Procurement Strategies for Reducing Capital Costs of Zero-Emission Buses

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Executive Summary

One of the challenges to deployment and commercialization of zero-emission buses is the high capital cost of the vehicles relative to vehicles powered using conventional technologies. A strategy for reducing these costs is to increase sales volume, which has been successfully driven through funding opportunities like the Federal Transit Administration's Low or No Emission Vehicle Program. Another strategy for increasing sales volume is to combine vehicle purchases from multiple transit agencies through a joint procurement. There have been extensive exercises in Europe to decrease the cost of fuel cell electric buses using a joint procurement strategy, with some level of success. This paper explores the current landscape for procuring zero-emission buses and evaluates whether a joint procurement strategy could be an effective way to decrease vehicle costs in the North American market.

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Abbreviations

APTA	American Public Transportation Association
BEB	Battery Electric Bus
CTE	Center for Transportation and the Environment
DERA	Diesel Emissions Reduction Act
FCEB	Fuel Cell Electric Bus
FTA	Federal Transit Administration
JIVE	Joint Initiative for hydrogen Vehicles across Europe
HVAC	Heating, Ventilation, and Air Conditioning
ITS	Intelligent Transportation System
MHCOE	Midwest Hydrogen Center of Excellence
OEM	Original Equipment Manufacturer
P3	Public-Private Partnership
RFP	Request for Proposals
ZEB (BEB and FCEB)	Zero Emission Bus

Introduction

As concerns about air quality and the climate impacts of burning fossil fuels continue to rise, zero-emission transportation technologies are of great interest to transit agencies. As with any new market or evolving technology, capital costs can be a barrier to commercialization. Transit agencies looking to procure zero-emission buses (ZEBs) currently face high capital costs, which create a significant barrier to widespread adoption without assistance from governments.

This paper focuses on the challenges of procuring ZEBs and explores the effectiveness of a joint procurement strategy as a method of increasing sales volumes for ZEBs and thus reducing the price of the vehicles. There are a number of different strategies for reducing zero-emission vehicle costs, and one of the more effective ones is increasing sales volumes. The joint procurement strategy has been tried in Europe through the JIVE and JIVE2 programs. This paper assesses the joint procurement strategy within the context of the North American transit market and provides information on other relevant procurement strategies for increasing sales volumes to bring down costs.

Initial sections provide an overview of the current procurement landscape and potential opportunities to drive down costs of ZEBs for further deployments and commercialization. Strategies include education on vehicle specifications for ZEBs, and the impacts that warranties and training have on transit agencies adding these vehicles into their fleets.

For a transit agency, procuring buses is a significant effort, from developing technical specifications for the vehicles to drafting and releasing a Request for Proposals (RFP) to the selection of a vendor and contract negotiation process. Agencies will sometimes partner with each other to conduct a joint procurement, with one goal being to increase sales volume and decrease the purchase price of a vehicle.

Traditional procurement processes also pose challenges for ZEB purchases that are unrelated to cost. In general, every bus order is unique since transit agencies customize their vehicles to be specific to their operations and aesthetics. When designing a bus for a new transit agency partner, an OEM must go through a rigorous configuration review and may need to do engineering work to meet the agency's requirements. This may make it difficult for agencies to partner with new OEMs.

Stakeholders interviewed for this report expressed the need for additional support and funding for infrastructure development for ZEBs. While some agencies have procured vehicles in combination with infrastructure, this approach introduces additional complexities that are outside of the scope of this paper. Since infrastructure is a complex topic worthy of its own paper, this paper focuses on ZEBs only.

Current Zero-Emission Bus Procurement Landscape

The policies and regulations for procurements in the United States are governed by overarching federal requirements, but individual states may have additional requirements and include differing timelines and processes. Federal regulations require that states follow their own policies and regulations (2 C.F.R. § 200.317), and non-state recipients and subrecipients use their own procurement policies and regulations that reflect their applicable state and local laws (2 C.F.R. § 200.318). If procurements are funded through FTA, such as ZEBs purchased using formula funds (5307 or 5311 funds) or through the Low or No Emission Vehicle (Low-No) program, those procurements must comply with applicable federal policies and regulations, which can affect third-party contracting.[1]

The state of Georgia's Department of Administrative Services breaks down the procurement process into seven steps, which is representative of the process followed by many transit agencies nationally:[2]

1. Need Identification
2. Pre-solicitation
3. Solicitation Preparation
4. Solicitation Process
5. Evaluation Process
6. Award Process
7. Contract Process

Current Challenges to Procurement Partnerships

The complexity of this process, combined with the need to follow state and local regulations and transit agencies' need to align their procurement with specific funding opportunities, can make it difficult for agencies to partner on a procurement.

