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Advancing Clean Mobility: Hydrogen Fuel Cell Electric Bus Workforce Development for Transit Agencies

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Introduction

The transition to hydrogen fuel cell buses (FCEBs) in public transit is a critical strategy for reducing greenhouse gas (GHG) emissions, particularly in regions like California where transportation contributes a substantial share of total emissions. FCEBs represent a promising solution due to their zero tailpipe emissions, long operational range, and rapid refueling capabilities. However, this technological transition introduces significant workforce challenges. The existing transit workforce, already strained by labor shortages and retirements, must adapt to hydrogen-based technologies, and current training systems and workforce development strategies are not fully aligned with these needs. This study addresses a critical gap by examining the knowledge, skills, and abilities (KSAs) required for FCEB operations and maintenance, assessing limitations in existing training frameworks, and identifying effective workforce development strategies. The findings provide actionable insights for transit agencies seeking to build a capable and sustainable workforce to support large-scale FCEB adoption.

Study Methods

This study employed a qualitative research design to explore workforce development challenges associated with FCEB adoption. The methodology combined two primary data sources: a systematic literature review and semi-structured interviews with industry stakeholders. The literature review synthesized academic, governmental, and practitioner sources to establish a foundational understanding of FCEB technology, workforce requirements, training systems, and policy context. Multiple databases and repositories were used, and sources were selected based on relevance, credibility, and recency. The review was structured around key themes, including policy drivers, technical characteristics of FCEBs, workforce challenges, KSAs, training ecosystems, and workforce strategies.

Primary data were collected through semi-structured interviews with 20 participants representing transit agencies, original equipment manufacturers (OEMs), training organizations, and industry stakeholders across the United States. Participants were selected using purposive and maximum variation sampling to capture diverse perspectives across agency size, geographic location, and stages of FCEB adoption. Interviews were conducted remotely, recorded with consent, and transcribed for analysis. Data analysis was done following Braun and Clarke's (2006) six-phase framework. Coding was both inductive and deductive, aligned with the study's research questions on KSAs, training gaps, and workforce strategies. The research team repeatedly reviewed the findings and compared them with existing studies to strengthen reliability and identify consistent patterns. This approach ensured a comprehensive and practice-grounded understanding of FCEB workforce development challenges.

Findings

The study identifies three major findings related to workforce competencies, training gaps, and workforce strategies. First, FCEB workforce requirements are significantly more complex than those for conventional transit technologies. Maintenance technicians must develop tri-disciplinary competencies spanning electrical systems, hydrogen safety, and fuel cell diagnostics, with electrical fundamentals emerging as a critical prerequisite. Operators require targeted training in hydrogen safety, energy management, and emergency response, though their training needs are

less extensive than those of maintenance technicians. Second, substantial gaps exist in the current training ecosystem. There is no standardized national training framework or certification pathway for FCEB workforce development, resulting in inconsistent skill levels across agencies. Training is heavily reliant on OEMs, which provide product-specific instruction that is not transferable and often not sustained over time.

The workforce crisis in transit is already severe. FCEBs make it worse, demanding tri-disciplinary expertise in electrical, mechanical, and hydrogen chemical safety that no predecessor technology ever required of a single worker.

Additionally, training for operators and facility staff is underdeveloped, and smaller agencies face limited access to training resources, creating a two-tier system of workforce readiness. Third, effective workforce development depends on strategic organizational approaches rather than training alone. Agencies rely on "grow-your-own" models, recruiting individuals with general mechanical or electrical aptitude and developing FCEB-specific skills internally. Success is strongly associated with cognitive traits such as problem-solving ability and adaptability. Structured mentorship, clear career pathways, and partnerships with educational institutions are critical for recruitment and retention. Overall, workforce readiness is a system-level challenge requiring coordinated strategies across training, recruitment, and organizational capacity.

Policy/Practice Recommendations

To support effective FCEB workforce development, coordinated policy and practice interventions are required. First, a standardized national training framework and certification pathway should be established to ensure consistent competency levels across transit agencies. Second, public investment should prioritize regional training centers and shared infrastructure to address disparities between large and small agencies. Third, training programs must extend beyond technicians to include operators and facility staff, with an emphasis on safety and behavioral compliance. Fourth, agencies should adopt structured workforce strategies, including apprenticeship programs, mentorship models, and clear career progression pathways tied to skill development. Finally, stronger partnerships with community colleges and technical education programs are essential to building a sustainable talent pipeline. Policymakers should support curriculum development and funding mechanisms that align education systems with FCEB workforce needs. Together, these measures will enable transit agencies to develop a skilled, adaptable workforce capable of supporting the transition to zero-emission transit systems.

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To Learn More

For more details about the study, download the full report at https://transweb.sjsu.edu/research/2546

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