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Lawrence Transit Zero Emission Transition Plan

RFP 2300115

Submitted by:

Center for Transportation and the Environment & NV5

Operational Analysis

CTE's Requirements & Data Collection, Service Assessment, and Fleet Assessment

CTE will collect all route, block, fleet, operational, maintenance, and facilities information to define the baseline conditions and current operating costs of the City's existing service (Baseline Scenario). Because of CTE's prior and current work with Lawrence on the City's BEB deployments, CTE already has a some of the necessary data needed for the City's existing service. CTE will confirm the data already in possession of and acquire any additional data needed regarding the City's existing fleet and operations. This baseline scenario will be used as the basis for comparison with the ZEB transition scenarios (listed in previous section) analyzed for this project.

CTE will conduct a Service Assessment to evaluate expected energy needs for each route and block for battery electric and hydrogen fuel cell vehicles. CTE will model the City's routes based on the specifications of a generic battery electric bus to predict the range and performance of the battery electric buses on select Lawrence's routes. Through previous and current projects with the City, CTE already has GPS data (time, distance, vehicle speed, vehicle acceleration, and roadway grade) for a number of the City's routes that will be used for modeling purposes. CTE also has performance data on BEBs that are currently in operation in the City. This data will be used to calibrate CTE's models for a more accurate prediction of expected ZEB performance across the entire fleet.

CTE's model uses powertrain simulation software developed by Argonne National Laboratory called Autonomie. The software was developed for the heavy-duty trucking industry and modified by CTE for zero-emission transit buses. The results of the ZEB modeling activity will provide the City with expected efficiencies and energy consumption on the City's routes and blocks using real world route data, specific to Lawrence, Kansas, that CTE already has access to. The results will then be applied to all of the City's routes based on pre-determined route categories. CTE will then assess the feasibility of using BEBs on all of the City's fixed-route and paratransit blocks. CTE will then modify the parameters to assess feasibility of FCEBs on the City's routes.

The results of this analysis include minimum and maximum anticipated energy consumption and range on each service block depending on weather conditions, use of auxiliary fossil-fueled heating systems, battery degradation scenarios, and duty cycle specific to the City's blocking schedule, fleet composition, and operating environment. This analysis helps to determine if zero-emission technologies have sufficient range to replace the City's current buses on a 1:1 basis and complete every scheduled service day or route assignment. If it is determined that the vehicle range is insufficient to meet the City's current or planned service levels, CTE will analyze alternate technology-based scenarios to achieve the objective. If these alternate solutions are also insufficient, CTE will assess the impact that service changes may have on the scenarios previously analyzed.

CTE will then use the outputs of the Service Assessment modeling for the Fleet Assessment. The Fleet Assessment will create a projected timeline for replacement of current vehicles consistent with the City's existing fleet replacement plan, with consideration for any technology constraints and alternative fleet compositions determined by the Service Assessment, and in compliance with the City's sustainability and transition goals. A fleet replacement schedule will be generated for each technology scenario. The Fleet Assessment also includes an analysis of projected fleet capital cost over the transition lifetime for each of the technology scenarios.

Deliverables

- A workshop for the City staff reviewing the BEB and FCEB service feasibility and alternate scenarios where vehicle(s) cannot be replaced on a 1:1 basis. Workshop will also include a summary look of the City's existing operating parameters and schedules, and potential operational impacts of the ZEB scenarios.

- A workshop for the City staff reviewing the vehicle replacement schedule and capital cost estimates for the City's fleet for each scenario, as well as incremental cost comparisons to the baseline scenario.

Estimated Duration: ~ 4 months

Fuel

CTE's Fuel Assessment

During the Fuel Assessment task for the Baseline fleet, CTE will use available data from the City for current diesel and gasoline fuel prices, as well as current electricity prices for fueling of the City's current BEB fleet, and project the changes in fuel prices through 2035 using historical data.

Deliverable

- A summary of the Baseline fuel costs.

Estimated Duration: ~ 1 month

Electricity and Hydrogen Fuel

CTE's Fuel Assessment

During the Fuel Assessment task for the ZEB scenarios, CTE will analyze daily fuel consumption and demand requirements, projected annual fueling costs, and the potential for savings over current fuel costs.

