



CLEAN FUELS PROGRAM ADVISORY GROUP AGENDA
SEPTEMBER 19, 2019, 9:00 AM – 3:30 PM
DoubleTree Hotel
2800 Via Cabrillo-Marina
San Pedro, CA 90731

Members of the public may address this body concerning any agenda item before or during consideration of that item (Gov't. Code Section 54854.3(a)). Please provide a Request to Address the Committee card to the Committee Secretary if you wish to address the Committee on an agenda item. If no cards are available, please notify South Coast AQMD staff or a Board Member of your desire to speak. 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 three (3) minutes each.

Welcome & Overview - 9:00 – 10:00 AM

- | | | |
|-----|---|--|
| (a) | Welcome & Introductions | Naveen Berry, Assistant Deputy Executive Officer |
| (b) | Pacific Rim Initiative for Maritime Emission Reductions | Elaine Shen, Program Supervisor, Planning & Rules |
| (c) | Goals for the day | Joseph Impullitti, Manager, Technology Demonstration Group |
| (d) | Feedback and Discussion | All |

Areas of South Coast AQMD Focus

1. Heavy & Medium-Duty Technologies Project Updates - 10:00 AM – 11:45 AM

- | | | |
|-----|---|--|
| (a) | GGRF Project: Kenworth & Peterbilt | Seungbum Ha, Ph.D., Air Quality Specialist |
| (b) | Daimler Electric Truck | Phil Barroca, Program Supervisor |
| (c) | Volvo LIGHTS Project | Patricia Kwon, Program Supervisor |
| (d) | Medium Duty Trucks & Engine Development | Joseph Lopat, Air Quality Specialist |
| (e) | In Use Emission Study Project | Sam Cao, Ph.D., Air Quality Specialist |
| (f) | Light and Heavy-Duty Hydrogen Stations | Lisa Mirisola, Program Supervisor |
| (g) | Feedback and Discussion | All |

Working Lunch 11:45 AM - 12:30 PM

2. Tour of Total Transportation Services (TTSI) – 1:00 PM – 2:30 PM

- | | | |
|-----|---|-------|
| (a) | Tour of TTSI facility freight depot to review project trucks and infrastructure | Staff |
|-----|---|-------|

3. Wrap-up – 3:00 PM – 3:30 PM

- | | | |
|-----|-----------------------------|--------------|
| (a) | Discussion & Wrap-up | Naveen Berry |
| (b) | Advisor and Expert Comments | All |

Other Business

Any member of the committee, 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. (Government 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 Committee's authority that is not on the agenda. Speakers may be limited to three (3) minutes each.

Document Availability

All documents (i) constituting non-exempt public records; (ii) relating to an item on the agenda for a regular meeting; and (iii) having been distributed to at least a majority of the Advisory Group after the agenda is posted, are available prior to the meeting for public review at the South Coast Air Quality Management District Public Information Center, 21865 Copley Drive, Diamond Bar, CA 91765.

Americans with Disabilities Act

The agenda and documents in the agenda packet will be made available, upon request, in appropriate alternative formats to assist persons with a disability. Disability-related accommodations will also be made available to allow participation in the meeting. Any accommodations must be requested as soon as practicable. Requests will be accommodated to the extent feasible. 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.

September 2019

Clean Fuels Program

2019 Plan Update

Technology Advancement Office

Leading the way to zero and near-zero emission technologies

NAVEEN BERRY

ASSISTANT DEPUTY EXECUTIVE OFFICER
SCIENCE & TECHNOLOGY ADVANCEMENT

Los Angeles named smoggiest U.S. city

It's won that title 19 of the last 20 years

By **Elijah Chiland** | Apr 24, 2019, 11:58am PDT

f t SHARE



Trump plans to revoke a key California environmental power; state officials vow to fight



Must Reads: The war on Southern California smog is slipping. Fixing it is a \$14-billion problem

And the smoggiest city in the US is ...

Los Angeles. The 18 million Californians who live in and around the Los Angeles area breathe the nation's smoggiest air.

USA's top 10 smoggiest cities:

- 1 Los Angeles / Long Beach
- 2 Visalia, Calif.
- 3 Bakersfield, Calif.
- 4 Fresno / Madera / Hanford, Calif.
- 5 Sacramento / Roseville, Calif.
- 6 San Diego / Chula Vista / Carlsbad, Calif.
- 7 Phoenix / Mesa, Ariz.
- 8 San Francisco / Oakland / San Jose, Calif.
- 9 Houston / The Woodlands, Texas
- 10 New York City / Newark (New York, New Jersey, Connecticut)

SOURCE American Lung Association



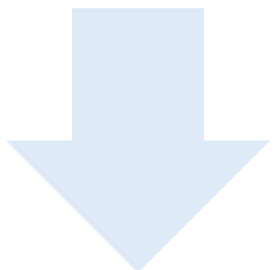
Air quality has slipped in recent years, and regulators are falling far short of raising billions they say is needed to clean ozone pollution in time to avoid tough economic sanctions. Here, smog hangs over downtown Los Angeles in 2018. (Wally Skalj / Los Angeles Times)



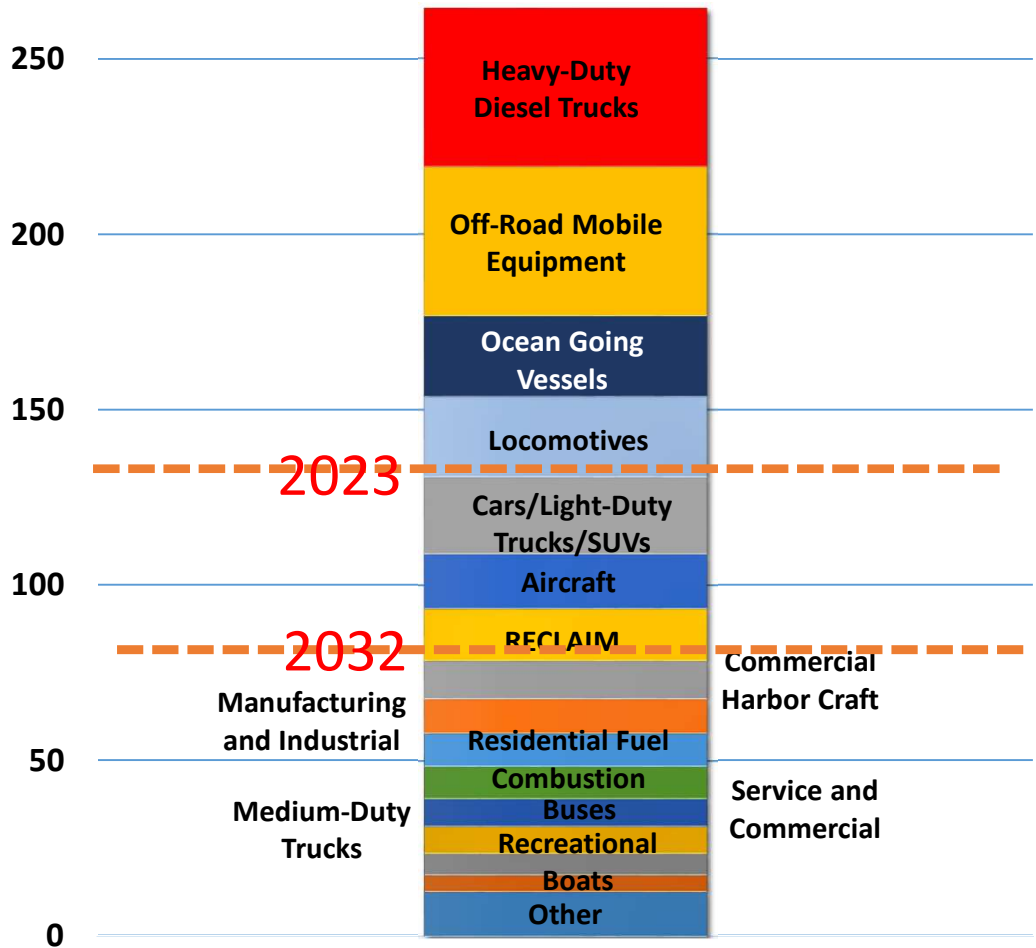
Air pollution gets closer to a fetus than scientists had realized, study suggests

NOx Reductions Needed

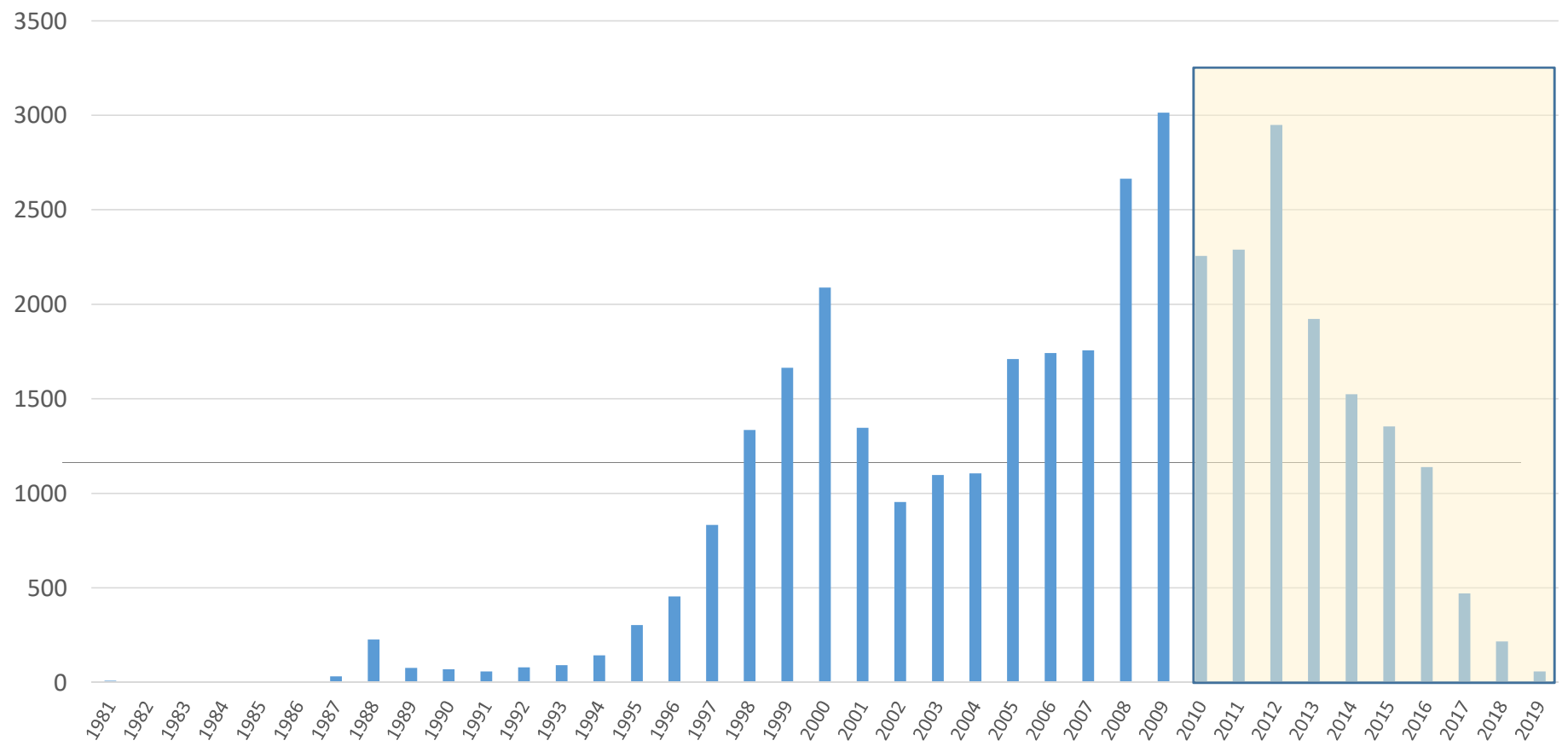
45-55%



Tons/day



IHS/Polk Data - CA Heavy Duty Trucks Aggregate)



2018 Annual Enforcement Report, June 2019

| Registration | Fleet Size (Trucks) | Heavy Trucks | | Light Trucks | |
|-----------------|---------------------|----------------|-----------------|---------------|-----------------|
| | | Non-compliant | Compliance Rate | Non-compliant | Compliance Rate |
| California | 1-3 | 25,566 | 71% | 21,791 | 73% |
| | 4-20 | 16,322 | 77% | 6,314 | 85% |
| | 21-100 | 5,549 | 87% | 1,584 | 90% |
| | >100 | 3,557 | 92% | 1,825 | 94% |
| Total CA | | 50,994 | 79% | 31,514 | 81% |
| Other States | All | 229,453* | 78%* | 1,254* | 98%* |
| Total | All | 280,447 | 79% | 32,768 | 86% |

*Heavy trucks have GVWR greater than 26,000 lbs light trucks are between 14,000 and 26,001 lbs.





Pacific Rim Initiative for Maritime Emission Reductions a Clean Vessel Incentive Concept



Elaine Shen, Ph.D., Program Supervisor

September 19, 2019

Importance of Ship Emissions

Top 5 NOx Categories in Ports of LA/LB
2015

Ocean Going Vessels
53%



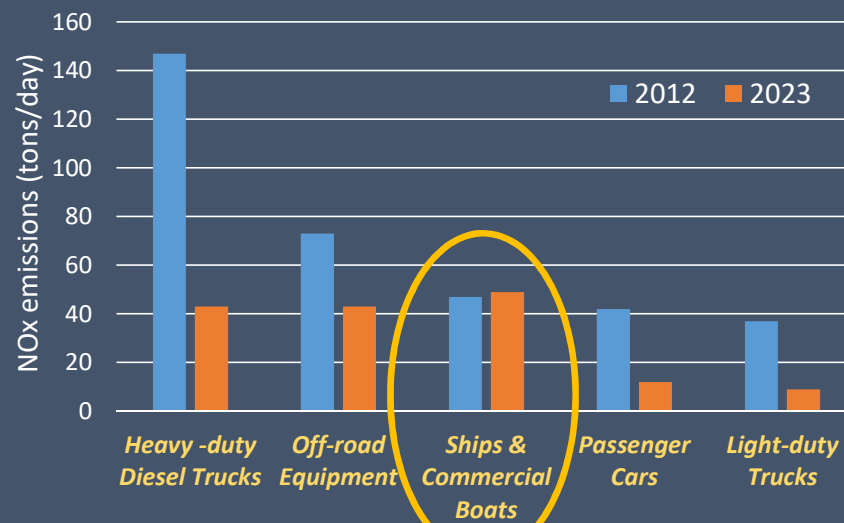
Trucks
20%

Locomotives
10%

Cargo Handling Equipment
7%

Harbor Craft
10%

Top 5 NOx Categories in South Coast
2012 and 2023



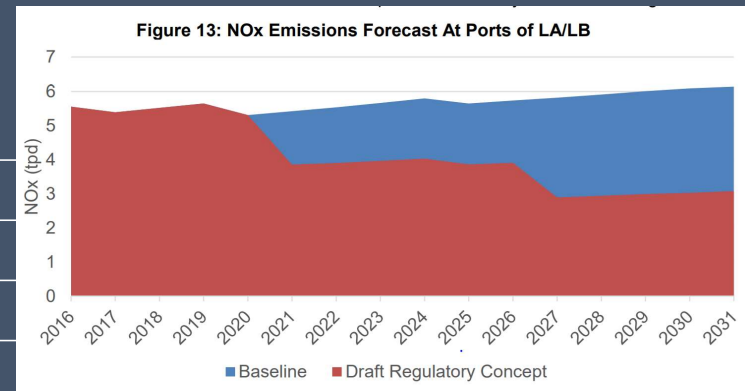
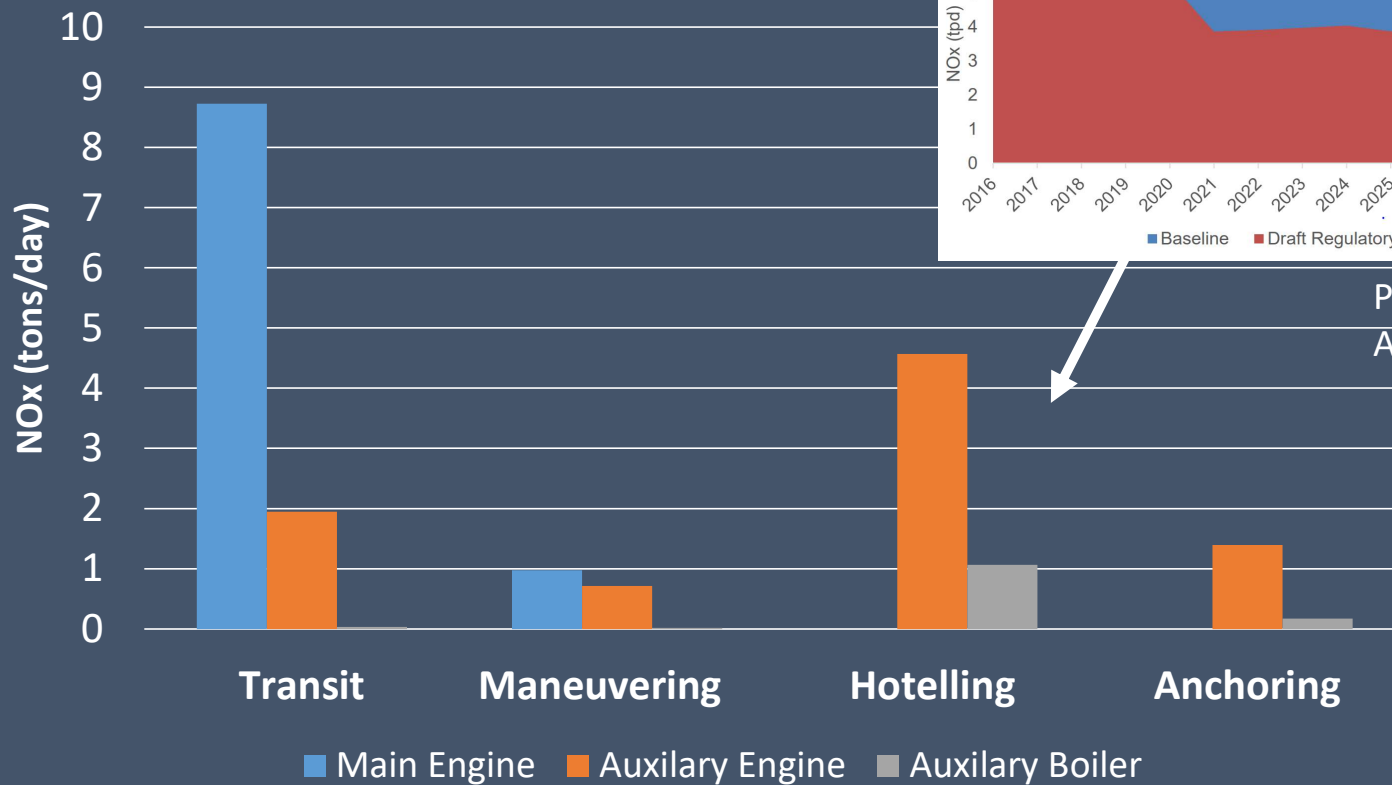
Shipping is the only category with a projected increase in NOx emissions

