

Hydrogen and Fuel Cell Transit Bus Evaluations

**Joint Evaluation Plan for the U.S.
Department of Energy and the Federal
Transit Administration**

**Appendix A: Summary of Hydrogen and
Fuel Cell Transit Bus Demonstration Sites
in the U.S.**

Technical Report
NREL/TP-560-42781-2
May 2008

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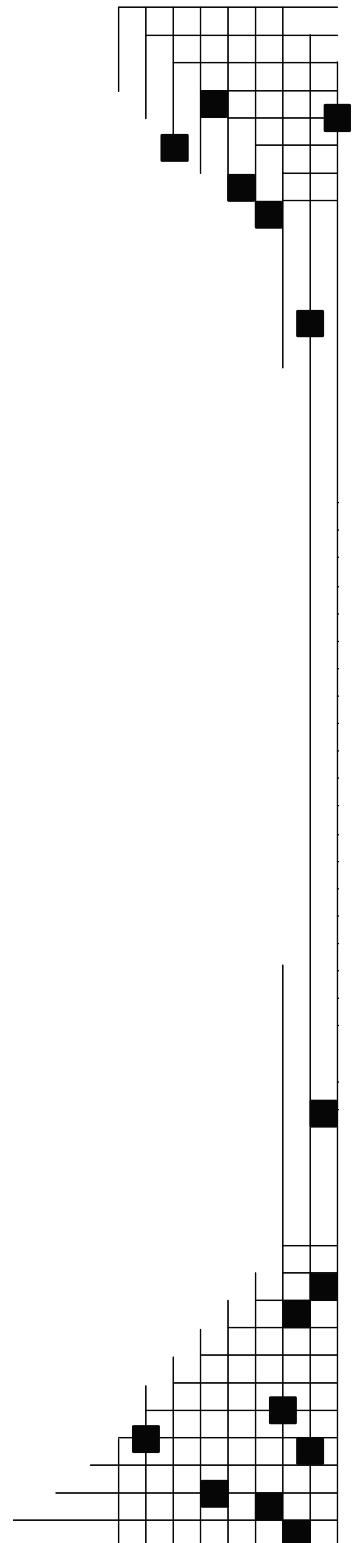
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Table A2. AC Transit: HyRoad

| | |
|-----------------------------|--|
| Project | HyRoad |
| Lead Organization | AC Transit |
| Consortia | N/A |
| Partners | UTC Power: fuel cell system ISE: hybrid system & integration Van Hool: bus chassis Chevron Technology Ventures: infrastructure Golden Gate Transit: demo |
| Technology description | 40-ft hybrid FCB with a 120 kW fuel cell and ZEBRA batteries |
| Operating Site and location | AC Transit, Oakland, CA |
| Demo Start Date | March 2006 |
| Duration | 2 years |
| Number of buses | 3 |
| Infrastructure description | Natural gas reformer with two dispensers, also fuel light duty FCVs |
| Evaluation Type | Full |
| Funding source | DOE |



Table A3. AC Transit: Accelerated Testing

| | |
|-----------------------------|---|
| Project | Accelerated Fuel Cell Bus Testing |
| Lead Organization | AC Transit |
| Consortia | WestStart-CALSTART |
| Partners | UTC Power: fuel cell system ISE: hybrid system & integration Van Hool: bus chassis Chevron Technology Ventures: infrastructure |
| Technology description | Accelerated testing to failure of current generation buses |
| Operating Site and location | AC Transit, Oakland, CA |
| Estimated Demo Start Date | November 2007 |
| Duration | 15 months |
| Number of buses | 3 |
| Infrastructure description | Natural gas reformer and two dispensers |
| Evaluation Type | Full |
| Funding source | FTA |



Table A4. AC Transit – Advanced ZEB Demonstration 2009

| | |
|-----------------------------|--|
| Project | AC Transit CA ZEB 2009 |
| Lead Organization | AC Transit |
| Consortia | N/A |
| Partners | UTC Power: fuel cell system Van Hool: bus chassis and hybrid system Chevron Technology Ventures: infrastructure Golden Gate Transit: demo |
| Technology description | 40-ft hybrid FCB with newest fuel cell system and advanced batteries |
| Operating Site and location | AC Transit, Oakland, CA |
| Estimated Demo Start Date | 2009 |
| Duration | 2 years |
| Number of buses | 8 |
| Infrastructure description | Natural gas reformer with two dispensers, also fuel light duty FCVs |
| Evaluation Type | Full |
| Funding source | DOE (planned) |

