

WILL ELECTRIC CHARGE AHEAD OF DIESEL?



UPNEXT
DRIVING TRANSPORTATION FORWARD

INTRODUCTION

During the last several years, alternative fuels have been a hot topic in the trucking industry. Some of these have the potential to offer significant benefits, not just to the environment, but to the bottom line of many in the industry.

More recent discussion has been on electric-powered vehicles – the technology, capability of suppliers, and infrastructure. The opportunity of electric has invited new entrants into the industry. At International Truck, we welcome these new entrants, and believe closer evaluation is needed for us to make informed decisions about how to drive the industry forward.

Within this point of view, we're going to delve further into the potential of electric trucks and the need to come together, as an industry, to drive change.



AS IMPORTANTLY, THERE ARE LARGER QUESTIONS AND ISSUES REGARDING THE FUTURE OF THE INDUSTRY THAT HAVE ACCELERATED THE CONVERSATION ABOUT ELECTRIC.

- Is electric viable today for use in commercial transportation?
 - When will electric battery costs reach parity with diesel?
 - What about the charging and maintenance infrastructure?
 - Will low residual value and other risks associated with electric vehicle technology slow adoption?
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As a leader in the trucking industry, International Truck understands the questions and concerns of those invested in the future of the industry, as well as our own company stockholders. In this point-of-view (POV), we intend to do more than just evaluate claims within the marketplace by new competitors. We aim to elevate the discussion and offer a more pragmatic view of the future of our industry, as well as an overview of the International Truck roadmap to electric.

In doing so, we want to do more than just demonstrate our continued commitment to innovation and leadership in trucking. We hope to move the conversation away from distraction and disruption, and focus it on unlocking the potential of this exciting technology in a strategic way that makes sense to all our customers, suppliers, and stakeholders.

CONTENTS

01

THE SHIFT TO ELECTRIC 2

02

UNDERSTANDING ELECTRIC TRUCKS 3-4

03

THE REAL FACTS AND 4 ISSUES YOU CAN'T IGNORE 5-8

04

THE INTERNATIONAL TRUCK APPROACH TO ELECTRIC 9-13

05

CONCLUSION..... 14

THE SHIFT TO ELECTRIC

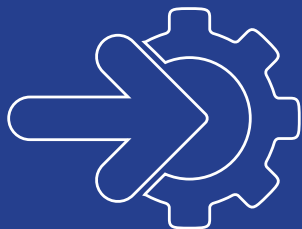
Disruption is a good thing. Every industry benefits from disruption, and trucking is no different. Disruption shakes things up. It separates the innovators that truly embrace the opportunity to transform an industry from those that will soon be on the outside looking in.

As an industry leader, the International Truck family – customers and supplier partners – has a huge stake in what’s happening today as we trailblaze into an electric transportation ecosystem. Failing to acknowledge the inevitability of electric vehicles would be what Ted Levitt, editor of the Harvard Business Review, called “marketing myopia” back in 1960. Referring to the railroad industry, he said: “The industry is

failing because the people behind it assumed they were in the railroad business, rather than the transportation business.”

In other words, they were too tied to the exact way they’d been doing things, and not enough to what their customers needed. As a result, they didn’t foresee the impact of new technologies that did a better job of meeting those needs. We run the same risk in trucking if we don’t acknowledge today that it’s not a question of “if” but “when” electric could be a dominant energy fueling commercial vehicles within specific applications in the (relatively) near future.

AN INDUSTRY SHIFT



Yes, in our view, there’s no question that electric will cause a giant industry shift. This shift isn’t due to the novelty of electric vehicles, but is being driven by forces like emission standards, air pollution, increasing urbanization and traffic congestion, growing truck driver shortages, and advances in vehicle technologies. And, of course, electric trucks have an immense potential to save fleet owners a lot of money in fuel and maintenance costs.

In short, there are many powerful factors that make electric trucks (and buses) a sensible and logical choice.

UNDERSTANDING ELECTRIC TRUCKS

It's important to understand the fundamental nature of this new technology and its potential impact on our industry. There are some unique factors that make electricity as a commercial vehicle power source both advantageous and problematic.

