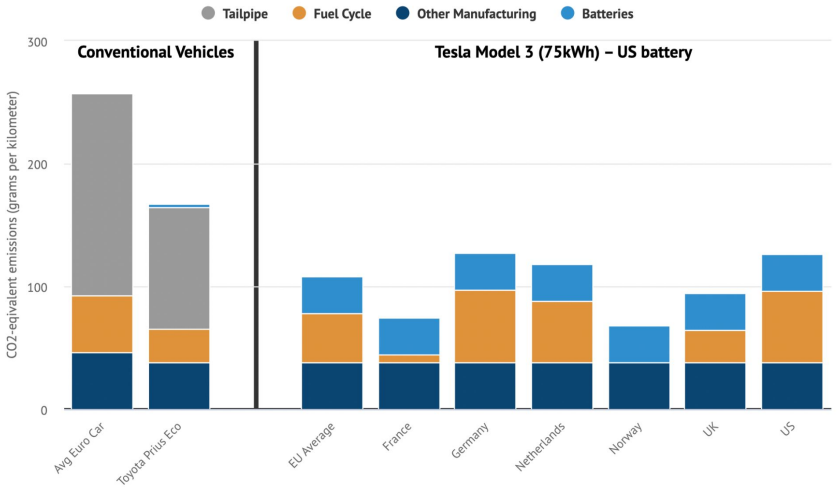



# Electric Vehicles vs. Gasoline Powered Cars

# EVs vs Internal Combustion Engine Efficiency

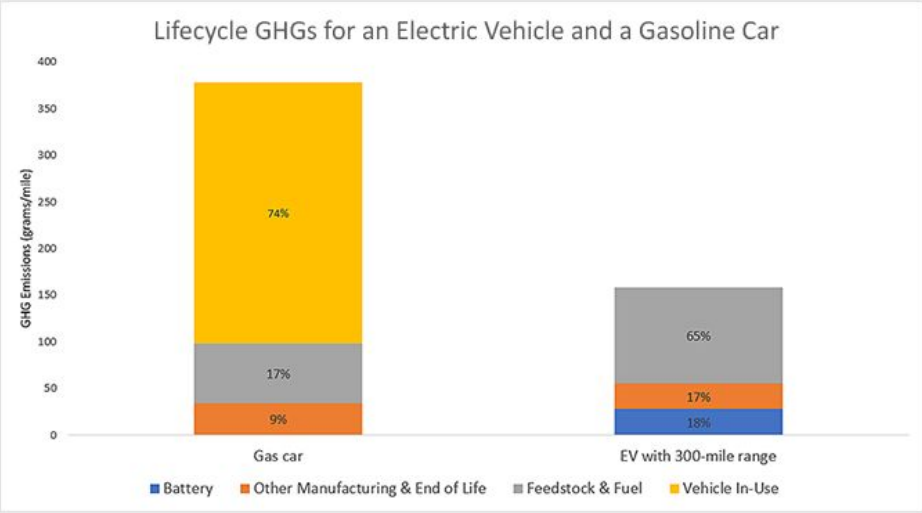
- Efficiency is important because
  - Reduces carbon emissions
  - Save more money
  - Use less resources
- Regenerative braking gives EVs large upper hand

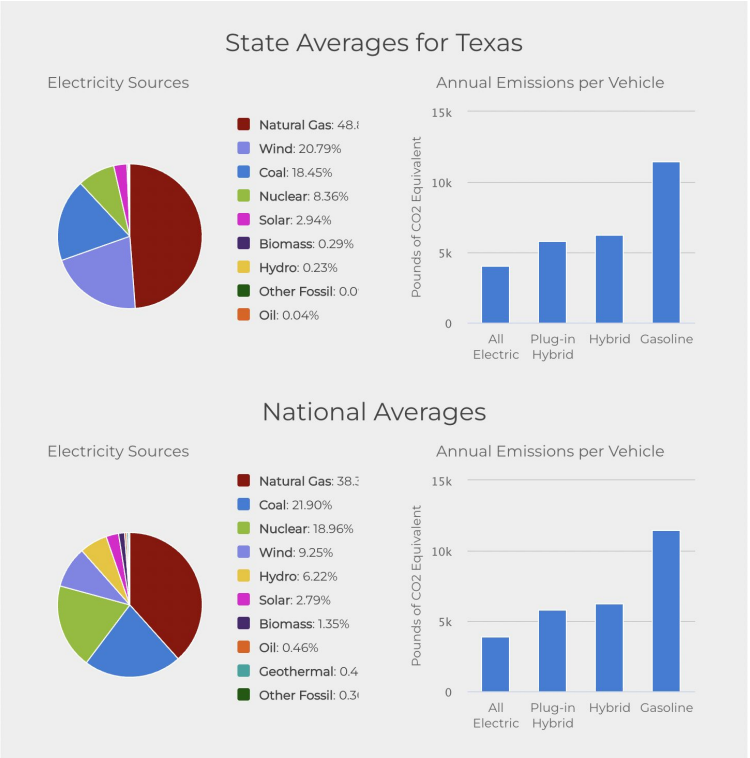


# Emissions and Sustainability

- EV battery: 15-20 years average life cycle
- ICE engine: 10 years average life cycle
- **The emissions for EVs are much lower than traditional cars**

