*EVS29 Symposium*
*Montreal, Quebec, Canada, June 19-22, 2016*

# Best Practices in Hydrogen Fueling and Maintenance Facilities for Transit Agencies

Steven Sokolsky[1], Dr. Jasna Tomic, Jean-Baptiste Gallo
[1] *CALSTART, Pasadena, CA ssokolsky@calstart.org*

## Summary

CALSTART recently completed a *Best Practices in Hydrogen Fueling and Maintenance Facilities for Transit Agencies* publication for the Federal Transit Administration. The objective of the project was to create a high-level resource that advances the adoption of fuel cell bus technology within the transit industry. It accomplishes this by compiling a planning and decision-making tool for the best practices in developing hydrogen fueling and maintenance facilities. This comprehensive effort is the first of its kind, and provide an easily digestible – and much needed – document for managers of transit agencies across the United States.

*Keywords: bus, fuel cell, hydrogen, infrastructure*

## 1. BACKGROUND AND PROJECT FOCUS

Roughly 20 percent of the United States' public transit buses (about 10,000 buses) are powered with some form of petroleum alternative or advanced technology, whether it is compressed natural gas or liquefied natural gas fuels, or diesel-electric hybrid powertrains. By contrast, about 50 fuel cell buses are currently in service. While this number may seem small, it represents a significant and growing accomplishment. In fact, fuel cell buses are on a commercial pathway to overcoming the two most substantial barriers to adoption: technological readiness and cost. Within the next few years, it is anticipated that fuel cell buses will be ready for full deployment and will not only begin to compete against other bus offerings in the United States, but will also compete against other fuel cell buses in China, Europe, and Latin America.

While a great deal of focus to date has been placed on the development and advancement of the technology of fuel cell transit buses under the FTA's National Fuel Cell Bus Program, less attention has been paid to the infrastructure portion of the work, specifically the written and visual presentation of the standards, practices, rules, and understandings that govern the development and management of hydrogen refueling stations and bus maintenance facilities. In fact, the importance of creating just such a best practices guide has been acknowledged in recent efforts that have been funded by the Federal Transit Administration since 2008, including the *East Tennessee Hydrogen Initiative* in December, 2010 (Report No. FTA-TN-26-7033-2011.2) and the *Report on Worldwide Hydrogen Bus Demonstrations* in March, 2009 (Report No. FTA-GA-04-7001-2009.01), both of which recommended the development of a best practices document as a crucial next step for the industry.

The anticipated growth of fuel cell bus deployments is a direct result of fuel cell electric buses funded by the Federal Transit Administration National Fuel Cell Bus Program (NFCBP) and the follow on Low and No Emission Bus Funding. Federal legislation funds the Federal Transit Administration "National Fuel Cell Bus Program" which is focused on commercializing fuel cell electric buses. The Congressional authorizing legislation was the Safe, Accountable, Flexible, Efficient, Transportation Equity Act - A Legacy for Users (SAFETEA-LU). To date, over $90,000,000 in federal funds matched by industry with

another $90,000,000 has resulted in a total of over $180,000,000 investment in the technology. The projects and the teams that execute the projects are all competitively selected resulting in a well-balanced portfolio.

## 2. GUIDEBOOK CONTENT

The *Best Practices* guide provides an easily digestible resource to help transit properties plan and clearly understand the parameters for refueling and fuel filling; the guidelines for safety; the requirements of maintenance facilities, and the economics of hydrogen facilities. Although these outcomes have merit in their own right, they also help to advance many specific program and performance objectives, including:

- increasing the public's awareness and acceptance of fuel cell vehicles and fuel cell bus technologies;
- collaborating in the development of design standards for fuel cell bus technologies;
- developing an understanding of the requirements for market introduction;
- and compiling and maintaining key information on fuel cell bus technology development and needs.

With these objectives in mind, the *Best Practices* guide educates transit agency fleet managers about the basics of designing and operating a hydrogen fueling station. The main topics include:

- the generation or delivery of fuel (including liquid or gaseous hydrogen delivery; onsite refromation of methane; pipeline delivery of hydrogen; onsite electrolysis of water; mobile fueling; or the development of an energy station)
- options for equipment and site design
- permits, codes, setbacks, and standards
- refueling operations and economics
- equipment sizing
- capacity expansion considerations
- operating costs
- issues specific to fuel cell bus maintenance
- fueling protocols
- hydrogen properties and their relationship to facility safety
- facility upgrade options and costs
- transit fueling infrastructure case study

## 3. PROJECT APPROACH

CALSTART assembled a project team with the Gas Technology Institute, Air Products, and the Linde Gas Company. Together, the team convened a *Best Practices Advisory Committee* of expert transit properties and industry suppliers throughout the United States who have significant experience in planning and managing the construction of hydrogen refueling stations and maintenance facilities.

