Exhibit No.: _____
Issue(s): Distribution Line Extension/ Charge Ahead – Business Solutions/ Charge Ahead – Electric Vehicles
Witness/Type of Exhibit: Marke/Rebuttal
Sponsoring Party: Public Counsel
Case No.: ET-2018-0132

REBUTTAL TESTIMONY

OF

GEOFF MARKE

Submitted on Behalf of
the Office of the Public Counsel

**UNION ELECTRIC COMPANY D/B/A
AMEREN MISSOURI'S**

Case No. ET-2018-0132

October 1, 2018

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of the Application of Union Electric Company d/b/a Ameren Missouri for Approval of Efficient Electrification Program	))))	File No. ET-2018-0132

AFFIDAVIT OF GEOFF MARKE

STATE OF MISSOURI)
) ss
COUNTY OF COLE)

Geoff Marke, of lawful age and being first duly sworn, deposes and states:

1. My name is Geoff Marke. I am a Regulatory Economist for the Office of the Public Counsel.

2. Attached hereto and made a part hereof for all purposes is my rebuttal testimony.

3. I hereby swear and affirm that my statements contained in the attached testimony are true and correct to the best of my knowledge and belief.

Geoff Marke
Chief Economist

Subscribed and sworn to me this 1st day of October 2018.

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

JERENE A. BUCKMAN
My Commission Expires
August 23, 2021
Cole County
Commission #13754037

Jerene A. Buckman
Notary Public

My commission expires August 23, 2021.

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REBUTTAL TESTIMONY

OF

GEOFF MARKE

UNION ELECTRIC COMPANY
d/b/a Ameren Missouri
CASE NO. ET-2018-0132

I. INTRODUCTION

Q. Please state your name, title and business address.

A. Geoffrey Marke, PhD, Chief Economist, Office of the Public Counsel ("OPC"), P.O. Box 2230, Jefferson City, Missouri 65102.

Q. What are your qualifications and experience?

A. I have been in my present position with OPC since 2014 where I am responsible for economic analysis and policy research in electric, gas, and water utility operations.

Q. Have you testified previously before the Missouri Public Service Commission?

A. Yes. A listing of the cases in which I have previously filed testimony and/or comments before the Commission is attached in Schedule GM-1.

Q. What is the purpose of your rebuttal testimony?

A. The purpose of this testimony is to respond to the direct testimony regarding Ameren Missouri's proposed tariff and program additions including the:

- Distribution Line Extension
  - Ameren Missouri witness Michael W. Harding and Steven M. Wills;
- "Charge Ahead – Business Solutions"
  - Ameren Missouri (or "ICF") witness David K. Pickles and Steven M. Wills; and
- "Charge Ahead – Electric Vehicles"
  - Ameren Missouri witness Patrick E. Justis and Steven M. Wills.

Q. Please provide a brief summary of Ameren Missouri's proposal.

A. Ameren Missouri is proposing two new "load building" programs: Charge Ahead-Business Solutions and Charge Ahead-Electric Vehicles; and a revision to an existing program: the distribution line extension. According to Ameren Missouri witness Mr. Wills:

> Each of the programs stands on its own merit and can operate independently of the other.[1]

Q. What is OPC's position?

A. OPC has come to an agreement with parties regarding Ameren Missouri's line extension offering and opposes the Charge Ahead-Business Solutions program in its entirety. Regarding the Charge Ahead—Electric Program, OPC believes the subsidization of EV charging stations is an inappropriate and regressive use of ratepayer dollars. OPC also believes that the estimated revenues and costs associated with the program are suspect; however, in the spirit of compromise OPC is willing to consider a risk-sharing mechanism as a possible path forward towards support from our Office. The rest of this testimony will describe OPC's positions in greater detail.

II. DISTRIBUTION LINE EXTENSION

Q. What is Ameren Missouri's proposed line extension policy?

A. Ameren Missouri has modified its line extension tariff utilizing a similar methodological framework that is currently in place by KCPL/GMO.

Q. What is OPC's position?

A. OPC and Staff have come to an agreement with Ameren Missouri regarding the modifications to its line extension policy. It is my understanding that at stipulation and agreement is forthcoming and expected to be filed on the same day as this testimony or reasonable thereafter.

[1] ET-2018-0132 Direct Testimony of Steven M. Wills p. 5, 3-4.

III. CHARGE AHEAD – BUSINESS SOLUTIONS

Q. What is the Charge Ahead—Business Solutions program?

A. It is a load building program to encourage the adoption of electrically powered equipment in place of fossil-fuel powered equipment. Such adoption should have the effect of reducing average rates to electric customers and may reduce environmental emissions. Mr. Pickles cites similar programs at CenterPoint Energy, Entergy, Southern Company, TVA, Jackson Electric Authority, Alliant Energy, and SRP as utilities with programs in place.

Q. Are you familiar with the programs that he cites?

A. I can speak to CenterPoint Energy, Entergy, and Jackson Electric Authority programs. OPC DR-2007 requested the following information and received the following response:

> Data Request: OPC 2007
>
> Please provide copies of any and all presentations Mr. Pickles has made pertaining to efficient electrification or beneficial electrification over the past six year. For each presentation, include the corresponding date(s) and venue of said presentation. Figure 1, 2 and 3 include snapshots referencing the first three utility-sponsored programs:
>
> Response:
>
> Mr. Pickles has served as a co-presenter in two public presentations (webinars) pertaining to efficient electrification or beneficial electrification over the past six years. The materials used for these webinars are provided as attachments. The dates of the webinars were 7/21/15 and 9/27/16. All other presentations made by Mr. Pickles on this topic are proprietary and confidential to ICF and/or its clients.

Figure 1: CenterPoint Energy Clean Air Technologies (CAT) Program

- No CenterPoint Incentives
- State Incentives

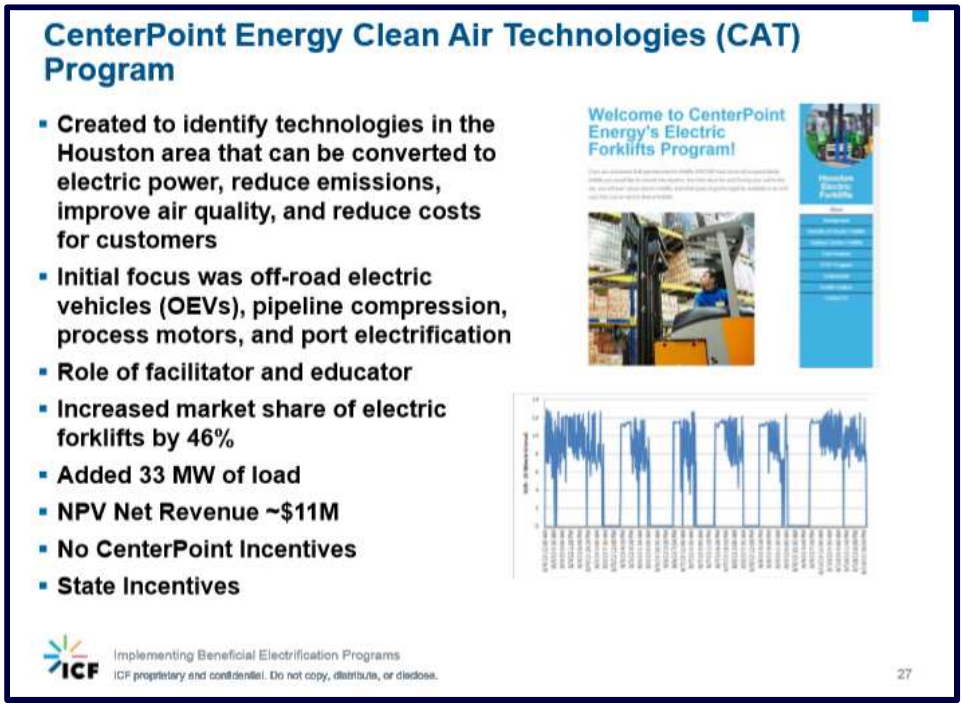


Figure 2: Entergy Agricultural Pumping Program

- No direct customer incentives

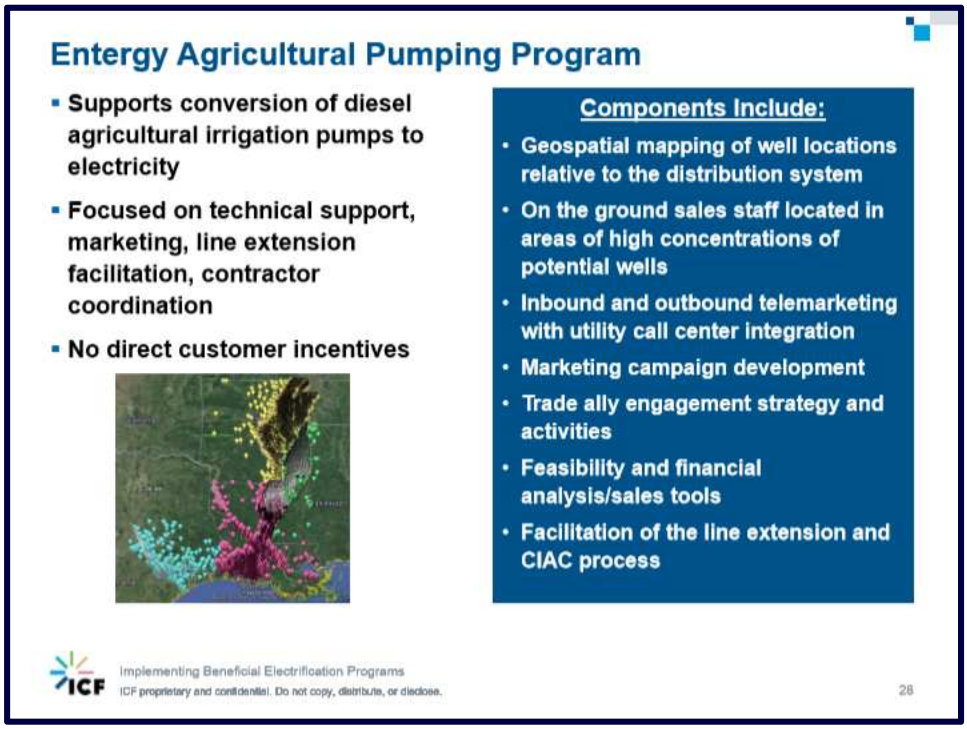
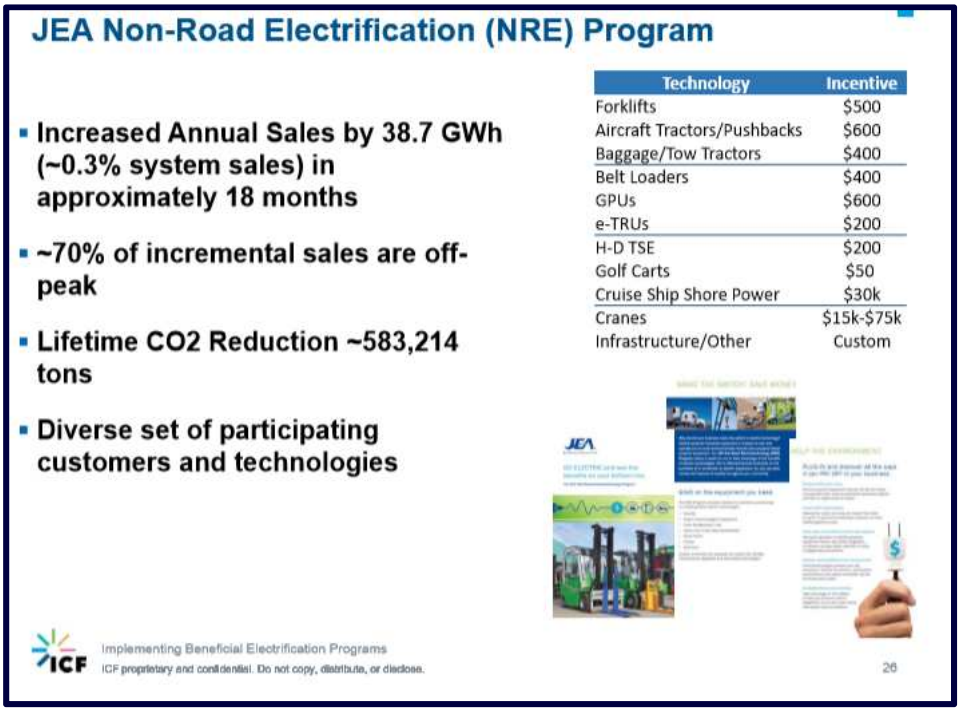


Figure 3: JEA ("Jacksonville Electric Authority") Non-Road Electrification ("NRE") Program



The Commission should note that two of the three utility-sponsored beneficial electrification programs required no direct subsidies from customers. The third program (JEA), was put forward by a municipal electric utility and thus, is not directly comparable as ratepayers in that case are also taxpayers.