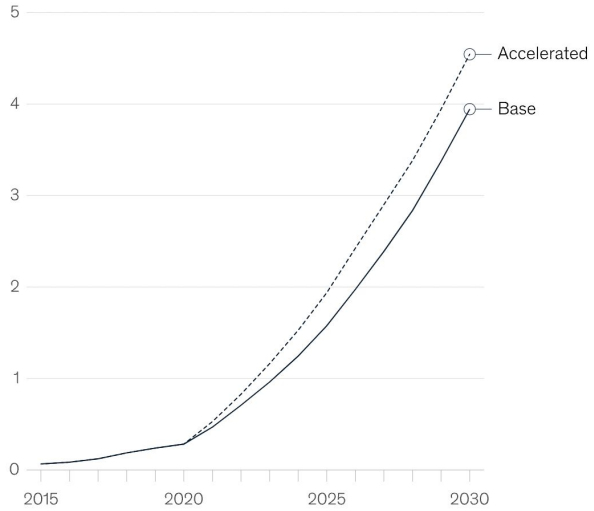


# Lithium-Ion Batteries: Are they Sustainable?

- The mining process for lithium is intensive and poses risks to the environment
  - Done through a system that uses large amounts of water and toxic chemicals
- With more and more technology being introduced to the world, lithium demand will only increase

**Global lithium-ion battery demand by scenario,**
thousand gigawatt-hours

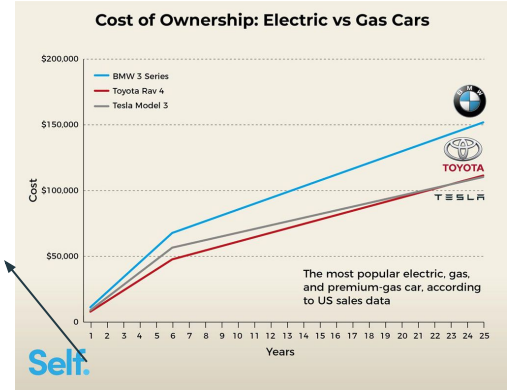


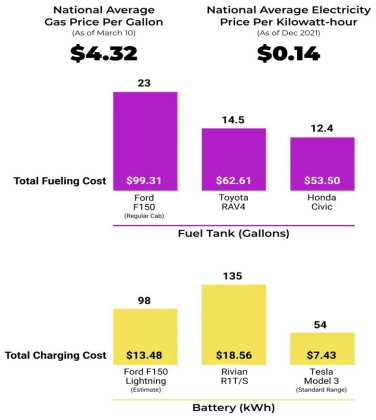

Source: McKinsey battery demand model

# Comparative Costs and Trade-Offs

# EV’s are expensive

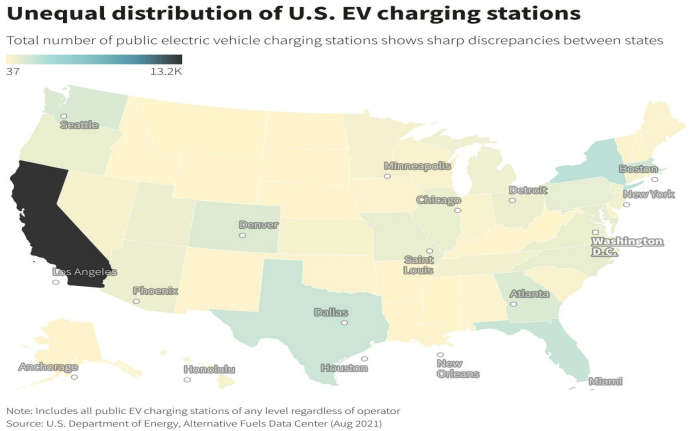
- There is a significant difference between the price of EV’s and gasoline cars
  - The average price of an EV is $55,000 compared to the average price of a gasoline car which is $30,000
  - However, prices will fall as the cost of manufacturing gets cheaper
- However, EV’s are much more cost effective in the long run
  - A 2018 study stated that EV owners are able to break even after 6.7 years of purchasing the car, and start saving money post that
- EV’s also have much lower maintenance costs since they are a lot less moving parts.
  - According to AAA, they cost $330 less per year on maintenance.

