



Zero Emission Bus Implementation Plan Scope

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Center for Transportation and the Environment



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DASH
Zero Emission Bus Implementation Plan Scope
Alexandria Transit Company

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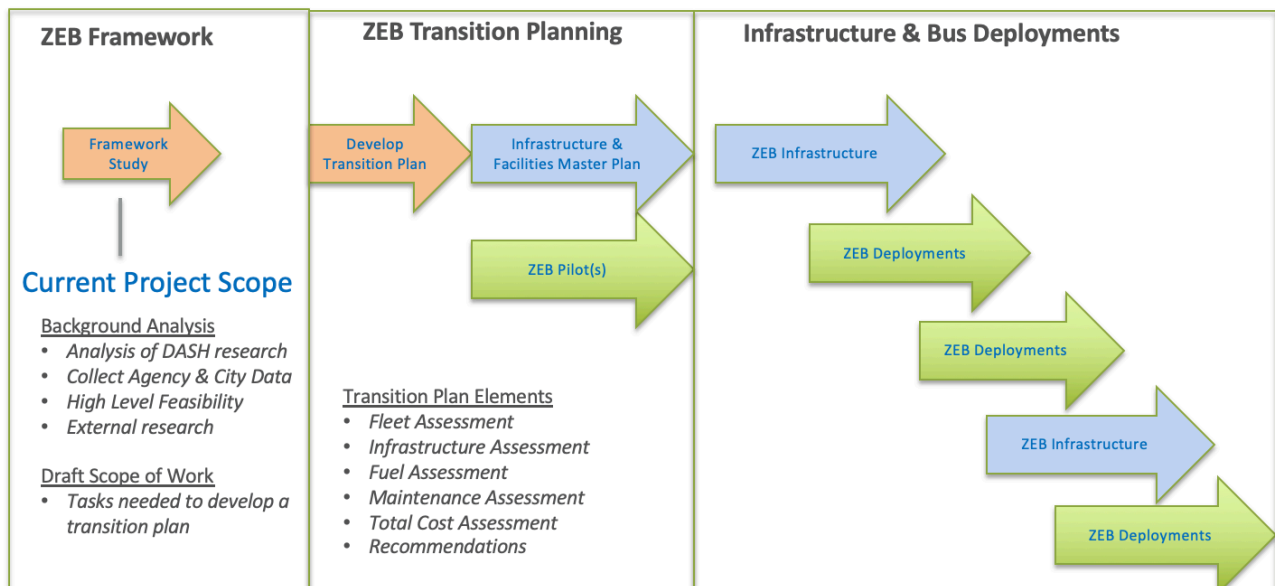
1 Introduction

DASH is the city bus system for Alexandria, Virginia. It is operated by the Alexandria Transit Company, a non-profit service corporation wholly owned by the City of Alexandria. DASH provides service to more than four million passengers annually within portions of the City of Alexandria and between the City and the Pentagon Metrorail station. As part of its key role in providing safe, reliable service while supporting key city goals to provide environmentally friendly alternatives to the single occupant vehicle, DASH has undertaken several initiatives to understand zero emission bus technologies and their implementation. As part of their overall long-term fleet policy planning, DASH has engaged the Center for Transportation and the Environment (CTE) to perform a zero-emission bus fleet feasibility and planning study.

The study was conducted in two parts:

- **Part 1 - Background Analysis & Feasibility Study:** This body of work helps DASH understand the feasibility of transitioning to a zero-emission bus fleet based on: 1) Evaluation of the internal efforts taken to date, 2) collecting information on DASH’s fleet, facilities, routes (including current and future block schedules) as well as governmental support and environmental conditions in the city, 3) performing a high level feasibility assessment based on this information, and 4) including supplemental best practices and external research.
- **Part 2- Implementation Plan Scope:** Based on the information from Part 1, CTE developed a draft scope of work that identifies tasks that are needed to develop a plan to transition the fleet to 100% zero emission.

This document describes **Part 2 – Implementation Plan Scope**, detailing the tasks required for future ZEB Transition Planning, shown in the figure below. ZEB Transition Planning is typically split into three primary activities: ZEB Transition Master Plan, Infrastructure & Facilities Master Plan, and a ZEB Pilot. This document is intended to describe the scope of work required to complete each activity.



2 ZEB Transition Master Plan

The goal of the DASH ZEB Transition Master Plan is to establish a timeline and budget to migrate the DASH fleet to a 100% zero emission fleet over a period of time. The plan may include several scenarios so that DASH may assess the impact and incremental costs vs. the baseline of each alternative before selecting a given path. The plan is intended to establish a timeline for transition based on DASH's current fleet procurement schedule, transition goals and constraints, and the current and anticipated future state of technology.

To develop the ZEB Transition Master plan, DASH must first analyze components of their operation to assess impact, timing, and costs associated with alternative zero emission technologies and deployment strategies. The primary analysis that must be conducted include: Service Assessment, Fleet Assessment, Fuel Assessment, Maintenance Assessment, and Facilities Assessment, each described in further detail, below.

