Climate Science and Climate Solutions for the State of California

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Abstract

Covering the sustainable development of the State of California through the lens of the Bay Area Climate Science and Climate Solutions for the State of California discusses current infrastructure issues that the state of California faces and how the state government can implement immediate and long term solutions in order to address climate change, increase standard of living, and boost state economic growth. Discussing NOx pollution, electronic and human waste, CO and CO_2 pollution, electrification, and implementation of renewable energies in response to pollution coming from agriculture, waste, energy generation, and transportation. The discussed literature and proposed solutions utilized a case study model in order to adapt solutions both domestic and abroad to specialized use and implementation by the California state government.

1.0 Introduction

For the last several decades, California has been a leader in environmentalism, not just for the United States, but for the world at large. One of the reasons California has been able to stay such an important environmental leader on the world stage is because of the overwhelming amount of technological innovation that occurs here. In order for California to maintain this status, it must also maintain its pace of innovation. The authors of this paper have come together to analyze several different sustainable technological innovations and recommend some that we believe California should pursue. The innovations decided upon after extensive research are in various sectors of California's economy and lifestyle. The first section of the paper focuses on agricultural innovations that would help California create a more sustainable agricultural sector. The second section focuses on waste management, which is important as California produces over 75 million tons of waste each year. The third section focuses on railways and how they can be leveraged to make transportation in California much more sustainable. Electrification and the personal savings Californians could see as a consequence of electrification is the fourth topic discussed in the paper. To power the process of electrification, the fifth topic dives into renewable energy sources and how transitioning to them can make a difference. Lastly, the paper examines methods of handling the electronic waste that these, and other, innovations will inevitably produce. As progress is made in these areas, California will lead the world forward in environmental engineering and sustainability.

2.0 Agriculture

Ecologically Sustainable Agricultural Solutions in California

2.1 Introduction:

The relationship between soil microbiomes, human health, and sustainable farming practices have shown to have a great effect on our agriculture. The studies discussed in this essay show the multifaceted relationships among these three areas. The essay talks about the dual nature of soil microbiomes as both contributors to how productive agriculture has been and potential sources of where human pathogens can arise. Additionally, the global threats of antimicrobial resistance stemming from extensive antibiotic use in livestock farming and the far-reaching consequences of chemical pesticides on environmental and human health underscore the urgency for transformative approaches. We have proposed some solutions that advocate for utilizing the soil and plant microbiomes to optimize agricultural practices, mitigate antimicrobial resistance, and promote sustainable farming. These studies collectively advocate for a holistic approach to foster a more sustainable, resilient, and health-conscious agricultural future.

2.2 NOx pollution due to Agricultural Soils:

In this research, the authors Almaraz, et.al. identifies hitherto unrecognized sources of NOx, which is a combination of NO - Nitrous Oxide and NO2 - Nitrogen Dioxide, emissions from the agricultural soils. Through a dual method approach of "bottom-up" spatial modeling and "top-down" airborne NOx measurements, the authors provide compelling evidence that anywhere between 20 and 50 percent of NOx emissions are attributable to croplands of California. (Almaraz, M, et. al., 2018, p. 5) The study also provides evidence that the density of NOx emissions are proportional to the use of fertilizers in the Central Valley of California. The study challenges the current focus only on vehicular emission controls to limit NOx emissions, which account for 1 in 8 premature deaths in the world. (Almaraz, M, et. al., 2018, p. 1)

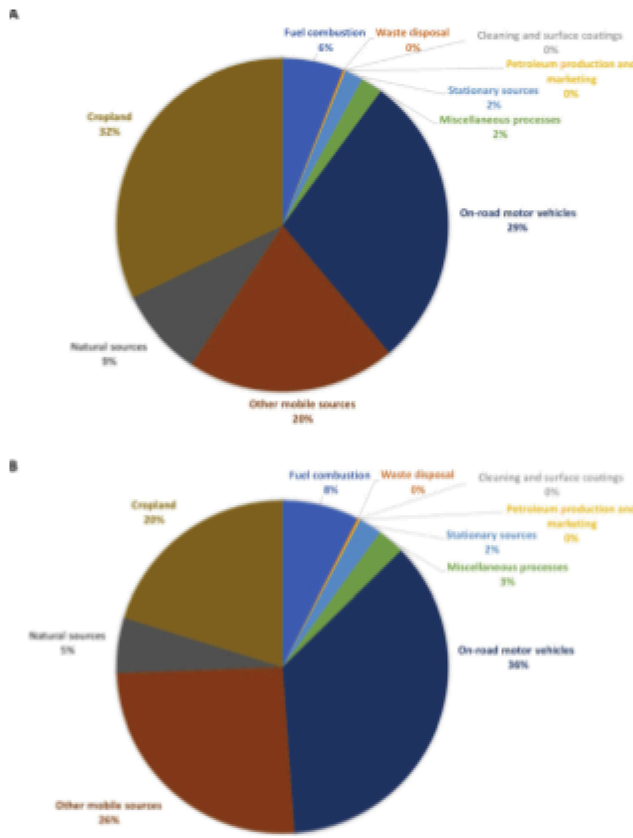


Figure 1: For A, this pie chart shows the emission estimates for cropland and natural ecosystems. For B, this pie chart shows the emission estimates for cropland and natural ecosystems with 50% of soil NOx emissions.

Previous research identified that NOx emissions are controlled by water-filled pore space, nitrogen availability and temperature. This study finds that NOx emissions are more responsive to change in soil texture, solid drainage and climate. The study predicts that biogenic NOx emissions will increase due to increased use of nitrogen fertilizer to meet the increasing food demands. At the same time vehicular emissions are likely to reduce due to existing automotive NOx controls. (Almaraz, M, et. al., 2018, p. 5)

In the face of these revelations, the study provides several existing actionable approaches to curb soil NOx emissions from croplands.

1. Improve Fertilizer Efficiencies: Implement strategies to enhance efficiency of fertilizer use by minimizing the risk of spillovers and also benefit farmers by reducing costs. Using different fertilizers like slow-release or precision application to target the development stage have shown to reduce NOx release into the atmosphere. Organic fertilizers have also shown to reduce nitrogen emissions. (Almaraz, M, et. al., 2018, p. 5)

2. Precision Fertilization (as opposed to broadcasting) to help nitrogen uptake and minimize losses. (Almaraz, M, et. al., 2018, p. 6)

3. Cover Crops: By covering the crops into agricultural practices will help the residual nitrogen be absorbed into the soil, preventing it from being released into the atmosphere. This will improve soil health, reduces further use of nitrogen fertilizers. (Almaraz, M, et. al., 2018, p. 5)

4. Incentivize plant production for human consumption, and control plant production for livestock. Since livestock manure and nitrogen used to grow livestock feed are major sources of nitrogen pollution in air and water. (Almaraz, M, et. al., 2018, p. 5)

5. Promote Reduction of NOx to Environmentally Benign gas N2. This can be achieved by installing riparian zones to collect fertilizer runoffs or introducing nitrification inhibitors to reduce denitrification rates. (Almaraz, M, et. al., 2018, p. 5)

6. Optimize Irrigation Strategies: Strategies for irrigation should be implemented to reduce the nitrogen losses from agriculture. As the ratio of NOx to inert gas N2 emitted from soils depends on factors such as nitrogen availability, soil moisture and temperature. (Almaraz, M, et. al., 2018, p. 5)

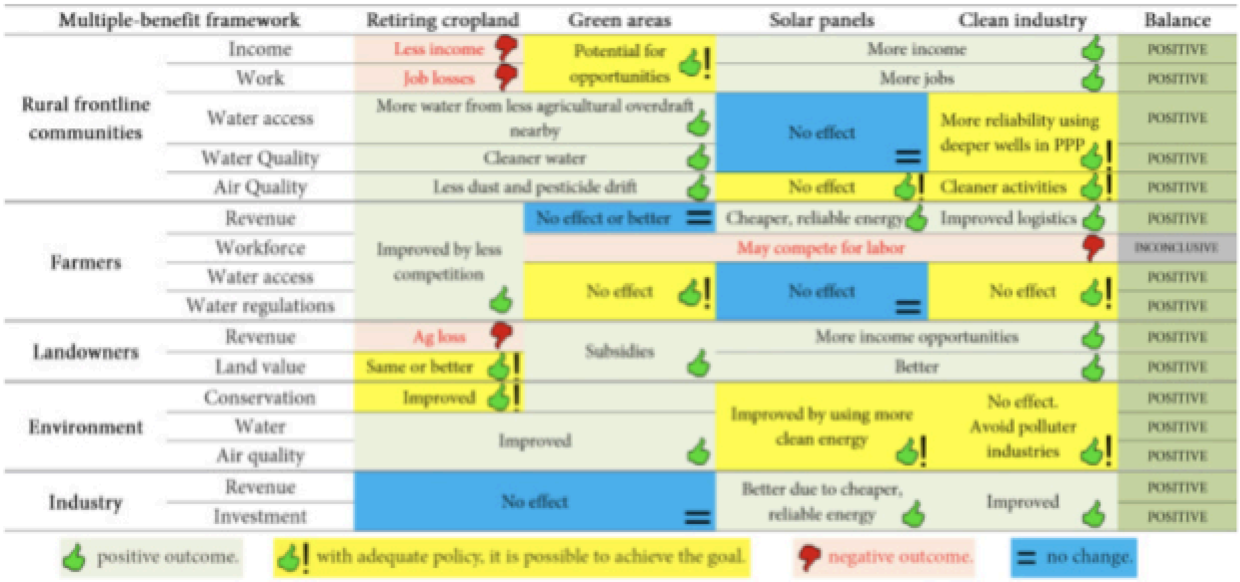
These detailed strategies not only aim to reduce harmful nitrogen losses from agriculture but also contribute to cost savings for farmers and minimize environmental and health damages associated with nitrogen pollution. Almaraz, et. al. emphasizes the potential for a win-win situation, benefiting both agricultural practices and broader societal and environmental well-being.

2.3 Pursuing Socio Economic justice for Rural Communities:

This research, which aims to enhance regional sustainability while mitigating social injustice and environmental injustice of the rural frontline communities in Central Valley in California. The study proposes creating a buffer zone from 400 meters to 1600 meters targeting small rural communities. (Fernandez-Bou, 2022, p. 2) Study proposes to repurpose the agricultural land for environmentally sustainable uses, leading to reduction in pesticide use, nitrogen leaching, and greenhouse gas emissions. While the community may lose employment opportunities due to loss of agriculture, the study estimates there will be net positive direct economic impact ($169M in San Joaquin Valley alone). (Fernandez-Bou, et al., 2022, p. 11)

These communities are suffering from water and air quality issues. The study is performed with objectives to create a novel land use strategy, reduce net water usage, restoring degraded regional ecosystems among others. (Fernandez-Bou, et al., 2022, p. 2)

While water sustainability is an overall concern, especially problematic for the rural frontline communities. By analyzing the data on water application, evapotranspiration and groundwater overdraft, the study projects significant net water use reductions. This reduction helps the state's water planning goals and contributes to groundwater sustainability. The resulting savings will help compensate for 3-4% of groundwater overdraft. (Fernandez-Bou, 2022, p. 12)



Multiple-benefit framework		Retiring cropland	Green areas	Solar panels	Clean industry	Balance
Rural frontline communities	Income	Less income	Potential for opportunities	More income		POSITIVE
	Work	Job losses		More jobs		POSITIVE
	Water access	More water from less agricultural overdraft nearby		No effect	More reliability using deeper wells in PPP	POSITIVE
	Water Quality	Cleaner water				POSITIVE
	Air Quality	Less dust and pesticide drift		No effect	Cleaner activities	POSITIVE
Farmers	Revenue	Improved by less competition	No effect or better	Cheaper, reliable energy	Improved logistics	POSITIVE
	Workforce		May compete for labor			INCONCLUSIVE
	Water access		No effect	No effect	No effect	POSITIVE
	Water regulations					POSITIVE
Landowners	Revenue	Ag loss	Subsidies	More income opportunities		POSITIVE
	Land value	Same or better		Better		POSITIVE
Environment	Conservation	Improved		Improved by using more clean energy	No effect. Avoid polluter industries	POSITIVE
	Water	Improved				POSITIVE
	Air quality					POSITIVE
Industry	Revenue	No effect		Better due to cheaper, reliable energy	Improved	POSITIVE
	Investment					POSITIVE

positive outcome. | with adequate policy, it is possible to achieve the goal. | negative outcome. | = no change.

Figure 2: This chart shows the different impacts of retired cropland, green areas, solar panels, and clean industry, towards the different aspects of marginal communities.

The buffer zone land is proposed to be repurposed for many environmentally friendly industrial activities - like clean industry, solar energy generation. While industry helps generate employment, solar energy farms will help create energy self-sufficiency for these communities. The study estimates the revenue estimate ranging from \$468 million to \$4.938 billion per year in San Joaquin Valley. (Fernandez-Bou, et al. , 2022, p. 10)

Apart from these potentially transformative recommendations, the study also deals with potential policy changes to encourage local employment, stakeholder engagement, and community based participatory research. (Fernandez-Bou, et al., 2022, p. 13) The research not just presents a theoretical model but presents practical policy options urging policy makers to consider the recommendations to help California's rural communities.

2.4 Sustainable Agricultural Practices:

There is an intricate relationship between soil microbiomes, agricultural systems, and human health that is explored by Yan, et. al., in this research. There is a diverse microbial reservoir critical for plant microbiome interactions and agricultural productivity. These microbiomes serve the dual purpose of beneficial microbes for crops and a conduit for soil-borne human pathogens. These pathogens may cause symptoms from gastrointestinal issues to severe diseases, hence it is necessary to understand the pathways for the transmission.

