CLEAN FUELS PROGRAM ADVISORY GROUP AGENDA
SEPTEMBER 17, 2026, 9:00 AM – 4:00 PM
South Coast AQMD, Room GB
21865 Copley Drive, Diamond Bar, CA 91765

TELECONFERENCE LOCATION

A meeting of the South Coast Air Quality Management District Clean Fuels Program Advisory Committee will be held at 9:00 a.m. on Thursday, September 17, 2026, through a hybrid format of in-person attendance in the South Coast AQMD, 21865 Copley Drive, Diamond Bar, CA 91765, and remote attendance via videoconferencing and by telephone. Please follow the instructions below to join the meeting remotely. Please refer to South Coast AQMD's website for information regarding the format of the meeting, updates if the meeting is changed to a full remote via webcast format, and details on how to participate:

INSTRUCTIONS FOR ELECTRONIC PARTICIPATION

Join Zoom Webinar Meeting - from PC or Laptop
https://aqmd.zoomgov.com/j/1601382674
Zoom Webinar ID: 160 138 2674
Teleconference Dial In: +1 669 254 5252
One tap mobile: +16692545252,1601382674#

Audience will be allowed to provide public comment through telephone or Zoom connection.

INSTRUCTIONS FOR ELECTRONIC PARTICIPATION AT BOTTOM OF AGENDA

AGENDA

Members of the public may address this body concerning any agenda item before or during consideration of that item (Gov't. Code Section 54954.3(a)). If you wish to speak, raise your hand on Zoom or press Star 9 if participating by telephone. All agendas for regular meetings are posted at South Coast AQMD Headquarters, 21865 Copley Drive, Diamond Bar, California, at least 72 hours in advance of the regular meeting. Speakers may be limited to two (2) minutes each.

Please note that under the California Public Records Act (Gov't. Code § 7920.000 et seq.) your written and oral comments, attachments, and associated contact information (e.g., your address, phone, email) become part of the public record and can be released to the public on request or posted on the South Coast AQMD website.

Breakfast (GB Conference Room)
8:00 AM – 9:00 AM

Welcome & Overview
9:00 AM – 10:30 AM

(a)	Welcome and Opening Remarks	Vasileios Papapostolou, Sc.D., Technology Demonstration Manager* & Mei Wang, Assistant Deputy Executive Officer*
(b)	SB 707 Updates: Vote to Allow Non-elected Members of the Advisory Group to Participate Remotely Without Using the Traditional Brown Act Requirements Pursuant to SB 707 (Motion Required)	Sheri Hanizavareh, Principal Deputy District Counsel**
(c)	Goals for the Day	Vasileios Papapostolou, Sc.D.
(d)	Updates on Grants and Incentives	Mei Wang
(e)	Status Update on Attainment Planning and Facility-Based Measures	Ian MacMillan, Assistant Deputy Executive Officer***
(f)	Elemental Trucks and the Pursuit of Gradeability and Payload in Hydrogen Fuel Cell Electric Vehicles	Jamie Ally, Ph.D., Chief Executive Officer, Elemental Trucks, Inc.

(g) Feedback and Discussion — Advisors and Experts

(h) Public Comment (2 minutes/person)

1. Lighting off the Commercial Hydrogen Market
Moderator - David Park, Hydrogen Fuel Cell Partnership
10:30 AM – 12:00 PM

(a) Conversational Roundtable Panel – Participants:

- Jamie Ally, Ph.D., Chief Executive Officer, Elemental Trucks, Inc.
- Greg Bermoy, Operations Manager, Savage Services Co.
- Ryan Clayton, Head of Sales – Commercial Vehicle, Hyundai Translead
- Lewis Fulton, Ph.D., Co-Director of Energy Futures Program – Institute of Transportation Studies, University of California, Davis
- Leslie Goodbody, Staff Zero-Emission Vehicle Infrastructure Specialist, California Air Resources Board
- James Kast, General Manager of Hydrogen, Iwatani Corporation of America
- Lilian Liu, Program Manager, Hydrogen and Fuel Cell Market Development, California Governor's Office of Business and Economic Development
- Jason Nunamaker, Fuel Cell Solutions Manager, Toyota Motor North America, Inc.
- David Perzynski, Assistant Manager, Hydrogen Fuel Cell Business, American Honda Motor Company, Inc.
- Leela Rao, Ph.D., Manager of Air Quality Practices, Port of Long Beach
- Jeffrey Reed, Ph.D., Senior Fellow, Clean Energy Institute, University of California, Irvine
- Eugene Reyes, Head of Commercial Partnerships – North America Hydrogen Mobility, Shell Low Carbon Solutions, Shell USA, Inc.
- Zisimos Toumasatos, Ph.D., Assistant Researcher, Center for Environmental Research & Technology, University of California, Riverside
- William Zobel, Senior Director, Hydrogen and Infrastructure, Pilot Travel Centers LLC

(b) Feedback and Discussion — Advisors and Experts

(c) Public Comment (2 minutes/person)

Lunch
12:00 PM – 1:30 PM

2. Advancing Hydrogen Technologies for Heavy-Duty Transportation
Moderator – Maryam Hajbabaei, Ph.D., Program Supervisor*
1:30 PM – 3:00 PM

(a)	Clean Power Without the Cost: Liquid Organic Hydrogen Carrier for Trucks, Ports, and Stationary Load	Sayandeep Biswas, Ph.D., Chief Executive Officer and Co-Founder, LNK Energies, Inc.
(b)	The Battery-Free Fuel Cell Coach: Bench test results from a first-of-a-kind heavy duty fuel cell engine	Jackson Danis, Engineering Services Manager, Center for Transportation and the Environment
(c)	Savage's Path to Zero: Advancing Toward a Zero-Emission Operation by 2028	Greg Bermoy, Operations Manager, Savage Services Co.
(d)	H2-ICE as a Near-Zero Pollution Reduction Pathway	Zisimos Toumasatos, Ph.D., Assistant Researcher, University of California, Riverside

(e)	Feedback and Discussion	Advisors and Experts
(f)	Public Comment (2 minutes/person)	

Break (Networking/Coffee)
3:00 PM – 3:20 PM

3.	**Wrap-up** **3:20 PM – 4:00 PM**	
(a)	2027 Clean Fuels Plan Update & Wrap-up	Vasileios Papapostolou, Sc.D.
(b)	Advisor and Expert Comments	All
(c)	Public Comment (2 minutes/person)	

* South Coast AQMD Technology Advancement Office
** South Coast AQMD Legal Office
*** South Coast AQMD Planning, Rule Development and Implementation Division

Other Business
Any member of the Advisory Group, or its staff, on his or her own initiative or in response to questions posed by the public, may ask a question for clarification; may make a brief announcement or report on his or her own activities, provide a reference to staff regarding factual information, request staff to report back at a subsequent meeting concerning any matter, or may take action to direct staff to place a matter of business on a future agenda.
(Gov't. Code Section 54954.2)

Public Comment Period
At the end of the regular meeting agenda, an opportunity is provided for the public to speak on any subject within the Advisory Group's authority that is not on the agenda. Speakers may be limited to two (2) minutes each.

Americans with Disabilities Act
Disabilities and language-related accommodations can be requested to allow participation in the Clean Fuels Program Advisory Group meeting. The agenda will be made available, upon request, in appropriate alternative formats to assist persons with a disability (Gov't Code Section 54954.2(a)). In addition, other documents may be requested in alternative formats and languages. Any disability or language- related accommodation must be requested as soon as practicable. Requests will be accommodated unless providing the accommodation would result in a fundamental alteration or undue burden to the South Coast AQMD. Please contact Donna Vernon at (909) 396-3097 from 7:00 a.m. to 5:30 p.m., Tuesday through Friday, or send the request to dvernon@aqmd.gov.

Reasonable Accommodations for Remote Participation by Members of this Brown Act Body
All public meetings held pursuant to the Brown Act must adhere to certain procedures to assist in processing requests for reasonable accommodations for remote participation by Board and Committee Members, and Members of other Brown Act bodies, consistent with the Americans with Disabilities Act of 1990 (42 U.S.C. Section 12132) and Government Code section 54953.8. Specifically, Board and Committee Members, or other Members of a Brown Act body, who have a disability within the meaning of the ADA, may request a reasonable accommodation to participate remotely in a public meeting in lieu of in-person attendance. Such requests must be made pursuant to the procedure set forth in South Coast AQMD Administrative Code Section 30.17 (Policy for Reasonable Accommodation and Remote Participation) and must be submitted in writing to the Chair of the Board or Committee, or Chair of the other Brown Act Body, copying the Clerk of the Boards and the Deputy Executive Officer of Administrative and Human Resources. In the event that the Chair requests an accommodation, that request must also be submitted to the Vice Chair for approval.

Document Availability
All documents (i) constituting non-exempt public records, (ii) relating to an item on an agenda for a regular meeting, and (iii) having been distributed to at least a majority of the Committee after the agenda is posted, are available by contacting Donna Vernon at 909-396-3097, or send the request to dvernon@aqmd.gov.

INSTRUCTIONS FOR ELECTRONIC PARTICIPATION

Instructions for Participating in a Virtual Meeting as an Attendee
As an attendee, you will have the opportunity to virtually raise your hand and provide public comment.

Before joining the call, please silence your other communication devices such as your cell or desk phone. This will prevent any feedback or interruptions during the meeting.

Please note: During the meeting, all participants will be placed on Mute by the host. You will not be able to mute or unmute your lines manually.

After each agenda item, the Chairman will announce public comment.

Speakers will be limited to a total of three (3) minutes for the Consent Calendar and Board Calendar, and three (3) minutes or less for other agenda items.
A countdown timer will be displayed on the screen for each public comment.

If interpretation is needed, more time will be allotted.

Once you raise your hand to provide public comment, your name will be added to the speaker list. Your name will be called when it is your turn to comment. The host will then unmute your line.

Directions for Video ZOOM on a DESKTOP/LAPTOP:

- If you would like to make a public comment, please click on the **"Raise Hand"** button on the bottom of the screen.
- This will signal to the host that you would like to provide a public comment and you will be added to the list.

Directions for Video Zoom on a SMARTPHONE:

- If you would like to make a public comment, please click on the **"Raise Hand"** button on the bottom of your screen.
- This will signal to the host that you would like to provide a public comment and you will be added to the list.

Directions for TELEPHONE line only:

- If you would like to make public comment, please **dial *9** on your keypad to signal that you would like to comment.

Vote to Allow Brown Act Teleconferencing Option Under SB 707

Teleconferencing Changes for Non-Elected Committee Members

Does not apply to Governing Board Meetings.

Does not apply to elected officials serving in an official capacity, but they can still participate in Committees remotely by using the traditional Brown Act Procedures.

Non-elected Committee Members will be able to attend Committees remotely without following the traditional Brown Act Noticing Requirements, including posting at the remote location and posting the remote location's address.

On May 1, 2026, the Governing Board made findings that allowed eligible subsidiary bodies to teleconference under these provisions.

Teleconferencing Changes for Non-Elected Committee Members

Before using this new procedure, a Committee or other subsidiary body must approve the use of teleconferencing by majority vote.

To use the new procedure, the Committee or body must designate a location where members of the public may physically attend, observe, hear, and participate in the meeting.

A member using this process must visibly appear on camera during the open portion of the meeting unless the appearance would be technologically infeasible.

If the member does not appear on camera due to challenges with internet connectivity, they must announce the reason for their nonappearance prior to turning their camera off.

Are there are any questions?

September 2026 Incentive & Grant Updates

Mei Wang

Main Incentive Programs

Carl Moyer Program

Replace HD On-Road, Construction, Ag, Marine, Cargo Handling Equipment, Locomotives and INF

Voucher Incentive Program

(for small fleets with ten or fewer vehicles)

Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program

Goods Movement Program Replace Program-Trucks, Locomotives, CHE, TRU and Shore Power

Volkswagen Environmental Mitigation Trust Program

Community Air Protection Program (supports AB 617)

Light-Duty Vehicle Replacement Program

School Buse and CNG Tank Replacement Program and INF

Commercial Electric Lawn and Garden Equipment Program

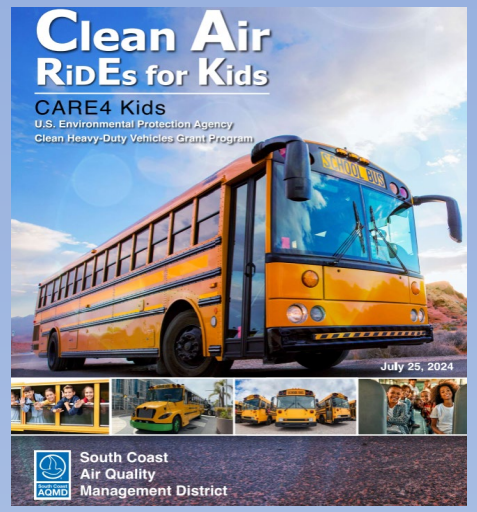
Federal Grants Incentive Programs

INVEST CLEAN

Replace Class 8 trucks, last-mile delivery vehicles, cargo Handling equipment, switcher locomotives, and install supporting charging infrastructure

Electric

Replace Class 6 and 7 Vehicles, including Box Trucks, TRU, Step Vans

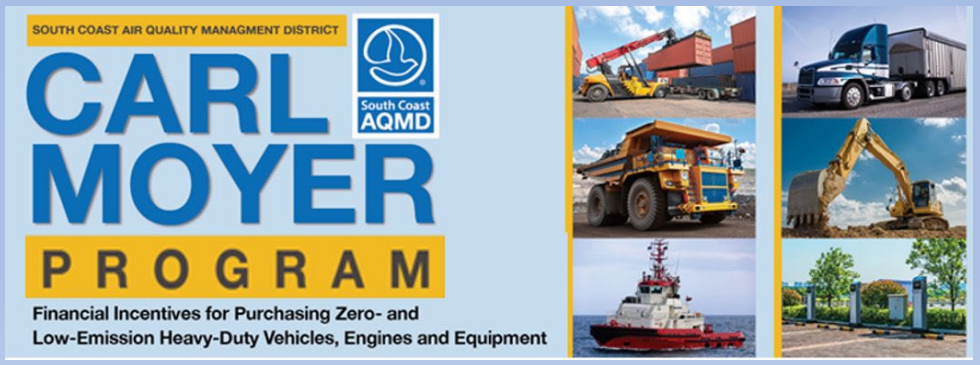


Care4Kids

Replace Class 6 and 7 School buses with ZE

Carl Moyer Program Updates

- Completed 24 years of program implementation in June 2026
  - Emissions Reduced (TPY): NOx: 9,554, PM: 271
  - Liquidated $723 million and upgraded over 9,400 engines
- Years 25 through 28 are in various stages of implementation, totaling $210 million
- Carl Moyer Guidelines revisions:
  - Flexibilities to fund new technologies
  - Higher Cost-Effectiveness limits
  - Lease-to-own (not yet finalized)
  - Other administrative flexibilities

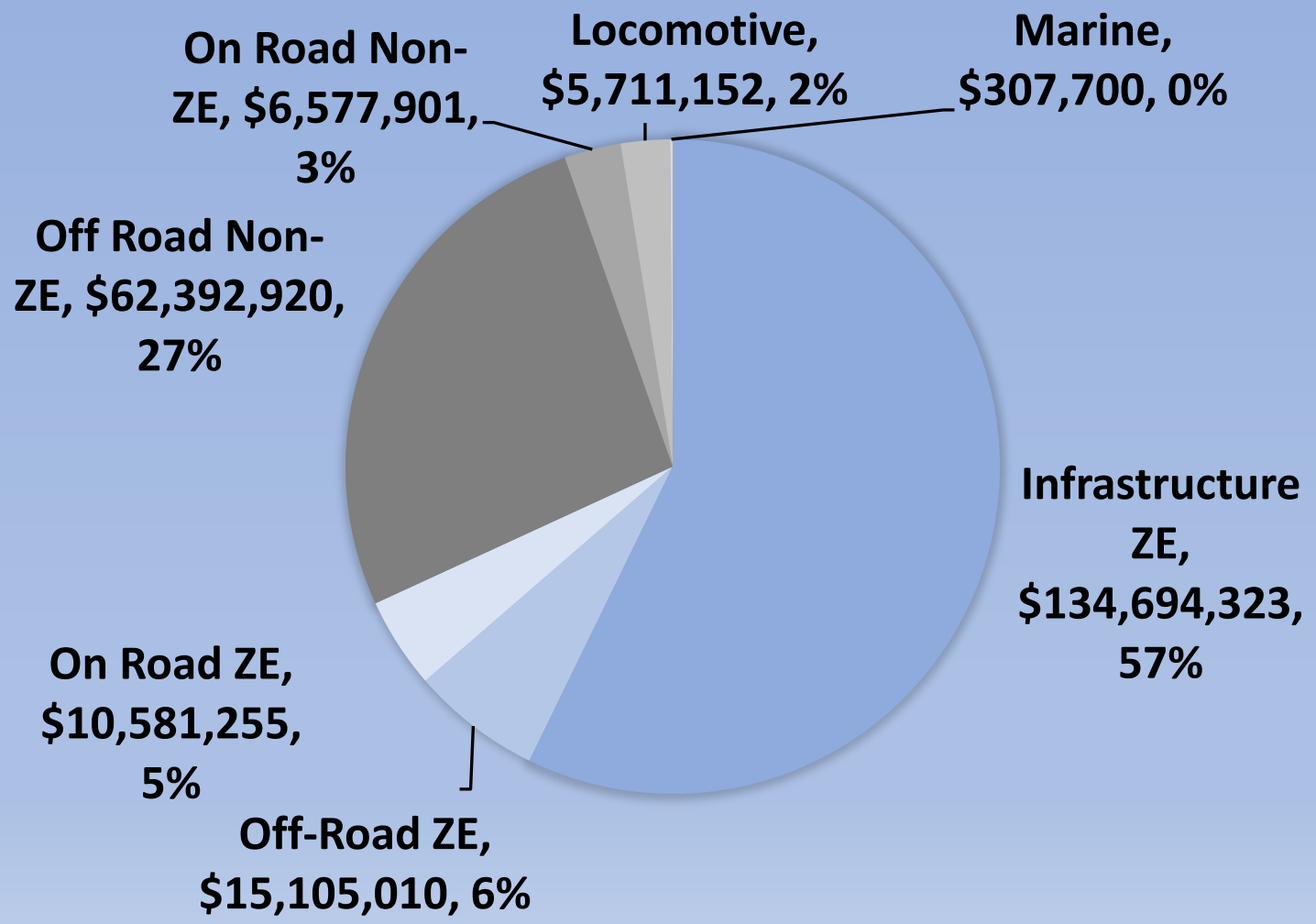


Carl Moyer Program Updates

- Most recent Carl Moyer solicitation opened in March 2025 and closed in July 2025
- Oversubscribed, with funding requested: $690 million
- Combined other available funds and awarded: $235 million in April 2026
  - Carl Moyer Funds: $123 million, combined years
  - At Berth Funds: $28 million
  - CAPP funds: $84 million

Carl Moyer Program Updates

April 2026 Board Awards Breakdown



VW Mitigation Program

- Inception in 2019
- Over 1,340 equipment/vehicle projects received, requesting $369 million
- To date, 496 eligible equipment/vehicles have been approved, totaling $88 million
- PA 2024-03 opened in March 2024
  - project categories include:
    - Combustion Freight and Marine Projects
      - Approximately $6.6M still available for Class 7/8 CNG and Marine
      - Switcher category is oversubscribed and new applications are waitlisted
    - Zero-Emission Class 8 Freight and Port Drayage Trucks (oversubscribed; new applications are waitlisted)

Proposition 1B - Goods Movement Emission Reduction Program

- Inception in 2009
- $485 Million in Funding
- Replacing Diesel Equipment
- More than 7,300 vehicles/equipment replaced
- Emissions Reduced (TPY) NOx: 7,086, PM: 220
- **Solicitation released on September 4, 2026, for locomotives, cargo handling equipment, TRUs and shore power projects (close on November 20, 2026)**
  - **$70 million available including $20 million of At berth funds**

Lower Emission School Bus Program

Since 2001, South Coast AQMD has funded over $372M to:

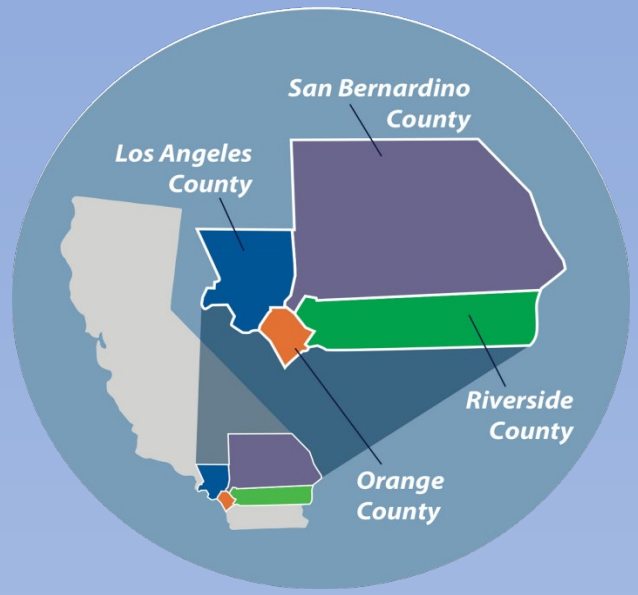
- Replaced over 1,900 diesel school buses with lower-emission CNG/Propane or zero-emission buses
- Retrofitted 3,400 diesel school buses with PM traps

2025 joint solicitation for LESBP, CARE4Kids, Carl Moyer Program and Special Revenue funds

- Awarded over 286 Zero Emission school buses and infrastructure totaling $78 million
- Over 33 public school districts applied

Replace Your Ride

- Program Inception in 2015
- Light Duty Vehicle Scrap & Replace Program
- Over 14,000 vehicles replaced and $120 million spent
- Alternative Mobility and E-Bike Options
- Average retired vehicle – 23 years old
- 88% of participants at lowest poverty level
- Up to $12,000 incentive for Zero-Emission Vehicles
- 41 tons NOx & 2.2 tons PM Reduced Annually



- Climate Pollution Reduction Grants of $500 million
  - Partnered with two Metropolitan Statistical Areas (MSAs): Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino-Ontario
- Workforce training-IBEW contract executed in December 2025
- Data collection and Validation- UCI contract executed in December 2025
- Community benefits – Third-party facilitators were selected and awarded contracts in October 2025
- Website: https://investclean.org

- Program announcements for all 4 measures released in June and September 2026
- Heavy-Duty Charging Infrastructure Program Announcement will re-issue in September 2026 and closes in January 2027

Heavy-Duty Charging Infrastructure

$191 million

Class 8 Heavy-Duty Trucks and Last Mile Freight for Class 4 and 5 Vehicles

$84 million

Battery Electric Locomotives

$199 million

Cargo Handling Equipment

$26 million

Current Awards Summary:

Measures	Number of Units	Funds Awarded
Charging Infrastructure	35 stations	$64,662,039
Class 8 Trucks	77 Trucks	$27,982,347
Cargo Handling Equipment	62 Yard Trucks 5 Top Handlers	$20,300,000
Locomotives	31 Locomotives	$190,800,000
Total		**$303,744,386**

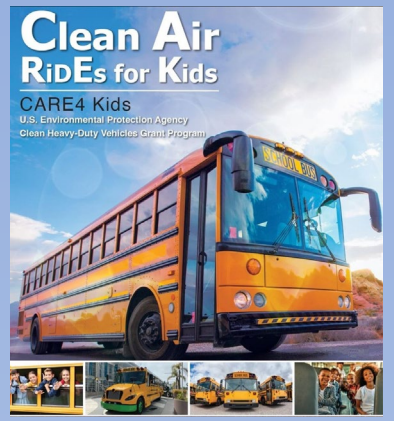
Clean Heavy Duty Vehicles Grants

ELECTRIC

- EPA awarded $33,898,522 for the replacement of Class 6 and 7 ICE freight vehicles with BEVs
- Program Announcement opened in August 2025 and closed in September 2025
  - undersubscribed

Rereleasing solicitation (pending board approval) in October 7,2025 and closed in January 15, 2027

CARE4Kids



- EPA awarded $22,180,000 for the replacement of ICE Class 6 and 7 school buses with zero-emission electric buses.
- Supporting School districts within the South Coast Air Basin
  - Replacing 74 school busses and installing 74 supporting chargers

Zero Emission Vessel Projects

- Balboa Island Ferry
  - Funded by CARB Demo Program (SHIFT) and Carl Moyer
  - Replace 3 short run ferry with ZE and Charger
- LA Lifeguard
  - Funded by EPA (CATI), Carl Moyer, CORE
  - Deploy 2 ZE work vessels
- Arc Boats w/Curtin Maritime:
  - Funded by CalSTA
  - Deploy 4 ZE ship-assist tugs
  - Charger funded separately
- In Development, ZE tug solicitation

Breathmobiles

- Deploy 2 Breathmobiles– One completed and another in progress
  - Funded by EPA (CATI), South Coast AQMD, San Bernardino County District 5, and Arrowhead Regional Medical Center (ARMC)

- EVSE upgrade

Other Funding Opportunities

Incentive Program Funds:

- South Coast AQMD WAIRE Program: ~$70 million
- INVEST CLEAN Charging Infrastructure: $120 million
- INVEST CLEAN Last-Mile Freight (SCAG): $50 million
- CARB Climate Heat Impact Response Program (CHRIP): $6 million
- RFP for Hydrogen projects: $35 million
- CARB award: large-scale deployment and demonstration of municipality medium and heavy-duty vehicles: $32 million
- US EPA Targeted Airshed Grant: $270 million

Questions

AGENDA NO. x

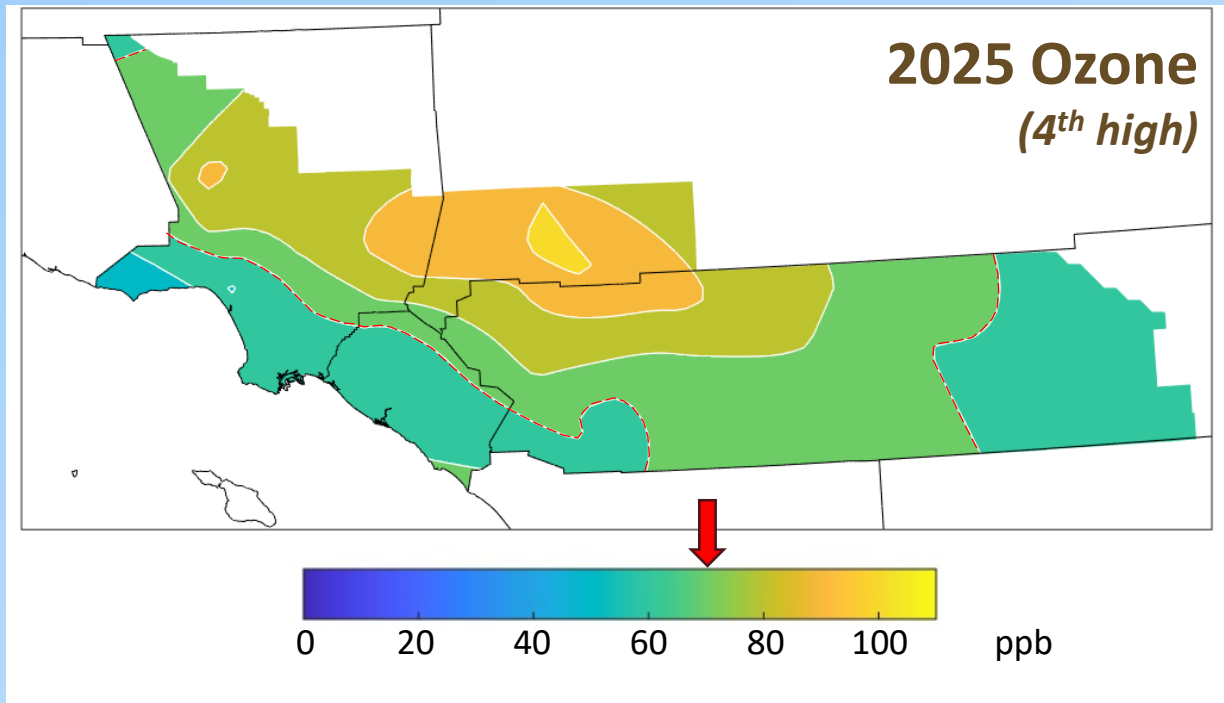
Status Update on Attainment Planning and Facility-Based Measures

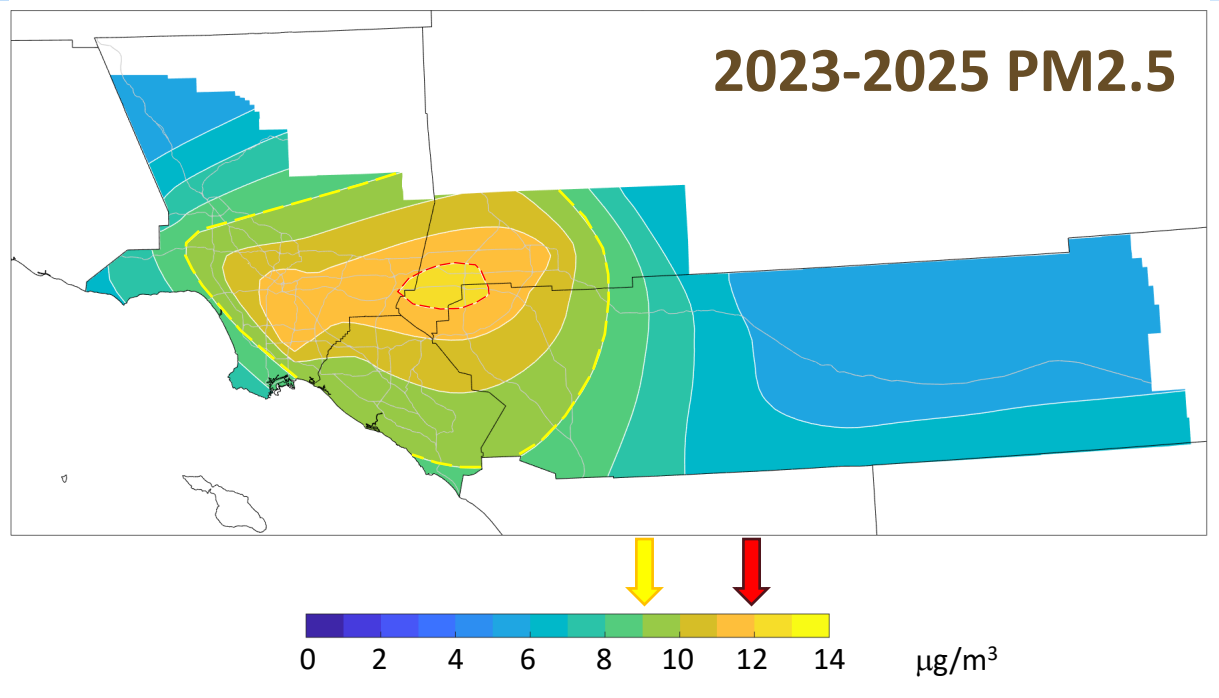
Clean Fuels Advisors Meeting

September 17, 2026

Our Greatest Air Quality Challenge

Attaining Federal Air Quality Standards





Upcoming Deadlines

Clean Air Act Requirements

- Prepare and implement air quality plans
- Attain air quality standards by set deadlines

