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Walmart's Sustainability Journey: Elizabeth Fretheim and the Search for Sustainable Trucking

It was February 2014, and Elizabeth Fretheim, Director, Business Strategy and Sustainability for Logistics with Walmart, had just left a meeting with Jeff Smith, Transportation Strategy Manager. During that meeting, they reviewed the fuel efficiency data for Walmart's private fleet, which included more than 6,000 trucks and 61,000 trailers operated by more than 7,000 drivers. With the company's sustainability goal—to double fleet efficiency compared with 2005 baselines by 2015—Fretheim and the transportation division were vigilant in loading trucks more efficiently, driving fewer miles, and investing in fuel-efficient equipment that improved miles per gallon (mpg). But this meeting focused more on the *drivers'* impact on mpg. Fretheim was concerned about recent upward trends in the amount of time that drivers were idling their trucks—that is, time when the motor was running but the truck was not moving. With all the tools that drivers had at their disposal to manage their idle time, Fretheim could not understand why it had been increasing, rather than decreasing.

On the heels of the company's announcement of its latest prototype truck technology, designed for significant mpg improvements, she also had questions about where to devote the department's future efforts to reach the 2015 goal. Beyond continuing to improve fleet efficiency from a logistics perspective, Fretheim knew she needed to make recommendations about where to invest in increasing mpg, whether by improving the technological operations of the truck or enhancing driver techniques. Were the best next steps forward to improve the technology or the people who used it? The answer likely laid somewhere in between, but Fretheim needed to make some bets in selecting the best portfolio of planned activities.

 This case study, designed to be read alone or as part of a series, was prepared by David Hyatt at the University of Arkansas. The case was developed solely as a basis for class discussion and is not designed to serve as a source of primary data or be construed as a commentary on management techniques. The authors thank Elizabeth Fretheim, Jeff Smith, Sarah Barrett, and Mike Sipes for their assistance and insights in the creation of this case. For more information about the Walmart Sustainability Case Project, a joint venture of the University of South Carolina and the University of Arkansas, please visit the project website, http://sustainabilitycases.kenexcloud.org/about.

Walmart: Fueled by Logistics and Transportation[i]

During 1970, the same year that Wal-Mart "went public" with a small initial public offering of 300,000 shares, it opened its first distribution center (DC) in Bentonville, Arkansas. Designed as a general merchandise and fashion DC with 60,000 sq. ft., it was expanded in 1971 to 124,800 sq. ft. and then to 236,800 sq. ft. in 1972. With this installation, Walmart became one of the first retailers in the world to centralize distribution with a hub-and-spoke system. Goods were ordered, amassed at a central, massive DC (the hub), and then dispatched to the individual stores (spokes). Because many stores located in rural areas, sometimes 60–70 miles off established trucking routes, large trucking companies were not interested in servicing them. So Walmart developed a private fleet to service its stores, with the purchase of three tractor-trailer trucks to service its first DC. The hub-and-spoke system in turn enabled Walmart to achieve significant cost advantages, because it facilitated centralized, bulk purchasing of goods and distribution through its own logistics infrastructure to retail stores, such that it could replenish stores quickly. The hub-and-spoke logistics approach in turn helped shape the company's overall expansion strategy over the next two decades as it built thousands of stores.

As the company scaled its operations, it also grew from a single to multiple regional DCs that attended to stores within a specific mile radius, and the size of Walmart's private trucking fleet saw a concomitant increase. This growth was particularly pronounced between 1990 and 2005, when general merchandise regional distribution centers (RDCs) went from taking up about 7 million sq. ft. to almost 50 million sq. ft. total.[ii] Even more pronounced was the growth in the grocery and perishables distribution centers (GDCs), which accounted for almost 30 million sq. ft. in this same period, such that total DC space reached almost 100 million sq. ft. by 2005. (See Exhibit 1 for DC locations.)

By late 2005, Walmart owned and operated a private trucking fleet that included 8,000 drivers, almost 7,000 Class 8 tractors, and 30,000 trailers (both 48- and 53-foot), making it the second largest private trucking fleet in the United States at the time. The fleet ran over 1 billion miles, moving more than 1 million loads from suppliers to around 40 DCs, along with 2 million store deliveries.[iii] Products picked up at suppliers' DCs by Walmart's private fleet were routed to its DCs. Most shipments were cross-docked, or directly transferred, from inbound to outbound trailers, without being stored in the DC. Automated conveyors with cameras and barcode readers

helped increase throughput. On the return trip from the stores, Walmart's trucks increasingly generated "back-haul" revenue by transporting unsold merchandise or operating as for-hire carriers, using trucks that would otherwise have returned empty.

The magnitude of the fleet, combined with the company's low cost strategy, led Walmart's logistics executives to seek greater efficiency and lower fuel costs even before CEO Lee Scott announced the company's sustainability strategy in October 2005. Walmart already was an industry leader.[iv] But what it lacked was a clear, public, long-term sustainability goal to meet when it came to fleet efficiency.

Walmart's Goal for Sustainable Trucking

When Lee Scott announced in October 2005, to company employees and more than 60,000 suppliers that Walmart would soon (1) be supplied 100% by renewable energy, (2) create zero waste, and (3) sell products that sustain the world's resources and environment, he was calling on Walmart's size and scope and its unique position to exert positive impacts on the world. And Scott was clear about his expectations for the company's logistics leaders, regarding the role of transportation in achieving the company goals and the expected impacts of actions they might take:

> We have one of the largest private fleets in the U.S. At today's prices, if we improve our fleet fuel mileage by just one mile per gallon, we can save over 52 million dollars a year. We will increase our fleet efficiency by 25 percent over the next 3 years and double it within ten years. If implemented across our entire fleet by 2015, this would amount to savings of more than 310 million dollars a year. Compare that to doing nothing. By being the leader, we will not only change OUR fleet, but eventually change trucks everywhere in the world. We will do ourselves a big favor, clean the air for our children, create new jobs, improve U.S. productivity, positively impact our country's energy security, and more.[v]

Scott acknowledged that the overall goals were ambitious and aspirational, and that he was not sure how to achieve them, but he and several company leaders already had been hard at work for over a year on developing a sustainability strategy. Scott, a former truck driver who eventually headed Walmart's trucking fleet, had realized during that year of work that the company's insular approach was no longer feasible and that the retail giant needed to reach outside of its vast organization to seek the expertise of supply chain partners and other stakeholder groups to

reach its sustainability goals. Initially, associates worked with members, stakeholders, and subject matter experts to understand key issues and identify opportunities to achieve measureable progress. Later, these collaborations expanded into formal network structures, called sustainability value networks (SVNs), that featured Walmart associates; suppliers; and external stakeholders such as academics, government entities, and nongovernmental organizations (NGOs), including both environmental and research groups.

The Logistics SVN, which Fretheim would come to lead when she joined the company in 2009, was no different. All of Walmart's sustainability networks, including Logistics, were charged with developing "quick wins" with short-term paybacks (incremental improvements), "innovation projects" designed for two- to three-year paybacks (intermediate improvements), and "game changers" that demanded long-term investments of time and resources (transformational improvements). Initially, the SVNs were to produce at least six quick wins, two innovation projects, and one game-changer. Faced with meeting Scott's aggressive goals, associates in the network began searching for expertise outside company walls. (See Exhibit 2 for a representative list of organizations engaged by the logistics and transportation group for help on the fleet efficiency initiative.)

One outsider engaged to work on fleet efficiency was Amory Lovins from the Rocky Mountain Institute (RMI). Lovins was a well-known environmentalist, energy expert, and proponent of smart growth—as well as a guy whose ideas the transportation team previously had found impractical. Lovins and Odd-Even Bustnes, an energy economist with RMI, encouraged the transportation executives to think differently, by viewing the truck as a system.[vi] Rather than focusing on more efficient engines, they asked the transportation team what could be done to overcome seemingly inherent trucking obstacles such as weight, rolling resistance, and wind resistance. If the impact of these factors could be reduced, then smaller, more fuel-efficient engines would be possible. In this approach, each part of the truck would be considered in the process of innovating for fuel efficiency.

Such systemic rethinking of the truck also was occurring in other places throughout the company. In 2004, the company joined a partnership with International Truck and Engine and Espar to test the Thermo King TriPac auxiliary power unit (APU) and the Espar Airtronic bunk heating system.[vii] The APUs are small diesel units containing generators, air conditioning, and

heating components, so they can support communications, lighting, and heating and air conditioning in the cab, without requiring that the larger truck engine remain idling while the truck was parked for loading or unloading or overnight stays. (See Exhibit 3.) After two years, the APU-enhanced trucks showed reduced main engine idle time and a 3–4% improvement in fuel efficiency.[viii] In addition, Espar cab heaters could be powered by electricity produced by the APU, but the versions installed later were powered by small diesel engines. Both the cab heaters and APUs ultimately were installed in nearly all large trucks with sleeper cabs, or about 90% of the fleet.

By mid-2007, the company was reporting gains of 15% compared with 2005 baselines for fuel efficiency, mainly due to changes in the fuel additive mix, more fuel-efficient tires, and the APU installations.[ix] Trucks were running more efficiently, at an average of about 7 miles per gallon compared with a 2005 base of about 6 mpg. This one-gallon increase could save Walmart $35–$50 million a year and reduce carbon dioxide (CO_2) emissions by an amount equivalent to taking around 65,000 cars off the road.[x]

Sustainability initiatives in packaging also had significant effects on transportation and fuel savings. Scott emphasized the importance of the link between packaging and transportation in his 2005 speech:

> Our packaging team, for example, worked with our packaging supplier to reduce excessive packaging on some of our private-label Kid Connection toy products. By making the packaging just a little bit smaller on one private brand of toys, we will use 497 fewer containers and generate freight savings of more than $2.4 million per year. Additionally, we'll save more than 38-hundred trees and more than a thousand barrels of oil.[xi]

Other packaging initiatives were producing similar results. Scott had selected Unilever's All Small & Mighty™ concentrated laundry detergent as his 2006 Volume Producing Item, or VPI—the one product he would personally promote and market. He later committed to offering only concentrated detergent in stores by May 2008. Unilever had estimated that Small & Mighty™ used only one-third of the diesel fuel to transport regular liquid detergent.[xii] In procurement, a buyer's suggestion to replace box packaging used for infant car seats with a thick plastic cover resulted in savings in both shipping and fuel costs. Changes to some packaging in produce had saved approximately 800,000 gallons of fuel. In all of these examples, the concept

was that reduced packaging would allow more product to be loaded onto the trucks, which was more efficient.

