# DRIVING DOWN CORPORATE CO$_2$ EMISSIONS THROUGH ALTERNATIVE TRANSPORTATION METHODS: A GIS APPROACH

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## 1. INTRODUCTION

Carbon dioxide (CO$_2$) emission is a major contributing factor affecting earth's atmosphere and causing global climate change (The National Academies, 2008). Recently corporations worldwide have been striving to reduce their CO$_2$ emissions. In a written report to Nature Reports Climate Change published on nature.com, Kleiner (2007) described how corporations raced to reduce carbon footprints: In 2006, Virgin Group's Chairman, Richard Branson, committed to produce lower-carbon fuels with $3 billion investment funding; In 2007, Virgin Atlantic Airline announced that by 2008 they would fly a Boeing-747 with biofuels; In 2006, Wal-Mart pledged to make a reduction of 20% of the carbon emissions in its trucking fleet and to make a reduction 30% of its energy consumption in all of its retail stores; In 2007, media conglomerate News Corporation and the Fox News Network committed to become 'carbon neutral' by 2010; Automaker GM joined an alliance of corporations in 2007 asking governments to regulate the emissions of greenhouse gasses (Carbon Trade Watch, 2007; The Climate Group, 2007; Lash and Wellington, 2007 ). More recently, a taxi company in Northumberland, United Kingdom has purchased low emission vehicles for a cleaner environment (McCann, 2010).

The United States (U.S.) contributes 22.2 percent of total global CO$_2$ emissions and is ranked second in the world in CO$_2$ emissions in 2009 (Thompson, 2009). There are many sources of CO$_2$ emissions, including transportation, electricity, industrial energy, residential and commercial energy. But, it is obvious that driving is the main transportation method in the U.S. because of its extensive road networks. According to the U.S. Department of Transportation (2010), there were more than 4 million miles of public roads in the U.S., 74.2 percent of which is accounted for the rural areas. The other 25.8 percent of the total mileage, or urban mileage, carried approximately 2/3 of the 3.0 trillion vehicle miles traveled in the U.S.

Meaningful action to reduce greenhouse gas emissions requires organizations/ corporations to adopt appropriate alternative transportation methods (Hoffman, 2006; Washington, et al., 2008). However, in literature, there is no documented research on determining CO$_2$ emissions produced from transportation by an organization or a corporation, and on how to reduce CO$_2$ emissions through alternative transportation methods. The objective of this research project was to study how much CO$_2$ emissions produced from transportation by a Kentucky Fried Chicken (KFC) restaurant located in Glen Carbon, Illinois and how much the CO$_2$ emissions can be reduced using alternative transportation methods. The study involved three steps. First, the most frequently consumed items at the KFC were identified, the products to prepare and serve these items determined, and all the suppliers for the items and their locations identified. Second, the distances in miles from the KFC restaurant to the locations of all the suppliers were calculated using GIS network analysis. Third, CO$_2$ emissions were estimated and compared with three transportation methods: heavy-duty trucks (i.e., truck-trailers), truck flaps (i.e., trucks with freight wings to improve aerodynamics and fuel

efficiency), and trains. It is anticipated that this research project provides a new insight for similar corporations/industries to determine their $CO_2$ emissions produced by transportation and possibly to adopt alternative transportation methods in order to reduce $CO_2$ emissions.

## 2. METHOD

### 2.1 STUDY SITE: KFC IN GLEN CARBON, ILLINOIS

According to KFC (2010), there are more than 15,000 KFC restaurants operated worldwide and more than 12 million customers served every day. There are more than 5,200 KFC restaurants in the United States. There are ten (10) KFC restaurants within a 15-mile radius of the campus of the Southern Illinois University Edwardsville. Three of them share the trucks for the deliveries of goods from the same suppliers (described below). The study site for this research is the KFC restaurant located in Glen Carbon, Illinois and we chose this site simply because one of the authors has been working part time at the restaurant in the past several years. He was familiar with the operation of the restaurant and his manager was willing to help with the study. It is our understanding that more than one site is probably needed for this research project. However, we chose only the site closest to the university campus for the sole purpose of developing and/or simplifying a working procedure for the intended analysis.

