Business & Technology Strategies

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C&I CASE STUDIES IN **BENEFICIAL ELECTRIFICATION**

Forklifts

BY **TOM TATE**, SEPTEMBER 2017

SUBJECT MATTER EXPERT FOR QUESTIONS ON THIS TOPIC

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INTRODUCTION

The wise use of electricity, *Beneficial Electrification,* has sparked widespread re-thinking of policies that encourage or mandate less electricity use and promote infrastructure planning. Advancements in electric technologies continue to create new opportunities to use electricity as a substitute for on-site fossil fuels like natural gas, propane, gasoline, and fuel oil, with increased efficiency and control. It also offers local economic development and enhances the quality of the product used by the customer.

Electrifying industrial and commercial processes is a proven method to help local businesses stay competitive. Beneficial electrification strengthens the cooperative presence in the community and offers benefits to the electric system. Working with C&I customers is a good place to start. To provide examples of various approaches to working with C&I customers on beneficial electrification initiatives, NRECA is developing a series of case studies. This article focuses on beneficial electrification of forklifts. For other case studies in this series, please visit **cooperative.com**.

NRECA
America's Electric Cooperatives

MEMBER PROFILES

Great River Energy (GRE) of Maple Grove, Minn. is a not-for-profit cooperative that provides wholesale electric service to 28 distribution cooperatives in Minnesota and parts of Wisconsin. Those member cooperatives distribute electricity to approximately 685,000 member consumers. With $4 billion in assets, Great River Energy is the second largest electric power supplier in Minnesota and one of the largest generation and transmission cooperatives in the United States. Learn more at **www.greatriverenergy.com.**

Connexus Energy is the largest customer-owned utility in Minnesota providing electricity and related products and services to approximately 130,000 homes and businesses in portions of Anoka, Chisago, Hennepin, Isanti, Ramsey, Sherburne and Washington counties. Additional information about Connexus Energy is available online at **www.connexusenergy.com.**

Beneficial electrification is the process of replacing a fossil-fueled technology with a more efficient, electric alternative.

DESCRIPTION OF PROBLEM/OPPORTUNITY

Background

Building load in an environment of mandated load reduction and an emphasis on increasing the percentage of renewal sources in the fuel mix may seem like a daunting, if not impossible, task. However, building load through beneficial electrification provides cooperatives with a mechanism to satisfy every stakeholder, while delivering significant benefits to members. Implementation of beneficial electrification programs can have substantial beneficial impacts in:

- Reduction of Greenhouse Gas (GhG) emissions.
- Providing operational savings for members.
- Improving the health and safety of members' employees.
- Helping members achieve corporate green energy/efficiency goals.

Great River Energy (GRE) decided to find ways of equipping their members with the programs and tools to pursue beneficial electrification in just such an environment to benefit the members, the co-op, and the environment.

Beneficial electrification is the process of replacing a fossil-fueled technology with a more efficient, electric alternative. The case can be made that the entire cooperative movement is built upon beneficial electrification of a different type, replacing manual, labor-intensive processes with electric powered alternatives. So, the concept is part of the co-op DNA.

For load growth, co-ops need to take over market share currently served by fossil fuel technologies, especially those using propane, diesel, and gasoline. With the current abundance of natural gas driving those prices down, tackling situations in which that is the fuel is far more difficult to justify financially to a member.

The Forklift Market

According to the Industrial Truck Association[1], the number of forklifts in use today in the United States by type breaks out as shown in **Figure 1.** The Electric Rider type includes Classes 1 and 2; Motorized Hand is Class 3; and Internal Combustion includes Classes 4 and 5.