IS A LONG-HAUL BATTERY VIABLE?'

Let's look at a concrete example of the impact of an electric battery on cargo.

Let's say you have a truck with a maximum allowable cargo weight of

59,525 LBS

To get your load to its destination, it would require a battery weighing

55,116 LBS

Such a large battery would also take too long to charge with current technology

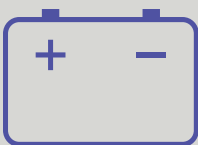
12 HOURS OR MORE

You need to haul the load

621 MILES

That means you could only haul

4,400 LBS



IT'S NOT THE TRUCK. IT'S THE BATTERY IN THE TRUCK.

If you look past the novelty and sleek designs of electric truck prototypes and schematics, it's vital to understand that the development of battery technology will continue to be the main driving force behind industry change. The pace of battery technology evolution will have a direct impact on the speed at which electric truck adoption will occur.

THERE ARE THREE FACTORS THAT ARE CRUCIAL FOR BATTERY TECHNOLOGY USE IN COMMERCIAL VEHICLES TODAY.



COST

Although battery prices continue to drop, they have not reached parity with diesel, nor are they expected to for at least a few more years. Some analysts predict prices are headed below the magic \$150 per kilowatt-hour in the next decade. Some say the supply base could approach \$100/kWh by 2025, making electric vehicles at parity with diesel.



RANGE

While some in the industry have claimed a 500-mile range for their planned semi, multiple variables should be looked at closer. Load, speed variability, traffic congestion, extreme weather conditions, cabin heating in cold weather, and other factors have a significant impact on battery range.



CHARGING

Besides the viability of a charging infrastructure for commercial vehicles, the current technology requires an immense amount of electricity. In addition, any fast-charging technology would generate heat that may adversely impact battery life.

Despite this primer on today's battery technology limitations, make no mistake - International Truck is bullish on electricity. We believe battery technology will advance and eliminate many of these limitations along the way, and we intend to be a major player in its advancement. Nevertheless, it's important that our customers understand this evolving technology and these vital factors in their current state.

THE REAL FACTS AND 4 ISSUES YOU CAN'T IGNORE

To get a full and accurate picture of what is possible with electric vehicles for our industry, it's important to take a close look at operational factors that impact electric vehicles.

International Truck welcomes new innovations in our industry and simply wants to offer greater clarity in the beginnings of an industry shift to electric trucks.

1 LONG-HAUL RANGE

We've already covered some of the challenges regarding the range of electric batteries as we know current capabilities, but a deeper dive is needed as we look at other relevant operating factors such as:



Real-life speed variability on even the clearest of routes



The impact of additional loads on range, such as HVAC needs



By our estimates, auxiliary loads alone can reduce range by 15 to 20 percent on average



Extreme weather conditions that can have a significant impact on battery range

One new entrant initially claimed their semi could travel 500 miles. The battery energy required for a semi to travel 500 miles is 1,500 kWh (kilowatt-hours). However, this can be deceiving, since only a portion of the battery's capacity can be used when a vehicle is in operation. Instead, you must consider usable energy, which refers to the amount of a battery's energy that can actually be used over the state-of-charge (SOC) range.

Considering the factors above, 80 percent of SOC (or 974 kWh installed) is a more realistic range for class 8 trucks. That puts the 500-mile range of this semi at 400 miles at best.

2 INFRASTRUCTURE

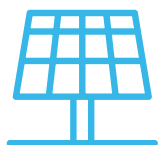
The lack of a charging infrastructure that can support long-haul routes is a chief concern among trucking industry analysts. Charging stations that allow trucks to “fill up” on electricity or swap out batteries along well-travelled routes simply do not exist, with no immediate plan for breaking ground on a single facility.

So, clearly a true network is needed. Yet there are many formidable challenges to building a network of “superchargers” capable of fueling class 8 trucks.



3 COST

There are many unknowns when calculating the potential cost of a viable charging station network throughout the most frequented corridors around the nation. However, most experts say it would be a huge financial investment – likely in the hundreds of millions or even billions of dollars.



