RTD Hydrogen Mobile Fueling Solutions

April 2026

John Van Camp Maintenance Superintendent

SAN JOAQUIN RTD

RTDs Mobile Hydrogen Infrastructure Beginnings

- RTD Board approved plan to comply with Innovative Clean Transit (ICT) regulations by 2040.
- In 2022, In 2022, RTD evaluated developments in Fuel Cell Electric Bus (FCEB) technology and amended its ICT plan to include 5 FCEBs as a pilot program.
- RTD staff conducted industry benchmarking and technical evaluations.

Program Timeline

Where we have been:

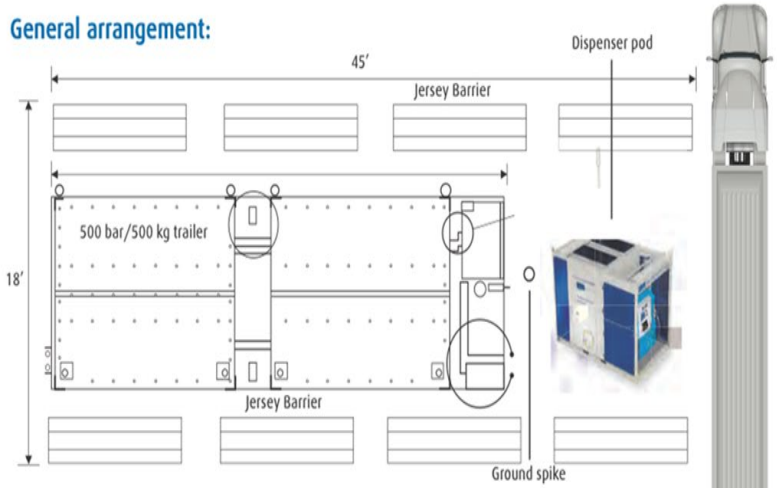
- August 2022 – 4 Fuel Cell Electric Buses (FCEB) Ordered
- January 2023 - Plug Power Liquid Hydrogen Trailer Ordered
- April 2023 - Additional FCEBs ordered, totaling 5 buses
- November 2023 – Staff rejects completing the purchase of the Hydrogen Liquid Trailer – Financial instability
- January 2024 – 1st FCEB arrives, RTD contracts with AC Transit to fuel FCEBs at Emeryville
- September 2024 – Linde Hydrogen Gaseous Trailer placed at RTC & begins fueling FCEBs
- October 2024 – Safety concerns required removal of Linde unit pending repairs
- May 2025 – Major issues resolved with the Linde Dispenser unit placed in service with no issues
- January 2026 – Component failure between the dispenser and trailer was taken out of service pending root cause analysis

RTDs Hydrogen Infrastructure Plan Phase I

Specifications

- Power requirement 110V/15A
- Integrated SAE compliant dispenser
- General footprint 18 ft x 45 ft
- Automated cascade refueling
- Fuels up to 350 bar

General arrangement:



- **PHASE I**
- RTD procures and takes delivery of 5 FCEBs in early 2024 and places them into service in mid-2024. Performance, reliability, and range data are being collected.
- RTD contracted with Kruger Transit Consulting (KTC) to assist in developing plans.
- RTD leases interim gaseous fueling infrastructure, hydrogen fuel supply, and maintenance services to support these buses for one year, testing and monitoring fueling performance with this technology.

Permit Information

Fuel Cell Electric Bus (FCEB) Operations: Permitting Successes and Lessons Learned

California Fire Code §5809 Mobile Gaseous Hydrogen Fueling – Permitting Requirements

<u>Required Documentation for all California Hydrogen Mobile Fuelers:</u>

1)Safety and Emergency Response Plan
2)Standard Operating Procedures (SOP)
3)Training records for personnel dispensing hydrogen
4)Site plan showing fueling layout and operations
5)Key Compliance Requirements: Mobile fueling areas must comply with NFPA 2 setback distances and Must adhere to California Fire Code §5809.4.1 – §5809.4.3 for mobile fueling operations

RTD successfully developed all required documentation through KTC and Linde's consultants and secured permitting approval within 4 weeks.