Antimicrobial resistance (AMR) emerges as a significant global threat due to extensive antibiotic use in human health, livestock farming, and aquaculture. The research underscores alarming statistics revealing that approximately two-thirds of global antibiotic usage is directed toward industrial livestock production. Veterinary antibiotics, notably β-lactams and tetracyclines, constitute a substantial proportion, transforming livestock farms into major reservoirs of antimicrobial-resistant strains. The correlation between reduced antibiotic use and diminished AMR gene abundance in animal-based food products underscores the critical importance of responsible antibiotic practices in agricultural settings. (Yan, et al., 2022, p. 5-6)

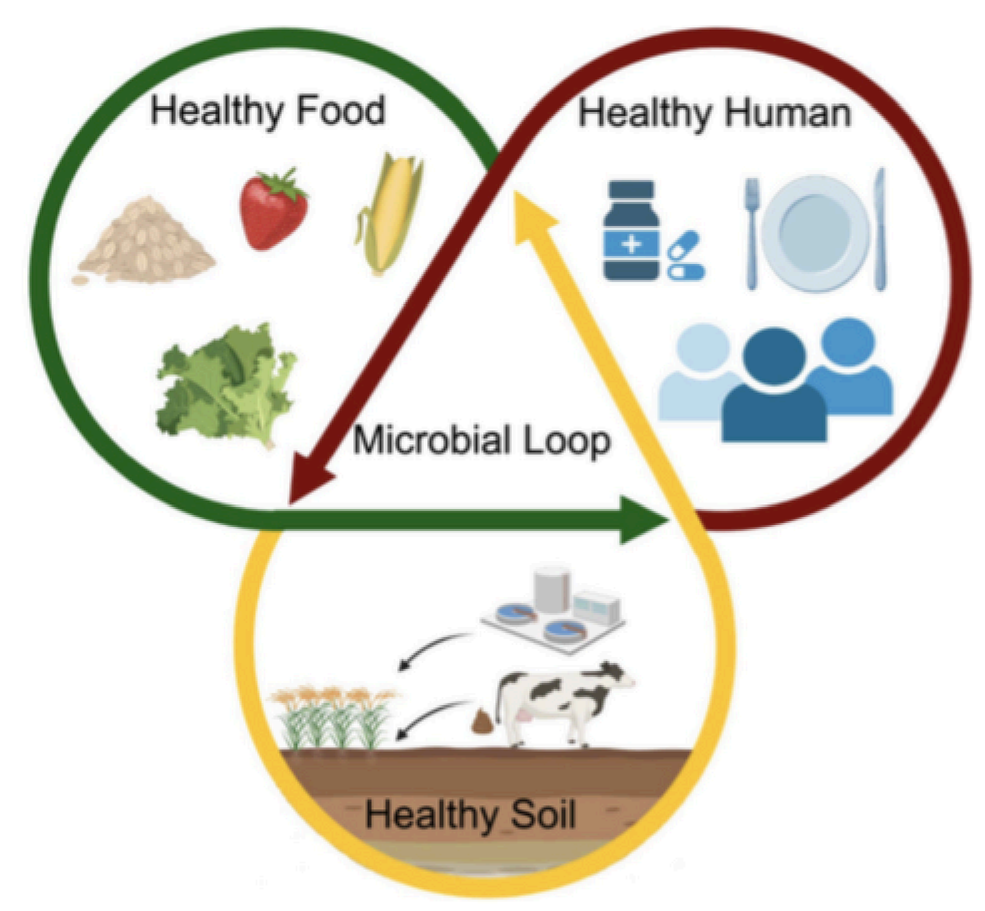


Figure 3: This shows the relationship between healthy soil, healthy food, and healthy people.

The study further delves into the repercussions of chemical pesticides on human and environmental health. Excessive use of agrochemicals, especially pesticides, poses challenges through human exposure via skin contact, ingestion, and inhalation. Pesticide residues, characterized by their persistence in soil, raise environmental concerns with organochlorines exhibiting long half-lives and potential bioaccumulation in human tissues through food consumption. (Yan, et al., 2022, p. 7) Organophosphorus pesticides, initially introduced as environmentally friendly alternatives, are associated with neurotoxic and endocrine-disrupting effects. The negative impact extends to biodiversity loss and disruptions in soil microbial diversity, illustrating the broad-reaching consequences of chemical pesticides.

In response to these multifaceted challenges, the authors propose leveraging soil and plant microbiomes to enhance sustainable agricultural production. Manipulating soil and rhizosphere microbiomes is highlighted as a promising avenue to increase crop productivity and nutrient uptake. The study also underscores indirect contributions, such as mitigating AMR dissemination by increasing microbial biodiversity and promoting microbial degradation of chemical pesticides. (Yan, et al., 2022, p. 8-9) However, the authors stress the need for systematic, interdisciplinary research to comprehend the complex interactions involved in optimizing agricultural practices. Urgency is emphasized in developing comprehensive policies and sustainable investments to address the intricate nexus of agriculture, microbiology, and human health.

The authors conclude, based on the exploration of soil microbiomes, agricultural systems, and human health shows a connected landscape where these elements are interwoven together. The studies discuss the dual role of soil microbiomes, serving both as contributors to agricultural productivity and as potential sources of human pathogens. To deal with the challenges posed by antimicrobial resistance and the environmental impacts of chemical pesticides, the authors proposed solutions advocating for a transformative approach. Harnessing the power of soil and plant microbiomes emerges as a promising strategy to optimize farming practices, mitigate health risks, and foster sustainability. These findings show the necessity for interdisciplinary collaboration, urgent policy action, and sustainable investments to have a future that aligns the well-being of the environment, agricultural systems, and human health.

3.0 Waste

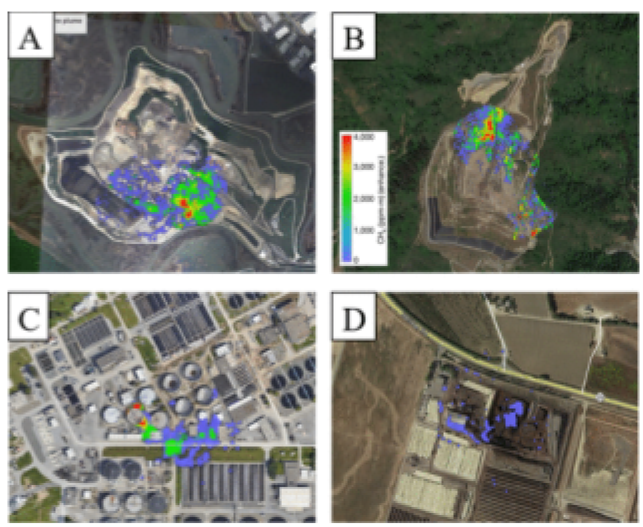
Waste is a major contributor to climate change and environmental harm. Whether water is being overused or too much food is being thrown away, the excessive consumption of resources needs to be reduced. A certain level of waste production is unavoidable, but it is worth trying to decrease the amount of waste produced in California in order to benefit the environment. By evaluating the climate effects of waste, waste reduction efforts, and how waste disposal methods affect the environment, new solutions for eliminating waste can be developed.

3.1 Climate Effects

There is no precise way to measure exactly how waste affects the climate. However, it is possible to estimate the greenhouse gasses produced by waste facilities. Guha et al. (2020) study how much methane, a potent greenhouse gas, is emitted by different facilities in the San Francisco Bay Area. These facilities included ten landfills, four wastewater treatment plants, and two composting operations. By using airplanes to take multiple measurements of methane emissions above the facilities, Guha et al. are able to approximate how much methane each type of facility produces each year. Based on their research, every year in the Bay Area, landfills release about 136,700 tons of methane, wastewater treatment plants release about 11,900 tons of methane,

Figure 4

Methane Hotspots over Waste Facilities



Note. Methane plume hotspots coincident with the location of hydrogen production plants (A,B), refinery flares (C), and organics storage tanks (D). From "Assessment of Regional Methane Emission Inventories through Airborne Quantification in the San Francisco Bay Area," by A. Guha, et al., 2020, *Environmental Science & Technology*, *54*(15), 9254–9264.

and composting operations release about 11,700 tons of methane. It is clear that landfills are the type of waste facility that creates the most methane compared to other waste facilities. This may be a result of there being far more landfills than any other type of waste facility, but landfills also produce a lot of methane inherently due to how waste is stored underground. On top of that, according to Guha et al., methane is 86 times more potent than carbon dioxide when it comes to trapping infrared radiation. The research by Guha et al. implies that reducing the intake of waste facilities leads to a healthier atmosphere. Therefore, it stands to reason that if California reduces the amount of waste it produces, climate change can be slowed down.

3.2 Waste Reduction

In order to reduce waste, it helps to know what type of waste California produces. "Organics like food scraps, yard trimmings, paper, and cardboard make up half of what Californians dump in landfills" ("California's Short-Lived Climate Pollutant Reduction Strategy," n.d.). Since a sizable portion of landfills are occupied by organic waste, decreasing the amount of organic waste produced in California will reduce the size of landfills and their environmental impact. SB 1383, signed into law in 2016 by Governor Edmund Brown Jr., is designed to pursue this goal. SB 1383 sets two objectives to be completed by 2025: reduce organic waste disposal by 75% and rescue at least 20% of currently disposed surplus food for people to eat. To accomplish these objectives, SB 1383 has several specific requirements and plans for all jurisdictions. First, every jurisdiction must provide organic waste collection services to all residents and businesses and find ways to recycle and reuse the organic waste in products such as renewable energy, compost, and mulch. By reusing organic waste into useful materials, less organic waste is sent to landfills. Second, food service businesses must donate edible food to food recovery organizations. Not only will this decrease the amount of food waste California produces, but it will also help feed people who do not have enough to eat. Third, there is to be enforcement, recordkeeping, reporting, exemptions, and complaint collection for the previous policies. If it is not ensured that counties are following the instructions of SB 1383, then it is unlikely that any meaningful progress towards reducing waste will be made. Altogether, these steps will give California a healthier environment. Should SB 1383 succeed in significantly reducing California's organic waste by 2025, it is a good idea to explore other policies in order to further reduce waste.

3.3 Disposal Methods

When it comes to disposing of the waste that can't be recycled or composted, there are not very many acceptable methods, and practically none of them are environmentally friendly. Ha and Schleiger (2021) state that the three primary methods of waste disposal are open dumps, sanitary landfills, and incineration. Open dumps are simply areas where trash gets piled up. Although trash in open dumps decomposes quicker due to being exposed to air, it also creates toxic leachate when contaminants mix with rain and spread through the environment. The openness of dumps also promotes disease and creates odorous fumes. Landfills are much cleaner than dumps, as waste gets buried underground over a leachate collection system to prevent ground contamination. However, landfills are still not perfect. As established earlier, they release a lot of methane and other greenhouse gasses. They also have limited capacity, and making new landfills is not ideal given the environmental dangers they pose. Incineration is the process of burning waste, which massively reduces its volume and can be used to produce electricity. Unfortunately, the fumes created by incineration are air pollutants, so while incineration is much less space-dependent than dumps and landfills, it is not healthy for the environment either. This is why there is such a large push for reducing, reusing, and recycling waste, because even with proper precautions, waste disposal pollutes the environment.

3.4 Biochar as a Solution

Still, there is room for innovation in the area of waste management. It is possible for more environmentally friendly methods of handling waste to emerge, given the chance. One particularly promising solution is biochar. While similar to the process of incineration, biochar is created when organic matter is burned with little to no oxygen present, leaving behind a substance similar to charcoal ("As Uses of Biochar Expand," 2014). Any organic matter can be used to make biochar: food scraps, plant waste, manure, etc. Biochar has some promising properties. For one, the carbon in the organic matter gets trapped in solid form as biochar, which can then be buried underground to effectively prevent the carbon from entering the atmosphere. Also, biochar can boost the fertility, drought and flood resistance, and purity of the soil it is added to. These properties are influenced by the organic matter and temperature used to produce the biochar. Johannes Lehmann, a professor of agricultural science at Cornell University and one of the world's top experts on biochar, believes it is a good idea to use the massive amounts of organic waste from agricultural and forestry industries as the fuel for biochar. This strategy allows for more organic waste to be reused in an environmentally beneficial way rather than being sent away to break down in landfills or dumps.

The Dilemma

While biochar sounds like a perfect solution for disposing of organic waste, it has some issues. After intensely scrutinizing the properties of biochar, Mukherjee and Lal (2014) share some constraints and warnings concerning biochar. Again, biochar's properties are affected by its formation, and biochar can have varying effects on different types and acidities of soil. Although biochar can greatly improve the quality of soil, it can also harm soil health if applied incorrectly. For instance, the addition of biochar to soil can both increase and decrease the amount of nutrients available. Another example is that biochar is capable of absorbing toxic metals so that they are not absorbed by plants instead, but biochar can also agitate the movement of toxic metals so that they are more likely to contaminate water or crops. Both the positive and negative effects of biochar need to be further researched before it can be reliably used in agricultural settings.

Economic Potential

Should biochar be explored as a means of reducing organic waste and fighting climate change, there is promising evidence that biochar could be a valuable economic prospect. Nematian et al. (2023) researched the economic value of introducing biochar production into Central Valley, California. Since biochar has yet to be established as an industry, Nematian et al. had little information to utilize. However, they were able to use an economic software and database called IMPLAN to predict biochar's economic impact. Nematian et al. claim the following:

> Results suggest that depending on the biochar price and conversion rates, biochar would create between 16.56 and 17.69 new full- and part-time jobs per year that would contribute between $1.2 and $5.75 million per year to labor income. Biochar production would add to the Gross Domestic Product (GDP) about $106,295 ($5.2 million) per year with a conversion rate of 15% (35%) and a biochar price of $280 ($2,512) per metric ton (para. 1).

With proper investment, biochar can be a fruitful endeavor for California, especially considering how important agriculture is in the region. In fact, the more biomass there is in a county, the more profitable biochar is for that county. As a result, it is worth investigating biochar's uses not only for its environmental benefits but also its economic benefits.

