Manufacturing Climate Solutions

Carbon-Reducing Technologies and U.S. Jobs

CHAPTER 12

Public Transit Buses: A Green Choice Gets Greener

Marcy Lowe, Bengu Aytekin and Gary Gereffi

Contributing CGGC researchers:

Ghada Ahmed, Tyler Hall and Saori Tokuoka

CENTER ON GLOBALIZATION Governance & Competitiveness

This research was prepared on behalf of Environmental Defense Fund (EDF) (http://www.edf.org/home.cfm).

To see all the reports in the *Manufacturing Climate Solutions* series, please visit http://www.cggc.duke.edu/environment/climatesolutions/index.php

List of Abbreviations:

APTA	American Public Transportation Association
DOE	U.S. Department of Energy
EERE	Energy Efficiency and Renewable Energy
EIA	Energy Information Agency
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
FTA	Federal Transit Authority
NFCBP	National Fuel Cell Bus Program
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
UNIDO	United Nations Industrial Development Organization

Photo Permission:
Cover photo by Richard D. Stedall www.ttmg.org

Summary

Public transit substantially reduces fuel use and greenhouse gas emissions, making it a wise public investment in a new, carbon-constrained economy. A typical passenger car carrying one person gets 25 passenger miles per gallon, while a conventional bus at its capacity of 70 (seated and standing) gets 163 passenger miles per gallon. These fuel savings yield commensurate cuts in CO_2 emissions. A passenger car carrying one person emits 89 pounds of CO_2 per 100 passenger miles, while a full bus emits only 14 pounds. In addition, these benefits of conventional transit buses are further enhanced by a growing number of alternative options known as "green buses," including electric hybrid, all-electric, and other advanced technologies.

The U.S. market for heavy-duty transit buses is small, currently delivering 5,000 to 5,500 buses per year. U.S.-based firms dominate the North American bus market, with an 88% share in total buses and a 51% share in heavy-duty transit buses. Only five original equipment manufacturing (OEM) firms supply nearly the whole market, and four of them are either domestic firms or local subsidiaries of foreign firms. A small and shrinking manufacturer base is a major concern. For instance, Cummins is now the only supplier of bus engines, the single most expensive part in a transit bus, accounting for roughly 20% of the total cost. General Motors, formerly an important supplier to the bus industry, left the market in the summer of 2009, posing a significant challenge.

Under current U.S. transportation policy, which favors highway spending and de-emphasizes public transit, bus orders are small and sporadic; this makes it difficult for the bus industry to grow. In the current recession, some plants will likely be busy filling orders stimulated by the American Recovery and Reinvestment Act of 2009, but this boost is also partly offset by sharp cutbacks in states' transit spending. In addition, firms given a temporary lift by stimulus funds may see orders fall in subsequent years when funding diminishes to typical levels. Unpredictable demand from a small pool of customers (municipal transit authorities) makes it difficult for manufacturers to maintain their capacity and workforce without periodic layoffs. In addition, firms are often required to build buses specifically to each transit agency's preferences. This increases bus costs an estimated 20-30%, affects production stability, and makes R&D more expensive than is typical of other motor vehicle industries.

One promising niche lies in several varieties of green buses. About 32% of U.S. transit buses have an alternative power source, i.e., other than diesel or gasoline. The bus industry serves as an important entry point for advanced vehicle technologies, especially in new vehicles that require refueling infrastructure and other major changes. For instance, since transit agencies have a well-defined base of centrally managed fleets, they are ideal for testing and proving plug-in hybrid and all-electric buses—thus leading the way for the passenger car industry. Also on the horizon are hydrogen-fueled hybrid buses and hydrogen fuel-cell buses. Although the bus market is not export-oriented, if U.S. firms continue to lead green advances as they have in electric hybrid buses, they have potential to build an export market in selected components for green buses.

The bus manufacturing industry comprises an estimated 25,000-33,000 jobs, including many that overlap with the heavy truck industry. The value chain involves a considerable number of small and large manufacturers in nearly every state in the eastern United States, including Indiana, Michigan, Ohio and other hard-hit industrial states. These encompass makers of components from engines and transmissions, to windows, lighting, seating and flooring—including a very important after-market segment, which accounts for an estimated 10% of industry revenue.

If federal, state and local policy were to shift to a clear, sustained commitment to public transit, the nation would have the manufacturing capability to meet the resulting increased demand for transit buses. However, the transit bus industry is unlikely to have significant market growth in the absence of several major changes: better management of public transit funds and improved coordination with manufacturing firms; significant, sustained public funding; and perhaps most important, a comprehensive transportation policy shift that encourages public transit use.

Introduction

Bus transit offers major savings in fuel use and emissions when compared to private passenger vehicles. These savings depend on the number of passengers carried, with a full bus achieving up to six times the fuel economy per passenger mile as a passenger car carrying a single person.[1] For example, if a passenger car gets an average fuel economy of 25 passenger miles per gallon (pmpg), a transit bus, even operating far below capacity with 11 people on board, equals the passenger car at 25 pmpg. At peak transit hours, a bus at its capacity of 70 passengers—seated and standing—would get 163 pmpg. These fuel savings are accompanied by commensurate reductions in CO_2 emissions per person. While a passenger car carrying one person emits 89 pounds of CO_2 per 100 passenger miles traveled, a full bus emits only 14 pounds (see Table 1.)

Table 1. Fuel Savings and CO_2 Reductions, Bus Transit v. Passenger Cars

	Number of Commuters	Passenger Miles per Gallon	Pounds CO_2 emitted per 100 Passenger Miles
Passenger car (25 mpg)	1	25.0	89
Heavy-duty Transit Bus (2.33 mpg)	1	2.3	953
	5	11.7	191
	11	25.6	87
	40	93.2	24
	70	163.1	14

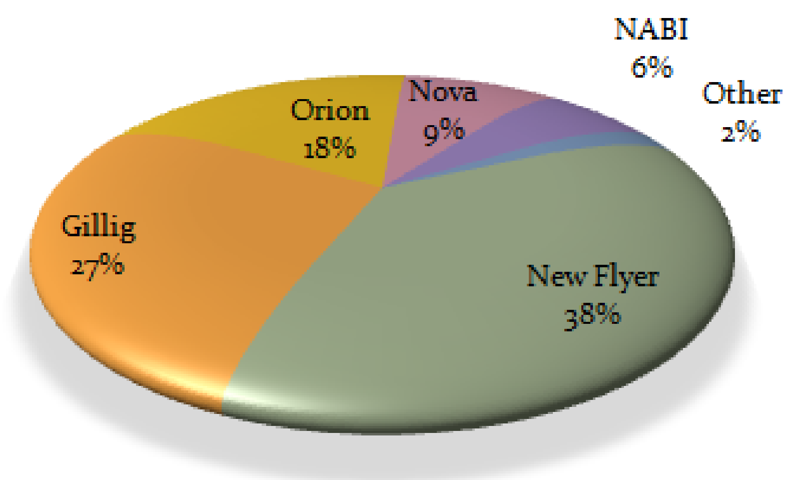
Source: CGGC, based on mpg figures from (Barnitt, 2008) and CO_2 per gallon of fuel from (EPA, 2009).

[1] In U.S. conditions. Bus ridership per vehicle in much of the world, especially developing countries, is much higher, yielding even greater improvements in fuel economy per passenger mile.

The per-passenger-mile fuel savings and emissions reductions offered by conventional transit buses are further enhanced in a growing number of alternative options often referred to as "green buses." These include buses that run on alternative fuels such as compressed natural gas (CNG) or hydrogen; battery-assisted vehicles such as diesel-electric hybrids; buses combining alternative fuels and battery power such as hydrogen-electric hybrids; hydrogen fuel cell vehicles; and fully electric buses (BEVs). Each of these green bus technologies is described in detail on page 22, in the section titled "Types of Green Buses."

Only five firms supply an estimated 98% of the North American transit bus market, and four of them are either U.S. firms or U.S.-based subsidiaries of foreign firms: Gillig (U.S., with 27% market share), Orion (U.S. subsidiary of German firm Daimler, with 18% market share), Nova (U.S. subsidiary of Swedish firm Volvo, with 9% market share), and NABI (U.S., with 6% market share). The current market leader, New Flyer, is a Canadian firm with 38% market share and two major U.S. manufacturing locations, in St. Cloud and Crookston, Minnesota (New Flyer Industries Inc, 2009). These companies and their market shares are shown in Figure 1.[2]

Figure 1. Heavy-duty Transit Bus OEMs in North America



Source: CGGC, based on company websites and industry interviews.

This report examines the manufacturing value chain for medium- and heavy-duty transit buses between 25 and 60 feet in length (please see Table 2). The value chain includes raw materials through components, subcomponents and final assembly, accompanied by an analysis of the jobs, skills and locations that would likely be affected by future public investment in bus transit systems.

[2] The remaining 2% share is made up of smaller firms that make 20-50 buses per year.

Table 2.Transit Bus Definitions

Category	Length	Seats	Average Cost
Heavy-Duty Buses[1] **(Heavy-duty large buses and heavy-duty small buses)**	30 to 48 ft and 60 ft articulated	26 to 40	$200,000 to over $600,000
Mid-Size Buses **(Medium-duty and light duty mid-sized buses)**	25 ft to 35 ft	16 to 30	$50,000 to $175,000
Small Buses **(Light duty- small buses)**	16 to 28 ft	10 to 22	$30,000 to $40,000

[1] About two-thirds of active U.S. transit buses are heavy-duty 40-foot buses (APTA, 2008). *Source*: (FTA, 2007).

Transit Bus Market Overview

The global transit bus market is small, but growing. Transit buses account for roughly 18% of a total global bus market of 324,000 buses[3] (including motor coaches, school buses, and all other bus types). Motor coaches account for 22% of the global bus market, and school buses and medium-duty buses for transporting employees, patients and tourists account for the remaining 60%. Bus transit in recent years has grown most quickly in the Asia/Pacific region, especially China, the world's largest producer and consumer of buses (Ealy and Gross, 2008). According to a recent industry study, worldwide demand for transit buses is expected to rise through the year 2017 by 5.9% annually (Freedonia Group, 2008). As shown in Table 3, demand is expected to grow in North America by 6.1% annually. However, these data include not only heavy-duty transit buses (the focus of this report) but also—particularly in the case of developing countries—sales of used buses and buses built on commercial chassis or stripped-down commuter buses. Projected growth rates solely for heavy-duty transit buses, the market relevant to the five major North American transit bus OEMs, are therefore likely to be more modest.

