BATES WHITE
ECONOMIC CONSULTING

Renewable Natural Gas:

Transportation Demand

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I. Executive Summary

This report provides current estimates and projections of the U.S. transportation demand for natural gas, representing the combined transportation demand for geologic and renewable natural gas ("RNG"). These projections represent updates to analysis presented in the 2019 Bates White report: *Renewable Natural Gas Supply and Demand for Transportation* (April 2019). The earlier report evaluated estimates of natural gas demand for transportation produced by the U.S. Energy Information Administration ("EIA"), particularly those incorporated within the EIA's Annual Energy Outlook ("AEO"), and presented an independent estimate of demand based on natural gas vehicle ("NGV") counts and usage data.

The Annual Energy Outlook ("AEO") continues to be a standard reference, but the AEO estimates of the transportation sector's demand for natural gas is just one part of a 20-year economy-wide projection of the production and use of all types of energy, and may not fully capture detailed most-current data sources. Further, the AEO is an annual forecast developed over months and published each year in February. In periods of high volatility and uncertainty, such as that associated with the COVID-19 pandemic, the most recent AEO may not reflect more recent events, and this is particularly true of the 2021 AEO, released in February 2021, and developed in a period when COVID cases were surging and before COVID vaccines were available to the general public. Impacts from the economic lockdown were still substantial, and there was significant uncertainty surrounding both near- and longer-term economic growth.

This report presents an independent RNG demand estimate based on detailed transportation vehicle counts, and reflecting more recent information than was available for the development of the 2021 AEO forecasts. For example, economic activity has rebounded at a significantly higher rate than anticipated in the 2021 AEO. Table 1 summarizes the independent projection of demand for natural gas in transportation, as both compressed natural gas ("CNG") and liquified natural gas ("LNG") presented in millions of gasoline-equivalent and ethanol-equivalent gallons.

Table 1: Projected Transportation Demand for CNG/LNG, 2021-2025

Year	CNG/LNG Demand, mmGGE	CNG/LNG Demand, mmEGE
2021	1,264	1,887
2022	1,284	1,916
2023	1,303	1,945
2024	1,324	1,975
2025	1,344	2,006

II. Introduction

RNG production transforms discarded organic materials into productive fuel for transportation, heat and electric power generation. RNG is derived from raw biogas captured at landfills, wastewater facilities and agricultural digesters and is processed to high energy content fuel that that is completely interchangeable with conventional natural gas. Projects producing high-Btu RNG were developed in the U.S. beginning in the 1980s, and have grown in number, size and type, driven significantly by programs promoting the use of renewable and low carbon fuels in transportation, particularly the federal Renewable Fuel Standard ("RFS") program administered by the Environmental Protection Agency ("EPA") under the Clean Air Act. The RFS program provides critical support for the RNG industry by establishing renewable volume obligations ("RVOs") for cellulosic biofuels. The RVO levels, in turn, take account of the observed and projected transportation demand for renewable fuels, including RNG.

Natural gas use in transportation is growing because it is increasingly economic, particularly for vehicles used intensively, such as refuse trucks, parcel carriers, transit buses, and long-haul trucks, and RNG provides direct environmental benefits relative to petroleum-based transportation fuels. Supportive renewable fuel policies have accelerated the overall transportation demand for natural gas by creating additional economic benefit for end-users. RNG availability enhances the economic value of converting trucking and municipal fleets from diesel to natural gas, which in turn supports investments in supply infrastructure, increasing the value and viability of further conversions.

The total market for RNG has diversified because RNG is fully-interchangeable with geologic natural gas, with applications beyond transportation fuel including electricity generation, industrial heating, hydrogen production, fuel cell supply, liquid fuel refining, plastics manufacturing, and for delivery directly to gas consumers. While this diversification is likely to continue going forward, we focus in this report on the anticipated demand for RNG as vehicle fuel (as both CNG and LNG).

The Energy Information Agency ("EIA") estimates that in 2020, the transportation sector accounted for approximately 3% of total U.S. natural gas consumption.[1] However, around 94% of this demand stemmed from "natural gas pipeline and distribution operations."[2] In this application, natural gas is utilized as a fuel to operate compressors used to move natural gas through pipelines.[3] This end-use is classified under the transportation sector, but it is important to distinguish this distribution function from the sector's demand for vehicle fuel natural gas.

Technological and commercial maturity of medium- and heavy-duty natural gas vehicles have encouraged adoption of natural gas for commercial vehicle fleets, with reported reductions in the total cost of ownership through fuel cost savings and reduced maintenance, in addition to substantial emission reductions.[4]

Although transportation is not projected to be a high-volume sector, it is expected to see steadily increasing natural gas consumption through 2050 on the basis of improved economics of natural gas to power heavy-duty vehicles.[5] Our report focuses on the latter demand for vehicle fuel natural gas.

RNG can be used as fuel in a variety of transportation vehicle types, and demand for RNG follows aggregate demand for CNG and LNG in which RNG is fully-interchangeable with geologic natural gas. The potential for widespread adoption of RNG is enhanced by the fact that it can be distributed through the existing nation-wide natural gas distribution infrastructure. While large capital expenditures are necessary to initiate an RNG-producing project and to connect it to the existing natural gas supply infrastructure, an overhaul of the supply architecture is not necessary in order to replace

[1] U.S. Energy Information Administration (EIA), "Natural gas explained: Use of natural gas." (eia.gov) Accessed October 22, 2021.

[2] U.S. EIA, "Natural gas explained: Use of natural gas." (eia.gov) Accessed October 22, 2021.

[3] U.S. EIA, "Natural gas explained: Use of natural gas." (eia.gov) Accessed October 22, 2021.

[4] Penske Truck Leasing, "Fleets' use of sustainable technology is increasing across all sectors."

[5] U.S. EIA, "Annual Energy Outlook 2021 Narrative." P. 26.

natural gas supply with RNG. Further, as a drop-in fuel, RNG can be utilized in natural gas vehicles (NGVs) with no engine modifications necessary.

A. Projection Methodology

The projections of natural gas transportation demand presented in this report update and refine the method applied in the Bates White 2019 report referenced above. As in the prior report, the demand model presented below is based on the estimated number of natural gas vehicles, average annual vehicle miles and average fuel economy by vehicle class, which allows the estimated annual demand for natural gas to be calculated. This is similar to the approach applied to derive projected usage in EIA's AEO forecast, which also is a structural estimate based on vehicle counts and calculated fuel usage. Full details of the AEO methodology are not publicly available, so it is not possible to identify and validate all the relevant inputs. In any case, as described above, the projection of natural gas use in transportation included in the AEO is only a small part of a large, complex national model of energy use and production, developed over multiple months and published once a year. It is inevitable that the AEO projections are not uniformly comprehensive and up-to-date.

