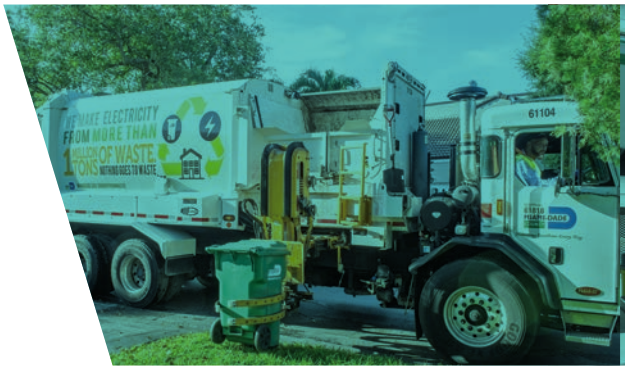
OFFICE OF THE COMMISSION AUDITOR
MIAMI-DADE BOARD OF COUNTY COMMISSIONERS

2020
ANALYSIS OF ENERGY ALTERNATIVES POWERING HEAVY FLEET



Research project produced by the Office of the Commission Auditor

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The Office of the Commission Auditor, Miami-Dade Board of County Commissioners

The Office of the Commission Auditor (OCA) was established in September 2002 by Ordinance 03-2 to provide support and professional analysis of the policy, service, budgetary and operational issues before the Miami-Dade Board of County Commissioners (BCC). The Commission Auditor's duties include reporting to the BCC on the fiscal operations of County departments, as well as whether the fiscal and legislative policy directions of the Commission are being efficiently and effectively implemented.

This report, prepared in collaboration with the Miami Dade County departments as subject matter experts, is substantially less detailed in scope than an audit in accordance with the Generally Accepted Auditing Standards (GAAS). OCA plans and performs the review to obtain sufficient, appropriate evidence to provide a reasonable basis for its findings and conclusions based on the objectives; accordingly, OCA does not express an opinion on the data gathered by the subject matter experts.

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I. Introduction

a. Purpose

The Office of the Commission Auditor (OCA) produced this report in response to a request from the Board of County Commissioners (BCC) at its May 21, 2019 meeting (see File No. 191378).[1] During the meeting, the BCC discussed the County's existing policy on its Compressed Natural Gas (CNG) fleet. The discussion focused on the long-term feasibility of transitioning the County's heavy fleet to CNG, while considering other existing and emerging energy alternatives. During discussion, the BCC requested for OCA to research and deliver a report on this discussion topic.

b. Scope

The scope of the report encompasses:

(1) The existing County CNG policy for heavy fleet, e.g., transit buses and refuse trucks;
(2) The County's current operating CNG fleet landscape, including capital investment and fuel station infrastructure;
(3) The return on investment for the County's heavy fleet and infrastructure costs;
(4) Review of conventional and alternative energy technologies powering heavy fleet; and
(5) Examination of select public and corporate entity fleet operations powered by alternative energy technologies.

c. Methodology

OCA conducted qualitative academic research to acquire a technical understanding of CNG, including how the fuel is sourced and its environmental advantages and disadvantages. OCA examined other commercially available energy technologies for powering both public entity and corporate heavy fleets. In an effort to document trends and establish a benchmark for the BCC to consider establishing a sustainable green fleet policy, OCA surveyed transit and solid waste operations across selected jurisdictions and corporate entities. Moreover, OCA consulted relevant government regulatory agencies such as the U.S. Department of Energy and U.S. Environmental Protection Agency, gathering data relating to agency costs and social impacts across a range of alternative energy technologies.

The quantitative metrics and approach utilized for this report consisted of the following: (1) identifying the most cost-efficient bus type over its useful life by performing a Net Present Value (NPV) analysis; (2) quantifying the total cost by main expense categories for each bus type considered; and (3) projecting Miami-Dade County's total cost under two scenarios over a 12-year timeframe from 2020 through 2032 – the projected date of full compliance with the Board's resiliency and clean energy legislation. This financial analysis was prepared based on data collected from and in consultation with County departments, federal government entities and financial journals.

The methodology applied also examined social costs, such as production of criteria air pollutants (CAPs) and greenhouse gases (GHGs), to assess the environmental and health ramifications of the deployment of energy alternative heavy fleet. Finally, selected County departments contributed to this report by providing data relating to their current heavy fleet operations and the types of energy powering such fleet. The departments also contributed by providing information regarding their short- and long-term planning policies to transition existing heavy fleet to cleaner burning fuel technologies. That departmental contribution aided OCA's assessment of whether the County is moving toward achieving its GHG emissions reduction and associated resiliency and sustainability policy goals.

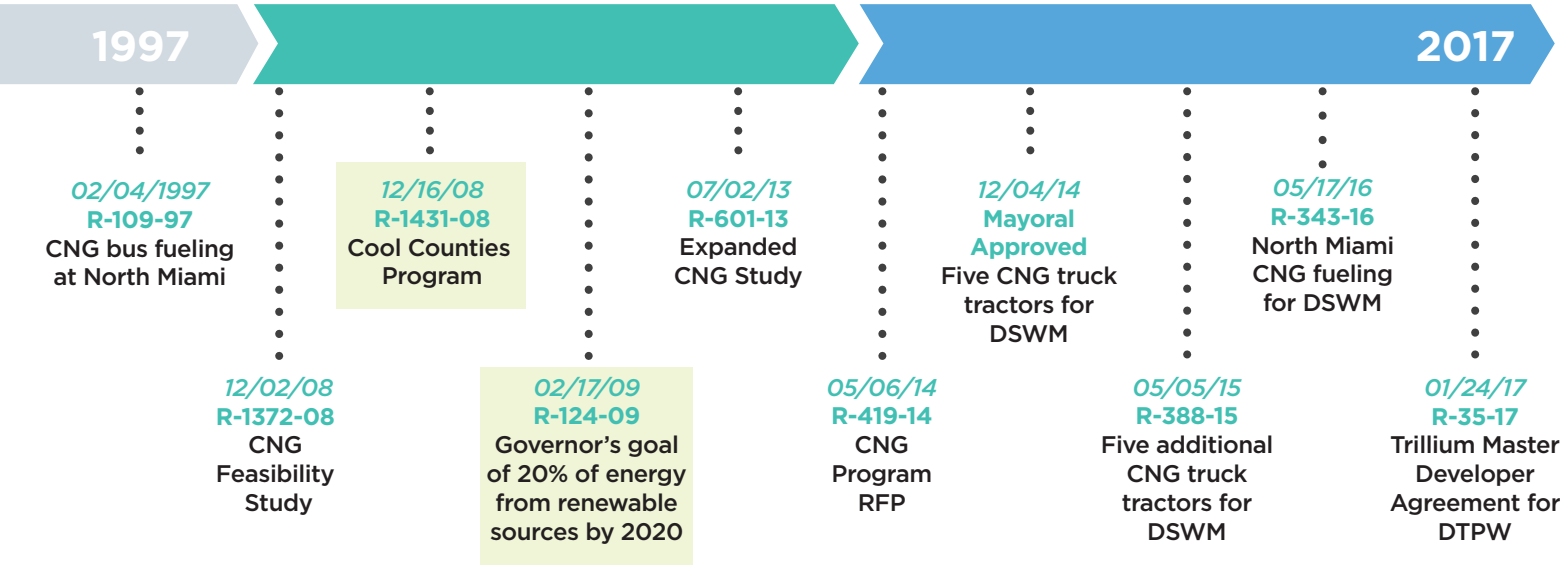
[1]Miami-Dade County Legistar No. 191378 (2019), http://intra/gia/matter.asp?matter=191378&file=false&yearFolder=Y2019

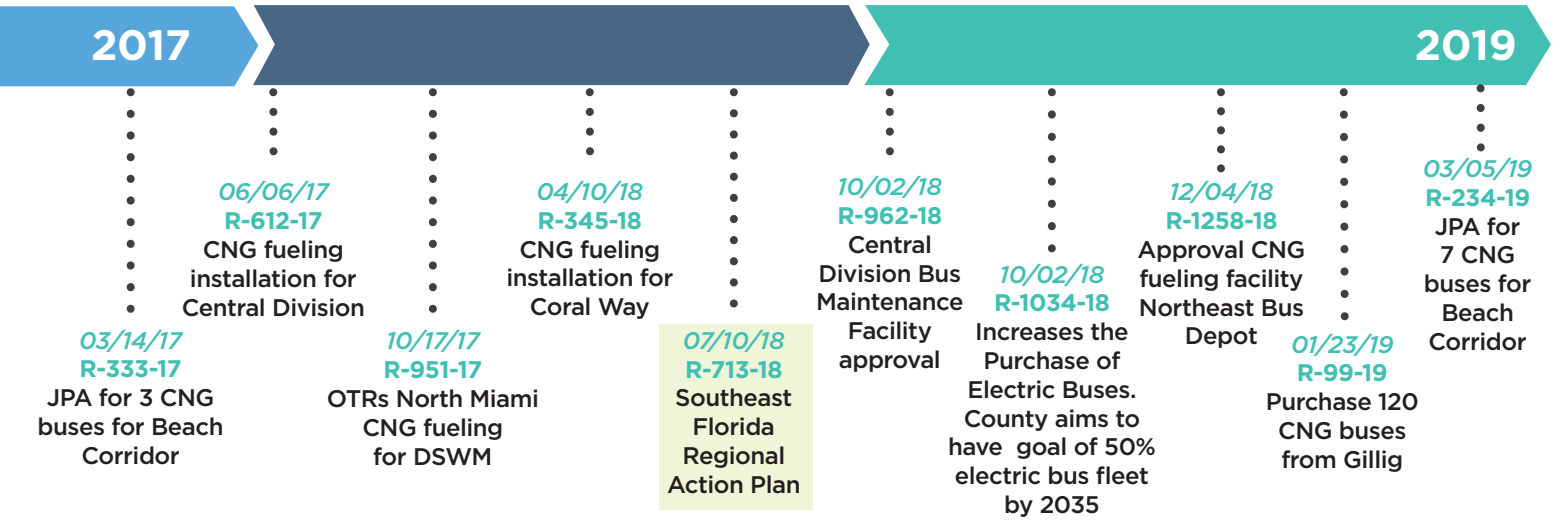
II. County's History of Clean Heavy Fleet Legislation, Policies and Contractual Developments

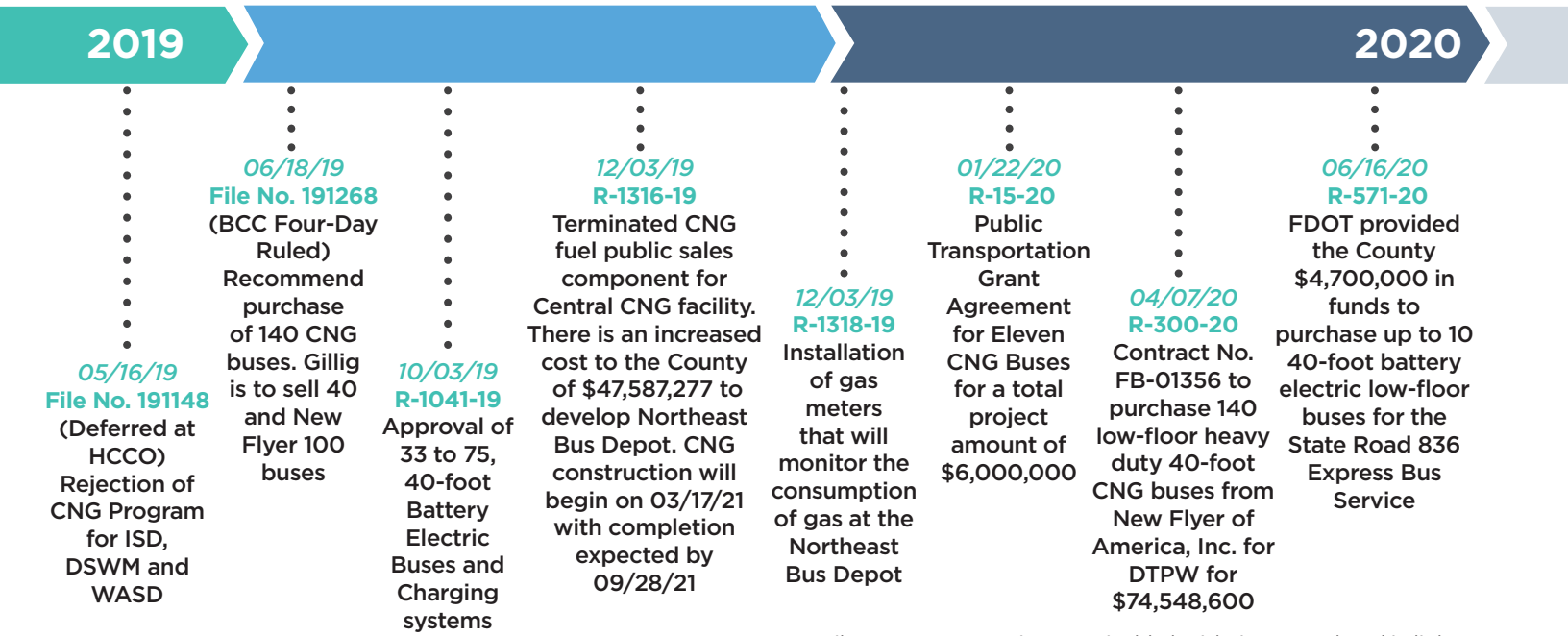
The timeline in **Graphic 1** depicts the chronological evolution of legislation approved by the BCC from 1997 through 2020.

Graphic 1 Miami-Dade County Policy & Legislative Chronology

CHRONOLOGY OF CNG POLICY & LEGISLATIVE DEVELOPMENT







*Milestones representing sustainable legislation are colored in light green

The County's history with CNG technology dates to the late 1990s. Pursuant to Resolution No. R-109-97, of February 4, 1997, the BCC ratified the execution of an agreement with the City of North Miami (City) allowing the County's transit agency to fuel CNG buses at the City's facility.[2] Per the agreement, the Department of Transportation and Public Works (DTPW) (formerly Miami Dade Transit Authority) fueled five CNG buses at North Miami's facility.

The BCC formalized its intent to transition to a cleaner burning energy fleet through Resolution No. R-1372-08, adopted on December 2, 2008.[3] The County Mayor was directed to study the feasibility of utilizing CNG in County vehicles, including transit vehicles and prepare a report stipulating the following: (1) the possible conversion of current vehicles; (2) the purchase of new vehicles; (3) hybrid CNG technology; (4) the infrastructure costs to dispense CNG; (5) the availability of natural gas and (6) possible funding sources. Nearly five years later, on July 2, 2013, Resolution No. R-601-13 refined the prior directive, now requesting the County Mayor to study the feasibility of using CNG or liquefied natural gas (LNG) to power County vehicles and the potential for public-private partnerships to supply natural gas and possibly generate revenue from those sales to other governmental entities.[4] The report also called for a cost benefit analysis of equipping County fuel servicing facilities with natural gas dispensing capabilities. The Administration responded to both resolutions via establishing a Compressed Natural Gas Planning Committee, drafting a solicitation for an energy and fuel savings services prequalification pool and ultimately steering the development and release of a solicitation for a transit CNG Program (See File No. 140032).[5]

On May 6, 2014, Resolution No. R-419-14 authorized the County Mayor to advertise a Request for Proposals (RFP) establishing a CNG Program.[6] The resolution authorized the advertisement of two solicitations inviting qualified proposers to deliver CNG programs. The first advertisement was for the Transit Department (currently Department of Transportation and Public Works). The second was for the Internal Services Department (ISD), the former Public Works and Waste Management Department (currently Department of Solid Waste Management) and the Water and Sewer Department (WASD). The selected proposer for each RFP would be required to negotiate a Master Developer Agreement to design, build, finance, operate and maintain CNG facilities and infrastructure. In the case of the Transit Department, the selected proposer would also convert the diesel bus fleet to CNG. Each RFP sought a single developer for implementation. The mayoral memorandum accompanying the resolution noted that fully implemented public-private partnerships would provide a positive fiscal impact for long-term fuel cost reductions and generate new revenue from CNG sales to private and public sector entities.

On December 4, 2014, the County Mayor approved a contract valued at up to $973,000 to purchase five CNG truck tractors for the Department of Solid Waste Management (DSWM). The acquisition was a pilot program providing DSWM and ISD an opportunity to compare performance and fuel savings between conventional and CNG powered fleets. On May 5, 2015, Resolution No. R-388-15, authorized additional expenditure authority of up to $973,000 for DSWM to expand the pilot program by purchasing five additional CNG-powered tractors.[7] DSWM confirmed that the additional tractors were never purchased. In an e-mail to OCA, the Department explained that it had canceled the order in July of 2015, as plans for

[2] Miami-Dade County Resolution No. R-109-97 (1997), http://intra/gia/matter.asp?matter=970209&file=false&yearFolder=Y1997
[3] Miami-Dade County Resolution No. R-1372-08 (2008), http://intra/gia/matter.asp?matter=082868&file=true&yearFolder=Y2008
[4] Miami-Dade County Resolution No. R-601-13 (2013), http://intra/gia/matter.asp?matter=131198&file=true&yearFolder=Y2013
[5] Miami-Dade County Legistar No. 140032 (2014), http://intra/gia/matter.asp?matter=140432&file=false&yearFolder=Y2014
[6] Miami-Dade County Resolution No. R-419-14 (2014), http://intra/gia/matter.asp?matter=140812&file=true&yearFolder=Y2014
[7] Miami-Dade County Resolution No. R-388-15 (2015), http://intra/gia/matter.asp?matter=150556&file=true&yearFolder=Y2015

a County fueling station were delayed.[8]

In the absence of a County CNG fueling station, the CNG-powered tractors were fueled via a Non-Exclusive Vehicle Fueling Services Agreement with the City of North Miami. That agreement was ratified by the Board on May 17, 2016 under Resolution No. R-343-16, for a term of one year with three, one-year options to renew.[9] The adopted legislation also authorized DSWM to spend up to $275,000 per fiscal year to fuel its CNG tractors.

On January 24, 2017, the BCC approved Resolution No. R-35-17, awarding a Master Developer Agreement to Trillium Transportation Fuels, LLC (Trillium) for a DTPW CNG Program in an amount not to exceed $428,773,000 for an initial 10-year term plus an option to renew for an additional 10 years.[10] The agreement's Scope of Work included the following:

- Finance, develop, construct, operate and maintain County CNG fueling stations at the Central Bus Depot and Coral Way Bus Depot;
- Convert existing facilities to accommodate CNG buses;
- Provide 300 CNG buses and CNG fuel; and
- Lease County property for public access to CNG fueling stations.

All 300 CNG buses have been delivered and are in service. The breakdown of the expenses under this resolution is as follows:

- $174,867,000 for CNG buses;
- $39,680,000 for CNG facilities;
- $82,049,000 for the purchase of CNG;
- $25,064,000 for operations and maintenance of CNG facilities; and
- $107,113,000 for the option term.

One of the components of the Trillium lease agreement was aimed to generate additional revenue to the County from the sale of CNG to the public. As of this report's publication date, the County has not yet generated revenue from the sale of CNG.[11] Construction of the Coral Way Depot, the only County depot where public sales are to take place, is still underway and scheduled for completion in September 2020.[12] The next CNG related development was via Resolution No. R-333-17, adopted March 14, 2017, which approved the County Mayor's execution of a Joint Participation Agreement (JPA) with the Florida Department of Transportation (FDOT) for $800,000 in State Transit Corridor Program funding to purchase three, 40-foot CNG buses for the Beach Corridor Alignment Project.[13] The agreement required a local match of $800,000. The buses were purchased and placed into service.

The County's second CNG infrastructure development action was approved by the Board on June 6, 2017, pursuant to Resolution No. R-612-17, authorizing a gas extension agreement with Southern Gas Companies doing business as Florida City Gas (FCG) to support DTPW's CNG Program, i.e., the Master Developer

[8] Email correspondence with DSWM dated July 25, 2019.
[9] Miami-Dade County Resolution No. R-343-16 (2016), http://intra/gia/matter.asp?matter=160954&file=true&yearFolder=Y2016
[10] Miami-Dade County Resolution No. R-35-17 (2017), http://intra/gia/matter.asp?matter=162416&file=true&yearFolder=Y2016
[11] Email Correspondence with DTPW dated March 21, 2020,
[12] Email correspondence with DTPW dated June 4, 2020,
[13] Miami-Dade County Resolution No. R-333-17 (2017), http://intra/gia/matter.asp?matter=170663&file=true&yearFolder=Y2017

Agreement with Trillium.[14] The agreement required the installation of equipment and gas meters to monitor the consumption of gas at the Central Division Bus Depot. The agreement required DTPW to provide and maintain, at no cost to FCG, a suitable space for metering and associated equipment. FCG estimated an annual revenue of $398,039 and a maximum allowable construction cost estimated at $2,388,234.

On October 17, 2017, pursuant to Resolution No. R-951-17, the Board retroactively approved the County Mayor's exercise of the first one-year option to renew period under the Non-Exclusive Vehicle Fueling Services Agreement with the City of North Miami.[15] The resolution also authorized the last two, one-year option periods, with the initial one-year term commencing on October 27, 2016. Since a County CNG fueling station was still unavailable, DSWM continued to rely on the City of North Miami's CNG facility to fuel its five CNG-powered tractors. The City of North Miami ceased providing CNG services on October 6, 2017, the date its pumps failed, resulting in DSWM's placement of its CNG tractors out of service while the department awaited the construction of a DTPW fueling site. Subsequently, DSWM commenced using DTPW's Central Bus Depot on May 8, 2019 to fuel the department's CNG truck tractors.[16]

On April 10, 2018, Resolution No. R-345-18 authorized a gas extension agreement with Florida City Gas for development of the Coral Way Bus Depot CNG fueling station.[17] As with the development of the Central Division Bus Depot fueling station, this agreement supported the Master Developer Agreement with Trillium for the DTPW CNG Program. FCG estimated an average annual revenue of $113,914 and a maximum allowable construction cost estimated at $683,484.

On October 2, 2018, pursuant to Resolution No. R-962-18, the Board approved the plan for the DTPW Central Division CNG Bus Maintenance Facility located at 3300 NW 32 Avenue.[18] The facility is designed to serve as the wash and fuel hub, including a public fueling station, for the County's CNG transit fleet. The facility is scheduled to be operational during the 2020 calendar year. Per the mayoral memorandum accompanying the resolution, funding for the facility will be from People's Transportation Plan (PTP) Surtax, General Fund, fees collected from the cost of the CNG fuel and $2,000,000 in projected revenues from the proposed public fueling station.