Ozone

2027	Last Remaining Plan Element* due for 75 ppb standard
2031	Attainment Year 75 ppb standard
2037	Attainment Year 70 ppb standard

** 'Black Box' Plan that describes how previously undefined emission reduction measures will be achieved*

PM2.5

2030*	Attainment Year 12 $\mu g/m^3$ standard
2037**	Attainment Year 9 $\mu g/m^3$ standard

** If extension finalized by U.S. EPA*
*** If U.S. EPA follows most recent court decision*

Why Attaining Air Quality Standards Matters

Public Health

Annual Public Health Benefits (examples of avoided outcomes)		Annual Monetized Public Health Benefit (2025-2037)
Asthma Symptoms	830,000	$19.4 Billion
School Absences	100,000	
Asthma-Related Hospital Admissions	8,700	
Lost Work Days	69,000	
Premature Deaths	1,500	

74% of benefit from avoided premature deaths due to reduced PM2.5

Why Attaining Air Quality Standards Matters

Clean Air Act Sanctions

- Increased permitting costs by requiring 67% more emission offsets
- Loss of federal highway funding
- Federal Implementation Plan

The Importance of NOx

NOx + Other Pollutants + Weather → Ozone, PM2.5

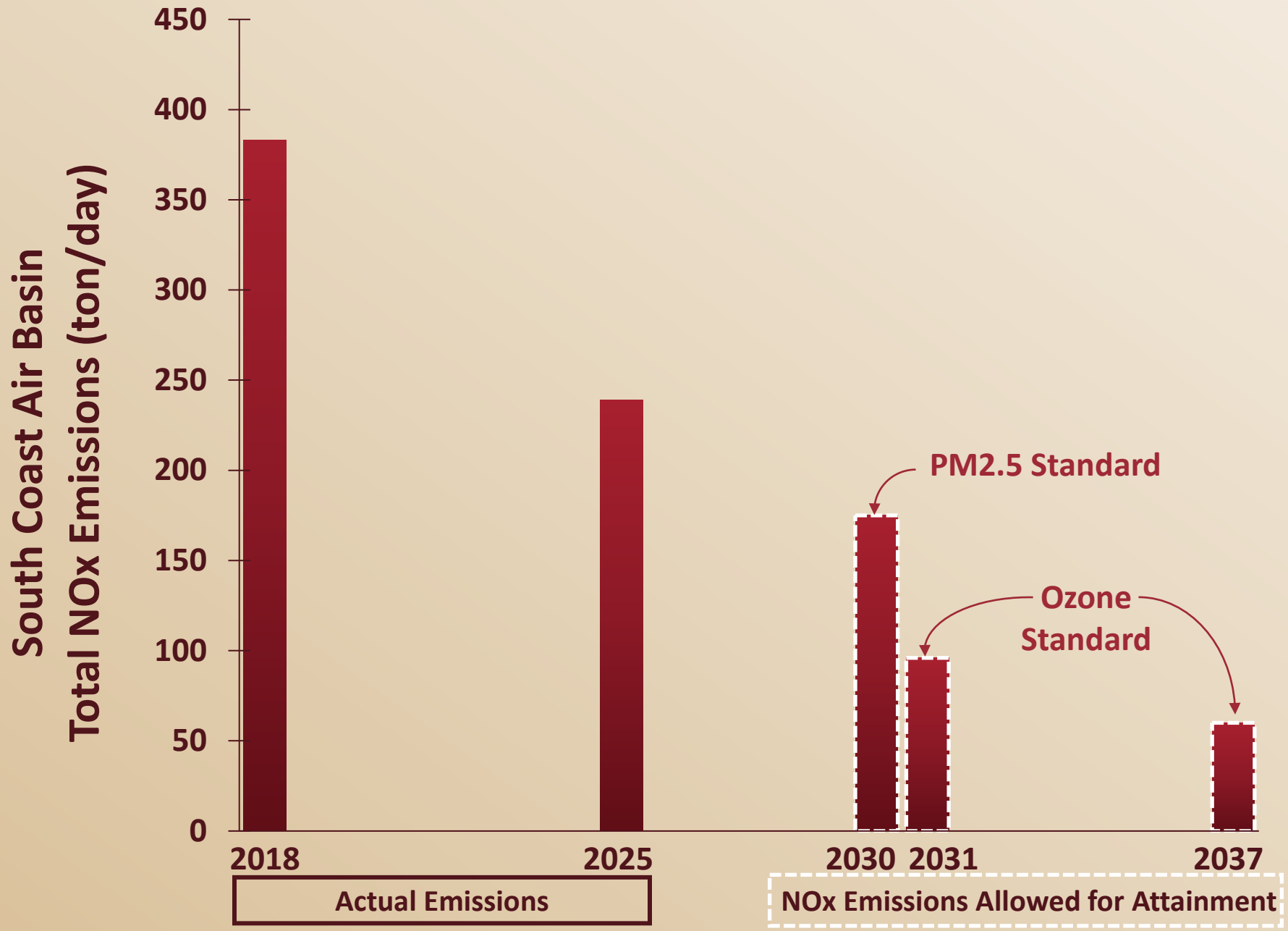
NOx is widely emitted

NOx Levels for Attainment

Ambient Air Quality Standards:

2008 & 2015 Ozone

2012 PM2.5



AQMP = Air Quality Management Plan

Regulations Affected by New Federal Policies

Most Actions Here are Either Proposed or Still in Litigation

CARB Withdrawal of Waiver Requests

- Advanced Clean Fleets
- In-Use Locomotive
- Partial: Commercial Harbor Craft
- Partial: Transport Refrigeration Unit

U.S. EPA SIP Decision

- Heavy-Duty Inspection and Maintenance (Clean Truck Check)

Loosening of Federal Rules

- Heavy-Duty Engines for 2027 and later
- Tier 4 Light-Duty Phase-In

Enacted CRA Resolutions

- Advanced Clean Cars II
- Advanced Clean Trucks
- Heavy-Duty Omnibus
- Zero Emissions Airport Shuttle Bus
- Zero Emission Powertrain Certification
- Heavy-Duty Warranty

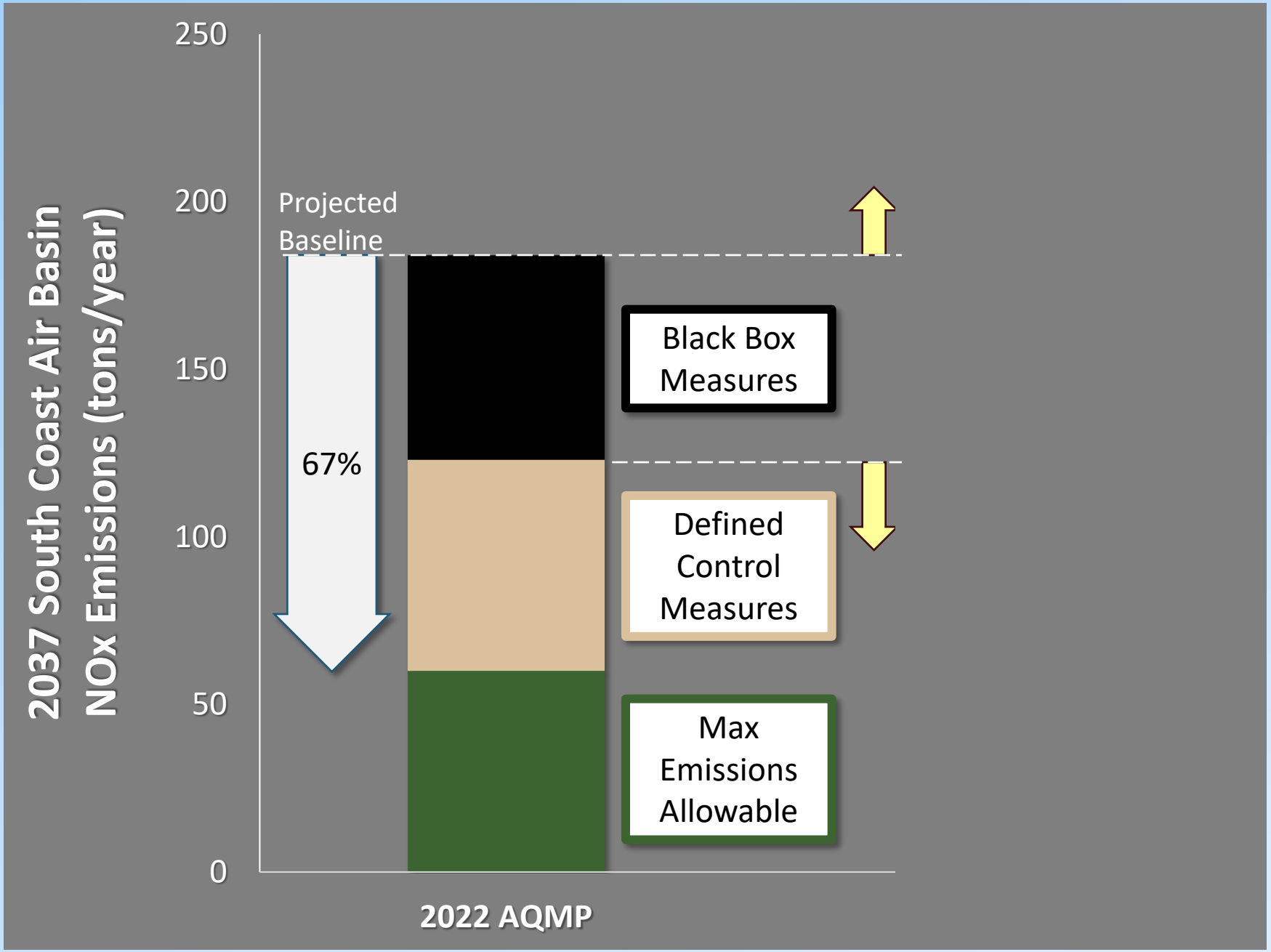
Pending CRA Resolutions

- Ocean-Going Vessels At-Berth (2022 amendments)
- Small Off-Road Engines (2022 amendments)
- Commercial Harbor Craft (2022 amendments)
- 2012 Advanced Clean Cars I emission standards
- LEV II GHG* standards for 2009 and later

CRA = Congressional Review Act, SIP = State Implementation Plan

How Big Is the Impact of Recent Federal Policy Change?

2037 Example

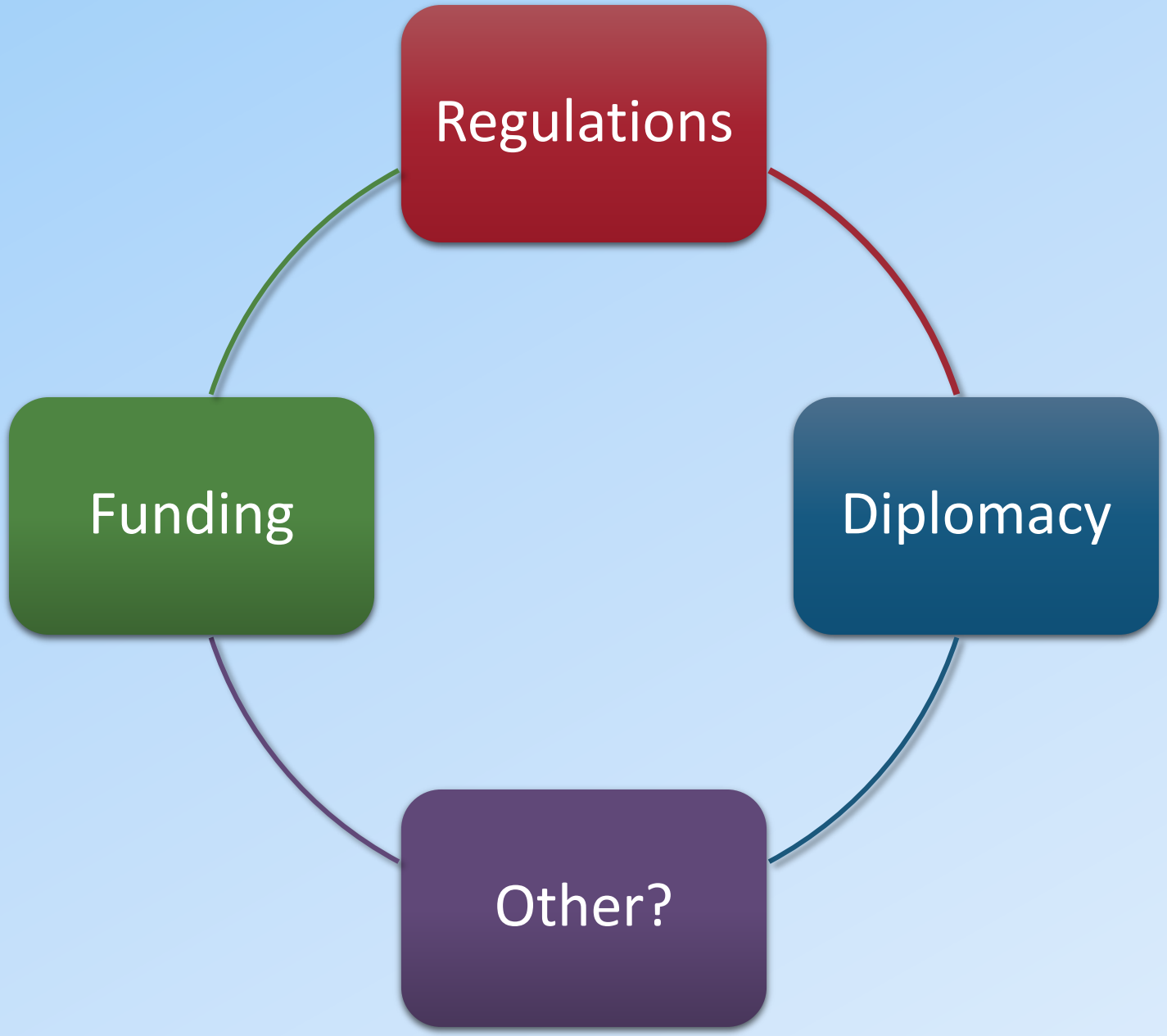


Estimates shown are subject to change with rapidly evolving policy landscape

**South Coast AQMD, CARB, and U.S. EPA are still working on these estimates*

What Tools Are Available to South Coast AQMD?

For broader discussion on this topic, see 9/10/26 Board presentation here:
[add link]



No single action can get us to attainment

Status Update Ports Cooperative Agreement (Port CA)

Infrastructure

December 2025 Cooperative Agreement

- On-port ZE infrastructure planning and implementation

+

Additional Measures

September 2026 Addendum

- Near-term actions to complement infrastructure plans:
  - Enhanced clean ship incentive
  - New ZE truck utilization incentive
  - Regional off-port infrastructure for ZE trucks

- Five-year term, beginning 12/17/2025
- Public process required
- Enforcement provisions

Port CA Measure Implementation Approval Timelines

Infrastructure

Phase 1 Plan

By December 31

Phase 2 Plan

By December 31

Phase 3 Plan

By December 31

2027 | 2028 | 2029

Additional Measures

ZE Truck Utilization Incentive

By February 28

Enhanced Clean Ship Incentive

≤12 months from start of ESI 2.0

Regional Off-Port Infrastructure

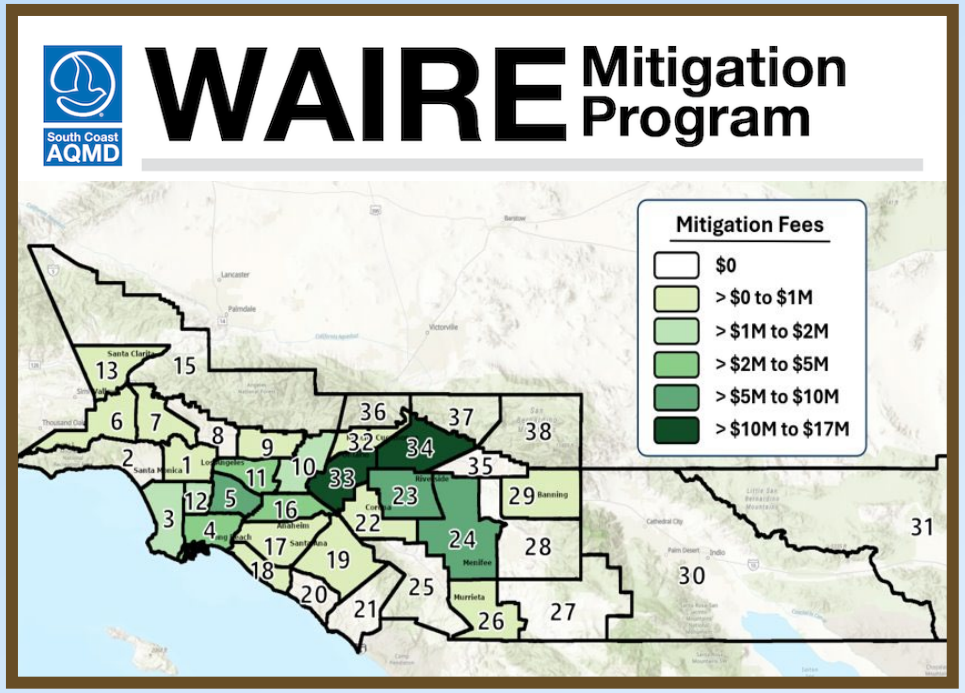
By February 28

* Draft plans/programs due for public review before Port's board approval

ESI 2.0 = Environmental Ship Index 2.0, which will start on January 1, 2027.

WAIRE Program Upcoming Activities

- Warehouse Indirect Source Rule (ISR) adopted in 2021 applies to about 4,000 warehouses
- 4th Annual Report expected mid-October 2026
- WAIRE 5-year Tech Assessment review expected mid-November 2026
- Year 1 of WAIRE Mitigation Program ($73 million)
  - Zero emission trucks, yard trucks, and charging/fueling stations
  - Application portal opens Sept. 22, 2026
  - Application submittal window Oct. 13 – Dec. 15



Contact Information

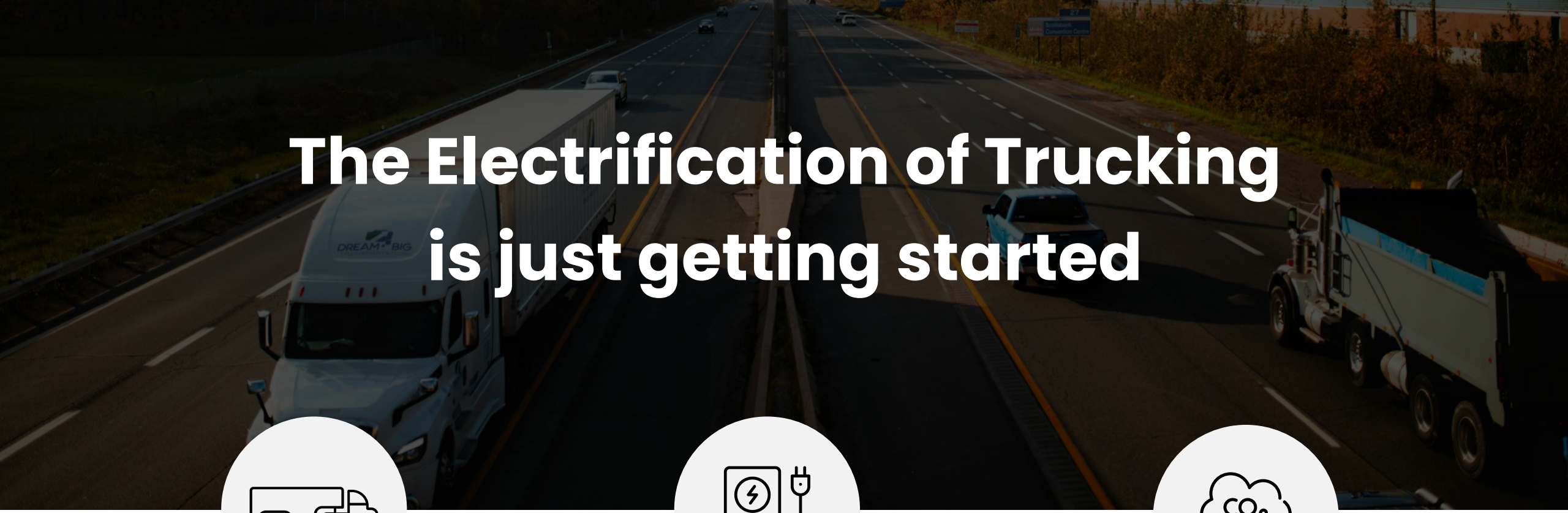
- WAIRE Mitigation Program:
  - waire-incentives@aqmd.gov
  - www.aqmd.gov/wairemitigation
- WAIRE Implementation (including Annual Report and Tech Assessment):
  - waire-program@aqmd.gov
  - www.aqmd.gov/waire
- Ports Cooperative Agreement:
  - ports@aqmd.gov
  - www.aqmd.gov/portsagreement

Elemental Trucks™

The future of sustainable Heavy Freight logistics.

September 2026

Jamie Ally, PhD, P.Eng
CEO



The Electrification of Trucking is just getting started

Fleets are electrifying but battery-electric trucks force too many tradeoffs: payload, range, cold weather ops, degradation.

Battery-only electric trucks need megawatt grid connections, but the grid is constrained. AI is consuming any available capacity.

Freight customers are demanding low-emission delivery options to meet their ESG mandates.

Our Solution

Built for performance. Engineered for the future.

Hydrogen-powered zero-emission tandem-trailer trucks purpose built for heavy duty and severe operational conditions.

KEY FEATURES

Powertrain
Hydrogen Fuel Cell Electric

Payload
Nearly double any other zero emission truck

Grade start
Startable fully-loaded at 14% grade

Mountain climbing
40 kph at 6% grade

Mountain descent
Brake resistors + regenerative braking

Cold weather ops
Startable from -25C

140,000 lbs
GROSS COMBINED WEIGHT

640 mi
RANGE*

6x4
AXLE CONFIGURATION

ZERO
EMISSIONS

Product specifications subject to change. For the most current information please contact Elemental Trucks. Reproduction in whole or part prohibited without written approval. *For range details, contact Elemental Trucks.

Elemental Trucks

Leading on the Metrics that Matter

OEM	Max Weight	Payload	Fueling Time	Range	Fleet replacement ratio
Other H_2 Trucks	82,000 lbs	<40,000 lbs	15 min	500 km	1.2 to 1
BEV Trucks	82,000 lbs	< 40,000 lbs	1-5 hrs	500 km	1.2 to 1
Elemental Trucks	**140,000 lbs**	**75,000 lbs**	**20 min**	**700-1000 km**	**1.05 to 1**

We know fuel cell trucks

60+ years combined experience.

Jamie Ally, PhD, P.Eng CEO
Former Ballard Systems Engineer. Co-founder of EMC (Australia).
Former VP at Almon

Frederic Delrieu
COO
Dana AZETEC lead. E- mobility lead at Nordresa, Novabus, Renault.

Paul Paterson, P.Eng
CTO
Ballard Principal Engineer.
Large portfolio of hydrogen mobility projects.

Elemental Trucks

Class 8 Tractor

GCW 63t

FC power 360kW
Range 800km
Available Q1 2026

BEV version

GCW 63t

Range 150km (for shuttle trips)
Charging speed 250km/h
Available Q2 2026

Class 8 10-wheeler

Boom truck, dump truck, flat bed

Range 500km
Up to 30,000lbs payload, PTO

Class 8 Delivery truck

16ft-26ft box

Range 500km
Up to 25,000lbs payload
Available Q2 2026

Class 8 12-wheeler

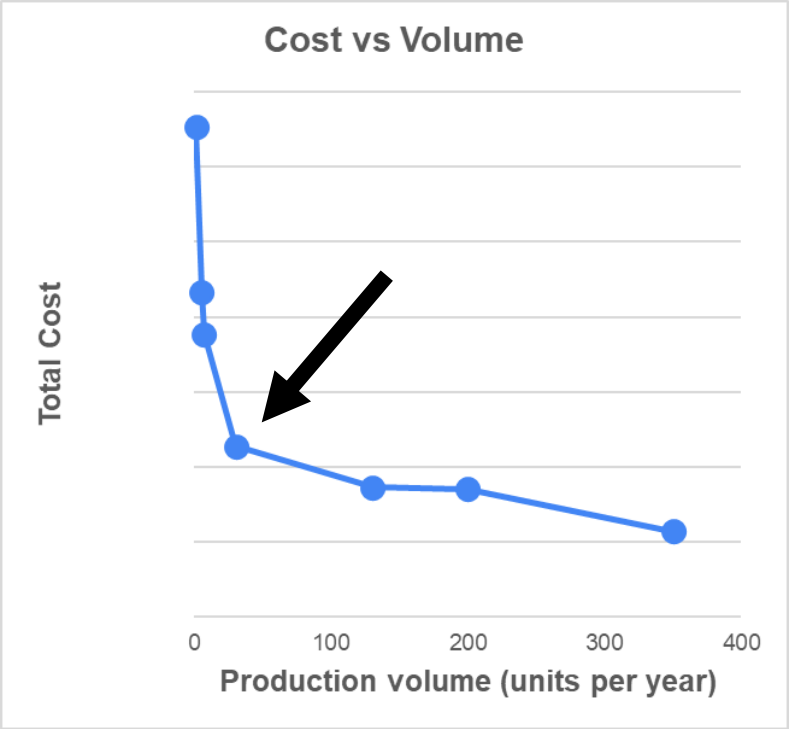
Dump truck, snow-plow, cement mixer

Up to 45,000lbs payload, PTO
Range 500km
Available Q2 2026

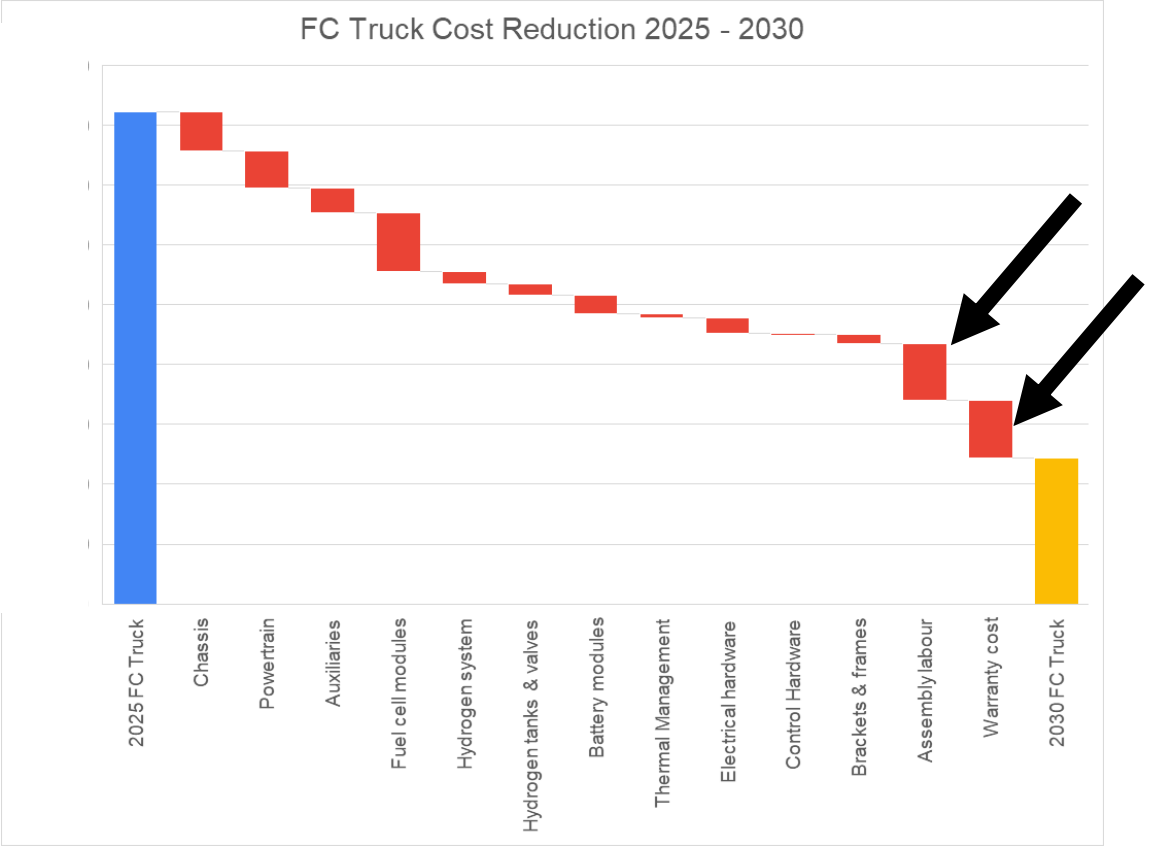
Building on a common electrified chassis platform.

Cost Reduction

Cost Curve bends at
30 units per year



Major contributors to cost reduction



Elemental Trucks

What it takes for hydrogen trucks to scale

Four barriers standing between demonstration and commercial scale

What the hydrogen truck market needs to scale.

REFUELING INFRASTRUCTURE

Fleet-Dedicated Stations

Private, fleet-dedicated stations outpace public corridor networks.

HYDROGEN FUEL COST

Trajectory to fuel costs *below* diesel parity

Hydrogen can remove fuel price volatility. But we need to go beyond parity to get true market uptake.

VEHICLE CAPEX

Mitigation of residual value risk

Need to mitigate both the technology risks and the first-mover commercial risks.

REFERENCE-SCALE DEPLOYMENT

Plans for a Reference Large-Scale truck fleet

A vision to evolve towards reference deployments that prove the economics work beyond pilot scale..

Policy leadership is the lever to achieve the Minimum Viable Scale.

The electrification of heavy trucking is inevitable…

…and is just getting started

Let’s go.