The company also instituted truck improvements in addition to the APUs and cab heaters in 2009. Some changes included tag axles that resulted in lower friction, which reduced weight by eliminating the internal axle drive chain; trailer side skirts that, at high speeds, reduced the turbulence resulting when air passes over dry vans and created a more aerodynamic shape for truck trailers; "super single" tires, or one very wide tire taking the place of two, providing a smoother ride and better fuel economy from the reduced surface area and improved tire wall stiffness; and an aerodynamic tractor package to reduce the fuel required to operate the truck.[xiii]

Fretheim Takes the Wheel

When Elizabeth Fretheim joined Walmart's logistics division in January 2009, she was immediately tasked with leading the Logistics SVN. It was her dream job, combining her passion for the environment with an opportunity to have an impact at scale. After receiving her business degree in Canada, Fretheim's first job was with a large Canadian company that partnered with companies under First Nations' banner to provide remote asset management in the far north. Working with First Nations honed her sensibilities regarding how sustainability could constitute a legitimate business pursuit; caring for the environment and their communities was integral to those groups' business strategies. Later, her company started working in the oil sands of Canada, "in the middle of what some environmental groups say is the dirtiest project on earth," which gave her a new perspective: "That's where—especially from a transportation perspective—my eyes really opened to the impacts of fuel use." Fretheim would have ample opportunity to consider those impacts in her job at Walmart, where she hoped to improve on early advancements by taking a systemic perspective on fleet efficiency:

> The sustainability strategy has really broadened out to include the whole division because you need to look at the whole system. And when you think about sustainability and transportation, there are basically three aspects that make it up: One is getting as much on every trailer as you can. Second is to drive those trailers the fewest miles possible. And, lastly, it is do that on the most efficient equipment.[xiv]

Early successes in getting more on each trailer arose from working with suppliers to reduce packaging, improving loading techniques, and rearranging the pallet configuration to improve cube utilization. Seemingly a simple idea, the work on pallet reconfiguration had proven more difficult than first imagined (see Exhibit 4):

> We experimented with arranging the pallets lengthwise side to side in the trailers, which literally left inches between them but you could put more in the trailer. But that meant distribution center people had to be much more precise in building those pallets so there was no overhang. And we had to account for how the lift trucks loaded the trailers because some pallets are made to be lifted from the long side. But now we've had success in dry groceries and are now trying to expand it to other areas—leveraging the learning from this project into other parts of our business. (See Exhibit 4.)

As well as working with suppliers to reduce packaging and improving loading techniques to rearrange pallet configuration, logistics associates implemented other initiatives to meet the stated goal of doubling fleet efficiency, including (1) lean routing and optimization which reduced the length of delivery routes and avoided congestion; (2) filling the fleet's tires with nitrogen instead of normal compressed air which reduced tire deflation (thus lowering fuel efficiency); (3) reducing empty miles, and (4) replacing almost two-thirds of the private fleet with more fuel-efficient tractors and adding skirts to 3000 trailers.[xv]

Walmart's measurement of improvement in fleet efficiency towards the 2015 goal went beyond mpg improvement. It calculated changes in fleet efficiency by looking over time at the number of cases delivered divided by the amount of fuel used to deliver the cases (calculated as cases delivered / (miles driven / mpg)). By the end of 2012 Walmart had achieved approximately 80% of their goal of doubling the fuel efficiency of the private fleet (now with 6,000 trucks and 61,000 trailers) based on the 2005 baseline: They reported that since 2008, they had delivered 658 million more cases and driven 298 million less miles than they otherwise would have. (See Exhibit 5 for a summary of progress against the 2015 goal.)

Although the company thus had achieved great success in increasing overall fleet efficiency, Fretheim still believed that solid opportunities remained for improving the actual mpg per truck. No immediate price relief was in sight on diesel fuel—prices were expected to remain around $4 per gallon or higher—so the company had to redouble its fuel economy efforts. Despite the

impressive gains in terms of fleet efficiency through logistics and other improvements, actual fuel economy still represented a massive opportunity for savings.

Improving Fuel Efficiency

Several factors determine the fuel mpg efficiency of a fleet, including driver techniques, such as time spent idling, time in top gear, use of cruise control, shifting style, and stopping techniques. Every hour of idle time in a long-haul operation could decrease fuel efficiency by 1%. Overall, poor driving techniques could account for a 35% reduction in fuel economy. Speed was also an important factor—each 1 mile per hour in speed over 55 decreased mileage by 0.1 mpg. The aerodynamics of the truck were important, as were equipment (engine, age, settings), maintenance (tires, leaks, alignments, fans), and load weights. Although overall fleet efficiency improved, load weights had been increasing due to efforts to fill the trailers, which might even have offset mpg gains from other initiatives.

Weather was another important factor (i.e., temperature, rain, snow, wind). Air becomes denser as temperatures drop, increasing air resistance. For every 10 degree drop in temperature, aerodynamic drag increases by 2% and fuel efficiency diminishes by 1%. Congestion, topography, and road surfaces also contribute to efficiency. Rough road surfaces could increase rolling resistance by up to 20% due to energy dissipation in the tires and suspension, reducing mpg by 10%. The quality of fuel and additives can play a role, as can tires (type, wear, inflation), such that winter fuel additives reduced mpg, and every 10 PSI of tire under-inflation would produce a 1% loss in fuel economy. (See Exhibit 6 for information shared with drivers.)

Walmart's sustainability efforts had taken a systems perspective to improve fleet efficiency. In addition to quick wins in packaging and other initiatives, the company began to think about making "transformational" rather than "incremental" improvements to the design of trucks and their engines.[xvi] These transformational changes potentially would reflect technological leaps, such as future hybrid diesel–electric engines with direct mpg improvements. Walmart was contributing $2 million a year to R&D by two different teams of truck manufacturers (International Truck with ArvinMeritor Inc. and Peterbilt with Eaton), in the hope that testing these prototypes would offer potential for 50% fuel efficiency increases, on top of those already achieved. The company also hoped that aerodynamic designs on prototype trailers (produced

with Great Dane) would add 5–6% in fuel efficiency with truck skirting and rounded back ends of the trailers, which cut down on wind drag.[xvii]

Experimentation with alternative fuels in prototype trucks continued, including a new Cummins Westport ISX 12-liter engine, powered by compressed natural gas. Natural gas trucks were not yet commercially feasible nationwide though, due to a lack of fueling infrastructure, heavy fuel tanks that reduced capacity and efficiency, and maintenance uncertainty. The company continued to experiment with diesel–electric hybrid power systems, including wheel-end hybrid-assist and a full propulsion Class-8 electric tractor. These solutions were not scalable either, but they served as learning platforms for what would eventually be game-changing innovations. The company began working with Daimler Trucks North America, Freightliner, and other suppliers on a Cascadia "technology truck" that included systems for improving fuel efficiency. For example, one system evaluated road profiles a mile in advance to determine the most efficient vehicle speed, offered adaptive cruise control, suggested maintenance timing, and gave real-time feedback to the driver about fuel economy.

In February 2014, during the same week that President Obama directed the EPA and the Department of Transportation to work with stakeholder groups on an initiative to improve heavy truck mpg, Fretheim helped unveil Walmart's new concept truck. The Walmart Advanced Vehicle Experience truck was a radical departure in form and function from trucks already in the fleet, as well as from prior experimental combinations. (See Exhibit 7.) It sported advanced aerodynamics, made possible by situating the driver in the middle of the cab and the hybrid powertrain entirely underneath it. The 53-foot trailer, mainly crafted from carbon fiber, cut about 4,000 pounds from the system. That reduction could count toward mpg improvements and allow for more weight hauled in the trailer. A Capstone Turbine engine connected to an electrical powertrain was key: Previous hybrids had a limited range, because of their battery recharging limitations, but the Capstone micro-turbine technology could extend the effective range to more than 500 miles. Foil bearings in the turbine promised maintenance- and fluid-free operations and reduced the system to a single moving part. Substantial investments were still required in the concept truck though, as well as in other technical advancements, because continued road track testing and improvements were needed before the new technologies could be scaled to a degree necessary to serve Walmart's vast operational network. Furthermore, Walmart's fleet was large among private fleets, but it still represented only a small part of the overall U.S. truck market.

These advanced technologies would need to be widely adopted to become economically feasible. Walmart had to rely on the manufacturers that owned the technology to bring about this shift.

Technological advances represented one direction for changes to fuel efficiency, but Walmart also needed to undertake a close examination of the driver's role. As Jeff Smith had just noted in his meeting with Fretheim:

> What we want is for drivers to make conscious, smart decisions about turning the truck off when it's not necessary to run it. It saves maintenance on the main engine and fuel. We need to build a strong culture around producing these savings. After all, logistics is about how much savings you can bring to the table—we are a cost center not a revenue center—and we have to constantly reassess our relevance.[xviii]

Her review of the fuel efficiency data for the private fleet left Fretheim deeply concerned about recent upward trends in the amount of time that trucks were idling. She hoped to make viable recommendations to improve the situation.

Truck Drivers and Idle Time

The exact amount of fuel consumed nationwide by idling is unknown, but a 2006 analysis by Argonne National Laboratory estimated that the fuel consumed by Class 8 commercial vehicles while idling may exceed 657 million gallons a year.[xix] Class 8 trucks have a gross vehicle weight of 33,000 lbs. or more; in common terms, they are tractor-trailers, the kind of trucks in Walmart's private fleet.

Overall, emissions from truck idling in 2005 were estimated to produce annual levels of 11 million tons of carbon dioxide (CO_2, a greenhouse gas), 200,000 tons of nitrogen oxide (a precursor to ozone formation), and 5,000 tons of particulate matter (a likely carcinogen).[xx] These air pollutants, particularly nitrogen oxide and particulate matter, had been shown to exist at potentially unsafe concentrations (i.e., exceeding EPA standards) around idling trucks, both inside and outside the cab.[xxi] In addition to wasting fuel and creating pollution, idling likely led to increased engine maintenance. Some large trucking companies even offered their drivers financial incentives to keep their number of idling hours below certain thresholds. Concerns about idling also had caught the attention of the mainstream media.[xxii]

For many long-haul truck drivers, their trucks are their second homes. Drivers idled their trucks to make the cab comfortable when they were stopped (e.g., running HVAC systems in cold and hot weather conditions) and to provide electricity for an increasing assortment of in-truck appliances, such as refrigerators, televisions, communications technology, and microwave ovens. Such tools were essential for overnight stays, but drivers also wanted these same comforts while waiting, whether to make or receive deliveries, at border crossings, or to satisfy safety-related hours-of-service regulations issued by the Federal Motor Carrier Safety Administration. According to one long-haul trucker, "This is a trucker's home, and without the truck running, he loses his creature comforts. It would be like you going home and losing your electricity."[xxiii]

Fretheim had convened a meeting with several drivers to understand the idling issue from their perspective. She recalled how one driver described the experience of driving for Walmart:

> Now, what you have to remember about my job is that it's in total flux all the time. I come in here on Monday morning and I have no idea where I'm going. When I get to work they may send me down to Fayetteville with a load. On the way there, they will send me the next stop. I may pick up a trailer at Hanna's candles and then head to Dallas. On the way there they will send me the next stop. So it's totally in flux all the time. But I'll spend the week on the road and I'll be sleeping in the truck, as most guys do. We're not technically "over the road" drivers but really, we are.