Since adoption of Resolution No. R-962-18, DTPW accepted a termination of the lease for the CNG Public Access Station at the Central Bus Depot due to changing market conditions for fuel costs (see Legistar File No. 200307).[19] More specifically, the developer intended to construct the public fueling facility at its own cost. However, according to information received from DTPW, the developer later determined that it was not "cost beneficial" to build the facility. As such, the lease reverted to the County.[20]

Not long after the approval of the Central Division CNG Bus Maintenance Facility, on December 4, 2018, the Board, through Resolution No. R-1258-18, determined that it was in the County's best interest to construct another CNG fueling facility; this time it was to be located at the Northeast Bus Depot. Accordingly, the Board exercised the option in the Trillium Master Developer Agreement to construct a

[14] Miami-Dade County Resolution No. R-612-17 (2017), http://intra/gia/matter.asp?matter=171964&file=false&yearFolder=Y2017
[15] Miami-Dade County Resolution No. R-951-17 (2017), http://intra/gia/matter.asp?matter=171013&file=true&yearFolder=Y2017
[16] Email correspondence with DSWM dated July 24, 2019.
[17] Miami-Dade County Resolution No. R-345-18 (2018), http://intra/gia/matter.asp?matter=180404&file=true&yearFolder=Y2018
[18] Miami-Dade County Resolution No. R-962-18 (2018), http://www.miamidade.gov/govaction/matter.asp?matter=182207&file=true&fileAnalysis=true&yearFolder=Y2018
[19] Miami-Dade County Legistar No. *200307* (2020), http://intra/gia/matter.asp?matter=200307&file=false&yearFolder=Y2020
[20] Email correspondence with DTPW dated June 17, 2020.

third CNG fueling facility.[21] Moreover, the County Mayor was directed to procure additional CNG buses for operation from the Northeast Bus Depot. The rationale behind this directive was that constructing this CNG fueling station, along with the Central Bus and Coral Way Bus depots, promoted countywide operation of the new CNG bus fleet. CNG construction at the Northeast Bus Depot was set to begin on March 17, 2021 with completion expected by September 28, 2021.

To supplement the CNG fleet acquired via Trillium, on January 23, 2019, pursuant to Resolution No. R-99-19, the County purchased an additional 120 low-floor, 40-foot CNG buses from Gillig LLC (Gillig).[22] In doing so, the BCC accessed a Central Florida Regional Transportation Authority (doing business as LYNX) contract and approved an allocation of $69,210,520. These buses have been delivered and placed into service.

On March 5, 2019, the Board approved the County Mayor's execution of a second JPA with FDOT for the Beach Corridor Alignment Project. Through Resolution No. R-234-19, the County received $1,866,563 from FDOT to purchase seven, 40-foot CNG buses for operation on major routes connecting the beaches and Downtown Miami.[23] The JPA required for the County to provide a local match of $1,866,563. The buses have been purchased, delivered, and placed into service.

The second CNG Program, the procurement of heavy fleet for ISD, DSWM and WASD, was presented at the Health Care and County Operations Committee (HCCO) meeting of May 16, 2019. The item recommended rejection of all proposals received in response to *Request for Proposals No. RFP-00085, CNG Program*. The solicitation required a plan similar to the master plan described for the DTPW CNG Program with Trillium (see Legistar File No. 191148).[24]

Three firms responded to the solicitation: Clean Energy, Nopetro-OHL MDC and Trillium Transportation Fuels. The Competitive Selection Committee ranked Trillium highest. However, following application of the County's Local Preference Ordinance, the second-ranked proposer, Nopetro, was recommended for negotiations. Ultimately, the County Mayor recommended rejecting all proposals received, stating that the cost to implement the CNG Program far exceeded the potential savings.

Costs considered included constructing fueling stations and maintenance facilities and purchasing the CNG heavy fleet. The Mayor reasoned that rejecting the proposals would afford the County the opportunity to review its current fleet needs, emerging technology in the market, new advances in electric vehicle technology and projected fuel prices to determine the best course for the acquisition of cleaner burning heavy fleet for ISD, DSWM and WASD. The rejection item was deferred during the HCCO meeting.

To justify its recommendation rejecting all proposals received for the CNG Program, the County Administration requested an independent study from its natural gas energy consultant, TriEnergy Solutions, relating to the solicitation for a CNG Program for DSWM, WASD and ISD. The study concluded that an economic analysis did not show an energy fuel savings, i.e., a three-year or shorter payback period, were the County to covert its DSWM heavy fleet from diesel to CNG. TriEnergy explained that its conclusion was based on a combination of factors, such as the low diesel gallon annual consumption of DSWM's heavy fleet and the low contract fuel cost of diesel per gallon currently being obtained by the County. When

[21] Miami-Dade County Resolution No. R-1258-18 (2018), http://www.miamidade.gov/govaction/matter.asp?matter=182862&file=true&fileAnalysis=false&yearFolder=Y2018

[22] Miami-Dade County Resolution No. R-99-19 (2019), http://www.miamidade.gov/govaction/matter.asp?matter=190042&file=true&fileAnalysis=false&yearFolder=Y2019

[23] Miami-Dade County Resolution No. R-234-19 (2019), http://www.miamidade.gov/govaction/matter.asp?matter=190118&file=true&fileAnalysis=false&yearFolder=Y2019

[24] Miami-Dade County Legistar File No. 191148 (2019), http://www.miamidade.gov/govaction/matter.asp?matter=191148&file=true&fileAnalysis=true&yearFolder=Y2019

replacing 100 vehicles per year within a six-year period the result is a greater payback period and a negative dollar value in the annual simple payback.[25] In addition, the TriEnergy report mentioned other advantages in deploying a CNG-powered heavy fleet in the areas of environmental benefits, vehicle safety and maintenance cost .[26]

On July 15, 2019, an award for the purchase of up to 75, 40-foot battery-electric buses and the installation of associated depot chargers for a total cost of $72,176,322 came before the Transportation and Finance Committee. The procurement had originally been advertised on October 21, 2016, via a Request for Proposals. The item was removed by the Administration at the Transportation and Finance Committee meeting. The item was ultimately approved by the BCC on October 3, 2019 through Resolution No. R-1041-19, awarding the contract to Proterra, Inc. for a five-year term. The subject contract included the installation of depot chargers at DTPW's three maintenance garages.[27] An initial 33 battery-electric buses will be delivered by March 22, 2022, including one pilot bus to be delivered by May 10, 2021.[28]

On December 3, 2019, the BCC approved Supplemental Agreement No. 1 to the Master Developer Agreement with Trillium Transportation Fuels, LLC for the CNG Program for DTPW under Contract No. 00096. The agreement increased the contract amount by $47,587,277 by exercising the option for the development of the Northeast Bus Depot (see Resolution No. R-1316-19).[29] The companion item to this agreement was also approved by the BCC at the December 3, 2019 meeting, i.e., a resolution approving a gas service agreement with Peoples Gas System for installation of a gas pipeline to service DTPW's CNG Program. That agreement included the installation of gas meters to monitor the consumption of gas at the Northeast Bus Depot (see Resolution No. R-1318-19).[30] The design phase for the Northeast Bus Depot is underway and temporary fueling is already being provided.[31]

Pursuant to Resolution No. R-15-20, on January 22, 2020, the BCC approved a public transportation grant agreement with the State of Florida Department of Transportation (FDOT). The agreement provides State Transit Corridor Development Program funding in the amount of $6,000,000 to purchase up to 11 40-foot CNG replacement buses for the I-95 Express bus service.[32] The I-95 Express bus service had 3,679 boardings per day, in FY2017-2018.[33] This grant pays for buses that the County would have otherwise financed and acquired under one of the established bus procurement contracts. The grant is not for additional buses to what has already been ordered.[34]

The County's most recent CNG bus purchase was approved pursuant to Resolution No. R-300-20 on April 7, 2020.[35] The item approved award of *Contract No. FB-01356* to purchase 140 low-floor heavy duty 40-

[25] TRIENERGY SOLUTIONS, MIAMI-DADE COUNTY INTERNAL SERVICES DEPARTMENT COMPRESSED NATURAL GAS ANALYSIS (2017).
[26] *Id.*
[27] Miami-Dade County Resolution No. R-1041-19 (2019), http://intra/gia/matter.asp?matter=191770&file=true&yearFolder=Y2019
[28] Email correspondence with DTPW dated June 16, 2020.
[29] Miami-Dade County Resolution No. R-1316-19 (2019), http://intra/gia/matter.asp?matter=192708&file=true&yearFolder=Y2019
[30] Miami-Dade County Resolution No. 1318-19 (2019), http://intra/gia/matter.asp?matter=192709&file=true&yearFolder=Y2019
[31] Email correspondence with DTPW dated June 16, 2020.
[32] Miami-Dade County Resolution No. R-15-20 (2020), http://intra/gia/matter.asp?matter=192905&file=true&yearFolder=Y2019
[33] FLORIDA DEPT. OF TRANSPORTATION, 95 EXPRESS ANNUAL OPERATIONS REPORT: FISCAL YEAR 2017-2018 (2019), https://95express.com/wp-content/uploads/2019/06/2019-4-22_-95-EL-Annual-Report-FY2017-2018_General_Final.pdf
[34] Email Correspondence with DTPW dated June 29, 2020.
[35] Miami-Dade County Resolution No. R-300-20 (2020), http://intra/gia/matter.asp?matter=200176&file=true&yearFolder=Y2020

foot CNG buses from New Flyer of America, Inc. for DTPW for $74,548,600.[36] Delivery of all buses is scheduled to be complete by February of 2021. [37]

The next electric bus purchase was facilitated through a state-funded grant agreement approved by the BCC on June 16, 2020 (See Resolution No. R-571-20).[38] Under the agreement, FDOT provided the County $4,700,000 in funds to purchase up to 10 40-foot battery electric low-floor buses for the State Road 836 Express Bus Service. The required local match for this agreement is $4,700,000. There is an additional $100,000 needed for the estimated project cost which will be paid for by the County. DTPW anticipates delivery of the new buses in June 2021. [39] This grant pays for buses that the County would have otherwise financed and acquired under one of the established bus procurement contracts. The grant is not for additional buses to what has already been ordered.[40]

On June 23, 2020, the County Mayor provided the County Commission a report updating the Commission on the status of the previously mentioned deferred DSWM CNG procurement item. In the report, the Mayor explains the progress made by the Administration with Nopetro relating to RFP-00085. While RFP-00085 envisioned a conversion of 1,356 vehicles of the County's heavy fleet from various departments to CNG, the proposal from the vendor originally recommended for award, Nopetro-OHL MDC, was limited to conversion of DSWM's heavy fleet to CNG.[41] The Mayor set forth the following four assumptions arguably necessitating re-soliciting these services under a new RFP with an updated scope:

> 1. Gas prices have decreased substantially no longer resulting in a cost savings with CNG. Accordingly, the intent to use savings from CNG fuel to fund the renovation of ISD fleet maintenance facilities is not currently viable;
> 2. The RFP contemplated that 100 percent of all Public Works Waste Management (now DSWM) heavy fleet (640 vehicles) would be converted to CNG and not just 110 Truck Tractors and 82 Automated Side Loading Garbage Trucks, which is now being proposed;
> 3. In the future, DSWM is open to expansion beyond the 192 vehicles and one permanent fueling station, if the economics and environmental benefits justify such a decision, as CNG is bridge fuel from diesel to electric vehicles; and
> 4. While conversations to procure 192 CNG vehicles yield a viable program for both DSWM and Nopetro, it represents a significant deviation from the scope of the RFP. The recommended solution is to solicit under a new RFP.[42]

Opining on the matter, the County Attorney's office concluded that: (1) if the County were to propose any award under the RFP, its office would recommend that the supporting memo address any or all of the factors in support of the rationality of the item, including specifically addressing the issues already identified in the Mayor's memo regarding the changes in the conditions which formed the basis of the RFP; and (2) a potential award of a phase of the larger project clearly would be within the scope of the proposal received and evaluated, the award of a consolation contract limited in scope to that currently under consideration would not.[43]

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[36] *Id.*
[37] Miami-Dade County Resolution No. R-300-20 (2020), http://intra/gia/matter.asp?matter=200176&file=true&yearFolder=Y2020
[38] Miami-Dade County Resolution No. R-571-20 (2020), http://intra/gia/matter.asp?matter=201076&file=true&yearFolder=Y2020
[39] *Id.*
[40] Email Correspondence with DTPW dated June 29, 2020.
[41] Memorandum from Hugo Benitez, Assistant County Attorney, to Edward Marquez, Deputy Mayor, and Jennifer Moon, Deputy Mayor/Budget Director (February 20, 2020), *available at* https://www.miamidade.gov/mayor/library/memos-and-reports/2020/06/06.23.20-Report-Providing-an-Update-for-Potential-CNG-Fueling-Stations-and-Services.pdf.
[42] *Id.*
[43] *Id.*

OCA contacted multiple departments to acquire updates on the status of the abovementioned legislation. **Table 1** sets forth the status of each resolution as of July 14, 2020.

Table 1 Legislative Status Updates

Resolution and Adoption Date	Approval Body	Description	Managing Dept(s)	Status
R-1372-08/December 2, 2008	BCC	Use of CNG in MDC vehicles feasibility study	Mayor's Office	Requested from the Administration on June 5, 2020. Nothing was provided.
R-601-13/July 2, 2013	BCC	Use of CNG and LNG in MDC vehicles and potential P3 to supply gas feasibility study	Mayor's Office	The County conducted research in the marketplace through the Mayor's Compressed Natural Gas Planning Committee. ISD staff posted a draft scope of services for industry comment and drafted a competitive solicitation for such a program. The competitive solicitation was presented to the Finance Committee on January 2014 and was deferred to no time certain by the full Board under File No. 140032. The final CNG Planning Committee report was included as an attachment to the item.
NA/December 4, 2014	County Mayor	Purchase 5 CNG truck tractors for DSWM	SWM	Analyzing the performance and fuel cost difference between CNG tractors and the DSWM diesel tractors, CNG trucks operate 10-15% inefficiently with their fuel consumption as compared to their conventional counterparts. Regarding maintenance, CNG trucks will be 5-10% more expensive to maintain as they require additional spark plugs, annual tank inspections for the fuel system, and potentially more frequent PM's. Diesel pricing is more volatile as compared to CNG, with the recent tumble in prices per gallon the savings are significantly reduced. DSWM did not proceed with purchasing the additional 5 CNG tractors.
R-388-15/May 5, 2015	BCC	Increased expenditure to purchase an additional 5 CNG tractors for DSWM		
R-35-17/January 24, 2017	BCC	Trillium Master Developer Agreement for DTPW CNG Program	DTPW	Breakdown of how the expenses under this resolution will be incurred: 1. $174,867,000 for buses; 2. $39,680,000 for CNG facilities and facilities modifications; 3. $82,049,000 for the purchase of CNG (this is an allocation paid based on actual consumption); 4. $25,064,000 for operation and maintenance of the 2 facilities. All the vehicles have been delivered and are in service; both facilities are under construction and providing CNG through new fueling stations.

Resolution and Adoption Date	Approval Body	Description	Managing Dept(s)	Status
				This CNG Program implementation is consistent with the County's resiliency initiatives and will be part of meeting the 70% diesel reduction goal for the fleet.
R-333-17/March 14, 2017	BCC	JPA with FDOT for $800,000 in State Transit Corridor Program funds for 3 CNG buses	DTPW	Buses were purchased and placed into service.
R-612-17/June 6, 2017	BCC	Gas extension agreement with FCG for Central Division Bus Depot CNG fueling station		There is no cost to the County under this agreement as long as CNG is purchased; if the County had executed the agreement, they had done the improvements, and the County never purchased gas, the value of the improvements owed to the gas company would have been $2.3 million.
R-345-18/April 10, 2018	BCC	Gas extension agreement with FCG for Coral Way Bus Deport CNG fueling station	DTPW	There is no cost to the County as long as CNG is purchased. If the County had executed the agreement, they had done the improvements, and the County never purchased gas, the value of the improvements owed to the gas company would have been $193,351.
R-962-18/October 2, 2018	BCC	Development of Central Division CNG Bus Maintenance Facility	DTPW	The Central Division public fueling facility was removed; the developer was going to build it at their own cost; the developer recommended that it was not cost beneficial to build the facility. The lease reverted to the County. Public fueling will remain at the Coral Way Depot. There is no fiscal impact to this item, which was the Governmental Facilities Plan Central Division.
R-99-19/January 23, 2019	BCC	Purchase of 120 CNG buses from Gillig	DTPW	All the buses have been put into service.
R-234-19/March 5, 2019	BCC	JPA with FDOT for Beach Corridor Alignment Project for 7 CNG buses	DTPW	All buses have been purchased and put into service.
R-1041-19/October 3, 2019	BCC	Purchase of up to 75 BEB buses from Proterra	DTPW	33 Battery Electric Buses to be delivered by May 10, 2021 and remaining buses by March 22, 2022.
R-1316-19/December 3, 2019	BCC	Supplemental Agreement No. 1 to Trillium Master Developer Agreement to exercise the option to develop the	DTPW	Temporary fueling is already being provided; CNG construction at the Northeast Bus Depot will begin on March 17, 2021 with completion expected by September 28, 2021.

Resolution and Adoption Date	Approval Body	Description	Managing Dept(s)	Status
		Northeast Bus Depot		
R-1318-19/December 3, 2019	BCC	Gas service agreement with Peoples Gas System for the Northeast Bus Depot	DTPW	There is no cost to the County as long as CNG is purchased.
R-300-20/April 7, 2020	BCC	Purchase of 140 CNG buses from New Flyer	DTPW	140 New Flyer – Delivery of first bus by November 6, 2020 and remaining buses by February 12, 2021.
R-571-20/June 16, 2020	BCC	Grant Agreement with FDOT to acquire 10 electric buses for State Road (SR) 836 Express Bus Service	DTPW	Approved by the BCC at the June 16, 2020 BCC meeting.

Table 2 below summarizes the County's fiscal activity in support of cleaner burning heavy fleet. The fiscal activity shown, totaling $708,708,282, reflects both mayoral and BCC-approved allocations.

Table 2 County's Fiscal Activity

Approval Date	Resolution or Authority	Subject	Term	Approved Value
12/04/14	Approved under County Mayor's delegated authority	Five CNG tractors for DSWM	1 year	$973,000
05/05/15	R-388-15	Five additional CNG tractors for DSWM	1 year	$973,000
05/17/16	R-343-16	DSWM-City of N. Miami Fuel Services Agreement	1 year plus 3 additional 1-year OTRs	$275,000
01/24/17	R-35-17	DTPW CNG Program with Trillium	10 years plus one 10-year OTR	$428,773,000
03/14/17	R-333-17	FDOT JPA for 3 CNG buses for Beach Corridor Project	1 year and 8 months	$800,000
10/17/17	R-951-17	Renewing DSWM-City of N. Miami Fuel Services Agreement	3 years	$825,000
01/23/19	R-99-19	Purchase 120 CNG buses from Gillig for DTPW	2 years and 8 months	$69,210,520
03/05/19	R-234-19	FDOT Public Transit Grant Agreement for 7 CNG buses for Beach Corridor Project	1 year and 9 months	$1,866,563
10/03/19	R-1041-19	Purchase of up to 75 battery-electric buses for DTPW	5 years	$72,176,322
12/03/2019	R-1316-19	Supplemental Agreement No. 1 to a Master Developer Agreement	10 years	$47,587,277

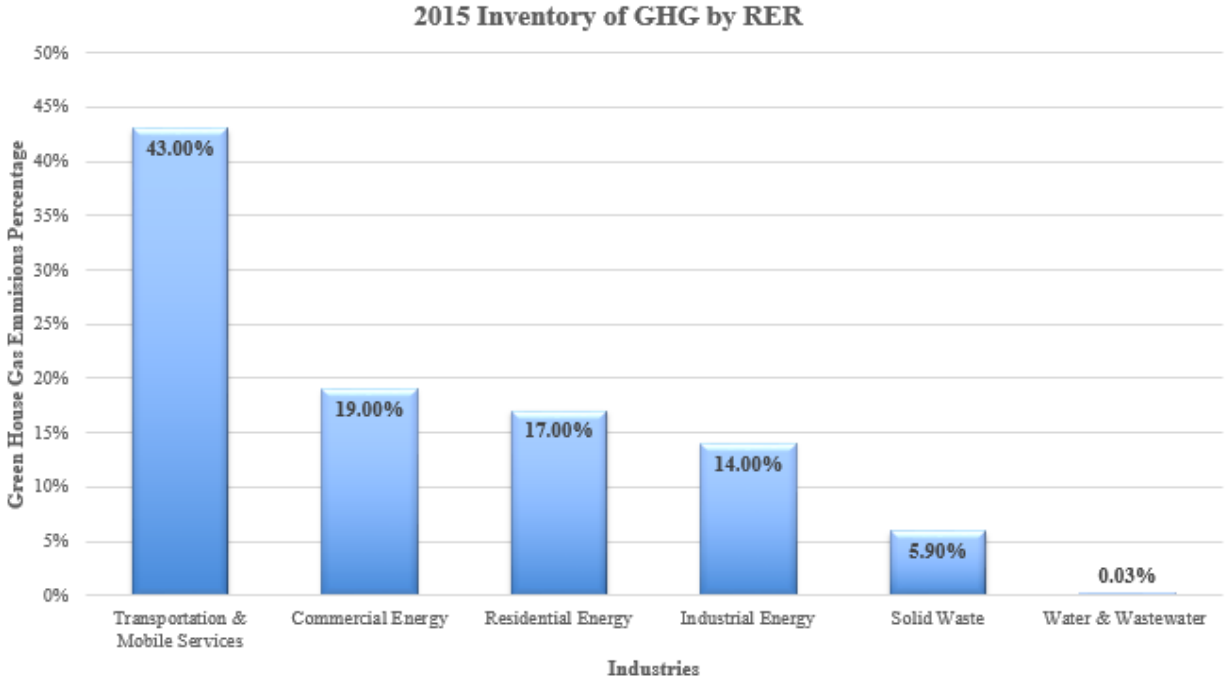
01/22/2020	*R-15-20	Grant Agreement with FDOT to acquire 11 CNG buses for I-95 Express Bus Service	N/A	$6,000,000
04/07/2020	R-300-20	Purchase of 140 CNG buses for DTPW	5 years	$74,548,600
06/16/2020	R-571-20	Grant Agreement with FDOT to acquire 10 electric buses for State Road (SR) 836 Express Bus Service. Buses are expected to be delivered by June 2021.	2 years and 6 months	$4,700,000
Total:				$708,708,282

*These funds are provided by FDOT grants.

a. Miami-Dade County Resiliency Policy and Sustainability Outlook

Pursuant to Resolution No. R-1431-08, Miami-Dade County on December 16, 2008 committed to participate in the U.S. Cool Counties Program.[44] Cool Counties Program members agreed to pursue the region-wide goal of reducing Greenhouse Gas (GHG) emissions by 80% from 2008 level emissions by 2050.[45] A 2015 inventory of GHG emissions by RER shows that various sectors throughout the County have reduced emissions. **Graphic 2** below highlights the strides the County has made with regard to GHG emissions reduction.[46]

Graphic 2 Percentage of GHG Inventory by Sector



On February 17, 2009, the BCC adopted Resolution No. R-124-09, supporting the State of Florida's Public Service Commission's goal of achieving 20% of Florida's energy from renewable sources by 2020, via the

[44] Miami-Dade County Resolution No. R-1431-08 (2008), http://www.miamidade.gov/govaction/matter.asp?matter=083495&file=true&fileAnalysis=false&yearFolder=Y2008

[45] *Id.*

[46] Miami-Dade County Climate Programs, Department of Regulatory and Economic Resources https://www.miamidade.gov/global/economy/resilience/county-climate-programs.page

use of solar, wind and biomass energy.[47] . The aforementioned resolution was interpreted by the department to be an urging and to date, the State has not passed any laws related to the item, and the State of Florida remains today one of only 12 states without a renewable energy portfolio standard or target/goal.[48] Furthermore, the County is a member of the Southeast Florida Regional Climate Compact (Compact). Other members of the Compact are Broward, Palm Beach and Monroe counties, with each member county committed to participate in a Regional Climate Team. The team's goal is to develop a Southeast Florida Regional Climate Change Action Plan addressing strategies for coordinated emission reductions from the transportation sector, including increased reliance on public transit, emerging vehicle technologies and advanced biofuels.[49]

On July 10, 2018, pursuant to Resolution No. R-713-18, the BCC accepted the Southeast Florida Regional Climate Action Plan 2.0, which includes actionable recommendations for regionally coordinated climate change mitigation and adaptation strategies and efforts in building community resilience.[50] It is a guidance document with options that each county and local government can voluntarily adopt. The energy and fuel goals of the plan are to reduce consumption of electricity and fuel while increasing renewable energy capacity, to reduce GHG emissions and improve emergency management and disaster recovery. To accomplish these goals, each region must promote a fuel-efficient public fleet that aligns with local GHG emission reduction targets. As noted in Miami-Dade County's Resilient 305 guide, one of the goals is to reduce GHGs by promoting public transit and dedicating more resources to the improvement of transit as a way to discourage single-vehicle usage.[51]

On October 2, 2018, pursuant to Resolution No. R-1034-18, the BCC established new goals for the reduction of gasoline and diesel fuel consumption in County operations. Specifically, the BCC directed that the County reduce from 2016 baseline year data, the consumption of gasoline by 30% and the consumption of diesel by 70% by 2028. Graphic 3 below illustrates the consumption of the aforementioned energy types from 2016 through 2019.[52] Under the resolution, the County Mayor was directed to use baseline inventory metrics that collects the following information for each County fleet vehicle class: (1) number of vehicles in fleet class; (2) average miles per gallon; (3) annual miles driven; (4) quantity of fuel consumed by fuel type; and (5) cost of fuel consumed by fuel type. Note that the consumption for the graphic was gauged from fuel dispensed at ISD facilities and does include the dispensing to other users such as the City of Miami and others that use our fueling facilities. There is currently no centralized system for the collection and reporting of this data. Additionally, the resolution directed the County Mayor to increase the purchase and use of electric buses and established a goal that, by 2035, the County's transit bus fleet has at least 50% battery electric powered buses.[53] The resolution evidenced the BCC's policy direction toward electrification of the County's passenger buses as a significant strategy for reducing carbon dioxide emissions in County operations.

