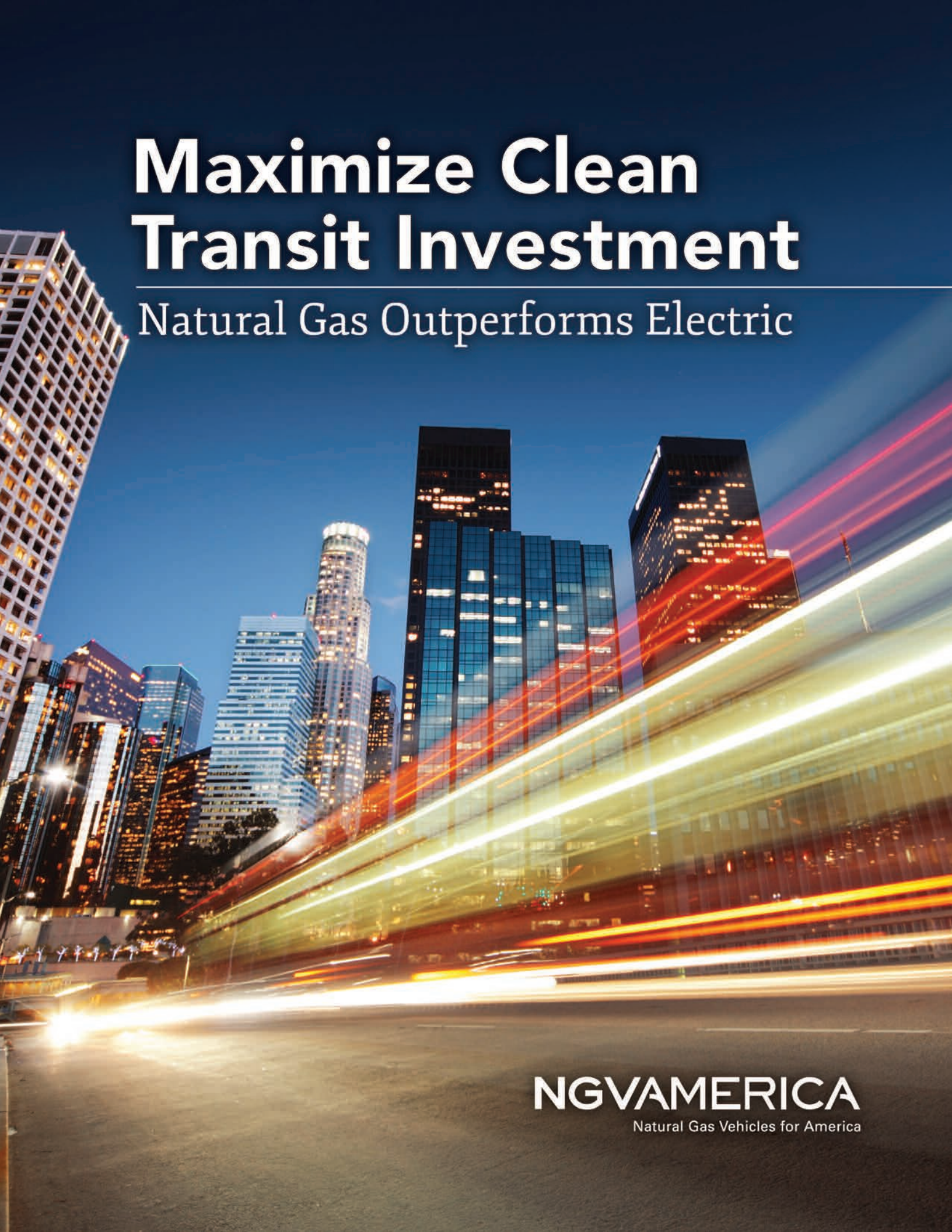
Maximize Clean Transit Investment

Natural Gas Outperforms Electric



NGVAMERICA

Natural Gas Vehicles for America

Executive Summary

The Move Toward Cleaner Transit

This report by NGVAmerica includes a review of recent studies and reports that evaluate natural gas and battery electric transit buses. Much of this report is based on data generated by the National Renewable Energy Laboratory as part of its evaluations of transit bus operations, including Foothill Transit in California, but also included are the findings from a number of other recent reports and studies.

