The Clean Side of Garbage
A Technical Paper on Emission Reductions with Hydraulic Hybrid Drive Systems

Data Behind the Gases
While the research exploring the resources needed to support the earth’s growing population is well-documented, the statistics detailing our impact on the planet are often overlooked. Today, human activity accounts for the release of over 30 billion tons of carbon dioxide (CO2) into the atmosphere each year. While this greenhouse gas is naturally present at low levels, the additional CO2 discharged by humans is altering the earth’s carbon cycle, causing imbalance throughout the natural circulation of carbon among the atmosphere, oceans, soil, plants and animals. (1)

Of all the human activities responsible for CO2 emissions, the greatest source is the combustion of fossil fuels such as coal, natural gas and oil. While the majority of these emissions are released in the process of generating electricity to power homes, businesses and industry, roughly 31% of CO2 emissions (and 26% of total greenhouse gas emissions) in the U.S. are tied to the combustion of fuels such as gasoline and diesel to transport people and goods. (2)

In the United States, CO2 emissions increased by about 10% between 1990 and 2011 and due to the rise in the number of vehicles needed to support an expanding population and economy, transportation emissions contributed significantly to this increase. The most effective way to counter this alarming trend is to reduce fossil fuel consumption, and one substantial first step would be to increase the efficiency of our heavy-duty transportation industry. (3)

Choosing a Starting Point
In the effort to reduce the amount of fuel consumed and emissions generated by the fleet of heavy-duty trucks supporting our population, refuse collection vehicles present an opportunity to make a significant impact. A typical refuse truck travels 25,000 miles each year, and since a conventional truck achieves 2-4 mpg, each consumes roughly 8,600 gallons of fuel each year. At this rate, our nation’s fleet of 120,000 refuse trucks in service collectively burns through more than 1 billion gallons of fuel each year. (4)

Reducing the fuel consumption of heavy-duty vehicles presents a significant challenge for manufacturers, particularly considering the already efficient and reliable engines they utilize. In recent years manufacturers have invested significantly in optimizing the performance of their engines, and the high costs of additional refinements would not be justified by the marginal reduction in fuel consumption they would yield.

Strategies to Reduce Environmental Impact
Many established and emerging technologies are available to help modernize existing fleets to reduce fuel consumption and emissions. The installation of exhaust after treatment devices, anti-idling upgrades and changes in operating strategies enable fleet managers to minimize the environmental impact of their operations. Transitioning from gasoline or diesel to clean fuels such as compressed natural gas (CNG) or propane can also help to reduce emissions, but this strategy presents unique challenges relating to vehicle maintenance and refueling infrastructure. Regardless of fuel source, every vehicle produces CO2 emissions during the combustion process, so the ultimate goal should be to improve vehicle efficiency and reduce overall fuel consumption to minimize environmental impact.

In order for trucking fleets to fully understand and properly assess the feasibility of all the options available to reduce fuel consumption and emissions, they must consider the use of an alternative drivetrain technology.
The Basics of Hydraulic Hybrid Technology

Parker’s RunWise® Advanced Series Hybrid Drive technology improves vehicle efficiency by:

a) **Capturing brake energy.** The brake energy recovery system converts the vehicle’s kinetic energy into stored energy by compressing nitrogen gas in a storage device called an accumulator. This stored energy is then released during acceleration to reduce the energy required from the engine to propel the vehicle.

b) **Decoupling the engine from the wheels.** Through the series drivetrain architecture, the engine can be operated at speeds independent of vehicle speed. As a result, the engine always operates at the ideal spot for any power level demanded by the vehicle operator, which can be a limitation of a conventional transmission.

By reducing energy demand, RunWise reduces fuel consumption, regardless of fuel source, by 35 to 50 percent, depending on route density and operating conditions.

A truck equipped with RunWise can consume 4,300 gallons less fuel per year than a truck utilizing a standard transmission. This equates to an average annual reduction in CO₂ emissions of 48 tons per year, equivalent to removing 10 midsized cars from the road or planting 1,100 trees and letting them grow for 10 years.

In addition to reducing fuel consumption and emissions, this brake energy recovery technology lengthens the brake replacement cycle to one or two brake jobs throughout the life of the truck (depending on duty cycle), dramatically reducing maintenance costs as well as the disbursement of brake dust into the atmosphere.

