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# Best Fleet Uses, Key Challenges and the Early Business Case for E-Trucks: Findings and Recommendations of the E-Truck Task Force

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## Abstract

Electric trucks (or E-Trucks) can achieve business case payback and satisfy fleet user needs even in the early market if the trucks are placed in applications that provide high daily petroleum offset (either in mileage or energy use) and can maintain high utilization rates. Initial vehicle cost and daily energy use are the two biggest business case factors. Fleet users also need to avoid unexpectedly high initial infrastructure costs and electricity demand charges through careful advance deployment planning.

This paper and its poster presentation will highlight and share the key findings of the E-Truck Task Force (E-TTF), formed by CALSTART and made up of more than 100 fleets, manufacturers and suppliers in the electric truck marketplace. It will outline the best use profiles for successful deployment of E-Trucks, targeting return-to-base, fixed route, centrally-refueled urban suburban fleet applications. It will describe the "sweet spot" needed in daily mileage or energy use in these vehicles to achieve payback, and show via an interactive Business Case Calculator that this daily offset of petroleum represents the biggest and most important variable in the E-Truck business case, together with purchase price. It will also explore the user data on early experience with E-trucks and the quality concerns that need to be addressed. Based on research with industry, it will provide fleets with best practices for how long to expect batteries to perform in given generalized duty cycles, and what future battery replacement costs will be. It will explain the infrastructure needs of E-Trucks that are different from passenger cars, and the potential barriers these represent to deployment of these vehicles, as well as share a fleet infrastructure planning guide for avoiding the biggest and most costly challenges. Finally, it will outline the core recommendations of actions required to speed market success.

*Keywords: electric vehicles, commercial vehicles, infrastructure, market, business case*

# 1 Introduction

Electric trucks represent a valuable first use of electric drive technology but are too often overshadowed by passenger cars. While medium and heavy-duty commercial trucks account for only 4% of the cars and trucks on the road in the United States, they consume over 20% of the gasoline and diesel used by all U.S. vehicles[1]. Recently, several commercial truck OEM's in the U.S. have partnered with suppliers to bring to market small quantities of plug-in and battery-electric trucks or "E-trucks." E-trucks are a viable alternative for many commercial vehicle applications because they can meet many urban/suburban duty cycle requirements while using zero petroleum and receiving all of their power from off-vehicle sources such as the electrical grid or solar power systems. The energy is then stored on the vehicle in batteries in the form of an electric charge which provides all the energy for the motors[2]. Depending on the weight they are carrying and their energy storage capacity, current E-truck models can generally cover between 50 miles to 100 miles per charge.

## 1.1 Primary Issues and Desired Outcomes

In early 2011, CALSTART formed the E-Truck Task Force (E-TTF or "Task Force") due to the recent promising emergence of this industry sector, its potentially large benefits, and the focused efforts needed to assist this segment's growth and maturation. The desired outcome of the E-TTF is to speed and support effective E-truck production and use. In the short term, the Task Force has specifically identified and defined the key issues that need targeting and developed this set of preliminary findings and recommendations. Going forward, the E-TTF will work to implement these recommendations with industry and public partners.

Based on CALSTART's industry experience and conversations with key users and manufacturers in this sector, it has become increasingly evident that there are some significant unknowns that may slow or inhibit future market growth of E-trucks unless targeted and addressed. The top issues include:

- Applicability of the technology (where to deploy)
- Financial payback and business case for the vehicles
- Expected improvements to the business case based on manufacturing improvements
- Future expected price reductions
- Validation of performance

The Task Force has taken on several of these issues to understand the challenges and opportunities with the goal of optimally positioning the industry for maximum long-term success. Some of the first efforts of the Task Force have included the following actions:

- Identify key market and technology barriers
- Identify fleet user needs
- Identify and quantify industry development and production needs
- Quantify benefits and better validate business case
- Identify fueling/charging issues and needs
- Highlight best duty cycles, ways to deploy vehicles, and cases for success
- Collect and report current validated data on performance
- Collect and outline expected price points for future volumes
- Recommend action steps to address key barriers identified

## 1.2 Task Force Process

The CALSTART project team recruited the members of the E-TTF from two primary groups: (1) early adopters and interested fleet users, and (2) early E-truck manufacturers and suppliers. These groups further self-identified their interest by responding to CALSTART's "E-Truck User and Industry Survey" distributed on April 12, 2011. Therefore, this report is not intended to serve as a comprehensive "survey" of all possible users and industry, but rather is a targeted compilation of the valuable knowledge and experience of those who have first entered the market to produce or use E-trucks.

After collecting and analyzing the scoping survey results, the CALSTART project team brought the interested parties together for the inaugural Task Force meeting on June 9, 2011. More than 125 respondents signed up to take part in the Task Force via the online survey, and 72 registered for the first meeting. During this meeting, CALSTART reviewed the initial findings from the survey and identified, with the Task Force members, the topics upon which the Task Force would focus and the areas needing additional research and data. At the first meeting, it became apparent that the two groups – fleets and suppliers/manufacturers – face some very different issues. The Task Force therefore was split operationally into two groups with a parallel two-track meeting schedule to assist each group with developing data on their specific needs.

