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Life Cycle Analysis of energy and Greenhouse Gas Emissions of Ground Shipping in the United States: Case Study of the U.S. Postal Service

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Summary

A significant increase in the use of shipping services has drawn public attention to energy consumption and associated air emissions. Despite the transportation sector being an important contributor to fossil energy consumption and greenhouse gas emissions, few detailed studies on the system-wide impacts of shipping exist. The U.S. Postal Service (USPS), a part of the federal government subject to public reporting requirements, represents a case study that can better inform the energy and emission impacts from shipping. Unlike other previous studies, this study takes both energy consumption and emissions from highway vehicles and support services such as buildings and equipment into account. The life cycle analysis (LCA) of the USPS is quantified in this paper by using a hybrid Life Cycle Assessment model involving process-based and economic input-output Model (EIO-LCA). Existing vehicle-only shipping emissions and energy use of are estimated at 600-630 grams of CO2 per ton-mile and 8,300-8,900 BTU per ton-mile; emission factor of direct energy consumption 2,500-2,700 grams per ton-mile; emission factor of the whole supply chain 7,000-7,600 kg per ton-mile. These numbers prove that the previous studies, which do not include overall impacts of shipping, greatly underestimate actual emission impacts, by up to a factor of 30. This underestimate is important and relevant for decision makers considering the energy and environmental impacts of shipping e.g. purchases of carbon offset. The LCA of USPS shows that USPS's focus should decrease electricity consumption in buildings to accomplish CO2 reduction goal.

Introduction

Increasing economic globalization has brought high growth rates in freight transport in recent years with the increasing rate of freight transportation, the energy and environmental impacts of the shipping industry are becoming gradually more visible. In the year 2005 the transportation sector was the largest source of anthropogenic greenhouse gas (GHG) emissions (when electric power sector emissions are distributed across sector) in the U.S., accounted for 33 percent (1,960 million metric tons) of total U.S. energy-related carbon dioxide emissions (EIA 2005). Passenger vehicles are the largest source of emissions (32 percent) followed by light trucks (27 percent) and heavy trucks (19 percent), respectively (EPA 2006) Trucking has carried a large share of domestic freight comparing to other modes of transportation. It moves approximately two-thirds of freight tonnage nationally (U.S. Department of Transportation 2006). Fuel use for all classes of trucks is increasing faster than for automobiles and is expected to be twice as much as automobiles by 2020.

Despite the increasing trend of shipping and vehicle use, few publications go into detail LCA impacts of shipping. Nigel (2003) provided emission factors which described the instantaneous emissions from each heavy duty vehicle. Emission factors were reported in grams per second for all heavy-duty vehicles according to the vehicle speed and acceleration. Delucchi (1991) analyzed the GHG emissions for specific fuel-cycle stages of various transportation fuels and electricity generation. The specific fuel-cycle stages involved the manufacture of motor vehicles, maintenance of transportation systems, manufacture of materials used in major energy facilities, and changesin land use caused by the production of biofuels. The input data of GREET 1.0 was derived from this study (Argonne National Laboratory 1999). National Renewable Energy Laboratory (NREL), provided transportation emissions factors of trucks, barge, and airplane, referred input data from GREET Transportation Model. Bentley (1992) and Argonne National Laboratory (1999) studied the fuel cycles which changed from petroleum to gasoline, natural gas (NG) to methanol, NG to compress natural gas (CNG), NG to hydrogen, corn to ethanol, and electricity generation from various fuels; however, an in-depth analysis of upstream fuel-cycle emissions did not include in this study. Brogan and Venkateswaran (1992) and Argonne National Laboratory (1999) estimated fuel-cycle energy use and CO2 emissions of various transportation technologies. Upstream emissions of HC, CO, NOx, and SOx were estimated only for fuel production stage; emissions from primary energy production and distribution, transportation and storage of fuels were ignored. Brogan and Venkateswaran concluded that the basis of the average electric generation mix in the United States, electric vehicle and hybrid electric vehicle generate fewer CO2 emissions than gasoline internal combustion engine vehicle. Ecotraffic (1992) estimated fuel-cycle emissions and primary energy consumption of various transportation fuels in Sweden. Ecotraffic concluded that the use of non-fossil fuel could result in a greater-than-50 percent reduction in GHG when compared to the use of petroleum-based fuels. Because most of all electricity in Sweden is generated from hydropower and nuclear energy, use of electrical vehicles reduce emissions of criteria pollutants and GHG dramatically; the result of this study could not apply for U.S. situation because 50 percent of electricity in the United States is generated from coal (Darrow 1994). Blevins, (1991) and Delucchi (1996) compared energy use and emissions of freight trucks and trains in Canada. They found that trains used 65 to 70 percent less fuel, emitted 65 to70 percent less CO_2 and 30 to 50 percent less NO_x than do trucks. All the emission factors from these studies are summarized in Table 1. Most of these studies focused on emissions from operational phases or direct emissions on driving truck.

The LCA of transportation has a significant potential to increase sustainability on resource utilization and make processes more efficient. Moreover, it can offer a broader perspective on the impacts of transportation (Facanha 2005). For this reason, we select the U.S. Postal Service (USPS) as representative of standard shipping system because USPS not only involve in the process of collecting and delivering mail but also support services such as mail sorting machines, retail postal offices etc. This analyse include CO_2 emissions from actual energy consumption of USPS (direct energy consumption) and total USPS, a summation of direct and indirect energy consumption, evaluated by means of a hybrid LCA model involving process-based and economic input-output Model (EIO-LCA). This case should help to better understand the actual impacts of truck shipping. Moreover, the LCA of USPS supports important policy decisions for USPS to accomplish an energy and emissions reduction goal.