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[47] Miami-Dade County Resolution No. R-124-09 (2019), http://www.miamidade.gov/govaction/matter.asp?matter=090133&file=true&fileAnalysis=false&yearFolder=Y2009

[48] Email Correspondence with RER dated March 30, 2020.

[49] SOUTHEAST FLORIDA REGIONAL COMPACT, *Regional Climate Action Plan 2.0* (Dec. 2017), available at https://southeastfloridaclimatecompact.org/about-us/what-is-the-rcap/

[50] Miami-Dade County Resolution No. R-713-18 (2018), http://www.miamidade.gov/govaction/matter.asp?matter=181326&file=true&fileAnalysis=false&yearFolder=Y2018

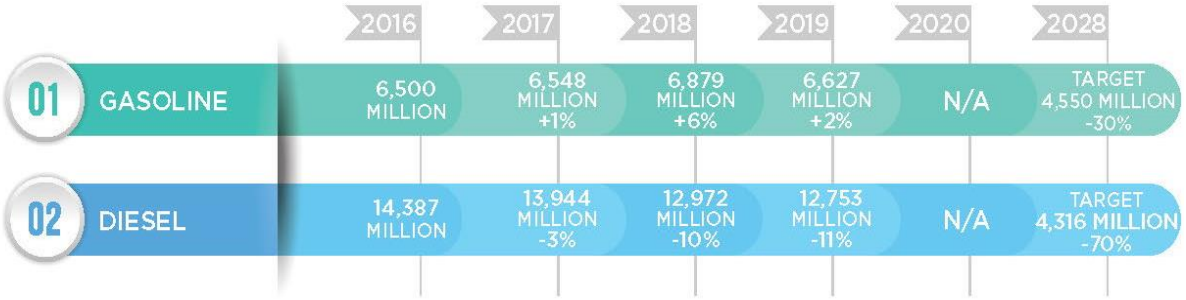
[51] Resilience 305, Office of Resilience, Miami-Dade County Department of Regulatory and Economic Resources, 2019, http://www.miamidade.gov/govaction/legistarfiles/Matters/Y2019/191773.pdf

[52] Email correspondence with ISD, June 5, 2020.

[53] Miami-Dade County Resolution No. R-1034-18 (2018), http://www.miamidade.gov/govaction/matter.asp?matter=182156&file=true&fileAnalysis=false&yearFolder=Y2018

Graphic 3 illustrates the progression of the County's gasoline and diesel fuel consumption over the last 3 years, using a numerical baseline and depicting the increase or decrease in percentage from the baseline year.

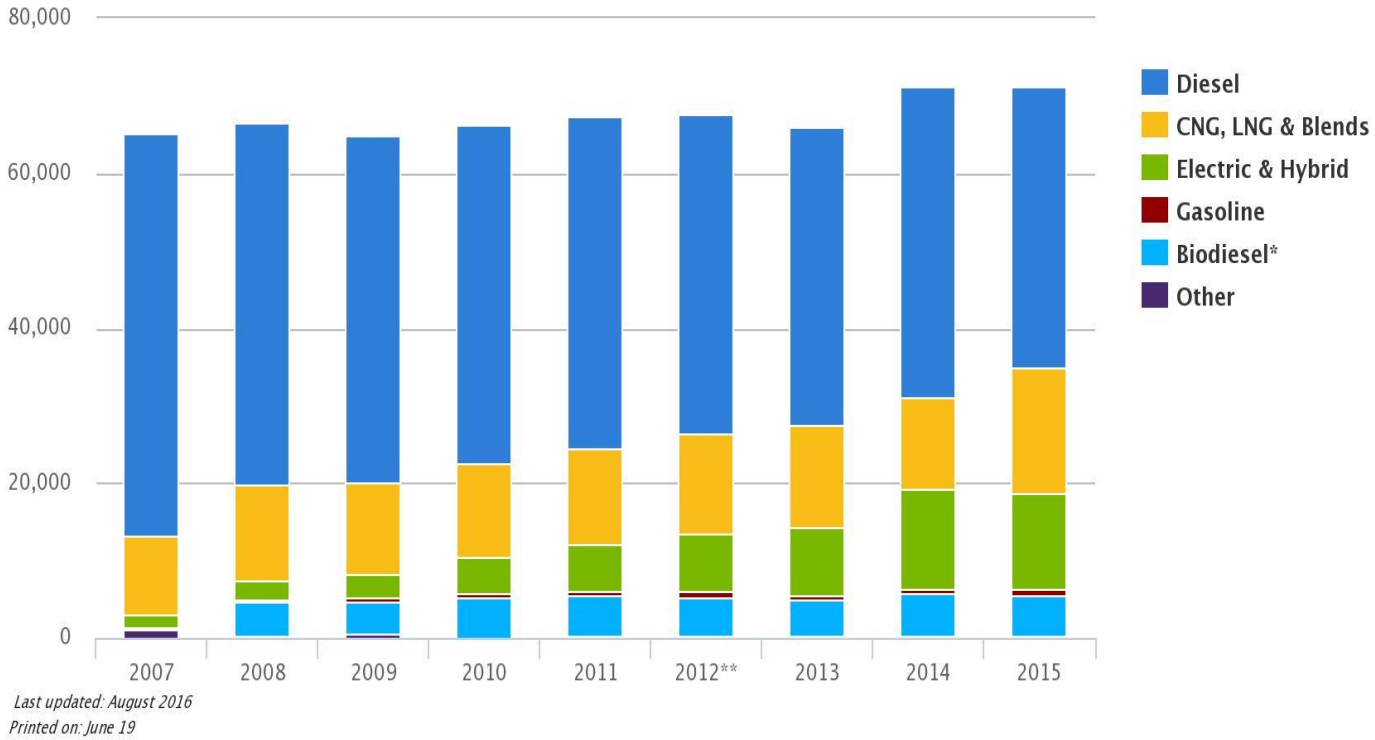
Graphic 3 Diesel and Gas Reduction Targets



A DOE review of transit buses by energy type from 2007 through 2015 shows diesel buses are heavily used in the U.S. market for the eight-year period analyzed. Nonetheless, diesel usage declined approximately 30% from 2011 through 2015. Diesel's decline in market share is evidenced by the growth in alternative energy types.[54]

Graphic 4 depicts the energy usage trend for U.S. transit buses by energy type.[55] According to the American Public Transit Association, diesel buses lead the market, but their numbers are declining due to a strong preference for cleaner technologies.[56]

Graphic 4 Energy Usage Trend for U.S. Transit Buses



Research relating to strategies reducing transportation emissions generally concludes that the transportation

[54] Alternative Fuels Data Center, *Maps and Data - U.S. Transit Buses by Fuel Type*, U.S. DEPT. OF ENERGY (Nov. 2018), https://afdc.energy.gov/data/10302

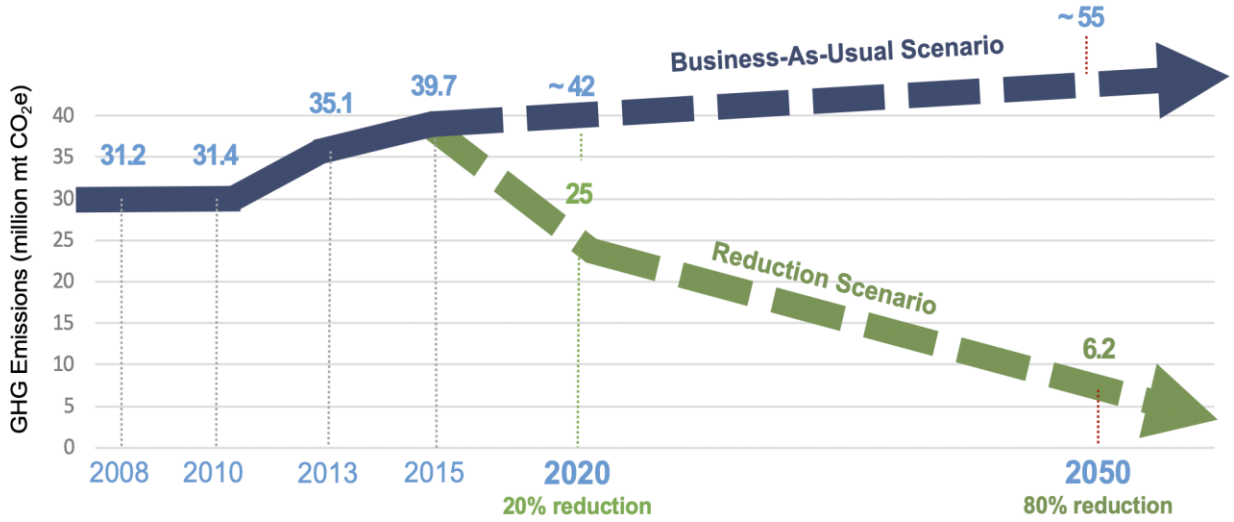
[55] U.S. Transit Buses by Fuel Type, https://afdc.energy.gov/data/10302

[56] *Id.*

sector is the largest source of GHG emissions in the United States. Research suggests that electrification of the transportation system, combined with a move to lower-carbon sources of electricity, can bring about the transformative change needed to curb climate change.[57] To mitigate these issues, Miami-Dade County's Resilient305 Strategy (released July 23, 2019) aims to continue collaboration among key stakeholders and work toward addressing the area's aging infrastructure, inadequate public transportation system and sea level rise.[58] Graphic 5 illustrates current emission trends with a reduction scenario to meet the target GHG emissions of 80% by 2050.[59]

Graphic 5 Emissions trends with the reduction scenario necessary to meet 2050 reductions goals.

Graphic 5 Emission Trends



Another mitigating factor to counter resiliency issues is through the implementation of progressive planning principles. Local governments have jurisdiction over land use, parking, and local road usage. Designing urban communities to promote walkability and transit-oriented developments (TODs) plays a vital role in reducing emissions in the transportation sector.[60] According to the American Society of Landscape Architects, cities can lower their carbon footprint by increasing their transit ridership, walking, cycling and reducing car use.[61] As such, a 2014 study found that these alternatives to using a car can help reduce transportation emissions by 40%, as well as potentially saving more than $100 trillion in public and private capital and operating costs of urban transportation between now and 2050 and eliminate about 1.7 gigatons of carbon dioxide (CO2) annually – a 40 percent reduction of urban passenger transport emissions – by 2050.[62] One option is for urban planners to adopt landscape-oriented strategies to help reduce emissions. For example, urban trees reduce an area's overall carbon footprint by absorbing carbon dioxide, which then offsets emissions.[63]

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[57] Vicki Arroyo, Kathryn Zyla, and Gabe Pacyniak, *New Strategies for Reducing Transportation Emissions and Preparing for Climate Impacts*, 44 Fordham Urb. L.J. 919 (2017). https://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?article=2701&context=ulj (*see page 921*)

[58] Resilient305 Strategy (2019), http://www.miamidade.gov/govaction/matter.asp?matter=191773&file=true&fileAnalysis=false&yearFolder=Y2019

[59] Email correspondence with RER, June 9, 2020

[60] Miami Dade Green Print (2020) *http://www.miamidade.gov/greenprint/pdf/landuse_transportation.pdf*

[61] AMERICAN SOCIETY OF LANDSCAPE ARCHITECTS, *Climate Change Mitigation: Cities* (2019). https://www.asla.org/mitigationurban.aspx

[62] *Id.*

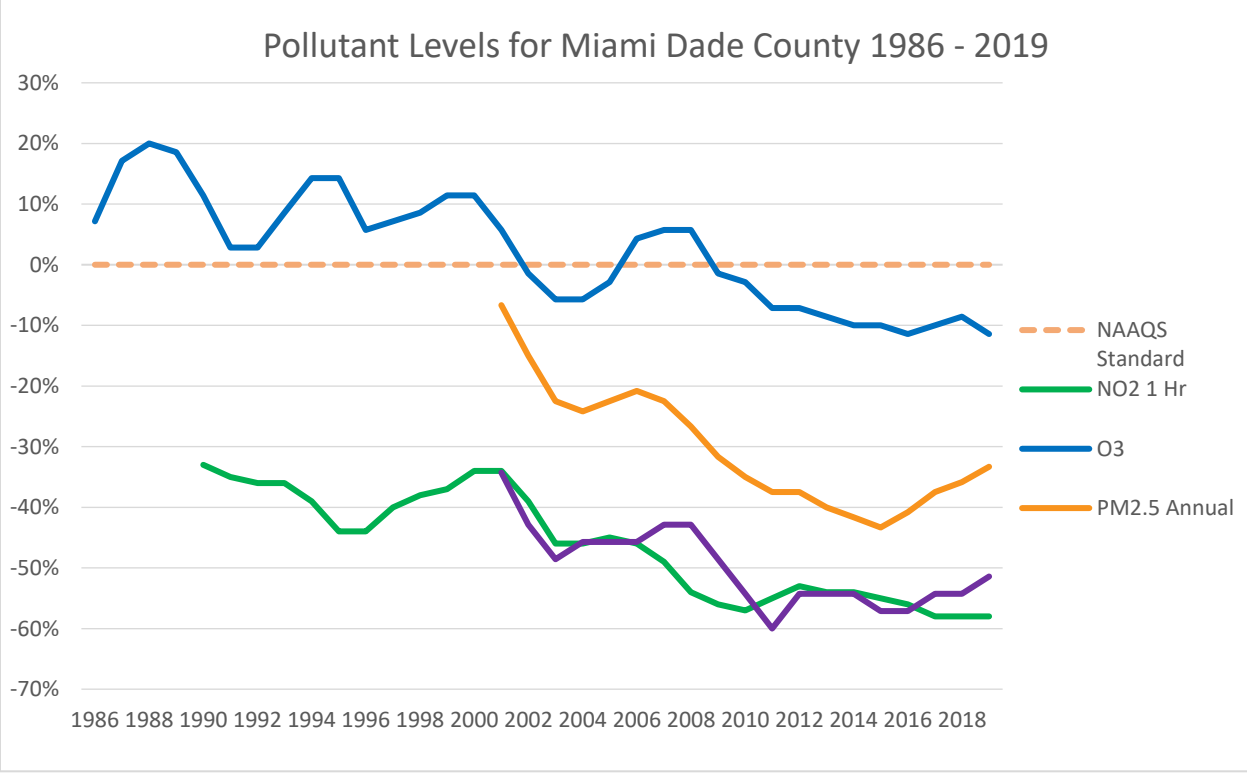
[63] *Id.*

With regards to Miami-Dade County efforts, the County's Comprehensive Development Master Plan (CDMP) contains language relating to energy conservation. The CDMP's transportation element goal is to "develop, operate and maintain a safe, efficient and economical traffic circulation system in Miami-Dade County that provides ease of mobility to all people and for all goods, is consistent with desired land use patterns, conserves energy, protects the natural environment, enhances non-motorized transportation facilities, supports the usage of transit and stimulates economic growth." The objective is to develop a transportation system that conserves energy; addresses climate change impacts and improves air quality.[64]

Miami-Dade County's Department of Regulatory and Economic Resources (RER) monitors the following five Criteria Air Pollutants, which are considered key contributors to environmental and health damages: (1) Ozone (O3), a highly reactive gas composed of three oxygen atoms; (2) Nitrogen Dioxide (NO2), an air pollutant contributing to the formation of photochemical smog, which can have significant impacts on human health; NO2 is the GHG released from the combustion of diesel energy; (3) Sulfur Dioxide (SO2), a colorless gas with a strong odor that is formed when fuel containing sulfur, such as coal and oil, is burned, creating air pollution; (4) Carbon Monoxide (CO), an odorless, colorless gas, which can cause sudden illness and death, is produced when a fossil fuel is burned; and (5) Particulate Matter (PM), defined as particles suspended in the air, including dust, dirt, soot, smoke and liquid droplets with diameters that are 2.5 micrometers and smaller. Of the five pollutants, O3 and PM have the greatest impact on Miami-Dade County's air quality.

Graphic 6 below is the National Ambient Air Quality Standards (NAAQS) table, showing downward GHG trends for these pollutants between 1986 and 2018 in Miami-Dade County.[65]

Graphic 6 GHG Trends



Recent efforts from the Southeast Florida Regional Climate Change have netted positive legislative actions at the State level. During the 2020 legislative session, State lawmakers enacted the first major climate-

[64] Email correspondence with RER dated July 1, 2019.
[65] Email correspondence with DERM RER dated June 9, 2020;

related legislation in a decade. Senate Bill 178, Public Financing of Construction Projects, was adopted and will require state and local governments to conduct a Sea Level Rise Impact Projection Study (SLIP) prior to construction of any state-funded projects within a coastal building zone.[66] The study, once completed, must be published in the State's Department of Environmental Protection's (FDEP) website for 30 days prior to any construction commencing. The bill also authorizes the FDEP to file court orders that would stop construction as well as compel jurisdictions to repay state funds if construction were to occur without following the adopted regulatory requirements.[67] The Compact has also been behind the passing of Senate Bill 7018, Essential State Infrastructure, which requires the Florida Department of Transportation (FDOT) to create a master plan for electric vehicle charging infrastructure along the State Highway System.[68]

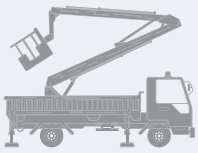
III. Current County Heavy Fleet Operational Landscape

While this report primarily examines the heavy fleets of DTPW and DSWM, as both departments are in the process of transitioning their heavy fleets to cleaner energy alternatives, in an effort to gain an understanding of the County's total heavy fleet population, OCA surveyed all County departments. The results of the survey demonstrate that the County maintains a sizeable heavy fleet inventory to support its vast operations. According to FleetNetAmerica, heavy fleet is defined as heavy-duty trucks that exceed 26,001 pounds.[69] For purposes of this report, OCA focuses on heavy fleet vehicles that have the capability of transitioning from conventional fuels to cleaner burning energy alternatives, such as buses, refuse trucks and truck tractors.

Graphic 7 below shows the County's total heavy fleet inventory by vehicle type as of March 31, 2020; the specific vehicle classes are: bus, refuse truck, fire truck, EMT truck, truck tractor, dump truck, bucket truck, straight truck and sewer cleaner. As previously indicated, currently, there is no centralized capability to review heavy fleet inventory by vehicle type and department.

[66] Southeast Florida Regional Climate Change Compact (2020), https://southeastfloridaclimatecompact.org/news/floridas-2020-legislative-session-recap/
[67] *Id.*
[68] *Id.*
[69] Becca Soard, *Classifying Medium and Heavy-duty Trucks*, FLEETNET AMERICA (Sept. 19, 2017), https://fleetnetamerica.com/blog/post/classifying-medium-and-heavy-duty-trucks

Graphic 7 Heavy Fleet Inventory

	PROS	WASD	AVIATION	DSWM	MDFR	DTPW	TOTAL
 BUS	2	0	40	-	-	767	809
 REFUSE TRUCK	8	0	0	266	-	-	274
 FIRE TRUCK	0	0	12	-	100	-	112
 EMT TRUCK	0	0	4	-	79	-	83
 TRUCK TRACTOR	8	27	24	132	8	2	201
 DUMP TRUCK	50	99	7	5	-	0	161
 BUCKET TRUCK	8	12	2	1	-	4	27
 STRAIGHT TRUCK	45	21	0	5	-	26	97
 SEWER CLEANER	0	51	8	2	-	0	61
TOTAL	121	210	97	411	187	799	

GRAND TOTAL: 1,825

OFFICE OF THE COMMISSION AUDITOR

*Inventory values were provided by the relevant County department.

a. Miami-Dade County Department of Transportation and Public Works

Miami-Dade County's Metrobus system provides service spanning Miami-Dade County and parts of Monroe and Broward Counties, providing approximately 52 million annual passenger trips for Miami-Dade County's estimated 2.7 million residents.[70] DTPW has made strides in transitioning to a fleet powered by alternative energy technologies. The active fleet of DTPW is made up of 767 buses, of which 137 are Diesel Hybrid Electric, 420 are CNG and the remaining buses are diesel buses. Of DTPW's current active fleet, 55% are CNG buses with an additional 140 CNG buses scheduled to be delivered by February 2021.[71] The County is also expecting the delivery of 33-75 Battery Electric buses by 2021.[72]

The purchase price of CNG buses varies slightly between vendors, with New Flyer buses costing the County $561,000 each on average, and Gillig buses costing the County an average of $576,000 per bus.[73] The average CNG bus cost of $568,500 is 3.7% higher than the average cost per bus of $547,962 as calculated by taking the County's most recent diesel procurement multiplied by the global average compound price increase of 3.4%, from 2016-2020.[74] When comparing CNG bus cost to that of diesel-electric hybrid buses, the average unit cost of CNG buses is 26.1% lower than the diesel-electric hybrid bus cost of $769,312.[75] Additionally, the cost of a CNG bus is 36.5 % lower than the $895,200 average unit cost of a battery electric bus.[76]

While CNG buses may be slightly more costly than diesel buses, DTPW reports savings in the form of CNG fuel cost when compared to diesel. The fuel cost savings is achieved by DTPW paying $1.04 per diesel gallon equivalent of CNG compared to the average $2.49 per gallon of diesel fuel.[77] However, the cost of fueling DTPW's CNG fleet may be negatively affected by CNG's lower energy density, a factor which should be considered when comparing CNG savings.[78]