For battery electric scenarios, CTE will create a charge model that will use the vehicle energy needs to determine the City's power requirements at the Transit Maintenance Facility over time. CTE will evaluate how many chargers that will be required during each year of the fleet replacement, and this information will be used to inform how the City should phase infrastructure installation. Analysis of current utility rate schedules will be incorporated to provide recommendations for minimizing operating costs for the vehicles. The analysis will evaluate the impacts of demand charges on cost and explore the benefits of charge management software for Transit's fleet should BEB be the option selected. The Fuel Assessment optimizes the amount of time to charge, as well as the time of day to maximize operational needs while minimizing costs. The Fuel Assessment also determines the annual cost of electricity needed to charge buses operating in a given year based on the available rate schedules. It considers time-of-use peak demand schedules as well as the charge rate (i.e., fast/slow charging) required to meet pull-out. If required, the impact of on-route chargers is considered in the energy, charging, and cost models. NV5 will also coordinate with the City's utility, Evergy, to discuss the power needs that the City would require with a transition to a zero-emission fleet by 2035, as the utility must be able to supply adequate power and support in order for the City's transition to be a success.

For fuel cell electric scenarios, CTE will analyze daily hydrogen consumption and assess storage capacity requirements as well as supply options and costs.

CTE's fuel consumption calculations include considerations of variable environmental factors such as topography and climate/seasonality in our modeling. Additionally, CTE's methodology takes changes in utility rates, both energy demand and energy consumption, into account with respect to time of use, day of the week, and seasonality. CTE's analysis will look out at least 25 years to include a projection of fuel cost stability for diesel, hydrogen, and electricity as transportation fuels.

Additionally, CTE's analysis will consider alternate sources of transportation fuel, i.e., solar PV and battery energy storage systems for BEBs and solar PV and hydrogen electrolysis for FCEBs. The analysis will be based on the results of the Energy Storage and Solar Assessment presented below.

Deliverable

- A workshop reviewing the charging assumptions, daily energy demand, annual energy consumption and annual energy costs to operate battery electric buses. The workshop will also review hydrogen assumptions, daily hydrogen consumption, annual hydrogen consumption and annual hydrogen costs to operate fuel cell electric buses.
- A workshop reviewing the impact of using renewable sources to provide fuel, i.e., electricity and/or hydrogen.

Estimated Duration: ~ 2 months

Maintenance

CTE's Maintenance Assessment

During the Maintenance Assessment phase, CTE will analyze labor and materials costs for vehicle maintenance as well as major component replacements, including drive failures and overhauls for each technology scenario over the transition period. The assessment considers various factors that impact the lifecycle of ZEBs, including, but not limited to battery degradation and overhaul of the fuel cell stack. The assessment considers the impact that extended battery warranties and leasing may have on maintenance, operating, and capital costs. It also considers industry averages of maintenance costs reductions as compared to baseline fleets. Additionally, the analysis will consider maintenance staffing level differences for the ZEB scenarios compared to the baseline. The Maintenance Assessment is performed for each scenario, including the baseline and will determine both annual maintenance costs over the transition period for each ZEB transition scenario as well as average maintenance cost per-mile by technology.

Deliverable

- A workshop reviewing the maintenance costs for the City's fleet throughout the transition to zero-emission vehicles. The workshop will also include the results of the staffing assessment and workforce development recommendations.

Estimated Duration: ~ 2 months

Capital Infrastructure Investment Needs, Cost and Schedule

CTE's Facilities Assessment

Using the results of the service and fueling assessments, CTE will provide NV5 with annualized requirements for BEB charging and FCEB fueling, as follows:

BEB: CTE will provide NV5 with the number of chargers and dispensers required to fuel BEBs each year throughout the transition period. CTE will also provide daily power (kW demand) and energy requirements (kWh) and estimated cost of the equipment.

FCEB: CTE will provide NV5 with estimated equipment requirements, footprint, and costs of the H2 fueling station.

Using the detail provided by CTE, NV5 will then develop scoping level concepts for the EV and hydrogen fueling options at the Transit Maintenance Facility. As part of the scoping effort, we will work with City staff to understand facility usage, any other planned improvements to the site, and available footprint for the new infrastructure. Through these discussions with City staff and our conceptual layouts, we will identify and note potential infrastructure projects needed at the site to accommodate the new charging/fueling infrastructure.

