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Final Project: Climate Change Solution

Executive Summary

Senate Bill 32 and 100 are landmark policies aimed at improving living conditions for Californians through the reduction of greenhouse gas emissions. GHG emissions must drop 40% below 1990 levels by 2030, and net-zero emissions must be achieved by 2045 (Millard-Ball and Press, 9-10). With the transportation industry accounting for over 50% of San Diego's emissions, some sectors such as electric vehicles have rapidly transitioned to battery-electric or alternative zero emissions; but the automotive industry suffers from massive emission setbacks from its lithium consumption. As such, alternative solutions beyond personal vehicles are necessary.

To achieve our 2045 goals, we must focus on two primary alternatives: a reduction in vehicle miles traveled and an increase in reliance on public transportation. Our policy concern regards the latter: a fundamental transformation of trains and freight locomotives in San Diego from diesel-electric to battery-electric. Rail companies that operate commuter transportation as well as cargo freight are slightly behind the curve.

Consider Amtrak's Pacific Surfliner, a passenger locomotive that runs through San Diego. This train consumes on average 2.3 gallons of renewable diesel per mile. Compared to conventional diesel, renewable diesel reduces overall CO₂ emissions by 63%. Using this calculation, 270 gallons of this fuel emits one metric ton of CO₂. With an average of thirteen

round-trip services from San Diego to Los Angeles, 24.5 metric tons of CO₂ are dispersed daily throughout this coastal area. The numbers are less favorable for other companies. A standard freight locomotive consumes roughly 3-5 gallons of conventional diesel per mile, emitting one metric ton of CO₂ per one hundred gallons. While these numbers are significantly smaller than the overall emissions from personal vehicles, the rapid electrification of cars is rapidly reducing emissions per passenger compared to trains, as many trips leave the station with empty seats. The first solution to accelerate California's emission goals by the target year is simple: advocate for an increase in research and development for the creation of battery-electric locomotives.

In recent years, efforts to create a battery-electric train have come to fruition. In San Francisco, the Caltrain rail services operates a battery-electric train to San Jose with success. While operation of a battery-electric train reinforces the viability of a full conversion to this technology, more development is necessary for freight locomotives to fully transition. Caltrain's current battery-electric locomotives operate with six cars. While Amtrak can transition without loss of passengers, freight locomotives operated by the San Diego Imperial Valley Railroad carry one hundred cars on average. These systems save their customers on total travel expenses that would not be feasible using battery-electric vehicles under the current conditions.

Based on our findings, it is imperative that we begin to accelerate the development of a more efficient battery-electric locomotive, updating the design by improving battery capacity to density ratios, setting up electricity networks above the rails similar to the trolley system, and developing an electric charging hub on already developed railway holdings. The positive impacts of transforming the railways into a fully electric system far outweigh the setbacks when considering the longevity of electric technology. Social injustices instigated by our dependence on petroleum and lithium are also significantly reduced. Lithium used for a battery-electric train is

roughly equivalent to one hundred EVs, yet San Diego's total rail system consists of a few dozen cars compared to the millions of EVs currently in use. Dependence on railway transportation also reduces highway congestion during peak hours, significantly reducing greenhouse gas emissions in vulnerable communities that are intersected by the freeway system. Finally, railway transportation is more affordable than the purchase or leasing of electric vehicles, regardless of the EV's rebates and incentives.

Introduction

This essay will focus on improving San Diego's railway transportation systems in an efficient and sustainable manner. It addresses the current issues with San Diego's GHG emissions from railway locomotives operated by companies such as Amtrak, North County Transit District, and San Diego Imperial Valley Railroad. There will be two proposals to solve this problem and meet California's proposed carbon-neutral emission standards by 2045. The first is a *Technology-based solution*: convert the most frequent operator's locomotives to a fully electric, battery-powered engine. Research and development are rapidly accelerating thanks to the transition from fossil-fuel vehicles to cleaner alternatives; as such, the transition to zero-emission trains has a head start in its completion. The second is a *Societal Transformation Solution*, to be in effect while the costs of battery-powered trains go down, is to reduce dependency on flight and personal vehicular travel and improve public opinion on the use of trains for short-distance transport. As vehicles are one of the most significant polluters in our fast-paced economy, their transition towards renewable energy will significantly reduce our emissions and pave the way for others to follow by example.