Fossil fuel (IC) forklifts continue to lead in number of sales, but the trend towards electric forklifts is clear from this chart. In 1994, IC forklifts held

[1] http://www.indtrk.org

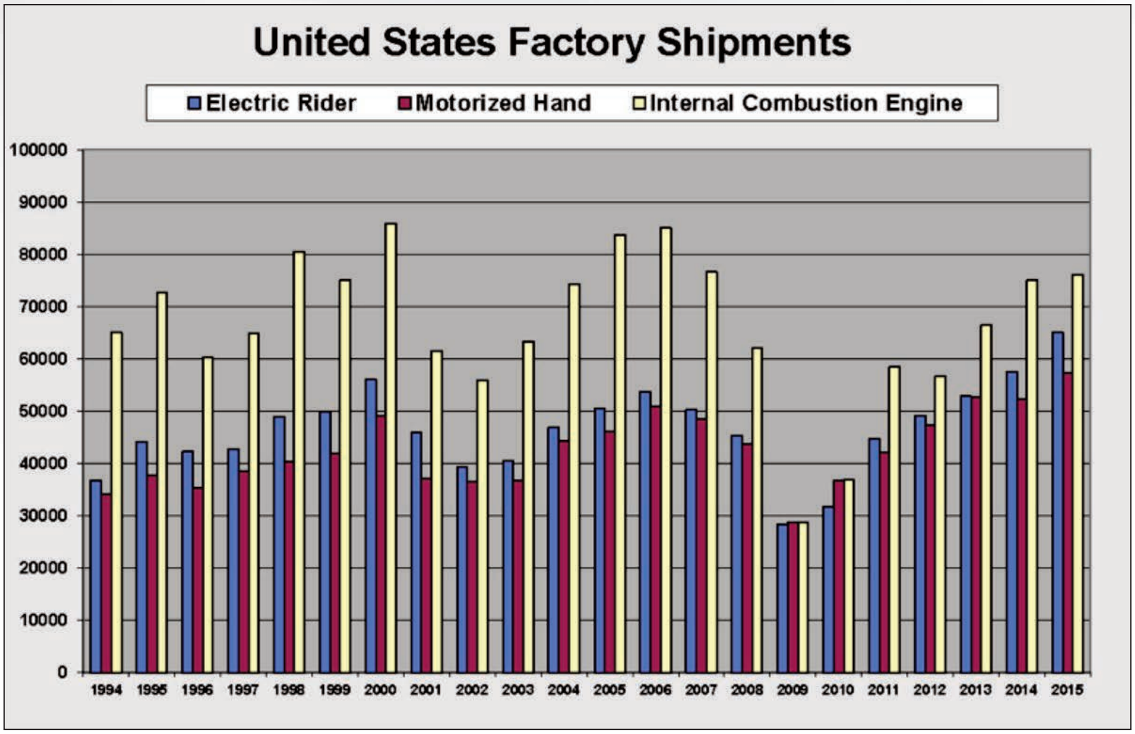

FIGURE 1: Number of Forklifts by Type

a 48 to 27 percent market share advantage over electric forklifts (excluding Motorized Hand). By 2015, that gap closed to 38 versus 33 percent.

Note: Factory Shipments represent the units sent to the distribution channel and do not necessarily represent actual sales in any given year. That said, it is an excellent indicator of market demand. Appendix A presents the chart's underlying data.

This case study looks at replacing IC forklifts with electric alternatives, currently heavily skewed to lead-acid batteries, but rapidly moving to lithium ion technology. With the advances in battery technology and the growing application of batteries in all transportation areas, this is an opportunity ripe for the taking.

DESCRIPTION OF THE TECHNOLOGY APPLICATION

Forklifts come in a range of lift capacities and capabilities. The sidebar *"Forklift Classifications"* provides a listing of the classes of forklifts, splitting apart the most common varieties.

Forklifts may be used in any material handling situation, both indoors and out. Wherever a member is using a forklift with an internal combustion (IC) engine, an electric alternative is a strong contender as a replacement.

FORKLIFT CLASSIFICATIONS

Most Common Forklift Classes

- Class I: Electric Motor Rider Trucks
- Class II: Electric Motor Narrow Aisle Trucks
- Class III: Electric Motor Hand Trucks or Hand/Rider Trucks
- Class IV: Internal Combustion Engine Trucks (Solid/Cushion Tires)
- Class V: Internal Combustion Engine Trucks (Pneumatic Tires)

Specialty Forklift Classes

- Class VI: Electric and Internal Combustion Engine Tractors
- Class VII: Rough Terrain Forklift Trucks

https://www.osha.gov/SLTC/etools/pit/forklift/types/classes.html

Forklifts are used in a wide range of industries and settings, both large and small. The following is a listing of some of the more promising opportunities for electric forklifts:

- **Materials handling:** In dusty or explosive environments where sparks and heat from an internal combustion engine exhaust pose a threat. Examples include:
  - Milling, grain handling
  - Saw mills, wood processing
  - Chemical plants, any environment with significant levels of VOCs or other potentially explosive/combustible vapors
- **Food storage and transshipment terminals (SIC Division F — Wholesale Trade):** These can range in size from primary production facilities, to regional distribution centers and down to retail outlets themselves.
- **SIC Division D — Manufacturing:** Manufacturing facilities of any type
- **SIC Division D — Manufacturing, Major Code 20:** Agricultural applications, especially food processing
- **Smaller retail operations:** When there is the need to move product from the dock to the storeroom to the floor. These may be simple pallet jacks, but there is an opportunity to replace manual versions with electric.

Electric forklifts may also be used outdoors. Just like the IC counterparts, the electric forklift needs to have the proper size and type of tires and be conditioned for the elements.

Electric forklifts are nearly identical to the IC alternatives in terms of controls and overall configuration (see Figures 2 and 3). In lieu of the internal combustion engine, these forklifts use electric motors and batteries. A nice additional feature in some electric forklifts is regenerative charging where energy is recaptured during braking, which extends operational time.

While the industry is moving towards lithium-ion batteries, the most common battery in use today is the lead-acid. According to an article by WarehouseIQ,[2] lead-acid batteries also serve as a counterweight to stabilize the forklift while it is lifting.

FIGURE 2: Electric Forklift Controls

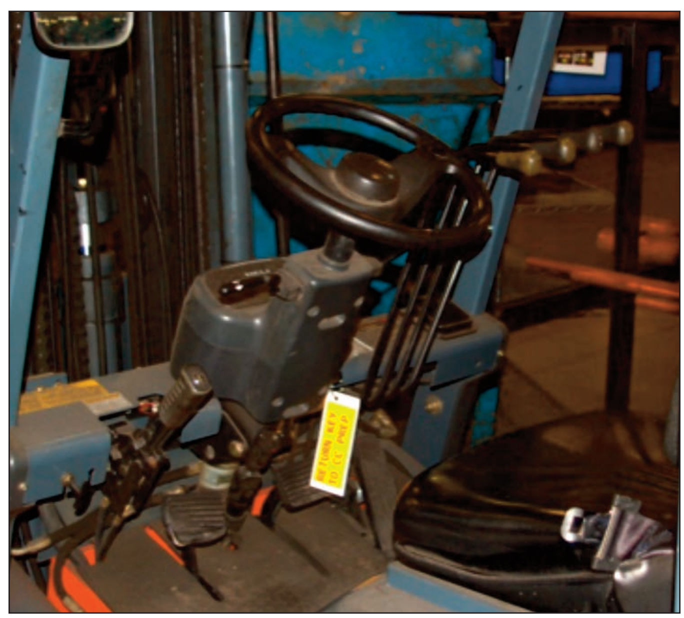

FIGURE 3: Propane Forklift Controls

[2] http://www.warehouseiq.com/forklift-batteries-explained

According to that same article, the following practices will provide maximum life from the lead-acid battery, and they close with a list of pros and cons for the lead-acid technology:

- Do not discharge the battery completely (deep-cycling). Many forklifts provide low battery warnings.
- Charge at least once every 30 days to prevent sulfation, a condition that makes recharging more difficult.
- Store batteries fully charged.
- Operation at high ambient temperatures reduces battery longevity.

Pros and Cons of Lead-Acid Forklift Batteries

Pros

- Inexpensive and simple to manufacture.
- Mature, reliable, and well-understood technology — when used correctly, lead-acid is durable and provides dependable service.
- The self-discharge is among the lowest of rechargeable battery systems.
- Capable of high discharge rates.

