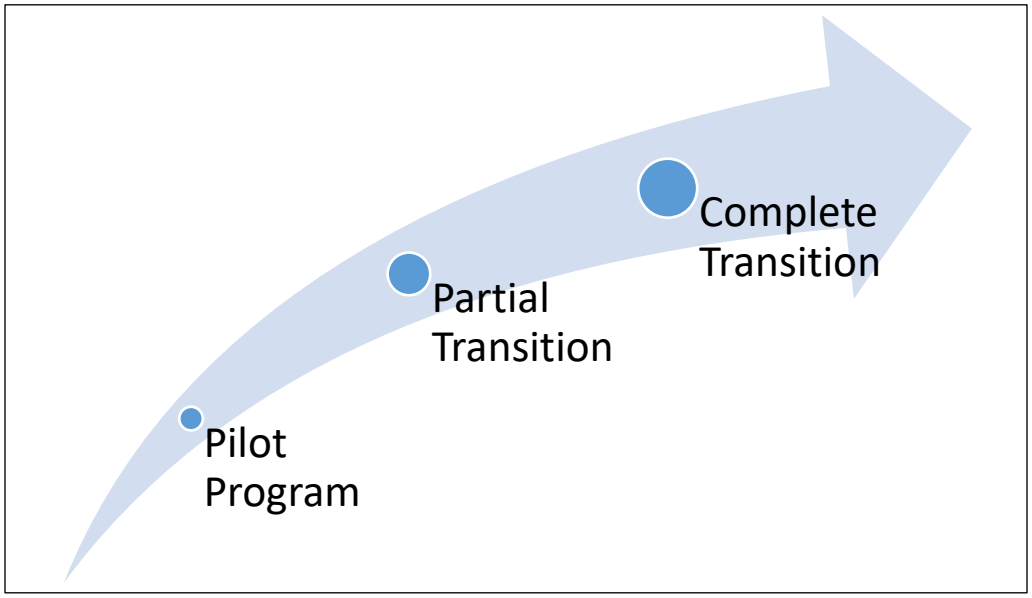
“HOW TO” TRANSITION FLEETS TO ELECTRIC©

AN OPERATIONAL GUIDEBOOK



OVERVIEW

This “How to” book is aimed at helping managers transition the vehicle fleet from gasoline, natural gas and diesel to electric and zero-carbon fuels. The transition can be complicated, costly and time consuming. Some fleet managers have described the transition as a giant jigsaw puzzle that has many parts of different shapes and sizes. The guidebook should be useful to managers of fleets of all sizes – from 10 vehicles to 10,000 vehicles. The guidebook also was written to explain issues involved in transitioning to other executives in the organization as well as Federal/state legislators considering emission-related legislation. The “How to” book spends more time addressing the recommended pilot program but also includes issues associated with a full transition. The task of transitioning is a group effort. The guidebook suggests how others, both inside and outside the organization, can help you complete the jigsaw puzzle. Good luck and have fun.

WORKING DRAFT

Introduction

This "How to" guidebook is designed to have information useful to managers of fleets from 10 vehicles to 10,000 vehicles. And useful whether the manager has access to a telematics system or very limited data. The goal is to provide you and the management team with more useful and specific information than usually found in guides about transitioning to electric.

The task of transitioning is complicated. As noted on the cover, some managers have referred to the transition as trying to solve a giant jigsaw puzzle with pieces of different shapes and sizes and no clear picture for reference.

While transitioning the fleet to all electric (or using zero-carbon fuels) includes the same steps, the order of the steps may vary by organization. Some organizations will be faced with a state mandate; other organizations will transition to save operating costs; other organizations will want to transition for image reasons, etc.

While organizations may have different reasons for transitioning and while organizations may have different approaches to decision making, the net result for the manager of the fleet is the same – you are in the middle of making the transition happen.

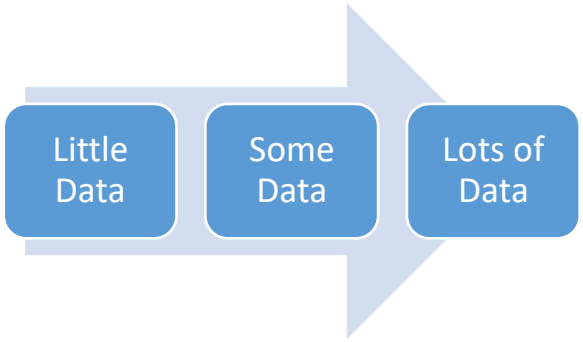
A bit of background about the author. I'm not an expert in fleet management – you are. However, I do have a long career in the auto industry that includes working closely with dealers and fleets. The career also includes developing and introducing new products ranging from family sedans to high-performance coupes to electric cars, electric and hybrid trucks to electric bikes and electric motorcycles.

When discussing fleets, 2 lessons come to mind:

1. Fleet managers view cars, trucks and buses as tools to get a job done. Whether the job is delivering packages or delivering children to school or some other task, vehicles are the means to help complete the task.
2. Reliability and durability are critical. A few years ago I was discussing a retrofit hybrid-electric drive system with the fleet manager, City of Charlotte, NC. During the conversation he asked, "Do you know the only time I get a call from the mayor's office?" I nodded no. He continued, "When they see one of the City's vehicles is on the hook (being towed)."

In this "How to" book the recommendations have been developed with the understanding fleet vehicles are tools to help get a job done and that the tools must work reliably.

What about Data? Whether you have limited data or an extensive telematics system, steps involved transitioning to electric are the same. Fleets with more telematics data will spend less time gathering information. However, we think all fleets, regardless of size, should complete the basic steps suggested in this "How to" book.



Electric and Zero-Carbon Fuels. The goal is to help achieve zero-tailpipe emissions of greenhouse gas for each vehicle. While the "How to" book emphasizes electric vehicles, using liquid hydrogen eliminates GHG emissions. If liquid hydrogen is not referenced, either as a direct fuel or as feed stock for a fuel cell, please consider it as an option. An issue with liquid hydrogen is availability, at least through probably 2035.

Using the "How to" Guidebook

The guidebook describes all the key steps and decisions necessary to migrate the fleet to electric/zero-carbon fuels. The text should be helpful for many fleets, regardless of size or the amount of telematics data available.

The text should also be helpful to others who likely will be involved in the decision to transition the fleet – the organization's management, utility executives, auto OEM's/dealers and legislators/staffers considering legislation affecting use of electric vehicles.

The book includes more detail for most of the tasks discussed. Chances are there will be some suggested tasks where you want additional explanation; there will be other tasks where no additional explanation is needed. The additional information can be accessed by clicking on the links in the primary section.

We also suggest you sign up for webinars that include managers of fleets presenting information about their experience transitioning to electric. For regular updates of product and legislation, consider registering (free) for Clean Commercial Transportation Update from CALSTART. Other information sources at the end of the guidebook.

On behalf of the alumni of the Massachusetts Institute of Technology who have volunteered to help find and promote practical solutions to address climate change, thank you for your interest. We hope this "How to" book helps you and your organization make the transition to zero-carbon transportation as smooth as possible.

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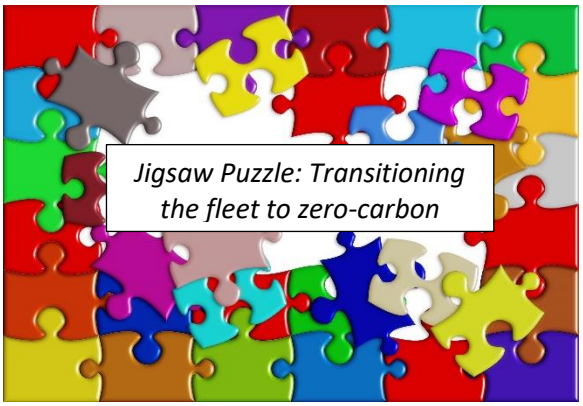
Contents

Managing the Transition

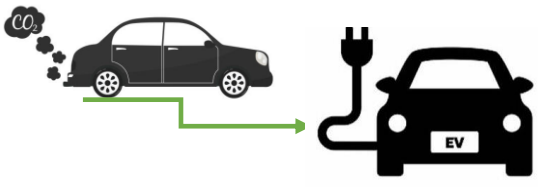
However your organization decided to transition or consider transitioning to zero-carbon transportation – comply with state mandate, react to competitive pressure, inquiry from or decision by the board/management – certain issues need to be addressed. The transition involves many parts – think about a giant jigsaw puzzle.