Vehicle specifications present another challenge to partnering on procurement efforts. Because many agencies require custom bus specifications, one of the key aspects of procurement in both the United States and Canada is the vehicle specification. Many agencies base their current vehicle specifications on the American Public Transportation Association's (APTA) bus procurement guidelines, but the current version of that document does not include ZEBs. As a result, many agencies try to develop their own ZEB specifications. Some agencies may choose to use their standard specification for conventional buses and ask for an electric version of their current diesel, hybrid, or CNG bus. However, creating a zero-emission version of a vehicle involves changing more than the propulsion system, and this approach may require OEMs to submit multiple deviation requests when responding to an RFP.

Specific configurations are based on an agency's operations and desired aesthetics. For example, an agency may have a standard seat they use across all of their buses. Purchasing a vehicle with

[1] *FTA Procurement Best Practices Manual*
[2] GA DOA Procurement Process Site

a different seat has implications for the agency's spare parts inventory and could add operational and maintenance complexity. Some transit agencies may be willing to compromise on standardization within their fleet if there is an opportunity to deploy ZEBs that they would not otherwise have access to, but it is not an ideal situation .

ZEB Funding Opportunities

The timing of funding with respect to a procurement cycle is critical for transit agencies and is especially important for ZEBs. ZEBs can be almost twice as expensive as their diesel counterparts, although the total cost depends on the specific vehicle configuration.

Funding sources have been critical to deployment and data collection for the ZEB market in the United States. These sources have come from U.S. federal agencies, such as Department of Transportation (DOT), Department of Energy (DOE), Environmental Protection Agency (EPA), and state programs and a few local sources.

Multiple funding programs administered by the U.S. federal government aim to alleviate the capital costs of ZEBs. The Federal Transit Administration (FTA), under the purview of DOT, provides funding for capital expenditures, and recently due to the COVID-19 pandemic, funding for operating expenses, to support transit agencies in the United States. The Low or No Emissions grant program provides capital funds to purchase low-emission and zero-emission buses for operation. The Diesel Emission Reduction Act (DERA) program, through the U.S. EPA, provides funding for capital expenditures in efforts to reduce diesel emissions.

Each of the fifty states has the ability to provide its own funding programs based on priorities. Only a handful of states actively disperse funds to ZEB projects. These programs include voucher programs, similar to rebates, to purchase ZEBs. Examples of these programs are found in California, New York, and Chicago.

Another funding option, available until 2028, is the Volkswagen Settlement. As the result of a settlement that arose from claims against Volkswagen AG, each of the fifty states, the District of Columbia, Puerto Rico, and certain Native American tribes received a portion of a $2.7 billion trust to replace medium- and heavy-duty diesel vehicles—model year 2009 or older—with zero-emission vehicles. Each trustee jurisdiction has its own mitigation plan, detailing how the funds will be spent. These plans vary widely between jurisdictions, but a number of them include funding for ZEBs.

Grant application timelines for these federal and state funding opportunities are scattered throughout the year. Budget timelines vary by state, but the federal fiscal year is from October 1 to September 30. Transit agencies have to plan ahead with procurement to get accurate pricing, data needs, and infrastructure when applying for grant funds. Such planning also means identifying buses that may be at the end of their lifecycle while not jeopardizing the transit agency's ability to meet its operational needs.

To better commercialize ZEBs, coordination of bus replacement cycles with funding availability is important. This is acknowledged in some grant programs, as applications proposing to replace older buses may score higher than applications proposing to replace newer vehicles. However, the uncertainty of winning an award can create challenges for agencies needing to have finalized plans for bus replacements and future procurements.

Comparison to the European Transit Market

While this paper is aimed at North American transit agencies, it is instructive to reference the European transit bus market. There are approximately 91 FCEBs in operation in Europe and many more planned through various programs.[3]

European transit operators use a distinctly different business model than many North American transit agencies.[4] While North American transit agencies often own, operate, and maintain vehicles in-house, many European transit agencies contract out those services. They may contract with an operator to provide service along a specific route corridor. That operator must then purchase and provide the vehicles, drivers, and maintenance to meet that service requirement. The full capital cost of the zero-emission vehicle is therefore borne by a different entity than the transit agency, namely a specialized contractor, leaving the transit agency funding focused on infrastructure and planning.