We will also engage with the local electrical utility to make initial inquiries regarding power availability, constraints, and preliminary siting for service upgrades. This will inform the concept layouts, schedule, and cost estimating effort.

Based on the conceptual layouts, NV5 will then develop scoping level cost estimates to design and construct either fueling option based on recent project experience and industry metrics. Cost estimates will consider project phasing and other potential improvements, such as onsite generation or storage systems.

A multi-year design and implementation schedule will be developed as part of the infrastructure scoping for both options, aligned with the zero-emission transition plan. The schedule will consider phasing of infrastructure to align with vehicle adoption, as well as power supply constraints identified through conversations with the utility.

CTE will identify available funding sources that could be an option for the City to mitigate infrastructure costs. As requested in the RFP, we will review match funding supplement mechanisms, including but not limited to Federal Fund Braiding and Transportation Infrastructure Finance and Innovation Act (TIFIA) programs.

Deliverable

- Concept drawings for EV and Hydrogen fueling infrastructure at the Transit Maintenance Facility.
- A workshop with the City's staff to review the facility impact assessment, scope, phasing plan, and schedule of infrastructure projects, and cost estimates for charging/fueling infrastructure to support the City's transition to a zero-emission fleet.
- A high-level timeline with estimated yearly projects of infrastructure projects necessary for a ZEB transition.

Estimated Duration: ~ 3 months

Energy Storage and Solar

CTE's Facilities Assessment

NV5 has worked successfully with CTE on a number of ZEB transition plans to evaluate onsite solar generation and stationary battery systems in support of both BEB and FCEB transitions. NV5's Clean Energy group has provided planning, design, and owner's rep services on hundreds of behind-the-meter solar and solar+battery energy storage system (BESS), including solar canopies integrated with EV charging.

For onsite solar, most installations at transit sites take the form of canopies, gantries or roof-mounted solar. In all cases, commercially viable and financially efficient installations will be considered, and all available incentives and favorable utility tariffs will be incorporated in the analysis. We are also intimately familiar with alternative financing scenarios and can consider third-party arrangements when assessing upfront and lifecycle costs. As an example, we assisted Anaheim Transportation Network in evaluating and negotiating P3 contracts for onsite solar, battery energy storage systems, and charge management as part of their BEB implementation.

Detailed modeling of the PV systems will be performed utilizing Helioscope, which produces conceptual layout, sizing, and detailed production modeling for each site. Using the energy consumption estimates established for each ZEB scenario, we will overlay the solar PV production modeling to generate a net consumption profile for the site over the course of a year. This net profile will then be modeled in a utility tariff analysis and battery energy storage system (BESS) modeling software (Energy Toolbase). The result is a detailed estimate of utility energy costs before and after implementation of solar and/or BESS systems. We also anticipate some iteration with the ZEB consumption estimates to optimize charge/fueling profiles and onsite generation/storage sizing.

A financial analysis would be developed with detailed lifecycle cost modeling for PV+BESS, including capital and operating costs, energy cost savings, system degradation over time, utility cost escalation, etc. We are intimately familiar with alternative financing scenarios and can consider Public Private Partnership (P3) models in our analysis. As an example, we assisted Anaheim Transportation Network in evaluating and negotiating P3 contracts for onsite solar, battery energy storage systems, and charge management as part of their BEB implementation, including securing $2.9M in grant funds for onsite batteries.

Finally, NV5 and CTE will collaborate on PV+H2 Electrolytic systems to assess hydrogen production capabilities, capital cost impact on infrastructure, and operating cost impact on hydrogen fuel.

As requested in the RFP, deliverables will include:

- A review of Solar and BESS technology compatible with the ZEB plans, including PV+H2 electrolysis described above.
- A financial proforma with detailed lifecycle cost analysis, incorporating capital costs, operating costs, energy cost savings, grants/incentives, and alternative financing arrangements.

Overview of solar+BESS integration with ZEB infrastructure. Anticipated as a scoping-level concept drawing for each site presenting solar, BESS, and ZEB infrastructure.