Jigsaw Puzzle: Transitioning the fleet to zero-carbon

Also, like a jigsaw puzzle, there is more than one way to approach completing the puzzle. What we do know is whatever approach you use to solve the zero-carbon emission puzzle, at the end all the pieces need to be put together.

The "How to" book recommends a list of general tasks for solving the problem -- #1 to #10. Choose the order that best fits your situation, as long as you complete all 10 tasks. The text is weighted toward a pilot program. Steps to a completion transition are outlined after the main text. Please read all the text.



General Program Goal(s) and Timing

One of the questions with this transition is "Should we set the goals first or should we try and assess what vehicles we could convert to electric right away?" For this project, we suggest you consider setting goals first.

Think of the goals as a reference picture for the jigsaw puzzle. The "picture" or goals will help establish boundaries for the project.

BUT, if your organization is in the early stages of the transition or just thinking whether to transition to zero-carbon, recognize the goals you set initially might need to change as you gather more information. Just like solving the jigsaw puzzle, you'll need to make some adjustments.

If the organization has not yet set goals, we suggest you consider goals being adopted by organizations worldwide trying to achieve zero-tailpipe emissions in transportation, especially with heavier-duty trucks. The goals are part of a program titled "Drive to Zero."

The primary goal is to have zero-tailpipe transportation by 2050. Like the jigsaw puzzle there are different approaches. However, for guidance, in order to achieve the 2050 zero-tailpipe goal, all new vehicles purchased in 2040 and thereafter would be electric or use fuel with no carbon. Vehicles already in use in 2040 would be phased out and replaced at a rate such that by 2050, the entire fleet would be electric or use zero-carbon fuel.

The 2050 goal is intended to apply to all public and private fleets, large and small. We believe the same 2050 (or sooner) goal will be applied to all personal-use vehicles so that by 2050 all vehicles on the road – cars, trucks, buses – would be electric or use zero-carbon fuel. There probably would be some exemptions for older, limited-use classic vehicles.

Interim Steps toward the 2050 Goal

- ≤2025 – All new vehicle purchases in your fleet will be hybrid or electric, with strong bias toward electric. Given the wide array of product available, for many fleets purchases of all new cars and most light-duty trucks could be electric.
- ≤2030 – All existing diesel-powered vehicles and any new diesel-powered vehicles will be modified to use 100% biodiesel or other low-carbon fuel(s).
- ≤2040 – All new vehicles purchased by your fleet, regardless of weight class, will be 100% electric or use liquid hydrogen. (While prototypes of electric-powered longer-haul Class 8 trucks are being tested, there are many hurdles left to overcome.)
- ≤2050 – All vehicles in the fleet will be 100% electric or liquid hydrogen (could be battery electric with fuel cell). All ICE vehicles will have been removed from the fleet. (Fleets will receive payment for the vehicles removed.)

Getting Started with a Pilot Program

We recommend all organizations have some level of pilot program. Think of the pilot program as filling in the outer edges of a jigsaw puzzle. You don't have the entire picture but you've made major progress.

Two benefits of a pilot include:

1. Implementing a limited-vehicle pilot program is a great way to learn how to select and use EV's and to avoid costly mistakes.
2. Transitioning to electric may include some topics and/or decisions where you have little or no training – determining the required electric infrastructure, for example.

   A pilot provides time to get some help. Many car and truck OEM's, e.g., can help with product assessment and even help secure incentives. Utilities can help with the electric infrastructure – that's their business. Other people can help as well.

Checklist for the Pilot Program

Use the task list for reference. The order of tasks is a suggestion. Your situation might be different. However, make sure to address all tasks during the pilot. The pilot will help make the full transition much easier. (More info about the tasks follows the table.)

√	#	Task List
☐	1	Goals and metrics. The pilot program needs to have goals and metrics. Begin discussing preliminary longer-term goals during the pilot.
☐	2	Determining vehicles/duty cycles for replacement by EV's. If you need an analysis tool, use our Excel model.
☐	3	Present pilot program plan to management for discussion, approval.
☐	4	Submit RFP's to OEM's or dealers for delivery consistent with pilot program. Biodiesel can reduce GHG immediately in all sizes of diesel trucks. Contact biodiesel dealers as well.
☐	5	Request utility assess electric infrastructure for proposed pilot and longer-term EV plan. Charging infrastructure may take a while to get zoning approval and construct.
☐	6	Confirm EV's meet needs. Match response to RFP's against pilot timing and tentative longer-term rollout plan. Adjust pilot plan if necessary.
☐	7	Calculate cost of pilot based on OEM's quotes. Include OpEx savings. Add electric infrastructure cost.
☐	8	Incentives – work with OEM's/dealers and other sources to determine what incentives are available. Might require outside assistance.
☐	9	Update pilot program plan for product, infrastructure cost less incentives and lower OpEx. Submit plan to management team for approval.
☐	10	Schedule regular updates. Start developing prelim plan for complete transition. Start early. Recharging Infrastructure a critical issue.

#1 Setting Goals/Metrics for the Pilot

The primary goal for a 5-10 vehicle pilot program should be to help you and the organization prepare for transitioning the entire fleet to electric/zero-carbon fuels. Since much information is readily available about electric cars, we suggest including more truck/buses in the pilot.

The metrics for measuring performance of electric vehicles selected for the pilot should be straightforward and simple:

1. Can EV's replace existing vehicles and complete the required tasks?
2. If adjustments are needed, can the task still be completed satisfactorily?

When selecting duty cycles or vehicles for pilot, be realistic. At this stage of development, EV's are not a 1:1 replacement for some duty cycles. Select a duty cycle that is reasonable. Even if the EV is not a perfect replacement, you likely can make some adjustment to determine if the EV can perform – a partial charge during the day, for example, will extend range.

The pilot will also help you and the organization understand better such issues as:

- Team members and roles for a successful transition – including outside members
- Infrastructure required to support electric
- Differences in cash flow – higher cost to purchase EV's but lower longer-term OpEx
- Training required for drivers, mechanics
- Concerns and questions from those inside and outside the organization

#2 "What's in the Fleet Today?"

This section includes a number of suggestions. Not to be concerned. We've tried to keep the suggestions simple and manageable. Even if your fleet does not have a telematics system, you probably have enough information close at hand to decide what vehicles/routes could be part of a pilot.

In addition, to help make your selection, we developed an easy-to-use Excel workbook. By entering some basic vehicle and/or route data (duty cycle) in the workbook, you'll have a good idea about which routes or vehicles could be part of a pilot program.

Most of the time the number of the routes/vehicles that could be replaced by an EV will exceed the number targeted for the pilot program. Also, there are many EV's on the market or soon-to-be introduced so you'll be able to choose different-sized cars and trucks/buses for the pilot.

Check with local dealers to make sure the EV's you want are available in your area. Another source for availability of EV'S worldwide is Global Commercial Vehicle Drive to Zero.

In the following section, to determine what vehicles or routes to include in the pilot, you'll need the item marked with a "√." The other info is "nice to have" but not required for the pilot.

1. Information about the Vehicle
   - ✓ Units by type and weight class
   - ✓ Special equipment/up-fits
   - ▪ Miles on each vehicle
   - ▪ Fuel usage/mpg by vehicle if available
   - ▪ Age of each vehicle
   - ▪ Condition of each vehicle

2. Operational Characteristic/Duty Cycle by Vehicle in the fleet
   - ✓ How vehicle is used – duty cycle
   - ✓ Miles travelled/route
   - ✓ Range of weather/temp conditions
   - ✓ Topography – hilly, flat, etc.
   - ✓ Special uses for vehicle and frequency
   - ✓ Does vehicle return to central location
   - ✓ Frequency/time at central location

3. Matching EV's on Market/Coming Soon to Existing Routes/Vehicles
   - ✓ Select 5-10 routes/vehicles to use for a pilot program
   - ✓ Determine which EV's on the market can meet requirements. *(An Excel workbook*

has some information to help you decide. Once you enter the data, the workbook will indicate whether the route or vehicle could be replaced with an EV.

The Excel workbook is easy to use. Instructions are included. You can add vehicles to the workbook if you want.)

