Sustainable Transportation: Environmental Benefits and Challenges of Alternative Fuels

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Executive Summary

Sustainable transportation is a topic of growing concern in urban areas due to increasing urban populations and the recognition of urban contributions to climate change. Motorized transport relies on oil for virtually all its fuel and accounts for almost half of world oil consumption (Kahn et. al, 2007). The United States transportation sector contributes to 28% of the production of greenhouse gas emissions, a large proportion of which occurs in urban areas, which produce 60% of the global carbon emissions (Sims et al., 2014; EPA, 2014; UN-Habitat, 2015). While public transportation only produces 35% of the total carbon emissions from the transportation sector (EPA, 2014), there is an opportunity, due to the high visibility and centralized maintenance of public transit, to become a leader in sustainable transportation. This includes many different strategies, including reducing dependency on fossil fuels through the use of alternative fuel technologies. This strategy needs to be supported by local and national government to help invest in alternative fuels by reducing the initial capital investments.

This document provides a brief analysis of what sustainable transportation planning means and the opportunity for public transit, specifically city buses, which account for 40% of passenger miles, to serve as a visible demonstration for the development and use of alternative fuel technology (fig. 1.0). City buses were chosen as the subject for this analysis due to the high proportion of passenger miles on buses in comparison to other modes of public transportation, and therefore, it is arguable that sustainable transportation planning for city buses effects the largest number of people. This analysis includes a basic comparison of current, widely used alternative fuels and the advantages and disadvantages for each.

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Introduction

The goal of this paper is to provide an introduction to sustainable transportation, an overview of how diesel as a fuel in public transit is detrimental environmentally and economically, and an analysis of different kinds of alternative fuels currently powering city buses across the United States. The paper ends by providing examples of alternative fuel implementation in other cities and then providing recommandations for further research on this topic.

The creation and implementation of sustainable transportation options is an increasingly important task for urban areas around the globe. This importance revolves around the fact that cities are home to a large proportion of the human population. Cities are growing in size every year and are major economic hubs. In order to ensure urban livability and productivity, cities need to provide affordable, accessible, environmentally-minded transportation systems. Additionally, in the face of climate change, urban mobility needs to be addressed more sustainably. This can be done by reducing the impact of transportation systems on the environment and reducing dependency on fossil fuels. This is challenging due to the current state of dependence on this limited supply of energy. If dependence on fossil fuels and foreign producers could be reduced, urban contributions to climate change could also be reduced (Cinquina, 2008).

Even though urban areas are only occupying 2% of the earth's surface, they use vast amounts of resources and make a large contribution to climate change by producing volumes of greenhouse gas emissions (GHGs) (UN-Habitat, 2015). Climate change is the phenomena that is predicted to increase overall variability of temperature, precipitation, and wind patterns. Within cities this variability will increase the probability of heat waves, flooding and/or drought (Rice, 2014; EPA, 2014).

Urban areas are currently consuming 78% of the world's resources and producing 60% of the global carbon dioxide emissions, one of the most common GHGs that identifed as a contributor to the changing climate (UN-Habitat, 2015). Currently, 54% of the world's population lives in an urban area and the United Nations predicts that this number will rise to 66% by the year 2050, meaning that the impact of cities is only going to increase overtime (United Nations, 2014). Within cities, transportation is one of the biggest producers of CO2 emissions. In 2010, the national transport sector produced 23% of the total energy-related CO2 emissions and in 2012, this rose to 28% (Sims et al., 2014; EPA, 2014). Since cities are large producers of GHGs, the battle to prevent catastrophic climate change will be won or lost in our cities (Hodson and Marvin, 2010; Bassett and Shandas, 2010).

Public transportation systems are great places for cities to develop new technologies that reduce environmental impacts associated with continued reliance on fossil fuels. There are to reach a broad range of strategies to achieve this goal including: increasing vehicle efficiency, reducing carbon content of fuels by switching city buses to alternative energy sources, and reducing vehicle miles of travel. Public transportation can enact all of these strategies and is therefore an important part of the solution. (US DOT, 2010). Switching city buses to alternative energy sources can reduce GHG emissions by getting people out of their personal vehicles while additionally reducing overall reliance on fossil fuels (US DOT, 2010).