To date, the Industry Group consists of 102 members representing OEM's, supplier companies, government agencies, and academic organizations. The Group has met on the following three dates via web-based meetings and conference calls, with email dialogue and research between meetings:

- July 14, 2011
- August 4, 2011
- September 8, 2011

Currently, the Fleet Group consists of 37 public and private fleets and has met on the following three dates, also with email dialogue and research in the interim:

- June 30, 2011
- July 21, 2011
- August 23, 2011

The two groups then met by webinar on September 21, 2011 to review all the findings and the draft recommendations from the Task Force work. The goal of the two groups was to individually identify key areas of needed action, and then develop joint industry approaches to address barriers and work collaboratively to help move the industry forward. The Task Force attempted to use existing data wherever possible, but found that the E-truck arena is still emerging, and much real-world experience and data remains scarce. Additionally, the Task Force actively chose not to duplicate work already established or underway by other groups, unless member feedback showed a need for a revised or new approach. The development of a Business Case Calculator and a Fleet Infrastructure Planning Guide are two examples where existing tools were deemed insufficient.

Based on these meetings and research, the full draft recommendations were presented to a broader cross-section of the industry for review during a special E-TTF Workshop at the National HTUF 2011 Conference on October 10-13, 2011 in Baltimore, Maryland. Final feedback and research stemming from that workshop has been incorporated into this report.

## 2. Key Findings and Recommendations

The first phase of the E-TTF effort involved secondary research designed to increase the CALSTART team's understanding of industry dynamics, market evolution, and opportunities for E-trucks in the U.S. market. The research began with an "E-Truck User and Industry Survey" which was designed to identify key opportunities, barriers and actions that are needed to speed the effective development and deployment of electric and zero-emission trucks. Responses were received from 200 fleets and industry representatives. Nearly 30% of survey respondents were fleet users (representing a range of uses from Class 3 to 8) [3], 14% were vehicle manufacturers, and 26% were suppliers. The remaining percentage included industry analysts, researchers and regulators.

The survey results clearly indicated that several factors are currently limiting the rate of E-truck adoption. While vehicle cost is unmistakably the key component of the E-truck business case and purchase decision, other important components include vehicle utilization, battery replacement, and infrastructure cost.

In Figure 1 below, respondents were asked to rank the importance of a given set of barriers.

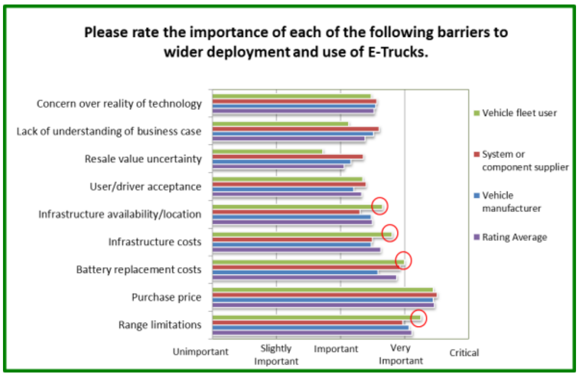



*Figure 1: Fleet and Industry Survey Responses: Relative Importance of E-Truck Market Barriers by Sector*

While purchase price still ranks as the number one barrier, there were several barriers that seemed to rank higher for fleets than for manufacturers and suppliers. Fleets determined that range limitations, battery replacement costs, infrastructure availability/location, and infrastructure costs were "important" to "very important" barriers when choosing to purchase E-trucks. This concern with infrastructure and vehicle reliability was also borne out in responses to other survey questions.

The following sections discuss each of these identified barriers, along with Task Force recommendations for overcoming them.

## 2.1 Cost

- ✓ ***Incremental cost is the biggest barrier to E-truck purchase/production, but costs do show decline over time; incentive funding is needed in the transition period to cover 50% or more of incremental cost.***

Currently, E-trucks cost considerably more than comparable gasoline- or diesel-powered trucks. The survey results indicate that this elevated purchase price is clearly the biggest perceived barrier to large scale E-truck adoption.

In response to this concern, most survey respondents felt that incentive funding was currently required to cover at least 50% or more of the incremental cost in order to spur E-truck purchase. Eighty-four percent of respondents replied that an incentive of between 50 percent and 100 percent of incremental cost was required. However, respondents also indicated that they believe that costs would decline over time, thereby potentially reducing the need for continued or increased incentives (see Figure 2 below). It is likely, though, that a cost decrease alone may not be fully sufficient to make the business case.

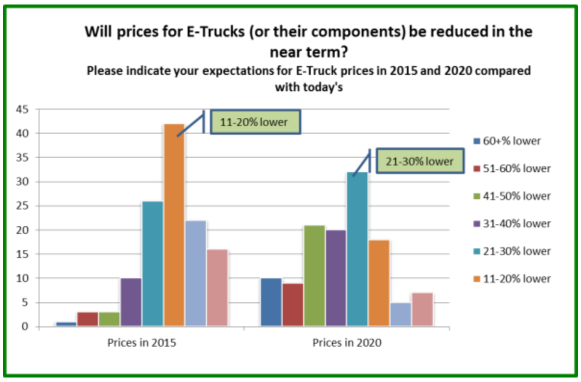



***Figure 2: Fleet and Industry Survey Responses: Near Term Price Predictions for E-Trucks***

Since batteries are usually the most expensive component of E-trucks, they make sense as a target for cost reduction. E-TTF members identified a number of different approaches to deal with high battery costs.

Battery leasing was identified by several E-TTF fleets as one of the key ways to reduce capital cost and minimize operational risk, which could speed market uptake of E-trucks.[4] It should be noted, however, that fleets were not universal in their interest in battery leasing – indeed, several of the largest fleets were not. Several of the medium-sized and municipal fleets were proponents. A key issue limiting battery leasing is the unknown residual value of these batteries. To overcome this barrier, the industry needs a greater amount of field data on battery life cycles in normal use, and on the residual value for both the batteries and the vehicles.