Note re Biodiesel: Biodiesel is an excellent way to reduce emissions from diesel engines immediately. For vehicles with an expected remaining useful life of say 10-15 years, the accumulated reduction in GHG can be substantial. The cost to equip existing diesel engines to burn 100% biodiesel is much less than converting a diesel to CNG. Please review the write-up on biodiesel.

#3 Develop Pilot Program Proposal

The proposal for a pilot program can be as simple as listing what routes/vehicles could be replaced with electric. The presentation to management does not have to be complicated or elaborate. Use a simple table explaining the selection process to start the discussion. Use the Excel workbook for the table or create your own.

In addition to a list of routes/vehicles, you should consider discussing in broad terms the next steps to prepare for the pilot. Next steps will include:

a) Contacting dealers/OEM's about availability, and vehicle price
b) Contacting the electric utility about charging infrastructure
c) Trying to determine what incentives might be available (OEM's, utilities can help)
d) Estimating how much additional staff time will be required for the pilot
e) Understanding "non-product" issues that might affect the selection – e.g., for private fleets, if certain customers are demanding suppliers eliminate fossil fuel; for municipal fleets, pending legislation or pending directives for transitioning to electric
f) Discussing lines of authority and other organizational issues that might affect the transition.

#4 Submit RFP's for Vehicles

√ Once you've selected the vehicles and receive approval to proceed exploring a pilot program, it is time to contact the dealer/OEM and contact the electric utility. The RFP to dealers/OEM should include a request to help secure any incentives available from the OEM or from gov't agencies. Some OEM's offer such help.

If you don't have an existing relationship with the dealer(s) or utility, starting to build a relationship during the pilot will make it easier to convert the rest of the fleet to electric.

#5 Contact Utility re Infrastructure

√ Charging requirements and charging infrastructure are critical to a successful pilot and even more critical to a successful complete transition to electric. Stating the obvious, you are replacing gasoline, natural gas or diesel fuel with electricity. The utility needs to make sure you have enough electricity to replace your fuel.

Even if you are confident that the inbound electrical service is adequate for the pilot program, call the electric utility and ask for help with the assessment. In addition to helping with the pilot program, the utility can begin an assessment of electrical service required for electrifying the entire fleet. Think of the utility as "Exxon Electric."

Information you should provide utility

- ✓ Expected frequency of charge by vehicle based on duty cycle. Charge could be once per day or several times per day.
- ✓ Time available to charge during duty cycle
- ✓ kWh required to complete charge (Use individual OEM EV battery pack specifications for estimate. The Excel workbook has some information about battery capacity. If not in the Excel workbook, ask the dealer or check the OEM website.)

Electric utility can provide you guidance re:

a) Whether current inbound electrical service is adequate for the pilot

b) Potential upgrades required for pilot and/or upgrades for full transition to EV's
c) Physical or zoning restrictions affecting expansion of electrical service. Waivers for zoning can take a long time. Beginning zoning process early will avoid problems later. Also, get estimate on construction time.

#6 Confirm Proposed EV's Available

√ Just to make sure there are no problems with getting vehicles for the pilot, confirm with dealers and/or OEM's the electric vehicles you want for the pilot will be available. Some OEM's limit availability to certain regions. If there's an issue, adjust list of vehicles for pilot.

#7 Cost of the Pilot Program

Once availability has been confirmed, use information from the dealers/OEM's to calculate the cost of vehicles for the pilot. Include any electrical service upgrades required.

For organizations large enough to have a financial staff, if you have not done so already, consider asking them to help. The financial staff can reduce your workload and be a good partner when the project is reviewed with the senior management team.

You know a senior manager is going to ask if they reviewed your estimates. The financial staff can help calculate life-cycle costs and expected ROI for transitioning to electric/zero-carbon fuel.

Note: some utilities are offering to upgrade service for EV's at no upfront cost to the user. If your utility does not have such a plan, check with other fleet managers you know to discuss their experience working with the utility. Then have your management talk to your utility about implementing a no-upfront cost program.

Calculating cost for the pilot program will be somewhat different than calculating cost for transitioning the entire fleet. The pilot will not capture the magnitude of savings in total operating cost over the life of the vehicle. Longer-term savings in operating costs can more than offset the higher initial price of electric.

For the pilot, we suggest the "cost calculation" should be structured more as a calculation of cash flow. Using cash flow is easier to understand and eliminates some non-cash accounting assumptions – annual depreciation, e.g.

The table indicates directional differences in cash flow by category between electric and fossil-fuel vehicles. Use for discussion.

Electric vs Gas/Diesel – Cash Flow

Category	Higher	Lower
Purchase Price	X	
"Fuel" Cost		X
"Engine" Maintenance		X
Battery Pack Replace	TBD	
Support Infrastructure	X	
Annual Depreciation		X
Total Cost Ownership		X
ROI with Electric	X	

Maintenance costs should be markedly less with electric. The electric motor has few moving parts and should last the life of the vehicle. Thus, no oil changes, other engine maintenance, etc.

Cars/trucks often are taken out of service because of high projected repair costs to the driveline. Yet, the frame, sheet metal and interior of the vehicle are satisfactory. The longer useful life of EV's will: (i) require fewer replacement purchases; (ii) likely increase residual value, thereby decreasing net cost (higher ROI).

Depending on how long your fleet normally keeps a vehicle, the battery pack may need to be replaced. Battery pack warranty on many EV's is 8-10 years. While replacement cost can be substantial, the cost/kWh for batteries has been declining so replacement cost should be less than current prices.

More discussion about calculating the cash flow associated with electrifying the fleet.

#8 Incentives to Lower Purchase Price

Securing incentives might be easier said than done. The process to secure incentives can be time consuming, confusing and frustrating. Your presentation about the pilot should include some discussion about the incentives available as well as the time involved to secure incentives.

Securing incentives is a separate jigsaw puzzle. Part of the problem securing incentives includes:

- Availability may not be publicized
- Availability can vary over time. Sometimes incentives are available; sometimes not
- Amount can vary over time
- Limitations on number of recipients
- Paperwork involved may be extensive
- Some incentives are linked to certain products or brands
- Some incentives require a certain percentage cost sharing

Make sure to capitalize on any help available to secure incentives. Help can come from inside the organization, from dealers/OEM's, the utility and some trade groups. If at all possible, get someone inside the organization to help find incentives and then manage the paperwork required. And keep the person motivated.

#9 Update Pilot Program Plan

Now it is time to update the pilot program proposal and secure approval to proceed. The plan should include four (4) sections:

1. Confirmation of the goals and how progress will be measured
2. Pilot program details – vehicles/routes selected, expected results, issues, etc.
3. General discussion about plans for complete transition following pilot, including discussing major infrastructure issues. (See "Steps to Complete Transition.")
4. Non-product issues that might affect pilot/transition

Confirmation of Goals/Metrics

Just to make sure everyone participating in the review and approval of the pilot is "on the same page," review the goals of the pilot and the metrics to measure whether goals are achieved.

Pilot Program Content

Make sure the info about the pilot is specific. Presentation topics should include info gathered so far: (i) timeline for the program; (ii) number of routes/vehicles selected – usually 5-10; (iii) specific EV products for the pilot; (iv) product cost, including available incentives and any electrical upgrades required. Be sure to include estimate of lower vehicle operating costs; (v) any concerns, especially time required to manage and who has authority to make what decisions.

Discussion about Transitioning Entire Fleet

Include general estimates for what to expect if the entire fleet were replaced with EV's/zero-carbon fuel vehicles. While preparing for the pilot you will have gained considerable knowledge about issues likely to be encountered transitioning the fleet to all electric/zero-carbon fuels. Some examples of what you should learn or have a better understanding of:

- Confidence in ability of OEM's/dealers to deliver product that will meet your fleet's needs and then their ability to help solve any problems that might arise. If any concerns, most will center on medium and heavier-duty class vehicles.
- Life-cycle cost of electric vehicles versus gas/diesel vehicles. Working with the financial staff or a 3rd party can help make sure all cost issues are addressed as well as lend credibility to the estimate. Check with other fleet managers for their experience. Also, check for information from webinars and publications – e.g. "Automotive Fleet."

  Make sure to emphasize and provide detail about the life-cycle cost. Some people tend to focus just on the higher initial price of electric rather than the lower life-cycle costs. Discuss battery replacement timing

and estimated cost, even if you believe battery replacement will not be an issue. Someone will ask.