There is a growing use of alternative fuel sources in the public transportation sector. In 2013, more than a third of the nation's city buses were run on fuels other than diesel or hybrids including: natural gas, propane, diesel-electric hybrids, biodiesel, and hydrogen (Copeland, 2013). The shift to alternative fuels has environmental and economic benefits including: reduced economic costs through reduced fuel usage, reduced negative environmental effects, and energy independence (Copeland, 2013). This shift also has social benefits, including increasing personal mobility and protecting human health.

The traditional fossil fuel for public transit, diesel, is expensive and detrimental to human health and the health of the environment. Therefore, transit agencies should be working hard to create a transit system that uses alternative fuels. Public transit is also a great place to show the safety and efficiency of alternative fuels, which will lead to a greater cultural shift away from the use of fossil fuels. This will further reduce infrastructure costs as the alternative fueling infrastructure is put in place.

The City of Pittsburgh has begun to create plans for mitigating and adapting to climate change. These plans address many environmental issues related to mitigating the local contributiong to global climate change. Identified in the Pittsburgh Climate Action Plan, Version 2 (2012), the city has historically dealt with many environmental issues, particularly concerning air quality. Historically a "smoky city," the air quality has improved drastically over the past couple of decades. However..."air pollutants such as ozone, particulate matter, carbon monoxide, and nitrogen dioxide [continue to] contribute to respiratory disease and illness, along with other detrimental health effects" (Pittsburgh Climate Initiative, 2012). By striving towards a sustainable public transportation system, Pittsburgh can address these public health concerns. The third version of the Pittsburgh Climate Action Plan is anticipated to include a special chapter on transportation to explore how this sector can further address mitigation strategies and public health concerns.

Sustainable Transportation

Sustainable transportation is a term that has no universal definition, however a common thread between many definitions is the importance of integrated solutions for transportation problems. These solutions include: improved travel choices, economic incentives, institutional reforms, land use changes and technological innovation (Litman & Burwell, 2006). The definition of sustainable transportation that will be used in this paper is the design and planning of systems to provide affordable and accessible means of transportation for everyone and promote connectivity while reducing environmental impacts, such as air pollution. Sustainable transportation is also not about removing all personal cars from the road (though that is important for reducing GHG emissions in cities)--it is about increasing the choices that people have to get to where they need to go. The "right mix" of transportation options would include a balance between driving, walking, cycling, and taking public transit (Duong, 2014). This "right mix" will privilege modes other than the personal car, which is an example of how sustainable transportation promotes mode shift.

Over the past couple of decades, sustainable mobility in urban areas has come a long way, including an increase in bus efficiency. For example, Bus Rapid Transit (BRT), a system that uses buses in a way that aims to combine the capacity of light rail with the flexibility and lower cost of a bus system (Zimmerman et al., 2003). There has also been an increase in bike-sharing programs like Citi Bike in New York City, car-sharing like Zipcar, and car-free, pedestrian only streets. These planning strategies utilize the principle of human-centered design, which draws from a "deep and empathic understanding of user needs and experience" (Duong, 2014). This kind of planning shifts transportation systems from catering to personal vehicles to allowing room other modes of travel to be planned for.

Challenges faced by transit planners and agencies include: greenhouse gas emissions (GHGs), reliance on fossil fuels, barriers to renewable energy, lack of or inconsistent funding, demand management (is transit running where there is need), commuting costs, human health, and public safety, just to name a few. Transportation systems are complex and dynamic and are not restricted to public transportation or personal vehicles, however, for this paper we will only be focusing on public transportation, specifically city buses due to the high proportion of passenger miles on buses in comparison to other modes of public transportation (Fig. 1.0).