The desire for cleaner air and the urgency of fighting climate change has put additional emphasis on ensuring that transit buses are powered by the cleanest available fuels. Many environmental advocacy and public interest groups contend that state and local governments must mandate the purchase of battery powered electric vehicles, arguing that only zero emission buses adequately address concerns related to urban emissions and climate change. The State of California has responded by mandating all new transit bus purchases be zero emission by 2029. Other government authorities are considering similar mandates.

Advocates for electric or zero emission bus mandates ignore the fact that natural gas-powered buses – including buses that operate on conventional (or geologic) natural gas and renewable natural gas (or natural gas derived above ground from renewable waste streams) – in many cases provide a more viable, proven and cost-effective solution to lowering urban pollution and addressing climate change emissions than battery electric buses.

By leveraging continued investments in new, cleaner natural gas buses communities can actually achieve greater reductions in pollution and generate greater economic savings compared to operating more costly (in all aspects) and unproven electric bus fleets. The savings reaped from continuing to invest in natural gas buses will allow communities to invest the additional funds in expanded public transit services or other worthy public projects.

Flawed Cost Arguments and An Impractical Solution

Battery electric bus (BEB) advocates contend that while electric buses are more costly to purchase today, they are less expensive to operate and maintain over their full lifetime, and that in the future, eventually battery electric buses will be less costly to purchase due to declining battery costs. As demonstrated in this NGVAmerica report, claims of significant lifetime savings are not supported by existing data. In fact, electric buses are not less costly to own and operate over their lifetimes than natural gas buses or diesel buses. Moreover, future demand for batteries driven by electric vehicle mandates in the U.S. and elsewhere for light-duty passenger automobiles combined with limited sources of needed battery components and elements are likely to result in upward, not downward, pressure on future battery prices.

Battery electric buses also have not demonstrated that they are capable of providing the reliable service required of public transit operations. As shown in this report, battery electric buses deployed in the U.S. have largely been operated on shorter, specially selected routes, accumulating far fewer annual miles than natural gas buses. Even in these less-demanding conditions, electric buses have failed to demonstrate the same level of reliability and cost-effectiveness as natural gas buses. Deploying electric buses on longer, more demanding routes will require installing additional batteries on electric buses (or greatly expanding costly on-route charging) resulting in higher costs. Available natural gas buses operated throughout the country have been deployed in numerous types of operations regardless of terrain and are capable of performing on shorter and longer routes without compromise.

While many portray electric buses as being capable of supplanting natural gas buses on a 1:1 basis and make cost comparisons based on this key assumption, several recent reports raise doubts about whether transit agencies will actually be able to completely switch to all-electric bus fleets without reducing service, shortening routes or adding additional numbers of buses into their overall fleets. When factoring in the need for additional buses and costly infrastructure upgrades, the costs for going fully electric can be staggering.

More Affordable, More Reliable, and Greater Environmental Impact

Based on a review of existing studies evaluating natural gas and electric buses, it is apparent that natural gas buses are more affordable, more reliable and deliver greater environmental benefit than electric buses. Compare the Benefits of CNG and Battery Electric Transit Buses Including Key Takeaways from their use in NREL's Foothill Transit Study:[1]

