# Electric Refuse Trucks

What OEMs and Fleet Owners Need to Know

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# Electrification is catching on in the commercial truck sector

## Though not yet at the momentum of passenger vehicles.

**Adoption especially lags among refuse fleets whose work needs are particularly demanding.** But with new climate policies and incentives around zero emissions targeting the heavy-duty world, change has begun. And the pace is about to step up fast by some industry accounts. The latest impetus is funding and tax credits available through the Inflation Reduction Act for the purchase and manufacture of electric commercial trucks and to build out charging infrastructure.

Refuse vehicles alone could make up 63% of total electric truck sales by 2030 and 73% by 2035, projects the International Council on Clean Transportation. This could spell big opportunity for OEMs who understand this industry's needs and are prepared to meet them.

As climate conversations escalate, waste operations are among entities busily working to cut their greenhouse gas emissions. And to visibly show their commitment to the communities they serve and drive through routinely. That's why some are eyeing electric trucks, with no tailpipe emissions and reported to deliver overall greenhouse gas emission reductions of 58% compared to diesel.

Municipalities and counties from New York to Los Angeles to Miami-Dade are among the first to see how these trucks do on routes. Private waste companies like Republic Services, Recology and Casella have introduced a few in North Carolina, Washington State, Maine and elsewhere. Early feedback has been positive. A more comfortable, quieter ride, smooth acceleration, easy braking and very precise speed control are among the praises. Most are finding they hold a charge well, at least for one full day's work. But as with any new technology, there are glitches to iron out if the goal is widespread adoption.

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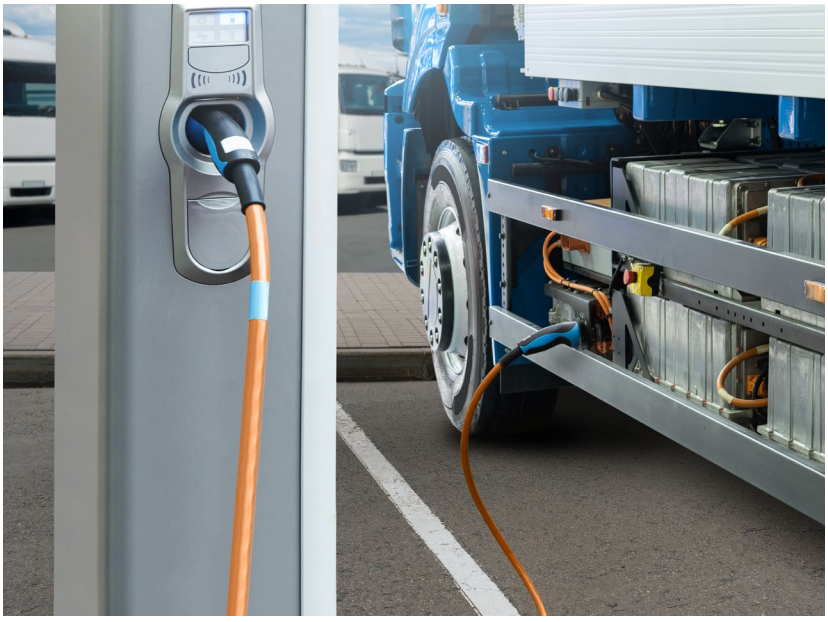


This white paper explores pressing issues that technology experts are working to address and how they are doing it. Some big areas are advancements to integrate hydraulics and electronics for efficiency and power, and new thermal management technologies to ensure safety and performance. The discussion moves into what's different about refuse fleets' business model and operations. And how electrification could meet needs associated with those differences.

# Transitioning to a New Power Source

Transitioning to all-electric vehicles is a giant technological leap for refuse truck OEMs. Electrified machines draw on an entirely different power source than combustion engines that drive the wheels and hydraulic pumps that do the work.

Now the hydraulic systems leveraged to lift trash cans and compact their contents – power-intensive functions critical to maximizing payload – must be configured to run on electric motors that draw on the battery that propels the truck.