Bus transit is an increasingly important strategy in developing countries for providing mobility and solving congestion in urban areas. Especially in emerging economies with large populations such as China, India, Brazil, Russia, Indonesia and Mexico, bus transit is growing rapidly. In addition, European countries and Japan have long invested heavily in bus and rail transit to reduce energy use and air pollution, resulting in heavy transit use (Ealey & Gross, 2008).

Reliance on bus and rail systems is far lower in the United States (serving less than 5% of workers), although ridership has increased markedly in recent years. The number of commuters using public transit to go to work increased from 5.98 million in 2004 to 6.80 million in 2007 (APTA, 2009).[4] When gasoline prices soared in 2008, U.S. public transit use increased even more sharply, although official figures are not yet available. Since buses are the main U.S. public

[3] 2007 estimate according to (Freedonia Group, 2008)

[4] These data include bus commuter rail, paratransit, heavy rail, light rail and trolleybus.

transit mode (accounting for 40% of all transit passenger miles), continuing growth in transit demand—if accompanied by adequate public funding—will likely translate into larger bus orders.

Table 3. Global Transit Bus Demand by Region 1997-2017 (in Thousands)

Year	1997	2002	2007	2012	2017	2007-2017 Ave. Annual Growth
	In Thousands					*%*
Global Demand for Transit Buses	**41.1**	**50.7**	**58.1**	**73.6**	**92.5**	**5.9**
North America	13.3	14.8	13.5	17.3	21.7	6.1
Western Europe	9.4	11.3	11.6	13.5	15.2	3.1
Asia/Pacific	13.3	18.5	25.7	33.8	44.5	7.3
China	1.9	5.3	9.8	14.7	22.0	12.4
Other Asia	11.4	13.2	15.9	19.1	22.5	4.2
Other regions	5.0	6.1	7.4	9.0	11.1	5.0

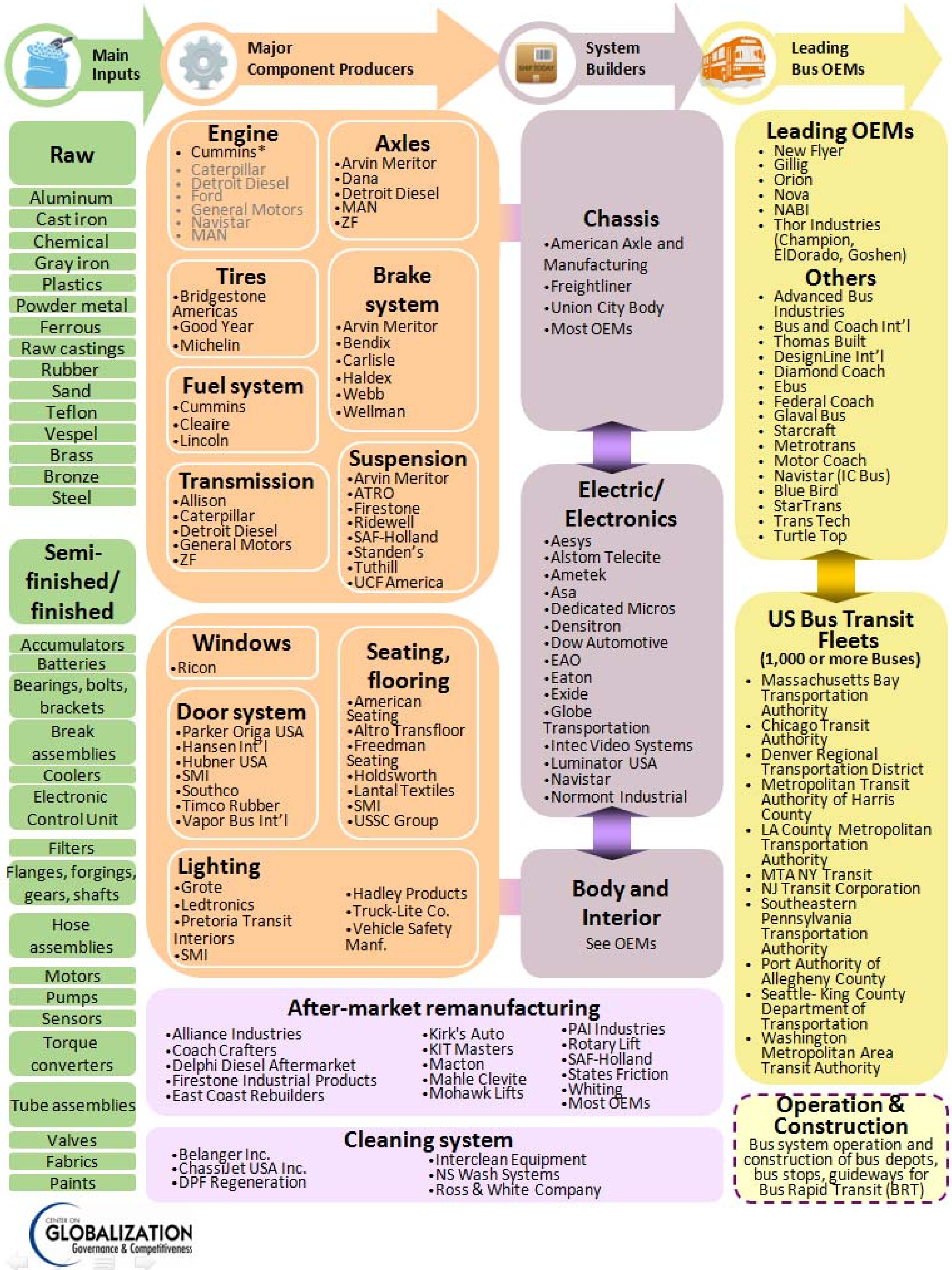
*These figures include not only heavy-duty transit buses but also commuter buses built for developing country markets that may have commercial chassis and/or bodies imported from outside the given region.
Source: CGGC, based on (Freedonia Group, 2008)

Since the U.S. transit bus market is limited, the main manufacturers are relatively small companies or subsidiaries of large OEMs. Transit bus manufacturers' clients comprise a few hundred municipal organizations, which typically have their own specifications. These dynamics make investment costs for production lines, R&D, marketing and administration higher than those for other industries (Eudy & Gifford, 2003). Small manufacturers are not well positioned to handle this instability and the associated economic risks (Ealey and Gross 2008).

U.S. Transit Bus Value Chain

The value chain for the U.S. transit bus manufacturing industry is found in Figure 2. For this study we have divided the value chain into four major categories, each of which is described in detail below: 1) inputs, including raw materials and semi-finished or finished materials; 2) components, from engines and transmissions to final parts such as bus lighting, seating and flooring; 3) system producers that manufacture the completed chassis, bus electric system and electronics, and body and interior; and 4) leading bus OEMs. The transit bus value chain also includes a large aftermarket segment, accounting for an estimated 10% of industry revenues (First Research, 2009), and a segment that manufactures automatic heavy-duty vehicle wash systems to wash transit buses. At the end of the value chain diagram we have included a list of 11 U.S. bus transit agencies with 1,000 or more buses in their fleets.

Figure 2. U.S. Value Chain for Transit Buses

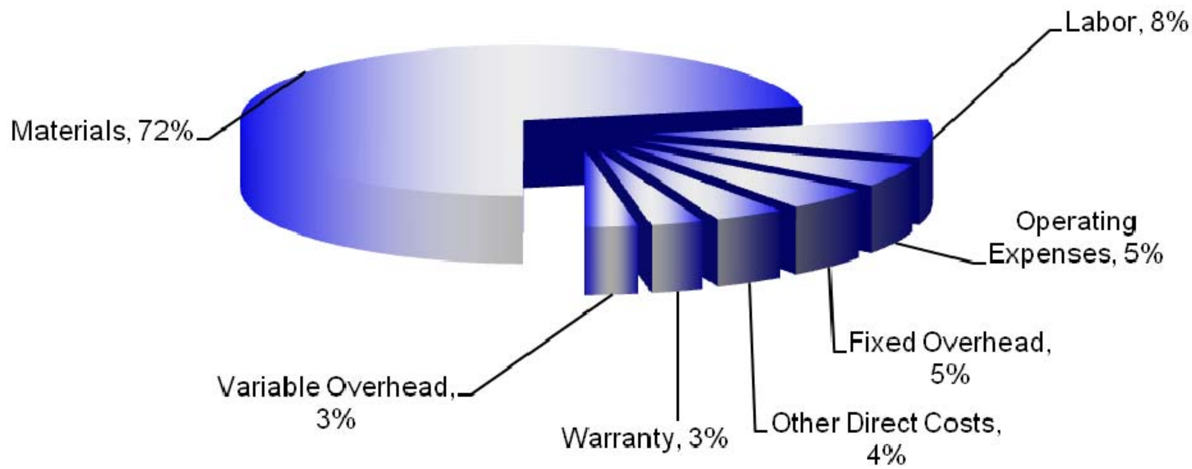


*Cummins is now the only remaining supplier of engines to the transit bus industry.

Source: CGGC, based on company websites and industry interviews.

1) Main inputs. In heavy-duty truck and bus manufacturing, the principal raw materials include steel, aluminum, plastics, glass, and rubber. The cost of materials represents roughly 85% of industry revenues (First Research, 2009). For the leading OEM, New Flyer, materials represented 72% of the cost of bus manufacturing operations in 2008 (see Figure 3). New Flyer notes that ensuring the availability of key materials is of critical importance. Hence, the company places considerable emphasis on trying to diversify vendors and maintain multiple supply sources for its raw materials and components (New Flyer Industries Inc, 2009).

Figure 3. Company Cost Structure, New Flyer



Source: (New Flyer Industries Inc, 2009).

