MHX
SAFE TIMELY ACCURATE

MHX Final Report
MSRC ON-ROAD
MS21017

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Executive Summary

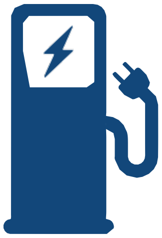
The MHX Electrification Strategy and MSRC On-Road Project MS21017 Final Repot

There are two basic operating models in the trucking industry: last-mile operations like MHX, in which cargo capacity is the priority, and the "truck stop" model, in which distance is the priority. When electrifying fleets, last-mile operations benefit from charging at all origin and destination points visited within a confined geography to allow for smaller batteries that don't compromise maximum cargo capacity, while long routes need very large (and therefore heavy) batteries.

The aim of MHX 's Electrification strategy focuses on the Last-Mile model as representative of our business. Through the implementation of our Pilot fleet of 10 Kenworth T680E's and 3 EVgo DCFC Delta 350kW Charging infrastructure at our anchor facility in Fontana, Ca, we will gain a thorough and practical understanding of how these vehicles operate and perform in the field, needed shifts in operational philosophy in planning ZEV's vs Diesel, the expertise that is needed to maintain them, the required charging infrastructure needed and the ability to scale this infrastructure as we grow and target the complete replacement of our current diesel fleet of 75 Heavy Duty trucks in California and ultimately, the capital required to execute this plan.

What we learned during this first phase of the pilot is that purchasing trucks is the easy part. The real challenge in understanding and then implementing a ZEV fleet falls in 6 major categories: range constraints, charge time constraints, magnitude and time-of-use of electricity needed to operate each truck, truck weight and the impact on cargo capacity, the cost per mile of that electricity in comparison to that of diesel and finally, the lack of availability and long lead-times required for utility companies (SoCal Edison in our case) to provide the needed infrastructure to supply the electricity. The following pages elaborate on each of these challenges and how we addressed, overcame and in some cases, are still working through them.

Range, Charge Times and Max Electricity Demand



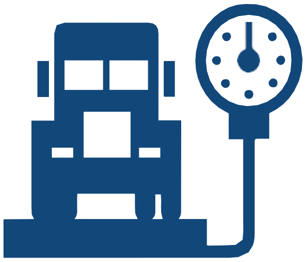
Drayage and last-mile operations like MHX are typically round-the-clock activities, which makes it difficult to schedule adequate time to recharge large batteries. We slip-seat our trucks so each one in our fleet runs 22 hours per day leaving a theoretical window of 2 hours to recharge. In our case, the Kenworth T680E's have a 396kWhr battery and a stated range of 150 miles, thus 2.64kW/mile "fuel economy". The battery charges at a rate of 120kW thus taking ***3.3 hours to fully charge*** as compared to a diesel truck that takes 10 minutes to refill and has a range of 600 miles. For diesel, fill up is never a consideration for operational planning, however, you can see that re-charging an EVvtakes a considerable amount of time, which *is* critical to our operational planning and strategy for deployment. Since we do not have the time needed to recharge at the end of the day, not to mention the extremely high utility demand of ***1.2 mega watts*** (power not available from SCE) to plug in everything all at once, we had to rethink our philosophy and mindset of "how we run trucks".

In our case, our facility holds the inventory, so it is the origin of all loads: we are hub and spoke model. We pick up at our facility, deliver to our customer, and then drive back to our facility to pick up the next load. The process to load one of our trucks is to drive through a specific loading bay and wait approximately 15 minutes while the load is placed on the truck. The driver then pulls out of the bay and goes to a specific area to secure that load, taking an additional 15 minutes.

We saw an opportunity to capture a charging event during the loading and securement process! Hence, we devised an ***Opportunity Charging*** strategy, the conclusion is that, instead of "filling up in one shot like a diesel truck", we need to re-think the way we view fueling and take little sips of "fuel" all day long during each trucks plan. Each truck plan will consist of about 6 loads per day, resulting in 3 hours of combined charging opportunity, leaving about 20-30 minutes of "top-off" charge at the end of the day to reach full charge; very doable. With this epiphany, we designed our charger layout accordingly and placed a charger in the loading bay, the securement area and a third charger in the truck parking area for "top-off" at the end of the 22 hr day.