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USPS background

USPS handles more than 44 percent of the world's card and letter mail volume, delivers approximately 200 billion pieces each year (Figure 2), and controls more than 34,000 leased or owned facilities in the United States as of 2005 (USPS 2006). USPS consumes approximately 40 trillion BTU of site-delivered energy each year.

Energy consumption data of USPS have been reported by the following agencies: 1) U.S. Department of Transportation (U.S. DOT) and U.S. Department of Energy (U.S. DOE) 2) Federal Energy Management Program (FEMP) 3) General Services Administration (GSA). USPS energy consumption is reported into two categories: 1) total primary energy consumption (energy including all resources used to generate and transport electricity and steam) and 2) total site-delivered energy consumption (direct energy consumption; energy actually delivered to the point of use, not accounting for estimates of energy efficiency at the power or steam plant). Total site-delivered energy consumption is the summation of energy consumption in buildings, equipment, and vehicles (Figure 3).

Fuel consumption for USPS vehicles is approximately 15 trillion BTU each year. In a wake of the energy crises, USPS has committed to reducing petroleum consumption and associated environmental impacts through the use of alternative fuels. Table 2 shows USPS energy consumption in vehicle by fuel types. While biodiesel and ethanol consumption in 2005 both increased significantly from 1997, 160 and 560 percent, respectively, gasoline use was also up by 1.1 trillion Btu, offsetting any gains in alternative fuels. In 2005, the USPS fleet has total vehicles 212,293; of these 37,000 are alternative-fuel vehicles, the largest in the nation.

In the bigger picture of USPS energy consumption 1997-2005, electricity is the major source of energy used in standard building followed by natural gas, and petroleum based energy. USPS' vehicles rely on gasoline. 56-58 percent of total site-delivered energy is energy consumption in buildings, 34-36 percent in vehicles, and 6-8 percent in equipment e.g. mail sorting and conveyors. Electricity and Gasoline are major sources of energy consumed by USPS (Figure 4).

One use of these studies is in the calculation of CO2 offset. Carbonfund.org is a nonprofit organization that educates the public about the dangers of climate change and support renewable energy, energy efficiency and reforestation projects that reduce and offset carbon dioxide emissions. Carbonfund charges donators' carbon footprint $5.5 per ton of CO2. By using this rate and NREL factor, donators pay only 0.5 cents to offset their emissions of buying online book weight 6 pounds in distance 1000 miles. However, the emission factor obtained from NREL is only emissions on the highway of driving truck. Energy consumption and emissions of entire supply chain e.g. support services and their impacts are recognized to be potentially significant. We want to prove the hypothesis that NREL and previous studies emission factors are too narrow and should not be used to represent actual emissions of shipping processes, especially when trying to represent energy or emission impacts of shipping for consumers or producers.

Analyses

The spotlight of this study is to quantify emission factor in term of CO2 per ton-mile and CO2 per mail from shipping to compare with other studies. The analyses are divided into two parts; part one focuses on energy consumption and CO2 emissions from site-delivered (or direct) energy consumption of USPS given public information in its vehicle fleets and energy use. Part two is an estimation of USPS's total (direct and indirect) energy consumption, by using EIO-LCA model.

<u>Part I: USPS (direct energy consumption)</u>

<u>*CO2 emissions from direct energy consumption*</u>

CO2 emission factors from fuel combustion are taken from EIA's emissions of GHG which reports emission factors in term of metric tons of carbon per billion BTU (EIA 1999; FEMP 2002). These factors do not show significant difference from other reliable sources such as U.S. Environmental Protection Agency (EPA). Since CO2 emissions from power generation in each state are different, the CO2 emission factor from electricity used is separately calculated for each region. It is calculated by multiplying percentage of postal office floor areas in each state by regional electricity coefficients (metric ton per billion BTU) also provided by EIA and sum all of region to get electricity emission factor for USPS (GSA 2002).

By multiplying CO2 emission factors from each fuel type and energy consumption together, CO2 emissions from USPS site-delivered energy consumption are in a range of 3-5 million metric tons; CO2 emissions form fuels used by vehicles are 1.0 -1.1 million metric tons. This means only 20-23 percent of CO2 emissions come from fuel consumption in vehicles while the remaining 77-79 percent of total CO2 emissions comes from energy consumption in buildings and equipment (Figure 5). Tremendous sources of CO_2 emissions come from electricity, gasoline, and diesel, respectively (Figure 6). As shown above, most studies on the energy and environmental impacts of shipping have focused on direct fuel combustion in vehicle. This finding inspired a broader investigation into the energy and CO_2 emissions of shipping. Part II considers an economy-wide life cycle assessment of USPS energy and CO_2 emissions.

CO2 emissions per ton-mile from fuel consumption in vehicles and direct energy consumption

We want to compare Btu per ton-mile and grams CO2 per ton-mile of USPS with other studies, to do this we need to normalize BTU and CO2 emissions from fuel consumption in vehicles by ton-mile. There are two methods to calculate total ton-mile.

- Multiply the distance of each movement by the weight in tons to get ton-miles for individual shipments; sum all ton-miles for individual shipments to get total ton-miles
- Compute the average length of haul (total miles/total shipments) for your operations, and then multiply this average haul by the total number of actual tons transported.

