Transportation Efficiency

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ABSTRACT

The transportation sector consumes 70% of the petroleum that the U.S. uses for fuel, which leads one to study transportation to identify significant opportunities to save energy. Every 1-cent increase in the price of a gallon of gas costs the U.S. Postal Service (USPS) $8 million per year for their 200,000-vehicle fleet. To reduce American dependence on fossil fuels, the carbon footprint left by vehicular fleets should be evaluated.

This article reports on the current state of fuel efficiency and fleet efficiency in the U.S., including government, municipal, and large commercial sectors. It also discusses opportunities in behavior modification to improve fleet efficiency. Case studies are presented showing evidence of best practices currently implemented. By studying transportation fleets and educating fleet managers about viable alternatives to improve fleet efficiency, we can save significant amounts of fuel and reduce our carbon footprint.

This analysis demonstrates that transportation efficiency is economically feasible for a wide variety of public and private entities and is beneficial to the environment.

TRANSPORTATION EFFICIENCY

All countries emit carbon dioxide, but certain countries emit more than others. The U.S. is historically the world's largest producer of greenhouse gases per capita, followed closely by Australia, Canada, and parts of Europe. (See Figure 1.) There are estimates for CO_2 emissions for most countries; developed countries usually have a higher level of emissions per capita. The transportation sector, including privately owned, commercial, and government vehicles, produces 23% of the total CO_2

Figure 1. Carbon dioxide emissions worldwide [1]

emissions in the world. However, developing countries have more high carbon-emitting vehicles on the road and may not be able to conform to the environmental standards held by more developed countries such as the U.S. and Europe. Countries with swiftly expanding economies, such as China, are projected to see high increases in CO_2 emissions through 2030 [0].

A large proportion of carbon dioxide production is traced directly to the internal combustion engines used to propel vehicles such as cars, trucks, buses, and trains. In the U.S., CO_2 emissions are proportional to the amount of oil used in the transportation industry. Although the U.S. has 5% of the world's population, it accounts for 33% of the world's oil consumption, or 18 million barrels of oil per day [3].

There are more than 246 million vehicles on American roads [5], and the number of vehicles increases every year [3]. (See Figure 2.) In 2010, 10.9 million passenger vehicles were registered in corporate fleets, which is 4.4% of the total number registered that year in the U.S. [5]. Changing fleet fuel consumption in America will take time—not all businesses will consider buying smaller vehicles or driving less often. However, higher consumption may be addressed with education to improve driving habits, and on-going research can improve the operating efficiency (miles per gallon) of new vehicles.

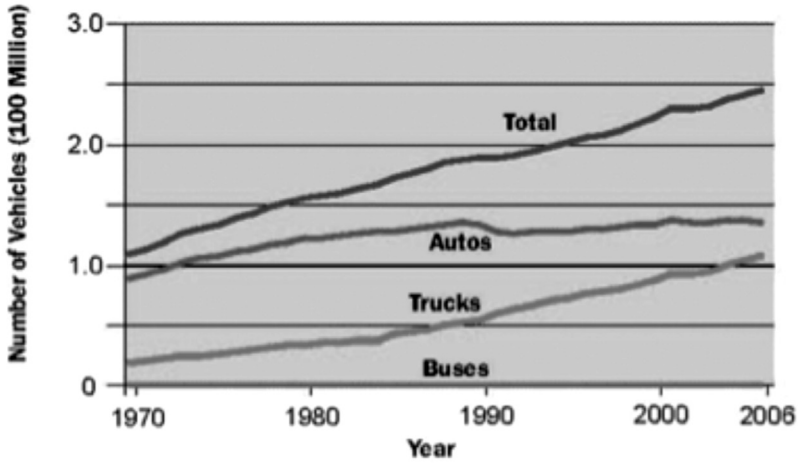

Figure 2. Number of registered vehicles, in 100 millions, in the United States, 1970-2006 [4]

Fleet Efficiency

An increasing number of commercial and government vehicles are on American roads every day, contributing to carbon emissions. Targeting commercial and government automotive fleets may prove more effective in the near term than solely targeting daily commuter vehicles. (A *fleet* is defined as a group of motor vehicles owned or leased by a corporation or the government, instead of by an individual.)

Large fleets are often made up of buses, taxicabs, police vehicles, and rentals. The environmental impact of fleets is higher than that of personal vehicles because of the distance driven each year. The average personal car is driven 12,000 miles/year, whereas the average fleet car is driven 23,000 miles/year [5]. Also, fleets have a large share of the new car market, as fleet cars are replaced more frequently.