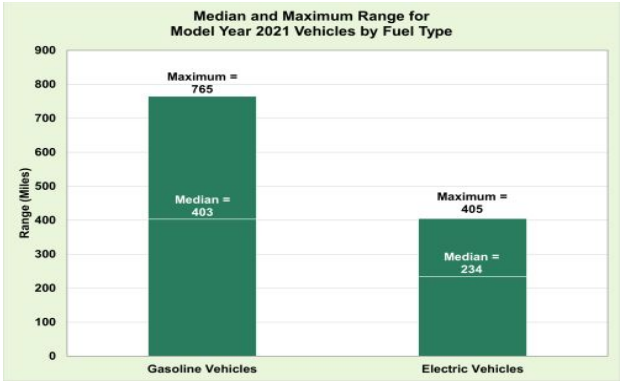


# Range and Charging Capabilities of EVs

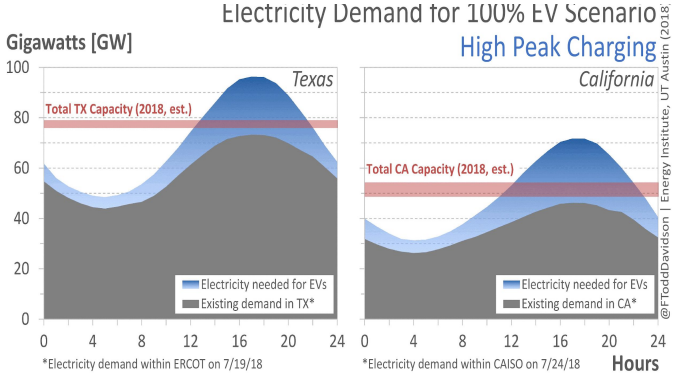
- The average range of EV's is around 200 miles, and the maximum range is 400 miles
  - However, the US and other governments are spending a large amount of money in the field of battery optimisation in an effort to increase the range.
- Another major drawback are the limited charging stations and the lengthy process of charging these vehicles
  - The US has about 55,000 charging stations, with about 136,000 chargers- versus 145,000 petroleum gas stations, with 1.5 million nozzles.
  - A gas station can also handle a number of cars at a time and filling a tank only takes up a few minutes. However, it takes 4-5 hours to fully charge an EV.
- In fact, the most common EV charger, the 240V level 2, takes 2-3 hours to add only 100 miles of range



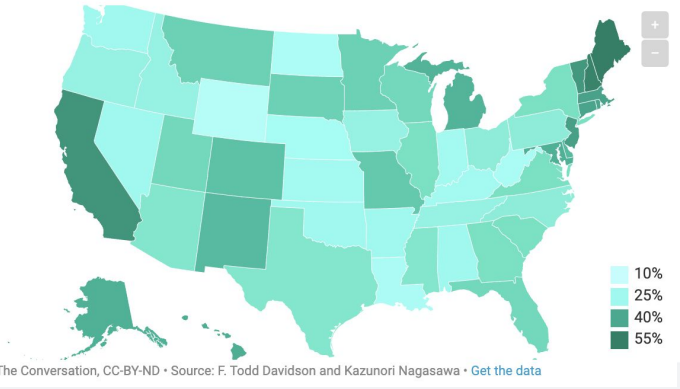



# Impact on the Power Grid

- US mandates to end purchases of gas-powered vehicles by 2035 will require bolstering the power grid
  - Projected growth will vary significantly state-by-state
- The sensible approach would be to strengthen existing renewable energy infrastructure
  - In fact, leading oil and gas companies like BP have started to build and advocate for renewable capacity and infrastructure.
- Many companies are looking to be net zero by the year 2050, but at the same time looking to increase the power output to meet the demand.
  - Not only are we increasing the power output, but also doing it in a sustainable way.




**Projected Electricity Consumption and EVs**

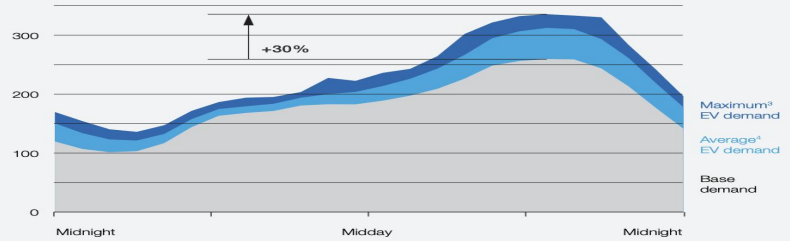



Map: The Conversation, CC-BY-ND • Source: F. Todd Davidson and Kazunori Nagasawa • Get the data

Exhi

When local electric-vehicle penetration hits 25 percent, peak circuit loads can grow 30 percent.