Cons

- Low energy density — poor weight-to-energy ratio limits use to stationary and wheeled applications.
- Cannot be stored in a discharged condition — the cell voltage should never drop below 2.10V.
- Allows only a limited number of full discharge cycles — well-suited for standby applications that require only occasional deep discharges.
- Lead content and electrolyte make the forklift battery environmentally unfriendly.
- Transportation restrictions on flooded lead-acid — there are environmental concerns regarding spillage.
- Thermal runaway can occur if improperly charged.

As in other industries, the lead-acid battery is being replaced by lithium-ion battery (LiB) technology. While LiB technology has dominated the battery news in the last few years, the first pioneering research began in 1912[3] and the batteries first became commercially available in the early 1970s. Unfortunately, the batteries were rather unstable, could overheat and catch fire, or “vent with flame.”

Sony developed an alternative technology in the early 1990s that replaced metallic lithium with a non-metallic solution using lithium-ions. That battery was actually a lithium-cobalt-oxide chemistry, but the name lithium-ion stuck.

LiB technology is superior to lead-acid technology for the forklift marketplace. Returning to the WarehouseIQ site, another article extoled the benefits and safety of this technology following attendance at the annual material handling show, Promat, in June of 2017. The pros and cons cited echo those of the Battery University information and other sites.

According to this article,[4] LiB technology has the following pluses and minuses.

Pros of Lithium-Ion Battery (Lib) Technology Versus Lead-Acid

- Because a lithium-ion forklift body is two feet shorter than a lead-acid body, an operator can work in tighter places when compared to its lead-acid counterpart. This is very handy for loading trucks and operating in narrow aisles.

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[3] http://batteryuniversity.com/learn/article/lithium_based_batteries

[4] http://www.warehouseiq.com/lithium-ion-batteries-forklifts

LiB technology is superior to lead-acid technology for the forklift marketplace.

Boost charging makes it possible to use LiB equipped lift trucks for up to 24 hours a day, 7 days a week without changing batteries.

- Less heat is generated during charging and discharging.
- The smaller LiB offers better rear lift truck visibility when compared to lead-acid models.
- LiBs are lighter (also a perceived disadvantage, see below).
- They are longer lasting — over 100 percent more life, claims Kalmar, a manufacturer.
- They charge faster than lead-acid batteries: A LiB can absorb 50 percent of its capacity from a boost charge time of just 30 to 40 minutes. After 80 minutes, a LiB can reach full charge status. Boost charging makes it possible to use LiB equipped lift trucks for up to 24 hours a day, 7 days a week without changing batteries.
- LiBs have higher energy efficiency and eliminate the need for a battery change after three shifts. Lithium-ion, and in particular Lithium Iron Phosphate (LiFePO4), is particularly good when it comes to industrial battery use. LiBs last five times longer than lead-acid batteries.
- LiBs do not have the voltage sag that lead-acid batteries suffer. They give a full charge until exhausted.
- They do not have sulfation issues or safety issues from out-gassing, meaning ventilation systems are not necessary in charging areas.
- LiBs are much safer overall.
- Over the lifetime of the battery, it costs less relative than the lead-acid alternative.

Cons of LiB Technology Compared to Lead-Acid

- LiBs are lighter and, because the weight of a lead acid battery acts as a counter weight on a forklift, anyone offering a LiB on a forklift has to compensate for the lost weight in the design of the truck or battery casing. Forklifts can be designed around this shortcoming, and additional counter weights can be added.
- Unlike the simple chargers for lead-acid batteries, LiB chargers need a management system to ensure proper charging and maximum longevity. This adds cost to the charger.
- Cost is still a factor relative to lead acid battery technologies, however it is dropping by half each year, and should be the same or cheaper than lead acid technology by 2020.

It is also important to compare the infrastructure required to properly maintain and safely operate either IC or electric forklifts (either lead-acid or LiB).

The support infrastructure for the IC forklift includes:

- Mechanics capable of servicing and maintaining the engine, tune ups, oil and filter changes, exhaust maintenance, etc. in addition to the general lifting and movement functions of the forklift.
- The appropriate tools, consumables such as filters, and spare parts need to be available for rapid return to service.
- Alternatively, these preceding two functions can be contracted out or backup equipment purchased.
- A means of storing fuel for the forklifts. These facilities are frequently in the form tanks, which require inspection and spill protection/remediation and appropriate ventilation to remove combustible fumes when located inside.
- Increased ventilation where the IC forklifts are used indoors, to remove CO and other products of combustion, which adds to facility operating and maintenance expenses.
- Requirement for increased ventilation can have the additional impact of reducing the effectiveness of plant energy efficiency efforts in areas of air sealing and insulation.