Fuel efficiency and fleet efficiency are two different concepts. *Fuel efficiency* is a form of thermal efficiency dependent upon unique engine parameters, aerodynamic drag, weight, and the rolling resistance of a vehicle. There have been advances in all of these vehicle characteristics by car manufacturers over the last decade. In comparison, *fleet efficiency* describes the fuel usage of a group of vehicles and can be affected by engine efficiency, route optimization, and behavior modification. Other aspects to consider include the origin of the fuel—how many miles it may have traveled on a ship, plane, or truck—and the CO_2 emissions associated with production. For instance, American-grown corn may be used to create biodiesel. The fuel (petroleum-based or otherwise) to grow the corn crop, along with the miles traveled from the corn field to the processing plant and on to the filling station, must be taken into consideration when determining CO_2 emissions of the biodiesel.

A viable option to reduce carbon emissions is to target the highest-emitting transportation fleets that are ordered in bulk annually. Some of these large fleets are operated by the following:

- Cities and schools
  - School buses
  - Police and fire departments
  - Public transportation
- Rental car companies
- Federal and state agencies
- Commercial entities
- Trucking firms

- Mail and package delivery services, such as USPS, Federal Express, and United Parcel Service (UPS)

For example, the police and fire department market accounts for about 60,000 vehicles purchased annually. Some of their purchases have been more forward-thinking and use a number of different technologies. In March 2010, BMW and Carbon Motors announced a joint effort to develop a police cruiser using a high-efficiency BMW turbo-diesel engine [6]. In February 2009, the New York Police Department introduced 40 hybrid Nissan Altimas into its fleet. (See Figure 3.) The fleet previously consisted of vehicles like the Chevrolet Impala and Ford Crown Victoria, which range 16-18 mpg in the city, whereas the hybrid Altima is expected to get an average of 35 mpg in the city. One concern regarding

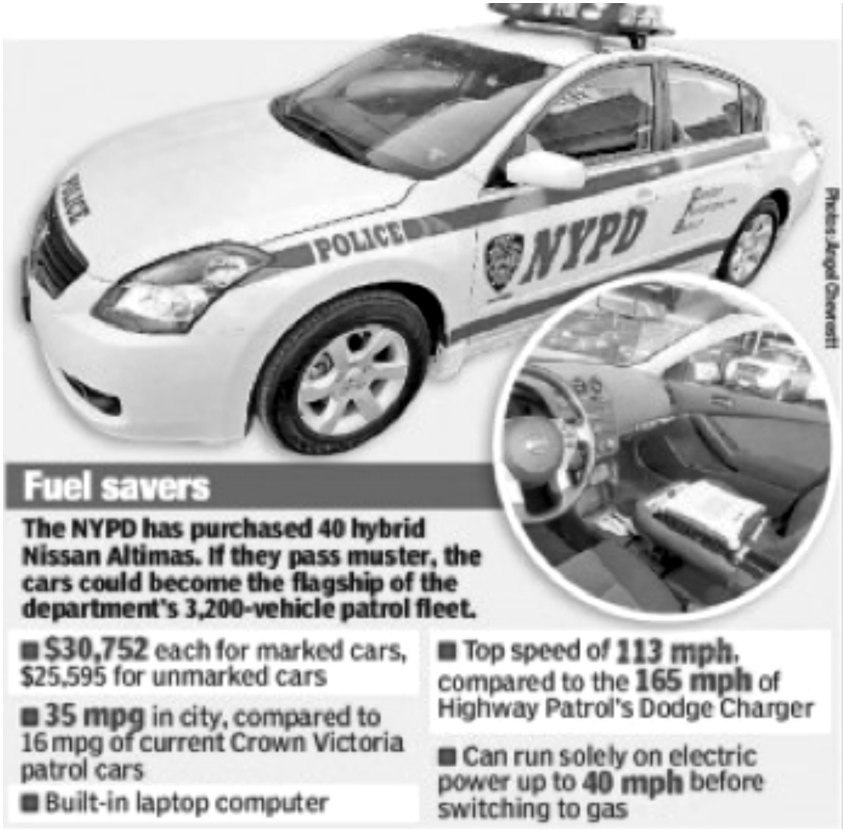

Figure 3. NYPD Nissan Altima hybrid patrol car [7]

the use of hybrid police cars is top speeds. The Nissan Altima hybrid can reach 113 mph, which appears sufficient in urban environments.

