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Beyond Compliance:

Developing an Implementable Zero-Emission Bus Transition Strategy for a Rural Transit Agency

Bincy Koshy | Transportation Planner

RABA ZEB Implementation Plan • Project Team: DKS

PRESENTATION OVERVIEW

Project Background

Approach

Scenario Planning

Implementation Pathway

Community & Environmental Benefits

Key Lessons

PROJECT BACKGROUND

Redding Area Bus Authority (RABA)

- **53 vehicles** (16 transit buses, 2 coaches, 28 cutaways, 7 non-revenue)
- **13 fixed routes** serving Redding, Anderson, Shasta Lake & County
- **Key facilities:** Downtown Redding Transit Center + Maintenance Depot
- **2019:** First Proterra BEB added

Funded by Caltrans Sustainable Transportation Planning Grant Program

THE CHALLENGE

California said: “100% ZEB by 2040.” Now what?

2026–28	25% of new purchases must be ZEB - starting now
2029+	100% of new purchases must be ZEB
2040	Entire fleet must be zero-emission

CARB

Per the ICT mandate adopted in 2018, all public transit agencies are gradually required to transition to 100% ZEB fleet by 2040.

HOW WE APPROACHED IT

Key Principle

Don't commit to a single technology. Model uncertainty, match technology to route characteristics, and build a plan that stays viable as costs evolve.

Key Challenge

H_2 fuel costs, battery improvements, and ZEB pricing 8-10 years out are all uncertain - so the plan must be flexible.

A structured decision framework - not a one-size-fits-all answer!

HOW WE APPROACHED IT

1

Understand the Fleet

Data collection, existing conditions: vehicles, routes, facilities

2

Analyze Each Route

Mileage, layover time, terrain per route

3

Evaluate Technologies

BEB vs FCEB: range, cost, risk

4

Model Scenarios

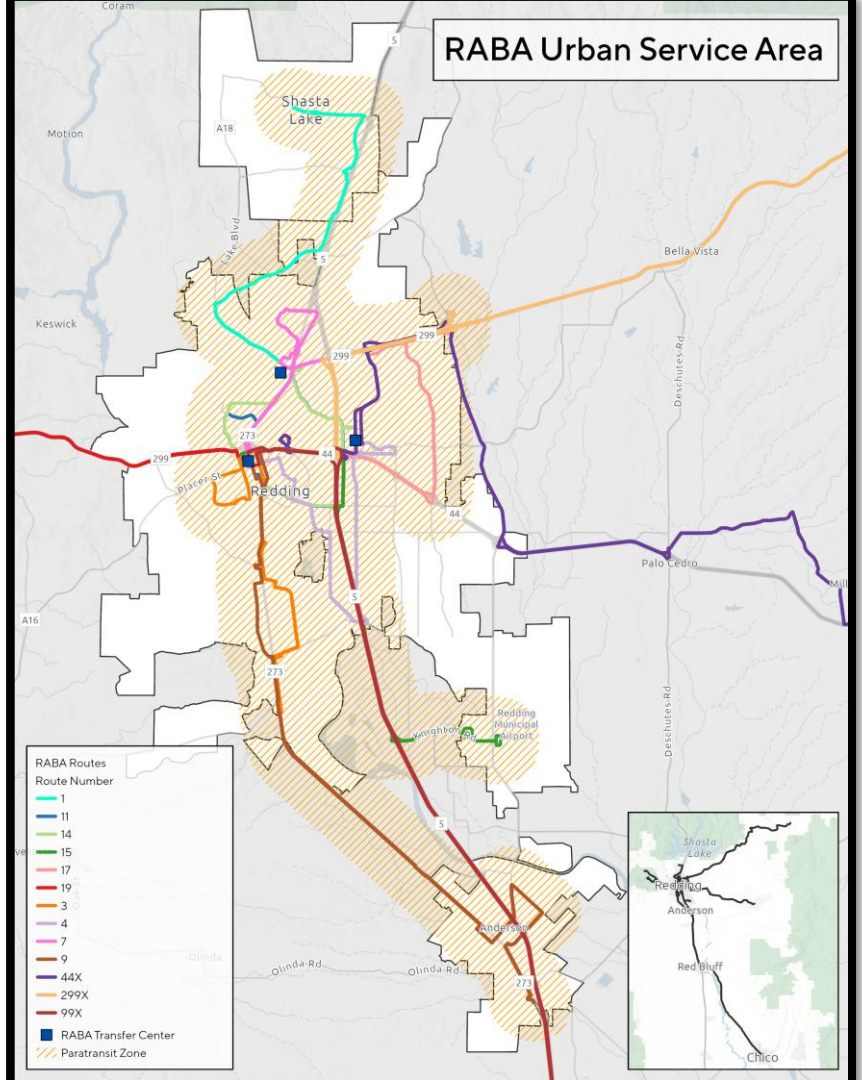
4 alternatives with full cost analysis

5

Build the Roadmap

Phased plan matching budget & fleet lifecycle

Stakeholder and Public Engagement



ROUTE ANALYSIS REVEALED...

