The CBA suggests that under most scenarios, electrification of the Alameda Corridor will likely not have a net positive value. Only under a scenario in which new rail yards are not included in the total costs do the monetized benefits of electrification outweigh the costs. Total benefits are estimated at $550,131,818—which, though substantial, will only outweigh costs when estimates exclude the construction of new rail yards that stakeholders argue are required to maintain interoperability. Any scenario including the construction of at least one rail yard will add significant costs that outweigh calculated benefits. Rail yards will almost certainly need to be constructed for an electrification project because of technical and regulatory feasibility issues. Electrifying the Alameda Corridor therefore will likely not be a profitable investment if this rail segment is electrified exclusively. However, if the Alameda Corridor were electrified as a part of a larger electrification project, the marginal cost of electrification could be outweighed by emission reduction benefits and fuel cost savings. If a larger electrified system existed, fewer rail yards would be needed for switching purposes.

Rail electrification involves environmental, engineering, health, land-use and community concerns. In terms of environmental justice, reducing poor air quality in regions with low-income and minority populations that are already exposed to disproportionately higher levels of disease and cancer risks becomes a priority. In addition, according to the Air Quality Management District, federal air quality regulations will be increasingly stringent in future years, pushing transportation in the South Coast Air Basin towards zero-emissions technologies. However, interstate commerce laws and technical feasibility issues present significant problems for proponents of electrification and make it unlikely that railroads will be willing to accept the costly delays associated with electrification. Electrification would add costs and time delays that could cause railroads to lose their customers. In terms of technical feasibility challenges, a patchwork electrified system may also cause lost business for railroads, as time delays and inconsistency in service.

If pursuing electrification of the Alameda Corridor is pursued, recommendations include:

- Utilize strategies for cost savings, such as contracting out labor to existing agencies and attempting to minimize the construction of new rail yards. Such strategies can reduce costs substantially if electrification is undertaken as a strategy for reducing emissions, the client is recommended to evaluate the net positive scenarios and aim to implement electrification in a way that would incorporate the lowest estimated costs and strategies.

- Another option for arriving at a cost-effective result would be to conduct a more in-depth examination of costs associated with environmental justice issues. The cost-benefit analysis used may not have captured all benefits associated with electrification, so it is possible that there are substantial environmental justice benefits unaccounted for in the analysis. If further research into the quantification of environmental justice costs can be conducted, some of the scenarios with negative net present values may become more cost efficient. If pursuing immediate electrification of the Alameda Corridor is not an option, alternative recommendations include:

- Invest in research and development of cleaner diesel locomotive technologies in order to expedite the introduction of cleaner Tiers of locomotives
- Consider options for investing in a nationwide fleet of dual-use locomotives that function on both catenary electrified rail and traditional rail tracks
- Investigate the costs and benefits of a nationwide electrification project, which would eliminate the need for additional locomotive switching operations and reduce interoperability concerns
- While investigating cleaner rail technologies, focus on “low-hanging fruit” such as removing diesel trucks from the I-710 and either replacing them with electric trucks or moving more cargo shipment to trains. As identified in this report, diesel trains produce fewer emissions than trucks and are therefore associated with lesser health impacts.

To answer the question of whether freight emissions pose a localized health threat, and in the long run, is electrifying the corridor a cost beneficial solution? If not, do the findings suggest other potential solutions? What factors create substantial barriers to electrifying the rail system, including cost and technical consideration in addition to political and institutional limitations?
METHODOLOGY

The methodological approach of analyzing rail electrification involved both quantitative and qualitative characteristics. First, analysis criteria were developed in order to answer the two proposed research questions. Next, the quantitative aspects of the analysis were addressed through conducting a CBA. The qualitative aspects of the project required an extensive review of political, technical and environmental justice concerns related to the implementation of the rail electrification. Finally, the strengths and weaknesses of the methodological approach were analyzed and evaluated.

The aim of this report is to address the two research questions that were developed, which evaluate the prospects for electrifying the Alameda Corridor. The first research question focuses on the quantitative aspects of the proposed electrification project; specifically determining if the benefits associated with electrification outweigh the capital costs of the project. This will serve as the criteria for evaluating the efficiency of the proposed project.

It was decided that the most appropriate and objective tool for quantitative evaluation was a cost-benefit analysis. Thus, in answering the first research question, determining the net present value of the proposed project was necessary. Due to significant discrepancies associated with the costs of electrification—in addition to different available strategies for implementing electrification—four different scenario analyses were included, as well as sensitivity analyses for each respective scenario. These scenarios are detailed on page 4. Once the four scenario analyses were completed, determining conditions under which electrification would be efficient were straightforward. Exploring variants for electrification strategies through scenario analyses provides a robust evaluation of the project given varying contingencies.

The second research question focuses on the less quantifiable aspects associated with rail electrification, such as environmental justice considerations, political feasibility, and technical feasibility barriers to implementation. As these aspects could not be easily quantified, they were not directly included in the CBA. Therefore, to address this second question, a more qualitative approach was conducted through conducting interviews with industry experts, reviewing relevant reports, and examining literature related to rail electrification. After accumulating this information, concerns deemed to be relevant challenges or barriers to implementation were evaluated; these barriers are discussed in the Analysis portion of our evaluation.