This is no easy engineering undertaking, especially since body builders that install the hydraulics must design around the battery. It's already in place once the chassis reach their shop, and not necessarily built with consideration to the demanding duty cycle unique to refuse.

Tapping into the existing battery to generate sufficient hydraulic power is among body builders' biggest challenges. It requires a very different way of thinking, says Germano Franzoni, senior systems engineer and business development manager for Parker.

In diesel trucks, the power required to complete a collection route was never a major concern; gas-fueled combustion engines have a lot of energy density. But battery is a different story, explains Rich Nagel, program manager, electrification growth team for Parker. Now, energy efficiency is critical.

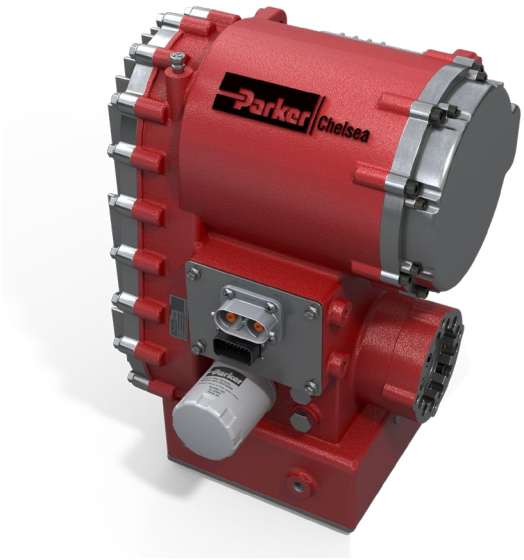
EV batteries lack that energy density, and they carry a premium price tag. They account for most of the roughly 66% hike in upfront cost for an electric truck over diesel. An electric refuse vehicle runs $500,000, estimates Argonne National Laboratory's AFLEET calculator (last updated March 2021). But they can cost more – about $600,000 to $700,000.

"So now that we are pulling off the battery that both propels the truck and drives hydraulics, we keep score on power losses. If you draw down too much energy because the hydraulic system is inefficient, fleet owners can't run the route as long, reducing their productivity and cutting into their bottom line," Nagel says.

On the plus side, the technology can generate savings in the long run, as electric motors and the power electronics that control them are typically three to four times more efficient than diesel engines. The propulsion and work motors use 80-90% of the available battery energy. Maintenance costs are generally lower too; there are few mechanical parts to deal with. Savings can add up over the vehicle's 10- to 15-year life.

# The Electric Power-takeoff Drives Performance

Key to maximizing performance is the electric power take-off (ePTO). A smartly designed ePTO optimizes how hydraulic and electric components work together.




Fairly new technology, it replaces the PTO on diesel engines, which the body builder simply mounted on the transmission and attached to the pump on a shaft. With no engine for the pump to spin off of, the electric truck calls for a different way to set up this power unit. The ePTO is an entirely new system, with new hardware and software  and more technical complexity.

Now power is transferred from the battery to electric motors that drive the hydraulics. The ePTO's components – hydraulic pumps, electric motors and inverters that control the motors – can be custom-engineered for the work, affording a lot of flexibility.

Perhaps the greatest advantage is that the speed of motors and pumps can be adjusted to match the requirements of a specific application. This helps overcome constraints imposed by combustion systems.

Franzoni explains: In diesel trucks, pumps move at the engine's speed.

"When you drive the truck and compact trash, the engine can be at a high speed. But when you operate the arm to lift trash containers, the engine idles, and the pump slows, which is a poor operating condition for the pump and engine." Being able to control the speed of the electric motors and pumps means you have the power needed, when needed. You do not tax the hydraulic components or waste battery power, he says.

Efficiency is also about pump technology, the number of pumps, number of motors and their configuration.

An important question for OEMs to ask before going into design mode is: should the hydraulic system include one pump to handle different functions or multiple pumps, each dedicated to one or more work applications?

If they opt to install multiple pumps, the next question should be: will these pumps be driven by the same large electric motor or by multiple smaller motors?