- Possible incentives for purchasing EV's. Be realistic. Note that many incentives may be temporary and may not be available for the entire transition. Many incentives also require considerable paperwork to secure.
- Infrastructure expansion and cost. Be frank in the discussion that without careful planning, infrastructure can become the Achilles Heel of transitioning to electric (non-carbon fuels). Given the amount of time involved and the expertise required, you are likely to need some help from inside the organization and at the utility. (Review "Steps to Complete Transition."
- Risks and contingency plan if some EV's don't work, or zero-carbon fuels are not available. Many things can go wrong during the pilot and even more during the full transition. A base contingency plan should be developed before a broader program is implemented. (More about what can go wrong.)

#10 Pilot Updates/Prep for Transition

We recommend you provide regular updates about progress with the pilot to:

- Organization's management
- Employees
- Suppliers
- Users – whether individuals or other organizations
- General public

Obviously, the updates within the organization and to key suppliers should include more detailed information. However, for all recipients, include both what has been positive about the pilot and some problems encountered.

Very likely there will be some hiccups along the way. Being honest about problems and the plan to fix the problem often builds confidence and goodwill with all involved. There are many examples of the most loyal customers to an organization are the ones who encountered a problem that was solved satisfactorily.

The updates of the pilot program should also include updates about the plan for complete transition to electric/zero-carbon fuels. Note any issues that you think might affect the full transition. Senior managers and the Board do not like surprises.

The balance of the "How to" book provides more detail about an array of issues. You are encouraged to read and study the issues and recommendations. Topics include:

- Non-product issues. Lists items or issues you had not considered or might be reluctant to include in your plan. Include tem.
- Data Gathering for the Pilot. Four key segments: (i) project timeline; (ii) determining candidates for pilot; (iii) calculating required EV range for each candidate; (iv) EV's available that meet criteria.
- Members of the Transition Team. The transition is a team effort. The section suggests team members and roles, including your role as the orchestra leader.
- More about Cost and Cash Flow. Suggestions for what costs and cost offsets to discuss in the presentation. Includes a table to compare costs and ROI of EV's and ICE's
- What Can Go Wrong? List intended as a start. You'll probably add more items. Some suggestions how to address issues.
- ✓ Steps to Complete the Transition. Emphasizes why getting the utility involved early is important and who can help you.
- Reduce Emissions with Biodiesel. Biodiesel is an excellent lower-cost interim step.
- Other Zero-Emission Fuels. Some zero-emission fuels in development but likely not widely available until >2030.
- Global Warming – Non-Believers. Suggested approach for dealing with those in the organization who don't believe it necessary to address climate change.
- Other Media/Sources of Info. List of additional resources. Use list as a start.

Non-Product Issues

Non-product issues are often overlooked in discussions about transitioning a fleet to electric/zero-carbon fuels. Yet, these non-product issues are as important as product and cost, and may be more difficult to analyze and discuss.

If one or more of the non-product issues listed is a concern, then we recommend expressing your concern in the pilot presentation. We understand and appreciate that some non-product issues might be highly sensitive. However, if you are responsible for managing the pilot, and especially the transition, then we strongly suggest you raise your concerns as part of the initial plan.

Time Available to Fleet Manager

Will you have time to manage the pilot and/or the larger transition and complete your other assignments? The demands on your time and/or the staff's time may be greater than management appreciates or even you anticipate. Don't be bashful about expressing your concerns.

Credibility of Internal Data

Completeness and/or credibility of data by vehicle. If an issue, then include plans to resolve before selecting vehicles for the pilot. If the concern concerns the entire fleet, then you need to resolve before expanding the transition.

Team Skillset

Skillset of the team, including you and/or staff, to manage the transition to electric. Additional training might be necessary. There are areas where you've likely had little or no training – assessing infrastructure, e.g. Don't assume OJT will be adequate to address the issue properly.

Financial Issues Affecting Transition

Discussing financial issues is always touchy. However, if you have some concerns, better to raise them now and get answers than to find out later the organization has financial issues. Some of the concerns might be:

a. Pilot Program – amount of funds available that would limit the number of or selection of vehicles for the pilot.
b. Full Fleet Transition – the cost to transition the entire fleet could be substantial. Knowing restrictions early will help with the planning of the pilot and phases for transitioning the entire fleet.

There are several ways to help manage cash flow for the pilot and transitioning the entire fleet. Knowing up front if cash flow is an issue will allow you to ask dealers and/or the utility for assistance.

Commitment to Electrifying by:

a) Fleet manager's organization. Is the organization committed to transitioning to electric or just talking for show?
b) Funding source. Is the organization's funding source, if external, committed or will a new source be needed?
c) Customer Base/User Base. What are customers' attitudes toward electric/ zero-carbon vehicles? If the organization is a government agency, what are the attitudes of taxpayers?

Who Is Responsible for the Plan?

Another often touchy subject is getting clarity on responsibility. Responsibilities during the pilot need to be clear for everyone involved.

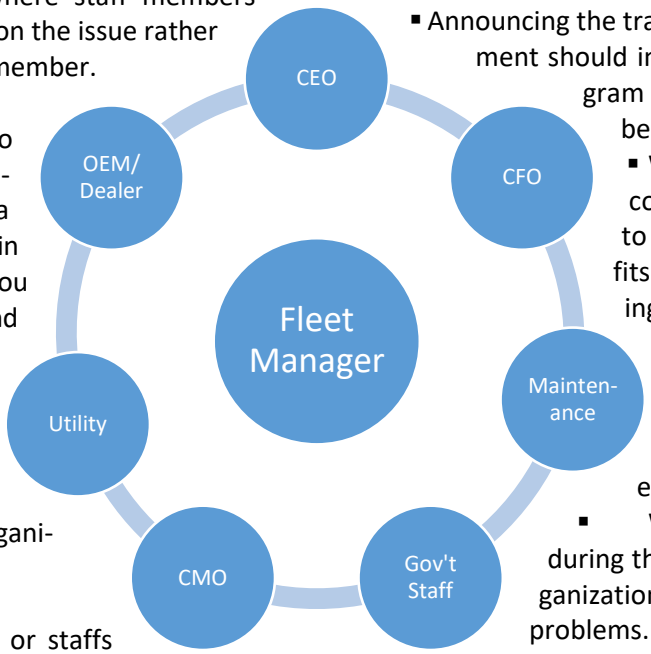
Responsibilities discussed should include:

- Reporting hierarchy and succession plan if there is a change in key personnel
- Clear understanding of the authority to approve PO's and contracts. The approval amounts might be the same as other PO's/contracts but should be confirmed.

Other Concerns for the Fleet Manager. You don't need to discuss these in the presentation but you should think about – career risk. If the pilot program fails or the transition fails, will your management support you?

Members of Transition Team

Who is going to be involved? The fleet manager and staff will need help. The text is written for larger organizations. If you're part of a smaller organization where staff members wear multiple hats, focus on the issue rather than the title of the staff member.



Transitioning the fleet to electric requires involvement and support from a number of staff members in the organization. While you can guide the selection and timing of the routes/vehicles to be converted to electric, to complete the transition you'll need help from other people inside and outside the organization.

Following are the people or staffs which should be part of the transition team, along with a general description of their roles and responsibilities. Consider yourself as the orchestra leader of this group and others involved are helping you make the music.

Put Team Together for the Pilot

An ideal time to "recruit" your support staff – orchestra members – is during development of the pilot program. Getting people involved early will allow them to offer ideas for the pilot and help them feel part of the program.

It might seem odd to ask some of the organization's senior management to help you, but transitioning the fleet to electric is as much, if not more an organizational issue as a fleet operations issue. Use the suggested roles and responsibilities in this guidebook when asking people to become part of the team. We think you'll be surprised at how many join your team.

Chief Executive Officer

The transition needs to have support and guidance from the CEO of the organization. The role of the CEO (or designated CEO representative) should include such tasks as:

- Announcing the transition. The announcement should include goals of the program and how progress will be measured.
- Why the organization is considering transitioning to electric and what benefits could accrue – cost savings, competitive position, societal benefits, etc.
- Explanation of the pilot program and what the organization expects to learn.
- What might go wrong during the pilot and how the organization will learn from such problems. Announce some "in-pilot" adjustments may be required.
- Members of the transition team, their roles and responsibilities.