Existing Control Programs for NOx Emissions from Ships

- International Maritime Organization (IMO)
 - NOx Engine Standards
 - Tier 3 engines for new vessels visiting Emission Control Areas (ECA) – POLA/POLB part of North American ECA
- California Air Resources Board
 - At-Berth Regulation
 - Shore power or equivalent alternatives
- Ports of Los Angeles and Long Beach
 - Clean Air Action Plan
 - Vessel Speed Reduction
 - Incentive Programs for Tiers 2 & 3 (\$5,000-\$7,500 per call for Tier 3)

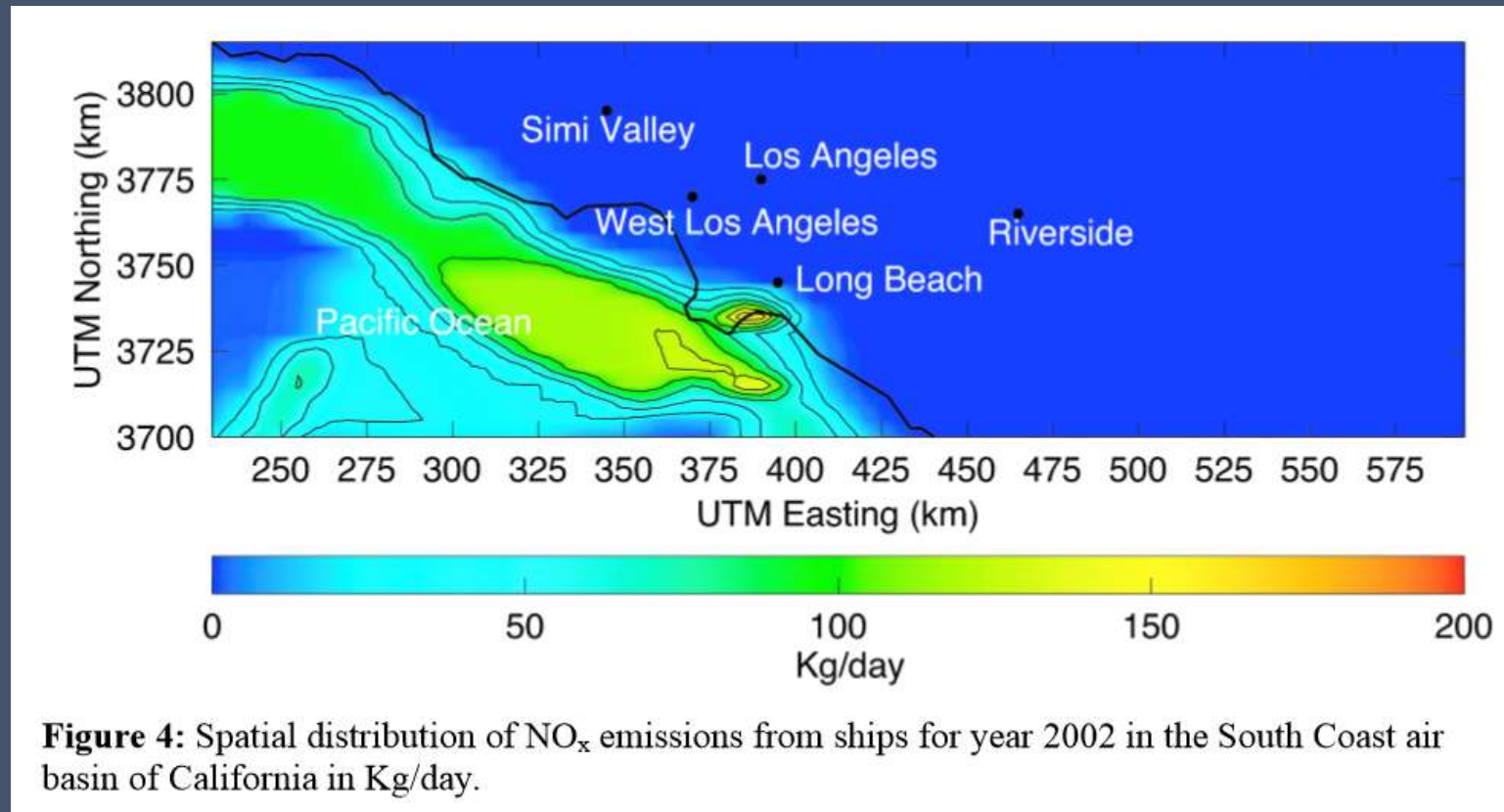


OGV NOx Emissions by Operational Mode at Ports of LA/LB (2016)



Proposed At-Berth Amendment

Significant NO_x Emissions while Ships are in Transit and Maneuvering Nearshore



Source: CARB, Air Quality Impacts of Ship Emissions in the South Coast Air Basin of California (2008).

Current IMO Regulations for NOx

- Established classification of engines required for vessels based on keels laid date

Not Restricted from Entering ECAs

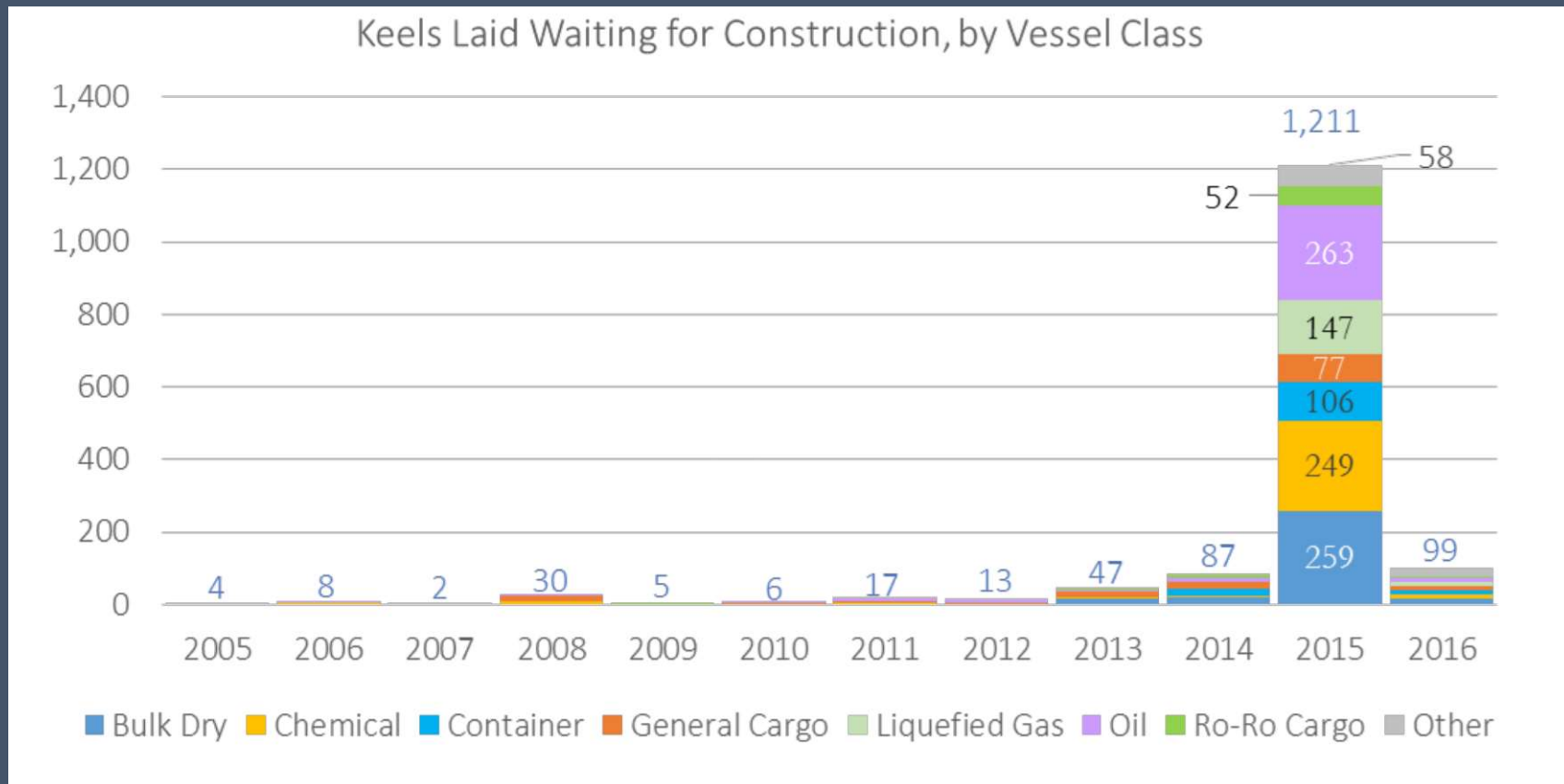
In 2016, 79% of vessel calls at POLA/POLB were Tier 0-1; rest Tier 2

| Year of Keels Laid | Engine Tier | NOx Emissions |
|--------------------|-------------|-------------------------|
| Pre-2000 | Tier 0 | uncontrolled |
| 2000 | Tier 1 | 9.8-17 g/kwh |
| 2011 | Tier 2 | 15% cleaner than Tier 1 |
| 2016 | Tier 3 | 75% cleaner than Tier 2 |

IMO Emission Control Area only

- Limited number of T3; only 1 T3 OGV called at POLB so far
- Surplus of pre-2016 keels; new vessels constructed on these keels not required to be T3
- Ships on order as % of existing fleet has been declining among ocean carriers

Number of Keels Laid Through 2016



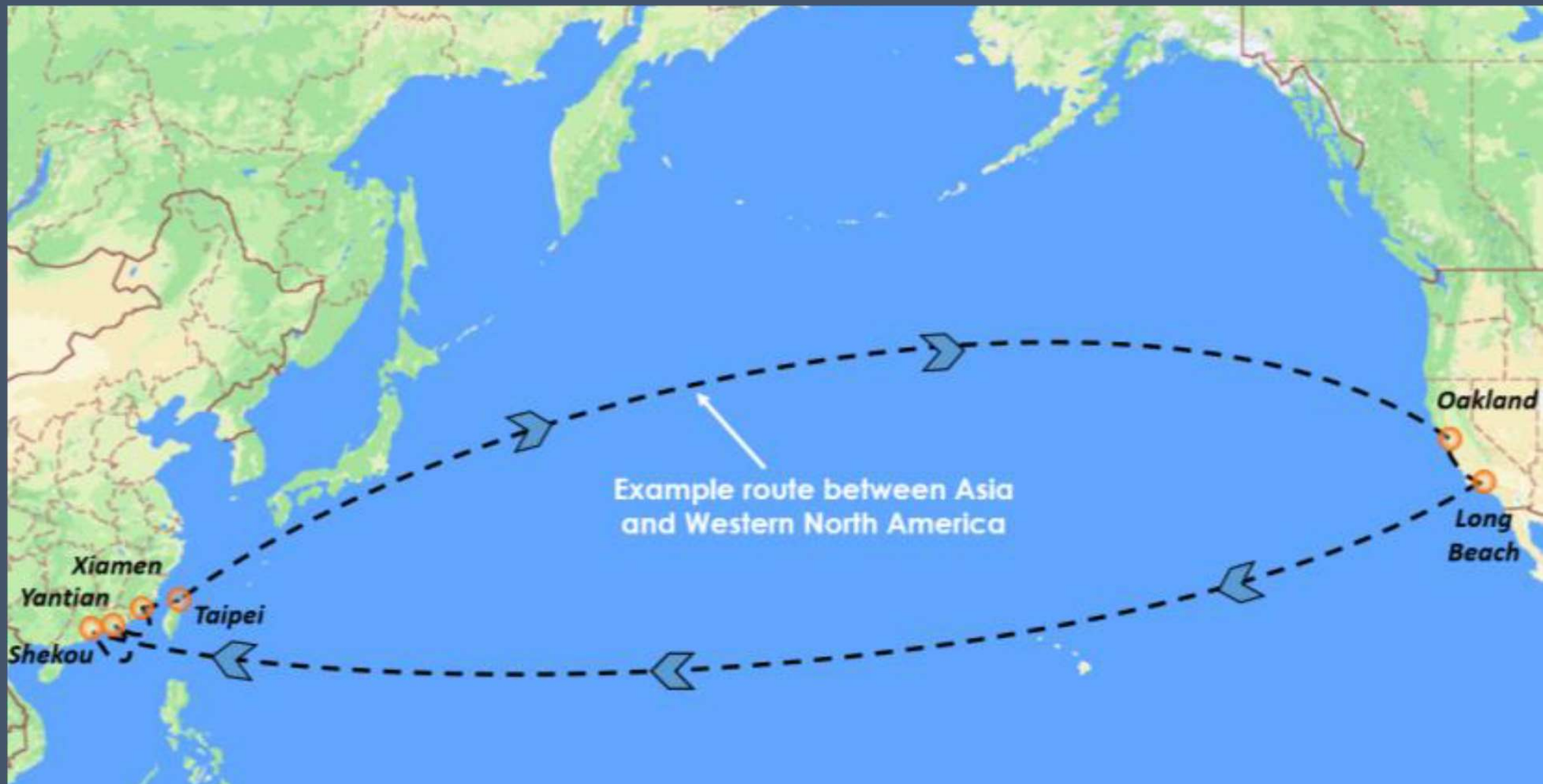
(Figure is from San Pedro Bay Ports 2017 CLEAN AIR ACTION PLAN)

Challenges of Controlling Ship NOx Emissions

- Ship emissions regulated by IMO; limited authority to regulate at the local level
- Limited near-term deployment of Tier 3 vessels at local ports
- Existing programs are not adequate to address our air quality needs
- Longer-term and future regulations will not provide needed short-term benefits, especially when they are applicable to newbuilds only