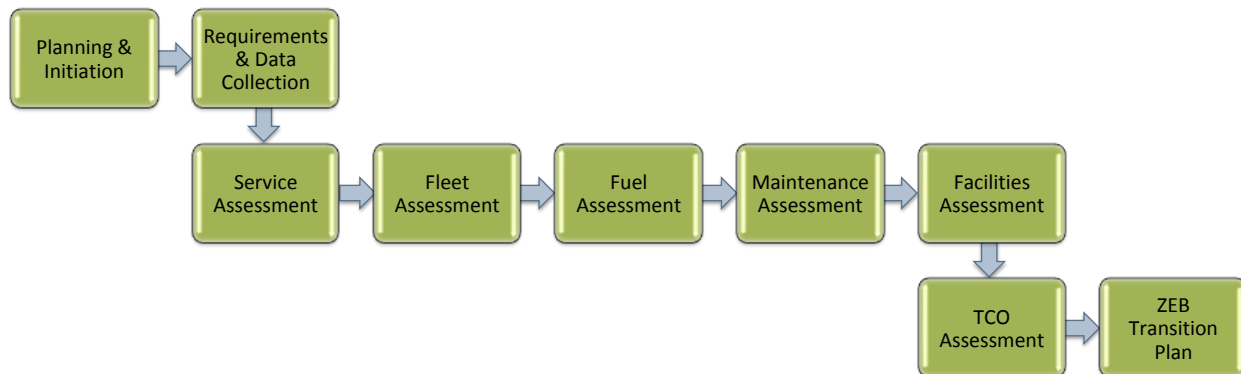
Prior to initiating these assessments, CTE recommends that DASH clearly defines the scenarios, assumptions, and constraints that will frame the analysis. For example, scenarios may include Baseline, BEB-only, FCEB-only, and BEB-FCEB mixed fleet. The Baseline scenario assumes no change to the propulsion technology and fuel type of the current fleet and is used to compare the incremental costs and benefits of each of the transition scenarios.

One of the key assumptions that must be determined before starting any assessments is how range limitations associated with current BEB and FCEB technologies is addressed. It is likely that current ZEB technology is not sufficient to meet all service requirements. In the event that a block is too long for a single overnight charged BEB, DASH must decide to a) split the block and buy more overnight charged BEBs to the fleet, b) add on-route charging to the route, c) use FCEB buses instead of BEBs, or d) continue using current diesel or CNG technology to serve the given block. Additionally, DASH will need to make an assumption regarding improvements to electric-drive technology over time. A ZEB transition could easily take 20 years or more. While some blocks may be too long for current-state ZEB technology, improvements in energy density and fuel efficiency may allow these blocks to be served by ZEBs in the future.

Once the assessments are completed, DASH may summarize the results into a Total Cost of Ownership (TCO) for each scenario. The following describes the scope of work for each phase in developing the ZEB Master Plan.

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ZEB Transition Master Plan Scope of Work



Task 1: Planning & Initiation:

During the **Planning & Initiation** phase, the project team shall finalize the scope, approach, tasks, assignments, and timeline. This is followed by a Kickoff with project stakeholders. First, a Work Plan should be developed to manage the project and accomplish its goals and objectives. The Work Plan should include an organizational chart with staff roles and responsibilities and an action item matrix with a task list and corresponding action plans. The Consultant should also prepare a schedule that includes all activities, start dates, critical path items, estimated activity durations, and relationships among tasks.

The Consultant shall convene an in-person kick-off meeting with the DASH/City of Alexandria to review and discuss the Work Plan and Schedule described above. At this meeting, DASH and the Consultant will discuss expectations, confirm requirements, and identify key milestone dates. The finalized Work Plan and Schedule will ensure understanding of expectations, in accordance with the scope of services, between the Consultant and DASH.

The Consultant's project manager, and requisite consultant staff, shall conduct conference calls twice per month (with additional calls if needed) with DASH staff throughout the duration of the project to provide progress updates, identify critical issues, and identify an action plan for any schedule changes.

Task 1 Project Deliverables:

1. *Initial Work Plan and Schedule*
2. *In-person kick-off meeting conducted at DASH offices*
3. *Memo identifying critical information and near-term changes that may impact the analysis*
4. *Conference calls at least twice per month*
5. *Introductory presentation to DASH project team, city staff and/or sponsor(s)*
6. *Final Work Plan and Schedule, including goals, and objectives identified*

Task 2: Requirements & Data Collection

In the **Requirements & Data Collection** phase, the project shall define transition goals and requirements, typically in the form of assumptions that drive the assessments. The assumptions collected during this phase provide key parameters used in each of the Assessment phases that follow. The Consultant shall also collect route, block, fleet, operational, maintenance, and facilities data used to define the “As Is” or baseline scenario, as well as the DASH Fleet Procurement plan and an inventory of any planned service, fleet, or facility changes that may impact the analysis. The Consultant shall meet with DASH for a “Route Modeling” workshop to review the process the consultant will use to analyze DASH service and to collect data required to support this process.

Task 2 Project Deliverables:

1. *ZEB Transition Assumptions*
2. *DASH Service, Fleet, and Facilities inventory*
3. *DASH Route Modeling requirements and data*

Task 3: Service Assessment

The **Service Assessment** shall calculate expected energy efficiency by route to determine if ZEB technologies have sufficient range to replace current buses on a 1:1 basis and complete every service block. In the event that there are blocks that cannot be completed on a 1:1 basis, the project team shall analyze technology projections and alternatives that allow for 100% ZEB fleet transition. This is similar in structure to the high-level feasibility assessment done in Part 1 of this study, however, it is more detailed and accurate relative to DASH’s operation since it utilizes actual route data and conditions collected in the Requirements & Data Collection task above. This assessment will also determine the timeline for when routes/blocks are eligible for electrification based on improving range parameters, which shall be reflected in the ZEB Transition Master Plan. Assessment will identify future service and operational characteristics based on the Final Recommended Bus Network from the Alexandria Transit Vision Plan.

