Center for American Progress

American Fuel

Developing Natural Gas for Heavy Vehicles

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Creating incentives to convert the nation's heavy vehicle fleet to natural gas would reduce oil use, invest in American energy sources, increase our energy independence and national security, and slash air pollution.

Natural gas is the cleanest fossil fuel—it produces less than half as much carbon pollution as coal for electricity and up to 25 percent less than oil for transportation. Recent technological advancements in developing unconventional shale gas resources have dramatically increased the amount of recoverable natural gas resources in the United States. And this creates an unprecedented opportunity to use gas as a bridge fuel to a 21st-century clean energy transportation system that relies on dramatically enhanced fuel economy; lightweight, electric vehicles; public transit; advanced bio-fuels; and low-carbon fossil fuels such as natural gas.

Cleaner, domestically produced natural gas has the potential to meet more than one-third of the fuel needs of heavy- and medium-duty trucks and buses by 2035. Our analysis, which is based on current fleet turnover rates for each class, determines that deployment of 3.5 million of these natural gas vehicles by 2035 would save at least 1.2 million barrels of oil per day compared to business as usual, which is more oil than we imported from Venezuela last year.

Our country's dangerous overdependence on foreign oil poses a triple threat to our energy security by endangering our energy supply, economic security, and national security. The Center for Naval Analysis's Military Advisory Board determined that, "Our dependence on foreign oil reduces our international leverage, places our troops in dangerous global regions, funds nations and individuals who wish us harm, and weakens our economy; our dependency and inefficient use of oil also puts our troops at risk."

Domestic natural gas can play a vital role in reducing reliance on foreign oil and enhancing national security by substituting it for the oil-based fuels such as diesel and gasoline used in heavy commercial transportation in the near term.

Natural gas can pave the way to our clean energy future

Natural gas is the cleanest fossil fuel, producing less than half as much carbon pollution as coal for electricity and up to 25 percent less than oil for transportation. Natural gas is also domestically available in vast quantities. The United States consumed 20.68 trillion cubic feet of natural gas in 2009, but only 13 percent of that amount was imported. And new techniques for extracting domestic gas should mean that we will not have to import significant quantities of natural gas in the foreseeable future.

Recent advances in horizontal drilling will enable us to affordably develop significant shale gas reserves in the lower 48 states. This could fundamentally alter the U.S. energy system and help speed the transition to a low-carbon economy that produces less global warming pollution. The Energy Information Administration estimates that the United States has approximately 1,770 trillion cubic feet of technically recoverable gas. The Potential Gas Committee estimates that "the current recoverable resource estimate provides enough natural gas to supply the U.S. for the next 90 years."

These shale gas plays in Arkansas, Louisiana, Michigan, New York, Ohio, Pennsylvania, Texas, and elsewhere have increased proven reserves of U.S. natural gas by 27 percent over the last three reported years and driven potential reserves even higher.

And because natural gas is produced in the United States, using it in lieu of imported oil will create jobs, reduce our trade imbalance, and keep energy dollars at home instead of exporting them overseas.

Of course, there are polluting ways to go about producing shale gas and there are sustainable ways. The "hydraulic fracturing," or "fracking," that frees the gas involves chemicals and water use that could contaminate the adjacent environment. We will need to make sure that the shale gas production can continue to develop without threatening public health, drinking water supplies, or worsening global warming.

Natural gas is a much-needed cleaner option for big vehicles

Nearly two-thirds of U.S. oil consumption goes to road transportation, with more than two-thirds of that for gasoline and one-fourth for diesel fuel. The United States should continue to pursue electric and plug-in hybrid electric options for gasoline-powered light-duty passenger cars and trucks, but these technologies are unlikely to be efficient or cost-effective for heavier vehicles. The batteries required for medium-weight and heavy trucks, especially long-distance freight trucks, would have to be so large and heavy that they would actually reduce vehicle efficiency. Natural gas vehicles are therefore an excellent option to reduce oil consumption in this segment of our nation's transportation fleet.

The vehicles most suited for natural gas conversion are medium- and heavy-duty trucks, and transit and school buses. The EIA estimates that there were a total of 41,000 vehicles fueled by compressed natural gas on the road in 2007, and 2,600 vehicles fueled by liquefied natural gas. The EPA notes that these natural gas vehicles emit up to 25 percent less carbon dioxide pollution than their diesel or gasoline counterparts.