**Feeder circuit load,[1] 150 homes with 2 vehicles per household,[2] with 25% electric-vehicle (EV) penetration,** kilowatts



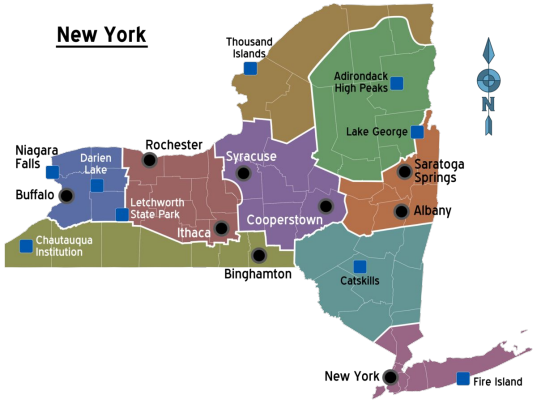

[1]Load shape for a typical feeder with 150 houses at 8 megawatt-hours per year; example shown for Midwestern US on typical September day.
[2]The average US household owns 2.1 vehicles.
[3]Statistically expected maximum EV demand—"peak day."
[4]Statistically expected average EV demand—"typical day."

McKinsey&Company | **Source:** OpenEI; McKinsey analysis

# EV Regulation and Policy

# Electric Vehicle Mandates

- California & New York
  - 2035 - EV or plug-in electric hybrids
- European Union
  - 2035 - ban sale of new petrol and diesel cars

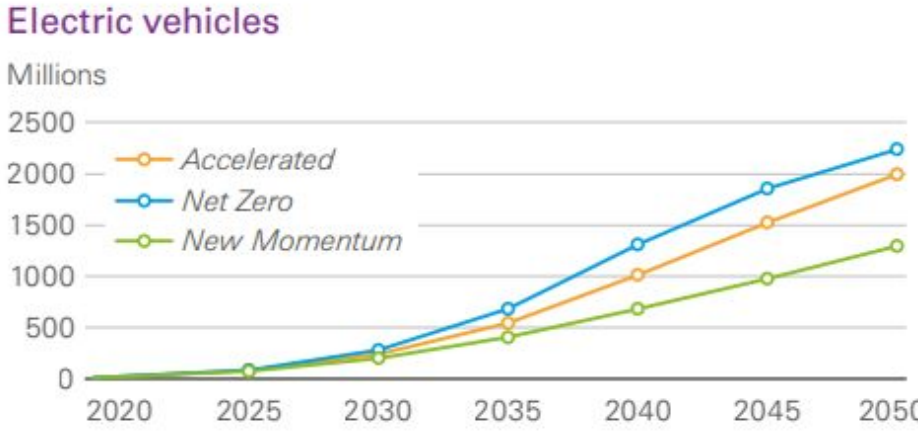

# Inflation Reduction Act

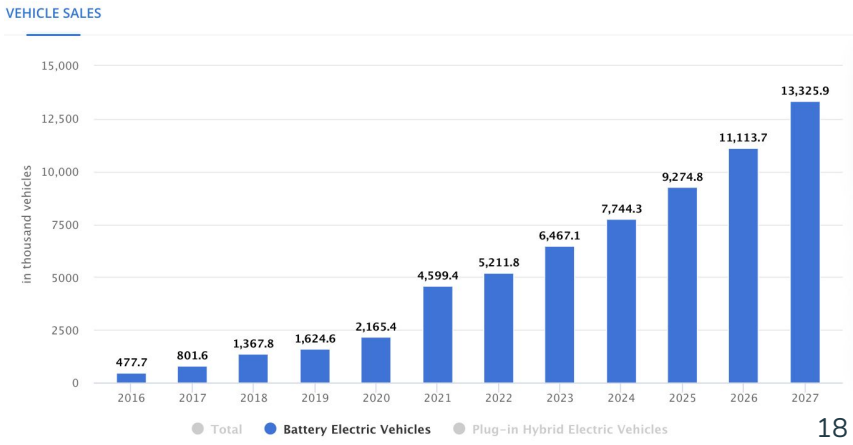
- Section 30D - EV Tax Credit
  - $3750 - critical mineral requirement
  - $3750 - battery component requirement
  - 2024 - no more foreign battery components
  - 2025 - no more foreign critical minerals
- Section 25E - Used EV Tax Credit
  - $4,000 or 30% of sale price
  - $25,000 minimum; 2 years old
- Section 45W - Commercial EV Tax Credit
  - 30% of sale price or incremental cost
    - (EV price - comparable ICEV price)
  - $7,500 for < 14,000 lbs; $40,000 for > 14,000 l

# Current EV Market

# EV Market - Overall

- The EV market is **large** ($24.03 billion domestically, $185 billion globally) and projected to **grow rapidly** (CAGR: 17.75%-25.4%)
- EV sales are **distributed unevenly** across countries, with China as the largest player, followed by Europe and the US.
- **No single manufacturer dominates** EV manufacturing, and almost all major automakers are expanding their EV presence.