SOLAR

When looking at how charging stations would get their “juice” for charging an immense truck battery, solar power is a potential option. Yet, given the amount of energy needed for a single truck charge, an array of solar panels simply would not suffice. Some estimate that a “solar farm” spanning many acres would be needed to power a single station. Obviously, this adds a substantial amount to the costs not mentioned above, in terms of both real estate and solar panel technology.



THE ELECTRICITY PIPELINE

Assuming charging stations cannot be powered entirely with solar energy, most facilities would need to be supplemented with an electrical pipeline of some sort. The availability of electricity nationwide is not an issue. However, the availability of pipelines offered by regional utility companies where stations will be located could become an issue.



CHARGING TIME AND TECHNOLOGY

For the charging stations to be viable for truck drivers, charging times would have to be reasonably fast to avoid delays. Again, the amount of energy transfer needed for a single rapid charge for a class 8 truck battery would generate heat. To our knowledge, no charging technology exists that can do this safely. Battery swapping may be another option, but strict protocols would have to be in place for the safe removal and install of a new battery – also not likely to be a fast turnaround.

Although we’ve focused on a nationwide charging infrastructure to support a long-haul rig, we also can’t ignore the need to have a dealer and service center network. To ensure uptime, access to nationwide locations for proper vehicle maintenance, speedy repairs, and prompt parts delivery is essential.

RESIDUAL VALUE VERSUS LIFECYCLE COSTS

The downside of electric vehicle technology, as evidenced by plummeting resale prices for used electric passenger cars, is the potential lack of residual value. (According to Kelley Blue Book, the 2011 Chevy Volt depreciated by 58 percent in just three years.) Long-haul truck operators place potential resale value as a priority, but once the electric technology in a purchased truck has been surpassed by newer models that can go longer at lower costs, and with greater efficiency and safety, residual value becomes a big issue.



Battery life may be a challenge too. It's very possible that the life span of batteries for long-haul vehicles may not exceed single digits - far shorter than the typical life of a tractor-trailer. Once a battery is dead and needs to be replaced, that's a hefty cost that could very well cut into margins for fleet operators.



Of course, many electric vehicle owners choose to lease for exactly this reason, and it's very possible fleet owners will opt for that route with electric trucks. However, leasing agreements hinge on the risks associated with residual value.



So, let's say a fleet owner wanted to lease a large number of long-haul electric trucks with a high initial price tag. Yet, there's the looming prospect and likelihood of low residual value just a few years down the road. Because these are the first generation of mass-produced long-haul electric rigs to reach the market, there's little for appraisers to go on (and they hate uncertainty). What bank or financial institution would be willing to take on that kind of significant risk?

4 UPTIME

At International Truck, we understand the importance of uptime to our customers. So, we'd be remiss if we didn't address quality control and production issues recently reported in the press with some electric vehicle manufacturers.

For many decades, production and quality control in the automotive industry has continued to evolve and improve to the point where we know what works and what doesn't. Proven processes, such as Advanced Quality Product Planning (AQPP), are executed industry-wide to help avoid product flaws that could result in

breakdowns and mechanical errors. Production lines rely on highly experienced employees with expertise in these processes who know how to make a vehicle that's highly dependable.

We believe it's important for electric vehicle manufacturers to implement quality control processes and procedures within their facilities. As electric begins to transform our industry, it's important to learn the lessons from the passenger car industry, and adapt so we're delivering quality products to our customers on day one.

THE INTERNATIONAL TRUCK APPROACH TO ELECTRIC

At International Truck, our overall view on electric trucks is very positive. And we understand that new players, emission standards, subsidies, and cost of battery parity will set the pace for this shift and lead the industry to electric.

But it's our customers and stakeholders that are our highest priority. Thus, our approach to electric can be described as methodical and pragmatic, not disruptive or distracting. And our strategies are designed to set our customers up for greater cost savings and efficiencies with electric trucks, versus exposing them

to unnecessary risk and potential downtime. As importantly, our strategic alliance with Volkswagen Truck & Bus is vital to accelerating our progress in electric commercial vehicles.