4.0 High Speed and Light Rail

4.1:Introduction

The state of California heavily relies on the interstate highway system in order to facilitate domestic travel and commercial transport. Furthermore the interstate highway system eventually connects into the California freeway system, the freeway system into roads and throughways and eventually into avenues and lanes. The easiest way to understand the road system is with a comparison to the circulatory system, in which highways and freeways are akin to major arteries with high throughput that eventually splinter off into smaller and more localized blood vessels. But the Californian circulatory system is hindered by the blood clots that are traffic, in which there are way too many cars and too few occupants. Thus leading us to ask: is there a better way?

High speed rail services such as bullet trains are directly positioned to reduce the ecological and urban strain imposed by the pervasiveness of automotive based transportation systems. As of 2023 the Bay Area is home to rail and light rail transit authorities such as the BART, VTA, CalTrain, and Amtrak, who offer affordable transportation solutions to the Bay Area. Yet all of which lack the fluidity offered by automotive transportation systems, disincentivizing commuters from making the switch to public transportation. Thus, expansion of light and high speed rail is limited by public perception of punctuality, fluidity between different types of rail, and ease of access for marginalized communities. Furthermore the implementation of high speed rail is encumbered by financial and geographical barriers, leaving us with a two pronged issue.

4.2: Light Rail

The greater Bay Area is serviced by the BART in the north and the VTA in the south, both rail services offered by the two transit authorities have proven themselves useful multiple times over. In spite of their usefulness both systems are plagued by service and punctuality issues that push pedestrians and commuters away from public transportation and to private vehicles. At a glance both light rail systems span a limited area and often have issues with speed and reaching the population groups who need it most. The VTA's light rail system only spans 42 miles across three lines, only being supplemented by the proximity of bus stops near light rail stations. The BART rail systems also face similar issues, leaving it evident that to increase commuter usage of public transit systems, light rail must undergo major renovation in order to serve as a backbone to other public transit systems provided by the BART and VTA.

4.2.1: Who does it Serve?

'Who Does Light Rail Serve? Examining Gendered Mobilities and Light-Rail Transit in Montreal, Canada' authored by Julian Villafuerte-Diaz, Rodrigo Victoriano-Habit, Aryana Soliz, and Ahmed El-Geneidy serves as an acceptable model of how Bay Area residents would interact with an expanded light rail system and which groups should be focused on when expanding the BART and VTA's services. Utilizing an English-French bilingual survey to quantify socioeconomic status, ethnicity, attitudes to the Montreal REM, transit behavior and physical activity, alongside data pertaining to where participants resided. (Villafuente-Diaz et al. 2020, p.106) As both the city of Montreal and the Bay Area reside within the northern hemisphere, mainly where the climate ranges from temperate summers to extremely cold winters, both populations are left to deal with very similar factors when deciding to take public transit in extreme seasons such as winter or summer. Similarly, the aforementioned study had been conducted in the year of 2019 and was interpreted and modeled as of 2020, meaning that the data discussed retains its relevance.

Before conducting research there are preset expectations as to how and why certain individuals utilize public transit or do not use public transit. Namely women are one such example, as justified fears of predation and assault leads women to consider private transport methods over utilizing public systems. Similarly, although present more so in men cultural stigmas lead individuals to prioritize purchasing and using personal vehicles as a status symbol. One such instance of gendered difference on the usage of LRT is exemplified in the following quote:"All else held equal, women who used public transit regularly in childhood had 55% greater odds of intending to use the REM than women who did not have this experience in childhood. This finding points to a gendered effect of life course on mode choice and builds on an emerging understanding of how life events affect individuals' travel patterns differentially by gender (49)." (Villafuente-Diaz et al. 2020, p.107) Thus exemplifying how childhood familiarity with utilization of public transit affects women at a higher rate than men. Such an occurrence can be rationalized as the participants who had childhood familiarity with LRT would be better equipped to identify other travelers with malintent or knowledge on which stations were safer.

Figure 5 Note: figures of probability to use LRT filtered on age, gender, and residency. Reprinted from 'Who Does Light Rail ServeExamining Gendered Mobilities and Light-Rail Transit in Montreal, Canada' Villafuente-Diaz et al. 2020, p.110. Copyright Transportation Research Board 2020

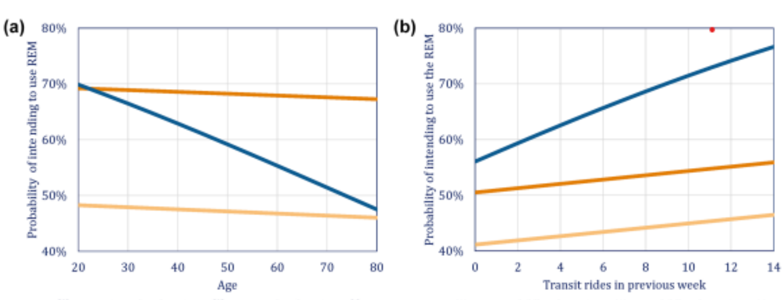


Figure 5 further exemplifies how the residency period of an individual affects their likelihood to utilize LTR, significantly affecting women more than men. Thus, creating the consideration that LTR transit systems and surrounding public outreach should be reworked to make transportation systems safer and more easily understandable.

4.2.2 How Does it Affect Cities?

More often than not, light rail systems fail to be properly integrated into already existing cities as city governments fail to model LRT as a backbone to already existing systems. ‘Do Light Rail Transit Planning Decisions Affect Metropolitan Transit Performance?’ authored by Michal A. Jaroszynski and Jeffrey R. Brown discusses how light rail systems within eight American cities on average carried more than 20% of their respective fixed route commuters based on the factor of coverage, integration, and access. Specifically an emphasis was placed on cities who prioritized creating robust LRT with frequent access to other transportation systems. In summation it is noted that cities such as Denver, Portland, and Saint Louis scored higher on the index due to their higher frequency and higher average LRT speeds. All of which averaged 6.5 minutes as the highest time and 12 at the absolute lowest, while lower scoring cities averaged 15 to 30 minute intervals between railcars. Similarly, the better planned cities retained average railcar speeds within the low 20mph range. Yet the deciding factor that lowered the scores of cities such as Dallas and Saint Louis had poor synchronization between LRT and bus systems, while cities such as San Diego and Sacramento had buses arriving in sync with rail cars alongside providing frequent transfers between LRT and bus routes. (Brown, Jaroszynski 2014, p. 58-59) Thus meaning that ideal transportation systems should provide a high frequency of light rail synchronized with bus arrivals in order to reduce lag times that would otherwise disincentivize commuters from making the swap from private to public. Similarly, parking access for commuters who live too far from stations is crucial to convince those already driving to make the swap to light rail and buses.

4.3: High Speed Rail and the Chinese Model

Historically within the state of California high speed rail services have never passed the planning and proposal stages due to being outbid by experimental programs with little foresight. High speed railway systems otherwise known as bullet trains have already seen widespread implementation within China and Japan, spanning both nations. Furthermore problems of emission, city integration, and noise levels have already been solved and only need to be adapted to the geography of the state of California.

The use of China as a case study applicable to the state of California is desirable as both territories retain very similar geographical compositions, the only differences being the distribution of arid and mountainous regions alongside the presence of a tectonic factor. Furthermore, Chinese HSR retains distance and age of high speed railway systems, spanning over 26,100 miles of track and dating back to 2008 at its earliest installation, therefore we are provided a unique long term record on how HSR affects pollution and commuter travel behaviors.

4.3.1: HSR as a Pollution Countermeasure

It is commonly known that the average CO emissions per person using public transit are lower than the CO emitted for private commuters as public transit carries more people per vehicle. But very little data exists to quantify the effects of HSR on the pollution generated by heavy highway usage. ‘Does high-speed railway reduce air pollution along highways?——

Evidence from China' by Xiaoyang Guo, Weizeng Sun, Shuyang Yao, Siqi Zheng is an experimental analysis into how already existing HSR services along Chinese interprovincial highways decrease Carbon Monoxide emissions within a five kilometer radius of the highway.W Within figure two, the scope of affected highways and quantity of monitoring stations used skews towards the center and eastern sections of China, establishing that the environments crossed consists of more mountainous and temperate regions, significantly differing from the intended area of implementation for HSR in california. Furthermore "The result in Column (1) indicates that, compared with the untreated highways, the CO concentration within 10 km around the treated highways decreased significantly by 0.047 mg/m3 after the nearby HSR's operation, which means a 4.3% decrease in the mean value of CO concentration." (X. Guo et al. 2020, p. 7-8). Thus meaning that although minimal, the introduction of HSR has an immediate effect on how commuters interact with public transportation systems. If compounded with further implementation of educational material CO emissions along a hypothetical HRS/ highway system through California could increase past 4.3%.

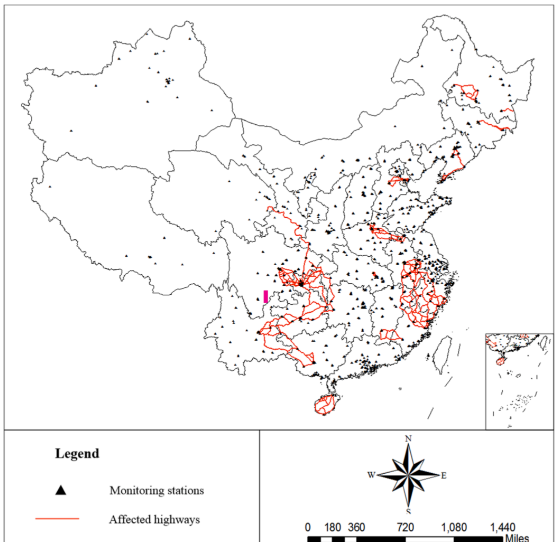


Figure 2 Note: figures of Chinese map of affected highways and used monitoring stations. Reprinted from 'Does high-speed railway reduce air pollution along highways?—— Evidence from China' X. Guo et al. 2020, p. 7. Copyright Elsevier Ltd. 2020

Although the benefits of implementing HSR systems possess an immediate benefit to air quality surrounding affected areas, can this net decrease in CO emissions be sustained over multiple decades if not centuries? Via collecting data from official city atmospheric logs, 'Sustainability by High–Speed Rail: The Reduction Mechanisms of Transportation Infrastructure on Haze Pollution' establishes an inverse correlation between the opening of new HSR lines and the presence of SO_2 and CO_2 emissions spanning the years 2005 to 2016. Figure two further denotes how nationwide the emissions decrease 0.1 tons per 10 million HSR riders. (Chen et al. 2020, p. 2)

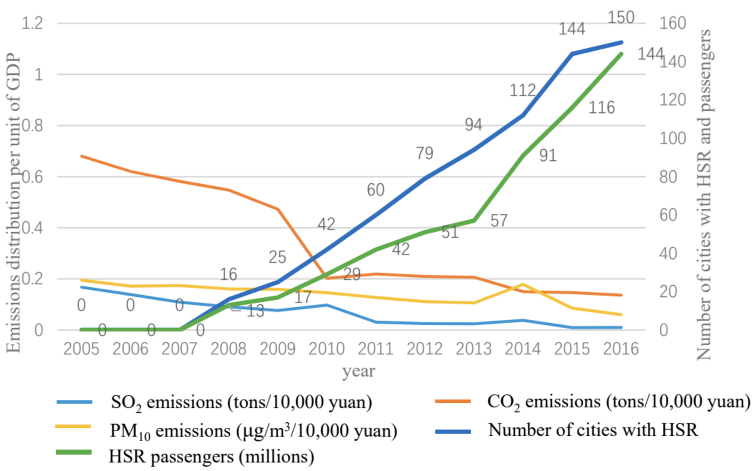


Figure 3 Note: Plot of chinese emissions reports versus the increase in passengers and high speed railways. Reprinted from Sustainability by High–Speed Rail: The Reduction Mechanisms of Transportation Infrastructure on Haze Pollution' Chen et al. 2020, p. 2. Reprinted with permission.

4.3.2: Is HSR Affordable?

In short HSR is an incredibly difficult transportation system to launch, as the state of california presents a set of unique engineering challenges that many other nations have not needed to face. For instance the San Andreas fault line resides on the majority of the state of California making seismic activity more frequent and destructive. Similarly from a civil standpoint much of the Californian rail infrastructure is not suitable for HSR, similarly when passing into the bay area HSR tracks would need to tunnel through very mountainous terrain in order even reach destinations such as San Francisco or Oakland. If a HSR system comparable to the Japanese or Chinese HSR systems were to be launched today it would fail for a lack of usable California GDP. Perhaps a lesson can be learned from the utilization of light rail infrastructure in order to plan HSR railways.

4.4: HSR as a Solution

Reaching speeds up to 200mph Bullet trains are ideal for long range transit while city based public transit systems are better suited for urban travel, therefore we propose that the integration of a single statewide route that passes through the central valley along the I-5 freeway and that splinters into two separate routes upon reaching the lower Bay area with the eastern railway following the 880 and the western section following either the 101 freeway or the 280. Having parity with the highway system serves a two pronged approach, both in incentivising the Californian public to make the switch to HSR alongside making integration into existing public transit systems nearly seamless.

If the HSR routes do not follow the 280 and the 880 it would become increasingly difficult to integrate into already existing systems as new connecting public transit hubs would need to be constructed in order to connect HSR systems to the BART and VTA. Furthermore as listed in section 4.2 it is necessary that HSR is centralized as commuters lose interest exponentially as transit stations become farther away from their residences. Similarly it is also necessary to incentivise private transit users to forego the highways for the much faster HSR system with the usage of tolls for highway usage alongside creating stations along the 280, 101, and 880. If these conditions are met, the construction of an HSR system based off a backbone line passing through California would not only cut emissions, it would also provide thousands of Californians with temporary and permanent employment, alongside allowing cities to further focus on streamlining internal transportation systems.