Another fleet segment to study is the national rental auto and light truck market. In 2009, there were approximately 1.5 million rental cars in the U.S. [8]. The main providers in the rental car industry, including Hertz, Avis and Enterprise, have taken measures to cut the emissions profile of their rental fleet. Enterprise has 4,000 hybrid vehicles available for rent nationwide. They also purchased 500 Nissan Leafs (electric) in January 2011 and installed charging stations at various locations nationwide in an effort to draw more "green-friendly" customers [9]. However, driving electric rentals will be limited to inner cities until the number of electric charging stations increases drastically. Other rental companies to target include those that rent vehicles designed for moving and hauling, such as Budget and U-Haul.

Behavior Modification

The cost of new, efficient vehicles is high, and not all fleet owners can gather the funds to make immediate investments. However, behavior modifications are reasonable, require little to no capital investment, and can lead to significant savings. For instance, UPS recently adopted a new policy of no left turns. Their engineers designed software to map every route in advance and provide right-turn only directions to drivers. In 2010, UPS's routing software eliminated 20.4 million miles from routes and reduced CO_2 emissions by 20,000 metric tons [17]. UPS is realizing efficiencies on several fronts from this policy, including reduced miles traveled per day, reduced fuel consumption through less idling while waiting to turn left, and more packages delivered per day per delivery vehicle.

Another example of behavior modification that can be applied to fleets is the use of a Global Positioning System (GPS). Programmed local, regional, and national routes for drivers offer significant opportunities to reduce fuel consumption because drivers will waste fewer miles searching for their destination. As obvious as these savings are, many national fleets still do not equip their semi-trailer drivers with GPS units, even though drivers often seek destinations to which they have never before made a delivery.

Staggering the start times of schools is another instance of behavior modification that has already been implemented by a number of school districts. If elementary, middle, and high school start times are

staggered, then the school bus fleet may be reduced in size. With fewer vehicle purchases and lower maintenance costs, there is an opportunity to use extra funds to explore alternative fuels and technologies.

Case Studies of Carbon Footprint Reduction in Fleets

Clark County School District [10]

Clark County School District (CCSD) is located in Las Vegas, Nevada and is the fifth-largest school district in the country. Its school bus fleet serves approximately 138,000 students and travels more than 18 million miles per year. With a fleet of 1,450 school buses in 2007 that used biodiesel, CCSD is well on its way to reducing its carbon footprint. Those 18 million miles per year use 3 million gallons of biodiesel, and CCSD plans to introduce 100 additional biodiesel buses each year. The school district has also installed 10 biodiesel filling stations in the Las Vegas area to service its school bus fleet. Nevada legislation recently began requiring 90% of all vehicles purchased by government-run organizations to use alternative fuels.

Dallas County Schools [11,12]

Dallas County Schools (Texas) has the 5th largest school bus fleet in the country, operating approximately 1,700 school buses. The school district operates buses which run on biodiesel and propane, and the district makes their own biodiesel. Every week, the district converts 400 gallons of vegetable oil into B10 (10% vegetable oil, 90% diesel) and B20 (20/80) that is used to fuel over 1,000 school buses. The vegetable oil is post-consumer grease, something often disposed of improperly that can clog sewers and wastewater treatment facilities. The school district also collects waste vegetable oil donated by local restaurants and food manufacturers. In this case, the carbon footprint of the biodiesel is significantly reduced since the vegetable oil did not need to be extracted, transported overseas, or refined. Dallas County Schools also operates a fleet of 600 propane-powered buses that were converted from existing gasoline-powered buses.

United States Postal Service

In 2006, Supreme Court Justice Kennedy delivered the following Opinion of the Court: "Each day, according to the government's submissions here, the U.S. Postal Service delivers some 660 million pieces of mail to as many as 142 million delivery points" [13]. In 2007, the fleet

Figure 4. Dallas County Schools "Fryer Flyer" [12]

spent $1.7 billion for gasoline. Every 1-cent increase in the price of a gallon of gas costs the USPS $8 million per year. With a fleet of more than 200,000 vehicles, the postal service operates one of the largest fleets in the country.

The majority of postal service vehicles are powered by gasoline, making USPS a candidate for improved fleet efficiency [14]. Attempting to reduce fuel costs, it operates the world's largest fleet of alternative

Figure 5. USPS hydrogen-powered fuel cell vehicle [14]

fuel-capable vehicles, with more than 44,000 of them fueled by ethanol, compressed natural gas, liquid propane gas, electricity, or biodiesel.