The second method is used in this study. We assume vehicles run one trip a day, 312 days a year (not operate on Sunday) (Grove 2007) minus holiday vacation 20, 15, days, and no vacation day. We get average mile per trip of each types of vehicle given 4 types of USPS vehicles; passenger, light, medium, and heavy truck. Multiply average mile per trip of each type of vehicle by total tons of mail, a summation of letters, flats, parcels, weight in tons to get ton-mile. Then divide CO2 emissions from fuel consumption in vehicles by ton-mile. As shown in Tables 3 (a) and (b), light truck category has the highest CO2 emissions per ton-mile of approximately 1.3-1.4 kg per ton-mile, while heavy truck shows the lowest emissions, in a range of 273-292 grams CO2 per ton-mile in year 2005. A possible reason that causes emission factor of heavy truck (gram CO2/ton-mile) in year 1997 lower than in year 2005, although in recent year USPS uses low emission vehicles (alternative fuel vehicle), is that USPS does limited long haul shipping. USPS now subcontracts some of its logistics to several commercial airlines and FedEx, which will be described in more detail in part two. This leads to a decreasing in average miles per vehicle and increasing in emissions per ton-mile of heavy truck in year 2005. Only emissions from heavy truck show close number to emission factor from single diesel truck reported by NREL (250 grams per ton-mile). BTU per ton-mile of USPS heavy truck (3.8-4.1 BTU per ton-mile) is higher than that of intercity truck, referred from other studies as shown in Table 1. The overall emissions, an average of all types of vehicles, are 545-583 grams CO_2 per ton-mile, which are double over NREL emission factor. This implies that NREL provides emissions factor suits for heavy truck and does not suite for a mix mode vehicles shipping. When calculating CO_2 emissions from total site-delivered energy consumption, not only fuel consumption in vehicle, CO_2 emissions per ton-mile are 1.0-1.1 kg for heavy truck and 2.5-2.7 kg for overall fleet. This means emission factor from total energy consumed by USPS is ten times higher than NREL.

Direct energy consumption per piece of mail and CO2 emissions per mail

We want to know energy consumption and CO2 emission per a piece of mail and per ounce of mail. We normalize total site-delivered energy consumption and CO2 emissions by pieces and weight (ounce) each type of mail (letter, flat, parcel, and other) (USPS 2005). Since we can access USPS number of domestic mails and weight by four categories in 2005, we extrapolate the proportion of those four categories for previous years (1997-2004). The calculation equations are shown below. First, we find the weight of each type of mail by dividing total weight of mail e.g. letter by total number of letter (pounds/letter). Then, we divide site-delivered energy consumption by total weight of mails to get BTU per pound. Then repeat all calculation for flat, parcel, and other. The calculation processes for emissions per each type of mail are similar.

$$\text{Pounds/letter} * \text{BTU/pound} = \text{BTU/letter}$$

$$\text{Pounds/letter} * \text{CO2/pound} = \text{CO2/letter}$$

As shown in Table 4, USPS requires approximately 190-210 BTU or 8 grams of CO2 per a piece of mail or 12 grams CO2 per ounce. Surprisingly, BTU per each type of mail decreases while CO2 emissions per each type of mail increases in year 2005 comparing to those in year 1997. This is because in year 2005, USPS consumes more electricity, despite increasing use of alternative fuels, it has small significant impact to total CO2 emissions. A reduction of electricity consumption would make massively decrease total CO2 emissions.

Part II: Total USPS

Indirect energy consumption is USPS outsourcing energy consumption e.g. energy consumption by USPS's subcontracts (air and truck transportation), power generation etc.

As mention above, USPS outsources a lot in transportation. FedEx has carried USPS Express Mail, Priority Mail, First-Class Mail and some International mail since 2001. The Postal Service pays FedEx Express approximately $6.3 billion over seven years for shared access to the FedEx national air transportation network. Under the contract, FedEx agrees to provide a capacity of 443,000 cubic feet of transportation space daily and to carry 250,000 pounds of cargo at night (USPS 2001). However, the actual data of mail carried by subcontracts are unpublished. For this reason, the EIO-LCA model is used to estimate the effects of these contracts.

EIO-LCA has been developed by Green Design Institute at Carnegie Mellon, (Hendrickson et al. 1998). It couples environmental impacts e.g. greenhouse gases, conventional air pollutions, and toxic release with the production of nearly 500 goods and services. A specific final demand (purchase) induces demand not just for that production, but also for all products and services in the entire supply chain. The model is based upon the U.S. Department of Commerce's 1997 and is publicly available on the Internet at www.eiolca.net (the 2002 benchmark will not be available until late 2007).

The results from EIO-LCA estimates that the overall supply chain consumed energy is 160,000 TJ and total CO_2 emissions 12,670,000 metric tons which are higher than our estimates above by 5 times and 3 times, respectively.

Total CO_2 emissions 12,670,000 metric tons are adjusted numbers from EIO-LCA. Because all emissions from electricity consumption by USPS are given to *Power generation and supply sector* in EIO-LCA model, we replace CO_2 emissions from *Power generation and supply sector* in EIO-LCA with CO_2 emissions from part one, calculated by multiplying total electricity consumption of USPS with CO_2 emission factor of electricity. Energy consumption in USPS accounts for 18 percent of total energy consumption from all relevant sectors− USPS outsources energy consumption 82 percent. The largest source of CO_2 emissions produce from truck transportation sector (USPS subcontract), accounted for 25 percent. Postal service shares 12 percent of CO_2 emissions −USPS outsources CO_2 emissions 88 percent. Table 5 summarizes all calculations of part one and part two USPS emission factors.