Table 1

	CNG	BEB	Results
Cost			
Unit Cost	X		Electric bus purchase price 57 – 67 percent higher than CNG bus (based on Foothill cost and average 2019 bus prices reported by APTA)
Fuel Purchase Cost	X		Electricity on an energy equivalent basis costs 6x more than CNG at Foothill
Fuel Cost Per Mile	X	X	Efficiency considerations can make this a tossup, but it is important that all relevant costs are considered including cost of maintaining and operating fueling equipment, which is often omitted in reported electricity costs
Repair and Maintenance Costs	X		$0.41/mile (CNG) vs. $0.68/mile (BEB)
Total Cost Per Mile	X		Overall, BEB cost 1.5x more than CNG to operate
1-to-1 Replacement for Diesel	X		Takes more than one new BEB to replace one diesel/CNG bus when considering range, capacity, and performance
Reliability			
Days Available for Service	X		93 percent (CNG) vs. 63 percent (BEB)
Miles Between Road Events	X		CNG performance exceeded BEB by 18,000-20,000 miles between road calls
Resiliency	X		CNG can be refueled quickly and returned to service, BEB needs multiple hours of charging to return to full readiness – difficult during times of emergency or longer- term loss of power
Performance			
Route/Deployment	X		BEB deployed only on carefully selected routes; no such limitations for CNG
Range	X		CNG buses do not require mid-route refueling
Vehicle Efficiency		X	BEB vehicle energy efficiency is higher than CNG, though ratings often do not reflect actual in-use results or sizable energy losses associated with BEB charging
Weather Impact	X		BEB efficiency suffers in extreme cold; no like impact on CNG
Passenger HVAC	X		BEBs have difficulty with battery-powered heating and cooling, requiring a fuel-powered solution
Made in America			
Fuel/battery components	X		100 percent domestic fuel vs. foreign-sourced and controlled battery components (i.e. cobalt)
Technology	X	X	FTA-funded buses required by law to be assembled in USA
Infrastructure	X		CNG refueling contributes to the Federal Highway Trust Fund which supports transportation infrastructure funding including FTA funding for transit buses; EV charging does not, undermining funding to maintain transportation infrastructure and FTA new bus funding programs
Environmental Impact			
Zero tailpipe	X	X	Zero (BEB) vs. 0.02 g/bhp-hr NOx (CNG), a negligible difference, as new CNG buses reduce emissions by 99 percent (NOx) and 96 percent (PM) than pre-2010 transit buses
Well-to-Wheel NOx	X		When considering full well-to-wheel emissions, in most cases CNG buses fueled with RNG beat BEBs on NOx impact due to how power is produced in electric grid mix
Carbon intensity of fuel	X	X	Up to -400 EER-adjusted CI (CNG) vs. up to zero (BEB) if all renewable solar or wind electricity is used
Net-carbon negative	X		When fueled with RNG, CNG bus can offer an emissions result 400 percent better than electric bus, even when BEB powered by 100 percent renewable solar or wind
Delivered Emissions Reductions			
$ for $	X		$105 per lb. of NOx reduced (CNG) versus $159 (BEB) based on acquisition cost of comparable size buses
More Buses and More Emissions Reduced	X		Replace more buses, get more emissions reductions with same $ investment

[1]https://www.nrel.gov/transportation/fleettest-electric-foothill.html

Other Key Findings and Takeaways

Fully Accounting for All Costs is Critical

The reason that transit agencies thus far have been able to deploy more costly electric buses without making significant sacrifices has been the availability of significant federal and state financial support that largely masks the true cost of owning and operating such vehicles. Several recent reports candidly acknowledge that but for these subsidies, electric buses (and really most other types of electric vehicles) would simply not be cost effective to operate as compared to natural gas vehicles. And while these funds can be useful in demonstrating the viability of electric buses for certain applications, there simply are not enough available public funds to fully offset the enormous cost of a wholesale shift to electric buses.

True cost effectiveness comparisons should consider all costs including upfront acquisition costs, operational and maintenance costs, and fueling infrastructure costs. Whether these costs are borne by the transit agency deploying the buses or some other governmental entity, these are still costs that could be deployed to support other technologies or fund different goods and services and therefore they should be properly considered.