2) Major components. The engine is the single most expensive component in a transit bus, accounting for roughly 20% of the total cost of a finished bus. Bus engines are supplied primarily by independent engine manufacturers, many of which have also produced engines for a number of other applications, including on-highway, marine, electric power, industrial, oil and gas, and machine engines. The drive cycle of a public transit bus puts particularly high stress on the engine, with frequent starts and stops and very little steady operation on the road. These inherent technical challenges are among the factors underlying the exit of several engine suppliers out of the transit bus industry. While in the past up to 22 companies manufactured bus engines, that number has dwindled to one major firm, Cummins, which now supplies nearly all U.S.-based bus OEMs and chassis producers. Other U.S. bus engine suppliers until recently included Caterpillar, Detroit Diesel, Ford, General Motors, Navistar, and MAN. Having to shift to a new supplier is complicated, costly and time-consuming, so a small and shrinking supplier base is a major concern for bus manufacturers. General Motors' exit in the summer of 2009 from the medium-duty truck market poses an especially large challenge, since it was an important supplier to the bus industry (Bell, 2009).

Table 4 provides a list of companies involved in manufacturing engines and transmissions for the bus industry. In addition to engine manufacturers, several other firms supply engine parts, including cooling systems and others. In transmissions, Allison is a leading manufacturer of medium- and heavy-duty automatic transmissions for buses. In Table 4 and all the company tables that follow, each company's headquarters is listed and, where available, the U.S. manufacturing and assembly locations relevant to the transit bus industry. Total company employees and total company sales figures, while not reflective of a given company's specific involvement in buses, help provide a sense of relative size of the players involved. In a few cases where data are available, the final columns in each table note two measures of "importance": how important the relevant bus component is within a given company's total sales, and how important the company is to the bus industry. For example, in the category of engines, Cummins, the sole remaining supplier of bus engines, is highly important to the bus industry, yet bus engines represent only a small percentage of the company's operations.[5] This "importance" indicator highlights two key dynamics. On one hand, the industry risks losing critical firms that would be difficult to replace; on the other hand, because of the size, diversity, and capacity of many firms, the industry shows potential for smooth future growth if a significant change in transportation funding were to create steady, predictable demand for buses.

Table 5 provides a list of companies involved in manufacturing suspension systems, axles, brakes and tires for the bus industry. As with engines, several firms have a large market share within the bus industry even though bus parts constitute only a small portion of their total company operations. With regard to bus brakes and bus axles, Arvin Meritor dominates the U.S. industry with 80% market shares in both products, even though each of these products represents only 1% of the company's total sales; truck components comprise the rest (Wolf, 2009). Major tire producers include Bridgestone Americas, Michelin, and Good Year, while other, related manufacturers include wheel product suppliers (principally Alcoa), valve producers, and tire monitoring system suppliers.

3) <u>System builders</u>. In transit bus manufacturing, basic system builders can be divided into three types: chassis, electric/electronics, and body and interior systems. Most OEMs assemble their own completed chassis for their buses. In general they source the major chassis components (engine, transmission, suspension, axles, tires, brakes, and fuel system) from other suppliers. The industry also includes independent chassis manufacturers such as Freightliner Custom Chassis (See **Table 6**). The main components of the body and interior system are windows, doors, seating, flooring, and lighting. Table 7 provides a list of companies involved in manufacturing these components. OEMs primarily purchase these components from independent manufacturers or source them from companies they own—a pattern that also holds for electric systems and electronics. The electric and electronics systems are embedded in the chassis and body/interior.

[5] According to the company's website, the engine segment represents 50% of total revenues. Medium-duty truck and bus engines represent 18% of total engine revenues, and most of these are truck engines.

Table 4. Selected U.S. Bus Engine and Transmission Manufacturers, 2008

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*	
					Of Item to Company	Of Company to Bus Industry
ENGINES						
Cummins	Columbus, IN	Whitakers, NC Lakewood, NY Cookeville, TN Stoughton, WI Fridley, MN Charleston, SC Seymour, IN Columbus, IN	38,000	$ 14,300	- Low -	- High -
Caterpillar (Engine Division of Caterpillar)	Peoria, IL	Mossville, IL		$ 51,324	-Low-	- High -
Detroit Diesel	Detroit, MI	Redford Township, MI **	2,600	$122,900		-High-
Ford	*Dearborn, MI*	**	*246,000*	*$ 146,300*		
Navistar	see OEMs			*$ 14,724*		
MaxxForce		Huntsville, AL Indianapolis, IN Melrose Park, IL				
TRANSMISSIONS						
Allison Transmission	Indianapolis, IN	Indianapolis, IN	*3,500*	*$ 17.8*		- High -
Altra	Braintree, MA	Braintree, MA	*3,146*	*$ 635.3*		
Caterpillar	see Engines					
Defeo Manufacturing & Supply ***	Brookfield, CT	*Brookfield, CT*	*29*	*$ 3.1*		
Detroit Diesel	see Engines					
Mustang (Dynamometers)	Twinsburg, OH	Twinsburg, OH	*60*	*$ 10*		
Powertest (Dynamometers)	Sussex, WI	Sussex, WI			- Low -	- High -
SuperFlow Technologies (Dynamometers)	*Colorado Springs, CO*	Des Moines, IA; Colorado Springs, CO	*115*	*$ 9.8*	- Low -	- High -
Voith Turbo Inc.[1]	Germany					
ZF Industries	*Gainesville, GA*	**	*230*	*$ 68.3*	- Low -	- Low -

Data are not available for all fields; many private firms do not disclose figures. * "Importance" category is for selected firms only. Buses may not be a large part of a firm's product mix, so sales and employee data may overstate importance to bus industry. **Ford bus engines and ZF bus components are not produced in U.S. plants; Detroit Diesel also has five remanufacturing centers in the United States. ***Defeo is the manufacturer and remanufacturer for Allison. [1]Voith is a German manufacturer with 3 distribution centers in North America. *Source*: CGGC. Unless stated otherwise, data are from company web-sites and interviews and, if in italics, from Selectory.com.

Table 5. Selected U.S. Bus Suspension, Axles, Brakes and Tire Manufacturers, 2008

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*	
					Of Item to Company	Of Company to Bus Industry
BUS SUSPENSION						
ATRO Engineered Systems (Suspension parts)	Sullivan, MO	*Sullivan, MO*	*45*	*$ 3.3*		
Firestone Industrial Products (Suspension parts)**	Indianapolis, IN		*133,752*	*$10,222*		
Ridewell	Springfield, MO	*Springfield, MO*	140	*$ 22.7*		
SAF-Holland	see Aftermarket					
Standen's Limited (Suspension parts)	Canada	**	*501*	*$ 103*	- High -	
Tuthill Transport Technologies	*Brookston, IN*	Mount Vernon, MO Brookston, IN	*160*	*$ 28*		
UCF America (Suspension parts)	*Arlington, TX*	Pennsauken, NJ Arlington, TX	*40*	*$ 1.9*		
BUS AXLES						
ArvinMeritor	see Brakes					
Dana Holding Corp.	Toledo, OH	**	*32,000*	$ 8,100		
Detroit Diesel	see Engines					
Man Engines & Components	Pompano Beach, FL	*Pompano Beach, FL*	*41*	*$ 25.2*		
ZF Industries	see Transmission					
BUS BRAKES						
ArvinMeritor	Troy, MI	Newark, OH York, SC	*19,800*	*$ 7,200*	- Low -	- High -
Bendix Commercial Vehicle Systems	Elyria, OH	Huntington, IN Sparks, NV Del Rio, TX Bowling Green, KY	*350*			
Carlisle Motion Control	*Netherlands*	Bloomington, IN Logansport, IN	*10*	*$ 43.9*	- High -	
Haldex	*Kansas City, MO*		*90*	*$ 1,300*	- High -	
KIC (Brake drum)	Vancouver, WA	*Vancouver, WA*	*15*	*$ 36.4*		- Low -
MGM Brakes *(Indian Head Industries Inc)* (Parking brakes and actuators)	Charlotte, NC		*400*	$ 53.5		
Rome Heavy Duty *(Rome Tool & Die Co Inc)* (Brake shoes)	*Rome, GA*	*Rome, GA*	*130*	*$ 29.5*	- Medium-	- Low -

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*	
					Of Item to Company	Of Company to Bus Industry
Webb Wheel Products	Cullman, AL	Cullman, AL	*330*			- High -
Wellman Products Group *(SK Wellman Corp)*	Solon, OH	***	*250*	*$ 94*		
BUS TIRES						
Alcoa (Wheel products)	Atlanta Norcross, GA	Bloomsburg, PA Hernando, MS Springdale, AR Visalia, CA	*32,300*	*$ 26,901*	- Low -	- High -
Bridgestone Americas	Nashville, TN	Graniteville, SC LaVergne, TN Abilene, TX Long Beach, CA Akron, OH Normal, IL Muscatine, IA Morrison, TN	*133,752*	$ 10,222		
Good Year	Akron, OH	22 facilities in 13 counties. Akron OH (bus tires)		$ 20,500	- Low -	- Low -
Haltec (Valves)	Salem, OH	Salem, OH	*45*	*$ 6.8*		
Michelin[1]	Greenville, SC	11 plants in US OK-1, NC-1, AL-3, SC-4, KY-1, IN-1	22,600	$ 23,100		
TireStamp (Tire monitoring)	Troy, MI	Troy, MI	*20*	*$ 1.3*	- Low -	- Low -

Data are not available for all fields; many privately held companies do not disclose figures. * "Importance" category is for selected firms only. Buses may not be a large part of a firm's product mix, so sales and employee data may overstate importance to bus industry. **Standen's Limited has no U.S. manufacturing locations; Dana has 3 manufacturing facilities in N. America but none of them produce bus axles. ***Wellman operates seven manufacturing facilities with locations in the United States, Canada, Italy and China. [1]Sales figures for Bridgestone, GoodYear and Michelin are for 2007, cited in Bridgestone's website; Michelin employment figure is for North America. *Source*: CGGC. Unless stated otherwise, data are from company web-sites and interviews and, if in *italics*, from Selectory.com.