In addition to differing business models, the transportation regulatory landscape in Europe is much different than in North America. Individual European countries have a lot of autonomy in how they manage transit operations. [5] At the same time, there is coordination across Europe to bring zero-emission technologies to market. Two of these programs can be instructive for evaluating joint procurement strategies. They are known as JIVE (Joint Initiative for Hydrogen Vehicles across Europe) and JIVE2 (Second Joint Initiative for Hydrogen Vehicles across Europe).

JIVE Program[6]

The JIVE and JIVE2 programs plan to deploy 300 fuel cell electric buses by the early 2020s. One of the main strategies employed in these programs is to form partnerships between groups of agencies and conduct joint procurements to increase sales volumes and drive down costs.

A 2018 report authored by Element Energy Limited summarized the state of the program at that time and the efficacy of the joint procurement strategy. The paper found that there is strong and growing demand for FCEBs, but there are still many challenges to meeting that demand. There need to be more OEMs participating in the market, as there are very few fully commercialized FCEBs available that meet operator's needs. The cost of purchasing a FCEB is still very high and

[3] *Cleaner Urban Transport with Hydrogen Buses*
[4] *A Bid for Better Transit*
[5] *Contracting Urban Public Transport*
[6] *Strategies for joint procurement of fuel cell buses*

provides a barrier to purchasing; many of the existing FCEBs were subsidized using government funds, and a transition to using traditional financing mechanisms needs to be made. However, this is not likely to be achieved until vehicle prices decrease. The JIVE and JIVE2 programs have attempted to employ joint procurement strategies in different regions of Europe to bring down these costs with varying levels of success.

The JIVE program was set up with five different geographic clusters, with each cluster coordinated by a third-party organization (Figure 1).

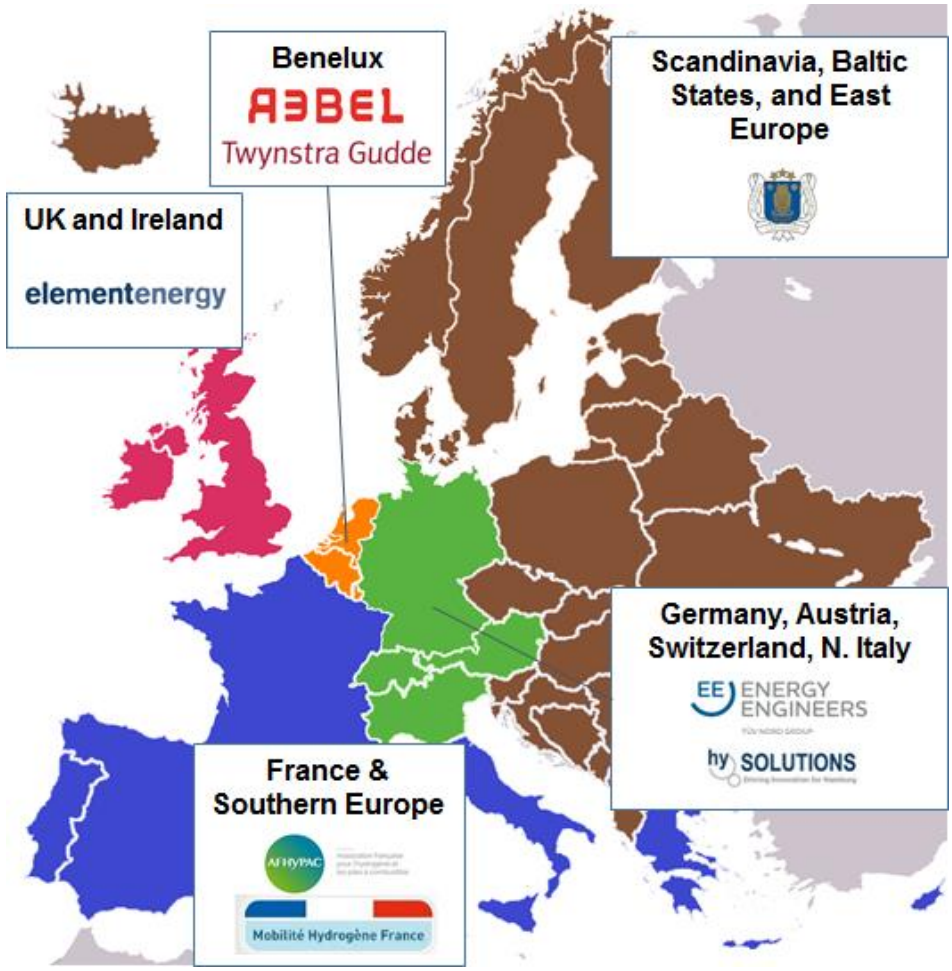

Figure 1. Geographic clusters of the JIVE program (Element Energy, 2018)