Q. What is the expected budget for the Ameren Missouri Charge Ahead-Business Solution proposal?

A. According to Mr. Wills the portfolio of programs is capped at $7 million dollars over a five-year period and is targeted at two specific areas: 1.) the material equipment program (including forklifts and idle truck stop electrification; and 2.) the airport ground support programs. Each of these programs are designed to provide "medium incentive level" rebates. Table 1 below includes the approximate implementation and incentive breakdown:

Table 1: 5-Year Cost Breakdown for Charge Ahead-Business Solutions

	Forklifts and Trucks	**Airport**	**Total**
3rd Party Program Administration[2]	$2,888,000	$213,200	$3,101,200 45%
Direct Commercial Subsidy[3]	$3,607,500	$204,200	$3,811,700 55%
Total[4]	$6,495,500 94%	$417,400 6%	$6,912,900.00 100%

Material Equipment: Forklifts

Q. What is Ameren Missouri's electric forklift adoption potential?

A. According to the ICF forklift analysis which consisted of 17 dealers, 26 locations and 8 interviews, it is estimated that approximately 54% of forklifts in Ameren Missouri's service territory are already electric. These figures are largely consistent with electric forklift adoption across North America based on a 2016 Navigant Research Brief which states:

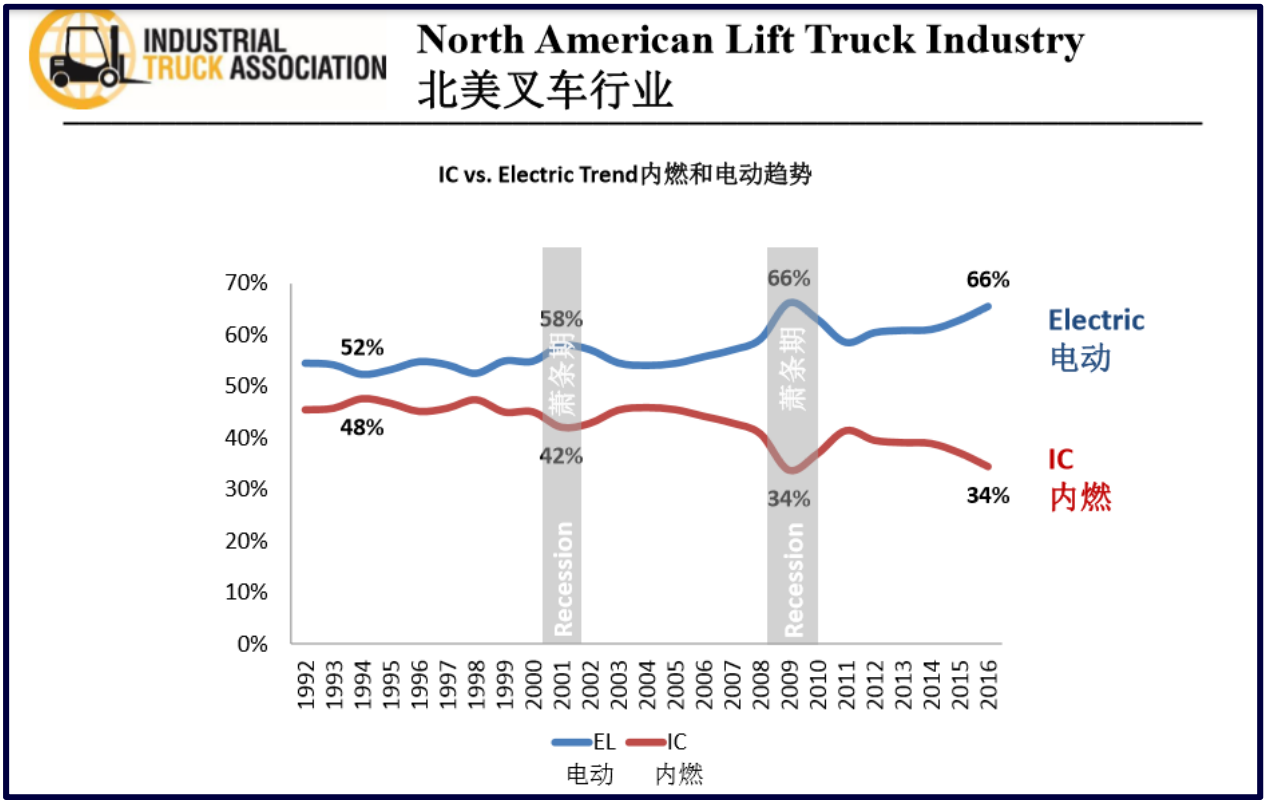
> A shift away from forklifts powered by propane, diesel, and other fossil fuels in favor of electric models for indoor applications started to occur in North America during 2009. To date, traditional lead-acid batteries have been the battery of choice of warehouse managers for Class 1, Class 2, and Class 3 electric forklifts due to their low upfront purchase costs. . . . The Industrial Truck Association (ITA), the leading North American trade organization for manufacturers and suppliers of forklift equipment, reported that electric forklift sales increased by over 8% from 2014 to 2015, representing 63.4% of the entire forklift market.[5]

The Industrial Truck Association year over year trends substantiate that electric forklifts have already gained widespread adoption and this trend will likely continue based on many of the

[2] See Schedule DP-D2-24.
[3] See Schedule DP-D2-29.
[4] The overall portfolio cost breakdown based off of these inputs is at $6,912,900 which is $30,000 more then what is listed as the total costs on DP-D2-31 at $6,882,900 for the two programs.
[5] See GM-2. Provided as s response, in part, to OPC DR-2010.

"beneficial" comments articulated in Ameren Missouri witness Pickles testimony. Figure 4 provides a market breakdown of internal combustion and electric forklifts from 1992 to 2016.

Figure 4: Internal Combustion Vs. Electric Forklifts adoption trends 1992-2016[6]



Q. Do electric forklifts need additional subsidies to spur market adoption?

A. No. Regarding market adoption and saturation, Everett Rogers *diffusion of innovation curve*, is widely cited as a means for understanding market adoption. It is based on the microeconomics of supplier behavior, wherein programs adopt a strategy that increases competition in the field, and that strategy leads to increased availability and diversity of products. Rogers' curve has been cited as a central framework for impact evaluation studies of energy efficiency products conducted by the US Department of Energy[7] and has been

[6] Alliance of Industrial Truck Organizations (2017) President's Forum Chengdu, China. Slide 19. http://www.jiva.or.jp/pdf/2017%20PF_ITA.pdf

[7] US Department of Energy (2007) Impact evaluation framework for technology deployment programs. http://www1.eere.energy.gov/analysis/pdfs/impact_framework_tech_deploy_2007_main.pdf

promoted within the energy efficiency community.[8] Rogers' categorizes five groups of product adopters and identifies market transformation through the percentages of people in each category.

2.5% Innovators – Innovators play "a gatekeeper role" in the social system of adopters. They are the first people in a social system to adopt the innovation. Innovators tend to be "venturesome," technologically savvy, and able to cope with uncertainty.

13.5% Early Adopters – "Early adopters put their stamp of approval on a new idea by adopting it, explains Rogers. Unlike innovators, early adopters enjoy a fair degree of respect among their peers and the general public. If they embrace a new technology, many others will likely follow suit because they have decreased uncertainty about the innovation.

34% Early majority – Individuals in the early majority look to early adopters for leadership regarding innovation but also may deliberate for some time before embracing a new technology; they constitute a numerically large group. Once an early majority member adopts a technology, other early majority members in their social network are likely to follow.

34% Late majority – Rogers describes late majority members as skeptics. Another numerically large group, they often decide to adopt an innovation due to peer pressure or because of some economic or other necessity to do so.

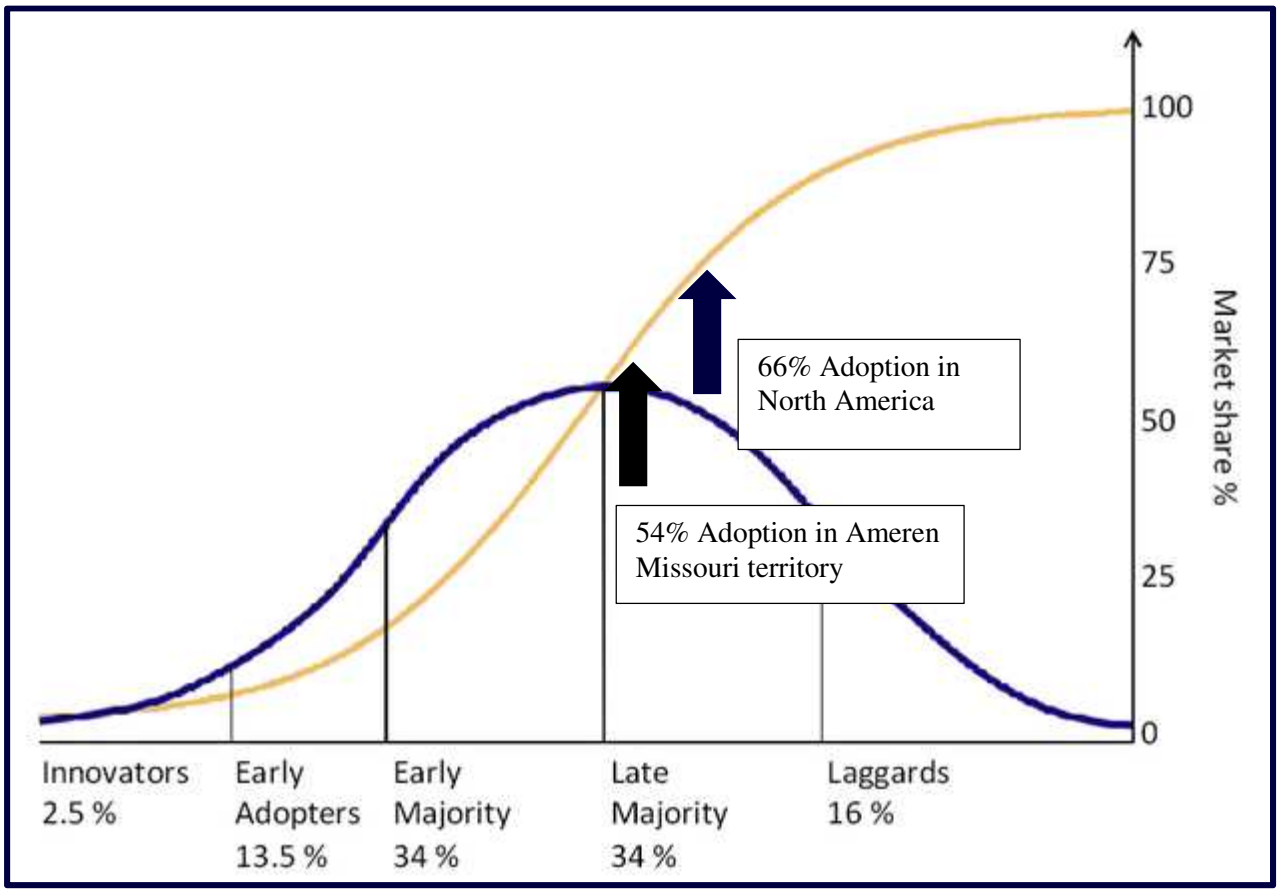
16% Laggards – According to Rogers, "Laggards are the last in a social system to adopt an innovation." They tend to look toward the past for guidance on their actions and remain suspicious not only of change, but also "of change agents [i.e., individuals promoting increased adoption of the innovation]." They may have very

[8] Vine, et al. (2006) An inside look at the U.S. Department of Energy impact evaluation framework for deployment programs. ACEEE. http://aceee.org/files/proceedings/2006/data/papers/SS06_Panel12_Papers12.pdf. OPC is cognizant that the Ameren Missouri, Charge Ahead – Business Solution program is not an energy efficiency program; however, the programs framework and justification is largely based on how the Commission has treated energy efficiency programs. Regardless, Rogers' theory is applicable to any product adoption.

rational and logical reasons for resisting an innovation and must be very sure "that the new idea will not fail before they can adopt."[9]

Figure 5 provides a visualization of Rogers curve and where electric forklifts fit on it in regards to adoption across North America (at least in 2016) and according to ICF's research in Ameren Missouri's service territory.

Figure 5: Rogers' Diffusion of Innovation Curve and electric forklift adoption in North American and Ameren Missouri service territory



[9] NMR Group (2013) A review of effective practices for the planning, design, implementation, and evaluation of market transformation efforts p. 16. http://www.calmac.org/publications/FINAL_NMR_MT_Practices_Report_20131125.pdf.

Readers will note that even though Ameren Missouri's commercial customers may be behind North American adoption trends for electric forklifts, the adoption rate is already in the "late majority" designation on Rogers' curve.

Q. Based on this information, what is OPC's position?

A. That ratepayers should not be subsidizing a load building technology that already has a commanding market share and user adoption. The "late majority" as characterized by Rogers, are customers who will adopt due to peer pressure ("sustainability concerns") or because of some economic or other necessity to do so. Stated differently, at this point, the "late majority" electric forklift program participant would largely be considered a "free rider," or a participant who would likely purchase the electric forklift regardless of the subsidy.

Material Equipment: Electric Standby Truck Refrigeration Units and Truck Stop Electrification

Q. Please describe the truck stop electrification program.

A. While parked, long-haul truck drivers would be able to plug into the grid instead of idling their truck or auxiliary engines to power their heating, air conditioning or other accessories.

Q. Please describe the electric standby truck refrigeration units.

A. Transportation refrigeration units control the temperature of cargo in shipping containers on trucks and are typically used by carriers that transport groceries, produce and other perishables.

Q. Does OPC support ratepayer subsidies for this load building program?

A. No. The Missouri Department of Natural Resources ("DNR") idle reduction rules would already enable much of this action. DNR's rules in 10 CSR 10-2.385 and 10-5.385, require that all commercial, public and institutional diesel vehicles in affected nonattainment counties (Clay, Platte and Jackson in Kansas City and the City of St. Louis, Jefferson, Franklin and St. Charles Counties in the St. Louis Area) limit their idling to 30 minutes while waiting to load or unload at a location. In addition, passenger load and unload locations are prohibited from causing or allowing vehicles covered by this regulation to idle for more than five minutes in

any 60 minute period. Vehicles are also limited from idling for more than five minutes when not waiting to load or unload in any 60 minute period, unless the vehicle meets one of the exemptions (e.g., emergency or law enforcement vehicles).

Airport Ground Support Equipment

Q. What is Ameren Missouri's airport ground support equipment potential?

A. It would consist solely of St. Louis Lambert International Airport.

Q. What does the program consist of?

A. Various baggage handling, belt loading, and ground power units for airport support staff.

Q. What are OPCs concerns with this program?

A. That 3rd party program administrator ($213,200) and commercial subsides ($204,200) are essentially equal yet the entire program consists of only one eligible participant. It is unclear why ratepayers would need to pay an estimated $213,200 to a third-party administrator over a five-year period to entice one customer with rebates that are actually smaller than the administration of the program itself.

Additionally, Lambert would likely be considered a free rider as well. The airport is currently owned by the City of St. Louis, who on October 27th, passed Resolution 124 that committed to 100% clean energy by 2035.[10]

Given the aforementioned information, OPC cannot support ratepayer subsidies for one customer especially in light of the disproportionate administrative overhead.

Load Reduction and Load Building Policy

Q. Is OPC opposed to load building in general?

A. Not necessarily. There are compelling arguments for load building programs; however, allocation of ratepayer funds for such programs need to be consistent and not at odds with other policy objectives. Putting aside the aforementioned flaws that OPC found in this application,

[10] St. Louis-MO.Gov (2018) Resolution No. 124/ Session 2017-2018: The City's Sustainability Plan. http://www.stlouis-mo.gov/govenrment/city-laws/resolutions.cfm?rDetail=true&resolutionId=10762

Mr. Wills makes a reasonable argument for ratepayer subsidized load building and the potential positive impact on fixed cost recovery. Where I disagree with Mr. Wills is on the subject of MEEIA.

Q. Is OPC opposed to load building in conjunction with promoting MEEIA?

A. Yes. As the Commission is well aware, Ameren Missouri currently has a MEEIA application (aka, load reduction or demand-side management) that approaches or will exceed $1 billion dollars in overall cost recovery (program, lost revenues and earnings opportunity). Much of those "savings" are predicated on recovery of lost revenues and savings from avoided costs from Ameren Missouri's cost of service. The Commission should be cognizant that the proposed Charge Ahead program will "find revenues" and cancel out "avoided costs." Ameren Missouri attempts to gloss over this fact by claiming macro-savings from fuel and emissions separate and aside from Ameren Missouri's cost of service (e.g., tailpipe emissions and vehicular gasoline). Though this may be true on an aggregate basis, OPC also believes this claim is both exaggerated (Ameren Missouri is still predominately fossil fuel based) and ultimately not the responsibility of ratepayers.

