



Waste Collection 101

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**Environmental Research
& Education Foundation**

Lighting a path to sustainable waste management practices

Course Outline

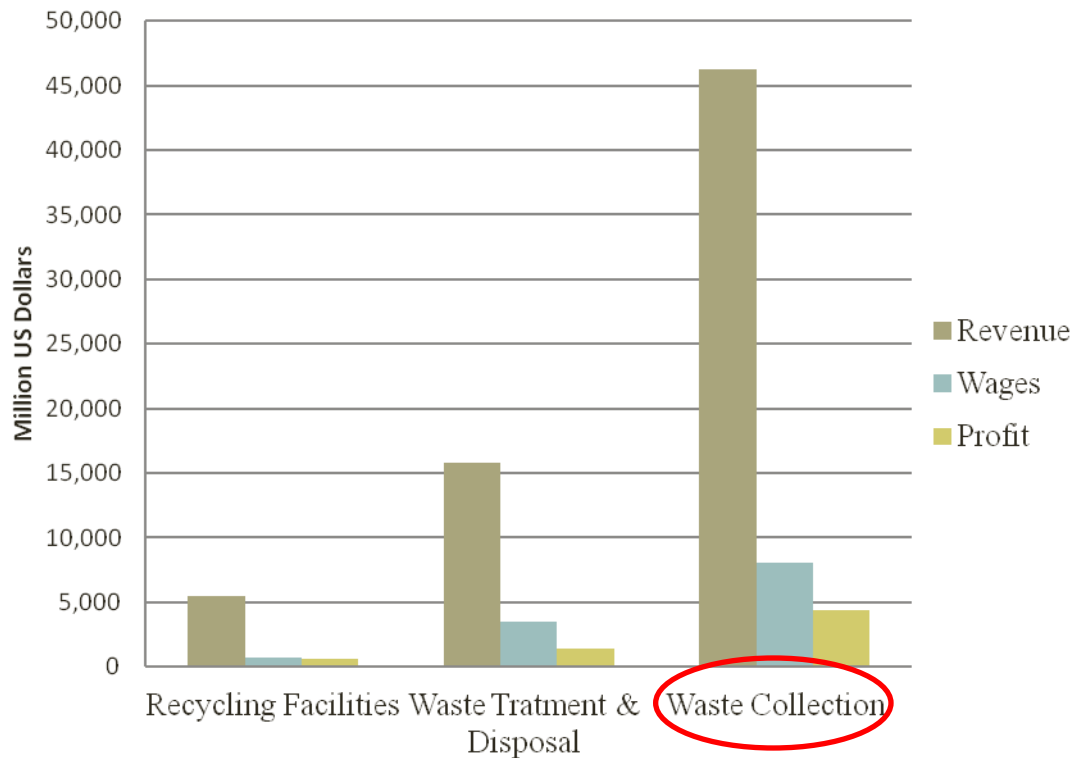
- Introduction
- History of Waste Collection Vehicles
- Solid Waste Collection Vehicles
- Waste Collection Management Issues
- Ergonomics of Solid Waste Collection
- Environmental Impacts of Solid Waste Collection

Course Objectives

- Understand problems and concerns associated with MSW collection
- Understand the types of collection systems and vehicles used
- Compare and contrast privately and publicly operated systems
- Understand the important issues involved in optimizing waste collection
- Appreciate the recent trends in collection technology

U.S. Collection Industry

Waste Management Services



Wages (US Dollars)



Profit (US Dollars)



Source: IBISWORLD, 2012

History of Waste Collection in the U.S.

1800's



Two-wheeled carts
drawn by horses

Late 1920's



First covered-body,
motorized truck

1950's



Rear Loader

1970's



Side Loader

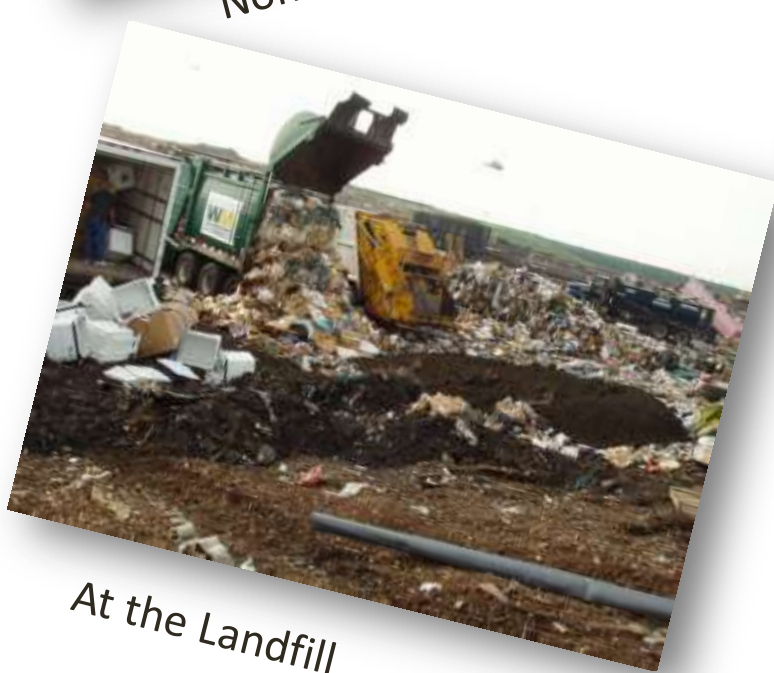
Source: Refuse Trucks Photo
Archive by John B. Montville



Non-Collection Drive Time



Waste Collection



At the Landfill



At the Transfer Station

Types of Solid Waste Collection



Types of Collection Vehicles – Location of Loading

- Front loader
- Rear loader
- Side loader
- Special (e.g. vacuum)
- Roll off

Waste Collection Trucks – Rear Loader



- Residential waste collection
- Typically 11 – 31 yd³
- \$110 – 140K
- Life ~ 10 years
- Can be fully or semi- automated
- Sweep and slide blade compactor
- Compacts as moving – reduces volume by half

Waste Collection Trucks – Side Loader



- Residential waste collection
- 6 – 28 yd³
- Accommodates automated collection
- \$115K – 140K, with automated up to \$250K



Automation of Rear and Side Loading Collection Vehicles



Manual

- Accommodates non-street container storage
- Trucks have longer lives, cheaper to operate
- Works better in urban areas with on-street parking, low hanging wires, narrow streets

Semi or fully Automated

- Reduced crew size from 2 or 3 to 1
- Reduced injury to crews, fewer Workers Comp claims, lower turnover
- Upfront (2x) and maintenance costs (5x) greater
- Requires public education
- Accommodates large carts (60-90 gal)
- Carts usually provided by hauler
- Increases participation in recycling
- Economic and logistical data gathering easier
- Resistance by public agencies to reducing work force prevents adoption



Waste Collection Trucks – Front Loader



- Commercial waste collection
- 30 – 40 yd³
- \$115K – 140K
- Accommodates dumpster boxes
- Packer blade to compact waste
- Compacts as truck moves

Source: <http://www.westchestercountywaste.com/commercial-services/trash-collection>

Other Commercial Waste Collection Vehicles



Source: <http://www.asa-group.com/en/A-S-A-Group/Technologies/Collection-and-Transport.asa>