Table 6. Selected U.S. Manufacturers of Bus Chassis and Electric/Electronic Systems, 2008

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*: Of Item to Company	Importance*: Of Company to Bus Industry
BUS CHASSIS						
American Axle and Manufacturing (AAM)	Detroit, MI	Fort Wayne, IN Cheektowaga, NY Malvern, OH Minerva, OH Salem, OH Detroit, MI Auburn Hills, MI Oxford, MI Rochester Hills, MI Three Rivers, MI	*7,250*	*$ 2,109*		- Low -
Freightliner Custom Chassis	Gaffney, SC	Gaffney, SC	750	*$ 122,899*		
Union City Body Co. *(Union City Assembly)*	Union City, IN	*Union City, IN*	*25*	*$ 2.3*		
ELECTRIC SYSTEM/ BUS ELECTRONICS						
Aesys Inc. (Electronic destination signs)	Tenafly, NJ	*Tenafly, NJ*	*5*	*$ 1*	- High -	- Low -
AMETEK (Bus electronics)	*Paoli, PA*	Woodstock, NY	11,794	$ 2,500	- Low -	- Low -
Eaton (Bus electronics)	Cleveland, OH		*80,913*	$ 15,400		
Luminator USA (Destination sign mechanisms)	Plano, TX	Plano, TX	*8,010*		- High -	- High -
Navistar	see OEMs					
Normont Industrial (Access hardware)	Plattsburg, NY					
Prestolite Electric Leece Neville Heavy Duty Systems (Bus electronics)	Plymouth, MI	Arcade, NY	*2,500*			- Medium-
Transign (Destination sign mechanisms)	Waterford, MI	Waterford, MI				
Twinvision (Destination sign mechanisms)	Durham, NC	Durham, NC	*186*	*$ 70.5*		
Vansco Electronics (Parker Vansco) (Bus electronics)	Canada	Valley City, ND Morton, IL	*220*	*$ 58*		- High -

Data are not available for all fields; many privately held companies do not disclose figures. * "Importance" category is for selected firms only. Buses may not be a large part of a firm's product mix, so sales and employee data may overstate importance to bus industry. *Source*: CGGC. Unless stated otherwise, data are from company web-sites and interviews and, if in *italics,* from Selectory.com.

.

Table 7. Selected U.S. Manufacturers of Bus Windows, Doors, Lighting, Seating and Flooring, 2008

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*	
					Of Item to Company	Of Company to Bus Industry
BUS WINDOWS						
Custom Glass Corp. (Fabricated glass)	Kittanning, PA	Kittanning, PA				
Ricon*	Panorama City, CA		*250*			
BUS DOORS						
Eberhard (Door latches and locks)	Strongsville, OH	Strongsville, OH				
Hansen International (Hardware and trim systems)	Lexington, SC	Lexington, SC	*120*	*$17.5*		
Hubner USA (Articulation system)	Mt. Pleasant, SC		*53*	*$ 4.2*		
Parker Origa USA (Door system and electronic control systems)	Glendale Heights, IL					- High -
SMI	see Lighting					
Southco (Door latches and locks)	Concordville, PA	Concordville, PA Honeoye Falls, NY Rockledge, FL	*1,000*	*$ 350*	- Low -	- Medium-
Timco Rubber (Rubber bellows, door and window seals)	Cleveland, OH	Cleveland, OH	*20*	*$ 3.1*		
Trimark (Door latches and locks)	New Hampton, IA	New Hampton, IA	*260*	*$ 26.3*		
Vapor Bus International (Door equipment)	Buffalo Grove, IL	Buffalo Grove, IL	*408*	*$ 37.7*		- High -
BUS LIGHTING						
Grote Industries (Ligthing and safety systems)	Madison, IN	Madison, IN	1,000	*$ 151*		- High -
Hadley Products (Formerly it was Transmatic Group)	Waterford, MI		*200*			
LEDtronics (LED bulbs and Products)	Torrance, CA	*Torrance, CA*	300	*$ 12.9*		
Pretoria Transit Interiors***	Murfreesboro, TN	Murfreesboro, TN				- High -
SMI	Pineville, NC	Murfreesboro, TN			-Low-	-High-
Truck-Lite Co. Inc.	Falconer, NY	Falconer, NY McElhattan PA Wellsboro, PA Coudersport, PA	*600*		- Low -	- Low -

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*	
					Of Item to Company	Of Company to Bus Industry
BUS SEATING, FLOORING						
American Seating (Seating)	Grand Rapids, MI	Grand Rapids, MI	*500*	*$ 119*	-Medium-	- High -
Altro Transfloor (Flooring products)	UK	Subsidiary in US				- High -
Dow Automotive (Design, engineering, prototyping, interior trim; seating; steering wheels)	Midland, MI					
Freedman Seating (Seating)	Chicago, IL	Chicago, IL	*300*			- High -
Holdsworth (Fabrics)	Indianapolis, IN	UK				
KSU (Seating)	Bellwood, IL		200			
Lantal Textiles (Fabrics)	Rural Hall, NC	Winston-Salem, NC	*147*			
SMI	see Lighting					
USSC Group (Seating)	Exton, PA	Exton, PA	*100*			- High -

Data are not available for all fields; many private firms do not disclose figures. * "Importance" category is for selected firms only. Buses may not be a large part of a company's product mix, so sales and employee data may overstate importance to bus industry. **Ricon primarily manufactures wheelchair lifts but is also a growing supplier of bus windows; parent company is Westinghouse Air Brake Technology Corporation ($1.6 billion annual sales). ***Pretoria Transit Interiors of Murfreesboro TN has become part of SMI. *Source*: CGGC. Unless stated otherwise, data are from company web-sites and interviews and, if in *italics,* from Selectory.com.

4) OEMs. The five bus OEMs that share 98% of the North American bus market—New Flyer, Gillig Corporation, North American Bus Industries (NABI), Orion Bus Industries and Nova Bus—had a total of $1.4 billion worth of sales in 2008 with a total employment of 2,482 in North American facilities. While each of the top five heavy-duty transit bus OEMs is of medium or high importance to the transit bus industry, three of these firms have total operations that include much more than transit bus production. For Orion (18% market share), parent company Daimler calculates that buses, vans and others represent only 16% of its (Daimler's) 2008 revenues. For Nova (9% market share) parent company Volvo put Orion's sales at 6% of Volvo group sales in 2008 (Volvo Group, 2008). In contrast, Gillig (27% market share) focuses solely on transit buses, and for New Flyer (38% market share), bus manufacturing comprised 90% of total revenues in 2008. The remaining lead firms are found in Table 8.

In small and mid-size transit buses, Thor Industries has three brands: Champion, ElDorado, and Goshen. The company is the largest manufacturer of small and midsize transit and commercial buses in North America, with a 37% share of that market (Thor Industries, 2008a, 2008b).

Table 8. Selected U.S. Bus Original Equipment Manufacturers (OEMS), 2008

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)	Importance*	
					Of Item to Company	Of Company to Bus Industry
Advanced Bus Industries	Marysville, OH	Marysville, OH				
Bus and Coach Int'l, (BCI)	Jennings, KS	Jennings, KS				
Daimler*	Germany		22,476	$138,570.00	- Medium -	- Medium -
Orion (Daimler Buses North America)	Greensboro, NC	Oriskany, NY ** Greensboro, NC	1,259	$566.00		- Medium -
Thomas Built		High Point, NC	1,600			
DesignLine International	Charlotte, NC	Charlotte, NC	*50*	*$ 25.6*		
Diamond Coach	*Oswego, KS*	*Oswego, KS*	*55*	*$6.80*		
Ebus	Downey, CA	Downey, CA	*45*	*$0.60*		
Federal Coach	Fort Smith, AR	Fort Smith, AR	*3,072*	*$ 706.4*	- Medium -	- Low -
Glaval Bus	Elkhart, IN	Elkhart, IN	*250*	*$34.20*		
Gillig	Hayward, CA	*Hayward, CA*	*700*	*$77.60*	- High -	- High -
Metrotrans Corporation	Atlanta, GA	Atlanta, GA	*300*	*$76.10*		
Motor Coach Industries International	Schaumburg, IL	Pembina, ND	2,000			
New Flyer of America***	Winnipeg, MN	St. Cloud, MN Crookston, MN	2,348	*$ 103.8*	- High -	- High -
North American Bus Industries (has 3 brands)	Anniston, AL		*121,200*			
NABI	*Tacoma, WA*	Anniston, AL	*121,200*	*$6.30*		- Medium -
Blue Bird	Fort Valley, GA	Fort Valley, GA	1,800	*$ 2.5*		
Starcraft Bus	Goshen, IN	Goshen, IN	*200*	*$27.40*		
StarTrans Bus Division	Goshen, IN	Goshen, IN Jonestown, PA	*2,200*	*$269.00*		
Thor Industries	*Jackson Center, OH*	Salina, KS Riverside, CA Imlay City, MI Elkhart, IN	7,064	$2,640.00	- Medium -	- High -
Champion Bus	*Imlay City, MI*	Imlay City, MI	*300*	*$90.00*		
ElDorado National	*Riverside, CA*	Salina, KS Riverside, CA	*350*			
Goshen Coach	*Elkhart, IN*	Elkhart, IN	*230*	*$36.00*		
Trans Tech	Warwick, NY	Warwick, NY				
Turtle Top *(Independent Protection Co Inc)*	New Paris, IN	New Paris, IN	*240*	*$3.00*		
Novabus[1]	*South Plainfield, NJ*	Plattsburgh, NY	195	$684.50	- Low -	- Medium -

Data are not available for all fields; many privately held companies do not disclose figures. * "Importance" category is for selected firms only. *Daimler employment is for US; sales is for North America. Orion employment is for North America; Oriskany, NY plant has 612 employees; figures include Setra motorcoaches. **New Flyer employment is for N America: 1,373 for Canada and 975 for the US. [1]Novabus employment is for U.S. facility; sales is for N. America. *Source*: CGGC. Unless stated otherwise, data are from company web-sites and interviews and, if in *italics*, from Selectory.com.

The transit bus industry has a limited client base consisting of local transit authorities, so demand is dependent on government funding, which is often short-term and unpredictable, preventing firms from establishing long-term supply agreements. The low-volume nature of bus manufacturing poses a further challenge in containing production costs. In addition, bus manufacturers in the United States primarily manufacture on a built-to-order basis. Unlike the vertically integrated system prevalent in Japan and Europe, in which bus OEMs produce most major components in their own plants, many U.S. manufacturers purchase the main components from other providers and assemble them. Although this strategy minimizes factory investment and maintains flexibility to respond to consumers' specifications (Ealey & Gross, 2008), it does present several challenges related to the resulting lack of standardization. Buses are built specifically to each transit customer's preferences, which increases bus costs an estimated 20-30%. Custom designs affect production stability and result in more difficult and expensive R&D than is typical of other motor vehicle industries (New Flyer Industries Inc, 2009). According to industry interviews, OEMs are capable of producing more "standard" bus models at 80% of current costs. This would require a major shift in the way the industry does business with its clients, but may reduce costs enough to make it worthwhile for both sides.