Background

Passenger electric systems have been a technology used since the turn of the 20th century. The San Diego Metropolitan Transit System operates fully electric trolleys that are powered by overhead wires. Their bus fleet is transitioning from compressed natural gas to fully electric by 2040. Freight locomotives, in contrast, work with heavier loads and have so far only progressed up to a diesel-electric engine. Depending on the loads being transported, freight locomotives consume about 3-5 liters of diesel per mile. As a result, this mode of transportation disperses heavy amounts of nitrogen oxides and particulate matter. Trains are one of the oldest methods of mass transportation, and modern systems have improved on the base model in terms of fuel efficiency; but they have retained their dependency on diesel fuel. It is imperative that the transition towards a greener alternative for freight locomotives happen in tandem with the transition of San Diego's transportation systems towards electric vehicles.

Solution One

Battery-electric locomotives are coming out of the prototype stage as more rail companies invest in zero-emission transport. Starting this year, the Caltrain rail services in San Francisco unveiled a fleet of battery-electric trains operating across the region. These trains emit no greenhouse gases, improve travel times, and eliminate the need for excessive diesel consumption (Peters, 2024). Investments in research and development on more efficient electric locomotives can lead to the accelerated discovery of more efficient or denser batteries, improve aerodynamics, and a reduction in production costs. Potential drawbacks include the dependence of lithium, a valuable element necessary to produce efficient batteries. Lithium mining in South America has produced the majority of US imports, resulting in increased water usage, increased vulnerability of ecosystems, and indigenous displacement from the lands they call their home (GlobalData, 2023). Solutions to these injustices are in the works, but at the cost of domestic natural resources.

Analyses of California's Salton Sea show that lithium deposits in this region could produce enough lithium for over 375 million batteries for electric vehicles (Department of Energy, 2023). While the total demand for lithium can produce devastating damage to both people and ecosystems, the demand for lithium for battery-electric trains is miniscule compared to that of the EV market.

Estimates show that a full transition of Amtrak trains to Electric battery trains will cost upwards of \$1B. Improving just one train, as well as NCTD's Coaster will cost significantly less and show immediate results in GHG emission reductions. Charging stations for trains would require minimal infrastructure, reducing the number of emissions generated by concrete and steel production. Train yards with idle locomotives already take up significant portions of land which can be restructured into charging stations. San Diego and Imperial Valley Railroad also operates 2 Diesel-Electric trains, but these are 10 years older than Amtrak's and NCTD's fleet. While battery technology is not feasible for these trains, purchasing fuel efficient models from companies transitioning to electric trains will also reduce emissions for the next few years as battery technology becomes more affordable.

Solution Two

California's emission goals for 2045 allow much needed time for development of affordable battery-electric technology. While some companies are able to transition quickly, others struggle to keep up with the most recent technologies as alternatives are significantly cheaper. As such, reducing short-distance transportation by plane in favor of rail transport would sharply reduce emissions from transport vehicles.

A 3-hour train ride from San Diego to Los Angeles produces half the number of emissions compared to flying or driving, which take 1 and 3 hours, respectively. Two primary drawbacks are

of particular importance. The first is that the rapid growth of electric vehicles is significantly reducing the percentage of emissions of passenger vehicles. Both San Diego and California's total emissions from the transportation industry amount to roughly 50% (Barth and Sperling, 14-9). The slow development of electric train systems keeps its share of emissions high. Until electric locomotives become more affordable for all rail companies, EVs will continue to close the gap in emissions. Additionally, some people prefer reduced travel times at the expense of more emissions. Trains usually stop at multiple stations for departures and arrivals between cities, whereas flights usually have only one destination. Driving also allows the user more freedom to choose precisely where to arrive and depart, whereas trains and flights are limited to specific points of departure.

To increase passenger transportation by train, we must identify methods to improve public opinion on the use of trains for transportation. Public Service Announcements regarding the emissions of trains being lower than that of flights or personal vehicles have shown favorable results among the environmentally conscious groups. Changes to the public's opinion start with social transformations at the local level (Forman, 6-18). By generating a system that works to the favor of its passengers and the communities that live near railways, people are more likely to take notice of the positive impacts and benefits of reducing travel by car or by flight. Furthermore, the remote work culture allows for train passengers to work while they travel, alleviating some of the discomfort some people would have on a long vehicular trip. Finally, if the market needs a helping hand, incentivize passenger and cargo transportation by freight over flight through subsidies. This can also reduce the cost of transportation by train compared to flights or the steep price of purchasing and maintaining a vehicle.