OPC has already articulated its position in Ameren Missouri Cycle III application and continues to stand by our recommendation to continue programs at a reduced level to reflect the operating environment the Company currently finds itself in. As stated earlier, if the goal of the state of Missouri is to reduce greenhouse gas emissions, policy ought to seek out the cheapest reductions first, such a price-based tools.

OPC cannot support the Charge Ahead-Business Solutions program as currently drafted due to present-levels of market adoption, inefficient program design, and conflicting policy objectives and programs (e.g., load reduction and load building) the utility is seeking.

IV. CHARGE AHEAD – ELECTRIC VEHICLES

Q. Do you agree with Mr. Wills' estimates regarding the impact to ratepayers due to the proposed Charge Ahead-Electric Vehicle programs?

A. No. These estimates are highly dependent on rate-case timing and other confounding variables.

Q. Do you agree with Mr. Justis' assertion that the proliferation of EV charging stations will result in widespread EV adoption?

A. No.[11]

Q. Do you agree that seeking information from 3rd party EV charging station providers is a reasonable and appropriate metric from which to base a decision on whether or not more EV charging stations need to be deployed?

A. No. An analogous situation would be asking a barber whether or not you need a haircut.

Q. Do you believe the 2013 State Zero-Emission Vehicle ("ZEV") Programs Memorandum of Understanding should influence the Commission's decision in this case?

A. No. Other than the fact that Missouri has elected not to be signatory to that MOU.

Q. Are you aware of any investor owned utility that owns and operates a vehicular fuel station that is not subsidized by ratepayers?

A. Yes. Spire Missouri.

Amended Application

Q. How does this element of Ameren Missouri's application differ from what was filed in ET-2016-0246?

A. Ameren Missouri is no longer requesting to rate base the prospective EV charging stations but, instead, requests the Commission approve its plan to encourage EV charging adoption by providing up to $10 million dollars in subsidies for third-party ownership under the proposed tariff/incentive breakdown (see below in Table 2).

[11] See GM-3 and GM-4 and the KCPL & GMO service territories.

Table 2: Proposed Ameren Missouri EV charging station breakdown by type and incentive-level[12]

Charging Category	Incentive Amount	Estimated Total Incentives	Number of Ports Expected
Multifamily	$ 5,000 per L2 port	$4M	800
Workplace	$ 5,000 per L2 port	$1M	120
	$25,000 per L3 ≥50kW		16
Public Around Town	$ 5,000 per L2 port	$1M	120
	$25,000 per L3 ≥50kW		16
Long Distance Corridor	TBD thru RFP Reverse Auction Process	$4M	10-12
Except for Long Distance Corridor, all incentives are capped at 50% of project cost.			

What third party would ultimately "own" the long distance corridor stations and at what incentive level is not entirely clear. Further discovery is warranted.

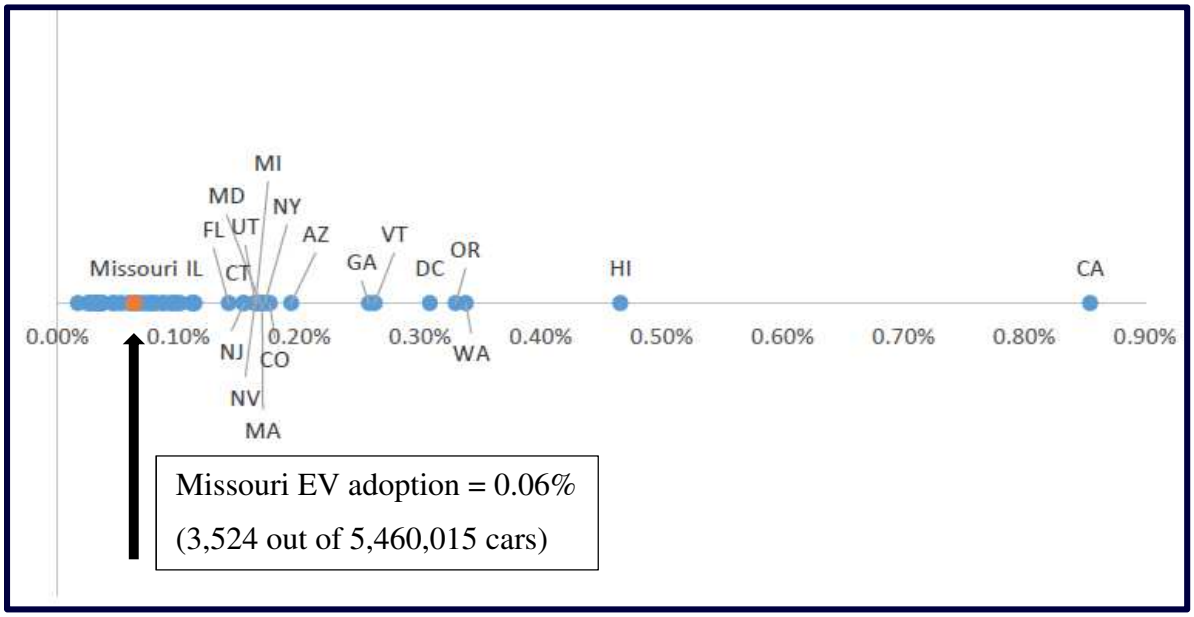
Missouri EV Sales & the KCPL Clean Charge Network ("CCN")

Q. Both Mr. Justis and Mr. Wills's point to depressed EV sales in Missouri. Do you agree?

A. I agree that sales of EV are very low throughout the United States. Missouri is no exception and is ranked #34 overall in US states with an overall adoption rate of 0.06% of registered vehicles.[13] Mr. Wills provides a breakdown of registered plug-in vehicles by state in his testimony and reprinted here in Figure 6.

[12] ET-2018-0132 Direct Testimony of Patrick Justis p. 36, 5.
[13] ET-2018-0132 Direct Testimony of Patrick E. Justis p. 12.

Figure 6: Registered plug-in vehicles by state [14]



Q. Both Mr. Justis and Wills point to KCPL's Clean Charge Network as a success in promoting EV stations. Do you agree?

A. No. I addressed the KCPL Clean Charge Network ("CCN") recently in my rebuttal testimony in KCPL and GMO most recent rate cases Case No: ER-2018-0145 and ER-2018-0146. My testimony was as follows:

> **Q. Please summarize KCPL/GMO's request.**
>
> A. KCPL and GMO witness Mr. Caisley is requesting that the Commission "reconsider" its position on the unrecoverable capital and O&M costs related to its Clean Charge Network ("CCN").
>
> **Q. What is OPC's position?**
>
> A. Consistent with the Commission's ruling in ER-2016-0285, OPC recommends the continued removal of these costs as the Commission has already ruled it has no statutory authority to regulate the CCN operations. Both ratepayers and drivers

[14] ET-2018-0132 Direct Testimony of Steven M. Wills p. 20, 6, and footnote 5.

are best served by a competitive market for EV charging services rather than by a regulated monopoly. The best ways for KCPL and GMO's *regulated* services to enable the promotion of EV adoption by emphasizing its essential services, primarily through offering time-of-use ("TOU") rates on an opt-in basis that encourages charging during low-cost, off-peak hours (this specific recommendation and its benefits will be discussed at length in my rebuttal rate design testimony).

The Commission has already rejected KCPL and GMO's proposal to recover EV charging station costs "above the line" and there has been no change in circumstances to warrant a different decision. The Commission should continue to leave deployment of EV charging infrastructure to non-regulated services and importantly, to existing and future free-market competition; thereby reducing the risk of future stranded utility assets and costs.

Q. What do you mean by stranded assets?

A. Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities. There is no question EV charging is a developing technology. EV charging stations can become stranded assets when new technologies are introduced and nimble companies out-compete incumbent utilities. Regulated electric utilities are then exposed to the risk of having stranded assets on their books. Failure to account for changing technologies may result in ratepayers funding assets that are outdated and are no longer useful by or useful to customers.

Q. Would KCPL and GMO's current CCN investments be considered stranded assets?

A. No, not for ratepayers because of the Commission's Order in ER-2016-0285. It may be too soon to know if the Companies' 929 charging stations will prove to

be a stranded investment for shareholders, however, the early returns are not encouraging.

According to the response to OPC DR-2032, from 2010 to 2017 there were 905,455 conventional vehicles (non-electric) registered in the KCPL-KS, KCPL-MO and KCPL-GMO service territories.[15] During that same time span only 2,789 EVs were registered in total (or 16 .03%), with only 972 in KCPL-MO and 434 in the GMO service territory.[16] [The rest were in Kansas].

Furthermore, according to OPC DR-2034, there have been a total of 2,092 "unique drivers" who have used the CCN through 2017. This means that, at least, more than 700 of the registered EV drivers who reside in the three KCPL service territories have never utilized the CCN. For perspective, there are 1,862 available charging ports on the Clean Charge Network, or roughly one charging port for each of the 2092 unique EV drivers who have *ever* used the CCN.[17]

It is also important to note that up until 2018 using the CCN charging stations was entirely free.[18] Moving forward, drivers will have to pay for charging service, at least at the 749 non-host paid sites. Equally important, the vast majority of these charging stations are also not "fast charging" but instead "Level 2" models that take 4-5 hours to fully charge an EV with a 100-mile battery.[19] The likelihood of generating enough revenues to cover the cost of the capital (and O&M) investments will be a challenge. Thankfully, and correctly, ratepayers do not have to bear those costs.[20]

[15] See ER-2018-0145 & ER-2018-0146 Rebuttal "Revenue" Testimony of Geoff Marke p. 3 GM-1.
[16] Ibid. GM-3.
[17] Ibid. GM-4.
[18] ER-2018-0145 & ER-2018-0146 Direct Testimony of Charles A. Caisley p. 5, 11-12.
[19] ChargePoint (2018) Level up your EV charging knowledge. https://www.chargepoint.com/blog/level-your-evcharing-knowledge/
[20] ER-2018-0145 & ER-2018-0146 Rebuttal "Revenue" Testimony of Geoff Marke p. 2,7 thru p. 4, 7.

Risks

Q. Do you have the same concerns with Ameren Missouri's proposal?

A. In part. As stated earlier, the Ameren Missouri Charge Ahead—electric vehicle program is categorically better than the KCPL CCN initiative as the capital would not be included in rate base which minimizes some of the concerns raised by OPC in earlier testimony.[21]

That being said, there is still a risk that the $11 million in ratepayer-funded requested subsidies will not produce commensurate value for ratepayers. The Charge Ahead-EV application is built on the premise that the EV market will "further" materialize as a result of populating the Ameren Missouri service territory with a "holistic charging station environment." It's a bet on future consumer actions of non-essential service and OPC is largely risk averse when it comes to speculative value-added services.

Q. Please explain some of those risks.

A. In addition to the concerns I raised in the ET-2016-0246, it has since come to OPC's attention that the global supply chain for cobalt is highly volatile and may perpetuating human rights violations. Cobalt is an essential element in EV batteries and is largely mined from the Democratic Republic of the Congo. According to recent report from the S&P Global:

> Automakers spending fortunes on a bet that electric vehicles are the industry's future are virtually silent on the mining risks tied to cobalt, a key metal for the batteries on which their plans depend. . . .
>
> A critical ingredient in lithium-ion batteries and a core enabling material in electric cars, energy storage systems, smartphones and other electronics, cobalt is chiefly mined in the Democratic Republic of the Congo, which accounted for 58% of global production in 2017 and 49% of world reserves, according to the U.S. Geological Survey. Tight global supplies recently have sent cobalt prices soaring to over $90,000 per metric ton on the London Metal Exchange, almost tripling since January 2017.

[21] See GM-3 and GM-4 for copies of ET-2016-0246 Rebuttal and Surrebuttal Testimony of Geoff Marke which are included in their entirety where many of OPC's policy concerns are explained.

> The DRC, which is already plagued by instability, political polarization and deficient infrastructure, could face more trouble with a long-awaited presidential election scheduled for December. The country is at an "inflection point" that could either lead to a "historic" democratic transition or to a "breakdown and … a great deal of violence," Tom Perriello, a former U.S. special envoy to the Congo and eastern Africa, said in March at the Brookings Institution, a think tank in Washington, D.C.
>
> In addition to supply-chain risks, human rights groups have routinely cited Congolese mines for child labor, forced evictions and water pollution, black marks that may be particularly troublesome for clean energy industries sold on their green credentials.
>
> "We all see this cobalt pinch looming," Chris Berry, founder and president of House Mountain Partners, an advisory firm focused on raw material supply chains, said in an interview. "A large part of it has to do with the fact that it comes from the DRC, and it's just a very challenging place to do business, and there's just no easy solution here if [electric vehicle] adoption continues at its current pace.". . .
>
> "There will be no electric vehicle industry without DRC cobalt," said Simon Moores, managing director of Benchmark Mineral Intelligence, an independent research firm. "It's really the new blood diamond. If investors start talking with their feet, these companies will start to take action."[22]

Like all investments, Ameren Missouri could do everything right and still not see a return on its investment. As noted above, the global supply chain for cobalt could categorically change the cost (and value) of EVs moving forward. Other real risks impacting this investment include rising EV costs due to thin profit margins for automakers. As Reuters recently reported:

> Electric cars are poised to arrive en masse in European showrooms after years of hyped concept-car launches and billions in investment by automakers and suppliers.

[22] Copley, M. & G. Hering (2018) Cobalt key to electric vehicles but automakers hushed on risks. *S&P Global*. https://www.spglobal.com/en/research-insights/articles/cobalt-key-to-electric-vehicles-but-automakers-hushed-on-risks see also GM-5.

> Now comes the hard part: selling them at a profit.
>
> Battery models making their car-show debut in Paris this week, from PSA Group's (PEUP.PA) electric DS3 Crossback to the Mercedes (DAIGn.DE) EQC, will erode profitability as they struggle to stay in the black, executives generally acknowledge.
>
> But concerns are mounting that the impact could be worse, as consumers resist paying more for electrified vehicles - forcing carmakers to sell them at a bigger loss to meet emissions goals.
>
> "What everyone needs to realize is that clean mobility is like organic food – it's more expensive," said Carlos Tavares, chief executive of Peugeot, Citroen and Opel manufacturer PSA. . . .
>
> "It absolutely is impacting the profitability of the industry," said Rebecca Lindland, a senior analyst at Kelley Blue Book, which tracks vehicle pricing. "Demand doesn't justify investment at all - it's all regulation."[23]

Unlike other traditional investments, the notable difference here, is that if Ameren Missouri is wrong, ratepayers will bear the costs.