Two of the five clusters were able to move forward with joint procurement exercises, and they found that the strategy did seem to be decreasing costs. The Germany, Austria, Switzerland, and Northern Italy cluster released a joint procurement for FCEBs but ultimately found that the FCEB manufacturer market not mature enough to respond adequately. The cluster developed a specification suitable for multiple transit agencies and released a tender in 2017. This initial tender was canceled due to a lack of qualified OEMs. The team revised the requirements and re-released the tender. They still received limited responses, revealing that many bus manufacturers had not progressed their FCEB programs as far as their batter electric bus (BEB)

programs, and they could not respond to the solicitation. However, two agencies decided to move forward with negotiations with bus OEMs despite the desire for additional options, eventually ordering 40 buses[7].

The United Kingdom and Ireland cluster's procurement strategy resulted in a lead public authority (Transport for London) driving the procurement and negotiations with suppliers. The cluster planned to develop a framework that would allow multiple agencies or operators to buy FCEBs using that setup, similar to how a state purchasing contract may work in the United States.

The other three clusters were less successful in executing a joint procurement strategy. The Benelux cluster considered a joint procurement strategy either led by operators or transit authorities, but decided these may not be the most effective strategies to procure buses. Previous attempts to hold a joint procurement with operators in the Netherlands had been unsuccessful, and the participants questioned whether a joint procurement with agencies was the most effective way to coordinate a large purchase of FCEBs. As a result, they decided to pursue a Special Purpose Vehicle to procure FCEBs prior to exploring joint procurement. The Special Purpose Vehicle functions as a "Bus-as-a-Service" with one entity that purchases, maintains, and manages the buses. The Special Purpose Vehicle would purchase 50 buses, which would then be provided as a service to interested operators. The goal is to maximize vehicles purchased, obtain the best price, and distribute risks appropriately among all participants. As of 2018, the tender for the Special Purpose Vehicle had not been released. In 2019, twenty buses had been ordered for Groningen, indicating that there had been success in procuring FCEBs within the Benelux cluster, even if the goal of 50 buses purchased through the Special Purpose Vehicle had not been met.[8]

As of 2018, the French and Southern Europe cluster was still exploring the ability to conduct a joint procurement in that region. However, in 2019 five FCEBs were ordered in Toulouse and five in Auxerre, demonstrating continued interested in FCEBs.

The cluster comprised of Scandinavia, the Baltic States, and Eastern Europe determined that a joint procurement would not work in its region. The differences between the participants, ranging from legal frameworks to technical requirements, were too great.

As of the end of 2019, 12 buses had been delivered in Germany, and 35 were on order in the UK cluster under the JIVE program. [9] The program report also indicated that seven suppliers were able to meet the target price of €650,000 per standard-sized bus. This demonstrates progress toward increasing sales volume and decreasing cost of FCEBs, even if the total FCEB commitment does not yet meet the goals of the JIVE and JIVE2 programs. This report also highlights some of the challenges with joint procurement exercises, even as they seem to be a promising mechanism for increasing sales volume and decreasing vehicle price.

[7] *JIVE Best Practice and Commercialization Report 2*
[8] *Periodic Reporting for Period 2 – JIVE 2 (Joint Initiative for hydrogen Vehicles Across Europe 2)*
[9] *Periodic Reporting for Period 3 – JIVE Initiative for hydrogen Vehicles Across Europe*

Cost Factors Affecting ZEB Purchase Price

As technology for ZEBs rapidly evolves, OEMs face challenges that directly affect the costs to produce and sell ZEBs. These production costs ultimately show up in purchase prices. One challenge that OEMs face is the rapid pace at which vehicle specifications change. New suppliers are constantly entering the market, other suppliers discontinue products, and products are constantly changing. For example, fuel cells with higher power ratings are being introduced to the market, as are battery configurations with higher energy densities. Each of these changes results in new engineering that the OEM must do to provide the end-product requested by a customer. It can be difficult for an OEM to amortize those design costs without an order for a large number of vehicles.

