Low or No Emissions Transit Bus Implementation Rulemaking Recommendation for the California Air Resources Board’s proposed Advanced Clean Transit Rule

Catharine Crayne
Graduate Candidate
Mineta Transportation Institute
June 3, 2016
Table of Contents

Topic Introduction and Background.................................................................3

Literature Review................................................................................................10

Research Methodology/Design..........................................................................15

Research Results...............................................................................................20

Current Bus Fleet Composition in California.................................................20

Useful Life Assessment.......................................................................................28

Funding Assessment for Transit Vehicle Capital Procurement.......................41

Summary and Recommendations.......................................................................42

List of Tables

Table 1: Research Methodology........................................................................19

List of Figures

Figure 1: Active Bus Fleet..................................................................................21

Figure 2: California Total Active Bus Fleet by Region.....................................22

Figure 3: Total CNG Engine Buses by Region..................................................22

Figure 4: Active Diesel Engine Bus Distribution by Region.............................23

Figure 5: Southern California Active Bus Fleet Composition..........................26

Figure 6: Central California Active Bus Fleet Composition.............................27

Figure 7: Northern California Active Bus Fleet Composition..........................27

Figure 8: Buses Eligible for Retirement by Year..............................................28

Figure 9: Buses Eligible for Retirement in Southern California by Year.............29

Figure 10: Buses Eligible for Retirement in Northern California by Year...........30
Figure 11: Buses Eligible for Retirement in Central California by Year.................................30
Figure 12: CNG Buses Eligible for Retirement by Year..........................................................31
Figure 13: Diesel Engine Buses Eligible for Retirement by Year..............................................31
Figure 14: Gasoline Engine Buses Eligible for Retirement by Year........................................32
Figure 15: LNG Buses Eligible for Retirement by Year..........................................................32
Figure 16: LPG Buses Eligible for Retirement by Year...........................................................33
Figure 17: Hybrid Diesel Buses Eligible for Retirement by Year.............................................33
Figure 18: Hybrid Gasoline Buses Eligible for Retirement by Year........................................34
Figure 19: Electric Battery Buses Eligible for Retirement by Year..........................................34
Figure 20: Hydrogen Fuel Cell Buses Eligible for Retirement by Year.....................................34
Figure 21: CNG Bus Procurement Scenario Fleet Replacement Costs by Year........................36
Figure 22: Hybrid Bus Procurement Scenario Fleet Replacement Costs by Year ....................37
Figure 23: BEB Procurement Scenario Fleet Replacement Costs by Year ...............................38
Figure 24: FCEB Procurement Scenario Fleet Replacement Costs by Year .............................39
Figure 25: Procurement Scenario Comparison Fleet Replacement Costs by Year.....................40
Figure 26: Projected Capital Funding Availability 2016-2020.................................................42
Figure 27: Funding Availability vs. Need by Vehicle Type 2016-2020.................................43
**Topic Introduction and Background**

The last 40 years of State and Federal governance have brought changes in environmental regulations which have shaped the world in which we live in today. Due to concerns over the environmental impact of the transportation sector, the automotive and public transportation industries have achieved great advances in technology that help reduce and/or mitigate pollution caused by Green House Gas (GHG) emissions. Regulations have been strengthened in recent years, and have been directly applied to transportation agencies in the public sector, particularly in California. In 1970, the Federal legislature passed the Clean Air Act, which marked the first stage of the environmental movement’s push towards stricter standards for air pollution created by industry and mobile sources. The Federal Clean Air Act has paved the way for emissions regulation of both the public and private sector on both the Federal and State level.

In 2000, the California Air Resources Board (ARB) adopted the Fleet Rule for Transit Agencies. This rulemaking outlined new standards for reductions in “criteria pollutant emissions and exposure to air contaminants from urban buses and transit fleet vehicles”. Transit agency fleets are required to meet certain emissions caps based upon the year of the manufacture of the transit vehicle, guidelines which are set forth in Title 13, California Code of Regulations section 1956.1 and 1956.8. This regulation became the next stepping stone in the environmental movement’s push to reduce vehicle emissions and particulate matter buildup in cities across California.

Other legislation which further defined and regulated vehicular emissions soon followed. In 2006, the California legislature passed Assembly Bill (AB) 32, in which California introduced substantial initiatives to reduce GHGs in the State, including reducing the amount of passenger vehicle related emissions. The goal of AB 32 is to reduce GHG emission levels in California to
1990 levels by 2020. In 2008, the California State Legislature passed the Sustainable Communities and Climate Protection Act, Senate Bill (SB) 375. This legislation supports AB 32, creating strategies and oversight to ensure local governments are making planning decisions which will support regional and statewide emissions reduction goals.

ARB is now looking to strengthen the Fleet Rule for Transit Agencies and restrict the levels of allowable emissions from transit fleet vehicles. A symposium was held in Sacramento on February 8, 2016 to discuss the future of transit vehicle emissions regulations in California and will seek stakeholder input for the proposed rulemaking. ARB stipulates that as transit agencies become “familiar” with alternative fuel technology and as the technology becomes more widely available, requirements for implementation should be strengthened proportionally.

As a result of the legislation enacted and proposed rulemaking which mandates or may soon mandate the reduction of GHG emissions, transportation agencies who seek State and Federal funding must also meet emission reduction targets which help meet regional and statewide goals. Proposed rulemaking by ARB must take into account financial hurdles which transit agencies are faced with when purchasing and replacing transit vehicles.

In order to evaluate and mandate a specific timeline for low or no emission transit vehicle acquisition, four key aspects of procurement and implementation should first be evaluated before a timeline for replacement is mandated through rulemaking and subsequent regulations. There are four research questions whose answers will help put the puzzle of environmentally and economically sound public transit vehicle replacement together:

1) What is the current transit vehicle fleet composition in California?