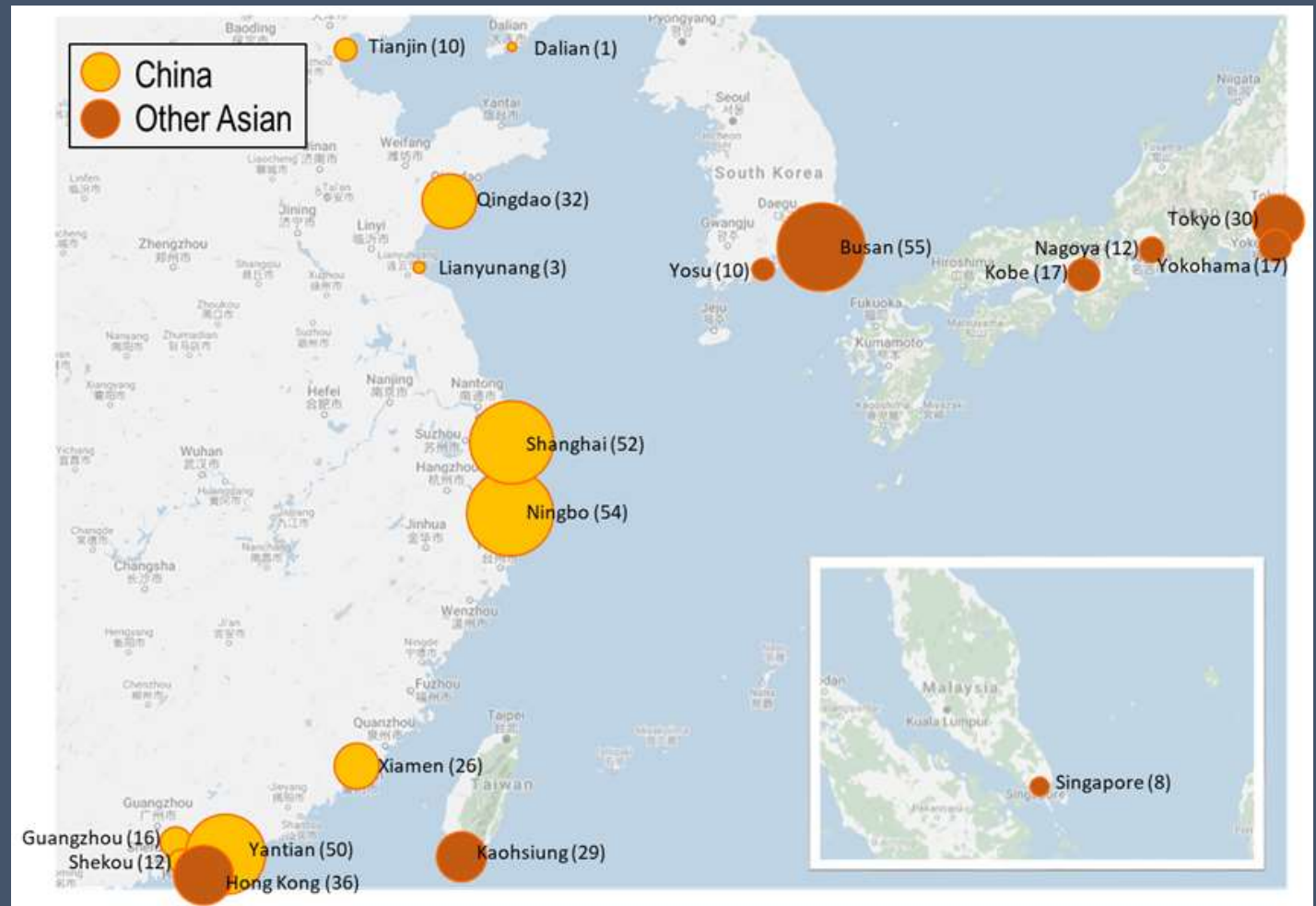
New and Innovative Incentive Programs Are Needed for Reducing Ship Emissions

Concept – Partner with Asian ports on shared routes to incentivize cleaner vessels on these routes



Frequent Caller (≥5) Vessels at Ports of LA/LB and Key Asian Ports in 2018

Based on South Coast AQMD staff's analysis of
IHS-Seaweb Data



Concept: Partner with Asian Ports & Other Entities to Leverage Incentives

- Collaborate with regional authorities/ports/shipping lines to develop a program where each participating port provides incentives for calls by cleaner vessels
- Incentives at each participating port may be monetary or non-monetary (e.g., preferential berthing)
- Each port's individual incentive is then leveraged to encourage changes in shipping behavior
 - Re-routing of existing Tier 3 vessels
 - Encourage construction of Tier 3 vessels on pre-2016 keels
 - Encourage retrofits of existing vessels to be cleaner than Tier 2

Retrofit Technologies are Key

- OGVs have long lifetime of 20+ years; very slow fleet turnover
- Limited number of Tier 3 OGVs globally: expected to account for a tiny fraction of all calls at POLA/LB in the near term
- Retrofit technologies for existing OGVs are available and can be implemented relatively quickly
 - Require demonstration/validation, and emission reductions verification
- Significant NOx reductions possible through retrofits:
 - Tier 0/1 to Tier 2: 15-20%
 - Tier 0/1 to Tier 2+: 15-80%
- South Coast AQMD held a technology forum on OGV retrofits in 2018 and is pursuing technology demonstration projects with multiple engine manufacturers

Technology Demonstration Projects

- Proposal received from MAN Energy Solution for first retrofit technology demonstration project
 - Water in Fuel emulsion technology for main engine with up to 40% NOx reductions at low load condition with distillate fuel (0.1% S)
 - MSC confirmed to provide a Tier 2 vessel for demonstration
 - Schedule: 2019 Q4 - 2022
 - May extend to auxiliary engine
- Potentially a cost-effective pathway to near-term NOx emission reductions

| Retrofit Control Technology | NOx Reduction Efficiency |
|-------------------------------|--------------------------|
| Selective Catalytic Reduction | 80% - 90% |
| Exhaust Gas Recirculation | 50% - 80% |
| Air Humidification | Up to 70% |
| Direct Water Injection | Up to 50% |
| Water in Fuel Emulsion | 20% - 40% |
| Engine De-Rating | Up to 10% |

Ongoing Activities

- Continue research & gathering information
 - Analyze AIS-based datasets for ship routing behavior
 - Conduct optimization modeling to help evaluate incentive needed per call
 - Collect information on feasible technologies & costs
 - Identify and work with key industry partners
- Build relationships with key partners
 - Continue meeting/information exchange
 - Two delegation trips to China and met with central and local authorities
 - Continuous dialogues with key agencies and think tanks
 - Hosted multiple delegations from various Asian countries
 - Met with several major shipping lines
 - Working towards a potential pilot incentive program with other US West Coast port regions and interested partners in Asia (potentially starting with Shenzhen)

Questions?





South Coast
AQMD

South Coast
Air Quality
Management District

October 2019

Clean Fuels Program

2020 Draft Plan Update

Technology Advancement Office

Leading the way to zero and near-zero emission technologies



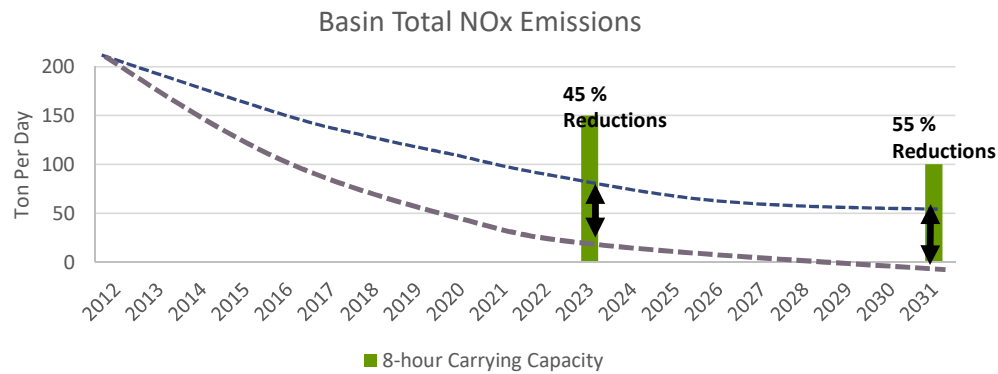
Federal/State Actions

- Feds – FY 2020 Interior, Environment and Related Agencies funding bill
- USEPA – Cleaner Trucks Initiative
- CEC – Low Carbon Fuel Production Program (LCFPP)
- CARB Regulations
 - Heavy-Duty On-Road “Omnibus” Low NOx Regulation
 - Truck and Bus Regulation (Compliance begins 2020)
 - Advanced Clean Truck Regulation (ACT)



South Coast Plans & Policies

- 2016 AQMP – NAAQS
 - 2008 8-hr Ozone – 75 ppb



- Facility Based Mobile Source Measures
 - MOB-01 – Commercial Marine Ports
 - MOB-02 – Railyard and Intermodal Yards
 - MOB-03 – Warehouse Distribution Centers
 - MOB-04 – Commercial Airports
 - EGM01 – New/Redevelopment Projects



2020 Plan

Key Proposed Projects

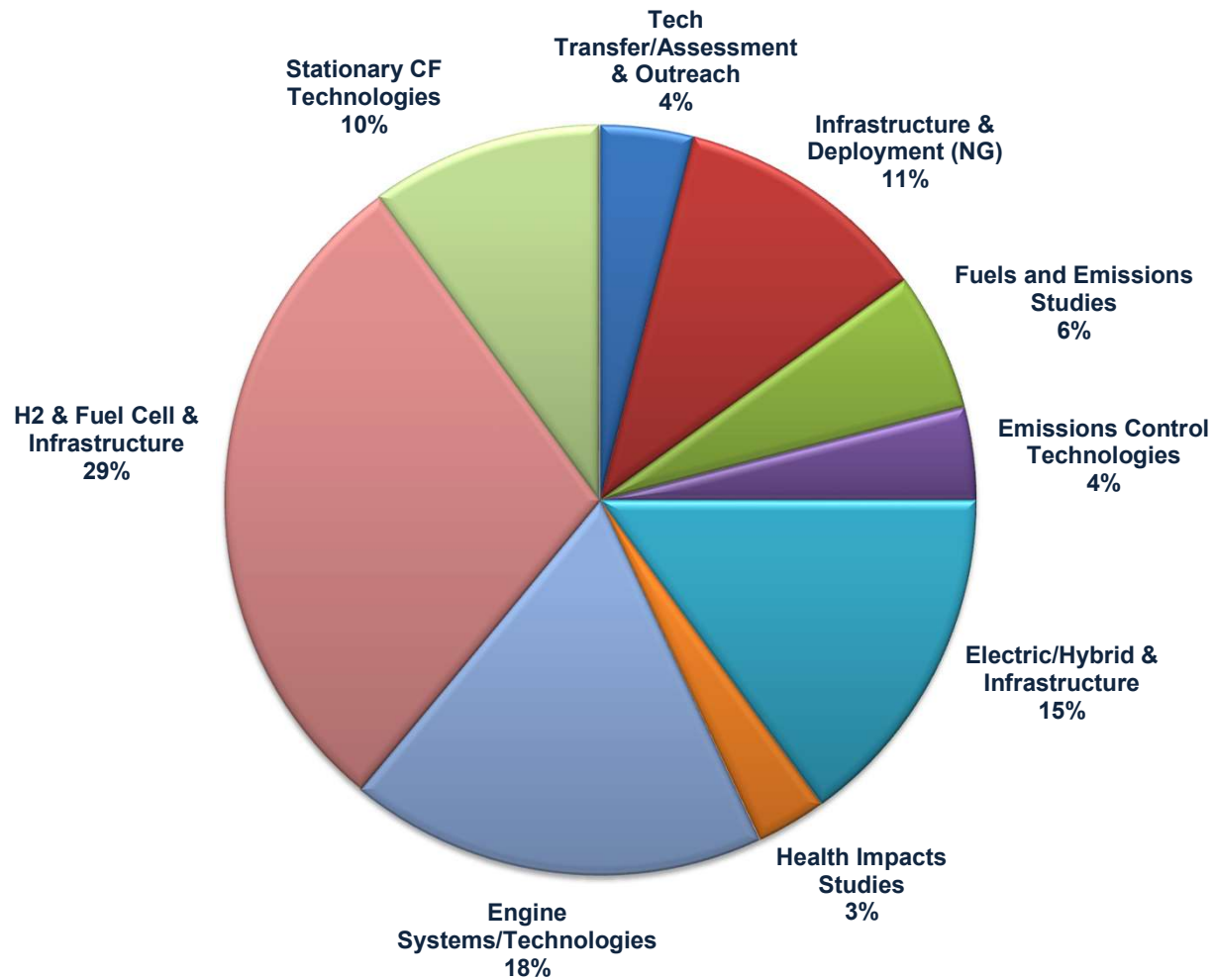
- Zero Emission Container Truck Development
- Medium and Heavy-Duty Fuel Cell Vehicles
- Medium and Heavy-Duty Near-Zero Emission Vehicles
- Infrastructure – Medium- & Heavy-Duty
 - Hydrogen Refueling Stations
 - Electric Vehicle Charging Infrastructure
 - Micro-grids & Distributed Generation – Vehicle Charging
- Development & demonstration of advanced engines
- Renewable Fuels
- Freight Efficiency Studies

Projects not funded in 2019 may be considered for funding in future years

Draft 2020 Plan Update (Key Technical Areas)

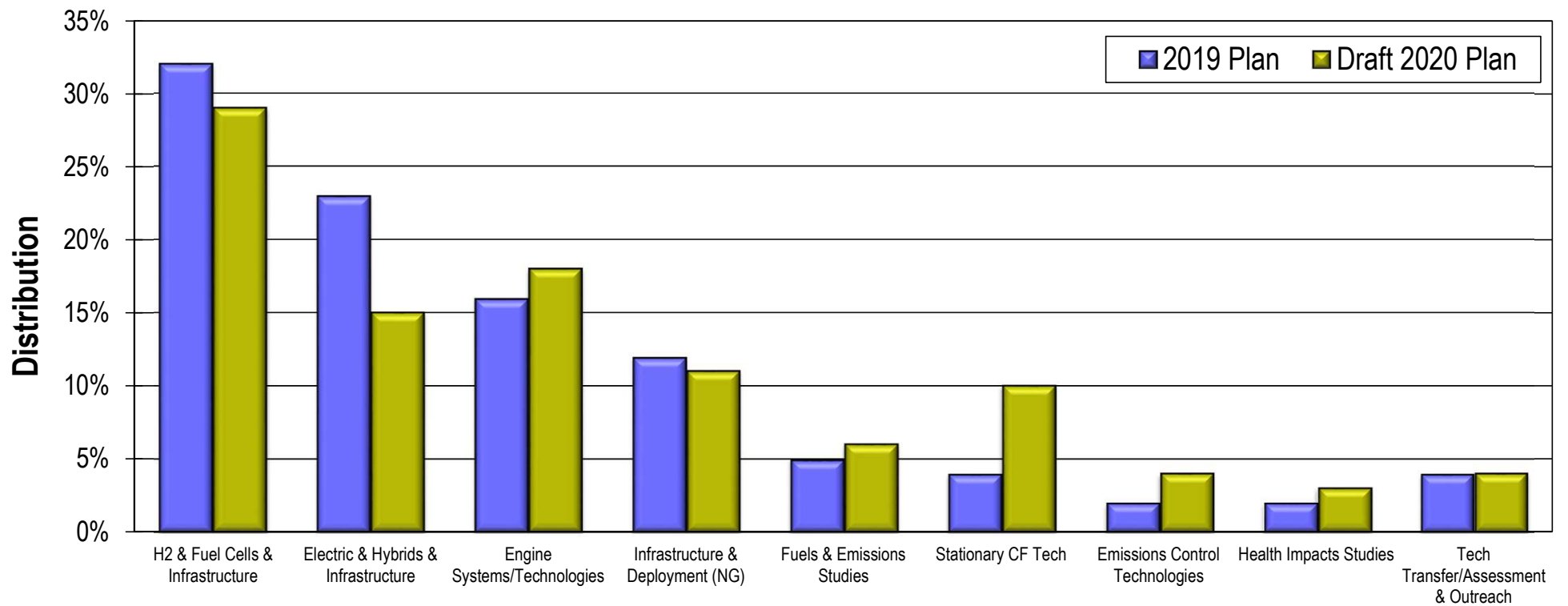
- Maintain focus priorities on zero and near-zero emissions goods movement technologies
- Near-zero emission (gaseous and liquid fuel) engine systems, especially high HP uses
- Expand focus on local biogas production and use
- Maintain focus on hybrid, plug-in, electric-drive technologies and infrastructure
- Onsite hydrogen production and dispensing
- Maintain other areas of emphasis

Proposed 2020 Plan Distribution



\$16.7M

Plan Update Comparison



Proposed Distribution

| | 2019 Plan | Draft 2020 Plan |
|-------------------------------------|-----------|-----------------|
| H2 & Fuel Cells & Infra | 32% | 29% ↓ |
| Electric & Hybrids & Infra | 23% | 15% ↓ |
| Engine Systems/Technologies | 16% | ↑ 18% |
| Infrastructure & Deployment (NG) | 12% | 11% ↓ |
| Fuels & Emissions Studies | 5% | ↑ 6% |
| Stationary CF Tech | 4% | ↑ 10% |
| Emissions Control Technologies | 2% | ↑ 4% |
| Health Impacts Studies | 2% | ↑ 3% |
| Tech Transfer/Assessment & Outreach | 4% | 4% |
| | 100% | 100% |

