Caltrans initiatives and goals contributing to the ZEHTRANS vision and mission

**ZEHTRANS**

**Vision**
Competitive and equitable zero-emission rail in California

**Mission**
Work in partnership across government, communities, and industry to transition to a zero-emission rail system supportive of a sustainable, carbon neutral economy.

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**Become an innovation leader in ZE rail vehicles**

**Partnership**
- Lead innovative initiatives in ZE rail vehicles
- Integrate state-wide efforts to accelerate rail projects
- Coordination and cooperation through ZEHTRANS, particularly for rail
- Strive to facilitate coordination between agencies to achieve transition to ZE

**Transition**
- Develop and propose strategies to achieve ZE intercity rail fleet by 2035
- Implement operational efficiencies to reduce emissions
- Continually reduce emissions with equipment upgrades, renewable fuels, and ZE technologies
- Provide technical assistance

CARB ZE Seminar | Draft ZE strategy for intercity fleet | October 29, 2020
Caltrans Owns the Equipment for Three Intercity Passenger Rail Corridors – Services Are Managed by Regional Joint Powers Authorities

California’s Intercity Passenger Rail

San Jose
Los Angeles
San Diego
Bakersfield
Sacramento
San Luis Obispo
Oakland
San Jose
Fresno
Stockton
Auburn
Sacramento
Fresno
Stockton
Auburn
Sacramento
San Luis Obispo
Oakland
San Jose
Fresno
Stockton
Auburn
Sacramento
San Luis Obispo
Oakland
San Jose

Focus of our zero-emission (ZE) strategy

Intercity diesel-electric locomotive fleet

F59PHI (EMD)
Year introduced: 1991 / 2001
Emission standard: Tier 2

SC-44 (SIEMENS)
Year introduced: 2017
Emission standard: Tier 4
Become an Innovation Leader in Zero-Emission Mobility
Contributing to a livable environment
Strategic Goals for Our Intercity Fleet to Become an Innovation Leader in Zero-Emission Mobility

Decarbonizing our transportation system and improving our air quality
– Substitute fossil with renewable energy, thereby reducing GHG emissions
– Pilot and deploy hydrogen-hybrid motive power vehicles to achieve zero-emissions – as an intermediate solution, and consider adding batteries to the existing diesel trains

Increasing our energy efficiency
– Invest in technology and procedures to enable energy-efficient driving as well as regenerative braking
– Invest in ground power for expanded use at layover facilities
– Invest in energy efficient railcars, reducing HEP\(^1\) requirements

Fostering leadership and facilitating collaboration in sustainable mobility
– Lead and promote pioneering initiatives in zero-emission vehicles
– Integrate state-wide efforts to accelerate implementation
– Engage in public outreach and promote the benefits of rail to encourage modal shift and increase load factor (thereby decreasing emissions per passenger mile)

(1) HEP = head-end power (e.g. for HVAC, lighting)

Develop Strategies to Reduce GHG and criteria pollutants by 2035

100%
Reduction of fuel usage per train mile by 2030
35%
Work with passenger rail agencies to coordinate zero-emission action plan by 2021
Our Goal: Develop Strategies to Achieve a 100% Emission-Free Intercity Fleet by 2035 - Taking the Lead Among Other Modes of Transportation

100% emission reduction targets

<table>
<thead>
<tr>
<th>Year</th>
<th>Light-duty vehicles</th>
<th>Medium- and heavy-duty vehicles</th>
<th>Buses</th>
<th>Intercity rail</th>
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EO N-79-20:
- In-state sales of new passenger cars and trucks 100% ZE from 2035

EO N-79-20:
- Trucks fully ZE by 2045 wherever feasible

Innovative Clean Transit Regulation:
- New buses ZE from 2029 onwards
- Bus fleets of public transit agencies fully ZE by 2040

Caltrans-DRMT\(^4\) goal:
- Develop and Propose Strategies to achieve fully ZE Intercity fleet by 2035\(^3\)

(1) No intermediate targets (linear interpolation)  (2) No fleet-wide target  (3) Develop Strategies for Off-Road Vehicle to achieve ZE by 2035 per EO N-79-20  (4) DRMT = Division of Rail and Mass Transit