2) What is the retirement timeframe for transit vehicles in California based on FTA Useful Life Standards?
3) What are the capital procurement costs of Low or No Emissions Transit Vehicles?

4) How much funding can transit agencies reasonably expect to receive for LoNo vehicle capital procurement projects?

5) What is a realistic timeframe for mandating LoNo transit vehicle procurement and implementation in California given current funding availability?

Current Transit Fleet Status in California

By reviewing the current transit fleet vehicle composition in California, a close estimate of the total number of transit vehicles that may need to be replaced as a result of increased emissions standards can be gained. Agencies and regions which have a relatively lower percentage of low or no emissions vehicles will be particularly affected by increased emissions standards. In addition to the economic struggle to acquire the improved technology, transit operations procedures, including fueling, will need to change to coincide with procurement and integration into revenue service. The road to gaining enough funding to alter the composition of their fleet will be difficult, but these efforts will yield positive environmental health benefits for the constituents to whom these agencies provide service. In turn, the total number of transit vehicles which meet the low or no emissions standards which California hopes to achieve can be identified. Agencies which have a high percentage of low or no emissions transit vehicles can be studied to identify successful procurement and funding strategies. Publications and reports from these agencies will help demonstrate successes and failures which have occurred as a result of the pursuit of clean public transit.

Replacement Timeframe Comparisons

A review of current fleet vehicle composition will also identify age and mileage of vehicles statewide, which will serve as a baseline for comparison against ARB regulation imposed
timeline acceleration. This baseline will also be compared to a replacement timeline based upon anticipated capital funding availability. Through an analysis of current fleet age and fuel type, this research paper will identify an overall timeline for fleet vehicle replacement using the FTA’s Useful Life Standards. An analysis of the fuel type of the vehicles which will have met or will soon meet the FTA’s Useful Life Standards will evaluate the feasibility of transit agencies being able to comply with increased regulations and emission caps from ARB rulemaking barring substantial increases in capital funding availability. Any rule making proposed by ARB will need to consider the feasibility of transit agencies meeting the proposed deadlines for implementation.

**Capital Cost Considerations for LoNo Vehicle Procurement**

Newly emerging technology almost always comes with a higher price tag than older and more widely available technology. This trend holds true in all manner of industries. Electric fuel cell and battery powered vehicles represent the peak of the current technological advancement. Electric transit vehicle pollution is anticipated to be limited to up-stream emissions related to fuel production. Electric transit vehicles are the most fuel efficient, but come with a significantly higher price tag than other alternative fuel engine models. Additionally, the fuel infrastructure required to run electric transit vehicles are very costly and significantly increases the total initial capital investment. Further, battery life for electric transit vehicles is limited in duration and range. In order to avoid having the vehicle leave revenue service to charge multiple times a day, an agency can elect to install wired or wireless charge booster stations along routes. Combination Hybrid-Electric vehicles are also available for purchase, and come in both Diesel-Electric and Gasoline-Electric models. However, the initial capital investment required to procure these vehicle types is much greater than standard gasoline and diesel engines. Per the CalAct Purchasing Schedule, a Hybrid transit vehicle costs approximately 40-44% more than a regular
gas engine model. Other alternative fuel engine models which will be researched and discussed is Compressed Natural Gas (CNG), Hydrogen Fuel Cell, and Battery Electric vehicles. It is important to note that an agency’s procurement decision for the vehicle engine type is often determined by the amount of funding and fueling infrastructure available to the purchasing agency.

**Funding Sources Available for Transit Agencies to Meet Current and Future Regulatory Requirements**

An understanding of federal, state, and local funding sources and likelihood of award of grant monies is necessary to understand the context of the economic climate in which transit agencies operate. In order for transit agencies in California to comply with current and future regulations regarding transit vehicle emissions, a variety of funding sources must be leveraged in order to procure compliant vehicles and infrastructure. Though the Federal government takes the lion’s share in taxes when compared to State and Local taxes, most Federal funding sources will not pay for the entire cost of transit vehicle and alternative fuel infrastructure procurement.

Traditional caps on Federal funding range from 50% to 88% of total project costs. The remaining balance of the project costs must be paid for through Local Match funding, which includes State grants, Local transportation funding (usually through the means of a sales tax measure), and in some circumstances Toll Credits is allowable Local Match funding.

**Federal Funding Sources**

There is a variety of Federal funding sources available to transit agencies in California, some of which are formula funding and others are discretionary (competitive grants). Formula funding is population based funding, where agencies do not have an opportunity to increase the amount of funding available to them and often the share of the regional pot is determined by the
Metropolitan Planning Organization (MPO). Formula funding grant programs are categorized by an applicant’s status as an urban or a non-urban area operator. Some grant programs make a further categorical refinement by requiring applicants to meet certain population and density characteristics. An example of an other than urbanized area grant program is FTA Section 5311, which provides both discretionary and formula funding for qualifying agencies. An example of a Federal grant program which provides funding to an urbanized area are the FTA Section 5307 grants. This particular grant program provides funding to small, medium, and large urban operators. Discretionary and formula funding is available through this grant.

**State Funding Sources**

There is a variety of State funding sources available to transit agencies in California, and State funding can be used to meet the Local Match requirement of Federal grant funding. State grants are available to fund both capital and operating expenditures. SB 862 allocated funds from the Greenhouse Gas Reduction Fund to create both the Low Carbon Transit Operations Program (LCTOP) and the Transit-Intercity Rail Capital Program (TIRCP). Both the LCTOP and TIRCP programs are competitive and regional transit operators compete for funding against other state agencies.

In addition to current available balance in Cap and Trade auction proceeds, in the Governor’s Budget Summary 2016-17 Report to the Legislature indicated that Cap and Trade auction proceeds dedicated to public transit, sustainable communities, and high speed rail are estimated to reach $1.2 Billion from 2016-17 auctions\(^{iii}\). This gain in funding is offset by a reduction in gas tax revenue which has occurred due to a nationwide reduction in gas prices.