<u>Sensitivity Analysis</u>

Sensitivity analysis of emission factor, grams CO_2 (from fuel consumption in vehicles) per ton-mile of overall vehicles, is conducted to analyze types of fuel consumption which have influence on emission factor. Suppose USPS decreases gasoline 10 percent and supplements that amount by alternative fuels 500 percent, bio-diesel, CNG, and ethanol, whereas fixes amount of diesel, LPG, and electricity consumption, grams CO_2 per ton-mile of overall fleets will decrease 8 percent while alternative fuels, CNG, causes increase in CO_2 less than 1 percent. When decreases 10 percent of gasoline, while other variables are fixed, grams CO_2 per letter decrease fewer than 2 percent. When decrease electricity consumption 10 percent and other variables are fixed, grams CO_2 per letter can be reduced by 7 percent. Since total CO_2 emissions are greatly influenced by electricity consumption, USPS should concern a reduction of electricity consumption as a first priority.

CO2 offset

Carbonfund uses the following equation to calculate CO2 offset. The emission factor is referred from NREL, 250 grams of CO2 per ton-mile. If we order book weight 6 pounds (0.003 tons) and distance of delivering is 1000 miles; CO2 offset cost would be 0.5 cents. If we replace NREL factor by our emission factor from total USPS, 7.3 kg per ton-mile, the rate of charge would be 12 cents (20 times higher). Using either factors does not have a severe effect to donators; however, emission factor from total USPS above is better representative of actual emissions since all impacts from supply chain are considered.

Rate of charge = weight of book (ton)* distance (mile)*emission factor (ton CO2 per ton-mile)* $5.5 per ton of CO2.

Conclusions

USPS emission factors are summarized in Table 5. Emission factors from other studies underestimate emission impacts of shipping because they do not integrate energy consumption of support services or upstream and downstream supply chains. For example, NREL, reported emission factor of truck as 250 grams CO2 per ton-mile, can be considered as a typical emission factor for heavy truck for point-to-point delivery only. The actual emissions from shipping, including entire life-cycle processes of shipping, sorting, etc., have higher emission factors by a factor of 30 (7.0-7.6 kg CO2 per ton-mile). For this reason, the study of impacts from shipping e.g. for use in estimating

CO2 offsets, should consider these broad calculated emission factor instead of NREL or previous studies as mentioned earlier.

The sensitivity analysis shows that CO2 emissions per mail are more sensitive to electricity consumption. For USPS, it is a fair strategy to reduce the cost of fuels and associated CO2 by increasing number of alternative fuel vehicles. However, the goal of reducing CO2 emissions will be better achieved by diminishing electricity consumption in buildings.

Table 1: Summarized BTU and CO_2 emissions from various modes of transportation

Emissions factors	CO2 emissions	Energy	References
Truck (single) Diesel Gasoline	 250 grams CO2 per ton-mile 193 grams CO2 per ton-mile	 3,083 Btu/ton-mile 2,925 Btu/ton-mile	NREL
Railroad Waterborne		344 BTU per ton-mile 417 BTU per ton-mile	Oak Ridge National Laboratory for the U.S. Department of Energy[Association of American Railroads 2007 #25]
Intercity trucks air freight air freight carried in the belly of a passenger plane		3,400 BTUs per ton-mile 28,000 BTUs per ton-mile 3,900 BTUs per ton-mile	[Richard R. Mudge 1982 #29]
Average passenger	5.2 metric tons of CO2 per year		EPA MOBILE6.2 fuel economy numbers [EPA: Office of Transportation and Air Quality 2005 #30]
Passenger Cars Light Trucks All passenger vehicles	4.78 metric tons of CO2 per year 6.00 metric tons CO2 per year 5.23 metric tons CO2 per year		DOT fuel economy numbers [EPA: Office of Transportation and Air Quality 2005 #30]
Energy consumed in coal transportation by truck		2,349 Btu/ton-mile	Delucchi 1993[Delucchi, 1993 #42]
Inter-city truck		3,357 BTU per ton-mile	The OTA (reference cited in the Washington State Action Plan) reports 1990, *[U.S. Environmental Protection Agency 2007 #19]*.

Table 2: USPS energy consumption in vehicles by fuel types (trillion BTU)

year	Biodiesel (B20)	Diesel	Electricity	Ethanol(E85)	Gasoline	LPG	CNG	Total
1997	0	3.0	0	0	11.4	0	0.3	14.8
2000	0.05	3.9	0	0.010	10.6	0.000	0.074	14.6
2001	0.08	3.9	0.001	0.045	10.7	0.002	0.054	14.8
2002	0.09	3.5	0.005	0.014	10.7	0.002	0.044	14.4
2003	0.13	3.7	0.002	0.048	11.8	0.002	0.004	15.7
2004	0.07	3.2	0.000	0.051	11.1	0.002	0.041	14.4
2005	0.13	2.4	0.000	0.066	12.2	0.002	0.025	14.8

Source: GSA (1997 2000 2001 2002 2003 2004 2005).