Roll Off Container

Magna-Hoist™ Tilt Frame



McClain E-Z Pack



Vacuum Collection



- Suction force at nozzle
- Underground waste storage unit
- Loose green waste



Pneumatic Vacuum Waste Collection System



Underground Containers and Collection Piping

http://www.waste-management-world.com/index/display/article-display.articles.waste-management-world.collection-transport.2012.10.Pneumatic_Vacuum_Waste_Collection_System_for_Ouen__France.QP129867.dcmp=rss.page=1.html



COLLECTION OF RECYCLABLES

Recyclables Collection Programs



Single Stream (Commingled)

- Rapidly increasing trend
- Collection of mixed MSW with sorting at Materials Recovery Facility at increased cost over multi-stream
- Main disadvantages: broken glass, contaminated cardboard and paper recyclables, reduced quality control at curb
- Automated collection possible (if roll-out carts provided)
- Increased participation observed
- Expanded collection of material types
- More convenient for customers and haulers
- Vehicles have multiple uses

Dual or Multi Stream

- Collection of separated recyclables and MSW (dual stream)
- Hand sorting of recyclables at Materials Recovery Facility
- Hand sorting at point of collection (multi-compartment trucks)
- Curbside collection costs are \$15/ton more than single-stream

Residential Recyclables Collection Trucks



**Split Body Rear Loader
(Dual Stream)**



Curb Sorting

Recyclables Collection Program Challenges



- Low public participation rates
- Customer sorting (vs. commingled) is not convenient
- Size of collection containers can limit recycling
- Unlimited garbage collection (e.g. second day) leads to lower recycling rates



WASTE COLLECTION MANAGEMENT ISSUES

Public vs. Private Collection



Public Collection

- Municipality owns and operates all equipment
- Municipality manages personnel
- Funded from property tax, user fees, or utility bill
- Disadvantages
 - ✓ Municipalities tend to be less efficient than private companies
 - ✓ Capital expenditures can be difficult
 - ✓ May require passage of bond
 - ✓ Tendency to minimize short-term spending without considering long-term implications
- Advantages
 - ✓ Non-profit
 - ✓ Centralized operation
 - ✓ Municipality maintains complete control over waste

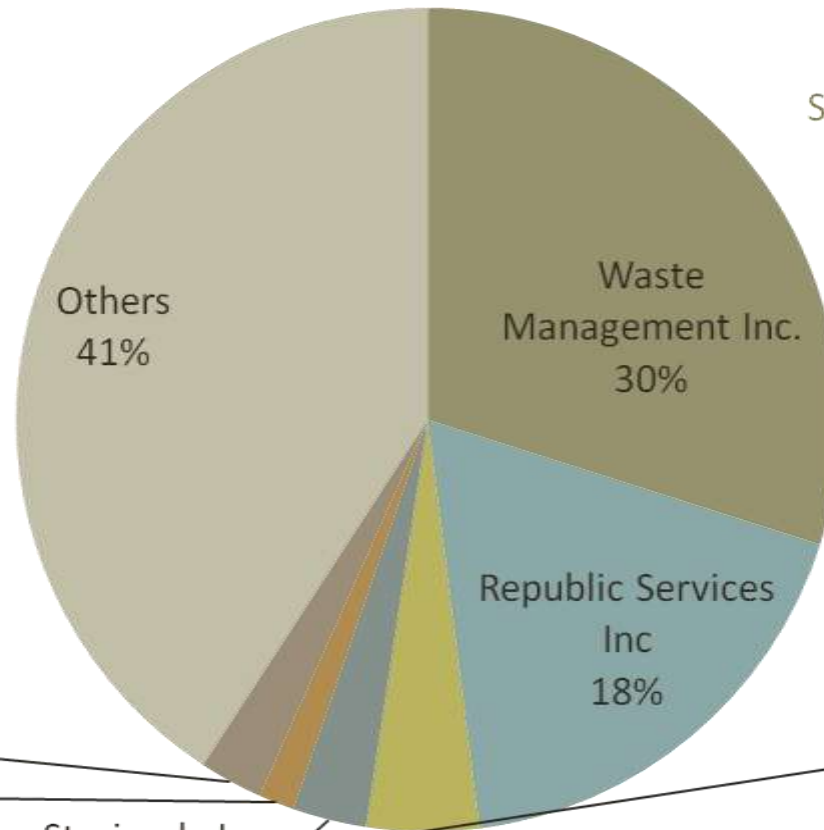
Private Collection

- Non-exclusive vs. exclusive franchise
- Advantages
 - ✓ No capital expenditure for city
 - ✓ Long-term lower costs
 - ✓ Impose order on collection (exclusive franchise)
 - ✓ Regular pickup schedules (exclusive franchise)
 - ✓ Trash cans/trucks on street one or two days per week (exclusive franchise)
 - ✓ Lower costs due to improved routing and technology (exclusive franchise)
- Disadvantages
 - ✓ Difficulty to compete with large haulers leads to domination by a few haulers (exclusive franchise)
 - ✓ Citizens provide a profit to waste hauler
 - ✓ Requires oversight by city



Major Companies

Source: IBISWORLD, 2012



Veolia
Environmental
Services North
America
Corporation
4%

Labor Challenges

- Labor intensive
- Labor unskilled
- High turn-over rates
- Injuries and poor working conditions
- Limited career opportunities

Routing Optimization

- Minimize labor, fuel, tire costs
- Minimize unnecessary mileage and overtime
- Maximize customer service
- Maximize crew accountability
- Maximize accuracy of pricing
- Accommodate additional of customers and expanding route
- Maximize balance of routes and level workloads
- Avoid trucks backing up
- Avoid multiple trips up and down street
- Accommodate alternative container access (alley, rear of house)

Ergonomics of Solid Waste Collection

Risks during Waste Collection



According to U.S. Labor Department waste collection is the fourth most dangerous job behind fishing workers (highest fatality rate), logging workers and aircraft pilots/flight engineers.

Injuries are due to:

- ✓ Falls off trucks
- ✓ Hit by cars
- ✓ Inappropriate wastes (e.g. needles, hazardous wastes)
- ✓ Lifting improperly