Mobile Hydrogen Refueling Station

Linde KTC

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Key Insights and Lessons Learned from Early Development on Mobile Fueler

- Mobile refueler supports 1–5 FCEBs at 350 bar; includes 500-bar tube trailer and PLC-controlled dispenser, start- stop button for operation
- Leased fueler arrived 45 days after contract execution, on-site with bus delivery; FCEBs operate reliably with **326-mile range**, similar to diesel hybrids
- Re-fueling occurs every 3 days; gaseous H_2 fueler now performing as designed; delivery is reliable and on schedule
- Mobile fueling remains costly as a leased solution; gaseous H_2 priced at ~$18/kg vs. ~$10/kg for liquid H_2

Mobile Fueler Upgrades

RTD worked with Linde on adopting more stringent safety protocols.

Operational Challenges

- Slow refueling: **1.5–3 hours per bus**
- ~50% fuel loss due to residual pressure
- High effective cost: **$18/kg**
- High pressure system (~5,000 psi)
- Reliability and downtime concerns

Fueling Times

Observed Fueling Performance – Gaseous System

KG Dispensed	Fuel Duration	Ambient Temp
27.37	2:44:00	92
35.705	2:30:00	90
26.035	0:50:00	55
21.875	0:45:00	55

Gaseous Fueler Pros and Cons

PROS:

- ✓ Familiar system - Already operational, staff trained
- ✓ Lower upfront capital - $180K vs. $5.9M
- ✓ Contract flexibility - Can extend to May 2027
- ✓ Proven reliability - Established vendor relationship

CONS:

- ✗ 7-year cost - $6.9M total
- ✗ 50% fuel waste - Must purchase 7,000 kg but only need 3,500 kg; ~50% inaccessible due to residual pressure
- ✗ Extremely slow refueling - 1.5-3 hours per bus (operational inefficiency)
- ✗ Not scalable - Cannot support fleet expansion efficiently
- ✗ Contract expiring - May 2026 (renewal required)
- ✗ High effective cost - $18/kg (nearly double liquid cost)
- ✗ High operating pressure - ~5,000 psi safety concerns
- ✗ Gaseous fuel availability is unknown

Liquid Mobile Fueler Pros and Cons

PROS:

- ✓ 90% faster refueling - 6-12 minutes vs. 1.5-3 hours per bus
- ✓ Lower fuel cost - $10.25/kg vs. $18/kg effective
- ✓ 100% fuel accessible - No stranded hydrogen
- ✓ Scalable to 30 buses - Supports future fleet growth
- ✓ $5M grant available - CEC EnergIIZE funding
- ✓ Pay only for consumed fuel - No wasted residuals
- ✓ 99% lower pressure - 5-130 psi vs. 5,000 psi (inherently safer)
- ✓ LCFS revenue - $100K+ annually + 40-70% HRI bonus credits
- ✓ Boil-off mitigation - 2% losses (grant-funded system included)
- ✓ Transfer loss pump included - Further reduces waste