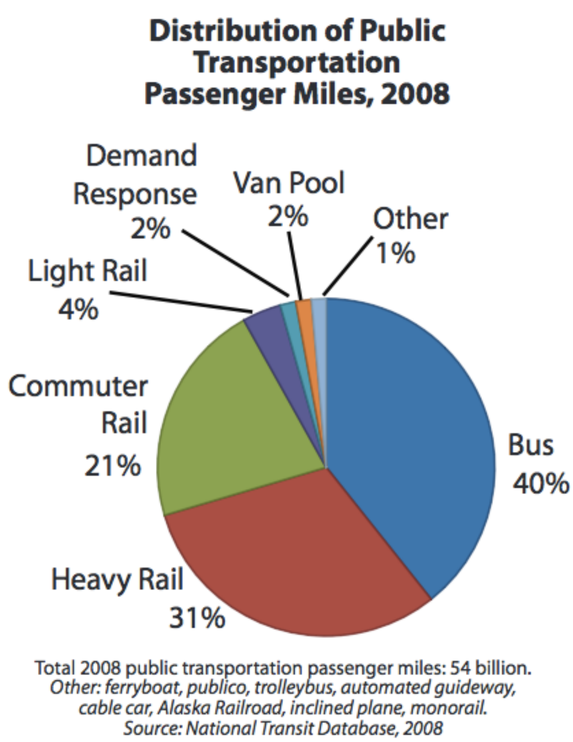

Figure 1.0: Proportion of Passenger miles for different modes of public transportation in 2008 (US DOT, 2010).

In 2005, combustion of fossil fuels in transportation sector was responsible for 31% of US CO2 emissions--1% of which corresponds to buses, 61% personal vehicle, 20% medium and heavy-duty trucks, 10% aircraft (Wayne et al., 2009). By encouraging mode shift and creating a public transit system that uses alternative fuels, there is significant potential to lower GHG emissions and help mitigate climate change and improve public health (Fig. 1.1).

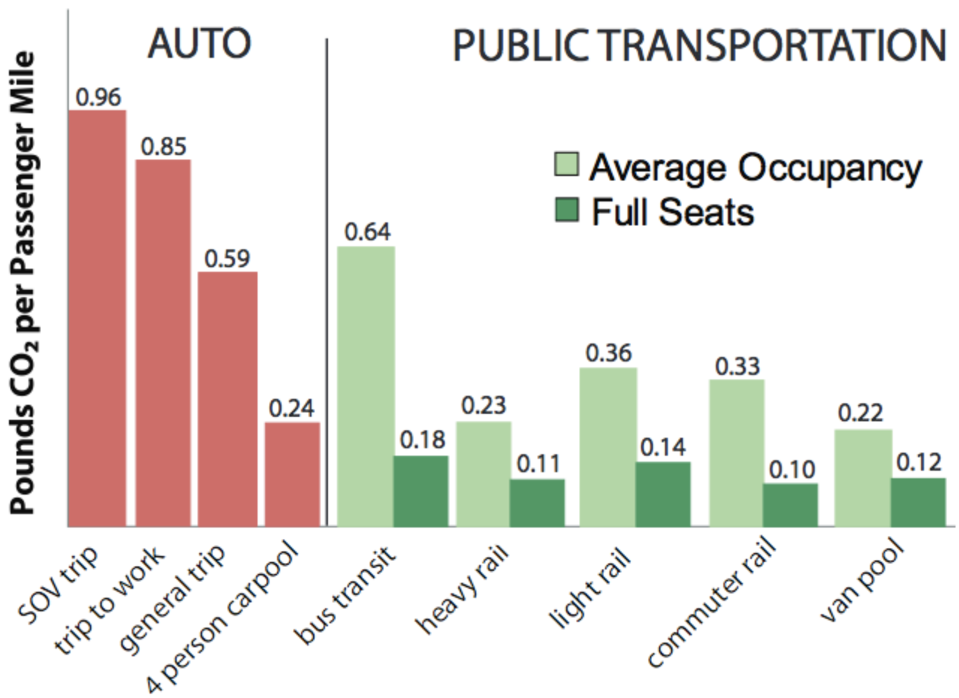

Figure 1.1: Comparison of pounds of CO2 per passenger mile for difference personal vehicle trips and different modes of public transportation, showing the potential of increased public transit use and reduced personal vehicle use could have on GHG emissions (US DOT, 2010).