KEY TO SUCCESS: VIEW IT AS AN ENTIRE ELECTRIC ECOSYSTEM

It's easy to get caught up in all the hype of a sleek, new electric truck. Our view is more holistic. International Truck believes that success in transitioning from diesel to electric in the trucking industry depends on addressing the major components of an entire electric ecosystem.

COMPONENTS OF AN ELECTRIC TRUCK ECOSYSTEM



PRODUCT (ELECTRIC TRUCKS)

- VIABLE RANGE
- RELIABLE
- LIGHTWEIGHT (FULL-LOAD READY)
- LOW ADOPTION COSTS
- REASONABLE RESIDUAL VALUE



OPERATIONAL REQUIREMENTS

- DIFFERENT THAN DIESEL, SO THE INDUSTRY WILL HAVE TO ADAPT
- DRIVER TRAINING
- VIABLE LEASING OPTIONS FOR FLEET OWNERS
- PARITY WITH DIESEL (OR LOWER COST)



CHARGING INFRASTRUCTURE

- NATIONWIDE NETWORK ALONG MAJOR ROUTES
- FAST AND SAFE CHARGING
- COMPATIBLE WITH ALL ELECTRIC VEHICLES



PARTS AND SERVICE NEEDS

- SUPPLIERS WILL HAVE TO REINVENT THEMSELVES
- MAINTENANCE COSTS MAY BE LOWER
- MODULAR APPROACH TO SERVICING AND PARTS

OUR METHODOICAL AND PHASED APPROACH

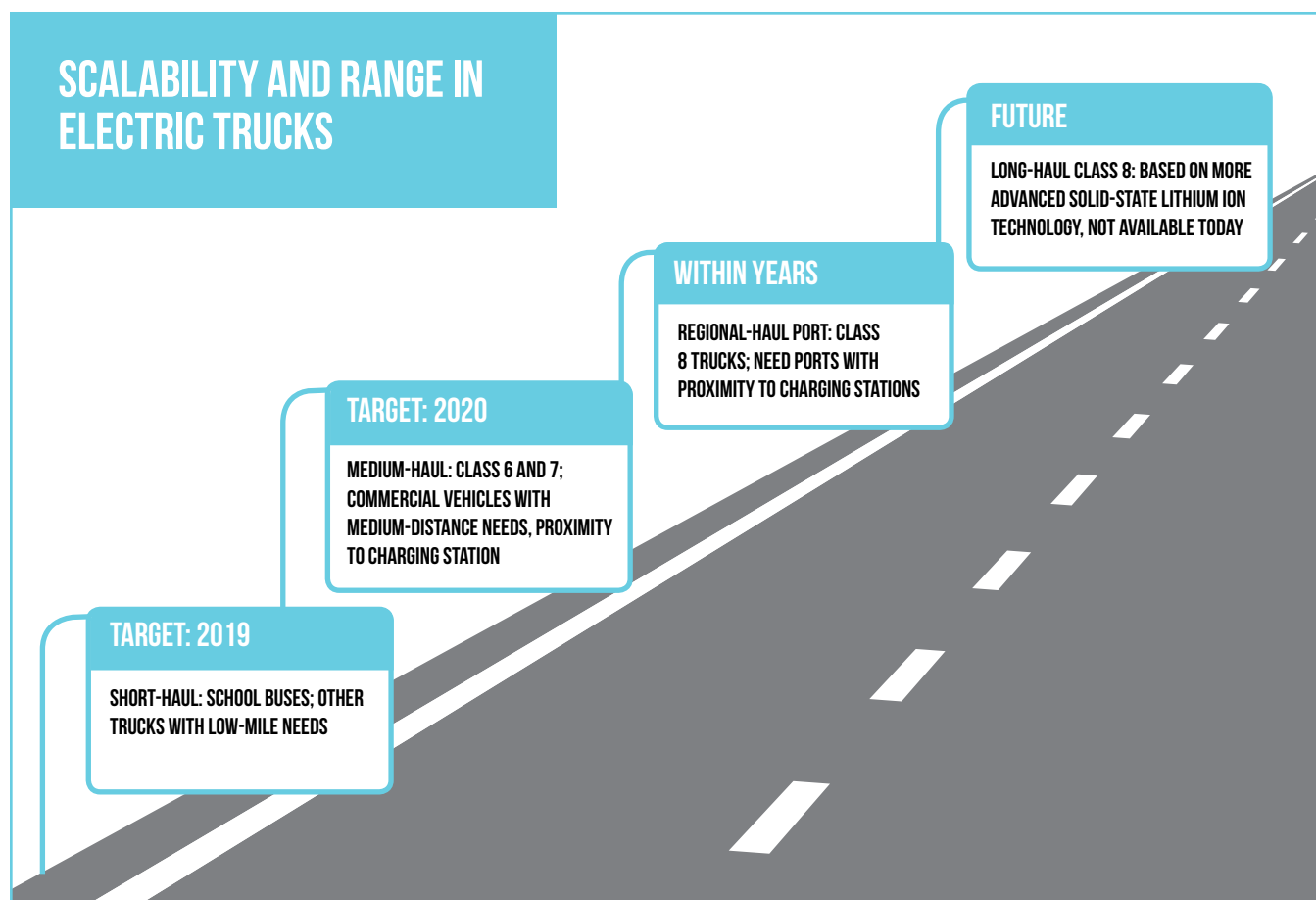
We believe in a methodical and phased strategy to transitioning to electric. We look at this process as building a new business model, as opposed to just a product strategy. This approach hinges on leveraging the scalability of electric for trucking in a way that makes sense, as well as designing vehicles that allow for cost-effective adoption in the short-term.