That is, Walmart's drivers did not normally spend months on the road (i.e., most made it home once a week), they still had some of the same needs. Because Walmart saw drivers as strategic elements of its effort to deliver superior customer service and keep prices low, it had very high standards for new-hire drivers. They had to have an Interstate Class A commercial driver's license with Hazmat endorsement; three current, consecutive, accident-free years' experience logging at least 50,000 miles over the road (OTR) in each year, with a minimum experience of 250,000 miles; and no driving-related convictions involving alcohol or drugs in the past 10 years. (See Exhibit 8 for a published list of qualifications.) As Jeff Smith noted, these qualifications were just the minimum required to get drivers in the door to submit their application:

> So if they meet these qualifications and they move onto the interview process, then they go to a location that's hiring and do what's basically a ride-along with somebody to evaluate their driving habits. Even down to how somebody exits and enters the truck. If somebody just jumps out of the truck, we already have flags that go up because that's a potential safety concern. So all this is being monitored throughout the process to then lead up to an offer.

But drivers regarded these jobs as good ones; turnover was extremely low, and drivers tended to be older. Jeff Fackler, vice president of transportation, reported in October 2013 that Walmart's turnover rate was about 5–6%, low for private fleets. Still, because the company only hired very experienced drivers, it was difficult to find qualified applicants in some regions. It had hired only 350 candidates from a pool of 13,000 applications in 2012.

Speaking to the audience at an American Trucking Association Management Conference, Fackler noted that Walmart faced the same challenges that other carriers did when seeking to improve the drivers' experience: "How do you make a driver's life better?" One way was to pay competitively for the experience, skills, and safety record demanded by the company. As Fackler reported, the average pay for a first-year OTR driver was about $76,000, two-thirds of which was mileage-based and one-third activities-based, plus a substantial benefit package.[xxiv] Drivers were paid for everything that they did while at work, even time spent in the sleeper or waiting to pick up or deliver freight. Walmart led the field among companies with private fleets, which in turn already paid about 25% more than salaries offered by for-hire OTR truckload providers.

Drivers in Walmart's fleet did not handle the freight while loading or unloading; they were paid to drive and safely deliver the products. Drivers also benefited from the company's emphasis on safety, such that Walmart was recognized as having one of the safest fleets in the country, driving 2.11 million miles per preventable accident. Before going out on the road, new drivers spent a week in orientation and training, including eight hours of defensive driving training, which was updated annually. This training also emphasized the driver's role in fuel efficiency. After that, a new driver might spend two weeks riding with an experienced Walmart driver, called a master trainer, to learn the strategic importance of timely service to stores.

But Fretheim also knew that truck technology was changing. Driving a 2013 truck was very different than driving a 1995 truck, yet when Walmart was recruiting they looked for drivers with significant experience. Although they recruited some of the best drivers in the world, many of those drivers likely had gained most of their experience driving older technology that required different techniques than Walmart's modern fleet. Furthermore, some drivers had been well served by their old habits, leaving them unconvinced that technology could improve on their own

judgment and experience. The truck's onboard computer even provided readings of some of these ingrained habits:

> So we can get readings from the onboard computers in the truck that will tell us some of the driving behaviors that we want to look at: How much are they idling? How much are they in top gear? Are they revving the engine too high? Are they shifting properly? Also we track habits that should improve mpg. How much are they in top gear? How much are they in cruise control? But we had a driver in the other day who's one of our top mpg drivers. If you talk to him he'll say he can beat cruise every time. And maybe he can, but then you have variability between drivers and not every driver can beat cruise.

Idling was one fuel efficiency factor that fell under the drivers' control. Although it mainly was interested in "need-based idling" versus "habit-based idling," Walmart chose to calculate three categories of idle time:

- **Operating idle:** Idling of 3 minutes or less that cannot be avoided, such as when the driver is waiting at a stoplight. Anything longer than 3 minutes is counted as short idle.
- **Short idle:** Idle time between 3 and 30 minutes, when the driver has stopped but the parking brake is not engaged, possibly because of delays in highly congested areas or accidents, or while warming or cooling the engine.
- **Extended idle:** Idle time greater than 30 minutes, which might occur in congested traffic but also includes overnight stays or rest periods required by driver hours-of-service laws. The latter cause should be rare, because the engine automatically shuts down in these circumstances, but some communities also limited APU use to reduce noise pollution, in which cases the truck engine idled.

The short and extended idles were tracked and cumulatively referred to as truck idle, expressed as a percentage of total engine hours. The company shared information about idling with drivers, including the following:

- Idling achieves 0 mpg; 1 hour of idle equals 1 gallon of diesel burned.
- In normal conditions, 3 minutes is all that is needed to warm up or cool down a tractor.
- Idling more than 6 seconds uses more fuel than shutting the tractor off and restarting.
- Idling causes twice the wear on internal parts, compared with driving at regular speeds.
- Idling leads to increased maintenance costs and shorter engine life.
- Reducing idle also reduces Walmart's carbon footprint, is required by government, and is reported to environmental groups.
- Reducing idle helps Walmart meet its environmental commitments.

Of the five main types of idling-reduction technologies (i.e., cab and block heaters, automatic engine start-stop controls, battery-powered air conditioning systems, on-and-off truck

electrification, and APUs), Walmart had installed diesel APUs and small diesel heaters in most of the tractors in its private fleet, allowing drivers to access cabin comforts even with the main engine shut off. But it adopted several policy approaches too. After the company's pilot idle-reduction incentive system had not produced tangible results,

> …we did a test at four offices—we did two offices originally, and then we added two more. And what we looked at is, at the DC level, "here's where you're at today, here's the goal for the quarter," and they start pushing towards that. So what that introduces is, "if I'm at 7 and our goal is 7.1 and we hit 7.1, well, is 7.2 feasible, is 7.3 feasible? Where does it end?" And then if it hits this point, then what is that incentive going to be for maintaining it? And so we kind of stepped back and said one, is the incentive high enough and two, what would that look like if we hit that goal and we maintain that goal, what would the incentive be?

Yet as Fretheim knew, other policies compelled drivers to use the APUs in certain situations:

> Idling is a big issue. We have idle shut down on all of our trucks. We have "no idle" policies. We have all these things in place. We have APUs so they don't have to idle, all these aspects and yet we still have this idle. The question now is getting the drivers to use the APU versus the main engine; for instance, you've stopped at a store; you're waiting for someone to offload you. Turn it off and turn on the APU. You pull up to a guard gate and there are six trucks waiting; turn off the engine.

If drivers followed the recommended APU procedure, total idling time should have been less than 1%; ideally, it would never be greater than 1%. But recent analyses at the DC level indicated that idle averages in some DCs exceeded 2%. (See Exhibits 9–12.) Those levels, though lower than driver idling rates in 2005, were still higher than expected and questionably necessary.

The main engine would cut off if the truck parking brake had been engaged for 3 minutes, but if drivers preferred that the engine not stop, on older trucks they could engage the trailer brake instead. Alternately, tapping on the brake, gas, or clutch would reset the timer and provide another 3 minutes before the main engine stopped (though that time would be counted as short idle). This feature was problematic for some drivers in some operations, such as when they had to perform a "drop and hook" or "multiple drops." The former involved dropping a trailer and picking up another; the latter meant making multiple deliveries from the same trailer. The drop and hook involved multiple steps and might require starting the engine multiple times, which

some drivers resisted by circumventing the shutdown. Others complied with the policy but were concerned about the perceived maintenance costs of replacing the starters.

The APU or Espar could be engaged to cool or heat the cab when the motor was not running, and the APU started automatically if the temperature or battery thresholds were met, as long as its switch was in the "on" position. Unusually cold weather could induce drivers to use the engine idle, rather than Espar, for practical and safety reasons though. For example, if a truck had been sitting for some time, it might take extra time to pressurize the truck's air tanks; colder temperatures generally meant that it took longer to warm up to operating temperature. Some drivers maintained that warm-ups took 6–8 minutes in winter months, regardless of what the engine specifications might say. Yet Jeff Smith noted, "they build the engines differently nowadays, the warm up and cool down timeframes aren't as long as they used to be."

In addition to idle information, onboard systems captured APU hours and Espar hours—that is, the amount of time that those units were running. Although both units aimed to save fuel by reducing the main engine idle, their diesel engines did consume fuel; the APU consumed about 0.12 gallons per hour. Fretheim knew that drivers might use the APUs unnecessarily, increasing total fuel cost. For example, some drivers ran the APU over the weekend, to keep their cab comfortable in extreme temperatures or to keep their refrigerator running. But the company did not have a metric or real-time visibility to discourage such activity.

The APU usage data and other information produced by the onboard computers were used centrally for planning purposes, though some information also funneled back to the drivers, through their home DC. In addition, interested drivers could see their daily performance on the Qualcomm system, mounted on the dashboards of their trucks.

Each drivers was domiciled at and reported to a particular DC location;[xxv] each DC featured a general transportation manager (GTM), who was responsible for those drivers. The GTM provided them data about their driving habits, including speed, braking, revving, idling, APU usage, and the other measurements captured by the computer. Managers at each location also had access to individual driver data and could review those data with underperformers, to suggest ways they could improve. Yet drivers appeared unconvinced that such comparisons were meaningful, citing the effects of different kinds of trucks, different routes, different congestion

patterns, and other variables. Still, GTMs could respond: "Are you improving, and if so, how did you do that?" The actual practices to communicate performance varied from DC to DC. Some GTMs posted aggregate performance data and the best averages; others highlighted individual drivers' information. According to Smith,

> A few DCs have GTMs or drivers that are a little bit more proactive and will take the standard tools that go out and try to take it to the next level to provide better visibility or easier to understand metrics. If somebody is doing a very good job, it's taking that and learning from others in that office. So what are my top GTMs doing to then learn from each other and build off of that.

For example, one location reported six-week averages to drivers, according to the type and year of truck they were driving. It also compared them with drivers in similar trucks and vintage. Managers then used the data to exemplify best practices in training sessions. One such situation was profiled in the company's 2011 Global Responsibility Report:

> Lynn Halterman and Wyatt Jepsen, from the regional distribution center in Grantsville, Utah, took on the challenge to improve fuel mileage. They reviewed the driving skills and fuel mileage of their drivers and searched for best practices. After compiling a list of five best practices—Auxiliary Power Unit (APU) usage, cruise time, idle time, gear-down time and top gear time—they confirmed that the drivers who were achieving poor results needed to develop these driving skills. With this knowledge, Lynn and Wyatt created a training plan that would produce outstanding results. Thousands of dollars in fuel have been saved and thousands of tons of CO_2 eliminated.[xxvi]

Beyond their effectiveness for communicating the company's initiatives and successes to the general public, such stories provided internal means to share best practices and give associates a sense of what would be possible if they took the initiative to solve common company problems and create customer value. Yet the wide geographic range of the DCs meant that it was not fully clear how such practices might be adopted or how the different DCs worked with drivers to improve company performance to reach the 2015 goal. It was equally unclear whether drivers really understood all of the metrics, such as the different idle times. Fretheim kept coming back to the drivers: Were they getting the right training?