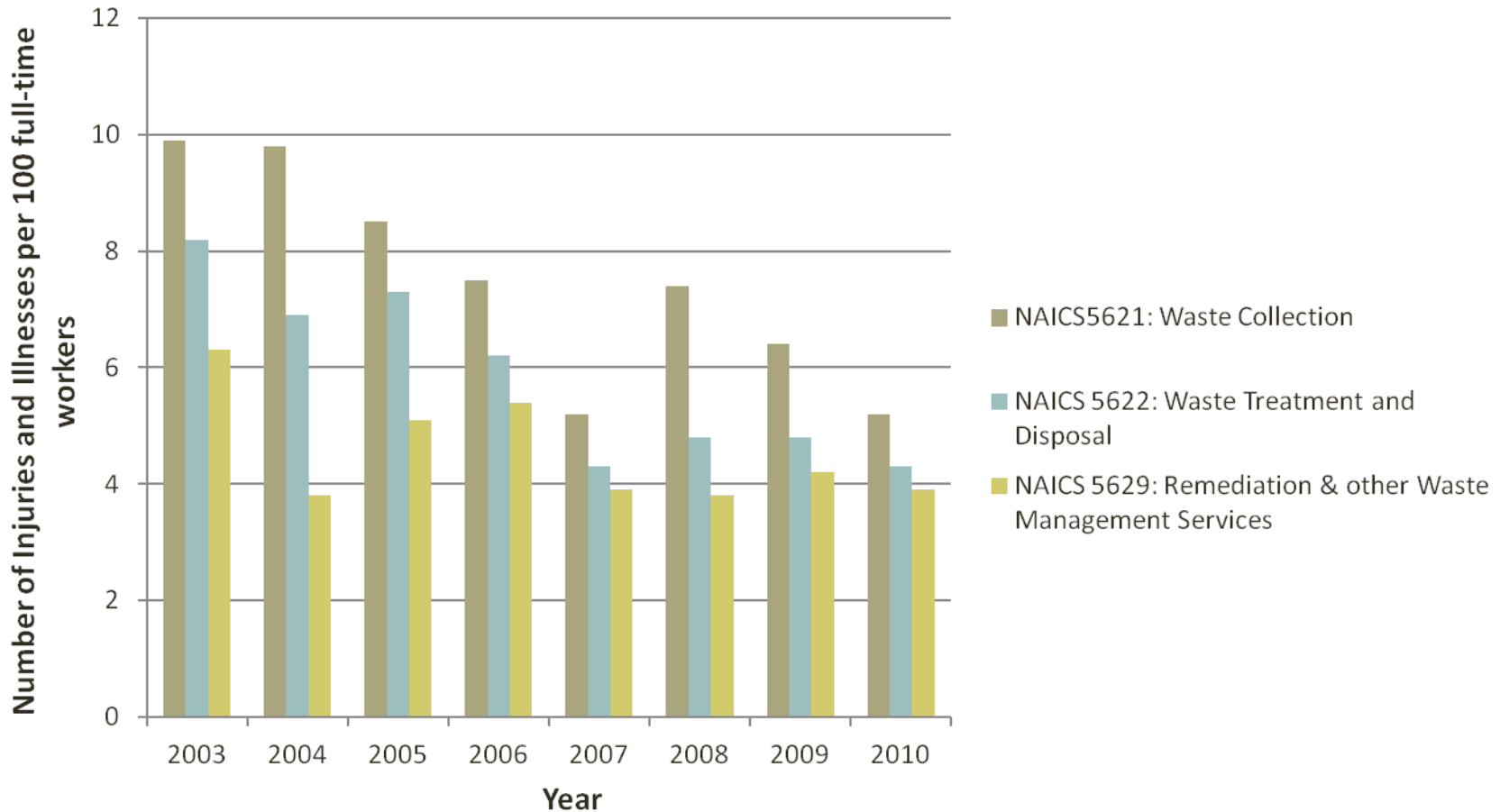
Ergonomics Definition

Ergonomics is the science of designing jobs, equipment and workplaces to fit workers. Proper ergonomic design is necessary to prevent repetitive strain injuries, which can develop over time and can lead to long-term disability.