Task 3: Project Deliverables:

1. *DASH Service Assessment, including*
 - a. *Schedule of block electrification eligibility*

Task 4: Fleet Assessment

The **Fleet Assessment** shall result in a projected timeline for replacement of current buses with ZEBs consistent with the agency’s fleet replacement plan, with consideration for any technology constraints and alternative fleet compositions determined by the Service Assessment, and in compliance with the agency’s ZEB transition goals. The Fleet Analysis also includes an assessment of projected fleet capital costs over the transition lifetime. Analysis will include fleet replacement costs in context of the City of Alexandria’s Capital Improvement Program

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(CIP), and fleet expansion from VDOT/DRPT (SmartScale) and NVTA 70% grant funding sources. These projections shall help DASH prepare future-year capital budgets.

Task 4: Project Deliverables:

1. *DASH Fleet Assessment, including*
 - a. *Fleet Transition Schedule*
 - b. *Fleet Transition capital costs projections*

Task 5: Fuel Assessment

The **Fuel Assessment** shall analyze daily fuel consumption (i.e., electricity or hydrogen) and fuel demand requirements (i.e. amount of fueling in a given period of time). To assess Demand, the Consultant shall consider various charging strategies and provide comparative data regarding advantages, disadvantages and financial risks associated with the strategies in terms of charge management, charge concurrency, and consideration of pull-in and pull-out times, as well as overnight service requirements. The assessment shall also develop a projection of annual fueling costs, and the potential for savings over current fuel costs. Cost projections shall consider currently available utility tariff schedules as well as any proposed electric vehicle (EV) utility tariff schedules. Recommendations for changes to available or proposed utility tariff schedules may also be considered. The findings will provide a planning basis regarding the estimated energy and demand requirements and a discussion basis to identify the appropriate level of energy supply redundancy and resiliency. This task will interface with other tasks such as the alignment with current and near-term charging equipment and load management solutions based on energy and demand projections, the investigation of facility-specific requirements and available options regarding electricity distribution, and the specific operation requirements.

Task 5: Project Deliverables:

1. *DASH Fuel Assessment, including*
 - a. *Annual fuel consumption schedules*
 - b. *Daily demand projections*
 - c. *Rate schedule analysis comparisons*
 - d. *Recommendations for changes to existing or proposed rate schedules*
 - e. *Annual fuel operating costs projections for all fuel types used over the transition period*

Task 6: Maintenance Assessment

The **Maintenance Assessment** analyzes labor and materials costs for ZEB and infrastructure maintenance over the transition period as well as major component replacements for each technology type. The maintenance assessment also includes an evaluation of mid-life overhaul costs to keep buses in a state of good repair (i.e., battery replacement, fuel cell overhaul, etc.). The Consultant shall assess any unique maintenance and tooling requirements on ZEBs and related fueling equipment.

Task 6: Project Deliverables:

1. *DASH Maintenance Assessment, including*
 - a. *Annual maintenance costs projections for all propulsion systems over the transition period*

Task 7: Facilities Assessment

The **Facilities Assessment** defines the requirements for charging infrastructure and/or hydrogen fueling infrastructure to support the transition to battery electric and/or fuel cell electric buses, respectively, in terms of equipment and infrastructure costs, design, construction, and installation costs, space and siting requirements, operational impact, and utility service requirements. The assessment also provides a high-level timeline for various facility and infrastructure projects to build-out the charging capacity consistent with the addition of battery electric buses, or hydrogen fueling equipment consistent with the addition of hydrogen fuel cell buses. Since the transition is likely to take at least 15-20 years, it is envisioned that infrastructure and fueling capacity will be added in a series of projects over time, rather than building out all required fueling capacity at the beginning of the transition period. The assessment shall result in a series of charging equipment and related infrastructure (or hydrogen fueling equipment) requirements, order-of-magnitude cost estimates, and a conceptual timeline for the provision of infrastructure and fueling capacity in coordination with the delivery of BEBs and/or FCEBs during the transition period. The Facilities Assessment can be used by DASH to evaluate transition alternatives (i.e., BEB only, FCEB only, or mixed fleet). Once a decision is reached, the assessment shall be an essential input to the Infrastructure & Facilities Master Plan.

The Consultant shall develop a schedule of infrastructure projects to meet the anticipated fueling requirements commensurate with the increase in fueling requirements based on the fleet transition projections developed in Task 4: Fleet Assessment and the energy and demand projections developed in Task 5: Fuel Assessment. A narrative shall be developed with descriptions of how installations should be phased over time to meet the fleet needs. Topics include a build out schedule to develop infrastructure in phases and the equipment that would be needed at each phase. The schedule shall include cost estimates for each project to establish an annualized capital plan.

To support the transition to 100 percent ZEB operations, the Consultant must establish a planning basis which will help to identify the charging infrastructure needed for each of the phases understanding that the fleet composition will evolve over time and that diesel, diesel hybrids and/or clean diesel buses and ZEBs will be in service in some combination at each phase. This planning basis must specify the charging demand and available charging time for the buses at each phase of the fleet procurement plan. It is anticipated that the percentage of BEBs and/or FCEBs (and thus fueling requirements) will increase every year as diesel buses are replaced by zero emission buses. However, the consultant should consider strategies to build

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out sufficient capacity to meet several years of capacity requirements to minimize construction disruption at the depot.

Because transit bus operations are not typically planned in such level of detail for a long-term planning horizon (i.e. 12 years), assumptions to derive the forecast of charging infrastructure for each phase must be as realistic as possible to minimize over-sizing and avoid stranded assets.