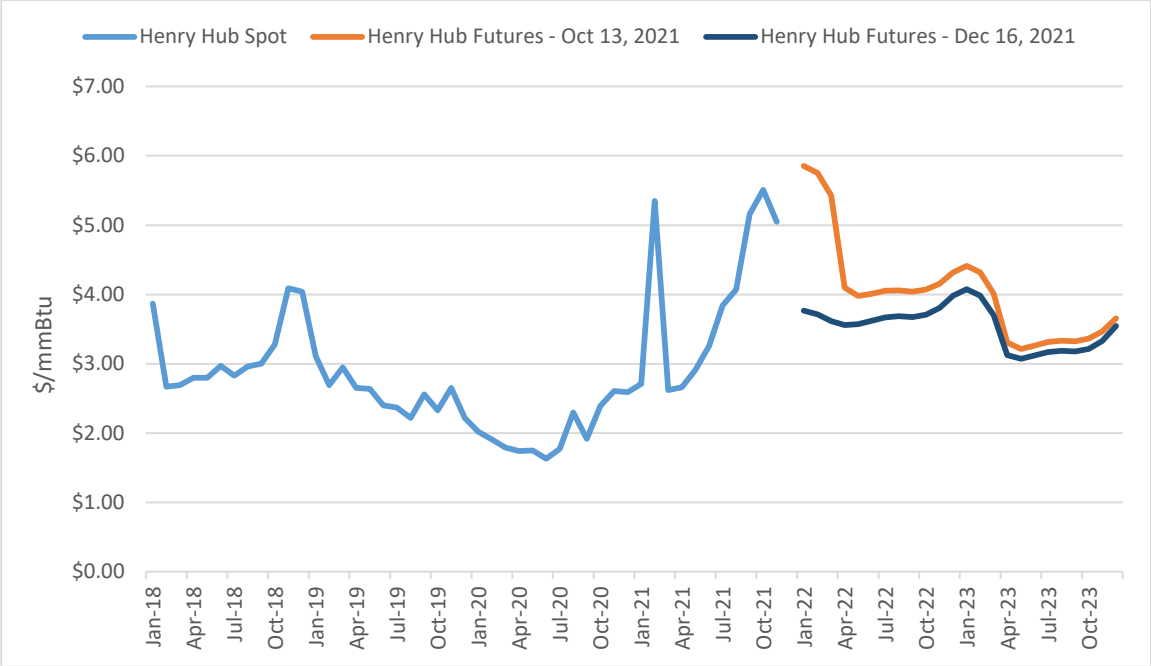
B. Complicating Factors

The AEO is the standard reference for energy use projections across the U.S. economy. In periods of rapidly changing economic conditions, the uncertainty around near-term projections is likely to be high, and this is particularly true for the 2021 AEO, which was developed in late 2020 in the midst of the most extreme economic effects from the COVID-19 pandemic. The U.S. economy had contracted on with unprecedented speed and extent, with substantial depressive effects on energy use, particularly in transportation. As discussed below, the rebound from the pandemic recession has been much more rapid than was anticipated at the end of 2020 and as reflected in the 2021 AEO.

Further complicating forecasts of natural gas demand, natural gas prices began rising in late 2020, spiked in early 2021 and rose significantly above recent historical levels

through much of the rest of 2021. Futures prices out several years indicated that price levels could remain high for an extended period. More recently, however, natural gas prices have dropped back, and futures prices have also moderated substantially. Figure 1 shows average monthly spot prices for natural gas at Henry Hub, Louisiana and futures price quotes from mid-October and mid-December 2021, showing that near term prices for natural gas have dropped below $4.00/mmBtu for 2022 and to near $3.00/mmBtu in 2023. The reversion of natural gas prices indicates that the economic advantages of operating natural gas vehicles is likely to continue.

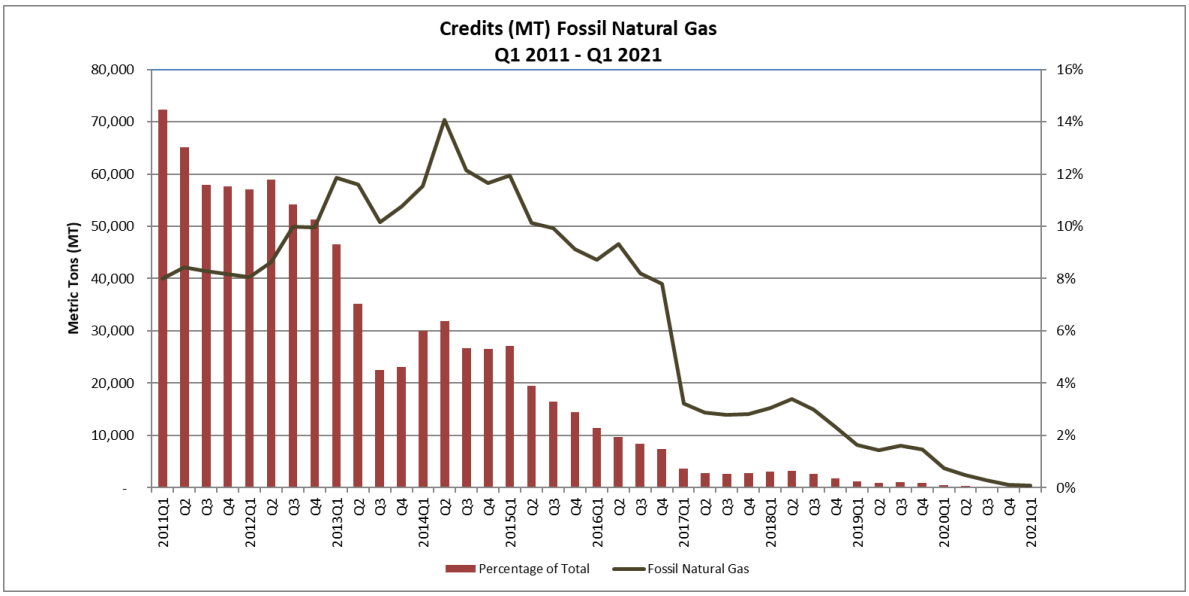
Figure 1: Henry Hub Natural Gas Spot and Futures Prices 2018-2023, $/mmBtu



Diversification of alternative fuels in the pursuit of decarbonizing the transportation sector is another complicating trend. RNG is one of a range of alternative fuels that reduce emissions of CO2 and other air pollutants. In California, the dominant market for RNG, there are indications that there is limited scope for further growth of natural gas in transportation.

Based on data from the California Air Quality Quarterly summary published in July 2021, Figure 2 shows that the percentage of low carbon credits generated by fossil natural gas has declined to almost zero, consistent with the fact that RNG constitutes virtually the entire market for natural gas in transportation for the state – 98% for the latest four quarters of available data, through Q3 2021.[6]

Figure 2: CARB LCFS Fossil Natural Gas Credits[7]



Recent rules look to advance decarbonization through the expansion of electric vehicles in the state. For instance, a new rule from the California Air Resources Board will require every new truck sold in California to be zero-emission by 2045.[8]

[6] CARB, LCF Quarterly Data Spreadsheet, accessed via https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries.

[7] CARB, "2021 LCFS Quarterly Data Summary Report #1" (Jul. 2021); https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/dashboard/quarterlysummary/20210730_q1datasummary.pdf

[8] California Air Resources Board (CARB), "California takes bold step to reduce truck pollution." Updated June 25, 2020.

Elsewhere in the country, various state policies are being advanced that will expand the use of renewable fuels, including RNG, in transportation. A summary of recent (2019 to 2021YTD) state government proposals is provided in Appendix B. The information in is derived from the American Gas Association's RNG tracker updated in October 2021.[9] The California context, with RNG now making up 98% of the market for natural gas in transportation, points to the potential for substantial growth of RNG use in other states. Based on the economics to end-users, it would be expected that all natural gas vehicles would transition to RNG if it is accessible.

III. Forecasts of Natural Gas Demand for Transportation

In our 2019 report, we described different available projections of natural gas demand for transportation. In particular, we discussed the discrepancies between two standard references produced by the EIA: the Short-term Energy Outlook ("STEO"), released on a monthly basis, and the Annual Energy Outlook, released annually. As discussed more fully in the 2019 report, the two projections were based on distinct methodologies, and this caused the resulting projections to differ, sometimes substantially. As of January 2019, the EIA suspended the annual collection of the Form EIA-886, *Annual Survey of Alternative Fuel Vehicles,* which was used to generate projections of renewable natural gas and other alternative fuels in transportation for incorporation in the STEO.[10] The STEO therefore no longer incorporates the associated data.

A. EIA Annual Energy Outlook

EIA's AEO continues to be the standard reference for projected energy use and production in the U.S. The AEO projection methodology uses a buildup of data for vehicle counts, vehicle miles traveled, and fuel economy to estimate transportation fuel demand. The AEO also accounts for rail use of natural gas. Forecasted fuel use, extending out twenty years, is estimated using dynamic projections of each factor,

[9] RNG Activity Tracker (aga.org)

[10] U.S. EIA; "Changes to Form EIA-886, Annual Survey of Alternative Fueled Vehicles."