Risk Sharing

Q. Does OPC have a recommendation on how to move forward?

A. Yes. At a minimum, OPC believes that value-added services should be premised on a sharing of symmetric risk. Symmetry in both potential outcomes and equality in the uncertainty surrounding the investment. No person in a transaction should have certainty about the outcome while the other one has uncertainty, especially when one of the parties in the transaction is "captive."

[23] Frost, L. (2018) Electric cars cast growing shadow on profits (Reuters) https://www.reuters.com/article/us-autoshow-paris-electric-squeeze-analy/electric-cars-cast-growing-shadow-on-profits-idUSKCN1MB2GD

In Mr. Wills's testimony, he puts forward several data points from which a potential resolution to this proposal might be realized. Mr. Wills cites Ameren Missouri's filed 2017 Integrated Resource Plan ("IRP") base forecast of EV adoption in Ameren Missouri's service territory over the next decade at 25,000 EVs by 2028, Mr. Wills then states:

> Given the $11 million proposed budget, and the roughly $1,500 investment that I previously calculated could be supported by each car, simple division suggests that approximately 7,500 new cars over the life of the program would need to be added to the system for the incremental effect of the program to result in rate benefits *directly* arising from the program for all customers.[24]

OPC suggests that the Commission could consider approval of Ameren Missouri's Charge Ahead—Electric Vehicle application with the following customer protections based on forecasted figures Mr. Wills relies on:

- $10 million in subsidies to promote EV charging stations as articulated in Table 2 above;
- $1 million in associated program administration and marketing;
- A 5-year time limit; and
- A risk-sharing mechanism between ratepayers and shareholders based on the number of registered plug-in EVs in Ameren Missouri's service territory by the close of calendar year 2028.

Q. Please describe OPC's risk-sharing mechanism.

A. Keeping in mind that Ameren Missouri's proposal is supposed to further spur sales of already expected EV adoption, OPC believes that cost-recovery of the entire program should be predicated on exceeding 25,000 "new" registered EVs based on calendar years 2019 to 2028 for the counties in which Ameren Missouri provides service.

[24] ET-2018-0132 Direct Testimony of Steven M. Wills p. 32, 22-23 & p. 33, 1-3.

To calculate the risk sharing mechanism, all registered EVs in counties in which Ameren Missouri provides service as of the close of December 2018 would be subtracted from the total number of registered EVs in Ameren Missouri's service territory at the end of 2028.

Ameren Missouri shareholders would bear all program costs if the overall number of registered EVs (minus the aforementioned existing registered EVs as of the close of 2018) is below 25,000 (based on Missouri Department of Revenue registered EVs) in the counties in which Ameren Missouri offers service.

Ratepayers will cover a percentage of the expense of costs related to the program if registered EVs result in 25,001 to 32,500 in counties in which Ameren Missouri serves. For illustrative purposes, the calculation would be as follows:

- Pre-2019 registered EV cars = 2,500
- Registered EV cars 2028 = 30,000
- Pre-2019 registration – 2028 EV registration = 27,500
    - 25,000 registered EVs as a result of regular market adoption absent no investment (base IRP assumption);
    - 2,500 registered EVs attributable to Charge Ahead investment
- 27,500 – 32,500 = 5,000 cars short of expected induced adoption
- Sharing mechanism =
    - 33.3% ratepayer funded or $3,663,000
    - 66.7% shareholder funded $7,337,000

If EV adoption exceeds 32,500 new (post-2018) registered EVs then ratepayers will cover the costs of the program in its entirety.

Q. Does this conclude your testimony?

A. Yes.

CASE PARTICPATION OF
GEOFF MARKE, PH.D.

Company Name	Employed Agency	Case Number	Issues
Union Electric Company d/b/a Ameren Missouri	Office of Public Counsel (OPC)	ET-2018-0132	**Rebuttal:** Line Extension / Charge Ahead – Business Solutions / Charge Ahead – Electric Vehicle Infrastructure
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2018-0211	**Rebuttal:** MEEIA Cycle III Application **Surrebuttal:** Cost Effectiveness Tests / Equitable Energy Efficiency Baseline
Union Electric Company d/b/a Ameren Missouri	OPC	EA-2018-0202	**Rebuttal:** Renewable Energy Standard Rate Adjustment Mechanism/Conservation **Surrebuttal:** Endangered and Protected Species
Empire District Electric Company /Kansas City Power & Light & KCP&L Greater Missouri Operations Company/Union Electric Company d/b/a Ameren Missouri	OPC	EO-2019-0066 EO-2019-0065 EO-2019-0064 EO-2019-0063	**Memorandum:** Additive Manufacturing and Cement Block Battery Storage (IRP: Special Contemporary Topics)
Kansas City Power & Light & KCP&L Greater Missouri Operations Company	OPC	ER-2018-0145 ER-2018-0146	**Direct:** Smart Grid Data Privacy Protections **Rebuttal:** Clean Charge Network / Community Solar / Low Income Community Solar / PAYS/ Weatherization/Economic Relief Pilot Program/Economic Development Rider/Customer Information System and Billing **Rebuttal:** TOU Rates / IBR Rates / Customer Charge / Restoration Charge **Surrebuttal:** KCPL-GMO Consolidation / Demand Response / Clean Charge Network / One CIS: Privacy, TOU Rates, Billing & Customer Experience
Union Electric Company d/b/a Ameren Missouri	OPC	ET-2018-0063	**Rebuttal:** Green Tariff
Liberty Utilities	OPC	GR-2018-0013	**Surrebuttal:** Decoupling

Empire District Electric Company	OPC	EO-2018-0092	**Rebuttal:** Overview of proposal/ MO PSC regulatory activity / Federal Regulatory Activity / SPP Activity and Modeling / Ancillary Considerations **Surrebuttal** Response to parties **Affidavit** in opposition to the non-unanimous stipulation and agreement
Great Plains Energy Incorporated, Kansas City Power & Light Company, KCP&L Greater Missouri Operations Company, and Westar Energy, Inc.	OPC	EM-2018-0012	**Rebuttal:** Merger Commitments and Conditions / Outstanding Concerns
Missouri American Water	OPC	WR-2017-0285	**Direct:** Future Test Year/ Cost Allocation Manual and Affiliate Transaction Rules for Large Water Utilities / Lead Line Replacement **Direct:** Rate Design / Cost Allocation of Lead Line Replacement **Rebuttal**: Lead Line Replacement / Future Test Year/ Decoupling / Residential Usage / Public-Private Coordination **Rebuttal**: Rate Design **Surrebuttal**: affiliate Transaction Rules / Decoupling / Inclining Block Rates / Future Test Year / Single Tariff Pricing / Lead Line Replacement
Missouri Gas Energy / Laclede Gas Company	OPC	GR-2017-0216 GR-2017-0215	**Rebuttal:** Decoupling / Rate Design / Customer Confidentiality / Line Extension in Unserved and Underserved Areas / Economic Development Rider & Special Contracts **Surrebuttal:** Pay for Performance / Alagasco & EnergySouth Savings / Decoupling / Rate Design / Energy Efficiency / Economic Development Rider: Combined Heat & Power
Indian Hills Utility	OPC	WR-2017-0259	**Direct:** Rate Design
Rule Making	OPC	EW-2018-0078	**Memorandum** on cogeneration and net metering
Empire District Electric Company	OPC	EO-2018-0048	Integrated Resource Planning: Special Contemporary Topics Comments

Kansas City Power & Light	OPC	EO-2018-0046	Integrated Resource Planning: Special Contemporary Topics Comments
KCP&L Greater Missouri Operations Company	OPC	EO-2018-0045	Integrated Resource Planning: Special Contemporary Topics Comments
Missouri American Water	OPC	WU-2017-0296	**Direct:** Lead line replacement pilot program **Rebuttal:** Lead line replacement pilot program **Surrebuttal:** Lead line replacement pilot program
KCP&L Greater Missouri Operations Company	OPC	EO-2017-0230	**Memorandum** on Integrated Resource Plan, preferred plan update
Working Case: Emerging Issues in Utility Regulation	OPC	EW-2017-0245	**Memorandum** on Emerging Issues in Utility Regulation / **Presentation**: Inclining Block Rate Design Considerations **Presentation**: Missouri Integrated Resource Planning: And the search for the "preferred plan." **Memorandum**: Draft Rule 4 CSR 240-22.055 DER Resource Planning
Rule Making	OPC	EX-2016-0334	**Memorandum** on Missouri Energy Efficiency Investment Act Rule Revisions
Great Plains Energy Incorporated, Kansas City Power & Light Company, KCP&L Greater Missouri Operations Company, and Westar Energy, Inc.	OPC	EE-2017-0113 / EM-2017-0226	**Direct**: Employment within Missouri / Independent Third Party Management Audits / Corporate Social Responsibility
Union Electric Company d/b/a Ameren Missouri	OPC	ET-2016-0246	**Rebuttal**: EV Charging Station Policy **Surrebuttal**: EV Charging Station Policy
Kansas City Power & Light		ER-2016-0156	**Direct:** Consumer Disclaimer **Direct:** Response to Commission Directed Questions **Rebuttal:** Customer Experience / Greenwood Solar Facility / Dues and Donations / Electric Vehicle Charging Stations **Rebuttal:** Class Cost of Service / Rate Design

			Surrebuttal: Clean Charge Network / Economic Relief Pilot Program / EEI Dues / EPRI Dues
Union Electric Company d/b/a Ameren Missouri	OPC	ER-2016-0179	**Direct:** Consumer Disclaimer / Transparent Billing Practices / MEEIA Low-Income Exemption **Direct**: Rate Design **Rebuttal:** Low-Income Programs / Advertising / EEI Dues **Rebuttal:** Grid-Access Charge / Inclining Block Rates /Economic Development Riders
KCP&L Greater Missouri Operations Company	OPC	ER-2016-0156	**Direct:** Consumer Disclaimer **Rebuttal:** Regulatory Policy / Customer Experience / Historical & Projected Customer Usage / Rate Design / Low-Income Programs **Surrebuttal:** Rate Design / MEEIA Annualization / Customer Disclaimer / Greenwood Solar Facility / RESRAM / Low-Income Programs
Empire District Electric Company, Empire District Gas Company, Liberty Utilities (Central) Company, Liberty Sub-Corp.	OPC	EM-2016-0213	**Rebuttal:** Response to Merger Impact **Surrebuttal:** Resource Portfolio / Transition Plan
Working Case: Polices to Improve Electric Regulation	OPC	EW-2016-0313	**Memorandum** on Performance-Based and Formula Rate Design
Working Case: Electric Vehicle Charging Facilities	OPC	EW-2016-0123	**Memorandum** on Policy Considerations of EV stations in rate base
Empire District Electric Company	OPC	ER-2016-0023	**Rebuttal:** Rate Design, Demand-Side Management, Low-Income Weatherization **Surrebuttal:** Demand-Side Management, Low-Income Weatherization, Monthly Bill Average
Missouri American Water	OPC	WR-2015-0301	**Direct:** Consolidated Tariff Pricing / Rate Design Study **Rebuttal:** District Consolidation/Rate Design/Residential Usage/Decoupling **Rebuttal**: Demand-Side Management (DSM)/ Supply-Side Management (SSM) **Surrebuttal:** District

			Consolidation/Decoupling Mechanism/Residential Usage/SSM/DSM/Special Contracts
Working Case: Decoupling Mechanism	OPC	AW-2015-0282	**Memorandum:** Response to Comments
Rule Making	OPC	EW-2015-0105	Missouri Energy Efficiency Investment Act Rule Revisions, Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0084	Triennial Integrated Resource Planning Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0055	**Rebuttal**: Demand-Side Investment Mechanism / MEEIA Cycle II Application **Surrebuttal**: Potential Study / Overearnings / Program Design **Supplemental Direct:** Third-party mediator (Delphi Panel) / Performance Incentive **Supplemental Rebuttal:** Select Differences between Stipulations **Rebuttal:** Pre-Pay Billing
The Empire District Electric Company	OPC	EO-2015-0042	Integrated Resource Planning: Special Contemporary Topics Comments
KCP&L Greater Missouri Operations Company	OPC	EO-2015-0041	Integrated Resource Planning: Special Contemporary Topics Comments
Kansas City Power & Light	OPC	EO-2015-0040	Integrated Resource Planning: Special Contemporary Topics Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0039	Integrated Resource Planning: Special Contemporary Topics Comments
Union Electric Company d/b/a Ameren Missouri	OPC	EO-2015-0029	Ameren MEEIA Cycle I Prudence Review Comments
Kansas City Power & Light	OPC	ER-2014-0370	**Direct** (Revenue Requirement): Solar Rebates **Rebuttal:** Rate Design / Low-Income Weatherization / Solar Rebates **Surrebuttal:** Economic Considerations / Rate Design / Cyber Security Tracker
Rule Making	OPC	EX-2014-0352	**Memorandum** Net Metering and Renewable Energy Standard Rule Revisions,
The Empire District Electric Company	OPC	ER-2014-0351	**Rebuttal:** Rate Design/Energy Efficiency and Low-Income Considerations

Rule Making	OPC	AW-2014-0329	Utility Pay Stations and Loan Companies, Rule Drafting, Comments
Union Electric Company d/b/a Ameren Missouri	OPC	ER-2014-0258	**Direct:** Rate Design/Cost of Service Study/Economic Development Rider **Rebuttal:** Rate Design/ Cost of Service/ Low Income Considerations **Surrebuttal:** Rate Design/ Cost-of-Service/ Economic Development Rider
KCP&L Greater Missouri Operations Company	OPC	EO-2014-0189	**Rebuttal:** Sufficiency of Filing **Surrebuttal:** Sufficiency of Filing
KCP&L Greater Missouri Operations Company	OPC	EO-2014-0151	Renewable Energy Standard Rate Adjustment Mechanism (RESRAM) Comments
Liberty Natural Gas	OPC	GR-2014-0152	**Surrebuttal:** Energy Efficiency
Summit Natural Gas	OPC	GR-2014-0086	**Rebuttal:** Energy Efficiency **Surrebuttal:** Energy Efficiency
Union Electric Company d/b/a Ameren Missouri	OPC	ER-2012-0142	**Direct:** PY2013 EM&V results / Rebound Effect **Rebuttal:** PY2013 EM&V results **Surrebuttal:** PY2013 EM&V results **Direct:** Cycle I Performance Incentive **Rebuttal:** Cycle I Performance Incentive
Kansas City Power & Light	Missouri Public Service Commission Staff	EO-2014-0095	**Rebuttal:** MEEIA Cycle I Application testimony adopted
KCP&L Greater Missouri Operations Company	Missouri Division of Energy (DE)	EO-2014-0065	Integrated Resource Planning: Special Contemporary Topics Comments
Kansas City Power & Light	DE	EO-2014-0064	Integrated Resource Planning: Special Contemporary Topics Comments
The Empire District Electric Company	DE	EO-2014-0063	Integrated Resource Planning: Special Contemporary Topics Comments
Union Electric Company d/b/a Ameren Missouri	DE	EO-2014-0062	Integrated Resource Planning: Special Contemporary Topics Comments
The Empire District Electric Company	DE	EO-2013-0547	Triennial Integrated Resource Planning Comments
Working Case: State-Wide Advisory Collaborative	OPC	EW-2013-0519	Presentation: Does Better Information Lead to Better Choices? Evidence from Energy-Efficiency Labels
Independence-Missouri	OPC	Indy Energy Forum 2014	Presentation: Energy Efficiency