Not All Routes Are Equal

BATTERY-ELECTRIC SUITED — RABA Routes 1, 4, 7, 11, 14, 15, 17, 19

Moderate to high daily energy demand ✓ Mid-day layover charging at DRTC ✓ Sufficient dwell time for inductive top-up charging between trips

FUEL CELL SUITED — Routes 3, 9, 99X (Amtrak)

Longer, higher speed routes with higher daily energy demand • Refuel in the evening using mobile hydrogen delivery and dispensing system • FCEBs offer 250-300 mi range from 30–50 kg H_2

This route-by-route analysis is what drove the mixed-fleet recommendation, not assumptions.

WE MODELED 4 SCENARIOS

Then asked: which survives uncertainty?

SCENARIO A

100% Battery-Electric

STRENGTHS

Simpler ops
One technology

RISKS

Highest charger cost
Grid demand risk

SCENARIO B

~25% Fuel Cell

STRENGTHS

Right tech per route
Flexibility as H_2 costs evolve
Mixed fleet increases resiliency

RISKS

Two technology streams
H_2 supply coordination

SCENARIO C

~50% Fuel Cell

STRENGTHS

Higher range buffer
Mixed fleet increases resiliency

RISKS

Higher H_2 dependency
Cost risk if H_2 stays expensive

SCENARIO D

100% Fuel Cell

STRENGTHS

Max range, zero charging infrastructure

RISKS

Highest H_2 cost exposure
Uncommon at scale for small agencies

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RECOMMENDED ✓

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Scenario B: A blended technology approach, tailored to each route's demands and built to flex as costs and conditions evolve

DECISION – MAKING

Mixed BEB + Fuel Cell Fleet

Right Tech per Route
BEBs on 8 routes with adequate layover • FCEBs on 3 demanding routes

Manages Transition Risk
Existing diesel buses serve as contingency during the phased ZEB rollout throughout 2040

Hedges Uncertainty and Enhances Resiliency
Not a single-technology - blended approach increases overall system resiliency

Cost Effectiveness and Technology Maturity
BEB's are the more mature and cost-effective technology; FCEBs are added only where operationally justified

RECOMMENDED IMPLEMENTATION PATHWAY

BATTERY-ELECTRIC (8 Routes)

Local routes 1, 4, 7, 11, 14, 15, 17, 19
Overnight depot (Maintenance Facility) + layover inductive charging (DRTC)

FUEL CELL ELECTRIC (3 Routes)

Routes 3, 9, 99X (Amtrak)
H_2 delivered to Ellis St. lot (adjacent to maintenance facility) by third-party vendor- no station build required

Routes 44X & 299X: under 14,000 lb GVWR - exempt from ICT

Two Sites • Two Technologies • One Integrated Strategy

DOWNTOWN TRANSIT CENTER (BEB layover charging)

7 inductive pads • 300 kW each • 3 power cabinets •
Charges during normal layover stops
Est. installation cost: $3.1M (across 2 phases)

MAINTENANCE DEPOT (BEB overnight + FCEB H_2)

10 DC ports • 50 kW (ceiling, under solar canopy)
1 dual-port DC fast charger • 150 kW
Est. installation cost: $1.5M (across 2 phases)
H_2 delivered to Ellis St. lot - trailer-mounted dispenser

COST SUMMARY & PHASED APPROACH

$14.6M
Total Bus Purchases
BEB + FCEB combined

$4.6M
Infrastructure Deployment
Charging + H_2 setup

$640K–$1.1M
Annual Fuel Costs
Electricity + Hydrogen (Purchases)