The CALSTART team performed specific research on each of the elements by collecting, evaluating, and organizing the existing research in the field. Additional research was also performed to fill in areas that need to be addressed. The advisory council provided the project team with its input, experience, and counsel on the key planning elements provided within the publication. Additionally, the advisory committee provided the project team with the key early research that it has used during the course of its individual activities.

The advisory committee consists of a broad range of industry suppliers and transit operators. The transit agencies represent agencies of varying sizes, with distinctive customer needs preferences, and with varying local and state policy and regulatory drivers of demand. The original target list included the following transit agencies:

- Alameda Contra Costa
- Foothill Transit
- Stark Area Regional Transit Agency (SARTA)
- SunLine Transit

## 4. OUTREACH

While the creation of the publication is important, for this particular project, it was crucial to make sure that the document is seen by the industry's decision-makers. To do this, CALSTART and GTI executed an ambitious outreach campaign to assure that communities and transit properties nationwide receive and utilize the document, as well as the findings therein. The team is soliciting additional partnerships with the American Society of Civil Engineers, American Public Transportation Association, various state transit associations, and other industry stakeholders to help distribute the publication and present the findings at targeted industry events. Additionally, the advisory committee assisted to put the publication in front of these transit general managers. The document was previewed at last year's Fuel Cell Seminar and this conference will be another element in disseminating the information in the publication.

## Acknowledgements

The authors would like to thank the following organizations who contributed content and review during the production of the guidebook:

- Gas Technology Institute
- The California Fuel Cell Partnership
- The U.S. Department of Energy National Renewable Energy Laboratory
- Alameda-Contra Costa Transit
- Sunline Transit Agency
- Stark Area Regional Transit Agency
- Hydrogenics
- Linde
- Ballard
- BAE Systems
- Nuvera
- ITM
- US Hybrid
- Air Products
- Siemens

## Authors

**Steven Sokolsky** is a Program Manager at CALSTART, America's leading non-profit clean transportation consortium. In this role he leads several activities that contribute to the advancement of clean technologies for commercial vehicles. In addition to this fuel cell infrastructure program with the Federal Transit Administration he leads the High-Efficiency Truck Users Forum for the U.S. Army and has authored a technology roadmap for heavy-duty natural gas vehicles for Southern California Gas Company. He has a Bachelor's degree in International Business and Economics from California State University, Sacramento.

**Dr. Jasna Tomic** is the Research Director at CALSTART. In this role she is investigating the best opportunities for alternative fuels in transportation sector, with particular emphasis on the use of alternative fuels in the heavy-duty sector. She led the largest deployment and field testing of twenty-four pre-production hybrid trucks. She is also investigating the best pathways and uses for plug-in and electric vehicles. Jasna's expertise includes research in vehicles-to-grid power (V2G) – innovative use of electric-drive vehicles for transportation and power generation. She holds a Ph.D. in Fuel Science from Pennsylvania State University and has over 15 years of experience working in the field of energy and fuels. Jasna previously held positions as Research Scientist at University of Delaware, Princeton University, and French Institute of Petroleum. She has published extensively on energy conversion processes as well as use of electric-drive vehicles.

**Jean-Baptiste Gallo** is a Senior Project Engineer at CALSTART. He manages and implements data collection and analysis activities for performance evaluation projects of advanced vehicle technologies such as hybrid electric, hydraulic hybrid and battery electric vehicles, as well as Lithium-ion starter batteries. He also provides technical expertise for market research and analysis projects focusing on zero-emission buses and drayage trucks, battery electric trucks, workplace charging for passenger vehicles and vehicle-to-grid (V2G). Prior to joining CALSTART, Jean-Baptiste worked for PSA Peugeot – Citroën in France as a Control Systems Engineer. He obtained a Master's Degree in Mechanical Engineering from the Ecole Polytechnique de l'Université d'Orléans in Orléans, France with a specialty in energy and thermal systems engineering. He also holds a Certificate in International Environmental Policy from the Monterey Institute of International Studies in Monterey, California where he studied energy policy, environmental economics, electric power systems and sustainable transportation.