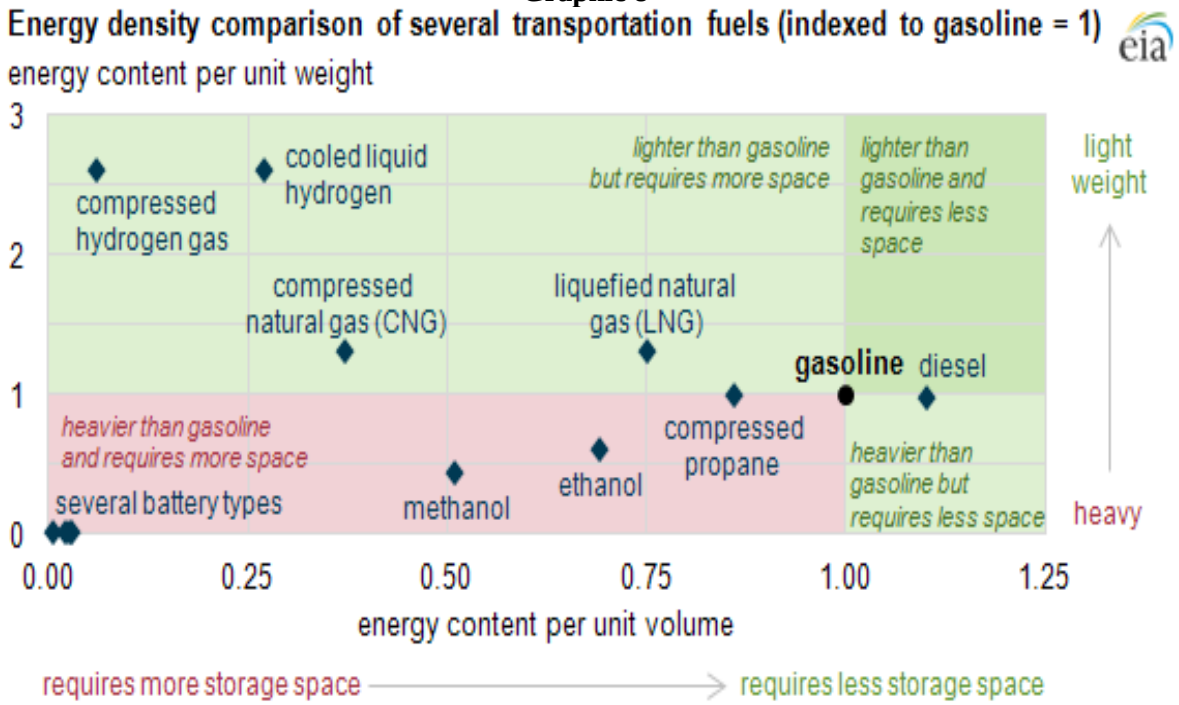
Energy density, or the amount of energy that can be stored in a given mass of a substance or system, is an important metric that needs to be considered when evaluating performance of alternative fuel vehicles when compared to their diesel counterparts. Fuels that require large or heavy storage can weigh down a vehicle causing it to operate less efficiently.[79] CNG, which requires significantly more storage space than diesel, is lighter than diesel but has lower energy densities per unit volume.[80] Compared to diesel, other fuel options may have more energy per unit weight, but none have more energy per unit volume.[81] It takes 6.38 pounds,

[70] June 18, 2019 Quarterly Fleet Status Report January – March 2019 – Directive 180356, http://www.miamidade.gov/mayor/library/memos-and-reports/2019/06/06.18.19-Quarterly-Fleet-Status-Report-January-March-2019-Directive-180356.pdf
[71] Email Correspondence with DTPW dated March 13, 2020.
[72] Miami-Dade County Resolution No. R-571-20 (2020), http://intra/gia/matter.asp?matter=201076&file=true&yearFolder=Y2020
[73] *Id.*
[74] Email correspondence with DTPW dated June 2, 2020.
[75] The costs of the hybrid buses was calculated by taking the average cost of 40' buses seen in the 2010 and 2014 County procurements as reported by DTPW. Email correspondence with DTPW dated June 2, 2020.
[76] The cost of battery-electric buses was calculated by taking the average cost per bus seen in the County's 2019 battery-electric bus procurement; Miami-Dade County Resolution No. R-1041-19 (2019), http://intra/gia/matter.asp?matter=191770&file=true&yearFolder=Y2019
[77] Email correspondence with DSWM dated February 10, 2020 and DTPW dated February 26, 2020.
[78] U.S. ENERGY INFORMATION ADMINISTRATION, *Few Transportation Fuels Surpass the Energy Densities of Gasoline and Diesel,* February 14, 2013, https://www.eia.gov/todayinenergy/detail.php?id=9991
[79] *Id.*
[80] *Id.*
[81] U.S. ENERGY INFORMATION ADMINISTRATION, *Few Transportation Fuels Surpass the Energy Densities of Gasoline and Diesel,* February 14, 2013, https://www.eia.gov/todayinenergy/detail.php?id=9991

or 139.30 cu ft. of CNG to achieve the energy content of one gallon of diesel.[82] The lower energy density of CNG generally results in limited driving range and thus greater fueling needs relative to diesel-powered vehicles.[83]

Graphic 8 below compares energy densities (both per unit volume and per unit weight) for several transportation fuels that are available throughout the United States.[84]

Graphic 8



Engine lifetime for transit buses and fleet life cycle can be used as additional metrics to analyze the costs of operating a transit bus system. DTPW reports that the County's current CNG bus fleet requires on average two engine replacements during the life of each bus. The first five years of the CNG bus's lifespan is covered under warranty for engine replacement at no cost to the County, with each engine replacement thereafter costing approximately $49,000.[85] Diesel buses also require, on average, two engine replacements over the 12 year average life of a bus, but at a cost of about $40,000 per replacement ($32,000 for the engine plus $8,000 labor).[86]

b. Department of Transportation and Public Works Infrastructure Development

While there are benefits to CNG in terms of fuel cost savings, the initial CNG infrastructure costs are significant. In October 2018, the BCC approved a major overhaul of the Central Bus Depot to incorporate CNG, including demolition of the existing fuel facility, construction of the new facility, and a retrofit of the bus maintenance garage to accommodate CNG buses. The cost of construction for the CNG facility is

[82] ALTERNATIVE FUELS DATA CENTER, DEPT. OF ENERGY *Alternative Fuels Data Center – Fuel Properties Comparison* (October 2014), https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf
[83] U.S. ENERGY INFORMATION ADMINISTRATION, *Few Transportation Fuels Surpass the Energy Densities of Gasoline and Diesel,* February 14, 2013, https://www.eia.gov/todayinenergy/detail.php?id=9991.
[84] *Id.*
[85] Email correspondence with DTPW dated June 4, 2020.
[86] Email correspondence with DTPW dated March 31, 2020.

$21,141,000 with completion expected August 10, 2020.[87] The DTPW Coral Way Bus Depot is also undergoing renovations to accommodate CNG. The project budget for construction of the Coral Way CNG facility, slated for completion September 25, 2020, is $18,539,000.[88] During this construction period, the two facilities operate temporary fueling dispensers to supply fuel to County CNG buses.[89] Upon completion, the Coral Way facility will also be open for public sales, making it the only CNG fueling station in Miami-Dade County with public fuel access.[90] The sales of CNG to the public are forecasted to generate County revenue—$1,550,250 over a 10-year period.[91] Florida City Gas is the fuel vendor for both facilities.[92]

After the December 3, 2019 Board approval of a supplemental agreement with Trillium, the County is also moving forward with a $47,587,277 additional investment in CNG infrastructure development in the County's Northeast Bus Depot, inclusive of a one-time construction cost of $18,495,365, a $20,032,740 allocation for the purchase of natural gas from TECO Gas Company, and $6,932,205 to operate and maintain the CNG equipment.[93] Construction at the Northeast Bus Depot will begin on March 17, 2021, with an anticipated completion date of September 28, 2021.[94]

These three facilities are capable of providing fueling to approximately 540 buses.[95] **Table 3** below depicts the address and status of all the CNG fueling sites located within Miami-Dade County as of June 15, 2020.[96]

Table 3 CNG Fueling Sites within Miami-Dade County

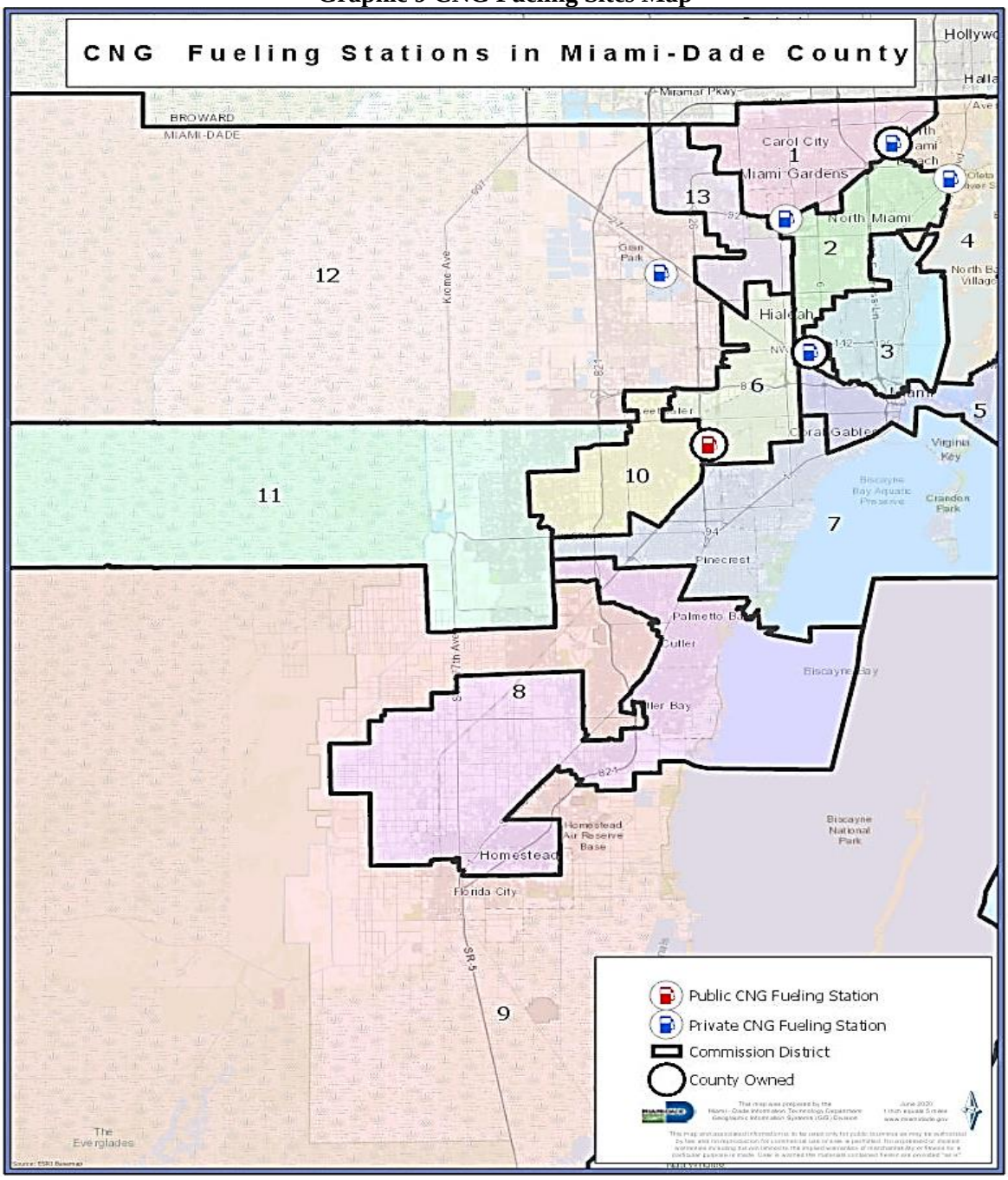
CNG Fueling Stations	Location	Status
Central - DTPW (Miami-Dade County)	3300 NW 32 Avenue, Miami, FL 33142	Temporary fuel dispensers for County buses. Current exclusive County use while under construction. Completion expected by August 10, 2020.
Coral Way - DTPW (Miami-Dade County)	2775 SW 74 Avenue, Miami, Florida 33155	Temporary fuel dispensers for County buses. Current exclusive County use while under construction. When construction is complete, it will be open for public sales. Completion expected by September 25, 2020.
Northeast – DTPW (Miami-Dade County)	360 NE 185 Street, Miami, FL 33179	Construction is expected to start March 17, 2021 and be completed by September 28, 2021.
Waste Management	9350 NW 89 Avenue, Medley, FL 33178	Active

[87] Miami-Dade County Resolution No. R-1316-19 (2019), http://intra/gia/matter.asp?matter=192708&file=true&yearFolder=Y2019; Email correspondence with DTPW dated June 4, 2020.
[88] Email correspondence with DTPW dated June 4, 2020.
[89] Email correspondence with DTPW dated June 20, 2019.
[90] Email correspondence with DTPW dated June 20, 2019; ALTERNATIVE FUELS DATA CENTER, U.S. DEPT. OF ENERGY, *Natural Gas Fueling Station Locations*, https://afdc.energy.gov/fuels/natural_gas_locations.html#/find/nearest?fuel=CNG (last visited June 15, 2020).
[91] Miami-Dade County Resolution No. R-1316-19 (2019), http://intra/gia/matter.asp?matter=192708&file=true&yearFolder=Y2019
[92] Email correspondence with DTPW dated June 12, 2019.
[93] Also included in the Trillium contract, increased to incorporate the Northeast Bus Depot CNG infrastructure buildout, are a ten percent contingency allowance account of $1,849,537, and a dedicated allowance account of $277,430 intended for Art in Public Places. Miami-Dade County Resolution No. 1316-19 (2019), http://intra/gia/matter.asp?matter=192708&file=true&yearFolder=Y2019.
[94] Email correspondence with DTPW dated June 4, 2020.
[95] *Id.*
[96] Email correspondence with DTPW dated July 29, 2019; ALTERNATIVE FUELS DATA CENTER, U.S. DEPT. OF ENERGY, *Natural Gas Fueling Station Locations*, https://afdc.energy.gov/fuels/natural_gas_locations.html#/find/nearest?fuel=CNG (last visited June 15, 2020).

CNG Fueling Stations	Location	Status
Waste Connections	13300 NW 38 Court, Opa Locka, FL 33054	Active
TECO Peoples Gas	15779 W Dixie Highway, Miami Beach, FL 33181	Active

Graphic 9 below illustrates the location of all the CNG fueling sites located within Miami-Dade County, including the three owned and operated by Miami-Dade County.[97]

Graphic 9 CNG Fueling Sites Map



[97] *Id.*

Three County maintenance facilities are also being retrofitted to support charging of the County's incoming electric fleet at a cost of $4,089,715 (for construction and installation). These charging stations are forecasted to provide simultaneous electric charging to a minimum of 33 electric buses.

c. Miami-Dade County Department of Solid Waste Management

ISD has explored transitioning County fleets to CNG. When ISD recommended rejecting proposals from *Request for Proposals No. RFP-00085* to establish a CNG Program for Solid Waste Management (DSWM) and other County departments in May 2019, ISD cited in its justification that the proposals had failed to demonstrate a cost savings, as required by the solicitation. ISD explained that while there would be a cost savings in the purchase of CNG over higher-priced diesel fuel, there was at least a $35,000 cost increase to purchase a CNG refuse truck, when compared to a traditional diesel refuse truck.[98] This cost differential, according to the Tri-Energy analysis, did not consist of savings from fueling using natural gas. The cost estimates did not consider additional costs for maintenance, fuel mileage differences and infrastructure requirements.

According to ISD, the CNG bus contract did not have the challenges that surfaced during the RFP for CNG refuse trucks. ISD indicated there were no discernable price differences between a CNG bus when compared to the cost of certain diesel buses. ISD also stated that there was more mileage output for buses that travel in the County as opposed to the County refuse trucks that have a lower mileage output, thus DTPW's CNG fleet achieves the needed savings per mile to compensate for the infrastructure costs of the fueling stations and retrofitting maintenance facilities while a DSWM CNG fleet would not.[99]

DSWM reported that one of its short-term strategic goals for transitioning its heavy fleet to cleaner energy was to determine the best mix of CNG vehicles for single generation investment, with an average generation ranging from seven to 10 years. DSWM's current total heavy fleet consists of 595 vehicles as of June 29, 2020, five of which are CNG truck tractors procured as part of a departmental CNG pilot program.[100]

DSWM operates 63 hybrid and 194 "clean diesel" trucks.[101] ISD noted that, as part of a 2010 federal emissions mandate, all newly-purchased heavy diesel vehicles within the DSWM fleet are "clean diesel compliant," meaning the vehicles utilize Ultra-Low Sulfur Diesel (ULSD) and are equipped with appropriate exhaust control technology.[102] ISD stated that the reduced GHG emissions resulting from ULSD were comparable to that of similar CNG vehicles, without the need for additional fueling infrastructure costs. A U.S. Department of Energy Office of Scientific and Technical Information study from 2003 reached the same conclusion: for all emissions, both technologies are shown to be comparable.[103] A 2016 article, however, does show that diesel has greater overall GHG emissions compared to CNG when considering the well to wheels lifecycle of a bus.[104] Moreover, DSWM currently has over 200 vehicles in

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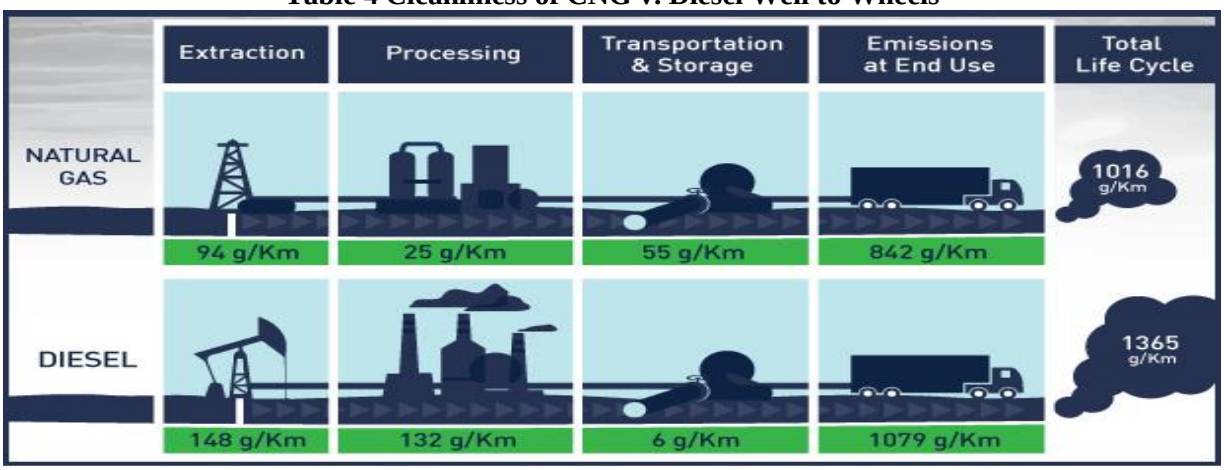
[98] Email correspondence with ISD dated June 13, 2019.
[99] *Id.*
[100] Email correspondence with DSWM on June 29, 2020.
[101] Email correspondence with DSWM dated August 2, 2019.
[102] In January 2001, the U.S. Environmental Protection Agency promulgated a rule to establish stringent standards designed to reduce emissions from on-road heavy-duty trucks and buses by up to 95% and to cut the allowable levels of sulfur in diesel fuel by 97%. Before EPA began regulating sulfur in diesel, diesel fuel contained as much as 5,000 parts per million (ppm) of sulfur. The rule prescribes more stringent regulations lowering the sulfur in diesel fuel to 15 ppm. This fuel is known as ultra-low sulfur diesel (ULSD). Beginning with the 2010 model year, the EPA's diesel standards required that all highway diesel fuel supplied to the market be ULSD, and all highway diesel vehicles use ULSD with the appropriate exhaust control technology. The U.S. Environmental Protection Agency, https://www.epa.gov/diesel-fuel-standards/diesel-fuel-standards-and-rulemakings
[103] Dana M Lowell et al., COMPARISON OF CLEAN DIESEL BUSES TO CNG BUSES, U.S. DEPARTMENT OF ENERGY OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION (2003), https://www.osti.gov/servlets/purl/829622.
[104] How Natural Gas Stacks up in the Race to Reduce Emissions, CLEAN ENERGY COMPRESSION (2016),

its fleet that are older than 2010 and are therefore not equipped with the appropriate exhaust control technology to yield the reduced emissions afforded by clean diesel.[105] Those vehicles will be retired over the next three years.[106]

Table 4 below depicts the cleanliness of both CNG and diesel from well to wheels, demonstrating CNG only has higher GHG emissions during the transportation & storage phase, while regular diesel has higher GHG emissions in the extraction, processing, and end of use phases.[107]

Table 4 Cleanliness of CNG v. Diesel Well to Wheels



As previously noted, DSWM has experienced CNG fueling challenges due to lack of CNG infrastructure.[108] As to whether DTPW's current fueling and maintenance facilities can accommodate the potential expansion of DSWM's CNG fleet, DTPW reported that the department would have to know the number of Solid Waste vehicles and the time needed to fuel the trucks in order to make this determination.[109] DTPW further stated that once its CNG fueling stations are fully functioning, DTPW could fuel approximately 24 DSWM refuse trucks per hour, per station with fueling taking place between 7:30 AM and 5:00 PM. Accommodating the potential DSWM CNG fleet at DTPW's fueling stations could present logistical concerns, but fueling a maximum of 10 DSWM vehicles per hour is not expected to disrupt the flow of bus and employee traffic on the existing bus lots.[110]

In the Mayor's June 23, 2020, memorandum to the Board providing an update on potential CNG conversion, it was stated that DSWM would require one permanent, fast-fill CNG fuel station at its 58th Street facility to accommodate 192 CNG vehicles comprised of 110 truck tractors and 82 automated side loading garbage trucks. Nopetro-OHL MDC stated that it could provide mobile fueling services to the acquired CNG fleet while this fueling facility is under construction.[111]

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https://www.cleanenergyfuels.com/compression/blog/natgassolution-part-1-clean-natural-gas-stack-race-reduce-emissions/.

[105] Email correspondence with DSWM dated June 2, 2020.

[106] *Id.*

[107] How Natural Gas Stacks up in the Race to Reduce Emissions, CLEAN ENERGY COMPRESSION (2016), https://www.cleanenergyfuels.com/compression/blog/natgassolution-part-1-clean-natural-gas-stack-race-reduce-emissions/.

[108] Email correspondence with DSWM dated July 25, 2019.

[109] Email correspondence with DTPW dated June 21, 2019.

[110] Email correspondence with DTPW dated January 13, 2020.

[111] Memorandum from the Mayor of Miami-Dade County to the Board of County Commissioners, Report Providing an Update for Potential CNG Fueling Stations and Services (June 23, 2020), *available at* https://www.miamidade.gov/mayor/library/memos-and-reports/2020/06/06.23.20-Report-Providing-an-Update-for-Potential-CNG-Fueling-Stations-and-Services.pdf.