Several E-TTF members noted that the central challenge of the battery leasing model lies in clever OEM, battery, and financing solutions. One member noted that separate financing entities will enter the market as long as battery conditions can be monitored. One example of this might be a financing entity that monitors battery use, aging, and charging and uses this information to charge a customer for the use of the battery as a fuel source. Leasing models are well understood with established vehicles with known price curves and values, and therefore a challenge for E-trucks. Some fleets are interested in being involved in the aftermarket for batteries. However, leasing may be good for smaller fleets that do not plan to be as deeply involved in potential future battery applications.

A low cost extended warranty on batteries could also provide longer term certainty about operations and maintenance costs, thereby affording the fleets a degree of comfort. Most E-TTF fleets noted that the average battery warranty length is 3 to 5 years. Typically, additional years may be purchased, though many fleets don't have the funds for the extension. This impacts the business case calculation drastically in some cases, as some fleets assume that battery replacement must take place as the end of warranty (E-TTF findings showed that batteries should last 8-10 years in standard E-truck applications). One fleet suggested a preferred warranty period of 8 years for light duty vehicles and 10 years for heavy duty trucks. In response, industry members cautioned that some applications will allow for longer warranties than others. To consider extending warranties, battery manufacturers need a better understanding from fleets on the key performance parameters for the various applications, including information about duty cycles, the temperature gradient in the geographical area of operation, the rate of discharge, the number of discharge cycles, the time in operation vs. time in storage, and the charging methods.

"Right-sizing" the battery for the application could also reduce upfront costs. In this scenario, the battery would be customized to the well-defined needs of the particular duty cycle of the vehicle, and would be no bigger than those needs required. This would also reduce the weight of the vehicle and allow for more payload capacity. But because a smaller battery often requires more frequent, deeper discharges, suppliers advised that battery life could be curtailed since there is a correlation between depth of discharge on the battery and the number of charge and discharge cycles it can perform. There is likely a trade-off point on the business case between reduced battery cost and reduced life.

Looking beyond just the battery, improved engineering and production design of both the components and the vehicles could minimize the purchase price and reduce total system costs, as could expanded volumes and supply chains. The pooling of purchase orders through high volume purchase cooperatives is another solution. Cooperative purchasing can save significant time and money in contract production, and can lower prices through the power of aggregation and economies of scale. A cooperative is formed when the parties identify common vehicle performance requirements and sign a written agreement to cooperate on a bulk purchase.

## 2.2 Quality and Support

- ✓ ***Vehicle quality, warranty, and support are barriers to faster adoption and need to be improved***

Another key signal from fleets is that they need greatly increased service and support from vehicle manufacturers. Currently, the perceived lack of support from OEM's is serving as a deployment barrier. High vehicle failure rates coupled with slow parts and service support means fleets are hindered by non-operational vehicles for longer than anticipated times.

During the Task Force meetings, the fleets were asked to further articulate their concerns about OEM support, and they responded as follows:

- **Local dealer, local support staff, local parts storage**

The fleets perceive there is little local support for E-trucks and there are some high initial vehicle failure and reliability rates. While manufacturers have been generally very responsive to problems, local and regional support needs improvement, as does training for fleet technicians. The service network is not sufficiently built out, and parts are not in local supply.

- **Factory testing before sending vehicle out**

Early vehicles have had very low reliability and availability. The fleets expect to encounter issues with new technologies, but the number of units that are failing seems to indicate that initial quality control may be low and manufacturers are not doing due diligence on the vehicles, although they have been quick to respond to problems.

OEM's could address these concerns by expanding their dealer or support network, or by limiting their sales areas to regions that they could adequately support. One E-TTF manufacturer noted that many truck/bus manufacturers have their product delivered to a local dealer with service and parts ability. The dealer performs a pre-delivery inspection and also provides local repair and local parts inventory. However, not all E-truck makers deliver vehicles in this way.

Additional solutions could include shipping critical parts to regions where trucks are deployed to speed same day service/repair, instituting more rigid quality checks before vehicles leave the manufacturing facility, and requiring secondary inspection at the dealer source.

## 2.3 Performance Validation and Business Case

- ✓ ***Fleets need better performance data on E-trucks in real-world usage to validate***

***the reliability and business case of the vehicles, including guidance on best use profiles for their operation and payback***

Fleets have indicated they'd like to see improved, in-use operation data of E-trucks from manufacturers. Fleets were surveyed about the performance data they need to help them make purchase decisions or expand purchase decisions. They were also asked about the common vehicle performance parameters that they desire. In broad terms, they need data on the following parameters (ranked in order of importance): (1) vehicle reliability, (2) range, (3) battery life/ replacement time and cost, (4) maintenance requirements and cost, (5) energy use, and (6) infrastructure costs.

While the top-level survey results show that the fleets value reliability/uptime and vehicle range/charge as the top two factors that would encourage them to expand their purchase decisions, an interesting split on desired range appeared when the data was analyzed more deeply. Approximately half of the fleets want to put vehicles in applications where they can stretch the mileage, while the other half (mainly municipal fleets) want less mileage and therefore a smaller battery pack and a less expensive vehicle. The desire for a shorter range option likely represents a need to cut the entire capital cost of the system, not just the battery pack. Infrastructure costs are still generally important to all, but performance and field operation data on vehicle reliability is most highly valued in the early market.