With this strategy, we solved the charge time problem as well as the max facility demand of 1.2MW of power that a) was not available, b) would take Edison years to put in c) would be cost prohibitive from a utility rate structure and finally d) wouldn't scale as our fleet grew!

Weight Problem



While the current focus of vehicle electrification is typically on maximizing range, MHX's journey has cast a light on the other side of the coin -- battery weight. Battery weight is the single heaviest component of an electric truck, adding several thousand pounds more than diesel trucks, with total additional weight dependent on battery size and resulting range.

Like many drayage and intermodal transportation operations, profitability is linked to the maximum allowable weight transported. MHX trucks operate along the designated heavyweight corridors, which allow a maximum gross vehicle weight (GVW) of 95,000 pounds, and inland locations like Fontana, where the our 10 Pilot Program trucks are operating, allow a maximum GVW of 80,000 pounds (with a 2,000-pound allowance for zero-emission trucks).

Added weight from batteries exceeds the 2000-pound electric truck allowance, which therefore reduces cargo capacity to operate within weight limits. At typical day-cab diesel truck weighs 16,000 lbs, while our T680E's weigh 22,000lbs resulting in a 4,000lb net reduction of cargo. This in turn causes the cost per delivered ton to increase as more trucks will be needed to deliver the same tonnage. Customers will not want to subsidize this extra cost, meaning the added cost burden will fall on carriers like MHX. MHX and other carriers would be forced to either cut rates or lose business to a diesel carrier until California has fully transitioned to ZEVs. While emissions will be reduced by using ZEV's, there will be more trucks on the road due to decreased cargo capacity, resulting in increased traffic congestion and road degradation. MHX's experience informs the need for California agencies including Caltrans and CEC to evaluate increases to truck weight limits. This could solve the price/rate and congestion issues as well as minimize the road degradation issue relative to additional truck loads.

Another solution to this problem is to reduce battery size. This seems to be in direct conflict to the current OEM design strategy, however, as noted in the introduction, there are really two trucking models, Long Haul and Last mile. These two models might benefit from a truck design that is configured to the specific needs.

Since last-mile runs are relatively short, distance is not the concern, but weight is. MHX is in conversation with truck original equipment manufacturers (OEMs) about designing and deploying smaller electric battery packs as an option to reduce the weight of tractors, and therefore maximize freight ("payload") capacity. Downsized batteries have environmental benefits as well, including requiring the mining of fewer minerals such as cobalt and lithium, helping to mitigate a growing global supply concern. This developmental process will take years, so it is not an immediate solution to the battery weight vs. carrying capacity conundrum. In the mean-time, we will deploy small fleet of light weight, all-aluminum trailers that will be used to off-set *some* of the cargo capacity lost by the added ZEV Truck weight. With that interim solution in place, we hope that we can continue to serve our customers profitably while reducing additional truck congestion caused by the increased EV truck weights.

Fueling vs. Charging Costs

MHX analyzed how pricing for vehicle fueling may change based on existing and new electricity rate schedules compared to diesel costs. Our target fueling cost is $1.18/mile to be at parody with Diesel; this is our break-even cost, all-in including charging infrastructure. Substantial savings can be realized from replacing high-cost diesel with relatively lower-cost electricity, but there is significant variation in utility Time of Use (TOU) and demand charge schedules that affect the relative economic advantage of electrification. Also, it is clear that Grant Funding is a critical component to a cost-effective charging solution that allows us (and others like us) compete with diesel. Note: without grand funding, charging infrastructure would throw the all-in cost per mile well over that of diesel and significantly slow ZEV adoption in any meaningful or impactive way to the electrification goals of set by California.

MHX has two SCE program options, CRT or Rule 29, for deploying a dedicated electric truck charging meter. The specific rate depends on the total load connected to the meter. Under CRT, demand charges were waived until 2023, with charges gradually increasing by 16% per year until reaching the full rate in 2029.