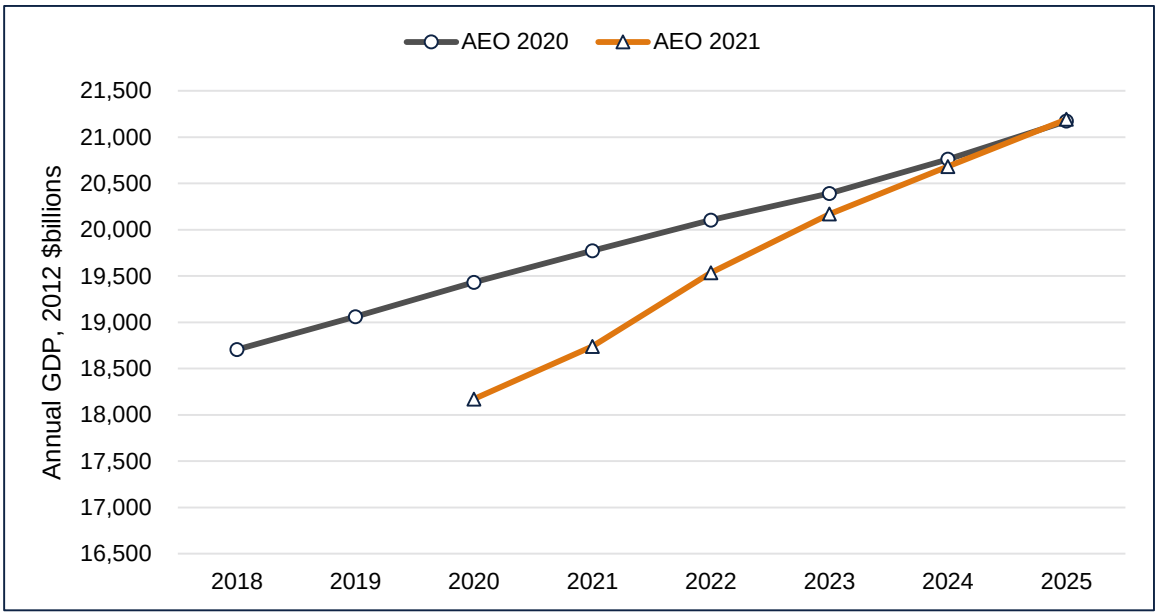
including engine economics, relative fuel prices, technology adoption, macroeconomic growth, and a variety of other variables.[11]

The most recent available AEO, released in February 2021, was developed during a particularly fraught and uncertain period in the latter part of 2020. The economic shutdown had caused an unprecedentedly rapid and sharp economic contraction, and the path of recovery was highly uncertain, with employment rates remaining low even as the unemployment rate improved (a statistical consequence of people not working but not meeting the definition of unemployed, because they were not actively seeking jobs). COVID vaccines were given emergency use authorization by the U.S. Food and Drug Administration in December 2020, but would not be widely available for months.

The AEO released in February 2021 clearly reflects the then-apparent slow and uncertain recovery in its forecasts. Figure 3 shows annual U.S. GDP (2012 $billions) – actual for 2018 and as projected in the 2020 and 2021 AEOs, respectively. The 2021 AEO projected U.S. GDP in 2021 to be more that 5 percent lower than the 2020 AEO did.

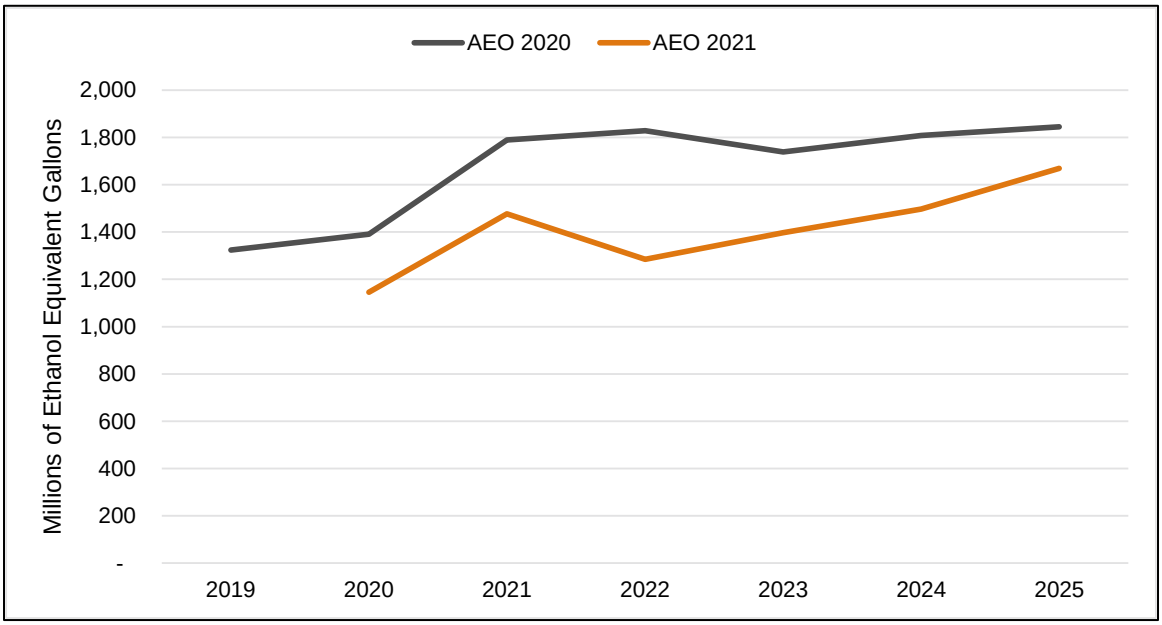
[11] The underlying National Energy Modeling System (NEMS) used by EIA to develop the AEO projections is a dynamic model of the entire U.S. energy system, representing supply, demand and prices, across energy sources and end-use sectors, and which is also linked to a macroeconomic model.

Figure 3: U.S. GDP 2018 and Projections from 2020 and 2021 AEO (2012$ billions)



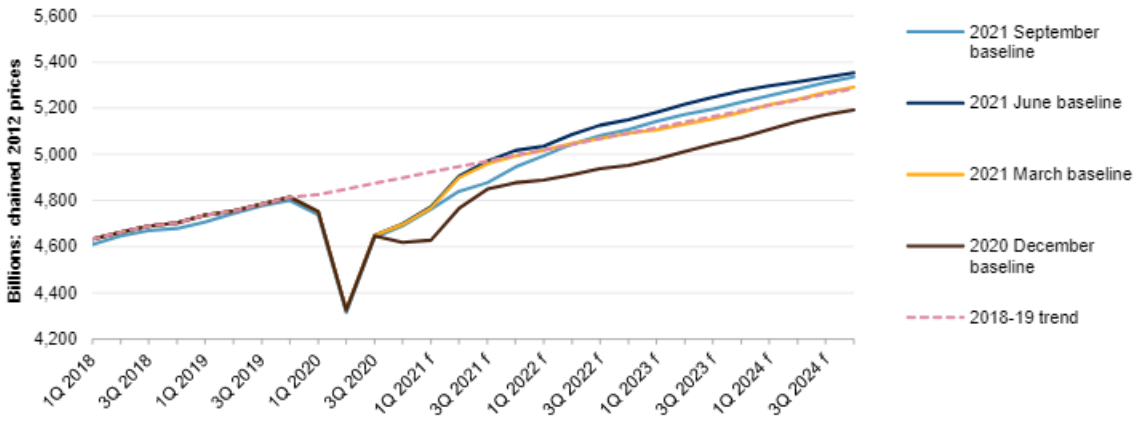
Transportation fuel use, both actual and projected, were necessarily substantially affected by the unusual COVID-19 economic effects, and the AEO projections of natural gas use in transportation are consistent with the differences in the overall forecasts of the economy. This is shown in Figure 4, which focuses on the period to 2025.