### 2.3.1. Vehicle Placement and Use

Performance data is critical to a fleet manager when determining the business case for E-trucks. In simple terms, a business case analysis helps a manager decide whether an E-truck is of economic value to his/her business and achievable compared to the relative merits of alternative technologies. The primary issue of the E-truck business case is generally not whether it can do the duty, but whether it will pay back its incremental cost while doing that duty. In the near term, with vehicles costs high, that means focusing on those 'best use profiles' that give the greatest pay-back opportunities (see Figure 3). In most cases, the way a truck is used and the way it is driven are dependent on its end-

**Preliminary 'Best Use Profiles' / Duty Cycles for E-trucks**

1. Fixed route applications
   - Stop and go
   - Localized, dedicated routes
   - Short haul
   - Limited range
   - 'Spoke and hub'
   - Urban Delivery, Refuse, Mail trucks, Transit Buses
2. Facility vehicles
   - Airports, seaports, railyards, military bases, parks, resorts
   - Warehouse support and maintenance
   - Cargo handling
3. High idle, work site applications
   - Aerial devices
   - Utility Vehicles
   - PTO

***Figure 3: Preliminary 'Best Use Profiles'- Duty Cycles for E-Trucks***

use application. As a result, whether a truck is a good candidate for using an electric drivetrain depends much more on its end-use application than its size or chassis style.

Based on E-TTF findings, the value proposition for E-trucks is overwhelmingly based on three variables: maximizing fuel displacement, reducing purchase price, and minimizing infrastructure installation costs. Both the industry and fleet members of the Task Force have indicated that fuel savings is the most important component of the E-truck business case, in addition to reducing the incremental cost .The savings in using less expensive electricity, and off-setting as much petroleum fuel use as possible, is what pays for the truck. In terms of fuel displacement, the E-TTF business case model data show that a truck needs to be driven the maximum number of miles possible (or make the maximum use of energy) to get sufficient payback. In order to maximize fuel savings, E-TTF identified that 70-100 miles/day (or its equivalent energy use) appears to be an initial "sweet spot" for payback. The more days per week of such driving, the better - indicating that circulator shuttles and other seven day per week applications show promise. In most applications, short driving range simply does not off-set sufficient fuel to pay for itself. However, some trucks, especially those in municipal applications like refuse collection, operate for only 20 miles or less per day but they will displace 28-45 diesel gallons per day. In that case, the value proposition should be phrased in terms of fuel displacement, or gallons per day, rather than miles per day.

Other costs that could feed into business case include increased tire costs due to higher torque and battery weight. An interesting addition to the 'benefit' side of the business case proposition is the ability of E-trucks to operate outside of traditional business hours in residential neighborhoods (due to their quiet operation), and generally provide more flexibility of time and thus faster operation, which can result in huge benefits and cost savings or revenue gains.

The cost of infrastructure installation is also a key element of the business case and is higher than anticipated for multi-vehicle fleets. If there are too many costs upfront for infrastructure installation, it could deplete the payback potential as well (see further discussion below).

#### 2.3.2. Common Performance and Cost Data for Batteries and Components

In terms of battery performance data, most surveyed fleets expect the battery pack to last the life of the vehicle (10 years). But there is concern in some cases that there may be one or even two replacements required (even though there have been few or no hybrid battery replacements to date). Manufacturers signaled their confidence that the batteries could provide at least 80% of their energy for 10 years of life, but noted that each truck application is very different. For example, a beverage delivery truck may need less battery power because it goes out full and returns to base empty, while a package delivery truck may require more power since it goes out full, can come back full, and has a 100 mile delivery route. Battery suppliers indicated that they need better use profiles from fleets and real world field data to analyze the draw rates and to consider extending warranties. In an effort to facilitate this process, industry members of the Task Force were surveyed about (1) projected battery life based on three general use profiles that seem to represent some of the best earliest applications for E-trucks, and (2) projected battery cost through 2025 (average results of the survey are presented in Figure 4 below).

**Average Battery Life:**

(Based on 3 standard use profiles for E-trucks):

1. **70 mile/day fixed route suburban delivery vehicle:**
   - 8 years
2. **80% daily battery discharge work site vehicle** (e.g., utility truck):
   - 8-10 years
3. **20 mile/day urban driving vehicle:**
   - 10 years

**Average Battery Cost over time:**

(Installed pack per kwh):

1. **2015:**
   - \$500 - \$600/kWh
2. **2020:**
   - \$450/kWh
3. **2025:**
   - \$300/kWh

***Figure 4: Expected Battery Pack Life in Common Use Profiles, and expected future pack costs***

CALSTART believes this data on expected battery life by application is powerful and can be of immense importance in two ways. First, it can assist fleets to develop realistic expectations regarding battery survival based on how closely they match the standard use profiles described. Second, these standard profiles can assist battery manufacturers to better customize their products, develop confidence so that they can offer more attractive warranties, and give guidance to customers on expectations. The E-TTF will likely try to further refine and possibly add to these first three profiles.

Additionally, battery manufacturers counseled that even at the end of these battery lifetime periods, their data shows that the batteries are unlikely to "fail" or stop working. Rather, they simply will have lost some percentage of their capacity and therefore will lack full range or utility. Batteries at the end of their life periods above will still likely maintain 80 percent of their initial capacity and can be used in slightly less demanding routes or applications.