Another important issue for transit bus OEMs is the limited number of producers, not just of engines but of several key bus components. These segments are often small, dominated by two or three suppliers. New Flyer notes that reliance on a constricted group of suppliers poses ongoing risks that firms will lack key supplies, be forced to interrupt production of certain products, or have less control over pricing and timely delivery (New Flyer Industries Inc, 2009). Firms' choices are further narrowed by the Buy America provision, which requires that buses purchased for federally financed transit projects have 60% local content and undergo final assembly in the United States. Industry interviews suggest that this rule places additional restrictions on firms' ability to source supplies for their products.

<u>Aftermarket and bus cleaning systems</u>. For the heavy-duty truck and bus manufacturing industry, sales of aftermarket parts are an important segment, accounting for 10% of revenues (First Research, 2009). Most OEMs acquire aftermarket parts and services from other suppliers and then provide them to clients for their own brands and other buses. These activities help determine the competitive advantage of transit bus OEMs, constituting an important factor for transit authorities in their buying choices. The value chain also includes manufacturers that provide automatic heavy-duty vehicle wash systems to wash transit buses. Selected independent aftermarket firms and bus cleaning system manufacturers are listed in Table 9.

Table 9. Selected U.S. Bus Industry Aftermarket Remanufacturers and Bus Cleaning System Manufacturers

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)
Alliance Industries (Remanufacturing torque converters)	Springfield, MO	Springfield, MO	*15*	*$1.1*
Balcrank Products (Lubrication equipment)	Weaverville, NC	*Weaverville, NC*	*100*	*$14.9*
Coach Crafters (Repair and remanufacturing)	Tavares, FL	Tavares, FL	*26*	*$ 3.5*
Delphi Diesel Aftermarket North America (Remanufacturing engines)	*Troy, MI*	Troy, MI	*168,700*	*$ 18,060*
East Coast Brake Rebuilders (Rebuilding brakes)	*Norfolk, VA*	Norfolk, VA	*12*	*$ 5*
Firestone Industrial Products (Suspension spare parts)	See suspension			
Kirk's Auto (Remanufacturing bus components)	Detroit, MI	Detroit, MI	*70*	
KIT Masters (Aftermarket components)	Perham, MN	Perham, MN		
Leyman Manufacturing (Lift gates)	Cincinnati, OH	*Cincinnati, OH*	*90*	*$ 7*
Macton (Lift systems)	Oxford, CT	*Oxford, CT*	*55*	*$ 10.4[(E)]*
Mahle Clevite (Aftermarket replacement parts*)	*Ann Arbor, MI*	11 plants incl. Churubusco, IN Trumbull, CT Murfreesboro, TN Mcconnelsville, OH	*91*	*$ 91.1*
Mohawk Lifts *(Mohawk Resources Ltd)* (Lift systems)	Amsterdam, NY	*Amsterdam, NY*	*70*	*$ 11.5*
PAI Industries (Service parts for engines)	Suwanee, GA		*100*	
Rotary Lift	Madison, IN		*32,300*	*$ 7,568.8*

Company Name	Headquarters	U.S. Manufacturing Locations	Total Company Employees	Total Company Sales (millions)
(Lift systems)				
SAF-Holland (Lift systems and suspension)	Muskegon, MI	Muskegon, MI	*273*	*$ 386.3*
States Friction Group *(Page Brake Warehouse Inc)* (Brake repair)	*Salt Lake City, UT*	Salt Lake City, UT Charlotte, NC Chaplin, MO	*88*	*$ 5.4*
Whiting (Repair)	Monee, IL	Monee, IL	*320*	
Belanger Inc. (Automatic transit wash system)	Northville, MI	Northville, MI	*212*	
ChassiJet USA Inc. (Automatic chassis cleaning system)	Northridge, CA	Northridge, CA		
DPF Regeneration (Cleaning of Diesel Particulate Filters)	Stratford, CT			
Interclean Equipment (Automatic transit wash system)	Ypsilanti, MI	*Ypsilanti, MI*	*50*	*$ 13.6*
NS Wash Systems (Wash system)	Inglewood CA	Inglewood CA		
Ross & White Company (Wash equipment)	*Cary, IL*	Cary, Illinois	*15*	*$ 1.6*

Data are not available for all fields; many privately held companies do not disclose figures. Buses and bus parts are not necessarily a large percentage of a company's product mix, so sales and employee data may overstate a company's importance to the bus manufacturing industry. *Mahle Clevite provides aftermarket replacement parts for Caterpillar, Cummins, Detroit Diesel, Mack, Case/IH and John Deere. ***Source:*** CGGC. Unless stated otherwise, data are from company web-sites and interviews and, if in *italics*, from Selectory.com.

Transit Bus Market Outlook

The U.S. market for heavy-duty transit buses is small, delivering roughly 5,000 to 5,500 buses per year. Heavy-duty buses have a 12-year life and old buses are expensive to keep running, so the need to replace buses in current fleets is a factor in future sales. The United States has roughly 1,200 transit agencies with bus fleets, and the average bus age in the American Transportation Association's (APTA)'s sample of current U.S. fleets is 7.5 years (APTA, 2009). This means the replacement market alone implies a certain minimum level of future bus orders.

Public transit spending is not sufficiently steady or reliable to encourage growth in the industry. Firms may receive increased orders only to see them fall in subsequent years when funding levels drop and demand has already been satisfied. This makes it difficult for bus manufacturers to maintain their capacity and workforce without having to lay off workers periodically. In the current recession, many agencies can no longer meet federal financing formulas that require a local funding match of 20%. Cutbacks in state funding appear to threaten even the gains promised by funding from the stimulus bill, the American Recovery and Reinvestment Act of 2009. To illustrate, the Chicago Transit Authority used stimulus money to order 58 new hybrid buses from New Flyer. It also placed a larger order of 140 buses, which it intended to pay for with state money. However, the state funds were subsequently cut and the CTA was forced to delay the large order. This so disrupted New Flyer's production schedule that, in August 2009, the company was forced to begin laying off 320 people, or 13% of its workforce (Cooper, 2009).

U.S. export potential of transit buses is also constrained. Differences in technology levels resulting from higher standards for emissions, safety and accessibility increase the capital costs of U.S.-made buses and major components. In international markets this constitutes an added disadvantage beyond general political and market pressures that ensure that buses are mainly produced in the country where they are sold—or at least in countries at similar levels of economic development (Ealey & Gross, 2008). For example, developing nations tend to trade buses only with other developing nations, with China exporting only to developing countries in Asia and South America. Similarly, Eastern European countries export buses to South America. Emerging countries' lower technology levels and standards appear to prevent them from competing in industrial country bus markets, while industrial countries' higher production costs and standards appear to prevent them from competing in emerging country markets.

In certain key components, U.S. manufacturers do supply foreign companies, using the same platform but with different sub-components to meet local in-country requirements. For example, Allison Transmission has sold some 14,000 transmissions for transit buses throughout the world, about 12,000 of them in China. Allison supplies several Chinese transit bus OEMs, including Kinglong, Zhongtong, Bonluck-BCI, Foton, Yutong, Dandong Hunghai, Youngman and Xiamen Golden Dragon (International Organization for Public Transport, 2009). Cummins, the U.S. engine maker, has 21 facilities, 14 manufacturing plants,12 distribution centers and one research center in China (Cummins 2005). Cummins also established joint venture companies with local vehicle OEMs in China and India (Cummins, 2005, 2007). Firestone Industrial Products, U.S. bus suspension producer, has an assembly factory in Beijing and a sales office in Delhi, India (Firestone Industrial Products 2009). This indicates the potential for U.S. makers of selected components to respond to rapidly growing emerging markets in the global transit bus industry.

Types of Green Buses

The diesel engine is by far the most prevalent technology for transit buses due to its availability, durability, familiar maintenance, and good performance including fuel economy and torque power (Ealey & Gross, 2008). However, as governments seek to enhance their energy independence and reduce fuel use and the emission of greenhouse gases and other air pollutants, the market is growing for greener alternatives. Today, an estimated 32% of U.S. transit buses have an alternative power source, i.e., other than diesel or gasoline (APTA, 2008). The transit bus industry has played a crucial role in proving and adopting advanced vehicle technologies. Transit fleets have the advantages of large-scale refueling and centralized management of vehicles, which facilitates the testing and refining of new technologies. The examples of CNG, plug-in hybrid, and all-electric buses show how transit buses are well-suited to preparing the way for other motor vehicles in new technology applications (Silver, 2009).

A summary of the status of the five green bus types addressed in this study—all-electric, diesel-electric, hydrogen-electric, hydrogen fuel cell, and compressed natural gas—is found in Figure 4. The value chain for these bus types is essentially the same as that for conventional buses (see Figure 2), except for key components in the propulsion system, such as the motor/generator system or energy storage. These specific components that distinguish a green bus from a conventional bus are listed in Figure 4, below. Also included are R&D activity, the status of refueling infrastructure (if needed), major manufacturing firms, and selected transit fleets that have adopted the vehicles. A fuller discussion of each green bus type appears after Figure 4.

Figure 4. Summary of the Status of Selected Green Bus Types, United States, 2009

Note: Components listed are in addition to those of a conventional bus.
Please see list of acronyms on page 2. All Electric includes Battery Electric Buses (BEV) and Electric Trolleys attached to the grid. Recharging infrastructure for All Electric is for BEVs only. Hydrogen-electric buses have hydrogen-fueled internal combustion engines (ICE) assisted by electric batteries. * New Flyer refers to Electric Trolleys only.
Source: CGGC, based on agency and company websites and interviews.

Compressed Natural Gas (CNG): CNG is simply liquid natural gas that has been compressed. CNG buses are the most common type of green bus, very popular in China and accounting for about half of all bus sales in Western Europe (Ealey & Gross, 2008). Bus fleets throughout the United States have incorporated CNG, including Los Angeles transit authority, which operates 2,200 CNG buses, comprising 88% of their fleet (APTA, 2003). Since natural gas combustion produces lower levels of particulate matter and toxic emissions, CNG buses have pollution advantages over diesel. As for greenhouse gases, when the entire fuel cycle including fuel production is considered, CNG buses appear to emit levels similar to or perhaps slightly better than diesel buses, even accounting for their higher levels of the powerful greenhouse gas methane (DOE, 2000). The United States already has an extensive refueling infrastructure for CNG, with CNG pipelines connecting the entire continental United States. The infrastructure includes refueling stations in every state, some compressing the LNG onsite while others bring in CNG already compressed (DOE, 2009c).