Sources: CARB, Caltrans, Governor’s office

CARB ZE Seminar | Draft ZE strategy for intercity fleet | October 29, 2020
# Primary Power for Caltrans Intercity Fleet: Renewable Diesel to Reduce Emission and Hydrogen to Achieve Zero-Emission

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- **Status quo**
  - Emission targets cannot be achieved even with after-treatment systems

- **Feasible**
  - Emission reduction compared to regular diesel, likely transition technology, limited modifications needed

- **Impractical**
  - Possibly transition technology but requires new refueling infrastructure and motive power modifications

- **Preferred**
  - Most suited option according to initial analysis

- **Impractical** (as stand-alone)
  - Suited for hybrid solution but not suitable as sole power source for intercity due to long range requirements

- **Not feasible** (system-wide)
  - Electrification requires large capital investment and has ROW<sup>1</sup>-implications but can be utilized where available in dual-mode.

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<sup>1</sup> ROW = Right of Way
<sup>2</sup> Considering system-wide electrification

Source: DB assessment

**Rating:**  
- Excellent  
- Good  
- Mediocre  
- Inferior  
- Requirements not fulfilled

CARB ZE Seminar | Draft ZE strategy for intercity fleet | October 29, 2020
Hybrid Solutions Create More Options: Hydrogen-Hybrid with Batteries and Dual-Mode Capability Using Electrification Where Available

Assessment of hybridization options for Caltrans intercity fleet

| Primary power source | Secondary power source | Utilization of existing OCS
|----------------------|------------------------|-----------------------------
| Diesel               | Diesel                 | 1                           |
| Ren. Diesel          | Ren. Diesel            |                             |
| Hydrogen             | Hydrogen               |                             |
| Batteries            | Batteries              |                             |
| Electrification      | Electrification        |                             |

Explanation

- A hybrid powertrain has at least two power sources.
- Various combinations are possible:
  - **Energy storage hybrids.** Primary powerplant combined with on-board energy storage (e.g. hydrogen fuel cell and batteries).
  - **Dual-mode.** Power provision from wayside infrastructure and on-board generation (e.g. OCS electric and diesel, OCS electric and hydrogen fuel cell).
- Hydrogen ($H_2$) and batteries enable significant energy reduction while achieving ZE goals.
- Hydrogen and dual-mode capability enable use of existing OCS infrastructure.

Intermediate solution: Blend of fossil and renewable diesel
Long-term solution: Utilization of existing or planned electrification

Notes:
1. Blend of fossil and renewable diesel
2. Utilization of existing or planned electrification
3. OCS = Overhead Contact System, wayside electrification

Preferred solution: Hydrogen-hybrid dual-mode
Driving toward Zero-Emission Caltrans Intercity Rail: Start with Energy Efficiency Measures, Followed by Engine Upgrades and Renewable Diesel, and Hydrogen Powered Trains

2020 -2021
Develop and adopt ZE strategy in accordance with EO-N79-20
Set goals and provide a structured approach to move towards ZE, incl. setting technological cornerstones

2022
Implementation of short-term measures
Implement energy efficiency measures and increase the use of ground power

2025
Use of renewable diesel for entire fleet
Upgrade aftertreatment systems and use renewable diesel only; complete first intercity hydrogen pilot

2030
Shift to ZE for parts of the fleet
Intercity fleet average will be Tier 4 or higher and parts of the fleet are zero-emission

2035
Zero-emission fleet
All motive power vehicles use zero-emission primary energy source

Emission reduction per train mile compared to 2020 levels: GHG Criteria pollutants

-25% -15% -50% -45% -75% -90% -100%

(1) Adjustment of strategy possible, if technological breakthrough occurs
(2) Retrofitting existing F59 locomotive with H₂ powertrain – if successful, consideration of rollout to remaining motive power equipment
(3) Currently, hydrogen-hybrid (hydrail) is the best option, supplemented with dual-mode where feasible
(4) Achieving remaining reduction in emissions is even more challenging (similar to the transition from Tier 3 to 4, to 5)
The presented strategy could be used as a blueprint for other passenger railways.

Joint efforts in the development and deployment of zero-emission motive power possible, enabling synergies.

Caltrans strives to lead efforts towards an integrated, statewide zero-emission rail network in collaboration with other railway and infrastructure agencies.