O&M costs for a lead-acid electric forklift average 30 percent less than those for an IC version.

– Washington State University, and EPRI total cost of ownership tool

- Refueling locations need to be established, which are also subject to inspection and may require spill prevention/remediation procedures and equipment.
- For propane forklifts, a common solution is replaceable cylinders. Full cylinders must be properly stored and space set aside for empties.

The infrastructure for LiB and lead-acid electric forklifts includes:

- Mechanics capable of servicing and maintaining the general lifting and movement functions of the forklift.
- A charging station with a charger appropriate for the forklift battery type (see Figure 4, for example). When lithium-ion batteries are used, the chargers will include the management system necessary to properly charge and recharge the batteries.

FIGURE 4: A Representative Charging Area

- Proper ventilation where lead-acid batteries are used to remove off gassing fumes. This is becoming less of an issue with the switch to LiBs, where ventilation of the charging area is not necessary.

HOW DOES THE COMMERCIAL/INDUSTRIAL CUSTOMER BENEFIT?

As with the application of any technology, the exact combination of benefits will vary with the specific needs and situation of each member. Saying that, when a member makes the conversion from IC to electric forklifts, either lead-acid or LiB, the benefits can be classified into the following areas:

- Lower Total Cost of Ownership when all the maintenance and support infrastructure considerations are taken into account. *According to an article from Washington State University*[5] *and supported by the total cost of ownership tool developed by EPRI for GRE, the O&M costs for a lead-acid electric forklift average 30 percent less than those for an IC version.*
- Reduced insurance premiums by removing the IC forklift's products of combustion from enclosed work spaces.
- Potential reductions in premiums through elimination of on-site fuel storage.
- Reduced ventilation and monitoring costs by removing the combustion sources.
- Reduced employee exposure to possible injury from handling the propane cylinders.
- Reduced employee exposure to fuels and spills.
- Reduced expenses for spill control and remediation.
- Reduced noise levels in the facility.
- Reduced spark and heat hazard in dusty or explosive environments.

[5] http://postharvest.tfrec.wsu.edu/pages/PC98X

- When paired with the renewable portion of the co-op's fuel mix, the member may be able to apply the savings towards meeting corporate green goals.

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HOW DOES THE COOPERATIVE BENEFIT?

When a cooperative implements a program to convert IC forklifts to electric, benefits include:

- New load that comes from a fossil fuel market share.
- Move the recharging load to an off-peak or other low cost rate to avoid impacting the co-op's coincident peak load.
- Reinforce the relationship with the member by providing a solution that impacts a wide range of business cost factors helping their bottom line.
- When the IC forklifts are replaced incrementally, it allows the cooperative to stay involved, maintain positive visibility, and be positioned to identify other areas where the member can benefit from other programs and services.