Current strategies for sustainable public transportation include: transit-centered development, demand management, traffic calming, and the use of high-efficiency vehicles. This paper is concerned solely on the last strategy: high-efficiency vehicles, which is focuses on reducing the use of fossil fuels in public transit vehicles and increasing the use of alternative fuels.

Issues with Diesel & Importance of Alternative Fuels

The majority of the transportation sector in the United States relies on fossil fuels as a main energy source with petroleum supplying 95% of the total energy used by world transport (Kahn et al., 2007). Within the United States, near 80% of city transit buses are run on diesel fuel (Public Transportation, 2014). Even though emissions from transit buses are small in comparison to total emissions by motor vehicles within the transportation sector (a large portion belonging to personal vehicles)--these bus emissions are nevertheless important because they are operating in heavily populated urban areas where air quality is a large concern for public health and welfare (Wayne et al 2009).

Historically, the most commonly used fuel for public transportation has been diesel, which is the cheapest and crudest form of gasoline and also the most hazardous, emitting higher levels of pollutants per mile than conventional gasoline (NYC DOT, 2015; Shandilya and Kumar, 2013). Diesel also significantly contributes to ground-level ozone formation, commonly referred to as smog (Cooney et al., 2013; Diesel Emission Health and Environmental Effects). The primary pollutants that are found in diesel exhaust include: particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons, and volatile organic compounds (VOCs) (Wayne et al 2009). Diesel exhaust also consists of 40 other chemicals that are listed as hazardous air pollutants, including the known carcinogens benzene, arsenic, and formaldehyde (Diesel Emission Heath and Environmental Effects).

Within Pittsburgh, air pollution has been a major concern. Of these pollutants, particulate matter is the most threatening to public health. Particulate matter (PM) is microscopic particles that are suspended in the air and are usually produced through the combustion process. These suspended particles have adverse health effects that correlate to the degree of exposure. The more PM in the air people breathe, and the longer they are exposed, the more severe health risks become.

R.H. White Consultants created a report from an analysis of literature from 1970 to 2012 about the relationship between health and air quality in Pittsburgh and concluded that exposure to pollution has resulted in adverse health effects including: premature death, exacerbation of lung and heart disease, and adverse birth outcomes (R.H. White Consultants, 2013, p. 26). The effects of this air pollution is more pronounced in urban areas due to the concentration of pollution and the high density of human population, which means large numbers of individuals are affected by poor air quality. Air quality has improved drastically since the industrial revolution and the period after World War II. However, Pittsburgh continually surpasses the limit of pollution set by national air quality standards, posing continued concerns for public health.

Transportation relies on oil for virtually all of its fuel. Due to this, the transportation sector faces a challenging future (Kahn et. al, 2007). This dependence on fossil fuels is a concern for various reasons. Firstly, is the finite nature of fossil fuels. Eventually easily accessible oil and coal will be a thing of the past, and the remaining reserves will be too difficult or costly to extract. Secondly, is the concern about the price, which goes hand in hand with the limited nature of fossil fuels. The cost of fuel will only rise, and this affects everyone--from people in personal vehicles, to those riding the bus. The third, though not necessarily the least concern about fossil fuels, is the environmental damage caused by their production and consumption.

Transit agencies should be working to find alternatives which reduce impact for the environment and do not pose a threat to human health. This will help ensure that our future generations have continued mobility and a healthy environment (Cinquina, 2008; Greene et al., 1997). Switching from diesel to an alternative fuel source has the potential to improve local air quality and consequentially public health (Shandilya and Kumar, 2013).