Estimated Duration: ~ 1 month

Start-Up and Lifetime Costs

CTE's TCO Assessment

During Total Cost of Ownership Assessment phase, CTE will summarize the results of the previous assessments, providing a detailed breakdown of capital costs, (including costs of annual bus procurements, fueling infrastructure, facility upgrades, and design, construction and installation costs) and operating costs (annualized fuel and maintenance costs) over the transition timeline. CTE will

provide total cost of ownership for each plausible scenario from 2023 through 2050, to includes replacement and rehabilitation costs, as well as incremental cost comparisons to the baseline scenario.

Deliverable

- The deliverables for this task will be a workshop for the City's staff reviewing the total cost of ownership for the ZEB fleet transition scenarios compared to the baseline scenario for the timeline of 2023 to 2050.

Payback Period and Net Present Value (NPV)

CTE's TCO Assessment

Once the TCO assessment is completed, CTE will conduct a financial analysis to calculate Net Present Value and the Payback period based on the annual cost estimates for each scenario.

Sensitivity Analysis

CTE's Facilities and TCO Assessment

CTE's financial analysis for each Assessment will include a look at today's costs, as well as future costs with conservative and aggressive inflation scenarios. CTE will work with the City to confirm the inflation assumptions for a conservative and aggressive cases. The inflation scenarios will be carried through to the Total Cost of Ownership assessment, providing a comparative look of each ZEB transition scenario with the City's baseline scenario, with both a conservative and aggressive inflation case applied.

TCO Assessment Estimated Duration: ~1 month

Draft Report

This task shall combine the results of the previous tasks to provide a recommendation and propose an overall approach for the City's transition to a zero-emission bus fleet. CTE will prepare a draft technical report to document the assumptions, methodologies, modeling results, analyses, conceptual layouts, cost estimates, findings, and conclusions. Critical to this report is showing a clear rationale for selecting a recommended ZEB mode, a summary of associated operating and capital costs for transitioning to this ZEB mode, and a timeline of key activities to be completed to reach Transit's ZEB transition goals.

CTE is experienced with helping agencies write the Low-No grant application, including FTA's requirements for a Zero-Emission Transition Plan. CTE's report will be inclusive of the requirements from FTA to ensure the City is positioned to pursue future FTA funding, when desired. The plan intended for inclusion into FTA's Low-No grant application addresses the following elements:

- Demonstrate a long-term fleet management plan, demonstrating a transition to zero-emission vehicles;
- Address the availability of current and future resources to meet costs for the transition and implementation;
- Consider policy and legislation impacting relevant technologies;
- Include an evaluation of existing and future facilities and their relationship to the technology transition;
- Describe the partnership of the applicant with the utility or alternative fuel provider; and

- Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.

Deliverable:
- Draft Report (MS-Word file)

Estimated Duration: ~ 1 month

Final Report

CTE will prepare a final technical report that incorporates revisions to the draft in response to the City's staff comments. CTE will also provide the City with a Microsoft PowerPoint summary of the ZEB Plan and present this to the Public Transit Advisory Committee (PTAC), if requested.

Deliverables:
- Final Report (PDF file)
- PowerPoint Summary of the ZEB Plan
- Presentation of PowerPoint Summary to PTAC (if requested)

Estimated Duration: ~ 1 month

Project Management and Administration

CTE will guide the entire project by the control and risk management procedures detailed below in the "Elements of Project" and. "Project Controls" sections. CTE's centralized management of the work program will enable team members to concentrate on exceeding project goals and ensure production of deliverables in a clear and well-coordinated manner. Details of CTE's processes for ensuring the efficient accomplishment of these tasks are listed in the following sections.

Elements of Project

Collaboration Tools

CTE will use e-mail, Dropbox and Smartsheet to share project files and communications, coordinate tasks, track issues, and maintain project calendars.

Communications Plan

Team members will participate in weekly or bi-weekly conference calls to discuss project status and current issues. Meeting minutes will be taken and shared to ensure open access to proceedings. Online video conferencing will be employed when team members desire a presentation format to share status updates. CTE will schedule additional conference calls with team members as needed.

Reporting Plan

CTE will provide the City with monthly status reports detailing project status, activities completed each month, schedule updates, any known risks and plans for mitigation.