Task 7: Project Deliverables:

1. *DASH Facilities Assessment, including*
 - a. *Schedule of Facility Planning & Design projects, including upcoming DASH Facility Expansion project, and any additional facilities or infrastructure necessary that may not be addressable at DASH's current location.*
 - b. *Schedule of Power Upgrade Projects*
 - c. *Schedule of infrastructure projects (i.e. gantries, pads, duct banks, etc.)*
 - d. *Schedule of charger and dispenser installation projects*
 - e. *Capital cost projections and schedule for all planning & design, power upgrade, infrastructure, and charger/dispenser projects and related equipment.*

Task 8: Total Cost of Ownership Assessment

The **Total Cost of Ownership Assessment** summarizes annualized capital and operating costs developed during the previous assessments over the transition period, including annual bus procurements; annual fuel cost; annual maintenance and mid-life overhaul costs; training costs; and costs of charging equipment, hydrogen fueling equipment, supporting infrastructure, facility upgrades, and design, construction and installation over the ZEB transition timeline. A TCO shall be created for the baseline as well as each alternative ZEB scenario in order to provide a comparison of the incremental TCO.

Task 8: Project Deliverables:

1. *Total Cost of Ownership Assessment, including*
 - a. *Comparative cumulative schedule of annual capital and operating costs.*

Task 9: ZEB Transition Plan

The **ZEB Transition Plan** is the final result of the previous assessments. The DASH ZEB Transition plan shall be based on DASH's current fleet replacement schedule to project the timing and costs related to future ZEB procurements, facility upgrades, installation of charging/fueling equipment, and related operating and maintenance costs. It will also take into consideration any additional requirements or commitments made based on established funding sources or strategic planning activity (i.e., Alexandria Transit Vision & Transit Development Plans, EAP2040, etc.).

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We anticipate the DASH ZEB Transition Plan shall be a “living” document. The technology supporting zero emission buses, charging equipment, and charge management software is rapidly changing and we expect it to continue to improve over time. The Plan that is developed as part of this project will reflect the current state of the technology and related costs. The plan shall be designed to allow DASH to periodically update the ZEB Transition Plan to reflect the latest developments throughout the transition period. DASH shall consider updating the transition plan every two to three years to ensure the plan considers the impacts of new and developing technologies.

Task 9: Project Deliverables:

1. *DASH ZEB Transition Plan Final Report*

Task 10: ZEB Market Analysis (Optional)

As an option, DASH may desire a Market Analysis from their consultant. The purpose of the market analysis is to educate DASH staff and stakeholders on the latest developments in ZEB and fueling equipment technologies, as well as an understanding of the vendors delivering ZEBs and equipment to the market. DASH may consider periodic updates to the analysis to coincide with periodic updates to their ZEB Transition Plan.

The consultant shall analyze ZEB vendors and develop a summary of technical specifications of each ZEB model offered, as well as a narrative on projected improvements to efficiency and range. The consultant must provide an update on the status Altoona testing for each bus model.

The Consultant shall analyze the types of charger endpoint equipment and technologies available today or that are under development for near-term adoption, including plug-in, overhead, and in-ground technology. This analysis should include operational limitations, construction challenges, and costs for each charging technology mode.

The Consultant shall summarize the current status and anticipated future developments in charging standardization, and how it would impact the development of a depot infrastructure project today and at various phases of implementation. Specific attention should be given to how this would align with DASH’s fleet replacement schedule. The Consultant shall explore the different type of electric bus chargers that are on the market or will be coming to market. This includes the charger configuration, footprint, standardization, and compatibility with different bus types that DASH has or will have in the fleet as well as compatibility with DASH’s existing technology for facility and asset management.

The market analysis shall consider the vehicles being purchased in terms of battery capacity, the manufacturer’s recommended charger type and specifications, and anticipated changes in battery and charging technologies at various timeframes including two, five, ten, and 12 years into the future in accordance with planned procurement/replacement dates on the fleet plan.

The analysis shall include the following components:

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1. Based on DASH's procurement strategy, the Consultant will contact approved or preferred ZEB providers to obtain specifications of currently available ZEBs (nominal range, charge rates, projected efficiencies, etc.). The Consultant shall obtain information from approved or preferred ZEB manufacturers on their current and future charging interface and interoperability with the preferred ZEB types. The Consultant shall provide current and future analyses of interface between ZEB manufacturers and charging equipment manufacturers. The recommendations shall support infrastructure build-out that still allows for interchangeability between ZEBs and charging equipment.
2. The Consultant shall use data obtained from charging equipment manufacturers to create a table that will include technical specifications and capabilities, operational limitations, compatibility limitations, key warranty information, product costs, anticipated near- term or long-term advancements, interface with DASH's existing transit technologies, and other pertinent information including feasibility or non-feasibility within the space constraints of the DASH property. This formalized technical summary of charging equipment shall include specifications, costs, and data sheets that shall be used to inform analysis of infrastructure needs and charger optimization.
3. The Consultant shall identify construction challenges, limitations, or impediments, and the installed cost constraints of each charging equipment configuration assessed. This will include an assessment of the charging equipment's suitability for overhead or underground installations whether supported by lattice support structures, overhead masts, underground conduit runs, or by other means.
4. The Consultant shall meet with DASH staff who maintain and service vehicles and facility maintenance staff to help establish a baseline and for input regarding their subject matter expertise to identify staff procurement and training needs and requirements for successful implementation and maintenance of the ZEB charging/fueling infrastructure at each phase of its implementation. The consultant will identify differences in procurement and training needs based on the analysis of various zero emission bus manufacturers and charging equipment providers.