SCALABILITY AND PRIORITIZATION

One of the key advantages of electric vehicle technology is its ability to scale to meet the different needs and ranges of commercial vehicle applications on the road today. At International Truck, we believe scalability should be an inherent part of the roadmap to an electric future.

This implies testing shorter-range electric commercial vehicles in real-world situations, such as school buses. These vehicles are also vulnerable to substantial battery drainage in colder climates due to the constant opening and shutting of the door which puts a strain on HVAC systems. Such real-world testing is needed to determine the impact on battery range and life span.

From there, we believe electric class 6 and class 7 commercial vehicles become even more feasible.



CONVERSION VERSUS GROUND-UP DESIGN

Another important aspect of scaling up is leveraging current truck designs for conversion to electric as a stepping stone to vehicles designed from the ground up to run on battery power.

Of course, we understand the advantages of designing an electric truck from the ground up, and it's in our roadmap. Ground-up design allows for the true optimization of electric technology, and will help to fulfill its ultimate potential and promise. Yet, conversion vehicles simply provide a sensible and pragmatic approach for our customers during this relatively new technology phase. Best of all, it allows fleet owners to “dip their toes” in electric without incurring substantial adoption costs.

BUILDING AN INDUSTRY CONSENSUS

There's a lot that must happen in the trucking industry along the commercial electric journey. If the trucking industry is going to seamlessly and methodically transition, we must build consensus on several fronts. Questions abound...

- Will the industry be willing to come together?
- Can we all agree on new standards?

International Truck is committed to leading the way in adopting industry standards, collaborating on a viable infrastructure, and helping to create an efficient electric truck supply chain.

ESTABLISHING STANDARDS

We intend to support policies and standards that help all stakeholders in the industry not just comply with federal and state regulations, but accelerate the industry towards greater efficiencies and safety. Battery and energy storage capacity and handling need to be governed by standards that ensure the safety of not just truck drivers, but every person that touches an electric truck in the production and supply chain.

STANDARDS NEED TO APPLY TO VITAL AREAS SUCH AS:



VEHICLE DESIGN



POWER SYSTEMS



CHARGING



MAINTENANCE & REPAIR

INFRASTRUCTURE COLLABORATION

Creating an infrastructure grid for charging and other operational requirements that is compatible with all electric trucks is a crucial piece of the puzzle. Building and maintaining separate charging station networks for each trucking manufacturer would come at a tremendous cost to customers and shareholders.