Statistical Analysis of Bureau of Labor Statistics (BLS) Data

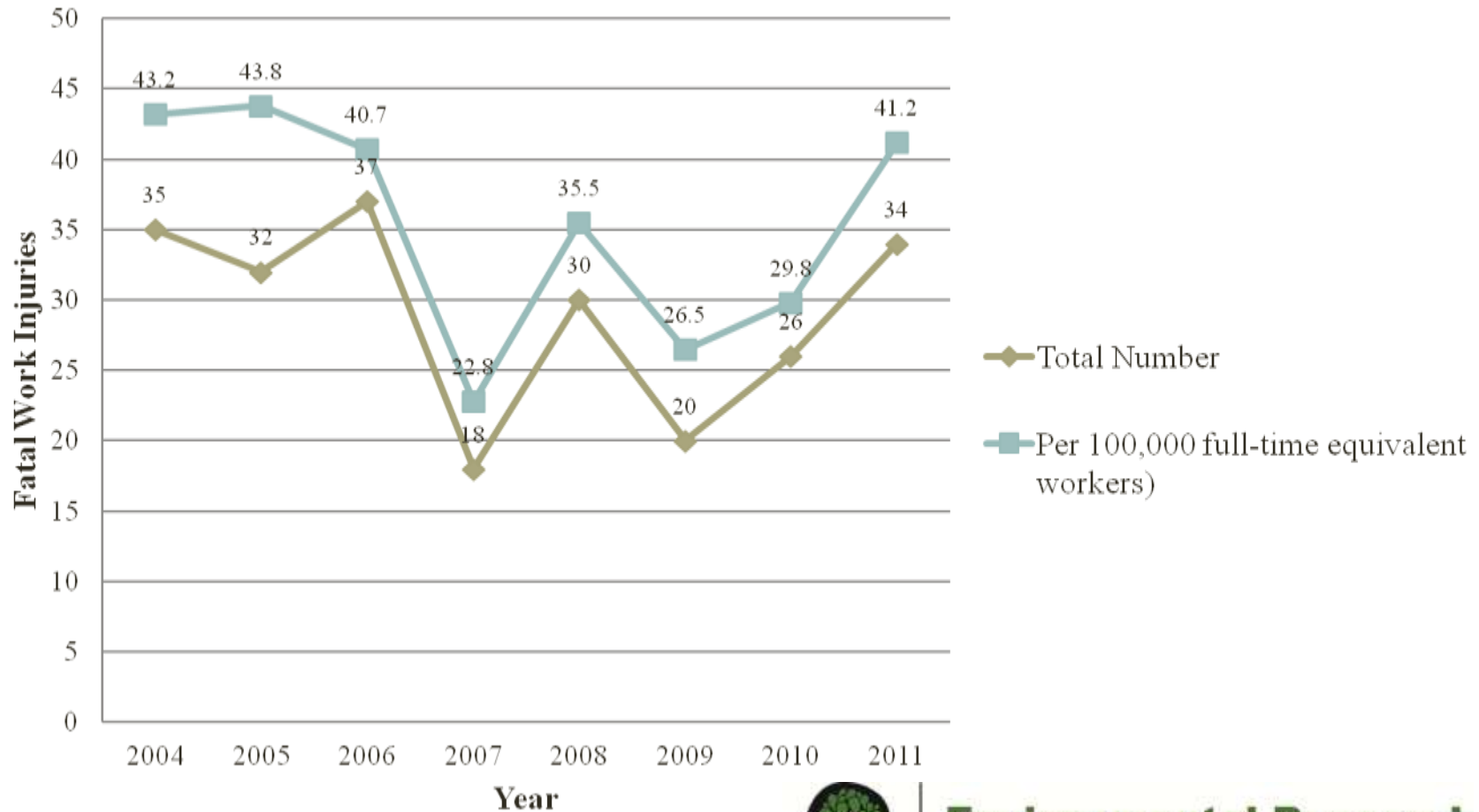


Rate of Non-fatal Injuries in the Waste Management Industry

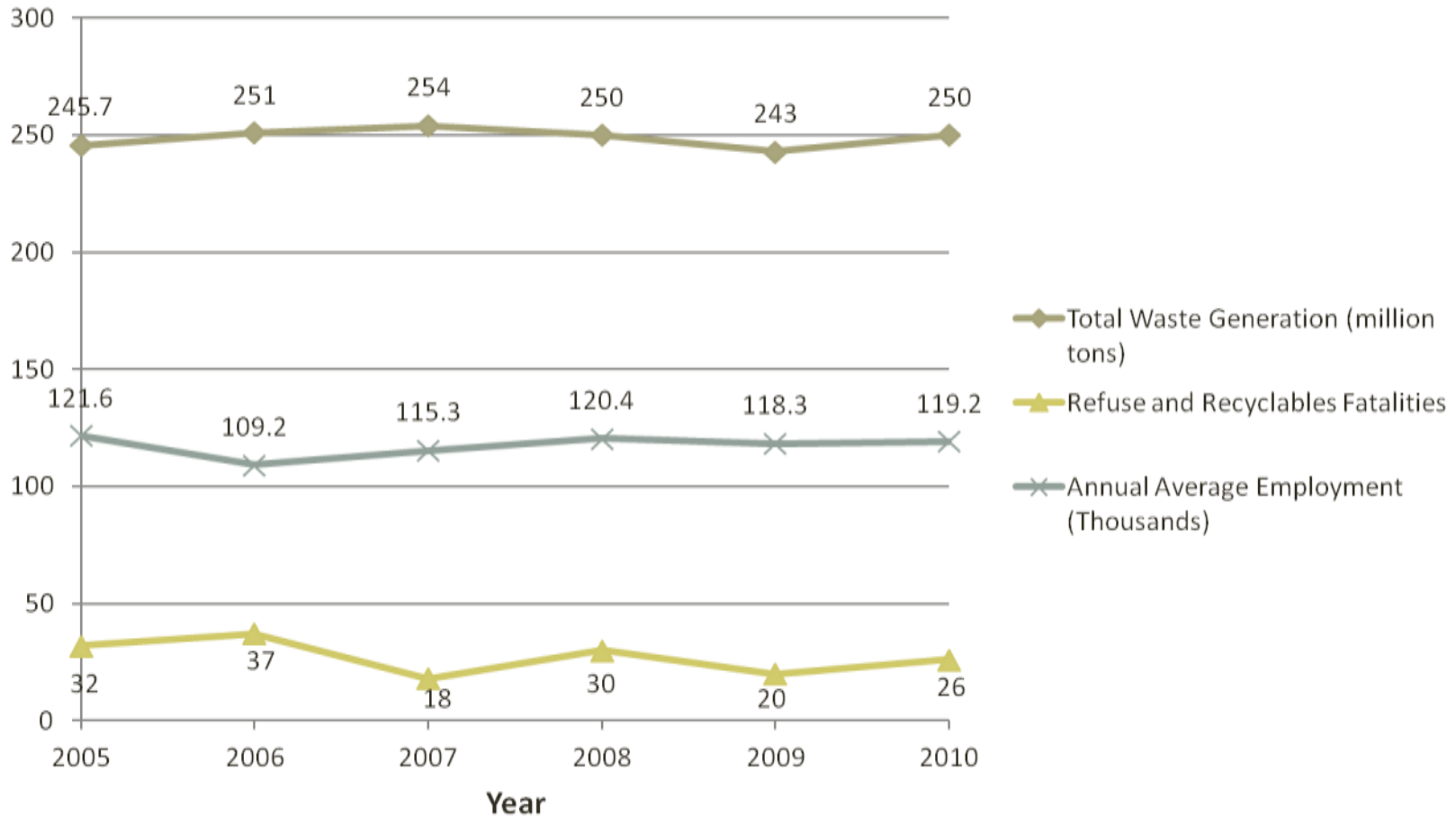


BLS Data – Fatal Injuries

Refuse and Recyclable Material Collectors

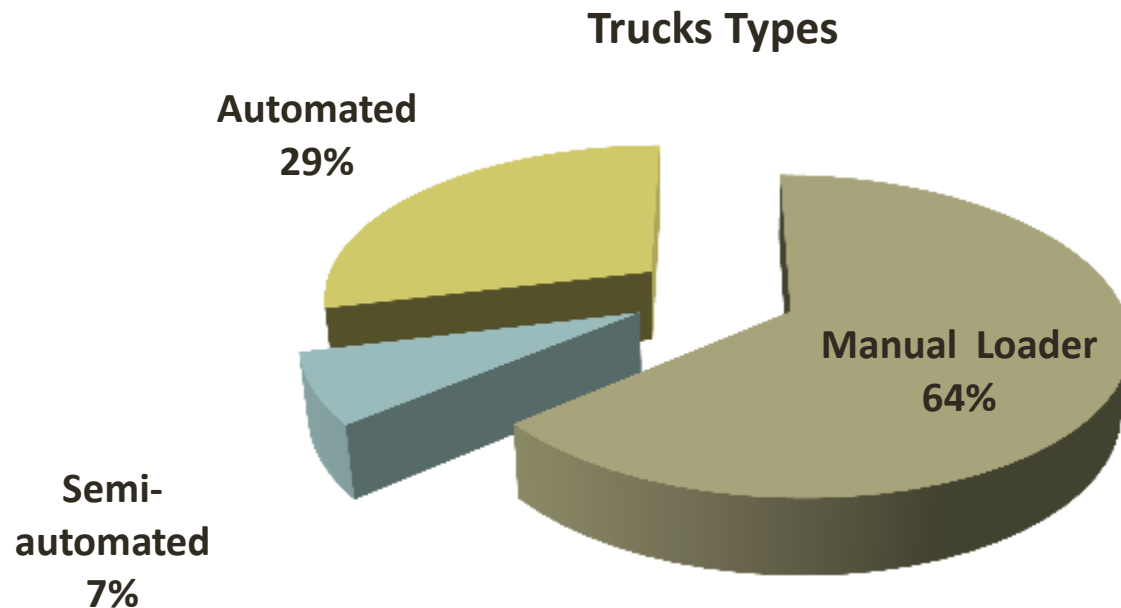


Trends of Waste Fatalities, Employment and Waste Amount



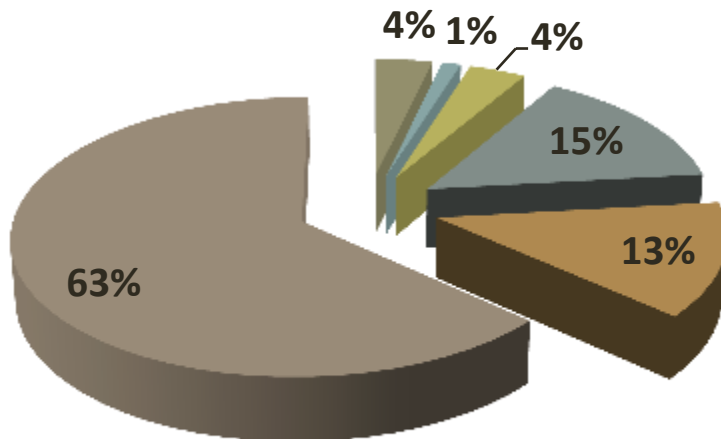
Survey Results

- Two survey forms were distributed to solid waste collectors and safety personnel at three waste companies.
- 63 waste collectors were surveyed, 27% of them reported that they had not experienced pain or injuries.

