NC STATE UNIVERSITY

SUSTAINABLE FLEET TECHNOLOGY CONFERENCE & EXPO 2023

Track B Session 4: Off-Road Equipment

August 16, 2023

NC CLEAN ENERGY TECHNOLOGY CENTER

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Going Electric with Material Handling Equipment

Material handling equipment industry, electric forklift operations and what to expect when trying to electrify with your material handling equipment fleet.

Speaker -
Robert Bond
VP of Sales & Marketing
Tri-Lift Industries Inc

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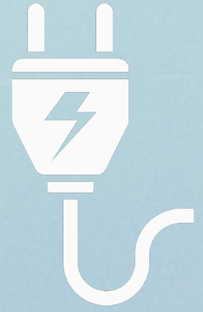
Tri-Lift Industries and Electrification

Tri-Lift Industries is a market leader in material handling equipment electrification efforts through deployment of electric forklift technology. Assisting companies with their efforts in fleet electrification for decades.

Who?/What?	Tri-Lift Industries, Material handling equipment, market impact, future of material handling.
Goal	Creating a pathway to sustainable material handling equipment that will drive a safer work environment, reduced carbon footprint and directly impact the bottom line.

Material Handling Equipment and N.C.



Market Size

North Carolina is one of the largest markets in the United States when it comes to forklift orders/ships. Manufacturing and distribution companies in North Carolina have tremendous cost exposure due to market mix of equipment and other factors.

Market Opportunity

A large portion of the material handling equipment in North Carolina is LP Gas or Diesel fuel driven. A focus on electric material handling equipment could save North Carolina based manufacturers hundreds of millions of dollars per year.

TLI and Programs for Conversion

Tri-Lift Industries (TLI) is a family business with a passion of our people and our mission, vision, and values. The idea of converting material handling equipment to electric can be daunting but there are numerous programs available to help companies through the process.

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Primary I.C. Forklift Cost Drivers

Fuel Costs

In North Carolina, the average price per gallon of LP gas is between $0.93-$1.79 (Bulk/Wholesale) and the average price per gallon of diesel is $4.18 as of 8/1/22. Fuel costs are one of the largest cost points for most forklift fleets.

Maintenance Costs

Maintenance costs on internal combustion equipment are inherently higher due to the higher wear and tear on equipment generated by all of the moving parts as well as the heat generated from engines.

Safety Costs

Emissions, warehouse safety, equipment safety, and employee/pedestrian safety costs are soft costs that can be hard to get a good grasp on but they can be huge cost drivers.

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Electric Forklift Options

Lead Acid

Most common option for current market electric material handling equipment. Good option but has drawbacks to consider based on overall application and usage needs. Consider - runtime, charging, storage, maintenance, watering, support, lifecycle, and disposal needs.

Drop-In Lithium

Drop-in lithium battery solutions fork material handling equipment are becoming more common. Currently there are options from several third party providers to fit into most major material handling equipment brands. Consider – chemical make up, voltage, kilo-watt capacity, charge/discharge rates, warranty, support, product ratings, and price.

Integrated Lithium Iron Phosphate

Integrated lithium solutions are packages of material handling equipment where the forklift, the battery, and the charger are all manufactured by the same company so items are married perfectly. There is only one truly integrated lithium forklift currently available (BYD) but other third party-O.E.M. partnerships exist.

Notes:

There are a number of different chemical compounds available when it comes to lithium batteries. The current market leading technology is lithium iron phosphate from BYD. The BYD LiFePO4 battery differs chemically from the typical Lithium Cobalt Oxide (LiCoO2) or Lithium Manganese Oxide and is thoroughly tested for safety.

Process

01. Survey/Document

Application survey, process documentation. justification building, and proposal construction.

02. Implement/Adjust

Equipment control implementation, process adjustments, service/support design, planning for next steps.

03. Connect and deploy

Control data used to create a plan for fleet conversion with financial justification across the board.

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What to Expect

Planning

Going to electric material handling equipment doesn't need to be difficult but taking the time to properly plan for the transition and what it will be mean business is key to success. Charging location, equipment end of life planning, warehouse space configuration, etc.

Training

Operationally, electric material handling equipment functions the same as internal combustion but there will be a learning curve. Management must be onboard with the tranisiton and make sure use and charging guidelines are followed.

Culture Shift

A culture shift must occur for a successful transition to electric. Opportunity charging equipment during breaks and lunches is required for optimal performance.

Savings

Like most things, it takes money to make money. Or in this case, to save money. Going to electric material handling equipment requires an upfront investment that generates long term returns. Most fleet return schedules average less than 24 months depending on fleet size, application, and runtime hours.

Recommendation - BYD

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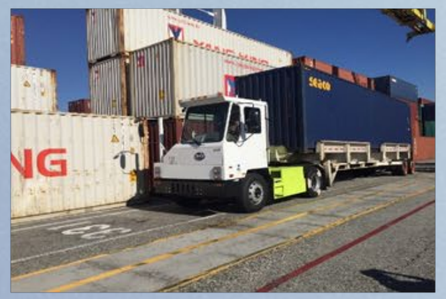
BYD

BYD Family of Products

On-Road

MHE

Specialty



BYD Product Certifications

- ✓ QC/T 743
- ✓ UL 1642
- ✓ UL 2580
- ✓ UN 38.3
- ✓ UL1973
- ✓ ISO 12405*
- ✓ IEC 62660*
- ✓ SAND 2005*

Clear-View Mast

Great visibility through the mast; The low profile front cowl also provides enhanced forward visibility.

Larger Operator Assist Grips

Designed to meet diverse operator needs.

Soft Lowering

Give operators speed control of the heaviest and lightest loads.

Clean & Easy Charging

No acid vapor released during the charging process.

Optional Fingertip Controls

Optional fingertip controls increase productivity and reduce operator fatigue.

Dual 3-Phase AC Brushless Motors

Weather proof dual 3-phase AC brushless motors; produce high power and torque and allow greater maneuverability.

Iron-Phosphate Battery

BYD's world leading Iron-Phosphate Battery is green, long-lasting and the most reliable battery that can withstand the toughest working conditions.

Solid Pneumatic Tire

Solid pneumatic tires are ideal for even the harshest terrains.