5.0 Electrification

5.1 Purpose

As humanity continues to advance our technology, our energy consumption will only increase. With California as the center of technological innovation, we should also aim to be the leaders in transitioning away from the use of non-renewable energy. A key step in this process is the electrification of our end-user products. The purpose of this section is to examine the potential advantages of electrifying more of our infrastructure here in California; more specifically, how electrifying end-user products could benefit everyday Californians. There are widespread benefits that may apply to California as a whole, but this section is primarily focused on those who make up a majority of Californians.

5.2 Background and Summary

Electrification is the process of systematically replacing end-user products that rely on energy from something other than electricity with electric devices and products that are able to accomplish the same goal but through the use of electricity. end-user products are generally anything that is sold or marketed towards individual users instead of larger corporations. Often, people will rightfully claim that a focus on the end-user is misguided, but that is not the case when it comes to electrification. This is because electrification does not happen on an individualistic level but systematically. When it comes to most climate discussions, there is often propaganda spread by corporations that each of us needs to do our part. This is meant to shift the blame from said corporations to us as individuals which has sparked a counterargument that correctly identifies large corporations as the most significant polluters (Perera). And they are still the target of this electrification argument. Electrification is not about having end-users change their habits, but forcing companies and corporations to provide electric alternatives to their otherwise non-electric products. Electrification could be especially beneficial to California. One of the reasons gas is so expensive in this state is that we are not very well connected to the rest of the country's oil and gas pipelines.

The following section of this paper highlights the cost-effectiveness of electrifying transportation and home appliances. These savings are shown through both our own research and the research of others. Our research was in comparing the cost of use for a typical gas car and an electric car. The research we compiled agreed with our findings, and showed other potential benefits of electrification, like the ability to integrate new energy management systems. These systems, like model predictive control (MPC), are able to optimize energy usage for both cost and comfort. This is especially useful for regions with extreme weather like California.

5.3 Discussion

When making claims about cost and expenses, it is best to have a direct comparison. When it comes to end-user products that remain non-electric, the primary other source of energy is fossil fuels in the form of natural gas, propane, and gasoline. When comparing electricity to these fossil fuels, there are two primary ways that electricity is more cost-effective. First, electricity is often just cheaper than its fossil fuel alternatives. Second, by electrifying more of what still relies on fossil fuels, we are able to leverage the unique properties of electricity to our advantage which would further reduce costs. Overall, electrification will lead to average Californians saving money on energy, while leading us towards a more sustainable future.

I decided to investigate the cost of electric transportation vs gasoline transportation over Thanksgiving break this last year. In order to do this, I used my gasoline car, which gets approximately 23 miles per gallon (only two miles per gallon more than the national average), and my mother's Tesla. I drove about 40 miles round trip in each car. In order to isolate the cost of that specific trip, I filled up my gas tank and charged the Tesla (to its recommended 80%) before starting the drive. Then, after the trip in the gas car, I refueled it and noted the cost to do so. My gasoline car came out to a total cost of $13.48. After doing the same drive in the Tesla, recharging it only cost $1.91. This shows the gasoline car to cost over seven times the price of the same trip in an electric car. This cost disparity was something that I knew existed but not necessarily to this extent (Marczinkowski, 2020). These anecdotal findings are admittedly weak, but they are strengthened by research that has come to the same conclusion. In fact, one paper found that the electrification of transport was the “most cost-effective solution for creating a sustainable [energy] infrastructure” (Paniyil, 2021, p. 14). These cost savings are felt most by those who are actually switching to using electrified personal transportation.

Furthermore, electric appliances tend to be more efficient and save money compared to their non-electric counterparts. One such example of this phenomenon is Dr. Eugene Cordero’s story of renovating his home.

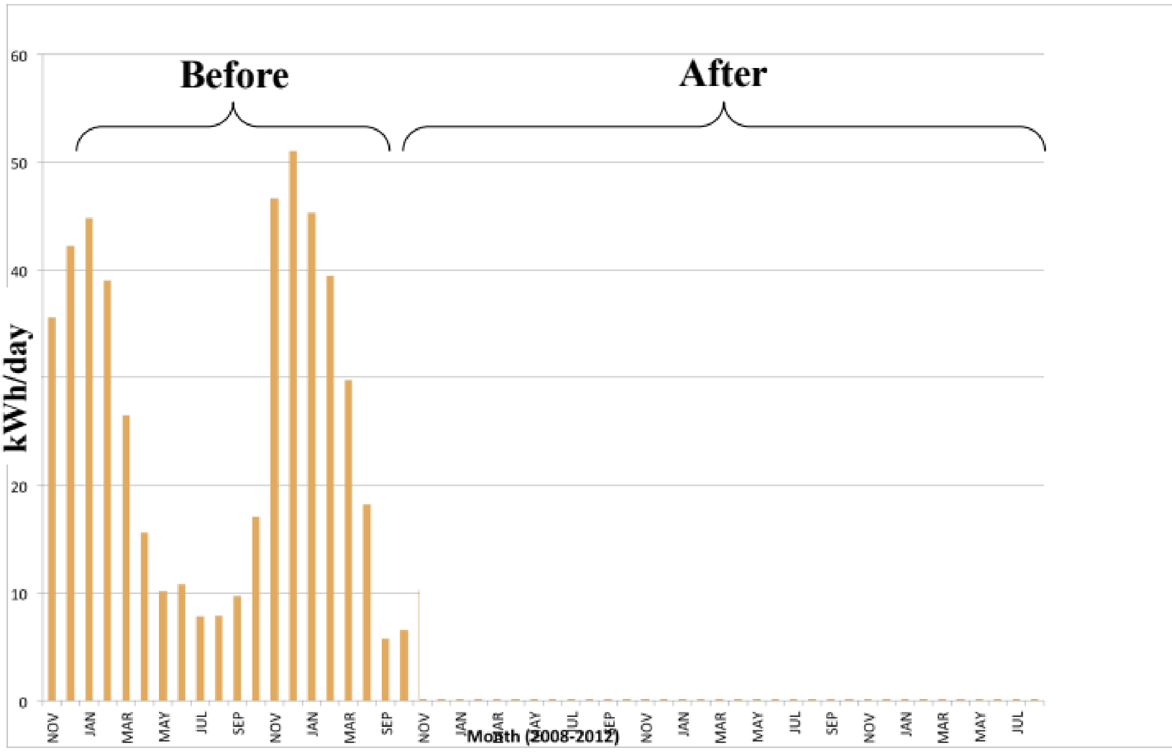


Figure 6: Graph from Eugene Cordero's Green Talk on Climate Science and Climate Solutions that Highlights the Greater Efficiency of Electric Appliances

Figure 6 shows the drastically reduced energy consumption of his home following his renovations which included electrifying his home appliances. In the Green Talk where he discussed this renovation, he stated that electric heat pumps are three times more efficient than traditional gas furnaces. While these may only be anecdotes that further demonstrate already researched facts, both of them are specific to California. And even beyond these cost savings, electrification is also considered "vital for reducing the [residential] sector's carbon foot-print" (Yang, 2023, p. 1). In this study, building energy consumption was examined and the differences between electric and non-electric appliances were examined, as well as how to best leverage electric appliances. This finding that just electrification is beneficial was important, but they also examined how to manage an energy system that was all electric.

The energy system management option that the previously mentioned study examined is called a model predictive control (MPC) management system. By switching our appliances to electric, we make it possible for these devices to become more interconnected and communicate with one another. This is crucial to the implementation of an MPC system.

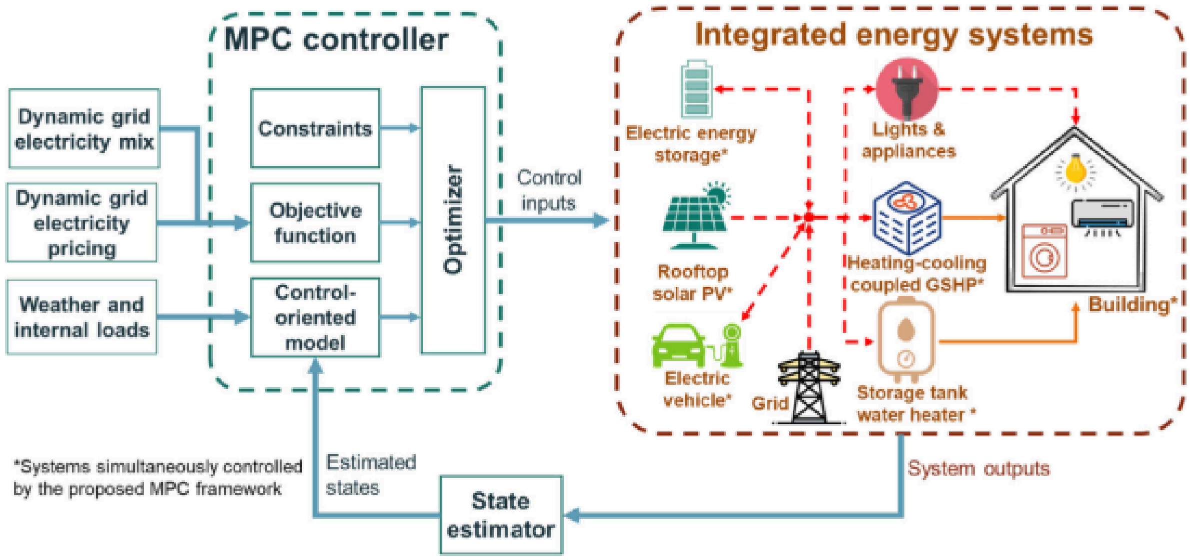


Figure 7: A Detailed View of Where and How an MPC is Implemented

As shown in Figure 7, an MPC is given a set of constraints, an objective function that is based on the energy coming in from the local power grid, and a control-oriented model that factors in local weather and internal energy demand. By running these through its optimizer, an MPC is able to control a home in a much more efficient manner than otherwise possible. This is especially useful here in California because we tend to have very hot summers and somewhat cold winters that lead us to use our air conditioning and heating systems fairly often. In order to save money, Californians will often allow their homes to remain warmer or cooler than otherwise desired. However, through the implementation of an MPC, this problem can be eliminated.

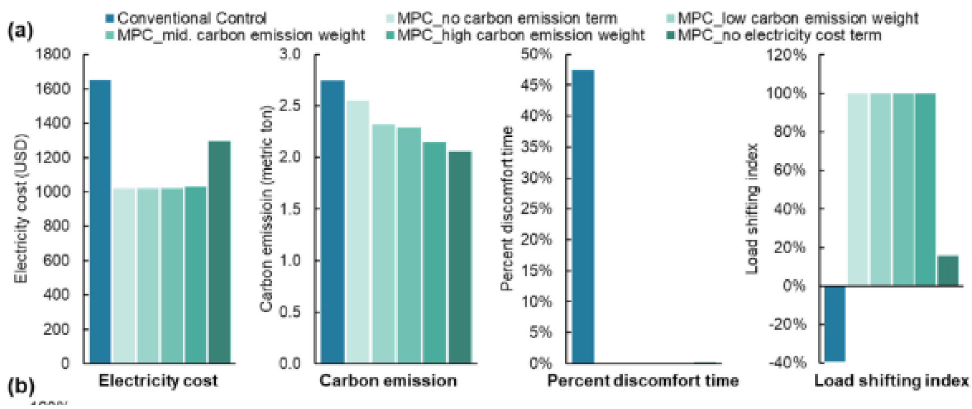


Figure 8: A Comparison of Conventional Control and 5 Versions of an MPC

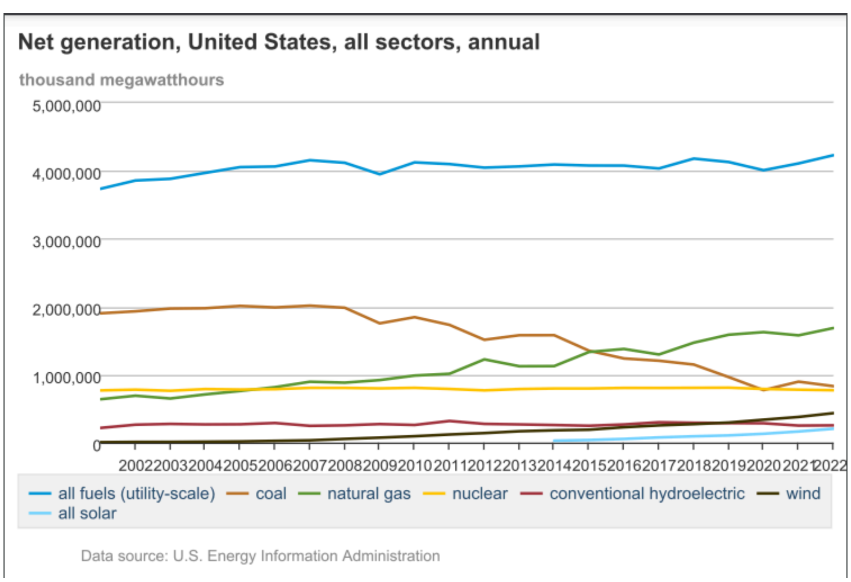
Figure 8 shows how various parameters of an MPC affect the cost of electricity, the net carbon emissions, and the percent discomfort time. The load shifting index is relevant to the paper this figure came from but is not relevant to this argument. What is most compelling about this graph is that costs can be cut by hundreds of dollars while reducing both discomfort and carbon emissions. It is even possible that people could set these parameters for their homes and prioritize whatever is important to them.