Figure 4: Projected Natural Gas Use in Transportation to 2025 (MM of EEG)



However, not surprisingly (and as has been the case since the beginning of the pandemic), actual events differed significantly from expectations. The rebound in economic activity and jobs was more rapid than expected, with the demand for goods rising particularly fast. The understanding of economic growth, and expectations for the future, have changed substantially since the end of 2020. S&P published an assessment of GDP forecast changes in September 2021, showing that growth expectations beyond 2021 had changed radically from December 2020, and that projected GDP for 2023 and 2024 was actually greater than that based on the 2018-2019 growth trend. This is shown in Figure 5.

Figure 5: GDP Forecast Changes Since Dec 2020, S&P Global[12]



f--Forecast. Sources: Bureau of Economic Analysis, Oxford Economics, and S&P Global Economics forecasts.

In effect, the expected economic rebound has been compressed into a much shorter period than had been anticipated in December 2020, with demand for goods now reaching near- pre-pandemic levels. With respect to the AEO projections, actual GDP at the end of 2021 is estimated at $19.8 trillion (2012$), slightly above the level projected in the 2021 AEO for the end of 2022.

There remain significant economic uncertainties looking forward, including the timing in resolving supply chain issues, and the efficacy of current vaccines against new coronavirus variants, but it is clear that actual economic performance has outstripped expectations reflected in the 2021 AEO, and consequently that projected transportation fuel use in that forecast is likely biased downward.

[12] Standard & Poor's Financial Services, Economic Outlook U.S. Q4 2021, accessed at https://www.spglobal.com/ratings/en/research/articles/210923-economic-outlook-u-s-q4-2021-the-rocket-is-leveling-off-12120697.

B. Independent demand estimate

Bates White updated and refined the independent estimate and projection of natural gas use in transportation that was presented in the 2019 report. The projection presented below applies a methodology similar to that used for the AEO forecasts, in that it relies on data for NGV counts, annual vehicle miles and fuel mileage by vehicle category, and also incorporates some data from the AEO forecast itself. The main difference with the AEO projection is that data for specific NGV categories have been drawn from the most recent available information from other authoritative sources as well as individual company reports.

The categories of vehicles reflected in this analysis include: heavy freight trucking, refuse trucks, transit buses, school buses and light-duty vehicles. Fuel demand is modeled by vehicle category as a function of vehicle count, average distance traveled in a year and average fuel efficiency of the vehicle. Information on operation characteristics is drawn from the Alternative Fuels Data Center.[13, 14] Data for use in rail and international shipping are drawn from the 2021 AEO detailed datasets.[15,16,17] NGV numbers per category are drawn from individual sources, provided in the footnotes to Table 2.

[13] U.S. Alternative Fuels Data Center (AFDC), "Maps and Data - Average Annual Vehicle Miles Traveled by Major Vehicle Category."

[14] U.S. AFDC, "Maps and Data - Average Fuel Economy by Major Vehicle Category."

[15] Natural gas heat content: 1,037 Btu per cubic foot. U.S. EIA, "Frequently Asked Questions (FAQs)."

[16] Cubic foot to gasoline gallon equivalent: 0.877 cubic feet of CNG per GGE. U.S. Department of Energy (DOE), "Fuel Conversion Factors to Gasoline Gallon Equivalents."

[17] Gasoline gallon equivalent to ethanol gallon equivalent: 0.67 GGE per EGE. U.S. AFDC, "Fuel Properties Comparison." P. 1.

Table 2: Independent Estimate of Demand for 2021

Vehicle category	NGV Count	Average Annual Miles Traveled	Fuel Efficiency (miles/GGE)	Fuel Demand for 2021 (mmGGE/year)	Fuel Demand for 2021 (mmEGE/year)
	(a)	(b)	(c)	(d) = (a) x (b) / (c) /10^6	(e) = (d) / 0.67
Refuse trucks[2]	15,015	25,000	2.5	151.5	226.1
Transit buses[3]	24,000	43,647	3.3	319.9	477.5
Light-duty vehicles[4]	28,900	11,485	22.6	14.7	21.9
School buses[5]	5,500	12,000	6.2	10.7	15.9
Heavy freight trucking[6]	47,684				652.4
LNG: Non-trucking freight[7]					493.0
Total				**496.7**	**1,886.8**

Notes:

1 Implied fuel consumption calculated using formulae shown in subheader row of table.

2 Fleet data from the largest refuse/waste management companies are used. Detailed fleet data unavailable for smaller companies such as Rubicon, Junk King, and others.

3 Estimate published by U.S. Department of Energy Alternative Fuels Data Center. Estimate does not include school buses, verified through American Public Transportation Association Fact Book 2020.

4 Estimate published by U.S. Department of Energy Alternative Fuels Data Center. Includes cars, wagons, vans, sport utility vehicles, and pickups. Vehicles with short wheelbases (<121") are generalized as cars, weighted 45% in calculations, and vehicles with long wheelbases are generalized as light trucks, weighted 55%.

5 Estimate published by Natural Gas Vehicles of America.

6 U.S. Energy Information Administration Annual Energy Outlook 2021, excluding data for refuse trucks.

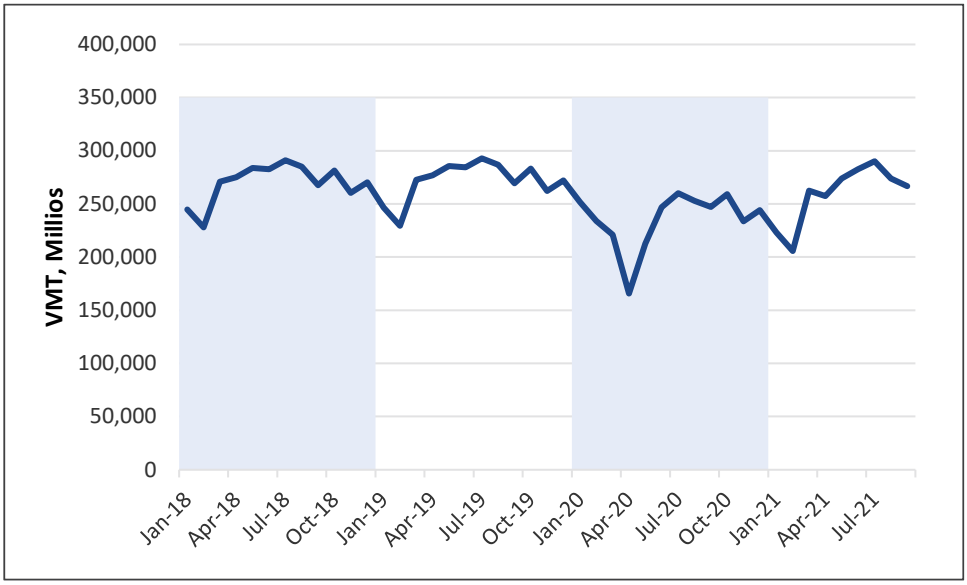
7 U.S. Energy Information Administration Annual Energy Outlook 2021. Includes Railroads and International shipping.

Additional information on the respective vehicle categories, data and assumptions is provided in Appendix B.

The independent estimate relies on current available data on vehicle counts, and applies vehicle miles traveled ("VMT") data from 2019. While the VMT data clearly are not consistent with the economic circumstances that existed in 2020, as discussed above, the rebound from the nadir of the pandemic period has been much more rapid than anticipated at the end of 2020 when the 2021 AEO was finalized.