LOWEST OPERATING COSTS

>50%

Lower operating costs as compared to diesel,gas or lead acid forklifts

EXCELLENT TEMPERATURE PERFORMANCE

-40°C to +60°C

Normal use when the temperature is between -40° C to +60° C.At -40° C ,the discharging rate of the iron battery remains over 60%, WHEREAS LEAD-ACID IS ALMOST O.

LONG LIFE

4,000+

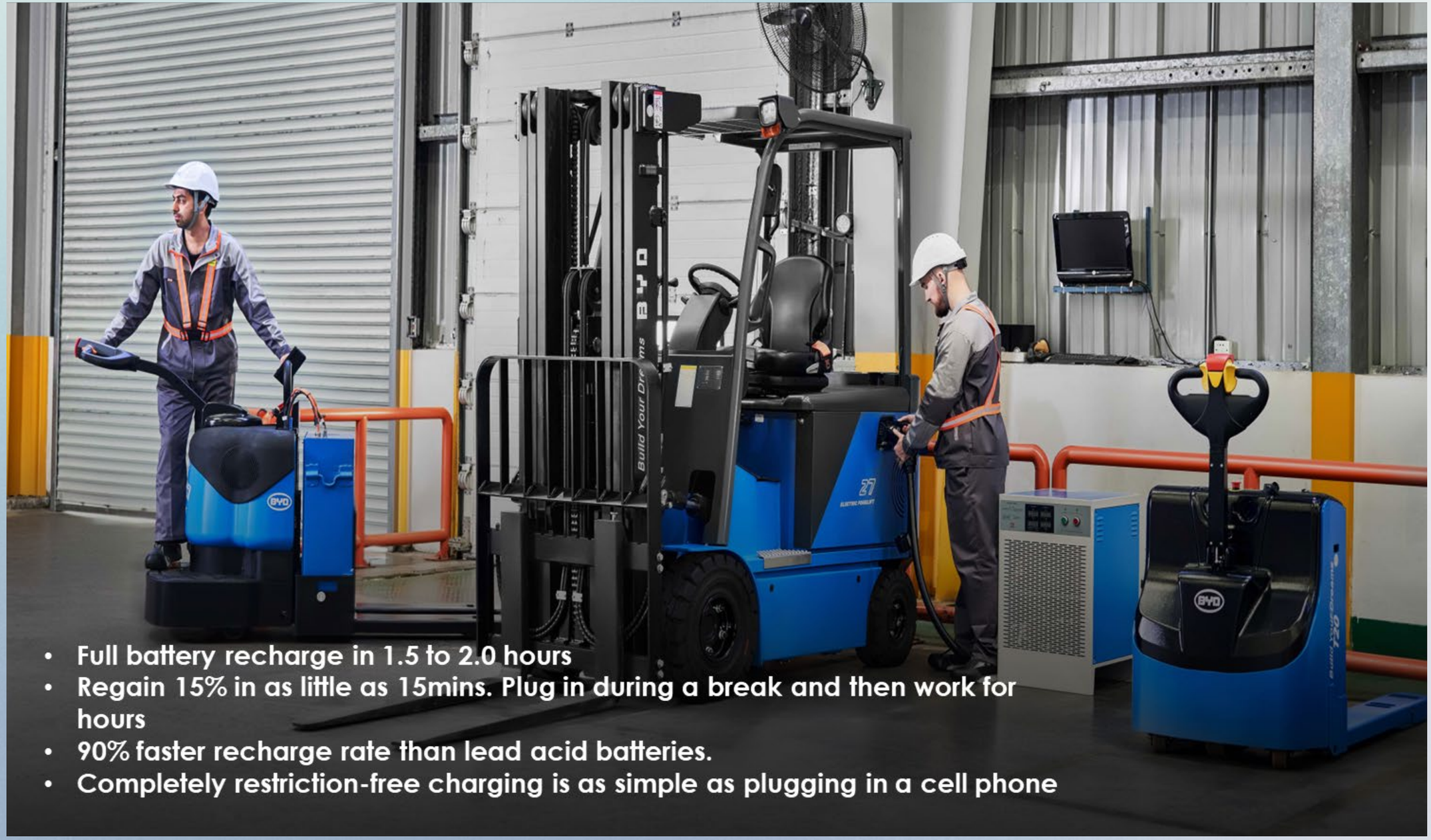
After 4,000 cycles,the battery retains 80% of its original capacity.4,000 cycles mean around 12 years' operation,considering once a day charging.

EXCELLENT ROI AND PAYBACK

Superior ROI and Payback as compared to any other forklift technology.

After 4,000 cycles,the battery retains 80% of its original capacity.4,000 cycles mean around 12 years' operation,considering once a day charging.

Ultrafast, Unlimited Recharging



- Full battery recharge in 1.5 to 2.0 hours
- Regain 15% in as little as 15mins. Plug in during a break and then work for hours
- 90% faster recharge rate than lead acid batteries.
- Completely restriction-free charging is as simple as plugging in a cell phone

MORE POWER

BYD's Chemistry–Density–and 80 volt Platform combined = More Power and Runtime and faster charging cycles ..... PERIOD!

240AH X 80 VOLT = 19.2 KWH
460AH X 80 VOLT = 36.8 KWH
540AH X 80 VOLT = 43.2 KWH
600AH X 80 VOLT = 48.0 KWH (2018)

LITHIUM COMPETITORS

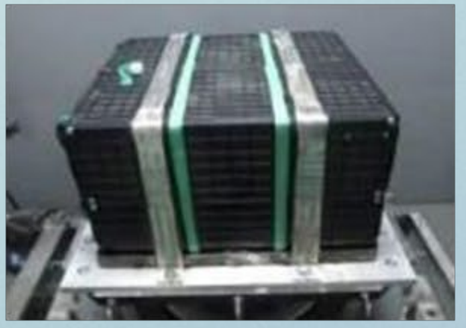
240AH X 48 VOLT = 11.5 KWH	**240AH X 36 VOLT = 8.64 KWH**
460AH X 48 VOLT = 22.1 KWH	**460AH X 36 VOLT = 16.6 KWH**
540AH X 48 VOLT = 25.9 KWH	**540AH X 36 VOLT = 19.4 KWH**

NOTE: KWH = AH X VOLTAGE DIVIDED BY 1000
LiFePo4 Comparison

Safe, Stable, Sustainable Chemistry

BYD batteries put to the test

Batteries **still operational** after these tests. No damage to the modules and no leaks, ruptures, or fires.