5.4 Conclusion

By leveraging MPCs and the cheaper end-user cost of electricity, the advantages of electrification are blatantly apparent. The only real disadvantage is the upfront cost (Paniyil). But, over time, this upfront cost will be offset by the long-term savings. California already suffers from an abnormally high cost of living and these potential energy savings could help reduce that. When it comes to transportation and home appliances, electric versions of home appliances and personal transportation are both objectively cheaper. We proved this both anecdotally and with our broader research. However, there is still a cost to running or charging both of these sections of our lives. The real advantage Californians gain by electrifying is essentially a smart energy grid. MPCs could easily be marketed as a smart energy management system that can reduce the cost of electricity while increasing comfort. Overall, electrification stands to greatly benefit all Californians and leaving these savings on the table would be an insult to everyone who lives here.

6.0 Renewable Energy

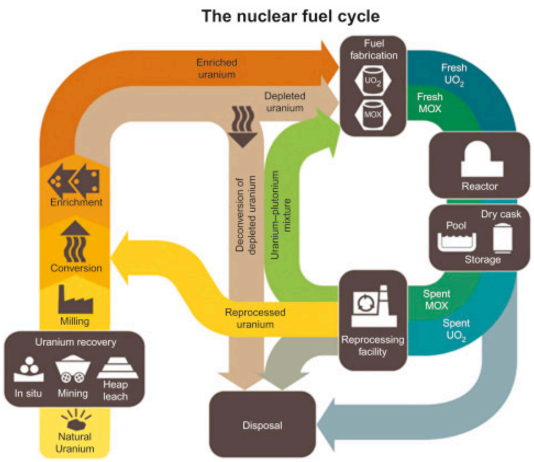
California currently utilizes coal, natural gasses, nuclear, hydropower, wind, solar, petroleum liquids, petroleum coke, biomass such as; wood, and geothermal to produce 4,230,672 megawatt hours of electricity. In terms of California's renewable energy capabilities, it stands second in the nation, behind Texas. In 2022, percentages of different types of renewable methods from the total show that; hydropower accounts for approximately 18.24%; Wind stands at 10.26%; Solar at 3.4%; Biomass at 1.23%; while Geothermal at 0.4% (U.S. EIA, 2023). California also relies heavily on imported fuel for electricity, more than any other state, and on average receives about one-fifth to one-third of its total electricity supply in two different regions. The two sources of this imported electricity are the Northwest which consists of Alberta, British Columbia, Idaho, Montana, Oregon, South Dakota, Washington, and Wyoming. The Southwest includes Arizona, Baja California, Colorado, Mexico, Nevada, New Mexico, Texas, and Utah. A breakdown of imported electricity reveals that 31% of the imported electricity comes from renewable sources, and hydroelectric sources supply 16%. Nuclear at 11%; natural gasses and coal combined contributed 10% (EIA, 2023).



To meet 100% renewable energy reliability by 2045, California has the opportunity to utilize research-based technologies that will provide economic advantages, safety, and innovations as the nation's leading renewable energy pioneer. Publicly, Nuclear power has been under the scrutiny of multiple misconceptions that resulted in the closure of facilities throughout California. This alienation from a safe and efficient method will hinder our plans for total renewable energy by 2045. Another method that has been overlooked would be the wind turbine deployment near the coast of California which can have endless potential. Lastly, solar panels to cover the Mojave Desert, Colorado Desert, and the Great Basin Desert will provide abundant electricity to power commercial, and residential needs.

6.1 Nuclear Power

Nuclear power is not only safe and reliable but it lowers the cost of electricity passed on to residents. In terms of technical definition Nuclear methods are not renewable but recoverable. U-235 or Pu-239 the fuel used in nuclear fusion is 50,000 times more recoverable than petroleum or coal (Suppes & Storvick, 2007). California's current and only nuclear facility Diablo Canyon power plant splits uranium atoms and in this process, it creates a large amount of heat. The heat is then used to generate electricity by boiling water creating steam, to run a steam turbine. The only byproduct would be heated water returned into the ocean and recoverable uranium which if technological advances continue, could bring it to 100% recoverable, turning it into a renewable resource.



The plans to close the facility in 2025, will cost the state $2.6 billion in terms of expenditure on other sources of electricity and could cost $21 billion by 2050 (CNBC). A rough estimate is that it takes 17,000 kg of coal to produce the same amount of electricity as 1 kg of nuclear uranium fuel (Suppes & Storvick, 2007). There have been multiple estimates that if the facility closes without proper infrastructure support from other sources of imported fuel such as natural gasses, California would not be able to support its residents in terms of electricity demands causing dangerous blackouts to hospitals and residents with essential life supporting devices that require electricity to function.

6.2 Wind Turbine

Electricity from the wind stands fourth in the country behind natural gas, coal, and nuclear energy as a reliable source. Today wind turbines are not only a cost-competitive source of electricity, they are also 30 times more efficient than older turbines and cost 4 times less than previous models (CEC 2023). That is why investment in floating wind turbines could aid California from summer blackouts that have been rampantly disrupting the lives of residents across the state. Floating wind turbines work similarly to conventional vertical wind turbines except they are deployed off the coast. The method hasn't been implemented widely yet, but research has shown that if mass-produced, the cost of wind turbines will range from $2.88

million to $4.26 million per cluster unit. Spreading this cost through a turbine's lifetime could reduce the cost to wholesales of electricity to about $17/MWh using cost of energy versus avoided cost of energy model analysis. We could potentially identify sites with more levelized economic benefits (Beiter, 2023).

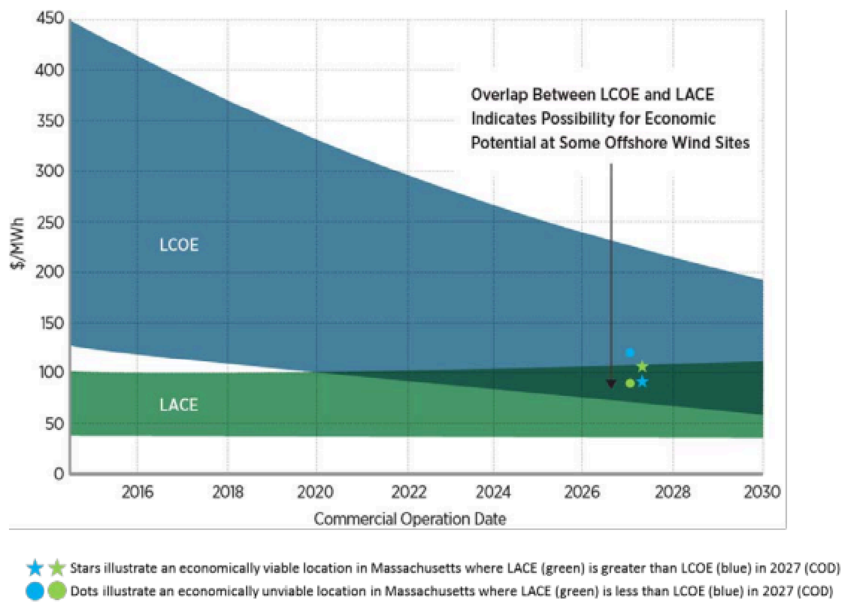


Figure ES-4. Comparison of LCOE to LACE estimates (unsubsidized[11]) from 2015–2030 (COD)

Note: Data plotted are an exponential curve fit through the modeled LCOE and LACE values (2015, 2022, and 2027 [COD])

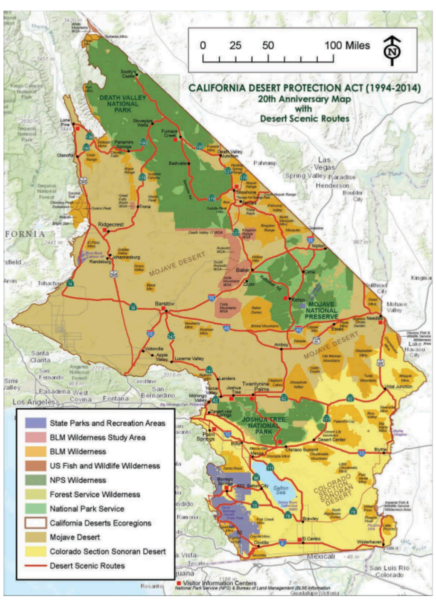
Table ES-1. Estimated Potential LCOE Ranges for the Reference Scenarios (Fixed-Bottom and Floating) from 2015–2030 (COD)

Reference Scenario	$/MWh			
	2015 (COD)	**2022 (COD)**	**2027 (COD)**	**2030 (COD)[8]**
Fixed-Bottom	185	141	106	93
Floating	214	145	108	89

Note: Values are rounded and based on defined scenarios that assume that the U.S. offshore wind industry can leverage the recent European offshore wind technology and industry experiences. Data is modeled for the focus years 2015, 2022, and 2027 (COD), and an exponential curve fit is used for the 2030 (COD) data. The generic reference sites approximate the average site conditions at the current BOEM wind energy areas along the East Coast, but they do not represent any specific site. Policy or direct subsidies are not considered.

6.3 Solar

California possesses three massive deserts: The Mojave Desert 47,877 miles, the Colorado Desert covers an enormous 10,000 square miles and stretches from Mexico to California, two-thirds of which encompasses California, and the Great Basin Desert which lies east of Nevada covering 210,000 square miles. 90% of Nevada is the Great Basin desert, with this the Great Basin Desert covers approximately 9000 square miles of California. Studies have shown that to meet the U.S. demand for electricity, we need approximately 22,000 square miles of solar panel-filled land (Bruno 2021). This is assuming that the solar panels have an efficiency rating of 14%. California could not only cut the cost of electricity in the state, but it could also sell the electricity to other states with more than enough surplus.



6.4 Conclusion

California has the potential to lead the country as an innovative state, one that prioritizes research over fallacies. Research has shown that Nuclear power is not only safe and reliable in terms of economic benefits, but it also reduces the cost of electricity passed on to consumers over multiple decades. And with proper investments into further development, we could turn the technology into 100% renewable by reusing the Uranium fuel spent. California can also leverage its vast coastal area by deploying mass amounts of floating turbines. Cost analysis has shown that if trends continue with proper investments, we could lower the cost of wholesale electricity from the floating turbine to $17/MWh by 2030, compared to other sources of electricity $40/MWh with coal, a hazardous pollutant. California also has the space and plenty of sunlight to power the whole continuous United States if it takes advantage of three massive deserts: The Mojave Desert, the Colorado Desert, and the Great Basin Desert. The state's consumption of electricity totaling 4 million MWh, could simply be satisfied with around 5000 square miles assuming the solar panels have an efficiency rate of 14%.

7.0 Electronic Waste: Impact, Management, Programs as a Solution

7.1 Environmental and Health Impact

In our digital age, the demand to utilize, maintain, and create electronic devices for our everyday needs and reliance increases exponentially. A vast majority of twenty-first-century Americans incorporate some form of electronic devices into their everyday lives. With technology giants such as Samsung, Apple, Nvidia, AMD, and IBM continually promoting new products every couple of years, the average consumer feels the need to update their own devices, such as purchasing the newest phone in line, or updating specific components in their devices, such as graphics cards. This new electronic consumer culture introduces a major problem in the world: a byproduct of the increased electronic waste put into the environment. This increase in electronic waste creates dangerous consequences for our environment, our health, and many other aspects of our lives. At the heart of California's Silicon Valley, the Bay Area is no exception to this impact; striving for technological advancements may lead to our own undoing.

The health impacts related to the improper disposal of electronic waste have proven to be detrimental to human health if precautions are not taken to safely and properly dispose of such materials. According to the article "E-waste management and its effects on the environment and human health" by Rautela et al. (2021), there are two ways of treating electronic waste: formal recycling and informal recycling. Formal recycling involves recycling centers that take major steps and consideration to minimize the toxic waste produced by electronics. These wastes include heavy metal fumes such as cadmium, lead, and mercury that are mixed with halogenated dioxins (Rautela et al., 2021). These toxic mixtures have disastrous effects on the human body, and these effects are stronger in areas using informal recycling, or recycling that is done by inexperienced workers or organizations, or recycling that does not take into consideration the filtering of pollutants. According to Rautela et al. (2021), "Direct inhalation of heavy metals in E-waste recycling sites is associated with an increased risk of abnormalities of the thyroid, cell proliferations, changes in mood and behavior, negative neonatal effects, and impaired lung function." This shows that we need to take into careful consideration where exactly our electronic waste is going, and how exactly we are disposing of this waste, making sure to invest in filters for recycling plants in order to have a minimal impact on human health.