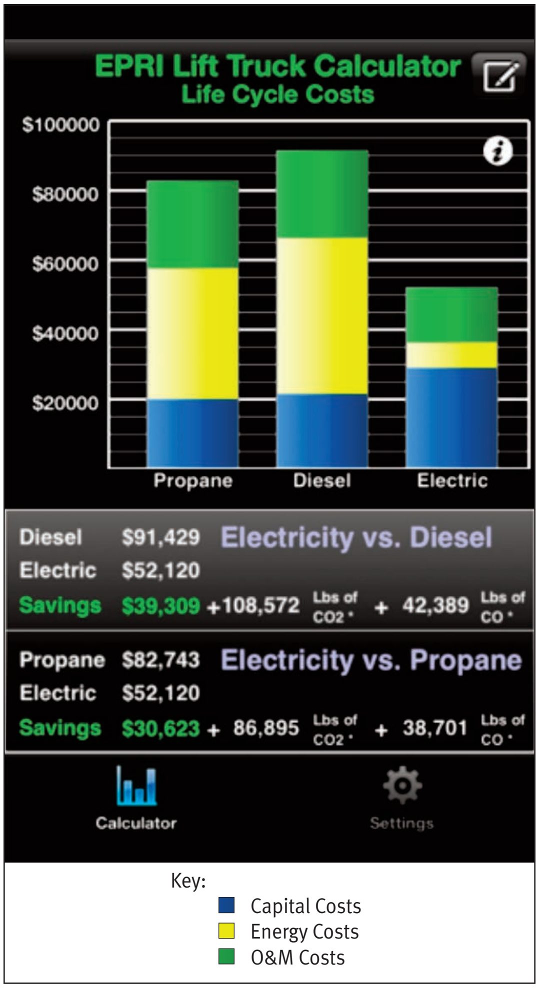

FIGURE 5: Performance of Electric Forklifts vs Diesel & Propane

WHAT ARE THE EXPECTED REDUCTIONS IN FOSSIL FUEL USE AND COST?

Aside from the reduction in general O&M expenses, electric forklifts can provide attractive reductions in the emission of greenhouse gasses (GhG) through reducing the use of fossil fuels.

Using the EPRI LiftTruck Calculator, a freely available iPhone (no Android version could be found in the Google Store) app that was developed for the GRE program, a single electric forklift using lead-acid batteries with a 5,000 pound capacity provides substantial GhG reductions over a 72 month period, operating 8 hours per day, 5 days per week, 52 weeks per year, as shown in Figure 5.

PROGRAM PERFORMANCE FOR GRE AND ITS MEMBER COOPERATIVES

Since 2015, GRE has had 12 members participate in the forklift rebate program, which has resulted in 73 electric forklifts being put into service throughout the GRE service territory. In 2015, 2 forklifts were rebated, 54 in 2016 (32 were for a single member), and 17 year to date in 2017. As both cooperatives and members become familiar with the program, GRE expects a rapid increase in program participation.

WHAT CHALLENGES DID THE CONVERSION POSE?

This opportunity requires close cooperation with the member to collect the necessary data to make an accurate estimate of the benefits to the conversion. There are a number of factors that need to be addressed and emphasized with the member, so that there are no unpleasant "surprises" either during or following the conversion.

While the overall cost of ownership will decline, the member's electric bill will increase – something cooperatives should communicate about to reinforce benefits gained.

First of all, the member's electric bill will increase. While the overall cost of ownership will decline, the electric bill is singularly visible and the increase needs to be communicated before and during the conversion and afterwards to reinforce the benefits gained.

Second, care must be taken to determine how the member operates. How many shifts do they run? Is there a potential for recharging to hit a peak which, when combined with a particular rate, could generate a massive bill for the member? This provides an opportunity to get creative with rate design, developing one that maximizes the benefit to both the co-op and the member.

Given the long life of electric forklifts, it is important for the cooperative to develop a relationship with the member, so it can be part of future replacement and fleet expansion decisions.

Third, are the existing facilities serving the member capable of handling the increased load represented by the charging stations? Could the new load be better served by a separate metering point, allowing the application of innovative rates and minimization of peak and demand charge issues? When an incremental program of conversion is being pursued, this is especially important, as the co-op must weigh construction of additional facilities against the additional load, and be able to justify co-op incurred costs.

Fourth, the average life of a forklift is between 10,000 and 13,000 pedal hours,[6] depending upon maintenance and the operating environment. As a result, once purchased, it will be a long time before they are replaced. It is important for the cooperative to develop a relationship, so it can be part of future replacement and fleet expansion decisions.

Aside from these more tangible potential issues are the less tangible:

- Preconceived notions regarding battery technology and electric forklifts.
- Decision makers being entrenched in old methods of handling materials.
- Existing relationships with the IC vendor or fuel supplier.
- Lack of budget to move the project forward.
- No local decision-making authority.

Fortunately, most of these less tangible issues can be overcome during the sales cycle and with the use of accurate and compelling data documenting the benefits to the member.

HOW DID THE CO-OP MAKE THE SALE?