Independence-Missouri	OPC	Indy Energy Forum2015	Presentation: Rate Design
NARUC – 2017 Winter	OPC	Committee on Consumer Affairs	NARUC – 2017 Winter Presentation: PAYS Tariff On-Bill Financing
NASUCA – 2017 Summer	OPC	Committee on Water Regulation	NASUCA – 2017 Summer Presentation: Regulatory Issues Related to Lead-Line Replacement of Water Systems
NASUCA – 2017 winter	OPC	Committee on Utility Accounting	NASUCA – 2017 Winter Presentation: Lead Line Replacement Accounting and Cost Allocation

NAVIGANT
RESEARCH

RESEARCH BRIEF

Advanced Electric Forklift Technologies in North America

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1. Executive Summary

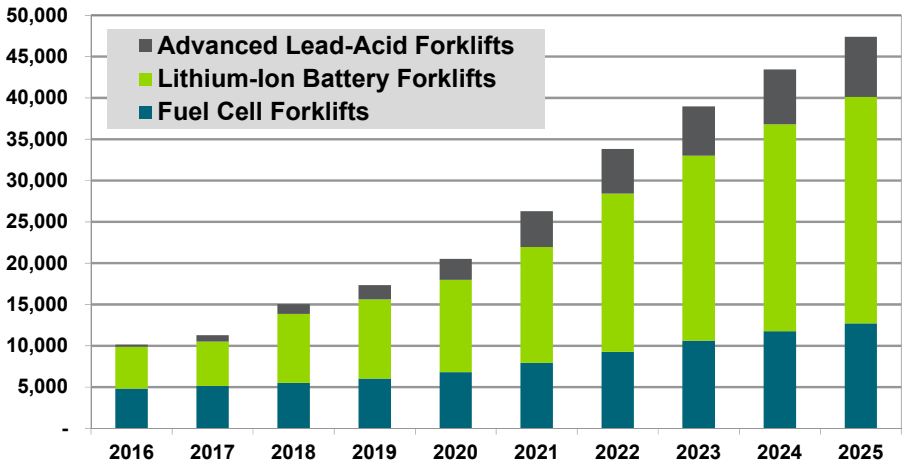
A shift away from forklifts powered by propane, diesel, and other fossil fuels in favor of electric models for indoor applications started to occur in North America during 2009. To date, traditional lead-acid batteries have been the battery of choice of warehouse managers for Class 1, Class 2, and Class 3 electric forklifts due to their low upfront purchase costs. Forklift manufacturers, advanced lead-acid battery manufacturers, lithium ion (Li-ion) battery manufacturers, and fuel cell technology providers are now beginning to help warehouse managers improve throughput and efficiency and save resources by utilizing new electric forklift technologies in their industrial vehicle fleets.

This research brief covers the advanced electric technologies being incorporated in Class 1, Class 2, and Class 3 forklifts. It aims to provide forklift market stakeholders with answers to key questions:

- What are the primary market drivers and barriers that Class 1, Class 2, or Class 3 advanced electric forklifts face in the evolving indoor warehouse sector?
- How can advanced lead-acid batteries, Li-ion batteries, and fuel cells improve the total cost of operations in forklifts for warehouse managers?
- What are the sales forecasts for advanced electric forklift technologies over the next 10 years?

While advanced electric powertrain options for forklifts are nascent technologies in the materials handling industry, they represent improvements over traditional options. Warehouses that operate multiple shifts per day and cold storage will be the main market for advanced electric technologies in forklifts. As shown in Chart 1, the advanced electric forklift market is expected to reach over 47,000 forklifts by 2025.

Chart 1 Advanced Electric Forklift Sales by Technology, North America: 2016-2025



(Source: Navigant Research)

GM-2

2. Market Update

The Industrial Truck Association (ITA), the leading North American trade organization for manufacturers and suppliers of forklift equipment, reported that electric forklift sales increased by over 8% from 2014 to 2015, representing 63.4% of the entire forklift market. Today, the predominant powertrain technology for electric-drive forklift trucks is the lead-acid battery. However, warehouse managers are being pressured to increase the productivity of daily operations, adjust quickly to market demands, and become more environmentally friendly. These pressures, in turn, are spurring companies to explore opportunities for other sources of energy.

In the past decade, materials handling operators in North America have been adopting more advanced electric technologies as alternatives to conventional lead-acid batteries and conventional chargers. This research brief covers the leading alternatives to lead-acid batteries that are now being offered or are under development for the North American electric forklift market. Specifically, the technologies discussed in this report are advanced lead-acid batteries, lithium ion (Li-ion) batteries, and fuel cells.

2.1 Market Overview

The Occupational Safety and Health Administration works alongside the ITA to define forklift classifications used in the North American forklift market. Forklift classifications are distinguished by a number of factors, including:

- Electric versus internal combustion engine (ICE)
- Type of operation
- Sit down versus stand up riders
- Indoor versus outdoor usage (with respect to terrain/steep grades)
- Ambient temperature operations versus hot/cold operations

Forklifts used in similar operations can be classified differently based on one or several of these factors. The ITA outlines seven classifications for forklifts; Classes 1 through 3 are exclusively electric-powered, while Class 6 can be either electric or ICE. These classes are listed in Table 1.

Table 1 Forklift Classifications

Classification	Title	Examples
Class 1	Electric Motor Rider Trucks	Counterbalanced Rider Type, Stand Up or Sit Down
Class 2	Electric Motor Narrow Aisle Trucks	High Lift Straddle, Low Lift Pallet
Class 3	Electric Motor Hand Trucks or Hand/Rider Trucks	Tractors, High Lift Straddle, Reach Type Outrigger
Class 6	Electric and ICE Tractors	Sit Down Rider

(Source: Occupational Safety and Health Administration)

This report highlights the advanced electric technologies being incorporated into Class 1, Class 2, and Class 3 forklifts. Class 6 forklifts are not included in this report because the market for new electric alternatives for this class of vehicles is not large due to the limited towing capacity of electric systems. Table 2 outlines the vehicle classes and associated specifications for traditional lead-acid battery forklifts.

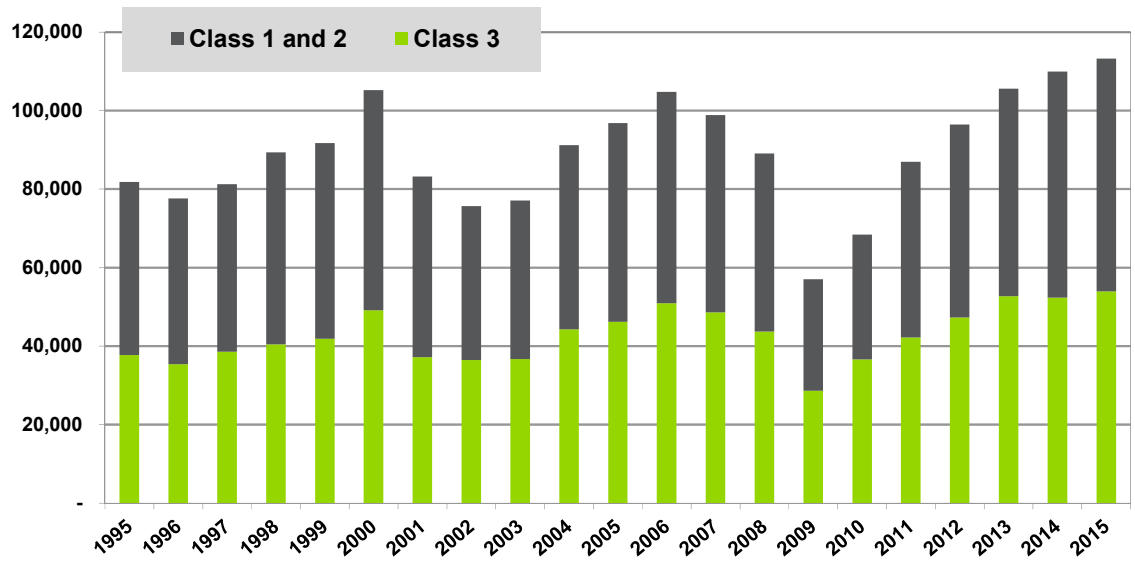
Table 2 Lead-Acid Forklift Characteristics: North America

Metric	Class 1 and Class 2	Class 3
Battery Size	22 kW-50 kW	10 kW-12 kW
Battery Module Cost	$6,500 average	$2,450 average
Lift Capacity	3,000-20,000 lbs	3,000-6,000 lbs
Battery Duration	4-6 hours	6 hours
Battery Life	3-5 years	3-5 years

(Source: Navigant Research)

Class 3 forklifts are the smallest and least expensive option, and they also have the lowest power requirements. These forklifts remain the leading type of forklift procured by warehouses and industrial site managers, representing approximately 47% of annual Class 1-3 forklift sales in the United States during 2015.

Chart 2 Electric Forklift Shipments by Class, United States: 1995-2015



(Source: Industrial Truck Association)

Historical forklift sales are cyclical based on the state of the economy and the lifespan of forklift equipment assets. In North America, the forklift market suffered a drop in sales due to the financial crisis of 2008. However, the forklift market has shown steady growth since 2010, as illustrated by the shipment data provided by the ITA in Chart 2. Note that while the ITA only reports on shipments from its member companies, it represents over 90% of the forklift manufacturers in the United States and Canada.

As the forklift market continues to evolve, it is vital that companies evaluate their operations and seek out customizable solutions to support specific applications and improve facility infrastructure and best practices. Acquiring the correct equipment will considerably improve operations efficiency and eliminate lengthy decision-making processes, enabling managers to spend more time and resources on other aspects of business. Within the forklift truck market, there is value in identifying customizable assets to fit a warehouse's processes. Customizable technology options allow forklifts to provide the necessary tools and support needed to respond quickly to change, manage the fleet throughout lifecycle operations, and expand business opportunities.

2.1.1 Market Drivers

Conventional lead-acid batteries (with a lead dioxide cathode and lead metal anode) are the leading powertrain for electric materials handling vehicles. Although lead-acid batteries have a well-established supply chain and a low initial cost per battery relative to other battery types, they are limited in their performance parameters. Their shortcomings in performance result in higher operations and maintenance (O&M) costs over the lifetime of the battery cells. Some characteristic traits of conventional lead-acid batteries are listed in Table 3.

Table 3 Lead-Acid Battery Characteristics

Metric	Traditional Lead-Acid Battery
Energy Density	25-45 Wh/kg
Efficiency	50%-75%
Discharge Time	4-8 hours
Cycle Life	500-1,000

(Source: Navigant Research)

Additionally, as a lead-acid battery's state of charge (SOC) drops, performance suffers due to the high power requirements for heavy lifting applications while in use. Full discharges result in increased strain on battery cells, furthering the need for additional units across shifts.

Achieving higher levels of productivity and overcoming bottlenecks/disruptions are standard issues that companies that procure forklifts face. Speed and responsiveness are key indicators of how successful they will be in the marketplace, and advanced electric technology options provide the best way to improve on these metrics. Below are key issues that can be addressed with new electric forklift powertrains:

- Long and/or multiple shift operations call for two to three lead-acid batteries per vehicle—one in operation, one recharging, and perhaps another cooling after recharging—resulting in a higher total cost of operations relative to other advanced electric technologies.
- Lead-acid batteries perform poorly in cold warehouse temperature operations.
- Lead-acid battery charging stations and battery swapping equipment take up valuable warehouse space.
- Some companies are transitioning to electric-drive forklift trucks to reduce their overall carbon footprint.

Although innovation in the materials handling industry has been historically flat—largely due to a lack of resources—there is a trend of increased consolidation as smaller companies combine to form larger organizations. Subsequently, these larger companies can gain more capital and move faster in adopting advanced technologies. Today's evolving supply chain service market is heavily driven by technology, and adopting new powertrain options for materials handling equipment can contribute to improved efficiency and less downtime.

2.1.2 Market Barriers

Upfront costs are the biggest obstacle facing new electric technologies in the forklift market. Current lead-acid batteries have price points of $200-$250 per kWh, with conventional charging apparatuses costing around $2,000. These prices are likely to remain flat due to the well-established distribution chain that lead-acid batteries have in the materials handling market. Compounded by the fact that the forklift industry has traditionally been risk averse, alternative technology options must prove that they are able to compete in cost over the lifespan of the vehicle powertrain.

There are technology options that can currently compete with lead-acid batteries in cost over their lifespans, but many companies are unable to address internal accounting challenges to demonstrate overall total cost of operations savings. For example, the person in charge of the budget for procuring new technology is often not the same person that is in charge of the budget for O&M activities. This presents a departmental budget problem that companies must address to accurately evaluate the cost of new forklift powertrain technologies. To help solve the cost issue, leasing rather than purchasing outright could be a way that companies can test and evaluate new powertrain technologies to see how they affect operations. Approximately half of all forklifts currently in use in warehouses across North America are leased from a third-party vendor. Thus, switching from one forklift powertrain technology to another after the leasing period expires could be accomplished without adversely affecting business.

A lack of innovation in the way that forklifts are manufactured is also preventing new technology penetration. Materials handling OEMs design machinery to fit lead-acid batteries exclusively, making it more difficult for battery manufacturers to develop alternative plug-and-play powertrain designs. This presents issues of sustaining the right power level throughout operations and chassis counterbalancing. Forklifts are designed to lift and carry significant weight (anywhere between 3,000 lbs and 20,000 lbs depending on the vehicle class), and utilizing the significant weight of a lead-acid battery is the standard way of stabilizing the chassis during operation.

2.2 Advanced Technology Options for Electric Forklifts

Traditional lead-acid batteries have a well-established supply chain, and therefore are anticipated to play a significant role in the electric-powered forklift market in North America for years to come. This section explores three alternative electric powertrain technologies that can be used in Class 1, Class 2, and Class 3 forklifts.

Table 4 gives a brief overview of the primary advantages and disadvantages of the alternative electric technologies discussed.