> I think this idling issue raises the general question of, are we giving them the right education and the right data to help them care, to really understand the impacts of their actions? Are we training them well on the new equipment? How well are we communicating how different this equipment is from even 10 years ago?

She recalled reading a study from the American Trucking Association that suggested that a truck running at a low speed (idling) could cause twice the wear on internal parts, compared with driving at regular speeds, which in turn could lead to increased maintenance costs and shorter engine life. She was not sure how many drivers understood or believed this correlation.

However, to retain Walmart's high standards of excellence in logistics and distribution, Fretheim needed the drivers to remain focused on driving their trucks efficiently, safely, and on time. Walmart's drivers were arguably among the best of the world, and they prided themselves on their independence, judgment, and experience. Was it worth it to push them about idling or their other driving techniques?

Analyzing the Data and Assessing the Opportunity

As Fretheim sat down to analyze the idle data that the team had amassed, she wondered where her energies should be focused for meeting the 2015 goal—and beyond. How much could be gained by focusing on driver behavior versus fleet technology to improve mpg? What, ultimately, could explain the change in idling, and how much was it costing the company? Were the changes significant from one year to the next or within normal ranges of variation? If trucks were idling more, were they using the APU and Espar less? Would the data provide her with answers, and if they did not, what then? What data or other elements would she need to take the next steps in the analysis?

The drivers, and how they operated the trucks, were critical to achieving company goals on fleet efficiency. It was not yet clear to Fretheim whether individual successes in improving idling time could span the multiple DCs and thousands of trucks owned by Walmart to ensure meaningful and measurable success in the aggregate, but if she decided to pursue this option, she needed to select the most appropriate next steps.

At the same time, she needed to compare these opportunities against those offered, were she to invest in more technological improvements to the fleet. She reflected on the intensive effort and resources already invested into the multi-company partnership that had produced the Walmart Advance Vehicle Experience concept truck. It had been one of the most exciting projects she had ever worked on at Walmart, but what would it take to move these high-tech trucks into

production? How did the investments in new technology relate to her choices? She wondered if the next steps she chose should be to improve the technology or the people who used it. Or instead, should the company pursue both options at the same time in a search for a balanced portfolio of initiatives?

Exhibit 1: RDC and GDC Locations in the United States

Source: Walmart: http://walmartprivatefleet.com/Services/NetworkMaps.aspx. Regional DCs are shown in the top map and Grocery DCs are in the lower map. The numbering of DCs varies by the unit under consideration for that location. If the second number is a "0," it is the DC. If the second number is an "8," it is the Transportation Office; a "7" indicates the Truck Maintenance Garage. Data were not available for all Grocery DCs, because some are serviced by other transportation providers.

Exhibit 2: Logistics and Transportation Fleet Efficiency Partners

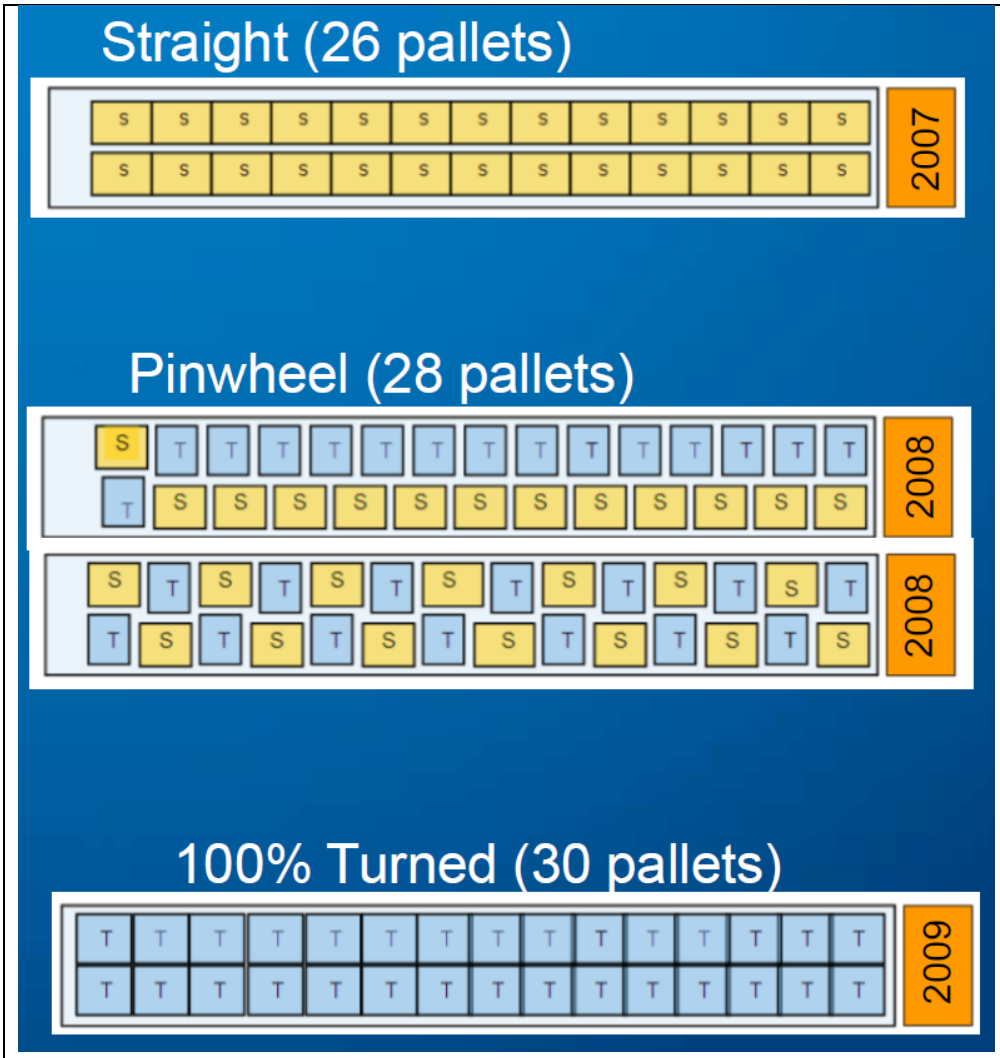
Industry Partner Relations	**Domain**
Cummins, Inc.	Engine
Detroit Diesel Corporation	Engine
Great Dane Trailers	Trailers
Hyundai Trailers	Trailers
International Truck & Engine	Truck
Peterbilt Truck & Engine	Truck
Freightliner Truck & Engine	Truck
Eaton Corporation	Drivetrain components; hybrid
Meritor Corporation	Drivetrain components; hybrid
Goodyear Tire	Tires
Bridgestone Firestone	Tires
Michelin Group	Tires
Power Service Products	Fuel additives
Exxon Mobil Corporation	Oil
Thermo King	Auxiliary Power Units
Purkey's Fleet Electric	Electrification
Stakeholder Relations	**Type**
California air quality agencies	Government
Department of Defense	Government
Department of Energy	Government
EPA SmartWay Partnership	Government
Rocky Mountain Institute	NGO
BSR: Clean Cargo Working Group	NGO
BSR: Future of Fuels	NGO
Southwest Research	Independent Research
National Private Truck Council	Trade Association
American Trucking Association	Trade Association
Arkansas Trucking Association	Trade Association

Source: Elizabeth Fretheim, Walmart

Exhibit 3: TriPac APU

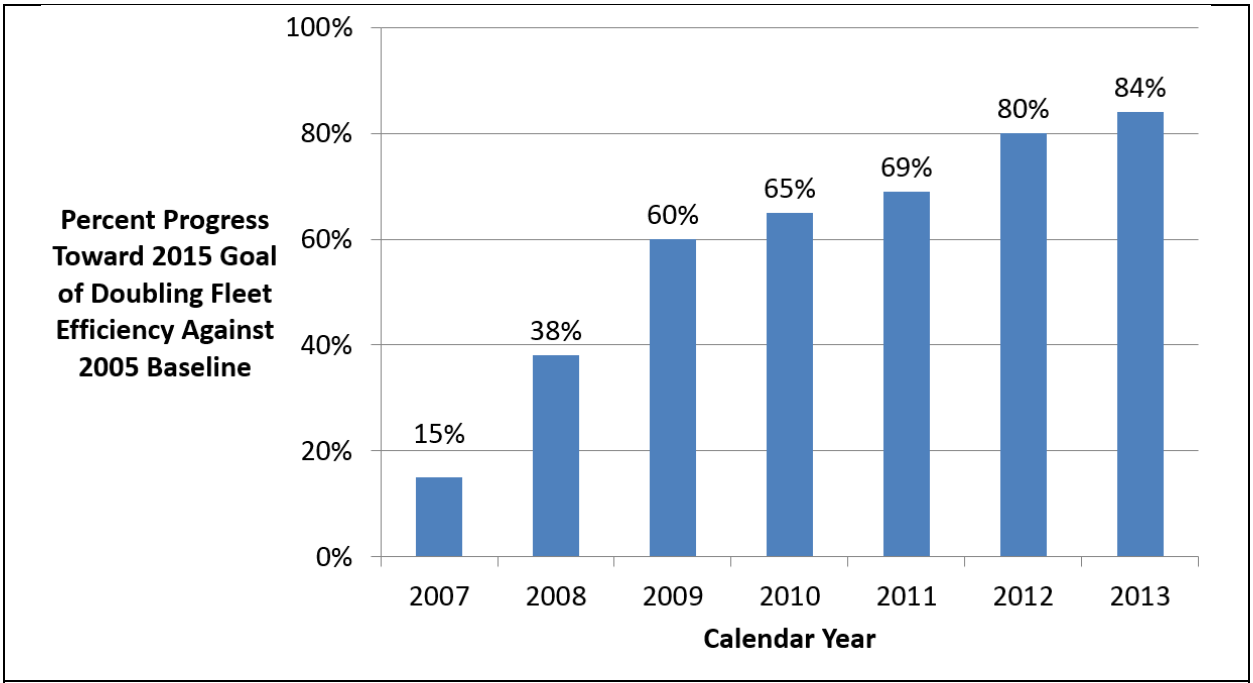
Source: Thermo King, http://www.thermoking.com/products/product/tripac.asp?inc=no&pg=print