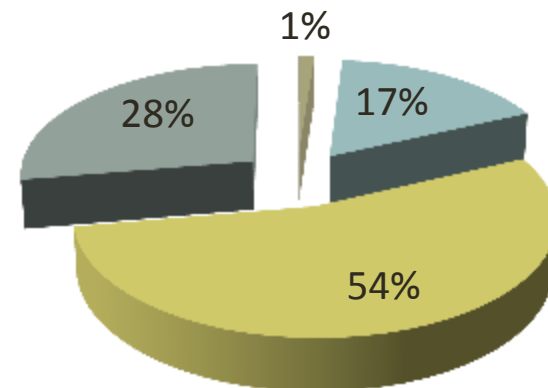
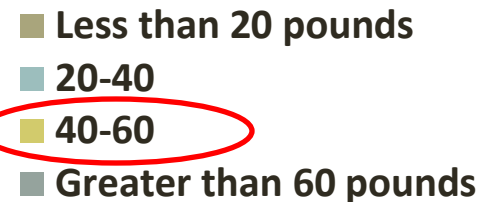


Survey Results-Cont'd

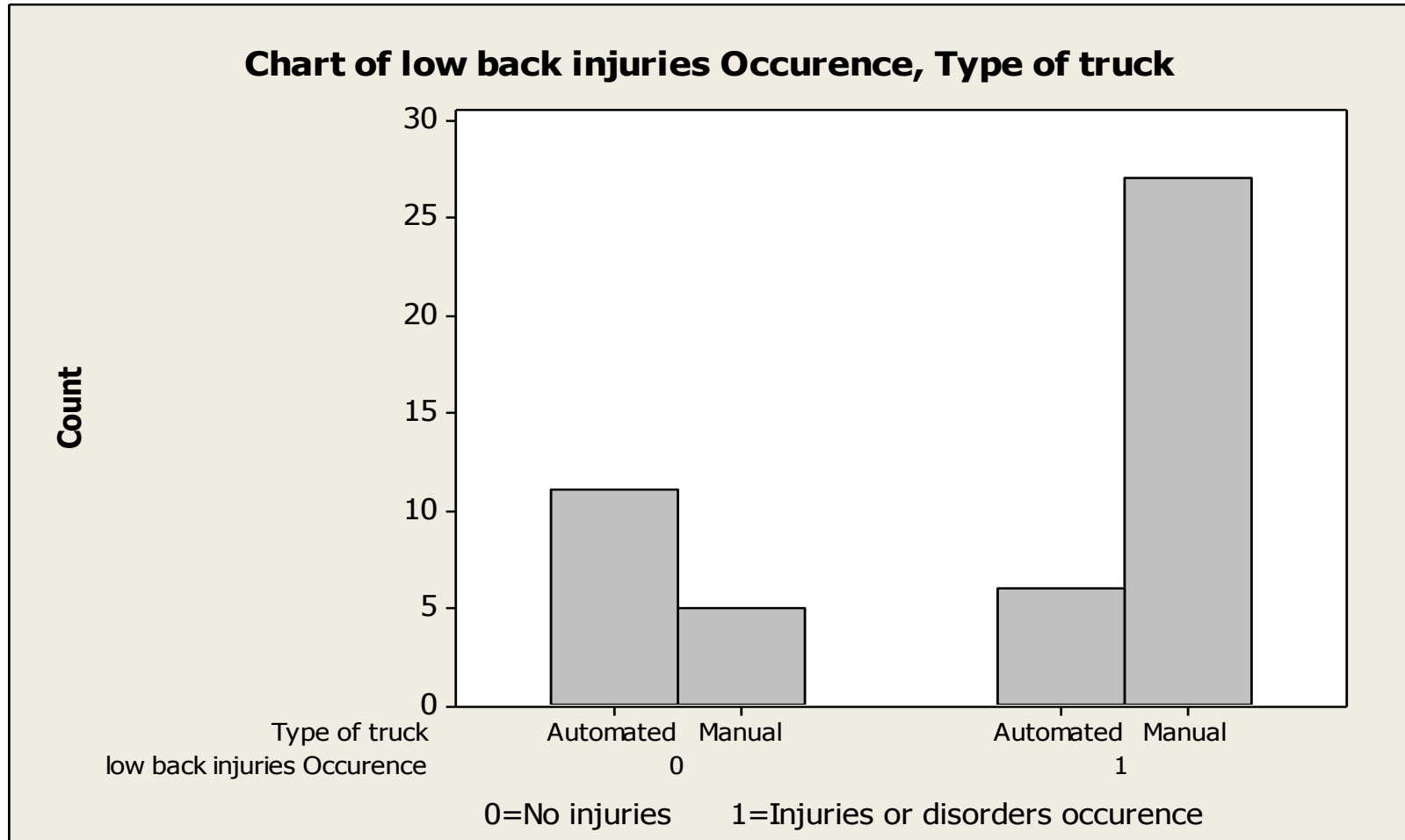
Number of stops collected on average route day



Estimated Average Container Weight



Disorders and Injuries



Observational Analysis of Waste Collectors



WISHA Check list Results : Manual Collection Tasks

Body Zone	Overall Evaluation		
	None	Caution	Hazard
Low Back			X
Hands and Wrists			X
Neck and Shoulder			X
Knee			X

WISHA Check list Results : Semi-Automated Collection Tasks

Body Zone	Overall Evaluation		
	None	Caution	Hazard
Low Back	X		
Hands and Wrists		X	
Neck and Shoulder	X		
Knee	X		



Ergonomic Conclusions and Recommendations



- Waste collectors of manual waste vehicles are at risk for musculoskeletal disorders more than the waste collectors of automated and semi-automated vehicles due to excessive load and the awkward postures during lifting and dumping garbage containers.
- Pulling and pushing waste containers cause less compression forces on the lower back which don't exceed the acceptable NIOSH limits.
- Periodic surveillance for waste collectors should be conducted to detect early signs of occupational disorders.
- Safety training programs should be held on regular basis for waste collectors to ensure following the proper techniques in handling and lifting waste containers.

Environmental Impacts of Solid Waste Collection

Emission Regulations

The 2007 USEPA regulations introduced stringent emission standards for waste collection vehicles:

Pollutant	Emission Standard
Particular Matter (PM)	0.01 grams per brake horsepower-hour (g/bhp·hr)
Nitrogen Oxides (NO _x)	0.2 g/bhp·hr
Nonmethane Hydrocarbons (NMHC)	0.14 g/bhp·hr

Emission Regulations (Cont'd)



- By June 1, 2006, all refineries were mandated by the U.S. EPA to produce 15 ppm Sulfur diesel fuel.
- The need for catalytic diesel particulate filters and NO_x catalysts to meet the 2007 emissions necessitated the use of ultra-low sulfur diesel fuel.
- According to the U.S. EPA, the use of low-sulfur fuel increased the fuel cost between 4.5 to 5 cents per gallon.
- The use of catalytic filters, ironically, increases the weight of the vehicles.
- According to the U.S. EPA, the 2007 standards increased the vehicle costs between \$1,200 to \$1,900.