Many transit agencies in the U.S. already have natural gas fueling infrastructure, so a true cost comparison should factor the savings associated with continuing to monetize this infrastructure instead of having to invest in new, costly electric charging infrastructure. As part of its compliance with the California Air Resources Board's (CARB) Innovative Clean Transportation (ICT) regulation requiring transit agencies in California to switch exclusively to zero emission buses, Foothill Transit commissioned Burns & McDonald Engineering Company to produce an "In Depot Charging and Planning Study." That study found that Foothill Transit will need to invest $120.6 million in infrastructure development over the next twelve years in order to adequately power a full fleet of 373 mandated electric buses.[2] This figure does not include required investments the local electric utility and its ratepayers must incur to support this transition.

A 2016 study by MJ Bradley & Associates and Ramboll Environ commissioned by the Los Angeles County Metropolitan Transportation Authority (MTA) and the Advanced Transit Vehicle Consortium concluded that the agency would save between $3.5 billion to $5.7 billion over 40 years by continuing to utilize its existing natural gas fueling infrastructure and transitioning 100 percent to all low-NOx natural gas buses fueled by renewable natural gas (RNG). This same study also projected much higher overall and immediate environmental benefits generated by going with natural gas buses over electric or fuel cell buses.[3]

Based on current evaluations and comparisons, it is fair to say that electric buses in most cases will be more expensive to fuel and maintain than natural gas buses and in limited other cases are only slightly less expensive to fuel and maintain. As noted in this report, it is important to consider whether comparisons fully evaluate all factors and adjust accordingly since, to date, no study has evaluated natural gas and electric buses operating in exactly the same conditions on the same routes. It is clear, however, that the savings associated with operating electric buses where they do exist are far from sufficient to offset the higher capital costs for fueling infrastructure or bus acquisition; therefore when all factors are considered, natural gas buses are significantly more cost-effective.

Grid Upgrades

Electric bus advocates fail to evaluate the cost and extent of major utility upgrades needed to accommodate an expected surge in electricity transmission and demand for electric buses, upgrades not needed to fuel natural gas buses. These factors are easily overlooked in the case of demonstration projects involving only a limited number of buses but can quickly become overwhelming when converting an entire fleet to electricity. This is not an issue for natural gas as many bus facilities around the country have been converted entirely or almost entirely to natural gas with hundreds of buses fueling at a single depot. Nearly 100 transit agencies currently operate more than 10,000 natural gas buses with additional natural gas buses successfully in service at many other facilities such as airports and colleges across the United States.

Reliability

In the reports evaluated by NGVAmerica, natural gas buses have demonstrated that they are more reliable than electric buses, accumulating far more service miles, spending fewer days out of service and under-repair than electric buses. A key factor of reliability is availability for pull out. In the studies prepared by NREL evaluating real-world bus fleets, natural gas buses more than exceed the expected rate of 85 percent availability while electric buses struggle to meet the requirement. In the Foothill fleet, during the most recent evaluation period the twelve 35-foot electric buses had an average availability rate of 63 percent. Daily per-bus

[2] "In Depot Charging and Planning Study," Burns & McDonald Engineering Company, Inc. for Foothill Transit, Report Project Number 110549, Page 13-4, September 9, 2019.

[3] "Zero Emission Bus Options: Analysis of 2015-2055 Fleet Costs and Emissions," MJ Bradley and Associates and Ramboll Environ for Los Angeles County Metropolitan Transportation Authority and the Advanced Transit Vehicle Consortium, September 29, 2016.

availability for electric buses was as low as 46 percent during the first half of 2019. In contrast, CNG buses had an availability rate of 93 percent for the same period and an overall availability rate of 96 percent.[4]

Once out on route, CNG buses had far fewer road calls, or revenue vehicle system failures, than their electric counterparts in the Foothill study. Such incidents require a bus to be replaced on route and/or cause a significant schedule delay affecting system operations. Such reliability in the transit industry is measured in mean distance (miles) between failures (road calls), or MBRC. At Foothill, the average miles between road calls for natural gas buses exceeds that of the BEBs by between 18,000 to almost 20,000 miles.[5]