Vibration Testing
10-2000 Hz range, 8hrs

Thermal Testing
-40°C to 85°C, 5 cycles of 6 hrs each

Salt Spray (simulate ocean or road salt)
56 continuous days

No fires or explosions in any of the following tests

Short Circuit
Bypassed protections

Crush Testing
100kN force

Piercing

Collision Testing
Different speeds

Oven

Fire simulation
1 hr

Gas flame
continuous engulfing

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Converting material handling equipment to electric power can be a very rewarding process. Business profits as well as employee safety and overall quality of life will improve dramatically in the long run. Tri-Lift Industries is providing free application surveys, safety audits, and entire fleet Return on Investment studies for local businesses, free of charge. Contact information below or ask for a copy of this presentation.

866-393-9833
Phone

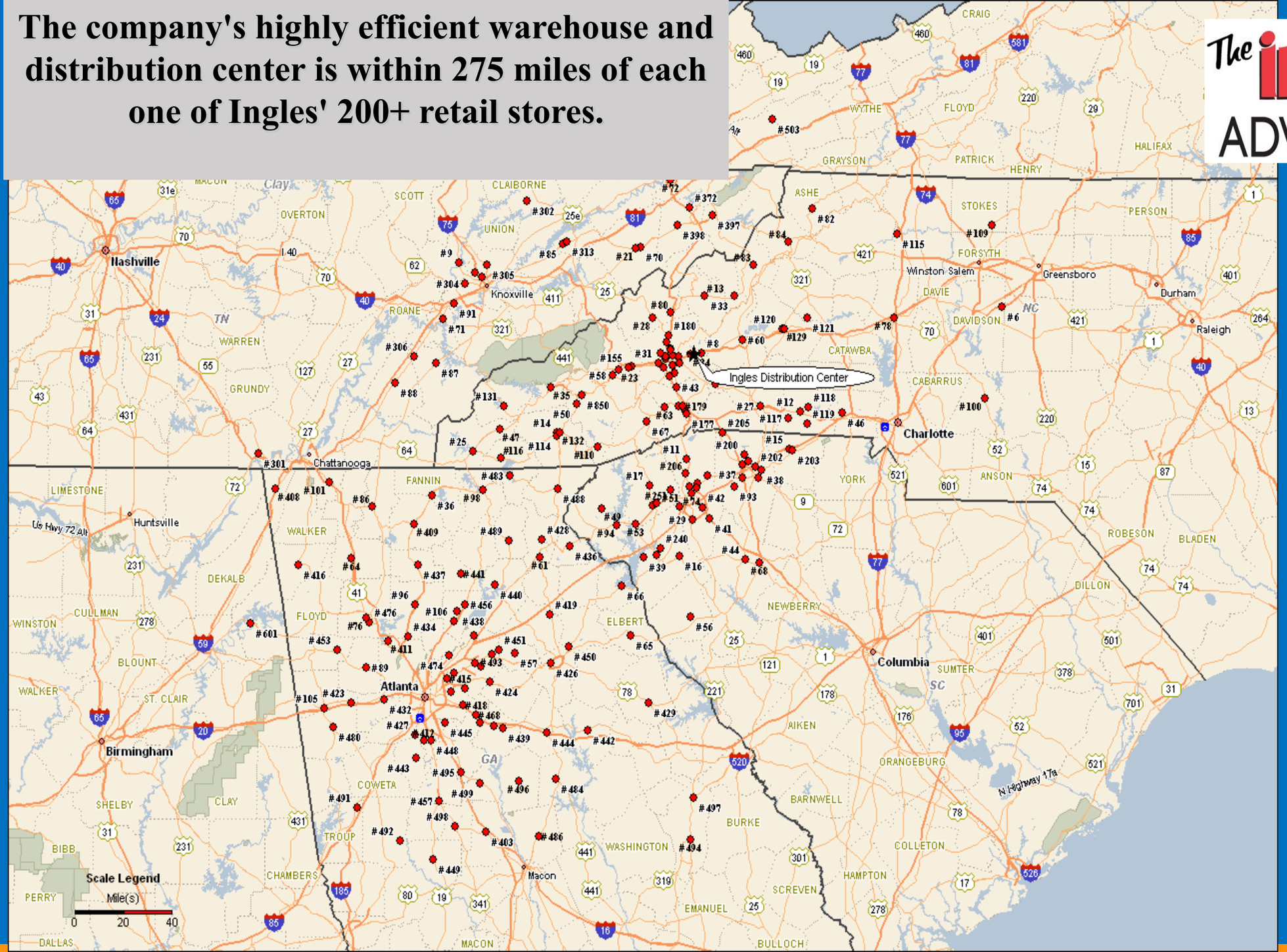
www.tri-lift.com
Website

rbond@tri-liftnc.com
Email

Ingles Markets Distribution

The company's highly efficient warehouse and distribution center is within 275 miles of each one of Ingles' 200+ retail stores.

The ingles ADVANTAGE™



What are Yard Trucks?

a.k.a. hostlers, spotters, terminal trucks, yard dogs, yard goats, shunt trucks, etc.