Table 3(a): Fuel consumption and CO2 emissions per ton-mile (2005)

Total tons of mail in FY 2005 = 11,721,478 tons; total fleet miles = 1,229,875,851

FY 2005	Passenger	Truck			
		Light	Medium	Heavy	
Overall fleet 1	11,090	186,074	10,008	5,115	
total miles operation (million miles) 2	146	903	58	122	
Average mile per vehicle	13,198	4,854	5,834	23,830	
Average trips/year					
Lower bound	292				
Best estimate	297				
Upper bound	312				
Total ton-mile (million)					Sum total ton-mile
Lower bound	530	195	234	957	1,915
Best estimate	521	192	230	940	1,883
Upper bound	496	182	219	895	1,793
BTU/ ton-mile					
Lower bound	6,994	19,017	15,823	3,874	7,738
Best estimate	7,114	19,342	16,094	3,940	7,871
Upper bound	7,473	20,319	16,907	4,139	8,268
Grams CO2/ ton-mile					
Lower bound	493	1,340	1,115	273	545
Best estimate	501	1,363	1,134	278	555
Upper bound	527	1,432	1,192	292	583

Sources: [1]GSA (2005 table 1-1 page 11) and [2]GSA (2005 table 1-3 page 13)

Table 3 (b): Fuel consumption and CO_2 emissions per ton-mile (1997)

Total tons of mail in FY 1997 = 10,592,649; total miles = 1,105,694,668

FY 1997	Passenger	Truck			
		Light	Medium	Heavy	
Overall fleet 1	7,777	178,511	9,193	4,880	
total miles operation (million miles)2	72	837	57	140	
Average mile per vehicle	9,269	4,688	6,170	28,698	
Average trips/year					
Lower bound	292				
Best estimate	297				
Upper bound	312				
Total ton-mile (million)					**Sum total ton-mile**
Lower bound	336	170	224	1,041	1,771
Best estimate	331	167	220	1,024	1,741
Upper bound	315	159	209	974	1,658
BTU/ton-mile					
Lower bound	10,988	21,727	16,507	3,549	8,344
Best estimate	11,177	22,099	16,790	3,610	8,487
Upper bound	11,741	23,215	17,638	3,792	8,916
grams CO_2/ ton-mile					
Lower bound	780	1,543	1,172	252	592
Best estimate	794	1,569	1,192	256	603
Upper bound	834	1,648	1,252	269	633

Source: [1,2] GSA (1997)

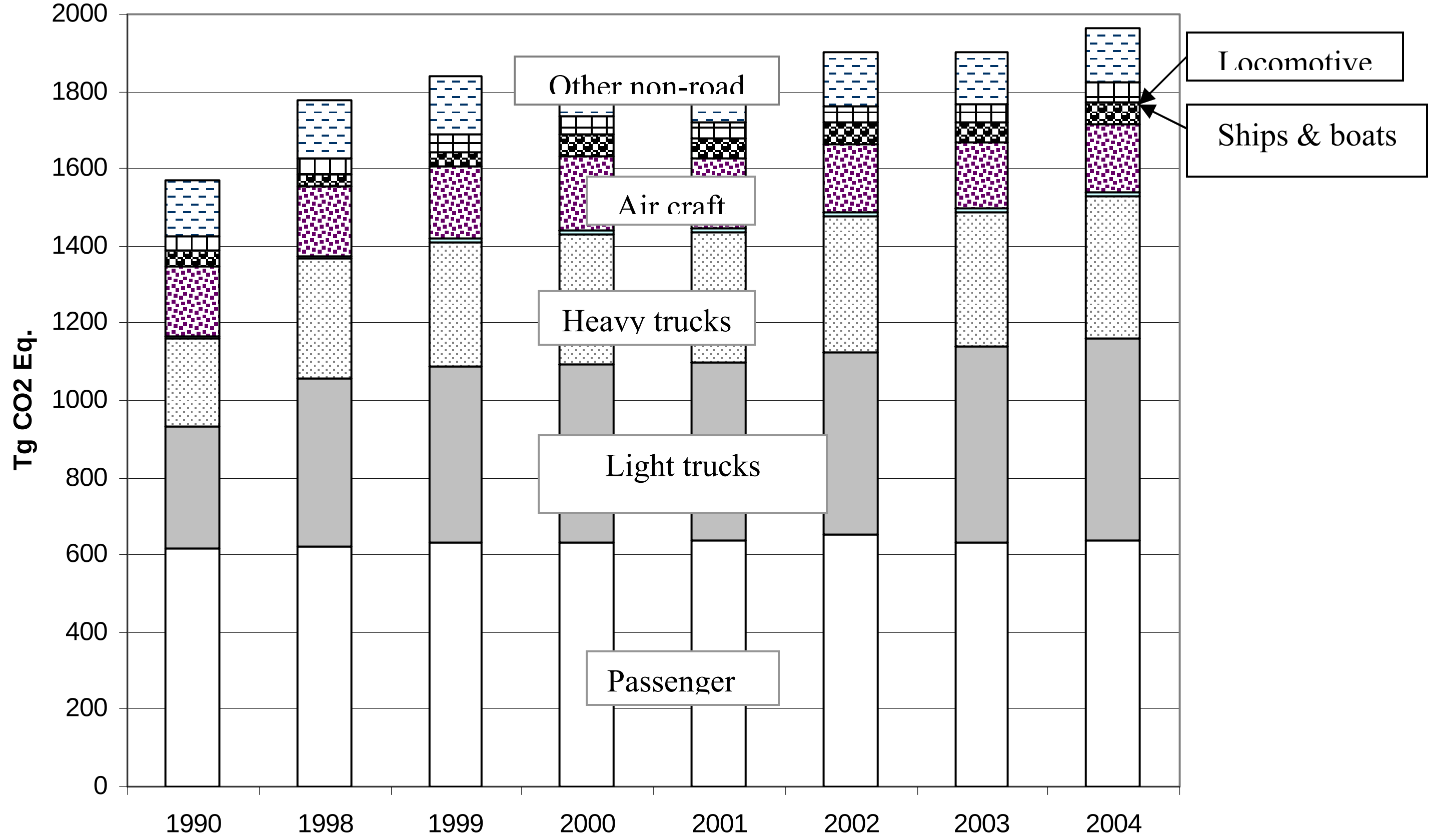
Table 4: Standardize total site-deliver energy consumption and CO_2 emissions by various type of mail