Table A5. SunLine Fuel Cell Bus

| | |
|-----------------------------|--|
| Project | SunLine Fuel Cell Bus |
| Lead Organization | SunLine |
| Consortia | N/A |
| Partners | UTC Power: fuel cell system ISE: hybrid system & integration Van Hool: FC bus chassis HyRadix: infrastructure |
| Technology description | FCB: 40-ft hybrid with a 120 kW fuel cell and ZEBRA batteries |
| Operating Site and location | SunLine, Thousand Palms, CA |
| Demo Start Date | January 2006 |
| Duration | 2 years |
| Number of buses | 1 |
| Infrastructure description | Natural gas reformer, station open to public and also fueling light-duty FCVs |
| Evaluation Type | Full |
| Funding source | DOE |

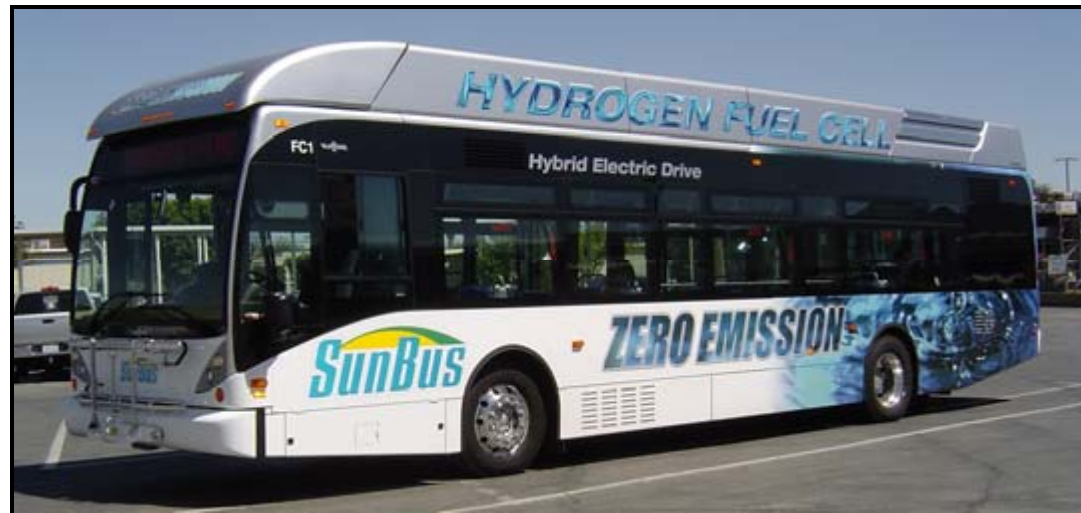


Table A6. SunLine Fuel Cell Bus – Extended Service

| | |
|-----------------------------|--|
| Project | Fuel Cell Bus Extended Service |
| Lead Organization | SunLine |
| Consortia | N/A |
| Partners | UTC Power: fuel cell system ISE: hybrid system & integration Van Hool: FC bus chassis HyRadix: infrastructure |
| Technology description | FCB: 40-ft hybrid with an updated 120 kW fuel cell and ZEBRA batteries |
| Operating Site and location | SunLine, Thousand Palms, CA |
| Estimated Demo Start Date | April 2008 |
| Duration | 1 year |
| Number of buses | 1 |
| Infrastructure description | Natural gas reformer, station open to public and also fueling light-duty FCVs |
| Evaluation Type | Full |
| Funding source | DOE |



Table A7. SunLine HHICE bus

| | |
|-----------------------------|--|
| Project | HHICE Bus |
| Lead Organization | SunLine |
| Consortia | N/A |
| Partners | ISE: hybrid system & integration Ford: Hydrogen ICE engine New Flyer: HHICE bus chassis HyRadix: infrastructure |
| Technology description | HHICE: 40-ft hybrid using a Ford V10 engine modified to operate on hydrogen and ultracaps |
| Operating Site and location | SunLine, Thousand Palms, CA |
| Demo Start Date | January 2006 |
| Duration | 2 years |
| Number of buses | 1 |
| Infrastructure description | Natural gas reformer, station open to public and also fueling light-duty FCVs |
| Evaluation Type | Full |
| Funding source | DOE |



