Stantec

Fleet Fit Trade-Off Considerations

Trade-off/criteria	Option A (100% FCEBs)	Option B (blended fleet inclusive of 61% FCEBs, 15% depot-only charging BEBs, and 24% depot+on-route charging BEBs)	Notes/comments
Scheduling and planning	• Requires scheduling consideration for FCEB **average** range of ~280 mi (37.5 kg tank) and 365 mi (50 kg tank) • FCEBs offer greatest flexibility for detours and other unplanned/planned service changes and road calls/changeouts • Two to three buses with FCEBs (50 kg tanks) may require midday refueling (depending on operating conditions) to complete service as currently blocked/scheduled • One block will need redesigning • Smaller battery pack in FCEBs experience less degradation than BEBs so that operating range decreases are less significant over time, making service planning more consistent and with fewer variables to consider ★★★	• Requires scheduling consideration for FCEB **average** range of ~280 mi (37.5 kg tank) and 365 mi (50 kg tank) • Requires scheduling consideration for BEB (400+ kWh battery models) **average** range of ~160-180 mi • Requires consideration of mixed fleet to ensure that appropriate units are scheduled for appropriate blocks/services • Two to three buses with FCEBs (50 kg tanks) may require midday refueling (depending on operating conditions) to complete service as currently blocked/scheduled • One block will need redesigning • Smaller battery pack in FCEBs experience less degradation than BEBs so that operating range decreases are less significant over time • Degradation of BEB batteries can significantly decrease the operating range over time, adding complexity to service redesign ★★☆	• FCEB range most closely approximates to current CNG range • FCEB most closely resembles current CNG "business as usual" scenario at OCTA • Leverages OCTA's experience with FCEBs • Option A presents the simplest scheduling considerations and minimizes reblocking • Bravo service would require particular attention if Bravo-branded buses are of only one type of technology and this would increase the bus variants required in Option B (2 service types, OCBus and Bravo, x3 technologies, vs. 2 service types and x1 technology in Option A)
Operations and dispatching	• All units can be dispatched for nearly any service or block • Dispatch will have greater flexibility to assign units to blocks because of comparable ranges across vehicles, which will maintain a comparable yearly mileage among FCEBs • Refueling hydrogen on FCEBs can be completed during a 7-hr refueling window as currently done for CNG buses (hydrogen fueling station equipment designed to fill FCEBs in under 10 minutes, as per peer agency experience) • Fueling, cleaning, and maintenance and other service cycle functions would require minimal changes for FCEBs	• Dispatch (and maintenance) will need to consider and manage two technologies when buses leave and return to the garages, as well as different ranges to ensure units are dispatched as scheduled to the correct blocks • Bus assignment between blocks will be limited due to driving range of BEBs, resulting in fewer accumulated yearly mileage than FCEBs • Fueling, cleaning, maintenance and other service cycle functions will require modification for BEBs • Parking and charging times for BEBs needs to be closely monitored to ensure a full state of charge and free dispatching for the next service day	• Having the fewest variants or types of bus technologies is preferable especially given OCTA's multiple service types • Operations and dispatching of FCEBs will be closer to OCTA's business as usual and comparable to operations of CNG buses • Leverages operations' and dispatching's experience with FCEBs • Managing charging of BEBs adds to the operational activities of OCTA's staff and would likely result in additional personnel and shift modifications

ATTACHMENT B

Trade-off/criteria	Option A (100% FCEBs)	Option B (blended fleet inclusive of 61% FCEBs, 15% depot-only charging BEBs, and 24% depot+on-route charging BEBs)	Notes/comments
	★★★	• Recharging BEBs can take between two and six hours and will likely require swapping dispensers' connections to buses overnight or smart charging software to manage charge remotely • Refueling hydrogen on FCEBs can be completed during a 7-hr refueling window as currently done for CNG buses (hydrogen fueling station equipment designed to fill FCEBs in under 10 minutes, as per peer agency and OCTA experience) • Fueling, cleaning, and maintenance and other service cycle functions would require minimal to no change for changes for FCEBs ★★☆	
Training and agency-wide adoption	• Requires training for operators, mechanics, schedulers, etc. for FCEBs ★★★	• Requires training for operators, mechanics, schedulers, etc. for BEBs • Requires training for operators, mechanics, schedulers, etc. for FCEBs ★★☆	• Option A presents a less steep learning curve than Option B because it recommends one technology type rather than two • Option A leverages existing in-house expertise and experience with FCEBs
Technology availability/OEMs /procurement	• Fewer FCEB OEMs at present • Procurement would require one procurement contract/process • Requires one set of spare parts, tools, etc. for FCEBs ★★☆	• More BEB OEMs • Fewer FCEB OEMs at present • Procurement would require two separate procurements contracts • Requires two sets of spare parts, tools, etc. for BEBs and FCEBs ★★☆	• Option A relies on FCEBs solely, and there are fewer OEMs available than for BEBs • Option A would require fewer tools and spare parts than Option B
Service area-specific considerations	• OCTA has a relatively compact service area (435 sq. mi.) with hills and several routes with cruising (i.e., freeway-type) portions • FCEBs provide flexibility to short and long routes, but special planning for hilly routes	• OCTA has relatively compact service area (435 sq. mi.) with hills and several routes with cruising (i.e., freeway-type) portions • FCEBs provide flexibility to short and long routes, but special planning for hilly routes	• Option A provides the most flexibility for all OCTA services • Option B requires coordination for on-route charging infrastructure with different jurisdictions in Orange County

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	★★★	• BEBs could provide better fuel economy on stop-and-go (urban) services • Installation of on-route chargers require permitting and buy-in from project jurisdiction ★★☆	
Total cost of ownership	• Estimated TCO is $2.05 per mile (per bus) over 18 years ★★★	• Estimated TCO at $2.07 per mile (per bus) over 18 years ★★⯪	• Hydrogen infrastructure becomes comparable to BEBs in cost with unit discount for large purchases • TCO estimates include capital investment for infrastructure and bus acquisition, operational considerations like maintenance and fuel cost, and mid-life battery or FC replacement. The TCO per mile for Option B is 1% lower than for Option A. • Initial upfront capital cost of Option B is 9% lower than Option A • From an O&M life cycle perspective, Option B is 12% more expensive overall relative to Option A.
Other	• Power resiliency requires diesel or CNG generator for FCEB fueling infrastructure • Deviation from modeled fuel efficiency of FCEBs can be mitigated by additional refueling during the day either at an OCTA garage or by arranging fueling contracts with public hydrogen stations currently expanding across California ★★★	• Power resiliency requires diesel or CNG generator for BEB and FCEB fueling infrastructure • Range requirements could be accommodated by midday fueling of FCEBs with municipal or shared infrastructure • Range requirements for BEBs would require in-depot charging for several hours, either during the day or overnight • Deviation from the modeled fuel efficiency when operating buses under real operations can be disruptive for BEBs and could represent adding additional buses to complete service ★★☆	

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Overall fit for OCTA