- Class 8
- GCWR 81,000 lbs
- Up to 25 mph

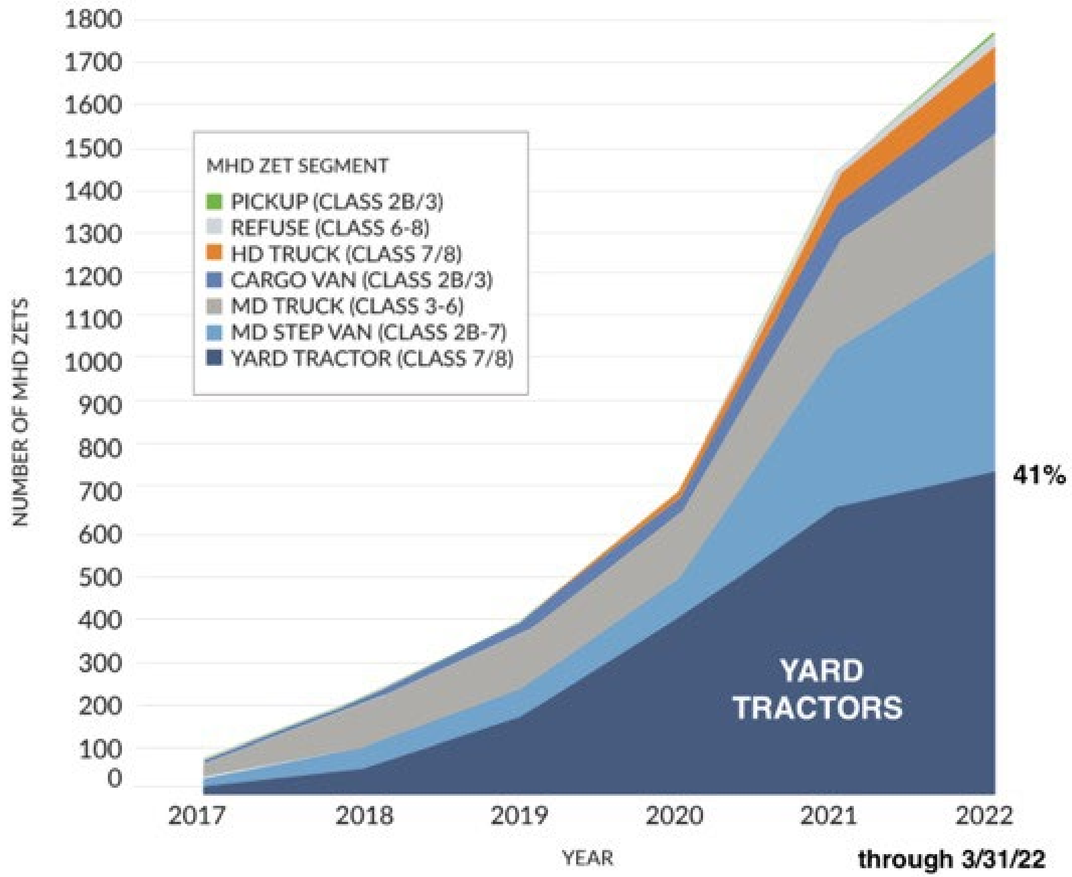
- Moves trailer & containers at:
  - Distribution Centers
  - Warehouses
  - Manufacturing Plants
  - Agriculture
  - Railyards
  - Ports
  - and more

Why Yard Trucks Should be Part of Every Electrification Conversation

The ingles ADVANTAGE™

- No range anxiety
- Don't need power to go 60+ mph
- Regen braking turns frequent start/stop into a good thing
- Minimal energy consumption during “idle” time
- Simple charging solutions available, requiring as little as 22kW
- Replaces one of the most inefficient, highest downtime, most-polluting but mission-critical diesel vehicles
- **41%** of ALL medium and heavy-duty zero-emission truck deployments in the US are yard trucks and **the majority of those are Orange EV**.*

*CALSTART “Zeroing in on Zero-Emission Trucks”
June 2022 Market Update
Cumulative U.S. MHD ZET Deployed Sales (January 2017 - March 2022)



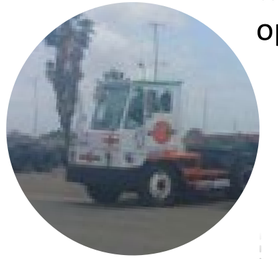
NACFE
NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

“One of the best, if not THE best, vehicles for electrification”

Why we chose Orange EV

Pure play EV truck company

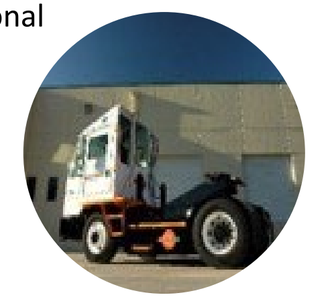
Orange EV founded



2012

2013

Demo truck operational



2014

Demonstrations with major operators

2015

Delivered first production truck to DHL

2016

Introduced all-new purpose-built EV vehicle

2017

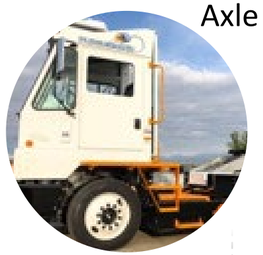
Introduced fast charging for 24x7 operation

2018

Partnership with Outrider to develop **autonomous yard trucks**

2019

Expanded operations, development, sales, and service



2020

Introduced the Tandem Axle truck

2021

Improved battery technology; increased battery warranty to 7.5 years; launched rental program

2022

Launched e-TRIEVER® enhanced digital (DTS) trucks; expanded rental program nation-wide

LFP Batteries and Yard Trucks: The winning combination

Apples-to-Apples Study

A recent study[1] performed at Sandia National Laboratory has shown Lithium Iron Phosphate (LFP) superiority versus Nickel Manganese Cobalt (NMC) and Nickel Cobalt Aluminum (NCA).

LFP Lasts Longer

As shown in the graph (left), most of the tested LFP cells lasted thousands of cycles longer than other chemistries, retaining greater than 80% of initial capacity.

[1] "Degradation of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions", Yuliya Preger et al 2020 J. Electrochem. Soc. 167 120532

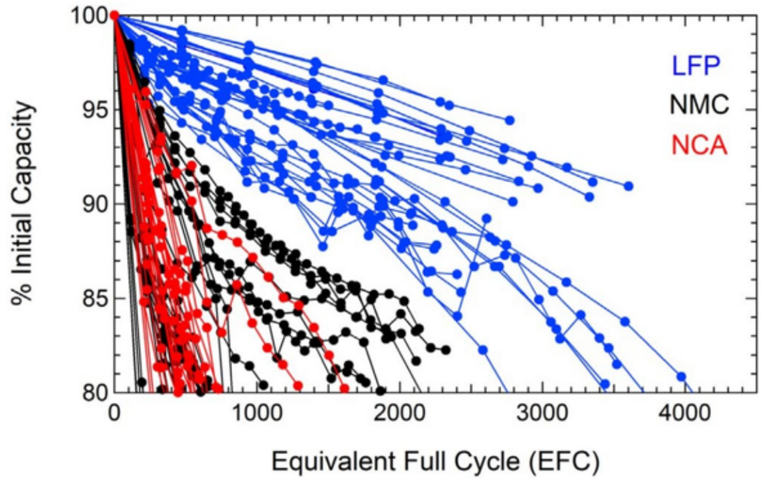


Figure 1. Discharge capacity retention for all LFP (blue), NMC (black), and NCA (red) cells relative to the initial capacity of each individual cell. Circles are data points from the capacity check at the conclusion of each round of cycling and lines are a guide to the eye.