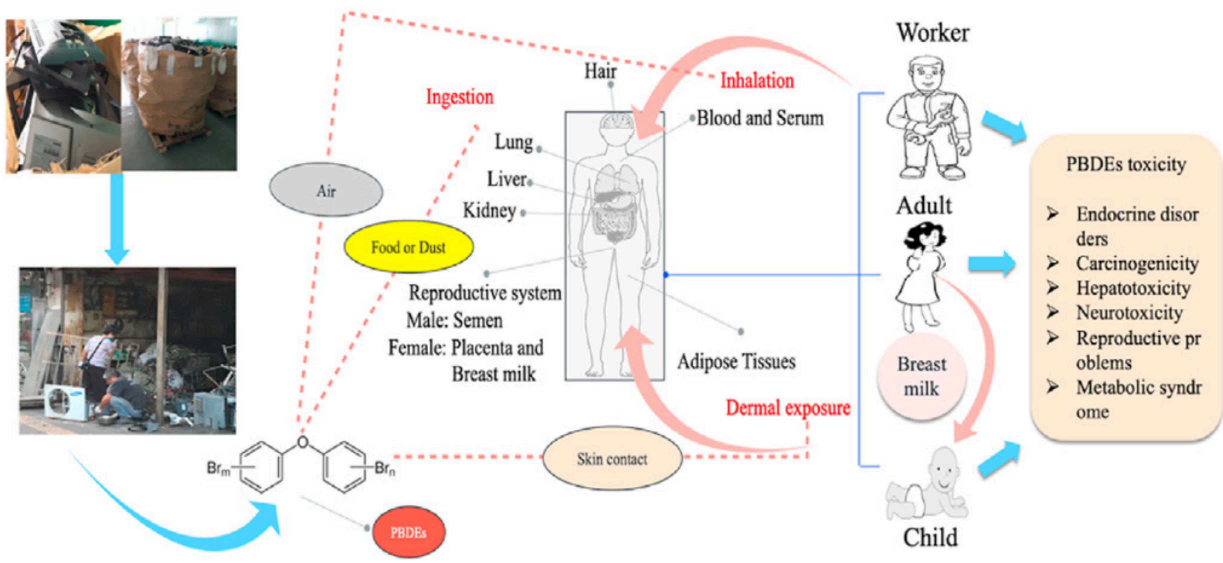
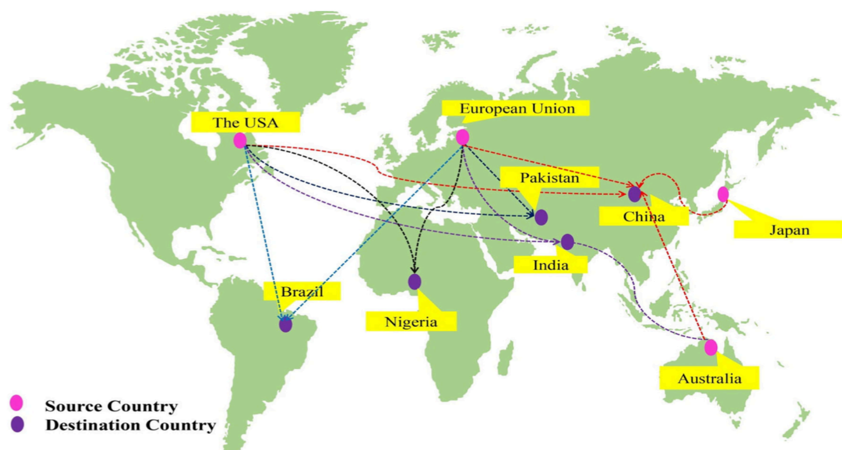


Fig. 1. Human burden of PBDE exposure from e-waste.
Cai, K. (2020)

Polybrominated diphenyl ethers (BPDEs) is a component used in electronics that acts as a fire retardant; however, through improper disposal, this chemical pollutes the environment and, in turn, poses a threat to human life. As stated by the article "Human exposure to PBDEs in e-waste areas: A review," “In 2016, 44.7 million tons of e-waste were generated around the world, equivalent to 6.1 kg per capita. It is estimated that the world's e-waste will increase to 52.2 million tons by 2021” (Cai et al., 2020), showing just how much e-waste is contributing to global pollution. The hazardous materials in e-waste leak into the environment when improperly disposed of, releasing PBDEs into the air, water, as well as soil, further polluting the food we eat while destroying the local environment around these recycling centers. California's Bay Area needs to take into consideration the large impact that e-waste has on both our health and environment through proper electronic waste management.

7.2 Electronic Waste Management



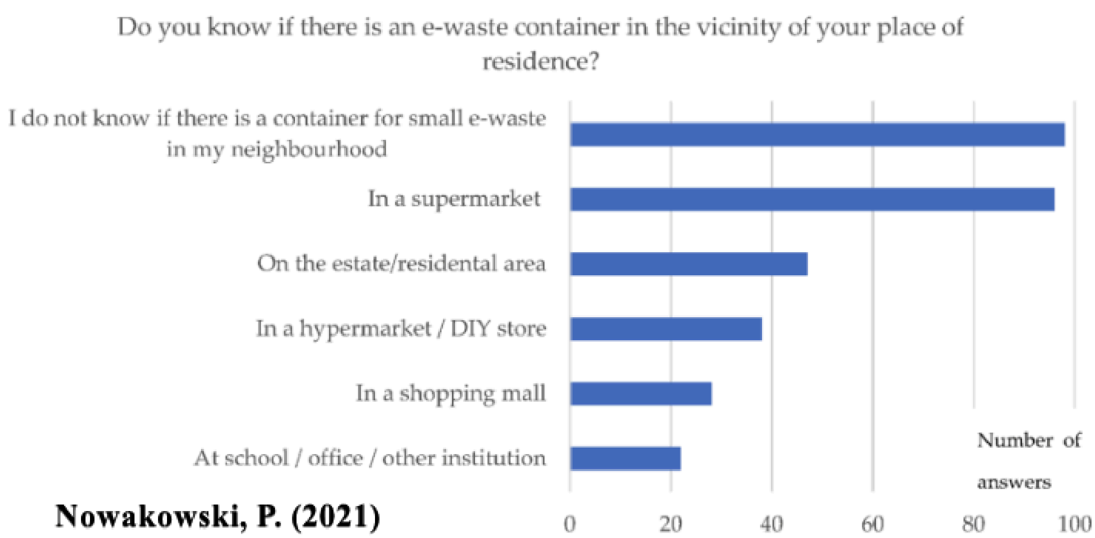
Rautela, R. (2021)

Fig. 3. Global distribution of E-waste export (source) and import (destination) countries.

Proper electronic waste management is necessary for keeping our environment clean and maintaining public health. However, large amounts of waste are exported to countries where informal recycling is abundant due to cheaper prices. As shown in Figure 3 by Rautela, R. The United States exports electronic waste to Brazil, Pakistan, India, Nigeria, and China, where under qualified workers and informal recycling are abundant due to different laws regarding electronic waste pollution. Therefore, it's critical for us to know what proper electronic waste management includes and how we could implement those ideas into the Bay Area. A first step could be the introduction of local laws that regulate, control, and manage PBDEs, as stated by Rautela: "With the restrictions on PBDEs in the Stockholm Convention... It has been shown that the exposure trend of PBDEs is decreasing, but at a very slow rate, especially in China " (Rautela, 2021). This evidence shows that the regulation and monitoring of PBDEs are beneficial to local life and the environment, and we must try our best to keep our e-waste local and our workers healthy.

We can take inspiration from the European Union, as they have established two key management systems for electronic waste: the Waste Electrical and Electronic Equipment (WEEE) and the Restriction of Hazardous Substances (RoHS). As described by Rautela, “The WEEE directive was intended to reduce the deleterious impacts of toxic emissions from E-waste recycling on human health and the environment by encouraging the application of the 4 R's to E-waste management and discouraging disposal in landfills" (Rautela, 2021). The 4 R's mentioned are reduce, reuse, recycle, and recover. We can also take inspiration in this aspect by incorporating the fourth R into our education: recovery. Recovery is more in line with energy recovery or waste-to-energy recovery. This involves the production of energy through the means of waste disposal, such as burning. When properly filtered, the incinerated waste can produce energy, which can then be put back into our electric systems. Therefore, the implementation of waste incinerators could prove useful to the Bay Area as an aspect of general waste management, but not e-waste.

A study conducted by Piotr Nowakowski, Sandra Ku´snierz, Julia Płoszaj, and Patrycja Sosna in Poland observed the effects and statistics behind introducing containers that collect small waste electrical and electronic equipment (WEEE) in supermarkets. While this study was conducted in supermarkets in Poland, this could also be applied to the Bay Area as a method of electronic waste management. Researchers in the article communicated with supermarket owners to introduce bins for electronic waste disposal and observe how people would interact with these bins. The bins were placed in easily accessible and visible places so that customers would easily identify the bins. They also contained slogans, bright colors, and artwork for the purpose of creating attention to the bins. However, as with regular recycling, cross-contamination of these bins was also abundant. It was found that in the conclusion of the experiment, “proposals to improve the collection rate of small e-waste, the majority of respondents expect to provide seasonal events to collect such equipment (44 percent of participants). Further, the placement of containers in residential areas is expected by 35 percent of respondents. Providing more containers in other supermarkets is welcomed by 21 percent of respondents” (Nowakowski et al., 2021).

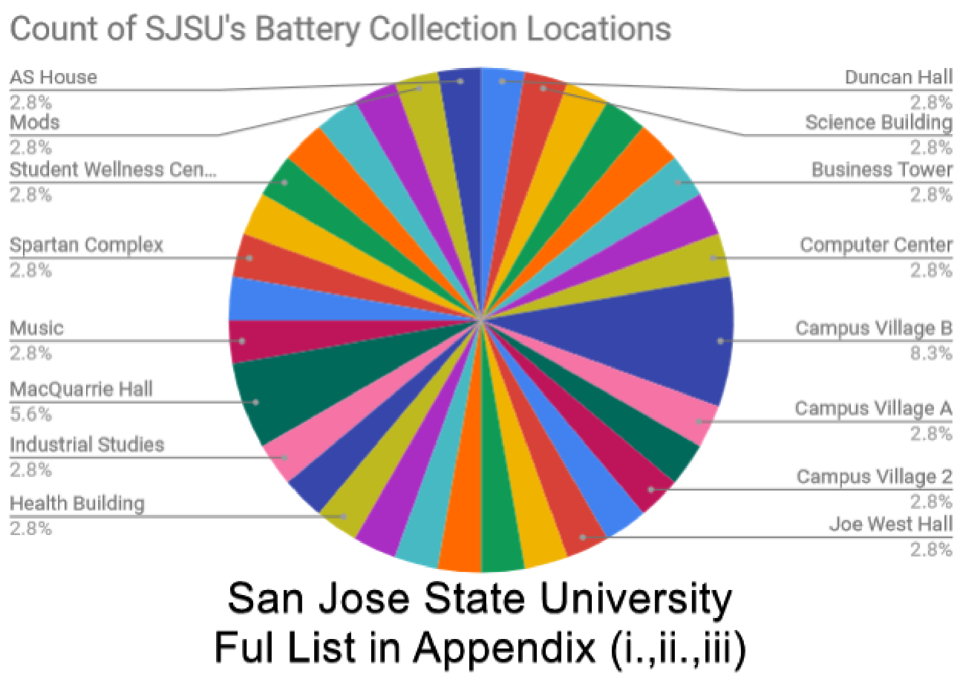


Nowakowski, P. (2021)

The conclusion above shows that, in order to implement better e-waste management, it's critical to introduce methods that are convenient to citizens. This could include scheduled pick-ups similar to our trash, placing collection bins within close proximity to residences, and within convenience stores. All of these ideas can be implemented within the Bay Area to create better systems for electronic waste collection. However, in order to do this, we need to implement different strategies to educate citizens on proper disposal, as cross-contamination would be abundant otherwise.

7.3 Primary Research: SJSU Batteries and City Disposal

San Jose State University currently implements a single-stream collection for processing waste, meaning that instead of having different collection bins for waste management, only a single bin is used for the collection of many different types of waste. This waste is then processed later on. However, this is not optimal for e-waste, as stated previously, cross-contamination of electronic waste makes it much more difficult to recycle. Therefore, there must be a different method of collecting e-waste



Currently, San Jose State University maintains a battery collection program where battery drop-off locations are available in every building on campus. However, when prompting students around campus about the existence of the drop-off locations, we found that many students were unaware of them. This mirrors the findings in the experiment conducted by Nowakowski et al. (2021). Not only were students unaware that a battery collection program was available and abundant on campus, but they were also unaware of any information sources about where these battery collection boxes were. Through some digging, I was able to find a link to all of the battery deposit locations available on campus; however, many of them were in inconvenient or not easily accessible locations, such as rooms on different floors or far away from the entrance. This sort of battery collection program should be more abundant throughout the Bay Area. However, San Jose State University shows how critical Nowakowski's points were; collection bins should be easily accessible, clearly visible, and information should be provided to make people aware of the existence of these drop-off locations (Nowakowski et al., 2021).

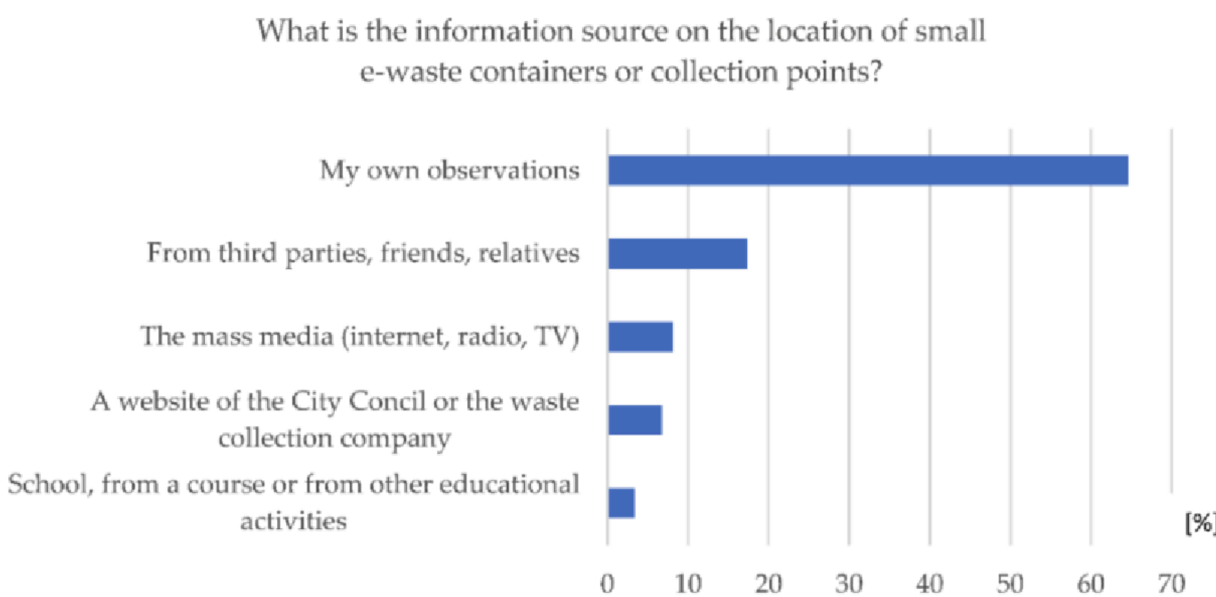


Figure 6. Identification of the information source of a resident regarding small e-waste collection points.
Nowakowski P. (2021)

7.4 Recycling Programs as a Solution

Currently, the method in which the City of San Jose implements its E-Waste collection is underwhelming, as the way citizens can find out how to dispose of their waste is by searching online, finding the website for sanjoserecycles.org, and setting up an e-waste appointment. Some waste is available through the city's "Junk Pickup Program," where waste is collected at residences, optionally donating it to an organization that accepts e-waste, such as Goodwill

Industries via recyclestuff.org. Though it seems there are many methods to dispose of e-waste, the system implemented within San Jose seems convoluted and not convenient, which means that proper recycling of electronic waste will be decreased (Nowakowski et al., 2021).