Vehicle classes most appropriate for significant conversion to natural gas

Vehicle class	2009		Projected 2035			
	Number (all fuel types)	Oil consumption (barrels of oil per day)	Number (all fuel types)	Oil consumption under business as usual scenario (barrels of oil per day)	Oil consumption with increased natural gas vehicles (barrels of oil per day)	Net oil savings under increased natural gas vehicles (barrels of oil per day)*
Heavy-duty trucks	4,806,621	1,625,000	6,448,489	2,230,000	1,235,000	1,010,000
Medium-duty trucks	3,904,902	364,000	8,544,441	779,000	665,000	139,000
Transit buses**	67,502	40,000	75,424	23,000***	22,000	45,000
School buses**	693,752	57,000	808,678	76,000	42,000	36,000
Total						1,230,000

Sources: Energy Information Agency, Annual Energy Outlook 2010, Supplemental Tables 46 and 67; Federal Highway Administration, Highway Statistics 2008; American Public Transport Association, 2009 Public Transportation Fact Book, Appendix A, Table 17

*Business as usual scenario already includes some natural gas vehicle penetration, but total oil savings are calculated with reference to total energy used by each vehicle class.

**See methodology note six for details on how we estimated the number of transit and school buses.

***The EIA already forecasts a significant decrease in oil consumption for transit buses due to a conversion to natural gas.

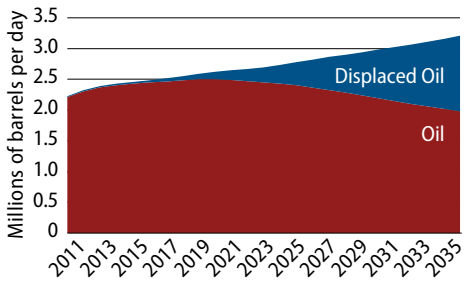
Replacing 3.5 million of these heavy vehicles with natural gas vehicles by 2035 would save more than 1.2 million barrels of oil per day compared to business as usual, which is more than we imported from either Venezuela or Saudi Arabia in 2009. This would be accomplished primarily by replacing aging traditional vehicles with new natural gas vehicles over time, but we also assume a small number of retrofits to convert existing vehicles to natural gas.

We project, based on existing fleet turnover rates, that nearly half of all heavy trucks would be powered by natural gas. Natural gas would also fuel one-fifth of medium trucks, nearly half of all school buses, and two-thirds of transit buses.

Natural gas may be used as a transportation fuel in either of two forms: compressed natural gas or liquefied natural gas. CNG is currently the more widely available form of natural gas and is already being successfully used in short-range, centrally fueled vehicles such as refuse trucks, concrete mixers, straight trucks, and school buses. But the American Trucking Association has concluded that CNG is an impractical fuel for long-distance freight trucks because its lower energy density limits vehicle range and necessitates more frequent fill-ups.

FIGURE 1

Potential oil displacement from natural gas trucks and buses



Sources: Energy Information Administration, Annual Energy Outlook 2010, Supplementary Tables 46 and 67, available at: http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C170 and http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C2275

LNG is likely to be a better option for longer-distance freight trucks. It is cryogenically liquefied to approximately negative 260º F and has higher energy density than CNG, but there is currently no LNG refueling infrastructure. It is relatively easy and economical to add natural gas refueling stations to the central owner-operated facilities that service shorter-range trucks and buses. Long-range, heavy-duty trucks, on the other hand, refill at public gas stations, and federal assistance would likely be necessary to spur proliferation of commercial liquefied natural gas for these vehicles. Federal policymakers should examine the feasibility of creating "natural gas highway corridors" with LNG refilling facilities at truck stops along interstate highways.

The lifecycle costs of natural gas fueled trucks are already competitive with diesel. A California Natural Gas Vehicle Coalition report found that these trucks and buses are highly competitive with their diesel counterparts, and "the relative average annual cost difference of owning, maintaining, and operating comparably equipped vehicles was found to be small over the range of expected fuel prices, vehicle technology costs and vehicle fuel economy."

Policies to encourage the transition from diesel vehicles to natural gas vehicles would help overcome the barriers of higher up-front costs and lack of infrastructure that are impeding their widespread adoption.

Heavy-duty trucks

Heavy trucks represent the largest opportunity to replace foreign oil with homemade natural gas as transportation fuel. "Heavy trucks" include Class 7 and Class 8 trucks weighing more than 26,000 pounds. These vehicles are commonly called "semis" or "18-wheelers" and are generally used for freight transportation. The Energy Information Administration estimates that there are currently 4.8 million heavy trucks on the road, consuming more than 1.6 million barrels of oil per day, mostly in the form of diesel fuel.