	LFP	NMC	NCA
Can last 10+ years	✅	✗	✗
Retains 90% of capacity later in lifespan	✅	✗	✗
Does NOT contain cobalt or nickel	✅	✗	✗
More resistant to thermal runaway	✅	✗	✗

Compare Battery Chemistries

Compared to other battery chemistries (NMC and NCA), LFP is more durable and reliable, has better capacity-retention, and is safer and more environmentally friendly. Importantly, LFPs do NOT require complex cooling systems for safety and battery longevity.

LFP is the Best Choice

The battery is one of the most important components of a battery electric truck, and Lithium Iron Phosphate (LFP) is the superior choice for yard trucks.

Reasons for Fleet Electrification

- Don’t want to be left behind
- Regulators are making me do it
- Made GHG reduction commitments to investors and others
- Our customers are demanding/delegating it
- Believe it could be a better vehicle that will save me money

List of Barriers is Long

The reasons why progress has been slow are valid for many trucks.

Typical Barrier #1: Unproven Technology
Orange EV Solution: 7+ Year Track Record of Success

- Over 600 Orange EV Trucks Deployed across 160+ Fleets
- 8 million miles and 2.5 million hours of use
- Original 2015 trucks still in use, with >20,000 hours and original battery packs
  - New trucks come with 7.5 year battery warranty

Typical Barrier #2: Current Diesel Trucks are Perfect Orange EV Solution: Huge Improvements vs. Diesel

DIESEL

- Downtime of 20%+ is not unusual
- Noisy, vibrations, jerky transmission
- Uncomfortably hot in summer
- Driver spends significant time outside by exhaust stack

ORANGE EV

- Average Downtime of 1-2%
- Quiet, smooth, no transmission
- Not sitting on engine, great A/C
- Zero emissions, breathe fresh air

Typical Barrier #3: Lack of Charging Infrastructure

Orange EV Solution: Trucks and Chargers Stay in Same Lot

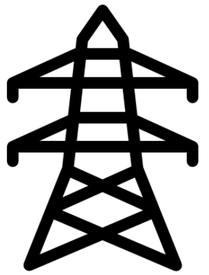
No range anxiety

Typical Barrier #4: Insufficient Power Availability

Orange EV Solution: Minimized Power Draw

Other EV Trucks

- Chargers at **150kW, 250kW**, **350kW**, discussion of 1MW
- Utility Company says 1-3 years to scale



Orange EV Yard Trucks

- Orange EV charger that works for most operations up to 16 hrs/day: **22kW**
- Orange EV fast charger for 24/7 operations: **70kW**
- Most Orange EV customers never have to talk to their utility company

Typical Barrier #5: Questionable ROI

Payback Potential in 2-3 Years, Without Incentives

Fuel Cost			6000 Annual Hour Example	
Diesel	2 gal/hr	$4.00/gallon	$48,000	
Orange EV	7 kWh/hr	$0.12/kW	$5,040	
			$42,960	Annual Fuel Savings

Maintenance & Repair Cost			
Diesel		$5.00 / hr	$30,000	
Orange EV		$2.60 / hr	$15,600	
			$14,400	Annual M&R Savings
			$57,360	Combined Annual Savings

The more you use the truck, the faster it pays you back!

The more you use the truck, the faster it pays back!

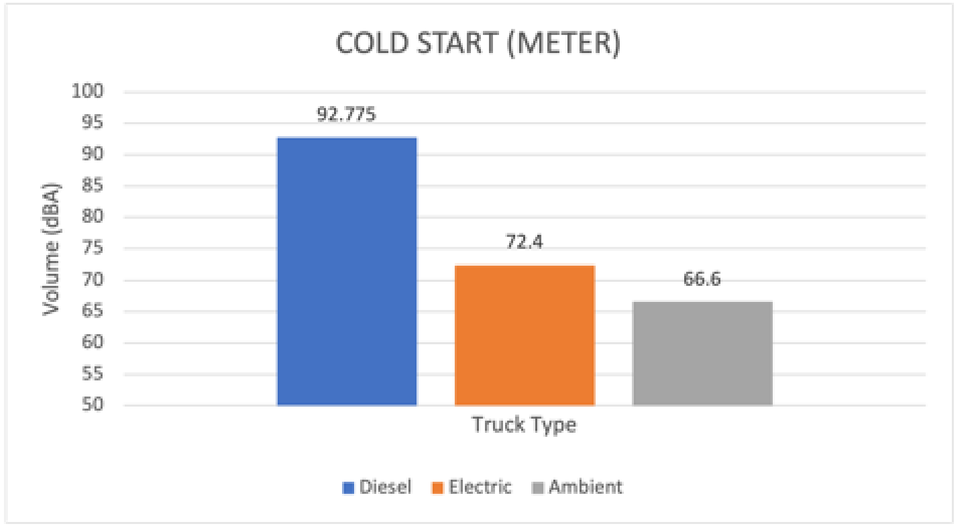
Typical Barrier #6: Lack of Trained Technicians

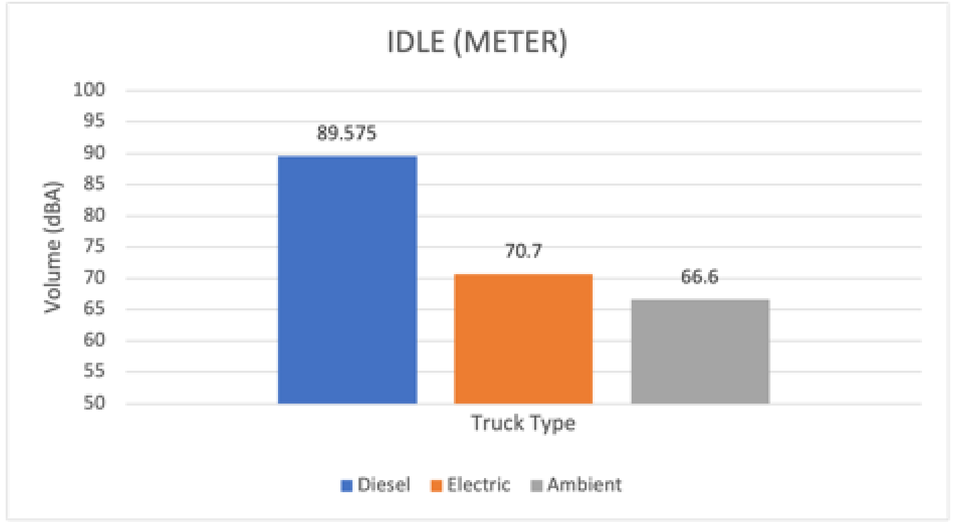
Orange EV Solution: Mobile Service from OEV Employees