When looking to create sustainable transportation systems, it is not always realistic to instantaneously stop using fossil fuels due to capital and operating costs, technical challenges (Alternate Fuels, 2006). Therefore, transportation agencies should be always actively striving to improve the efficiency of their diesel fueled vehicles and reducing harmful emissions, such as particulate matter. Arguably, even though it will not result in an instantaneous change, proactive investment in these alternative technologies will make the eventual transformation of the system possible. While the initial investment for alternative fuels is large, the savings incurred by reduced fuel costs pays off over time (Copeland, 2013).

Alternative Fuel Analysis

Not all alternative fuels are created equal. Below is an analysis based primarily on the Alternative Fuel Report created by the Federal Transit Administration (2006) and the U.S. Department of Energy's fuel economy website (fueleconomy.com), with some supplemental information from academic and news sources. This analysis looks at common alternative fuels that are currently being used and implemented by transit agencies in urban areas nationally, including their environmental impacts and a basic overview of the economic aspect for each fuel. The analysis of environmental impacts are not limited to the tailpipe emissions of these alternative fuels, and instead shows a basic well-to-wheels analysis, which is a type of environmental analysis that seeks to quantify all environmental impacts for a fuel from its initial production through its consumption. An example of the importance of well-to-wheel analysis of different modes of transportation is illustrated in fig. 2.0, which shows how different environmental analysis can be if only looking at one aspect of transportation.

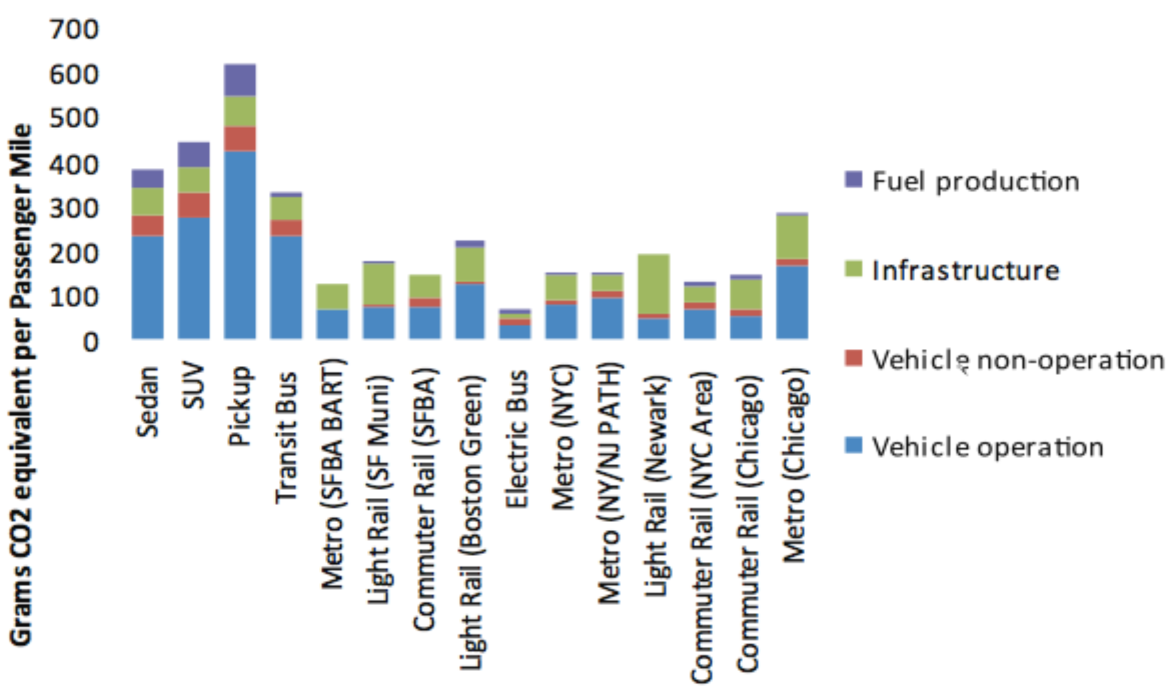

Figure 2.0: Example of a well-to-wheels analysis of greenhouse gas emissions from fuel production, infrastructure, non-operation of vehicles, and operation of vehicles for different modes of transportation including alternative fuel use in public transportation (US DOT, 2010).