Chief Financial Officer

- Can help with calculating total cost of ownership. CFO (or rep) involvement will add credibility to program cost estimates.
- Complete the cash flow forecast for the pilot and complete transition. Analysis should assess whether to lease or buy vehicles. Also consider renting vehicles for the pilot program if cash flow is an issue.
- Work with utility to determine cost of infrastructure and how to finance, possibly through the utility.
- Negotiate, where appropriate, with OEM/dealer and charger manufacturer
- Manage filing applications for incentives

Building Maintenance

- Can lead the effort with the utility on building issues and cost issues associated with inbound electrical service, space requirements, and change in zoning.
- Help plan changes to facilities required for charging stations, especially for the full transition.

Government Relations Staff

Many organizations do not have a separate staff for government relations. However, we recommend someone in the organization should be assigned to the team to help with such tasks as:

- Determining what purchase incentives are available from Federal, state and local agencies. Effort on incentives should be coordinated with the financial staff.
- Understanding what legislation or directives might be forthcoming that could affect the transition plan
- Understanding zoning restrictions or use restrictions that could affect operations, infrastructure. Tasks might be better suited for Building Maintenance group. Just make sure someone is handling.
- Determining who at Federal, state and local governments could be of assistance to organization. A senior executive should be assigned to make the initial contacts.

Chief Marketing Officer

The scope of the marketing staff differs by organization. However the various marketing and communication functions are grouped, someone needs to be assigned as the designated contact for media. The pilot and the transition should be promoted inside and outside the organization, including with the general public.

The person assigned to the media should provide the team guidance re such issues as:

- Arranging interviews re the pilot program
- Coordinating the message to the media. Everyone in the organization who talks to the media should be "singing out of the same hymnal."
- Providing the team information about media coverage, positive and negative
- Private organizations should work to understanding customer interest and expectations about EV's. Expectations can range from "Must have" to "don't care." Work with the sales staff to gauge interest.
- Government/Public organizations should work to understanding interest and support of EV's by taxpayers, those using government vehicles – e.g., transit-bus riders, school-bus riders.

Electric Utility

Participation by the electric utility is critical. Make the utility your friend. Even if the existing inbound electrical service appears to be adequate for the pilot, we recommend making the electric utility part of the transition team.

The electric utility can help with:

- Zoning restrictions affecting charging
- Calculating kW capacity requirements
- Guiding how to manage charging times, especially to avoid a premium for charging during periods of peak-load demand
- Locations of other charging facilities that the fleet might use. Info useful for "opportunity charging" during the duty cycle.
- Helping guide selecting the appropriate charging-station manufacturer
- Planning for electrical service upgrades early on to avoid cost penalties later
- Incentives available from various sources, including government agencies
- Government regulations – all utilities have a government relations staff. Talk to the utility about how your organization might leverage their staff.

Vehicle OEM/Dealer

Most of the interactions associated with electric vehicle products will involve the OEM-franchised dealer. You might have several dealers as part of

the team since not every dealer will offer EV's for the range of vehicles in your fleet.

You probably have more knowledge about dealers' capabilities than anyone else in your organization. Make sure any dealer representative can be of value to the team. If you're not comfortable with the rep, contact the dealer principal and/or regional office or even the OEM HQ.

As a reminder, dealers can help provide such helpful information as:

- Recommending which electric vehicles can meet your needs
- Detailed vehicle specifications, especially for the battery pack and electrical system. The size of the battery pack affects range and importantly the recharge time.
- Performance and maintenance issues that may not be widely known. As you know, OEM's issue service bulletins that often are not publicly available.
- Vehicle pricing and available discounts. For medium and heavier-duty electric trucks/ buses, there may be significant discounts.
- Lease and even rental options. Dealers may have direct access to leasing; you may want to lease through your organization's financial institution. As noted earlier, your financial staff can help here.
- Order to delivery turnaround time. Until production volumes increase for certain EV's, lead times might be longer than expected. If one of the vehicles for the pilot is going to be delivered months late, consider selecting another vehicle.
- New product introduction schedules. Knowing the development and introduction timeline of EV's by chassis size might influence selection of vehicles for the pilot.
- Service tech training availability/issues. Most of the new training will center on the electric-drive system and battery pack. As a reminder, make sure any vehicle purchase includes dealer-provided training.
- Non-OEM incentives available. Existing dealers are seeking to maintain brand loyalty with EV's. Most OEM websites indicate that the OEM and/or dealers can help secure incentives. If you are willing to consider changing OEM's, the dealer might be even more helpful securing incentives.
- Dealer's other customers you can contact for info about experiences. Contacting other customers is an excellent way to find out mistakes other fleet managers have made and how they solved the problem.
- Service parts availability. Fortunately, the new components in an electric vehicle should have very high reliability. Because demonstration of reliability and serviceability are important during the pilot, make sure service parts are readily available – just in case.
- Issues that might affect any up-fitting. If special equipment can be transferred easily to the EV, then using an up-fit vehicle in the pilot program should be OK. If special equipment is not easily transferred or very expensive to transfer, then discuss the implications with your management team.
- Secondary market for existing vehicles. Ask the dealer upfront to help with disposing of the vehicles after the pilot is finished. Having an estimated residual value should be included in the pilot presentation.

Other Team Members

Each organization operates a bit differently. Use this list as a guide. Probably you will think of other people who could be of help, or there may be people volunteering to be part of the team.

We suggested at the beginning of this section you were the orchestra leader. If you want to add some people to the orchestra, you should do so. Try and make sure everyone on the team has fun and enjoys the music.

Data Gathering for the Pilot

Data gathering for the pilot consists of four (4) main segments. You may have your own system to complete the preparation, or feel free to download an Excel workbook (free download) designed to guide you:

1. Project Planner –helpful in estimating project length and which tasks should be completed before others. (more details follow)
2. Range Adjuster. Guide to determine how much EV range is required to meet existing duty cycles. Required range adjusted for: (i) battery temperature; (ii) topography: (iii) age of battery pack.
3. Vehicle/Duty Cycle Qualifier. Asks you to list basic description of how an existing vehicle is used. Based on the info, the range adjuster will calculate the required useful mileage of an EV. The current vehicle might travel say 50-60 miles per day. Because of operating conditions, an EV replacement might need a published range of 90-100 miles. The guide is not perfect but a good start for deciding which vehicles to include in the pilot. The guide can also be used to assign an order of replacement for the full transition.
4. Selected Vehicle Specifications. Product specs are being updated regularly. The Excel workbook provides some guidance on range for school buses, refuse trucks, Class 3-4 transit shuttles, etc. Please consider the list as a start.

Project Planner. One of the Excel worksheets is designed to be a basic project planning tool. The tasks included on the worksheet are the same the 10 tasks as on the Pilot Program Checklist.

The planning worksheet includes a series of sub-tasks, many of which are discussed further in this document. For each task/sub-task there is an estimated number of days to complete. The days can be changed to fit your schedule. When the number of days for a task are changed, the entire project timeline updates automatically.

The tasks are assigned numbers to indicated suggested order of completion – 1st, 2nd, 3rd, etc. Tasks are linked to other tasks which may need to be completed before the current task.

If you are familiar with MS Project or similar project management tools, you still may want to review the list of tasks in the Excel workbook. The list is a good start on overall tasks required and includes suggested precedent tasks.

Instructions are included on the worksheet. Cells highlighted in "light yellow" are the ones you'll want to review and change if appropriate. The other cells are not locked and you may change if you want.

If you are not familiar with Excel or use only on a limited basis, this workbook should be helpful in allowing you to determine which routes or vehicles should be part of the pilot.

Backup – If you are not used to writing formulas in Excel, then please consider making a copy of the file and saving the using a different file name. If you inadvertently change one of the formulas and the worksheet displays "error messages" that you cannot fix, return to the original file.

Displaying Formulas. To view the formulas, go to "Formulas" in the Display Bar, then click "Show Formulas."

Keep in mind the tasks and dates on the worksheet are suggestions. Feel free to make changes, including adding tasks. Please change the starting date to fit your project.

If you run into a problem and no one in your organization can help – or your teenage child or relative can't help – then feel free to send an email and I'll try to fix the problem.