**Local and Regional Funding Sources**
Due to funding shortfalls in Federal and State funding, many counties in California have achieved the passing of a sales tax measure which provides funding for transportation system and public transportation improvements. Counties which have an active sales tax measure for transportation projects are called Self-Help counties. MPOs have also been successful in asking voters to approve sales tax measures for transportation improvement projects. An example of a regional transportation funding measure is the Metropolitan Transportation Commission’s (MTC) Regional Measure 2 which was approved by voters in November 2004. This grant provides funding to transit operators in the form of capital and operating grants. While these grant programs also provided funding for highway improvements, a significant portion has been dedicated to transit capital improvement projects.

**Summary**

In order to effectively define and mandate a timeline for low or no emissions vehicle implementation, ARB and those contributing to new rulemaking in ACT may want to consider the ability of transit agencies to comply with pending regulations through the lens of current fleet retirement age, technology available and associated price points, and current and future funding opportunities those agencies will have available to meet regulatory demands. Without an evaluation of the current market and the context in which new rules are being made, regulations imposed could place a heavy financial burden on agencies, one that may be difficult to withstand and could lead to service cuts and job loss. The goal of ARB’s new ACT rulemaking should be to set forth a low or no emissions vehicle procurement and implementation timeline which will enable transit agencies to comply with State and federal emissions reduction targets while not placing the agencies in precarious financial positions. The goal of this research is to provide a realistic timeline to ARB to help shape economically and environmentally sound policy.
Literature Review

Transit agencies in California have consistently struggled to provide meaningful service to constituents in the face of shrinking budgets and increased operating costs. Regulations which have been passed in California over the course of the past two decades have created an additional challenge for these agencies in the form of emissions standards for which the implementation of low or no emission vehicle technology is the only means of compliance. As discussed in the previous section, ARB created the Fleet Rule for Transit agencies in 2000. This rule-making created standards for allowable levels of particulate emissions based upon the type of vehicle and the year of manufacture. Title 13, Sections 1956.1 and 1956.8 of the California Code of Regulations sets out specific guidelines for these emission caps that transit agencies are required to abide by.

In 2006, the California Legislature passed Assembly Bill (AB) 32, the California Global Warming Solutions Act, which mandated the reduction of emissions from passenger vehicles. AB 32 also sets a statewide goal of reducing emission levels to 80% below the level of emissions produced in 1990. Per the legislation, this must take place prior to 2050. This mandates the reduction of GHGs by 30% by 2020. AB 32 then goes on to mandate a total reduction of GHG emissions by 80% below 1990 GHG emission levels by 2050. California Senate Bill 375, called the Sustainable Communities and Climate Protection Act, created additional emissions reduction requirements and mandated that Metropolitan Planning Organizations (MPOs) plan and program projects which enable regions to meet reduction targets identified by ARB. SB 375 supports the State goals created in AB 32, and requires Metropolitan Planning Organizations (MPO) in California to create Sustainable Communities Strategies, which must be incorporated into the Regional Transportation Plan (RTP). MPO’s, responsible for most transit funding allocations in
their region, must create housing, land use, and transportation plans which enable their region of responsibility to meet GHG emission reduction targets established by ARB. MPO’s must balance funding for these respective disciplines to efficiently and equitably distribute resources.

ARB is currently in the process of creating the Advanced Clean Transit rule, which will eventually replace the Fleet Rule for Transit Agencies with updated regulations regarding the timeframe for clean vehicle implementation\textsuperscript{viii}. The ultimate goal of current and future regulations will be the retirement of traditional gasoline and diesel fueled transit vehicles in favor of alternative fuel or electric powered transit buses. The problem that transit agencies in California face is how to afford the new transit vehicle technology when they go to replace their aging fleets. The up-front capital investment cost of an alternative fuel vehicle is “significantly higher” than gasoline and diesel engine models according to the California Transit Association\textsuperscript{ix}. The most expensive of the alternative fuel vehicles are electric, and implementation is only successful if fueling infrastructure is concurrently implemented. In order to formulate a realistic timeframe for clean transit vehicle implementation and to inform regulatory bodies of cost barriers, a number of factors must be considered. These factors will inform the creation of a successful asset management plan which will provide direction for capital investment in low or no emission transit vehicle technology in California.

The typical retirement age for public transit buses nationally is 12 years. However, lack of sufficient capital funding for the acquisition of public transit vehicles frequently results in continued use in revenue service well after the end of the useful life period due to transit agency budget constraints\textsuperscript{x}. The National Transit Database (NTD) contains fleet information for most transit operators in California and in the United States. The NTD report lists in-service dates and vehicle manufacture dates which can be used to assess regional and statewide transit assets and
the timeframe in which these vehicles will meet the FTA defined useful life\textsuperscript{xii}. However, this data is not sortable by federal region or by State, and so a regional assessment using the information available in this database does not provide summary information from which a policy maker could easily attain relevant transit asset data for a specific region.

Procurement of public transit vehicles is completely dependent upon the availability of sufficient funding. While different types and kinds of capital funding were identified in the introductory section of this research prospectus, there are other economic elements which both impact the amount of funding available in those grants and turn agency will against making costly procurements which are not deemed mission critical to agency operations. In the California Transportation Commission’s 2015 Report to the Legislature (released in October 2015), the Commission identified funding shortfalls in the 2016 STIP which will lead to some programmed projects being delayed for up to 4 years\textsuperscript{xiii}. A reassessment of available funding was performed post-release of the annual report, and it was announced by the California Transportation Commission in January 2016 that the transportation budget would be further “slashed” by $754 Million over the next 5 years due to a decline in gas tax revenue\textsuperscript{xiii}. This funding shortfall will affect both highway and transit projects. As stated in the January 22, 2016 news release by the commission, the light at the end of the tunnel is that most transit and transportation projects use a variety of funding sources, and the practice is called “leveraged funding”. This allows transit agencies to seek alternative funding sources when one source of funding is not adequate to complete a project. Local and Federal funds are also available to transit agencies for capital investments. According to the 2011 Statewide Transportation System Needs Assessment prepared for the California Transportation Commission, local funding accounts for approximately 65% of total transportation funding. This same report states that
approximately 13% of transportation funding is received by local agencies from the Federal government\textsuperscript{xiv}.