This analysis is only a basic comparison, and does not include all the options for alternative fuel. The analysis can and should be expanded upon in the future, especially as more alternative fuels begin to be adopted. Additionally, due to the early stage of development for many alternative fuels, it is safe to assume that not all advantages or disadvantages have been identified.

Natural Gas

Natural gas is an alternative fuel that has been growing in popularity with the increased supply of domestically produced natural gas and is widely used as an alternative fuel for bus fleets. There are two fuel forms of natural gas, liquidized natural gas (LNG) where the methane has been subjected to extremely low temperatures, condensing it into a liquid and compressed natural gas (CNG) where the methane that has been pressurized and is still in a gaseous form.

There are two sources for natural gas: fossil fuels or biogas. Conventional CNG is produced from the many underground natural gas reserves (fossil fuel) that are in widespread production worldwide today. New technologies such as horizontal drilling and hydraulic fracturing - used to economically access unconventional gas resources - appear to have increased the supply of natural gas in a fundamental way. Renewable natural gas or biogas is a methane-based gas with similar properties to natural gas that can be used as transportation fuel. Present sources of biogas are mainly landfills, sewage, and animal/agricultural waste. Based on the process type, biogas can be divided into the following: Biogas produced by anaerobic digestion, Landfill gas collected from landfills (treated to remove trace contaminants), and Synthetic Natural Gas (SNG), which is a blend of liquidized gas with a diluent, which is most commonly compressed air.

Natural gas that is harvested from underground reserves has a number of disadvantages including high investment costs for infrastructure (Chan 2005; see Table 1), high maintenance costs, low fuel economy, and continued use of non-renewable fossil fuels. Additionally, the threat of methane leaks from drilling wellheads, valves and pipelines raises concerns, as methane has a Global Warming Potential (relative measure of how much heat is captured by a specific GHG in the atmosphere) number of 21 compared to carbon dioxide which has a number of 1. Inventories and emissions factors consistently underestimate actual measured methane emission across scales (Brandt 2014, 733).

There is a larger question about how reasonable it is to switch from one fossil fuel to another. Often natural gas is cited as a bridge fuel, or a fuel that will hold us over until the next appropriate technology presents itself. While more research needs to be done, arguably, to reach the goal of sustainable, renewable energy future, diligence will be required to ensure that leakage rates are low enough to achieve sustainability goals (Brandt 2014, 735). Investing in cleaner technologies may be the clearest way to this sustainable future.

Table 1: Advantages and Disadvantages of Natural Gas (fossil fuel) as alternative fuel. Adapted from fueleconomy.com and FTA Alternative Fuels report (2006)

Advantages	**Disadvantages**
About 94% of U.S. natural gas used is domestically produced	Limited vehicle availability
Roughly 20% to 45% less smog-producing pollutants from tailpipe emissions	Less readily available than gasoline and diesel
About 5% to 9% less GHG emissions	Fewer miles on a tank of fuel
Currently less expensive than diesel	Methane leaks from drilling wellheads, and valves and pipelines
	requires fueling and maintenance facility modification
	facilities incur an additional electrical cost to power the compressors
	Needs special, expensive maintenance infrastructure (Chan 2005)
	Environmental impacts to water sources from natural gas drilling (NRDC)

Diesel-Electric

Also known as hybrid vehicles, diesel-electric combines an internal combustion engine with electric propulsion system. There are two types of hybrid vehicles, series hybrids and parallel hybrids (Ranganathan, 2007). Series hybrids are well suited to stop-and-go transit buses, such as the buses that run in urban areas with short distances between stops and that operate in congestion. Parallel hybrids are better suited to long distance. Diesel is the most common fuel that is used in hybrid buses, however, other alternative fuels, like CNG or fuel cells have been used. The use of hybrid-electric vehicles has grown in the past few years. In 2006, there were more than 900 hybrid buses that were deployed by 40 different transit agencies and in 2011 almost 9% of the total national public transit buses were hybrid vehicles. Currently, the Port Authority of Pittsburgh has 32 hybrid buses on the road.