Range Adjuster

A key issue when selecting vehicles for the pilot and then the rollout plan for a complete transition is determining "effective range" for the conditions your fleet faces. The vehicle OEM's published range is calculated under ideal, or "best case" operating conditions – moderate temperature, moderate humidity, flat terrain and a new battery pack.

⇒ Ask the OEM if the "published range" is 80% depth of discharge or 100%. If 100%, then adjust by multiplying by 80%.

While the "range adjuster" reflects my estimate -- the vehicle OEM and the battery manufacturer might have different estimates – the range adjuster will point out where you might need to plan for an "opportunity charge" during the duty cycle. Or, point out why you should plan in the winter to keep vehicles under charge all night to maintain battery temperature so range is not shortened as much.
Using the range adjuster will help guide selection of vehicles/duty cycles for the pilot. The range adjuster will also help select the order of vehicles for the full transition to EV's/zero-carbon fuels.

Even though vehicle range will increase over time as battery technology improves and/or fuel cells are added to extend range, you may determine that a few vehicles in the fleet must use a liquid fuel (liquid hydrogen, e.g.) to meet duty cycles as currently defined.

If you have such vehicles, consider as many adjustments as possible to the duty cycle to avoid relying on liquid fuels. Availability of zero-carbon fuels will be limited for some time.

To estimate adjusted range, multiply the "published" range by the various percentages. For example, let's assume you want to replace a diesel school bus with new electric school bus.

The "worst-case" conditions for the school bus are 20°F temperature and rolling terrain. The school bus has a "published range" of 130 miles.

$$130\ miles * 80\% * 90\% * 100\% = 94\ miles$$

Two years later range would be about 89 miles.

$$130\ miles * 80\% * 90\% * 95\% \cong 89\ miles$$

RANGE ADJUSTER (ESTIMATED)

Battery Temp F°	
120°	85.0%
100°	95.0%
80°	97.5%
70°	100.0%
60°	100.0%
40°	100.0%
20°	90.0%
0°	80.0%
-20°	70.0%
-40°	60.0%

Topography	
Flat	100.0%
Rolling	90.0%
Hilly	80.0%
Steep	70.0%
Battery Age (Yrs)	
02	95.0%
04	90.0%
06	85.0%
08	80.0%
10	75.0%

More about Plan Cost/Cash Flow

We've suggested making sure there is a 3rd-party assessment of the plan cost and cash flow. The 3rd-party check could be from the organization's financial staff or from someone outside with appropriate credentials.

Based on personal experience with developing and introducing new products, the "cost" of a project is easier to understand for all involved if presented in terms of "cash flow" rather than "accounting costs." Cash flow is more like "piggy-bank accounting" – what cash is coming in, what cash is going out and how much is left – and easier to understand.

Keep in mind costs for the pilot program will be a directional estimate and are not expected to be too detailed. You will have to make some assumptions for which there is limited, if any historical reference, especially for electric-powered medium and heavy-duty trucks/buses, which are still early in the life cycle or still in the prototype stage. More data are available for electric cars and more data will be available as electric-powered light-duty trucks are introduced.

Even if based on rough estimates, the cash flow projections can be useful in helping answer questions from management and outside groups about program cost.

What information should be included in the comparison of life-cycle costs for an EV to life-cycle costs of an existing vehicle?

1. Product cost for vehicle. Use MSRP less any fleet discount. If possible estimate the cost of the battery pack as if the pack were purchased separately. Excluding the cost of the battery pack, the cost of an EV should be less than a fossil-fuel vehicle.
2. Less: incentives. Be realistic in the dollar amount of incentives to be received.
3. Add: infrastructure cost. If the utility will install infrastructure at little or no cost, then agree to amortize over kWh usage, include the higher kWh cost in "fuel" costs.
4. Add: "fuel" costs. For fossil-fuel vehicles, consider building in a cost escalator for higher oil prices and/or higher taxes.
5. Add: maintenance costs. As a start, use the organization's normal replacement cycle for maintenance. Include driveline repairs based on vehicle experience. EV cost for driveline maintenance should be minimal.
6. Add: battery pack replacement cost, if appropriate. Ask the dealer for reference cost. Given the steady decline in battery cost/kW over the last decade, an estimate of 50% of current replacement cost would be reasonable. If the vehicle replacement cycle is less than say 8-10 years, no replacement cost for the battery pack required.
7. Less: residual value for EV's. Consider "normal" residual for vehicles at time of replacement and then add 20-25% for EV's longer life. Residuals for fossil fuel vehicles will go the opposite direction. By 2035, residuals for fossil-fuel light-duty cars/trucks likely close to $0.00.
8. EV only: longer expected useful life. Will not have to replace vehicles as often. The longer life should be reflected in the cash flow analysis. Rather than replacing a vehicle at say year 6, the EV stays in service until year 8, thus freeing up cash.

Lease vs buy option. While the organization might not have leased vehicles in the past, doing so helps reduce the amount of upfront cash for buying electric. Consider leasing, or even possibly renting, for the pilot program.

"Non-Product" Cash-Flow. Using electric vehicles can help improve an organization's image. For organizations selling products or services, the improved image can translate into higher consideration and purchase by existing customers, help attract new customers and help build morale among employees. The image created by EV's and/or use of low-carbon fuels is the equivalent to some level of advertising expenditure.

Municipal governments can also use the EV/low-carbon fuel truck to help build image and gain support among residents. The City of Ames, IA promotes the use of biodiesel and the city's image by painting "Biodiesel" in huge letters on snowplows.

The "cash value" of the image does not change the overall cash flow of the project. However, we believe the image value worth mentioning in your presentation.

What Can Go Wrong?

Many things can go wrong during the pilot and even more things during the transition. Discussing these issues and developing a back-up plan before getting too far into the pilot will help reduce the "surprise factor" and help you and your team implement a solution.

Any list of "what can go wrong?" should include product and non-product issues. Some examples follow along with some ideas how to solve the problem. You might want to expand the list.

Product

- Preferred EV is not available when promised and lengthy delay expected. Delays should be less of an issue if you're purchasing light-duty cars or trucks. The issue of a delay will diminish over time.

  GM's announcement in January 2021 that it will offer only EV cars and trucks by 2035 is a major step forward for ensuring EV availability for much of the fleet. Starting in 2021 the availability of EV cars, SUV's, pickups, and lighter-duty vans will increase dramatically.

  However, in the higher-weight classes, there might not be an EV available or the delivery might be delayed. Depending on the length of the expected delay, select another duty-cycle/vehicle to replace with an EV. The initial list of potential EV candidates should exceed the number of vehicles anticipated for the pilot.
- EV is not performing all the tasks of the vehicle replaced. If the shortfall in performance is range, then determine if there's an opportunity to recharge the vehicle during the duty cycle, either say during lunch break or even at another location. "Opportunity charging" may solve the problem. Also, consider modifying the routes of a couple of vehicles so the EV can meet the duty cycle requirements. Longer term, as battery tech improves, range will improve.
- Reliability an issue. Make sure the reliability issue is related to the electric-drive system. Find out from the dealer/OEM how significant the problem is and the expected resolution date. Reliability should not be an issue in Classes 1-3.
- Durability an issue. Have spare parts on hand during the pilot for any components where durability might be an issue. Even though electric motors are long-lasting with few problems, having spare parts on hand will minimize possible downtime.
- Safety defect. Obviously, whatever the defect, pull the vehicle from service. As part of the pilot, determine if the defect is related to electric drive system.

Charging

- Inadequate electricity to meet needs. If a problem occurs when trying to charge all vehicles at once, consider staggering the charging. Software associated with the charging station and/or on the vehicle should allow staggered charging. Also, consider which vehicles could be partially

recharged during the day to reduce demands on the electrical system at night.

- Utility cannot expand to meet needs. Given the growing public pressure to replace fossil fuels with "clean" electricity, some utilities might face capacity constraints sometime after say 2030. Some locations within a utility's geographic area might experience service limitations – substation, e.g.

  This problem should be determined during planning for the pilot and not after the pilot begins, or even worse after the pilot. If utility capacity is a localized issue, consider finding another location for charging. Also, consider if vehicle routes can be modified to accommodate the new location.

  If the service limitation is more widespread and higher capacity is not forthcoming, then the organization will be faced with installing its own generating capacity.