Elemental Trucks

Jamie Ally, PhD, P.Eng CEO
jamie.ally@elementaltrucks.com
416-559-9449

Lighting Off the Commercial Hydrogen Market

Roundtable Panel Session

SCAQMD Clean Fuels Advisory Group
September 17, 2026

Panelist Bios

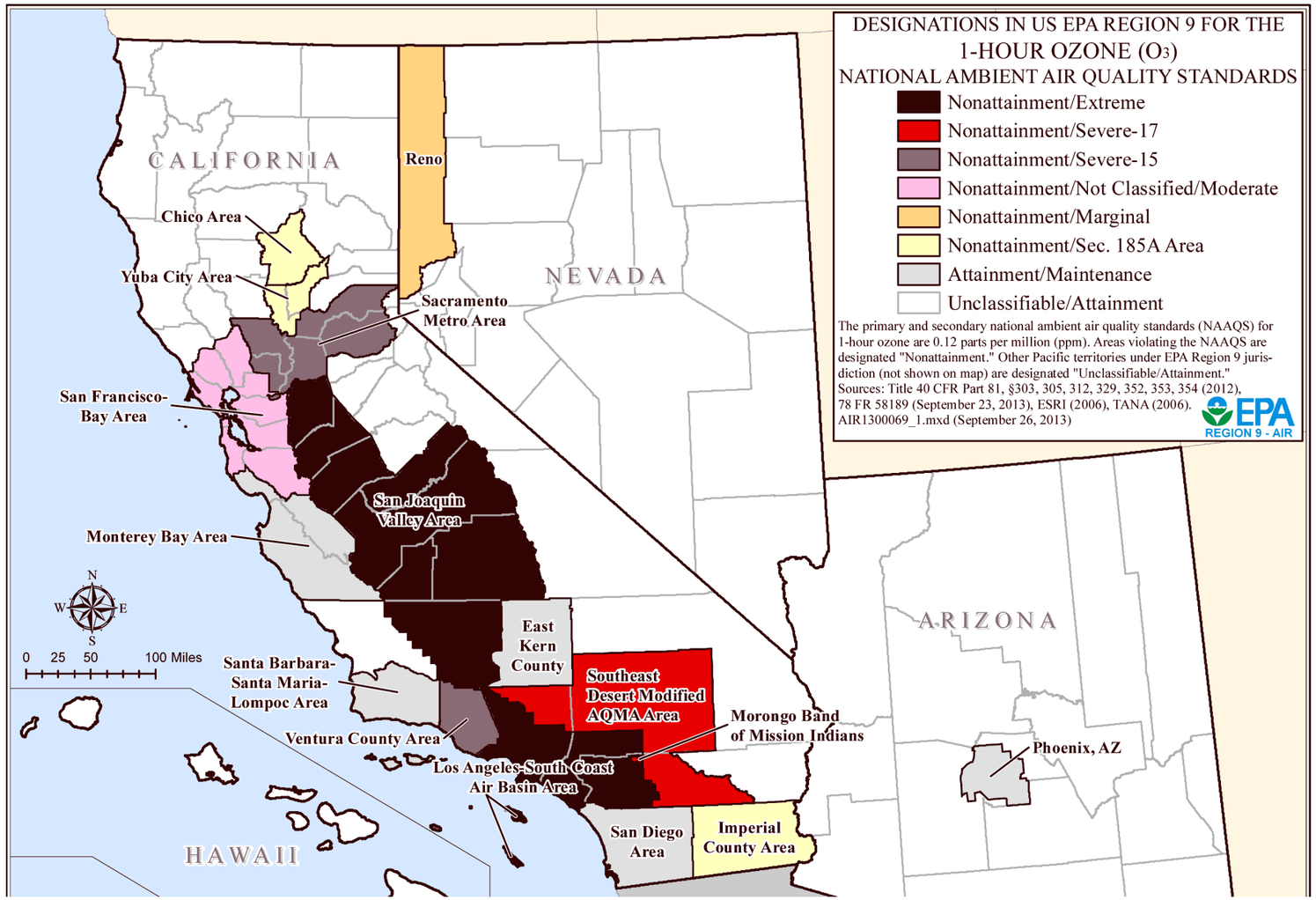
- **American Honda Motor Co:** *David Perzynski, Assistant Manager of Hydrogen Solutions Development*. Responsible for leading the company's hydrogen product, service, business strategy, and business development activities across North America with focuses on automobiles, commercial vehicles, stationary power stations, and construction equipment, building collaborations and partnerships to support new product applications and services for Honda's hydrogen fuel cell systems.
- **California Air Resources Board**: *Leslie Goodbody, Staff ZEV Infrastructure Specialist*. Work involves providing charging and hydrogen infrastructure-related support to CARB teams responsible for implementing zero-emission fleet regulations like Innovative Clean Transit. Working on hydrogen infrastructure related initiatives since 2005.
- **California Governor's Office of Business and Economic Development (GoBiz)**: *Lillian Liu, Program Manager, Hydrogen and Fuel Cell Market Development*. Role involves scaling the renewable hydrogen economy to help California decarbonize and achieve net zero across the transportation, ports, power, aviation, maritime, and agricultural sectors.
- **Elemental Trucks**: *Jamie Ally, CEO*. Focused on commercializing hydrogen-powered Class 8 trucks for heavy-haul. Engineer and entrepreneur with two decades designing and deploying energy infrastructure across Canada, Australia, Europe and the US, spanning hydrogen vehicles, microgrids, and many other advanced energy technologies.
- **Hydrogen Fuel Cell Partnership**: *David Park, Director of Industry Affairs*. Role aligns the economics of fuel cell electric vehicle manufacturing with the retail and commercial hydrogen supply chain, while building industry consensus to inform local, state, and federal agencies working to stimulate ZEV markets.
- **Hyundai Translead**: *Jeonghwan (Ryan) Kim, Head of the North America Commercial Vehicles*. Leads business strategy, planning, and business model development to expand Hyundai's commercial vehicle business in North America, with a particular focus on hydrogen fuel cell commercial vehicles. *Austin Mattsion, Head of Operations*, Hyundai Commercial Vehicle North America, supporting the deployment and operational success of the Hyundai XCIENT Fuel Cell truck program.
- **Iwatani Corporation of America**: *James Kast, General Manager, Hydrogen*. Focused on expanding Iwatani's North American hydrogen market. This includes achieving operational excellence at Iwatani's current hydrogen stations, and growing Iwatani's hydrogen value chain across multiple sectors.
- **Pilot Company**: *Bill Zobel, Senior Director of Hydrogen Supply and Infrastructure*. Clean hydrogen strategy.
- **Port of Long Beach**: *Leela Rao, PhD, Manager of Air Quality Practices*. Team leader implementing the Port's clean air strategies, including transitioning to zero emission goods movement at the Port. The team both secures grant funding to assist with the deployment of zero emission equipment and infrastructure, as well as develops incentive programs to reduce the barriers to own, operate, and maintain zero emission trucks.

Panelist Bios (cont'd)

- **Savage Services**: *Greg Bermoy, Operations Manager III*. Savage is a leading bulk material handling and logistics operation in Southern California. Greg is focused on delivering reliable service while advancing sustainability initiatives. He plays a key role in Savage's journey toward zero-emission operations by 2028, helping implement innovative technologies and operational strategies that support cleaner air, environmental stewardship, and long-term value for customers and surrounding communities.
- **Shell**: *Eugene Reyes, Hydrogen Commercial Mobility Lead, Low Carbon Solutions*. Leadership within venture development, commercialization and external partnerships
- **Toyota Motor North America**: *Jason Nunamaker, Fuel Cell Solutions Business Development.* 24-year career working for or with Toyota, mainly in automotive retail operations. 3 years with Toyota's Fuel Cell Solutions (Product Team) working on Toyota's Class 8 truck Fuel Cell Powertrain development.
- **UC Davis, Institute of Transportation Studies**: *Lew Fulton, PhD, Co-director, Sustainable Freight Program*. Leader of research on energy transitions, new vehicle technologies and fuels, and how they can gain rapid market acceptance. Coordinator of international research through ITS-Davis's research centers in Europe and the Global South, and until recently chair of the Transportation Working Group of California's hydrogen hub (ARCHES).
- **UC Irvine, Clean Energy Institute**: *Jeff Reed, PhD, Senior Fellow.* From 2018 to 2025 led the research activities of the Institute in the areas of renewable fuels and technoeconomic and life cycle analysis as the Chief Scientist for Renewable Fuels and Energy Storage. He continues as a senior advisor to the institute on these issues.
- **UC Riverside, Center for Environmental Research and Technology (CE-CERT)**: *Zisimos Toumasatos, PhD, Principal Investigator*. His research focuses on the experimental characterization of gaseous and particulate emissions from light-duty and heavy-duty vehicles through laboratory, on-road (PEMS), and continuous in-use measurement campaigns. His work spans real-world heavy-duty NOx and particulate emissions, low-cost emissions sensing for in-use compliance, hydrogen–natural gas blends and other low-carbon fuels, and sub-23 nm particle number measurement, contributing to the scientific basis for next-generation emission standards in the US and EU.

Heightened Focus on Air Quality

The need for solutions that clean the air hasn't changed. Expand existing programs where possible



Zero-Emission Technologies are a Critical Need

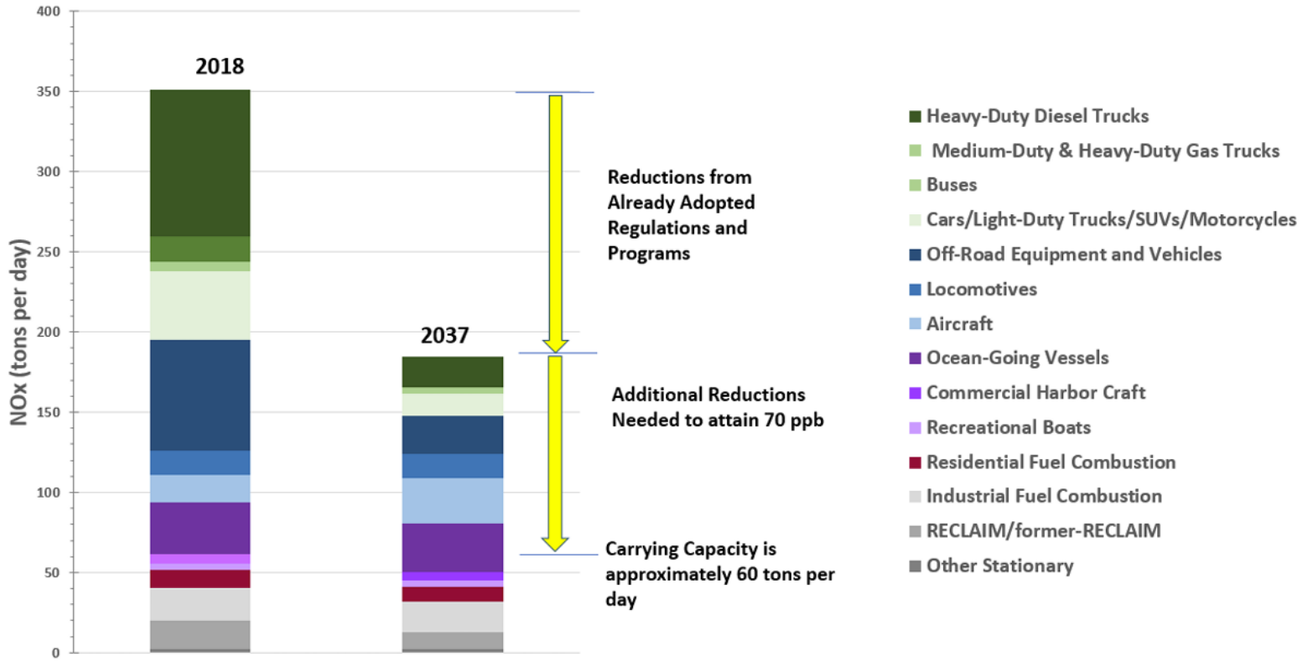
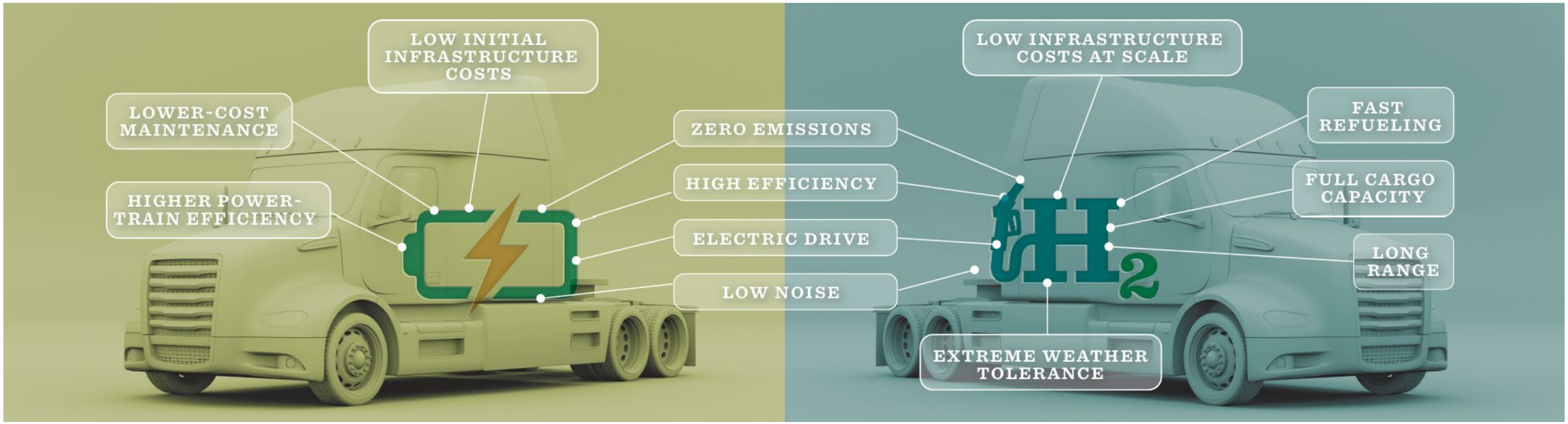


FIGURE ES-2
BASELINE NOX EMISSIONS INVENTORIES AND ADDITIONAL REDUCTIONS REQUIRED TO ATTAIN THE 2015 OZONE STANDARD
*2022 Air Quality Management Plan, SCAQMD, December 2022, p. ES-5

- Diesel Freight is the largest contributor to NOx along port, rail and warehouse corridors
- The communities closest to goods movement carry the heaviest health burden
- Ozone attainment deadlines are statutorily mandated by the Clean Air Act

Battery - Electric AND Hydrogen Fuel Cell are Synergistic



→ Return-to-base and shorter routes

→ Duty cycles where charging fits the schedule

Constraints: duty cycle restrictions, access to ample power (MW charging), larger real estate footprint

→ Multi-shift, high-utilization freight

→ Payload-, range-, and turnaround-sensitive routes

→ High PTO utilization

Constraints: limited product options, higher initial infrastructure CAPEX

Not one-size-fits-all. Support each where it delivers the most value.

https://h2fcp.org/content/guiding-principles-hydrogen-truck-market-development

Search term: “H2FCP Guiding Principles”

Five Issues Determine the Outcome

The structured model surfaced five: one is the barrier, four are the forces that move it

THE CENTRAL BARRIER

1 Dispensed Hydrogen Cost vs. Diesel

Everything else eventually rolls up to end user costs

It is the outcome that the other four issues determine

THE FOUR MAJOR FORCES

2 Fleet Size & Fuel Consumption

Scale and predictability drive economics

3 Station Network

Density, cost, and reliability of heavy-duty stations

4 Air Quality Policy

Localized impacts to communities

5 Regulatory Mandates

ZEV sales/adoption rules and climate impacts

Fuel Cost is the Central Barrier

THE TARGET

$5–12 / kg

dispensed price range where FCET adoption is possible

PROOF POINT

~$10/kg

sustained by transit under long-term supply contracts*

RETAIL, LESS PREDICTABILITY

$13–36/kg

the volatile range retail experienced

Same fuel, different outcomes —the difference is market structure

**(Note ~$10/kg reflects today's contracts; the industry is watching renewal pricing.)*

Policies Change. Let's Move Forward

Policy levers may shift, yet progress can continue using different tools

WHAT CHANGED

Federal waivers for vehicle mandates, and **federal funding** for hydrogen programs

WHAT ENDURES

California State goals and mandates, **air quality** obligations, and **Port** targets

WHAT LIES AHEAD

A new policy toolkit leveraging existing programs while developing others

Dual-Track Strategy

COMPLIANCE-DRIVEN

- Engage CARB, CEC, and local air districts
- Prioritize CAA Section 177 states (Pacific NW, Northeast)
- Stack HVIP, LCFS, and public grants to lower fleet TCO

ECONOMICS-DRIVEN

- Lower dispensed cost via scale and supply-chain efficiency
- De-risk infrastructure with offtake agreements and coalitions
- Leverage low-cost supply hubs and incentives as accelerants

The paper is explicit: these run in parallel, not in sequence.

Panel Recommendations

1. Accelerate aggregated demand
2. Deploy public funding strategically
3. Harmonize incentives across tech
4. Increase market transparency
5. Align agencies & timelines

Shore to Store in Los Angeles

Europe's H2Accelerate Initiative

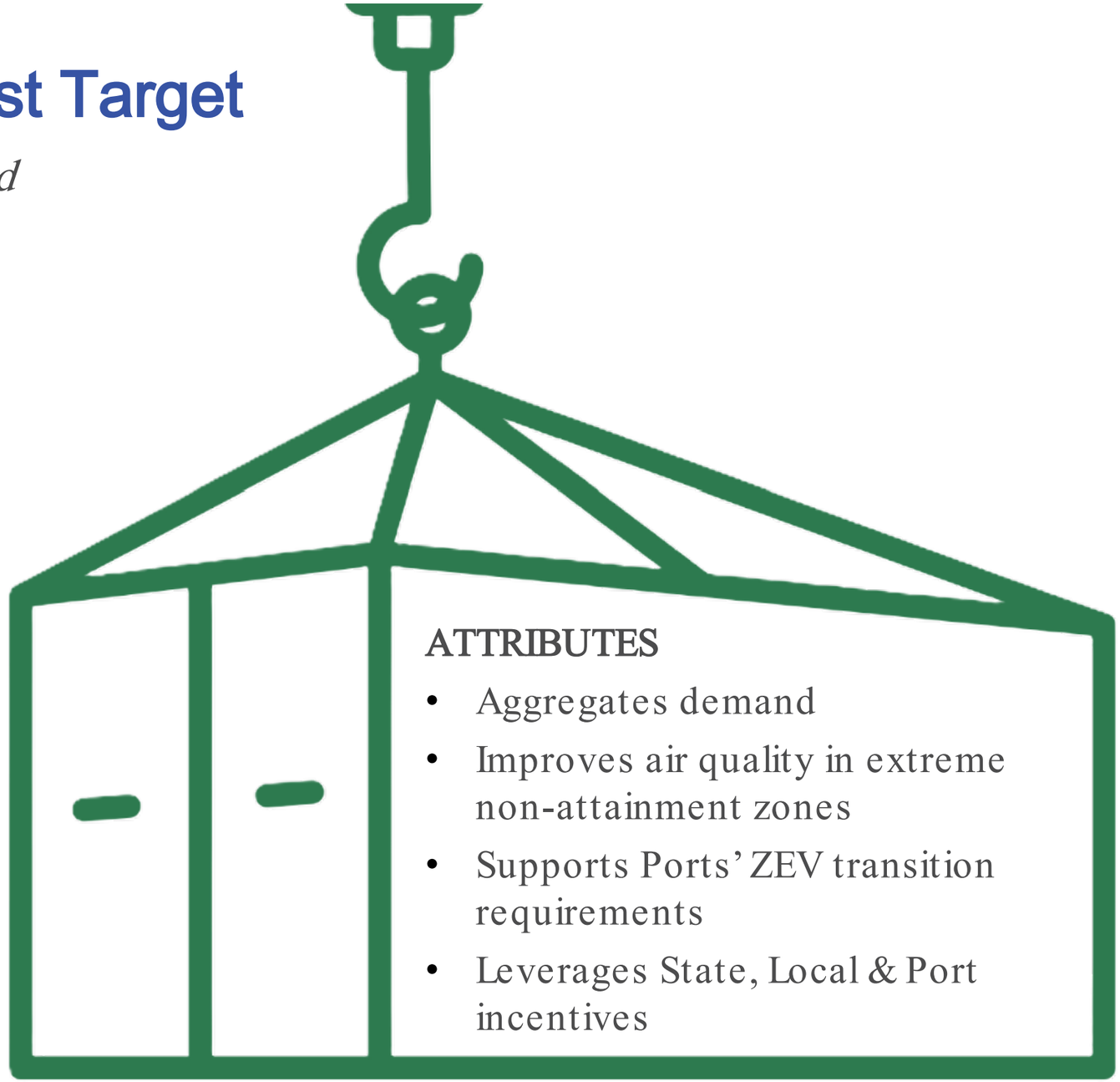
Toyota & Hyroad

NorCal Zero in Oakland

Why Drayage is a Strategic First Target

The use case maps to the Core Issues identified (LA/Long Beach Ports example)

- These attributes connect to the five main drivers enabling FCET adoption
- Ability to de-risk initial projects
- Starts the positive feedback loop of Scale → lower cost → scale….



Aggregated Demand: Commercial Trucking Opportunity

PASSENGER RETAIL		COMMERCIAL FREIGHT
Anonymous drivers	→	**Named fleet counterparties**
Demand estimated, not contracted	→	**Demand contracted — volume, location, duration**
Stations financed against projected, not contracted, demand	→	**Stations financed against committed offtake**
Dispersed, unpredictable fueling	→	**Concentrated depots, corridors, return-to-base routes**

Secure demand before capital is spent

Anchors of Market Predictability

ECONOMICS

Economics stand on their own

Make the numbers work and progress will be made

AIR QUALITY POLICY

Communities and Public agencies demand solutions

The human health impacts are real and cannot be ignored

The level of political support may ebb and flow. **These two anchors stay.**

"The most resilient strategies thrive across political cycles, grounded in fleet economics, infrastructure efficiency, and business fundamentals."

One decision sets the rest in motion.

- Economics supported by sound policy
  - The builders make it real
    - The movers make it scale
      - Everyone breathes the result

When every hand gains, the market doesn't need a mandate to hold.

*nonvoting technical advisor

AC Transit
Avina Clean Hydrogen Inc
Bayotech
Cal State LA
CA Dept of Food & Agriculture
Compressed Gas Association
CHBC
CSA Group
CTE
CW Clean Cities
DLZ Engineering
Ebara Corporation
FASTECH
FCHEA
First Public H2
GenH2
HERE Technologies
HydrogenXT
ITS UC Davis
Linde
Look Inc.
Luxfer Gas Cylinders
NFCRC
National Laboratory of the Rockies
Nikkiso
PACC Services LLC
RE+ Events
RHA
Sacramento Air Quality
Management District
Sandia National Laboratories
SF Environment
Shasta Regional Transit Agency
Suburban Propane
Sunline Transit Agency
Symbio
TAIT and Associates, Inc.
Tatsuno
ITS UC Berkeley
UC Riverside CERT
Wolftank Group

Questions & Discussion

HYDROGEN FUEL CELL

PARTNERSHIP®

h2fcp.org

LNK ENERGIES

Cheaper power without the cost.

30,000 TRUCKS. 9 YEARS.

THE GOAL

San Pedro ports target to have 100% zero-emission drayage fleet by 2035.

ECONOMIC REALITY

Logistics is a low margin business, can't absorb additional costs

3–5%

net margins in trucking

Current solutions do not work

Battery Electric Trucks → Can't do the job

- Insufficient range
- Long recharge times
- High charging costs for DCFC

Hydrogen Trucks → Economics don't work

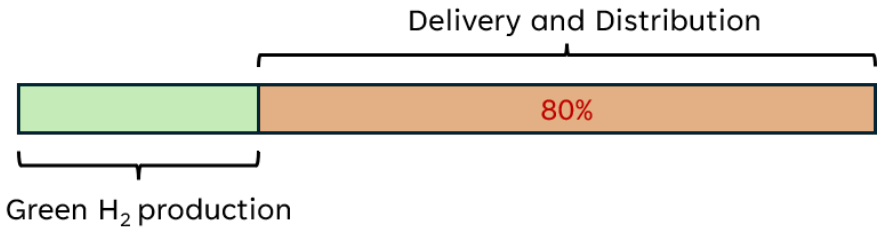
- Hydrogen distribution is 80% of the delivered cost at pump – kills economics
- Safety concerns
- Scaling requires massive upfront CAPEX

no economically viable option

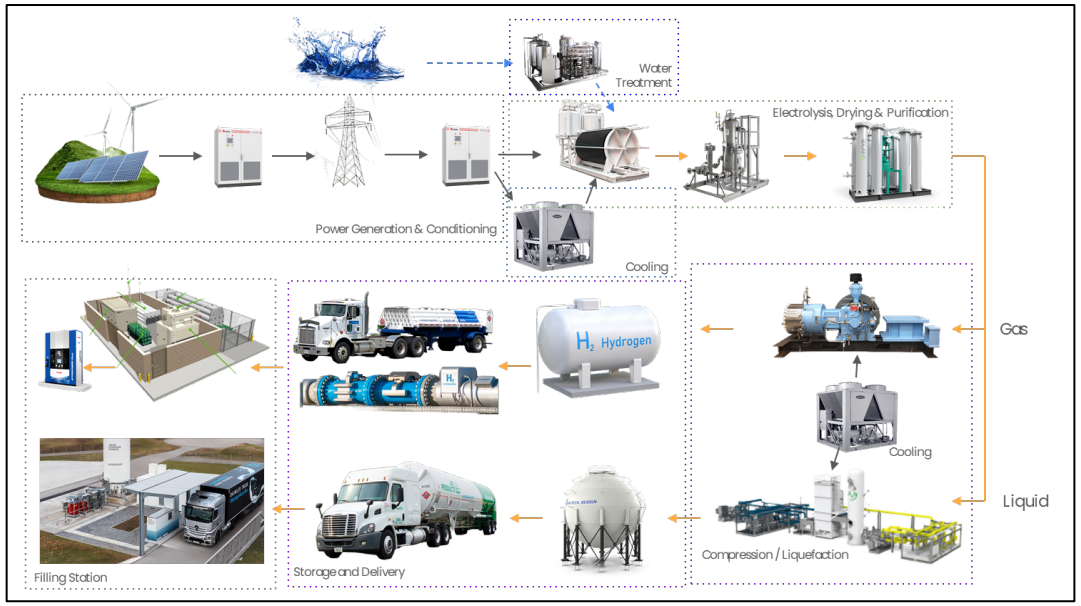
The clean trucks exist. The economics don't.

WHAT IS WRONG WITH HYDROGEN?

Conventional



- Massive upfront CAPEX
- Complex supply chain
- Compression and Liquifaction is expensive
- Safety concerns and permitting challenges

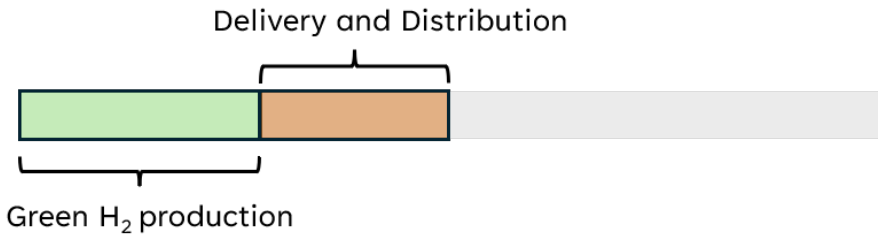


Messy and Complex

Pay for what you use, not for moving it around

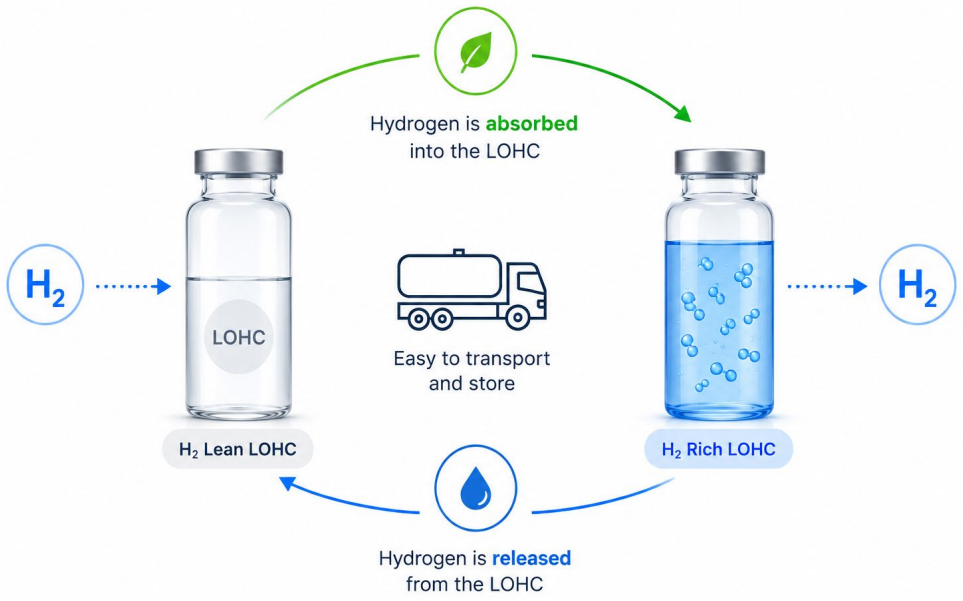
THE LNK FIX – LIQUID ORGANIC HYDROGEN CARRIERS

The LNK solution



- Compatible with existing fuel infra
- Commercially available molecule
- Safer than diesel

Scalable. Safe. Sensible.