Year	BTU/piece	Btu/letter	Btu/ flat	Btu/parcel	Btu/Other	g CO2/oz	g CO2 /letter	g CO2/flat	g CO2/ parcel	g CO2/other
1997	213.5	70	455	3,562	478	11.7	7.6	48.8	382.5	51.3
1999	197.3	65	420	3,292	442	11.3	7.7	48.8	382.7	51.3
2000	208.2	69	443	3,473	466	11.7	7.8	51.5	403.9	54.2
2001	209.1	69	445	3,489	468	11.9	7.4	50.9	398.7	53.5
2002	200.3	66	426	3,341	448	12.6	7.9	50.7	397.2	53.3
2003	210.7	70	449	3,515	472	12.0	7.8	50.1	392.9	52.7
2004	197.3	65	420	3,292	442	12.3	7.9	51.2	401.6	53.9
2005	192.4	63	410	3,210	431	11.9	7.6	49.3	386.1	51.8

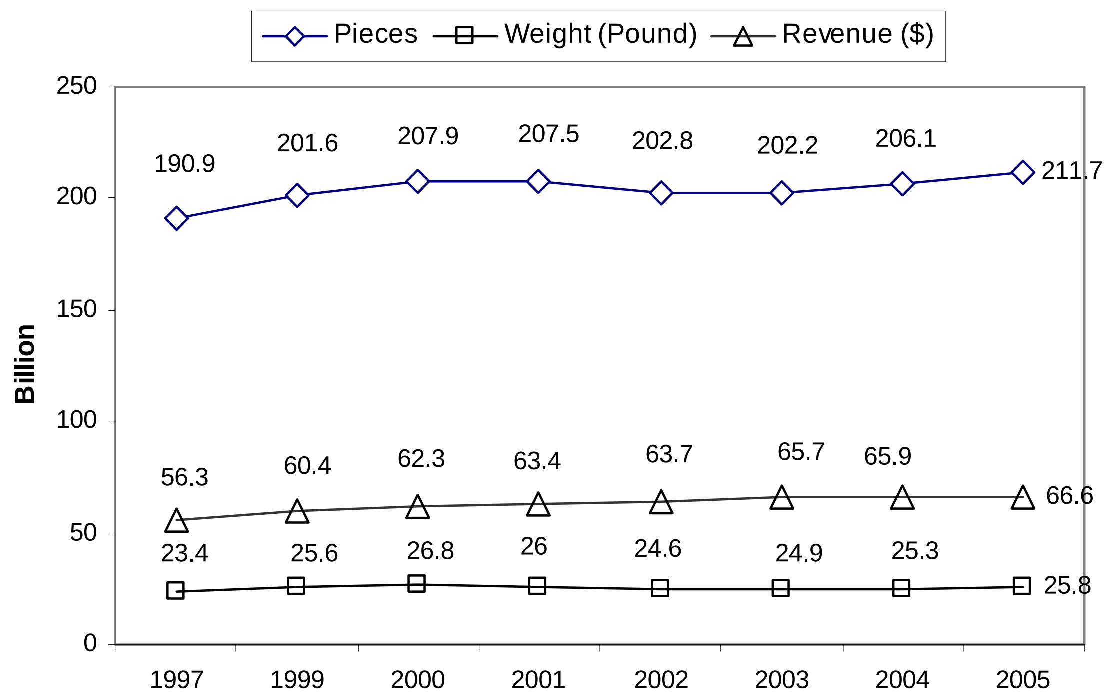
Table 5: Summarized USPS emission factors based on year1997

	CO2 per ton-mile		Energy consumption					CO2 Emissions				
	Heavy truck	Overall	BTU/ pieces	Btu/ letter	Btu/ flat	Btu/ parcel	Btu/Other*	g CO2/oz	g CO2 /letter	g CO2/flat	g CO2/ parcel	g CO2/other
NREL	250 g											
USPS (CO2 emissions from fuel consumption in vehicles)	250-270 g	600-630 g										
USPS (Direct CO2 emissions)	1.0-1.1 kg	2.5-2.7 kg	214	70	455	3,562	478	11.7	7.6	49	383	51
EIOLCA	3.0-3.3 kg	7.0-7.6 kg	795	260	1,690	13,260	1,780	34	22	140	1,110	150