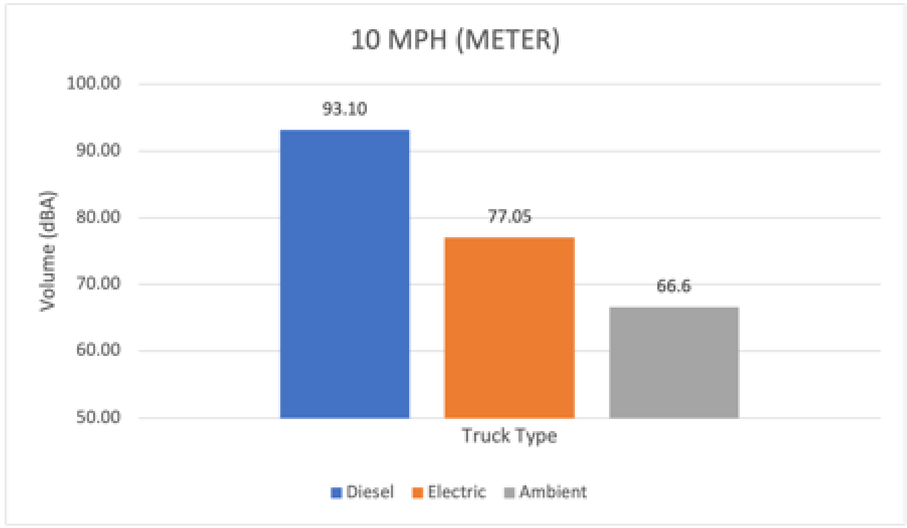
No need to worry if a customer's team or a local dealer isn't trained

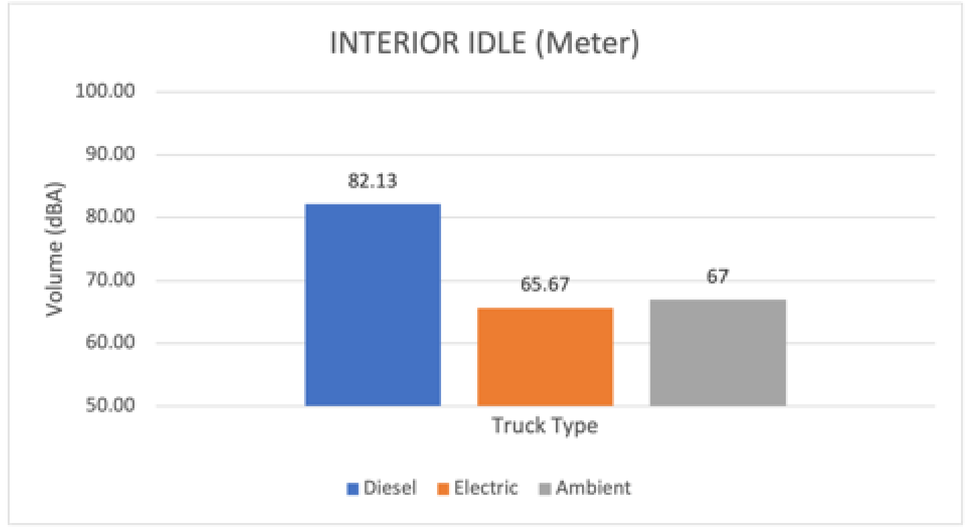
How Loud? Orange EV Electric vs Diesel

Orange EV e-TRIEVER® trucks are dramatically quieter than their diesel counterparts, providing a safer, healthier environment for operators, site personnel, and the surrounding community.









Data was collected by Orange EV using a decibel meter. Each test was conducted 6 feet away from the vehicle, capturing peak volume data within a 10-second frame. For more details, contact Orange EV.

Battery End of Life Plans

Orange EV e-TRIEVER® batteries come with a warranty of 7.5 years or

- 220,000 kWh (100 kWh battery pack) useful life cycle
- 396,000 kWh (180 kWh battery pack) useful cycle life

If batteries need replacement during the warranty period, Orange EV will handle at no cost to the customer.
If batteries need replacement sometime after the 7.5-year warranty period, customers may:

- Swap and update for a brand-new battery:
  - $24,950 for 100 kWh battery pack
  - $49,995 for 180 kWh battery pack
- Recycle the old battery. Current estimates (excluding packaging and transport) from
  - ~$1,000 for 100 kWh battery pack
  - ~$1,900 for 180 kWh battery pack

Note that by the time fleets need to address this issue, there will likely more and better options available. Costs are expected to decrease, and second-life/recycling options should be more plentiful.