Pay for what you use, not for moving it around

LNK MAKES THE ECONOMICS WORK

THE SOLUTION

Patented Technology

- ✓ 600-mile range, <15 min refuel
- ✓ Safer than diesel
- ✓ Can be distributed using diesel stations
- ✓ CARB-ready, mandate-proof

13%
cheaper than diesel in CA

0%
Tail-pipe emissions

Our technology

Easy to scale, cheaper than diesel

ON- BOARD HYDROGEN RELEASE ENABLED BY LNK

Incumbent LOHC systems are **as big as shipping containers**

Our technology is **as small as a mini fridge**

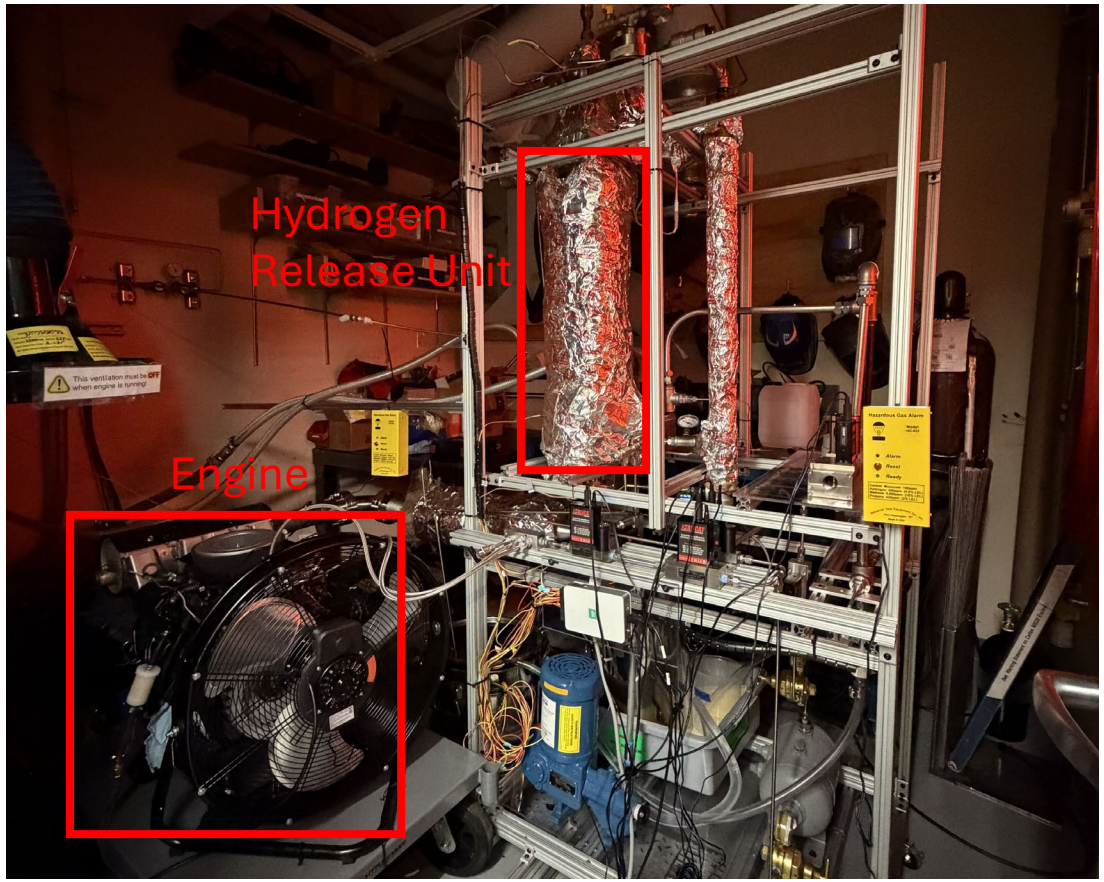
Key Technical Unlocks:

- High power density
- Improved thermal efficiency
- High pressure hydrogen release

→ LNK manufactures a fuel system that replaces compressed hydrogen tanks, making hydrogen safer and cheaper than diesel

LNK unlocks LOHC as a fuel

OUR TECHNICAL MOAT: BUILT AND DEMONSTRATED



- ✓ Complete system demonstrated with Honda engine
- ✓ **50-hours** of operational data collected
- ✓ **5x power density** validated

LNK has demonstrated the on-board concept at TRL 4

FROM LAB TO ROAD: A 24-MONTH COMMERCIALIZATION PROGRAM

SCAQMD Grant · 24 Months · 3 Phases · Zero-Emission Class 8 Trucks for LA ports

Phase 1 Q3 2026 – Q2 2027
Truck scale (180 kW) system validation

Phase 2 Q3 2027 – Q4 2027
Complete truck integration and on-road demo

Phase 3 Q1 2028 – Q2 2028
Full pilot campaign under real world operation

Potential Partners

HYROAD · Elemental Trucks · SYMBIO · UCR CE-CERT · PCC Hydrogen · IEGO · LEVELIZED CAPITAL

Class 8 LOHC trucks hauling freight on California roads with zero emissions

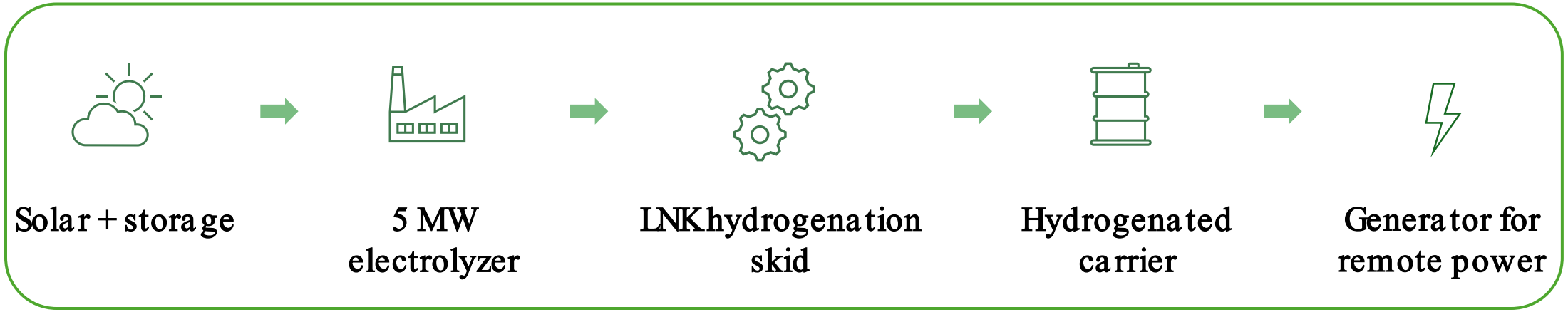
A NAMED PARTNER FOR EVERY PIECE OF THE TRUCK

Powertrain	Truck platform	Fuel cell + integration	Carrier fluid
LNK Energies	**Elemental Trucks**	**Elemental Trucks · Symbio**	**Nippon Chemical Texas**
In-house	In discussion	In discussion	Quoted

Validation	Demand	Agency support
UC Riverside CE-CERT	**Hyroad Energy · Elemental Trucks**	**SCAQMD**
Finalizing SOW	MOU / LOI	Engaged

Credible syndicate to deliver LOHC truck

BUILDING THE FUEL SIDE IN CALIFORNIA



Objectives

1. Pilot scale deploy of 30 kg H_2 /day unit
2. Demonstrate LNK systems with linear generators
3. California's first LOHC supply point — renewable hydrogen, hydrogenated on site.

Potential Partners

RIC ENERGY · Cadiz · GTI ENERGY

Enabling the LOHC ecosystem in California

MEET THE TEAM

Dr. Sayandeep Biswas

CEO

MIT PhD ChemE
Martin Family Society for Sustainability Fellow
MIT Delta v

Alexis Huynh

CTO

MIT B.S. MechE
MIT Motorsports Mechanical Lead
776 Fellow

Prof. William Green

CSO

Director, MIT Energy Initiative
Co-inventor of core IP
Leading LOHC researcher

WE'RE BUILDING THIS IN CALIFORNIA

THIS WEEK

Met machine shops and fabricators across the Inland Empire and LA basin

THE LNK VISION – PLATFORM SOLUTION FOR HEAVY-DUTY POWER APPLICATIONS

Adjacent Markets: Hydrogen buses, Gensets to power critical infrastructure

>$100B

Combined TAM

Cleaner air at the ports, built by California shops

The Battery-Free Fuel Cell Coach

Bench test results from a first-of-a-kind heavy-duty fuel cell engine

September 17, 2026

Jackson Danis
Engineering Services Manager
Center for Transportation and the Environment

TVIDC Transit Vehicle Innovation Deployment Centers

cte

nimbus POWER SYSTEMS

About CTE

Who We Are
501(c)(3) non-profit engineering and planning firm

Portfolio
$3.8B+

- Research, Demonstration, Deployment
- 100+ active projects

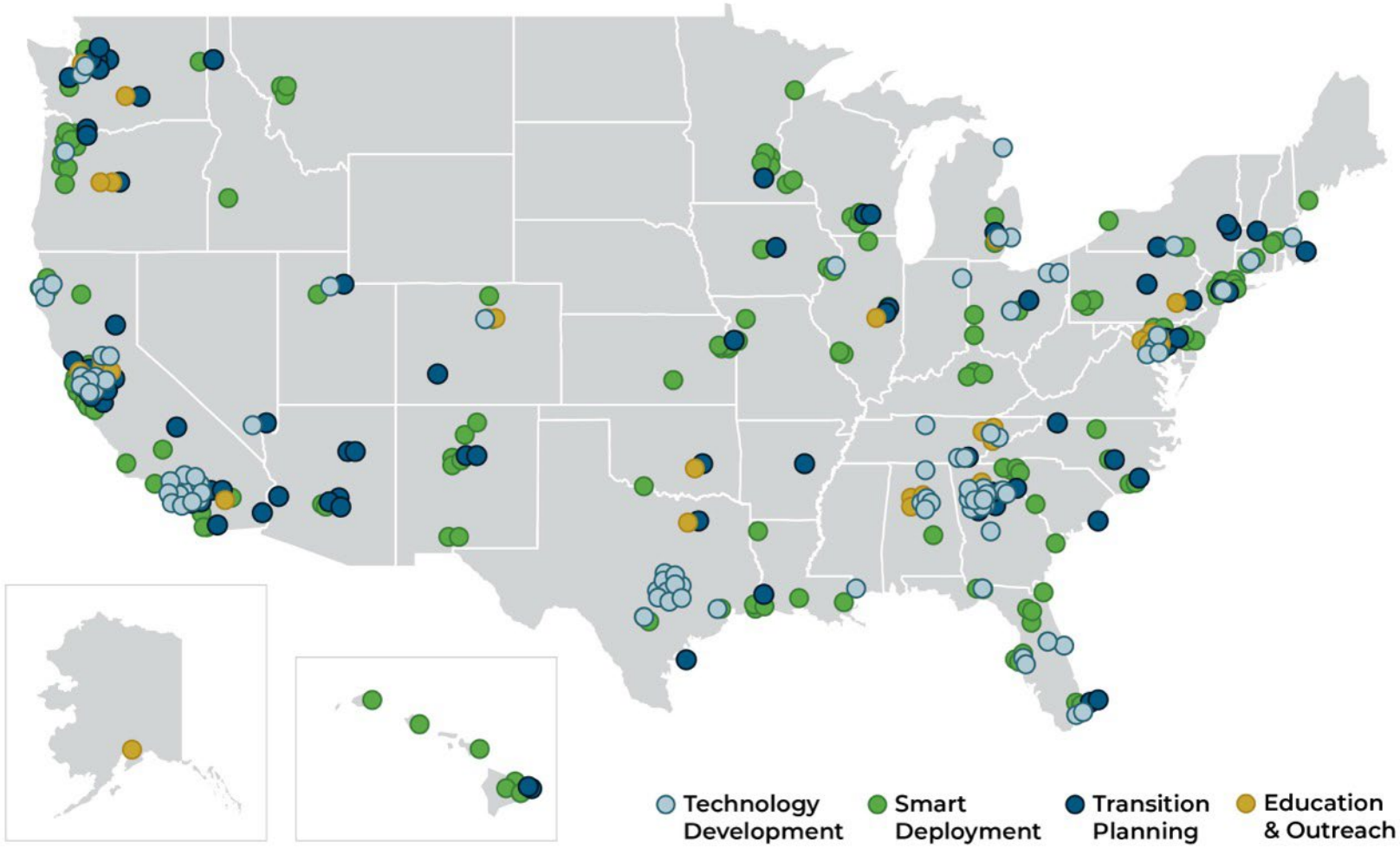
Our Mission
Improve the health of our climate and communities by bringing people together to develop and commercialize clean, efficient, and sustainable transportation technologies

Our Focus
Zero-Emission Transportation Technologies

National Presence
Atlanta, Berkeley, St. Paul

CTE Project Map

2,300+ Zero-Emission Vehicles Deployed



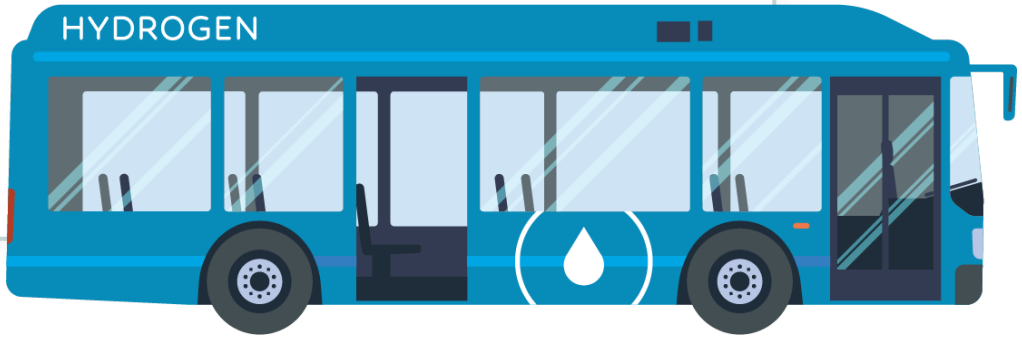
Fuel Cell Electric Buses (FCEBs)

Advantages

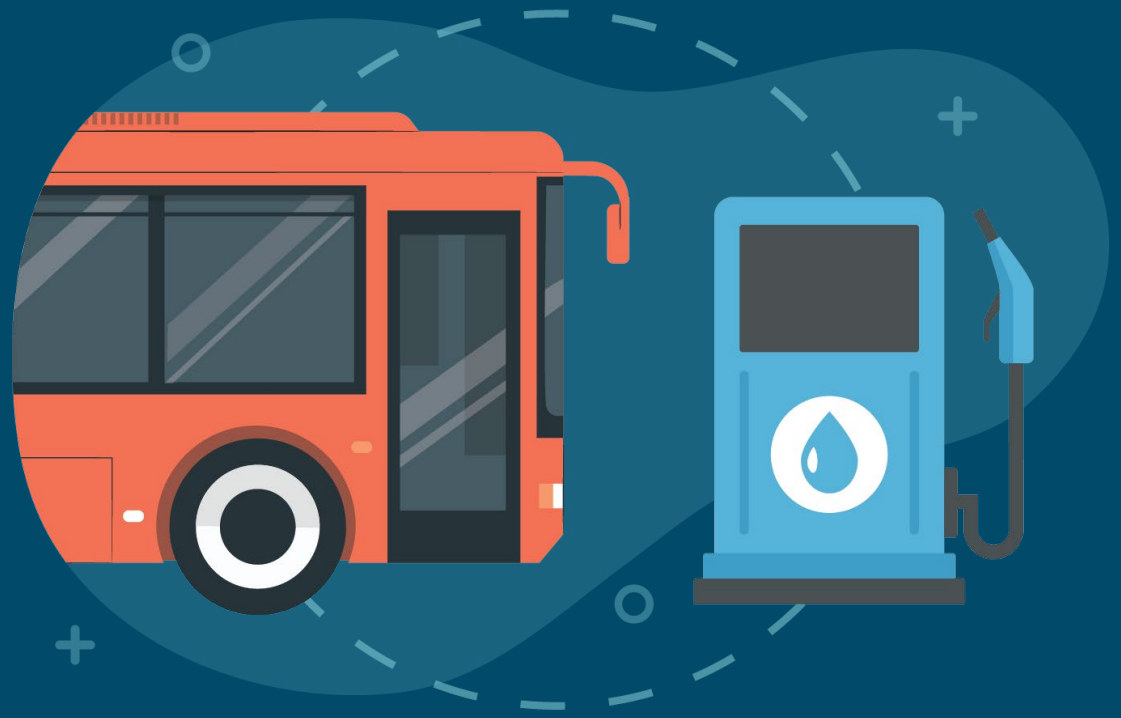
- Tailpipe emits only water
- Longer range
- Shorter fueling times
- Fuel economy is less affected by extreme ambient temperatures
- Nearly a one-for-one vehicle replacement solution
- Fueling infrastructure has a similar footprint and size to diesel and CNG fueling stations

Disadvantages

- Performance limitations on extended grades
- Highway capability
- Limited market availability
- No coach offering
- Cost & complexity



Fuel Cell Dominant Proof of Concept



Project Goals

- ✓ **A fuel cell dominant design of 200 kW and greater**
- ✓ Fully adaptable to transient power requirements to **replicate the operating performance of a diesel engine**
- ✓ **Improved fuel economy**
- ✓ **Lighter weight and more compact** for easier vehicle integration and servicing
- ✓ **Diminished supply chain risk** with the use of ultracapacitors or smaller battery energy storage systems
- ✓ Lighter vehicle curb weight, enabling **higher passenger loads**
- ✓ The capability of managing varying voltage outputs **without the need for a DC-DC converter**

Outlook

- **Greater durability** with less power degradation compared to existing fuel cell designs
- **Lower manufacturing cost**
- **Lower capital and operating costs** for transit fleets due to fewer components and more efficient operations

nimbus POWER SYSTEMS™

The Nimbus FCS:
A New Era for Mobility Fuel Cells

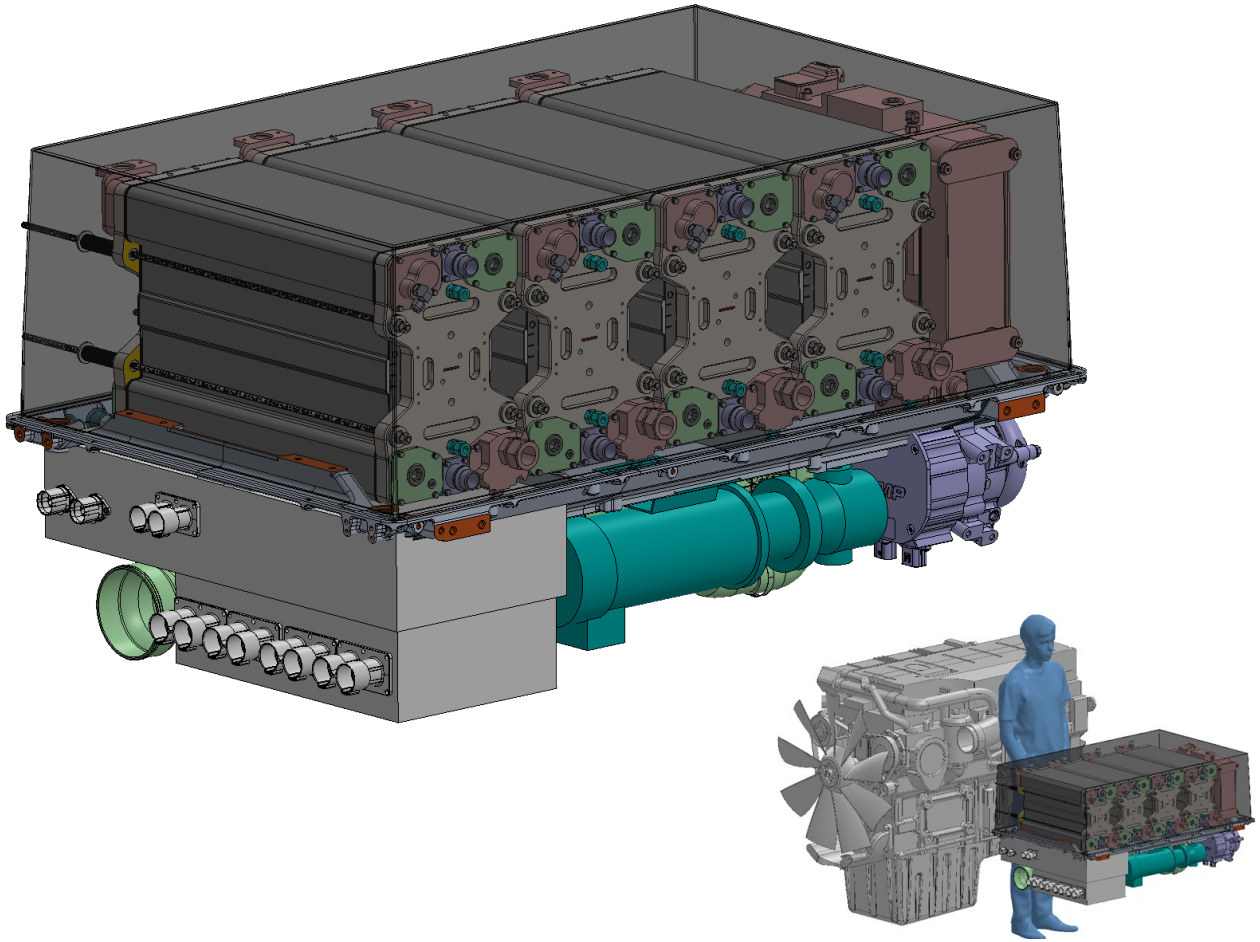
- No batteries
- No DC/DC converter
- Fully load-following

➢ Lower weight

➢ Lower cost

➢ Better durability

➢ Better fuel economy



Fuel Cell Dominant Technology

Water management is critical to fuel cells, impacting durability, performance, and efficiency

Fuel Cell Industry

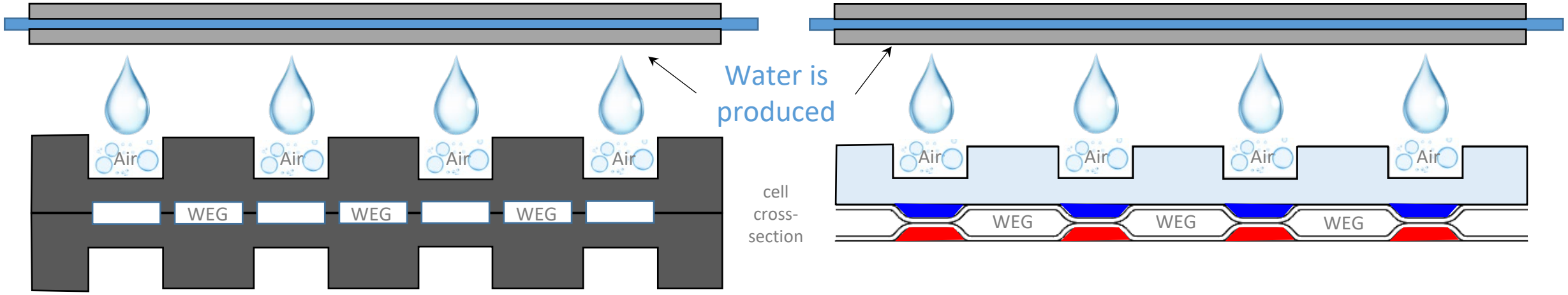
External water management
with solid bipolar plates

Water is removed with reactant flow, which is directly linked to Durability, Performance and Efficiency

Nimbus

Internal water management
with porous bipolar plates

Water is removed by porous plates, allowing reactants to be optimized for Durability, Performance and Efficiency



15k-hrs
Poor load following capability
Low temperature operation
Lower efficiency

30k-hrs
Excellent load following capability
High temperature capable
Higher efficiency

Fuel Cell Dominant Technology

Water management is critical to fuel cells, impacting durability, performance, and efficiency

WTP Water Removal Capability

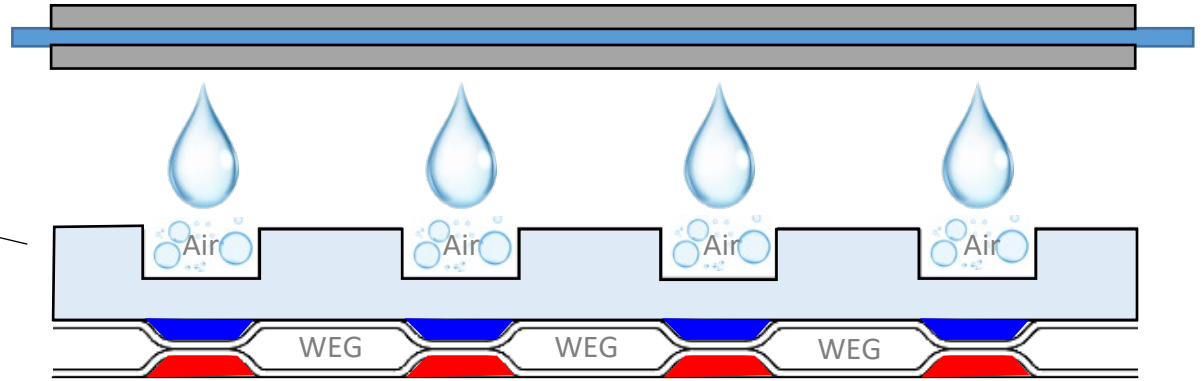
(>50A/cm^2 equivalent water removal)

Video not available on the web

Nimbus

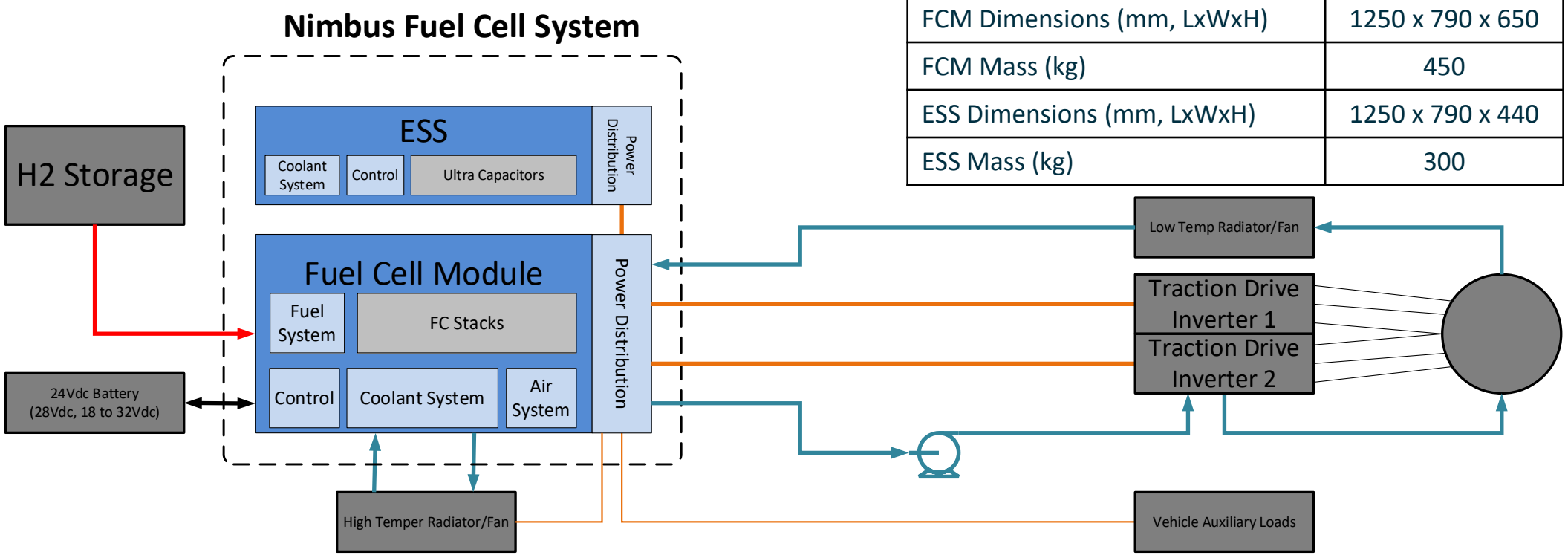
Internal water management
with porous bipolar plates

Water is removed by porous plates, allowing reactants to be optimized for Durability, Performance and Efficiency

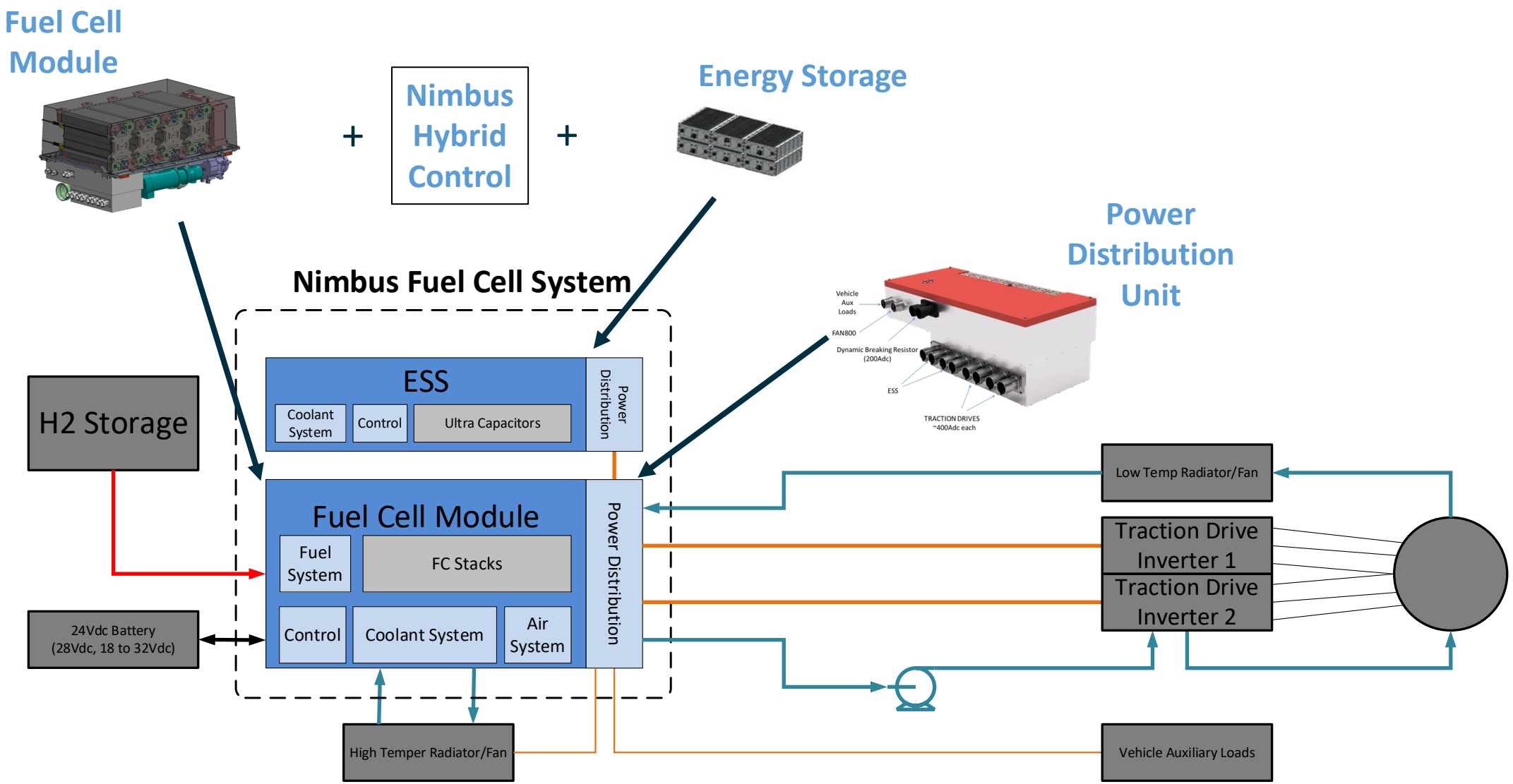


Fuel Cell Dominant Drivetrain for Heavy-Duty Applications

FCS350 Parameter	Specification
Peak power (kW_{net})	+350 / -260
Rated power (kW_{net})	+300 / -140
Output voltage (V_{DC})	530-750
Transient – Idle to Peak Power (s)	<1
Coolant inlet temperature (°C)	70 to 90
24V Battery Charging (kW)	4.0
FCM Dimensions (mm, LxWxH)	1250 x 790 x 650
FCM Mass (kg)	450
ESS Dimensions (mm, LxWxH)	1250 x 790 x 440
ESS Mass (kg)	300