A CBA was selected to evaluate this project, as this tool is commonly used to evaluate large-scale infrastructure projects. A limitation of the CBA is that it quality depends on the objectivity and precision of information used to quantify the costs and benefits. Many of the cost and benefits in this CBA are estimates and proxies because future train and transportation technology is uncertain. Nor is it possible to predict how the use of the Alameda Corridor will change due to increases in exports and imports at the POLB and POLA. This report includes the best estimates of the costs and benefits of electrification and includes outlines of the assumptions made to arrive at those estimates.

There may be unforeseen of unquantifiable costs associated with the project, but for the purpose of simplifying the cost-benefit analysis only those costs which could be most easily quantified were included. The following four cost centers were determined to be the most relevant quantifiable factors to include in the analysis for the electrification of the Alameda Corridor:

- Cost of a new fleet of electric locomotives
- Cost of infrastructure needed to electrify the Alameda Corridor, including catenary lines, transmission lines and substations
- Cost of operations and maintenance of new electric fleet locomotives & associated infrastructures
- Cost of new switching yards at either end of the corridor (depending on the scenario, this cost is omitted from the BCA)

BENEFITS

Health Benefits Assuming electrification would completely eliminate diesel emissions, reduction benefits were calculated by determining savings associated with eliminating emissions produced under a business-as-usual scenario. Future rail traffic on the Corridor was projected to exceed 48,500 trains per year by 2035 (Jelenic, 2011) (See page 2). Using this data, emissions per locomotive were calculated and multiplied by the projected number of trains to estimate the total emissions produced per year from all locomotive traffic. Emissions reductions were then converted into monetary savings associated with avoided health and welfare damages.

Fuel Savings Benefits Electrification would produce fuel cost savings by eliminating the need for diesel gasoline. Based on current locomotive efficiency standards, the total cost of gasoline for one train trip on the Corridor thus equates to $880.

Total Benefits: Total benefits from reduced emissions and fuel cost savings amount to over $550 million.

Table: Cost of New Switching Yards

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Benefits (2015-2035)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC Reductions</td>
<td>$2,077,820</td>
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<tr>
<td>CO Reductions</td>
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<td>NOx Reductions</td>
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<td>DPM Reductions</td>
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<tr>
<td>Fuel Savings</td>
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</tr>
<tr>
<td>Total Benefits</td>
<td>$550,131,818</td>
</tr>
</tbody>
</table>

ANALYSIS

Electrification of the corridor requires complex political, engineering, and environmental and health decisions.

POLITICAL An infrastructure project of this magnitude will fall under the jurisdiction of all three levels of government; local, state and federal. At the local level, the Alameda Corridor spans across seven different independent localities and transports freight from both the Ports of Los Angeles and Long Beach. At the state level, the freight transported across the corridor utilizes California’s interstate rail system and is subject to state regulations. The California Air Resources Board has jurisdiction over in-state emissions, including locomotive emissions. At the federal level key pieces of legislation such as Interstate Commerce laws could impede rail electrification, while federal air quality standards may facilitate the project.

INFRASTRUCTURE It is technically feasible to electrify the Alameda Corridor, and to maintain interoperability, which is an essential characteristic of rail in the U.S. A catenary system was selected, predominately due to cost, and a 50kV power supply was determined to provide the most advantageous mix of cost, capacity, and flexibility. It delivers adequate power to support the long-haul trains that traverse the corridor, provides sufficient spacing between substations to control costs, and ensures future compatibility if a wider electrification deployment occurs. The corridor was constructed with over 35 feet of vertical clearance and 50 feet of horizontal clearance (SCAG, 2008). While these characteristics reduce the engineering costs for traditional catenary line installation, challenges related to switching, voltage and substation siting remain. The U.S. freight rail network moves approximately seven times more freight than its E.U. counterpart due in large part to the systems interoperability. U.S. freight is significantly less expensive than virtually all other western countries, in many cases less than half as costly (The Economist, 2010).

ENVIRONMENTAL & HEALTH CONSIDERATIONS Projections of population and income along the corridor indicate increased emissions exposure to communities with high rates of poverty and disproportionately more children and minorities than the county average. These trends are projected to continue through 2035 (SCAG, 2008). Without electrification, emissions and corresponding health impacts are projected to increase with freight movement and prolong the environmental injustices associated with diesel pollution. If electrification were to interfere with goods movement along the corridors, freight transportation could shift from trains to trucks. Truck pollution from the I-710 freeway contributes to higher levels of emissions than trucks and would continue the environmental harms to at-risk communities. If the corridor were to be electrified, pollution should be reduced completely and not shifted from one source to another. Rail yards also pose a health risk, exposing nearby communities to elevated levels of pollution and higher risks of respiratory illnesses including lung cancer (Hricik, 2011). Electrification would reduce emissions along the corridor, but, additional rail yards may worsen air quality elsewhere, raising distributional, efficiency and environmental justice issues.