Today's Waste Collection in the U.S.



- Today, approximately 91% of the U.S. collection fleet is diesel-fueled, with fuel efficiency averaging 3 miles per gallon.
- Only 1% of the U.S. collection fleet is currently using alternative fuels.



CAUTION
DIESEL FUEL ONLY

Challenges



- Rising fuel prices and greater environmental regulations issued by the U.S. EPA and individual states.
- Reduce emissions to the atmosphere, reduce cost, and at the same time increase collection efficiency and equipment optimization.



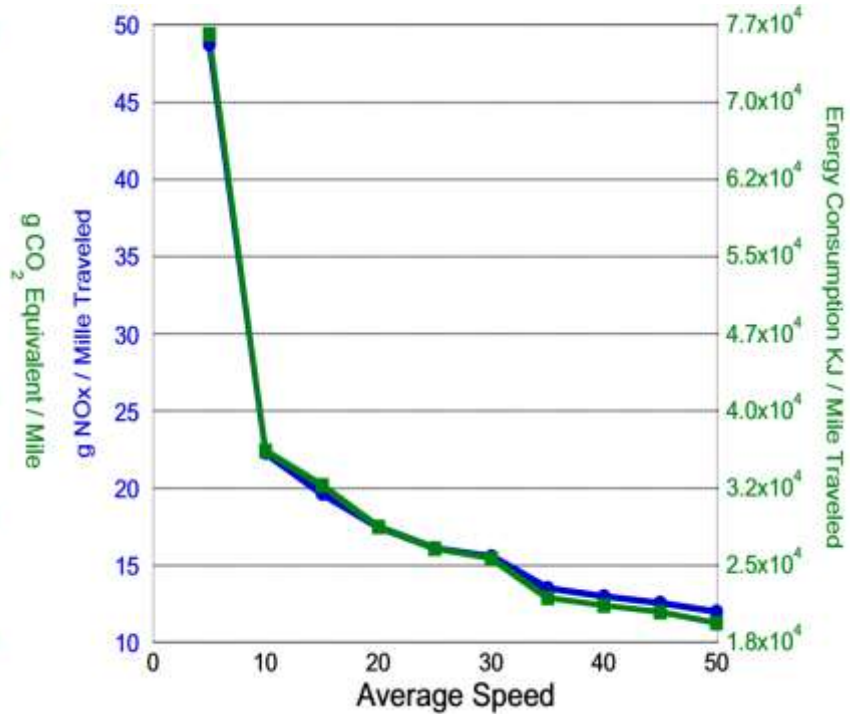
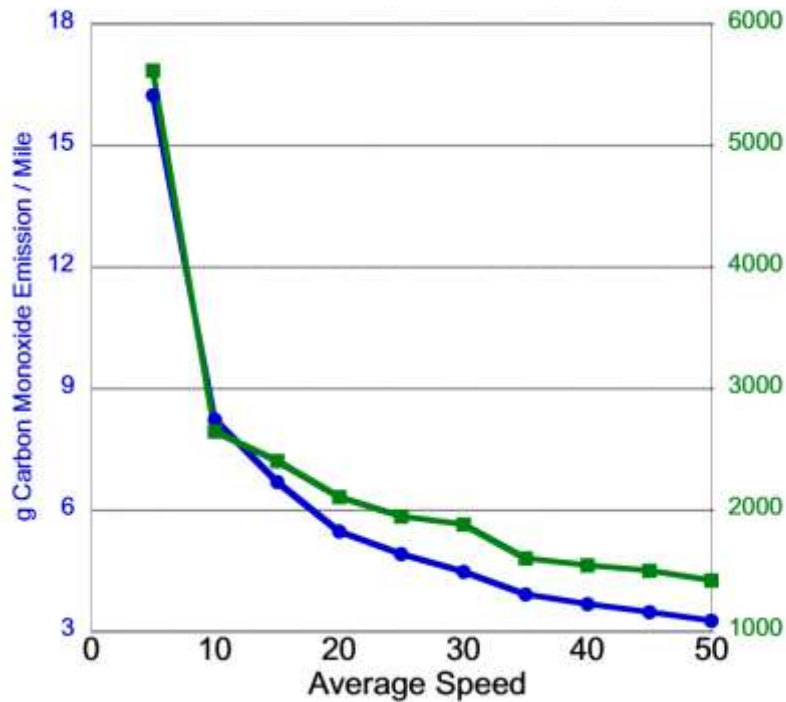
Waste Collection Switch to Natural Gas in 2012



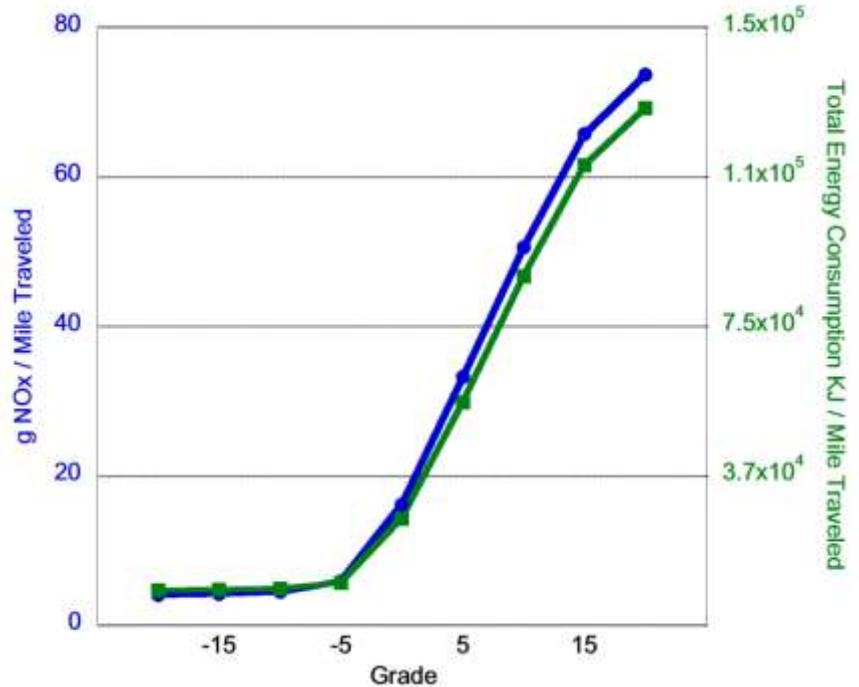
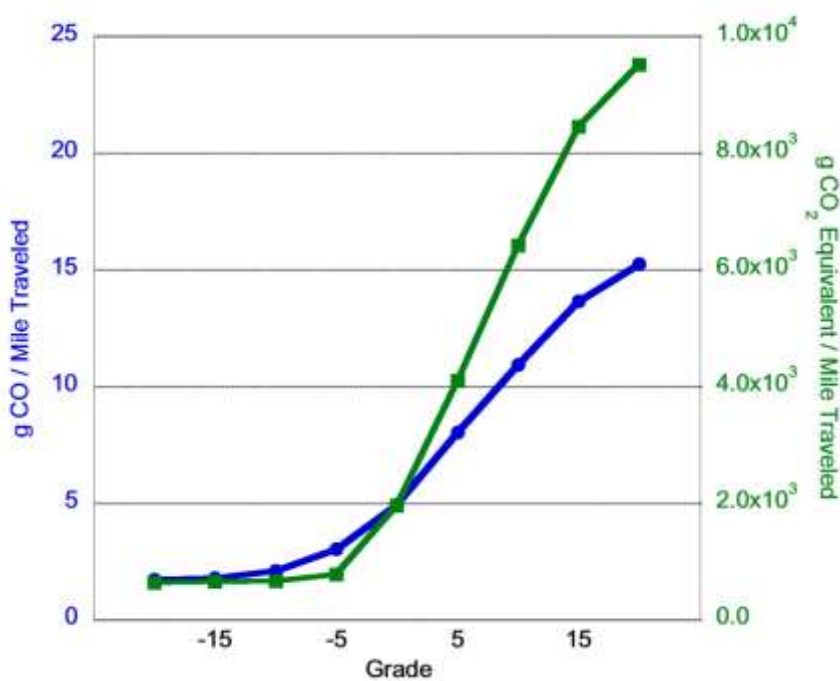
- Waste Management Inc. operates the largest natural gas fleet in North America with nearly **1,700 CNG and LNG** vehicles.
- In the next five years, WM plans to make **80%** of the annual new truck purchases fueled by natural gas.
- WM added **13 CNG fueling stations** in the first-half of 2012, which brings their total to **31** fueling stations. WM plans to construct another **17** stations by the end of 2012 (WM, 2012).
- Republic Services currently operates more than **1,000** alternative-fueled vehicles, and plans to add another **3,100** vehicles by the end of 2015 (Republic Services, 2012).
- Waste collection and transfer vehicles currently account for **11 percent of the total U.S. natural gas vehicles** (NGVAAMERICA, 2012).