Task 10: Project Deliverables:

1. *Market Analysis Report summarizing the current state of ZEB and charging technology*
2. *A workshop with DASH staff that provides Consultant with an understanding of existing conditions regarding daily fueling system operations and an understanding of staff resources, needs, and concerns regarding implementation and maintenance of the ZEB charging/fueling infrastructure at each phase*

3 Infrastructure & Facilities Master Plan

The ZEB Transition Plan shall provide DASH with several ZEB transition alternatives to consider, a proposed timeline for the transition, and high-level cost estimates. Once a transition path is selected, the next step is to conduct a lower level of analysis and develop an Infrastructure & Facilities Master Plan.

Due to the complexity of building the required infrastructure to transition an entire fleet to zero emission technology over period of time, CTE recommends a phased approach to minimize technology risk and operational disruptions. The master plan describes the phasing strategy to upgrade facilities and add the ZEB infrastructure needed to fuel and maintain ZEBs at the time they are needed. It identifies a workplan for a series of projects that will provide near term ZEB fueling capacity and allow for transit fleet operations to continue uninterrupted.

Key activities of an Infrastructure & Facilities Master Plan master planning effort include the following items:

- Review existing electrical service, on-site electrical infrastructure, and underground or overhead utilities at the agency.
- Identify the types of high-voltage equipment needed on property to support different phases of ZEB roll-out
- Develop information on footprint, costs, and other constraints.
- Identify any changes that may be necessary to current on-site infrastructure and identifying any electrical capacity bottlenecks that may be encountered.
- Build a preliminary, future-state conceptual electrical infrastructure plan that identifies the footprint of charging equipment, electric grid infrastructure, and any on-site renewable or conventional generation or storage integration and controllability, including a layout for electrical infrastructure such as wire, conduit, and electric transformation or controlling equipment for overhead and underground options.
- Develop a budgetary cost estimate to support future-state conceptual infrastructure plans at each depot.

DASH should expect that the procurement of master planning services to take 3-4 months with the completion of a master plan within 4-6 months from Notice to Proceed. Qualified vendors are likely to be architectural & engineering firms with specific experience with transit depot operations and large-scale, high power charging and electrical infrastructure design, permitting, construction, installation, and commissioning experience. The evaluation and implementation plan for the electric infrastructure required for an all-electric fleet can be broken into six tasks, described in the following sections. CTE recommends that requests for a proposal for any entity (“Consultant”) performing this work should include the following items.

Task 1: Work Plan and Schedule

First, a Work Plan should be developed to manage the project and accomplish its goals and objectives. The Work Plan should include an organizational chart with staff roles and responsibilities and an action item matrix with a task list and corresponding action plans. The

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Consultant should also prepare a schedule that includes all activities, start dates, critical path items, estimated activity durations, and relationships among tasks.

The Consultant shall convene an in-person kick-off meeting with the DASH/City of Alexandria to review and discuss the Work Plan and Schedule described above. At this meeting, DASH and the Consultant will discuss expectations, confirm requirements, and identify key milestone dates. The finalized Work Plan and Schedule will ensure understanding of expectations, in accordance with the scope of services, between the Consultant and DASH.

The Consultant's project manager, and requisite consultant staff, shall conduct conference calls twice per month (with additional calls if needed) with DASH staff throughout the duration of the project to provide progress updates, identify critical issues, and identify an action plan for any schedule changes.

Task 1 Project Deliverables:

1. *Initial Work Plan and Schedule*
2. *In-person kick-off meeting conducted at DASH offices*
3. *Memo identifying critical information and near-term changes that may impact the analysis*
4. *Conference calls at least twice per month*
5. *Introductory presentation to DASH project team, city staff and/or sponsor(s)*
6. *Final Work Plan and Schedule, including goals, and objectives identified*

Task 2: Phased Analysis of Infrastructure and Equipment Needs

DASH plans to grow its electric fleet incrementally to support its 2030 vision (detailed in the Alexandria Transit Vision). This means that the infrastructure will need to grow incrementally as well, without creating stranded assets or necessitating re-work. This task will determine how much infrastructure DASH will need as the BEB fleet grows. This includes identifying the number and sizes of transformers, sizes and number of vaults and/or substation, bus parking changes, and other infrastructure needs. This assessment shall be based on the results of the ZEB Transition Plan that shall provide estimates for daily energy and demand requirements, number of chargers, and charge rate. The ZEB Transition Plan shall also establish the schedule for when charging equipment must be available, which shall drive the phasing plan for equipment installation. The task shall include an analysis of the space required for the equipment and the location of the equipment in the context of existing locations (or propose additional needs outside the footprint of current locations), the staffing required to support installations and maintain the equipment, and how bus parking would be affected.

- A. The Consultant will report on the types of high-voltage equipment needed on property to support different phases of charger rollout. This study will include information on footprint, costs, and other constraints. Topics shall include any changes that may be necessary to current onsite infrastructure and identifying any electrical capacity bottlenecks that may be encountered.

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Specifically, the Consultant shall review existing electrical service, on-site electrical infrastructure, and underground or overhead utilities at the DASH facility including already installed charging equipment and infrastructure required to support bus charging. This will include a review of the low-voltage and medium- voltage infrastructure and a baseline of the existing electrical loads at the DASH facility. The Consultant shall document findings and identify potential areas of concern such as equipment with electrical capacity constraints, inadequately sized conductors, or potentially problematic interface points with various electrical infrastructure components.