Feedback

Email

Naveen Berry

nberry@aqmd.gov

or

Joseph Impullitti

jimpullitti@aqmd.gov

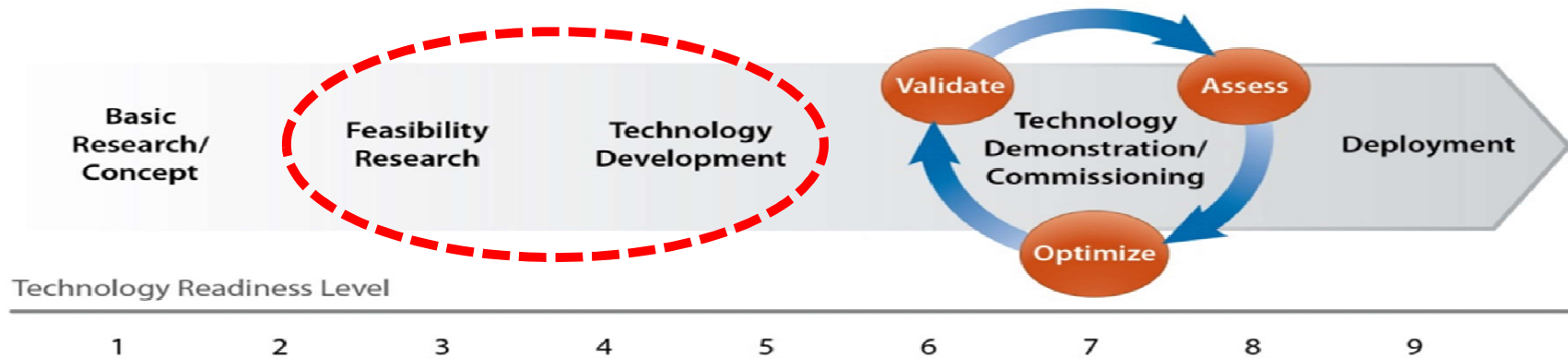


Greenhouse Gas Reduction Zero-Emission Drayage Demonstration

Technology Advancement Office
Air Quality Specialist

Seungbum Ha

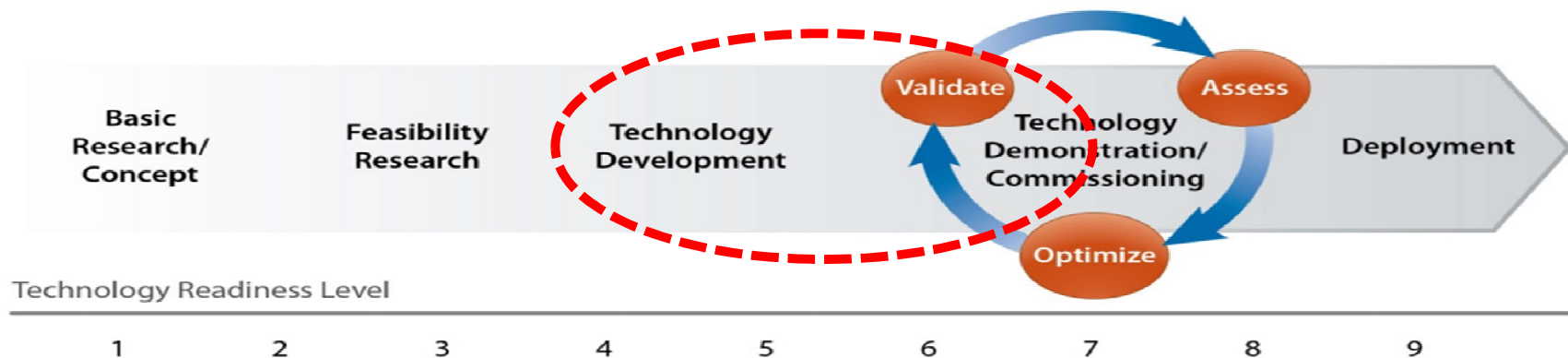
South Coast AQMD Vehicle Demonstration Project



Projects

- Upgrade Electric Yard Truck With Lithium Batteries(2008)
- Foothill Transit Quick Charge Electric Bus(2010)
- EVI/UPS Zero Emission Goods Movement Medium Duty Truck(2011)
- TransPower Heavy Duty Battery Electric Truck(2011)

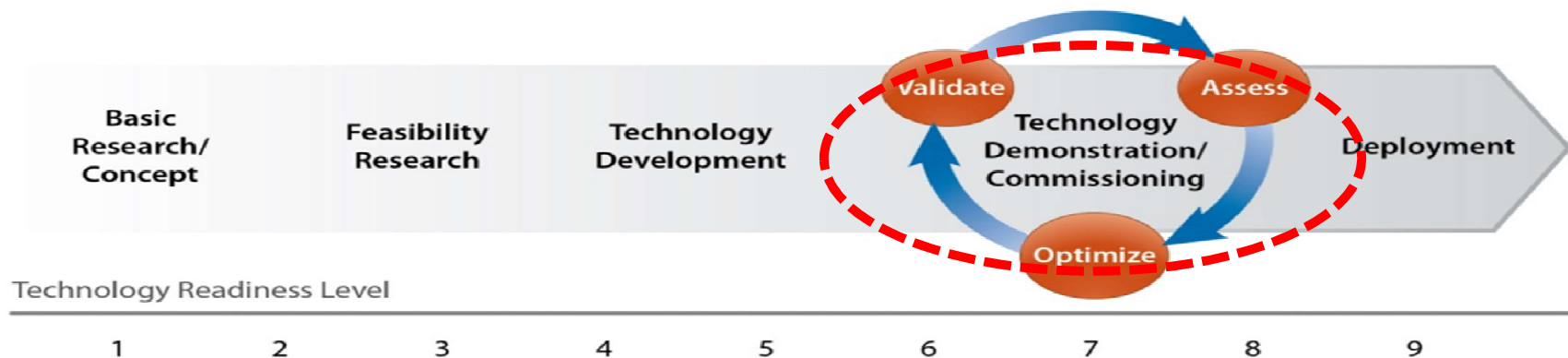
South Coast AQMD Vehicle Demonstration Project



ZECT 1 – Awarded: 2012; Kickoff: 2012

- Two technologies: Battery Electric and Plug-in Hybrid Electric Trucks
- Two technology integrators: TransPower and U.S. Hybrid
- Data Analysis: NREL
- Funding: DOE: \$4,169,000; Match Share: \$5,205,641; Total Cost: \$9,374,641

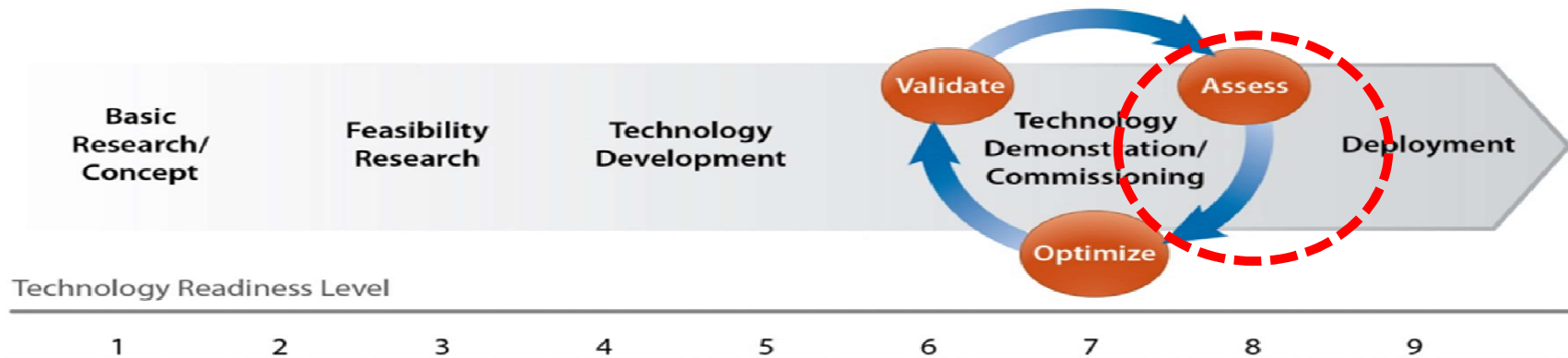
South Coast AQMD Vehicle Demonstration Project



ZECT 2 – Awarded: 2014; Kickoff: 2015

- Three Technologies: Fuel Cell, Battery Electric with Fuel Cell, Battery Electric with CNG ICE
- Four technology integrators: TransPower, U.S. Hybrid, Hydrogenics, BAE/Kenworth
- Fleet Participation: Drayage fleets, Kenworth Trucks
- Funding: DOE: \$10,000,000; Match Share: \$7,183,979; Contractors: \$3,075,841;
Total Cost: \$20,259,820

South Coast AQMD Vehicle Demonstration Project



- **CARB GGRF Electric Truck Projects**
- **CEC Sustainable Freight Transportation Project**

GGRF Electric Truck Projects

- \$23.6M Award from ARB, \$10.4M State Air Districts, \$6M In Kind – Total of \$40.1M
- 44 pre-commercial Class 8 zero- and near-zero emission drayage trucks and infrastructure
 - 25 Battery Electrics - BYD
 - 12 Battery Electrics – Peterbilt
- In addition to the Battery electrics:
 - 4 CNG Hybrids - Kenworth
 - 3 Diesel Hybrids - Volvo



Peterbilt Electric Drayage Truck

- Take the legacy from previous demo project

ZECT I

| | BET |
|-------------------------------|-------------------|
| Developer | TransPower |
| No. of Trucks | 4 |
| APU Displ./Fuel | N/A |
| APU Power | N/A |
| Battery/Fuel Storage Capacity | 215 kWh |
| Charger On-Board | 70 kW |
| Recharge/Refuel Time | 2.5-4 hrs |
| Drayage Range (miles) | 75-100 (@215 kWh) |



GGRF Peterbilt BET

ZECT II

| | PHET/ NZ-CNG |
|--------------------------------|------------------|
| Developer | BAE/Kenworth |
| # of Vehicles | 1 |
| Battery Capacity | 100 kWh |
| Range (per fueling) | 150 miles |
| Fuel Cap.: H2 (kg) / CNG (DGE) | 30 DGE (assumed) |
| Plug-in Charging | Yes |



GGRF KW PHEV

Peterbilt Electric Drayage Truck

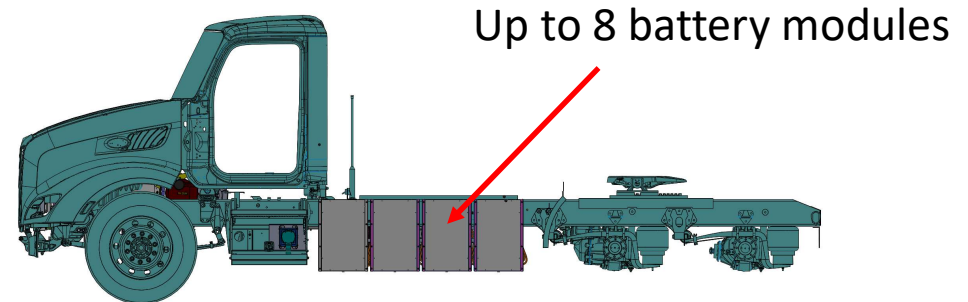
- TransPower/Peterbilt to develop 12 BETs based on EDD drivetrain
 - Phase 1 trucks (4)
 - Phase 2 trucks (8)



- Motor Power Rating - 330kW



- Total Capacity: NMC up to 352 kWh



Peterbilt Electric Drayage Truck

| Truck# | LMC | Terminal |
|--------|---------------|-------------------|
| 1 | TTSI | San Pedro, CA |
| 2 | LADWP | Sun Valley, CA |
| 3 | CMI / NFI | Carson, CA |
| 4 | ESTES Express | Fontana, CA |
| 5 | AJR Trucking | Compton, CA |
| 6 | Four Seasons | National City, CA |
| 7 | Biagi | Napa, CA |
| 8 | Fedex | TBD |
| 9 | PepsiCo | TBD |
| 10 | Oak Harbor | Montebello, CA |
| 11 | Werner | Fontana, CA |
| 12 | Daylight | TBD |



Peterbilt Electric Drayage Truck - Accomplishments & Challenges

- Increased battery capacity at same system weight to increase electric range
- Achieve over 120 miles
- 12 BET delivered to fleet operators

- No established certification process for retrofitted BET/HET
 - Lesson-learned to be compliant for demo trucks
- Standardize charging port type for heavy-duty sector
- Driver and technician - Training and Experience

Kenworth CNG Hybrid Truck

- Develop Class 8 plug-in hybrid electric trucks with zero emission operation capability for demonstration in revenue drayage service

| Parameters | Expected Performance |
|--------------------|---|
| Range | ~ 200 miles |
| Top Speed | 62 mph |
| All-Electric Range | ~50 miles or 1 hour of operation depending on duty cycle and trailer load |

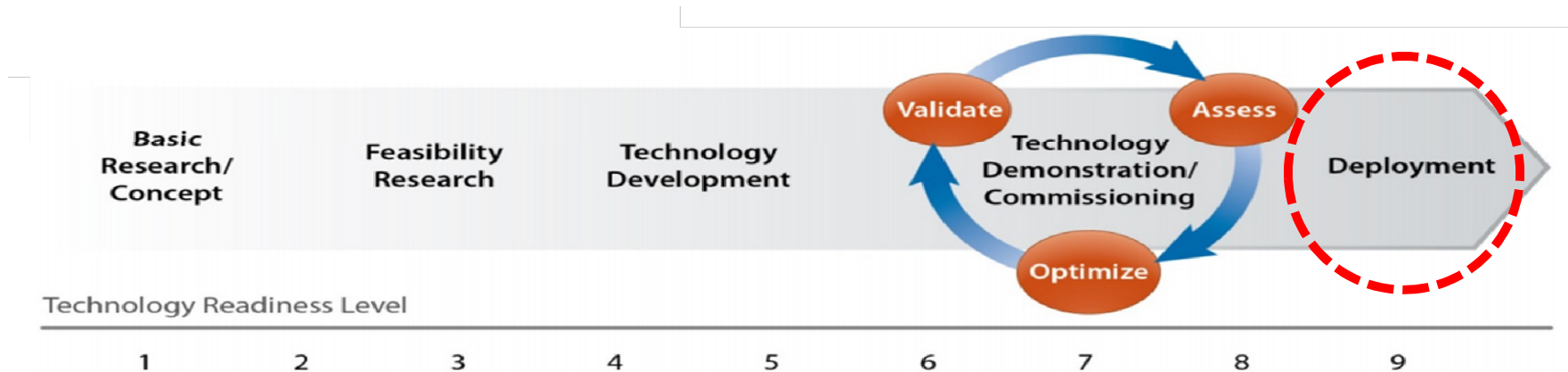


Kenworth CNG Hybrid Truck

- Accomplishments & Challenges

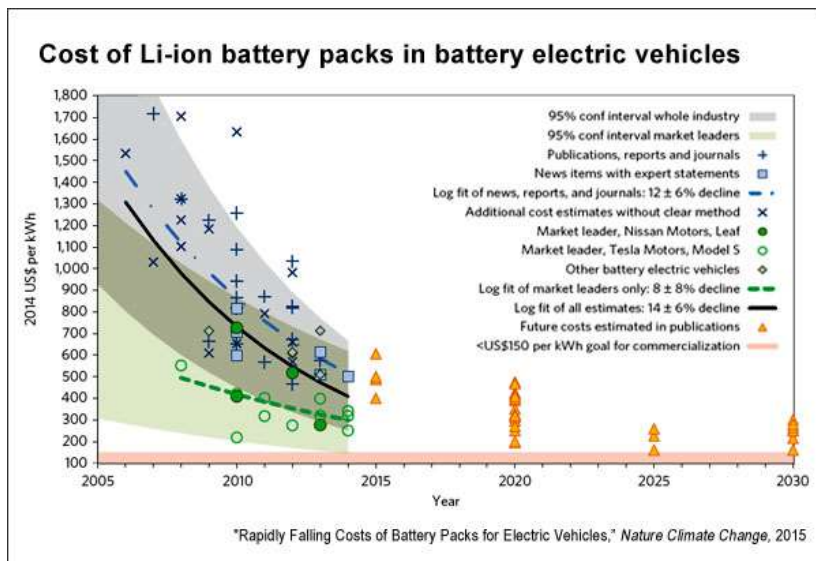
- PHEV powertrain using Cummins 8.9L ultralow NOx engine certified to 0.02 g/bhp-hr
- Chassis design influenced by HECT project
- Continue refining hybrid drive train to operate in all electric and hybrid electric mode
- 2 Phase I trucks will be delivered
- String of failures and downtime due to hardware and software issue
- Support from suppliers for Hybrid power train components
 - Balancing supplier delivery issues against potential reliability issues