When a transit agency decides to perform a capital transit vehicle procurement, the initial capital and life cycle costs of replacement transit vehicles will inevitably be weighed heavily in the selection process. Initial capital costs are defined as “purchase costs of the buses and charging infrastructure if need” in \textit{Energy Consumption and Cost-Benefit Analysis of Hybrid and Electric City Buses} by Antti Lajunen\textsuperscript{xv}. The initial purchase cost of a hybrid electric bus can in some circumstances be “50% to 70% more than a conventional diesel transit bus”\textsuperscript{xvi}. The California Association for Coordinated Transportation (CalACT) purchasing schedule confirms that purchasing alternative fuel vehicles costs transit agencies a significantly higher percentage than traditional gasoline and diesel engines\textsuperscript{xvii}. \textit{Fuel Cell Buses in U.S. Transit Fleets: Current Status 2014}, released by the National Renewable Energy Laboratory lists the current average capital purchase cost of Fuel Cell Electric Buses as $2 Million\textsuperscript{xviii}. The initial purchase and installation cost of electric transit vehicle charging stations will cost a transit agency up to $1 Million per unit, as was the case for Foothill Transit’s Sole Source Procurement of Proterra electric buses and charging stations in April 2013\textsuperscript{xix}.

Operating and maintenance costs when coupled with capital costs equal the total life-cycle cost of the transit vehicle. Operating and maintenance costs of alternative fuel and electric vehicles are usually lower than that of their diesel and gasoline engine counterparts. In a study conducted by Shauna Hallmark and Robert Sperry, in school transit buses the hybrid-electric vehicle models had a 13% reduction in operating costs as compared to the traditional fuel model\textsuperscript{xx}. In this study the fuel savings was modest, and this savings might not be significant enough to justify the high capital costs of the technology without additional subsidization from
government agencies. Sonoma County Transit, an agency in Northern California, has had better life-cycle cost reduction results with CNG vehicles. CNG vehicles typically have a GHG emission reduction of 12.5% over diesel engine models according to a study released by Transportation Research Part D\textsuperscript{xxi}. Sonoma County Transit was able to reduce the cost of fuel through recapturing methane released at a landfill in the City of Windsor, as stated in an article by Kerry Benefield of the Press Democrat on October 14, 2005\textsuperscript{xxii}.

Through the evaluation of current asset status, projected funding availability, and anticipated capital procurement costs of alternative fuel technology, rule makers and transit managers can better plan for low or no emissions vehicle implementation on a statewide level. However, the literature available on this subject, reviewed in this research prospectus, was not able to provide a comprehensive view of the economic context in which transit agencies pursue low or no emissions transit vehicle procurement in a way that would intelligibly inform ARB rule-makers and produce economically sound regulations. An analysis of this sort will help inform the members of ARB of realistic timeframes for low or no emission transit vehicle implementation.
Research Methodology/Design

Introduction

The methods of this research capstone are designed to answer the following question: What is the best possible time to mandate low or no emissions (LoNo) transit vehicle procurement and implementation in California given current funding availability? The answer to this research question is meant to inform the California Air Resources Board’s (ARB) Advanced Clean Transit rulemaking regarding implementation viability given the current availability of funding for transit capital procurement projects. The research methodology will draw upon secondary data that has been gathered but not fully analyzed by transportation agencies and management organizations at the local, state, and federal level.

Current Transit Fleet Assessment

What is the current transit vehicle fleet composition in California?

In order to determine the current fleet status of transit agencies in California, this paper will examine and analyze data reported to Federal Transit Administration’s (FTA) National Transit Database by isolating California transit vehicles by engine type, age, and mileage. The National Transit Database contains fleet reports of transit agencies nationwide, categorized in part by the type of vehicle, year of manufacture, mileage, fuel type, etc. The most recent report available from the National Transit Database is for Reporting Year 2014. The 2014 Revenue Vehicle Inventory database is not categorized by State or region, and so a manual search and compilation of State specific information will be required. The intent of using this database is to acquire statistically significant data regarding the overall fleet composition of transit agencies in California.
End of Useful Life Assessment

*What is the retirement timeframe for engine transit buses based on FTA Useful Life Standards?*

Through an analysis of current fleet age and fuel type, this research paper will identify an overall timeline for fleet vehicle replacement using the FTA’s Useful Life Standards. FTA’s Useful Life Standards will be compared to the vehicle age listed in the National Transit Database. An analysis of the fuel type of the vehicles which will have met or will soon meet the FTA’s Useful Life Standards will evaluate the feasibility of transit agencies being able to comply with increased regulations and emission caps from ARB rulemaking. MPOs generally perform analysis and produce reports on transit agencies in their jurisdiction, but analysis of fleet age and expected useful life of these assets are not readily available. In the Metropolitan Transportation Commission’s Statistical Summary of Bay Area Operators, the report provided regional information on the total number of transit vehicles in the area by type of vehicle. There is no discussion in the report of the anticipated retirement of fleet vehicles, or of specific engine models or fuel types. It is important to develop a thorough and accurate retirement timeline since any rule making proposed by ARB will need to consider the feasibility of transit agencies meeting the proposed deadlines for implementation.