It is important to note that there are many assumptions that need to be made before coming to any final conclusions about battery life, particularly with regard to cooling strategies and thermal management. As the marketplace becomes more sophisticated, fleets are beginning to understand that they need a good battery management system (BMS) and a good cooling strategy to extend the life of the battery. Temperature is one of the critical battery life determiners. It would be helpful to fleets to identify a "temperature sweet spot" for extending battery life, after which thermal management needs to be more proactive. The challenge for manufacturers is to balance the overall cost of vehicle versus the longevity of batteries.

### 2.3.3 E-TTF Business Case Calculator

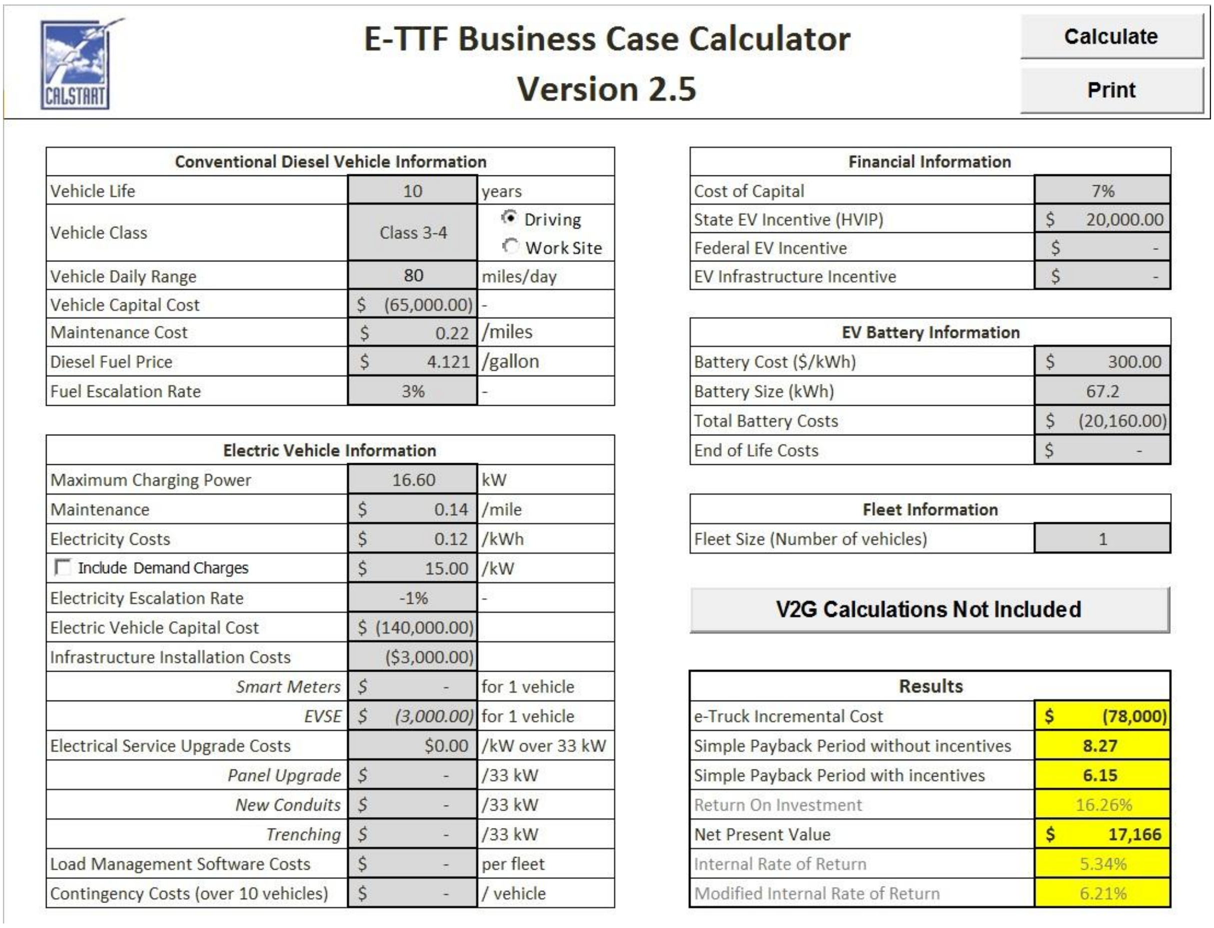
Based on the findings of the Task Force regarding the key factors in the E-truck business case, the life of batteries, the cost of infrastructure and other issues, it was determined that an independent method to evaluate business case was needed by fleets. Therefore, one of the primary tasks of the E-TTF was to develop a tool for fleets to analyze the business case of E-trucks based on their specific applications. To that end, the following "E-truck Business Case Calculator" illustrates the number of years it takes to recoup the initial purchase investment through various operational savings and assumptions about the availability of government subsidies, fuel prices, and vehicle usage (see Figure 5 below). The calculator allows the user to analyze the business case of replacing conventional diesel (or gasoline) trucks with battery electric trucks. It is an interactive Excel spreadsheet designed to be a transparent and easy-to-use business decision making tool.

The calculator includes a comprehensive list of vehicle and infrastructure inputs that can be modified with fleet specific numbers, ultimately allowing a fleet manager to have a realistic economic assessment of battery electric trucks. It is also designed to compute sensitivity analyses on key inputs such as vehicle daily range, diesel fuel prices or electric vehicle purchase incentive. The calculator provides a range of economic analysis indicators such as simple payback period. It also goes a step further and provides the Net Present Value, which gives a simple measure of profit or earnings from the investment, considering the time-value of money, as well as Internal Rate of Return, a percentage figure that describes the yield or return on an investment over a multiyear period.