A comparison of data from the St. Louis Federal Reserve indicates that VMT numbers have increased, both in absolute terms and on average in the first 8 months of 2021 compared to the same period in 2020. Further, the year-over-year change appears to be returning to its 2019 average.[18]

Figure 6 Vehicle Miles Travelled, Monthly, Not Seasonally Adjusted[19]

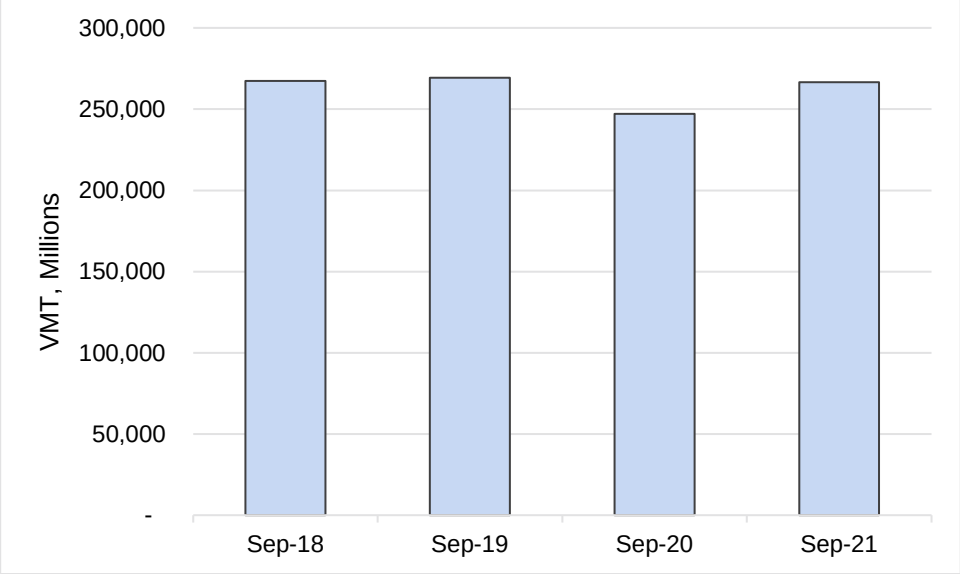


[18] The use of year-over-year measures is particularly important for travel data, due to seasonal variation in VMT data, as seen in Figure 4.

[19] Based on data from the St. Louis Federal Reserve. Vehicle Miles Traveled (TRFVOLUSM227NFWA) | FRED | St. Louis Fed (stlouisfed.org)

A comparison of VMT data for the most recent available month, September 2021, to data for the three previous Septembers is shown in Figure 7. VMT for September 2021 is only 1.0% below the level for September 2019.

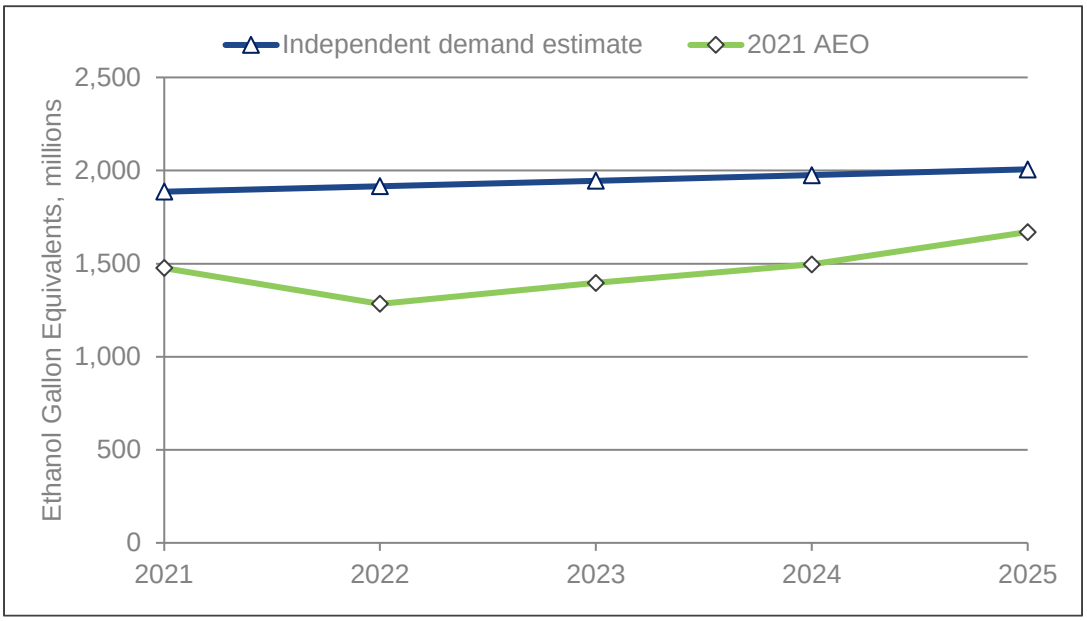
Figure 7: September VMT Data, 2018-21



We have developed the 2021 natural gas demand estimate for 2021 without modification to the vehicle miles traveled assumption. While this likely results in an overstatement of what actual demand will be for 2021, accounting for continuing effects of the pandemic, we believe it is an appropriate basis for projecting demand forward through 2025. However, we have applied conservative growth assumptions for the future period. Our projection does not attempt to capture economic dynamics that are incorporated in EIA's comprehensive energy model and, as discussed above, there is substantial uncertainty associated with such near-term dynamics. To carry our estimate of natural gas demand forward, we have applied an annual growth rate of approximately 1.5%. This corresponds to the compound annual average growth rate for natural gas demand for transportation from the 2020 AEO over the five year period starting in 2021. This method avoids the exaggerated pandemic effects evident in the 2021 AEO, and also averages out the near-term dynamics from the 2020 AEO, which are no longer relevant,

while still reflecting the broader fundamentals of EIA's energy model. The 1.5% growth rate we apply through 2025 is substantially below the longer-term natural gas demand growth rates from the 2020 and 2021 AEO, which both show compound annual growth of 5.0% per year from 2025 to 2030. The independent demand projection is shown in Figure 8, compared to the values from the 2021 AEO. The values for the independent projection correspond to those in Table 1.

Figure 8: Independent Demand Estimate of NG for Transportation, and AEO 2021, 2021-2025 (MM EGE)



Appendix A – Vehicle Categories and Data Sources

A. Demand Drivers of Natural Gas Use in Transportation

1. Medium and heavy-duty trucks

According to industry estimates, commercial trucking is responsible for approximately 30% of U.S. greenhouse gas emissions.[20] As the country's policies and regulations promote zero-emissions technology, the commercial trucking industry is seeking alternatives to continued reliance on fossil fuel.

The country's leading Original Equipment Manufacturers ("OEMs") have expanded their NGV offerings for the commercial trucking industry. There are approximately 90 models of Class 2 through Class 8 CNG vehicles, with around 85 percent of the 53,000 registered NGVs used in heavy-duty applications including refuse, public transit and goods movement.[21] As a drop-in fuel, RNG allows the commercial trucking industry ready fuel access via existing infrastructure.[22]

Large corporate entities such as Amazon, SoCalGas, and UPS have made substantial commitments to the implementation of RNG in their vehicle fleets. In early 2021, Clean Energy Fuels Corp. announced an agreement with Amazon to provide RNG in 15 different states.[23] In mid-2021, SoCalGas announced that it will convert 200 new Ford F-

[20] Fleet Equipment Mag, "Renewable natural gas for trucking fleets that want a lower carbon footprint." Updated January 7, 2021. Accessed October 22, 2021.

[21] Penske Truck Leasing, "Fleets' use of sustainable technology is increasing across all sectors."

[22] Fleet Equipment Mag, "Renewable natural gas for trucking fleets that want a lower carbon footprint." Updated January 7, 2021. Accessed October 22, 2021.