US Government Fleet [15]

The federal government has recently shown increased interest in downsizing current vehicles and moving toward fuel-efficient compacts. Boasting a fleet of more than 600,000, the acquisition of compact vehicles, rather than their larger counterparts, will save the government a significant sum and boost the fleet-wide fuel efficiency from 19.1 mpg in 2010 to 23.4 in 2011. President Obama plans to implement an entire fleet of advanced-technology vehicles by 2015, including electric, hybrid, plug-in hybrid electric, fuel cell, and biodiesel vehicles.

Walmart Trucking [16]

Walmart's goal is to double its fleet efficiency, after already successfully increasing it by 25% between 2005 and 2008. Within its arsenal of efficient trucking rigs are several new prototypes, including two heavy-duty, commercial hybrid trucks and two alternative fuel trucks. One hybrid is a dual-mode, diesel-electric hybrid made by Arvin Meritor. The other hybrid is a diesel-electric power system built by Peterbilt. For alternative fuel, Walmart has prototype trucks that operate on liquid compressed natural gas (Peterbilt) and biodiesel made from waste cooking grease recovered from Walmart stores (in addition to other sources). Walmart is known as a leader in the energy efficiency industry and could have a large impact on the trucking industry if it switches entirely to hybrid technologies and alternative fuels.

Intermodal Rail

Intermodal rail is the strategic combination of trucking and rail to transport freight over long distances to minimize the distance and time traveled. Both trucks and trains use diesel fuel, but a freight train with more than 100 railroad cars can transport significantly more freight per gallon of diesel fuel than can be done by truck. However, trucks offer more flexibility in their service and scheduling options, which explains why trucks currently carry four times more cargo than rail [19].

Perhaps the greatest single strategic opportunity for transportation efficiency is moving truck traffic to rail. Over the past 20 years, rail intermodal traffic has more than tripled, growing from 3.1 million

trailers and containers in 1980 to almost 10 million in 2003. A graphical comparison of trailer-on-flatcar (TOFC) and container-on-flatcar (COFC) growth since 1980 is shown in Figure 6 [18].

The use of rail for long-distance transport combined with trucking for short distances, or *intermodal rail*, offers savings on shipment of truckload quantities over 500 miles. Intermodal can carry many different kinds of freight, using a combination of over-the-road trucking and rail. Freight delivered in containers via ships is picked up at the dock by an intermodal semi-trailer and delivered by truck to the nearest intermodal yard. There, the truck-mounted containers are loaded onto specially designed intermodal train cars and moved via rail to a local train yard near the destination. At the intermodal train yard, they are loaded back onto a container truck chassis and then delivered to their final destination.

According to the EPA, a freight train emits two-thirds less greenhouse gas emissions for every ton-mile than does a typical truck. More

Figure 6. Intermodal growth, in millions of units [18]

than one billion gallons of fuel would be saved each year if 10% of the highway freight were moved by rail [19]. Intermodal shipping has the potential to significantly reduce the number of semi-trailer rigs on the road; fewer trucks will reduce traffic congestion, directly contributing to fuel saved by vehicles operating on all highways. Also, there is the additional benefit of a longer lifespan for road and bridge infrastructure.

SUMMARY AND MOVING FORWARD

With an increasing number of vehicles on the road every year, it is no wonder that the transportation sector in the U.S. accounts for 70% of the petroleum that Americans use. The increasing efficiency of fleet automotives and better driving habits will combine to significantly reduce petroleum consumption. Those improvements, combined with the increased efficiency of commercial, government, and school district fleets, will move America well down the road to lowering carbon emissions. Fleet managers can start by replacing vehicles regularly and optimizing routes.

The three items discussed in this article that will most affect CO_2 emissions are targeting high-emitting fleets, behavior modification, and the transition to intermodal rail.

Corporations and the government can target fleets consuming the most gasoline by moving to more efficient vehicles or investing in alternative fuels and technologies. Behavior modification is vital, from the highest executive levels to the drivers, to reduce fuel consumption. The case studies provided in this article demonstrate progress being made, along with examples of viable opportunities to save fuel, reduce CO_2 emissions, and save operational expense. A definitive example of fleet efficiency is transitioning long-distance freight hauling from roads to rail. As business, industry, and government entities identify ways to cut costs and reduce their fuel consumption, transportation is a clear opportunity for quick implementation and significant savings.

Changes in fuel and fleet efficiency take time. Wide participation is needed to achieve a significant reduction in fuel use and protect America's immediate and long-term future. For every thousand gallons of fuel that is saved, America moves a thousand steps closer to energy independence and a reduced carbon footprint.

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