The calculator includes several assumptions to keep its design relatively simple:

- The user has the possibility to include demand charges in the calculation. When they are included, we assume a "worst-case scenario" where the power demand from the electric vehicles is added to the maximum power demand of the fleet facility.
- The infrastructure installation costs include smart meters and electric vehicle supply equipment (EVSE) and are calculated for 1 vehicle.
- The electrical service upgrade costs include an electrical panel upgrade, installation of new conduits and trenching if necessary. These costs are calculated by increments of power: for each 33 kW power increments over 33 kW (representing 5 electric trucks at 6.6 kW maximum charge), we add 1 electrical service upgrade cost.
- The electric vehicle incentives (state and federal) are for 1 vehicle, while the electric vehicle infrastructure incentive is a 1 time incentive, regardless of the fleet size.
- The load management software is calculated for the fleet, i.e., 1 software package per fleet.
- We included optional contingency costs to represent the current uncertainties of electric truck availability and reliability, and the need to have conventional replacement vehicles. Contingency costs apply over 10 vehicles.
- Battery replacement costs can be included if the user believes batteries will reach end of life before the vehicle end of life. There is guidance on what life to expect based on use profile.
- End of life costs can be set to a positive value to represent battery resale value or a negative value to represent recycling costs.

Several of the municipal fleet managers in the Task Force mentioned that they had been mandated to purchase vehicles that reduce emissions, thereby rendering the breakeven point much less critical than the upfront costs. In fact, most of these government managers are not calculating the breakeven point; rather, they are



E-TTF Business Case Calculator
Version 2.5

Calculate | Print

| Conventional Diesel Vehicle Information | | |
|---|---|---|
| Vehicle Life | 10 | years |
| Vehicle Class | Class 3-4 | Driving / Work Site |
| Vehicle Daily Range | 80 | miles/day |
| Vehicle Capital Cost | $ (65,000.00) | - |
| Maintenance Cost | $ 0.22 | /miles |
| Diesel Fuel Price | $ 4.121 | /gallon |
| Fuel Escalation Rate | 3% | - |

| Electric Vehicle Information | | |
|---|---|---|
| Maximum Charging Power | 16.60 | kW |
| Maintenance | $ 0.14 | /mile |
| Electricity Costs | $ 0.12 | /kWh |
| Include Demand Charges | $ 15.00 | /kW |
| Electricity Escalation Rate | -1% | - |
| Electric Vehicle Capital Cost | $ (140,000.00) | |
| Infrastructure Installation Costs | ($3,000.00) | |
| *Smart Meters* | $ - | for 1 vehicle |
| *EVSE* | *$ (3,000.00)* | for 1 vehicle |
| Electrical Service Upgrade Costs | $0.00 | /kW over 33 kW |
| *Panel Upgrade* | $ - | /33 kW |
| *New Conduits* | $ - | /33 kW |
| *Trenching* | $ - | /33 kW |
| Load Management Software Costs | $ - | per fleet |
| Contingency Costs (over 10 vehicles) | $ - | / vehicle |

| Financial Information | |
|---|---|
| Cost of Capital | 7% |
| State EV Incentive (HVIP) | $ 20,000.00 |
| Federal EV Incentive | $ - |
| EV Infrastructure Incentive | $ - |

| EV Battery Information | |
|---|---|
| Battery Cost ($/kWh) | $ 300.00 |
| Battery Size (kWh) | 67.2 |
| Total Battery Costs | $ (20,160.00) |
| End of Life Costs | $ - |

| Fleet Information | |
|---|---|
| Fleet Size (Number of vehicles) | 1 |

V2G Calculations Not Included

| Results | |
|---|---|
| e-Truck Incremental Cost | $ (78,000) |
| Simple Payback Period without incentives | 8.27 |
| Simple Payback Period with incentives | 6.15 |
| Return On Investment | 16.26% |
| Net Present Value | $ 17,166 |
| Internal Rate of Return | 5.34% |
| Modified Internal Rate of Return | 6.21% |

**Figure 5: E-TTF Business Case Calculator**

relying on manufacturer data to calculate an operating cost for budgeting purposes. The E-TTF Business Case Calculator attempts to incorporate early fleet data and performance feedback, in addition to manufacturer data, to ideally present a more representative snapshot of the E-truck business case that does not overpromise results.

Valid fleet concerns about the business case for E-trucks could be addressed by disseminating this calculator to interested fleets and by creating an additional tool that provides fleets with clear guidance on vehicle use and placement to get the best payback. This guide could steer fleets to these best-use profiles and could also incorporate a clearinghouse for in-use data on E-trucks that is shared across the industry.

## 2.4. Infrastructure Needs

- ✓ ***Infrastructure cost and planning complications are a surprise to fleets and are important next tier issues needing resolution***

Another primary goal of the E-TTF is to help E-truck fleets understand their options, trade-offs, and costs when setting up EV charging infrastructure. Infrastructure was identified by fleets as one of their biggest surprises and is a critical emerging issue just behind vehicle cost and reliability.

It is essential to note that there is not a great deal of standardization yet with regard to upfront costs of EV infrastructure for medium and heavy duty trucks. Thus, to develop some guidance while creating the infrastructure template, the CALSTART team asked the E-TTF fleet members the following questions in an online survey:

1. What numbers are you seeing as the average cost of EVSE installation, with and without breaking concrete to run new conduits?
2. What level of EVSE do you anticipate installing? (Level 1, 2, DC Fast Charging (Level 3)
3. How often do you anticipate replacing batteries over the life of the vehicle?