Table 4 Comparison of Technology Types

Technology Type	Advantages	Disadvantages	Value Proposition	Market Status
Advanced Lead-Acid	Can be efficiently fast charged without suffering lifespan losses Operates effectively in a partial SOC	New to market and not well understood in the sector Environmental risk of corrosive chemicals	Infrastructure is similar to traditional lead-acid Decreased forklift downtime	Immature technology
Li-Ion	Higher energy density than lead-acid Rapidly decreasing costs	Higher cost per battery than traditional lead-acid Has not gained much traction in sector yet	Decreased forklift downtime Fewer batteries per truck	Early commercial stage
Fuel Cells	Increased runtime and quick refueling times No operational degradation	High capital expenditures Unproven durability and variability of hydrogen fuel	Increased operational efficiency Decreased forklift downtime	Early commercial stage

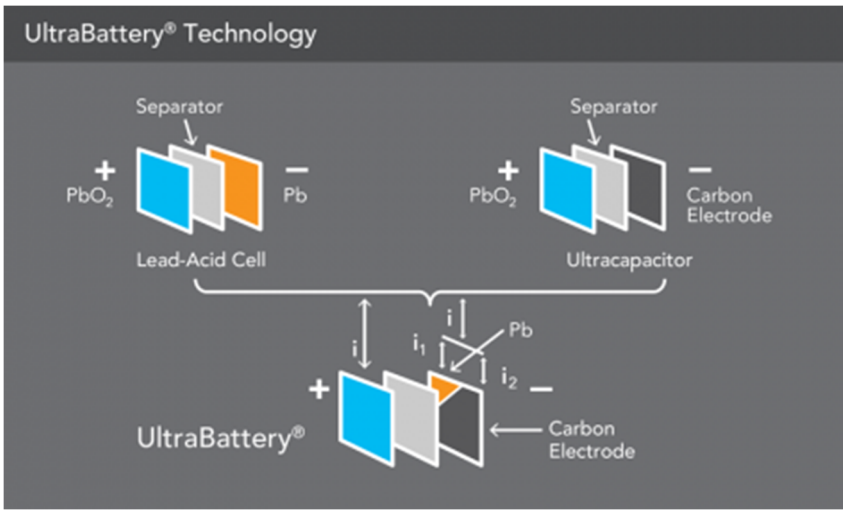
(Source: Navigant Research)

2.2.1 Advanced Lead-Acid Batteries

Advanced lead-acid batteries offer improved discharge capabilities and increased cycle life over traditional lead-acid batteries. The lead-acid chemistry has remained the battery of choice for applications such as uninterruptable power supply and utility vehicles. However, its narrow depth of discharge (DOD) makes it less than ideal for applications that require frequent cycling and rapid charge/discharge.

Perhaps the most popular option in the advanced lead-acid battery arena is the UltraBattery, which combines the energy storage potential of a lead-acid battery with the high charge potential of an ultracapacitor. The cathode uses lead dioxide as the principal material and utilizes a carbon-doped metal to increase discharge time and DOD. An illustration of the makeup of an UltraBattery is provided in Figure 1.

Figure 1 Construction of the UltraBattery



(Source: UltraBattery)

The UltraBattery has a number of advantages over traditional lead-acid batteries:

- The battery has an improved cycle life of 1,000 cycles at 80%-85% DOD.
- It exhibits efficient operation on a partial SOC.
- The UltraBattery has a low hydrogen gassing rate and is not as prone to sulfonation (accumulation of lead sulfate crystals on the anode leading to high internal resistance).
- It can maintain its lifespan when subjected to fast charging, reducing charge times by up to 75%.

Charging infrastructure is largely the same for advanced lead-acid and traditional lead-acid batteries, so from a technical perspective, it may be relatively easy to adapt the UltraBattery to the materials handling industry. UltraBatteries can also be fabricated in existing lead-acid battery factories, making it easy for traditional players to enter the space. Yet, these batteries face various challenges in the industry:

- The UltraBattery represents an emerging technology with limited use in the materials handling industry. It will have to see more adoption among traditional lead-acid players to make headway in the sector.
- The battery's electrolyte is made of corrosive acid, presenting safety and environmental hazards if not handled properly.
- There are a limited number of suppliers of this technology, and few are focused on the materials handling sector.

2.2.2 Li-Ion Batteries

Li-ion batteries have perhaps the largest opportunity to penetrate the Class 1, Class 2, and Class 3 forklift market over the next several years. These batteries are now produced in mass quantities, are much further along the experience curve relative to other electric technologies, and are a flexible option when considering different types of applications.

Li-ion batteries operate by way of lithium ion intercalation between the anode and cathode. The market consists of many different cathode variances classified into subchemistries, but the predominant options are lithium iron phosphate and lithium manganese oxide spinel. Both of these subchemistries are optimized to fit high power or high energy applications and thus can be utilized in a wide variety of applications. The anode is fabricated most often from graphite and is separated from the cathode by a liquid or solid electrolyte. The cells are constructed in a cylindrical, prismatic, or pouch format, allowing for efficient packing into larger battery assemblies.

Compared to traditional lead-acid batteries, Li-ion batteries can offer a number of operational advantages for forklifts:

- Li-ion cells are built for deep-cycle applications and are less subject to cell degredation over time, lasting on average for 1,200-2,000 full cycles (7-10 years depending on the operation).
- Only one battery is needed per truck, eliminating the need for battery swapping equipment and large charging infrastructure and curbing excessive O&M costs.
- Li-ion batteries have a significant runtime advantage (greater than 30%) over lead-acid batteries in cold temperatures (less than 0°C), making them a better fit for warehouses handling perishible items.
- Li-ion batteries do not run hot when in use, aiding in increasing lifespan and making them safer and less subject to thermal runaway under energy-intensive operations.
- Li-ion is a better chemistry for fast charging and can increase productivity over an 8-hour span when utilizing strategic charging techniques during worker breaks (i.e., opportunity charging).

In order to compete in the electric forklift market, the batteries must increase productivity around the clock and decrease overall costs of operations. Leasing forklifts that utilize these batteries could be an initial way for warehouses to determine whether a Li-ion powertrain can positively affect operations. Over the past several years, Li-ion batteries have steadily declined in cost, and Navigant Research estimates that this trend will continue over the next 5-10 years. Yet, there are several challenges that Li-ion batteries face in the materials handling market:

- High upfront cost per kilowatt-hour compared to lead-acid batteries can discourage warehouse budget managers from the initial purchase. Electric forklifts have a complex go-to-market channel; companies that procure forklifts for their warehouse operations need to have a vested interest in decreasing costs over a 7- to 10-year period.
- Lead-acid batteries and Li-ion batteries cycle differently. This means that plug-and-play Li-ion batteries must be compatible with telematics in the forklift and be able to adjust to the power duties of heavy lifting requirements experienced throughout operations.

- Infrastructural inertia must occur in the sector. Lead-acid batteries occupy such a large portion of the current market that it could be difficult for immature technologies to have a noteworthy market share.

2.2.3 Fuel Cells

Fuel cells used for motive applications have often been viewed as an expensive science experiment, but they offer a cost-competitive power delivery system in the materials handling industry. Electrically powered vehicles make up roughly half of all sales in the Class 1, Class 2, and Class 3 forklift industry in North America, according to the ITA, and many companies are exploring the use of fuel cells for these applications. Fuel cells are expected to continue to decrease in price as more OEMs adopt them.

Fuel cells run much like a battery, but instead of the fuel being contained within the cell, it is held outside of the cell. The leading type of fuel cell technology used for motive applications is the proton exchange membrane fuel cell (PEMFC). PEMFCs oxidize hydrogen at the anode (the fuel) and reduce oxygen at the cathode (from air) to produce an electrical charge, forming water and heat as byproducts.

The business case for utilizing fuel cells in electric forklifts largely arises from productivity gains. Some benefits include those listed below:

- Compared to charging conventional lead-acid batteries 2-3 times per day, forklifts equipped with fuel cell stacks can run up to 3 times longer and have refueling times of only 3-4 minutes.
- PEMFC stacks can be used as range extenders in conjunction with a battery, enabling constant operation over multiple shifts and quick refueling times and eliminating the need for battery swapping.
- There is little to no drop in power across the duty cycle when using fuel cells while working across shifts, which enables drivers to perform more lifts much quicker and allows for faster traverses.
- PEMFCs can potentially reduce fuel/electricity costs by lowering peak power needs, reducing the amount of high-priced peak power electricity consumed by the warehouse.

Warehouse owners and operators believe that leasing and having fuel cells available from OEMs rather than forcing manufacturers to purchase stacks from aftermarket suppliers will drive further interest in the technology. Conversely, there are a number of market barriers facing the increased adoption of fuel cells:

- Fuel cell stacks can cost anywhere from $14,000 to $30,000 per system (depending on the power capabilities). A company seeking to adopt them must be committed to supporting maintenance and infrastructure over the lifespan on the system to see a viable return on investment.
- PEMFCs are best suited for companies with medium- to large-sized fleets (30 or more units) and heavy duty operations of high weight/multiple shifts. Installing refueling stations in or around a warehouse costs roughly $100,000 today, and hydrogen fuel costs currently hover around $8 per kg. A site would typically need around 50 kg of hydrogen fuel per day to fuel 30 Class 3 vehicles.

- Reports of fuel variability (not enough fuel synthesized by hydrogen fuel companies to satisfy market demands) could be a major setback for warehouses. If hydrogen fuel is not readily available when needed, operations could be affecting, resulting in a severe loss of revenue.

Since hydrogen infrastructure is relatively nascent to the forklift industry, hydrogen gas distributers are continuing to engage with the materials handling market to provide solutions. There is also a secondary issue relating to siting of the hydrogen storage and dispenser needed to refuel fuel cells. Industrial gas companies are offering trucked-in hydrogen, which is then stored and dispensed onsite. Some smaller independent companies generate hydrogen onsite that must then be stored and dispensed. These storage facilities are situated outside of the operations facility to comply with safety codes, and the hydrogen is piped in for fueling indoors.

It is also important to note the Investment Tax Credit (ITC) that fuel cell modules receive in the North American forklift industry. An 8-year extension of the Emergency Economic Stabilization Act of 2008 (which included the ITC) was approved in 2008, and it was intended to accelerate the full-scale commercialization of fuel cell technologies. Companies can benefit from a credit of 30% of the purchase price (up to $3,000/kW) for procuring fuel cell technologies in their vehicle fleets. Other considerations are that the vehicle must have a minimum capacity of 0.5 kW and an electric-only efficiency of greater than 30%. The ITC entitles the taxpayer to subtract the dollar-for-dollar credit from total federal tax liability. This tax credit is valid until December 31, 2016.

Table 5 compares the total costs of operations for Class 1 and Class 2 forklifts, accounting for the upfront cost (including the ITC), O&M, power packs, and infrastructural/labor costs of recharging/refueling in the annual cost of operations calculation. These costs are calculated assuming that materials handling operations are ongoing, with equipment replacements made on a routine basis. This analysis does not include potential revenue gains for added productivity. Additionally, Class 2 forklifts are higher in cost than Class 1, but the 5- to 10-year total costs of operations are likely to be similar.

Table 5 10 kWh Class 1 and Class 2 Forklift Total Cost of Operations Comparison

Parameter	Fuel Cell-Powered	Lead-Acid Battery
Annual Cost of Ownership	$17,800	$19,700
System Maintenance	$2,200	$3,600
Labor Costs	$800	$4,400
Refueling Infrastructure	$500	$1,900
Fuel Cycle Greenhouse Gas Emissions	800 g/kWh	1,200 g/kWh
Total Fuel Cycle Energy Use	-12,000 BTU/kWh	>14,000 BTU/kWh
Estimated Product Life	8-10 years	4-5 years

(Sources: U.S. Department of Energy, National Renewable Energy Lab)

2.3 Key Industry Players

2.3.1 AeroVironment

Simi Valley, California-based AeroVironment is one of the longest tenured companies serving the electric vehicle (EV) charging industry. Founded in 1971, the publicly traded company offers fast charging and battery solutions for the industrial fleet market and provides proprietary chargers based on its PosiCharge

technology for industrial vehicle charging. The company recently introduced the ProCore Series, its intelligent charging family that supports and charges any materials handling battery chemistry. AeroVironment makes fast charging units for single or double shift operations and for indoor or outdoor use. The company is a leader in the fast charging forklift battery market and reports that it has sold over 18,500 chargers, servicing over 30,000 materials handling vehicles. Other PosiCharge solutions include the PosiNet Systems and Battery Rx fleet management software tools and fuel meter/e-meter assessments, which provide fleet managers with real-time fuel and battery usage data.

2.3.2 Aker Wade Power Technologies

Charlottesville, Virginia-based Aker Wade Power Technologies designs and manufactures advanced fast charging systems for EVs and industrial forklifts. Founded in 2000, the company's primary market is fast charging lead-acid batteries for industrial forklifts. Aker Wade is collaborating with battery companies, infrastructure suppliers, and EV manufacturers to deliver advanced direct current (DC) fast charging solutions for the coming generation of battery EVs. Companies that Aker Wade is working with include EnerSys, A123 Systems, ChargePoint, and Tokyo Electric Power Company. In the North American electric forklift market, Aker Wade products are distributed by industrial battery manufacturer EnerSys. EnerSys offers Aker Wade's fast chargers as part of its line of express fast charge solutions for the materials handling market. Aker Wade reports that it has supplied more than 14,000 DC fast chargers in North America, Europe, Latin America, and Asia.

2.3.3 Crown Equipment

New Bremen, Ohio-based Crown Equipment produces electric-powered forklifts, as well as automation and fleet management technologies, for the materials handling market. As of 2015, it was ranked the fifth top supplier in the global materials handling market based on revenue, according to industry publication *Modern Materials Handling*. With 17 manufacturing facilities worldwide and more than 500 retail locations in 84 countries, Crown has an extensive global production, sales, and service network. The company was one of the early players in promoting fuel cells for forklifts, indicating that it is willing to take a leading role in this new technology option for the materials handling sector. Crown uses a vertical integration strategy to unify 17 global manufacturing facilities, which enables the company to design and manufacture up to 85% of the components used in its forklifts. This strategy will allow the company to offer its electric-powered forklifts at a lower price than other companies that procure parts from several other suppliers.

2.3.4 Hyster-Yale

Cleveland, Ohio-based Hyster-Yale Materials Handling is a global designer, engineer, manufacturer, seller, and servicer of electric, warehousing, and ICE forklift trucks and aftermarket parts. As of December 2014, the company was one of top three world leaders in the forklift industry, with 825,000 forklifts in operation worldwide. Although the company's current and principal focus is battery-powered forklifts (traditionally for lead-acid, but more recently Li-ion retrofits), Hyster-Yale made headlines with its acquisition of fuel cell manufacturer Nuvera in late 2014. The company has said that it intends to commercialize Nuvera's research and technology through rapid integration of its fuel cell modules across Hyster-Yale's forklift products. Its purchase of Nuvera is a strategic acquisition to expand Hyster-Yale's reach in the forklift market, even though the company is expected to accrue operating losses in the next 1-2 years.