# EV Market - By Country

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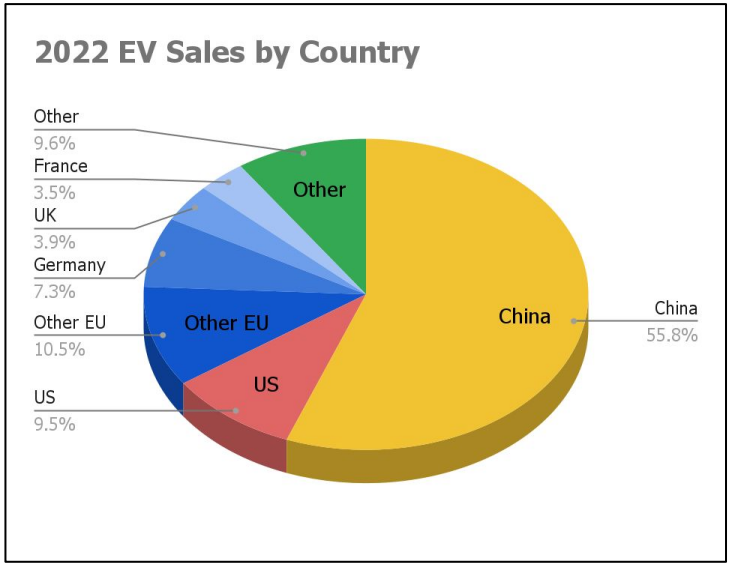