DSWM forecasts the department's transition toward electric vehicles in seven to 10 years, roughly the same time span as the lifecycle of a refuse vehicle.[112] DSWM recognizes that electric vehicles eliminate emissions, operate far more quietly, require less maintenance and potentially offer a unique opportunity to leverage its Resources Recovery Facility (RRF) to charge a future electric fleet.[113]

The daily operations of the RRF include separating recyclables for sale and incinerating up to 4,000 tons of waste, which generate approximately 60 megawatts of electricity per hour. Power generated at the facility is currently sold to a private company and supplied to the electrical grid, producing energy sufficient to operate the plant and to supply the electrical needs of approximately 35,000 homes.[114]

OCA's research found that, while it is DSWM's intent to eventually power its electric fleet from the electricity produced at the RRF, there are currently no approved plans or procurement efforts underway to power an electric fleet with energy produced at the RRF.

d. Financial Analysis per Bus Type – DTPW Fleet

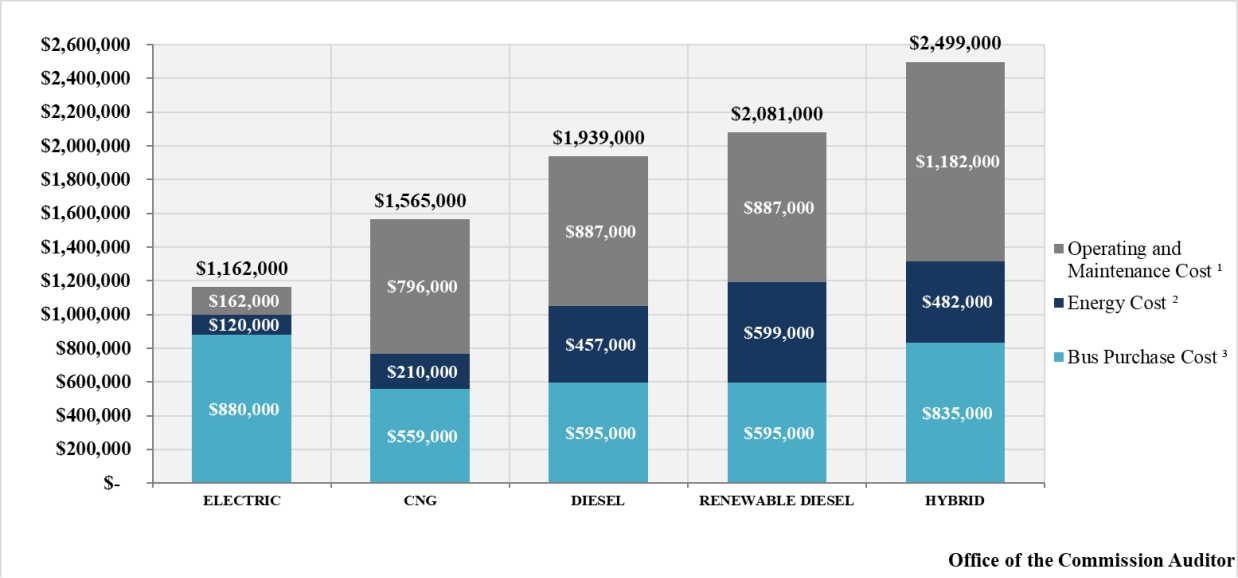
1. Projected Operating Cost per Bus Type

The Office of the Commission Auditor conducted an independent financial analysis on the Miami-Dade County's Department of Transportation and Public Works transit fleet, which currently operates a total of 767 diesel, compressed natural gas, and hybrid diesel electric (hybrid) powered buses.[115] In addition to the existing bus types, this analysis also considers battery-powered electric and renewable diesel (RD) powered buses.

Graphic 10 depicts results of the cost analysis[116] for different bus types described above projected over the average useful life of 12 years[117] at the market discount rate[118] to account for the time value of money. An electric bus resulted to be the most cost-efficient bus type across all with the total estimated cost of $1.16 Million while a hybrid bus with the approximate $2.50 Million is the least favorable option. This graph also illustrates that operating and maintenance cost is the highest across all cost categories, representing, 51% of the total projected operating cost for CNG, 47% for hybrid, 46% for diesel, 43% for RD buses except for electric, which represents only 14%.

[112] Email correspondence with DSWM dated June 13, 2019.
[113] *Id*.
[114] *Resources Recovery Facility*, MIAMI-DADE COUNTY, https://www.miamidade.gov/global/service.page?Mduid_service=ser150282068351856 (last visited October 30, 2019).
[115] Miami-Dade County transit fleet inventory as of April 1, 2020 provided by the DTPW via email correspondence received in June 2020.
[116] Cost analysis considers purchase price, fueling/energy cost, operating and maintenance cost of the bus with no revenues taken into account. It does not take into consideration the estimated time required for the infrastructure cost buildout or the time lag between the bus acquisition and its delivery if any.
[117] Email correspondence with DTPW dated July 2, 2020.
[118] A discount rate of 1.77% is estimated based on the 1.53% coupon rate for the 7-year term Miami-Dade County special obligation bond refinanced as of April 21, 2020 as per email correspondence with Miami-Dade County Finance Department received on May 26, 2020. This rate was further adjusted to include the variance between the 5- and 7-years treasury yield rates of 0.24% as of April 21, 2020. U.S. Department of Treasury, https://www.treasury.gov/resource-center/data-chart-center/interest-rates/pages/TextView.aspx?data=yieldYear&year=2020 (last visited May 27, 2020).

Graphic 10 Projected Cost Per Bus Type by Cost Category Over a 12-year Period



Notes

[1] "Operational and Maintenance Cost" (O&M cost) include: 1) maintenance and repair (M&R) - all preventive maintenance and repair costs, assuming 0.2%[119] increase year-over-year (YOY); 2) battery and engine replacement (B&E replacement) over the bus's lifespan. M&R cost per bus is calculated by multiplying an estimated M&R cost per mile for each bus type by the 45,286 average driven miles per year[120] over the 12-year period: diesel, hybrid, and CNG data provided by DTPW,[121] while an electric bus estimate is based on Proterra Proposal Response to Miami-Dade County attributable to RFP 00456.[122] On average, two B&E replacements are assumed to be required over the life of the CNG, diesel, RD and hybrid buses. The B&E replacement during the first five years of the CNG, diesel, RD and hybrid buses are covered by the warranty, thereafter, costing approximately $49,000,[123] $40,000,[124] $40,000[125] and $100,000,[126] respectively. An electric bus has a 12-year warranty on the battery;[127] therefore, the battery replacement cost was not considered.

[2] "Energy Cost" is estimated by multiplying the energy cost per mile[128] for each bus type by the average annual miles driven.[129] RD has a lower energy density content than diesel; as a result, it would take approximately 5% more RD to produce the same energy content as diesel.[130] RD energy cost per mile is

[119] 0.2% is the annual average variance on Consumer Price Index (CPI) for the period 2017 through 2019, which is used as a proxy for the yearly increase in the operating and maintenance cost. Bureau of Labor Statistics, U.S. Department of Labor, The Economics Daily, *Consumer prices increase 2.3 percent for the year ending February 2020*, http://www.bls.gov/opub/ted/2020/consumer-prices-increase-2-point-3-percent-for-year-ending-february-2020.htm (visited June 12, 2020).
[120] Email correspondence with DTPW received on June 5, 2020.
[121] Email correspondence with DTPW received on December 6, 2019.
[122] Miami-Dade County, *Proterra Proposal Response to Miami-Dade County, Department of Transportation and Public Works (DTPW) (2019)*, email correspondence with ISD received on May 6, 2019.
[123] Email correspondence with DTPW received June 4, 2020.
[124] Email correspondence with DTPW received March 31, 2020.
[125] Email correspondence with DTPW received May 5, 2020
[126] *Id.*
[127] *Id.*
[128] Email correspondence with DTPW received December 6, 2019.
[129] Email correspondence with DTPW received on May 5, 2020.
[130] Green Transportation Summit & Expo, Renewable Diesel Specifies: Panel, Richard Battersby, (2017)

calculated considering the percentage change of price per gallon between diesel and RD. Furthermore, 5% was applied to factor energy content. Projected YOY percent increase applied for energy cost is approximately 1%, which is based on the National Energy Modeling System (NEMS) from Energy Information Administration data,[131] which reflects market economics, industry structure, and existing energy policies and regulations that influence market behavior for energy prices.[132]

[3] "Bus Purchase Cost" for CNG and diesel buses considers the County's current procurements[133] with RD being equal to the diesel price.[134] Hybrid bus uses the latest available bus purchase cost of $743,700 from an available 2016 local government procurement[135] adjusted to include 3.4% of compounded annual growth in prices through 2020.[136] The electric bus purchase cost based on the negotiated price under Proterra agreement.[137]

2. Projected Compliance Estimates - Buses

The Office of the Commission Auditor estimated the financial impact of the current transit bus fleet to comply with the requirement of resolution R-1034-18 (2018), which is to have a transit fleet that consists of at least 50% battery-electric buses by 2035.[138] **Graphic 11** illustrates these projections for Scenario 1 (a low end scenario) and Scenario 2 (a high end scenario), assuming the replacement of buses from the current transit inventory at the end of their useful life,[139] this projection shows the County achieving full compliance by 2032. This analysis considers the replacement of 524 buses, of which 325 are currently in different stages of the procurement process and 199 recommended to be procured. For further details on the assumptions used, refer to Exhibit 1.

[131] "Energy Cost" is forecasted based on U.S. Energy Information Administration, Energy Prices by Sector and Sources, https://www.eia.gov/outlooks/aeo (last visited March 16, 2020).

[132] YOY percent increase is based on the National Energy Modeling System (NEMS) from Energy Information Administration data, which reflects market economics, industry structure, and existing energy policies and regulations that influence market behavior. Energy Information Administration, *The National Energy Modeling System, An Overview 2018 (2018)*. https://www.eia.gov/outlooks/aeo/nems/overview/pdf/0581(2018).pdf (last visited June 12, 2020).

[133] Email correspondence with DTPW received on June 2, 2020.

[134] RD has the same chemical structure as petroleum diesel, and it can be used in engines that are designed to run on conventional diesel fuel — with no blending required. Government Fleet, *What You Need to Know About Renewable Diesel*, March 10,2016, https://www.government-fleet.com/156621/what-you-need-to-know-about-renewable-diesel#:~:text=Because%20it%20has%20the%20same,fuel%20%E2%80%94%20with%20no%20blending%20required (last visited July 2, 2020).

[135] Tri-County Metropolitan Transportation District of Oregon Resolution 16-07-50 (2016) https://trimet.org/meetings/board/pdfs/2016-07-27/res-16-07-50.pdf

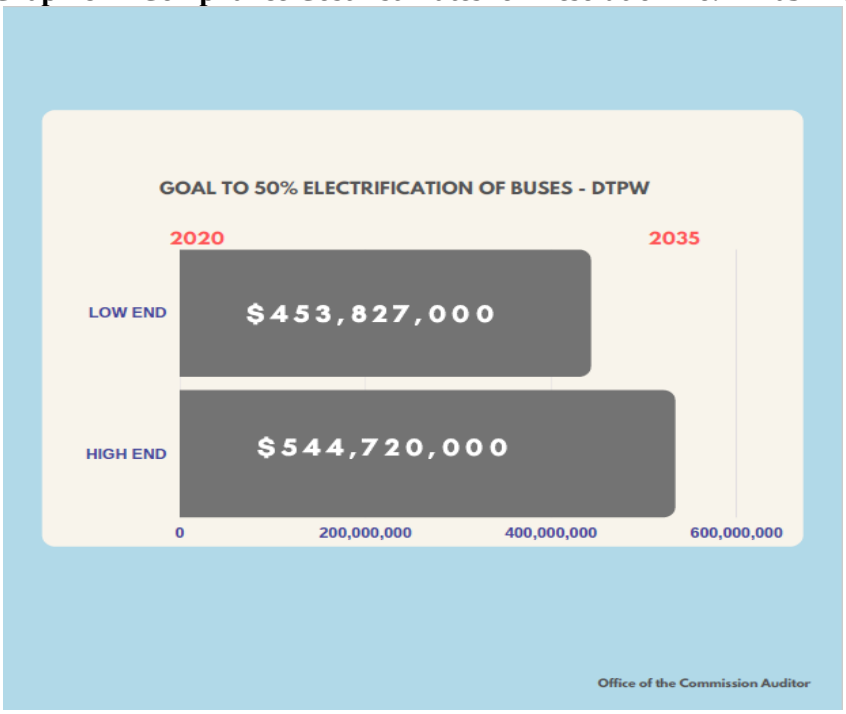
[136] FREEDONIA, GLOBAL BUS MARKET BY PRODUCT AND FUEL TYPE, 6TH EDITION (2001-2020).

[137] Miami-Dade County Resolution No. R-1041-19 (2019), http://intra/gia/legistarfiles/Matters/Y2019/191770.pdf

[138] Miami-Dade County Resolution No. R-1034-18 (2018), http://www.miamidade.gov/govaction/matter.asp?matter=182156&file=true&fileAnalysis=false&yearFolder=Y2018.

[139] The useful life of each bus is calculated from the bus make year over the period of 12 years based on Miami-Dade County transit fleet inventory as of April 1, 2020 provided by DTPW via email correspondence received on June 2, 2020.

Graphic 11 Compliance Cost Estimates for Resolution No. R-1034-18



Notes

The current Peak Vehicle Requirement (PVR) of 767 was used [140] through 2032. The Bus Purchase Cost for CNG buses considers the bus length, 40- and 60- foot, as well as a bus purchase cost range under each scenario.

"Bus Purchase Cost" in Scenario 1 assumes a price of $895,200[141] for each 40-ft electric bus and an estimated price of $1.2 Million[142] for a 60-ft electric bus, $929,000[143] and $1.3 Million[144] for Scenario 2, respectively, with the exception to the procured 75 40-foot electric buses under Proterra agreement with the average purchase price of $895,200 per bus.

Table 5 below shows the bus type mix of 767, from the current 2020 transit bus inventory to the year 2032 projected year of compliance with 50% CNG buses and 50% electric buses.

[140] "The Peak Vehicle Requirement (PVR) is the total number of buses needed simultaneously in the peak periods to satisfy passenger demand while keeping vehicle passenger loads at or below a pre-determined level, based on MDT's load factors." *Metrobus Fleet Management Plan,* Miami-Dade Transit, https://www.miamidade.gov/citt/library/strategic-financial-studies/2013/cost-other-studies/mandated-plan/2002-3%20MetrobusFMP-RevII.pdf (last visited June12, 2020).

[141] $895,200 is the negotiated price for a 40-foot electric bus under the Proterra agreement, used for a low end Scenario 1. Email correspondence with ISD received on May 6, 2019.

[142] $1.2 Million is the projected price for a 60-foot electric bus used for a low-end Scenario 1. Tong, F., Hendrickson, C., Biehler, A., Jaramillo, P., & Seki, S. Life cycle ownership cost and environmental externality of alternative fuel options for transit buses. TRANSPORTATION RESEARCH PART D: TRANSPORT AND ENVIRONMENT 57 (2017).

[143] $929,000 is the original price for a 40-foot electric bus under the Proterra agreement, used for a high end Scenario 2. Miami-Dade County, *Proterra Proposal Response to Miami-Dade County, Department of Transportation and Public Works (DTPW)* (2019), email correspondence with ISD received on May 6, 2019.

[144] $1.3 Million is the projected price for a 60-foot electric bus used for a high end Scenario 2.KOMONEWS, *King County Metro agrees to buy 40 new battery-electric buses* (2020), https://komonews.com/news/local/king-county-metro-agrees-to-buy-40-new-battery-electric-buses (last visited June 12, 2020).

Table 5 Current vs. Fully Compliant Total Count of Transit Bus Inventory by Bus Type

Bus Type	CURRENT STATE:		TARGET STATE:	
	Bus Count	Percentage To Total Bus Count	Bus Count	Percentage To Total Bus Count
CNG	420	55%	383	50%
HYBRID	137	18%	0	0%
DIESEL	210	27%	0	0%
ELECTRIC	0	0%	384	50%
TOTAL	**767**	**100%**	**767**	**100%**

Exhibit 1 Projected Replacement Schedule by Bus Type, Procurement and Scenario

BUS COUNT	CURRENT OR RECOMMENDED PROCUREMENT	INITIAL STATE:	TARGET STATE:	
		Bus Count and Type	SCENARIO 1: LOW END Bus Count and Type	SCENARIO 2: HIGH END Bus Count and Type
140	Current Procurement: • Resolution No.R-300-20 • Resolution No.R-15-20	140 Diesel (40 ft)	140 CNG (40 ft)	140 CNG (40 ft)
75	Current Procurement: Resolution No.R-1041-19	42 Diesel (40 ft) 33 Hybrid (40 ft | 60 ft)	75 Electric (40 ft)	75 Electric (40 ft)
10	Current Procurement: State-Funded Grant 438970-1-94-01	10 Hybrid (40 ft | 60 ft)	10 Electric (40 ft)	10 Electric (40 ft)
100	Current Procurement: RFP-01501	27 Diesel (40 ft) 73 Hybrid (40 ft | 60 ft)	100 Electric (60 ft)	100 Electric (60 ft)
199	Recommended Procurement	1 Diesel (40 ft) 21 Hybrid (40 ft | 60 ft) 177 CNG (40 ft)	199 Electric (40 ft)	199 Electric (60 ft)

e. Financial Analysis per Refuse Truck Type – DSWM Fleet

1. Projected Operating Cost per Refuse Truck Type

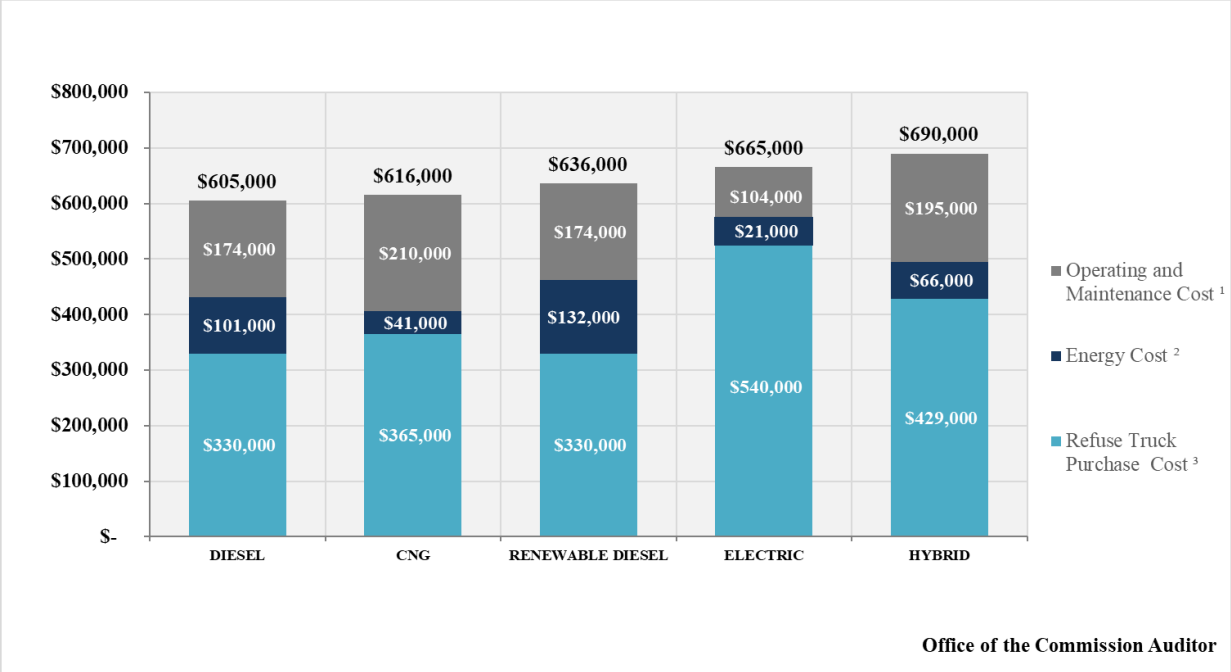
The Office of the Commission Auditor conducted an independent financial analysis on Miami-Dade County's Department of Solid Waste and Management refuse truck fleet, which currently operates a total of 266 "clean diesel"(diesel)[145] and hybrid-powered refuse trucks.[146] In addition to such refuse trucks types, this analysis also considers battery electric powered and renewable diesel powered trucks.

Graphic 12 depicts results of the cost analysis[147] for different refuse truck types described above projected over the average useful life of seven years[148] at the market discount rate[149] to account for the time value of money. The diesel refuse truck had the lowest estimated total operating cost of $605,000, while the hybrid

[145] Email correspondence with DSWM received on June 26, 2020.
[146] Miami-Dade County refuse truck fleet inventory provided by the DSWM via email correspondence received on July 2, 2020.
[147] Cost analysis considers purchase price, fueling/energy cost, operating and maintenance cost of the bus with no revenues taken into account. It does not take into consideration the estimated time required for the infrastructure cost buildout or the time lag between the refuse truck acquisition and its delivery if any.
[148] The DSWM refuse truck has a relatively short useful life of seven years due to the vehicle body being highly corroded because of its constant contact with the garbage. Received via email correspondence with DSWM on May 21, 2020.
[149] 1.37% is used as a discount rate based on the coupon rate of 1.37% on the Miami-Dade capital asset acquisition special obligation bond with a seven-year maturity. Email correspondence with Miami-Dade County Finance Department received on May 26, 2020.

refuse truck's estimated operating cost of $690,000 was the highest. This graph also illustrates that the purchase cost is the highest across all cost categories, representing, 81% of the total projected cost for electric, 62% for hybrid, 59% for CNG, 55% for diesel, and 52% for RD refuse trucks.

Graphic 12 Projected Cost Per Refuse Truck Type by Cost Category Over a 7-year Period



Notes

[1] "Operational and Maintenance Cost" (O&M cost) includes all preventive maintenance and repair costs associated with refuse trucks, assuming 0.2%[150] increase year-over-year (YOY). The O&M cost per refuse truck for diesel and RD is calculated by multiplying the estimated O&M cost per mile for each refuse truck type by the average 12,480 miles driven per year over the seven-year period based on the data provided by the DSWM. [151] The O&M cost for a CNG refuse truck is 23% higher than diesel[152], an upcharge for a hybrid refuse truck is approximately 13%[153], while the cost for electric is 60% of conventional refuse truck O&M cost. Battery and engine replacement cost is not considered due to the relatively short useful life of the truck.[154] Diesel and RD O&M cost is based on department numbers.[155]

[2] "Energy Cost" is estimated by multiplying the energy cost per mile for each truck type by the average

[150] 0.2% is the annual average variance on Consumer Price Index (CPI) for the period 2017 through 2019, which is used as a proxy for the yearly increase in the operating and maintenance cost. Bureau of Labor Statistics, U.S. Department of Labor, The Economics Daily, *Consumer prices increase 2.3 percent for the year ending February 2020,* http://www.bls.gov/opub/ted/2020/consumer-prices-increase-2-point-3-percent-for-year-ending-february-2020.htm (last visited June 12, 2020).

[151] O&M data provided to Lion Electric Co. by the DSWM, received via email correspondence with Lion Electric Co. on May 20, 2020.

[152] Email correspondence with DSWM received on February 10, 2020

[153] Email correspondence with DSWM received on June 29, 2020.

[154] Email correspondence with DSWM received on June 16, 2020.