Table A8. SunLine – All American Fuel Cell Bus

| | |
|-----------------------------|--|
| Project | All American Fuel Cell Bus |
| Lead Organization | SunLine |
| Consortia | WestStart-CALSTART |
| Partners | ISE: hybrid system & integration UTC Power: fuel cell New Flyer: bus chassis modified to be more efficient |
| Technology description | Demonstrate 40-ft FCB with design improvements in an American-made bus chassis; improvements include: newest fuel cell design, lithium-ion batteries, reduced weight to hybrid system, various changes to overall bus to reduce weight and increase efficiency |
| Operating Site and location | SunLine, Thousand Palms, CA |
| Estimated Demo Start Date | Late 2008 |
| Duration | 15 months |
| Number of buses | 1 |
| Infrastructure description | Natural gas reformer (existing) |
| Evaluation Type | Full |
| Funding source | FTA |

Table A9. SunLine – Advanced Fuel Cell Bus (Thor rebuild)

| | |
|-----------------------------|---|
| Project | Advanced Hybrid Fuel Cell Bus Project |
| Lead Organization | SunLine |
| Consortia | N/A |
| Partners | Ballard: fuel cell ISE: hybrid system and integration Thor: bus chassis |
| Technology description | An upgrade of the 30-ft Thor FCB to include the latest Ballard FC as well as advanced batteries and hybrid system |
| Operating Site and location | SunLine, Thousand Palms, CA |
| Estimated Demo Start Date | November 2008 |
| Duration | 1 year |
| Number of buses | 1 |
| Infrastructure description | Natural gas reformer (existing) |
| Evaluation Type | Partial |
| Funding source | DOE |



Table A10. Connecticut Transit – Fuel Cell Bus

| | |
|-----------------------------|---|
| Project | CTTRANSIT Fuel Cell Bus Demo |
| Lead Organization | CTTRANSIT |
| Consortia | N/A |
| Partners | UTC Power: fuel cell system ISE: hybrid system & integration Van Hool: bus chassis |
| Technology description | 40-ft hybrid FCB with a 120 kW fuel cell and ZEBRA batteries (same as ACT and SunLine buses) |
| Operating Site and location | CTTRANSIT, Hartford, CT |
| Demo Start Date | May 2007 |
| Duration | 2 years |
| Number of buses | 1 |
| Infrastructure description | Liquid hydrogen delivery, storage, and dispensing – station located at UTC Power HQ; renewable H2 production from Niagara falls |
| Evaluation Type | Full |
| Funding source | DOE |



Table A11. CT Hybrid Fuel Cell Bus

| | |
|-----------------------------|---|
| Project | CT Hybrid Fuel Cell Bus Demo |
| Lead Organization | UTC Power |
| Consortia | NAVC |
| Partners | UTC Power: fuel cell |
| Technology description | Advanced version of the current 40-ft hybrid FCB incorporating the latest technology to increase durability, reliability, and performance of the bus. |
| Operating Site and location | CTTRANSIT, Hartford, CT |
| Estimated Demo Start Date | 1 st qtr 2009 (1 st bus delivery: 4 th qtr 2008, last bus: 2 nd qtr 2009) |
| Duration | 2 years |
| Number of buses | 4 (3 at site and one floating; could test at up to 4 total sites) |
| Infrastructure description | UTC Power fueling facility, potential to add fueling at the bus depot |
| Evaluation Type | Full |
| Funding source | FTA |

Table A12. Hickam AFB – Fuel Cell Bus & Van

| | |
|-----------------------------|--|
| Project | Hickam Fuel Cell Vehicle Demo |
| Lead Organization | HCATT |
| Consortia | N/A |
| Partners | Hydrogenics: fuel cell system Enova: hybrid system & integration El Dorado: bus chassis, Workhorse/Utilimaster: van body HydraFLX: infrastructure |
| Technology description | 35-ft battery dominant, plug-in hybrid FCB; FC dominant van |
| Operating Site and location | Hickam AFB, Honolulu, HI |
| Demo Start Date | Jan 2008 (data collection delayed due to FC issues) |
| Duration | 1 year |
| Number of buses | 1 bus, 1 van |
| Infrastructure description | Deployable station design using two Teledyne Electrolyzers |
| Evaluation Type | Partial |
| Funding source | DOE |