Exhibit 4: 2007–2009 Pallet Reconfiguration



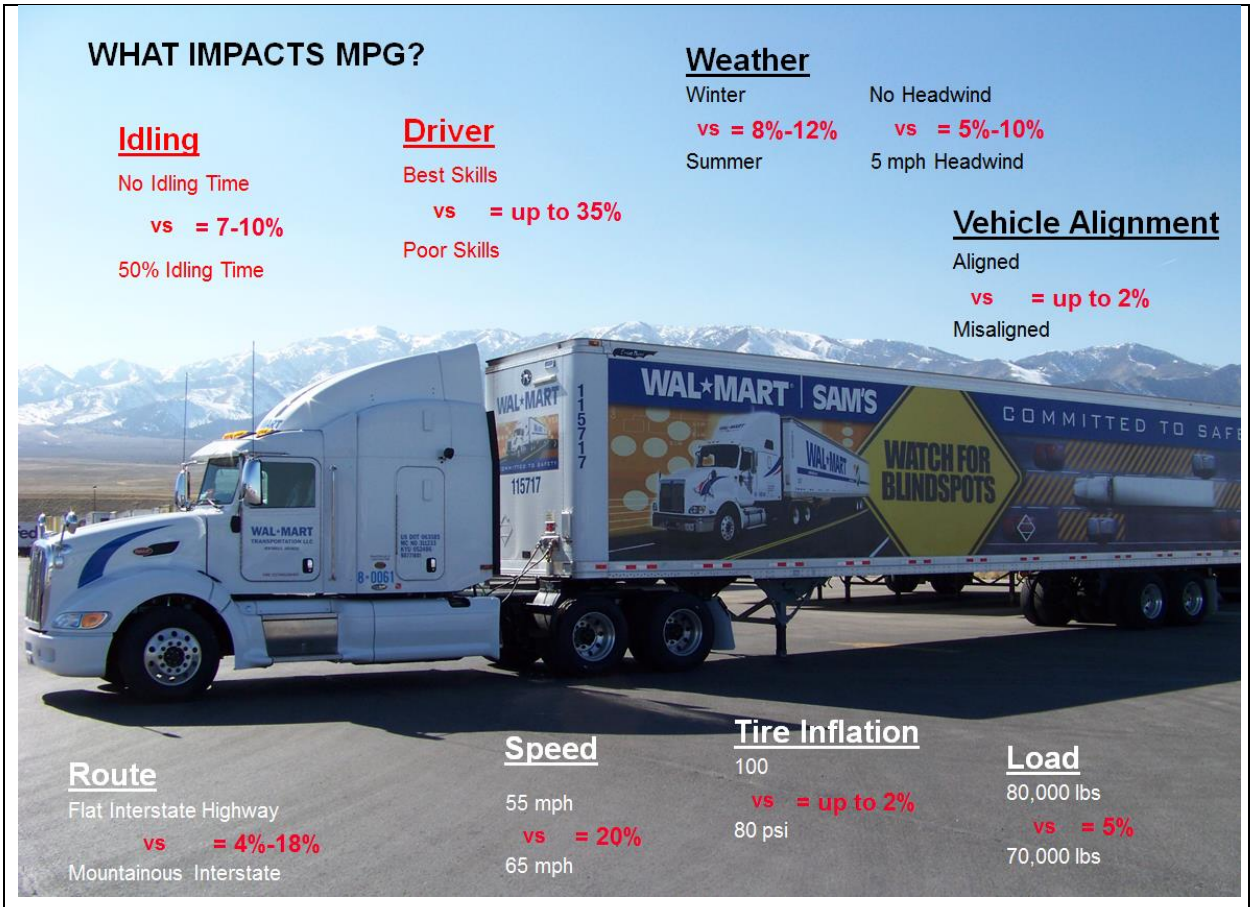
Source: Courtesy of Walmart. Excerpt from deck shown at October 2012 Presentation to Educators

Exhibit 5: 2005–2013 Progress against 2015 Goal



Source: Walmart Global Responsibility Reports

Exhibit 6: MPG Impacts



Source: Courtesy of Walmart: Slide from deck shown at March 2012 Driver Grassroots training

Exhibit 7: February 2014 Concept Truck

Source: Walmart

Exhibit 8: Minimum Qualifications for Walmart Drivers

- Interstate Class A Commercial Driver's License with Hazmat endorsement
- Three years of current over-the-road tractor/trailer experience
- Minimum of 50,000 miles over-the-road tractor/trailer experience in each of the last three years
- Minimum of 250,000 miles over-the-road tractor/trailer experience
- No preventable accidents while operating a commercial motor vehicle in the last three years
- No preventable accidents while operating a commercial motor vehicle resulting in a fatality (lifetime)
- No preventable DOT recordable accidents while operating a commercial motor vehicle in the last 10 years
- No more than 1 non-preventable accident while operating a commercial motor vehicle in the last three years
- No more than two moving violations while operating a personal or commercial motor vehicle in the last three years
- No serious traffic violations while operating a commercial motor vehicle in the last three years
- No convictions for a DUI, DWI, OUI, or reckless driving with alcohol/drugs involved within the last 10 years

Source: http://careers.walmart.com/career-areas/transportation-logistics-group/drivers/

Exhibit 9: 2012–2013 Idle Data by Week

Source: Walmart.
Idle Time (Idle) is the percentage of time the engine is idling, other than for allowable warm-ups, cool down, or short stops due to traffic conditions (not expected to exceed 3 minutes). Short Idle (S_Idle) is the percentage of time the engine is idling for events of medium durations, such as a lunch break or truck unloading/loading (between 3 and 30 minutes). Extended Idle (E_Idle) occurs during extended operations and exceeds 30 minutes. Idle = S_Idle + E_Idle. These idle averages were calculated by aggregating driver weekly records by DC and Week, then calculating the averages and standard deviation (SD) for the DCs (N = 68 and 69).

		2012							2013						
Wk	**Wk_End**	**Idle**	**SD**	**S_Idle**	**SD**	**E_Idle**	**SD**	**DCs**	**Idle**	**SD**	**S_Idle**	**SD**	**E_Idle**	**SD**	**DCs**
1	01-04	1.46	0.56	1.30	0.48	0.17	0.23	68	1.68	0.64	1.48	0.57	0.20	0.21	69
2	01-11	1.42	0.53	1.27	0.44	0.15	0.28	68	1.32	0.49	1.18	0.45	0.15	0.15	69
3	01-18	1.64	0.64	1.48	0.57	0.16	0.16	68	1.55	0.60	1.33	0.44	0.22	0.29	69
4	01-25	1.47	0.55	1.32	0.48	0.15	0.18	68	1.66	0.71	1.44	0.59	0.23	0.27	69
5	02-01	1.24	0.47	1.14	0.44	0.10	0.13	68	1.50	0.59	1.30	0.53	0.20	0.19	69
6	02-08	1.31	0.52	1.20	0.46	0.11	0.16	68	1.38	0.59	1.23	0.51	0.15	0.14	69
7	02-15	1.44	0.56	1.29	0.49	0.14	0.17	68	1.29	0.61	1.15	0.47	0.14	0.24	69
8	02-22	1.23	0.49	1.12	0.44	0.11	0.15	68	1.48	0.58	1.28	0.51	0.20	0.24	69
9	03-01	1.21	0.49	1.09	0.43	0.12	0.19	68	1.37	0.51	1.22	0.44	0.15	0.15	69
10	03-08	1.14	0.39	1.05	0.37	0.09	0.11	68	1.27	0.49	1.15	0.45	0.12	0.11	69
11	03-15	1.08	0.45	1.00	0.41	0.08	0.10	68	1.21	0.46	1.08	0.42	0.13	0.16	69
12	03-22	1.11	0.46	1.01	0.42	0.10	0.14	68	1.27	0.52	1.14	0.47	0.13	0.18	69
13	03-29	1.05	0.44	0.97	0.42	0.08	0.07	68	1.22	0.44	1.10	0.38	0.12	0.12	69
14	04-05	1.02	0.47	0.94	0.41	0.09	0.14	68	1.09	0.44	0.99	0.40	0.10	0.11	69
15	04-12	1.01	0.45	0.92	0.43	0.09	0.11	68	1.17	0.46	1.04	0.39	0.13	0.17	69
16	04-19	0.99	0.45	0.91	0.42	0.09	0.10	68	1.20	0.53	1.06	0.41	0.14	0.22	69
17	04-26	1.02	0.42	0.90	0.38	0.12	0.13	68	1.14	0.44	1.01	0.39	0.13	0.19	69
18	05-03	1.08	0.48	0.96	0.41	0.12	0.15	68	1.14	0.46	1.02	0.41	0.12	0.17	69
19	05-10	1.06	0.45	0.95	0.41	0.11	0.11	68	1.12	0.44	1.01	0.39	0.11	0.16	69
20	05-17	1.07	0.44	0.95	0.40	0.12	0.10	68	1.27	0.56	1.10	0.40	0.18	0.33	69
21	05-24	1.19	0.45	1.04	0.39	0.15	0.18	68	1.37	0.51	1.19	0.44	0.17	0.15	69
22	05-31	1.23	0.52	1.10	0.46	0.13	0.13	68	1.34	0.52	1.21	0.47	0.13	0.13	69
23	06-07	1.18	0.48	1.02	0.40	0.16	0.20	68	1.42	0.63	1.22	0.50	0.19	0.28	69
24	06-14	1.23	0.50	1.11	0.45	0.13	0.16	68	1.53	0.62	1.31	0.49	0.22	0.25	69
25	06-21	1.44	0.53	1.23	0.42	0.21	0.27	68	1.44	0.57	1.26	0.51	0.18	0.16	69
26	06-28	1.49	0.63	1.28	0.49	0.21	0.28	68	1.61	0.60	1.38	0.51	0.23	0.25	69
27	07-05	1.58	0.58	1.37	0.45	0.20	0.28	68	1.48	0.61	1.27	0.50	0.21	0.22	69
28	07-12	1.48	0.58	1.27	0.45	0.21	0.39	68	1.58	0.63	1.32	0.50	0.25	0.25	69
29	07-19	1.50	0.76	1.29	0.44	0.21	0.53	68	1.67	0.63	1.41	0.48	0.27	0.39	69
30	07-26	1.55	0.60	1.31	0.49	0.24	0.25	68	1.49	0.60	1.28	0.46	0.21	0.30	69
31	08-02	1.51	0.55	1.28	0.47	0.23	0.24	68	1.39	0.58	1.20	0.46	0.20	0.24	69
32	08-09	1.47	0.58	1.27	0.47	0.20	0.24	68	1.43	0.57	1.24	0.46	0.19	0.18	69
33	08-16	1.36	0.64	1.18	0.51	0.18	0.24	68	1.38	0.54	1.19	0.45	0.19	0.18	69
34	08-23	1.26	0.52	1.12	0.44	0.14	0.15	68	1.43	0.53	1.24	0.45	0.19	0.14	69
35	08-30	1.35	0.58	1.17	0.43	0.17	0.27	69	1.47	0.59	1.28	0.49	0.19	0.23	69