Next: Pre-commercialization Demo Project

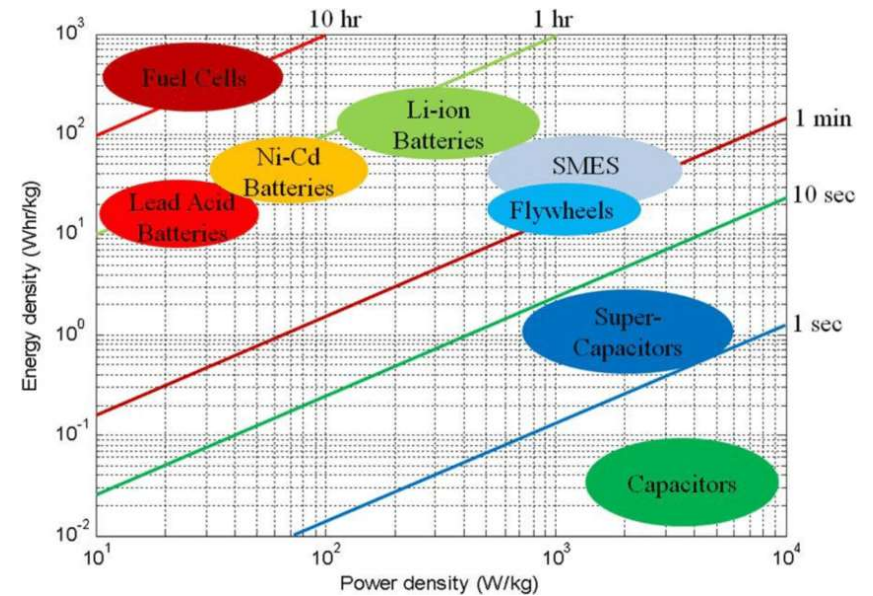


- Battery Electric Airport Shuttle Replacement Projects
- **Daimler - Battery Electric Trucks and EV Infrastructure Project**
- **Volvo LIGHTS Project**

Pathway to Zero-Emission Heavy-Duty Truck



Rapidly Falling Costs of Battery Packs for Electric Vehicles, Nature Climate Change, 2015

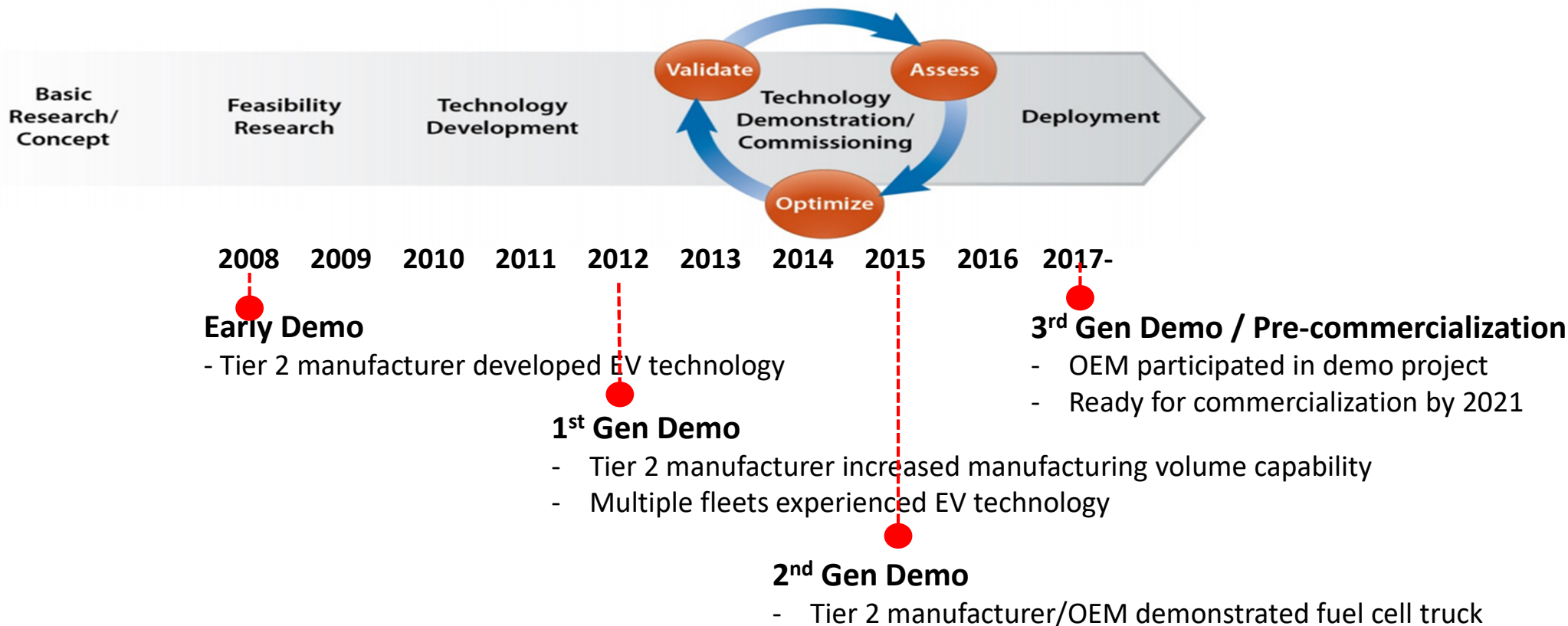


US Defense Logistics Agency Report

Pathway to Zero-Emission Heavy-Duty Truck



Summary





Zero Emission Trucks / EV Infrastructure

Daimler Trucks North America

Clean Fuels Advisory Meeting

South Coast Air Quality
Management District

September 19, 2019

Phil Barroca
Program Supervisor, Technology Demonstration
Technology Advancement Office



Overview

- ▶ Class 8 - eCascadia DTNA
- ▶ Class 6 - eM2 Agility/DTNA
- ▶ Infrastructure
 - DC Fast Charging
 - Energy Storage Systems
- ▶ Demonstration/Outreach
 - Penske Truck Leasing and NFI
- ▶ Cost Sharing
 - DTNA, POLA, POLB, EPA



Vehicles

- ▶ 15 eCascadias – DTNA, Portland, OR
- ▶ 5 eM2 – Agility, Fontana, CA

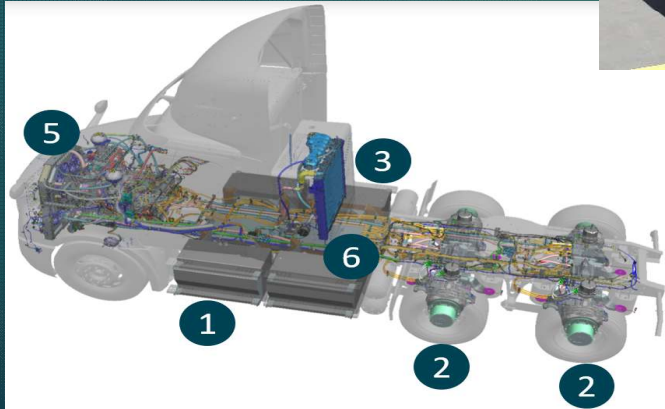


eCascadia – Design/Construction

DTNA - Portland, OR



Class 8
80,000-lb GVWR
670 peak h.p.
1 430 lb-ft. torque
400 kWh battery (useable)
1 60 mile full load range
<3 hours full recharge @150kW



1. Battery (Agility/Romeo)
2. E-Axle (ZF-Germany) – four (4)
3. Power Distribution Unit (Agility)
4. Inverter (Semikron)
5. Vehicle Control Unit (Bosch)
6. Brake Resistor (Backer)

eCascadia - Project Status



- ▶ Two vehicles have been delivered
 - one to NFI, one to Penske
 - two more expected within a week
- ▶ Six vehicles are 75% assembled
- ▶ Five are 10 - 20% assembled
- ▶ All 15 trucks expected to be delivered by end of 2019



| Assembly Phase | Description |
|----------------|--|
| 1 | Chassis Pre-Paint |
| 2 | In-Frame Coolant and Air Plumbing |
| | Install LV chassis harness |
| 3 | Front Box Build-Up |
| | DC-DC, Brake resistor, Inverters |
| | Battery Heater, A/C, Pumps, Coolant plumbing |
| | Cab Heater, Batteries, Air Compressor |
| | Coolant Pump, Prep for move to chassis |
| | Radiator assembly build-up |
| 4 | Front of Chassis |
| | Install front box into chassis |
| | Connections to front box |
| | Install radiator into chassis |
| 5 | PDU and HV Batteries |
| | Install PDU and HV batteries |
| | Install steps, wheels, and tires |
| 6 | Back of Cab Radiator |
| | Assemble BOC radiator |
| | Deck plates, quarter fenders, mud flaps |
| 7 | Cab Drop |
| | Install Cab |
| | Pressure test cooling circuits |
| 8 | Build Completion |
| | Inspections |

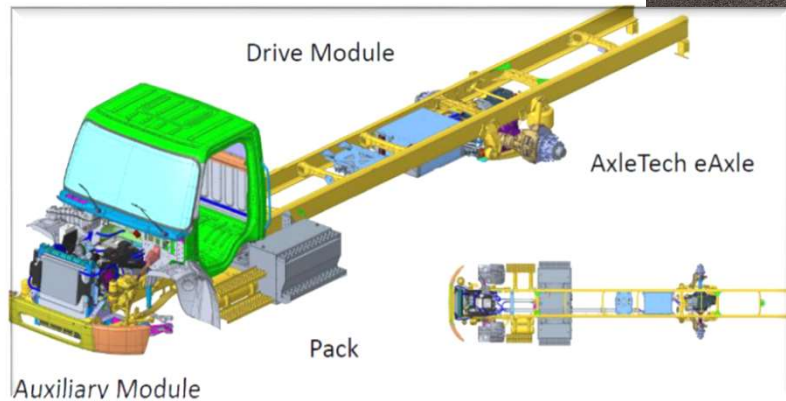
Commissioning

- A:** Prepare Front Box to Mate with Chassis
- B:** Prepare Chassis to Mate with Cab
- C:** Cab ECU Programming and Driver Controls
- D:** High Voltage Link
- E:** Thermal Management Testing
- F:** Network Management and Sleep
- G:** HV Charging and Drivetrain Testing
- H:** Final Checks
- DL:** Data Logger Check
- RG:** Reliability Growth Drive
- PDI:** Pre-Delivery Inspection

eM2 – Design/Construction Agility (Fontana, CA)/DTNA



Class 6
26,000-lb GVWR
333 peak h.p.
737 lb-ft. torque
220 kWh battery (190 kW useable)
150 mile full load range
2 hours full recharge @150kW



Battery (Agility/Romeo)
E-Axle (Meritor) – single unit
Power Distribution Unit (Agility)
Inverter
Vehicle Control Unit
Brake Resistor (energy dissipation through auxiliary systems, e.g. cabin heating)

eM2 - Project Status



- ▶ Agility is completing construction of a test truck not part of this project but integral to developing the five eM2's in this project
- ▶ For this project:
 - One eM2 has completed Assembly Phase 1
 - One eM2 is 25% complete in Assembly Phase 2
 - Three eM2's have not yet commenced Assembly

Specification and design work for the eM2 vehicles was completed by Agility Fuel Solutions in Fontana, California with support from the Daimler E-Mobility Group.

| Assembly Phase | Milestone |
|----------------|--------------------------------|
| 1 | Truck De-Contented |
| | LV battery box relocated |
| | eAxle install |
| 2 | Auxiliary module build |
| | Drive module build |
| 3 | Auxiliary module install |
| | Drive module install |
| | Thermal systems install |
| 4 | LV harness install |
| | HV harness install |
| 5 | Battery install |
| 6 | Key On / Vehicle Commissioning |
| 7 | Drive testing/Shakedown |
| 8 | Ready to Ship |



Video clip of eCascadia and eM2

Test drive by press

<https://youtu.be/gniikUXQhZ4>

eM2 – short tech

<https://youtu.be/EsIS9LeBqXo>

Matt's speech at unveiling in Napa

<https://youtu.be/kAIAJyqL5dA?t=875>

eCascadia abbreviated press event
and Pairing test

<https://youtu.be/qwl4Wt5Av3k?t=123>

Las Vegas test run with DTNA driver

<https://youtu.be/-BmZxqHsXpw>

Unveiling and comprehensive look

<https://youtu.be/qwl4Wt5Av3k>

eM2 walk around at Indiana Truck show

<https://youtu.be/4GUxvhiOack>

EV Infrastructure

- ▶ Infrastructure: CCS-1 DC Fast Charging
- ▶ 150 kW, 62.5 kW, 50 kW
- ▶ 10 Locations, 21 DC Fast-Chargers
- ▶ Energy Storage System – Ontario
 - 300 kW Power
 - 800 kWh storage
 - New Utility rates affecting ROI



CCS Type1 Connector

EV Infrastructure – Locations



| Demo. | Location | Type | Chargers | Dispensers | kW/Charger | Total kW | Status |
|---------------------|---------------|-------|-----------|------------|------------|-------------|----------|
| Penske | Anaheim | CCS-1 | 2 | 4 | 150 | 300 | Ongoing |
| Penske | Temecula | CCS-1 | 1 | 2 | 50 | 50 | Ongoing |
| Penske | Chino | CCS-1 | 2 | 4 | 150 | 300 | Ongoing |
| Penske | La Mirada | CCS-1 | 2 | 4 | 150 | 300 | Complete |
| Penske | San Diego | CCS-1 | 2 | 2 | 150 | 300 | Complete |
| Penske | Ontario | CCS-1 | 3 | 6 | 150 | 450 | Q4-19 |
| NFI | Chino | CCS-1 | 5 | 5 | 150 | 750 | Complete |
| NFI | Port Location | CCS-1 | 1 | 1 | 62.5 | 62.5 | Q4-19 |
| NFI | Shop Location | CCS-1 | 1 | 1 | 62.5 | 62.5 | Q4-19 |
| DTNA | Fontana | CCS-1 | 2 | 2 | 62.5 | 62.5 | Q4-19 |
| | | | | | | | |
| Penske Total | 6 | | 12 | 21 | | 1700 | 2 |
| NFI Total | 3 | | 7 | 7 | | 875 | 1 |
| DTNA Total | 1 | | 2 | 2 | | 125 | 0 |
| Totals | 10 | | 21 | 30 | | 2700 | 3 |



2 at Penske – La Mirada



5 at NFI - Chino

Demonstrators

▶ Penske Truck Leasing

- 5 eM2 trucks
- 10 eCascadia
- 6 locations



▶ NFI Logistics

- 5 eCascadia
- 3 locations



Project Funding - \$31,340,144



\$1,000,000 each Port



\$1,000,000



\$15,670,072
Cost-Share

\$13,170,072 +
\$2,500,000 (reserve)
NTE \$15,670,072

Thank You



VOLVO LIGHTS



Clean Fuels Advisory Committee
September 2019

Patricia Kwon
Program Supervisor
Technology Advancement Office





**Demonstrating innovations critical to the commercial success
of battery electric trucks and equipment for goods movement**
LIGHTSproject.com



**Advanced Vehicle
Technologies**



**Charging
Infrastructure**

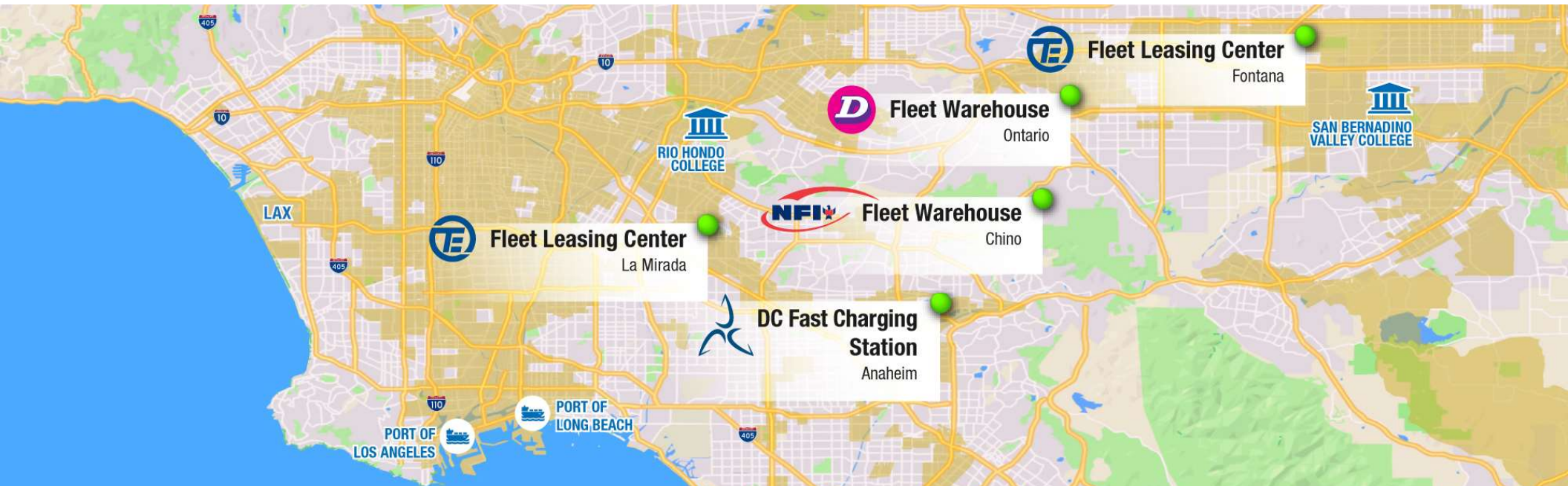


**Sales & Service
Network**

Project Partners



Volvo LIGHTS is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment —particularly in disadvantaged communities. www.caclimateinvestments.ca.gov