[155] RD has the same chemical structure as petroleum diesel, and it can be used in engines that are designed to run on conventional diesel fuel — with no blending required. Government Fleet, *What You Need to Know About Renewable Diesel*, March 10,2016, https://www.government-fleet.com/156621/what-you-need-to-know-about-renewable-diesel#:~:text=Because%20it%20has%20the%20same,fuel%20%E2%80%94%20with%20no%20blending%20required

annual miles.[156] CNG, and diesel use a 2014 cost per mile amounts based on 2014 energy pricing.[157] OCA factored the pricing percentage change compared to the 2019 baseline energy pricing, resulting in a more current cost per mile figure used in this analysis. RD has a lower energy density content than diesel, as a result, it would take approximately 5% more RD to produce the same energy content as diesel.[158] RD energy cost per mile is calculated considering the percentage change of price per gallon between diesel and RD. Furthermore, 5% was applied to factor energy content. Hybrid trucks on average are 35% more fuel-efficient than diesel,[159]this percent was factored into the Hybrid energy cost per mile used in this analysis. Projected YOY percent increase applied for energy cost is approximately 1%, which is based on the National Energy Modeling System (NEMS) from Energy Information Administration data,[160] which reflects market economics, industry structure, and existing energy policies and regulations that influence market behavior for energy prices.[161]

[3] "Refuse Truck Purchase Cost" for a diesel refuse truck is based on the quoted price from the Autocar Dealer.[162] RD refuse truck expected to be the same price as diesel.[163] CNG refuse truck cost is assumed to be $35,000 higher than diesel based on the Trienergy report.[164] Hybrid refuse truck has an upcharge of $100,000 over a conventional diesel refuse truck.[165] Electric refuse truck cost is based on the price quote provided to Miami-Dade County by Lion Electric Co.[166]

2. Projected Compliance Estimates – Refuse Trucks

The Office of the Commission Auditor estimated the financial impact of the current refuse truck fleet[167] under two scenarios to comply with the requirement of reducing diesel consumption by 70% by 2028.[168] **Graphic 13** illustrates these projections for Scenario 1 (a low end scenario) and Scenario 2 (a high end scenario), assuming the replacement of refuse trucks is based on DSWM projected ten-year replacement plan,[169] which will lead the County to full compliance by 2025. This analysis considers the replacement of 187 refuse trucks with 187 CNG refuse trucks under Scenario 1 or with 187 electric refuse trucks under Scenario 2 to consider the industry pivoting towards electrical vehicles (for further details refer to Exhibit 2).

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[156] Email correspondence with DSWM received on May 19, 2020.
[157] U.S. DEPARTMENR OF ENERGY, *Case Study-Compressed Natural Gas Refuse Fleets*, Andrew Burnham (2014)
[158] Green Transportation Summit & Expo, *Renewable Diesel Specifies: Panel*, Richard Battersby (2017)
[159] Email correspondence with DSWM received on June 29, 2020
[160] "Energy Cost" is forecasted based on U.S. Energy Information Administration, Energy Prices by Sector and Sources, https://www.eia.gov/outlooks/aeo (last visited March 16, 2020).
[161] YOY percent increase is based on the National Energy Modeling System (NEMS) from Energy Information Administration data, which reflects market economics, industry structure, and existing energy policies and regulations that influence market behavior. Energy Information Administration, *The National Energy Modeling System, An Overview 2018 (2018)*. https://www.eia.gov/outlooks/aeo/nems/overview/pdf/0581(2018).pdf (last visited June 12, 2020).
[162] Email correspondence with DSWM received on June 29, 2020.
[163] This renewable diesel option has little to no infrastructure overhead and does not require retrofitting the current diesel fleet. Email and Phone Conversation with DSNY date June 7, 2019.
[164] TRIENERGY SOLUTIONS, MIAMI-DADE COUNTY INTERNAL SERVICES DEPARTMENT COMPRESSED NATURAL GAS ANALYSIS (2017).
[165] Email correspondence with DSWM received on June 29, 2020.
[166] Email correspondence with Lion Electric Co. received on May 15, 2020.
[167] Email correspondence with DSWM received on June 26, 2020.
[168] Miami-Dade County Resolution No. R-1034-18 (2018), http://www.miamidade.gov/govaction/matter.asp?matter=182156&file=true&fileAnalysis=false&yearFolder=Y2018.
[169] Email correspondence with DSWM received on June 29, 2020.

Graphic 13 Compliance Cost Estimates for Resolution No. R-1034-18

Notes

A refuse truck fleet inventory of 266 is assumed to be constant through 2025.[170] "Truck Purchase Cost" under Scenario 1 for CNG refuse trucks assumes a price of $370,000[171] for the low-end option, while $548,000[172] for electric refuse truck is assumed for high end option.

Table 6 below shows the refuse truck type mix of 266, a current inventory, from 2020, being the initial state, to 2025 being the end "compliant" state, with 70% CNG or electric trucks and 30% diesel.

[170] Email correspondence with DSWM received on June 29, 2020.
[171] $335,000 is an estimated cost. $370,000 is an estimated price for a CNG refuse truck used for a lower bound Scenario 1. It is based on the incremental cost of $35,000 over a diesel refuse truck price of $335,000 provided per Trienergy Solutions Report. TRIENERGY SOLUTIONS, MIAMI-DADE COUNTY INTERNAL SERVICES DEPARTMENT COMPRESSED NATURAL GAS ANALYSIS (2017).
[172] Electric refuse truck cost is based on the price quote provided to Miami-Dade County by Lion Electric Co. Email correspondence with Lion Electric Co. received on May 15, 2020.

Table 6 Current vs. Fully Compliant Total Count of Refuse Trucks

Refuse Truck Type	INITIAL STATE:		TARGET STATE:	
	Refuse Truck Count	Percentage To Total Count Of Refuse Trucks	Refuse Truck Count	Percentage To Total Count Of Refuse Trucks
CNG or Electric	0	0%	187	70%
Hybrid	63	24%	0	0%
Diesel	203	76%	79	30%
TOTAL	**266**	**100%**	**266**	**100%**

Exhibit 2 Projected Replacement Schedule by Refuse Truck Type

PROJECTED YEAR FOR REFUSE TRUCKS REPLACEMENT	INITIAL STATE:	TARGET STATE:	
	Refuse Truck Count and Type	SCENARIO 1: LOW END Refuse Truck Count and Type	SCENARIO 2: HIGH END Refuse Truck Count and Type
2020	36 Diesel	36 CNG	36 Electric
2021	29 Diesel	29 CNG	29 Electric
2022	9 Diesel 29 Hybrid	38 CNG	38 Electric
2023	4 Diesel 29 Hybrid	33 CNG	33 Electric
2024	5 Diesel 23 Hybrid	28 CNG	28 Electric
2025	23 Diesel	23 CNG	23 Electric

IV. Case Studies and Cross-Jurisdictional Comparative Analysis

National trends show a growing shift toward battery electric bus (BEB) fleets and infrastructure based on maintenance, fuel cost savings and positive environmental impacts. A 2016 report issued by the California Environmental Protection Agency analyzed the operating and maintenance costs between CNG buses and BEBs. The findings indicate that, aside from a slower duty cycle (more stop and go driving), the BEBs had a higher fuel economy by almost four times when compared to CNG buses.[173] The BEB purchase price included an extended battery warranty of 12 years.

A 2014 U.S. Department of Energy case study analyzed the use of CNG in heavy-duty trucks deployed by three Clean Cities projects.[174] The study analyzed three fleets using CNG: Republic Services, a national waste and recycling company; Groot Industries, Inc., a residential and commercial disposal company; and the City of Milwaukee's Department of Public Works. The study analyzed the motivating factors for adopting CNG technology as financial, environmental, and energy sustainability goals for each of the target organizations. The participants reported an average savings of 40% to 50% of fuel costs by using CNG

[173] California Air Resources Board of the California Environmental Protection Agency, Advanced Clean Transit Program (PDF).

[174] Michael Laughlin & Andrew Burnham, *Case Study – Compressed Natural Gas Refuse Fleets*, U.S. DEPARTMENT OF ENERGY (Feb. 2014), https://afdc.energy.gov/files/u/publication/casestudy_cng_refuse_feb2014.pdf

because natural gas pricing is less volatile than petroleum.[175] The average incremental cost per CNG vehicle in this study was $38,200 and the average cost of construction for the CNG infrastructure in these projects was $1.1 million per station.[176]

OCA also analyzed Foothill Transit Agency, a California entity serving 22 cities in the San Gabriel and Pomona Valleys of Greater Los Angeles. The Agency has purchased battery electric buses (BEB) and CNG buses and uses fast-charging stations at its in-depot charger maintenance facility. The fast charging stations allow buses to fully charge within 10 minutes. Additionally, Foothill Transit has entered into private contracts to maintain the chargers, equipment and operations, as part of the infrastructure component required for battery electric buses.[177] The Foothill Transit Agency has a total fleet size of 373 buses of which 33 are battery electric and the rest are CNG.[178]

OCA contacted the City of New York Sanitation Department (DSNY) concerning how the city's heavy fleet was powered. DSNY offered an alternative to diesel energy with its use of renewable diesel as opposed to CNG or electric power because higher urban density diminishes available real estate to build fueling and charging stations. DSNY forecasts a 60% reduction in its emissions by using renewable diesel and is shifting toward renewable diesel as a long-term solution, which is in line with the City's OneNYC target. The renewable diesel option has little to no infrastructure overhead as it does not require retrofitting the current diesel fleet.[179]

In the State of Maine, a strategy similar to what is envisioned long-term for DSWM is being pursued. Ecomaine is a non-profit waste management organization serving more than 70 member communities – comprising a combined population of more than 400,000 people, or a third of Maine's population.[180] Ecomaine plans to use a grant from Maine's Department of Environmental Protection to cover 57.5% of the capital investment for electric trucks.[181] A spokesperson for Ecomaine stated "If we can use those same trucks to go out and collect the waste, bring it back to the waste-to-energy plant, use that to generate electricity for those trucks to go back out the next day, I think that there will be much value in that circular system."[182]

In an effort to benchmark the County's green heavy fleet operations, OCA evaluated 10 metropolitan jurisdictions concerning their respective transit and refuse truck fleets and associated energy infrastructure.[183] OCA also contacted several private entities that adopted alternative energy types and infrastructure. Unfortunately, not all were willing to share what they considered proprietary information. Waste Pro USA, a private entity, referenced in the chart below provided limited information as well.[184]

[175] *Id*.
[176] *Id*.
[177] Leslie Eudy & Matthew Jeffers, *Foothill Transit Battery Electric Bus Demonstration Results: Second Report*, NATIONAL RENEWABLE ENERGY LABORATORY, https://nrel.gov/docs/fy17osti/67698.pdf
[178] Email correspondence with Foothill Transit Agency March 22, 2020.
[179] Email and Phone Conversation with DSNY date June 7, 2019.
[180] ECOMAINE, https://www.ecomaine.org/ (last visited Mar 25, 2020).
[181] Mary Catherine O'Connor, ELECTRIC TRUCKS MAY BE THE FUTURE, BUT WASTE AND RECYCLING MARKET STILL CHARGING UP WASTE DIVE (2019), https://www.wastedive.com/news/electric-trucks-may-be-the-future-but-waste-and-recycling-market-still-cha/567651/.
[182] *Id*.
[183] OCA communication with respective entities and jurisdictions.
[184] *Id*.

Among those examined were:

- Broward County, Florida
- City of Chicago, Illinois
- City of Fresno, California
- City of Los Angeles, California
- Miami-Dade County, Florida
- New York City, New York
- Central Florida Regional Transportation Authority, Florida
- City of San Antonio, Texas
- City of Seattle, Washington
- City of Tampa, Florida
- Waste Pro USA Inc.

Miami-Dade County

OCA analyzed our jurisdiction of **Miami-Dade County**, specifically the Department of Solid Waste Management (DSWM). Currently, the refuse trucks are powered by diesel, with an average cost between $115,000-$360,000. The brands of the existing refuse trucks range between Peterbilt, Ford, Rechtien, and International. However, DSWM possesses 5 CNG truck tractors. Additionally, the fleet has 63 hybrid refuse trucks currently in its operations. These hybrid vehicles are not diesel electric hybrid rather diesel hydraulic hybrid. The Internal Services Department Fleet Management Division maintains 29 fueling countywide facilities that dispense both unleaded and diesel gasoline products. OCA interviewed Mr. Michael Ruiz, Assistant Director from DSWM and the question as to how these tractors were being fueled was posed; Mr. Ruiz advised that the tractors were fueled from a DTPW CNG facility.

In the short term, DSWM continues analyzing the best mix of CNG vehicles in which to invest for one generation, roughly 7 – 10 years, to reduce direct emissions. The existing five truck tractors form the basis of a pilot on the Disposal side of the operation and may be expanded, should they perform appropriately. In the FY 2019-20 fleet cycle, should funding be available, DSWM was considering a pilot of CNG vehicles for Collections operations (e.g. Automated Side Loaders, Lightning Loaders, Trash Cranes, Trash Trucks, etc.). Depending on performance, this pilot could then be expanded. The logic of planning for one generation of vehicles is based on a projected pivot toward Electric Vehicles at roughly the same time as the end of life of the CNG vehicles. Electric vehicles eliminate emissions, operate far more quietly, require less maintenance, and offer a unique opportunity to leverage our Resources Recovery Facility (RRF). At the RRF, the County separates and sells recyclable metals and burns waste to generate electricity. This offers us a future where the waste vehicles cleaning up our streets are fueled by the garbage and trash they pick up, creating a closed environmental loop.

On the transit side, Miami-Dade County's Department of Transportation and Public Works (DTPW) has an annual customer base of 51,759,916. A new CNG station is planned for the Northeast depot and Miami-Dade County has procured 75 battery electric bus vehicles.

Broward County, Florida

Unlike Miami-Dade County, **Broward County** outsources its solid waste operation to Coastal Waste and Recycling, which has 3 CNG trucks dedicated to service unincorporated Broward County. Broward's Solid Waste department's short-term and long-term plan is to continue contracting a private hauler.

On the transit front, **Broward County Transit's** intention is to have its entire fleet (100%) electric by the year 2030. BCT has 10 electric buses with an approximate cost of $9,400,000. The average price per electric bus unit is $940,000 per bus. The manufacturer for these buses is Build Your Dream (BYD). The fuel economy for the buses is estimated to be at 200 miles per charge according to BYD. Broward County's outlook matches the plurality of jurisdictions across the United States, as they seem to be trending towards

going electric on their bus fleets (i.e., Antelope Valley Transit Authority, Chicago Transit Authority, City of Fresno Transit Authority, Los Angeles Department of Transportation, City of New York Mass Transit Authority).

The City of Fresno, CA

The next jurisdiction that was evaluated was the **City of Fresno, CA**. City of Fresno implemented liquid natural gas (LNG) as an alternative fuel type back in 2004 for its refuse trucks. The City did not have to retrofit existing diesel trucks with an LNG burning engine since the trucks were new and originally manufactured with LNG technology. City of Fresno did not specify how many LNG fueling stations it has, but the City advised that they had to purchase LNG fueling stations for their 95-truck fleet. The cost of purchasing an LNG station is approximately $2.4 million dollars and was implemented in three phases over a term of 6 years. Phase one attained a 12,000-gallon capacity, phase two increased the capacity to 15,000 gallons and phase three added another 15,000-gallon to the capacity. The City can store 37,000 gallons of LNG on site and have the fuel delivered two to three times a week. The LNG fuel vendor is Clean Energy Fuels, Inc., and the cost of LNG per gallon is $1.20 per Diesel Gallon Equivalent (DGE). The City of Fresno does not anticipate a change from LNG as it has phased out most of its diesel applications; however, the City maintains an open look towards other alternative fuel types including renewable diesel and electric applications. Though the City appears to be content with the output of LNG, like Miami-Dade County it is also exploring additional alternative fuel sources for its refuse fleet.

On the transit side, the **City of Fresno** purchases LNG buses from New Flyer, Gillig and Orion. The City's LNG fuel infrastructure is comprised of two fast fill fuel pumps. The fuel economy for these buses is about 3.168 mile per gasoline gallon equivalent (GGE). The City of Fresno is currently in the design phase of its electrical infrastructure to begin converting its bus fleet to electric. The City of Fresno has two electric buses currently on order from Proterra and the City plans to have zero emissions buses by the year 2040 pursuant to a state mandate. The City of Fresno plans to transition as early as possible as it pertains to electrical infrastructure.

New York City

The next jurisdiction OCA analyzed is the **New York City Department of Sanitation (DSNY).** New York City has a Citywide policy titled the "OneNYC" which lays out a road map requiring the City to achieve an 80% reduction in fleet greenhouse gases by the year 2035. DSNY has 6000 vehicles in its sanitation fleet and they are broken down as 2,400 diesel powered refuse trucks and 40 CNG powered refuse trucks. The remaining 3,560 vehicles are made up of light-duty (Sedans and SUV's) powered by gasoline. The manufacturer of the CNG trucks is Mack Trucks equipped with a Cummins ISL engine. No information was provided as to the costs for these trucks as there was a current bid opening and no awards for new trucks had been done at this time. DSNY owns and operates one CNG station that was built in 2007 at a cost of 2.9 million dollars. The CNG fuel provider is Con Edison and Clean Energy. Mr. Spiro Kattan, Director of the DSNY, was interviewed over the phone and he explained "that the challenge associated with CNG are fuel filling stations". "New York City has a high-density status and the room to build is not easily attainable. CNG vendors have offered to build DSNY fueling station and donate it to DSNY. However, when the firms go out to search for viable space, they find out that it is not easily attainable. Additionally, for these same reasons electrical applications are also frustrated because charging stations would need to be built. The same density challenges apply to the electrical application as they do the CNG application. Mr. Spiro advised that the renewable diesel option was the least costly because it required zero retrofitting of trucks and fueling stations. Moreover, the existing trucks and fueling stations could use the renewable diesel without alteration to the existing hardware found in both the trucks and fueling stations".

The primary vendors of buses for **New York City's Transit (NYCT)** are Proterra and New Flyer and the fleet composition not including diesel are 1,415 HEV, 736 CNG and 15 Battery-Electric Buses. As far as infrastructure is concerned NYCT has three on-street charging stations, two depots with charging stations (up to 275 miles-charge), and four depots with CNG fueling stations. The short-term and long-term plan for

NYCT are governed by the OneNYC strategy to achieve 100% electric buses by 2040.

City of Orlando

OCA attempted to obtain information pertaining to the City of Orlando's Solid Waste Department refuse truck technology; however, OCA did not receive a response.

OCA also analyzed the transit system for **City of Orlando**. The City of Orlando first incorporated alternative fuel vehicles in 2010. Later in 2015, Lynx signed a contract with Nopetro to use CNG technology for the City's transit. Currently, Orlando has a transit fleet of 313 buses, of which 243 are biodiesel and 70 are CNG buses. Nopetro is the vendor for the CNG buses. Each CNG bus cost approximately $500,000 each, or about $35,000,000 for the 70 CNG buses, in addition to the city's infrastructure investment of two CNG fueling stations. The City of Orlando presently has 1,689 advanced fuel vehicles in its fleet and plans to grow this number to 2,389 by 2030.

City of Seattle Washington

The **City of Seattle Washington** was the next jurisdiction that OCA analyzed. The primary vendor of refuse trucks for the City is Mack Trucks. The cost per unit was not provided by the City. The fleet composition as it relates to alternative energy is comprised of 40 CNG refuse trucks. The Solid Waste Department's infrastructure is made up of fueling sites operated by Puget Sound Energy. The City did not provide short- and long-term plans.

King County Washington

King County Washington transit department has a total fleet size of 1,623 and the average cost is $750,000-$999,999 per diesel hybrid unit. Prices were not provided for the battery electric buses and electric trolleys. The primary vendors of buses for the Transit department are New Flyer, Gillig, Proterra and Orion. The fleet composition is comprised of 174 electric trolleys, 11 battery electric, and 1,260 hybrids. King County Transit's infrastructure is made up of County owned chargers. Hybrid buses are powered by 5% biodiesel. The short-term and long-term plans for King County Washington are focused on achieving a zero emissions fleet by 2035.

City of San Antonio

The **City of San Antonio** transit system has a fleet size of 515 buses and the average cost per bus unit is $545,000. The fleet composition of the alternative energy bus fleet is 400 CNG, 30 diesel hybrid, 8 propane trolleys and 3 electric buses and the remaining vehicles are diesel. The primary vendors of buses for the transit system are Nabi, New Flyer, Nova, Proterra. The transit system's infrastructure system is made up of 3 CNG stations operated by CPS Energy (city-owned utility supplies natural gas), Loves, and Trillium who provides operation and maintenance. The short-term and long-term plans are to transition upcoming large bus replacement to CNG with continued evaluation of other propulsion systems.

City of Los Angeles

LA Metro's primary vendors of buses for the City are Build Your Dream (BYD), New Flyer and El Dorado. The average cost for the buses is as follows: the alternative energy fleet composition for the City of Los Angeles transit agency (LA Metro) is 145 Electric buses (on order) and 2,163 CNG. The infrastructure for the City's transit system was not provided. The City's short-term and long-term plan is to achieve a 100% zero emission fleet by the year 2030.

Waste Pro USA. Inc.

Waste Pro has an approximate customer base of 2,000,000 accounts. In 2011, the company added CNG technology to its refuse trucks. Currently, the company has 463 CNG refuse trucks in its fleet from manufacturers Autocar and Peterbilt. Each CNG truck cost approximately between $330,000 and $450,000. The CNG support infrastructure consisted of building seven CNG fuel stations, with an average cost of $1.5 million each. Pesco and TECO are the CNG distributors. With regards to fuel economy, Waste Pro indicated that CNG is actually less efficient than diesel by about 5%; notwithstanding, when the cost comparison is made between both, CNG costs less because there is still a $1.00 cost difference between the average retail price of diesel versus the CNG per gallon cost (for three stations with 50-plus trucks). The company's cost per gallon includes depreciation, utilities, maintenance, et al. Waste Pro officials stated that within two to three years, many of its stations will have depreciation taken out of the CNG gallon cost model and the gap will improve to favor CNG. If an organization is planning a large fleet conversion to 50 or more trucks, the cost to build an in-house station is considered a good investment. As far as short-term and long-term plans, Waste Pro will continue to invest in CNG trucks and fuel stations (when applicable to the volume of fuel and fleet size).

Table 7 depicts alternative energy utilized to power refuse trucks across selected jurisdictions by population, fleet size, refuse truck vendor(s) and fleet composition. Population served represents actual customers and not necessarily total population.

Table 7 Refuse Truck Jurisdictional Comparison Table

Refuse Trucks				
Entity	**Population**	**Customer Base**	**Vendor**	**Fleet Composition (Not including diesel)**
Miami-Dade County, FL	2,717,000	337,753	Peterbilt, Ford, Rechtien International	63 hybrid refuse trucks; 0 CNG refuse trucks; 5 CNG truck tractors
Broward County, FL	1,953,000	4,231	Not Provided	3 CNG
City of Fresno, CA	530,093	113,000	Clean Energy Fuels, Inc.	95 LNG
City of New York, NY	8,600,000	8,300,000	Mack Trucks	40 CNG
City of Seattle, WA	744,955	355,225	Contracts with 2 private firms	200 CNG
Waste Pro USA	N/A	2,000,000	Autocar, Peterbilt	463 CNG

*Source: OCA contacted the entities listed in this table. These are estimated figures.

Table 8 depicts alternative energy utilized to power buses across selected jurisdictions by population, fleet size, bus vendor(s) and fleet composition.

Table 8 Transit Bus Jurisdicitonal Comparison Table

Entity	Population	Customer Base (Annual Ridership)	Cost per unit- Total Cost for units purchased	Vendor	Fleet Composition (Not including diesel)
Miami-Dade County, FL	2,717,000	51,759,916	$568,500 per CNG Bus	New Flyer, Gillig	137 Diesel Hybrid Buses); 420 CNG Buses; 75 Electric Buses.
Broward County, FL	1,953,000	34,427,165	$940,000 per Electric bus	Not provided	10 Electric Buses
City of Chicago, IL	2,706,000	242,173,010	$1,600,000 per Electric bus	Proterra	10 Electric Buses
City of Fresno, CA	530,093	10,000,001	$630,000 per LNG bus	Orion, New Flyer, Gillig	98 LNG Buses and 2 Electric Buses
City of Los Angeles, CA	3,990,000	227,308,845	$1,019,531 per Electric bus $814,590 per CNG Bus	Build Your Dream (BYD), New Flyer and El Dorado	145 Electric Buses and 2,163 CNG Buses
City of New York, NY	8,600,000	557,036,504	Not provided	Proterra & New Flyer	1415 Diesel Hybrid Buses; 736 CNG Buses; and 15 Electric Buses
City of Orlando (CFRTA-Lynx), FL	285,713	25,157,382	$500,000 per CNG bus	Nopetro	70 CNG Buses and 243 Biodiesel Buses
City of San Antonio, TX	1,700,000	34,864,333	$545,000 per CNG bus	Nabi, New Flyer, Nova, Proterra	400 CNG Buses; 30 Diesel Hybrid Buses; 8 Propane Trolleys; and 3 Electric Buses
King County Metro Transit, Seattle, WA	2,253,000	122,446,992	$875,000 per Diesel Hybrid Unit	New Flyer, Gillig Proterra and Orion	174 Electric Trolleys; 11 Electric Buses; and 1,260 Diesel Hybrid Buses

*Source: OCA contacted the entities listed in this table. These are estimated figures.