The pros of this alternative fuel outweigh the cons (Table 2). The major drawback of this fuel type is the large initial investment. However, this is quickly offset by the savings incurred by an increased fuel efficiency (APTA, 2012; Alternative Fuels, 2006). Many transit agencies are replacing older diesel buses with new hybrid-electric buses, which consume 15% to 40% less fuel, and produce 15% to 40% fewer carbon dioxide emissions (US DOT, 2010). This large initial investment can be offset by federal or state funding.

Diesel-Electric buses are growing in popularity thanks to the benefits of this alternative fuel (Table 2). By 2011, diesel-electric hybrids were operated by more than 60 agencies nationwide, accounting for about 9% of the national bus fleet. This number is expected to increase; in 2011, hybrids accounted for about 17% of the new buses on order by transit agencies (APTA, 2012).

Table 2: Advantages and Disadvantages of Diesel-Electric as alternative fuel. Adapted from fueleconomy.com and FTA Alternative Fuels report (2006).

Advantages	**Disadvantages**
May increase fuel economy by 14-48% (APTA, 2012)	Large initial investment for buses and maintenance infrastructure
Requires minimal maintenance facility changes.	Continued use of fossil fuels, unless running on biodiesel

Likely reduction of brake system maintenance frequency and costs.	
Generally lower emissions of both regulated pollutants and greenhouse gases.	
Electric motors produce full rated torque from zero speed resulting in superior acceleration.	
Passengers and bus operators like hybrid buses – good for ridership and community acceptance.	

Electric

Electric plug-in buses rely solely on electricity. The source of electricity varies depending on the location of the grid in use. For example, in the Northwestern United States, electricity from the grid is supplied from hydropower while much of the electricity in the Eastern United States is supplied from the burning of coal. The source of electricity is therefore important to identify to analyze the full impact. Plug-in electric buses are less common than hybrid-electric vehicles but have similar advantages and disadvantages. A notable drawback of electric only vehicles is that they are not as powerful as diesel-electric (Table 3).

Table 3: Advantages and Disadvantages of electric as alternative fuel. Adapted from fueleconomy.com and FTA Alternative Fuels report (2006).

Advantages	**Disadvantages**
Electric buses, including battery-electric and trolley buses powered by overhead catenary wires, have no tailpipe emissions.	Production of electricity can come from nonrenewable sources, like coal burning electric plants

Biodiesel

Biodiesel is fuel that has been created out of living or recently deceased organisms, also known as biomass. Ethanol from corn and sugarcane, and biodiesel from soy, rapeseed, and oil palm dominate the current market for biofuels, but a number of companies are moving forward aggressively to develop and market a number of advanced second-generation biofuels made from non-food feedstocks, such as municipal waste, algae, perennial grasses, and wood chips (Bio-energy, 2014).

Biodiesel is an expensive alternative fuel. While it has the environmental benefits of less air pollutants (except nitrogen oxides) and is biodegradable, this fuel is often not suitable for public transit due to its lower fuel economy. Furthermore, reliance on feedstock sources for the production of biodiesel negates much of the environmental benefits (Table 4).

Table 4: Advantages and Disadvantages of biodiesel as alternative fuel. Adapted from fueleconomy.com and FTA Alternative Fuels report (2006).

Advantages	**Disadvantages**
Domestically produced from non-petroleum renewable resources	Lower fuel economy and power
Can be used in most diesel engines, especially newer ones	Currently more expensive than diesel
Less air pollutants (other than nitrogen oxides)	Some biodiesel blends are not suitable for use in low temperatures
Less GHG emissions	Slight increase in nitrogen oxide emissions
Biodegradable, Non-toxic, Safer to handle	Reliance on feedstock sources for fuel development

Fuel Cells

Fuel cell vehicles are powered by hydrogen, instead of batteries. A fuel cell is a device that creates electricity from a chemical reaction between a fuel source and an oxidizing agent. Fuel cells differ from batteries in that they need a constant supply of fuel to sustain the initial chemical reaction. The most common fuel type for fuel cells is hydrogen and oxygen. Hydrogen can be produced from fossil fuels, such as natural gas, or from water using electrolysis, the breaking of hydrogen bonds with the help of electricity or hydrolysis, the passive breaking of hydrogen bonds through processes similar to evaporation.