4. What is your expectation for speed of recharging? (need 8 hour full charge; need 3 hour full charge; etc.)
5. How often do you expect to recharge your vehicles? (every week; every day; twice a day)?
6. Where do your vehicles normally park? Are they already close to electricity? Will you need to bring power to vehicles or take vehicles to power?

The survey showed that the most common EVSE (Electric Vehicle Supply Equipment) installation among the few fleets who responded is Level 2, with some limited consideration of fast charging at a range from 25-50 Amps. The average cost of EVSE installation was $3,300 per 1 charge site (range: $1500 – 8,000; $10,000 w/conduit installation). However, several fleets reflected that this single number was likely too low, as this does not include costs to upgrade service or bring more power to a facility as needed (which can be substantial for tens of trucks). One survey respondent noted that with a large fleet of 300 trucks, the infrastructure upgrade could cost more than $1 million. This would include the cost of running conduit, the cost of the EVSE, and the cost of upgrading the electrical service to accommodate the vehicles. For example, one large fleet is planning a separate 2500 amp service just for 50 trucks, which requires a new 480 Volt service to their site that is then stepped back down to 220 at the chargers. It was noted that any service over 2500 amp range will increase capital costs significantly. Additionally, most surveyed fleets recharged only once a day and usually overnight for 8 hours. One fleet is looking at load management software to optimize recharging time since some trucks won't need a full charge.

### 2.4.1. E-TTF Infrastructure Planning Guidelines for E-truck Fleets[5]

The cost of establishing EV charging infrastructure in fleet facilities can be extremely surprising to fleets due to the many variables that are often overlooked. At the outset, fleet managers must be realistic yet foresighted when determining the number of EVSE to install. Estimates should include the number of fleet vehicles to be added over the next three to five years, with special attention to the availability of state and federal incentives. The fleet manager should also consider planned flexibility that allows the site to grow with developing technologies or changes in charging requirements. Managers should also consider installing extra circuits and additional electrical capacity during initial construction to minimize overall costs.

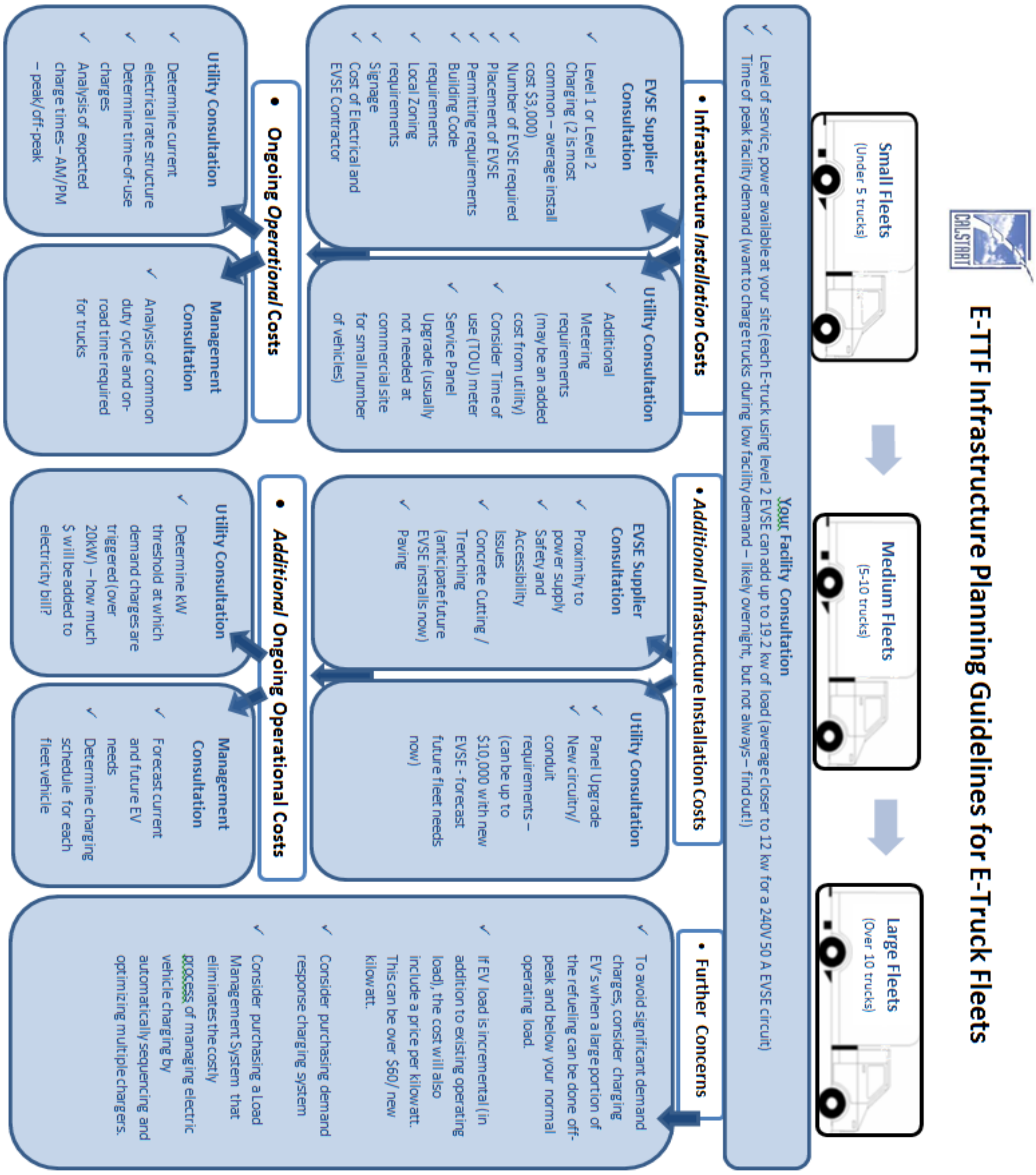
How a fleet uses its vehicles will determine the appropriate charging method between Level 1, Level 2, or fast charging. Vehicles requiring expanded range may require a fast mid-day charge; however, fast charging will likely raise equipment and electricity costs. In addition, some EV manufacturers may void the vehicle's warranty if the owner uses anything above Level 2.