36	09-06	1.39	0.60	1.18	0.46	0.20	0.24	69	1.45	0.59	1.24	0.49	0.21	0.25	69
37	09-13	1.24	0.54	1.10	0.43	0.13	0.21	69	1.47	0.59	1.27	0.49	0.20	0.20	69
38	09-20	1.15	0.51	1.04	0.46	0.12	0.12	69	1.28	0.58	1.13	0.45	0.15	0.24	69
39	09-27	1.14	0.61	1.01	0.44	0.13	0.29	69	1.28	0.47	1.13	0.42	0.15	0.20	69
40	10-04	1.11	0.62	0.98	0.42	0.13	0.33	69	1.26	0.47	1.13	0.41	0.13	0.16	69
41	10-11	1.07	0.43	0.96	0.37	0.11	0.14	69	1.26	0.44	1.13	0.41	0.13	0.13	69
42	10-18	1.04	0.49	0.93	0.39	0.11	0.24	69	1.19	0.46	1.08	0.40	0.11	0.17	69
43	10-25	1.07	0.47	0.95	0.37	0.12	0.24	69	1.22	0.43	1.11	0.39	0.11	0.15	69
44	11-01	1.12	0.46	1.00	0.39	0.12	0.18	69	1.24	0.42	1.11	0.39	0.14	0.13	69
45	11-08	1.08	0.47	0.98	0.41	0.10	0.13	69	1.24	0.45	1.11	0.40	0.13	0.17	69
46	11-15	1.11	0.47	1.01	0.40	0.11	0.18	69	1.36	0.47	1.21	0.41	0.15	0.20	69
47	11-22	1.09	0.51	0.99	0.40	0.10	0.22	69	1.35	0.47	1.21	0.42	0.15	0.17	69
48	11-29	1.22	0.50	1.10	0.44	0.12	0.12	69	1.78	0.63	1.57	0.53	0.21	0.28	69
49	12-06	1.05	0.43	0.95	0.38	0.10	0.14	69	1.69	0.82	1.43	0.49	0.26	0.54	69
50	12-13	1.25	0.47	1.11	0.41	0.14	0.15	69	2.38	1.03	1.94	0.64	0.44	0.64	69
51	12-20	1.39	0.56	1.19	0.45	0.20	0.33	69	1.72	0.66	1.50	0.60	0.21	0.21	69
52	12-27	1.71	0.74	1.46	0.60	0.25	0.37	69	1.81	0.75	1.57	0.59	0.23	0.38	69

Exhibit 10: 2012-13 Idle Data by Distribution Center

Source: Walmart.
Idle Time (Idle) is the percentage of time the engine is idling, other than for allowable warm-ups, cool down, or short stops due to traffic conditions (not expected to exceed 3 minutes). Short Idle (S_Idle) is the percentage of time the engine is idling for events of medium durations, such as a lunch break or truck unloading/loading (between 3 and 30 minutes). Extended Idle (E_Idle) occurs during extended operations and exceeds 30 minutes. Idle = S_Idle + E_Idle. These idle averages were calculated by aggregating driver weekly records by DC and Week, then calculating the averages and standard deviation (SD) for the 52 weeks (N = 52).

	2012						2013					
DC	Idle	SD	S_Idle	SD	E_Idle	SD	Idle	SD	S_Idle	SD	E_Idle	SD
6801	2.07	0.36	1.83	0.25	0.24	0.14	2.02	0.41	1.76	0.28	0.25	0.19
6806	1.58	0.37	1.44	0.29	0.14	0.12	1.87	0.30	1.72	0.24	0.15	0.11
6809	1.17	0.41	1.06	0.31	0.11	0.14	1.49	0.50	1.40	0.46	0.09	0.09
6810	1.42	0.41	1.24	0.26	0.18	0.21	1.16	0.18	1.06	0.15	0.10	0.08
6811	1.06	0.22	0.95	0.16	0.11	0.08	1.48	0.33	1.23	0.22	0.25	0.17
6812	1.50	0.17	1.38	0.17	0.11	0.06	2.04	0.38	1.83	0.31	0.21	0.11
6815	0.90	0.23	0.80	0.15	0.10	0.12	0.67	0.16	0.61	0.13	0.06	0.10
6816	1.20	0.24	1.11	0.20	0.09	0.08	1.42	0.26	1.30	0.18	0.12	0.10
6817	1.22	0.33	1.06	0.25	0.16	0.12	1.27	0.32	1.10	0.24	0.17	0.10
6818	0.97	0.30	0.83	0.20	0.14	0.13	1.23	0.37	1.06	0.28	0.18	0.12
6819	0.71	0.30	0.54	0.20	0.16	0.15	1.10	0.62	0.75	0.27	0.35	0.38
6820	1.07	0.32	1.00	0.30	0.07	0.08	1.89	0.36	1.73	0.31	0.16	0.11
6821	2.40	0.28	2.26	0.19	0.14	0.12	2.69	0.28	2.51	0.21	0.18	0.12
6822	0.67	0.46	0.44	0.26	0.23	0.28	0.67	0.40	0.50	0.24	0.17	0.25
6823	0.97	0.19	0.87	0.17	0.09	0.06	1.34	0.26	1.20	0.20	0.14	0.10
6824	0.85	0.26	0.79	0.26	0.05	0.04	0.79	0.24	0.72	0.22	0.07	0.05

6825	1.11	0.41	1.02	0.34	0.08	0.10	1.49	0.58	1.36	0.48	0.12	0.13
6826	1.38	0.29	1.23	0.19	0.15	0.12	1.55	0.35	1.37	0.24	0.18	0.14
6827	1.21	0.36	1.11	0.30	0.10	0.09	1.37	0.61	1.22	0.49	0.15	0.17
6829	0.74	0.21	0.57	0.10	0.17	0.16	0.91	0.32	0.66	0.13	0.25	0.26
6830	1.29	0.50	1.16	0.41	0.13	0.18	1.61	0.53	1.40	0.39	0.21	0.23
6831	1.39	0.32	1.28	0.22	0.11	0.12	1.25	0.28	1.11	0.22	0.14	0.12
6835	1.10	0.34	1.04	0.30	0.07	0.07	1.43	0.57	1.26	0.45	0.17	0.17
6836	0.58	0.16	0.51	0.13	0.07	0.08	0.92	0.40	0.78	0.31	0.14	0.12
6837	1.67	0.52	1.11	0.29	0.55	0.29	1.68	0.46	1.08	0.23	0.60	0.30
6838	1.48	0.38	1.38	0.35	0.10	0.07	1.73	0.50	1.63	0.45	0.11	0.07
6839	1.40	0.29	1.13	0.19	0.27	0.16	1.36	0.31	1.15	0.21	0.21	0.17
6840	1.29	0.23	1.21	0.18	0.08	0.09	1.05	0.15	1.00	0.14	0.05	0.04
6843	1.02	0.37	0.96	0.35	0.06	0.05	0.93	0.34	0.87	0.30	0.07	0.07
6847	1.51	0.32	1.43	0.27	0.08	0.10	1.62	0.59	1.50	0.50	0.11	0.15
6848	1.53	0.31	1.36	0.24	0.17	0.14	1.49	0.29	1.24	0.14	0.25	0.21
6854	2.27	0.42	1.95	0.31	0.31	0.16	2.34	0.46	1.87	0.22	0.47	0.27
6855	1.03	0.33	0.93	0.24	0.11	0.17	0.93	0.28	0.75	0.19	0.17	0.15
6857	1.31	0.38	1.15	0.22	0.17	0.32	1.37	0.29	1.24	0.23	0.14	0.15
6859	0.89	0.51	0.82	0.33	0.06	0.27	1.58	0.92	1.33	0.43	0.25	0.57
6865	1.48	0.37	1.43	0.34	0.04	0.08	1.80	0.55	1.68	0.39	0.12	0.36
6866	1.29	0.32	1.16	0.25	0.14	0.11	1.54	0.29	1.38	0.25	0.16	0.13
6868	0.87	0.34	0.72	0.25	0.15	0.13	1.09	0.39	0.96	0.29	0.13	0.13
6869	1.33	0.33	1.23	0.29	0.10	0.08	1.33	0.31	1.22	0.26	0.11	0.08
6870	1.25	0.23	1.20	0.20	0.06	0.04	1.39	0.21	1.30	0.17	0.10	0.07
6872	0.91	0.19	0.86	0.16	0.05	0.16	1.08	0.43	0.96	0.29	0.12	0.24
6873	1.53	0.39	1.47	0.34	0.06	0.10	1.26	0.36	1.20	0.32	0.06	0.11
6880	1.45	0.34	1.36	0.30	0.10	0.07	1.83	0.55	1.67	0.44	0.16	0.16
6882	0.43	0.25	0.41	0.21	0.02	0.09	0.59	0.36	0.55	0.28	0.04	0.11
6885	0.49	0.32	0.47	0.30	0.02	0.04	1.05	0.51	0.97	0.46	0.08	0.14
6890	0.70	0.39	0.53	0.15	0.18	0.30	0.98	0.50	0.73	0.22	0.25	0.33
6892	1.37	0.36	1.25	0.31	0.11	0.09	1.94	0.50	1.71	0.41	0.24	0.15
6895	1.58	0.34	1.44	0.27	0.14	0.17	1.55	0.38	1.38	0.24	0.16	0.23
6896	1.22	0.34	1.17	0.34	0.05	0.05	1.74	0.48	1.66	0.43	0.08	0.08
6897	1.37	0.53	0.99	0.20	0.37	0.41	1.28	0.41	1.06	0.20	0.22	0.26
6899	2.39	0.85	1.77	0.28	0.62	0.78	1.48	0.48	1.27	0.23	0.22	0.34
7812	0.79	0.27	0.75	0.26	0.04	0.05	0.86	0.27	0.81	0.24	0.05	0.09
7813	0.85	0.61	0.77	0.50	0.07	0.17	0.72	0.39	0.62	0.20	0.10	0.30
7814	1.05	0.33	0.77	0.27	0.28	0.18	1.32	0.43	1.09	0.30	0.23	0.18
7815	0.33	0.36	0.27	0.17	0.06	0.27	0.46	0.32	0.41	0.21	0.05	0.17
7818	1.54	0.68	1.14	0.29	0.41	0.52	1.68	0.72	1.22	0.29	0.46	0.58
7821	0.92	0.37	0.77	0.25	0.15	0.24	0.96	0.40	0.82	0.27	0.14	0.21
7824	0.48	0.41	0.39	0.21	0.08	0.32	0.95	0.63	0.80	0.42	0.15	0.46
7826	0.63	0.21	0.48	0.11	0.15	0.15	0.85	0.49	0.56	0.24	0.28	0.28
7830	1.16	0.53	1.10	0.51	0.06	0.07	1.54	0.54	1.40	0.39	0.14	0.17
7833	1.54	0.29	1.37	0.20	0.17	0.11	1.45	0.25	1.25	0.18	0.20	0.11

7834	0.67	0.39	0.57	0.32	0.10	0.12	0.62	0.19	0.54	0.17	0.08	0.08
7835	1.00	0.33	0.84	0.20	0.16	0.22	0.72	0.20	0.63	0.11	0.09	0.15
7836	1.11	0.22	0.98	0.18	0.13	0.11	1.19	0.26	1.06	0.23	0.12	0.11
7838	1.07	0.15	1.04	0.13	0.03	0.05	0.97	0.15	0.93	0.14	0.04	0.06
7839	1.29	0.41	1.25	0.35	0.04	0.08	1.56	0.52	1.46	0.44	0.11	0.15
7845	1.01	0.24	0.91	0.19	0.10	0.11	1.13	0.28	0.98	0.21	0.15	0.14
7855	0.76	0.27	0.65	0.20	0.10	0.13	0.72	0.44	0.59	0.34	0.12	0.23
7877	1.34	0.55	1.05	0.37	0.29	0.33	1.70	1.01	1.15	0.38	0.56	0.67

Exhibit 11: 2012–2013 Engine Hours, Miles, Average MPG, APU, and Espar by DC

Source: Walmart

Total Engine Hours (EngHrs), Total Distance (Miles), and average MPG (by week) and Standard Deviations (of 52 weekly totals). Both APU and Espar total hours are sums of quarterly summaries and are not collected for every DC in this data set. Number of reports (Rpts) reflects the number of quarters that data were collected for the APU/Espar hours (i.e., "3" indicates 3 quarters of data were collected).