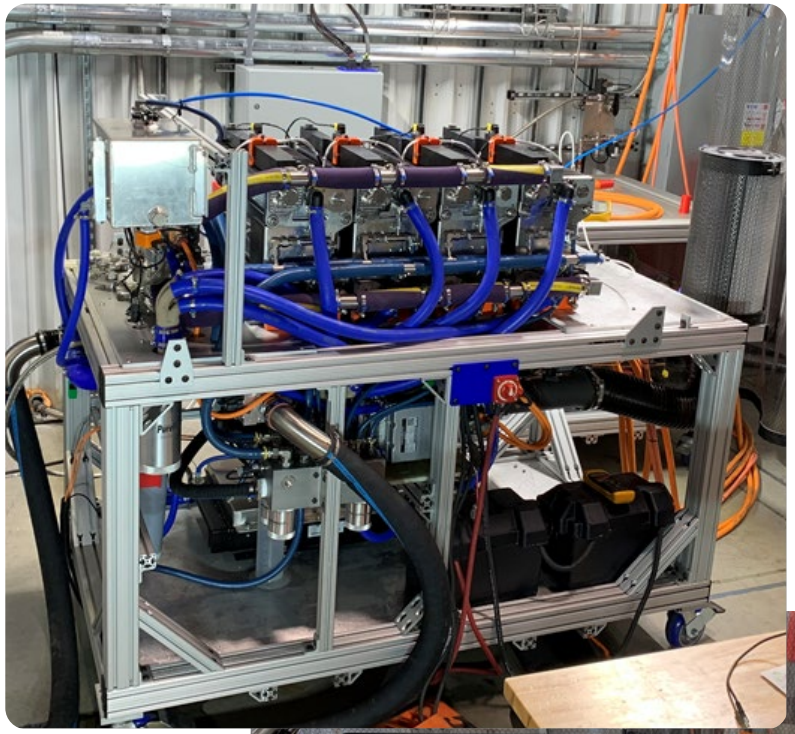


Fuel Cell Dominant Drivetrain for Heavy-Duty Applications



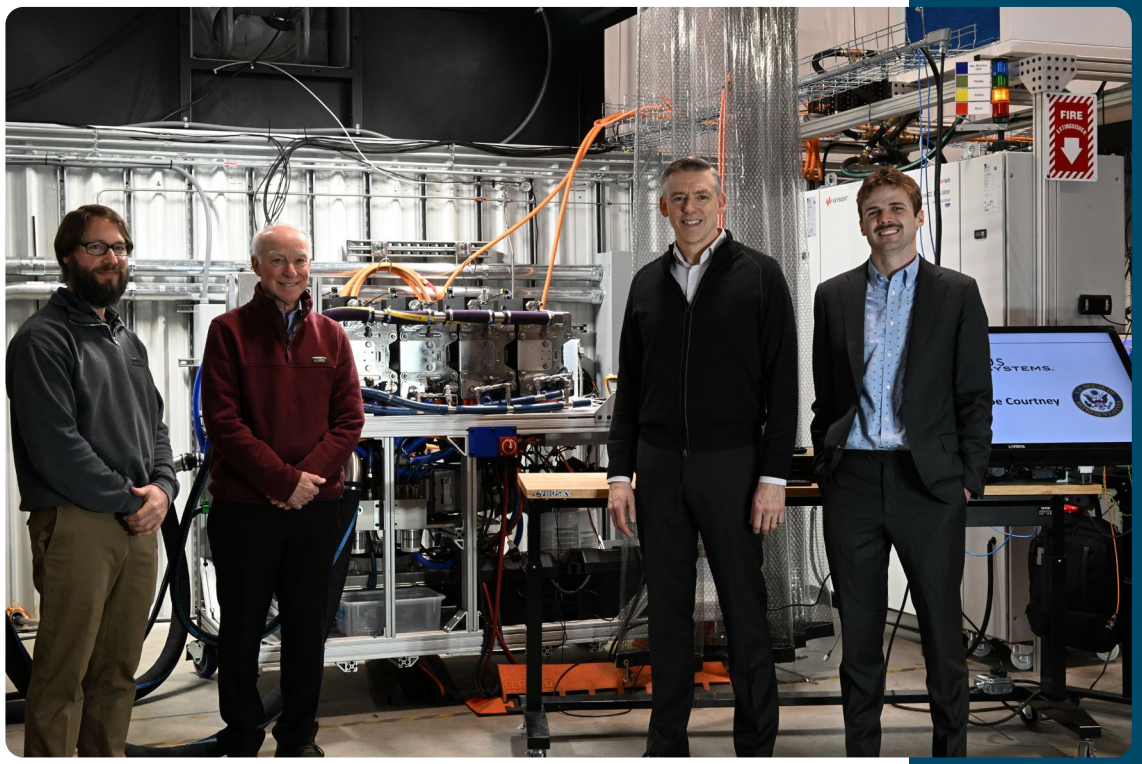
Fuel Cell Dominant Drivetrain for Heavy-Duty Applications

Breadboard



Fuel Cell Dominant Breadboard Testing

- Operational breadboard April 20, 2026
- 200kW achieved May 6, 2026
- Stable, discrete transients
- Tuning for drive cycles and higher power



Fuel Cell Dominant Breadboard Testing

Video not available on the web

Fuel Cell Dominant Breadboard Testing

100, 150, 200 kW transients

Video not available on the web

Long-Term Outlook

- **Addresses key technological limitations**
  - Cost/complexity
  - Performance on grades
  - Performance at highway speeds

- **Reduces barriers to adoption**
  - True replacement for heavy-duty diesel engine in all duty cycles
  - Reduce manufacturing & maintenance costs
  - Improved fuel economy

Thank you.

Questions?

Jackson Danis
Engineering Services Manager
Center for Transportation and the Environment

jackson@cte.tv

Savage's Path to Zero: Advancing Toward a Zero-Emission Operation by 2028

September 17, 2026

Who is Savage?

- Family-owned business established in **1946** in American Fork, Utah — **80 years** of service
- Started with a single truck hauling essential materials; grew into a **global supply chain services business**
- Founded by the Savage brothers on principles of **integrity**, **hard work**, **fair dealing**, and **innovation**
- **Vision & Legacy** statement values guide us: **Do the Right Thing**, **Find a Better Way**, and **Make a Difference**

- Approximately **4,000** Team Members in **150+** locations
- Ongoing operations in the **U.S., Mexico, Canada,** and **Saudi Arabia**
- Bartlett, Energy and Mineral Services, Texon, and Refinery Services

SAVAGE

Wilmington Terminal

Refinery Transportation

Operation Summary:

- 65 Tractors
- 75 Trailers
- 120 Drivers

Wilmington Terminal specializes in the transportation of petroleum coke, coordinating shipments from the five remaining refineries in the Southern California to the Port of Long Beach while maintaining a strong focus on safety, reliability and innovation.

SAVAGE

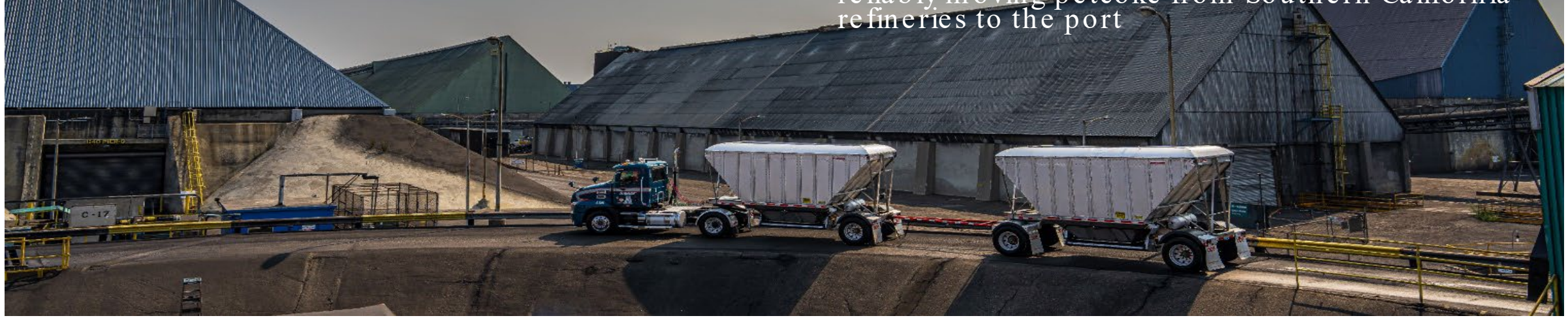
Petroleum Coke

What is petroleum coke?

- Carbon-rich byproduct produced during the oil refining process
- Generated as refineries convert crude oils into fuels and other products
- Used as a fuel and raw material in industries such as cement, steel, and aluminum manufacturing
- Must be removed from refineries regularly due to limited on-site storage capacity

Why it matters

- Timely petcoke transportation helps keep refineries operating efficiently
- Prevents storage constraints that would impact refinery throughput
- Supports uninterrupted fuel production and refinery operations
- Enables delivery to export markets and downstream customers via the Port of Long Beach
- Wilmington Terminal plays a key role in safely and reliably moving petcoke from Southern California refineries to the port



SAVAGE

Why Savage Is Pursuing Zero-Emission Vehicles

Building a Sustainable Transportation Future

Innovation

- Invest in next-generation transportation technology
- Lead the industry through sustainable solutions
- Build expertise for the future of transportation

Finding a Better Way

- Reduce emissions and improve air quality
- Improve efficiency and sustainability
- Support customer and community environmental goals

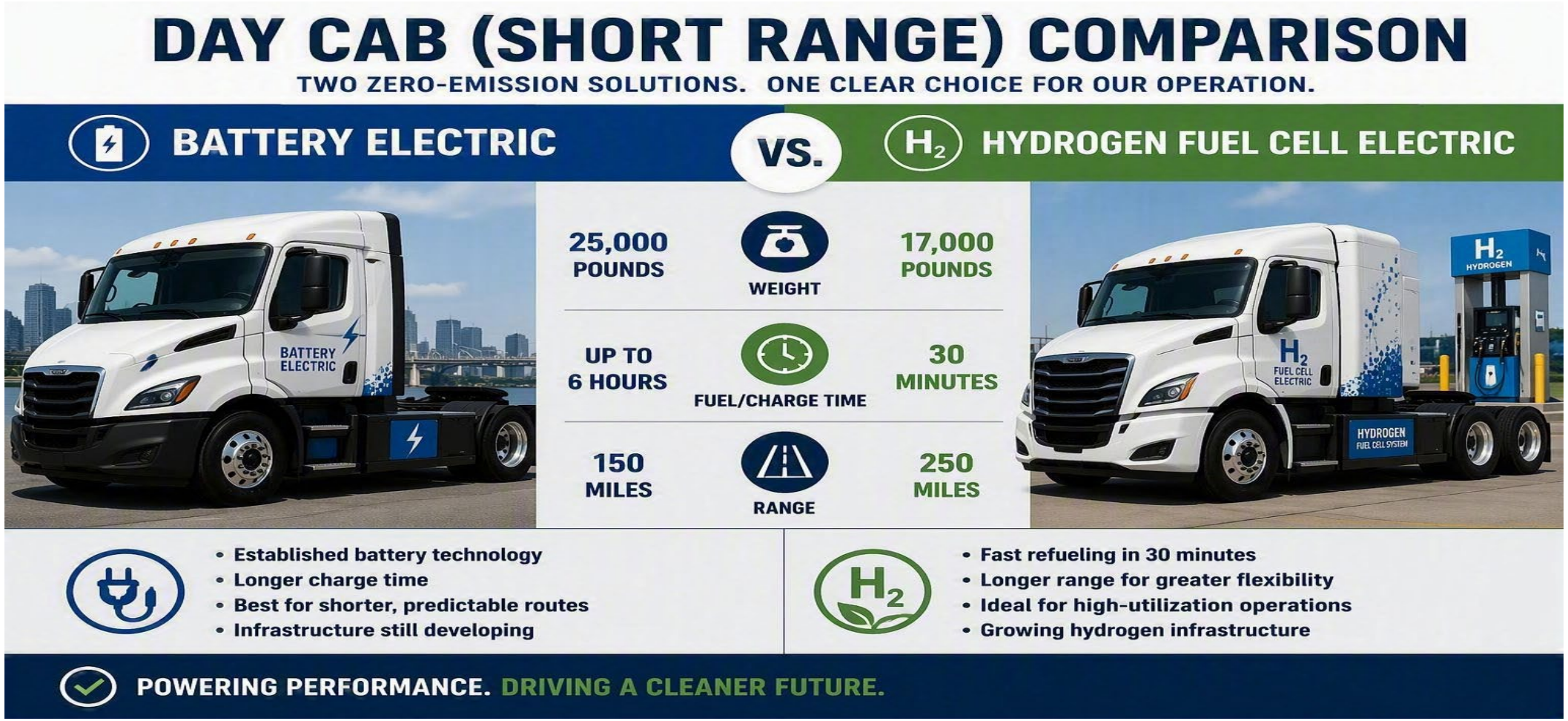
Future-Ready Operations

- Prepare for evolving regulations (POLB Covenant w/tenants)
- Strengthen Savage's reputation as an industry leader
- Create long term competitive advantage
- Deliver safe, cleaner, and more sustainable transportation solutions

SAVAGE

Hydrogen FCEV vs. Battery Electric:

Why We Chose Hydrogen



SAVAGE

Savage and Symbio Partnership

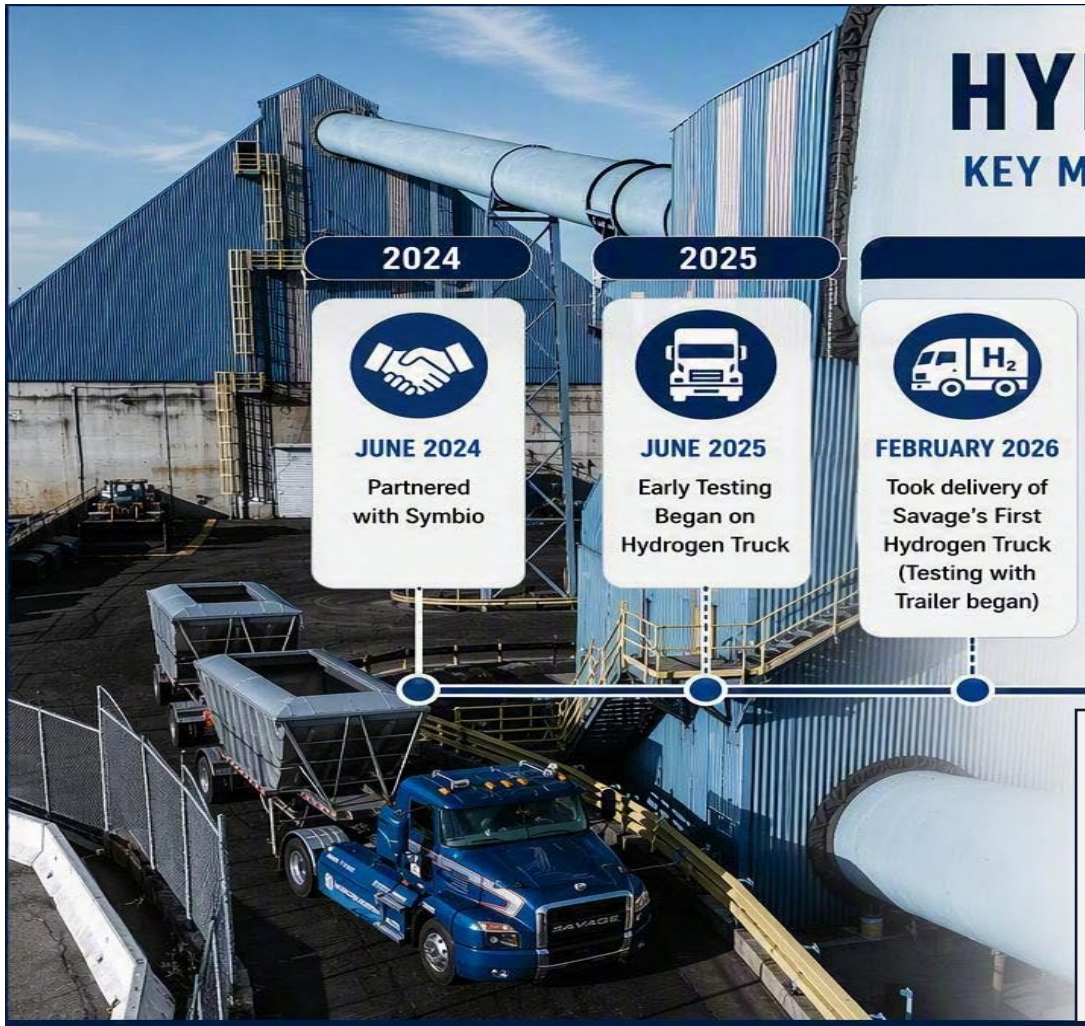
Use Case and Requirements

- Operation: 24/7, 2 shifts
- Re-fueling Frequency: 1 per shift
- Autonomy: +220 miles
- Average miles per shift: 195 miles
- Typical route: 5 - 20 miles
- Driving Profile: Drive through traffic, High Stop and Go
- Road: Paved, limited high vibration
- Peak Torque: 2,330 Nm
- Max. Speed: 65 mph
- Continuous Speed at 6% Grade: 20 mph
- Startability: 5.2%
- Gross Combined Weight: 82,000 lbs.
- Gross Vehicle Weight: <17,200 lbs.

SAVAGE

HYDROGEN FLEET JOURNEY

KEY MILESTONES AND ROADMAP TO ZERO EMISSIONS



2024

JUNE 2024
Partnered with Symbio

2025

JUNE 2025
Early Testing Began on Hydrogen Truck

2026

FEBRUARY 2026
Took delivery of Savage's First Hydrogen Truck (Testing with Trailer began)

MARCH 2026
Registered Hydrogen Truck with Port of Long Beach and got Refinery Approval

APRIL 2026
First Load of petroleum coke delivered by a Zero Emission Vehicle

APRIL 2026
Colton Incident, Hydrogen supply halted

MAY 2026
Testing Hydrogen Truck with full load (discovered hardware issues)

DECEMBER 2026
Receive upgraded hydrogen truck

2028

JANUARY 2028
Entire Fleet must be Zero Emission

Building Tomorrow's Fleet, Today.

INNOVATING TODAY.
POWERING A CLEANER TOMORROW.

- PROGRESS / ACHIEVEMENT
- MAJOR ACCOMPLISHMENT
- CHALLENGE / SETBACK

SAVAGE

H2-ICE as a Near-Zero Pollution Reduction Pathway

September 17th, 2026

Presented By:

Zisimos Toumasatos, Georgios Karavalakis

University of California, Riverside
Bourns College of Engineering
Center for Environmental Research and Technology

UNIVERSITY OF CALIFORNIA, RIVERSIDE

Acknowledgements

PHINIA

SAC METRO AIR DISTRICT
CLEAN AIR FOR ALL

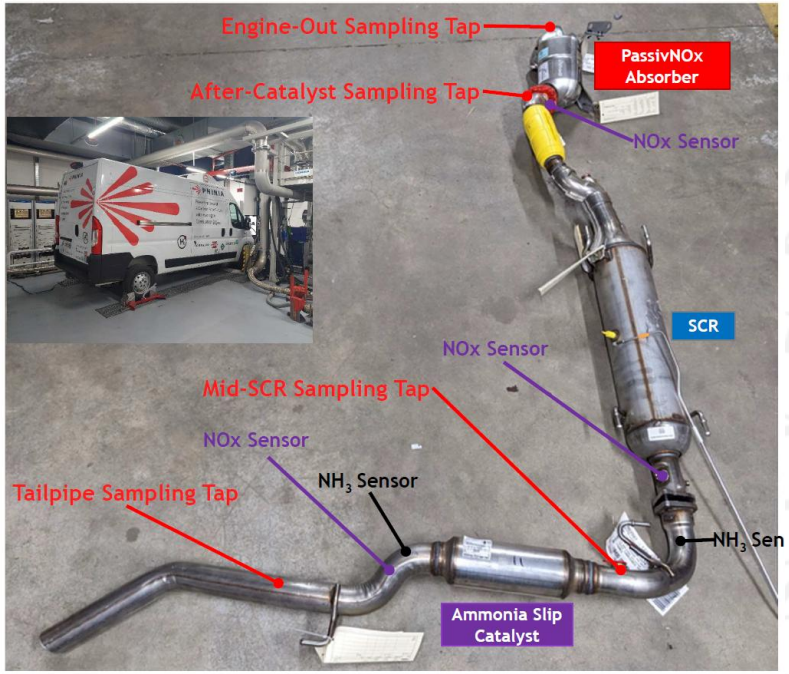
South Coast AQMD

AVL

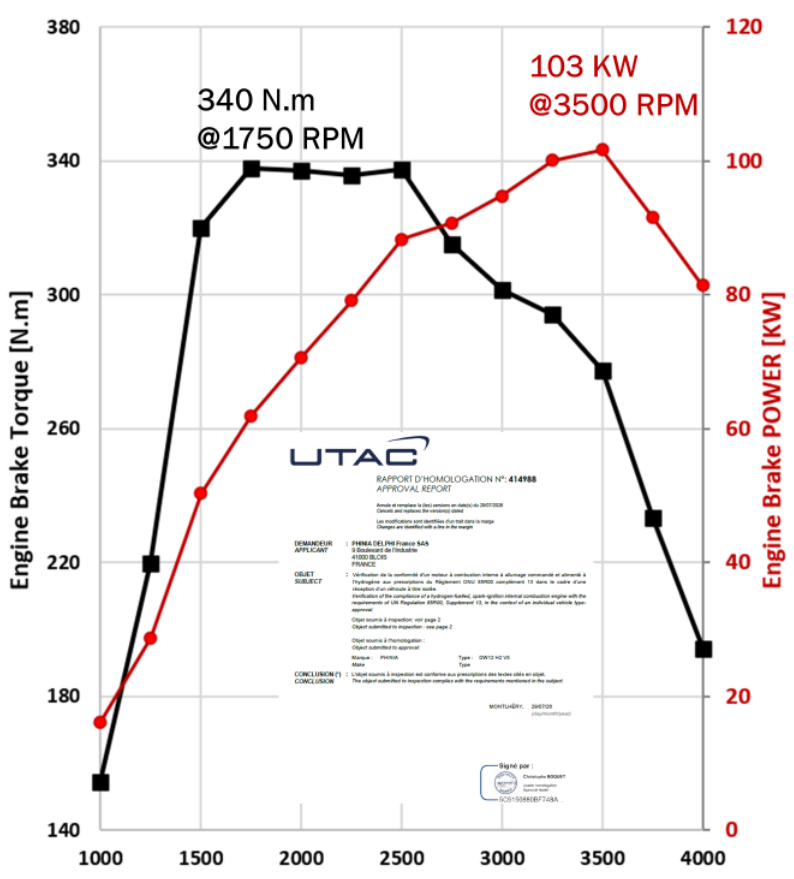
sensors

Data analysis performed with AVL Concerto

Engine Specifications	Diesel Basline	PHINIA H2ICE-V4
Injector Type	Common rail Diesel	Medium pressure DI CHG10-7
Injection Pressure	250-2000 bars	15-30 bars
Aerodynamic	Swirl	Swirl
Injector Position	Central	Central
Spark Position	-	Lateral
Compression Ratio	16.0	9.5
Displacement	2.2	2.2
Boost System	Single stage VGT	Single stage VGT (original)
Aftertreatment	DOC + SCR + ASC	DOC + SCR + ASC (original)



Engine Performance Tested as per UNR85



PHINIA

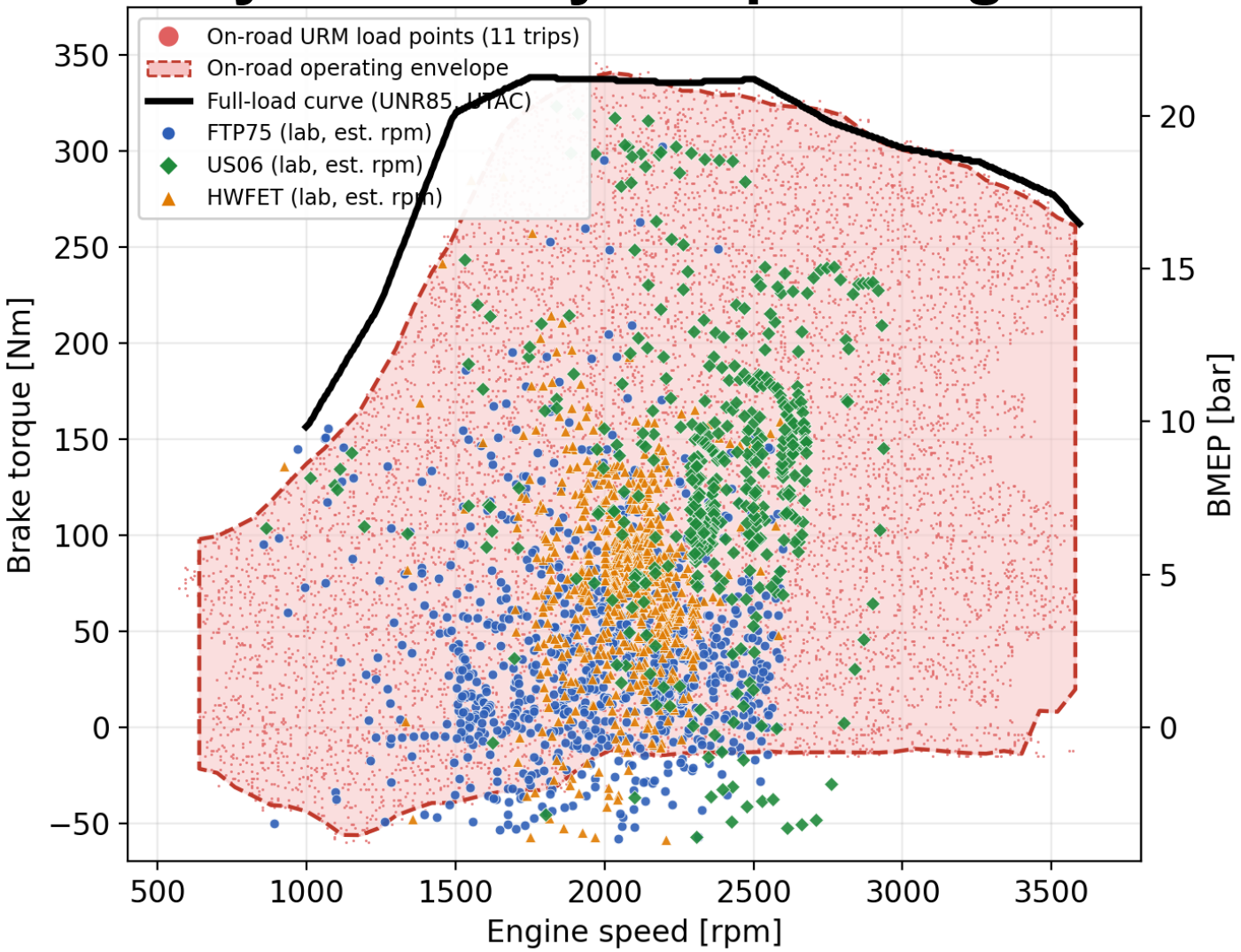
Why on-road testing matters — beyond the dyno operating envelope

- **Certification cycles cover a narrow band of the engine map.** On-road URM trips hold sustained >85% load at 2,000–2,800 rpm — exactly where NOx and CO_2 production peak — with the N_2O ridge at 60–80% load and the NH_3-slip hotspot at 50–80% load / 2,000–2,600 rpm

- **Emissions are dynamics-driven, not cycle-driven.** Trip NOx EF correlates with RPA (r = 0.80) and va_pos[95] (r = 0.85); second-by-second NOx tracks VSP (r = 0.96) even downstream of a ~98%-efficient SCR

- **Real-world thermal transients dominate.** The SCR pre-light-off window (~200 s) is the single highest-NOx event of a trip; sustained motorway load triggers NH_3 slip (27–36 ppm above 60% load) and N_2O formation (≈ 15 g/km CO_2e)

- **SPN10 is event-driven** — overrun/fuel-cut contributes up to 59% of trip PN in 37% of the time and is uncorrelated with power (r ≈ −0.1): invisible in cycle-average lab metrics



Engine load points: on-road URM trips (ECU/XETK, 11 trips) vs the certification cycles, against the full-load curve (UNR85, UTAC; 340 N·m @ 1,750 rpm). Cycle torque from dyno road load + ETW inertia (F0=133.8 N, F1=−4.95, F2=1.223 SI; 2,827 kg); cycle rpm estimated via a 5-speed shift model (ECU not logged in lab exports) — to be replaced with measured ECU data.