In some cases, and especially with larger fleets, the electrical service at the facility will need to be upgraded which can be very costly. The fleet manager should contact the utility to determine if an upgrade is necessary of if existing equipment can provide the service. If an upgrade is required, the fleet manager should add sufficient capacity to meet the site's EV charging needs for several years.

It is especially important to note that the additional electrical demand for each EV charging during peak-demand periods may move a fleet into a higher rate category. No utilities in California have commercial EV-specific rates, but most do have commercial Time Of Use (TOU) rates which are beneficial to charging EV's when a significant portion of the refueling can be done off peak. Demand charges are determined by a customer's peak in a given month vs. its peak throughout the entire year. To avoid these significant charges, managers should consider charging EV's when it can be done off-peak and below the normal operating load. To get the most value and use out of the system, it makes economic sense to make charging stations available to the public or employees during the day and use them for charging fleet vehicles at night, off-peak.

In sum, fleets need an easy-to-follow tool that provides clear guidance on infrastructure planning and operation to reduce their current and future costs. The following E-TTF Infrastructure Planning Guidelines begins that task (see Figure 6 below). The deployment planning template is based on the size of the fleet: Small fleets - 1 to 5 trucks; Medium fleets – 5 to 10 trucks; and Large Fleets - over 10 trucks.

**Figure 6: E-TTF Infrastructure Planning Guidelines for E-Truck Fleets**




## 3. Next Steps

The E-TTF process has produced several important take-aways about the current status of E-trucks in the marketplace, has identified key findings on the barriers impacting market growth, and has developed recommendations for actions needed to address those barriers. These recommendations will shape the work of the next phase of the E-TTF.

The following action plan outlines these steps to further the success of E-truck production and deployment.

First, E-TTF will work with fleets and industry to prioritize and as needed refine the top recommendations identified here. This will take the form of teleconference and face-to-face meetings, followed by joint activities – in the form of work groups, position papers, policy activities and the like – required to drive needed actions.

For instance, joint work on incentives is likely one of the highest priority items, both for vehicle and infrastructure deployment. Encouraging continued targeted research and development funding will also be a top item. Similarly, training on business case and further refinement of the E-truck Business Case Calculator, together with distribution of the Infrastructure Planning Guide, are also high priority issues.

Second, the E-TTF, consisting of the original task force and new participants encouraged to take part, will lay out an action plan for implementing the top prioritized recommendations. These will take the form of discrete steps over time, with a focus on the next year, to achieve results on these top items. This plan will be iterative and enhanced as needed. It will rely on industry and fleet buy-in and support to succeed.

Third, CALSTART and the E-TTF will provide briefings to policy makers, decision leaders and other stakeholders on the findings and key issues to be addressed to raise the profile of E-trucks and direct focus on the key issues of need, particularly the priority items. These briefings have already begun. Some briefings will be performed by other groups focused on incentives or other specific topics, such as the Hybrid, Electric and Advanced Truck Action Group (HTAG).

Finally, the E-TTF is a key activity of HTUF, the Hybrid, Electric & Advanced Truck Users Forum, and will inform and guide the activities and work plan of this national program. HTUF can serve as a good platform to take on some of the technical items identified and raise their visibility as well as potentially develop demonstration or other efforts to address them (such as battery leasing).

E-TTF activities and progress will be tracked at its web site (http://www.calstart.org/Projects/E-Truck-Project.aspx), at Task Force meetings and at yearly reports during the HTUF National Conference (the 2012 HTUF National Conference will take place September 17-20, 2012 in Charlotte, NC).

## Authors

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## References

[1] *Delivering Jobs: The Economic Costs and Benefits of Improving the Fuel Economy of Heavy-Duty Vehicles* (2010); Union of Concerned Scientists and CALSTART.

[2] Some variants are exploring range extender systems to create electricity, such as turbines or small fuel cells.

[3] It should be noted that the online survey data is influenced by the types of fleets that responded. The segment that chose to take the survey may not be representative of the entire fleet universe. However, the fleets that took the survey are more likely interested in E-trucks in the first place and therefore fairly represent the needs of first movers/purchasers who are the key influencers in the early market.

[4] This model is being used in Europe by Renault as the approach to sell their electric vehicles: the vehicle will be sold or leased, and the battery provided as a separate lease, helping lower the upfront vehicle cost significantly.

[5] The *E-TTF Infrastructure Planning Guidelines for E-Truck Fleets* is modeled in part on information found in the following documents: (1) “Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene” by Electric Transportation Engineering Corporation, April 2010; (2) Sonoma County EV Installation Guidelines, July 2011; and (3) “Electric Vehicle Infrastructure Installation Guide,” Pacific Gas and Electric Company, March 1999.