### 2.2 DATA SETS

The data sets for this research included:
1) The most frequently consumed items (a total of nine) at the KFC;
2) The suppliers of those items and their street addresses, cities, states, and zip codes;
3) Road network data for the Midwestern and Northeastern region that covers all the locations of the suppliers; and
4) Railroad network data for the same region.

The most frequently consumed items at the KFC include deserts, vegetables, sandwiches and sauces, chicken products, drink syrup-Pepsi and non-Pepsi, condiments, food containers, and drink containers (Table 1). The suppliers of those items and their street addresses, cities, states, and zip codes were identified. Road network data in the form of TIGER/Line files for the Midwestern and Northeastern region was downloaded from the official web site of the Environmental System Research Institute (ESRI) (www.esri.com). In addition, railroad network data for the region was downloaded from the same web site. Both data sets were in ArcView Shapefile format and in Geographic Coordinate System (latitude and longitude in decimal degrees) under WGS84 datum (Figure 1).

TABLE1
CONSUMED ITEMS AND LOCATIONS OF THE SUPPLIERS

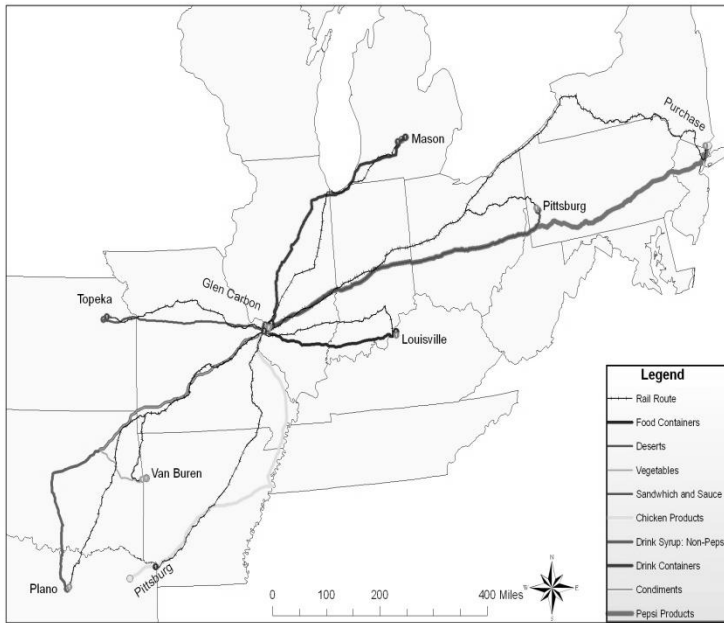| Items | Town of Origination |
|---|---|
| Jellies, Dipping Sauces | Mason, MI |
| Vegetables | Van Buren AR |
| Sandwich Bun and Sauce | Pittsburgh, PA |
| Chicken, Livers, Gizzards | Pittsburgh, TX |
| Containers For Drink | Mason, MI |
| Pepsi Products (syrup and POP) | Purchase, NY |
| Desert Products | Topeka, KA |
| Containers for Food | Louisville, KY |
| Variety of Other Drink Products | Plano, TX |

FIGURE 1
INTERSTATE AND RAILROAD ROUTES FROM LOCATIONS OF ALL THE SUPPLIERS
TO THE KFC RESTAURANT IN GLEN CARBON, IL.

## 2.3. DATA ANALYSIS

The first step of the data analysis was to perform a geocoding procedure in ESRI's ArcGIS. Geocoding is to assign geographic locations (i.e., points) to street addresses (e.g., 8022 Davis Dr., Edwardsville, IL) (Chang, 2010). In the second step, ArcGIS Network Analyst was used to analyze shortest or quickest routes between each geographic location of the nine suppliers and the location of the KFC restaurant in Glen Carbon, IL. The shortest route is defined by travel time. The speed limit for calculating the travel time is 65 miles per hour (though the actual speed limit within a city is usually 25 to 35 miles per hour and the actual speed limit on interstate highways is usually 55 to 70 miles per hour). The distance in miles from each location of the nine suppliers to the KFC restaurant can be generated from the shortest route analysis. An average mileage per week was calculated based on the frequency of the consumed items that needed to be shipped by trucks or truck flaps from their sources and based on a one-way trip from the supplier to the restaurant.