These trucks have an average fuel economy of only about six miles per gallon due to their heavy weight, so most would require liquefied natural gas. If we can get nearly 3 million natural gas heavy trucks on the road by 2035, they could eventually displace up to about 1 million barrels per day, or 45 percent of the projected oil consumption of heavy trucks by 2035. See methodology for more details.

Medium-duty trucks

There are currently almost 4 million medium trucks on the road, consuming about 380,000 barrels of oil per day. "Medium" trucks include Class 3 through 6 trucks weighing between 10,000 and 26,000 pounds. Most of these trucks are used for business or for individuals with heavy hauling or towing needs.

There is real potential for natural gas to replace diesel and gasoline for this portion of the medium truck population since 38 percent of these vehicles are centrally fueled. If natural gas vehicles make up about one-third of new medium truck sales by 2035, that will put nearly 1.4 million natural gas medium-duty trucks on the road. These natural gas vehicles could eventually displace up to about 139,000 barrels of oil per day, or 17 percent of medium trucks' projected oil consumption by 2035

Buses

The three main categories of buses—transit, school, and intercity—currently use a total 113,000 barrels of oil per day. Because they operate on well-defined routes in local areas, transit buses and school buses are usually centrally refueled, whereas intercity buses are not. Natural gas is already widely used in transit buses, providing 20 percent of the total fuel needs for these vehicles in 2009. If we can get 420,000 of these vehicles on the road by 2035—a 25-fold increase from the 17,500 natural gas buses in 2007—then natural gas transit and school buses could eventually displace half of the oil used for all buses by 2035, saving 80,000 barrels per day.

The NAT GAS Act

Oil and gas man T. Boone Pickens proposed a bold plan in 2008 to increase wind electricity generation, upgrade and secure the transmission grid to carry renewable energy, make buildings more energy efficient, and replace foreign oil with domestic natural gas in heavy trucks. He spent months traveling across America to promote "The Pickens Plan" and created a grassroots network to support it.

The plank that urges conversion of heavy- and medium-duty trucks to natural gas is embodied in the New Alternative Transportation to Give Americans Solutions Act, or NAT GAS Act (S. 1408), sponsored by Sens. Robert Menendez (D-NJ), Harry Reid (D-NV), and Orrin Hatch (R-UT). Its House companion (H.R. 1835) is sponsored by Reps. Dan Boren (D-OK), John Larson (D-CT), and John Sullivan (R-OK).

These bills would create economic incentives to boost investments in heavy-duty vehicles powered by natural gas and the necessary refueling infrastructure. It does this by increasing and extending several key tax credits:

- **Alternative Fuel Tax Credit:** Allows natural gas users to receive a 50-cent credit per 121 cubic feet (for CNG) or gallon (for LNG) of natural gas they purchase through at least 2019

- **Alternative Fueled Vehicle Tax Credits:** Makes all dedicated natural gas vehicles eligible for a credit equal to 80 percent of the vehicle's incremental cost; Makes all bi-fuel natural gas vehicles eligible for a credit equal to 50 percent of the vehicle's incremental cost; And increases the light duty vehicle purchase tax credit by 150 percent—from $5,000 to $12,500—and doubles the vehicle purchase tax credits for all other vehicle weight classes

- **Alternative Minimum Tax applicability:** Allows the natural gas vehicle and fueling infrastructure tax credits to count against the alternative minimum tax provisions and makes them transferable under certain conditions

- **Refueling Property Tax Credit:** Creates an incentive to build CNG or LNG refueling facilities by increasing the refueling property tax credit from 50 percent or $50,000 per station to 50 percent or $100,000 per station

- **Research and development grants:** Provide grants through the Department of Energy to light- and heavy-duty engine manufacturers for research and development of better natural gas engines

The bill also encourages the federal government to set an example by mandating the purchase of alternative fuel vehicles, including natural gas vehicles, in its fleet. It also expresses that the EPA should streamline the process for certifying natural gas vehicle retrofit kits.

These incentives could increase the number of natural gas heavy-duty vehicles that replace gasoline or diesel trucks and buses beyond these estimates. This would increase the oil savings beyond the 1.2 million barrels per day estimate.

A program to encourage the conversion of heavy vehicles to run on natural gas like the one outlined in the NAT GAS Act should be included in any comprehensive clean energy and climate change bill.

Natural gas vehicles can work

The risks associated with converting our heavy truck and bus fleet to natural gas are small. Yet some people worry that the rapid adoption of natural gas as a transportation fuel would exhaust our domestic gas supplies much faster and cause a rise in the price for natural gas. Natural gas prices are expected to rise steadily over time, but much less than oil prices, and its use as a transportation fuel would not significantly disrupt the nation's supply or price.