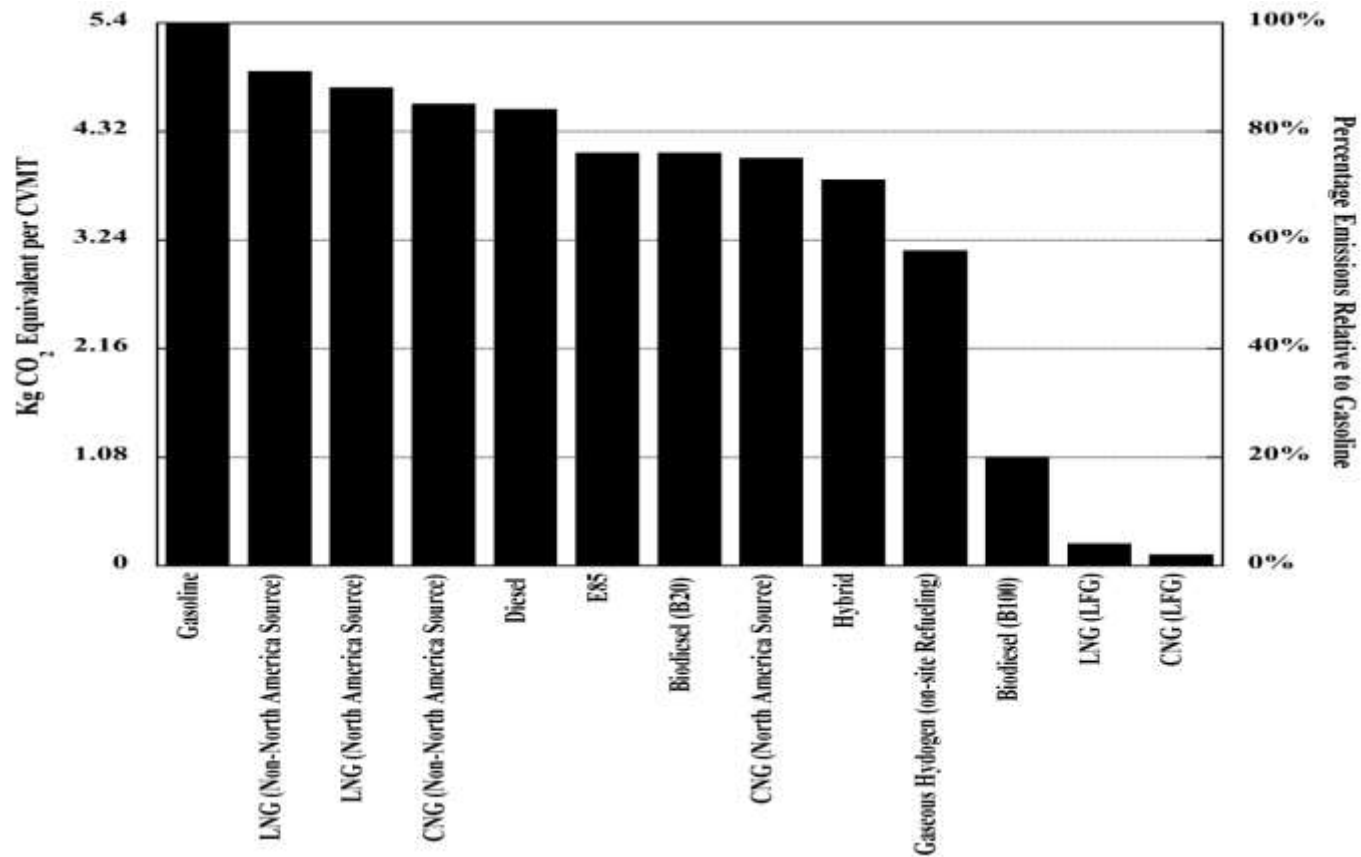
Diesel Emissions per Collection Vehicle Mile Traveled