Low or No Emissions Transit Vehicle Capital Cost Review

*What are the capital procurement costs of Low or No Emissions Transit Vehicles?*

The information required to demonstrate a comprehensive review of the types and prices of low or no emissions transit vehicles on the market today will be gathered from a variety of secondary data sources. The most comprehensive compilation of procurement costs for low emissions vehicles comes from the California Association for Coordinated Transportation’s (CalACT) Procurement Schedule. This procurement schedule lists negotiated prices for a gasoline, diesel,
and alternative fuel transit vehicles. However, this procurement schedule does not list anticipated or average life-cycle costs associated with the vehicles. The report does not by itself provide a complete picture for the total vehicle costs as the report is tailored to transit agencies that purchase small to medium size transit vehicles, and additional research was needed to provide ARB with a realistic assessment of capital costs which include large transit buses. Further, the CalACT Procurement Schedule does not provide purchasing options for electric transit vehicles, which represent the most favorable low or no emission transit vehicle technology available. These sources of information will provide a dataset of low or no emission vehicle initial capital procurement costs which can be compared with vehicle retirement information. This analysis can be used as a general reference for price point comparisons to traditional transit vehicles.

**Funding Availability Analysis**

*How much funding can transit agencies reasonably expect to receive for transit bus capital procurement projects?*

In 2013, the California Transit Association contracted with CH2MHILL to determine unmet transit needs in the State of California. This report, in addition to the Federal State Transportation Improvement Program (FSTIP), will be evaluated to determine current capital funding availability for transit buses. These reports provide funding estimates for future fiscal years and can be evaluated in order to compare them to bus replacement needs of transit agencies in California.

**Implementation Timeline Recommendation**

*What is the best possible time to mandate low or no emissions (LoNo) transit vehicle procurement and implementation in California given current funding availability?*
The last research topic and analysis section of this paper will compare the timeline for transit vehicle replacement against funding projections available to transit agencies for capital procurement projects. The goal of this comparison is to evaluate a best case timeline and rate of replacement based upon current fleet vehicle needs to maintain a stable level of service without resulting in a loss of operating capacity. The average cost of electric and other alternative fuel vehicle initial purchase price will be compared to annual funding projections to see when the agencies can be expected to make the transition to LoNo vehicles. This will be accomplished through mapping funding allocations to specific fiscal years and estimating funding shortfalls based upon the stated funding availability and current procurement costs. This section of the research paper will fulfill the primary deliverable goal: A recommendation for the best possible timeframe for mandating stricter emissions standards on the procurement and implementation of LoNo transit vehicles in California given current funding availability.
Table 1

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<th>Method</th>
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<tbody>
<tr>
<td>Literature Review</td>
<td>Government Reports, Academic Literature</td>
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<tr>
<td>Current Transit Fleet Assessment</td>
<td>National Transit Database</td>
</tr>
<tr>
<td>End of Useful Life Assessment</td>
<td>National Transit Database/Government Reports</td>
</tr>
<tr>
<td>LoNo Vehicle Capital Procurement Cost Review</td>
<td>CA transit agency Request for Proposals bid results/CalACT Purchasing Schedule/Government Reports</td>
</tr>
<tr>
<td>Funding Availability Analysis</td>
<td>Government Reports</td>
</tr>
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<td>Implementation Timeline Recommendation</td>
<td>Conducted by Researcher</td>
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Research Results

Current Bus Fleet Composition in California

The composition of bus fleets in California by engine type can be assessed using the National Transit Database (NTD) 2014 reporting period data which represents the most comprehensive and up to date information available for evaluation. Through isolating information provided by transit agencies in California, the total number of vehicles and the respective proportions of certain engine types can be assessed.

The total number of articulated buses, cutaway buses, over-the-road buses, double-decker buses, and regular transit buses in California is 13,535. The total number of these classifications of buses that are being used as active fleet is 12,883. Active fleet vehicles are those currently being used to provide revenue service. Northern California is home to 3,884 of these vehicles, Central California is home to 1,134, and Southern California transit operators claim the lion’s share with 7,865 transit buses in their active fleet. One of the buses included in the Southern California fleet assessment will not be evaluated by engine fuel type due to the fuel type being classified as “other” in the NTD 2014 Revenue Vehicle Inventory report.
Figure 1

Data displayed in the following order: Engine Type, Number of vehicles in California, Percentage of total bus fleet
Compressed Natural Gas (CNG) buses represent the largest share of transit buses in California. There are a total of 6,355 active fleet CNG buses in California, representing 49% of the overall fleet composition. Southern California has a disproportionately large share of active CNG buses relative to Central and Northern California. Southern California owns and operates 5,397 CNG buses, whereas Central California has 459 and Northern California has 499.
The next largest share of transit buses are diesel engine models. The total number of active bus fleet diesel engine models is 3,634. This represents 28% of the overall bus fleet composition in California. Northern California has the highest proportion of diesel engine transit buses compared to other regions in California, and has a total of 2,574 in the active fleet. Central California has a total of 399 active diesel engine buses, whereas Southern California owns and operates 661.

The third largest share of transit buses are gasoline engine models. There are a total of 1,824 active bus fleet gasoline engine buses in California, representing 14% of the overall fleet composition. Central California transit agencies own and operate 225 gasoline engine buses. Northern California agencies have 608 gasoline engine transit buses, less than their Southern California counterparts which own and operate 991.
Liquefied natural gas (LNG) engine models have the fourth largest share of buses in California. There are a total of 331 active LNG models, representing 2.57% of the overall fleet composition. Southern California has a disproportionate share of LNG buses, owning and operating 325. Central California has 6 LNG transit buses, whereas Northern California has none.

Liquefied petroleum gas (LPG) engine models have the fifth largest share of buses in California. There are a total of 258 active LPG models, representing 2% of the overall fleet composition. The only agency in Northern California which operates LPG engine vehicles is the Santa Clara Valley Transportation Authority, and has a total of 11 buses in this classification. Southern California operators have a disproportionate number of LPG vehicles, owning and operating a total of 247. Central California agencies do not have a share of the total LPG transit bus fleet.