International Truck encourages the active participation of all stakeholders, including state government and regional utilities companies, in helping to design and build a brand-agnostic charging infrastructure that offers affordable, safe, and rapid charging for truck drivers and fleet owners. State transportation authorities and port officials recognize the value electric trucks bring to minimizing pollution, and utilities see this as an opportunity for another form of revenue. We believe there's a way for all interested parties to collaborate to build a viable charging grid for all electric trucks.

We also encourage innovation in the development of new product-agnostic charging technologies. An example of this is a testing program in Colorado of road-embedded technology capable of charging batteries while driving (using third-party technology that can be retrofitted on any electric truck).²

SUPPLY CHAIN COLLABORATION

The transition to electric trucks will have radical implications for logistics supply chains, likely revolutionizing today's delivery systems. Sustainability, safety, cost-effectiveness, and greater efficiencies mean huge supply chain benefits. Carriers and shippers should be prepared for this transition by investigating new strategies and scenarios that involve electric trucks. The next generation supply chain will certainly have to adapt and evolve to accommodate electric trucks.

OUR PARTNERSHIP WITH VOLKSWAGEN TRUCK & BUS

In 2017, Navistar finalized a strategic alliance with Volkswagen Truck & Bus to allow us to move much quicker into electric propulsion. With Volkswagen Truck & Bus's level of expertise in alternative drivetrains, the strategic alliance puts International Truck in an ideal position to lead the trucking industry into the electric future.

The Volkswagen Truck & Bus partnership helps us to leverage their substantial technology innovations and components in segments of the market where International Truck is already a leader. In addition, it helps us increase our global scale, strengthen our competitiveness, and provide our customers with expanded access to cutting-edge products, technology, and services.

VOLKSWAGEN TRUCK & BUS'S STAKE IN ELECTRIC TECHNOLOGY:

- THEY PLAN TO INVEST \$1.7 BILLION IN INNOVATION AREAS BY 2022, WHICH INCLUDE CLEAN DRIVING, AUTOMATED DRIVING AND CONNECTED DRIVING.
- INTERNATIONAL TRUCK AND VOLKSWAGEN TRUCK & BUS PLAN TO LAUNCH A MEDIUM-DUTY ELECTRIC TRUCK IN NORTH AMERICA, CURRENTLY IN TESTING, BY LATE 2019 TO EARLY 2020.

WITH VOLKSWAGEN TRUCK & BUS'S EXPERTISE IN ELECTRIC, THE STRATEGIC ALLIANCE PUTS INTERNATIONAL TRUCK IN AN IDEAL POSITION TO LEAD THE TRUCKING INDUSTRY INTO THE ELECTRIC FUTURE.

VOLKSWAGEN TRUCK & BUS

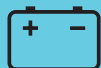
DIFFERENTIATED VOLKSWAGEN TRUCK & BUS ADVANTAGES

Besides the benefits of the strategic alliance mentioned previously, Volkswagen Truck & Bus brings some very unique advantages to the International Truck electric roadmap—in particular, the scale and investments.



SCALE CAPABILITIES

Volkswagen Truck & Bus Group's scale will decrease the costs of key components, such as both battery systems and cells, as well as drive other compelling competitive advantages.



BATTERY TECH INVESTMENT

Volkswagen Truck & Bus Group's innovation in battery technology will accelerate improvements in range, weight, and costs.



MODULAR INTEGRATION STRATEGY

Volkswagen Truck & Bus Group's joint platform strategy features a modularization approach with key e-powertrain components.³



At International Truck, we're excited about the future of trucking and electric technology. We'd like to thank all the stakeholders, existing and new, for helping to accelerate our industry's continued evolution into the electric-powered era.

As an industry leader, we embrace a more holistic, methodical view of this promising new technology. This is reflected in our phased

electric roadmap for success. As importantly, we are in a unique position through our strategic alliance with Volkswagen Truck & Bus to combine industry heritage and know-how with game-changing resources to win tomorrow's electric market opportunities.

Bottom line, we intend to lead the industry in electric...the right way. This smart approach will ensure uptime and value for our customers.

SOURCES

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