MHX created a smart charging assessment to minimize electricity costs associated with the deployment of electric vehicles and EV infrastructure. ***MHX's Opportunity Charging*** strategies include avoiding charging electric trucks during high time of use (TOU) rate times (4-9 pm), and scheduling charging to minimize the number of trucks charging at one time to reduce the total demand from the existing MHX facility load, combined with new truck charging load. MHX plans to distribute charging among facilities as we grow its charging node network and limit depot charging to no more than two trucks at a time to keep the combined demand of the facility and truck charging under 500 kW, which allows MHX to utilize SCE tariffs that have lower demand charges than tariffs when total demand exceeds 500 kW. Our next step which is to install a solar micro grid with battery storage system to function for demand peak shaving and power deployment during the high rate, time of use period between 4:00pm and 9:00pm. This will support our cost per mile structure while taking demand off the grid during this critical window.

In addition, we are in talks with key customer delivery locations to partner on charging infrastructure which would allow us to Opportunity Charge at the destination as well as our origin facilitates. This would further increase our range while reducing max demand on the grid and support our ZEV targets as we scale.

Ultimately, we believe that we will be able to achieve under $1.00/mile with our current ZEV charging strategy, which we will test now that the first phase of our project is complete. The solar micro-grid with battery storage will support our fleet as we scale and ensure that we maintain the targeted better-than-diesel cost per mile needed to continue adoption.

Wait Problem (Infrastructure Interconnection Delays)

The utility deployment strategy has been one of the most challenging and time-consuming components of this project, including analyzing required electrical capacity upgrades, supply chain issues, rate considerations, cost estimates, and energy modeling. Initially, MHX explored utilizing the Southern California Edison (SCE) Charge Ready Transport (CRT) program, but the CRT would have taken 12-18 months from program application to deployment, jeopardizing our truck delivery times, and thereby delaying putting new electric trucks in service. The opportunity would be over $4 million per year in lost revenue. In other words, the infrastructure costs that would have been saved through participation in CRT do not compensate for the delayed deployment of revenue-producing trucks.

MHX subsequently explored using California Public Utility Commission (CPUC) Rule 29, which allows SCE and other California utilities to pay for utility-side electric infrastructure. However, MHX faced a 50-week lead time to obtain new switchgear that would be required to comply with the Rule 29 approach. Like the expected implementation delay from participating in Charge Ready Transport, utilizing Rule 29 would also incur opportunity costs from not putting new trucks into revenue-generating service. Therefore, MHX chose a traditional route for upgrading electrical service, using CPUC Rule 16, in which it could use its existing switchgear that luckily, would be sufficient for this project along with some additional growth, but would incur higher utility and customer-side infrastructure costs.

Following its Rule 16 application, MHX has encountered significant delays ***despite*** having all necessary infrastructure on-site. Although plans were approved in six weeks starting in October of 2022 by San Bernardino/Fontana Building and Safety, MHX was slowed in proceeding due to the need for a transformer upgrade, which had been identified by SCE early on and deemed "not an issue "and not a long lead-time item. However, even though applications were submitted at the same time as building permits, due to internal issues at SCE, MHX worked to secure an engineering site visit for six months. Finally, SCE completed this visit and we were able to move forward with necessary design changes and transformer ordering, which at that time was now deemed to be ***"a long lead-time item".*** The delay from SCE in reviewing and approving the new transformer cut into the faster time to deploy calculation, jeopardizing business revenue opportunities that would outweigh additional utility infrastructure investment costs. Delay in approving and building electric infrastructure was a dominant theme at the 2023 Advanced Clean Transportation Expo in Anaheim, CA. To address this problem, MHX met with former leadership of the California Public Utilities commission to discuss regulatory and legislative remedies to electric infrastructure interconnection delays. Recommended solutions include new regulatory requirements to process requests in a timely manner and/or supporting utility expenditures to hire additional staff to manage and expedite electrification projects. In the end, we finally received our transformer upgrade after 13 months from application submittal and are now fully deployed. ***Availability of existing power and the need for Utilities to deploy new infrastructure is the current and major structural roadblock to timely ZEV implementation. It's a problem that money through company CapEx and/or subsidized by grant funding doesn't solve.***

Conclusion & Next Steps

MHX's ZEV Strategy was developed on the theoretical knowledge gained in partnership with our OEM's over the past two years. With the completion of our10 truck pilot project, we can now begin putting our collective theoretical knowledge to the test and apply those findings to our Strategy moving forward. Concurrently to our operational testing, we will also include the following action items:

1 Pilot Program and Testing

The ability to rapidly incorporate data from existing pilot demonstrations (both MHX's own demonstration and those conducted by others) is critical to a successful and lasting ZEV planning process. Upon deployment, MHX will test the performance of its zero-emission trucks in real-world conditions, and develop a full fleet transition timeline based on this data and experience.