Table A13. Dual Variable Output Fuel Cell Hybrid Bus

| | |
|-----------------------------|--|
| Project | Dual Variable Output Fuel Cell Hybrid Bus |
| Lead Organization | Innovation Drive |
| Consortia | CTE |
| Partners | MES: bus chassis and hybrid system Hydrogenics: fuel cell stacks (2) Altairnano: batteries |
| Technology description | Battery dominant fuel cell system employing a strategy using two 16kW FC stacks packaged into a single 32kW parallel operating system and lithium titanate batteries |
| Operating Site and location | 1) RTC, Columbia, SC 2) second site TBD 3) CTTRANSIT, Hartford, CT (will replace fuel cells) |
| Estimated Demo Start Date | 3 rd Qtr 2008 |
| Duration | One year at each location for a total of 3 years |
| Number of buses | 1 |
| Infrastructure description | TBD |
| Evaluation Type | Partial |
| Funding source | FTA |

Table A14. Massachusetts Hydrogen Fuel Cell Powered Bus Fleet

| | |
|-----------------------------|--|
| Project | Massachusetts Hydrogen Fuel Cell Powered Bus Fleet |
| Lead Organization | Nuvera/ISE |
| Consortia | NAVC |
| Partners | Nuvera: fuel cell ISE: hybrid system and integration A123Systems: energy storage |
| Technology description | 40-ft bus with an 82kW Nuvera fuel cell integrated into a hybrid system with advanced energy storage |
| Operating Site and location | Massport: Logan Airport, Boston, MA |
| Estimated Demo Start Date | Mid-year 2009 |
| Duration | 2 years |
| Number of buses | 1 |
| Infrastructure description | Nuvera's PowerTap – natural gas reformer |
| Evaluation Type | Full |
| Funding source | FTA |

Table A15. Lightweight Fuel Cell Bus Demo – GE/ Niagara

| | |
|-----------------------------|--|
| Project | Lightweight Fuel Cell Hybrid Bus |
| Lead Organization | GE |
| Consortia | NAVC |
| Partners | GE hybrid system & integration Ballard: fuel cell |
| Technology description | Lightweight FCB incorporating a 75kW Ballard fuel cell, ultracaps, and lithium ion batteries |
| Operating Site and location | Site in NY |
| Estimated Demo Start Date | 1 st Qtr 2009 |
| Duration | 2 years |
| Number of buses | 1 |
| Infrastructure description | |
| Evaluation Type | Full |
| Funding source | FTA |

Table A16. Hydroelectric Hydrogen Powered FCB Demo

| | |
|-----------------------------|---|
| Project | Hydroelectric Hydrogen Powered FCB Demo |
| Lead Organization | New York Power Authority |
| Consortia | NAVC |
| Partners | Ballard: fuel cell New Flyer: chassis ISE: hybrid system & integration NYPA: overall lead and fueling stations |
| Technology description | Demonstrate two 40-ft hybrid FCBs with the latest technology (similar to buses for BC Transit) |
| Operating Site and location | Site in NY |
| Estimated Demo Start Date | 1 st Qtr 2009 |
| Duration | 2 years |
| Number of buses | 2 (one prototype and one pre-commercial) |
| Infrastructure description | Hydrogen produced from electrolysis at Niagara facility. |
| Evaluation Type | Full |
| Funding source | FTA |

Table A17. Compound FCB Hybrid Bus for 2010

| | |
|-----------------------------|--|
| Project | Compound Fuel Cell Hybrid Bus for 2010 |
| Lead Organization | BAE Systems |
| Consortia | WestStart-CALSTART |
| Partners | BAE: hybrid system & integration Orion: bus chassis Hydrogenics: fuel cell APU Lincoln Composites: hydrogen storage |
| Technology description | 40-ft diesel hybrid bus with fuel cell APU to handle auxiliary loads, and advanced energy storage; design includes a 15 – 25 kW fuel cell and integrated starter generator coupled to a diesel engine and energy storage system. |
| Operating Site and location | SFMTA, San Francisco, CA |
| Estimated Demo Start Date | 1 st Qtr 2010 |
| Duration | 8 months |
| Number of buses | 1 |
| Infrastructure description | TBD |
| Evaluation Type | Full |
| Funding source | FTA |