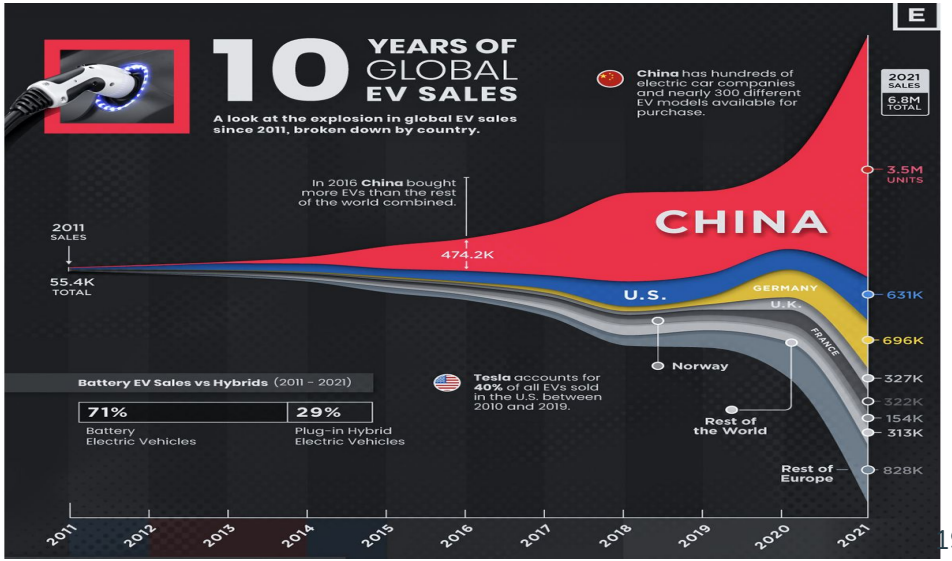

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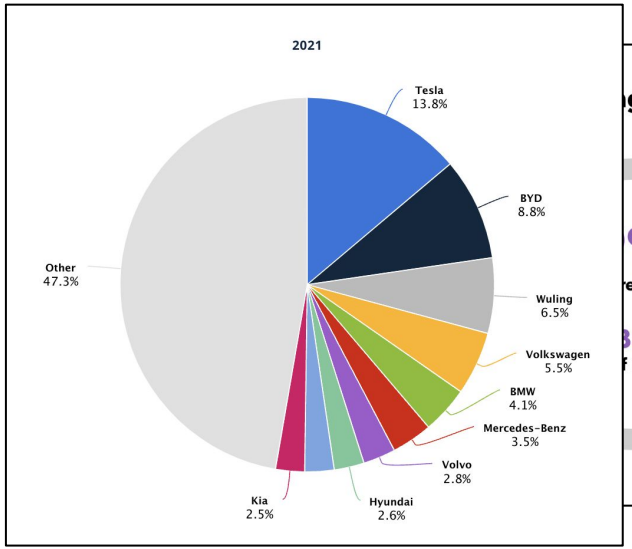
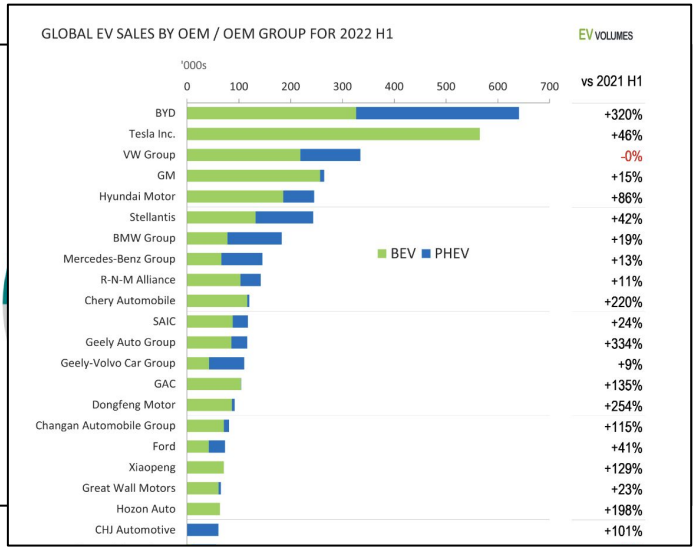
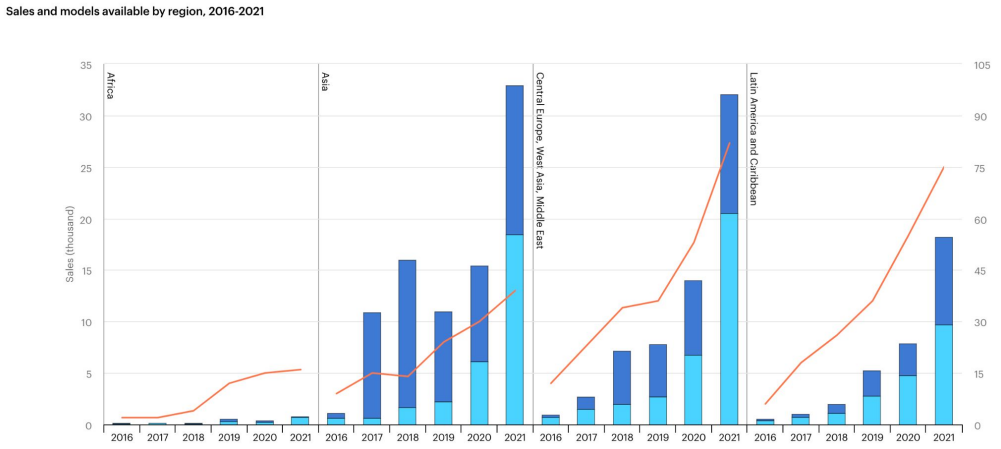


# EV Market Trends

- Companies are **diversifying** EV options, including expanding **types of EV** (SUVs, sedans) and **electrification options.**
  - Europe & China → US → Latin America & Caribbean → Asia → Africa
- EV **infrastructure is expanding**, which could fuel greater investment and consumer spending.
  - US: $5 billion IRA investment, electricity grid reliance
- Markets and capital flows towards **developing countries** are steadily increasing, but not fast enough.
  - India: 2021 FDI $6 billion vs $180 billion estimate

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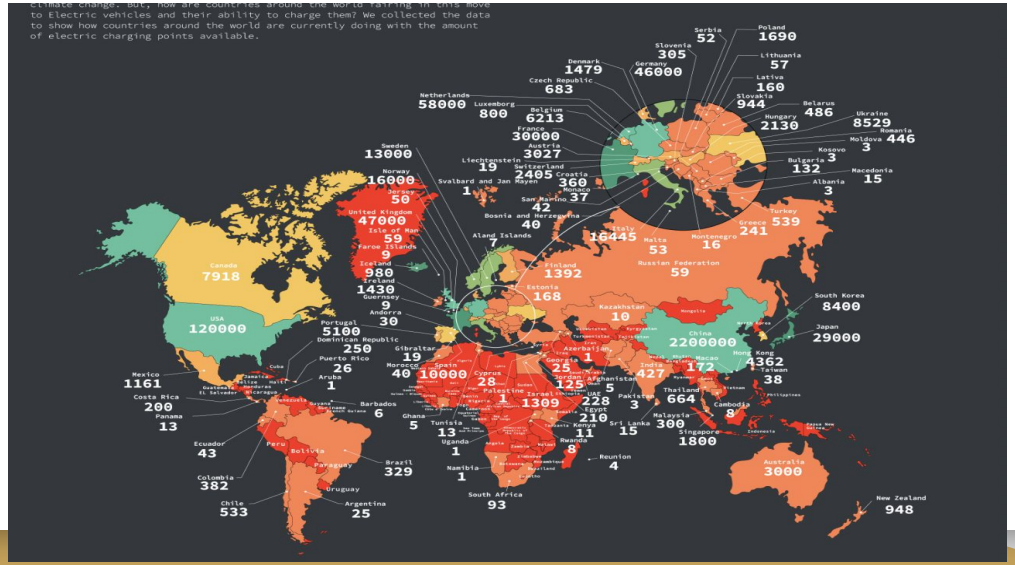