Sub-task Deliverables:

1. *Familiarity with existing infrastructure and charging deployments and identification of potential constraints. These shall be incorporated into the Task 2 deliverables described below.*
- B. The Consultant shall design a preliminary, future-state conceptual electrical infrastructure plan that identifies the footprint of charging equipment, electric grid infrastructure, and any on-site renewable or conventional generation or storage integration and controllability. Consultant shall develop a conceptual layout of electrical infrastructure such as wire, conduit, and equipment for overhead and underground options.

The Consultant shall develop a budgetary cost estimate to support future-state infrastructure plans at each depot. The Consultant shall document potential deployment constraints identified while laying out the future state, conceptual electrical infrastructure plans. These preliminary electrification infrastructure plans will help inform the incremental deployment and help to identify full-scale deployment constraints.

Sub-task Deliverables:

1. *Preliminary electrification infrastructure plans that will inform incremental deployment and identify full-scale deployment constraints. The plans shall include a title sheet, general notes, details, and a site electrical plan at 1:40 (or other acceptable scale). The plan sheets shall be submitted with a Narrative (technical memo)*
- C. The Consultant shall, utilizing forecasted infrastructure needs and fleet deployment plans, develop a conceptual, future state electrical infrastructure plan that aligns with DASH's recommended deployment strategy. This will integrate the bus yard layout analysis that best minimizes impacts to facility operations and identify points of interface that allow for the incremental build-out.

Sub-task Deliverables:

1. *Future state electrical infrastructure plan*
- D. The Consultant shall develop a conceptual, incremental build-out of electrical infrastructure required to support ZEB transition and evaluate and iterate conceptual plan as needed to find

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an incremental build-out that best aligns with fleet procurement plan and minimizes depot operational impacts. This plan will be based on the recommended charging equipment strategy identified in Task 2.

Sub-task Deliverables:

1. *Step-by-step plan to deploy necessary infrastructure to support ZEB transition.*

- E. The Consultant shall prepare budgetary cost estimates, footprint, and operational impacts based on incremental build-out of electrical infrastructure.

Sub-task Deliverables:

1. *Budgetary cost estimate of incremental electrical infrastructure build-out.*

- F. The Consultant, in coordination with DASH staff, shall provide an assessment of whether DASH has the appropriate level of staffing resources to maintain the ZEB charging/fueling infrastructure, including technology support for any smart charging proposals submitted.

Sub-task Deliverables:

1. *Recommendations for internal staff augmentation that may be require for each phase of execution and for subsequent maintenance of the installed infrastructure.*

Task 2 Project Deliverables:

1. *Report detailing actions, findings, and analysis from the topics and sub-task deliverables set forth in the above sub-tasks' descriptions and deliverables.*
2. *Preliminary engineering and construction budgets for all phases.*
3. *Preliminary schedule for all the phases understanding the lead-time of the DASH for procurement of each phase.*
4. *Potential long-lead items and associated time impact matrix.*
5. *Implementation Plan ("roadmap") that outlines budgetary cost and required steps and staffing to incrementally build-out electrical infrastructure to support transition to ZEBs.*
6. *Presentation slides in PowerPoint format to communicate the contents of the Task 2 Memo.*

Task 3: Evaluation of Utility Grid Infrastructure and Sufficiency

This task will examine the relevant utility grid infrastructure to determine if it will be sufficient for DASH's needs as the operation grows. For this task, "grid infrastructure" is defined as any electrical equipment not sited on DASH property.

- A. The Consultant shall provide an overview of the utility grid, including the different components of the grid infrastructure, and how they intermesh to provide electricity to the DASH campus. This shall include a detailed analysis of the local electric distribution grid infrastructure serving DASH must be coordinated with the local electric distribution utility, Dominion Energy Virginia. Because information on the local distribution circuits and

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substation is not publicly available, there will need to be coordination with the utility to determine the available electrical capacity on the distribution circuits. The Consultant shall perform an initial assessment of the local grid infrastructure to identify potential areas of concern. The Consultant shall coordinate with the utility on behalf of the DASH and provide them with the forecasted load growth to support the transition to ZEBs so they can analyze impacts to the local electrical distribution grid, including identifying potential redundancies to ensure that buses can be charged in event there is disruption of electricity supply, and work with the utility to understand grid reliability implications and communicate those findings to DASH.

The Consultant shall review and provide input on any electric distribution system upgrades proposed by the utility to serve the incremental load at the DASH facility and identify any potential electric utility EV infrastructure incentive programs that may be utilized to deploy electrical infrastructure to support DASH's transition to ZEBs. In addition, the Consultant shall assess any impacts that the timing of proposed utility upgrades may have on the ZEB transition plan and recommend updates to the plan as needed. Once the utility finalizes the proposed distribution system upgrades, the Consultant shall review the proposed system costs and cost-sharing arrangements to maximize the benefits received by DASH.

Sub-task Deliverables:

1. *Identification of local utility's distribution grid infrastructure serving the DASH Maintenance/Operations facility.*
 2. *High-level overview of the local grid infrastructure serving DASH's facility. This will include identification of the local distribution circuit and local distribution substation using publicly available data.*
 3. *Summary of electrical infrastructure upgrades and a recommendation on the distribution system upgrades, cost sharing, and electric rates.*
- B. The Consultant shall identify any medium- and heavy-duty vehicle infrastructure programs proposed by the utility that may benefit DASH and work with the utility on implementation strategies that maximize the benefits received by DASH. This will include aligning DASH's infrastructure and charging equipment needs to support ZEB deployment with the local utility's available funding for such infrastructure.