Proper recycling programs that inform people about the convenience, availability, and importance of proper electronic waste disposal are necessary to implement in the Bay Area. A study in Dubai found that, "over 50% of respondents had little to no idea about the e-waste concept and e-waste recycling... 77.2% were also not aware of any recycling companies dedicated to e-waste recycling despite having respondents who have recycled their electronic devices at least once (31.6%)" (Attia, Soori, & Ghaith, 2021), further showing the importance of properly educating and informing those within the Bay Area about the proper methods of electronic waste recycling. This can be achieved through the implementation of awareness programs, along with the installation of easily accessible electronic waste bins.

In conclusion, the improper disposal of electronic waste can have horrible repercussions on the local environment, and the health and well being of residents, therefore it's necessary to inform our residents within the Bay Area about how to properly dispose of electronic waste through the implementation of awareness programs, collection programs, easily accessible and convenient bins, both located near residents and or within high traffic areas such as supermarkets. If they are within supermarkets, it's important to place them in the front where it's much less likely to be missed. Creating and encouraging a culture surrounding electronic waste disposal is also helpful for people to become more educated on the topic; All of these aspects are important to implement within the Bay Area.

8.0 Conclusion

The first half of this research paper summarizes how unsustainable forms of agriculture harm our environment, how we can reduce waste, and how railways help the environment. NOx pollution from agricultural soils in California produces a lot of NOx emissions. Solutions to reducing these emissions include improving fertilizer efficiencies, implementing precision fertilization so that no excess fertilizer is given to each plant, incentivizing alternative forms of food consumption via plant production, and using optimal irrigation strategies. These solutions will help reduce the amount of nitrogen emissions, and reduce the harmful health impacts. Implementing these solutions will also have economic benefits and increase the amount of job opportunities. By using soil and plant microbiomes to enhance sustainable agricultural production, we can help improve all the facets of our lives.

Improper methods of waste management is also a major contributor to why we have harmful levels of greenhouse gas emissions in California. To mitigate these harmful effects, we need to pursue solutions that reduce the amount of waste that is being produced in order to reduce the amount of greenhouse gas emissions. SB 1383 pursues targets for reducing the amount of organic waste and having a food restoration plan by 2025. A solution that should be pursued is the usage of biochar, which is created in a controlled environment of burning organic matter. This offers many environmental and economic benefits, thus showing the importance of pursuing efficient waste management strategies.

California has a transportation problem because of how much carbon monoxide vehicles produce. Thus, integrating high-speed and light rail systems would help alleviate the carbon monoxide pollution caused by highway traffic. In order to implement these solutions, challenges such as considering the mass population and the infrastructure of railways need to be addressed in order for these systems to successfully be implemented. Proposing a statewide high-speed rail that is aligned with highways is an initiative that should be pursued, as it provides environmental benefits by limiting the amount of carbon monoxide be emitted, having better transit integration, and more economic opportunities for California.

Furthermore, the latter half of our research paper provided ideas for shaping the future of the Bay Area, along with the state of California. We hope that others, such as the rest of the United States, or different countries, follow suit for creating sustainable environments using the ideas and solutions provided in our paper. These ideas include, but aren't limited to, implementation of a high speed and light rail symbiotic system connecting the Bay Area to the rest of California, the proposition of mass electrification across various aspects around the Bay Area, the strive to implement and upgrade current renewable energies, and the reduction of electronic waste through policy initiatives designed to promote and encourage proper waste disposal, taking into consideration of the research done in Poland as described in section 7.2 . Given the increasing demand for energy consumption, it is critical that we strive for electrification in as many different aspects of our lives as possible, aiming to decrease reliance on non-renewable energies.

Alongside mass electrification, we need to take into consideration the implementation and expansion of nuclear power, solar energy, and wind turbines as different methods of creating renewable energy in California, allowing us to reliably electrify as many different aspects around the Bay Area as possible. With the effort to electrify everything, we should keep in mind the goal of reaching 100% renewable energy by 2045, and to further assist these efforts, we propose the implementation of programs to raise awareness about the disastrous effects of improper electronic waste disposal. Specific policies should also be introduced to restrict and monitor the use of PBDs in electronics, along with policies ensuring that electronic waste bins are easily accessible to everyone, motivating people to recycle more often.

By implementing these different aspects, we hope to make the state of California healthier for both the environment and our own well-being. We hope to inspire individuals across the United States or even across the world to join in creating a greener, sustainable planet for future generations.

Appendix

Appendix (i.)

SAN JOSÉ STATE UNIVERSITY						
USED BATTERY COLLECTION LOCATIONS						
Battery Location Number	Campus Grid Location	Building Number	Building Key	Collection Container Room Location	Building Name	College or Department Name
1	D1	52	DH	436	**Duncan Hall**	***College of Science***
2	B1	48	SCI	148	**Science Building**	***College of Science***
3	B3	35	ENG	147	**Engineering Building**	***College of Engineering***
4	B2	30	ADM	143	**Administration**	Office of the Provost
5			ADM	255		Career Center - ADM-255
6	C3	31	ART	101B	**Art**	Art (Spray Booth)
7			ART	106/104		Jordan / Lydia's office
8	C4	92T	BT	650	**Business Tower**	School of Management
9	B2	59	CL	Lobby - 102	**Clark Hall**	IT Help Desk
10				552		Provost Office
11	C2	27	CC	2nd Floor	**Computer Center**	UCAT
12	D4	152	CVB	243A Housing Office Front Desk	**Campus Village B**	Housing/ Dorms
13	D4	152	CVB	Lab	**Campus Village B**	Housing/ Dorms
14	D4	151	CVA	126C	**Campus Village A**	Housing/ Dorms
15	D4	152	CVB	136E	**Campus Village B**	Housing/ Dorms
16	D4	153	CVC	110B	**Campus Village C**	Housing/ Dorms
17	D4	156	CV2	Lobby-Front Desk	**Campus Village 2**	Housing/ Dorms
18	D3	89	WSH	MISSING - take to another building	**Washburn Hall**	Housing/ Dorms
19	D4	90	JWH	Lobby-Front Desk	**Joe West Hall**	Housing/ Dorms
20	C2	71	CCB	200 Hallw ay	**Central Classroom Buidling**	Nutrition & Food Science
21	D3		DC	Office - Main Level	**Dining Commons**	Spartan Eats
22	C2	21	DBH	105	**Dwight Bentel Hall**	Journalism Office

Appendix (ii.)

SAN JOSÉ STATE UNIVERSITY						
USED BATTERY COLLECTION LOCATIONS						
Battery Location Number	Campus Grid Location	Building Number	Building Key	Collection Container Room Location	Building Name	College or Department Name
23	C2	7	FOB	126	**Faculty Office Building**	English Printer Office
24	Off-Grid	38	3rd St. & Paseo de San Antonio	Loading Dock	**Hammer Theatre**	Humanities and the Arts
25	C4		HB	Lobby Desk	**Health Building**	Lobby
26	B2	49	HGH	138	**Hugh Gillis Hall**	University Theater
27			HGH	100		Theatre Arts/Drama
28			HGH	126A		Film and Theater
29	B4	39	IS	134B	**Industrial Studies**	EHS
30			IS - Ceramics	162		Ceramics / Division of Technology
31	D2	78	MH	208	**MacQuarrie Hall**	Computer Science
32			MH	431	**MacQuarrie Hall**	College of Health and Human Sciences
33	C3	44	MUS	178	**Music**	Music
34	D2	54	UPD	209	**South Garage-UPD**	Parking - UPD
35	D2		UPD	3rd Floor		University Personnel
36	C2	47	SPX-C	102	**Spartan Complex**	Kinesiology Main Office
37	B3	3	SU	Basement Near Loading Dock	**Student Union**	Facilities
38			SU -Print Shop	2904		Print Shop
39	C2	116	SWC	300B	**Student Wellness Center**	CAPS
40			SWC	316F		Batteries, Otoscope halogen Bulbs, Toner
41	D2	36	SH	103	**Sweeny Hall**	College of Education
42				305		College of Education

Appendix (iii.)

SAN JOSÉ STATE UNIVERSITY						
USED BATTERY COLLECTION LOCATIONS						
Battery Location Number	Campus Grid Location	Building Number	Building Key	Collection Container Room Location	Building Name	College or Department Name
43	C1	45	YUH	242	**Yoshihiro Uchida Hall**	Kinesiology - Exercise Physiology Research lab
44	C1	20	WSQ	115	**Washington Square Hall**	Environmental Studies
45			WSQ	118		Environmental Studies
46	B2	59	MODS	South Side	**Mods**	Office of Sustainability
47	B4		ASH	107	**AS House**	Associated Students
48	Off-Grid	N/A	N/A	Copier Room	**Finance Building**	60 South Market Street, Suite 470
49	Off-Grid	N/A	N/A	Check with Eric	**SJSU Research Foundation**	N. 4th St. (4th Floor)
50	Off-Grid	N/A	N/A	Basement	**International Student House**	360 S 11th St.
Not Applicable	B1		King		**MLK Library**	Managed by the City of San Jose

Annotated Bibliography

Almaraz, M., Bai, E., Wang, C., Trousdell, J., Conley, S., Faloona, I., & Houlton, B. Z. (2018). Agriculture is a major source of NOx pollution in California. *Science Advances*, *4*(1). https://doi.org/10.1126/sciadv.aao3477

NOx is linked to adverse effects on human health and biodiversity. There have been successful regulations that have targeted emissions from vehicular transportation. However, the authors show that agricultural soils are a major source of NOx pollution in California. Then, the authors propose solutions to reduce NOx emissions, and the economic benefits, ecosystems, and human health in California

As uses of biochar expand, climate benefits still uncertain. (2014, January 21). Yale E360. https://e360.yale.edu/features/as_uses_of_biochar_expand_climate_benefits_still_uncertain

Biochar is a substance produced by burning organic matter in a zero- or low-oxygen environment. When inserted into soil, biochar moves carbon from the atmosphere into the ground and can also improve soil fertility and health. Researchers are interested in how biochar can be used to improve the environment and agriculture. Johannes Lehmann, a top expert on biochar, says organic waste from agricultural and forestry industries can be used to produce biochar. This environmental magazine article provides a helpful introduction to the concept of using biochar as a tool to slow or potentially even reverse climate change.

Attia, Y., Soori, P. K., & Ghaith, F. (2021). Analysis of Households' E-Waste Awareness, Disposal Behavior, and Estimation of Potential Waste Mobile Phones towards an

Effective E-Waste Management System in Dubai. *Toxics (Basel)*, *9*(10), 236-. https://doi.org/10.3390/toxics9100236

This article discusses different aspects involving e-waste management in Dubai, and the issues following it. It's shown that landfilling and incinerating e-waste can cause harm to the environment because of the contaminant produced. It was also shown that challenges in the GCC region involving recycling e-waste was the lack of policies, recycling facilities, and documentation of e-waste. An important aspect of this document was the statistics involving awareness and active participation in recycling. 50% of respondents were unaware of e-waste concepts and recycling, and of those who did know about e-waste recycling, 77.2% percent were not aware of recycling companies responsible for handling e-waste. These statistics show that it's important to raise awareness and educate people about e=waste.

As stated above, I plan to use this article to enforce the idea of promoting awareness for e-waste in the Bay Area, as the document showed that many people were unaware about many different aspects of e-waste recycling, and how harmful it is to the environment, proving that it's necessary to spread awareness to this issue.

Cai, K., Song, Q., Yuan, W., Ruan, J., Duan, H., Li, Y., & Li, J. (2020). Human exposure to PBDEs in e-waste areas: A review. *Environmental Pollution (1987)*, *267*, 115634-. https://doi.org/10.1016/j.envpol.2020.115634

This article goes over the dangers of polybrominated diphenyl ether (PBDE), a chemical added to electronic components to act as a fire retardant. The article goes over areas where these PBDEs are most found, how people are exposed to them, the health complications associated with them, factors influencing exposure, and some

recommendations to reduce the amount of PBDE exposure through the means of regulations and awareness. The article has extensive data and research behind it, as it goes over multiple different statistics behind PBDEs and their complications.

I believe that this article would be useful implementing into my own research paper as it describes the harmful effects of e-waste. I plan on using this research to help persuade the reader into taking into consideration the possible solutions offered in the article, and why it's important to take notice of them.

California's short-lived climate pollutant reduction strategy. (n.d.). CalRecycle. https://calrecycle.ca.gov/organics/slcp/

California is currently implementing SB 1383, a law that seeks to reduce organic waste and the resulting greenhouse gas emissions. Every jurisdiction is required to significantly improve recycling and waste services and to throw away less food with food recovery programs. Progress is to be documented, reported, and enforced. This page on the CalRecycle website describes the steps that California is taking to reduce waste.

Chen, Y., Wang, Y., & Hu, R. (2020). Sustainability by high–speed rail: The reduction mechanisms of transportation infrastructure on Haze Pollution. *Sustainability*, *12*(7), 2763. https://doi.org/10.3390/su12072763

Having been published and peer reviewed in 2020 'Sustainability by high–speed rail: The reduction mechanisms of transportation infrastructure on Haze Pollution.' is both relevant and trustworthy as it focuses on the environmental pros and cons of implementation of high speed rail. Specifically, the article analyzes haze pollution levels in 288 prefecture level cities in China across a span of 11 years, finding that high speed rail reduced Haze

pollution by a total of 17%. The findings from the article prove useful in justifying the long term implementation of high speed rail in the state of California.