Fuel Efficiency

Much attention is given to the efficiency of electric buses but very few studies or reports acknowledge efficiency losses associated with charging infrastructure which can increase energy consumption by 10 – 15 percent. And when determining the overall energy efficiency of electric bus transit operations, it is important to consider that more than 60 percent of energy used to generate electricity is lost in conversion. According to the U.S. Department of Energy, U.S. utility-scale generation facilities consumed 38 quadrillion British thermal units (quads) of energy to produce only 14 quads of electricity last year.[6]

Efficiency claims also almost never acknowledge the trade-offs associated with heating and cooling of buses, which is not accounted for in the test cycles used to determine efficiency ratings of transit buses. Another fact that is often omitted is the large percentage of electric buses that are equipped with fossil fueled heaters to reduce the need to draw on electricity to provide heat. Such heaters can be a significant emission source that are not at all considered.

CNG Buses Provides More Work, More Reliability

In the Foothill study, natural gas buses performed more work and were more reliable than the BEBs, two critical metrics for transit agencies. The average miles traveled by the natural gas buses exceeded that of the BEBs each month by between 2,200 and 2,800 miles.[7] While most cost comparison studies assume equivalent mileage for electric and natural gas buses, the reality is that fewer lifetime miles means that these studies greatly underestimate the true cost of operating electric buses.

New Natural Gas Buses are Zero Emissions Equivalent

Natural gas buses today reduce harmful emissions of nitrogen oxides (NOx) and particulate matter (PM) by more than 95 percent compared to transit buses built prior to 2010, thus the emission difference between new natural gas buses and electric buses, which have no tailpipe emissions but do have particulate matter emissions associated with tire wear and braking, are miniscule. Importantly, natural gas buses produce these emission reductions without relying upon costly and cumbersome emission control equipment.

Fueling transit buses with conventional (geologic) natural gas reduces greenhouse gas emissions (GHG) by about 12 percent compared to diesel. But according to the California Air Resources Board, fueling buses with renewable natural gas (biomethane) collected at local landfills, wastewater treatment plants, commercial food waste facilities, and agricultural digesters can yield a carbon-negative lifecycle emissions result. According to CARB data, renewable natural gas (RNG) holds the lowest carbon intensity of any on-road vehicle fuel, including fully renewable electric. On-road natural gas fueling trends show increasing adoption of RNG. According to data from the U.S. Energy Information Administration (EIA) and U.S. Environmental Protection Agency (EPA) Renewable Fuel Standard reporting, 39 percent of all on-road natural gas fuel in 2019 was RNG. In California, 77 percent of all on-road natural gas fuel in 2019 was RNG.

Adding It All Up

When you add it all up, natural gas provides a winning solution for transit agencies looking to lower costs and reduce emissions. As estimated in this report, it could cost billions – as much as $24 billion more – to switch the majority of the U.S. larger bus fleets to an all-electric fleet. Switching the majority of the U.S. bus fleet to an all-CNG fleet powered by RNG would not only save significant capital and operating amounts of money but also would generate much greater annual emission reductions: 10,000 tons of GHG, 25 tons of NOx, and 6.26 tons of PM2.5.

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[4]Foothill Transit Agency Battery Electric Bus Progress Report: Data Period Focus: Jan. 2019 through Jun. 2019, NREL/PR-5400-73516, National Renewable Energy Laboratory, slide 21, October 2019.
[5]Foothill Transit Agency Battery Electric Bus Progress Report: Data Period Focus: Jan. 2019 through Jun. 2019, NREL/PR-5400-73516, National Renewable Energy Laboratory, slide 35, October 2019.
[6]"More than 60 percent of energy used for electricity generation is lost in conversion," Today in Energy series, U.S. Energy Information Administration, July 21, 2020.
[7]Foothill Transit Agency Battery Electric Bus Progress Report: Data Period Focus: Jan. 2019 through Jun. 2019, NREL/PR-5400-73516, National Renewable Energy Laboratory, slide 14, October 2019.

Investing in Natural Gas Buses = More Clean Buses

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More Cost-Effective Emissions
and Climate Impact

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No Deterioration of Service
Due to Technology Limitations

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