Hybrid-Electric Vehicles (HEV): Currently, HEV transit buses primarily consist of diesel-electric hybrids, although early testing for hydrogen-electric hybrids (HHICE, or hybrid hydrogen internal combustion engine) is ongoing in California, at Sunline Transit, Santa Barbara Valley Transit Authority and AC Transit, and in Connecticut at CTTRANSIT (L. Eudy et al., 2008). HEVs are powered by a combination of the conventional internal combustion engine (ICE) and a battery, which is charged by regenerative breaking. Plug-in hybrid electric vehicles (PHEVs) offer the advantages of hybrid-electric and all-electric vehicles, by using the engine to expand the driving range and charge the battery, while also having the ability to plug into the electric grid and be powered solely by the stored electricity (DOE, 2009a).

Battery Electric Vehicles (BEV): BEV vehicles run solely on batteries that must be recharged on the grid. The only pollutants from a BEV are those resulting from generating the electricity used to recharge the battery. BEVs are distinguished from electric trolley buses, which are powered through overhead cables. Proterra, a firm developing a BEV transit bus, plans by June 2010 to have infrastructure in place for the Foothills Transit Agency, operating in the San Gabriel and Pomona Valleys in California, with four more cities to come online afterwards. Apart from Foothills Transit and MTD Santa Barbara, no other transit authorities run full-size BEV transit buses yet, although Proterra aims to expand the market (Goldman, 2009).

Fuel Cell Vehicles: These vehicles have no internal combustion engine; instead, fuel cells strip electrons from the hydrogen fuel and use them to power an electric motor. The only exhaust from the vehicle is water vapor. As of December 2008, the United States had only 10 fuel cell buses, all in field testing with transit agencies. New Flyer and Van Hool now have fuel cell buses on their production lines, with New Flyer working to fill an order for 20 fuel cell buses for BC Transit in Canada (Edwards, 2009)**.** The refueling infrastructure for hydrogen is also at an early stage, with stations set up in 18 states. California is the only state with more than 10 stations (DOE, 2009b).

Hydrogen internal combustion engines (HICE) and hydrogen-blend gaseous fueled internal combustion engines (HBICE). Along with the hydrogen-electric hybrid and hydrogen fuel cell bus, HICE vehicles are the least developed of green bus types, especially in the United States. A HICE vehicle simply fuels its internal combustion engine with hydrogen as opposed to conventional fuel. The only exhaust is water vapor, while all criteria emissions from the vehicle are at practically zero. While HICE technology in the United States is not progressing at the pace experts had hoped, HICE buses have been tested successfully in Berlin at the 2006 soccer World Cup, and in London with city buses. By 2010, London plans to have 10 hydrogen buses in its fleet, five powered by fuel cell, and five by HICE. While North America has no similar testing stories, the California based non-profit CALSTART is optimistic that the HICE will continue to gain ground in the North American market (CALSTART, 2009).

Light-Weight Buses: Further gains in fuel economy have been achieved with the recent development of light-weight transit buses. The first light-weight, stainless steel[6] bus debuted in July 2008, developed and produced by the Oak Ridge National Laboratory (ORNL) and DOE, along with two Michigan companies: Autokinetics, which developed the bus, and Fisher Coachworks, which licensed the technology and built the prototype. The weight reduction is due in part to increased use of stainless steel, which is lighter but stronger than conventional steel and can be used more sparingly in the chassis while still offering improved durability. Weight is further reduced by improving design of the shell, welds and fastenings. Lower chassis weight means that the size of wheels, brakes, suspension components and related running gear can be reduced as well, reducing overall weight as much as 50%. The improved bus design enables it to carry 20% more passengers than other 40-foot vehicles while costing up to 30% less to produce (Discoveries and Breakthroughs Inside Science (DBIS), 2007). The prototype was equipped with a diesel-electric hybrid drive train, complete with a battery capable of being plugged into the grid. The reduced-weight prototype achieved double the fuel efficiency of conventional diesel-hybrids. Fisher is in the process of negotiating supplier relations for production of their GTB-40 light-weight transit bus (Fisher Coachworks, 2009).

Alternative fuel and hybrid technologies can save thousands of gallons of fuel and dramatically reduce emissions of CO_2 and other greenhouse gases. For instance, while a conventional transit bus uses about 15,508 gallons of fuel per year and emits roughly 153 tons of CO_2, a diesel-electric hybrid uses about 11,544 gallons of fuel per year and emits 114 tons of CO_2; an all-electric bus uses the equivalent of 1,825 gallons of fuel per year and emits roughly 13 tons of CO_2 (See Table 10).

[6] While *ultralight-weight* stainless steel buses are a new development, stainless steel buses are widely available, accounting for perhaps 60% of new buses.

Table 10. Estimated Fuel Use and CO_2 Emissions, Selected Green Bus Types

	Diesel	Diesel-Electric Hybrid (HEV)*	Compressed Natural Gas (CNG)	Electric BEV, Full Hybrid or PHEV running on battery only	Hydrogen Fuel Cell (HEV)	Hydrogen Internal Combustion Engine (HICE)
Heavy Duty Transit Bus Fuel Use (Gal/Yr)**	15,508	11,544	21,255	1,825	4,337	7,285
Heavy Duty Transit Bus CO_2***** (Tons/Yr)**	153	114	115	13	42	72

*Fuel savings from HEVs can vary according to the degree of reliance on battery power v internal combustion engine; number used here is an average from (Barnitt 2008). **Numbers for electric bus and hydrogen are in gallons of diesel equivalent. *** Neither the electric hybrid (BEV) nor the Hydrogen HEV emits any tail exhaust CO_2. Electric number is CO_2 from power plants generating the electricity for the car, assumed here to be coal-fired; hydrogen number is based on diesel equivalent.

Source: CGGC, based on fuel economy from (Barnitt, 2008), annual bus mileage from (Chicago Transit Authority, 2009), lbs of CO_2 per gallon of fuel from (EPA, 2009), electric bus fuel economy from (Green Car Congress, 2009) and hydrogen buses fuel economy from (K. Chandler & L. Eudy, 2007).

Emergence of Green Bus Market

Despite the fuel use and emissions benefits of green buses, two factors have so far limited their wider adoption. First, appropriate infrastructure must be set up for hydrogen and electricity. Only 18 states have hydrogen refueling stations and only 15 states have battery recharging stations, only some of which are for transit vehicles (DOE, 2009b). Second, manufacturing costs remain much higher than for conventional diesel buses—in the range of 10% more for CNG buses, roughly 70% more for diesel-electric hybrids, and perhaps ten times as much for hydrogen fuel cells.[7] As light-weight stainless steel buses continue to develop they could cost up to 30% less to produce than conventional bus bodies, helping to offset the increased cost of the various green buses being built on conventional bus bodies.

Globally, CNG transit buses are the main alternative to diesel, constituting a mature technology and the lowest cost option for countries with natural gas resources. Although the capital cost of a CNG bus is moderately higher than that for a conventional diesel bus, gas-rich countries enjoy lower fuel costs and thus lower lifetime costs with CNG transit buses. Extensive gas supply infrastructure is in place in Western Europe, where CNG buses constitute half of bus sales (Green Car Congress, 2006b). Other gas-abundant countries where CNG bus fleets are growing rapidly include China, Pakistan and Brazil. China had more than 55,000 CNG buses on the road by 2005, with thousands more expected to be added for the 2008 Beijing Olympics. In India, Delhi alone had roughly 10,000 CNG buses on the road by 2006 (Ealey & Gross, 2008).

[7] Estimates based on fleet numbers in (DOT, 2007).

The United States was an early leader of CNG transit bus technology development (Watt, 2001) and continues to have strength in the technology, even though several gas-rich developing countries are stepping up their own CNG transit bus production (U.S. Commercial Service, 2008). The U.S. firm Allison has partnered with Hyundai and Daewoo Bus to develop CNG engines in Korea, and with Tata in India. Over 500 CNG buses with Allison transmissions are on the road in Seoul, and in Delhi, there are over 650 Allison-equipped CNG buses (International Organization for Public Transport, 2009).

In the United States, diesel-electric hybrid buses are rapidly overtaking CNG as the primary green bus option. In 2007, 686 additional diesel-electric hybrid transit buses were made available in the United States, a 57% increase over the previous year. This marked the first time that any alternative surpassed the number of CNG buses made available in a given year (see Table 11). Unlike CNG buses, diesel electric hybrids do not require new fuel supply infrastructure, one reason transit authorities are moving toward hybrids. Gasoline electric hybrids and ethanol vehicles, available in other applications, are not available in the U.S. transit market (EIA, 2007).

Table 11. Alternative Transit Buses Made Available, and Total U.S. Fleets, 2003 - 2007

Transit Buses Made Available	2003	2004	2005	2006	2007	Total Fleet Number in 2007
Total*	**1,200**	**1,487**	**1,465**	**1,524**	**1,564**	**23,578**
Compressed Natural Gas (CNG)	799	955	952	791	646	15,890
Electric*	176	0	1	188	188	784
Hydrogen	0	4	13	1	24	45
Liquefied Natural Gas (LNG)	44	39	43	8	5	1,562
Liquefied Petroleum Gas (LPG)	181	71	68	99	15	5,296
Diesel-Electric Hybrid**	0	418	311	437	686	NA

*Total includes shuttle buses and trolley replicas. **Beginning in 2004, diesel-electric hybrids are not grouped under the Electric fuel category because the input fuel is diesel. *Source:* CGGC, based on (EIA, 2007).

Although European firms are rapidly catching up, the United States is the global leader in hybrid transit bus manufacture (Mercedes-Benz, 2009) and so far has the largest markets, including New York City Transit, the world's largest hybrid transit bus fleet (Daimler, 2008b). Now operating 303 low-floor hybrid electric buses, the agency plans in its upcoming budget to expand this number to 520 (Metropolitan Transportation Authority, 2009). Orion, a North Carolina-based subsidiary of Daimler, estimates it has 60% of the U.S. transit hybrid bus market (Daimler, 2008b). Orion has delivered more than 1,700 hybrid buses in the U.S. and Canada, and 1,100 are on order (Daimler, 2009). New Flyer Industries Inc. received 1,253 buses orders from December 2007 to February 2008, and 248 of these orders are hybrids (Green Car Congress, 2008).