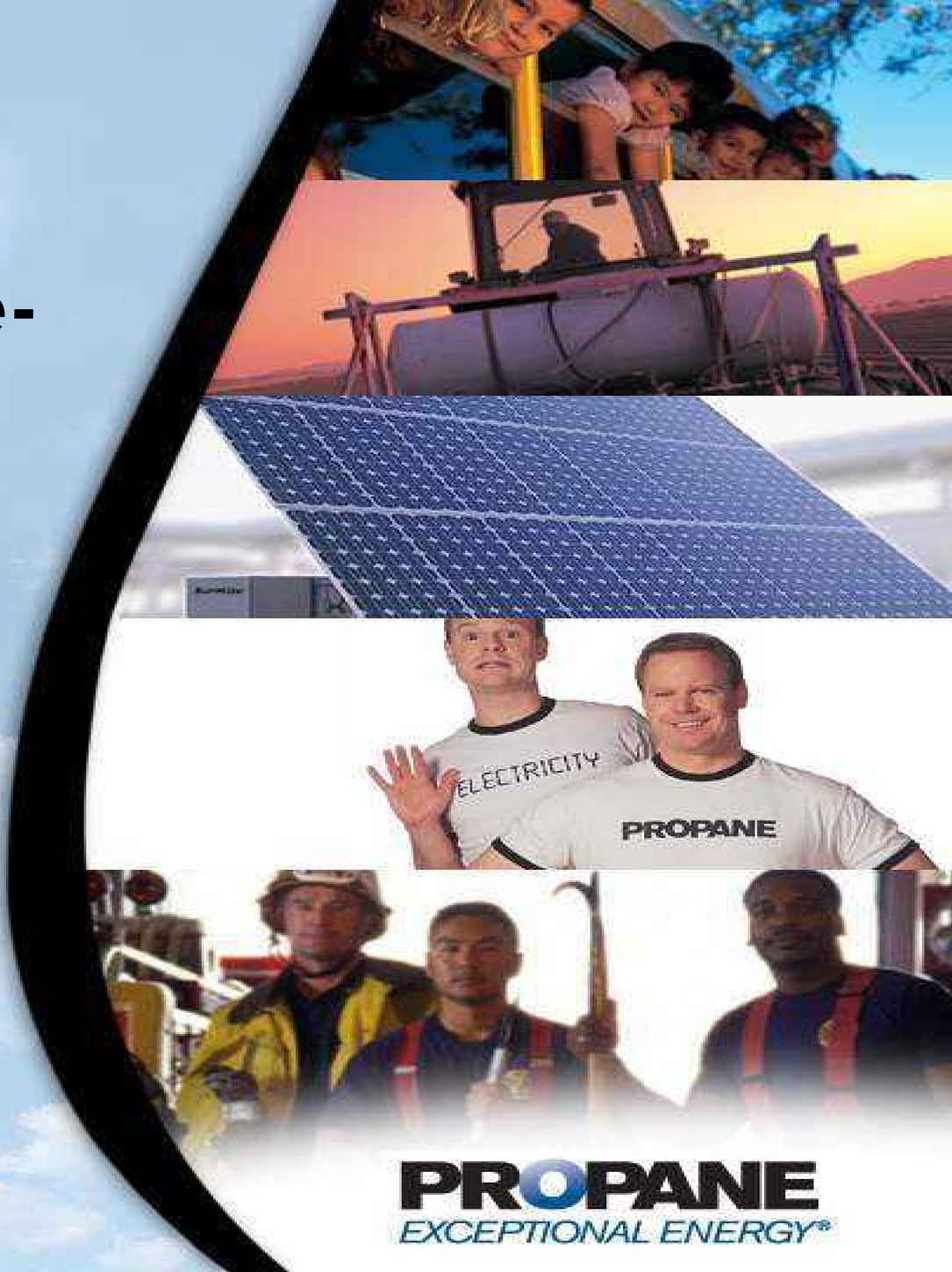
For more information on the Li-Cycle recycling process, visit: https://li-cycle.com/

Why Upgrade to an EV Switcher

- Improve operations
- Save money
- Get credit for tangible emissions reduction actions
- Gain a competitive advantage