Splitting one large pump into two smaller pumps driven by the same motor may boost efficiency considerably. Splitting those two pumps into two pump/motor combinations may yield even greater efficiency, Franzoni says. While these enhancements add cost, savings on battery can make up for it.

Which pump and motor design is best – and there are many – depends on several parameters: voltage supply and motors' required power levels and speed, which hinge on how it will spend most of its work time. But the end goal is always the same: extracting the most power in the most efficient way.

# Smarter May Translate to Simpler

Moving intelligence to the electric motor may actually enable simplification and or downsizing of the hydraulic system, along with other benefits.

Franzoni exemplifies with one design option. It entails using an upgraded version of open center valve technology, a relatively simple system that traditionally uses fixed displacement pumps that provide continuous flow. The system can be revamped to achieve performance comparable to more complex load-sensing technology, which leverages variable displacement pumps, allowing flow to be adjusted based on need. Adapting open center not only yields greater controllability, but cost savings and reliability as there are few parts to potentially fail.

Designs done right, whatever the final configuration, combine the best of hydraulics with the efficiency of electric, boosting battery life, time between charges and performance.

# Thermal Management: a Big Consideration

**As EV technology advances, batteries are gaining energy density and charging quicker. But, with these enhancements, dealing with heat generated from battery charge and discharge becomes a bigger bear to tackle. Thermal management is now increasingly crucial to prevent heat from degrading electronic components, extending their lives and ensuring safety.**

**A big focus is on battery packs and on-board chargers – integral parts of an electric truck's back bone and among the most expensive technologies these machines rely on.**

**New technologies with thermally conductive and electrically insulative properties have come online. As electronics aim for higher-power performance these solutions keep evolving to meet industry needs – and to brace for emerging policies.**

**The regulatory environment is changing fast around battery safety, particularly around potential for fire, which will be highly regulated in the EV industry. Mitigating thermal runaway will be a major focus, projects Eric Dean, global business development manager of Parker's LORD division.**

**At the forefront are thermal interface materials, which conduct heat from batteries and other critical components and facilitate its flow to the cooling plate or heatsink. These technologies are effective – substantially more thermally conductive than gap pads or greases that may entrap air due to tolerance stack-ups, Dean says.**

**Ultimately, in boosting conductivity, thermal management enables quicker charge and discharge, while keeping battery temperature below the battery cell or critical electronics limitations. If you accomplish these two**

feats, you've made your battery and on-board charging more capable.

There are several options in thermal interface materials, depending on application, and each can be customized per the OEM's requirements.

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For battery chargers, potting and encapsulation materials fill areas around heat-generating components, preventing air, moisture or debris from entering the box and from trapping the heat, enabling heat to flow properly from the component to the heat sink.

A second option: gap fillers, are placed between the charging box's components and its external aluminum housing, making a thermal connection between these elements, pulling heat from the components and moving it to the housing, which acts like a heat sink.

Gap fillers and encapsulants work in a similar way in battery packs as in chargers, as does a third option: adhesives. While they have unique features, each acts as a thermal link between batteries/modules and a cooling plate, helping to draw heat into the plate. Cold liquid pumped into the plate cools battery cells and recirculates.

"If thermal interface materials and heat sinks or battery cooling plates effectively remove heat from your battery pack and charging box, all of your essential components can work harder. With better temperature control, you reduce strain on them. They last longer and run more efficiently," Dean says.

Outside of thermal interface materials other product lines serve to ensure safety and effectively address heat, namely coatings and insulative foams.

Dielectric coatings are used on the interior of battery enclosures and on cooling plates to insulate these metals from the battery's high-voltage electricity. Dielectrically insulative foams fill empty space around battery cells while helping minimize heat transfer from cell to cell.

"All five technologies – the three types of interface materials, the dielectric coatings and foams – are proven and on the road. But we at Parker continue working to advance capabilities by engaging in development activities with OEMs across the world. Our continued goal is to develop the right technology at the right time to address the ever more demanding applications in the electrification of vehicles," Dean says.