Using gas as a transportation fuel would not consume a significant enough portion of the nation's gas supply to cause shortages or major price spikes, especially in light of the newly available supplies. We estimate that the United States would need 2.7 trillion cubic feet of

natural gas to replace the 1.2 million barrels of oil annually that would be saved by powering nearly 3.5 million heavy vehicles with natural gas by 2035.

The EIA forecasts that United States will consume a total of 22.9 trillion cubic feet of natural gas in 2035, so an additional 2.7 trillion cubic feet would mean an increase in consumption of only about 12 percent per year. Our proven reserves have increased by 27 percent over the last three reported years, and the Energy Information Administration estimates that the United States has approximately 1,770 trillion cubic feet of technically recoverable gas.

IHS Cambridge Energy Research Associates determined that, "The unconventional natural gas revolution has lowered the natural gas price outlook and made gas more competitive while encouraging higher expectations for security of supply—a dramatic shift from just half a decade ago." EIA also expects less volatility in natural gas prices.

Some are also expressing concerns that there are too few natural gas refueling stations. There are only 825 CNG and 38 LNG refueling stations throughout the United States, according to the Department of Energy, while there are approximately 68,000 stations that sell diesel. The Wall Street Journal also noted that it costs several times as much to build a natural gas fueling station as it does to construct a traditional diesel station.

To address this problem, NAT GAS Act provides financial assistance to speed the construction of refueling facilities. The most effective approach is to first target vehicles fueled at central stations and truck stops. A significant portion of heavy- and medium-duty trucks and buses are already centrally refueled. Heavy freight trucks are often refilled at truck stops along interstate highways, which could be targeted for natural gas installation and used to create natural gas refueling corridors. The federal government will have to provide incentives to jumpstart the initial refueling infrastructure expansion, but the costs of natural gas refueling stations will naturally decline due to economies of scale and innovation.

Environmental advocates are legitimately concerned about the "fracking" used in combination with improved horizontal well-drilling technology to help open vast new natural shale gas reserves. The fracking chemicals used with sand and water to fracture the rock and release natural gas can be toxic and contaminate drinking water supplies. Preventing underground leaks of fracking fluid requires proper installation of well casings and careful monitoring. Surface water contamination is also a concern because the used fluids are brought to the surface once drilling is completed and often stored in ponds that can leak. Environmental Protection Agency Administrator Lisa Jackson announced on February 24 that the EPA will soon begin a $1.8 million study of hydraulic fracturing. The U.S. House Energy and Commerce Committee has also launched an investigation into fracking's environmental and public health effects.

Potential methane leakage from natural gas trucks is also an environmental concern. Methane, the primary component of natural gas, is over 20 times more potent as a global warming pollutant compared to carbon dioxide. Natural gas vehicles that sit idle could leak

more methane from their tanks, offsetting some of the positive climate change effects of the switch from oil to natural gas. The EPA and Department of Energy should conduct a thorough assessment of this concern.

Conclusion

The United States' addiction to oil is a threat to our security and prosperity. Natural gas is a cleaner, cheaper, and domestically abundant fuel, and creating incentives to convert the nation's heavy- and medium-duty truck and bus fleets to natural gas is essential to relying on homemade American energy, increasing our energy independence, and reducing air pollution.

A strong national incentive program that encourages the purchase and retrofit of 3.5 million heavy vehicles to run on natural gas—along with the construction of refueling facilities—could allow us to displace 1.2 million barrels of oil per day by 2035, saving at total of 3.7 billion barrels of oil from 2011 to 2035.

A program to encourage the conversion of heavy vehicles to run on natural gas should be included in any comprehensive clean energy and climate change bill.

Methodology

All data for vehicle sales, stock, and fuel consumption used in these calculations were from the reference case forecasts in DOE's "Annual Energy Outlook 2010." We made the following assumptions to assess the oil displacement potential of natural gas vehicles in the heavy-duty fleet:

1. Any NGV entering the fleet would replace a traditional diesel or gasoline vehicle.

2. Each vehicle class (heavy trucks, medium trucks, transit buses, school buses) is independent, meaning that changes in the amount of natural gas used in one group of vehicles would not accelerate or decelerate the adoption of natural gas in other categories. In reality, the infrastructure build-out for any of these classes would probably accelerate the adoption of natural gas for all vehicle classes.