  While the likelihood of this problem is low, have someone on the staff spend time up front to determine if a potential issue exists. If so, then alert senior management and ask for help in resolving.
- Charging stations are not performing to specs. Having the utility involved up front should reduce the risk of this problem. Multiple companies offer charging stations so finding a viable replacement should not be a problem. As part of your pilot preparation, check the satisfaction ratings of the charger manufacturer.

Maintenance

- Service parts are not available. To avoid the problem, pick an EV model where service parts are available. Often one of the issues working with start-up companies is the lack of a fully developed service-and-parts support system. Consider a well-known OEM for the pilot or that you are confident in the service/parts network of the newer brand.

  Because the pilot will be well publicized, at least internally, maintaining maximum vehicle uptime is important for data gathering and important for building credibility.
- Staff cannot fix vehicle problem. If the organization's maintenance staff is not certified to repair the EV in question, then make sure the dealer can provide fast turnaround for complex maintenance issues.

Cost/Cash Flow

- Transaction price excessive. The estimated price should be discussed and approved by management before any order placed. Plus, the PO should have a firm price, possibly with some minor adjustment allowed.

  However, some heavier-duty EV's are still in development. Make sure the sales agreement limits the amount of any price increase or allows you to cancel the PO.

  An option would be to replace the vehicle in question with a lower-priced EV or to select another OEM. Having the financial staff involved upfront with price negotiations will help.
- Planned incentives/other funding disappear. Many incentives are limited to a certain number of vehicles or limited to an amount paid out. As a result the incentive might disappear before you can access.

  If the anticipated amount was substantial, you may have to select lower-priced EV. If the intent was to buy the EV, then leasing or renting will lower cash required.
- Residual value of existing fleet plummets. Residuals of fossil-fuel vehicles might drop no matter what you do. As more fleets transition to electric, supply of used ICE's will increase. By 2035 and beyond, the used vehicle market, particularly light duty, will be flooded with used vehicles.

Steps to Complete Transition to EV's

Once the pilot program is completed, the next step is firming up a timeline for transitioning to all electric/zero-tailpipe emissions. Maybe surprisingly, the most difficult hurdle to the full transition might not be securing product that meets your needs. The most difficult hurdle might be ensuring there is adequate infrastructure to "refuel" the vehicles – electricity and zero-carbon fuels.

Beginning in 2021, there will be an array of electric-powered sedans, SUV's, pick-ups and delivery vans introduced. The pace of introductions will accelerate through the decade. By 2030 and 2035 at the latest, there will be multiple companies offering electric-powered versions of virtually every configuration of light-duty vehicle. The announcement that by 2035 all General Motors-brand cars and trucks will be electric is but one example.

Among medium-duty vehicles, an array of electric–powered shuttle/transit vans, urban delivery vehicles, school buses, and work trucks are either available or soon to be available.

Among heavy-duty vehicles, there are commercial or prototype-test versions of electric transit buses, school buses, drayage trucks (aka "yard dogs"), refuse trucks and urban tractor-trailers. More models are in development.

Many electric medium and heavy-duty models use only batteries; a few incorporate fuel cells to extend range. Some heavy-duty development vehicles are retaining internal-combustion engines, achieving zero tailpipe emissions using hydrogen as a direct fuel.

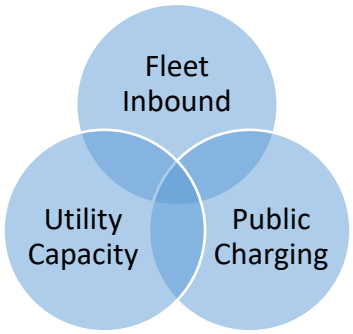
Depending on the mix of your fleet, there may be adequate product currently available or within a few years to complete the transition to all electric. An excellent reference page for an inventory of current or soon-to-be available electric work trucks/buses worldwide is Drive to Zero.

If product is not the major hurdle, then what is the major hurdle to transition the fleet? Adequate infrastructure for recharging may be biggest problem in trying to transition to all zero-tailpipe emission vehicles. Unfortunately, the solution to recharging infrastructure hurdle lies outside the control of the auto OEM's and outside the control of the fleet. The solution lies with the electric utility. (Infrastructure problems for refueling zero-carbon fuels can be solved more easily. In addition, for most areas such fuels will not be available until mid-2030's.)

The infrastructure for EV recharging consists of three key components:

- Inbound electric service and physical space available where fleet vehicles stored
- Lack of availability of public charging stations with capacity to recharge larger kWh battery packs in a reasonably short time
- Electric utility generating capacity and distribution network that will meet the needs of a rapidly expanding EV-user base.

The three components are inextricably linked and are highly influenced by and/or controlled by the electric utility.



Inbound Electrical Service at Fleet Location. If some or all of your vehicles are housed in a central location, then by all means work with the utility to determine the: (i) footprint required for charging stations; (ii) additional footprint required for upgrading electrical service; (iii) zoning restrictions that would affect any upgrades. No surprise, changes to zoning often have a long lead time.

Public Charging. While the number of public charging locations is increasing, many of these stations are/will be geared toward recharging light-duty vehicles. The kWh capacity of a medium and heavier-duty truck/bus can be 3-4x as large as a car/pick-up truck. As a result, an "opportunity charge" of say 30 minutes that would extend the range of the car 50-60 miles would extend the range of the truck 15-20 miles.

The capabilities of public charging stations are likely to improve over time. Eventually a version of an "EV truck stop" will emerge. Until such EV truck stops are widespread, plan on very limited use of public charging locations for medium and heavier-duty EV's.

Electric Utility Capacity. The concern with electric utilities is less of overall capacity and more one of capability to manage peak-load demand throughout the service area. When peak-load demand exceeds capacity, the utility has two options: (i) brownouts, which reduce the amount of electricity available to all but critical users; (ii) rolling blackouts, which temporary cut all power outages for a given area. The usual cause of the brownout/blackout is some combination of overall generating capacity, inadequate distribution capacity and/or an aging infrastructure that limits transmission. (The multi-day interruption in service during a cold snap in Texas, February 2021, is an example of aging infrastructure and inadequate preparation for peak-load demand during weather events.)

Both the brownout and blackout will interrupt recharging. For vehicles stored overnight, vehicles can be charged after the interruption. However, for vehicles in operation throughout the day – police and emergency vehicles, e.g. – charging cannot wait.

In the near-term, fleets subject to interruptions in power could use an existing fossil-fuel generator to provide some recharging to say 3-4 key vehicles. Longer-term a larger kWh battery back-up could be installed. Neither approach is adequate to ensure the entire fleet can be recharged as needed.

The only long-term solution is for the electric utility to add generating capacity and/or upgrade supporting distribution infrastructure. For the utility, the question is how much capacity to add, and when to add capacity?

Lead times for adding generating capacity or upgrading infrastructure could be five years, or more. In addition, if the new capacity is inadequate, then users will be subjected to continuing brownouts and maybe some rolling blackouts.

The concern over infrastructure needs to be part of the pilot presentation to senior management. You should also ask senior management, starting with the CEO, for help in addressing any concern. A good first step would be to assign someone or some group in the organization to begin working with the utility to develop a better understanding of utility capacity limits.

CAUTION: Battery Life & Fast Charging.

One of the issues with EV's is the time required to recharge. While "fast charging" does reduce the time for "refueling," the downside is the potential to shorten the life of the battery pack. How much battery life will be shorted is a combination of frequency of fast charging, battery chemistry and how "fast" the fast recharge. Efforts are being made to reduce the negative impact of fast charging on battery life. Be judicious about fast charging until more data are available.

Another factor affecting battery life is depth of discharge, aka state of charge. Most EV battery packs limit discharge to about 80% to avoid excessive shortening of battery life.

If you let the battery discharge too far, the battery will recharge, BUT the capacity of the battery will be reduced. Like humans, batteries lose

energy capacity over time. Ask yourself, "Do I have as much energy as 10-15 years ago?'

Over time batteries hold fewer electrons and range on a "full charge" will be less. Unlike lead-acid starter batteries, which one day don't have enough energy to turn the starter motor, EV batteries will operate but range will be less.

While it is impossible to stop the degradation in battery capacity, you can avoid worsening the degradation by not discharging the battery too much. The life of most batteries is shortened if the battery state-of-charge (SOC) falls below about 20.0% (Nickel-cadmium batteries are an exception).