Fuel cell transit vehicles have zero tailpipe emissions, which is beneficial for dense urban areas. However, the technology and infrastructure costs for fuel cells is currently prohibitive towards large scale adoption in transit fleets. In the United States, the San Francisco Bay area (including Oakland) is leading the way with fuel cell transit buses. In 2011, the San Francisco Municipal Transit Agency deployed 12 fuel cell buses.

Table 5: Advantages and Disadvantages of fuel cells as alternative fuel. Adapted from fueleconomy.com and FTA Alternative Fuels report (2006).

Advantages	Disadvantages
"Zero-emissions vehicles": Hydrogen fuel cells emit only water and excess (unreacted) fuel, with no carbon or greenhouse gas footprint at the point of use. **source of hydrogen can affect the overall total of emissions produced.	Fuel cells require a constant amount of power, requiring vehicles to include additional onboard electrical storage (similar to a hybrid-electric vehicle) to meet peak load and optimize vehicle range and fuel efficiency.
Hydrogen can be produced through multiple pathways, including the electrolysis of water (improving energy security and independence).	Hydrogen storage capability is a major limiting factor in fuel cell development, affecting vehicle range and fueling infrastructure.
Noise and vibration from the fuel cell are negligible and are produced by accessories (mainly air conditioning).	Fuel cell vehicles are still in the developmental stage, with the latest buses costing from $1.5 M to $3.5 M (up to 10 times the cost of an equivalent diesel bus).
	Significant investment required to develop hydrogen fueling infrastructure.

Discussion

There is growing use of alternative fuels within the public transit sector of the United States. Of all the current alternatives, the advantages of diesel-hybrid vehicles most outweigh the disadvantages, offering the best combination of economic and environmental benefits compared to other alternative fuels analyzed. Diesel-hybrid buses also provide significant advantages over pure diesel vehicles. These benefits include reduced maintenance and operating costs, reduced air pollution, and lower GHG emissions.

In comparison to diesel, all of the alternative fuels discussed here will have some degree of increased capital costs, operating costs, technical challenges, and institutional issues (Alternative Fuels, 2006). However, these costs are offset through reduced operation and maintenance costs over time, especially for diesel-electric hybrid vehicles. To further reduce the costs of these alternative technologies, public transit agencies need to be supported by their local, state and national governments. Policies, programs, and incentives have driven the leadership of public transportation with the development and use of alternative fuels. Maintaining and expanding these policies will help continue the transformation of public transit fleets to clean fuels and technologies (APTA, 2012).

Nationally, the Federal Transit Administration (FTA) has created the Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) program, which is focused on supporting and working directly with public transportation agencies to implement strategies for reducing GHG emissions, promoting energy savings and sustainable technologies. Further research should be done to identify current federal and state programs that seek give financial support to public transit agencies that are turning away from fossil fuels to explore healthier, renewable alternatives.

As new studies emerge, further analysis will be needed to explore the advantages and disadvantages of different fuels and technologies. Additionally, research should be conducted to look into performance case studies of transit buses running on these different alternative fuels, which will help transit agencies make with investment decisions.

Conclusions

Public transit agencies need to be working towards creating sustainable transportation systems to insure urban livability and equity in the face of growing urban populations and climate change. This includes increasing public health and safety through protecting environmental conditions, as well as mitigating the contributions to climate change. Public transit agencies should be actively seeking to increase efficiency and reduce harmful emissions from their diesel fueled transit fleets and at same time, making steps to invest in a long term transformation to cleaner, alternative fuels. By striving for these two goals, transit agencies can benefit economically, promote public health, and reduce environmental impacts.

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