Group 6-Transportation Electrification
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EAS 550/STRAT 566 Systems Thinking for Sustainable Development & Enterprise
Final Project Deliverable #1: Dynamic Hypothesis and Causal Loop Diagram
Due: February 10th at 5pm

Problem Description

With the path to decarbonization paved with electrification, the United States is prioritizing the transition from combustion engine to electric vehicles (EV) through public policy (The White House). The expected increase in demand for EVs will have cascading impacts including an increase in demand for rare earth metals, expansion of the electricity grid to meet consumer demand, and maturation of battery waste streams (IEA; Hauke et al.).
Through our system model, we hope to explore the equity and justice implications of increased EV demand on mining for rare earth metals, expansion of electricity generation and transmission capacity, and recycling of batteries.

Hypothesis

Electric vehicles (EV) are creating a cutting edge in the field of technology and automobiles. Public policy provides direct incentives for the market of EV to grow, increasing consumer demand for EV products and derivatives, enhancing the needs of lithium in batteries, and boosting industry political influence for advocacy. Market growth raises electricity demand and reinforces infrastructure upgrading to better satisfy the resilience, capacity, and reliability of the electricity grid. Used battery recycling contributes to environmental sustainability uncertainty, while maintenance and public budgeting draw financial and social sustainability interests. Humanity topics proposed in this dynamic system are social impacts to the city and the civics including the affordability, justice/equity, and public safety of the use of EV supported by more electricity provision, which simultaneously pushes concerns of international sourcing of rare minerals to the table. The CLD below illustrates our dynamic hypothesis.

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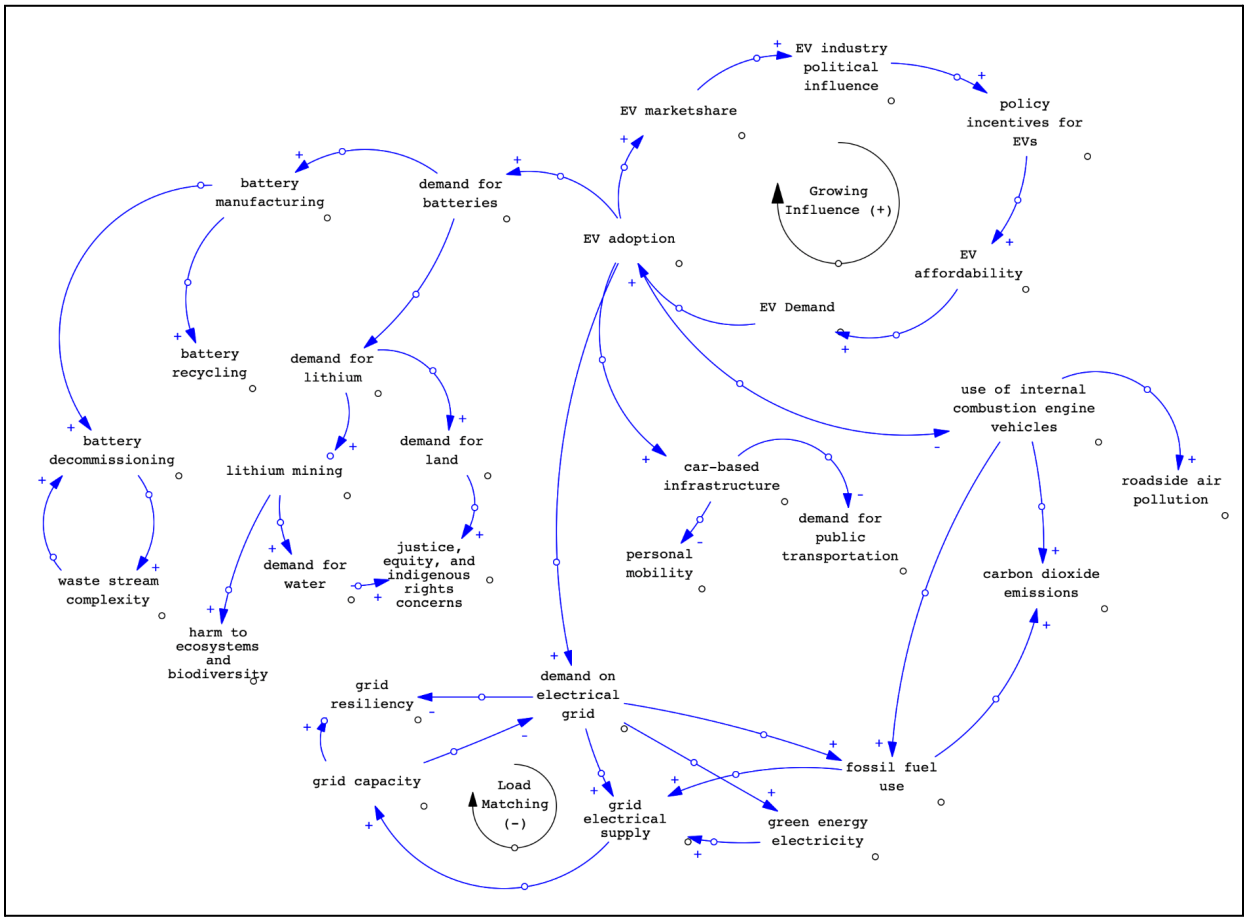
CLD



CLD Description

We have focused our causal loop diagram (CLD) on how EV adoption impacts the grid, car-based infrastructure, the use of internal combustion engine vehicles, battery demand and the main causes from those four elements. We identified two feedback loops within our CLD; load matching and the growing influence of electric vehicles (EV). The growing influence of EVs feedback loop is reinforcing with the adoption of EVs increasing EV market share, which increases the EV industry's political influence. This increases the policy incentives for EVs, increasing EV affordability and EV demand which further increases EV adoption. EV adoption branches out and impacts the demand for batteries, demand on the electrical grid, the use of internal combustion vehicles and car-based infrastructure. Car-based infrastructure decreases both the demand for public transportation and personal mobility. The demand for batteries increases battery manufacturing which increases battery recycling, battery decommissioning and waste stream complexity. The demand for batteries also increases the demand for lithium which increases lithium mining, the demand for land and the demand for water. These increase concerns over justice, equity and indigenous rights as well as harm to ecosystems and biodiversity. The demand on the electrical grid brings us to the second feedback loop in our

CLD, match loading. This feedback loop is balancing the demand on the electrical grid increasing the grid supply, increasing grid capacity which decreases the demand on the grid. The demand on the grid also impacts grid resiliency, green energy electricity and fossil fuel use. Fossil fuel use is also increased from the use of internal combustion vehicles which further increases CO2 emissions and roadside air pollution.

References

Hauke Engel, Russell Hensley, Stefan Knupfer, & Shivika Sahdev. (n.d.). *How electric vehicles could change the load curve | McKinsey*. Retrieved February 7, 2023, from https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-potential-impact-of-electric-vehicles-on-global-energy-systems

IEA (2021), The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions, License: CC BY 4.0

President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks | The White House. (2021, August 5). https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/