Hybrid diesel engine models come in sixth place with a total of 230 total active buses in California. This represents 1.79% of the total active bus fleet composition. Northern California, the Caltrans District 4 region in particular, has a disproportionally higher share of Hybrid diesel engine model transit buses. Santa Clara Valley Transportation Authority leads the way in implementation of this technology, and owns and operates 70 of these buses. The total number of hybrid diesel engine models in District 4 is 160. There are three transit agencies in Central California which own hybrid diesel engine models, totaling 37 buses. There are only 2 agencies in Southern California which use hybrid diesel engine buses, and they own a total of 33 between them.

Hybrid gasoline engine models come in seventh place with a total of 197 active buses. This represents a 1.53% share of the total active bus fleet composition. Southern California has a
disproportionately large share of hybrid gasoline engine model buses, with a total of 173 owned and operated in the region. Long Beach Transit leads the way in implementation of this technology, having a total of 89 buses with this engine classification. Northern California agencies own and use only 16 hybrid gasoline engine models. Central California comes in last place, with two agencies owning and operating these vehicles and having 8 between them.

The eighth largest share of transit buses are electric battery engine models. The total active bus fleet for electric battery engine models is 34. Foothill Transit owns 15 of these vehicles and the Santa Barbara Metropolitan Transit District owns the other 19. There are no electric battery engine models in Northern or Central California as of the 2014 reporting period. These 34 electric battery engine models represent a share of 0.26% of the overall bus fleet composition in California.

The ninth largest share of transit buses are hydrogen fuel cell engine models. There are a total of 15 active buses in this category, and this represents a 0.12% share of total transit buses in California. 12 of these bus models are owned by the Alameda Contra-Costa Transit District in Northern California. The other 3 are owned by Sunline Transit in Southern California. These buses were acquired as part of pilot projects aimed at assessing the feasibility of implementing this technology throughout California. There are no hydrogen fuel cell engine model transit buses in Central California as of the 2014 reporting period.

Dual fuel engine models have the tenth largest share of the overall bus fleet composition in California. Dual fuel engine technology combines diesel engine technology with the use of alternative fuels such as natural gas. There are a total of 4 dual fuel engine transit buses in California which are active, and this represents a share of 0.03% of the overall transit bus fleet.
These vehicles are owned and operated by San Mateo County Transit District in Northern California.

The charts displayed on the following pages show bus fleet composition of the fleets in Southern, Central, and Northern California.

Figure 5
### Central California Active Bus Fleet Composition

- **Gasoline**: 225 buses, 19.84%
- **Diesel**: 399 buses, 35.19%
- **CNG**: 459 buses, 40.48%
- **Other**: 51 buses, 4.50%
- **Hybrid Diesel**: 37 buses, 3.26%
- **Hybrid Gasoline**: 8 buses, 0.71%
- **LNG**: 6 buses, 0.53%
- **Other**: 51 buses, 4.50%

### Northern California Active Bus Fleet Composition

- **Diesel**: 2574 buses, 66.27%
- **Gasoline**: 608 buses, 15.65%
- **CNG**: 499 buses, 12.85%
- **Other**: 43 buses, 1.11%
- **Hybrid Diesel**: 160 buses, 4.12%
- **Hybrid Gasoline**: 16 buses, 0.41%
- **Hydrogen Fuel Cell**: 12 buses, 0.31%
- **LPG**: 11 buses, 0.28%
- **Dual Fuel**: 4 buses, 0.10%
Useful Life Assessment

FTA defines useful life as “The expected lifetime of project property, or the acceptable period of use in service.” Per the Federal Transit Administration’s Useful Life Standards, the maximum useful life for Heavy-Duty Transit Buses is 10-12 years, or 350,000 - 500,000 miles, whichever comes first. While Medium-Duty transit buses have a useful life standard of 7 years or 200,000 and Light-Duty transit buses have a useful life standard of 5 years or 150,000 miles, most transit agencies apply the Heavy-Duty bus standard maximum of 12 years due to a scarcity of funding to replace transit buses at the end of the lower useful life standard. It is common for transit agencies to defer vehicle replacement for this reason.

Figure 8

Buses Eligible for Retirement by Year
As of the 2014 reporting period to the National Transit Database, agencies in California reported owning and operating 4,402 transit buses which would be eligible for or overdue for retirement by 2016 per the FTA Useful Life standard 12 year criteria. As stated in the previous section, there are a total of 12,883 active transit buses in California, and so by 2016, 34.17% of the total transit bus fleet in California are eligible or overdue for retirement. Of the 4,402 transit buses which would be eligible for retirement by 2016, Southern California agencies own and operate 2,410 which is 54.75% of the total share of retirement age vehicles. Northern California agencies own and operate 1,660 of the retirement age buses, or 37.71% of the total share. This leaves Central California with 7.54% or 332 retirement age buses. Leadership at the California Transportation Commission and California State Transportation Agency should keep this in mind when allocating funding and determining State-wide budgets for transit capital procurement.

Figure 9

![Buses Eligible for Retirement in Southern California by Year](image-url)
There are 1,964 Compressed Natural Gas (CNG) vehicles which have reached or exceeded retirement age by 2016. This is 30.90% of the total CNG fleet in California. The remaining 4,391 vehicles will be eligible for retirement by 2026. Peak retirement classification change will occur in 2019 and 2020, with 1,517 buses becoming eligible for retirement. Funding for additional CNG vehicles should be focused on this time period.
There are 2,099 diesel engine buses, or 57.76% of the total amount of diesel buses, which have reached or exceeded retirement age as of 2016. The remaining 1,535 buses will be eligible for retirement by 2026, and peak years of retirement eligibility classification change will occur in the years 2021 and 2025. While diesel engine technology has improved over the last decade and significant reductions in emissions have been achieved, institutional and political will are leaning away from continued use of this fuel type. If government leadership desires to follow this trend, funding should be focused on near-term replacement of the 2,099 gasoline engine buses and then look to 2021 and 2025 as additional investment years.
There are only 79 gasoline engine buses, 4.53% of the total gasoline engine buses, which will have reached or exceeded retirement age as of 2016. The remaining 1,745 buses will be eligible for retirement by 2026, with a significant wave of retirement eligibility classification changes taking place in 2020. If transportation leadership determines that phasing out gasoline engine buses from transit fleets is an important goal when programming projects and allocating funding, then achieving vehicle retirements on schedule in 2020 will be an important milestone.