Technology Changes

Another challenge arises from balancing recent decreases in battery costs with improvements to battery performance. The market for batteries for transportation applications has grown enormously, leading to increases in battery energy density and reductions in the cost per kilowatt-hour, or cost per unit of energy, provided by the battery. As the costs go down and density goes up, OEMs are more able to respond to operators' demands for more energy onboard the buses to increase vehicle range. This trend of increasing energy density on the vehicles is important from a procurement perspective. Even as battery prices are dropping on per unit energy basis, the customer may not see a decrease in total vehicle cost because the energy onboard the vehicle has increased.

Warranties

In addition to vehicle design and production costs, there are contractual components to procurements that impact cost. Warranty is a critical component in procurements and a significant cost driver. For traditionally fueled vehicles, the parts replacement schedule is well-known, and suppliers, OEMs, and transit agencies are comfortable with standard warranty terms. However, for zero-emission vehicles, which may have components like batteries or fuel cells that have limited demonstrated operational experience, it can be much more difficult to agree on warranty terms and appropriate pricing.

Negotiating warranty terms may involve not only the transit agency and the bus OEM, but the OEM's supplier as well. In a standard procurement a bus OEM's suppliers provide their warranty terms, and these are passed through to the transit agency. With ZEBs, an agency may want stronger warranty terms, and without additional negotiation with a supplier, the OEM would need to assume the risk associated with a discrepancy between the supplier's warranty and whatever contractual obligations the OEM would have with the transit agency. This discrepancy could lead to increased pricing for a vehicle.

Training

Training is another incremental cost for ZEB procurements. Many American transit agencies perform maintenance on their vehicles in-house. Contracts for new ZEBs will often include a number of training modules for both operators and maintenance technicians.

Such OEM training support is critical because the technology is new to transit agencies. However, a one-time training upon delivery may not be sufficient for agency staff to learn everything about the new vehicle technology. Regular communication between transit agencies and OEMs can be limited, so an agency may elect to have a technician present when the OEM does work on their buses. In-depth information about ZEB technologies that can be sent to transit agencies from OEMs is critical for the long-term maintenance and operation of a vehicle.

Additionally, transit agency technicians may not have immediate access to diagnostic tools for new ZEB technologies, hampering efforts to troubleshoot battery or other issues. Existing tools may provide limited insight to transit agencies and there needs to be more development that accommodates technicians and their fleets. Without the ability to repair vehicles in-house, agencies incur operational costs for out-of-service vehicles while waiting on OEM maintenance services. These operational costs factor into the total cost of ownership of ZEBs and must be considered when justifying upfront capital investments in ZEBs.

Can Joint Procurements Bring Down Costs?

Some of these cost challenges can be addressed by increasing vehicle sales volume. Many procurement contracts include opportunities to purchase larger numbers of vehicles, contingent upon available funding, but this does not guarantee that participants will ever purchase the maximum number of ZEBs. In some ways, the Low-No program is an interesting example of efforts to drive down costs of ZEBs. There is a set amount of funding available for zero-emission buses. Historically, OEMs have been able to partner with specific transit agencies on a funding application, and they may be able to offer better pricing knowing how much funding is available and how many agencies they are partnering with.

Lower sales volumes reduce leverage of the OEMs with their suppliers and hampers the OEM's ability to access volume discounts. Joint procurements can help with this issue, particularly for smaller agencies, by pooling purchases from multiple agencies and increasing the minimum number of buses to be purchased. Transit agencies have found it easier to get better pricing if they know the specific number of buses being purchased. This may also help explain why small agencies might be more interested in joint procurement strategies than large agencies, which may more readily be able to take advantage of volume discounts independently.

One of the key challenges with conducting a joint procurement is agreeing on vehicle specifications. Increasing standardization is key to driving down costs of ZEBs. Because of the level of customization required by transit agencies, OEMs may build hundreds of different ZEB configurations each year, making it difficult to bring down costs. Transit agencies utilize joint

procurements to drive down costs as much as possible, but they will often have to compromise on their preferred vehicle configuration to participate in the joint procurement effort.