2 Strategic Planning

Upon completion of this pilot program, MHX will determine zero-emission vehicle and infrastructure deployment phasing and timeline for the rest of our fleet and facilities. This will include forecasting short and longer-term ZEV transitions, in consideration of technology choice (BEV or HFCV), financial resources, and electrical utility allocations. The plan will include a determination of the end of useful life for individual fleet vehicles to plan for expected replacement dates.

3 Energy Infrastructure

MHX will use the findings from the pilot project to develop a timeline and deployment plan for distributed energy resources (DERs) such as solar and/or Battery Energy Storage Systems (BESS). This will help offset increasing electricity consumption, manage demand, and maximize the value of LCFS credits generated. While the return on investment for solar-only projects under the new CPUC solar billing framework is not as attractive as it was under NEM2, solar + battery systems still offer attractive financial and resiliency benefits. NOTE: This is well under way.

4 Charging and Refueling Infrastructure

MHX will coordinate its investments in charging and/or refueling infrastructure with stakeholders, including at transportation hubs, such as ports, warehouses, and railyards. These efforts will include an in-depth investigation of the merits of inductive versus conductive charging, as well as the potential future role of FCEVs and fueling infrastructure. Last mile logistics operators throughout the LA Basin hauling heavy loads would all benefit from a charging node network that enables trucks to deploy smaller/lighter battery packs, with opportunity charging available throughout the intermodal system.

5 Funding Capture

MHX will create a funding capture plan to enable it to take advantage of government incentives for zero-emission trucks and infrastructure for its full fleet conversion of 75 trucks, such as tax credits and grants, to help offset the higher upfront costs of purchasing and deploying electric trucks.

6 Driver Training and Recruitment

MHX will develop a training plan for drivers on the operation and maintenance of zero-emission trucks, and use its commitment to zero-emission trucks to help recruit new drivers.

7 Research and Development Partners for Innovative Technology Deployment

MHX will continue to collaborate with other stakeholders, such as truck manufacturers, charging infrastructure providers, and partner fleet operators to create innovative technological solutions to the variety of challenges that are referenced in this report. These strategies include:

- Reducing vehicle battery capacity, and therefore weight, to maximize load weight and profitability.
- Partnering with vehicle OEMs to develop a short-range, lighter weight BEV with smaller battery capacity to serve drayage and last-mile logistics freight operators.
- Joint research and development efforts, sharing best practices, and communication of industry needs with technology providers.

8 Chart a Pathway to a Full Zev Fleet Transition

MHX plans to deploy charging infrastructure to support electric trucks at each of its key facilities. This charging node-network will be deployed next at our primary facility in Carson, Ca which supports operations in the Port of Long Beach/LA.

9 Maximize Return on Investment

The transition to zero-emission vehicles and equipment requires significant upfront investments. but is expected to yield considerable fuel, maintenance, and other savings long term. ***However, without grant funding, the ROI on truck electrification and charging infrastructure is very poor, thus continued funding is critical***. MHX's ability to scale its fleet is wholly contingent on additional funding, which is currently in supply from a variety of sources for early adopters.

10 Lobbying/Coalition Building/Advocacy

MHX will participate in lobbying and coalition-building efforts with its partners to create a supportive environment for zero-emission truck deployment. This includes engaging with utilities, policymakers, industry stakeholders, and other key players. MHX and its partners will hold discussions with policymakers and The California Department of Transportation (Caltrans) to inform them of the challenges associated with heavy-weight transport by electric trucks.

By following this path, MHX can successfully build on its initial pilot deployment of zero-emission trucks and contribute to a more sustainable future. By working with other stakeholders Southern California's intermodal transportation sphere, we can build a comprehensive strategy for transitioning to zero- emission trucks at transportation hubs, and help lead the way in creating a more sustainable future for the transportation industry.

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