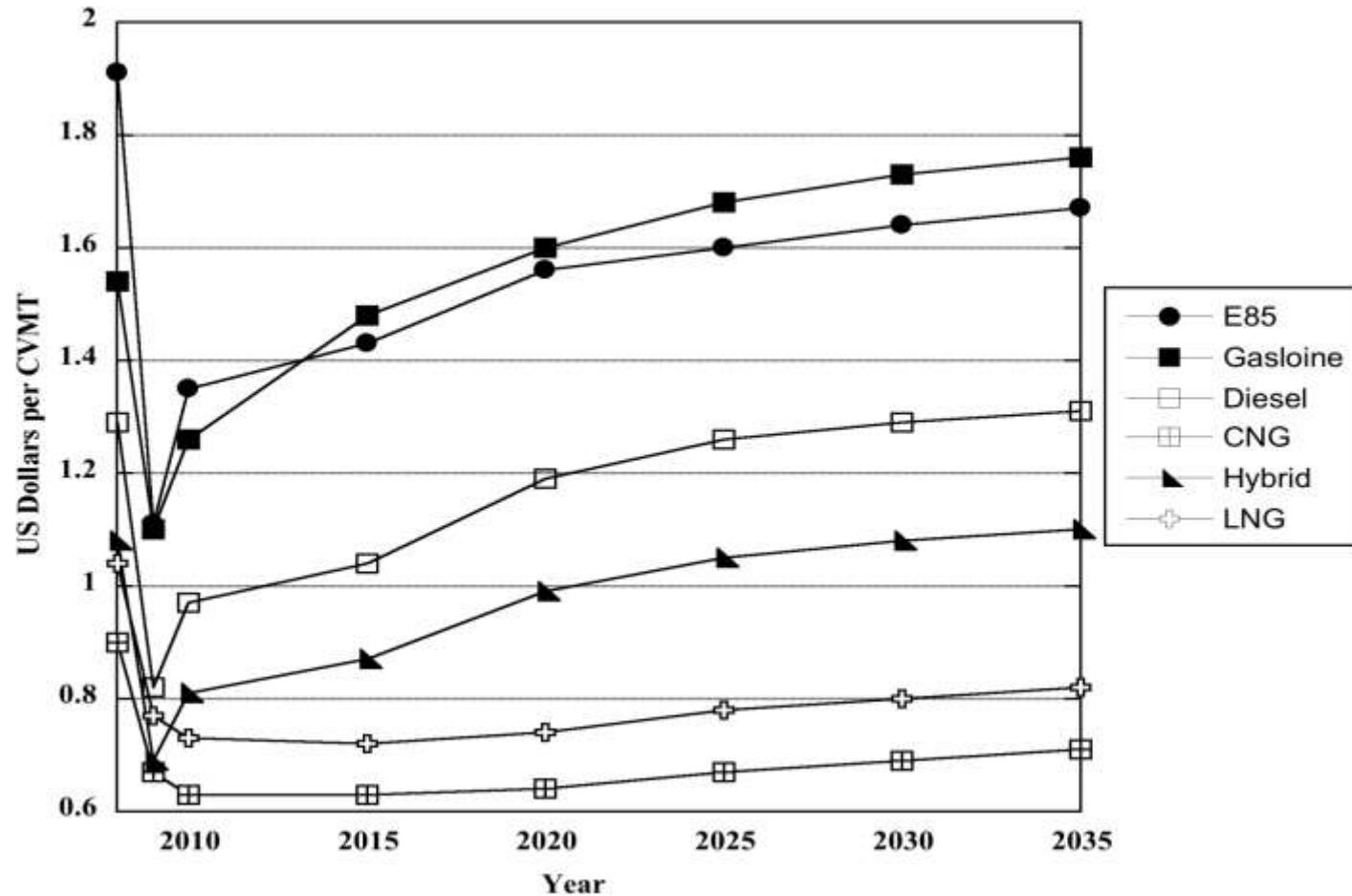
Diesel Emissions per CVMT as Function of Road Grade



Alternative Fuels Life-cycle Emissions



Cost Trend for Collection per Vehicle Mile Traveled (CVMT)



Environmental Issues



CNG

- Lower Air Toxicity Compared to Diesel
- Lower Water Consumption Compared to Oil Refining

Hybrid

- 30% Lower Fuel Consumption and Emissions than Diesel

Hydrogen

- Onboard Fuel Cell Allows Fuel Saving as well as Reduced Emissions

Biogenic Fuels

- Lower Life-cycle Emissions than any other fuel source

Security Issues



Growing Gap Between Local Consumption and Production

Petroleum Fuels

Growing Gap Between Global New Oil Discoveries and Oil Production Rate

The Recoverable Natural Gas in the USA would provides supplies for 100 years

Natural Gas

Reducing the US Energy Security Risk

Produced Domestically

Biogenic Fuels

Reducing the US Energy Security Risk

Landfill Gas (LFG) is a Sustainable Source of Natural Gas

The main Sources of Hydrogen are Natural Gas, Coal, LFG and water

Hydrogen

All Available in the US

Reducing the US Energy Security Risk



Operational Issues – Fuel Tank Size



Four Times Diesel Tank

Twice Diesel Tank

CNG

LNG

Diesel



Financial Issues



Advantages

- Low Capital Cost
- Low Infrastructure Cost

Disadvantages

- Imported Fuel
- Fuel Price Stability

Diesel

Advantages

- CNG Vehicles cost only 15-25% more than diesel
- Diesel Engine Can be Replaced by CNG easily
- Lowest Fuel Travel Cost
- Constant Fuel Price over the Next Three Decades

Disadvantages

- High Infrastructure Cost

CNG

Advantages

- Saves 30% on Fuel Consumption

Disadvantages

- Hybrid Vehicles Cost \$100,000 more than Diesel

Hybrid

Disadvantages

- New Infrastructure for Production, Transport and Fueling Stations.

Hydrogen



Safety Issues

Diesel

High Noise
Level

High Ignition
Energy

Toxic to
Humans and
Wildlife

Hydrogen

Extremely Low
Ignition Energy

Non-toxic in
Water Unless it
Displaces
Oxygen

CNG

Lower Noise
Level

Higher Ignition
Energy than
Petroleum Fuels

Non-toxic in
Water Unless it
Displaces
Oxygen

Fuel Analysis Summary



CNG waste collection vehicles have the lowest fuel cost compared to all the other fuel categories.

The CNG fuel cost is relatively constant over the next three decades.

The use of CNG waste collection vehicles has potential reduction in air pollution as well as noise levels.

Diesel-fueled waste collection vehicles can be easily changed to CNG.

The main drawback about CNG is the high infrastructure cost.

CNG

LFG is considered to be the best available alternative for waste collection vehicles based on life-cycle emissions.

The cost of LFG for waste collection vehicles ranges between \$5 and 8 per MBtu depending on the season and the weather. This makes LFG less expensive than natural gas which has a projected price range \$11.97-17.20 per MBtu over the next three decades.

LFG is a sustainable source of natural gas.

LFG



Fuel Analysis Summary (Cont'd)



Hybrid	The use of hybrid waste collection reduces the fuel consumption by 30%, as well as reducing emissions
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Hydrogen	The use of hydrogen as a fuel reduces the life-cycle emissions as well as air pollutant. However, it is in the research and development phase
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Biogenic fuels	Biogenic Fuels (LFG, Biodiesel) have the lowest life-cycle emissions
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Petroleum fuels	Petroleum Fuels have the highest life-cycle emissions
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Transfer Stations

Benefits

- Large trailers replace many collection vehicles
- Get collection vehicles back to work rapidly
- Locate disposal site far from population areas
- Opportunity to inspect waste
- Opportunity to process waste
- Use multiple disposal sites



Need

- Justified when cost to transport waste from generation point to disposal site is greater than cost to transport from generation point to transfer station plus haul to the disposal site
- Presence of illegal dumps and litter
- Remote disposal sites
- Small capacity collection vehicles
- Low density residential areas

Examples of New Trends in Waste Collection



- On board software (fleet tracking, weight of collected waste)
- RFID on carts/containers (improves customer services, more accurate billing, monitors hauler activity, track waste generation/recycling rates)
- Drive Camera – analyzes driving behavior (e.g., smooth driving, idling, speeding)
- Advanced Engine Models –Hydraulic Launch Assist (capable of capturing and storing energy during braking which can be used to initiate the next acceleration of the vehicle)
- Advanced Transmission Designs –Operate In Gear At Idle (OIGAI); lowers operating RPMs and therefore reduces operating noise and fuel usage
- Use of Alternative Fuels Technologies



Questions?

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