[23] California Natural Gas Vehicle Coalition (CNGVC), "Clean Energy Signs Agreement with Amazon for Low and Negative Carbon RNG." Updated April 19, 2021. Accessed October 22, 2021.

250 service pickup trucks to run on RNG, bringing the share of the company's service vehicles operating on clean fuels to approximately 40 percent.[24]

Even for very heavy-duty applications, this technology makes sense. According to Wegmans, natural gas vehicles can have stronger powertrains integrated, which will allow for natural gas-powered applications in grocery distribution vehicles.[25] Companies such as Anheuser-Busch are already moving to implement RNG in such applications.[26]

2. Railways

According to the EIA's 2021 projections, the non-trucking freight sector – comprised of Railroads and International shipping – will consume 3,793.08 mmEGE of LNG in the year 2050. This projected demand constitutes approximately two-thirds (67.1%) of the overall projected vehicle fuel natural gas demand for 2050 (5,657 mmEGE).

The railroads sector's changing fuel mix is inevitable. Railway Age, an online source for railway news, finance and regulatory information, states that "[i]n 2025, the U.S. EPA Tier 5 standard and the European Euro7 standard should come into effect. Both standards limit the emission of harmful substances by trains and locomotives to very low values."[27] As with other RNG applications, current locomotive designs do not have to be significantly modified in order to adopt RNG as a fuel.[28]

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[24] CNGVC, "SoCalGas Announces Plans to Convert 200 New Field Service Trucks to Run on Renewable Natural Gas." Updated April 22, 2021. Accessed October 22, 2021.

[25] Transport Dive, "Wegmans adds CNG truck with Hyliion powertrain to pull tandem trailer sets." Updated September 30, 2020.

[26] Transport Dive, "Anheuser-Busch to transition 180 trucks to renewable natural gas." Updated August 14, 2020.

[27] Railway Age, "Zero-Emission Locomotives on U.S. Railways?" Updated February 12, 2021.

[28] Railway Age, "Zero-Emission Locomotives on U.S. Railways?" Updated February 12, 2021.

B. Vehicle Categories Evaluated in Independent Demand Estimate

1. Refuse trucks

NGV numbers for the Refuse trucks subcategory are drawn from actual fleet data available through the sustainability reports of Waste Management, Republic Services, and Waste Connections, three of the largest waste management companies in the country. Reliably accurate estimates were generated for Recology and Atlas Disposal through information presented in their sustainability reports as well.

While NGV America states "more than 17,000 refuse and recycling trucks in the United States run on natural gas and about 60% of new collection trucks on order will be powered by the same,"[29] we have used a more conservative, but verifiable estimate of just over 15,000 vehicles. Our vehicle numbers do not capture data for the numerous waste companies, such as Rubicon and Junk King, as well as other smaller companies, for which precise data are altogether unavailable and cannot be reliably estimated. Further, although adoption rates for natural gas technology among the waste industry are high, there are companies that have not bought in. Stericycle "currently has no alternative fuel vehicles,"[30] and Covanta's SASB filings indicate 0% natural gas use in the company's fleet fuel mix.[31]

Furthermore, there are numerous 'closed-loop' RNG utilization projects that do not have reliable reporting available. "Often, the owner of the biogas source also has a vehicle fleet, for example a public works department that has a landfill and/or WRRF as well as a CNG-compatible fleet inventory. Some onsite fueling stations also allow corporate fleets operating in the area to use their stations. In either case, these types of projects, wherein

[29] Waste Dive, "CNG trucks still used by many in the industry, but electric vehicles gaining ground." Updated September 2, 2020.

[30] Stericycle, "2021 Corporate Social Responsibility Report." P. 61.

[31] Covanta, "2019 Sustainability Report." P. 12.

the vehicles delivering a feedstock (e.g., garbage or food waste) are fueled by RNG from biogas produced by that feedstock, are considered "closed loop" or circular projects."[32]

2. Transit buses

NGV numbers are taken as-is from the AFDC's data on "Transit Buses by Fuel Type."[33] This is likely to be an accurate estimation, as the AFDC appropriately derives and updates its numbers according to a methodology.

3. School buses

NGV numbers are taken as-is from the NGVA's reporting on its webpage.[34] This number has not changed from our earlier estimate.

4. Light-duty vehicles

Light-duty NGV numbers are taken directly from the AFDC's data on "Light-Duty AFV Registrations."[35] This subcategory was excluded from our 2019 demand estimate. However, due to recent growth in the sector, we now include it. Due to high fuel efficiency numbers, the fuel demand from this subcategory remains low relative to the overall estimate – at 1.3% of total estimated demand. However, our forecasted fuel demand is likely to be an underestimate as our source – AFDC's Light-Duty AFV Registrations – does not include data on retrofitted vehicles. Registration is not required when retrofitting an older vehicle resulting in an underestimation of the total number of light-duty CNG vehicles operational nationwide.

The Light-duty vehicles (LDVs) category aggregates data according to the length of the wheelbase, specifically those vehicles with a long wheelbase (greater than 121 inches) and those with a short wheelbase (less than 121 inches). According to data from the

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[32] U.S. EPA, "An Overview of Renewable Natural Gas from Biogas." P. 7.

[33] U.S. AFDC; "Maps and Data - Transit Buses by Fuel Type."

[34] Natural Gas Vehicles of America, "Schools."

[35] U.S. AFDC, "Maps and Data - Light-Duty AFV Registrations."

Bureau of Transportation Statistics,[36] approximately 23.4% of light-duty vehicles have a long wheelbase. This includes pickups trucks, SUVs with a larger wheelbase, and other such vehicles. As sales of these vehicles are surpassing sales of short wheelbase vehicles, we rounded the percentage up and utilized an estimate of 24% to define sales of light-duty vehicles with a long wheelbase (76% with a short wheelbase.) These estimates help us develop more accurate sales-weighted estimates of fuel demand for the LDVs subcategory.

5. Heavy Freight Trucking

For heavy freight trucking, we rely on the estimates from the 2021 AEO, reflecting approximately 48,400 heavy freight trucks operational in the U.S. in 2021, based on the 2021 AEO (data detail Table 49: Freight Transportation Energy Use, and AEO CNG/LNG usage estimates).

[36] U.S. Bureau of Transportation Statistics (BTS), "Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances."

Appendix B

Table B-1 Summary of State Government Proposals, 2019 to October 2021

State	State Government Proposals	Status	Year
Arkansas	SB 136: Amends state law related to gas rates allowing the PSC to consider utility purchase of natural gas or natural gas alternatives, such as RNG and hydrogen, as an operating expense if the purchase is in the public interest.	Signed into law.	March 2021.
California	SB 1440: CPUC can adopt a biomethane procurement program that benefits rate payers, is cost-effective, and advances the state's environmental and energy policies.	Signed into law.	2019.
	SB 457: extends the monetary incentives program established in D.15-06-029, which is set to run out on Dec. 31, 2021, until Dec. 31 2026.	Signed into law.	October 2019.
	SB 1352: mandatory RPS for gas utilities. Requires the commission to establish a biomethane procurement program requiring utilities by 2030 to procure at least 20 percent of its total volume of gas delivered to core customers in California with biomethane. The bill would require the commission, in designing and implementing the program, to ensure that the biomethane procurement program is a cost-effective means to achieve forecast reductions in emissions of shortlived climate pollutants.	Introduced.	February 2020.
	AB 3163: Amended definition of biomethane to include methane produced from a number of specified organic waste feedstocks.	Signed into law.	October 2020.
	CA SB 1122: Requires PUC to consider green electrolytic hydrogen as a zero-carbon resource; requires CARB to prepare strategic plan to accelerate green electrolytic hydrogen.	Introduced.	February 2020.
Colorado	HB 14-1159: Provides a sales tax exemption for anaerobic digester equipment.	Passed into law.	2019.