Similarly, ArcGIS Network Analyst was used to analyze shortest routes between each location of the nine suppliers to the KFC restaurant using the railroad network data set. The distance in miles from each location of the nine suppliers to the KFC restaurant can be generated from the shortest route analysis as well.

The final step was to calculate the $CO_2$ emissions from trucks. This was done using the mileage driven and fuel efficiency standards. According to the U.S. EPA (2005), one gallon

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of gasoline emits 8.8 kilograms or 19.4 pounds of $CO_2$; one gallon of diesel fuel emits 10.1 kilograms or 22.2 pounds of $CO_2$. In this study, we assumed that heavy-duty trucks run on diesel fuel. On average, each heavy-duty truck can carry approximately 2-ton of goods and its fuel efficiency is at 6 miles per gallon. Truck flaps, equipped with freight wings to improve aerodynamics, provides 7% better fuel efficiency (www.freightwing.com). Therefore, we assume the $CO_2$ emissions from truck flaps is about 93% of that emitted from trucks for the same distance driven. Trains, on the other hand, run on diesel fuel, which provides much better fuel efficiency. On average, the fuel efficiency for trains can reach to 46 miles per gallon per ton-mile.

## 3. RESULTS

The ArcGIS Network Analyst calculated the shortest route distance between the KFC and each of the nine suppliers. Table 2 shows that the average mileage by heavy-duty trucks (i.e., truck-trailers) driven on interstates from the suppliers to the KFC restaurant is 3,922 per week. Based on the fuel efficiency for trucks (i.e., 6 miles per gallon of diesel), that will emit 21,191 pounds of $CO_2$ (i.e., 3922 / 6 * 22.2) (Table 2).

The same procedure was used to calculate the shortest route distance between the KFC and each of the nine suppliers by trains. The result shows the average mileage on railroads from the suppliers to the KFC restaurant is 4,766.1 per week. Based on the fuel efficiency for trains (i.e., 46 miles per gallon of diesel), that will emit 2300.7 pounds of $CO_2$ (i.e., 4766.1 / 4 6 * 22.2) (Table 3).

Table 4 shows a comparison of $CO_2$ emissions by trucks, truck flaps and trains. We first converted the weekly $CO_2$ emissions in pounds from Table 3 and Table 4 into the weekly $CO_2$ emissions in tons. For trucks, 21,191.24 pounds of $CO_2$ is 10.6 tons (one ton is equal to 2,000 pounds). For truck flaps, since the fuel efficient is improved by 7%, we multiply 10.6 ton by 93% , which is 9.86 tons. For trains, 2003.7 pounds of $CO_2$ is 1.15 tons. Finally, annual $CO_2$ emissions in tons were calculated by multiplying weekly $CO_2$ emissions by 52 weeks.

TABLE 2
CO$_2$ EMISSIONS (IN POUNDS) BY HEAVY-DUTY TURCKS

| Items | Town of Origination | Number of Miles per Week* | CO$_2$ Emission (pounds) |
|---|---|---|---|
| Jellies, Dipping Sauces | Mason, MI | 440.30 | 1,629.11 |
| Vegetables | Van Buren AR | 518.10 | 1,916.97 |
| Sandwich Bun and Sauce | Pittsburgh, PA | 570.00 | 2,109.95 |
| Chicken, Livers, Gizzards | Pittsburgh, TX | 1,241.80** | 4,596.73 |
| Containers For Drink | Mason, MI | 440.30 | 1,629.11 |
| Pepsi Products (syrup and POP) | Purchase, NY | 933.30 | 3,454.77 |
| Desert Products | Topeka, KA | 328.80 | 1,217.11 |
| Containers for Food | Louisville, KY | 561.8** | 2,079.60 |
| Variety of Other Drink Products | Plano, TX | 691.01 | 2,557.89 |
| **Total** | | 3921.81 | 21,191.24 |