Finding agreement on specifications is a challenge, given the wide array of agency needs. Choosing different propulsion systems, batteries, and others components can all contribute to vehicle design differences that have effects beyond that particular component. For example, ITS systems can be restrictive and can require completely different wiring. There could be numerous configurations that can require different components such as heater or battery positions that can block wiring for the ITS system, block the wheelchair access, or limit the number of seats available in configurations. Some agencies want buses to come turnkey, which limits the liability on the backend if certain components are not installed by the OEM. However, other agencies want to install those components themselves, either to reuse existing equipment or to reduce the manufacturer's costs. This all plays a role in the ability to standardize bus purchases.

Agreement on vehicle specifications is often found among joint procurement groups that share some operational characteristics. While the number of participants in the procurement can vary based on many factors, creating a joint procurement group that shares common operational challenges can ease the burden of the vehicle specification challenge. For instance, regional partnerships tend to form within specific administrative borders because geography makes a difference when it comes to operational needs. In this case, one transit agency can take the lead by gathering input from other participants on their needs. This approach was taken by transit agencies in Georgia for a procurement for coaches and paratransit buses. The funds came from FTA and the joint procurement set a maximum number of buses purchased, due to an FTA rule requiring a cap on the number of buses being procured including for joint procurements. The joint procurement in this case led to a good base cost for participants with the number of buses varying by transit agency.

Another challenge with standardizing vehicle purchases is the lack of a widely available standard zero-emission bus specification. Often agencies will include their standard bus specification and request that the bus be electrified. However, transitioning from a diesel bus to a zero-emission bus may require multiple system changes, especially to get the most cost-effective vehicle with the best performance. The use of a standard white book specification for ZEBs would be beneficial to standardizing the procurement of ZEBs. APTA has been preparing a white book specification which may be able to fill this role once it is released.

Related Procurement Strategies

Cost challenges related to vehicle procurement can be overcome through innovative procurement strategies. Joint procurements, for instance, can provide access to volume discounts that are often out of reach of smaller transit agencies. This strategy has been an effective procurement strategy for insurance and alcohol and drug testing and has the potential to translate effectively to joint bus procurements. Alternative strategies also exist to generate sales volume.

Cooperative Purchasing through Sourcewell

Cooperative purchasing is a widely used and accepted procurement practice utilized by public agencies to purchase commodities, equipment, and services. Utilizing a cooperative purchasing entity like Sourcewell[10], a governmental entity that conducts the procurement process for its membership, provides an efficient means of purchasing that can bring further cost savings as these strategies do not require additional costs for participants to use. These purchasing strategies are not the same as a joint procurement, but they can realize many of the same benefits that would come from a joint procurement.

Sourcewell conducts competitive procurements to award suppliers contracts that are publicly available to its membership of government and non-profit entities. This form of cooperative purchasing is different from a joint procurement because the process is managed and led by an organization that may not be purchasing any of the equipment itself. Currently, there are over 350 active contracts of product and services based on membership feedback with suppliers providing products that range from vehicle flooring to ITS equipment. Sourcewell develops and solicits contract categories for vehicles with configuration options and pricing so an agency can get the configuration it needs. When placing an RFP on behalf of its membership, Sourcewell encourages suppliers to provide a full breadth of specification options, so its members can configure their own needs. There are currently Sourcewell contracts for shuttle buses, cutaway vehicles, school buses, and other vehicles.

Cooperative purchasing is currently not permitted under FTA grant rules. In order to utilize FTA funds, there must be a cap of the number of buses, which is difficult within cooperative purchasing contracts. However, there is still interest in cooperative purchasing for a transit body and as costs go down and non-federal sources of funding increase, opportunities to conduct joint procurements for ZEBs may be more prevalent in the future. Transit agencies have strong interest in cooperative purchasing for transit buses despite the FTA's current restriction of the practice as the procurement method is widely accepted and used for purchasing other products and services .

State Purchasing Contracts

Another mechanism for generating sales volume and reducing procurement burdens is a state purchasing contract. State contracts allow OEMs and transit agencies maximum flexibility without having to name specific participating operators like other consortia require. There are benefits to rural and small transit agencies as minimal resources are needed on their end to purchase from a state contract. States also often have a close

[10] Sourcewell is a local government unit, public corporation and public agency pursuant to the Minnesota Constitution and enabling law Minn. Stat. § 123A.21 created to provide programs and services to education and government agencies. Sourcewell is authorized to establish competitively awarded cooperative purchasing contracts on behalf of itself and its participating agencies. Sourcewell follows the competitive contracting law process to solicit, evaluate, and award cooperative purchasing contracts for goods and services. Sourcewell cooperative purchasing contracts are made available through the joint exercise of powers law Minn. Stat. § 471.59 to participating agencies. https://www.sourcewell-mn.gov/

relationship with their rural agencies, and may be well-positioned to develop a specification that meets the needs of the majority of their operators. It can be time intensive for states to put together contracts due to gathering the right specifications, but it does create multiple options that transit agencies can select from to meet their operational needs.