Figure 14

There are 123 Liquefied Natural Gas (LNG) engine buses, or 36.17% of the total number, which will have reached or exceeded retirement age as of 2016. The remaining 208 will reach or exceed retirement age by 2023, with 193 of those vehicles reaching retirement age during 2021.

Figure 15
There are 114 Liquefied Petroleum Gas (LPG) engine buses, or 44.19% of the total number, which will have reached or exceed retirement age by 2016. The remaining 144 will qualify for retirement by 2026, with retirement eligibility peaking in 2018 and tapering off until 2026.

Figure 16

There are currently no Hybrid Diesel engine buses which have reached or exceeded retirement age by 2016. The first Hybrid Diesel engine bus to reach retirement age will do so in 2018. The two peak years for retirement classification changes are 2022 with 77 vehicles reaching retirement age and in 2025 with 55 buses reaching retirement age.

Figure 17

As of the 2014 reporting period to the NTD, there were 3 Hybrid Gasoline engine buses which had reached or exceeded retirement age by 2016. Another 71 will reach retirement age in 2017, and the remaining vehicles will reach retirement age by 2023.
There are currently 19 electric battery buses, or 55.88% of the total number of electric battery buses, which have reached or exceeded retirement age as of 2013. Another 3 will reach retirement age by 2022 and the remaining 12 will reach retirement age by 2025.

Of the 15 Hydrogen fuel cell buses reported to the NTD for the 2014 reporting period, only 1 will have reached retirement age by 2016. The next vehicle to reach retirement age will do so in 2020, another 12 will do so in 2022, and the last vehicle will reach retirement age in 2024.
The last group of vehicles, dual fuel vehicles, was manufactured in 2013 and will not reach retirement age until 2025.

**Capital Procurement Costs of Low or No Emissions Transit Vehicles**

Transit agencies must balance available funding against their particular procurement needs. Often a vehicle’s price point will play a major factor in its selection for procurement. This means that transit agencies will be most likely to seek to procure replacement fleet vehicles with the lowest possible price point and least amount of tasks associated with enabling the procurement. Assessment of capital procurement costs will assume that agencies will be transitioning their fleet from gasoline and diesel engine buses to alternative fuel engine models over the next ten years. This section will review procurement cost scenarios for CNG, Hybrid, Electric Battery, and Hydrogen fuel cell vehicles. Rolling stock replacement/upgrade costs will be calculated from average bus cost multiplied by number of buses eligible for retirement by year.

**Compressed Natural Gas**

Agencies in Southern California will be most likely to acquire additional CNG vehicles as fueling infrastructure is already widely implemented and available in this region of California. Agencies that do not have readily available access to CNG supporting infrastructure may elect to acquire low or no emissions (LoNo) buses which do not require additional infrastructure procurement and installation in order to keep costs down. Based upon information available in the CalACT 2014 Procurement Schedule, a base model CNG bus costs between $72,611 and $231,389 for small to medium size transit vehicles. The average cost of a small to medium size CNG bus $152,000. This represents an average increase in price of 24.8% over the base gas engine model for a comparable class of vehicle. For larger transit buses, 35-40’ in length, a base model CNG bus costs between $231,398 and $525,382. The average cost of a large base
model CNG bus is $394,888. There are 2,910 small and medium size transit buses and 9,711 large transit buses in the fleets of California. Given these respective size proportions relative to the total number of vehicles which will eventually need to be replaced by 2026, the average cost of a CNG bus is $338,886. This does not include costs for additional features that an agency might need to provide its transit service. The chart below shows capital procurement costs for replacing retirement age vehicles in California with CNG buses.

Figure 21

**CNG Bus Procurement Scenario**
**Fleet Replacement Costs by Year ($338,886/bus)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
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</tr>
<tr>
<td>2017</td>
<td>$1,400,000,000.00</td>
</tr>
<tr>
<td>2018</td>
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<td>2024</td>
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<tr>
<td>2025</td>
<td>$Unknown</td>
</tr>
<tr>
<td>2026</td>
<td>$Unknown</td>
</tr>
</tbody>
</table>

**Hybrid Engine Buses**

Based upon information available in the CalACT 2014 Procurement Schedule, a base model Hybrid bus costs between $111,280 and $254,505. This represents an average increase in price of 38.6% ($182,893) over the base gas engine model for a comparable class of vehicle. Selecting a small to medium hybrid engine bus will cost approximately $23,000 to $38,000 more than procuring a Hybrid bus of comparable class and size. For larger transit buses, 35-60’ in length, a base model Hybrid bus costs between $254,505 and $650,000\textsuperscript{xxvi}. The average cost of a large
base model Hybrid bus is $468,862. There are 2,910 small and medium size transit buses and 9,711 large transit buses in the fleets of California. Given these respective proportions of small to large buses relative to the total number of vehicles which will eventually need to be replaced by 2026, the average cost of a Hybrid bus is $402,927. This does not include costs for additional features that an agency might need to provide its transit service. The chart below shows capital procurement costs for replacing retirement age vehicles in California with Hybrid buses.

Figure 22

**Battery Electric Buses**

Electric battery transit bus technology is evolving and prices for this technology is expected to decrease, particularly when the technology gains traction and mass production can ensue. The National Renewable Energy Laboratory estimates that Battery Electric Buses (BEB) cost $789,000 each. BEB manufacturer Proterra estimates that each BEB costs $750,000, while
manufacturer BYD estimates the current cost to be $770,000. Please note that these capital costs do not include fueling infrastructure such as en-route or base charging stations.