Easiest to deploy, easiest to scale

The Advantages of Propane-Powered Small Engines



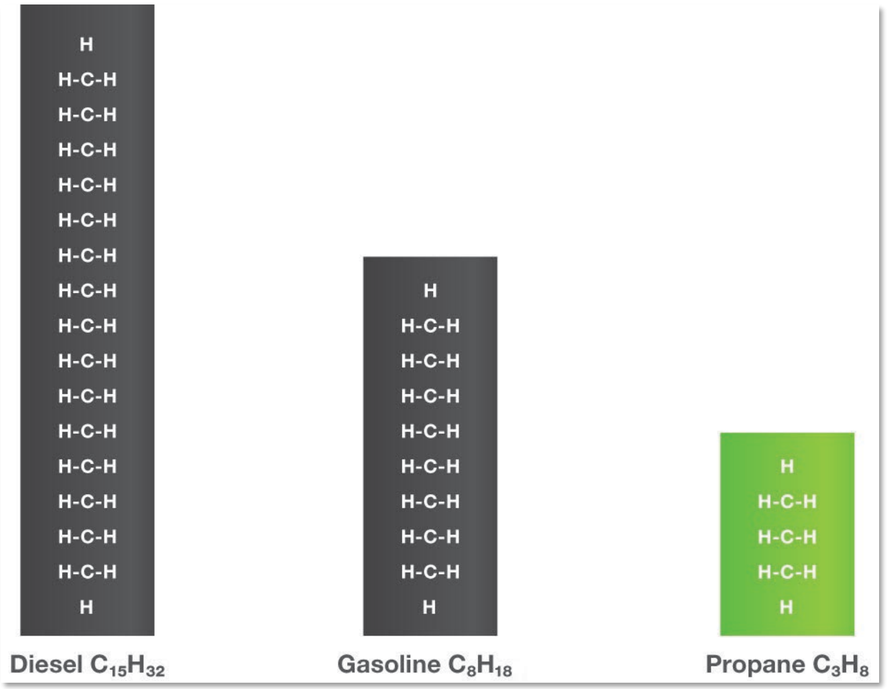
Introduction

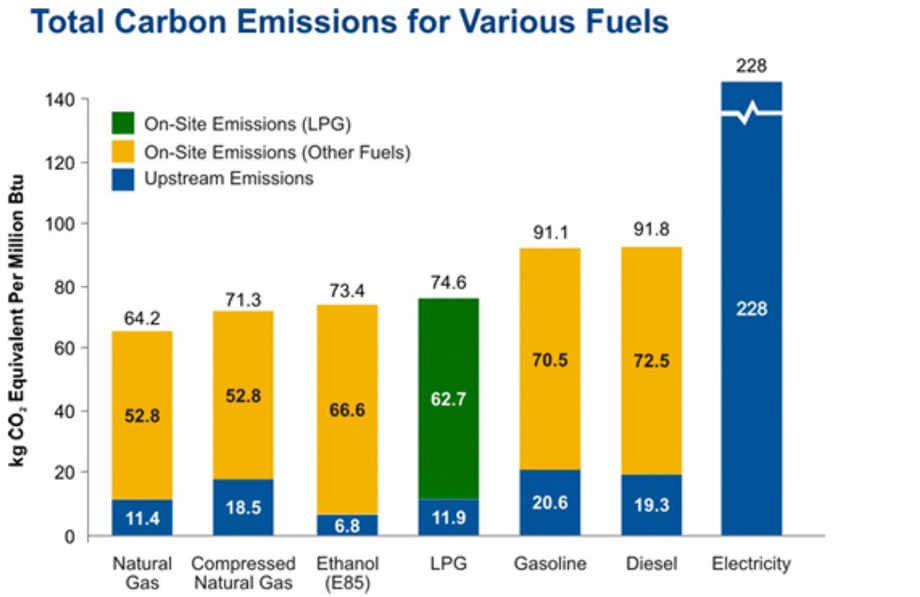
Today, I am delighted to share with you the remarkable advantages of propane-powered mowers and how they can revolutionize fleet operations, promote sustainability, and deliver substantial cost savings. In this presentation, we will explore the key benefits of using propane as a fuel source for mowers and highlight its impact on fleet efficiency, environmental stewardship, and financial considerations.

Environmental Benefits

- Reduced greenhouse gas emissions compared to gasoline or diesel.
- Lower carbon footprint due to cleaner combustion.
- Decreased air pollutants such as nitrogen oxides and particulate matter.

Statistical Comparison





Sources: DOE 1994, EPA 2007, GREET 2007
On-site emissions estimates based on chemical composition of the fuel with 99 percent combustion.
Actual life-cycle emissions vary by application; in many cases, electricity provides more useful energy on a per-Btu basis.

- **Produces lower level of CO2, NOx, PM, and VOCs**

Engine Maintenance Advantages

- Less carbon buildup in combustion chamber and exhaust systems.
- Prolonged engine life due to cleaner combustion.
- Reduced engine wear and oil contamination.

Statistical Evidence

- **Running a vapor thru engine is better because it burns cleaner and less contaminants that result in less carbon build up in the engine**

CLEANER COMMUNITIES

Propane Mowers Reduce Greenhouse Gas Emissions By 15 Percent And CO Emissions By 40 Percent To Keep Your City Cleaner.

CLEANER OPERATION

Compared with gasoline mowers, propane equipment produces 17 percent fewer greenhouse gas emissions, and 19 percent fewer NOx emissions. Imagine the impact that cleaner operation would have on your community greenspaces. Crews that work with propane also report enjoying the work environment more, increasing overall efficiency.

Cost Efficiency

- **Potentially lower fuel costs compared to gasoline or diesel.**
- **Reduced maintenance expenses and longer intervals between service.**

US avg. gas price chart per gallon vs. avg. since 2018

U.S. Propane Residential Price (Dollars per Gallon)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990										1.063	1.053	1.019
1991	1.002	0.939	0.884							0.877	0.908	0.919
1992	0.892	0.880	0.867							0.858	0.872	0.895
1993	0.979	0.946	0.956	0.930						0.871	0.878	0.881
1994	0.887	0.908	0.902							0.846	0.856	0.867
1995	0.880	0.892	0.898							0.886	0.892	0.914
1996	0.973	1.013	1.018							1.047	1.119	1.309
1997	1.287	1.174	1.091							0.956	0.971	0.978
1998	0.981	0.974	0.961							0.872	0.876	0.879
1999	0.887	0.891	0.890							0.960	0.981	1.002
2000	1.080	1.220	1.209							1.281	1.290	1.399
2001	1.663	1.556	1.432							1.139	1.132	1.120
2002	1.134	1.129	1.123							1.133	1.160	1.211
2003	1.307	1.480	1.652							1.308	1.330	1.384
2004	1.496	1.536	1.509							1.615	1.691	1.717
2005	1.728	1.720	1.717							1.942	1.944	1.974
2006	2.010	2.001	1.987							1.937	1.945	1.979
2007	1.992	2.020	2.038							2.183	2.407	2.489
2008	2.563	2.561	2.601							2.587	2.455	2.352
2009	2.313	2.311	2.248							1.991	2.152	2.306
2010	2.562	2.602	2.556							2.270	2.389	2.516
2011	2.639	2.684	2.716							2.635	2.685	2.708
2012	2.710	2.706	2.708							2.205	2.241	2.249
2013	2.279	2.312	2.315							2.370	2.495	2.692
2014	3.165	3.692	3.182							2.392	2.404	2.385
2015	2.367	2.360	2.337							1.919	1.939	1.983
2016	2.014	2.028	2.016							2.037	2.062	2.169
2017	2.329	2.442	2.406							2.313	2.399	2.479
2018	2.572	2.572	2.499							2.400	2.422	2.436
2019	2.429	2.431	2.410							1.843	1.952	2.021
2020	2.003	1.983	1.926							1.785	1.844	1.924
2021	2.118	2.304	2.378							2.663	2.724	2.702
2022	2.730	2.846	2.993							2.663	2.675	2.678
2023	2.699	2.703	2.684									

Propane Infrastructure

- There are more than 2,600 propane vehicle fueling stations with locations in all 50 states
- Ease of refueling and potential incentives for adopting propane.

Case Studies

PROPANE
EXCEPTIONAL ENERGY

Barnes, Inc.
Video Case Study

Fleet Manager and Purchasing Agent Troy Grindle took advantage of incentives from PERC to switch all 28 pieces of equipment to propane to help the company's bottom line. The cost savings showed up in terms of fuel and zero downtime with equipment, but the power and performance surprised him the most.

Businesses switching to propane for their fleets of small vehicles.

"WE FOUND PROPANE WOULD GET THE SAME PRODUCTIVITY AND POWER AS CONVENTIONAL FUELS, AS WELL AS A LOW TOTAL COST-OF-OWNERSHIP, WHICH WOULD PLEASE THE SCHOOL'S ADMINISTRATION AND THE STATE'S TAXPAYERS."

AARON BOGGS
ASSISTANT DIRECTOR OF MAINTENANCE AND RENOVATIONS, UNIVERSITY OF LOUISVILLE

Conclusion

- In conclusion, propane-powered mowers present a compelling case for enhancing fleet efficiency, promoting sustainability, and achieving cost savings. By adopting this technology, fleet operators can optimize productivity, reduce emissions, improve air quality, and realize long-term financial benefits.

Q & A