2.3.5 Navitas Systems

Woodbridge, Illinois-based Navitas is a leader in the integrated design, technology development, and manufacturing of Li-ion batteries, providing solutions and energy storage products for commercial, industrial, and government agency customers. The company arose from the consolidation of MicroSun Innovative Energy Storage Solutions, MicroSun Electronics, and A123 Systems' Government Solutions Group.

In late 2015, Navitas announced that it was the first battery company to have developed a series of heavy duty Li-ion batteries for Class 1 and Class 2 forklifts. Known as the Starlifter, this battery system spans voltages from 36V to 80V and energy capacities of 10 kWh-30 kWh. The Starlifter pack features a proprietary cell balancing feature that distributes power evenly between cells within the pack, optimizing its performance without the weakest cell diminishing the overall performance. It reportedly lasts up to 10 years depending on the duty cycle and no maintenance is required for the life of the pack.

2.3.6 Plug Power

Latham, New York-based Plug Power is a leading developer of fuel cells for industrial vehicles. The company has carved a first-mover advantage for itself in the North American market. Plug Power sells its GenDrive fuel cell systems for Class 1, Class 2, and Class 3 forklifts in high-throughput materials handling applications. The company has partnered with multiple OEMs, including Crown, Hyster-Yale, and Raymond. Plug Power has shipped more than 6,500 units (accumulating more than 100 million hours of runtime) to more than 20 customers, including some of the largest distributors in North America, such as Kroger, Procter & Gamble, Sysco, and Walmart. The company also recently unveiled its GenDrive 3340 fuel cell unit, the next-generation GenDrive Series 3000 product for pallet jack electric forklift trucks.

2.3.7 Raymond Corp.

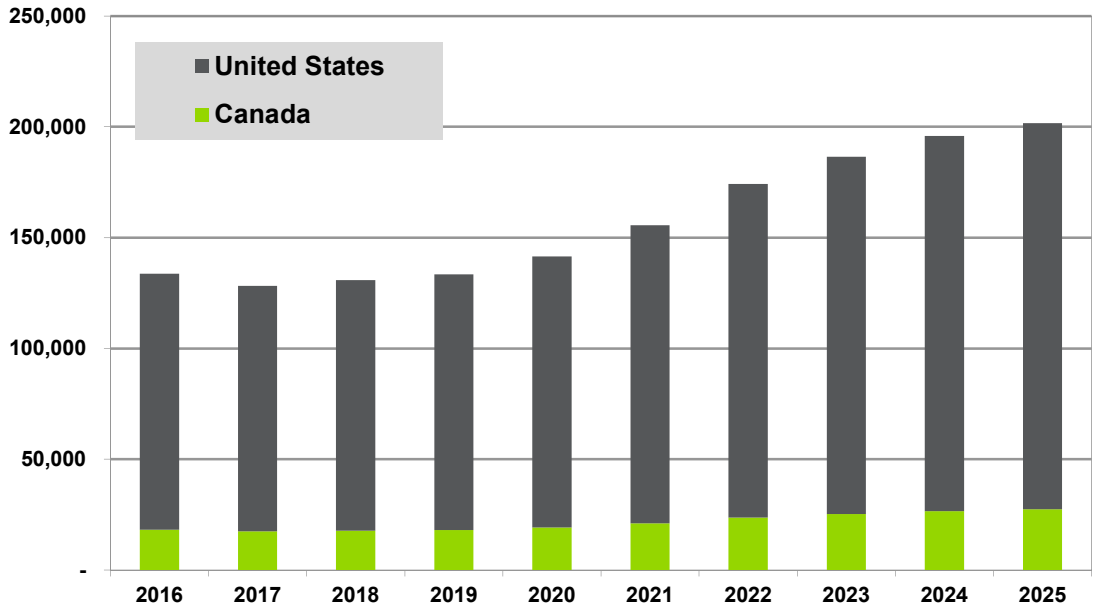
Raymond Corp. is a part of Toyota Industries Corp., which was the No. 1 industrial forklift truck supplier in the world in 2015, according to *Modern Materials Handling*. Based in Greene, New York, Raymond manufactures forklifts and designs end-to-end solutions to improve warehouse operations. The company has been one of the leading electric forklift companies looking at alternatives to conventional batteries. Raymond is committed to the R&D of the application of fuel cells to battery-powered forklift trucks.

3. Market Forecasts

This section forecasts the projected penetration of electric powertrains in forklifts by technology. Navigant Research envisions that conventional lead-acid batteries will retain ownership of around 75%-80% of the Class 1, Class 2, and Class 3 forklift markets in 2025 despite the potential of other technologies to reach lower total cost of operations benefits in the multi-shift operations and cold storage materials handling sectors. It is important to note that lead-acid batteries and advanced lead-acid batteries require similar infrastructure and maintenance procedures within the warehouse setting. Still, lead-acid batteries are expected to remain the leading electric option for forklifts throughout the forecast period.

While prices of advanced lead-acid and Li-ion batteries (collectively referred to as advanced batteries herein) and hydrogen fuel cells are expected to decrease throughout the forecast period, the overall percentage of market share for these technologies is anticipated to remain flat. Chart 3 shows the projected total sales for all Class 1-3 electric forklifts in North America by country, including traditional lead-acid batteries.

Chart 3 Electric Forklift Sales by Country, North America: 2016-2025

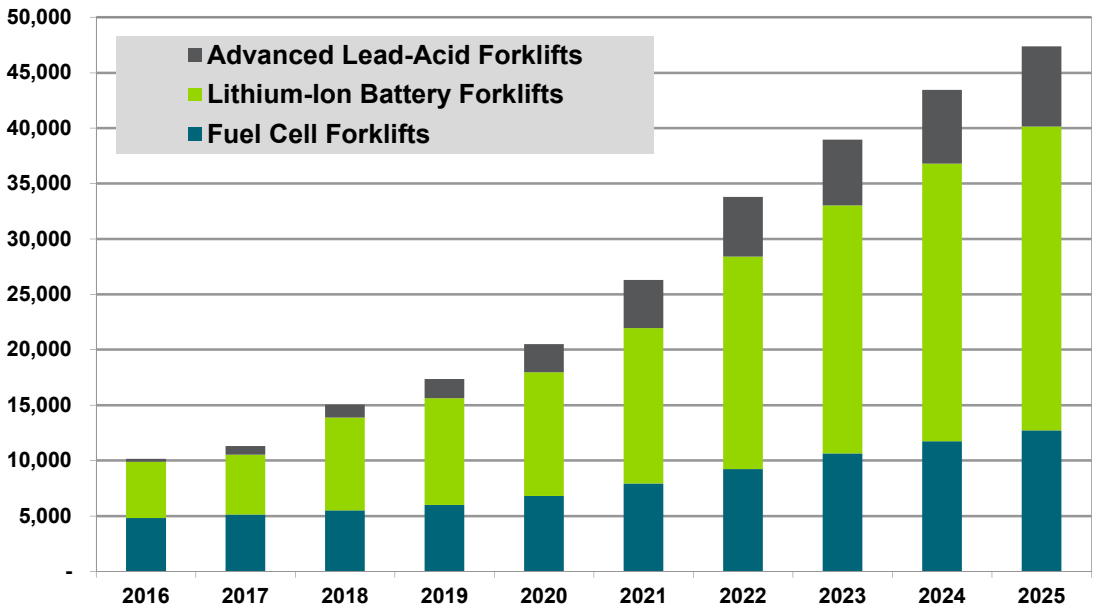


(Source: Navigant Research)

GM-2

Chart 4 highlights the anticipated market projections for the North American electric forklift market from 2016 to 2025 by electric drivetrain technology, not including traditional lead-acid batteries.

Chart 4 Advanced Electric Forklift Sales by Technology, North America: 2016-2025



(Source: Navigant Research)

The adoption of advanced lead-acid and Li-ion batteries is expected to increase incrementally in North America throughout the next 10 years. Navigant Research expects advanced lead-acid batteries to account for approximately 2.6% of the North American electric forklift market (excluding traditional lead-acid forklifts) in 2016. Li-ion batteries are projected to capture around 50.0% of the market. Combined, Navigant Research expects the market share of the two technologies to increase to over 73% by 2025. The value of fast charging compounded with the expiration of the ITC at the end of 2016 is expected to open up the market for current manufacturers of advanced battery technology and expand their presence in the North American forklift market. An estimated 20%-25% of the market for electric forklifts involves 24/7 operations and/or cold temperature operations, special segments where advanced batteries will likely see the largest adoption. New powertrain technologies have the potential to decrease in cost in this portion of the market, as well as expand to capture a larger portion of the electric forklift sector over the next 5-10 years.

Fuel cell models are projected to account for approximately 47.4% of unit sales in the North American electric forklift market (excluding traditional lead-acid forklifts) in 2016. Overall growth for fuel cell electric forklifts is projected to increase at a steady rate, but this technology is poised to lose its ITC at the end of 2016. With the loss of this credit, warehouses will no longer be incented to procure fuel cell technology, and shipments of these systems are expected to drop as a result. In addition, few companies are currently venturing into the fuel cell electric forklift market. Plug Power has been the leading provider for fuel cell powertrains in materials handling equipment.

4. Conclusions and Recommendations

Opportunities in North America for the incorporation of advanced electric technologies in Class 1, Class 2, and Class 3 forklifts lie in the 20%-25% of the forklift market focused on multiple shift operations and cold storage warehouses. Conventional lead-acid batteries are expected to remain popular in the North American forklift market in the near future because of a well-established supply chain and the conservative nature of the forklift sector. Supported by low first-cost materials, robust recycling processes, mature manufacturing operations, and supply chains, lead-acid batteries will continue to provide consistent support to the materials handling industry.

Important advantages of both advanced lead-acid and Li-ion batteries include longer cycle lives than traditional lead-acid batteries and the fact that both can be quickly charged without compromising the lifespan of cells. The main barrier that both advanced lead-acid batteries and Li-ion batteries must overcome in this sector is upfront cost. Both battery types are more expensive per kilowatt-hour than traditional lead-acid batteries and therefore must show that they are able to compete in cost over their lifespan.

Key solutions that fuel cells provide in this market include quick refueling times, longer durations of operations throughout shifts, and no power drops during operations. Conversely, fuel cells face learning curves and pose their own unique infrastructural requirements in the industry. As these technologies move further along the experience curve in this sector, they will be looked to as viable power options that can increase business and warehouse productivity over lead-acid and ICE powertrains.

With forklift OEMs and warehouse owners becoming more conscious of ways to reduce capital and operating costs and increase productivity, advanced lead-acid batteries, Li-ion batteries, and fuel cells are expected to see increased demand in the materials handling field in the next decade. Warehouse owners and operators looking to introduce their technologies to this market should keep the following factors in mind:

- The materials handling industry is anticipated to increase the adoption of electric forklifts (compared to ICE forklifts), but other niche technologies may also provide competition for electric alternatives. Several companies have explored using other alternative fuel powertrains. OEMs of the technologies discussed in this report will expect a warehouse owner to demonstrate the applicability of new electric technologies to forklift operations before venturing into this market.
- The advanced technology options discussed in this report offer an improved total cost of operations because they remove the need for multiple batteries for one truck, storage space for those batteries, large charging stations, and battery swapping machinery.
- Leasing new technology may be a cost-effective option for warehouses that are interested in realizing potential gains in around-the-clock productivity but do not want to purchase new equipment outright. Leasing can reduce the upfront cost hurdle and improve total cost of operations benefits.

- Companies looking to procure forklifts must develop communications methods within internal accounting departments (sectors in charge of capital cost must work with those in charge of O&M budget) to assess the total cost of operations for new forklift powertrain technologies.
- Plug-and-play technology options could be an easy way for warehouses to adopt electric alternatives discussed in this report in their forklift fleet. Doing so could reduce sunk costs in an existing lead-acid infrastructure.

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S&P Global

Cobalt key to electric vehicles but automakers hushed on risks

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By Michael Copley and Garrett Hering

A man enters a hand-dug tunnel at a cobalt mine in the Democratic Republic of the Congo.
Source: Associated Press

Automakers spending fortunes on a bet that electric vehicles are the industry's future are virtually silent on the mining risks tied to cobalt, a key metal for the batteries on which their plans depend.

Car companies expect evolving technology will eventually reduce or even eliminate their need for the blue metal ore, but, in the meantime, they could face pressure from investors who are asking questions about the new "blood diamond" and wondering why companies are not disclosing more information about their involvement with it.

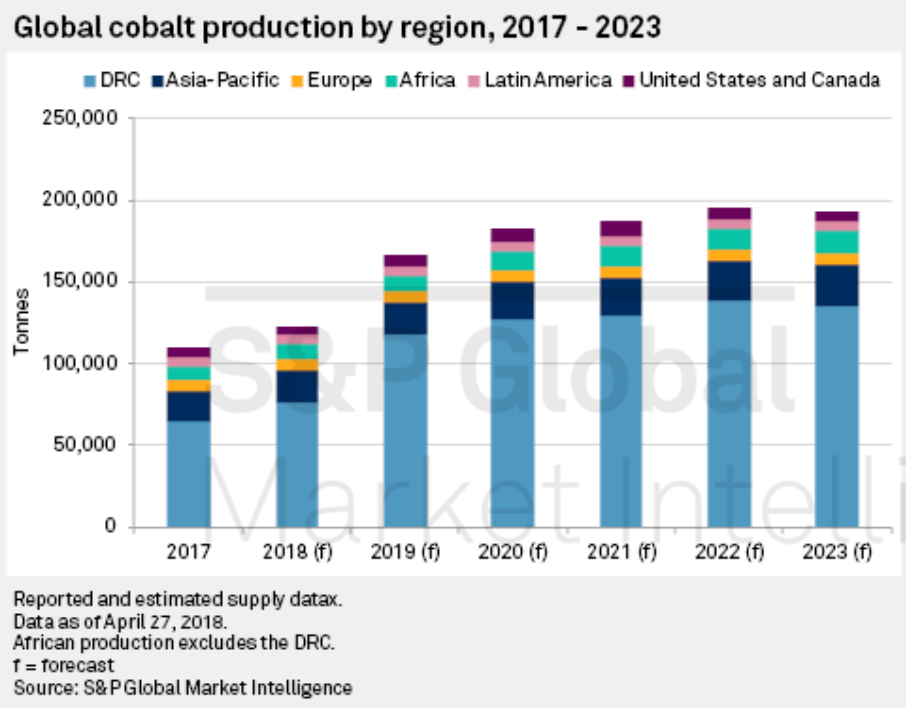
A critical ingredient in lithium-ion batteries and a core enabling material in electric cars, energy storage systems, smartphones and other electronics, cobalt is chiefly mined in the Democratic Republic of the Congo, which accounted for 58% of global production in 2017 and 49% of world reserves, according to the U.S. Geological Survey. Tight global supplies recently have sent cobalt prices soaring to over $90,000 per metric ton on the London Metal Exchange, almost

tripling since January 2017.