Figure 23

Hydrogen Fuel Cell Electric Buses

The National Renewable Energy Laboratory estimates that by 2016, the initial purchase price for a Hydrogen Fuel Cell Electric Bus (FCEB) will be approximately $1,900,000 per vehicle\textsuperscript{xxvii}. Prices for this type of vehicle technology have been steadily declining. In 2003 the initial purchase price for FCEBs was $3,100,000, so there has been a 61% reduction in up-front capital vehicle procurement cost over the last 13 years\textsuperscript{xxviii}. Other sources were not included in this review for comparison to the NREL data.
FCEB Procurement Scenario
Fleet Replacement Costs by Year
($1,900,000/bus)
Figure 25

**Procurement Scenario Comparison**

Fleet Replacement Costs by Year

- CNG Model ($338,886/bus)
- Hybrid Model ($402,927/bus)
- Electric Battery Model ($769,667/bus)
- Hydrogen Fuel Cell Model ($1,900,000/bus)
Funding Assessment for Transit Vehicle Capital Procurement

Transportation funding on the State and Federal level is continually in flux. As a result, programmed projects are often added and deleted depending upon funding availability for any given fiscal year. Projects are programmed into Regional Transportation Improvement Programs (RTIP) and Interregional Transportation Improvement Programs (ITIP). RTIPs and ITIPs are then submitted to the California Transportation Commission for inclusion in the State Transportation Improvement Program (STIP) and a comprehensive package is submitted to the Federal government in the Federal Transportation Improvement Program (FTIP). The FTIP is updated every 2 years. In between FTIP cycles funding for transit projects is subject to fluctuation as most funding sources require that projects leverage funding, or in layman’s terms, have funding come from several different sources. While funding programs evolve and change over time, capital funding availability can be estimated and judged based upon average growth rates for state funding xxix.

The total projected funding for transit vehicle replacement (including rail cars, ferries, and other modes in addition to buses) from 2016 to 2020 is approximately $4,000,000,000xxx. If the rate of capital investment growth remains at current levels in California, approximately $5,000,000,000 will be available for capital procurement of all types of transit vehicles between 2021 and 2026. Transit buses represent 12,882 of the 24,258 total transit vehicles in California. The additional revenue service vehicles include light, heavy, and cable rail cars, ferry boats, etc. If transportation decision makers invest half of the available funding to transit bus replacement, approximately $4,500,000,000 will be available for bus fleet replacement between 2016 and 2026. Slightly less than $2,000,000 will be available between 2016 and 2020. This is a $700,000,000 shortfall from the minimum funding required to purchase the least expensive of
the alternative fuel engine model transit buses (CNG). If California agencies opted to purchase Hybrid buses then the funding shortfall by 2020 would be approximately $1,200,000,000. If transit agencies opted to replace their buses with only BEB the funding shortfall, excluding infrastructure investments which would be necessary for implementation, would be approximately $4,156,000,000. For the most expensive option, FCEB, the funding shortfall would be $13,190,000,000.

Figure 26

![Projected Capital Funding Availability 2016-2020](image)

**Summary and Recommendation**

As of the 2014 reporting period to the NTD, there are 4,402 articulated buses, cutaway buses, over-the-road buses, double-decker buses, and regular transit buses which are eligible for or overdue for retirement in 2016. By 2026, all 12,882 transit buses in California will be eligible for retirement. The projected capital funding availability for transit vehicle replacement will inevitably be split between bus procurements and other transit vehicle categories. While there are 12,882 transit buses, there are an additional 11,376 revenue service vehicles which will require funding to maintain a state of good repair in the coming years. Funding dedicated to transit vehicle procurement for system preservation is estimated to be approximately $4,000,000,000 from 2016 to 2020. If capital funding growth remains consistent with existing trends,
approximately $5,000,000,000 will be available from 2021 to 2026. The bus transit vehicle replacement share will likely receive approximately one quarter to half of this funding, proportional to the fleet vehicle composition, and will total approximately $4,500,000,000 over the next decade. Slightly less than $2,000,000,000 is estimated to be available between 2016 and 2020 to purchase replacement vehicles for the aging bus fleet.

**Figure 27**

<table>
<thead>
<tr>
<th>Funding Availability vs. Need by Vehicle Type</th>
<th>2016-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Projected Capital Funding Availability</strong></td>
<td>2016-2020</td>
</tr>
<tr>
<td><strong>CNG Model ($338,886/bus)</strong></td>
<td>2016-2020</td>
</tr>
<tr>
<td><strong>Hybrid Model ($402,927/bus)</strong></td>
<td>2016-2020</td>
</tr>
<tr>
<td><strong>Electric Battery Model ($769,667/bus)</strong></td>
<td>2016-2020</td>
</tr>
<tr>
<td><strong>Hydrogen Fuel Cell Model ($1,900,000/bus)</strong></td>
<td>2016-2020</td>
</tr>
</tbody>
</table>

**Recommendation**

Based upon current estimates of capital procurement funding availability for transit buses in California, Fiscal Year 2018 represents the best possible time over the next few years to begin to introduce stricter emissions standards and purchasing requirements on transit agencies. FY2018 is the best possible time within the next few years to change the standards because there is the lowest number of transit buses reaching the end of their useful life during this time period and at
the same time having a slightly larger pool of funding for procurement. Transit agencies will be able to focus on reducing the replacement backlog without having to address a large number of vehicles newly eligible for retirement. It is also possible that within this two year time period the price per vehicle may decline and become more affordable. There is not a clear solution to the problem of funding scarcity for transit bus capital procurement projects; however, ARB can tailor their rule-making implementation deadline to give transit agencies the best possible chance of meeting the stricter transit bus purchasing and emissions requirements.

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See note xxix