Risk and Action Item Management and Mitigation Plan

CTE provides strong and engaged oversight of project progress through the suite of management controls and procedure outlined above. CTE's management method allows us to anticipate and manage potential risks and ensures quick recognition of any unexpected project risks that arise. All identified risks are documented; assigned to project team members for research, analysis, and resolution; and tracked through the project. Risks and related tasks are prioritized to ensure that project team members remain focused on the right activities at the right time. Critical issues that remain unresolved or proposed solutions that impact project timeline, scope, budget or resources are escalated to the City's management for immediate attention.

Project Controls

CTE will be responsible for maintaining the overall schedule and budget for this project. The proposed project budget can be found in the "Cost" section below. CTE has developed a high-level schedule for this project with the goal of completing all of the tasks by December 31, 2024 (see Figure 2), assuming a start date of January 15th, 2024. CTE will work with each project partner to develop a detailed schedule upon initiation of the project. Based on each partner's inputs, CTE will establish individual task durations and dependences and will identify the critical path for the plan and identify any project plan risks. CTE will be responsible for maintaining the overall schedule. Project partners will manage the detailed schedule for their assigned tasks and report schedule status for each regular team call. If the actual progress for a task is determined to be behind the planned schedule, CTE will determine if corrective action must be made based on the schedule variance, the amount of work remaining, the impact on other tasks, and impact on the overall schedule. Corrective action, if necessary, will be identified during the team conference calls. CTE's proposed core project team for this project are staff members already familiar with the City and the City's staff, through previous and current battery electric bus deployment projects for the City of Lawrence. CTE and the City already have established forms of communication and project management processes through those projects, which will carry over to this project.

Deliverables for Project Management and Administration

- Periodic project schedule and budget updates
- Monthly status reports
- Monthly invoices with accompanying invoice narratives
- Agenda and minutes for all meetings
- Copies of presentations given through project

Estimated Duration for PM: ~ 11 months

Optional Task: Resilience, Redundancy, and Response (3R) Planning

The Redundancy, Resilience, and Response Assessment would investigate the City's options to continue to provide service in fuel scarcity scenarios such as grid failures and shutdowns as well as review the City's ability to support an emergency response in natural disaster events that may require differing duty cycles and vehicle applications. At the conclusion of this assessment, CTE would conduct a workshop with the City to review the facility and vehicle technology solutions to support a zero-emission fleet in off-grid or grid-down, and emergency situations, as well as an overview of the costs associated with those options.

CTE offers customized Redundancy, Resilience, and Response (3R) planning for agencies to consider utility outages, natural disasters, and other impacts to operations. Risks are quantified by risk (likelihood of occurrence) and consequences, with mitigations options included with results. For BEBs, this includes scenarios related to charging from chargers out of service for several weeks to a total grid failure. Specific to mitigating charging issues, CTE's recommendations have included leveraging other local charge sites (such as an on-route charger or other depot) for localized failures; having enough charging capacity to handle an above average number of chargers offline; including a backup power generation source, such as a fossil fueled generator with a stable local fuel source (although emissions from fossil fuels are undesirable, the net gains of a full time BEB fleet outweigh the relatively low impacts from short-term fossil fuel use). Each scenario listed includes a risk assessment to help clients weigh the extra costs with potential impacts to service in the context of how often it may happen. The assessment can include concept level scoping of microgrid infrastructure, such as onsite generation and storage, with corresponding cost estimates to meet the selected resiliency scenarios.

COST PROPOSAL

Item	Cost
Project Management & Administration	$26,400
Financial Analysis	
Fuel	
Electricity & Hydrogen Fuel	$8,500
Maintenance	$5,000
Operations	
Operations & Maintenance during transition	$21,200
Startup & Lifetime Costs	
Payback Period & NPV	
Sensitivity Analysis	$4,100
Capital Infrastructure Investment Needs, Cost, and Schedule	
Energy Storage and Solar	$62,600
Report	
Draft Report	$7,200
Final Report	$15,000
Training, or other hourly services	
Office/admin expenses	
Items necessary for the project, but not listed elsewhere	
Total Cost	$150,000

*Table may be altered or reformatted as needed to provide clear cost proposal

*Optional Tasks excluded from budget