Connexus attributes their successes implementing the program to having a robust key account management program with the commercial and industrial members in their territories. This program has allowed the account managers to develop strong relationships of trust with their assigned members.

Using this base of trust, the account managers are positioned to collect the data necessary to provide an accurate assessment of the bottom line benefits the member can expect. That data includes the inputs required by the EPRI app in addition to having an understanding of the member's:

- Operational goals.
- Financial goals.
- Issues with current use of IC forklifts.
- Other intangible factors noted in the preceding section.

[6] http://www.warehouseiq.com/forklift-life-expectancy

In addition to maintaining strong relationships with members, Connexus built relationships with the local forklift distributors and vendors.

Incentives offered to members demonstrate commitment of the co-op to the member and positively impacts the financial return of the conversion.

In addition to these efforts, Connexus built relationships with the local forklift distributors and vendors. The Connexus account managers have taken advantage of the resources of these operations to support the determination and validation of the benefits the member can expect from moving to electric forklifts.

Having these relationships is important, as it extends the capabilities of the co-op, bringing in the people with the detailed understanding of material handling and how their forklifts perform. And, since the majority of major forklift manufacturers offer electric variants, these trade allies are likely to be objective in their support. They get a sale regardless of which fuel source is used.

The incentive was also an important part of the sale. While a fairly small percentage of the total cost of the electric forklift, it demonstrates the commitment of the co-op to the member and does impact the financial returns of the conversion.

WERE THERE LESSONS LEARNED AND HAVE THERE BEEN ANY NEW DEVELOPMENTS SINCE THE DEPLOYMENT?

The lessons learned are simple:

- It is not enough to just make the sale. The co-op needs to communicate regularly once the conversion has occurred, so that the member does not encounter pushback from others in the organization over the increase in the electric bill — particularly if those pushing back were not part of the conversion effort.
- Remain engaged with the member, so at the end of life for the equipment, the member buys electric again.
- Be flexible in providing rebates for situations where a member replaces an existing electric forklift. While it might be considered a free rider, retention of the load is important.
- Be flexible in extending the program and rebates to other electric material handling equipment, like pallet jacks. The rebate should be adjusted in such situations to reflect the financial contribution of the equipment to the co-op.

WHAT DO COOPERATIVES NEED TO KNOW ABOUT IT?

The first thing the co-op needs to do is to determine the extent of any opportunity and to create the underpinnings of an effective program offering. In the case of GRE's program, subsequently employed by member co-ops like Connexus Energy, GRE managed the concept with MN State Regulators and also the development of crucial tools required to calculate benefits of conversion working with EPRI.

The co-op needs to make its own assessment of the opportunity:

1) List the members known to have or thought to have forklifts. Estimate the number of forklifts.

2) Using that estimate, multiply the number of forklifts kWh to determine the potential new load.

3) Is the cooperative willing/able to offer a rebate?

   The rebate offered by Connexus is $2,000 per qualified conversion. Rebates are an important variable to the member as the typical 3000-5,000 pound capacity forklift can cost[7] between $18,000 and $29,000 for fossil fuel models, and $25,000 to $35,000 for an electric forklift with battery.

4) Are there any regulatory hurdles, and if so, how likely are they to be resolved? How long will it take to resolve them?

The next two items are not necessarily deal breakers for program participation, but should be considered as beneficial in terms of creating

[7] https://www.howmuchisit.org/how-much-does-a-forklift-cost

the maximum value for both program participants and the co-op:

5) Does your co-op have attractive off-peak or other rates that would be especially useful for this new load? Can these types of rates be developed?

6) Can you tie the new load to the renewable component of your fuel mix?

Rebate forms, internal processes for verification and payment of rebates, and plans to communicate the program to members are important for a successful program.

After confirming an opportunity and clearing any regulatory and rate hurdles, it is time to design the program specifics. Fortunately, the primary tool from the GRE program is freely available as an app, EPRI *LiftTruck* (Figure 6). Rebate forms and internal processes to manage the verification of compliance and subsequent payment of earned rebates are also needed, along with a plan to communicate the program with appropriate members.