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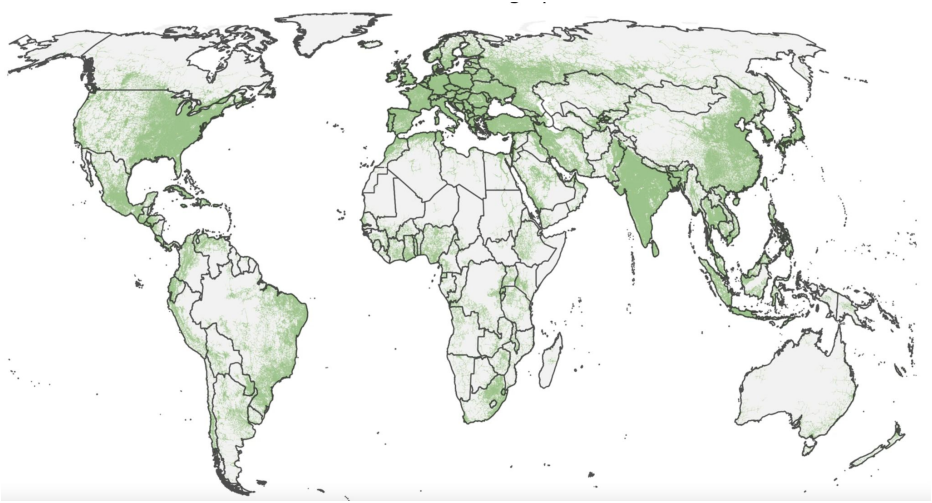
**TABLE 2.18.** Additional Investment Needs at 2030 of Pursuing the 30×30 Scenario

| | Vehicle capital investment | | | | | Charging infrastructure | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| US$, millions | 4W | 2W | 3W | Bus | Total | 4W private | 3/4W public | Bus public | Total | Private | Public | Aggregate |
| Brazil | 5,088 | 213 | 3 | 174 | 5,479 | 342 | 1,014 | 174 | 1,530 | 5,646 | 1,362 | 7,009 |
| Cambodia | 13 | 15 | - | 8 | 36 | 1 | 3 | 4 | 8 | 29 | 15 | 44 |
| Egypt | 799 | 548 | 143 | 320 | 1,810 | 105 | 307 | 160 | 571 | 1,594 | 787 | 2,381 |
| Ethiopia | 64 | 21 | 6 | 160 | 252 | 2 | 6 | 73 | 81 | 93 | 240 | 333 |
| Ghana | 24 | 4 | 10 | 92 | 129 | 5 | 14 | 43 | 62 | 42 | 149 | 192 |
| India | 8,410 | 6,375 | 722 | 2,449 | 17,956 | 857 | 2,525 | 1,065 | 4,447 | 16,364 | 6,039 | 22,403 |
| Jamaica | 150 | 3 | — | 0 | 153 | 10 | 29 | 0 | 39 | 163 | 30 | 193 |
| Jordan | 219 | 16 | — | 7 | 242 | 8 | 25 | 3 | 36 | 243 | 35 | 278 |
| Kazakhstan | 87 | 0 | — | 48 | 135 | 26 | 76 | 15 | 116 | 113 | 139 | 251 |
| Maldives | 3 | 6 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 9 | 1 | 10 |
| Nepal | 134 | 338 | 9 | 185 | 666 | 3 | 9 | 60 | 72 | 485 | 254 | 739 |
| Nigeria | (43) | 2 | — | 305 | 263 | 13 | 36 | 127 | 175 | (29) | 467 | 438 |
| Poland | 1,399 | 5 | — | 65 | 1,469 | 184 | 543 | 31 | 757 | 1,587 | 639 | 2,226 |
| Rwanda | (0) | 1 | 0 | 12 | 13 | 0 | 1 | 5 | 7 | 1 | 19 | 20 |
| Tajikistan | (3) | — | — | 1 | (2) | 1 | 4 | 0 | 5 | (1) | 5 | 3 |
| Turkey | 1,981 | 130 | — | 522 | 2,633 | 131 | 393 | 245 | 769 | 2,242 | 1,160 | 3,402 |
| Ukraine | 243 | 7 | — | 107 | 357 | 35 | 100 | 46 | 180 | 285 | 252 | 537 |
| Uruguay | 242 | 59 | — | (0) | 301 | 12 | 35 | 5 | 51 | 313 | 39 | 352 |
| Vanuatu | 1 | 0 | — | (0) | 1 | 0 | 0 | 1 | 2 | 1 | 1 | 2 |
| Vietnam | 863 | 2,047 | 374 | 258 | 3,542 | 41 | 123 | 111 | 275 | 3,325 | 491 | 3,817 |

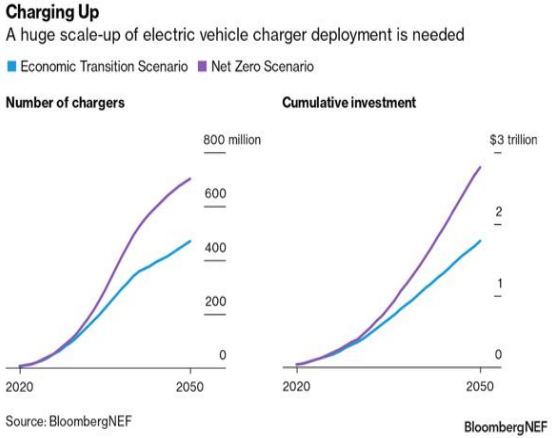
*Source:* World Bank, *Economics of Electric Mobility Scoping Tool*, 2022.