On-road test campaign

On-road measurement layout

Gaseous Emissions

Gas PEMS
- UV Analyzer: NO/NO2
- NDIR Analyzer: CO/CO2
- Electrochemical: O2

MOVE FT
- Measures NH_3, N_2O, CH_4 and HCHO and optionally
- CO, CO_2, NO/NO_2

System Control

Ambient & GPS

EFM (only for chassis dyno testing)
- 100 °C: 18-810 kg/h
- 400 °C: 28-610 kg/h

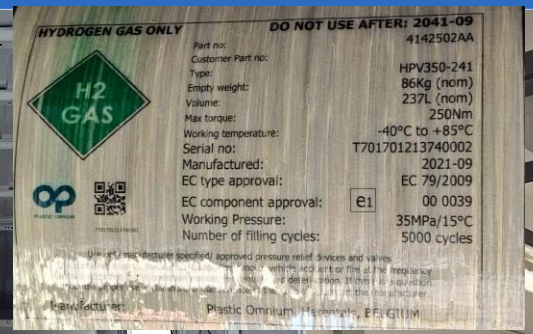
ECU OBD II
- ISO 9141-2
- ISO 14230 KWP2000
- ISO 15756 CAN

PM/PN Emissions

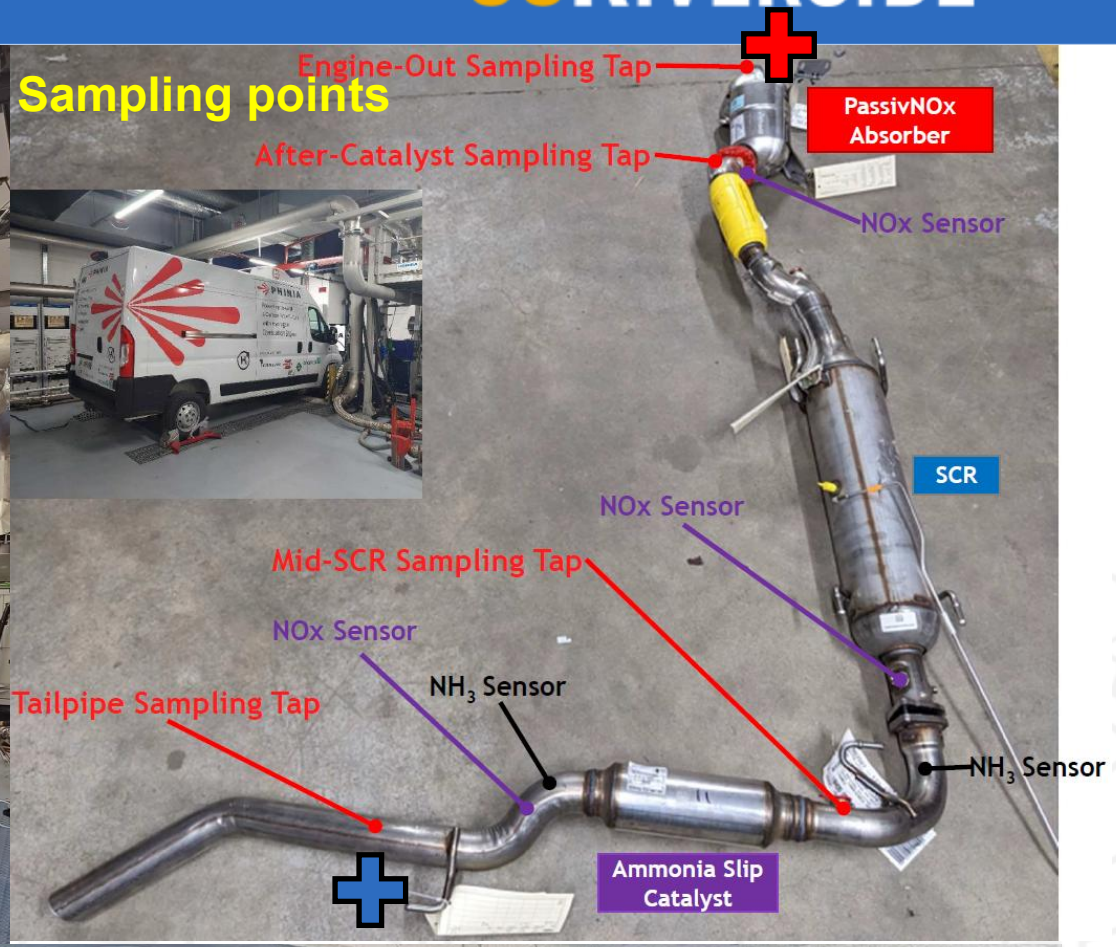
HIGH RESOLUTION ELPI+
- PN and PM particulate sizer
- Size range 6 nm – 10 µm

SEMTECH CPN 23|10
- PMP compliant CPC
- 10nm particle counter

Back view


HYDROGEN GAS ONLY
DO NOT USE AFTER: 2041-09
H2 GAS
Part no: 4142502AA
Customer Part no:
Type: HPV350-241
Empty weight: 86Kg (nom)
Volume: 237L (nom)
Max torque: 250Nm
Working temperature: -40°C to +85°C
Serial no: T701701213740002
Manufactured: 2021-09
EC type approval: EC 79/2009
EC component approval: e1 00 0039
Working Pressure: 35MPa/15°C
Number of filling cycles: 5000 cycles
Plastic Omnium

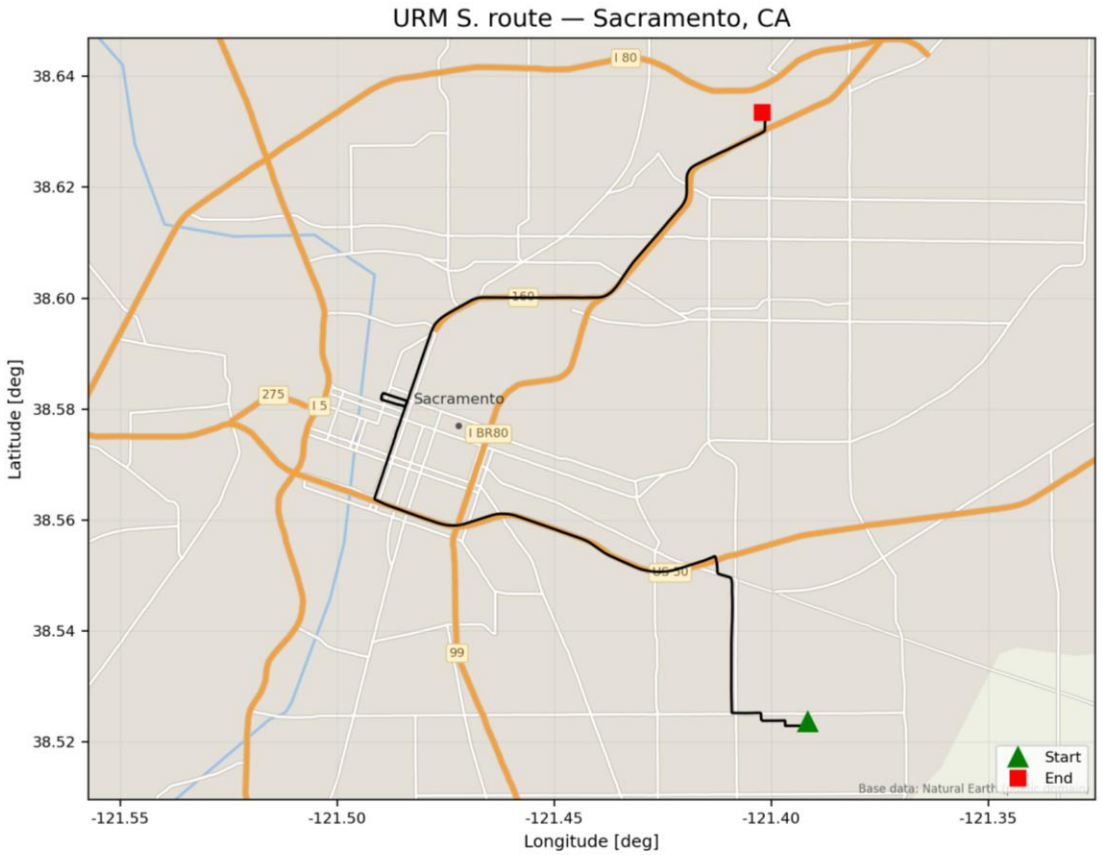
Chassis
PHINIA
FIAT

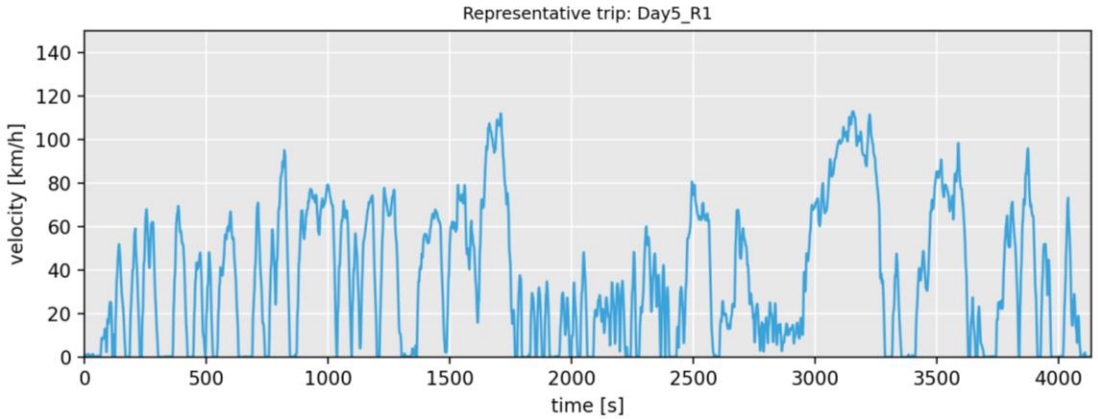

Sampling points
Engine-Out Sampling Tap
PassivNOx Absorber
After-Catalyst Sampling Tap
NOx Sensor
SCR
NOx Sensor
Mid-SCR Sampling Tap
NOx Sensor
NH_3 Sensor
Tailpipe Sampling Tap
NH_3 Sensor
Ammonia Slip Catalyst

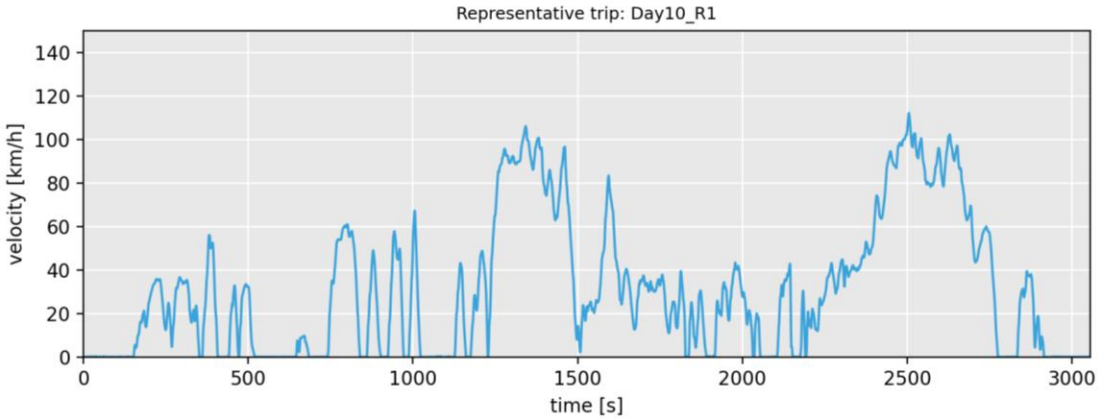
Side view

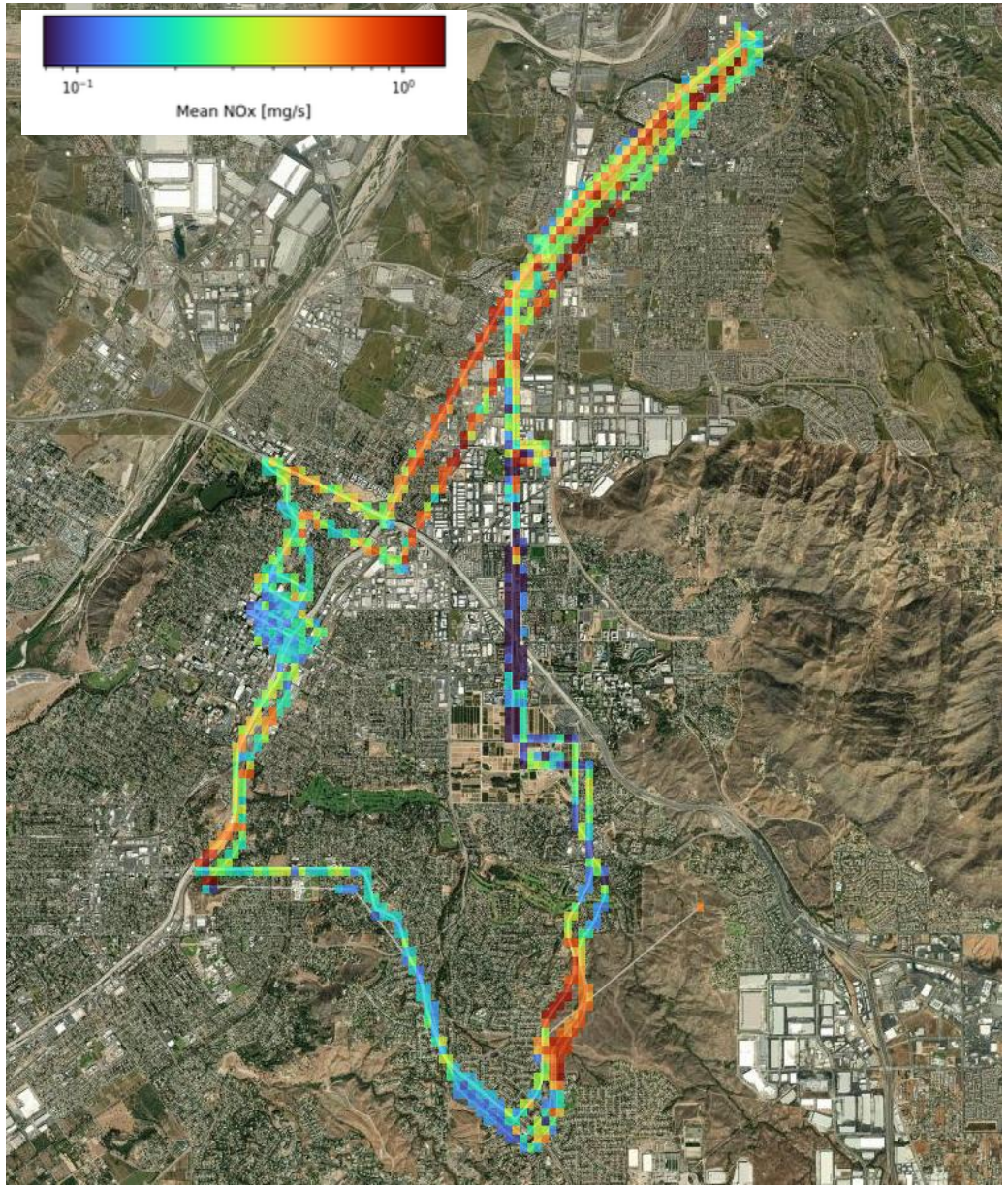
Sampling points

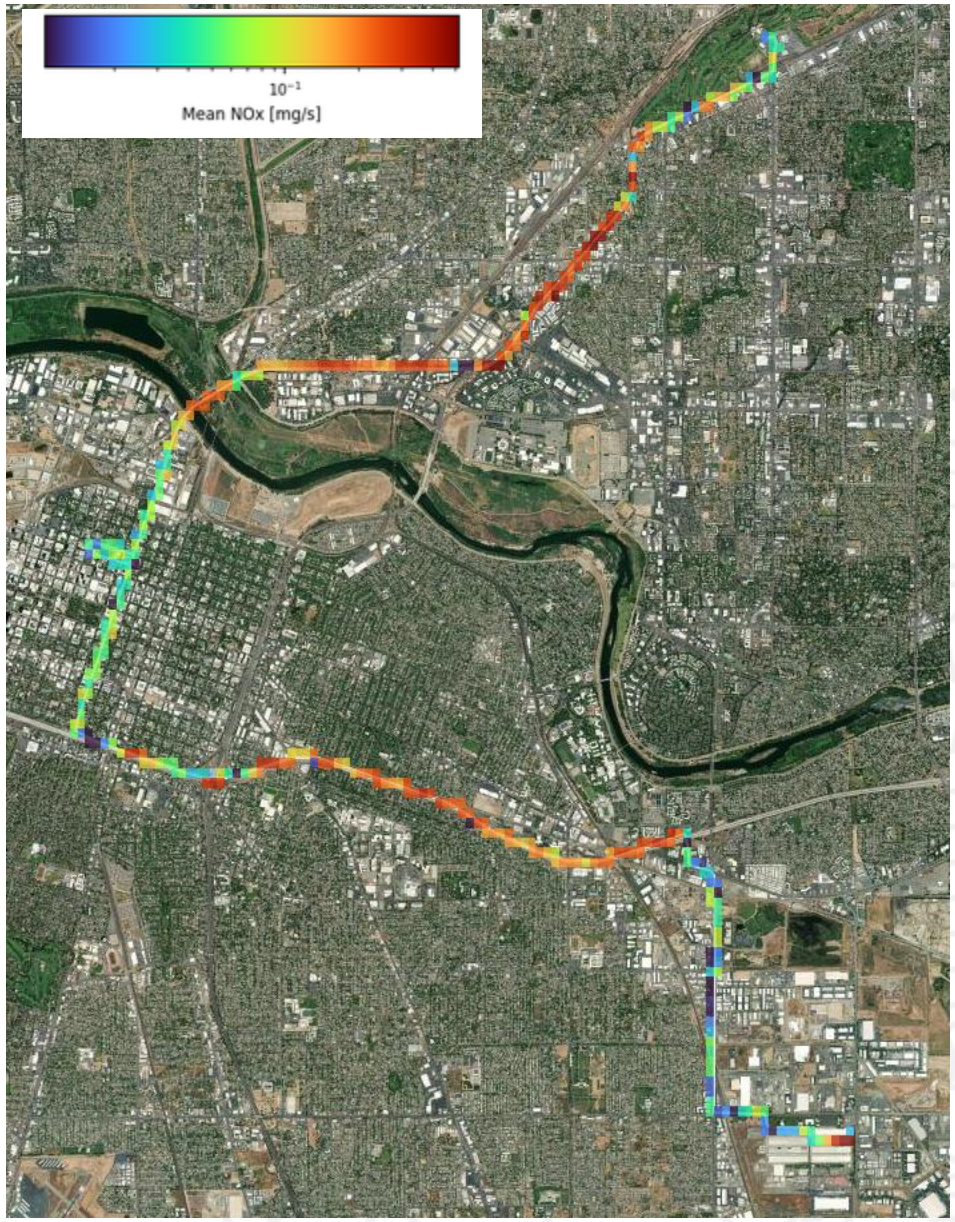
URM route — Riverside, CA
Latitude [deg]
Longitude [deg]
Riverside
I 215
60
91
Start
End
Base data: Natural Earth


URM S. route — Sacramento, CA
Latitude [deg]
Longitude [deg]
Sacramento
I 80
160
275
I 5
I BR80
99
Start
End
Base data: Natural Earth


Representative trip: Day5_R1
velocity [km/h]
time [s]

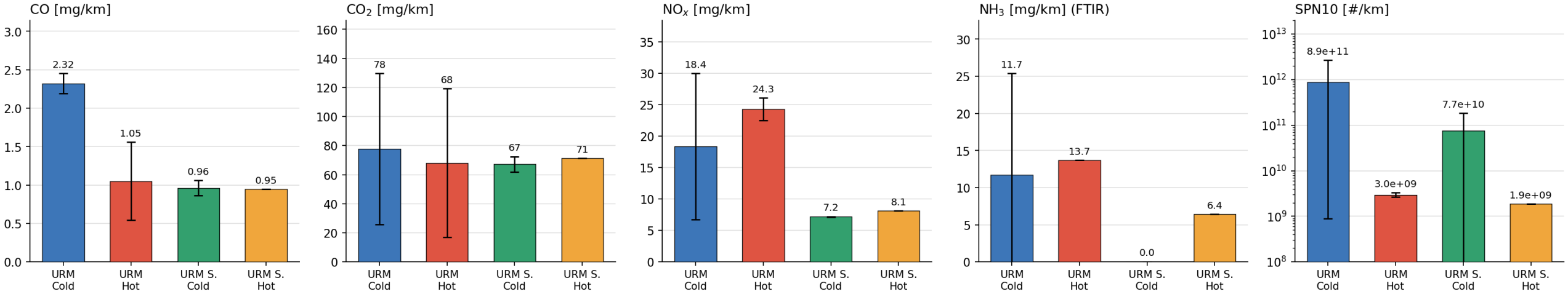

Representative trip: Day10_R1
velocity [km/h]
time [s]

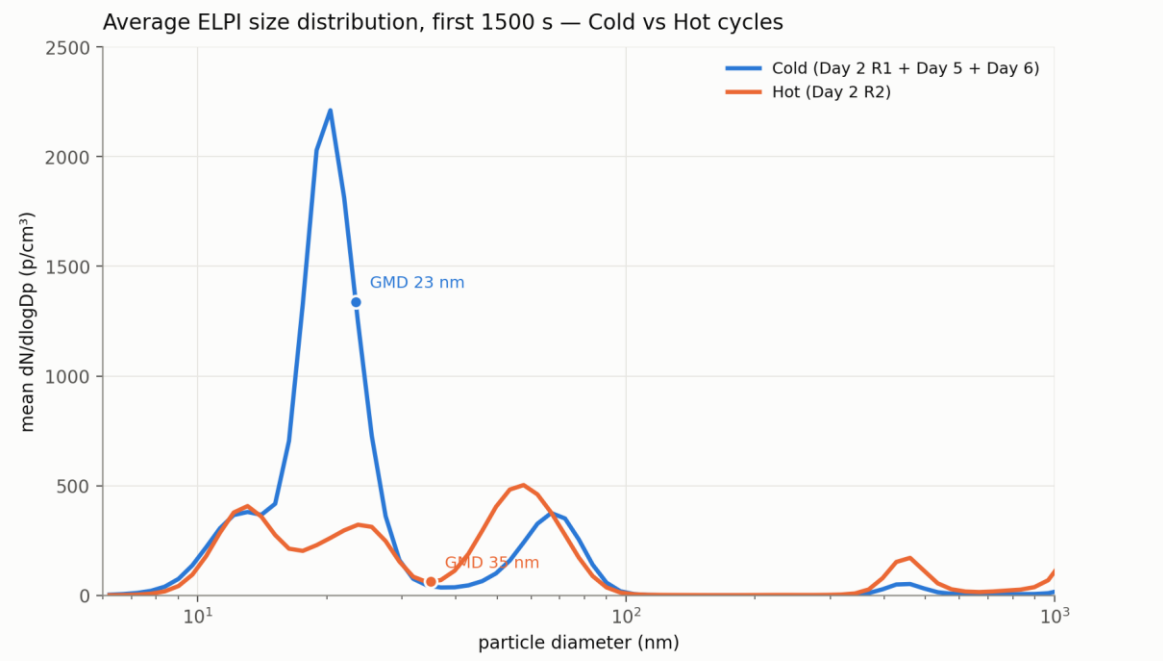

10^{-1}
10^{0}
Mean NOx [mg/s]

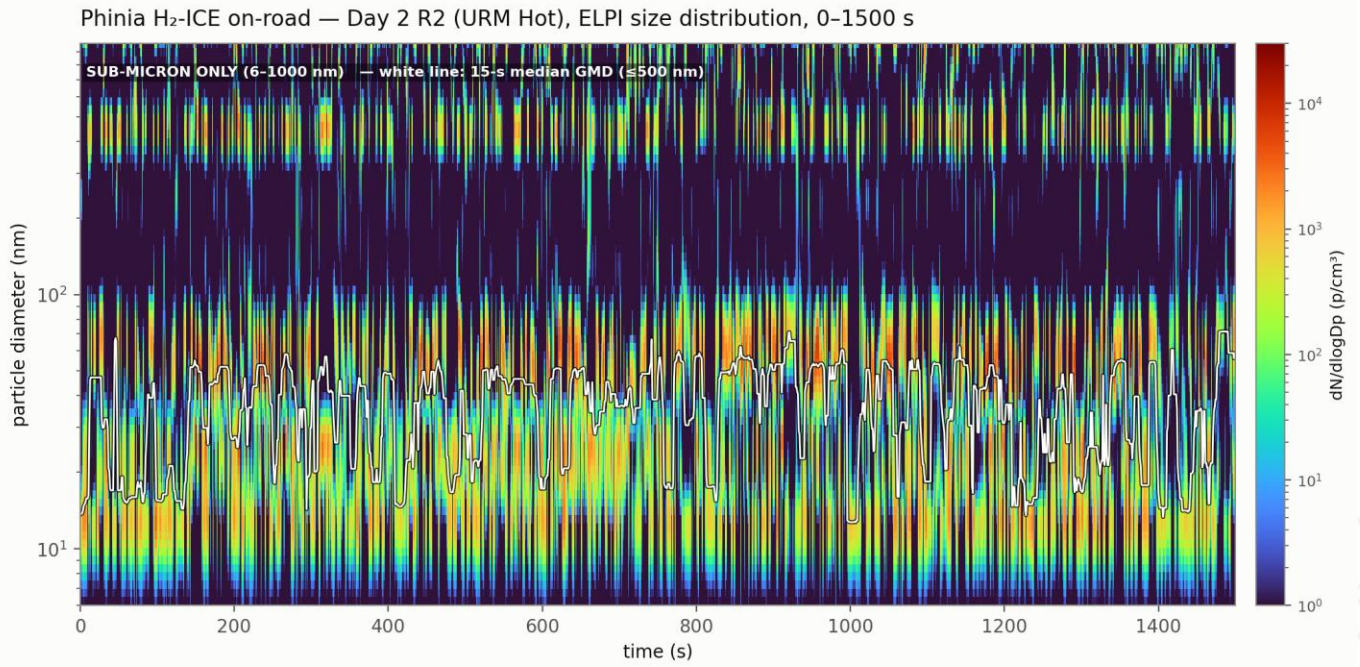

10^{-1}
Mean NOx [mg/s]

Aggregated emission levels - tailpipe

Category means ± 1 SD, tailpipe — Day 1 (engine-out) excluded from gaseous panels, included in SPN10 (PN measured at tailpipe in both configurations).

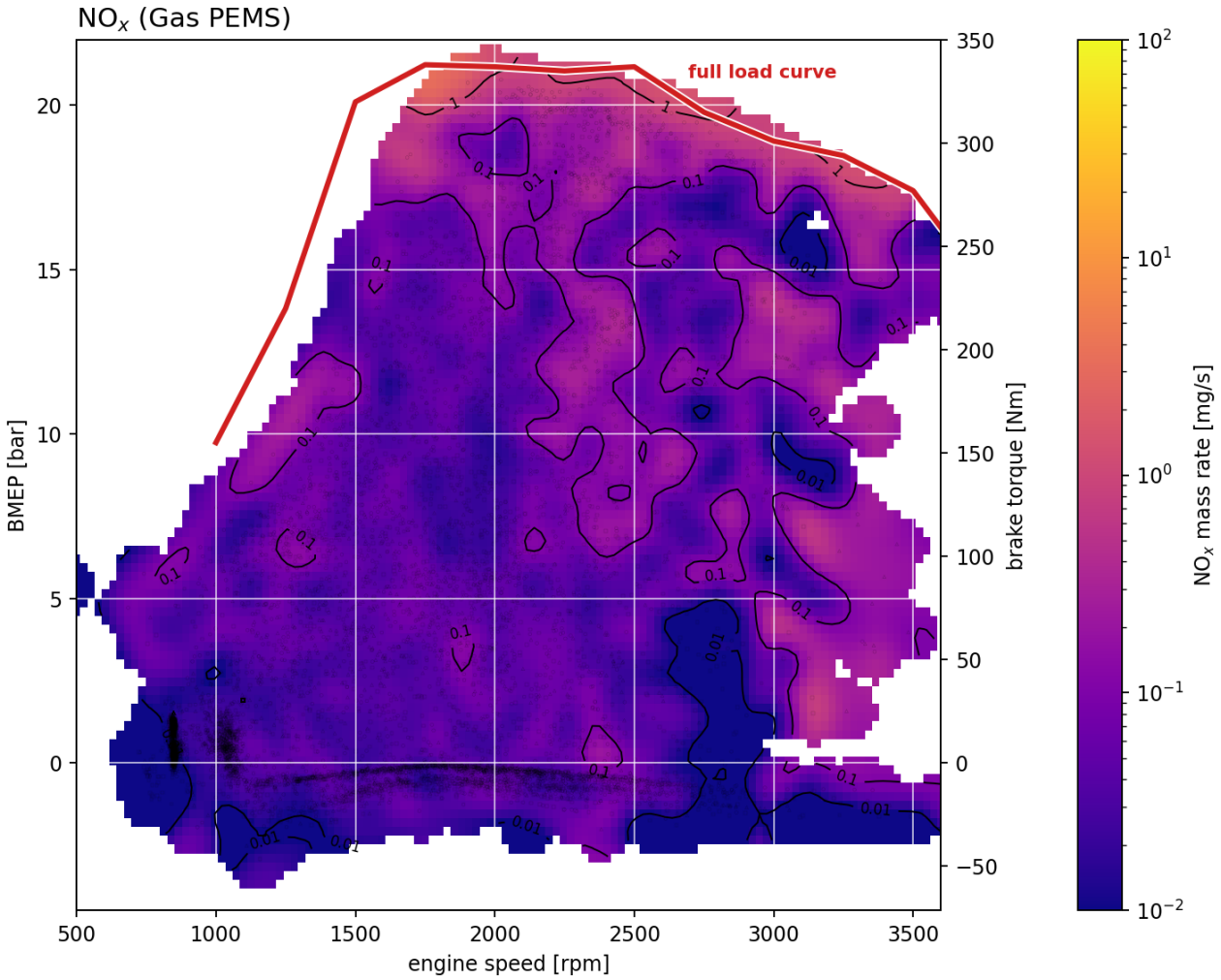


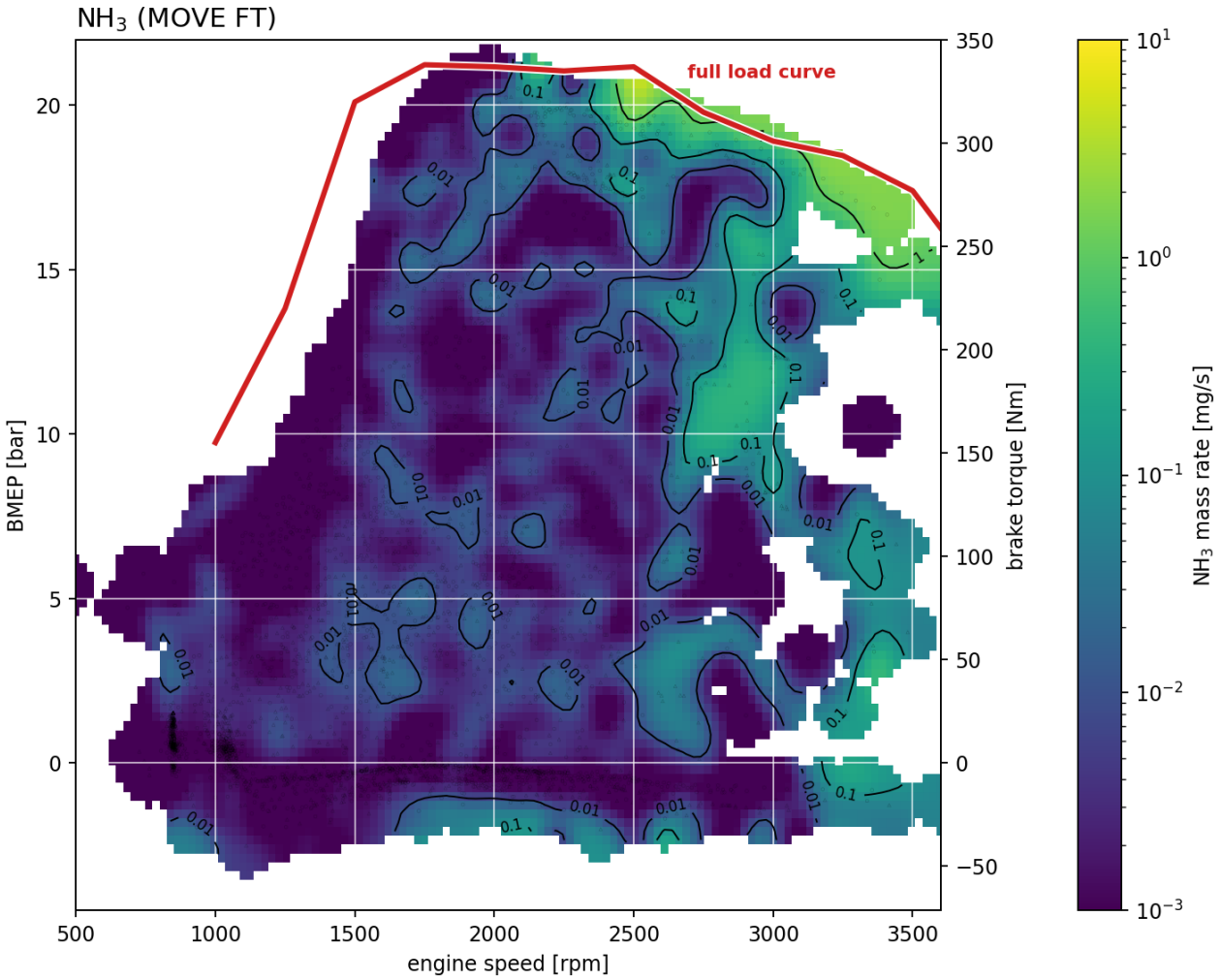




- Cold starts produce a sharp nucleation-mode peak at ~20 nm reaching ~2,200 p/cm³ — over 4× the maximum concentration observed during hot operation
- Hot operation shows a flatter, accumulation-dominated distribution peaking at ~58 nm (~500 p/cm³), consistent with lubricant-oil-derived particles
- Number-weighted GMD shifts from 23 nm (cold) to 35 nm (hot), reflecting the transition from nucleation-driven to soot/lube-mode aerosol as the engine warms
- Both conditions share a minor common mode at ~13 nm; concentrations above 100 nm are negligible (<50 p/cm³)