Although battery capacity is not shortened significantly each time of excessive discharge, the cumulative effect can be substantial, and costly since the pack will need to be replaced sooner.

Keeping the battery pack charged also will ensure a separate battery in the EV used for many electronics on the vehicle stays charged. Part of the driver training for using EV's should emphasize why keeping batteries charged as much as possible is important. (Link to one of many articles re why you should keep batteries charged.)

Reducing Emissions with Biodiesel

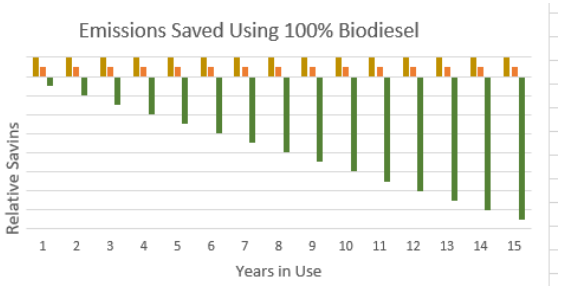
An issue for the organization is whether to reduce diesel emissions on existing lighter-duty, medium-duty and heavier-duty vehicles. Some diesel trucks/buses purchased in say the last five (5) years, could be in use another 15-20 years.

Based on information provided by managers of medium and larger-size municipal fleets, converting existing diesel engines, of most any size, to use 100% biodiesel can reduce tailpipe emissions by about 75%. The managers also reported that drivers did not notice any degradation in performance, even in cold weather.

Ames, IA, e.g., converted some snow plows to 100% biodiesel. (Ames, IA pilot program description. The link provides access to a good template to follow for describing to your management various aspects of a pilot program.)

Department of Public Works, Washington, DC, also has been piloting use of 100% biodiesel. Like City of Ames, IA, GHG reductions in DPW trucks were reduced 75% or more.

The cumulative effect of reducing GHG emissions in existing diesel engines can be substantial. The chart is based on a 75% reduction in GHG emissions using 100% biodiesel. Over the 15 years of remaining life, GHG emissions would be reduced the same amount as the reduction as a new EV operated for 10-11 years.



Steps for converting some trucks/buses to biodiesel are not complicated. A good source to learn more is BIODIESEL.ORG - Home.

Steps include:

1. Viewing webinars and/or checking with other fleet managers who have converted some or all trucks to 100% biodiesel. Managers are usually very open to discussing

successes and also what mistakes they made that you can avoid.
2. Checking that ready supply of 100% biodiesel is available in your area;
3. Installing aftermarket conversion equipment on existing diesel engines. One source of equipment for your consideration, Optimus Technologies. Optimus also works with biodiesel providers on pilot programs. Other companies can also help.

Webinars, usually free, often have real-world experiences from managers of different-size fleets and in different regions. Most webinars have Q&A sessions after presentation. Many webinars archived. Worth your time to review.

(*Note: Using 20% biodiesel will also reduce emissions but not as much as 100% biodiesel. Often, no special equipment required for 20% biodiesel.)*

Hydrogen, Other Zero-Carbon Fuels

Longer-term, liquid hydrogen should be available to use as a fuel in larger trucks. For the pilot program, liquid hydrogen is unlikely to be available other than a few locations – LA area, e.g.

Other zero-carbon fuels are in different stages of development. Such fuels are attractive for Class 8 trucks and longer-haul duty cycles. Watch for developments.

Global Warming: Non-Believers

What do I tell people who don't believe in global warming? What do I tell those who think EV's are a waste of money? What if I don't believe in global warming?

If our organization doesn't believe burning fossil fuels is a major contributor to global warming, why should the organization convert to electric?

Our MIT group has made every effort to stay apolitical. As MIT graduates, we are biased toward data and science. We also understand while some people disagree with the conclusion that burning fossil fuels – gasoline, natural gas and diesel fuel – contributes to global warming, there is overwhelming scientific evidence to support the conclusion is does. .

But rather than get into an argument, we suggest thinking about the issue a different way. Imagine you're buying an insurance policy so your children and/or grandchildren can have a reasonable lifestyle in the future. The insurance policy will protect them from the most severe impacts of global warming.

The insurance premium is not cash but transitioning your fleet and other fleets to all electric or zero-carbon fuels. If you don't buy the insurance, your children and/or grandchildren will face huge disruptions to their lifestyle, including more severe weather, crop failures, etc.

"Hold on," you say, "buying insurance doesn't guarantee something bad is going to happen. I have homeowners insurance and the house has never burned."

That's true. While we don't agree with the following assumption, imagine that in 25-30 years there is new scientific evidence that burning fossil fuel doesn't contribute to global warming. Then, the climate-change insurance will not have been needed, just as your homeowner's insurance hasn't been needed because your house hasn't burned.

What's the downside of taking action to address climate change? There is no downside. In that 20-25 year period, many positive things will happen. By converting to electric and/or zero-carbon fuels, society will benefit because of advancements in technology, many new jobs, cleaner air and lower health-care costs.

Taking action will also slow the rate at which the earth's temperature is warming. Keep in mind, there is already so much CO_2 in the atmosphere that the earth's temperature is going to rise for many decades.

Without EV's/zero-carbon fuels, the average temperature worldwide will rise even faster and everyday life will be disrupted even more. Taking no action is just like trying to buy home owners when your house is on fire, then it's too late. Your children and/or grandchildren will face a life never before experienced by mankind.

We believe the better approach, in fact the only approach, is to "take out the insurance policy" by converting the fleet to electric/zero-carbon fuels. Everyone's children and grandchildren will be thankful, enjoy cleaner air and benefit from economic growth.

Other Media/Info Sources

There are many good general sources of information available about electric vehicles and about issues to consider when transitioning to electric/zero-carbon fuels. The intent of this guidebook was to provide more details with the hope the book would make solving the transition jigsaw puzzle easier for you.

Following are some sources of information you might find helpful. More are available.

- CALSTART. Founded more than 20 years ago to help bring together fleet executives, OEM's, suppliers and legislators to solve policy and technical problems associated with reducing emissions in transportation. In addition to the professional staff at HQ, CALSTART has offices in key cities in the US. CALSTART is also the leading force behind the worldwide Drive to Zero program.

  Another valuable program for fleets with medium and heavier-duty trucks is CALSTART's High-Efficiency Truck Users Forum (HTUF). HTUF seminars include introduction of and discussion of emerging technologies. While some info is available at no charge, joining CALSTART provides access to significantly more detail.
- National Association of Fleet Administrators (NAFA). NAFA has range of certification programs. NAFA has been working with CALSTART on a certification program for electrifying the fleet. At publication, the program was still in development. Check NAFA website for updates.
- School Bus Fleet. Monthly publication (no charge) with regular email updates. Wide range of information including a whitepaper titled "7 Steps to Successfully Adopt an Electric School Bus."
- Government Fleet. Monthly publication (no charge) with regular updates available. Whitepapers available on range of topics, including electrifying fleets. Also, access to webinars, upcoming and archived. Site includes info about new vehicles, after-market equipment and software programs.
- Automotive News. Weekly pub with daily updates. Articles cover all aspects of the auto industry. Very affordable digital subscription. Long-time info gold standard.
- California Air Resources Board (CARB). If you want to keep abreast of current and likely future regulations affecting fleets, CARB website is worth reviewing periodically. The site has wide range of topics. Many topics do not apply directly to transportation, so some sorting will be necessary. Click on the "News" tab for recent rulings and updates.

  While CARB's efforts and rulings apply only to California, CARB long has been a template for rulings by US EPA. Reviewing the CARB website and receiving updates will help your organization prepare for future transportation emissions issues.
- State Organizations Supporting EV's. One example is E4Carolinas. Other state organizations exist as well.

  A national umbrella organization for the various state groups is Environment America (EA). EA addresses many environmental issues, including transportation.
- General Motors. GM announced that by 2035 all light-duty cars and trucks under the various GM brands will be electric. GM site has access to different brands and updates on availability.
- Other Auto OEM's. With the GM announcement, other auto OEM's worldwide are likely to accelerate introduction of EV's, at least light-duty models. A number of start-ups, some of which have ties to the OEM's and/or other major companies – Rivian and Lordstown Motors, e.g. – are expected to introduce EV's in 2021/2022. Tesla also is expected to begin production of an electric pickup truck.