V. Available Energy Technologies Powering Heavy Fleet

OCA researched available energy sources capable of powering heavy fleet, finding 13 dominant sources in the market. In addition to descriptive information per energy type, Table 8 below provides information pertaining to the energy type's cost, sourcing, environmental impact and GGE. The following 13 energy types were examined: gasoline, diesel, ultra-low sulfur diesel, biodiesel, renewable diesel, diesel hybrid electric, electric (EV), compressed natural gas (CNG), liquefied natural gas (LNG), renewable natural gas, ethanol, gaseous hydrogen fuel cell (FCV) and liquefied petroleum gas (LPG). The information in Table 8 was gathered from various sources, as cited at the bottom of the table. Compressed Natural Gas (CNG) technology is an alternative energy to gasoline and diesel, consisting of methane compressed to less than 1% of its volume at standard atmospheric pressure. CNG is odorless and tasteless and is derived from

domestically drilled gas wells in conjunction with crude oil production.[185] As per the scope of this report, OCA analyzed CNG as one of the alternative energy sources existing or emerging across the globe.

According to the U.S. Department of Energy's Alternative Fuels Data Center, as of March 22, 2020, compressed or liquefied natural gas powers more than 175,000 vehicles in the United States and approximately 23 million vehicles globally.[186] As it pertains to safety, CNG is considered a safe alternative when compared to other energy types and just as safe as diesel fuel buses.[187] Furthermore, CNG fuel tanks require inspection in a qualified facility every 36 months, pursuant to Federal Motor Vehicle Safety Standard (FMVSS) 304 pursuant to 49 C.F.R. § 571.304.[188] However, according to a 2017 Carnegie Mellon University Report, there are two primary infrastructure issues related to natural gas-based fuels: (1) compliance with fire code requirements; and (2) the selection of fast versus slow refueling equipment.[189]

Table 9 sets forth the different energy types by description, source, cost, Gasoline Gallon Equivalent (GGE) and Environmental Impact.

Table 9 Energy Types

Compressed Natural Gas (CNG)	
Description	Both CNG and LNG are produced domestically, are low-priced and commercially available. CNG and LNG were labeled alternative energy technologies under the U.S. Energy Policy Act of 1992 and are sold in units of gasoline or diesel gallon equivalent. The driving range of NGVs is typically less than that of gasoline or diesel vehicles because CNG and LNG have a lower energy density.[190]
Source	Retrieved from underground reserves and produced by compressing Natural Gas to 1% of its volume and stored in high-pressure containers.[191]
Cost	National Average price between January 1 and January 15, 2020. CNG - $2.18 per Gasoline Gallon Equivalent (GGE).[192]
Density Content & Gasoline Gallon Equivalent (GGE)	5.66 pounds or 123.57 cu ft. of CNG has 100% of the energy of one gallon of gasoline. [2][5](q) 6.38 pounds or 139.30 cu ft. of CNG has 100% of the energy content of one gallon of diesel 5.38 pounds of LNG has 100% of one gallon of gasoline and 6.06 pounds of LNG has 100% of the energy of one gallon of diesel (r).[193] Energy Content: 20.160 Btu per pound. Quantity of Fuel in 1 GGE: 5.76 per pound. Quantity of Fuel in 1 DGE: 6.37 per pound.[194]

[185] A.J. Rao, WESTFIELD CNG STATION OFFERS CLEANER ALTERNATIVE WESTFIELD CNG STATION OFFERS CLEANER ALTERNATIVE | NEWS, SPORTS, JOBS - POST JOURNAL (2016), https://www.post-journal.com/news/business/2016/11/westfield-cng-station-offers-cleaner-alternative/.
[186] Natural Gas Vehicles, ALTERNATIVE FUELS DATA CENTER: NATURAL GAS VEHICLES, https://afdc.energy.gov/vehicles/natural_gas.html.
[187] U.S. Department of Transportation Review and Analysis of Potential Safety Impacts of and Regulatory Barriers to Fuel Efficiency Technologies and Alternative Fuels PDF (June 2015).
[188] Compress Natural Gas Fuel Container Integrity, 49 C.F.R. § 571.304 (2018), *available at* https://www.law.cornell.edu/cfr/text/49/571.304
[189] Traffic 21, CARNEGIE MELLON UNIVERSITY, WHICH ALTERNATIVE FUEL TECHNOLOGY IS BEST FOR TRANSIT BUSES (2017), https://www.cmu.edu/energy/education-outreach/public-outreach/17-104%20Policy%20Brief%20Buses_WEB.pdf (*see page 14*)
[190] Natural Gas Fuel Basics, ALTERNATIVE FUELS DATA CENTER: NATURAL GAS FUEL BASICS, https://afdc.energy.gov/fuels/natural_gas_basics.html.
[191] *Id.*
[192] Fuel Prices, ALTERNATIVE FUELS DATA CENTER: FUEL PRICES, https://afdc.energy.gov/fuels/prices.html.
[193] Fuel Properties Comparison, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf
[194] How can I compare the energy content of alternative fuels and gasoline or diesel?, GREATER NEW HAVEN CLEAN CITIES COALITION (2017), http://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/.

Environmental Impact (GHG Emissions)	CNG cuts GHG emissions by 30% compared to diesel.[195]
Comments	Advantages - abundant, lower GHG emissions.[196] Disadvantages- Non-Renewable, Fracking- fracking fluid used to break the rock formations in order to release the natural gas and oil reserves contains sand and dangerous chemicals, which can poison the underground water supplies used by people.[197]
Liquefied Natural Gas (LNG)	
Description	Liquefied natural gas, or LNG, is natural gas in its liquid form. When natural gas is cooled to minus 259 degrees Fahrenheit (-161 degrees Celsius), it becomes a clear, colorless, odorless liquid. LNG is neither corrosive nor toxic. Natural gas is primarily methane, with low concentrations of other hydrocarbons, water, carbon dioxide, nitrogen, oxygen and some sulfur compounds. LNG weighs less than half the weight of water so it will float if spilled on water.[198]
Source	A majority of the world's LNG supply comes from countries with large natural gas reserves. These countries include Algeria, Australia, Brunei, Indonesia, Libya, Malaysia, Nigeria, Oman, Qatar, and Trinidad and Tobago.[199]
Cost	LNG- $2.77 per Diesel Gasoline Equivalent (DGE).[200]
Density Content & Gasoline Gallon Equivalent (GGE)	5.38 pounds of LNG has 100% of one gallon of gasoline and 6.06 pounds of LNG has 100% of the energy of one gallon of diesel (r).[201] Energy Content: 21.240 Btu per pound. Quantity of Fuel in 1 GGE: 5.47 per pound. Quantity of Fuel in 1 DGE: 6.05 per pound.[202]
Environmental Impact (GHG Emissions)	LNG cuts GHG emissions by 30% compared to diesel.[203]
Comments	Advantages - abundant, lower GHG emissions.[204] Disadvantages- Non-Renewable, Fracking- fracking fluid used to break the rock formations in order to release the natural gas and oil reserves contains sand and dangerous chemicals, which can poison the underground water supplies used by people.[205]

[195] How Natural Gas Stacks up in the Race to Reduce Emissions, CLEAN ENERGY COMPRESSION, https://www.cleanenergyfuels.com/compression/blog/natgassolution-part-1-clean-natural-gas-stack-race-reduce-emissions/.
[196] Rinkesh, ADVANTAGES AND DISADVANTAGES OF NATURAL GAS ENERGY CONSERVE ENERGY FUTURE (2017), https://www.conserve-energy-future.com/advantages-and-disadvantages-of-natural-gas.php.
[197] Danny OvyI, ADVANTAGES AND DISADVANTAGES OF FRACKING ALTERNATIVE ENERGIES (2018), https://www.alternative-energies.net/advantages-and-disadvantages-of-fracking/.
[198] California Energy Commission, FREQUENTLY ASKED QUESTIONS ABOUT LNG CALIFORNIA ENERGY COMMISSION, https://ww2.energy.ca.gov/lng/faq.html#100
[199] *Id*.
[200] Fuel Prices, ALTERNATIVE FUELS DATA CENTER: FUEL PRICES, https://afdc.energy.gov/fuels/prices.html.
[201] Propane Benefits and Considerations, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/fuels/propane_benefits.html
[202] How can I compare the energy content of alternative fuels and gasoline or diesel?, GREATER NEW HAVEN CLEAN CITIES COALITION (2017), http://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/.
[203] How Natural Gas Stacks up in the Race to Reduce Emissions, CLEAN ENERGY COMPRESSION (2016), https://www.cleanenergyfuels.com/compression/blog/natgassolution-part-1-clean-natural-gas-stack-race-reduce-emissions/.
[204] Rinkesh, ADVANTAGES AND DISADVANTAGES OF NATURAL GAS ENERGY CONSERVE ENERGY FUTURE (2017), https://www.conserve-energy-future.com/advantages-and-disadvantages-of-natural-gas.php.
[205] Danny OvyI, ADVANTAGES AND DISADVANTAGES OF FRACKING ALTERNATIVE ENERGIES (2018), https://www.alternative-energies.net/advantages-and-disadvantages-of-fracking/.

Ultra-Low Sulfur Diesel (ULSD)	
Description	ULSD is considered a clean burning diesel fuel, containing 97% less sulfur than LSD. As of December 2010, ULSD replaced Low Sulfur Diesel (LSD) at the commercial pump throughout the U.S. and is considered to be the diesel dispensed at present day fuel stations.[206]
Source	Low sulfur diesel is derived from hydrogen gas mixed with high sulfur distillates.[207]
Cost	Retail rate of 1 Gallon is $2.66 as of March 23, 2020.[208]
Density Content & Gasoline Gallon Equivalent (GGE)	1 gallon of diesel has 113% energy equal to one gallon of gasoline.[209] Energy Content: 128.488 Btu per gallon. Quantity of Fuel in 1 GGE: 0.90 gallon. Quantity of Fuel in 1 DGE: 1.00 gallon.[210]
Environmental Impact (GHG Emissions)	ULSD is a cleaner burning diesel fuel than LSD, reducing diesel emissions and particulate matter.[211]
Comments	ULSD was developed to allow the use of improved pollution control devices that reduce diesel emissions more effectively. ULSD is also safe to use with older diesel engines.
Biodiesel	
Description	Biodiesel is a mono-alkyl ester produced via transesterification. Biodiesel meets ASTM D6751 and is approved for blending with petroleum diesel.[212]
Source	Domestically produced renewable fuel manufactured from soybean, canola or other vegetable oils, animal fats and recycled restaurant grease.[213]
Cost	National Average price between January 1 and January 15, 2020. B-20 (B-20 is 20 percent biodiesel and 80 percent ULSD) is $2.89 and B-100 (100 percent biodiesel) is $3.72.[214]
Density Content & Gasoline Gallon Equivalent (GGE)	B100 (straight diesel) has 103% of the energy found in one gallon of gasoline. B20 (20% diesel to biodiesel blend) has 109% of the energy found in one gallon of gasoline or 99% of the energy found in one gallon of diesel.[215] B20 Energy Content: 126.700 Btu per gallon. B20 Quantity of Fuel in 1 GGE: 0.92 gallon. B20 Quantity of Fuel in 1 DGE: 1.01 gallon. B100 Energy Content: 119.550 Btu per gallon. B100 Quantity of Fuel in 1 GGE: 0.97 gallon. B100 Quantity of Fuel in 1 DGE:

[206] Ultra-Low Sulfur Diesel, WWW.FUELECONOMY.GOV - THE OFFICIAL GOVERNMENT SOURCE FOR FUEL ECONOMY INFORMATION, https://www.fueleconomy.gov/feg/lowsulfurdiesel.shtml.

[207] Tony Radich, U.S. ENERGY INFORMATION ADMINISTRATION - EIA - INDEPENDENT STATISTICS AND ANALYSIS LARGE REDUCTION IN DISTILLATE FUEL SULFUR CONTENT HAS ONLY MINOR EFFECT ON ENERGY CONTENT - TODAY IN ENERGY - U.S. ENERGY INFORMATION ADMINISTRATION (EIA) (2015), https://www.eia.gov/todayinenergy/detail.php?id=20092.

[208] Petroleum & Other Liquids, RETAIL PRICES FOR ULTRA LOW SULFUR DIESEL, https://www.eia.gov/dnav/pet/PET_PRI_GND_A_EPD2DXL0_PTE_DPGAL_W.htm.

[209] Fuel Properties Comparison, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf

[210] How can I compare the energy content of alternative fuels and gasoline or diesel?, GREATER NEW HAVEN CLEAN CITIES COALITION (2017), http://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/.

[211] Clean Fuels: Ultra Low Sulfur Diesel, AMERICAN LUNG ASSOCIATION - CLEAN AIR CHOICE, https://www.cleanairchoice.org/fuels/ulsd.cfm.

[212] Renewable Hydrocarbon Biofuels, ALTERNATIVE FUELS DATA CENTER: RENEWABLE HYDROCARBON BIOFUELS, https://afdc.energy.gov/fuels/emerging_hydrocarbon.html.

[213] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis, BIODIESEL EXPLAINED - U.S. ENERGY INFORMATION ADMINISTRATION (EIA), https://www.eia.gov/energyexplained/biofuels/biodiesel.php.

[214] Fuel Prices, ALTERNATIVE FUELS DATA CENTER: FUEL PRICES, https://afdc.energy.gov/fuels/prices.html.

[215] Fuel Properties Comparison, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf

	1.07 gallon.[216]
Environmental Impact (GHG Emissions)	Biodiesel contains no hazardous materials and is generally regarded as safe. Biodiesel biodegrades faster than conventional diesel and combusts with reduced emissions.[217] There are environmental benefits to biodiesel. According to EIA, using biodiesel combustion produces fewer air pollutants such as particulates, carbon monoxide, sulfur dioxide, hydrocarbons, and air toxics. Pure biodiesel is nontoxic, biodegradable and produces lower levels of air pollutants than petroleum. Nitrogen oxide emissions from burning a gallon of biodiesel may be slightly higher than emissions from burning a gallon of petroleum diesel.[218]
Comments	The advantages to using biodiesel are lower emissions, compatibility with existing diesel infrastructure and engines and it can be produced domestically from environmentally friendly sources.
Renewable Diesel	
Description	Renewable diesel fuel, also known as "green" diesel, is a biomass derived transportation fuel used for diesel engines.[219] Renewable diesel is a hydrocarbon produced through various processes such as hydrotreating, gasification, pyrolysis, and other biochemical and thermochemical technologies. It meets ASTM D975 specification for petroleum diesel.[220]
Source	It can be made from vegetable oil or other biomass feedstock (wood, agricultural waste, garbage, etc.). While renewable diesel is chemically similar to petroleum diesel, biodiesel is a mono-alkyl ester, which has different physical properties and hence different fuel specifications. The two fuels are also produced through very different processes.[221]
Cost	Renewable diesel $3.10 as of April 20, 2020.[222] OCA also found that the retail rate is approximately $3.75 price per gallon.[223]
Density Content & Gasoline Gallon Equivalent (GGE)	Density Content: Renewable Diesel is a true hydrocarbon just like diesel and meets ASTM International's standard for Diesel Fuel Oils (D-975). Because of this structural difference, Renewable Diesel is a superior product with a higher cetane index than typical ultra-low sulfur diesel (ULSD), and unlike biodiesel, an energy density value equivalent to ULSD.[224] According to the EIA, the EIA consider' s renewable diesel fully fungible with ultra-low sulfur diesel. When renewable diesel meets ASTM D975 properties, it is considered the same as conventional diesel fuel. The two fuels can be blended and moved in pipelines, saved in tanks, delivered from pumps at retail stations, same Btu value, etc. The EIA quantifies 1 gallon of diesel fuel or heating oil (with sulfur content less than 15 parts per million) = 137,381 Btu. By calculation 100 gallons renewable diesel = 100 gallons diesel = 13,738,100 Btu.[225]

[216] How can I compare the energy content of alternative fuels and gasoline or diesel?, GREATER NEW HAVEN CLEAN CITIES COALITION (2017), http://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/.
[217] Biodiesel Benefits and Considerations, ALTERNATIVE FUELS DATA CENTER: BIODIESEL BENEFITS, https://afdc.energy.gov/fuels/biodiesel_benefits.html.
[218] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis, BIODIESEL AND THE ENVIRONMENT - U.S. ENERGY INFORMATION ADMINISTRATION (EIA), https://www.eia.gov/energyexplained/biofuels/biodiesel-and-the-environment.php
[219] Shelley Ernst, WHAT YOU NEED TO KNOW ABOUT RENEWABLE DIESEL GREEN FLEET - GOVERNMENT FLEET (2016), https://www.government-fleet.com/156621/what-you-need-to-know-about-renewable-diesel.
[220] Renewable Hydrocarbon Biofuels, ALTERNATIVE FUELS DATA CENTER: RENEWABLE HYDROCARBON BIOFUELS, https://afdc.energy.gov/fuels/emerging_hydrocarbon.html.
[221] Lauren Fletcher, EVERYTHING YOU NEED TO KNOW ABOUT RENEWABLE DIESEL FUEL - WORK TRUCK ONLINE (2018), https://www.worktruckonline.com/320806/everything-you-need-to-know-about-renewable-diesel.
[222] Clean Cities Alternative Fuel Price Report, ALTERNATIVE FUELS DATA CENTER (2020), https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_april_2020.pdf (*see page 2*)
[223] Clean Cities Alternative Fuel Price Report, ALTERNATIVE FUELS DATA CENTER (2020), https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_jan_2020.pdf (*see page 20*)
[224] Renewable Diesel - INVESTANCIA - Reforestation Oil & Protein, INVESTANCIA (2018), https://investancia.com/what-is-the-difference-between-biodiesel-and-greendiesel/.
[225] Email correspondence with Energy Information Administration June 3, 2020.

Environmental Impact (GHG Emissions)	Reduces greenhouse gas (CO2) emissions by 80%, has 24% lower carbon monoxide levels, and it is a high cetane fuel, which is good for greater pickup, cold start, and quieter operation, according to Neste.[226]
Comments	The advantages to using renewable diesel are lower emissions, compatibility with existing diesel infrastructure and engines and it can be produced domestically from environmentally friendly sources. Renewable diesel is not blended with ULSD.[227] Additionally, this high-quality diesel delivers up to 80% lower lifecycle emissions compared to petroleum diesel.[228] The technical results of renewable diesel use have been outstanding with no known negative impacts. According to the Columbia-Willamette Clean Cities Coalition, the major obstacles in widespread adoption of the fuel are supply chain and economic issues. Currently, the renewable diesel used in Oregon is shipped from Southeast Asia to California (where the fuel is widely used) and then barged to Portland and trucked to end-users. As demand for renewable diesel increases this supply chain will be severely limiting. Current prices for renewable diesel is on par with B-20 biodiesel and if this pricing parity is maintained then renewable diesel will be economically feasible for widespread adoption.[229]
Diesel Hybrid Electric (HEV)	
Description	Diesel Hybrid Electric vehicles have generators powered by liquid fuels, such as diesel, and use batteries to capture generated energy.[230]
Source	ULSD is considered a clean burning diesel fuel, containing 97% less sulfur than LSD. As of December 2010, ULSD replaced Low Sulfur Diesel (LSD) at the commercial pump throughout the U.S., and is considered to be the diesel dispensed at present day fuel stations.[231] Production of electricity is derived from sources, like coal or nuclear, natural gas, hydroelectric and a small percentage of wind and solar.[232]
Cost	National Average price between January 1 and January 15, 2020. $3.05 per gallon diesel and .13 per kWh of electricity.[233]
Density Content & Gasoline Gallon Equivalent (GGE)	Not available.
Environmental Impact (GHG Emissions)	According to the manufacturer Proterra, a diesel hybrid emits 163,286 lbs. per year of GHG.[234]
Comments	The advantage of HEV is that it can increase, improve fuel economy and lower fuel costs while reducing emissions. The lifecycle emission of a HEV depends on the source of electricity used to charge the

[226] Shelley Ernst, IS RENEWABLE DIESEL STILL A 'MIRACLE FUEL'? GREEN FLEET - GOVERNMENT FLEET (2020), https://www.government-fleet.com/348069/is-renewable-diesel-still-a-miracle-fuel.
[227] Shelley Ernst, WHAT YOU NEED TO KNOW ABOUT RENEWABLE DIESEL GREEN FLEET - GOVERNMENT FLEET (2016), https://www.government-fleet.com/156621/what-you-need-to-know-about-renewable-diesel.
[228] Lauren Fletcher, EVERYTHING YOU NEED TO KNOW ABOUT RENEWABLE DIESEL FUEL - WORK TRUCK ONLINE (2018), https://www.worktruckonline.com/320806/everything-you-need-to-know-about-renewable-diesel.
[229] Curtis Nehring, COLUMBIA-WILLAMETTE CLEAN CITIES COALITION ALTERNATIVE FUELS: OTHER FUELS: RENEWABLE DIESEL | COLUMBIA-WILLAMETTE CLEAN CITIES COALITION, https://www.cwcleancities.org/alternative-fuels/renewable-diesel.
[230] NYCT Diesel Hybrid-Electric Buses, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/files/pdfs/nyct_diesel_hybrid.pdf (*see page 8)*.
[231] Ultra-Low Sulfur Diesel, WWW.FUELECONOMY.GOV - THE OFFICIAL GOVERNMENT SOURCE FOR FUEL ECONOMY INFORMATION, https://www.fueleconomy.gov/feg/lowsulfurdiesel.shtml.
[232] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis, ELECTRICITY IN THE U.S. - U.S. ENERGY INFORMATION ADMINISTRATION (EIA), https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php.
[233] Fuel Prices, ALTERNATIVE FUELS DATA CENTER: FUEL PRICES, https://afdc.energy.gov/fuels/prices.html.
[234] Fuel Economy, PROTERRA (2020), https://www.proterra.com/vehicles/catalyst-electric-bus/fuel-economy/.

	vehicles. One of the disadvantages of HEVs is that its batteries although designed for extended life eventually expires.[235] A Diesel-Hybrid Electric Bus emits 65,881lbs. per year of GHG less than a typical diesel bus that emits 229,167 lbs. of greenhouse gases annually, and 55,797 lbs. per year less GHG than a CNG bus which emits 219,083 lbs. per year.[236]
Electric (EV)	
Description	Electric vehicles (EV) have different capabilities from that of HEVs. Drivers of EVs can charge the vehicle from an off-board electric power source. A component of EVs is the all-electric vehicle (AEVs), which run only on electricity and average a driving range of 80 to 100 miles. Recharging can take approximately 30 minutes (with fast-charging) or a full day with the slower Level 1 charging capability. EVs are known to be responsive and more digitally connected than conventional vehicles. The potential of multiple charging stations provide transit managers options for efficient charging.[237]
Source	Production of electricity from sources, like coal or nuclear, natural gas, hydroelectric and a small percentage of wind and solar.[238]
Cost	National Average price between January 1 and January 15, 2020: $0.13 kilowatt hour (kWh).[239]
Density Content & Gasoline Gallon Equivalent (GGE)	33.70 kWh has 100% of the energy of one gallon of gasoline.[240] Energy Content: 3.414 Btu per kilowatt hour. Quantity of Fuel in 1 GGE: 34.00 per kilowatt hour. Quantity of Fuel in 1 DGE: 37.64 per kilowatt hour.[241]
Environmental Impact (GHG Emissions)	Zero emissions at the point of use.[242]
Comments	Advantage Zero tail pipe emissions and Disadvantage Battery Disposal and Battery Life (8-10 years) as opposed to the Bus Life (12 years).[243]
Hydrogen Fuel Cell	
Description	Hydrogen Fuel Cell can power a heavy fleet and only emits water vapor and warm air. It is produced domestically from natural gas, coal, solar energy and wind. Regarding energy density, hydrogen tanks take up much less space than batteries for given range of distance.
Source	Produced from natural gas, nuclear power, biomass, and renewable power like solar and wind[244]

[235] NYCT Diesel Hybrid-Electric Buses, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/files/pdfs/nyct_diesel_hybrid.pdf (*see page 10)*.
[236] Fuel Economy, PROTERRA (2020), https://www.proterra.com/vehicles/catalyst-electric-bus/fuel-economy/.
[237] Electric Vehicle Basics, ENERGY.GOV, https://www.energy.gov/eere/electricvehicles/electric-vehicle-basics.
[238] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis, ELECTRICITY IN THE U.S. - U.S. ENERGY INFORMATION ADMINISTRATION (EIA), https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php.
[239] Fuel Properties Comparison, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf
[240] *Id*.
[241] How can I compare the energy content of alternative fuels and gasoline or diesel?, GREATER NEW HAVEN CLEAN CITIES COALITION (2017), http://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/.
[242] Reducing Pollution with Electric Vehicles, ENERGY.GOV, https://www.energy.gov/eere/electricvehicles/reducing-pollution-electric-vehicles.
[243] Katie Pyzyk, STUDY QUANTIFIES BATTERY-ELECTRIC BUS ENVIRONMENTAL BENEFITS SMART CITIES DIVE (2018), https://www.smartcitiesdive.com/news/study-quantifies-battery-electric-bus-environmental-benefits/528224/.
[244] Hydrogen Fuel Basics, ENERGY.GOV, https://www.energy.gov/eere/fuelcells/hydrogen-fuel-basics.