Relationships with local forklift distributors and vendors are important. These relationships extend the capabilities of co-op personnel, reducing the learning curve of the employees involved with program implementation. ■

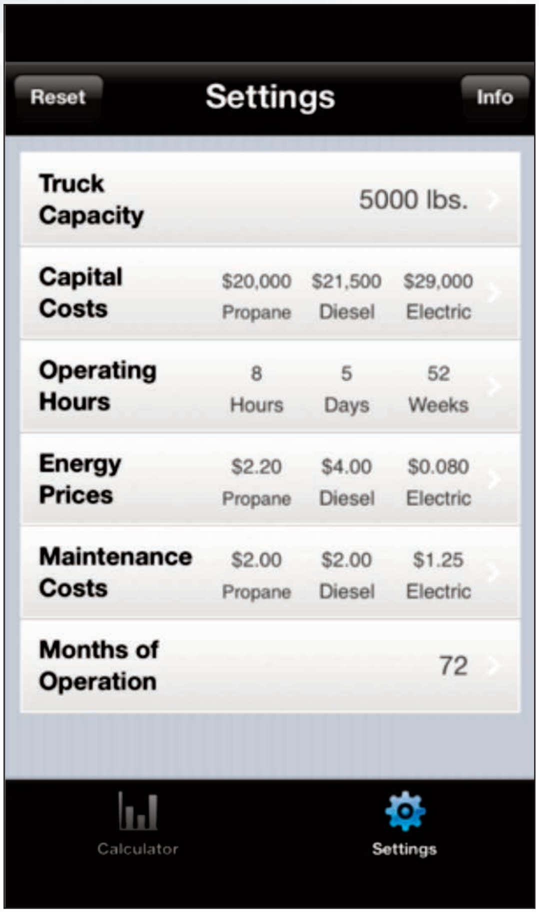

FIGURE 6: EPRI Lift Truck Input Screen

APPENDIX A: FACTORY SHIPMENTS OF FORKLIFTS[8] BY CLASS

TABLE 1: United States Factory Shipments

Year	Electric Rider (Classes 1 & 2)	Motorized Hand (Class 3)	Internal Combustion Engine (Classes 4 & 5)	Total Shipments	Market Share	
					Classes 1 & 2	Classes 4 & 5
1994	36,747	34,127	65,027	135,901	27%	48%
1995	44,087	37,746	72,685	154,518	29%	47%
1996	42,263	35,375	60,287	137,925	31%	44%
1997	42,675	38,538	64,946	146,159	29%	44%
1998	48,923	40,428	80,554	169,905	29%	47%
1999	49,843	41,899	74,994	166,736	30%	45%
2000	56,090	49,121	85,993	191,204	29%	45%
2001	45,980	37,210	61,507	144,697	32%	43%
2002	39,235	36,445	55,928	131,608	30%	42%
2003	40,463	36,659	63,365	140,487	29%	45%
2004	46,886	44,308	74,228	165,422	28%	45%
2005	50,604	46,206	83,725	180,535	28%	46%
2006	53,806	50,950	85,038	189,794	28%	45%
2007	50,260	48,615	76,664	175,539	29%	44%
2008	45,361	43,716	62,104	151,181	30%	41%
2009	28,409	28,635	28,740	85,784	33%	34%
2010	31,759	36,637	36,896	68,655	46%	54%
2011	44,720	42,213	58,483	145,416	31%	40%
2012	49,126	47,339	56,618	153,083	32%	37%
2013	52,834	52,766	66,473	172,073	31%	39%
2014	57,543	52,396	75,040	184,979	31%	41%
2015	65,042	57,329	76,075	198,446	33%	38%
Total	1,022,656	902,021	1,465,370	3,390,047	30%	43%

[8] http://www.indtrk.org

PREVIOUS VIEW

About the Author

Tom Tate has been in the electric utility world for 25 years, working in various capacities for both IOU and cooperative operations and is well versed in the municipal business model. With experience in every member service, marketing, and sales management role, Tom discovered a passion and talent for writing about technology in a manner that makes complex concepts easily understandable for members and customers. Today, he runs his own freelance writing company and provides content for a number of cooperative and industry operations from his adopted home of Minneapolis, MN.

Questions or Comments

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