2040
100% ZEB Deadline
Per ICT Regulation

INFRASTRUCTURE PHASING

PHASE 1 | 2025–2033

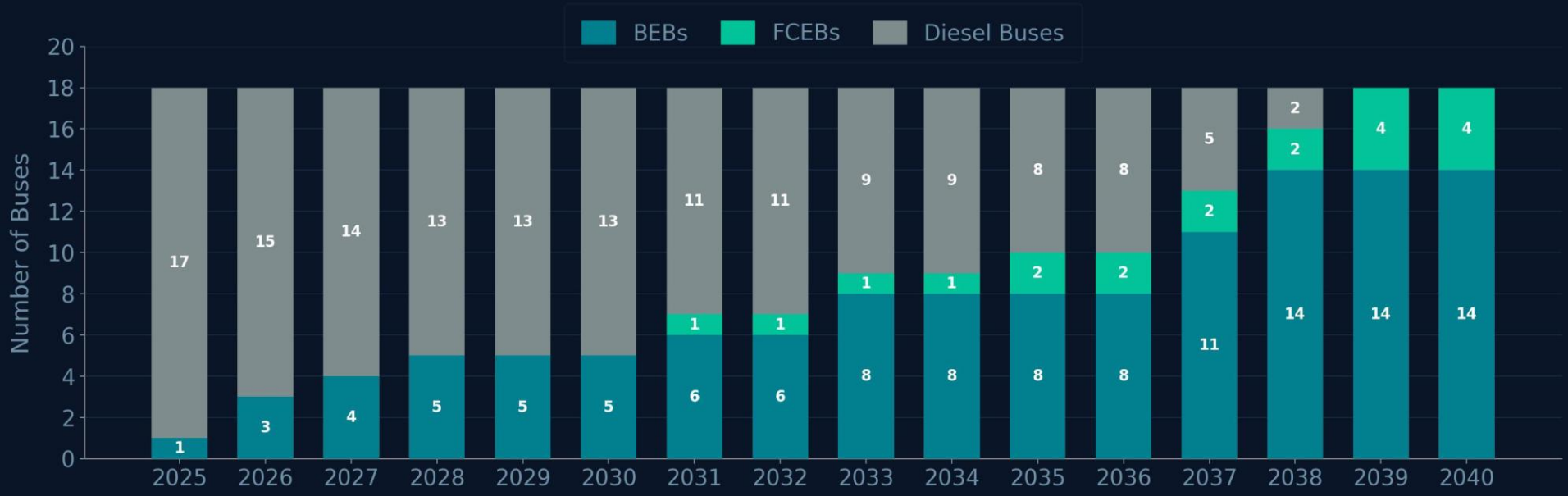
- **Depot:** 6 of 10 DC chargers (50 kW each)
- **DRTC:** 4 inductive charging pads (up to 300 kW each)
- **Fleet:** Begin BEB fleet replacement per schedule

PHASE 2 | 2034+

- **Depot:** 4 additional DC depot chargers
- **DRTC:** 3 more inductive pads (total: 7)
- **Fleet:** Full BEB + FCEB fleet transition to 100% ZEB

FLEET TRANSITION • THE NUMBERS

From 1 BEB Today → 18 ZEBs by 2040



2026: 25% new ZEB

2029: 100% new ZEB

2040: 100% ZEB Fleet

COMMUNITY & ENVIRONMENTAL BENEFITS

Equity Insight: Areas along RABA's core transit corridors have the highest concentrations of residents below the poverty line (>30%) and stand to benefit most from the ZEB transition through reduced pollution and cleaner and quieter transit service.

Air Quality

No CO, lead, NO_x, ozone, particulate matter, or SO_2 from tailpipes - reducing risk of respiratory illness, cancer etc.in Shasta County.

Environmental Justice

Core RABA corridors serve neighborhoods with highest poverty rates - these communities benefit most from cleaner, quieter transit.

Climate Action

No GHG emissions from bus operations - directly addressing wildfires, drought, and extreme heat impacts in the region.

Workforce Development

Staff training via FTA, APTA & CTE programs plus manufacturer courses to address ZEB skill gaps and wage competitiveness.

KEY LESSONS FOR RURAL TRANSIT AGENCIES

01

Plan for Flexibility

H_2 costs & battery improvements are unknowable. Mixed BEB/FCEB keeps options open.

02

Analyze Route by Route

Layover time, daily miles & terrain drive technology selection - not agency-wide assumptions.

03

Engage Your Utility Early

Early conversations with REU surfaced REU's demand charges ($21.50/kW), which became one of the key inputs shaping the charging strategy

04

Phase Your Infrastructure

Match charger installations to fleet growth. Avoid stranded assets in a resource-constrained agency.

05

Train & Prepare Staff

Train staff on ZEB technologies using FTA, APTA, CTE, and manufacturer resources.

06

Build on What You Have

Solar canopy at depot, Ellis St. for H_2 delivery - leveraging existing assets cut infrastructure costs.

Thank You!

Bincy Koshy | Transportation Planner
Email Address | bincymkoshy018@gmail.com

Project team: DKS • *Funded by Caltrans SCS Grant*

FULL REPORT & RESOURCES

Mass Transit Magazine | RABA Website | https://www.rabaride.com

777 Cypress Ave, Redding, CA 96001 • (530) 241-2877

Questions?