Cost	According to Clean Techinca.com The price for hydrogen fuel is $16.85 per kilogram. As of April 26, 2019.[245]
Density Content & Gasoline Gallon Equivalent (GGE)	1 kg or 2.198 lbs. of H2 has 100% of the energy of one gallon of gasoline.[246] Energy Content: 51.585 Btu per pound. Quantity of Fuel in 1 GGE: 2.25 per pound. Quantity of Fuel in 1 DGE: 2.49 per pound.[247]
Environmental Impact (GHG Emissions)	Production of FCEV considered a zero-emission vehicle because it only emits water vapor and warm air.[248] When producing hydrogen, if it is derived from low or zero emission sources (such as solar or wind), it can greatly lower GHG emissions.[249]
Comments	The main advantages of hydrogen fuel cells are environmental and health benefits. The hydrogen system has an advantage in basic energy density because hydrogen fuel cells are cleaner and more efficient than traditional combustion engines.[250]
Liquefied Petroleum Gas (LPG)	
Description	Liquefied Petroleum Gas consists of hydrocarbon gases, primarily propane, normal butane and isobutene and is derived from crude oil refining or natural gas processing. This fuel type is stored under very high pressure that maintains it in a liquid state, making it easy to transport. Other advantages of LPG are that it does not contain sulfur, making it cleaner burning than gasoline or diesel.[251]
Source	Propane is a three-carbon alkane gas (C_3H_8). It is stored under pressure inside a tank as a colorless, odorless liquid. As pressure is released, the liquid propane vaporizes and turns into gas that is used in combustion. An odorant, ethyl mercaptan, is added for leak detection.[252]
Cost	National Average price between January 1 and January 15, 2020: $2.79 per gallon.[253]
Density Content & Gasoline Gallon Equivalent (GGE)	1 Gallon of Propane has 73% of the energy of one gallon of gasoline. BTU 84,300 is equal to 1.35 GGE.[254]
Environmental Impact (GHG	LPG-fueled vehicles emit about 20% lower GHG emissions compared to conventional California gasoline-fueled vehicles.[255]

[245] Michael Barnard, HYDROGEN CARS HAVE 4× ANNUAL FUEL COST & 2–70× THE CARBON DEBT AS ELECTRIC VEHICLES CLEANTECHNICA (2019), https://cleantechnica.com/2019/04/26/hydrogen-cars-have-4x-annual-fuel-cost-2-70-times-the-carbon-debt-as-electric-vehicles/.
[246] Fuel Properties Comparison, ALTERNATIVE FUELS DATA CENTER, https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf
[247] How can I compare the energy content of alternative fuels and gasoline or diesel?, GREATER NEW HAVEN CLEAN CITIES COALITION (2017), http://nhcleancities.org/2017/04/can-compare-energy-content-alternative-fuels-gasoline-diesel/.
[248] Fuel Cell Electric Vehicle Emissions, ALTERNATIVE FUELS DATA CENTER: FUEL CELL ELECTRIC VEHICLE EMISSIONS, https://afdc.energy.gov/vehicles/emissions_hydrogen.html.
[249] Hydrogen Benefits and Considerations, ALTERNATIVE FUELS DATA CENTER: HYDROGEN BENEFITS AND CONSIDERATIONS, https://afdc.energy.gov/fuels/hydrogen_benefits.html.
[250] Hydrogen Benefits and Considerations, ALTERNATIVE FUELS DATA CENTER: HYDROGEN BENEFITS AND CONSIDERATIONS, https://afdc.energy.gov/fuels/hydrogen_benefits.html.
[251] Propane Fuel Basics, ALTERNATIVE FUELS DATA CENTER: PROPANE BASICS, https://afdc.energy.gov/fuels/propane_basics.html.
[252] Propane Fuel Basics, ALTERNATIVE FUELS DATA CENTER: PROPANE BASICS, https://afdc.energy.gov/fuels/propane_basics.html.
[253] Fuel Prices, ALTERNATIVE FUELS DATA CENTER: FUEL PRICES, https://afdc.energy.gov/fuels/prices.html.
[254] Scott Gable, HOW CAN GASOLINE GALLON EQUIVALENTS HELP GAUGE ALTERNATIVE FUELS? THOUGHTCO, https://www.thoughtco.com/fuel-energy-comparisons-85636.
[255] Stefan Unnasch & Love Goyal, LIFE CYCLE ANALYSIS OF LPG TRANSPORTATION FUELS UNDER THE CALIFORNIAN LCFS (2017), https://ww3.arb.ca.gov/fuels/lcfs/workshops/10242017_wpga.pdf (*see page 5*)

Emissions)	
Comments	Compared with vehicles fueled by conventional diesel (ULSD) and gasoline, propane vehicles can produce lower amounts of some harmful air pollutants and greenhouse gases, depending on vehicle type, drive cycle, and engine calibration.[256]

a. Health Ramifications of Criteria Air Pollutants and Greenhouse Gases

This subsection analyzes specific information provided by the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), and the Southeast Florida Regional Compact relating to the health consequences of GHG emissions. The findings indicate that while none of the agencies made specific recommendations regarding a preferred alternative energy source, they did reach the following consensus: 1) WHO advises governments to switch to low emission technologies; 2) CDC reports the effects of vehicle emissions as a contributor to a myriad of breathing issues; and 3) SE FL Regional Compact provides data on the effects of GHG on the health of Floridians.[257]

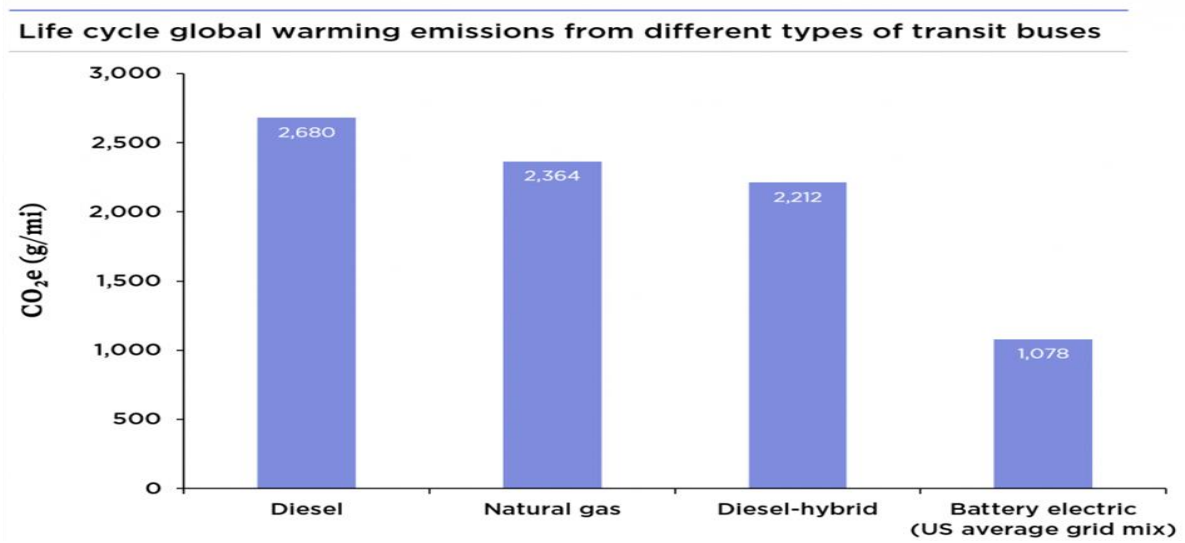
According to WHO, the transportation sector is not only a leading source of GHG emissions and NO2 emissions, but is responsible for a large portion of urban air pollution leading to respiratory illnesses.[258] On a global scale, air pollution is the leading cause of cancer, major respiratory illnesses, as well as heart disease.[259] WHO suggests that policies and investments supporting cleaner transportation, municipal waste management, power generation, energy-efficient homes and industries are key elements in reducing outdoor air pollution.[260]

There is evidence showing a correlation between respiratory illnesses and fuel emissions.[261] New York State's Energy Vision Report of 2018 (Energy Vision) found buses and trucks that operate on diesel fuel are to blame for respiratory illnesses associated with particulate and nitrogen oxide emissions that may lead to asthma and other breathing problems.[262] Energy Vision does not regard biodiesel as a true alternative to diesel because a portion of the biodiesel blend is petroleum diesel, thus decreasing GHG emissions by only 10%. Renewable diesel is another energy alternative to diesel that reduces GHG by approximately 90%.[263] According to the Energy Vision Report, CNG can reduce particulate matter emissions by almost 30% compared to ultra-low sulfur diesel.[264]

[256] Propane Benefits and Considerations, ALTERNATIVE FUELS DATA CENTER: PROPANE BENEFITS, https://afdc.energy.gov/fuels/propane_benefits.html.
[257] Air pollution, WORLD HEALTH ORGANIZATION (2020), https://www.who.int/airpollution/ambient/health-impacts/en/., Respiratory Health & Air Pollution, CENTERS FOR DISEASE CONTROL AND PREVENTION, https://www.cdc.gov/healthyplaces/healthtopics/airpollution.htm.,Regional Greenhouse Gas Emissions Inventory Baseline Period: 2005 - 2009 , SOUTHEAST FLORIDA REGIONAL CLIMATE COMPACT (2011), https://southeastfloridaclimatecompact.org/wp-content/uploads/2017/12/ghg-inventory.pdf.
[258] Health and Sustainable Development, *How Air Pollution is Destroying Our Health*, WORLD HEALTH ORGANIZATION, https://www.who.int/airpollution/news-and-events/how-air-pollution-is-destroying-our-health
[259] Umair Irfan, THE LAW THAT'S HELPING FUEL DELHI'S DEADLY AIR POLLUTION VOX (2019), https://www.vox.com/science-and-health/2019/11/8/20948348/delhi-india-air-pollution-quality-cause.
[260] *Ambient (outdoor) air quality and health*, WORLD HEALTH ORGANIZATION (May 2, 2018), https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
[261] ENERGY VISION. *The Time is Now* (2018), https://energy-vision.org/wp-content/uploads/2019/10/EV_News_Summer-Fall-2018.pdf
[262] ENERGY VISION. *The Time is Now* (2018), https://energy-vision.org/wp-content/uploads/2019/10/EV_News_Summer-Fall-2018.pdf
[263] NESTE. *Reduced Emissions*, https://www.neste.com/companies/products/renewable-road-transport/reduced-emissions#:~:text=Using%20Neste%20MY%20Renewable%20Diesel,fuel%20compared%20to%20fossil%20diesel
[264] Gunnison County, Colorado. *Why Compressed Natural Gas*, https://www.gunnisoncounty.org/DocumentCenter/View/4674/Why-CNG?bidId=

Graphic 14 below reflects the lifecycle global warming emissions from different types of transit buses.[265] Scientists have found that battery electric buses have lower global warming emissions than diesel and natural gas buses everywhere in the country. Charged with the national electricity mix, an electric bus produces 1,078 grams CO_2e per mile, while a natural gas bus produces 2,364 grams CO_2e per mile and a diesel-hybrid produces 2,212 grams CO_2e per mile. Natural gas buses have 12 percent lower global warming emissions than diesel buses. Electric bus emissions range from 29 to 87 percent lower than diesel buses and 19 to 85 percent lower than natural gas buses.

Graphic 14 Global Warming Emissions from types different types of transit buses



b. Snapshot of International Alternative Energy Panorama

OCA examined how other countries utilize alternative energy in their heavy fleets. The European Union (EU), a political and economic union of 27 member states that are located primarily in Europe, and Japan, for example, are currently shifting toward more environmentally friendly energy alternatives. According to the European Commission, which serves as the executive branch of the EU, large transport trucks, buses, and coach buses produce about a quarter of all CO2 emissions.[266]

The EU

As of 2018, the European Commission had proposed legislation requiring development of alternative energy infrastructure in the EU, as well as initiatives curbing emissions. The EU climate and energy framework consists of targets and policy objectives spanning 2021 through 2030. Key targets include: 1) achieving at least a 40% reduction in GHG emissions and 2) having at least 32% share of renewable energy.[267] The EU also launched project REVIVE (Refuse Vehicle Innovation and Validation in Europe) in 2018 to create sustainable and clean urban waste transportation.[268] The project seeks to pilot 15 Hydrogen

[265] Jimmy O'Dea, ELECTRIC VS. DIESEL VS. NATURAL GAS: WHICH BUS IS BEST FOR THE CLIMATE? UNION OF CONCERNED SCIENTISTS (2018), https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate.

[266] *Climate Action*, EUROPEAN COMMISSION, https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en (last visited March. 25, 2020).
[267] European Commission, https://ec.europa.eu/clima/policies/strategies/2030_en
[268] "REVIVE Project Under Way to Deploy Fuel Cell Refuse Trucks In Europe." *Fuel Cells Bulletin*, vol. 2018, no. 2, 2018, pp. 3 – 4, https://h2revive.eu/

Fuel Cell Vehicle (FCV) powered refuse collection trucks in eight sites for at least two years. The participating countries are Belgium, Italy, the Netherlands, and Switzerland. The project is expected to last four years and cost €8.7 million Euro, or approximately $10.7 million.[269]

Asia

In Asia, Japan has deployed Fuel Cell Vehicles (FCV) buses and refuse trucks, with the goal of reducing 25% of its emissions by 2030. Japan leads the world in carbon-free development with its advanced hydrogen technology.[270] The country's transportation sector contributes 19% to Japan's entire CO2 emissions. The U.S.'s transportation sector contributes 29% to the U.S.'s entire CO2 emissions.[271] Japan not only plans on deploying hydrogen for the country's buses and refuse trucks, but also for the country's forklifts, heavy-duty trucks and ships.[272] The takeaway of Japan's initiatives is that the Country is on track to achieving its 25% emission goal and has carved out a zero emission goal by 2050.

International Treaties

The Paris Climate Agreement went into effect on November 4, 2016 and aims to bring a global response to the threat of climate change. Under Directive 2014-94-EU, member states need to submit National Policy Frameworks (NPF) outlining their targets, objectives and supporting actions.[273] The agreement is part of a larger framework from the United Nations Framework Convention on Climate Change (UNFCC), which focuses its efforts on combating and reducing GHG emissions mitigation, adaptation and finance. Country-level contributions to the Paris Agreement are in the form of nationally determined contributions (NDCs) that typically contain quantified emission reduction commitments. An emissions metric is used to calculate total levels of combined GHG emissions in units of tons of carbon dioxide equivalent (GtCO2-eq) emissions, rather than specifying reduction targets for individual GHGs.[274] The Paris Climate Agreement aims to transform the development trajectories so that the world is on course towards sustainable development, aiming at limiting warming to 1.5 to 2 degrees C above pre-industrial levels.[275]

As of 2017, the United States officially withdrew from the Paris Agreement.[276] Critics of this decision are concerned that the long-term goals encompassing international cooperation on climate change will be jeopardized. Such long-standing effects include budget cuts to American climate change research as well as cancelled donations from environmental funds across the board.[277] Moreover, the federal government has rolled back auto pollution rules, relaxing efforts to limit climate-warming tailpipe pollution. The new rule allows cars on American roads to emit nearly a billion tons more carbon dioxide over the lifetime of

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[269] Chris Randall, EU PROJECT REVIVE WILL DELIVER FUEL CELL SYSTEMS FOR GARBAGE TRUCKS, ELECTRIVE.COM (2020), https://www.electrive.com/2020/01/27/eu-project-revive-will-deliver-fuel-cell-systems-for-garbage-trucks/.

[270] *Trend of Next Generation/Zero Emission Vehicle and Policy in Japan*, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (2018), https://www.nedo.go.jp/content/100878195.pdf

[271] Sources of Greenhouse Gas Emissions, EPA (2019), https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

[272] *Trend of Next Generation/Zero Emission Vehicle and Policy in Japan*, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (2018), https://www.nedo.go.jp/content/100878195.pdf

[273] *Directive 2014/94/Eu of the European Parliament and of the Council of 22 October 2014 on the Deployment of Alternative Fuels Infrastructure*, OFFICIAL JOURNAL OF THE EUROPEAN JOURNAL, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094&from=EN (last visited Aug. 9, 2019).

[274] Steve Denison1 et al., IOPSCIENCE ENVIRONMENTAL RESEARCH LETTERS (2019), https://iopscience.iop.org/article/10.1088/1748-9326/ab4df4/pdf

[275] The Paris Agreement and NDCs, UNFCCC, https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs.

[276] Yong-Xian Zhang, Qing Chen Chao, et al, The withdrawal of the U.S. from the Paris Agreement and its impact on global climate change governance, ScienceDirect.com (2017), https://www.sciencedirect.com/science/article/pii/S1674927817300849.

[277] *Id*.

the vehicles, more than will be emitted under standards implemented in Europe and Asia. While the federal government has rolled back motor vehicle GHG emissions standards, states, cities and the private sector are moving forward on decarbonization initiatives, collaborating on regional efforts to develop cap-and-invest programs to reduce transportation emissions and develop corridors for electric vehicle charging.

VI. Conclusion

The OCA conducted this research to provide information related to the County's legislation and policy history for CNG and other alternative energy initiatives, we further assessed the County's current heavy fleet landscape, along with fleet energy strategies implemented in other jurisdictions, and the different types of alternative energy technologies available. Overall, Miami-Dade County has enacted legislation to support a clean source of energy initiative for its fleet to transition to cleaner energy alternatives. For example, Miami-Dade County intends to achieve a goal of 50% electrification of its bus fleet by the year 2035 per Resolution R-1034-18 and has taken steps toward achieving this goal with the purchase of Electric Buses and studies centered on the transition. Overall, most jurisdictions seek to attain a zero-emissions output currently associated with electric-powered vehicles.

The selected surveyed jurisdictions' results illustrate how those jurisdictions have implemented alternative energy sources for their heavy fleet and observed that the electric-powered fleet is the destination in the evolution of alternative energy. The challenge faced by most jurisdictions is deciding which energy source is the most efficient bridge during the transition to electric, as the electric-powered fleet continues to establish industrial maturity and largescale adoption while addressing challenges related to increasing demand on the grid. While the industry notes that CNG is the most preferred clean energy option to bridge the transition to electric, they also identify that the financial investment for the infrastructure buildout for CNG is significant, though the jurisdictions balance such costs against long-term operating cost and environmental considerations.

Another significant change in the fleet energy landscape is that clean diesel among the other several variations of diesel fuel has become cleaner due to federal regulation, and is now being viewed as a favorable option to transition to electric as this requires very limited or no investment in infrastructure while achieving the goal to lower GHG emission during the transition period. In the past, the instability of diesel fuel prices was another incentive to consider CNG as a bridge gap to the electric-powered fleet; however, in recent times, diesel's price has become more stable and less costly than in previous years.

OCA's research shows that the shift for most of the surveyed jurisdictions and global trends is toward full electrification of the heavy fleet in the next decade. Multiple jurisdictions have already ordered electric transit buses to move away from diesel toward other alternative energy types. Energy alternatives to CNG are available, and while CNG does promote a lower GHG emission and lower energy cost per diesel gallon equivalent, clean diesel, and electric offer both a transition fuel and long-term alternative. Ultimately, a well-designed implementation strategy will be required to avoid over-investing in infrastructure and fleet for a short-term transition energy plan, which will create a financial strain and burden the long-term goal of achieving the electric-powered fleet.

VII. Appendix - Acronyms and Abbreviations

AFleet	Department of Energy tool used to calculate ROI
APS	ammonium persulfate
B-20	20 percent Bio-Diesel and 80 percent ULSD
B-100	100 percent Bio-Diesel
BEB	battery electric bus
BCC	Board of County Commissioners
BPO	Blanket Purchase Order
BYD	Build Your Dream bus manufacturer
CDC	Centers for Disease Control and Prevention
CNG	compressed natural gas
DERM	Division of Environmental Resource Management
DGE	diesel gallon equivalent
DOE	U.S. Department of Energy
DSWM	Miami-Dade County Department of Solid Waste Management
DTPW	Miami-Dade County Department of Transportation and Public Works
EU	European Union
EV	Electric Vehicle
FCEB	fuel cell electric bus
FCV	Hydrogen Fuel Cell Vehicle
FDOT	Florida Department of Transportation
GGE	gasoline gallon equivalent
GHG	Greenhouse Gases
ISD	Internal Services Department
JPA	Joint Participation Agreement
KG	kilograms
KW	kilowatts
KWH	kilowatt hours
LNG	Liquid Natural Gas
LPQ	Liquefied Petroleum Gas
MDTA	Miami-Dade Transit Authority
MPG	Miles Per Gallon
NAAQS	National Ambient Air Quality Standards
NGV	Natural Gas Vehicles
NPF	National Policy Framework
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
OCA	Office of the Commission Auditor
RER	Department of Regulatory and Economic Resources
RFP	Request for Proposal
RNG	Renewable Natural Gas
ROI	Return on Investment
RRF	Resource Recovery Facility
SFRPC	South Florida Regional Planning Council
SWANA	Solid Waste Association of North America
ULSD	ultra-low sulfur diesel
WASD	Water and Sewer Department
WHO	World Health Organization