23 Battery Electric Heavy-Duty Trucks



29 Battery Electric Equipment



58 Public & Private Chargers



2 Electric Truck After Market Service Centers



2 Colleges Designing Electric Truck Maintenance Programs



1.8 Solar Energy Generation
Million KWH



2 Ports Providing Infrastructure Planning



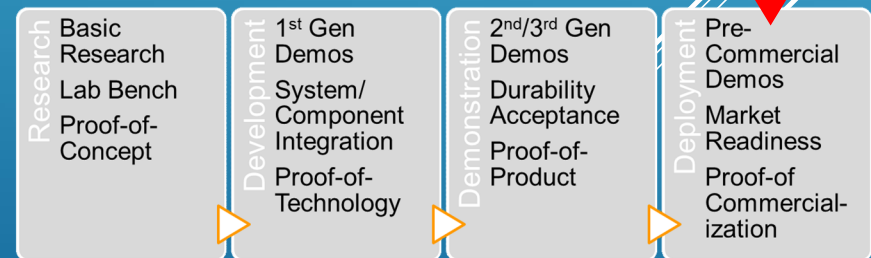
Disadvantaged Communities Disproportionately Exposed to Unhealthy Air



VOLVO LIGHTS



- ◆ Volvo LIGHTS (Low Impact Green Heavy Transport Solution)
 - ◆ Funded with \$44.8M from CCI, \$4M South Coast AQMD, \$41.6M from Partners
- ◆ Showcases zero-emission freight movement
- ▶ Commercial introduction of Class 8 HDBETs
- ▶ Installation of 58 DCFC + Level 2 chargers
- ▶ Installation of 1.8M kWh solar and facility upgrades
- ▶ Public outreach, data collection and reporting





The Volvo LIGHTS Project



INLAND EMPIRE



VOLVO LIGHTS



- ▶ Freight Haul Demonstration:
 - ▶ Develop 8 pilot and 15 production Class 8 battery electric trucks and 29 battery electric forklifts/yard tractors
 - ▶ VNR Electric perfect platform for short regional haul applications
 - ▶ From Ports to Inland Empire warehouse locations





TRUCK UPDATE



- ▶ Two pilot trucks and three pilot tractors built at Greensboro
- ▶ Self learning driveline control algorithms optimize energy usage, range
- ▶ Web based tools improve vehicle uptime
- ▶ Testing trucks on track
- ▶ Delivery of five trucks in California in December 2019





INFRASTRUCTURE UPDATE



- ▶ One of first public heavy duty fast charging stations—Trillium site in Placentia—with two 150 kW DCFC
- ▶ New lithium ion battery chemistry with 20% greater energy density
- ▶ Smart chargers integrated with vehicle telematics
- ▶ Field certification of CCS2 connector with ABB 50 kW and 150 kW DCFC to be completed in three months
- ▶ First installation at TEC Fontana site
- ▶ Fleet sites—TEC, DHE, NFI—coordinating with SCE on Charge Ready Transport

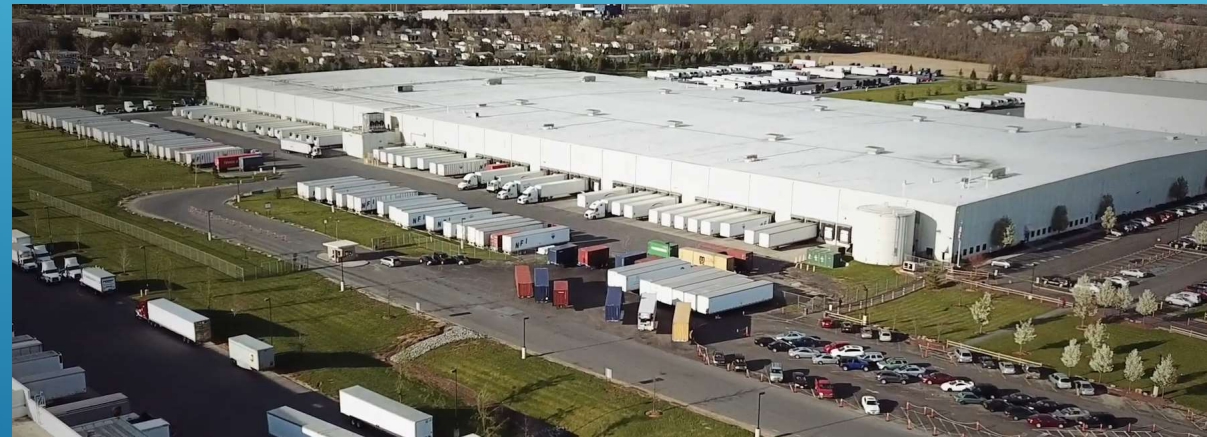




PROJECT UPDATE



- ▶ CARB grant agreement executed February 2019
 - ▶ Most subcontracts with Volvo and partners executed
- ▶ Kick off meeting March 2019
- ▶ Five trucks to be delivered to California
- ▶ Charging infrastructure up in time for truck deliveries
- ▶ Technology Showcase Feb 2020



Heavy-duty Engine Technology Update

Near-Zero NOx

Joseph Lopat



Near-Zero
NOx

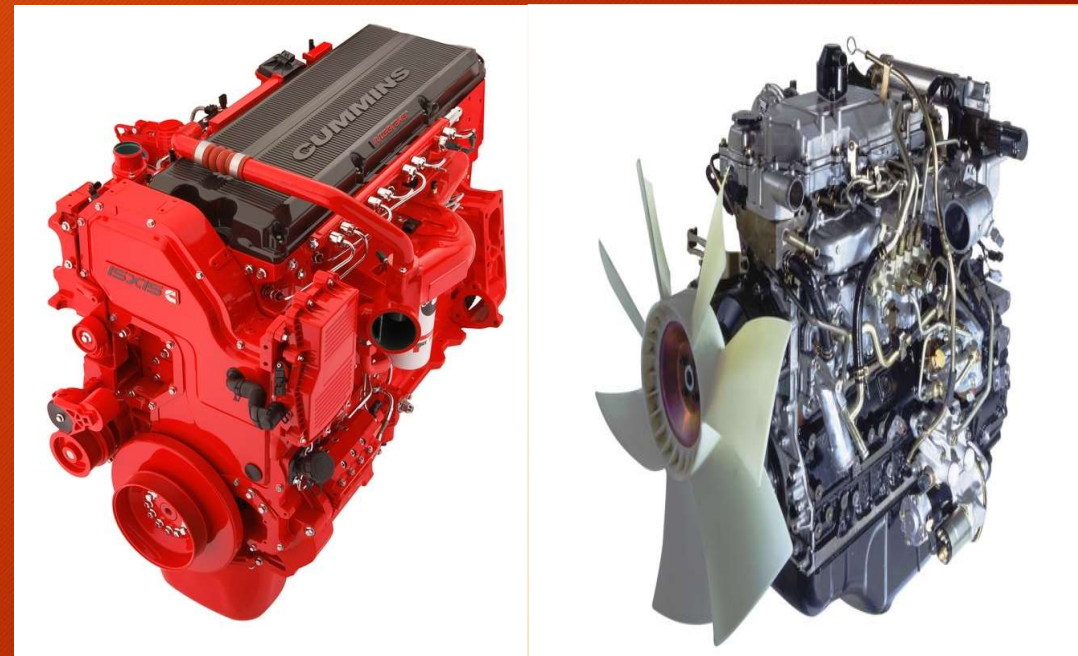


Picture compliments of (2019) Overdrive
magazine

Clean Fuels

Near-Zero
NO_x

- The Pathway to 0.02 g/bhp-hr NO_x emissions from heavy-duty diesel engines is here.
- 6.7, 6.8, 8.9, and 12 liter certified optional low NO_x standard CNG engines in production.
- Opposed Piston Engine technology preliminary testing at near-zero No_x.
- 3 CNG technology study grants underway for \$1.3 M.
- 3 projects for 7.3-liter natural gas engines expected to be certified next year at 0.02 g/bhp-hr No_x.

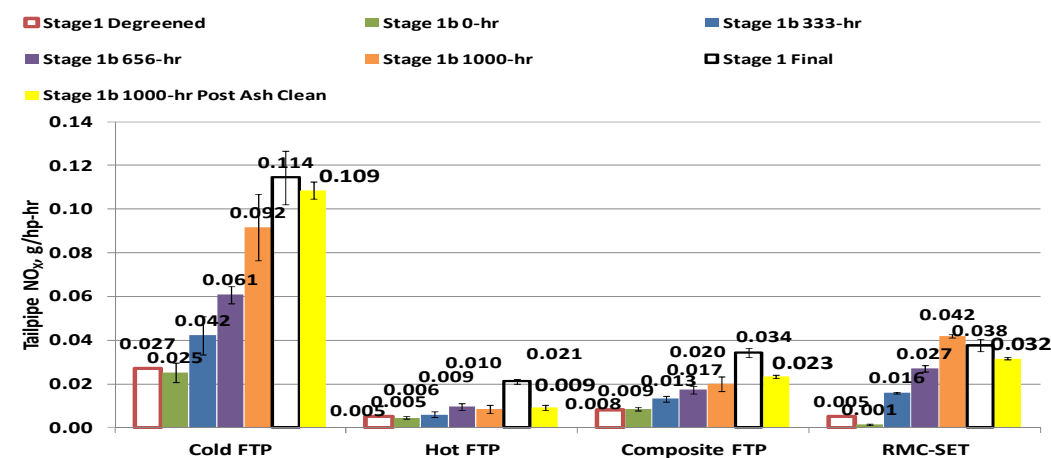


Heavy-duty Diesel Engine development

Near-Zero NOx

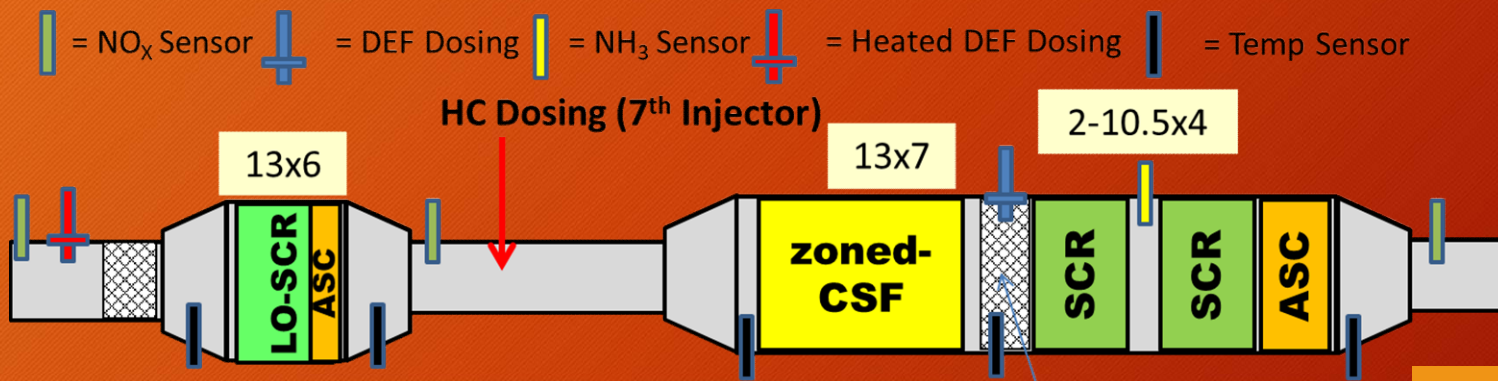
- SwRI completion of Low load test cycles development.
- Catalyst useful life studied at 1000 hrs.
- Near-Zero NOx pathway incorporating CDA, heated dosing, and a close coupled catalyst shows success at all load cycles.
- Opposed piston engine technology using the Aftertreatment designed in the SwRI project.

| Test Point | Stage 1 | | Stage 1b | | | | |
|------------|---------|----------|----------|---------|---------|----------|---------------|
| | 0-hr | 100% FUL | 0-hr | 33% FUL | 67% FUL | 100% FUL | 100% FUL, PAC |
| Cold FTP | 99% | 96% | 99% | 98.5% | 98% | 96% | 96% |
| Hot FTP | 99.8% | 99.3% | 99.8% | 99.7% | 99.7% | 99.7% | 99.6% |
| RMC | 99.5% | 98.2% | 99.8% | 99.3% | 98.8% | 97.8% | 98.4% |



Preliminary Results with CDA and modified AT

Near-Zero
NO_x



EO = 2.8, TP = 0.06 g/hp-hr
 98% Conversion
 CO₂ = 543 g/hp-hr (+2%)
 N₂O = 0.03 g/hp-hr

EO = 3.6, TP = 0.012
 g/hp-hr
 99.6% Conversion
 CO₂ = 475 g/hp-hr (-
 2.5%)
 N₂O = 0.07 g/hp-hr

Opposed piston Engine technology

Near-Zero
NO_x

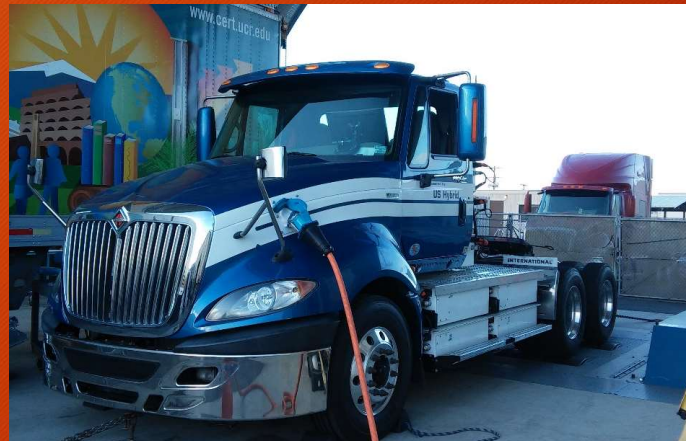
- \$16.7M Project started in January 2018.
- 3 engines completed and tested.
- Integration into truck beginning for in-use testing.



NREL CNG Projects

Near-Zero
NO_x

- US Hybrid development of 0.02 g/bhp-hr certified CNG powered Class 8 truck.
- Southwest Research Institute design of a high efficient 0.02 g/bhp-hr CNG engine for hybrid applications.
- Cummins Inc. high efficiency research and development for large displacement CNG engines.
- Projects co-funded by DOE and CEC.



7.3-Liter CNG Engine

Near-Zero
NOx

- 3 Ford authorized CNG conversion companies developing near-zero NOx 7.3-liter engines \$4.5M
- Engines expected to be certified at 0.02 g/bhp-hr NOx in 2020'
- 430 HP/475 ftlb Torque engine for class 6 and 7 truck chassis
- 0.02 g/bhp-hr NOx LP version



Future Technology

Near-Zero
NOx

- Demonstration of the successful near-zero heavy-duty diesel engine system in a class 8 truck.
- Further advancement of the heavy-duty near zero NOx technology involving heated catalysts, and variable valve timing.
- Continued near-zero NOx CNG and LPG projects.
- Further aftertreatment simplification and advancement.
- Promotion of a 0.02 g/bhp-hr optional low Nox standard for diesel engines. CARB Omnibus ruling meeting at South Coast AQMD 9/26/19.



I ♥ Clean Air.