Sub-task Deliverables:

1. *Summary of available programs including opportunities for DASH to engage with the utility.*
- C. The Consultant shall review the utility's proposed distribution system costs and cost-sharing arrangements based on utility ordinances and/or line extension policies and make recommendations to DASH. The Consultant shall review information provided by the utility and recommend which electric rate tariff is optimal based on load, peak- and off-peak rates, voltage, and required infrastructure.

Sub-task Deliverables:

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1. *Technical Report and PowerPoint presentation summarizing the utility proposal with recommendations on utility distribution upgrades, cost sharing, and electric rates.*

D. The Consultant shall act as the liaison between the utility and DASH for this project to identify the specific distribution circuits, substations, and transmission lines anticipated to serve DASH's facility. This will include meeting with the utility with DASH/City of Alexandria and on behalf of DASH to discuss the fleet electrification plans and the electrification timeframe. The Consultant shall provide the utility with forecasted load growth based on DASH's fleet electrification deployment plan and the analysis in Task 2.

Sub-task Deliverables:

1. *Provide utility with forecasted load growth and coordinate with the utility during their distribution analysis and planning process.*

E. The Consultant shall review and provide input on distribution system upgrades proposed by the utility to serve incremental loads at DASH. The Consultant shall review the scope of work and costs for reasonableness as well as potential options offered by the utility to serve the incremental electrical load. As appropriate, the Consultant shall recommend best option(s) to DASH based on timing, cost, power quality, and reliability.

Sub-task Deliverables:

1. *Presentation summarizing utility options along with costs and phasing along with best fit recommendation for client.*

F. As the size of the electric bus fleet and on-site charging infrastructure grows, there will be greater and greater demands placed on the electrical grid. The Consultant will analyze the existing grid to determine if any capacity constraints may arise, where the problem will be, and when the capacity will be reached. Working with the local utility, the Consultant will identify electric grid pinch points or bottlenecks that may impact DASH's ability to achieve its ZEB transition. As allowed by the utility, the Consultant will identify when the limitation(s) will occur, where the limitation(s) will occur, what the limitation(s) are, and if there are any opportunities for DASH to resolve these limitations outside the utility's purview.

Sub-task Deliverables:

1. *Identification and assessment of potential pinch points on the local electrical grid.*

Task 3 Project Deliverables:

1. *Memo detailing actions, findings, and analysis from the topics and Sub-task deliverables set forth above.*
2. *Identification of the utility programs or grant opportunities for infrastructure as identified in the plan.*
3. *Presentation slides in PowerPoint format to communicate the contents of the Memo.*

Task 4: Charger Location and Phased Yard and Layout Analysis

The Consultant will consider the impact of charging infrastructure on the operations of the DASH bus facility. Electric infrastructure has the potential to reduce the number of available parking spaces and interfere with the flow of buses around the facility. Some charger layouts may be incompatible with facility policies, such as a policy that limits the extent to which a bus can back up.

The consultant will work to understand the different charger layouts that can be implemented for an all-electric fleet, and how those layouts might impact parking and operations. This should be done in consultation with resources that conduct bus flow analysis, including parking, turning radius, and similar concerns.

The Consultant shall also consider the infrastructure that is currently planned as part of DASH's pilot ZEB deployment project that include six depot-charged battery electric buses.

- A. **ZEB Infrastructure Phasing:** Based on DASH's ZEB Transition Plan, the Consultant shall develop options for phased installations over time to meet the fleet needs as the fleet composition changes when battery-electric buses are procured and diesel/hybrid/clean diesel buses are retired, understanding that the fleet will continue to contain hybrids and/or clean diesel buses until approximately 2030 as the buses complete their useful lifespan. Topics include how much parking will be lost in different depot layout options for different phases of fleet composition, e.g. 10% electric, 25% electric, 50% electric, etc., and how the capacity of the facility (in terms of number of buses of various propulsion types) will change over time. Additional topics include if any extra yard space will be required, and if so, how much.
- B. **Facilities Assessment:** The Consultant will perform a detailed analysis and assessment of the existing facility, DASH's policies and procedures, and bus pull-out/pull-in procedures to identify any operational or procedural concerns that may impact the transition to ZEBs. This will include an assessment of the available yard space that can support any charging equipment, electrical grid infrastructure, and renewable power infrastructure. Consultant will develop a preliminary, future-state model of the facility and identify operational concerns at the facility.
- C. **Interim Parking & Movement Plan:** The Consultant shall develop a facility navigation and parking plan in conjunction with phases of construction. This plan will anticipate how parking will shift to different areas and how vehicles will travel throughout the yard during each project for the duration of the transition plan.
- D. **Final Parking & Movement Plan:** This analysis will present different options for the final layout of an all-electric depot, including impacts on bus flow and turn radius, along with the reduction in parking and strategies to mitigate this. Topics include how much parking will be lost in different depot layout options, and how the capacity of the yard (in terms of number of buses) will change. Additional topics include if any extra facility space will be required, and if so, how much.

Task 4 Project Deliverables:

1. *Memo detailing actions, findings, and analysis from the topics set forth above.*
2. *Presentation slides in PowerPoint format to communicate the contents of the Memo.*

Task 5: Renewable Energy Analysis

There are several benefits to augmenting the grid-supplied energy with on-site renewable energy generation and on-site energy storage. These benefits include peak demand shaving, redundant power supply, and further reduction to the agency's carbon footprint. Task 5 is focused on examining costs and benefits of alternative on-site renewable energy generation and storage strategies.