Calendar Year 2012										
DC	**Eng_Hrs**	**StdDev**	**Miles**	**StdDev**	**MPG**	**StdDev**	**APU_Hrs**	**Rpts**	**Espar_Hrs**	**Rpts**
6801	452,748	629	22,745,609	32,028	6.756	0.166	474,766	4	326,172	4
6806	222,956	363	10,750,124	17,299	6.857	0.089	141,534	4	81,203	4
6809	282,337	500	14,742,466	27,973	6.835	0.281	213,582	4	180,461	4
6810	234,706	281	11,245,627	13,205	6.962	0.117	175,389	4	58,510	4
6811	296,062	457	14,841,676	22,833	6.964	0.091	230,028	4	63,622	4
6812	434,675	586	23,166,529	31,318	6.790	0.193	320,688	4	164,199	4
6815	88,164	173	4,649,884	8,932	7.281	0.077	63,100	4	23,797	4
6816	407,646	772	20,956,543	39,421	6.889	0.128	304,490	4	49,908	4
6817	298,389	500	14,490,251	26,158	7.067	0.261	133,051	4	119,632	4
6818	351,325	467	17,628,491	24,209	7.005	0.150	276,533	3	151,703	3
6819	309,048	336	15,963,693	18,351	6.657	0.133	152,178	4	169,515	4
6820	199,408	323	8,812,065	14,301	6.806	0.104	175,218	4	26,834	4
6821	304,354	509	13,692,295	23,337	7.466	0.144	117,959	4	49,895	4
6822	94,723	228	5,009,068	12,013	7.366	0.287	34,435	4	43,520	4
6823	339,809	562	16,538,219	27,761	6.910	0.133	125,289	3	101,783	3
6824	284,694	390	13,377,973	19,341	6.713	0.170	198,691	4	191,082	4
6825	352,854	381	18,698,898	22,760	7.080	0.288	169,801	4	228,905	4
6826	373,344	475	17,722,509	23,914	7.613	0.140	149,598	4	112,910	4
6827	341,273	481	16,678,672	26,001	6.585	0.148	372,134	4	206,844	4
6829	161,875	257	8,728,528	13,979	7.159	0.108	74,449	4	64,837	4
6830	191,271	277	9,449,252	14,930	6.915	0.157	89,920	4	91,333	4
6831	338,754	352	16,217,835	16,939	7.201	0.176	286,621	4	115,630	4
6835	347,155	476	18,180,519	25,497	6.913	0.227	192,839	4	149,345	4
6836	354,628	594	17,551,273	29,308	6.856	0.173	270,467	4	77,826	4
6837	399,110	756	19,721,568	39,104	6.936	0.225	341,017	4	438,531	4
6838	345,866	513	16,936,042	26,941	6.772	0.231	187,994	4	220,652	4
6839	274,493	424	13,172,439	20,325	6.424	0.087	127,035	4	100,162	4

6840	268,817	475	13,396,761	23,926	6.939	0.100	145,832	4	70,690	4
6843	333,305	500	16,439,506	26,311	6.915	0.177	141,196	4	146,163	4
6847	65,730	96	3,033,676	4,596	6.381	0.109				
6848	176,869	303	8,506,189	14,302	7.098	0.181	189,960	4	27,795	4
6854	293,950	436	13,744,328	20,766	6.874	0.100	225,444	3	115,392	3
6855	53,879	75	2,502,280	3,584	6.615	0.158	41,238	4	16,534	4
6857	53,250	141	2,449,274	6,623	7.042	0.112				
6859	30,943	60	1,521,816	3,056	7.089	0.210	24,156	4	21,394	4
6865	43,538	88	2,287,347	4,585	6.959	0.268				
6866	192,807	318	9,631,116	16,388	7.128	0.163	165,483	4	89,627	4
6868	310,119	463	14,950,696	23,408	6.631	0.113	244,842	4	122,544	4
6869	297,768	351	15,257,887	18,384	6.898	0.220	150,011	4	114,611	4
6870	284,295	406	13,667,971	20,119	6.921	0.078	184,857	4	92,629	4
6872	58,312	93	2,865,377	4,615	6.816	0.164				
6873	65,707	122	3,091,403	5,883	6.770	0.120	42,550	4	24,584	4
6880	272,623	401	13,044,805	20,681	6.628	0.135	150,181	4	164,390	4
6882	31,095	76	1,628,437	3,849	6.863	0.165				
6885	31,476	83	1,674,021	4,487	7.119	0.277	15,178	4	19,369	4
6890	74,771	108	4,048,399	6,047	7.300	0.142				
6892	246,008	469	11,642,257	23,914	6.842	0.283	144,641	4	137,646	4
6895	82,283	140	3,906,821	6,598	6.792	0.093				
6896	101,015	152	4,881,518	7,892	6.362	0.207				
6897	90,444	92	4,294,039	4,462	6.509	0.100	52,265	4	40,393	4
6899	62,974	123	3,039,067	6,008	6.925	0.082	47,337	4	9,398	4
7812	97,241	151	4,596,538	7,386	7.057	0.201				
7813	29,942	71	1,430,327	3,493	7.192	0.204				
7814	147,975	159	7,313,446	8,814	6.720	0.129	150,656	4	159,331	4
7815	30,223	83	1,542,393	4,407	6.602	0.166				
7818	54,956	86	3,055,500	4,744	6.842	0.269	48,168	4	50,204	4
7821	13,124	92	655,137	4,817	7.064	0.179				
7824	29,934	64	1,446,029	3,181	6.733	0.328	13,678	3	17,716	3
7826	263,424	452	14,286,824	24,865	7.330	0.131	124,180	3	141,153	3
7830	196,906	226	8,706,332	10,677	6.072	0.099	85,822	3	71,457	3
7833	301,087	399	13,141,891	17,831	7.131	0.081	193,586	4	139,592	4
7834	212,970	357	9,620,971	16,444	6.835	0.295	65,192	3	49,678	3
7835	112,119	161	5,423,130	7,614	6.959	0.068	71,804	4	14,783	4
7836	256,400	390	12,136,020	18,886	6.863	0.160	181,480	4	44,210	4
7838	140,933	148	6,659,336	7,423	6.971	0.111	115,150	4	9,680	4
7839	120,073	220	5,813,943	11,115	6.940	0.272	63,047	4	60,104	4
7845	208,657	253	10,456,469	13,087	6.966	0.149	93,303	4	91,465	4
7855	64,005	115	3,174,073	5,913	6.985	0.310	20,842	3	38,048	3
7877	54,021	99	2,800,934	5,351	6.832	0.169	30,814	4	40,186	4

Calendar Year 2013										
DC	Eng_Hrs	StdDev	Miles	StdDev	MPG	StdDev	APU_Hrs	Rpts	Espar_Hrs	Rpts
6801	446,497	535	22,319,341	29,303	6.801	0.215	332,607	4	213,454	4
6806	227,354	399	10,881,329	19,560	6.839	0.127	129,300	4	87,778	4
6809	273,291	482	14,100,686	25,600	6.850	0.349	211,966	3	296,907	3
6810	243,573	322	11,622,518	15,201	7.119	0.108	143,444	4	37,503	4
6811	296,237	410	14,763,705	20,377	7.014	0.148	206,538	4	78,244	4
6812	428,353	507	22,581,688	27,675	6.736	0.174	231,221	4	125,826	4
6815	85,769	146	4,527,524	7,725	7.462	0.111	65,646	4	27,437	4
6816	380,308	501	19,356,551	25,461	6.775	0.138	250,555	4	75,493	4
6817	296,639	476	14,314,294	23,331	6.941	0.276	147,587	4	138,188	4
6818	335,656	422	16,589,346	22,243	6.945	0.201	348,375	4	234,534	4
6819	300,728	308	15,306,201	18,168	6.577	0.147	141,041	4	139,526	4
6820	215,525	251	9,472,139	11,838	6.898	0.136	80,000	4	8,217	4
6821	312,631	416	14,141,313	18,517	7.609	0.124	142,417	4	41,408	4
6822	91,831	206	4,788,935	10,575	7.114	0.340	33,964	3	30,077	3
6823	323,084	503	15,499,838	24,793	6.875	0.184	262,633	4	153,808	4
6824	276,947	330	13,052,274	15,748	6.599	0.214	220,064	4	173,987	4
6825	349,679	399	18,319,948	22,058	7.095	0.403	219,440	4	286,365	4
6826	363,852	429	17,227,019	20,996	7.521	0.081	130,763	4	102,143	4
6827	329,850	540	15,988,775	27,537	6.531	0.169	214,915	4	190,859	4
6829	159,861	208	8,606,428	11,262	7.072	0.079	72,004	4	68,592	4
6830	193,490	271	9,416,579	14,768	6.994	0.231	102,170	4	97,708	4
6831	329,304	433	15,768,474	21,132	7.384	0.107	203,095	4	140,770	4
6835	337,946	443	17,603,024	24,059	6.783	0.244	197,662	3	191,899	3
6836	336,371	411	16,462,528	21,063	6.931	0.131	170,574	4	65,285	4
6837	343,592	319	16,968,380	16,269	6.972	0.132	194,631	3	263,596	3
6838	319,065	446	15,437,443	22,795	6.740	0.255	197,590	3	231,172	3
6839	260,595	381	12,477,652	19,098	6.542	0.139	143,513	4	115,561	4
6840	264,446	385	13,033,946	19,164	7.041	0.163	142,843	4	88,136	4
6843	320,067	449	15,755,266	22,654	6.887	0.307	144,989	4	167,577	4
6847	70,185	113	3,221,846	5,370	6.300	0.171				
6848	199,775	335	9,671,412	16,028	7.204	0.186	258,896	4	41,430	4
6854	278,635	350	12,941,311	17,583	6.832	0.108	259,731	4	139,921	4
6855	60,901	150	2,827,272	6,811	6.710	0.101				
6857	59,927	145	2,818,020	6,915	7.085	0.151				
6859	32,350	60	1,555,362	2,957	6.892	0.238				
6865	42,421	84	2,207,751	4,612	6.891	0.284				
6866	189,436	284	9,348,725	14,390	7.007	0.214	114,327	4	85,949	4
6868	304,585	453	14,367,564	24,686	6.541	0.135	227,735	4	113,043	4
6869	313,271	383	15,976,489	19,469	6.871	0.249	162,077	4	135,957	4
6870	284,716	418	13,456,195	20,558	6.943	0.122	193,315	3	101,100	3
6872	56,662	83	2,767,938	3,933	6.783	0.198				
6873	60,021	108	2,817,439	5,041	6.764	0.138				
6880	256,136	326	12,116,817	16,609	6.608	0.176	136,162	4	148,651	4