South Coast
AQMD



200 Vehicle In-Use Emissions Testing Program Update

Clean Fuels Advisory Group | Sam Cao - Air Quality Specialist | September 19, 2019





South Coast
AQMD



Objectives

Identify technology benefits/shortfalls, feed information into future R&D opportunities, future regulation development and improve emissions inventory estimates



Total Vehicles Recruited

219

22 Vehicle OEMs, 9 Engine OEMs, 200 PAMS, 100 PEMS, 60 Chassis, 10 On-Road Trailer

Vocations Covered

5

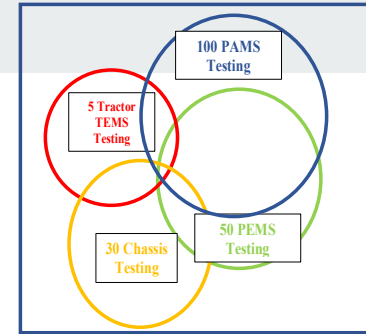
25 Fleet Participants: Delivery (44), Goods Movement (95), Transit Bus (21), School Bus (27) and Refuse (32)

Technologies Covered

9

Propane (4), CNG 0.02 (28), CNG 0.2 (79), No SCR Diesel (10), Diesel 0.2 (72), Diesel-Hybrid (6), BEV (12), FCEV (2), HDPI (4)

Experimental



1

(200) PAMS – ECM + telematics data logging for up to 4 weeks, fleet survey and maintenance/fuel records collection. Data to be used from new cycle development

3

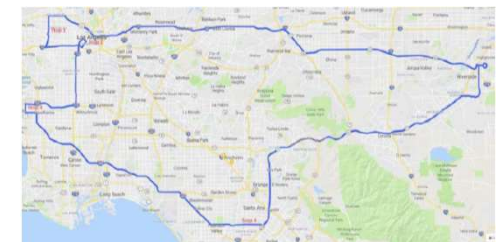
(60) Chassis – Fully lab equipment, regulated and unregulated gaseous, PM, PN, toxic and metals analysis, subset of 8 chassis cycles depending on vocation

2

(100) PEMS testing – one full-day operation, NTE analysis, ECM + telematics, regulated gaseous data only

4

(10) On-road trailer testing – Full lab equipment (same as chassis) on 4 real-world routes in SCAB (drayage, goods movement x2, grocery)





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Testing Phase Update

| Testing Phase | Assigned | Recruited | Completed |
|--|----------|-----------|-----------|
| Portable Activity Monitoring System (PAMS) | 200 | 219 | 206 |
| Portable Emissions Measurement System (PEMS) | 100 | 100 | 88 |
| Chassis Dynamometer | 60 | 62 | 21 |
| Real-World In-Use Trailer | 10 | 10 | 5 |

Testing Target Completion - 4Q2019

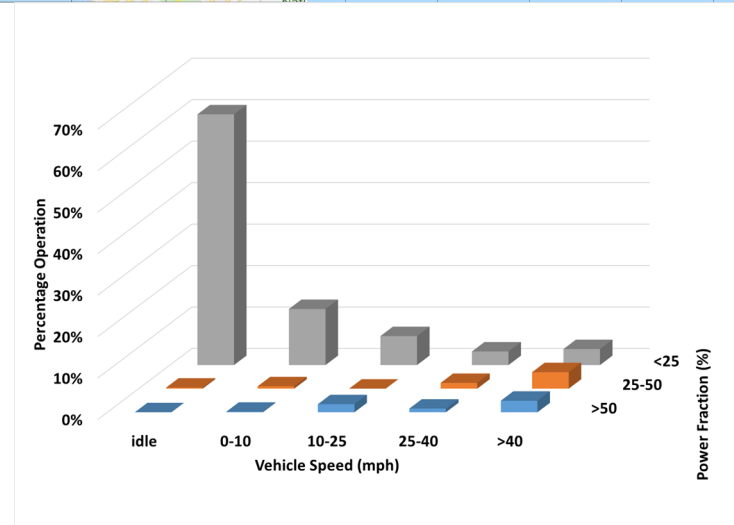
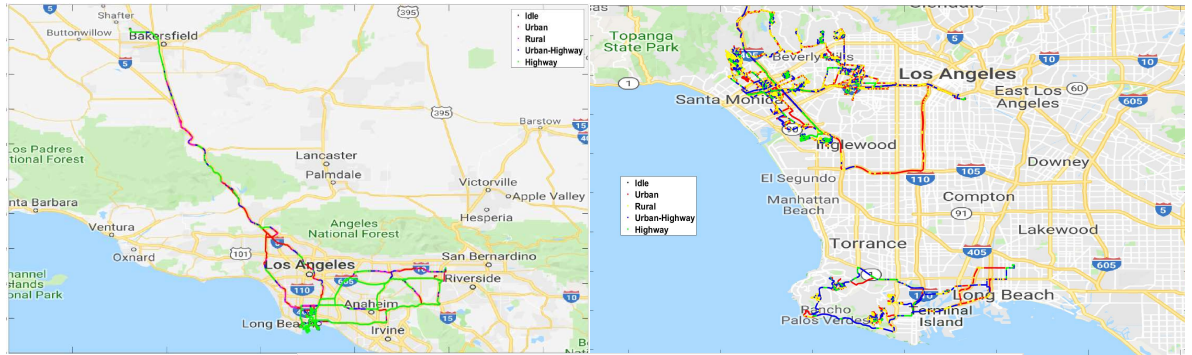




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AQMD

Preliminary Key Findings - PAMS

- Idle, low-speed, low power operation dominated the activity data set
- Higher vehicle speed for delivery and goods movement, transit and school buses lower, refuse lowest
- More detailed vocation specific analysis to be done in final report
- PAMS data submitted to CARB for additional analysis



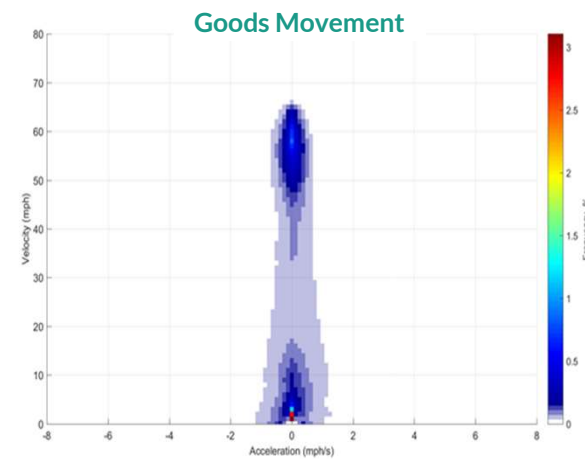
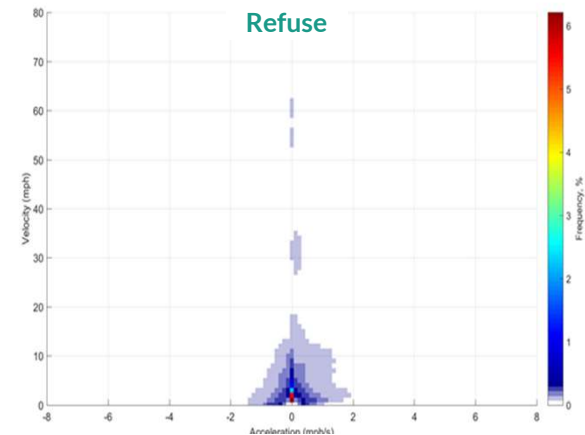
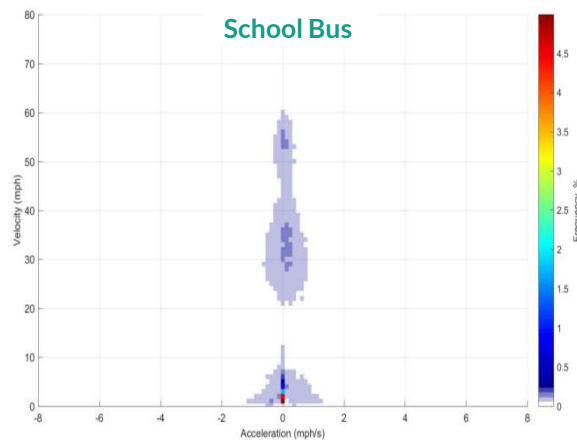
Top: A real-world route and speed characteristics of goods movement trucks (left), refuse (right)
 Bottom: Distribution of vehicle speed and power bins of CNG goods movement trucks (WVU)



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Preliminary Key Findings - PAMS

- Distinct speed profiles per vocation, as expected
- Idle time : 34-46% (UCR data set , more in WVU data set)
- Data used for new duty cycle development



Source: UCR VMT data analysis



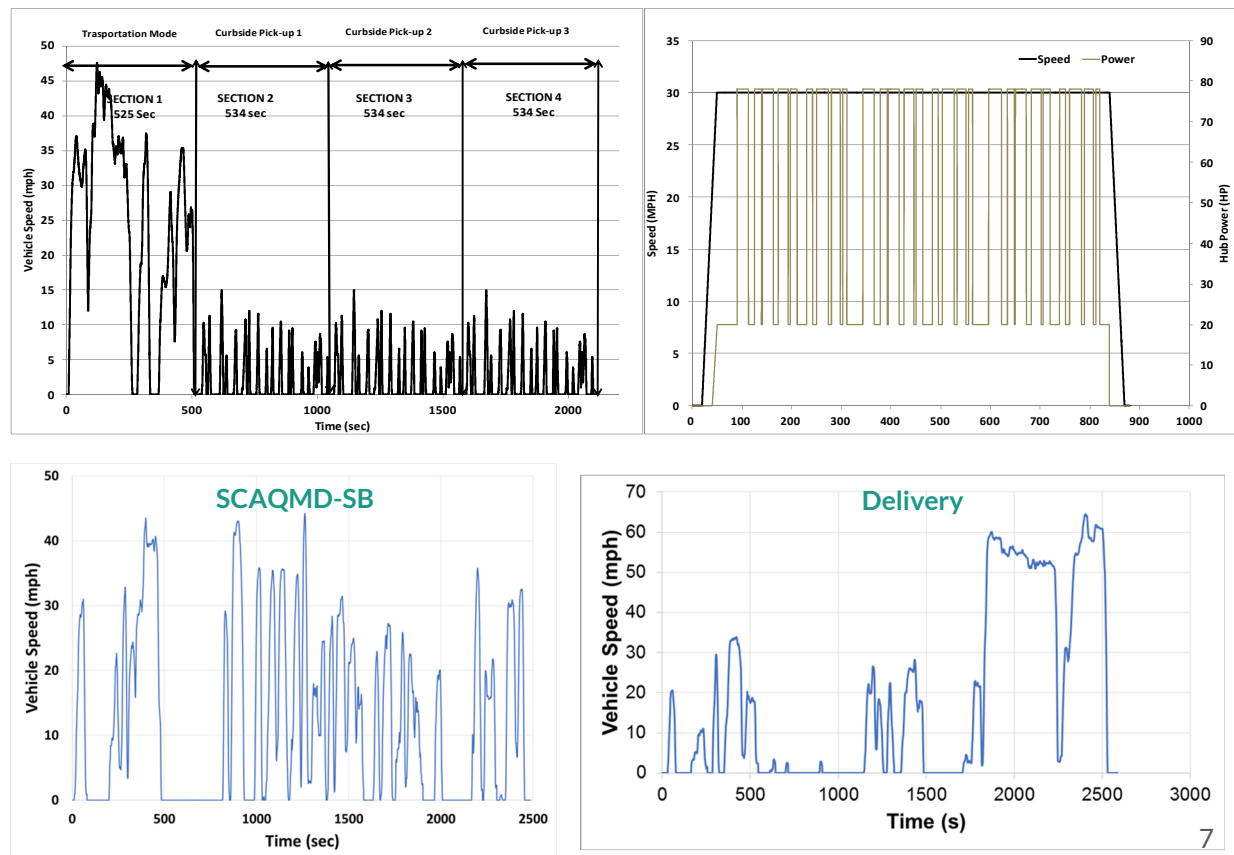
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New Chassis Test Cycles Developed

- Standard cycles: UDDS, CARB HHDDT, CBD, OCTA
- New cycles : Drayage (TIAX LLC), South Coast AQMD School Bus, Delivery, Modified South Coast AQMD refuse
- Standard and new cycles tested in chassis test plan

Source: Final chassis test plan, submitted to SCAQMD

Modified SCAQMD Refuse + Compaction Cycle for Hydraulic Load

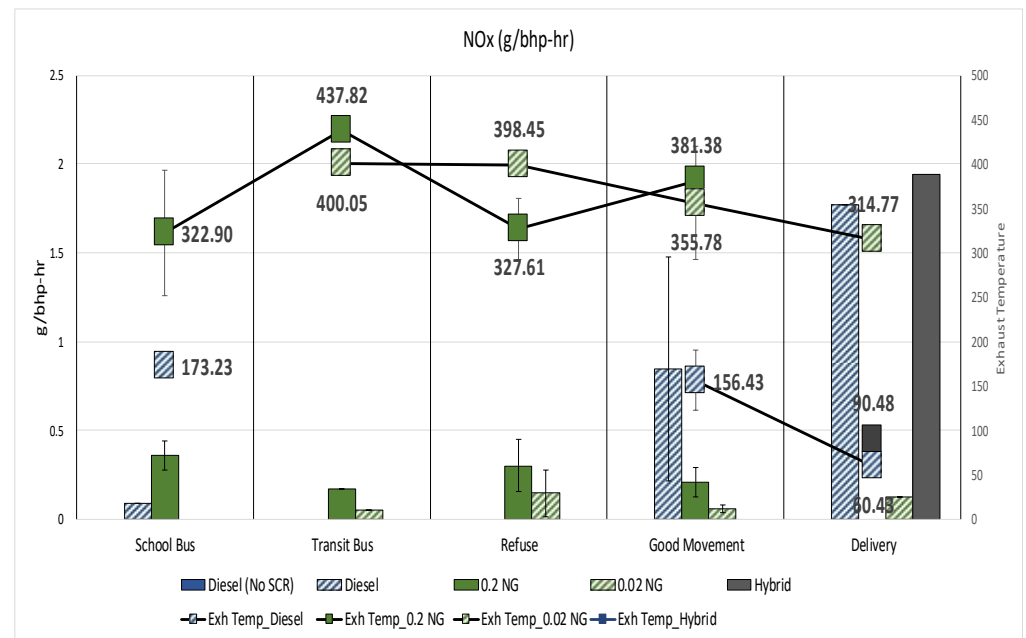




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Preliminary Findings – PEMS

- Diesel emissions vary greatly, highly dependent on duty cycle and vocations
- CNG emissions do not vary between vocations
- Diesel-electric vehicle lower emissions on g/mile (1.1 g/mile diesel-electric vs. 9.5 g/mile 0.2 diesel)





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In-Use Emissions - Key for Future NOx Regulation

- CARB released Staff White Paper outline plans for next rounds of low NOx rule making, significantly changes to HDIUT
- Truck and Bus Regulation?

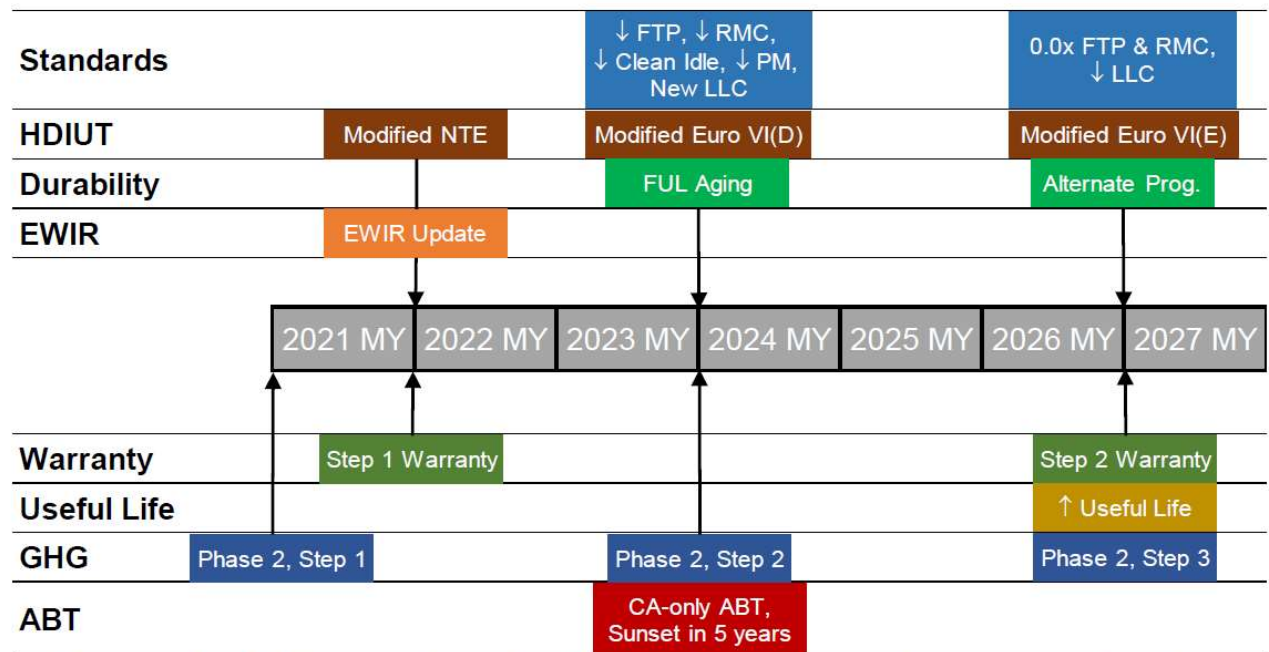


Figure 12 CARB Heavy-Duty Low NOx Rulemaking Implementation Timeline

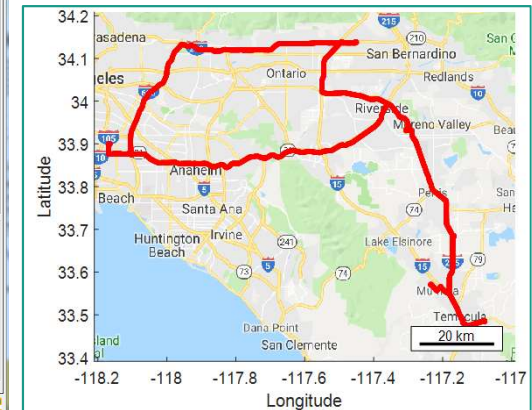
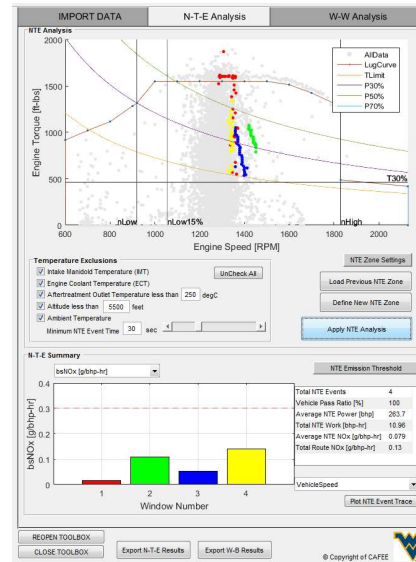


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Future Research: CARB Proposed In- Use Metric Deep Dive

How does the current PEMS data set/trucks today look against future metric?