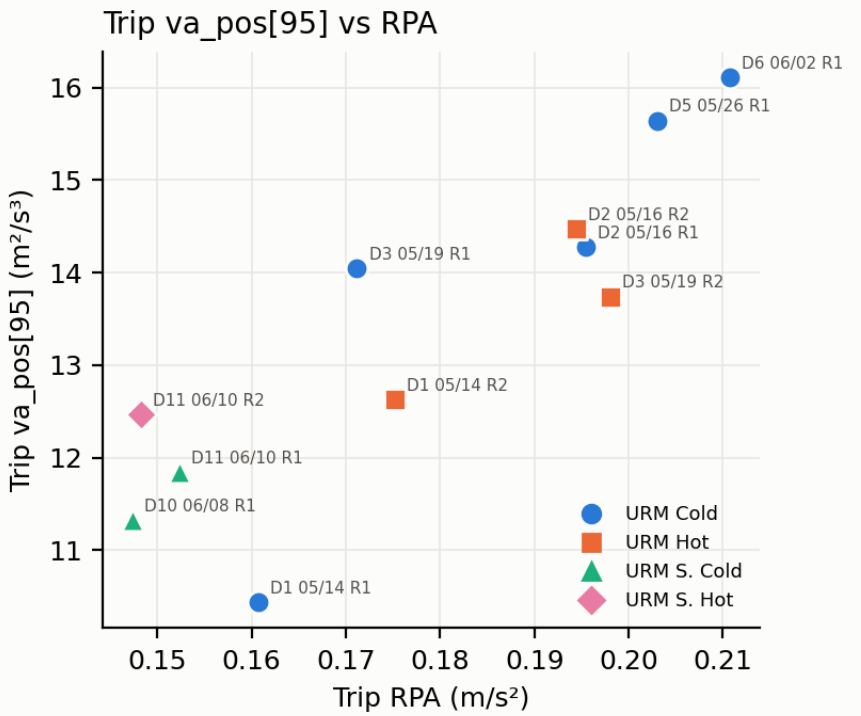
Engine operating maps – On-road testing

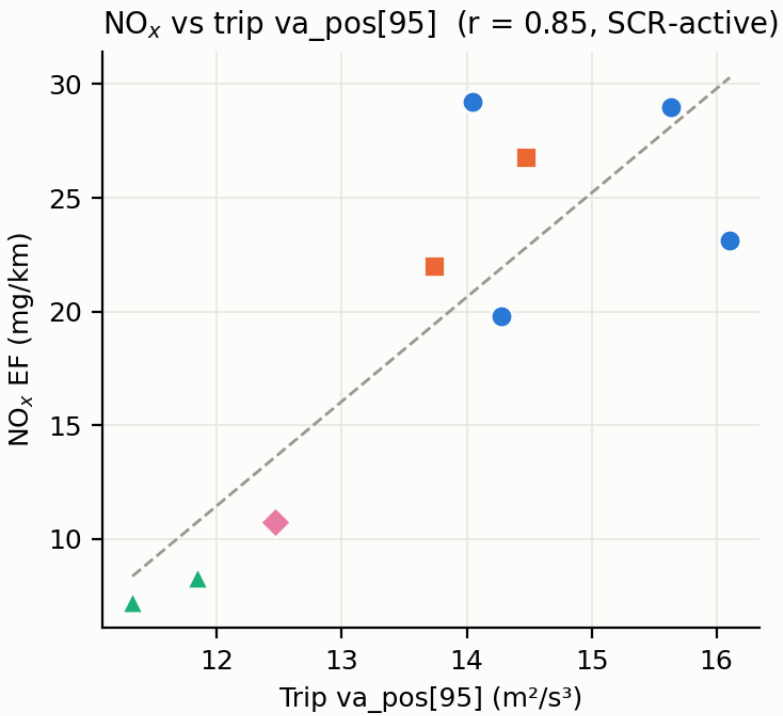


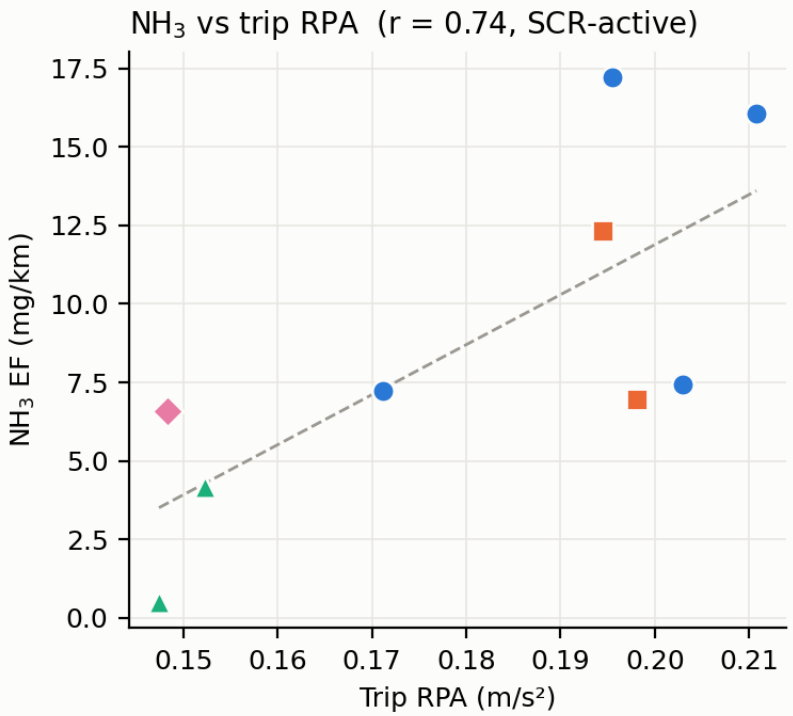


INTERPOLATED SURFACE — linear (Delaunay) interpolation of $\log_{10}$(mass rate) over the pooled 1 Hz points, nearest-neighbour fill outside the hull, Gaussian smoothing ($\sigma \approx 1.6$ grid nodes).
Grid nodes further than a set distance from any measurement are blanked. BMEP = $4\pi \cdot T / V_d$ with an ASSUMED V_d = 2.0 L; right-hand axis is brake torque.
Full-load curve: UNR85 homologation test (UTAC), 340 N·m @ 1750 rpm ≈ 21.4 bar BMEP, converted with the same V_d. NH_3 (MOVE FT) restricted to water-valid windows (D2 R2 0–2399 s, D11 R2 0–1644 s); NO_x uses all three hot cycles. Black lines are iso-mass-rate contours in mg/s.

Emission performance vs driving dynamics

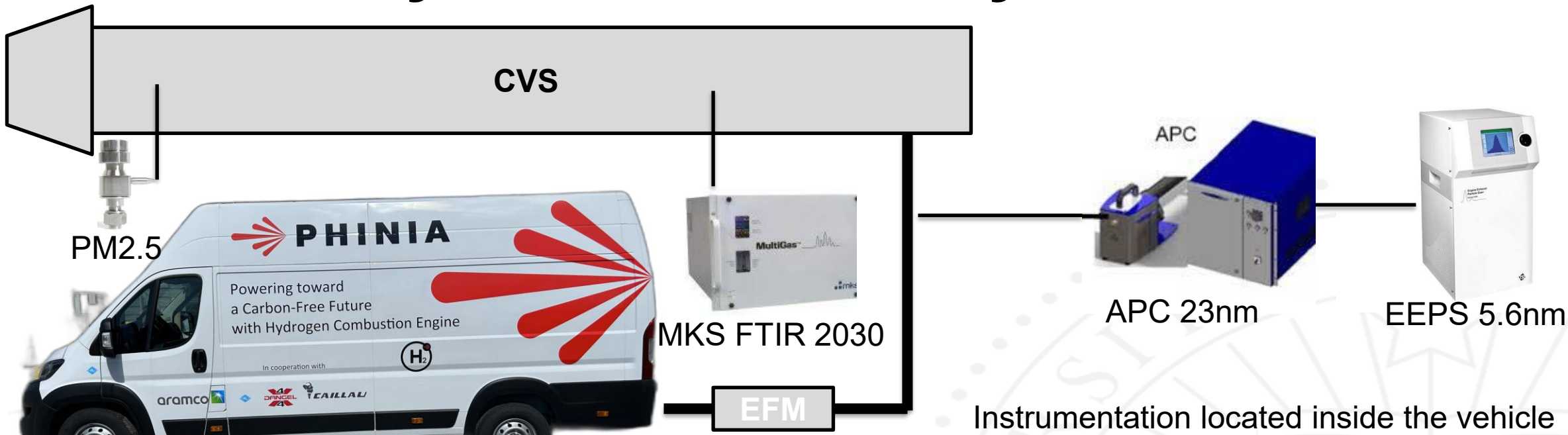




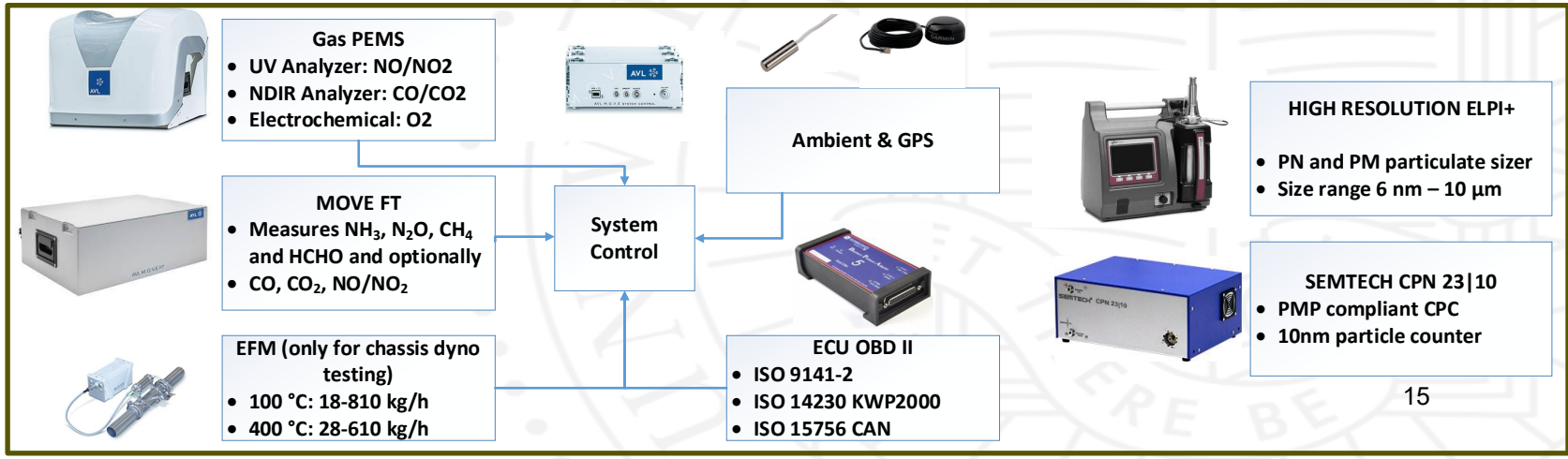


Laboratory test campaign

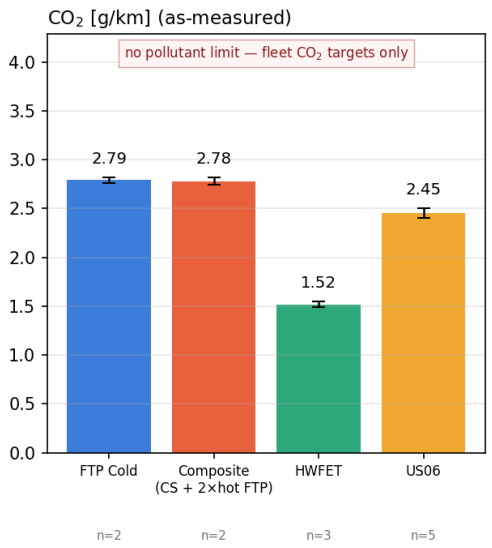
Laboratory measurement layout

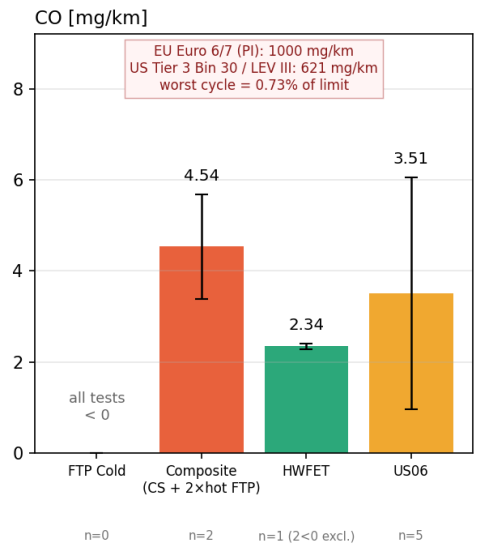


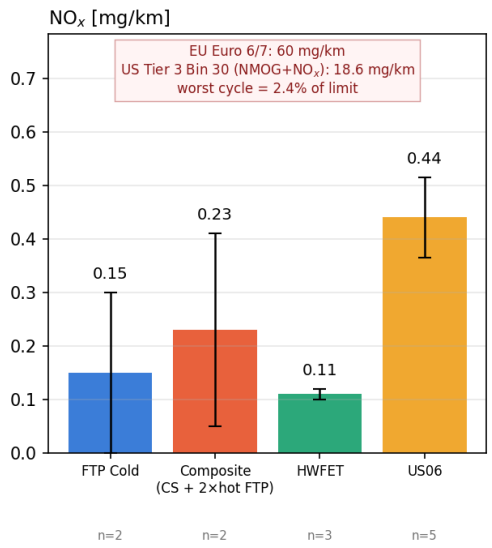
Instrumentation located inside the vehicle

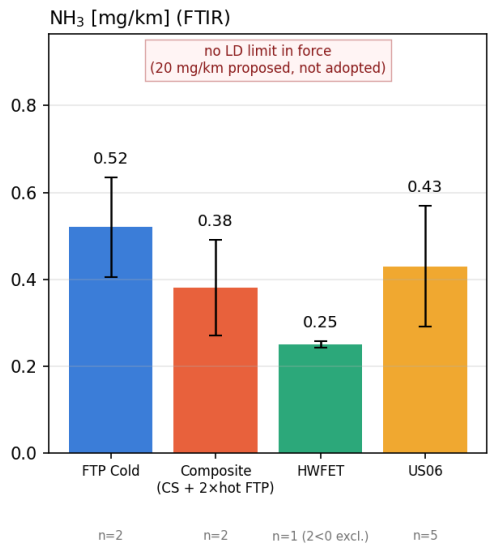


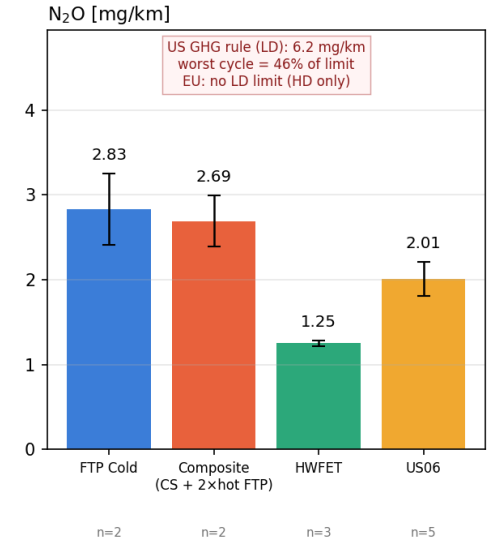
Bag analysis and DNPH filters

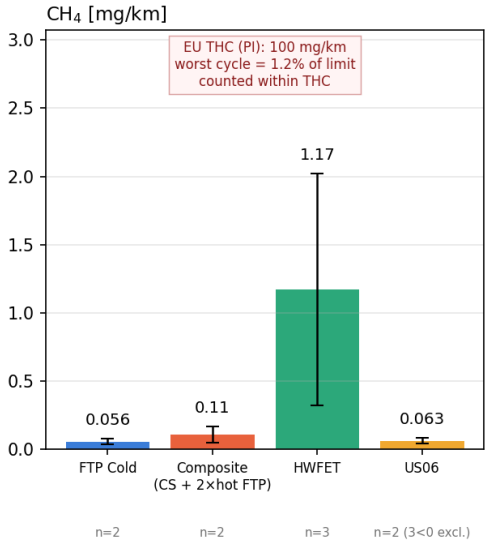


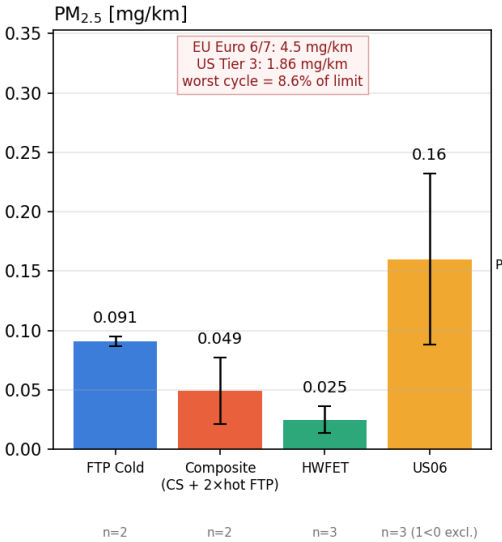


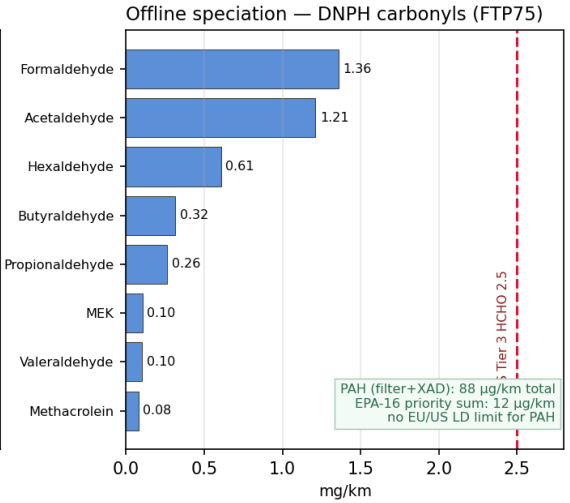






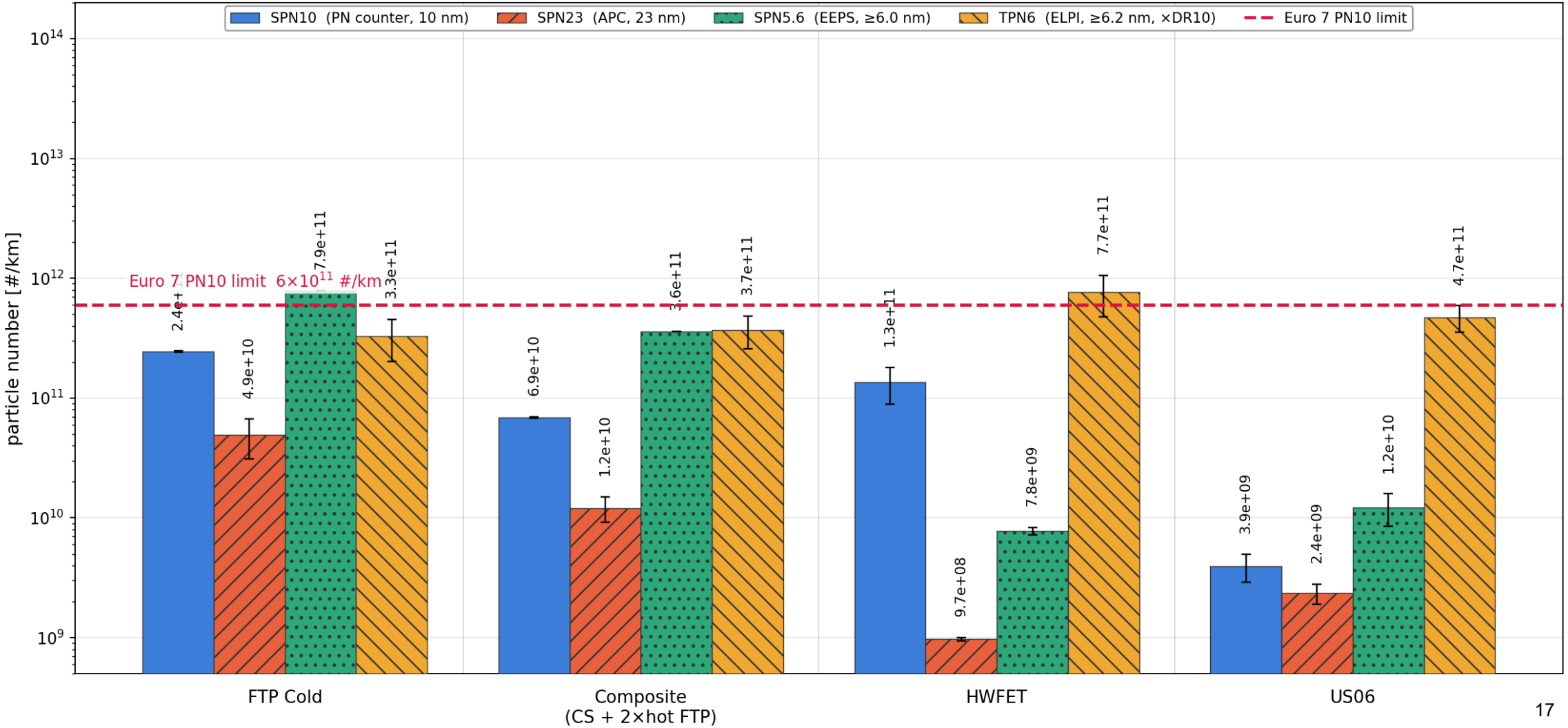






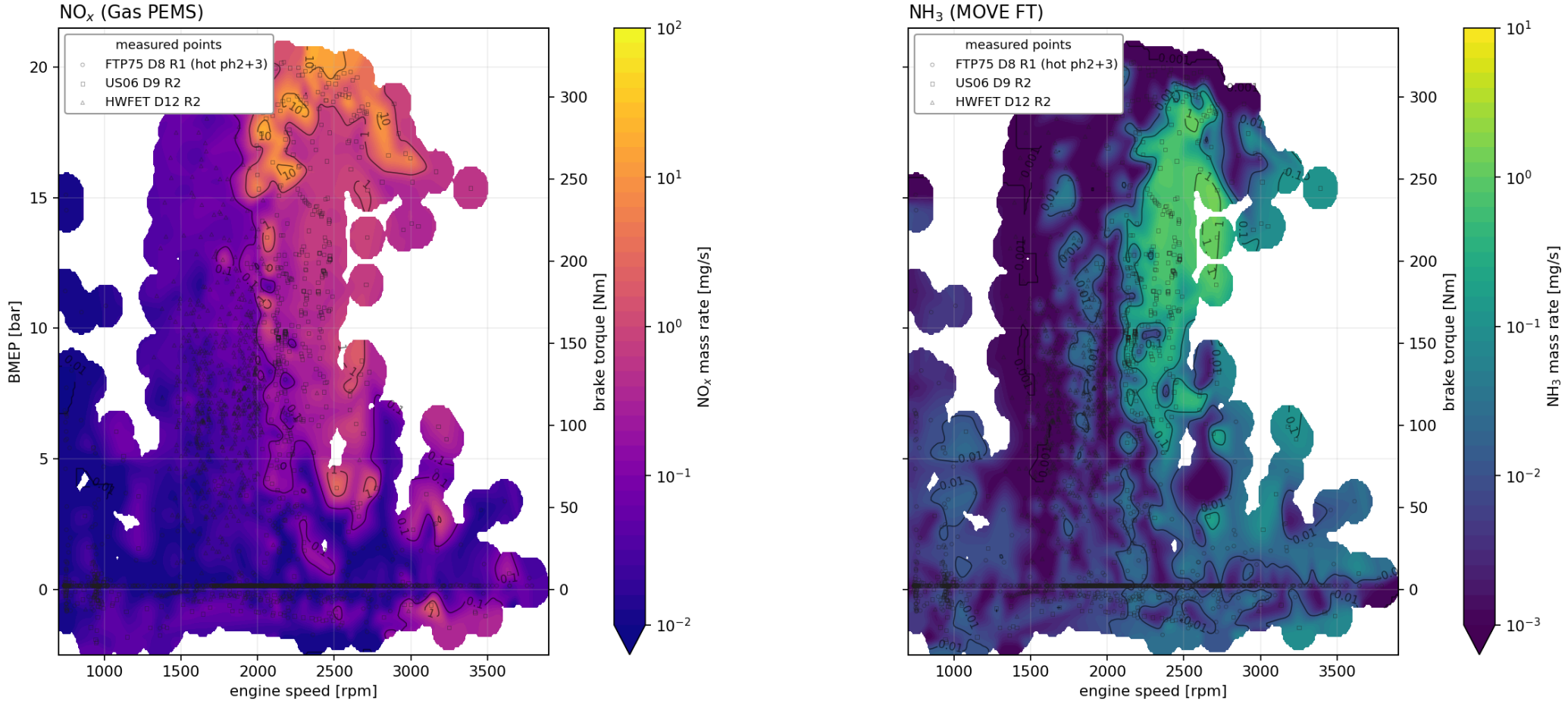
Particle number emissions SPN and TPN

H_2 combustion vehicle — tailpipe particle number by cycle and size cut (mean ± 1σ)



Engine operating maps – Lab testing

Combined engine operating map — interpolated NO_x and NH_3 mass rates (FTP75 hot + US06 + HWFET pooled)

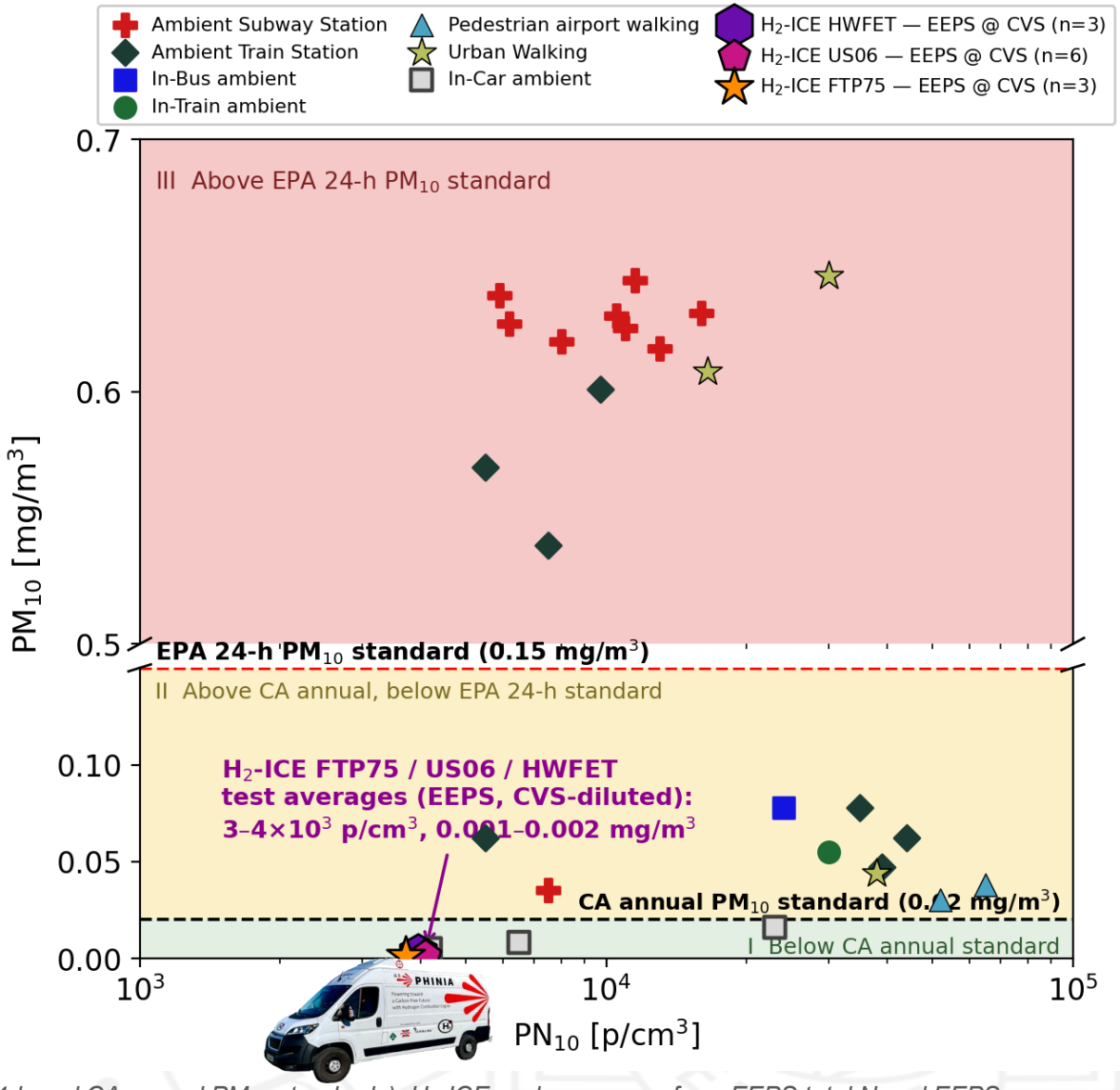


INTERPOLATED SURFACE — linear (Delaunay) interpolation of $\log_{10}$(mass rate) over the pooled 1 Hz points, nearest-neighbour fill outside the hull, Gaussian smoothing ($\sigma \approx 1.6$ grid nodes).
Grid nodes further than a set distance from any measurement are blanked, so the coloured area still reflects the measured operating envelope. Values between markers are estimates, not measurements.
BMEP = $4\pi \cdot T / V_d$ with an ASSUMED V_d = 2.0 L (not recorded in the merge); right-hand axis is the measured brake torque. Logarithmic colour scale; labelled black lines are iso-mass-rate contours in mg/s.