3. We used the DOE attrition rates for heavy- and medium-duty trucks and assumed the same rate would apply to natural gas vehicles. We calculated total feet attrition as the previous year's stock plus current year sales minus the current year stock, and then distributing that among traditional and natural gas vehicles in proportion to the previous year's stock of each.

4. For heavy trucks:

   - The percentage of new vehicles sold that run on natural gas would follow an S-shaped logistic growth function [N(t)=1/(1+e^((13-t)/3)), where t=0 in 2011], reaching 5 percent of new sales by 2015, 20 percent by 2020, 58 percent by 2025, 88 percent by 2030, and 97.5 percent by 2025. We assumed a slower initial ramp-up would be composed of mostly CNG in centrally refueled fleets. Innovation and economies of scale would then make natural gas trucks cheaper while refueling infrastructure for LNG becomes more available, especially along major highways. Finally, sales growth would eventually slow due to market saturation.

   - We assumed a small amount of vehicle retrofits, modeled with a bell curve that peaks at 0.5 percent of remaining non-natural-gas trucks in 2024.

5. For medium trucks, the new vehicles sales and retrofit percentages were assumed to be one-third of the corresponding heavy truck percentages for a given year.

6. To calculate estimates of the bus fleet size in Table 1, we started with 2008 estimates of the fleet stock for each type (see below) and projected increases proportional to the bus energy consumption forecast from EIA AEO2010 Table 46, while accounting for increases in fuel efficiency from the forecast for heavy trucks (assumed to have similar engines to buses) from EIA AEO2010 Table 67.

   - School buses: We began with the 2008 estimate of "Total School and Other" buses from Federal Highway Administration, Highway Statistics 2008.

   - Intercity buses: We estimated the number of intercity buses by subtracting the 2008 estimate of transit buses from the American Public Transport Association (see below) from "Total Commercial and Federal" buses from Federal Highway Administration, Highway Statistics 2008.

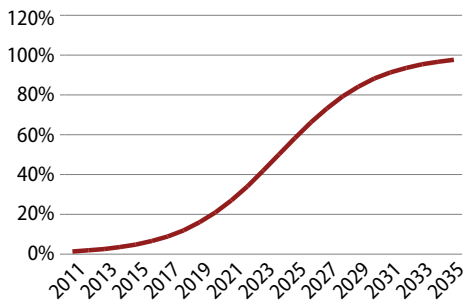
   - Transit buses: We began with the 2008 estimate of transit buses from the American Public Transport Association, 2009 Public Transportation Fact Book, Appendix A, Table 17.

7. Since direct forecasts of bus stock and sales were not available from EIA or other sources, we assumed that new transit and school bus sales and retrofits would grow at similar rates to heavy trucks. We therefore based the oil displacement figures for buses off of the heavy truck displacement rates.

   - Transit buses: Since natural gas already accounts for 21.74 percent of transit bus fuel energy in 2010, we added 21.74 percent to the corresponding heavy truck displacement percentage for each year.

FIGURE 2

New heavy truck sales penetration



Based on estimates from the Center for American Progress

Logistic growth function new heavy truck sales: N(t)=1/(1+e^((13-t)/3)), where t=0 in 2011

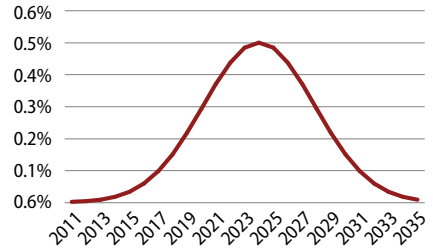
- Intercity buses: Assumed zero natural gas conversion.

- School buses: We added the 2010 natural gas consumption percentage for school buses (0.89 percent) to the corresponding heavy truck displacement percentage for each year.

8. To estimate the amount of natural gas required to replace the saved oil, we assumed a 7 percent fuel efficiency penalty for natural gas engines.

9. Conversion factors: 1 cubic foot natural gas = 1,028 British thermal unit
   1 barrel oil equivalent = 5,800,000 Btu

FIGURE 3
Truck retrofit percentage



Based on estimates from the Center for American Progress
Bell curve for retrofits: N(t)=0.005*e^(-(t-13)^2)/30), where t=0 in 2011

Our calculations show that the United States could realistically displace 1.2 million barrels of oil per day by 2035 compared to business as usual. This represents 38 percent of the 2035 projected diesel and gasoline consumption by buses and medium and heavy trucks. A conversion of 3.5 million heavy vehicles to natural gas by 2035 could save a total of 3.7 billion barrels of oil over the next 25 years.