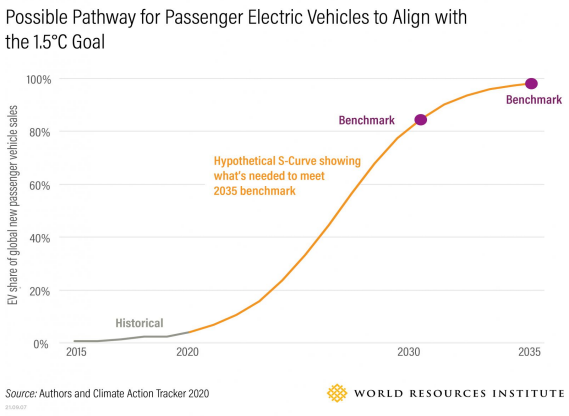


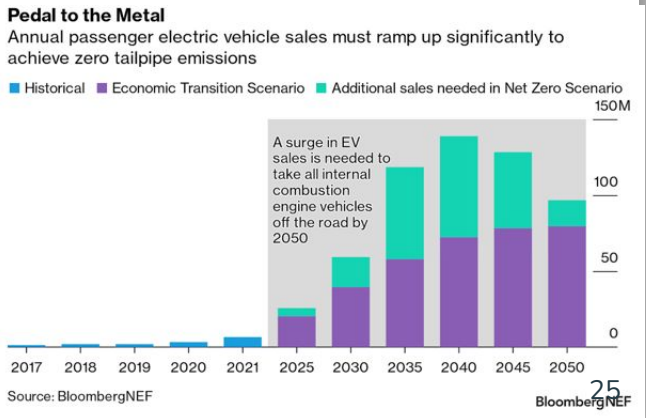
# The Future of EVs

# Plugging into the Future

- EV charging connectors must scale-up to around **700 million by 2040** in either a net-zero or economic transition scenario
- **Nearly 100% of new vehicle sales** should be EVs in order to hit 2035 benchmarks to limit global temperatures to 1.5°C
- Massive surge of sales is needed to replace the ICE—**over $10M by 2025; $60M by 2040; $70M by 2050**

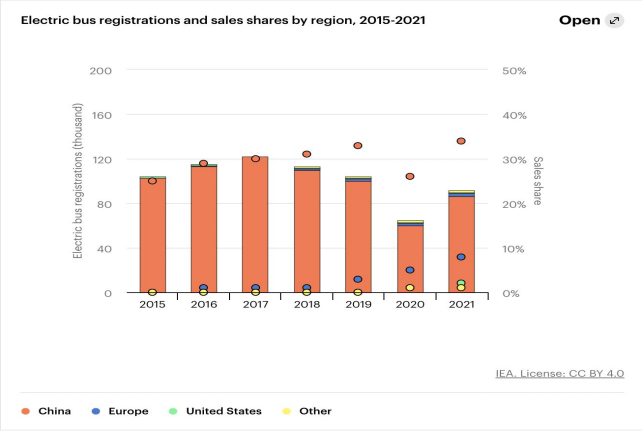


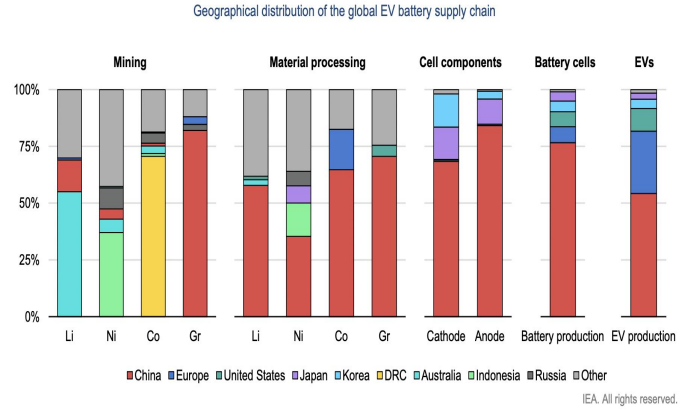



# Recommendations: Public and Private

- Jumpstart the **heavy-duty** market
  - Sales of electric buses rose 40%, but remain less than 1% of the total number of registrations for medium-heavy duty vehicles
- Promoting adoption and development in **developing and emerging economies**
  - Prioritize electrification of two/three wheelers due to cost competitiveness
  - Tighten fuel economy and emission standards
- Secure and sustainable EV supply chains
  - **Leverage private investment** to sustainably mine battery metals
  - Innovation of alternative chemistries and tracking of key EV components



# Thank you!