6882	33,184	60	1,703,576	3,024	6.836	0.198				
6885	32,679	67	1,728,797	3,693	6.997	0.373				
6890	78,335	118	4,223,668	6,516	7.233	0.141				
6892	255,505	439	11,979,354	20,864	6.947	0.387	150,826	4	180,686	4
6895	78,462	142	3,716,147	6,697	6.789	0.096				
6896	105,094	128	4,976,921	5,947	6.319	0.235				
6897	94,994	150	4,524,646	7,401	6.486	0.095				
6899	63,307	91	3,061,763	4,434	6.954	0.127	49,922	4		
7812	92,094	134	4,343,455	6,361	6.960	0.283				
7813	27,639	63	1,302,408	3,077	7.404	0.140				
7814	141,806	171	6,876,934	8,838	6.823	0.242	165,453	4	98,538	4
7815	30,947	85	1,564,587	4,296	6.644	0.221				
7818	58,283	103	3,232,759	5,725	6.699	0.292			27,730	3
7821	36,382	71	1,797,978	3,492	6.879	0.142				
7824	29,344	62	1,408,042	3,005	6.744	0.362	34,165	4		
7826	282,940	328	15,316,111	19,398	7.230	0.157	134,178	4	149,822	4
7830	170,540	309	7,432,447	13,159	6.118	0.132	92,265	4	113,395	4
7833	342,915	408	15,089,495	18,225	7.082	0.070	200,324	4	117,235	4
7834	237,211	314	10,749,917	15,177	7.021	0.216	102,783	4	98,433	4
7835	127,702	408	6,201,980	19,484	7.124	0.160	82,980	4	28,620	4
7836	267,670	355	12,710,783	17,318	6.788	0.152	184,440	4	46,105	4
7838	151,626	302	7,224,971	14,234	6.998	0.078	109,735	4	10,116	4
7839	132,826	241	6,383,435	11,901	6.785	0.370	70,992	4	86,285	4
7845	203,012	292	10,091,756	14,678	6.818	0.196	99,960	4	95,593	4
7855	74,237	126	3,668,802	6,590	6.929	0.353	42,721	4	45,286	4
7877	58,086	79	2,958,994	4,153	6.700	0.146			46,698	4

Exhibit 12: 2012–2013 DCs by Location and Type

Source: Walmart

DC	Location	State	Type
6801	Bentonville, AR	AR	RDC
6806	Cullman, AL	AL	RDC
6809	Mt. Pleasant, IA	IA	RDC
6810	Douglas, GA	GA	RDC
6811	Brookhaven, MS	MS	RDC
6812	Plainview, TX	TX	RDC
6815	Laurens, SC	SC	RDC
6816	New Braunfels, TX	TX	RDC
6817	Seymour, IN	IN	RDC
6818	Searcy, AR	AR	RDC
6819	Loveland, CO	CO	RDC
6820	Brooksville, FL	FL	RDC
6821	Porterville, CA	CA	RDC
6822	Greencastle, IN	IN	RDC

6823	Sutherland, VA	VA	RDC
6824	Grove City, OH	OH	RDC
6825	Menomonie, WI	WI	RDC
6826	Red Bluff, CA	CA	RDC
6827	Woodland, PA	PA	RDC
6829	Hurricane, UT	UT	RDC
6830	Raymond, NH	NH	RDC
6831	Buckeye, AZ	AZ	RDC
6835	Ottawa, KS	KS	RDC
6836	Palestine, TX	TX	RDC
6837	Hermiston, OH	OH	RDC
6838	Marcy, NY	NY	RDC
6839	Midway, TN	TN	RDC
6840	Hope Mills, NC	NC	RDC
6843	Coldwater, MI	MI	RDC
6847	Bedford, PA	PA	GDC
6848	Opelousas, LA	LA	RDC
6854	LaGrange, GA	GA	RDC
6855	Monroe, GA	GA	GDC
6857	Hammond, LA	LA	GDC
6859	Olney, IL	IL	GDC
6865	Harrisonville, MO	MO	GDC
6866	Hopkinsville, KY	KY	RDC
6868	Sanger, TX	TX	RDC
6869	St. James, MO	MO	RDC
6870	Shelby, NC	NC	RDC
6872	New Albany, MS	MS	GDC
6873	Pageland, SC	SC	GDC
6880	Tobyhanna, PA	PA	RDC
6882	Clarksville, AR	AR	GDC
6885	Tomah, WI	WI	GDC
6890	Corrine, UT	UT	GDC
6892	Spring Valley, IL	IL	RDC
6895	Opelika, AL	AL	GDC
6896	Johnston, NY	NY	GDC
6897	London, KY	KY	GDC
6899	MacClenny, FL	FL	GDC
7812	Washington CH, OH	OH	GDC
7813	Casa Grande, AZ	AZ	GDC
7814	Lewiston, ME	ME	GDC
7815	Bartlesville, OK	OK	GDC
7818	North Platte, NE	NE	GDC
7821	Grandview, WA	WA	GDC
7824	Sterling, IL	IL	GDC
7826	Grantsville, UT	UT	RDC

7830	Pottsville, PA	PA	GDC
7833	Apple Valley, CA	CA	RDC
7834	Smyrna, DE	DE	RDC
7835	Alachua, FL	FL	RDC
7836	Sealy, TX	TX	RDC
7838	Ft. Pierce, FL	FL	RDC
7839	Beaver Dam, WI	WI	RDC
7845	Mt. Crawford, VA	VA	RDC
7855	Gas City, IN	IN	GDC
7877	Cheyenne, WY	WY	GDC

Endnotes

[i] For the purposes of this case, we use "fuel efficiency" to refer to a typical measure of miles per gallon of fuel used. We use "fleet efficiency" to refer to Walmart's indicator of the overall efficiency of its trucking fleet, which is measured as the number of cases delivered per gallon of fuel used. An example illustrates the difference: If Walmart increases its pallet configuration and packaging to put more cases in a single truck, overall fleet efficiency improves, because the company is able to ship more cases per gallon of fuel used. However, the added weight of a heavily packed truck might decrease that truck's fuel efficiency, as measured in miles per gallon. Walmart uses the more inclusive measure of fleet efficiency, rather than mpg, to track progress toward its 2015 sustainability goal of doubling the efficiency of its trucking fleet.

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[iv] Ibid.

[v] Scott, Lee. "Leadership in the 21st Century," October 24, 2005. Bentonville, Arkansas. Accessed January 18, 2014 from http://news.walmart.com/executive-viewpoints/twenty-first-century-leadership.

[vi] Humes, Edward. *Force of Nature: The Unlikely Story of Walmart's Green Revolution*, 2011. New York: Harper Collins Publishers, p 88.

[vii] Wagner, Fred. "Heavy-Duty Truck Idle Reduction Technology Demonstrations: 2006 Status Report," 2007. U.S. Department of Energy, Washington D.C.

[viii] Ibid.

[ix] Kabel, Marcus. "Wal-Mart Truck Fleet Rolls Fuel Savings," July 17, 2007. USATODAY.com. Accessed January 18, 2014 from http://usatoday30.usatoday.com/money/economy/2007-07-17-2029804839_x.htm. Kabel interviewed Tim Yatsko, senior vice president of transportation.

[x] Ibid.

[xi] Scott, op. cit.

[xii] Capell, Kerry "Unilever's Laundry Biz Is Greener, and Growing," December 24, 2008. *Bloomberg BusinessWeek*. Accessed January 18, 2014 from http://www.businessweek.com.

[xiii] Kabel, op. cit.

[xiv] Fretheim, Elizabeth. Personal interview, conducted expressly for the development of this case. December 20, 2013.

[xv] Bearth, Daniel P. "Wal-Mart Hits 80% of Fuel Efficiency Goal with Two Years Remaining, Executive Says," October 21, 2013. *Transport Topics*. (Taken from speech by and later interview with Walmart EVP Chris Sultemeier) Accessed January 18, 2014 from http://www.ttnews.com/articles/petemplate.aspx?storyid=33224; Rosser, Tracy. Testimony in a prepared statement to the Congressional 21st Century Freight Transportation Panel, Hearing on How Logistics Facilitates Efficient Freight Transportation Systems, June 26, 2013. Accessed January 18, 2014 from http://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=101006; Kulisch, Eric. "Walmart's Fleet Efficiency: Fuel Savings Help Support Retailer's Everyday Low Prices," April, 2012. *American Shipper*. Accessed January 18, 2014 from http://digital.americanshipper.com/i/60095/41.

[xvi] Walmart. 2008. "Sustainability Progress to Date 2007-2008. Bentonville: http://corporate.walmart.com/global-responsibility/environment-sustainability/global-responsibility-report.

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[xviii] Smith, Jeff. Personal interview, conducted expressly for the development of this case. December 30, 2013.

[xix] Gaines, Linda, Anant Vyas, and John L. Anderson. "Estimation of Fuel Use by Idling Commercial Trucks." Argonne National Laboratory, Paper No. 06-2567. University of Chicago

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[xxi] Doraiswamy, Prakash, Wayne T. Davis, Terry L. Miller, Nicky Lam, and Paul Bubbosh. "Air Quality Measurements Inside Diesel Truck Cabs During Long-Term Idling," *Transportation Research Record: Journal of the Transportation Research Board*, Volume 1987/2006 Air Quality 2006, 82-91.

[xxii] Erard, op. cit.

[xxiii] Ibid.

[xxiv] Professional Truck Driver LLC, "Why Not Pay Hourly For Truck Drivers?" blog post from the American Trucking Association Management Conference and Exhibition in Orlando, Florida, October 19-22, 2013. ATA Chief Economist Bob Costello, Jeff Fackler, vice president of transportation, Wal-Mart Stores Inc.; Derek Leathers, president & COO of Werner Enterprises and Steve Gordon, COO of Gordon Trucking Inc. spoke in a panel discussion on driver issues moderated by Dave Osiecki, ATA senior vice president of policy and regulatory affairs. Accessed January 18, 2014 from http://professionaltruckdriverllc.wordpress.com/2013/11/17/so-why-not-pay-hourly-for-truck-drivers/

[xxv] Although the drivers are domiciled with particular DCs, when they went out on the road, they might be dispatched to service stores from many different DCs. The drivers were dispatched from a central location in Bentonville. Dispatchers determined the best and most efficient routes, based on driver locations.

[xxvi] Walmart. 2011. "2011 Global Sustainability Report. Bentonville: http://corporate.walmart.com/global-responsibility/environment-sustainability/global-responsibility-report.