Table A18. VTA – Advanced ZEB Demonstration 2009

| | |
|-----------------------------|--|
| Project | VTA CA ZEB 2009 |
| Lead Organization | VTA |
| Consortia | N/A |
| Partners | Manufacturers TBD SamTrans: demo partner |
| Technology description | TBD |
| Operating Site and location | VTA, San Jose, CA |
| Estimated Demo Start Date | 1 st Qtr 2009 |
| Duration | 2 years |
| Number of buses | 4 |
| Infrastructure description | Air Products liquid H2 delivery, storage, and dispensing |
| Evaluation Type | Full |
| Funding source | DOE (planned) |

Table A19. New Haven Hydrogen Bus Project

| | |
|-----------------------------|---|
| Project | New Haven H2 Bus Demonstration |
| Lead Organization | New Haven |
| Consortia | N/A |
| Partners | |
| Technology description | One hybrid FCB and a hydrogen ICE bus |
| Operating Site and location | Greater New Haven Transit District, New Haven, CT |
| Estimated Demon Start Date | |
| Duration | |
| Number of buses | 2 (one bus of each type) |
| Infrastructure description | |
| Evaluation Type | |
| Funding source | |

Table A20. University of Delaware

| | |
|-----------------------------|--|
| Project | University of Delaware FCB development/demo |
| Lead Organization | UD |
| Consortia | N/A |
| Partners | UD: development/demonstration, project lead Ballard: fuel cell Ebus: bus chassis and hybrid system |
| Technology description | 22-ft, Ebus hybrid with the latest design Ballard fuel cell and NiCd batteries, also a plug-in |
| Operating Site and location | UD Campus, Newark, NJ (Transit service in summer) |
| Estimated Demon Start Date | Bus delivered in spring 2007 |
| Duration | 6 mo. to 1 year |
| Number of buses | 1 |
| Infrastructure description | Air Liquide hydrogen station in Newark, NJ |
| Evaluation Type | Partial |
| Funding source | |



Table A21. University of Texas (Austin)

| | |
|-----------------------------|--|
| Project | University of Texas FCB demonstration |
| Lead Organization | UT |
| Consortia | CTE |
| Partners | UT: development/demonstration, project lead Ballard: fuel cell Ebus: bus chassis and hybrid system |
| Technology description | 22-ft, Ebus hybrid with the latest design Ballard fuel cell and NiCd batteries, also a plug-in |
| Operating Site and location | UT campus, Austin, TX |
| Estimated Demon Start Date | Bus delivered in fall 2007 |
| Duration | 6 mo – 1 year |
| Number of buses | 1 |
| Infrastructure description | GTI station |
| Evaluation Type | Partial |
| Funding source | |

Table A22. City of Burbank Fuel Cell Bus Demo

| | |
|-----------------------------|---|
| Project | Burbank FCB Demonstration |
| Lead Organization | City of Burbank |
| Consortia | N/A |
| Partners | MES: bus chassis and hybrid system Hydrogenics: fuel cells Altairnano: batteries CARB: funding organization |
| Technology description | Battery dominant fuel cell system employing a strategy using two 16kW FC stacks packaged into a single 32kW parallel operating system and lithium titanate batteries (This bus is expected to be identical to the MES bus for NFCBP) |
| Operating Site and location | Burbank, CA |
| Estimated Demon Start Date | Fall 2008 |
| Duration | 1 year |
| Number of buses | 1 |
| Infrastructure description | Burbank station |
| Evaluation Type | Partial or full |
| Funding source | |

Table A23. Ford HICE Shuttle

| | |
|-----------------------------|---|
| Project | Ford HICE demonstration |
| Lead Organization | Ford |
| Consortia | N/A |
| Partners | Ford: manufacturer of bus and engine, and lead organization Working with various organizations to test the buses in multiple U.S. and Canadian locations |
| Technology description | Ford hydrogen fueled ICE engine in a cut-away shuttle bus body. Not a hybrid, but a lower cost alternative to increase H2 use. |
| Operating Site and location | Orlando, FL; San Carlos, CA; Las Vegas, NV; Univ of Missouri, plus others |
| Estimated Demon Start Date | Buses began delivery in 2006 |
| Duration | 1 year |
| Number of buses | 30 |
| Infrastructure description | Depends on site |
| Evaluation Type | Partial |
| Funding source | |

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