* Other express mail and other domestic mail

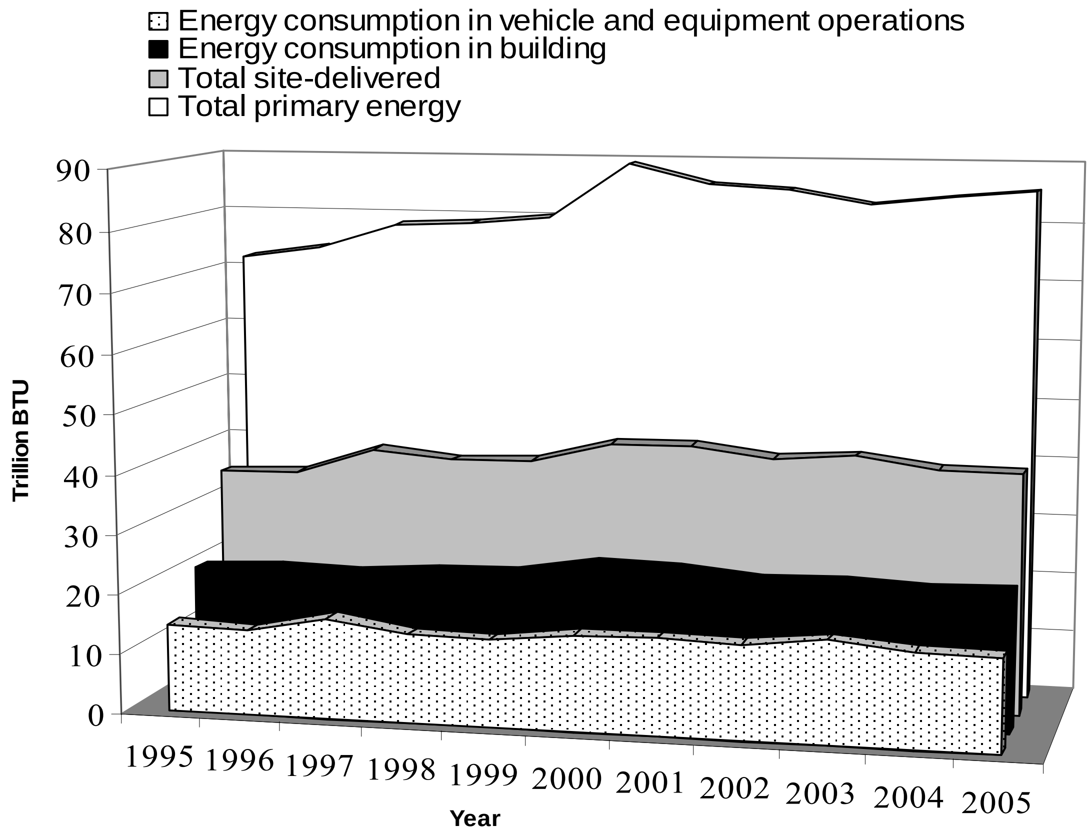


Other non-road CO_2 emissions include motorcycles, pipelines, and lubricants and also emissions from International Bunker Fuels include emissions from both civilian and military activities, but are not included in totals.
Source: EPA (2006)
Figure 1: CO_2 emissions by mode of transportation