- A. **Survey of Renewable Options:** The Consultant shall identify different strategies for utilizing on-site renewable power and energy storage, along with the costs and benefits of each.
- B. **Renewables Implementation Action Plan:** The Consultant shall outline key steps and strategies for implementing on-site renewables and energy storage..

Task 5 Project Deliverables:

1. *Memo detailing actions, findings, and analysis from the topics set forth above*
2. *Presentation slides in PowerPoint format to communicate the contents of the Memo.*

Task 6: Final Report and Presentation

Based on findings from Task 1 through Task 5, the Consultant will prepare a comprehensive infrastructure planning report. The final report shall include an executive summary and the main body of the report shall be organized in a logical manner which includes all aforementioned tasks and deliverables, and also takes into consideration other findings, assessments, evaluations, conclusions, and strategies uncovered over the course of this project.

The Consultant shall provide a draft of this final report for DASH's review and revise according to the feedback received. The Consultant shall bind, print, and distribute 10 hard copies of the final report to DASH, as well as provide an electronic PDF copy.

The Consultant shall also present and discuss the contents of its final report to City of Alexandria's designated staff and, if needed, the City Council.

Task 6 Project Deliverables:

1. *Draft and final report as described above (10 hard copies and an electronic PDF copy).*
2. *Presentation slides in PowerPoint format to communicate the contents of the final report.*
3. *Participate in an on-site meeting with City of Alexandria staff to review and discuss the final report.*

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4. *Present the final report of findings and recommendations at a Board Meeting or City Council meeting if needed.*

4 ZEB Pilot Deployments

As a complement to, and in direct support of its overall transition plan, an agency will typically purchase and deploy a small number of ZEBs and supporting infrastructure to develop staff experience with the new technology. DASH has initiated a pilot program to purchase and deploy six battery electric buses and supporting depot plug-in charging infrastructure. As part of this program, DASH will purchase three Proterra and three New Flyer BEBs with the goal of conducting an in-service performance evaluation and comparison of each vendor's product.

Key elements of a ZEB Pilot program include:

- Requirements Analysis: route, charge, and rate modeling to define project scope and specifications
- Bus Procurement and Build: Issue RFP, evaluate, select, and procure buses; monitor build, conduct inspections
- Infrastructure Procurement, Design and Build: Issue RFP, evaluate, select, and procure charging equipment and A&E and construction services
- Bus and Infrastructure Deployment: Receive, inspect, and commission buses and charges; test & validate buses; deploy into revenue service
- Deployment Validation: Monitor operations, collect data, and report on key performance indicators

Detailed tasks are as follows:

1. Project Planning and Initiation

This phase includes detailed project planning to finalize the scope, approach, tasks, assignments and timeline.

2. Requirements Analysis

This phase includes modeling the Transit Agency's route(s) to predict the performance of the bus on the selected route(s). The results of the modeling will determine if any changes are required to the bus specifications, routes, or passenger service schedules in order to optimize bus operations and operating costs. The Requirements Analysis shall also include an assessment of energy requirements, charging profiles, utility rate modeling, and annual fuel costs.

3. Bus Procurement and Build

Bus and charger specifications and other documents required for bus procurement are finalized during this phase. The Transit Agency will follow typical procurement and build activities, including contract execution, design approval, pre-production meetings, and

arrangements to monitor and inspect the buses. There are unique qualities associated with the technology that need to be addressed and followed during the procurement and build.

4. *Infrastructure Procurement, Design and Build*

Battery-Electric Bus (BEB) Deployments: If not included with the bus contract, the Transit Agency will be required to specify and purchase charging equipment. This phase includes finalizing site plans for the on-route and/or depot charging stations. The project team should also meet with the utility to review charging requirements and site plans to ensure there are no issues with meeting power requirements. The Transit Agency will issue an RFP or IFB for site engineering (including civil, electrical, and mechanical), permitting, construction, and equipment installation, as needed. Equipment commissioning is the final step.

Fuel Cell Electric Bus (FCEB) Deployments: The Transit Agency will be required to secure hydrogen production, storage, and a dispensing station if fueling is not already available. In addition, the Transit Agency will need to contract for engineering services to design and manage facility upgrades for the maintenance and storage of fuel cell buses as well as develop site and installation plans for the station and obtain all necessary permits. The Transit Agency and selected fuel supplier will obtain the services of one or more contractors to execute all civil, electrical, and mechanical designs for the station and maintenance facilities. Once the site preparation for the station is completed, the fuel system supplier will install and commission the equipment.

5. *Bus and Infrastructure Deployment*

As with Phase 3 Bus Procurement and Build, the activities undertaken under this phase are familiar to the Transit Agency. However, the unique characteristics of the technology are taken into consideration. For example, the bus manufacturer will need to commission the buses with the charging equipment or hydrogen fueling equipment. The Transit Agency's staff also receives training to operate and maintain the buses and fueling equipment during this phase. A Transit Agency may also choose to conduct a Full Service Validation prior to placing the bus in revenue service.

6. *Deployment Validation*

This phase focuses on validating the operational performance and realized benefits (i.e., actual energy savings, cost savings, and greenhouse gas emissions reductions) resulting from deployment of zero-emission buses into passenger service.

7. *Project Close-out*

After the data collection period is over, a final report summarizing project results, findings, and lessons learned will be issued and the Transit Agency will close out the project.