Fuel Savings

RunWise saves fuel two ways. First, by decoupling the engine from the wheels at speeds under 45 mph, this allows the engine to operate at its peak efficiency. Second, by recovering brake energy to reducing the total fuel consumption of the vehicle. Combined, these features reduce fuel consumption by to 35-50%.

On average, a refuse truck burns 8,600 gallons of diesel per year. You can imagine the savings RunWise can make on your bottom dollar!

Typical Route Comparison: RunWise® vs. Conventional Truck

RunWise positive brake energy recovery saves energy at each stop to use for the next.

GREEN = Energy recovery

RED = Loss of energy

The conventional truck is unable to capture brake energy therefore using more energy moving to each stop.
The Ohio State University Emissions Testing

To explore the potential for reducing the fuel consumption and emissions of heavy-duty trucks using hydraulic hybrid technology, The Ohio State University College of Engineering’s Center for Automotive Research conducted emissions testing on CNG, conventional diesel, diesel hybrid and CNG hybrid refuse trucks equipped with the RunWise technology.

The evaluations were designed to compare fuel economy and emissions, and were conducted in three separate cycles:

- Low speed based on a rear-loading refuse truck serving a densely populated neighborhood (below 20 mph)
- High speed based on a rear-loading truck traveling from a route to a transfer station (above 20 mph)
- Standard speed from a West Virginia University study (a special route cycle developed to compare performance)

The testing was carried out between December 2012 and September 2013 to determine the fuel economy, carbon dioxide (CO$_2$) emissions, hydrocarbon emissions (THC), carbon monoxide (CO) and oxides of nitrogen (NO$_x$) emissions.

The low speed comparison for fuel economy and CO$_2$ emissions clearly demonstrated the benefits of the trucks utilizing the RunWise drivetrain. The diesel hybrid achieved a low speed fuel economy of 1.31 mpg, more than double that of the CNG truck and 49% higher than the standard diesel. The diesel hybrid truck also produced just 7,800 grams of CO$_2$ per mile, a reduction of over 30% compared to the diesel configuration. Additionally, the CNG hybrid also demonstrated significant reductions over the CNG baseline, 37% reduction of CO$_2$ emitted per mile.

The hybrid trucks, while typically regarded for operational benefits at low speeds, also fared well in the high speed tests. The diesel hybrid truck achieved 4.32 mpg in the high speed fuel economy test, marginally higher than the 3.78 mpg for diesel. High speed CO$_2$ emissions were lowest with the CNG hybrid truck, followed closely by the CNG baseline at 2,035 grams per mile.

### Low Speed Cycle

<table>
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<tr>
<th></th>
<th>Fuel Economy</th>
<th>CO$_2$</th>
<th>CO</th>
<th>kNO$_x$</th>
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*Baseline CNG vehicle does not have aftertreatment catalyst.

### High Speed Cycle

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*Baseline CNG vehicle does not have aftertreatment catalyst.

For typical refuse routes, 80% of the drive time is spent in the low speeds.
**By the Numbers:**
**The In-Field Performance of RunWise**

Parker’s RunWise advanced series hybrid drive system made its commercial debut in September 2010 with the City of Miami and Miami-Dade County municipal fleets in Florida, and has since been adopted by municipalities and private fleets across the US. In the years since the first truck was placed into service, Parker’s fleet of refuse trucks equipped with the RunWise system is approaching 1,000,000 miles of operation, and vehicle owners continue to report extremely high uptime and fuel savings averaging 43 percent.

**Improving Fuel Efficiency for a Cleaner Future**

A sharp increase in CO₂ emissions as a result of human activity are affecting the earth’s carbon cycle and creating a negative impact on the environment. Given the inherently low fuel economy of heavy-duty vehicles, an ideal strategy to reduce CO₂ emissions is to reduce the fuel consumption of our largest vehicles.

Extensive research and years of real-world operation have proven the ability of Parker’s RunWise Advanced Series Hybrid technology to reduce fuel consumption and emissions of heavy-duty vehicles, regardless of fuel type. With solutions such as RunWise, Parker is applying its engineering expertise to create a meaningful and positive impact on the world.

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**Reduced Fuel Consumption**

On average, a RunWise vehicle saves up to 4,300 gallons of fuel per year. That equals 860 5-gallon cans!

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**Footnotes**


2. Ibid

3. Ibid

4. Waste and Recycling News research

5. Based on EPA figures

For more information, visit us at www.parker.com/refuse