The DRC, which is already plagued by instability, political polarization and deficient infrastructure, could face more trouble with a long-awaited presidential election scheduled for December. The country is at an "inflection point" that could either lead to a "historic" democratic transition or to a "breakdown and … a great deal of violence," Tom Perriello, a former U.S. special envoy to the Congo and eastern Africa, said in March at the Brookings Institution, a think tank in Washington, D.C.

In addition to supply-chain risks, human rights groups have routinely cited Congolese mines for child labor, forced evictions and water pollution, black marks that may be particularly troublesome for clean energy industries sold on their green credentials.

"We all see this cobalt pinch looming," Chris Berry, founder and president of House Mountain Partners, an advisory firm focused on raw material supply chains, said in an interview. "A large part of it has to do with the fact that it comes from the DRC, and it's just a very challenging place to do business, and there's just no easy solution here if [electric vehicle] adoption continues at its current pace."



The auto industry's reluctance to discuss the issue publicly is striking in light of the information mining companies provide.

General Motors Co., for example, which aims to roll out 20 new all-electric vehicles by 2023, has never mentioned the metal in filings to the U.S. Securities and Exchange Commission, according to a review of company documents by S&P Global Market Intelligence. Neither has Ford Motor Co., which plans to offer 16 electric vehicles by 2022.

Meanwhile, Glencore PLC Chairman Anthony Hayward said in an annual report in March that the Anglo-Swiss mining giant is working on human rights guidance for the commodities sector and on "addressing the challenges associated with the cobalt value chain." China Molybdenum Co. Ltd., another major producer, said in its latest annual report that an affiliate that mines cobalt and copper in the DRC is investing in water infrastructure, agricultural work programs and vocational training there to mitigate risks.

In February, Glencore CEO Ivan Glasenberg was asked how the company's cobalt customers were reacting to proposed DRC mining regulations that Glasenberg said could threaten future supplies: "We haven't heard" from automakers, he said. "But I'm sure they've got to look at it and monitor it just like what we're doing. … [What] happens in the DRC is going to be very important going forward."

However, while Glencore executives have spoken at length about the relationship between cobalt and electric vehicles during the past two years, auto executives have rarely if ever commented on the subject, according to a review of

transcripts of corporate earnings calls.

Mining companies may operate in closer proximity to the Congo's problems, but electric-vehicle manufacturers are the ones driving demand for cobalt. And as consumer brands, they run the highest risk of a public backlash.

Automakers "can definitely do more to bring this … to the attention of investors and stress more clearly what they're doing" to reduce risks, said Sonja Wallenborn, a research manager at Sustainalytics, an investment consulting firm focused on environmental, social and governance, or ESG, issues. "The main risk really stems from the automakers and not necessarily the companies delivering these resources."

A young man carries cobalt at a mine in the Democratic Republic of the Congo.
Source: Associated Press

Automakers engaging, if not disclosing

At the direction of Congress, the SEC in 2012 began requiring companies to disclose their use of the "conflict minerals" tin, tantalum, tungsten and gold that originate in the DRC or neighboring countries if those materials are "necessary to the functionality or production of a product." While cobalt was omitted from the list, analysts say that, for now, the metal is essential for electric vehicles. The U.S. Department of the Interior recently said cobalt is one of 35 minerals that are "critical" for America's economy and national security.

While some automakers have avoided discussing the topic openly, executives appear to be well aware of the risks in the cobalt supply chain — and are taking actions to avoid them.

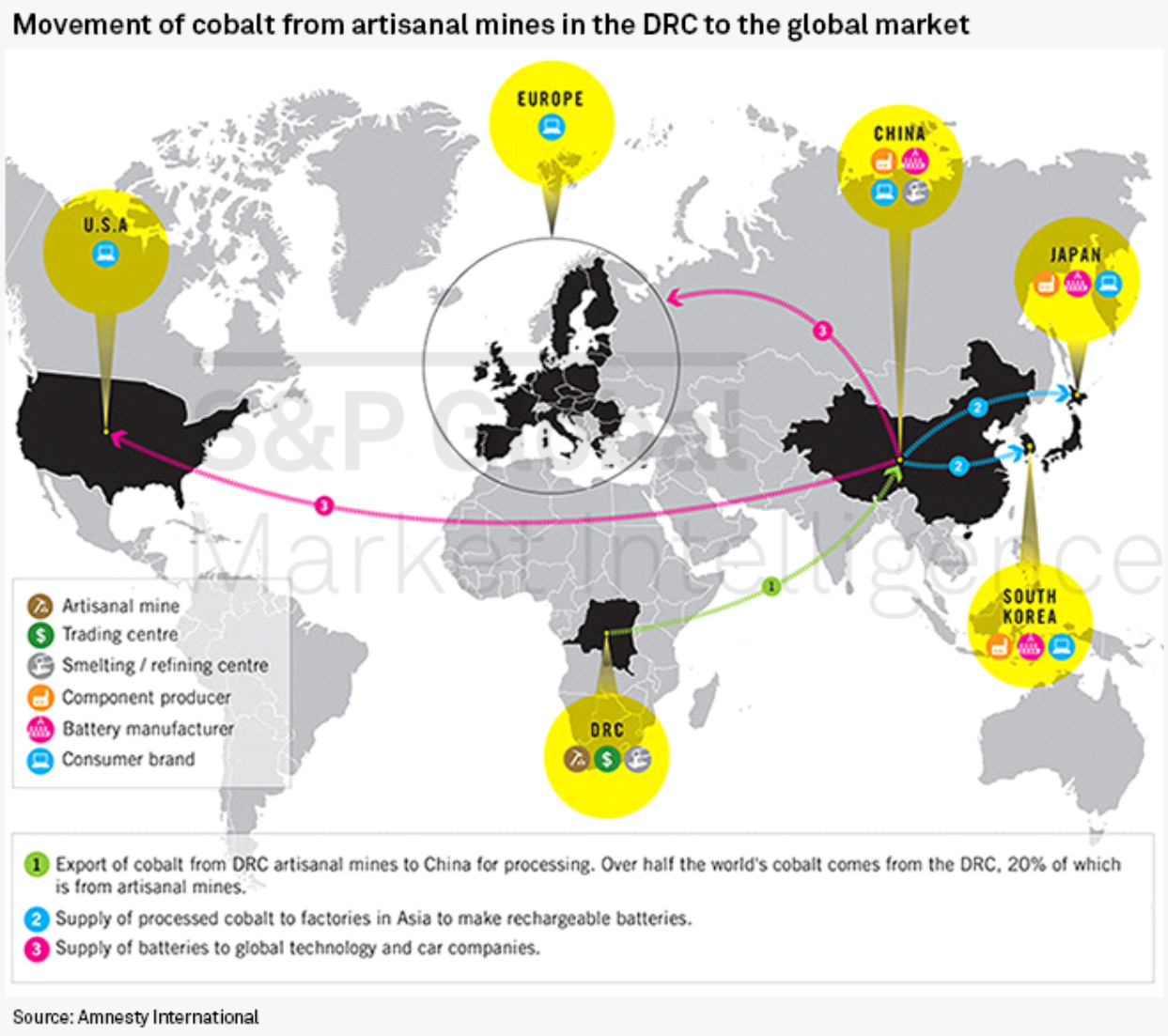
At a March battery conference in Florida, Mark Verbrugge, director of General Motors' Chemical and Materials Systems Laboratory, said raw material supplies — particularly of cobalt — pose the biggest threat to battery producers. GM declined to say whether the risks Verbrugge identified also apply to electric vehicle makers. While the company's SEC filings do not flag any risks specifically tied to cobalt, a sustainability report on its website notes "human rights issues"

associated with the metal.

"We continue to work with our suppliers to reduce the amount of cobalt in our battery cells," GM spokesman Kevin Kelly wrote in an email. "GM does not source individual cell chemistry materials ourselves but we do assure that our suppliers meet our requirements for responsible sourcing."

Ford did not respond to messages seeking comment.

At a shareholder meeting May 10, Ford executives were asked about a CNN investigation of the cobalt supply chain. Ford is "committed to respecting human rights everywhere we operate," said Bradley Gayton, a vice president and the company's general counsel. "And that includes robust purchasing processes that we have, supplier training and education on human rights issues," as well as third-party social-responsibility audits for suppliers. Gayton referred shareholders to a sustainability report on Ford's website for more information. That document does not mention cobalt.



A Tesla Inc. spokesperson said the electric vehicle and energy storage startup conducts "on-site audits to the best of our ability during the sourcing and vetting process for suppliers, to view operations and methods of risk management." Tesla mentioned cobalt twice in its latest annual report to the SEC, as one of a handful of materials that present supply and pricing risk; it did not identify any humanitarian concerns. The company has said that "the overwhelming majority" of its cobalt comes from outside of the DRC.

The annual report that Fiat Chrysler Automobiles NV filed with the SEC did not mention cobalt. However, a sustainability report posted on the company's website mentioned some of the "undesirable practices" related to cobalt and other raw materials. Fiat Chrysler, which is based in the U.K. but lists shares on the NYSE, did not respond to messages seeking comment.

Risk disclosures by electric-vehicle manufacturers listed outside of the U.S. have also been limited.

Germany's Volkswagen AG, which recently ordered €20 billion worth of lithium-ion batteries, mentioned cobalt once in its annual report, saying the metal carries pricing risk due to "political and economic uncertainty." In a sustainability report, the company said it directs suppliers to ensure their use of minerals, including cobalt, does not "directly or indirectly promote or support armed conflicts, and are in no way connected to human rights violations." Fellow German automakers Daimler AG and BMW AG did not address cobalt in their annual reports but did mention it in sustainability reports.

A young man carrying cobalt at a mine in the Democratic Republic of the Congo.
Source: Associated Press

Quietly, automakers have joined in partnerships intended to address some of cobalt's problems. One of the groups is working with Chinese refiners on a pilot program to improve supply chain transparency and reduce harm in the DRC. Another group, which includes Samsung SDI Co. Ltd., a battery affiliate of the South Korean electronics giant, is targeting "the worst forms of child labor."

However, initiatives like those are only "a start," said Nicholas Garrett, the CEO of RCS Global, a battery supply chain audit and advisory firm. Consumer brands "want to be seen on the right side of history," Garrett said. But "it would be extremely difficult to back up any child labor-free cobalt claim right now."

Amnesty International, a human rights group, said corporate due diligence alone cannot fix the human rights abuses in the cobalt supply chain. But "companies that are not performing due diligence in line with international standards risk contributing to, and benefiting from, those abuses," the group said in a 2017 report.

According to Amnesty International, GM and Daimler have made "minimal" efforts to detect, disclose and remediate human rights risks and abuses in their cobalt supply chains. Detection and disclosure efforts by Tesla, Fiat Chrysler and Volkswagen have also been minimal, though the companies have taken "moderate" steps to mitigate risks. BMW scored slightly better, taking moderate steps to detect and mitigate risks; however, disclosure by the company is still minimal,

Amnesty International said. The group did not evaluate Ford.

Amnesty International said it accounted for input from automakers who disputed their rankings before the report was published. GM, Daimler, Fiat Chrysler, Volkswagen and BMW did not respond to requests for comment. A Tesla spokesperson said the company has a human rights and conflict minerals policy for its suppliers and is "committed to only sourcing responsibly-produced materials."

Kristina Friedman, an ESG research analyst at Calvert Research and Management, said corporate initiatives around cobalt "significantly lag other conflict minerals disclosures where regulations, international frameworks, and reporting standards exist."

Congolese boys take part in a protest against President Joseph Kabila's refusal to step down from power in Kinshasa in 2017.
Source: Associated Press

New blood diamond

The stakes are high for the DRC, where the economics of resource extraction have been a major source of the country's woes, according to Omékongo Dibinga, a lecturer at American University's School of International Studies.

"It's not like people in eastern Congo … want to stop producing the minerals that are in our phones and in our televisions," Dibinga said, but "they want to get paid for it. They want to get a livable wage. They want health insurance. They want to be able to not have to work sun up to sunset without a mine collapsing on them. And that's what people are in the street fighting for."

For many in the industry, though, avoiding the need for the mineral is exactly the plan.

"We think we can get the cobalt [usage] to almost nothing," Tesla Chairman and CEO Elon Musk told investors May 2.

Tesla's main battery cell supplier, Panasonic Corp., is reportedly working on a cobalt-free technology.

BYD Co. Ltd., a China-based manufacturer of electric vehicles, energy storage systems and batteries, relies on cobalt-free lithium-iron-phosphate batteries, in addition to batteries that use cobalt sourced from nickel mines it owns in China.

The company "has a roadmap to a sustainable future," Micheal Austin, vice president of subsidiary BYD America Corp., said. In addition to being "chemistry neutral," BYD advocates for comprehensive battery recycling programs.

Additionally, electric vehicle producers, including Nissan Motor Co. Ltd., Renault SA, Mitsubishi Motors Corp., Volkswagen and BMW, as well the U.S. Department of Energy's Advanced Research Projects Agency-Energy, are funding research and startups focused on low- to no-cobalt batteries.

Such alternatives, however, could take years to commercialize. In the meantime, big consumer electronics and auto brands are trying to lock up as much cobalt as possible in long-term supply deals, ensuring years of exposure to the metal's risks.

"There will be no electric vehicle industry without DRC cobalt," said Simon Moores, managing director of Benchmark Mineral Intelligence, an independent research firm. "It's really the new blood diamond. If investors start talking with their feet, these companies will start to take action."

A visitor sits in a Ford electric vehicle during the Shanghai International Automobile Industry Exhibition in China in 2017.
Source: Associated Press

'Why don't you start disclosing?'

The tension between the potential benefits and risks of electric vehicles is a familiar one to ESG investors, said Christopher Ailman, chief investment officer of the California State Teachers' Retirement System.

"That's what makes ESG [investing] so hard," Ailman said. "Sometimes the energy issues come with environmental

problems and social problems. So it's got to be balanced and all together." The key is for companies to identify those risks and explain "How do they see this, how are they adjusting, how are they planning for the future?" he said.

While companies in the U.S. are unlikely to face new requirements to report on their cobalt supplies any time soon — President Donald Trump in 2017 reportedly considered suspending the rule requiring companies to disclose their use of conflict minerals from the DRC — the risks related to cobalt are "increasingly getting on investors' radar," said Wallenborn of Sustainalytics.

As a result, automakers could find themselves under more pressure from investors.

"The question I'm always asking when I deal with companies is, are they learning from these errors, or [do] they just [not] care and … see it as a cost of doing business? Do they really understand that there's an issue here with the branding or around their brand and the value of their brand?" Jeremy Cote, a research analyst at Trillium Asset Management LLC, said of companies exposed to ESG-related risks.

Cote added: "We need to show them these are our concerns … and go through our process, which starts off with, 'Hey, why don't you start disclosing stuff?'"