Communications Strategy

The first group my proposal will attempt to communicate with is the corporations responsible for San Diego's railway systems. While many corporations have taken a stand in favor of reducing their emissions, they do so only if it is within their profit margins. Trains already emit less than commercial flights and gas-powered cars, so they can choose to comply only until the technology is less costly than their current dependence on diesel.

My communication strategy will involve a series of three primary points: customer acquisition and retention, competitive advantages, and climate responsibility. The first point involves comparing the current customers for commercial transportation to those that can be acquired by gaining the favor of customers who chose to travel with the smallest carbon footprint. The second point emphasizes the competitive advantage of being a pioneer in technology compared to competing railway systems and even airlines. A fully electric vehicle is already a popular and favorable alternative to a gas-powered and pollutive one; the same idea holds true when comparing a zero-emission train to a heavily pollutant flight. Finally, the third point addresses the issues of climate responsibility as a corporation. It is up to those who pollute to redress the pollution either by adapting to climate-friendly technologies, aiding those negatively affected by pollution, or remedying the emissions through cleanup procedures.

The primary challenge to discussing electric train transportation to those in the commercial freight is that the alternatives are significantly faster in a world where deliveries are made in one to two days. Many customers choose to send their goods by air freight due to its expedited delivery, as consumers are able to receive their goods much faster than by freight rail. Electric trains may diminish the freight company's liability costs, allowing them to provide cheaper and more rapid solutions for its customers, but the transition comes at a high price. As such, my proposal will emphasize that there will need to be a change in public opinion on how much pollution commercial

freight produces. If the public opinion changes and demands are made to reduce emissions from all modes of transportation, freight trains are the quickest and simplest to adapt to a new model of zero emissions, gaining the support of consumers and potentially earning their favor.

The second group to target is those who are currently choosing how to travel independently: youth. The main communication strategy to youth is simpler, as many have strong opinions on reducing greenhouse gas emissions. San Diego MTS has made transit fare free to qualifying youth, allowing them access to their electric trolley systems as well as their bus fleet which is currently transitioning into fully electric. The opportunities to entice a youth audience with a positive association of accessible and clean transportation are already underway, which facilitates the introduction of battery-powered trains into the conversation. Additionally, many students and young adults find it more difficult than ever to associate personal vehicles with freedom as the older generations did, seeking alternative methods of transportation as vehicles become increasingly pricier to maintain. Trains provide both the accessibility of long-distance transportation and a guilt-free conscience by travelling with zero emissions.

The primary challenge to discussing electric train transportation to the youth is that priorities are mixed between climate-friendliness and time efficiency. One of the issues regarding public transportation is that the multiple stops significantly increase travel times compared to alternatives such as driving and direct flights.

To those who support the idea of reducing emissions using electric trains, my proposed solution will emphasize the long-term benefits of emissions reduction compared to standard hybrid locomotives, as well as bolster the solution to choose clean transportation over the time efficient methods as the needs of the many as well as the needs of our future far outweigh the needs of the “current” self.

To those who are skeptical of the idea of an electric train, as those who currently are still skeptical of the transition to electric vehicles, a compromise approach will be used. While the mining of lithium to produce the batteries causes significant pollution and disproportionate harm to the Global South, the production of a dozen train batteries requires significantly less lithium compared to the lithium required to mass produce the hundreds of thousands of electric vehicles the market currently demands. Any cleanup, restoration, or restitution to those negatively affected by the mining will also be significantly reduced.

Conclusion

Electrifying the fleet of freight and passenger locomotives is a lofty yet necessary goal San Diego and California need to accomplish to meet out net-zero emissions goal by 2045. The transportation industry composes roughly 50% of California's total GHG emissions, and the transition to renewables will offset hundreds of thousands of tons of CO₂. Battery-electric trains are less resource intensive compared to electric vehicles in terms of lithium, resulting in the need for less environmental damage as well as reducing its share of the social injustices that come from mining. Social transformations along with the technology-based solutions will work in tandem to improve the public opinion on passenger trains as well as the innovations and affordability for the rail companies operating them. With the current growth in the technology sector, twenty years of research and development is more than enough time to improve the community's dependence on railway travel into the most cost-effective, climate friendly, and efficient method of transportation.

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