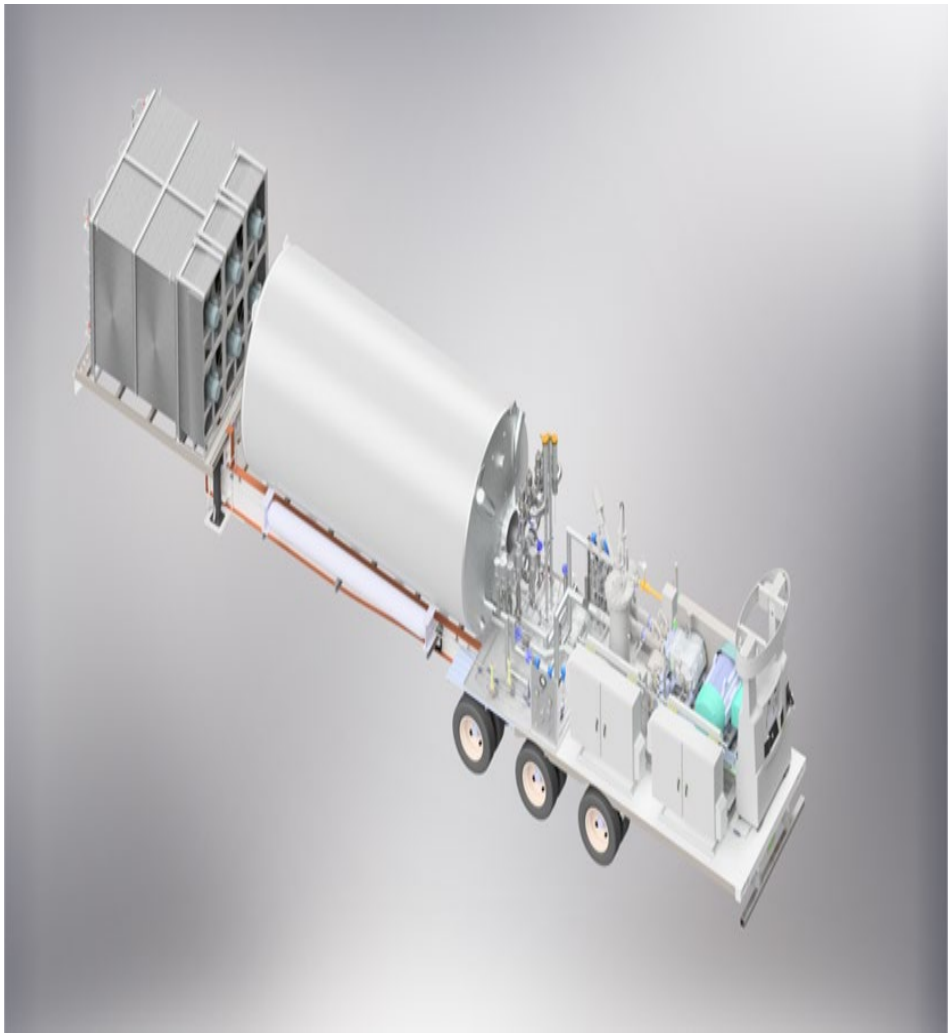
CONS:

- ✗ High upfront capital - $5,932,500 investment required ($2,450,000 boil-off + $3,482,500 trailer)
- ✗ Grant dependency - Relies on $5M CEC EnergIIZE approval
- ✗ Fleet expansion needed - Ideally requires 9+ buses to optimize utilization and minimize boil-off
- ✗ New system - Staff training required; operational learning curve
- ✗ Boil-off losses - 2% evaporation (though mitigated)
- ✗ First-of-its-kind R&D - Unproven at scale; potential technical risks
- ✗ Vendor coordination - Multiple vendors (Taylor-Wharton, Stirling, Nikkiso, GenH2, etc.)

RTDs Hydrogen Infrastructure Plan Phase II

Phase II focuses on implementing a mobile liquid fueling solution and facility upgrades

- As part of Phase II, RTD staff is currently engaged in obtaining grant funding for the retrofit and upgrade of Maintenance Shop
- Originally, a portable repair tent was proposed, but due to cost staff decided to pursue funding for the shop retrofit.
- The Grants Department is actively engaged in pursuing a variety of funding opportunities for this retrofit.



Fleet Strategy

- Pause BEB and FCEB purchases until FY2028
- Invest in hybrid buses as an interim solution
- Maintain a mixed fleet (BEB, FCEB, Hybrid)
- Evaluate performance, cost, and reliability

Key Takeaways

- Gaseous system has operational and cost limitations
- Liquid fueling improves efficiency and scalability
- Grant funding reduces capital risk
- Phased approach supports data-driven decisions

RTDs Hydrogen Infrastructure Plan

Thank you!