Summary

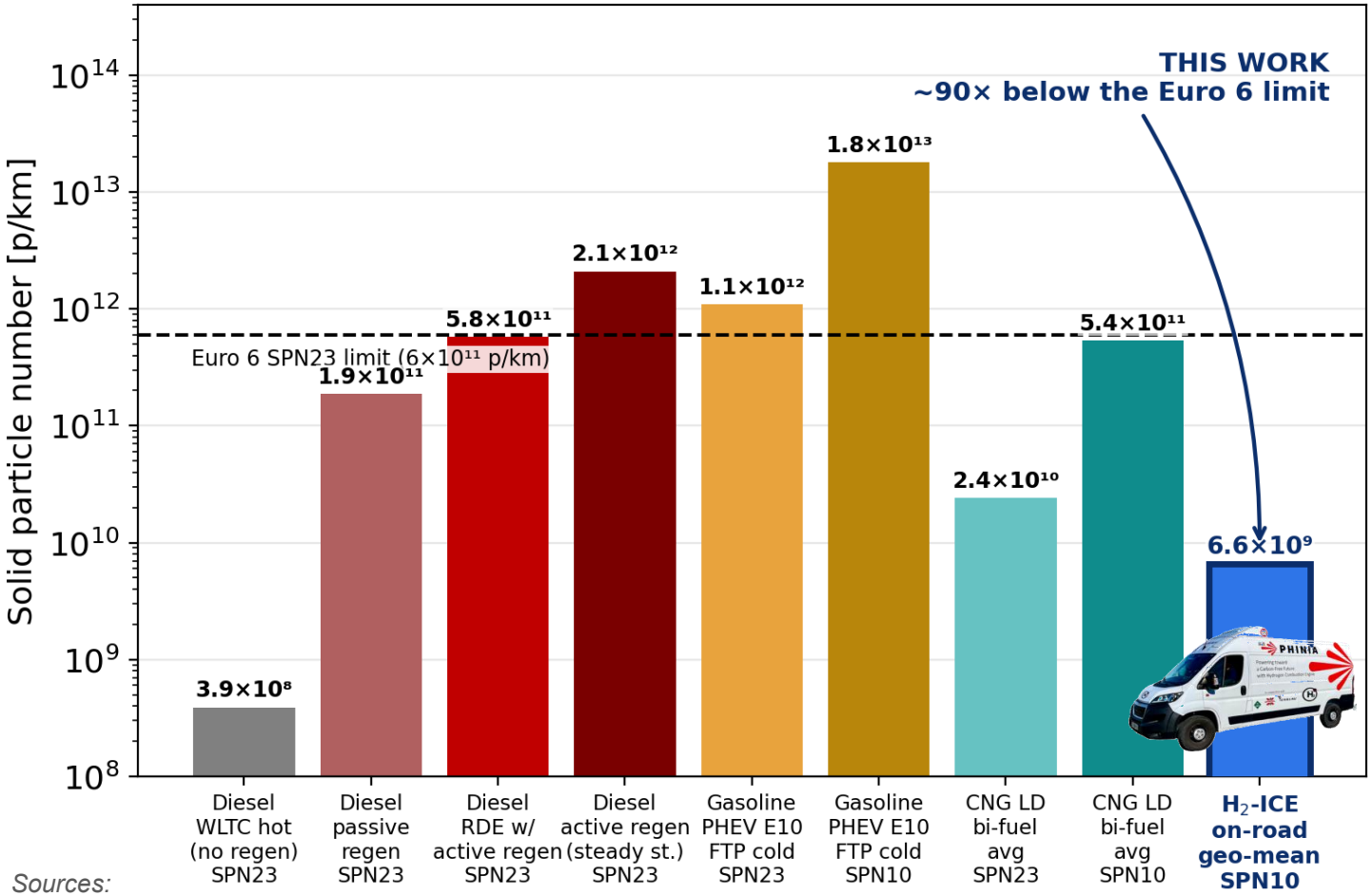
Tailpipe PN/PM in ambient context — Ped-Urban exposure data CRC 2026 presented results

- **What the plot shows:** breathing-zone PM_{10} vs PN_{10} measured across LA microenvironments (Ped-Urban study, CPC 3007 / DustTrak), against the EPA 24-h and California annual PM_{10} standards — with the H_2-ICE FTP75, US06 and HWFET test averages (EEPS, CVS-diluted exhaust) added for scale
- **The result:** across all three certification cycles the diluted H_2-ICE exhaust averages only 3–4×10³ p/cm³ and ~0.002 mg/m³ — below in-car cabin air and 1–2 orders of magnitude below sidewalk, transit-platform and airport exposures
- **Why so low — the fuel carries no carbon:** hydrogen combustion produces water, not soot. Without fuel-borne carbon there is no soot formation pathway and no accumulation mode — the mechanism that generates diesel/GDI particle mass simply does not exist
- **The only particle source is lubricating oil:** trace oil vapor nucleates into 15–22 nm ultrafines as the exhaust cools and dilutes. Since particle mass scales with d³, these sub-23 nm particles carry essentially no mass — PM_{10} stays at background, and PN is modest and event-driven (tip-in, overrun) rather than load-driven



PM_{10} vs PN_{10} across LA microenvironments (reconstructed from Ped-Urban Fig. 3; EPA 24-h and CA annual PM_{10} standards). H_2-ICE cycle averages from EEPS total N and EEPS-derived mass in CVS-diluted exhaust: FTP75 (n=3, Jun 16), US06 (n=6, Jun 4–5), HWFET (n=3, Jun 15).

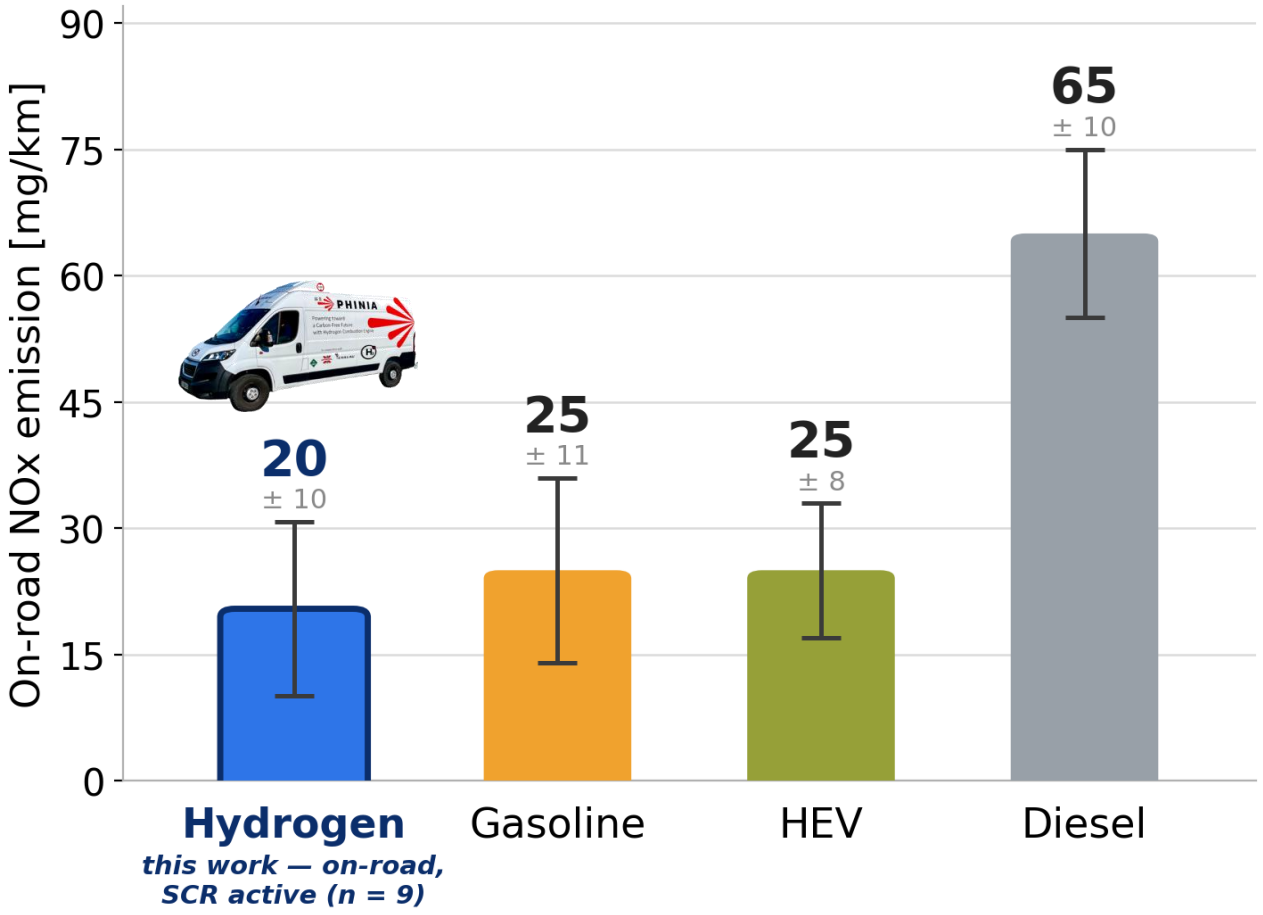
Benchmark: H_2-ICE vs diesel, gasoline-PHEV and CNG PN



- **Diesel is clean until the DPF regenerates:** active regeneration raises SPN23 ×1000 (5.77×10^{11} p/km over the RDE), passive regeneration ×100 on motorways; regeneration-weighted EFs rise ×1.5–3.9.
- **Gasoline PHEV (SULEV30, E10–E83):** cold-start FTP dominates — E10 SPN23 ≈1.1×10^{12} p/km exceeds Euro 6 and SPN10 runs up to ~60× SPN23 (sub-23 nm nucleation); E83 cuts SPN10 by 98%; hot-start US06 clears both limits — cycle effect > fuel effect
- **CNG — the 23-nm mirage:** light-duty CNG SPN23 sits at just 4% of the Euro 6 limit (2.4×10^{10} p/km), but only 7% of its solid particles exceed 23 nm — SPN10 jumps to ~90% of the limit and SPN2.5 overshoots it ×6.5. Heavy-duty CNG: SPN 10–10,000× above diesel-DPF, GMD ≈10 nm, lubricant-oil (Ca/Zn/P) — the same lube-oil mechanism as the H_2-ICE
- **H_2-ICE — lowest PN of the set:** no fuel carbon → no soot pathway, no DPF, no regeneration events; only lube-oil nucleation PN (GMD 15–22 nm), 6.6×10^{9} #/km on-road — 2–3 orders below gasoline-PHEV cold start, CNG, and diesel regeneration

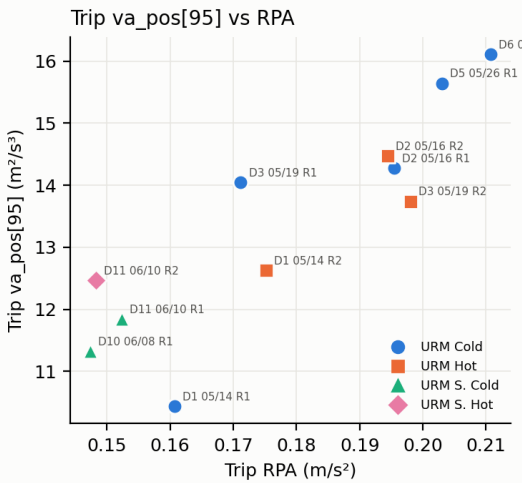
Sources:
1. *Toumasatos et al. (2022) J. Aerosol Sci. 161:105947*
2. *Makki, Hurren, Canchola, Toumasatos, Lin, Karavalakis (2025) Energies 18:6461*
3. *Toumasatos et al. (2024) Atmos. Environ. 327:120512*
4. *Toumasatos et al. (2027) Fuel 428:140398*
5. *Samaras, …, Toumasatos, et al. (2022) J. Aerosol Sci. 162:105957 (DownToTen)*
6. *Toumasatos, Kontses, Doulgeris, Samaras, Ntziachristos (2021) Aerosol Sci. Technol. 55:182–193*

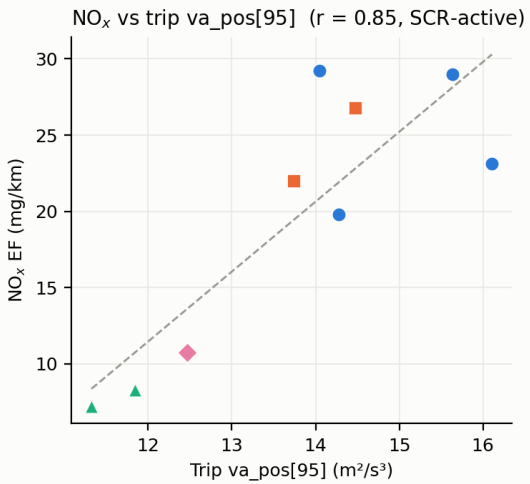
Benchmark: H_2-ICE vs diesel and gasoline-PHEV NOx



NOx emissions from different engine technologies under real driving conditions

- In H2 combustion, the NOx source is related to N2 gaseous content in the air that oxidizes during combustion and breaks into NO radicals.
- Engine emission severity is heavily associated with driving dynamics (driving aggressiveness) in all engine technologies





Sources:

1. *Li, C., Sato, S., Ma, T. et al. Real-World Evaluation of Pollutant Emissions from a Light-Duty DI-Gasoline Hybrid Electric Vehicles (HEV) Using PEMS. Emiss. Control Sci. Technol. 9, 1–11 (2023). https://doi.org/10.1007/s40825-023-00225-0*
2. *McCaffery C, Zhu H, Li C, Durbin TD, Johnson KC, Jung H, Brezny R, Geller M, Karavalakis G. On-road gaseous and particulate emissions from GDI vehicles with and without gasoline particulate filters (GPFs) using portable emissions measurement systems (PEMS). Sci Total Environ. 2020 Mar 25;710:136366. doi: 10.1016/j.scitotenv.2019.136366. Epub 2019 Dec 30. PMID: 31923692.*
3. *ADAC: Emissions from new Euro 6 diesels well below regulatory limits, https://dieselnet.com/news/2019/02adac.php.*

The 2027 Plan Update

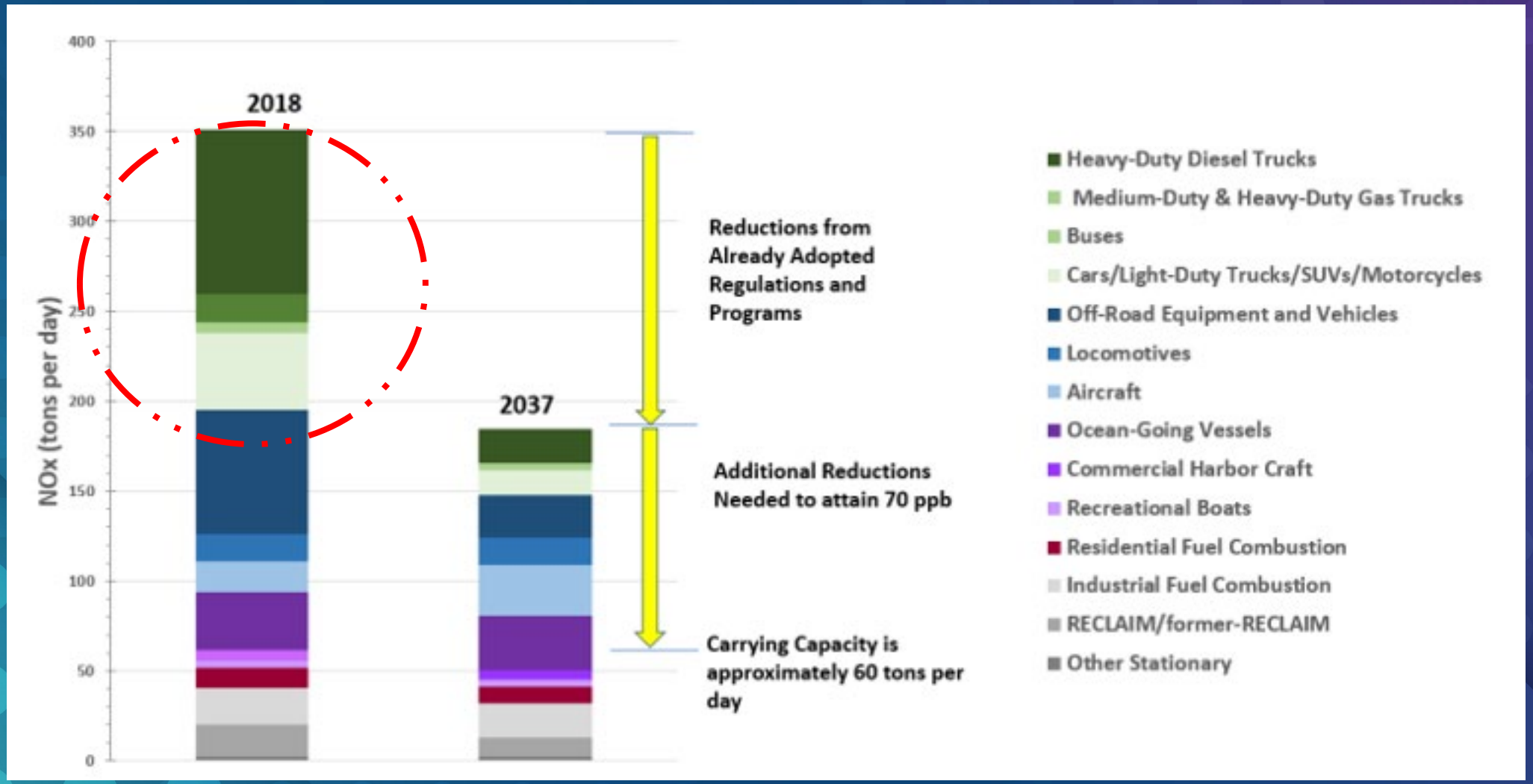
Clean Fuels Program Advisory Group Meeting

Vasileios Papapostolou, Sc.D.
Technology Demonstration Manager

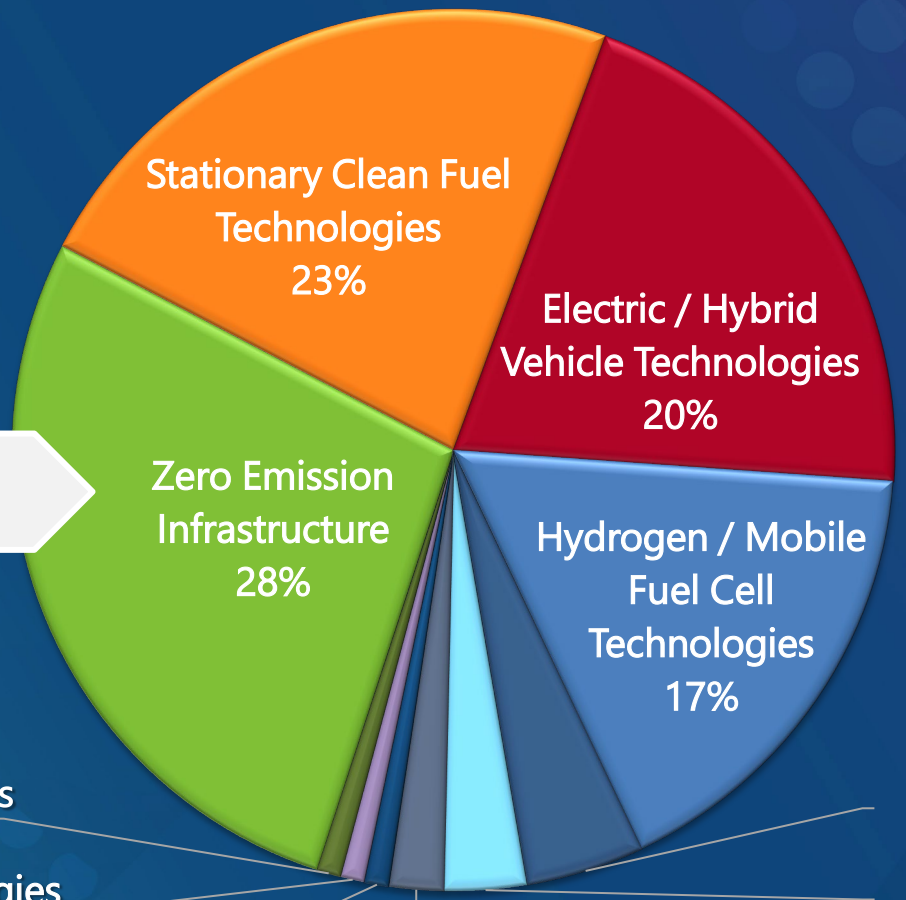
September 17, 2026

NOx Emission Reductions Needed

83%



Proposed 2027 Clean Fuels Plan Distribution



$14.3M: HFCEV Refueling
$1.2M: BEV Charging

Health Impacts Studies 1%

Engine Systems / Technologies 1%

Emission Control Technologies 1%

Technology Assessment and Transfer / Outreach 2%

Fuel and Emissions Studies 4%

Fueling Infrastructure and Deployment (renewable fuels) 3%

$55.9M

Another $25M for H_2 RFP

Draft 2027 Clean Fuels Plan Update Focus Areas

Zero Emission Infrastructure (28%)

- High-power and megawatt-scale charging for MD/HD vehicles
- Alternative charging for temporary, backup, grid-constrained sites
- Transportation-focused BESS and clean energy infrastructure

Stationary Clean Fuel Technologies (23%)

- Zero- and low-emission microgrids
- BESS and onsite clean/renewable power generation
- Resilient off-grid, grid-support solutions for electrification

Draft 2027 Clean Fuels Plan Update Focus Areas (cont.)

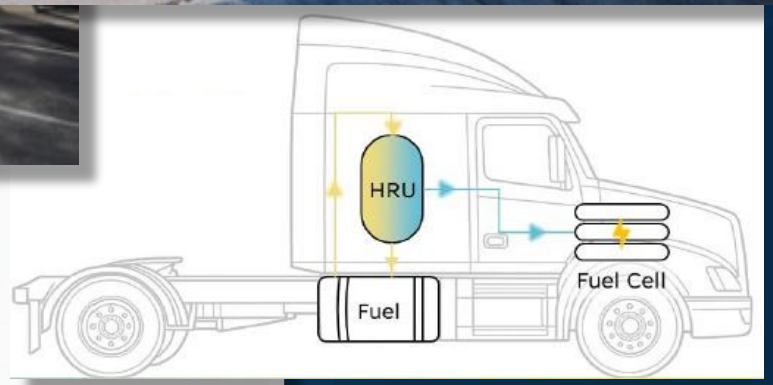
Electric / Hybrid Vehicle Technologies (20%)

- Battery-electric, plug-in hybrid, hybrid-electric, and fuel-cell MD/HD platforms
- ZE drayage trucks, cargo-handling, and container transport technologies
- Municipal and vocational vehicles – refuse, sweepers, maintenance emergency response

Hydrogen / Mobile Fuel Cell Technologies (17%)

- MD/HD fuel-cell vehicle and powertrain development
- Mobile hydrogen refueling and storage solutions
- Hydrogen production and integrated hydrogen ecosystems

Draft 2027 Clean Fuels Plan Update Potential Projects



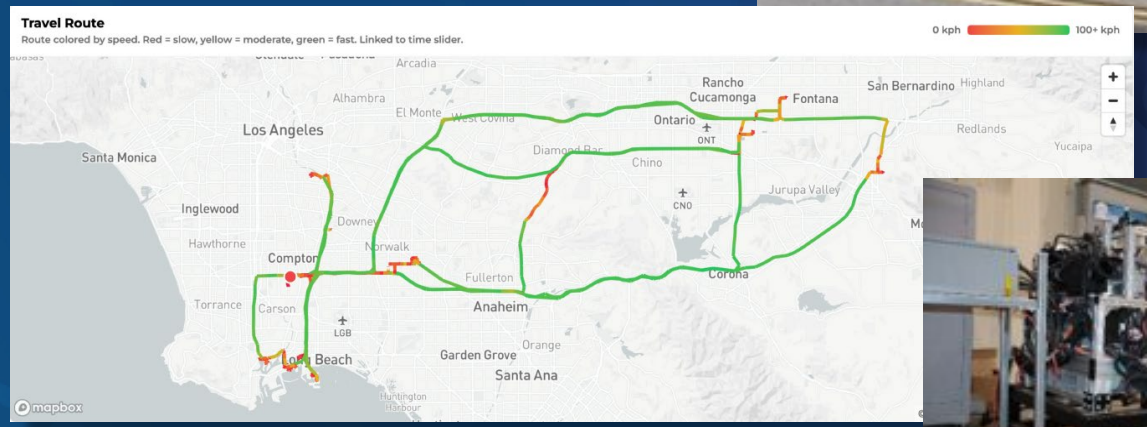
Hydrogen / Mobile Fuel Cell Technologies

- Medium- and heavy-duty fuel cell vehicle development and demonstration
- Class 8 fuel cell electric truck powertrain using liquid organic hydrogen carrier technology
- Fuel cell powerpack development for medium- and heavy-duty applications

Draft 2027 Clean Fuels Plan Update Potential Projects

Hydrogen / Mobile Fuel Cell Technologies (cont.)

- Fuel cell repower and retrofit for transit buses, and medium- and heavy-duty vehicles
- Advanced materials to improve fuel cell performance and cost-effectiveness
- Data platform accelerating zero-emission heavy-duty drayage deployment



Draft 2027 Clean Fuels Plan Update Potential Projects

Electric / Hybrid Vehicle Technologies

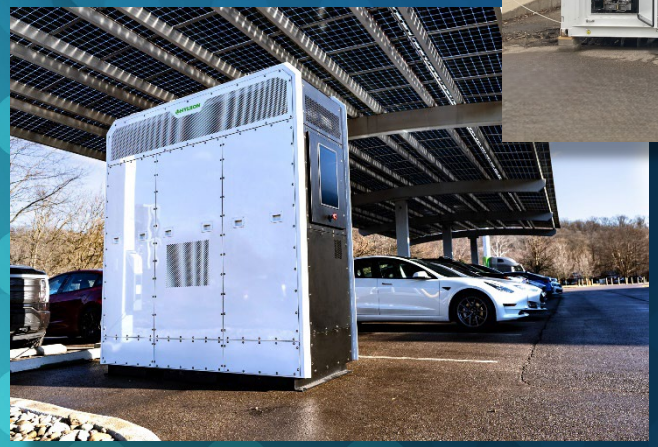
- Advanced hybrid technologies for medium- and heavy-duty fleets and ACF compliance
- Class 6/7 battery-electric vehicle and powertrain demonstration
- Electrified trailer technologies for heavy-duty freight
- Battery-electric municipal and vocational vehicles, and infrastructure

Draft 2027 Clean Fuels Plan Update Potential Projects

Zero-Emission Infrastructure

- Pilot-scale hydrogen production and fueling technologies
- Innovative hydrogen production and refueling technologies for transportation ecosystems
- Mobile hydrogen storage and refueling with low- or zero-boil-off capability
- Linear generator supported charging and grid-support technologies
- 5-MWh mobile battery charging system for medium- and heavy-duty electric vehicles

Draft 2027 Clean Fuels Plan Update Potential Projects



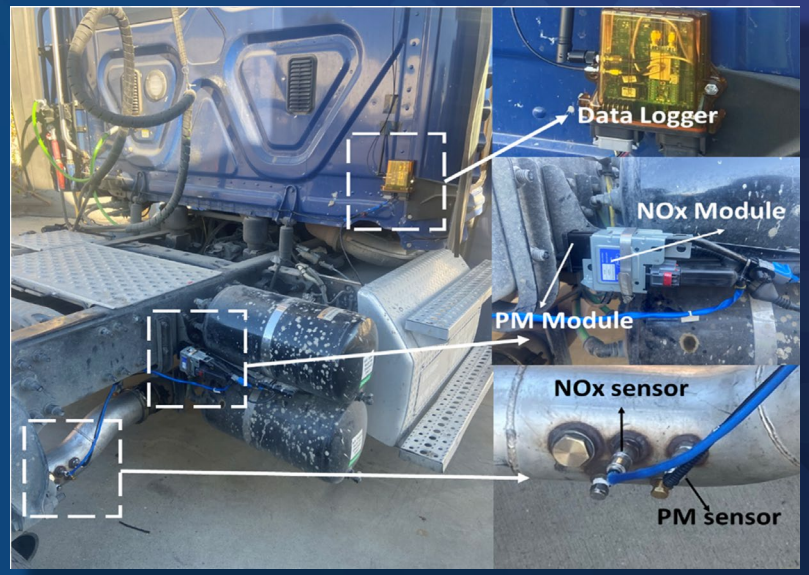
Stationary / Microgrid Solutions

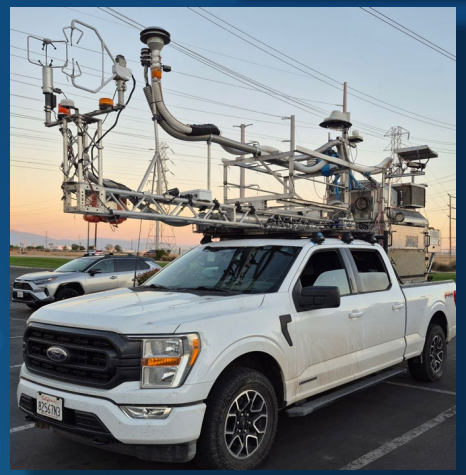
- Resilient off-grid microgrids & long-duration energy storage
- Megawatt scale charging microgrid and grid-constraint mitigation
- Linear generator technologies for stationary power and microgrids

Draft 2027 Clean Fuels Plan Update Potential Projects

Fuel & Emissions Studies

- Organic tracers associated with brake wear emissions
- Fugitive and naturally occurring hydrogen emissions in the LA Basin
- Onboard sensing and in-use hydrogen ICE emissions characterization





Feedback

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