Fernandez-Bou, A. S., Rodríguez-Flores, J. M., Guzman, A., Ortiz-Partida, J. P., Classen-Rodriguez, L. M., Sánchez-Pérez, P. A., Valero-Fandiño, J., Pells, C., Flores-Landeros, H., Sandoval-Solís, S., Characklis, G. W., Harmon, T. C., McCullough, M., & Medellín-Azuara, J. (2023). Water, environment, and socioeconomic justice in California: A multi-benefit cropland repurposing framework. *The Science of the Total Environment*, *858*(Pt 3), 159963-. https://doi.org/10.1016/j.scitotenv.2022.159963

The authors talk about how low-income, rural communities in California's Central Valley face environmental and socioeconomic challenges, such as having poor air quality, facing water insecurity, and having inadequate infrastructure. With their continuing trends, these communities may experience more setbacks due to facing water scarcity and having new policies which require certain farmland to be retired. The authors focus on potential solutions, such as repurposing cropland for disadvantaged communities to help enhance socioeconomic opportunities, environmental advantages, and diversifying businesses. They estimate reductions in water and pesticide use, nitrogen leaching, and greenhouse gas emissions. They also discover the effects of the economy and employment due to having clean industries and using solar energy.

Guha, A., Newman, S., Fairley, D., Dinh, T. M., Duca, L., Conley, S. C., Smith, M. L., Thorpe, A. K., Duren, R. M., Cusworth, D. H., Foster, K. T., Fischer, M. L., Jeong, S., Yesiller, N., Hanson, J. L., & Martien, P. T. (2020, July 7). Assessment of regional methane emission inventories through airborne quantification in the San Francisco Bay Area. *Environmental Science & Technology*, *54*(15), 9254–9264. https://doi.org/10.1021/acs.est.0c01212

Multiple measurements of methane emissions were taken at numerous different facilities in the San Francisco Bay Area via airplane. The facilities used for the study included refineries, landfills, wastewater treatment plants, composting operations, and dairy operations. The measurements are used to estimate the annual emissions produced by the facilities in gigagrams (One gigagram is equivalent to one thousand metric tons). While the refineries and dairy operations are not relevant to this essay, the measurements acquired from landfills, wastewater plants, and composting operations provide valuable information on how Bay Area waste facilities affect the atmosphere.

Guo, X., Sun, W., Yao, S., & Zheng, S. (2020). Does high-speed railway reduce air pollution along highways? —— evidence from China. *Transportation Research Part D: Transport and Environment*, *89*, 102607. https://doi.org/10.1016/j.trd.2020.102607

Having been published and peer reviewed as of 2020 'Does high-speed railway reduce air pollution along highways? —— evidence from China.' is both relevant and trustworthy. Furthermore the article discusses alleviation of highway pollution via the usage of high speed rail in order to reduce the amount of cars on the road. Thus attributing the decreased amount of cars on the road to an increase in high speed rail passengers. Relevant information from this article consists of pollution decrease data in respect to the amount of cars taken off of the highway, which can be adapted and extrapolated to application in the Bay Area.

Ha, M., & Schleiger, R. (2021, November 8). Waste Disposal. ASCCC Open Educational Resources Initiative. https://bio.libretexts.org/@go/page/72716

There are three main methods of disposing waste: open dumps, sanitary landfills, and incineration. Each has advantages: waste in dumps decomposes quickly, landfills prevent severe contamination, and incineration reduces waste volume and can provide energy. Each has disadvantages: dumps spread disease and pollution, landfills have limited capacity and produce methane, and incineration creates toxic fumes and is costly. None of these methods are very environmentally friendly. This textbook provides a quick summary on the pros and cons of different waste disposal methods so that they can be compared.

Jaroszynski, M. A., & Brown, J. R. (2014). Do light rail transit planning decisions affect metropolitan transit performance? *Transportation Research Record: Journal of the Transportation Research Board*, *2419*(1), 50–62. https://doi.org/10.3141/2419-06

Published in 2014 Do light rail transit planning decisions affect metropolitan transit performance?' is a cross sectional analysis of 8 U.S. cities and how light rail affects other transit systems such as bus routes. Since the academic article had been published in 2014 and is peer reviewed it can be stated that the article is both relevant and trustworthy. Furthermore light rail transit is established as a figurative backbone to other public transit services within each respective city and a focus was placed on how each city planned around light rail transit. Thus the information gathered can be extrapolated to existing light rail in Bay Area cities

Marcziynkowski, H. M., & Barros, L. (2020). Technical approaches and institutional alignment to 100% renewable energy system transition of Madeira Island—electrification, Smart Energy and the required flexible market conditions. Energies, 13(17), 4434. https://doi.org/10.3390/en13174434

In this paper, the integration of renewable energy in an island system is examined. This is done through a case study of Madeira Island. It presents a technical analysis of electrifying transport and heating demands with biomass and meeting the remaining needs by incorporating smart charging, vehicle-to-grid, thermal collectors, and electrofuel production. The results showed that in such a small energy grid, it was more beneficial to focus not on the electrification of heating demands and transportation, but on the other options. All together, 50% less biomass usage, no curtailment, and slightly higher costs (1–3%) were shown to be the results of the research.

This paper discusses the advantages of electrifying transportation and heating in buildings. This directly relates to my topic of how electrification can help us reach our sustainability goals here in the bay area.

Mukherjee, A., & Lal, R. (2014, March 31). The biochar dilemma. *Soil Research*, *52*(3), 217. https://doi.org/10.1071/SR13359

Biochar is not a miracle substance that will solve all climate issues. Compared to other solutions, there is much less data on biochar's effectiveness and efficiency. The effects of biochar can vary greatly depending on its composition, the heat it was made in, the type of soil it's being inserted into, etc. Improper biochar production may even be more harmful than helpful for the environment. In order to make the most of biochar, it must be carefully analyzed so that the optimal type of biochar for the region can be identified.

This article serves as a warning that biochar can be risky if misused, and these risks must be taken into account when assessing the value of biochar.

Nematian, M., Ng'ombe, J. N., & Keske, C. (2023, October 8). Sustaining agricultural economies: Regional economic impacts of biochar production from waste orchard biomass in California's Central Valley. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-023-03984-6

Biochar has been shown to have several environmentally beneficial effects, but it’s also important to consider the economic impact of biochar production. Biochar prices can vary depending on the production process and organic materials used. If biochar as an industry is expanded in California, it will create new jobs and boost GDP by millions of dollars while also being environmentally friendly. When considering what solutions should be explored, knowing how they can affect the economy can be very helpful in determining whether a solution is worth pursuing.

Nowakowski, P., Kuśnierz, S., Płoszaj, J., & Sosna, P. (2021). Collecting Small-Waste Electrical and Electronic Equipment in Poland—How Can Containers Help in Disposal of E-Waste by Individuals? *Sustainability (Basel, Switzerland)*, *13*(22), 12422-. https://doi.org/10.3390/su132212422

This article focuses on the effects and statistics behind implementing containers that collect small waste electrical and electronic equipment (WEEE) in Poland. These containers were placed within supermarkets and were collected monthly, however general waste would contaminate e-waste containers, making it more difficult to recycle these components. About half of the people noticed the containers, however some still found it difficult to locate, that being said, around forty percent showed interest in using these collection bins. It was also proposed that incentives could be offered for proper e-waste disposal, along with international collaboration efforts within the European Union to further increase the amount of e-waste recycling.

I plan on using this article to show different ways to implement recycling facilities within supermarkets in the Bay Area in order to increase recycling efforts. I also plan on relating this to the on-campus recycling bins, and how they are not very obvious, and are difficult

to find. This article shows the promising effects of these easy to access and public recycling bins, which I plan to reinforce in my essay.

Paniyil, P., Powar, V., & Singh, R. (2021). Sustainable intelligent charging infrastructure for electrification of Transportation. Energies, 14(17), 5258. https://doi.org/10.3390/en14175258

This paper advocates for the electrification of transportation and a sustainable charging network for such transportation. It chooses to focus on using photovoltaics, wind turbines, and lithium-ion batteries to build out such a system. It highlights the importance of certain electronics in a direct current (DC) based network. DC has an advantage over alternating current (AC) because it has the capacity to charge electric transportation vehicles faster. It also highlights the potential cost savings of an electric vehicle as opposed to a gas powered vehicle.

This article discusses the benefits of transferring from non-renewable energies to renewable energy sources and the advantages that are inherent to electrification, which is my topic. .

Perera, F., & Nadeau, K. (2022). Climate change, fossil-fuel pollution, and children's health. *New England Journal of Medicine*, *386*(24), 2303–2314. https://doi.org/10.1056/nejmra2117706

In this article, the authors discuss the harms done by fossil fuels and other non-renewable energy sources. The damage that they researched involved damage to the environment as well as the physical health of children. More specifically, it looked at how fossil fuel consumption causes harm through extreme weather events, bad air quality, water

availability and more. The article also briefly covers the cost effectiveness of switching away from fossil fuels.

I was able to use this article because it discussed the health issues that arise from our reliance on fossil fuels. By proposing electrification, I argue that these issues could be limited as well as reducing costs as the article showed that electricity is generally more cost effective.

Rautela, R., Arya, S., Vishwakarma, S., Lee, J., Kim, K.-H., & Kumar, S. (2021). E-waste management and its effects on the environment and human health. *The Science of the Total Environment*, *773*, 145623-. https://doi.org/10.1016/j.scitotenv.2021.145623

This article focuses on the issues surrounding e-waste management, as its effects can be devastating to both the environment, and human health. It's shown that e-waste becomes more of an issue as time progresses as new technological advances are made, and the demand for electronic parts increases, and with an ever increasing future of smart technology, it seems that this will not stop any time soon. The article discusses the harmful effects of e-waste if they are not recycled properly, this being exposure to hazardous materials leading to health complications, death, and environmental threats such as air, water, and soil pollution. Awareness programs, regulations and policies, and sustainable e-waste management practices were all possible solutions provided in the article.

I plan to use this article to further show the harmful effects of improper e-waste disposal, and its harmful effects on human and natural life. The extensive studies and infographics within the document are aspects that I want to include in my own paper, as they are extremely descriptive and allow for easier reading and understanding of the materials.

Overall, this is a great article to support my view on proposing different solutions to e-waste management.

Villafuerte-Diaz, J., Victoriano-Habit, R., Soliz, A., & El-Geneidy, A. (2023). Who does light rail serve? examining gendered mobilities and light-rail transit in Montreal, Canada. *Transportation Research Record: Journal of the Transportation Research Board*, *2677*(9), 104–115. https://doi.org/10.1177/03611981231158318

Having been published and peer reviewed as of 2023 'Who does light rail serve? examining gendered mobilities and light-rail transit in Montreal, Canada.' is both a relevant and trustworthy source of information. The article utilizes a binary logistic modeling approach to quantify why Montreal residents utilized light rail transit along gender identity and economic mobility. This information can be extrapolated to cities such as San Jose, Cuportino, and other Bay Area cities due to similarities in both sets of light rail transit systems. Furthermore this information is relevant as it is important to assess how and why populations use public transit.

de Vries, A., & Stoll, C. (2021). Bitcoin's growing e-waste problem. *Resources, Conservation and Recycling*, *175*, 105901-. https://doi.org/10.1016/j.resconrec.2021.105901

This article focuses on the environmental impact of Bitcoin mining, focusing on the large amounts of electronic waste created from the requirements needed for mining cryptocurrencies. The power and technology required for the operations involving Bitcoin mining has a large toll on the environment, both needing large amounts of energy to keep the mining rigs going, but also needing a large amount of electronic parts such as graphics cards. It was also found that the average lifespan of Bitcoin mining rigs was less than 1.29 years, as the rigs become “unprofitable”, meaning that they will need to be replaced.

This paper is useful in providing data in regards to the e-waste involved with mining cryptocurrencies. These operations create large energy usage, increase the prices of computer components for the average consumer, and also generate large amounts of e-waste. I propose to implement some of the suggestions into the Bay Area.

Yan, Z., Xiong, C., Liu, H., & Singh, B. K. (2022). Sustainable agricultural practices contribute significantly to One Health. *Journal of Sustainable Agriculture and Environment*, *1*(3), 165–176. https://doi.org/10.1002/sae2.12019

This article talks about how human health, animal health, and the environment are all connected to each other. It mentions how poor practices upon the environment have negative consequences on human health. The article proposes solutions to how we can leverage the usage of soil and plant microbiomes to perform sustainable agricultural practices.

Yang, S., Gao, H. O., & You, F. (2023). Building electrification and carbon emissions: Integrated Energy Management considering the dynamics of the Electricity Mix and pricing. Advances in Applied Energy, 10, 100141. https://doi.org/10.1016/j.adapen.2023.100141

This study highlights the importance of electrification and distributed energy resources (DERs) in reducing building carbon footprints. It introduces a novel model predictive control (MPC)-based framework for managing multiple DERs in buildings, considering dynamic grid electricity mix and pricing. Simulations across different climates demonstrate significant reductions (11.9% - 38.3%) in electricity costs and (7.2% - 25.1%) carbon emissions compared to conventional control. The framework also

minimizes discomfort time, shifts peak loads effectively, and shows potential for simultaneous cost savings and carbon emission reductions, emphasizing its effectiveness in promoting sustainable building energy systems.

This study discusses the advantages to a smart electric grid and how these advantages can be best leveraged if more of our infrastructure is dependent on electricity. Because my topic is electrification, this paper will help me argue why we should electrify heating and cooling in homes as well as our energy sources.

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