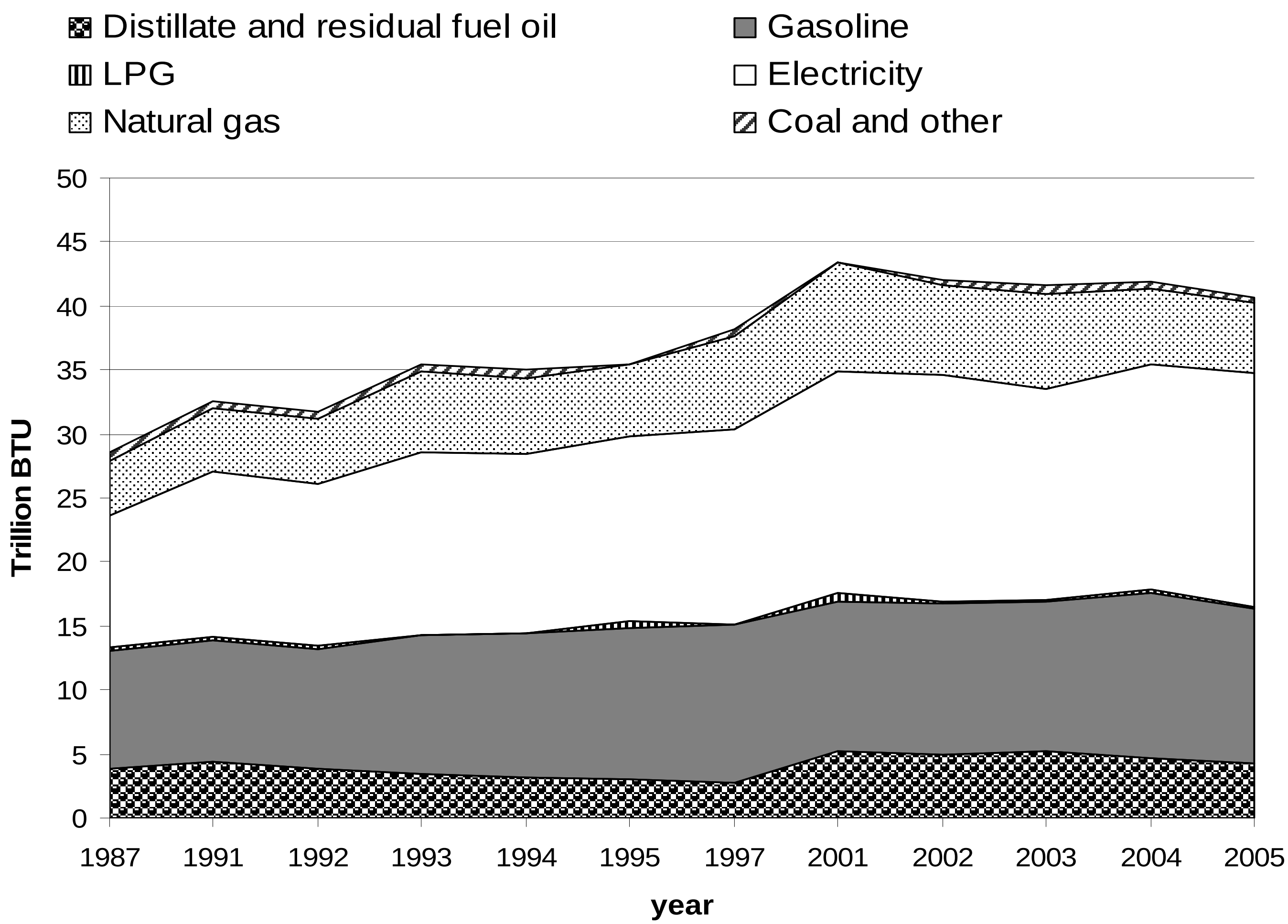


Source: USPS (2005 page 54)

Figure 1: Trend of number of USPS mails from year 1997 to 2005



Sources: FEMP (1995 - 2005) and GSA (1995 - 2005)
Figure 2: Total energy consumption in USPS



Source: EIA (2006 table 2-17)
Figure 3: Total site-delivered energy consumption by fuel type

Figure 5: A comparison between energy consumption and CO2 emissions from USPS in year 1997 and 2005

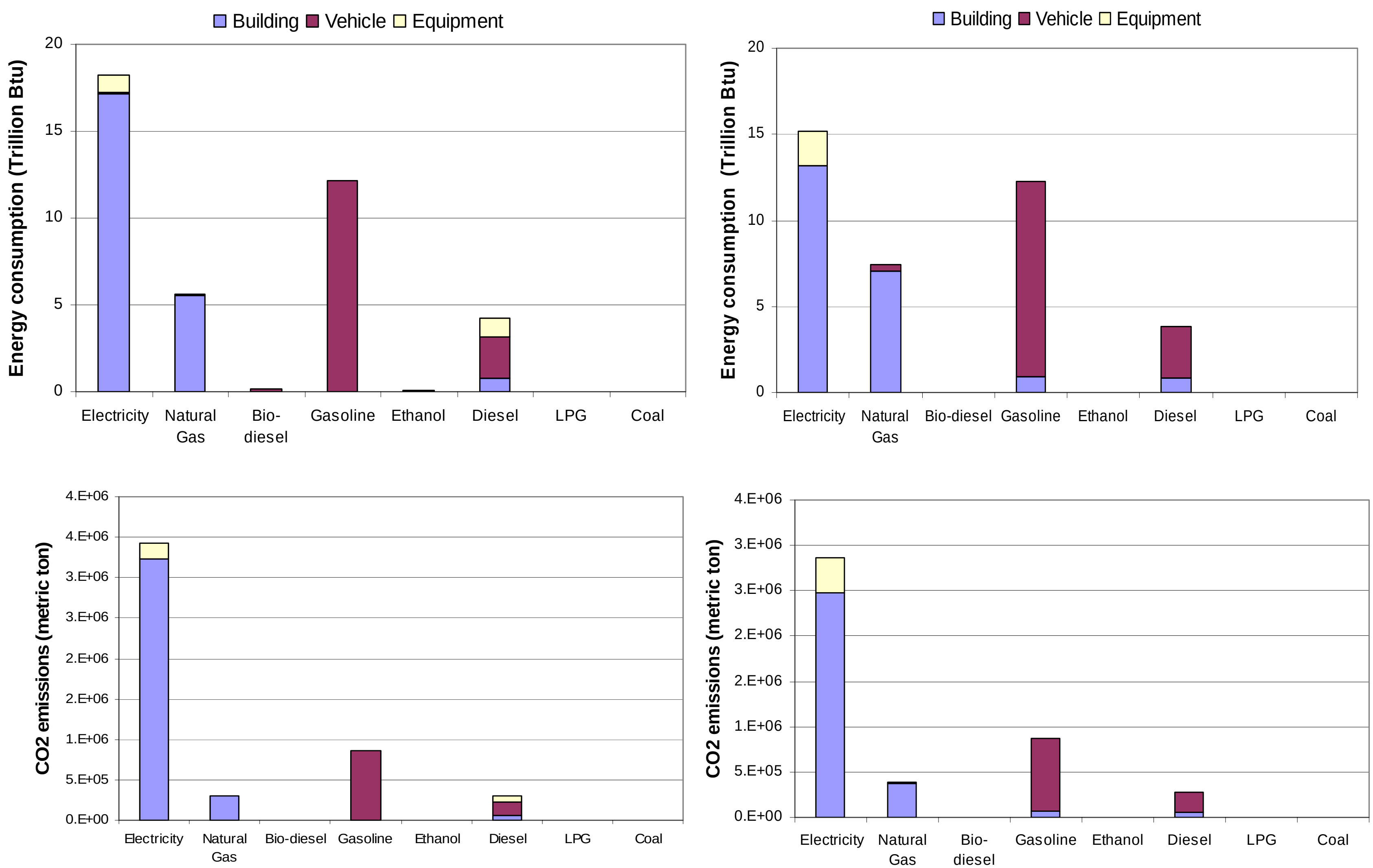


Figure 6: Energy consumption and CO2 emissions by fuel types (year 2005)

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