Prior to 2015, transit agencies had to be located in the state of the contract they were purchasing off of, but the FAST ACT in 2015 allows OEMs to be a vendor on any state schedule and transit agencies can purchase off of any state contract[11]. There are currently three state contracts that contain zero-emission bus options: California, Georgia, and Virginia. Only the California contract offers a fuel cell electric bus option.

Many agencies have expressed interest in using this purchasing mechanism, and it could be an effective way to increase zero-emission bus sales volumes.

Public-Private Partnerships

Another potential strategy for procuring ZEBs is through Public-Private Partnerships (P3s). P3s have served as a good stepping stone for adding new products and services into a city. In this kind of arrangement, a private company provides the initial capital for an investment, which the government agency pays back over time. Often this is positioned such that the agency is able to use operational savings from its initial capital investment to pay those long-term costs. For example, a company like an electric utility may provide funding for charging infrastructure for a transit agency. If designed well, the agency may see fuel savings from operating electric buses compared to diesel powered buses. Those savings can be used to pay the utility back for its initial investment. P3s can help transit agencies overcome financial barriers to their electrification goals. However, it is important to note that capital funds have historically been easier for transit agencies to obtain than operating funds, and this may make designing a mutually beneficial P3 challenging.

The Canadian Council for Public-Private Partnerships maintains a database of P3 projects throughout Canada. The P3s in Canada are procured through an open competitive RFP process that includes forms of negotiation. As of August 2020, there were 223 Canadian transit projects in the database, valued at $72 billion.[12]

100-Bus Initiative

Another initiative to generate sales volume and drive down the price of zero-emission buses is referred to as the "100-Bus Initiative." Spearheaded by Jaimie Levin at the Center for Transportation and the Environment, the plan calls for a consortium of agencies to commit to purchasing 100 FCEBs simultaneously, which will help drive down the capital costs of these vehicles to commercial viability without significant FTA support, which is believed to be approximately US $850,000: similar to the price of a BEB.

[11] *CalStart State Contract Document*
[12] *Demystifying Dialogue RFPs*

This initiative focuses on generating sales volume to drive down costs. It would still allow agencies to have custom configurations and individual contracts with warranty terms that meet their needs. One of the other major challenges to conducting joint procurements is aligning the funding among various agencies. By creating a consortium of agencies committed to a FCEB purchase, the initiative provides a ready opportunity for funding agencies to support the widespread deployment of FCEBs.

Currently, there is no set consortium of transit agencies committed to FCEBs. However, many transit agencies are exploring FCEBs, and as a group they are approaching 100 buses. Unfortunately, due to the transit agencies buying buses at different times and with different specifications, the target price of US $850,000 is not likely to be reached until demand grows. Increased demand and competition from other OEMs will continue to drive down the price.

Conclusions

Many of the challenges with bringing down the costs of ZEBs are related to scaling up the market. As more and more companies provide products for zero-emission technologies, bus OEMs must constantly update their product to keep up. This trend increases engineering and design workloads and limits the ability of suppliers to scale up before the next design iteration is released.

While joint procurements seem like a promising mechanism for increasing sales volume, they come with their own challenges. These include coordinating the timing of funding availability and bus replacement schedules across multiple transit agencies and developing a vehicle specification that either meets the needs of all agencies or is easily configurable to meet those needs.

This paper explored the barriers to driving down the cost of ZEBs and evaluated circumstances under which joint procurements may be a successful strategy for doing so. Alternatives to a traditional joint procurement such as state contracting mechanisms, P3s, and the 100-bus initiative were discussed. Each of these has its own benefits and challenges, and there is no single strategy that will work in all situations. However, some of these innovative procurement strategies may be able to help increase the market size for ZEBs and bring down costs for individual operators.

Continued innovations in procurements, industry-wide education on zero-emission technologies, and ongoing funding support for investments in ZEBs and associated infrastructure will be critical to bringing ZEBs to cost parity with fossil fuel-powered vehicles.

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