*Based on one-way trip;

** Requires two deliveries every week

TABLE 3
CO$_2$ EMISSIONS (IN POUNDS) BY TRAINS

| Items | Town of Origination | Number of Miles per Week* | CO$_2$ Emission (pounds) |
|---|---|---|---|
| Jellies, Dipping Sauces | Mason, MI | 427.1 | 206.2 |
| Vegetables | Van Buren, AR | 432.3 | 208.7 |
| Sandwich Bun and Sauce | Pittsburgh, PA | 602.7 | 291.0 |
| Chicken, Livers, Gizzards | Pittsburgh, TX | 484.9 | 234.1 |
| Containers For Drink | Mason, MI | 427.1 | 206.2 |
| Pepsi Products (syrup and POP) | Purchase, NY | 1099.3 | 530.8 |
| Desert Products | Topeka, KA | 338.1 | 163.2 |
| Containers for Food | Louisville, KY | 321.6 | 155.3 |
| Variety of Other Drink Products | Plano, TX | 633 | 305.2 |
| **Total** | | 4766.1 | 2300.7 |

*Based on one-way trip; per ton-mile

TABLE 4
COMPARISON OF WEEKLY AND ANNUAL CO$_2$ EMISSION
(IN TONS) BY TRUCKS, TRUCK FLAPS AND TRAINS

| | Truck | Truck flaps | Trains |
|---|---|---|---|
| **Weekly** | 10.60 | 9.86 | 1.15 |
| **Annual** | 551 | 512 | 60 |

## 4. SUMMARY, DISCUSSION AND CONCLUSIONS

The products regularly used by restaurants are transported by a large number of miles. The deliveries for the KFC restaurant in Glen Carbon, IL account for 3,922 miles by trucks each week, which releases 10.6 tons of CO$_2$ per week or 551 tons per year into the atmosphere. Even with existing low tech solution such as truck flaps, the company can decrease CO$_2$ emissions by about 40 tons. Train routes exist from the towns of all nine food suppliers to Glen Carbon, IL. , and use of train can significantly decrease CO$_2$ emissions by 490 tons or 89 percent annually. It should be pointed out that neither the KFC nor the 9 suppliers are located alongside train tracks. As such, trains are not a point-to-point solution and there exists multi-modal delivery. Even though there is a rail network, but that doesn't mean the train companies are going to operate directly along that origin-destination pair. The real networks such as BNSF, Norfolk Southern, Union Pacific, or CSX should be used so we know just how many miles and how much travel time it takes to get the supplies to the KFC restaurant. All these issues can be investigated in future research projects.

According to the Census Bureau, there are 16,241 restaurants in the state of Illinois and 504,641 restaurants in 2009 in the U.S. All of them require regular deliveries of food, cooking supplies, and serving containers. This research project provides a new insight for similar corporations/industries to determine their CO$_2$ emissions produced by transportation and possibly to adopt alternative transportation methods in order to reduce CO$_2$ emissions.

Reducing CO$_2$ emission is both a must-do and a challenge. Corporations and industries can become energy efficient by simply switching to more efficient lighting or weatherproofing buildings to improve efficiency. However, the transportation sector accounts

for approximately one-third of $CO_2$ emissions and is the fastest-growing major source of $CO_2$. This project addressed how corporations can use alternative transportation methods to help reduce $CO_2$ emissions.

Furthermore, this research provides another opportunity to investigate a whole of policy issues related to $CO_2$ emissions by companies that require transporting large quantities of goods through interstate highways, including Coco-Cola®, Pepsi®, and IceMountain®, to name just a few. They need to be proactive in reducing $CO_2$ emissions through alternative transportation methods such as truck flaps and trains. Government agencies such as the US Department of Transportation (DOT) and US Environmental Protection Agency (EPA) need to set carbon emission standards for not only light duty vehicles but also heavy duty vehicles, and regulate them accordingly.

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