State	State Government Proposals	Status	Year
	SB 20-013: Establishes innovative tech program approved by PUC where utilities may seek approval of projects relating to technologies such as RNG, hydrogen, and CCS. Allows utility to fully recover costs of project and capital investments. SB 20-1018: Directs PUC to adopt RNG program for small and large utilities by July 31, 2021. Allows utilities to fully recover costs on RNG programs. Targets of 5% RNG by 2025, 10% in 2030, and 15% in 2035.	Passed Senate; left on table.	2019.
	SB 21-161: Directs PUC to adopt rules for programs for voluntary emissions reductions for gas utilities; using a utility's 2019 GHG emissions as a baseline: By 2025 at least 5%; by 2030 at least 10%; and after 2035 at least 15%. RNG must account for at least 35% of a utility's emissions reductions.	Introduced. Tabled.	March 2021.
	SB 21-264: requires gas utilities to file a clean heat plan with the PUC. The targets are a four percent reduction below 2015 GHG emission levels by 2025 and 22 percent by 2030. Within the overall targets, RNG may only account for one percent of the 2025 target and five percent of the 2030 target.	Enacted.	June 2021.
Connecticut	HB 5350: Intended to increase the use of RNG in Connecticut and accelerate natural gas infrastructure repair and replacement. Allows for supply of biogas for injection into distribution system. Commissioner may direct utilities to enter into gas purchase agreements with biogas suppliers for periods of no more than 20 years. The bill allows utilities to recover costs on RNG-related infrastructure costs arising from a gas purchase agreement. A gas utility may elect to use the RNG procured to meet the needs of its customers or sell it to applicable third parties.	Introduced.	February 2020.
	CT SB 60: directs the permitting and siting process for anaerobic digesters be streamlined.	Introduced.	January 2021.
	CT HB 6409: Reintroduces provisions from HB 5350 (2020).	Introduced.	February 2021.

State	State Government Proposals	Status	Year
Florida	SB 896: aiming to support the growth of renewable natural gas as a renewable source of energy in the state. Adds definitions of biogas and renewable natural gas, adding the term renewable natural gas to the previously existing definition of renewable energy under state law. Allows PSC to approve cost recovery by utility for purchase of RNG where pricing exceeds NG market price but otherwise deemed reasonable and prudent.	Passed.	April 2021.
Hawaii	HB 1242: The bill requires gas RPS. Following renewable portfolio requirements: 25 percent of sales by 2025; 40 percent of sales by 2030; 70 percent of sales by 2040; and 100 percent of sales by 2050. Allows for cost recovery through an automatic rate adjustment clause.	Introduced.	January 2019.
	SB 289: The bill requires gas RPS. Following renewable portfolio requirements: 25 percent of sales by 2025; 40 percent of sales by 2030; 70 percent of sales by 2040; and 100 percent of sales by 2050. Allows for cost recovery through an automatic rate adjustment clause. Same as HB 1242.	Introduced.	January 2021.
Illinois	HB 3115: Under the bill natural gas utilities may seek authorization from the ICC to engage in RNG related activities such as facility investment, gas supply contracts, pipeline expansion to interconnect with RNG, and providing customers with the option to directly purchase RNG. Includes portfolio goals of 2% of the utility's supply portfolio by January 1, 2030 and not less than 3% by 2035.	Introduced.	February 2021.
Iowa	HF 522: Provides that farms may store and process manure through anaerobic digesters and produce biogas as an alternative to the current required manure storage structures.	Enacted.	May 2021.
Maine	LD-2017: Requires the PUC to develop and oversee a pilot project for the conversion of excess renewable energy into methane gas and hydrogen and the storage of the converted gas. Up to 3 energy-to-gas facilities, each up to 10 megawatts in production capacity, may be established. The commission is required to establish the pilot project no later than January 1, 2021; the pilot project expires December 31, 2026.	Carried over due to emergency adjournment.	2020-2021.

State	State Government Proposals	Status	Year
	LD 9: The bill would require the PUC to establish and oversee a power-to fuel pilot program. The commission is required to approve up to two power-to-fuel projects between January 1, 2022 and December 31, 2027, each up to 10 megawatts in production capacity, that convert renewable energy to hydrogen gas, methane gas or other fuel.	Introduced.	January 2021.
	LD 989: requires the PUC to allow utility to use RNG for no more than 2% of the gas it supplies to its customers starting in 2022 and to allow a utility to use an additional 2% annually thereafter. Utility may include the costs of RNG in its cost-of-gas adjustment rate.	Introduced.	March 2021.
Massachusetts	H 3887: seeks study on the opportunities for sustainable and cost-effective market deployment of RNG, hydrogen, and low-carbon fuels to reduce emissions associated with the supply of natural gas for heating.	Filed.	February 2021.
	H 4081: Beginning in 2025 the bill would establish a renewable heating standard requiring that at least 3 % percent of therms sold by obligated entities come from qualified renewable heating fuels. Beginning in 2030 it would go up to 5%, in 2035 7%, and by 2040 10%. The bill also directs the DPU to adopt regulations authorizing cost recovery by natural gas utilities of all prudent incremental costs arising from the implementation of the renewable heating fuel standards recovered by means of an automatic adjustment clause or any another recovery mechanism authorized by rule.	Introduced.	August 2021.
Michigan	HB 6036: expands the state's PACE financing program to include anaerobic digestion as a qualifying "energy program" eligible for financing.	Introduced.	August 2020.
	SB 138: The bill directs the PSC to develop and periodically update an inventory of biogas and RNG resources available in the state.	Introduced.	February 2021.
	SB 82: state budget bill includes $250,000 for the PSC to conduct an RNG study assessing the potential for RNG development in the state.	Passed legislature.	September 2021.

State	State Government Proposals	Status	Year
Minnesota	SF No. 3013: The bill would establish a state regulatory policy allowing a utility to add RNG and hydrogen to its distribution system. Must submit plan to MPUC, the cost of the alternative resource plan must be no more than five percent of the utility's total annual revenue requirement. Also calls for statewide inventory of Minnesota's potential renewable natural gas resources.	Passed Senate before session adjourned sine die.	2020*.
	HF 239/ SF 421: allows gas utilities to propose innovative resource plans. Innovative resource is defined to include biogas, RNG, and power-tohydrogen among others. Could invest up to 7.5% revenue requirement in RNG. May also seek separate green tariff.	Introduced.	January 2021.
	HF 6: reintroduced version of HF 239 in special session.	Enacted.	June 2021.
Missouri	HB 734: requires PSC to adopt rules for voluntary RNG program for utilities. Directs PSC to establish reporting requirements and a process for utilities to fully recover prudently incurred costs associated with a renewable natural gas program.	Passed.	May 2021.
Nevada	SB 154: requires the Public Utilities Commission of Nevada to adopt regulations authorizing a public utility which purchases natural gas for resale to engage in renewable natural gas activities and to recover the reasonable and prudent costs of such activities. Directs utilities to attempt to incorporate the following amounts of RNG into their supply: 1% by 2025; 2% by 2030; and 3% by 2035.	Signed into law.	2019.
New Jersey	A3726: Classifies landfills with gas capture as recycling facilities. The bill requires specific methods of food waste recycling and food waste-to-energy production. Sending food waste offsite for treatment with sewage sludge in an anaerobic digester for renewable natural gas or biogas recovery is an alternative authorized recycling method under the bill. Also amends the definition of "Class I renewable energy" to include methane gas from landfills, methane gas from a biomass AFacility, or methane gas from an anaerobic or aerobic digestion facilityng amounts of RNG into their supply: 1% by 2025; 2% by 2030; and 3% by 2035.	Passed House.	2020.