# Refuse Fleets Ideal for Regenerative Braking

Efficiency is a dominant theme in the world of electrification, and for refuse fleets there's another prevailing, related topic: acceleration, deceleration and braking. The way these functions work in electric vehicles is well suited for collection route operations.

These heavy-duty trucks spend their days moving very short distances, stopping, then starting about 800 to 1,000 times a day.

Electric motors are built for acceleration, especially of large masses, picking up speed much faster than diesel engines. So they get from point to point quicker, potentially cutting down on-road time needed to complete a job. And that's what matters to fleet operators: they generate revenue by running routes as fast as they can, squeezing in as many stops as possible.

The regenerative braking feature is what's especially catching the industry's interest. Nagel explains why: "The continual stop-start cycles along collection routes take their toll on the whole powertrain of diesel trucks. But this pattern can take advantage of regenerative braking, which recovers kinetic energy created during braking that would otherwise be lost as heat. It converts that energy to electricity that's ultimately routed through the motor to the battery to recharge it."

More stops translate to more recaptured power, a greater charge and longer battery range.

Trucks, Parts, Service reports that heavy-duty EVs have realized 12 to 15% energy gains through regenerative braking and names refuse trucks as among the top beneficiaries. Up to 20% of energy can be returned to refuse trucks, one OEM told FleetOwner.

Regenerative braking also leverages the inverter's intelligence to slow the vehicle down automatically when drivers let up on the accelerator pedal, reducing wear on the foundation brakes and extending the life of the brake shoes, meaning less-frequent replacements and longer service intervals.

The system is easier on drivers too; they rarely hit the brake pedal. Air brakes are still essential as a safety precaution, Nagel says, but they may be able to be downsized.

# A Potential Game Changer Poses Both Barriers and Advantages

**As technology progresses, challenges remain. The battery weight needed to propel a refuse truck and transport heavy trash loads adds expense, can reduce payload and shorten range. Charging infrastructure needs to mature more to be practical and work well at scale. Onsite charging systems to support a full city fleet will be costly, have to crank out a lot of power, and they require substantial physical space. Utilities who need to supplement power generated onsite could be looking at heavy expenditures too. Boston Consulting Group found the required grid upgrades may cost between $1,700 and $5,800 for each electric vehicle through 2030 (from Dec. 2019).**

**And the anticipated boom in electrification will call for a fast uptick in the manufacture of battery materials, namely lithium-ion. Credit Suisse analysts project global production in 2023 (measured as lithium carbonate equivalent) will be 736,000 tons and pegs demand at 902,000 tons. Electric vehicle batteries will account for roughly two-thirds of that volume, reports Reuters.**

# Hybrid as an Interim Solution

Electric hybrid could be a "bridge solution" as work continues toward higher power density storage devices and to build out charging infrastructure.

Hybrid incorporates some advantages of electric while maintaining performance and range of a diesel. The technology pairs a combustion engine with a smaller battery reserved only for hydraulic functions. Besides taking less battery and requiring less charging, maintaining a diesel engine and decoupling it from the hydraulics during lifting and compacting reduces emissions; the engine does not idle during work functions.

The AFLEET tool puts the price of a hybrid electric refuse truck at $350,000, compared to $300,000 for a diesel model – substantially lower than an all-electric truck.
Still the trend among early adopters is to move to full electric. More fleet owners are watching the technology evolve, curious to see what it has to offer as they look to break away from diesel.

At the end of the day, the refuse industry is looking to decarbonize and for an alternative transportation mode that fits its distinct business model and priorities. Fleet owners run their trucks hard. They depend on them to finish routes on time and to optimize throughput and payload. That means combining efficiency with power is meaningful.

Maximizing asset utilization and longevity weigh in big too. Collection fleets may spend more upfront for total cost of ownership advantages on the backend – if the truck is built to meet their operational, financial and sustainability objectives. As important, electric vehicles provide an improved driving experience, less fatigue and less exposure to diesel fumes, which aids in retention and operator health. It's all about running a successful business with the bull's eye on the bottom line.




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