Several manufacturers in Europe, Japan, China and Australia also make hybrid transit buses. In Japan, Mitsubishi Fuso, Isuzu, Hino Motors and Nissan Diesel now produce hybrid transit buses (Mitsubishi Fuso, 2009). In China, Dongfeng Motor Corporation (DFM), the FAW Group Corporation, and Xiamen King Long (Golden Dragon) are hybrid bus makers (Green Car Congress, 2006a) with Xiamen King Long planning to sell 50 all-electric and 860 hybrid vehicles to Beijing Public Transport by the end of 2009 (Automotive News, 2009). In Europe, hybrid transit buses are not prevalent (Daimler, 2008a), perhaps because of a greater focus on CNG buses and clean diesel. On November 2008, hybrid buses produced by Britain's Alexander Dennis Limited (ADL) entered London transit market (BAE Systems, 2008).

U.S firms have excelled in developing advanced hybrid propulsion systems for transit buses and have potential to sell these systems globally. Indeed, the United States recently began exporting hybrid propulsion systems to Europe, Japan and Australia. Allison Transmission, for example, exports hybrid propulsion systems to transit bus OEMs including Solaris (Poland), Optare (UK), APTS Phileas (Netherlands) (TheAutoChannel, 2009) and Volgren-Iveco (Australia) (Free Press Release, 2009). BAE Systems now supplies hybrid propulsion systems to Isuzu (Japan) and ADL (UK) (BAE Systems, 2008). Since hybrid transit buses are a new and growing phenomenon in Europe, Japan and Australia, such exports appear likely to increase in the future.

Jobs in the Bus Manufacturing Value Chain

Investments in public transit generate valuable employment, especially in quality skilled and semi-skilled blue collar jobs. A recent study concluded that the current mix of federal transit spending—71% for operations and 29% for capital spending—produces a blended average of 36,108 jobs for every billion dollars of pubic investment (Economic Development Research Group, 2009a). This translates into an estimated 23,788 jobs per billion dollars of capital spending and 41,140 jobs per billion dollars of operations spending (see **Table 12**). Previous research comparing spending on public transit versus highways found that transit created nearly 19% more jobs than new road or bridge projects. Many of these transit jobs were high-quality, long-term positions, not the short-term employment associated with road building (Surface Transportation Policy Project, 2004). In addition, public transit serves an important *job access* function providing transport to work sites for millions of U.S. households that do not own a car.

Table 12. U.S. Jobs Generated per Billion Dollars of Spending on Public Transit*

Jobs per Billion Dollars of Spending	Capital Spending	Operations Spending	Blended Average Spending
Direct Effect: manufacturing, construction, operations jobs	8,202	21,227	17,450
Indirect Effect: jobs at suppliers of parts and services	7,875	2,934	4,367
Induced Effect: Jobs supported by workers re-spending their wages	7,711	16,979	14,291
Total Jobs	**23,788**	**41,140**	**36,108**

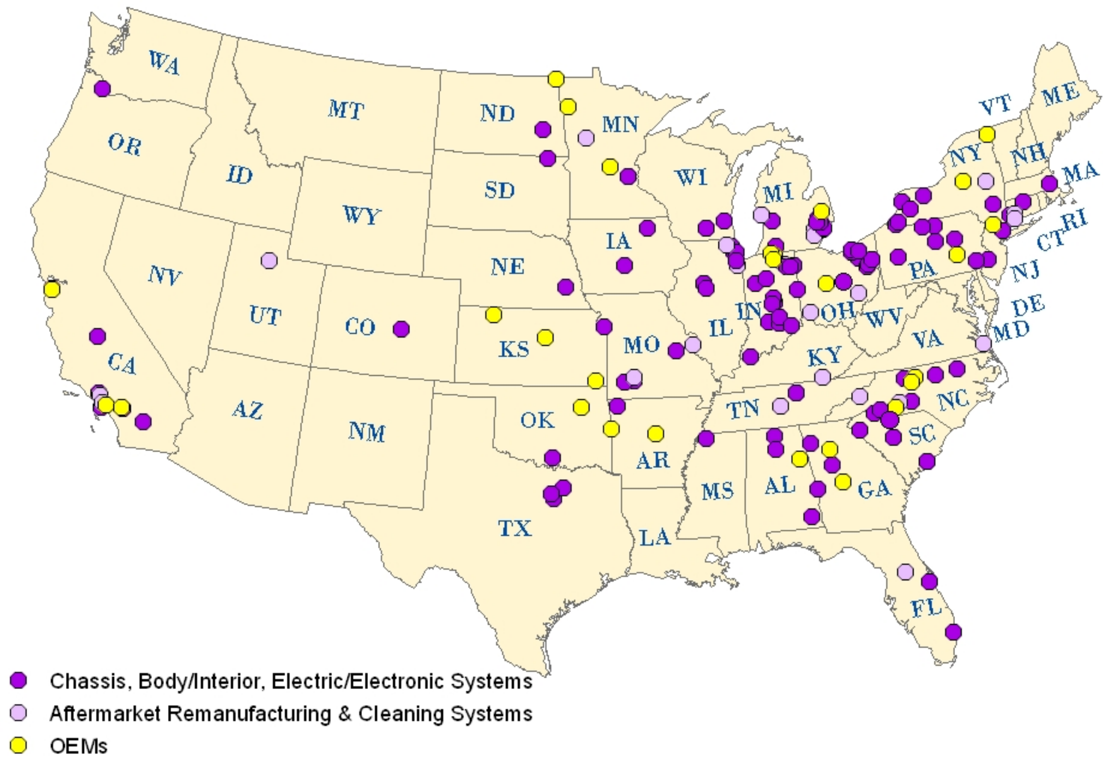
*According to national spending mix in 2007. Note: Capital spending includes vehicles and facilities. Operations include operating and maintaining bus and rail systems. *Source:* (Economic Development Research Group, 2009b)

This value chain study focuses on additional employment: jobs in the manufacturing segment of the transit bus industry, a category that, to date, has been less thoroughly studied or quantified. Since transit buses are a subset of the medium- and heavy-duty vehicle industry, which is dominated by heavy trucks, it is challenging to separate out employment that is only relevant to buses. In addition, where job estimates are available, they often refer to jobs in final assembly and manufacture of engines and transmissions and do not take into account the rest of the manufacturing value chain.

It is possible, however, to make useful job estimates based on general rules of thumb in the industry. For example, the leading transit bus OEMs employ approximately one employee per finished transit bus, in a U.S. market estimated by the FTA's National Transit Database at 5,000 to 5,500 buses annually. The bus value chain consists of supplied components, however, such that a multiplier can be applied in order to approximate total employment. According to industry interviews, a multiplier of 5 to 6 appears to be appropriate for the bus industry, higher than the multiplier of 4 often used for the motor vehicle industry as a whole. Applying the bus multiplier, total employment in the bus industry is likely to amount to 25,000 to 33,000 jobs. Many of these jobs do not entail work exclusively on bus components but include overlap with other segments of the motor vehicle industry.

The geographic distribution of selected U.S. manufacturing locations for transit buses and components is shown in Figure 5. These jobs are located in nearly every state in the eastern United States, with the highest concentrations in Indiana, Michigan, Ohio and Pennsylvania. Several OEMs and firms involved in tires, windows, lighting and aftermarket are found in California. North Carolina and South Carolina each have a number of relevant manufacturing locations in nearly all segments of the value chain, including major firms such as Daimler Buses North America (Orion), Freightliner Custom Chassis, Cummins, and Michelin.

Figure 5. Selected U.S. Manufacturing Locations for Transit Buses and Components



Note: Selected locations only; not exhaustive.
Source: CGGC, based on Tables 6-11 above, company websites and industry interviews.

Industry interviews suggest that in the absence of a major transportation policy change that includes significant, sustained funding for public transit vehicles, relevant firms in the bus industry are not expecting to increase employment significantly in the coming years. Domestic demand is heavily dependent on the availability of public funding for bus transit, an inherent constraint that is naturally worsened by the current economic recession. Lead firms anticipate adding small increments in employment commensurate with increases in bus orders that are anticipated as transit fleets replace aging vehicles.

It is likely that the fast-growing market for green buses, especially electric hybrids, will mainly help OEMs keep the workforce they already have, perhaps creating a modest increase in jobs. Since the transit bus industry is inherently not oriented toward exports, with buses mainly produced in the country where they are sold—or at least in countries at similar levels of economic development—U.S. exports of buses will likely continue to stay within the North American market. Within key components, however, fast-growing orders for hybrid buses do appear to create potential for U.S. firms to export hybrid propulsion systems for buses, which could have a positive effect on employment.

Conclusion

The total number of jobs in domestic manufacture of transit buses is relatively small, at 25,000 to 33,000 jobs, many overlapping with the heavy truck industry. Yet the value of this employment extends well beyond job numbers in several ways. First, many of these jobs are in Midwestern states deeply affected by the recession, where manufacturing employment and capacity, especially in the motor vehicle industry, are crucial for maintaining a leadership position throughout the recovery period and beyond. Second, the bus industry's shared skills and capacities with the heavy truck industry and other automotive segments help the motor vehicle industry as a whole maintain a diverse supplier base and wide range of competencies. Third, the bus industry provides an important entry point for innovations in automotive technologies, especially in new vehicles that require refueling infrastructure and other major changes. For instance, transit agencies constitute a well-defined base of centrally managed fleets, ideal for testing and proving plug-in hybrid and all-electric buses—thus leading the way for the passenger car industry. For these reasons, employment in the transit bus manufacturing industry is an important benefit of investment in public transit.

References Cited

APTA. (2003). Transit Resource Guide. Retrieved August 11, 2009, from http://www.apta.com/research/info/briefings/briefing_5.cfm.