State	State Government Proposals	Status	Year
	NJ S 3526/ A 5655: directs the BPU to establish a program to encourage the procurement of RNG and investment in RNG infrastructure by a gas utility. The bill establishes portfolio targets starting at 5% by 2024 the bill sets targets increasing by five percent every five years ending in 30 percent RNG by 2050. Allows utility to annually invest up to 5% of total revenue requirement.	Introduced.	March 2021.
North Carolina	SB 605: streamlines permit process for turning hog waste into RNG. Would create "general permits" for animal farm operations that allow the owner to operate a farm digester system that collects methane gas.	Passed.	June 2021.
Ohio	HB 166: Allows gas utilities to treat infrastructure related to biologically derived methane gas as "useful" facilities for distribution service, thus allowing utilities to recover on this investment as part of a normal rate case.	Effective.	July 2019.
Oklahoma	HB 3970: Requires OCC to issue a report by Dec. 2020 on recommendations regarding the ability and appropriateness of natural gas utilities to procure, transport and deliver renewable natural gas to customers	Introduced.	January 2020.
	HB 1815: Directs OCC, by December 1, 2021, to issue a report and recommendations to the legislature on the ability of utilities to procure RNG for customers. The report must also discuss the methods for recovery of associated costs from ratepayers, such as transport infrastructure and commodity costs.	Enacted.	April 2021.
Oregon	SB 98: Requires the PUC to adopt by rule renewable natural gas program for natural gas utilities to recover prudently incurred qualified investments in meeting certain targets for including renewable natural gas in gas purchases for distribution to retail natural gas customers. Law supports RNG targets of 15% by 2030, 20% by 2035 and 30% by 2050. Requires commission to adopt rules no later than December 31, 2019.	Became law.	2019.
	SB 314: Authorizes PUC to allow gas utilities to recover costs from retail customers for prudent investments infrastructure measures that support adoption and service of alternative forms of transportation vehicles.	Passed Senate.	March 2021.

State	State Government Proposals	Status	Year
Virginia	HB 461: establishes a tax credit for renewable energy property placed in service. The bill in part defines "renewable energy property" to include certain biomass equipment that uses renewable biomass resources and combined heat and power systems using waste heat to produce electricity or thermal or mechanical energy.	Introduced.	2020.
Washington	HB 1257: Requires gas utilities to offer by tariff voluntary RNG service for customers with participation limited by availability of supply. Customer charge for RNG cannot be more than 5% of amount charged to retail customers for natural gas.	Became law.	2019.
	HB 1070: provides a public utility tax exemption for sales of RNG by a gas distribution business, thereby subjecting the gas to the same (and therefore lower) tax rate as RNG used as transportation fuel.	Reintroduced and retained in present status.	2020.

BATES WHITE
ECONOMIC CONSULTING

Renewable Natural Gas:

Transportation Demand

Supplemental Estimates

April 29, 2022

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I. RNG Demand Estimates

This document presents updated estimates and projections of the U.S. transportation demand for natural gas, representing the combined transportation demand for geologic and renewable natural gas ("RNG"). These projections are intended as a supplement to the Bates White report: *Renewable Natural Gas:Transportation Demand* (February 2022). The estimates capture updated information from the most recent Annual Energy Outlook ("AEO"), produced by the U.S. Energy Information Administration ("EIA"), and released in March 2022, and also modify the treatment of demand from transit buses and refuse trucks, based on further analysis of data sources.

Table 1 summarizes the independent projection of demand for natural gas in transportation, as both compressed natural gas ("CNG") and liquified natural gas ("LNG"), for 2021-2025, presented in millions of gasoline-equivalent and ethanol-equivalent gallons. This table corresponds to Table 1 in the February 2022 report.

Table 1: Projected Transportation Demand for CNG/LNG, 2021-2025

Year	CNG/LNG Demand, mmGGE	CNG/LNG Demand, mmEGE
2021	995	1,486
2022	1,010	1,508
2023	1,025	1,531
2024	1,041	1,553
2025	1,056	1,577

Table 2, below, details the demand estimate for 2021, which applies a methodology similar to that used for the AEO forecasts, in that it relies on data for NGV counts, annual vehicle miles and fuel mileage by vehicle category, and also incorporates some data from the AEO forecast itself. The main difference with the AEO projection is that data for specific NGV categories have been drawn from the most recent available information from other authoritative sources as well as individual company reports. Relative to the estimates presented in the February report, the most significant changes, based on further research, are: 1) the estimate for demand from refuse trucks has been netted out from the heavy freight category, reflecting the fact that the heavy freight numbers from the AEO are inclusive of refuse trucks; and, 2) incorporation of transit demand estimates from the most recent National Transit Database, from the U.S. Department of Transportation. Data sources and assumptions are provided in the accompanying notes to Table 2.

Table 2: Independent Estimate of Demand for 2021

Vehicle category	NGV Count	Average Annual Miles Traveled[3]	Fuel Efficiency (miles/GGE)[4]	Fuel Demand for 2021 (mmGGE/year)	Fuel Demand for 2021 (mmEGE/year)[2]
Light-duty vehicles[1,5]	28,900	11,485	22.6	14.7	21.9
School buses[1,6]	5,500	12,000	6.2	10.7	15.9
Refuse trucks[1,7]	15,015	25,000	2.5	151.5	226.1
Transit buses[8]				195.9	292.4
Non-refuse heavy freight trucks[9]				292.3	436.2
LNG: Non-trucking freight[10]				330.3	493.0
Total				**995.4**	**1,485.6**

Notes:

1 Fuel Demand for 2021 (mmGGE/year) = NGV Count * Average Annual Miles Traveled (miles) / Fuel Efficiency (miles/GGE) / 10^6.

2 Fuel Demand for 2021 (mmEGE/year) = Fuel Demand for 2021 (mmGGE/year) / 0.67.

3 Data published by U.S. Department of Energy Alternative Fuels Data Center, "Average Annual Vehicle Miles Traveles by Major Vehicle Category;" updated February 2020.

4 Data published by U.S. Department of Energy Alternative Fuels Data Center, "Average Fuel Economy by Major Vehicle Category;" updated February 2020.

5 Vehicle count estimate published by U.S. Department of Energy Alternative Fuels Data Center, "Light-Duty AFV Registrations;" last updated August 2020. Includes cars, wagons, vans, sport utility vehicles, and pickups. Vehicles with short wheelbases (<121") are generalized as cars, weighted 76% in calculations, and vehicles with long wheelbases are generalized as light trucks, weighted 24%. These weights calculated on the basis of U.S. Bureau of Transportation Statistics' "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances;" published April 2016.

6 Estimate published by Natural Gas Vehicles of America.

7 Fleet data from the largest refuse and waste management companies are used--Waste Management, Republic Services, Waste Connections, Recology, Atlas Disposal. Detailed fleet data unavailable for smaller companies such as Rubicon and Junk King.

8 Fuel Demand for 2021 (mmGGE/year) estimated as follows: transit systems' nautral gas consumption in 2019 (mmGGE/year) as published in the 2020 Fuel and Energy dataset from the National Transit Database, multiplied by the 2019/2018 growth rate of NG consumed by transit buses as calculated using Tables 36 of the 2022 AEO Reference case and the 2021 AEO (simple average of High economic growth and Low economic growth cases used in lieu of Reference case).

9 Fuel Demand for 2021 (mmGGE/year) estimated as follows: heavy freight trucks' natural gas consumption in 2021 (trillion Btu) as estimated in Table 49 of the 2021 Annual Energy Outlook Reference case multiplied by the ratio of non-refuse heavy freight trucks to total stock of heavy freight trucks, and converted to mmGGE/year by (* 10^12 / (76,330 * 10^6)). We avoid double counting refuse trucks by subtracting our estimate of refuse trucks from the reported heavy freight truck stock.

10 U.S. Energy Information Administration 2021 Annual Energy Outlook Reference case, Table 49. Table estimates Liquefied Natural Gas consumption (trillion Btu) in Railroads and International shipping sectors. Converted to mmGGE/year by (* 10^12 / (76,330 * 10^6)).