--- (2008). 2008 Public Transportation Vehicle Database. Retrieved May 2008, from http://www.apta.com/research/stats/

--- (2009). 2009 Public Transportation Fact Book APTA. Retrieved August 27, 2009, from http://www.apta.com/research/stats/documents09/2009_apta_fact_book_with_outer_covers.pdf

BAE Systems (2008). BAE Systems, Isuzu to Introduce Clean-Air Hybrid Buses for Japan. Retrieved August 27, 2009, from http://www.baesystems.com/Newsroom/NewsReleases/2008/autoGen_10896171427.html

Barnitt, Robb A. (2008). In-Use Performance Comparison of Hybrid Electric, CNG, and Diesel Buses at New York City Transit. NREL. Retrieved August 27, 2009, from http://www.nrel.gov/vehiclesandfuels/fleettest/pdfs/42534.pdf

Bell, John. (2009). *Chief of Technical Services, Federal Transit Administration*. Personal communication with CGGC research staff. August 11, 2009.

CALSTART (2009). HICE Buses in Europe. Retrieved August 13, 2009, from http://www.calstart.org/Projects/Low-Carbon-Bus-Program/Publications/Low-Carbon-Bus-Program-Newsletter/HICE-Buses-in-Europe.aspx

Chicago Transit Authority. (2009). Facts at a Glance. Retrieved July 29, 2009, from http://www.transitchicago.com/about/facts.aspx.

Cooper, Michael. (2009). States Cut Back and Layoffs Hit Even Recipients of Stimulus Aid. *New York Times*. September 5, 2009. Retrieved September 6, 2009, from http://www.nytimes.com/2009/09/05/business/economy/05stcloud.html?_r=2&th=&emc=th&pagewanted=print.

Cummins (2005). Business Week Highlights Cummins Business in China and India. Retrieved August 27, 2009, from http://www.cummins.com/cmi/content.jsp?dataId=2311&anchorId=453&menuIndex=none&feed=1&siteId=1&overviewId=15&menuId=4&langId=1033&

--- (2007). Cummins Receives Bus Engine Orders from China Transit Agencies. Retrieved August 23, 2009, from http://www.cummins.com/cmi/content.jsp?dataId=2800&anchorId=1474&menuIndex=none&feed=1&siteId=1&overviewId=15&menuId=4&langId=1033&

Daimler (2008a). Mercedes-Benz Hybrid Bus Receives the 2008 DEKRA Environmental Prize. Retrieved August 23, 2009, from http://www.daimler.com/dccom/0-5-7153-1-1043883-1-0-0-0-0-0-8-7145-0-0-0-0-0-0-1.html

--- (2008b). Orion VII Hybrid Product Overview. Retrieved August 23, 2009, from http://www.orionbus.com/Projects/c2c/channel/files/270346_Orion_Hybrid_Transit_Presentation_Q2_2008.pdf

--- (2009). Daimler Trucks Sells 500th Hybrid Truck from Mitsubishi Fuso in Japan. Retrieved August 23, 2009, from http://media.daimler.com/dcmedia/0-921-614216-1-1186482-1-0-0-0-0-0-11700-0-0-1-0-0-0-0-0.html

Discoveries and Breakthroughs Inside Science (DBIS) (2007). Engineer Designs more Efficient, Quieter Bus. Retrieved August 17, 2009, from http://www.aip.org/dbis/stories/2007/17082.html

DOE (2000). Natural Gas Buses: Separating Myth from Fact. EERE. Retrieved August 7, 2009, from http://www.nrel.gov/docs/fy00osti/28377.pdf

--- (2009a). Alternative and Advanced Vehicles. EERE. Retrieved August 24, 2009, from http://www.afdc.energy.gov/afdc/vehicles/plugin_hybrids.html

--- (2009b). Alternative Fueling Stations. EERE. Retrieved September 4, 2009, from http://www.afdc.energy.gov/afdc/fuels/stations.html

--- (2009c). Natural Gas Distribution. EERE. Retrieved September 4, 2009, from http://www.afdc.energy.gov/afdc/fuels/natural_gas_distribution.html

DOT (2007). Fuel Cell Bus Life Cycle Cost Model: Base Case and Future Scenario Analysis. Retrieved August 23, 2009, from http://hydrogen.dot.gov/projects_across_dot/publications/fuel_cell_bus_life_cycle_cost_model/report/pdf/entire.pdf

Ealey, Lance A. and Andrew C. Gross. (2008). "The Global Market for Buses, 2000-2010". *Business Economics* (April 2008): 69-76.

Economic Development Research Group, Inc. (2009a). White Paper: Job Impacts of Spending on Public Transportation: An Update. Retrieved August 23, 2009, from http://www.apta.com/research/info/online/jobs_impact.cfm#_Toc223405553

---. (2009b). White Paper: Job Impacts of Spending on Public Transportation: An Update. Prepared for the American Public Transportation Association: Washington, DC.

Edwards, Tommy. (2009). *Director of Maintenance, Sunline Transit Agency*. Personal communication with CGGC research staff. August 18, 2009.

EIA (2007). Alternatives to Traditional Transportation Fuels 2007. Retrieved August 21, 2009, from http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html#supplied

EPA. (2009). Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel. Retrieved August 21, 2009 from http://www.epa.gov/OMS/climate/420f05001.htm.

Eudy, Leslie and Matthew Gifford. (2003). Challenges and Experiences with Electric Propulsion Transit Buses in the United States (Technical Report No. DOE/GO-102003-1791).

Firestone Industrial Products (2009). History of Innovation. Retrieved August 11, 2009, from http://www.firestoneindustrial.com/history/2000.shtml.

First Research (2009). Truck and Bus Manufacturing. Retrieved August 21, 2009, from http://www.firstresearch.com/Industry-Research/Truck-and-Bus-Manufacturing.html

Fisher Coachworks (2009). Fisher Coachworks Engages AVL. Retrieved August 17, 2009, from http://www.fishercoachworks.com/news.htm

Free Press Release (2009). GM-Allison Hybrid System Supplied to New Volgren-Iveco Bus. Retrieved August 21, 2009, from http://www.free-press-release.com/news/200907/1246974502.html

Freedonia Group (2008). World Buses to 2012. 2366. Retrieved August 21, 2009, from http://www.freedoniagroup.com/DocumentDetails.aspx?ReferrerId=FG-01&studyid=2366

FTA. (2007). Useful Life of Transit Buses and Vans (No. Report No. FTA VA-26-7229-07.1): Federal Transit Administration pp. 199.

Goldman, Joshua. (2009). *Marketing and Sales at Proterra*. Personal communication with CGGC research staff. July 16, 2009.

Green Car Congress (2006a). More Hybrids to Enter Chinese Market at Year's End. Retrieved August 21, 2009, from http://www.greencarcongress.com/2006/02/more_hybrids_to.html

--- (2006b). Tata Motors and ATFCAN in CNG Bus Demo for New Delhi. Retrieved August 21, 2009, from http://www.greencarcongress.com/2006/03/tata_motors_and.html

--- (2008). New Flyer Receives 1,253 Bus Orders; 248 Hybrids. Retrieved August 21, 2009, from http://www.greencarcongress.com/2008/03/new-flyer-recei.html

--- (2009). Testing finds Proterra Electric Transit Bus Achieves more than 20 mpg Diesel Equivalent. Retrieved July 27, 2009, from <http://www.greencarcongress.com/2009/05/proterra-20090505.html>

International Organization for Public Transport (2009). Allison Transmission Maintains Leadership of the Global Bus and Coach Market and Achieves Record Hybrid Sales. Retrieved August 21, 2009, from http://www.uitp.org/vienna2009/exhibition/pr/Allison%20global%20buses_ENG%2004-06-091.pdf

K. Chandler and L. Eudy (2007). Hydrogen Powered Transit Buses: Evaluation Results Update. NREL. Retrieved August 21, 2009, from http://www.nrel.gov/hydrogen/pdfs/42080.pdf

L. Eudy, K. Chandler and C. Gikakis (2008). Fuel Cell Buses in US Transit Fleets: Current Status 2008. NREL. Retrieved August 21, 2009, from http://www.nrel.gov/hydrogen/pdfs/tp44133.pdf

Mercedes-Benz (2009). Citaro G BlueTec Bus in Operation. March 30, 2009. Retrieved August 31, 2009, from http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/bus/home/buses_world/update/news_2009/Citaro_G_BlueTec_Hybrid.html

Metropolitan Transportation Authority. (2009). MTA 2010 Preliminary Budget: July Financial Plan 2010-2013. Retrieved August 31, 2009: http://www.mta.info/mta/budget/july2009.htm.

Mitsubishi Fuso (2009). Mitsubishi Fuso to Display Hybrid Bus at Eco Car World 2009 in Japan. Retrieved August 21, 2009, from http://www.mitsubishi-fuso.com/en/press/090604/090604.html

New Flyer Industries Inc (2009). Annual Information Form. Retrieved March 30, 2009, from http://www.newflyer.com/index/cms-filesystem-action?file=investor_relations/financial%20reports/2009_aif_final.pdf
Silver, Fred. (2009). *Vice President, CALSTART*. Personal communication with CGGC research staff. August 21, 2009.
Surface Transportation Policy Project (2004). Setting the Record Straight: Transit, Fixing Roads and Bridges Offer Greatest Job Gains. Retrieved July 17, 2009, from http://www.transact.org/library/decoder/jobs_decoder.pdf
TheAutoChannel (2009). Allison Transmission Achieves Record Hybrid Sales. Retrieved August 21, 2009, from http://www.theautochannel.com/news/2009/04/27/458354.html
Thor Industries (2008a). Annual Report. Retrieved August 21, 2009, from http://www.thorindustries.com/corporate/annualreport/Thor2008AnnualReport.pdf
--- (2008b). Investor Presentation. Retrieved August 21, 2009, from http://www.thorindustries.com/corporate/InvestorPresentation.pdf
U.S. Commercial Service. (2008). Pakistan. Retrieved July 30, 2009, from www.buyusa.gov/auto/pakistan.pdf.
Volvo Group (2008). Annual Report. 62, from http://www3.volvo.com/investors/finrep/ar08/annual_report_2008_eng.pdf
Watt, Glen M. (2001). Natural Gas Vehicle Transit Bus Fleets: The Current International Experience. Retrieved August 18, 2009, from http://www.cleanairnet.org/infopool/1411/articles-35682_naturalbus_watt.pdf
Wolf, John. (2009). *ArvinMeritor Bus and Coach Sales Manager*. Personal communication with CGGC Research Staff. July 23, 2009.