- 01 | Proposed 2022 CARB modified NTE vs. baseline
- 02 | Proposed 2024 & 2027 CARB modified Euro VI WBW
- 03 | CARB REAL binning analysis
- 04 | EPA MOVES binning analysis
- 05 | On-board NOx sensors vs. PEMS NOx



| | | Vehicle Speed (km/h) | | | | | | |
|------------------|----------------|----------------------|-------------|--------------|--------------|--------|------------------------|--|
| | | 0 | > 0 ≤ 16 | > 16 ≤ 40 | > 40 ≤ 64 | > 64 | | |
| Total (Bin 1) | ≤ 25% | | Bin 3 | Bin 4 | Bin 5 | Bin 6 | NTE Bin (Bin 15) | |
| | > 25% ≤ 50% | Bin 2 | Bin 7 | Bin 8 | Bin 9 | Bin 10 | Regen Bin (Bin 16) | |
| | > 50% | | Bin 11 | Bin 12 | Bin 13 | Bin 14 | MIL-On Bin (Bin 17) | |

Source: WVU Proposal to South Coast AQMD



Team

Contractors: WVU, UCR/CE-CERT

Funding Partners: CEC, CARB, SoCalGas and South Coast AQMD





South Coast
AQMD



Thank you.





Clean Fuels Advisory Group Meeting September 19, 2019

Light & Heavy-Duty Hydrogen Stations

Lisa Mirisola
Program Supervisor
Science and Technology Advancement
South Coast Air Quality Management District

CA Retail (Light-Duty) Hydrogen Stations

- 40 public retail hydrogen stations operating in CA, including 19 in South Coast AQMD, support 7450 cars (Plus buses & trucks)
- 23 additional retail stations in permitting & construction phase
- Walther H70 nozzle - helps address freeze issue, manufacturing/supply?
- New Tatsuma H70 nozzle

Station Status

| Open Retail Stations | H70 | H35 |
|-------------------------|-----|-----|
| Anaheim | ▲ | ● |
| Campbell | ● | ● |
| Costa Mesa | ● | ● |
| Del Mar | ● | ● |
| Diamond Bar | ● | ● |
| Fairfax-LA | ● | ● |
| Fremont | ● | ● |
| Harris Ranch | ● | ● |
| Hayward | ● | ● |
| Hollywood | ● | ● |
| La Canada Flintridge | ● | ● |
| Lake Forest | ● | ● |
| Lake Tahoe-Truckee | ● | ● |
| Lawndale | ● | ● |
| Long Beach | ● | ● |
| Mill Valley | ● | ● |
| Mountain View | ● | ● |
| Open 6:00 AM - 10:00 PM | | |
| Newport Beach (New) | ● | ● |
| Ontario (New) | ■ | ■ |
| Playa Del Rey | ● | ● |
| Riverside | ● | ● |

http://m.cafcp.org

Diamond Bar

H35* Status: **ONLINE**
H35* Capacity: 76.00 KG
H70* Status: **ONLINE**
H70* Capacity: 74.00 KG

Last Updated: 09/04/2018 4:50 pm
*H35 = 35 MPa or 5,000 PSI
*H70 = 70 MPa or 10,000 PSI

21865 Copley Dr, Diamond Bar, CA 91765

View in Map
Opening Hours: 24/7
Station Customer Service: (800) 224-2724
Use option 2 when calling the customer service number.

Sign Up for SMS updates

Home Login Sign Up
Regular Site Access

CA Hydrogen Stations



A.C. Transit

APCI Trailer
350 bar, 300 kg
10 fills/day



POLA ZANZEFF
Equilon (Wilmington & Ontario)
350 & 700 Bar
10 Kenworth Class 8 FC Trucks



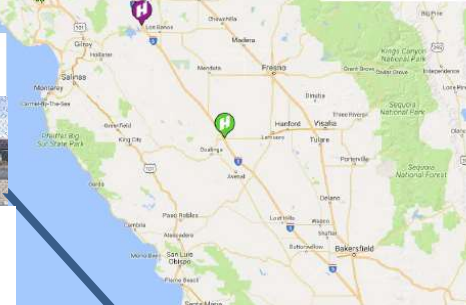
CEC NOPA 17-603
Equilon, Toyota (w/ FCE tri-gen)
350 & 700 bar, 1000 kg/day
2 dispensers, 10 Toyota CL8 FCT



(Photo: Toyota)



64 LDV
stations in
various stages



POLA

POLB

Nel H2 - Proton
350 bar, 900 kg/day
2 dispensers
5 New Flyer-10 min fill
8 FCB now – 20 min fill



SunLine Transit*

* - SMR production for 10+ years

UC Irvine

Upgrade to LH2 delivery
800 kg/day, 700 bar LD,
350 bar FC Bus (at night)

OCTA

Trillium, APCI LH2 delivery
350 bar, 1600 kg/day
10 New Flyer, 36 kg/bus,
6-10 min fill



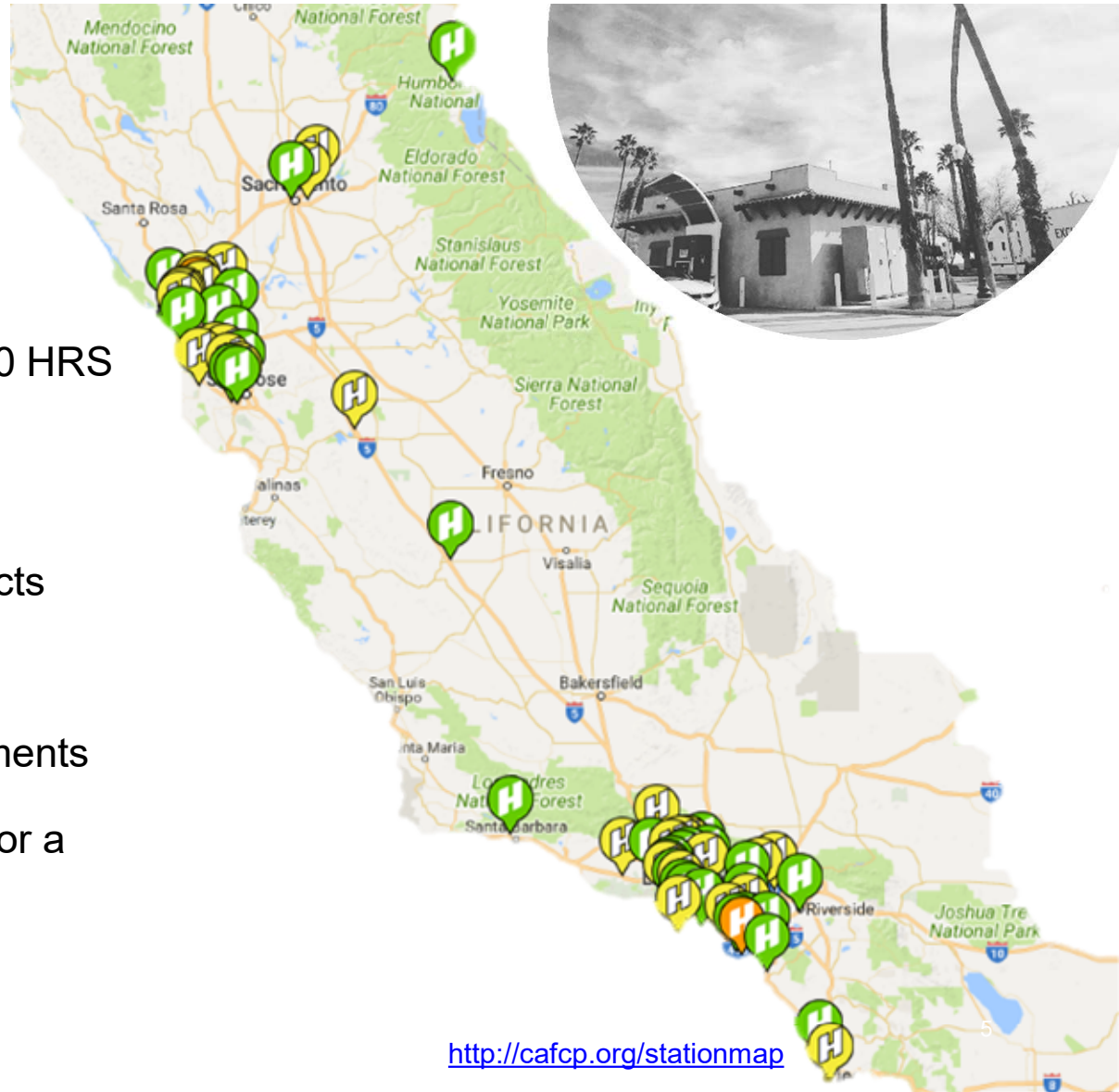
California Hydrogen Infrastructure Research Consortium

- U.S. DOE H2@Scale program with national labs, CA GO-Biz, CEC, South Coast AQMD, and CARB
- Joint agreement led by NREL to continue hydrogen infrastructure research efforts, focused on California near-term priorities
- Project Management Plan 2019 tasks: H2 Station Data Collection
Medium/Heavy Duty Fueling data
Hydrogen Contaminant Detection Nozzle
Freeze Lock
CA Hydrogen integration
Technical Assistance



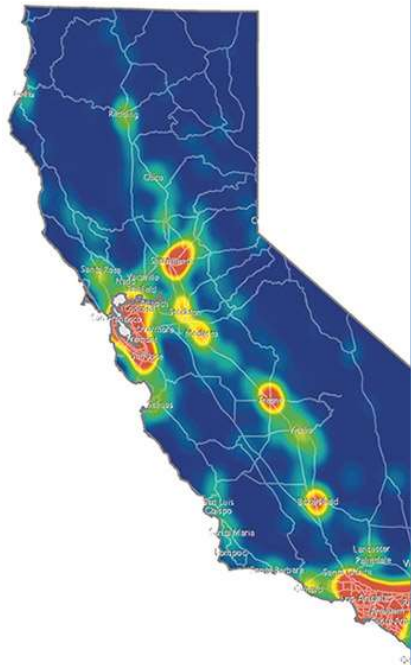
California Activities

- Executive Order B-48-18 targets 200 HRS by 2025 and 5MM ZEVs by 2030
- New H2 production facilities
- New heavy duty fuel cell truck projects
- Innovative Clean Transit regulation
- Low Carbon Fuel Standard Amendments
- CaFCP publishes new 2030 vision for a self-sustaining California market

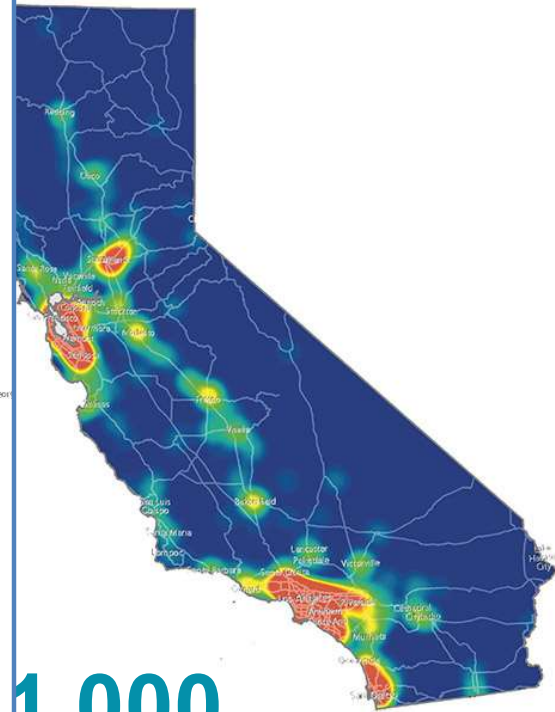
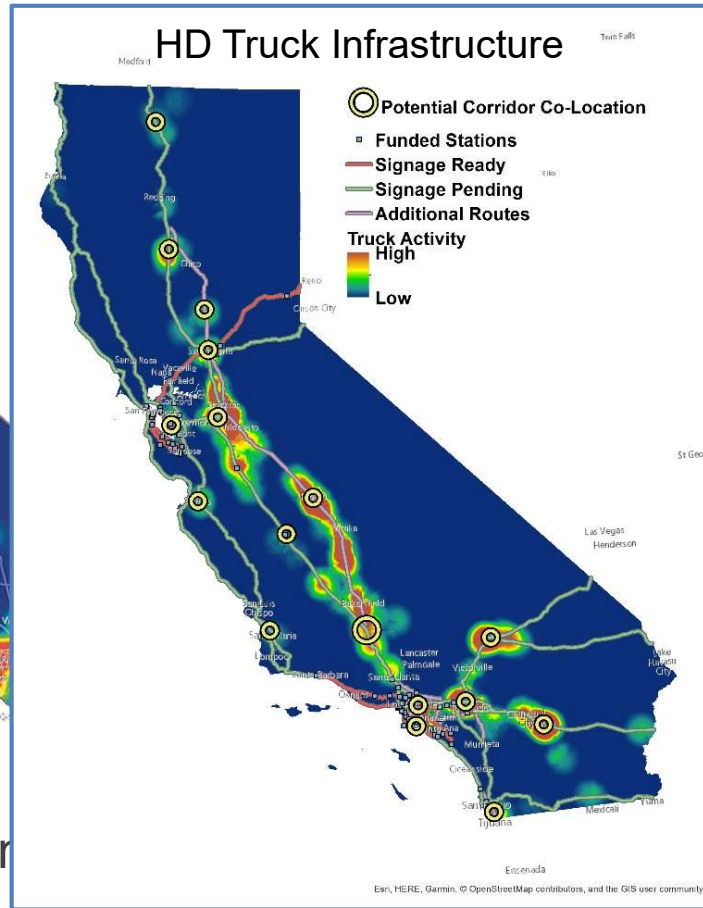


<http://cafc.org/stationmap>

Image of a Successful Self-Sustaining Market

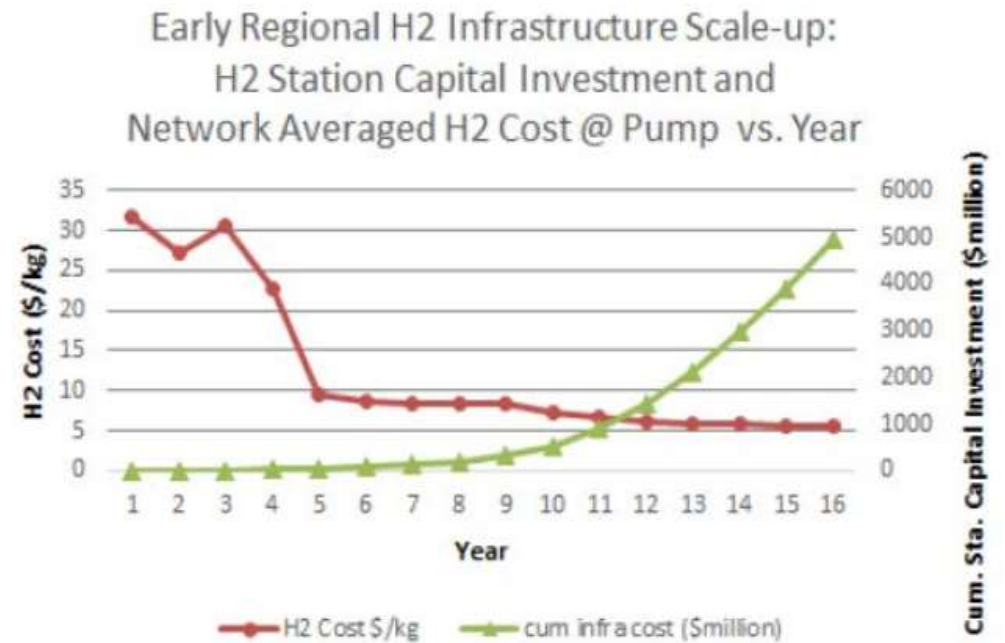
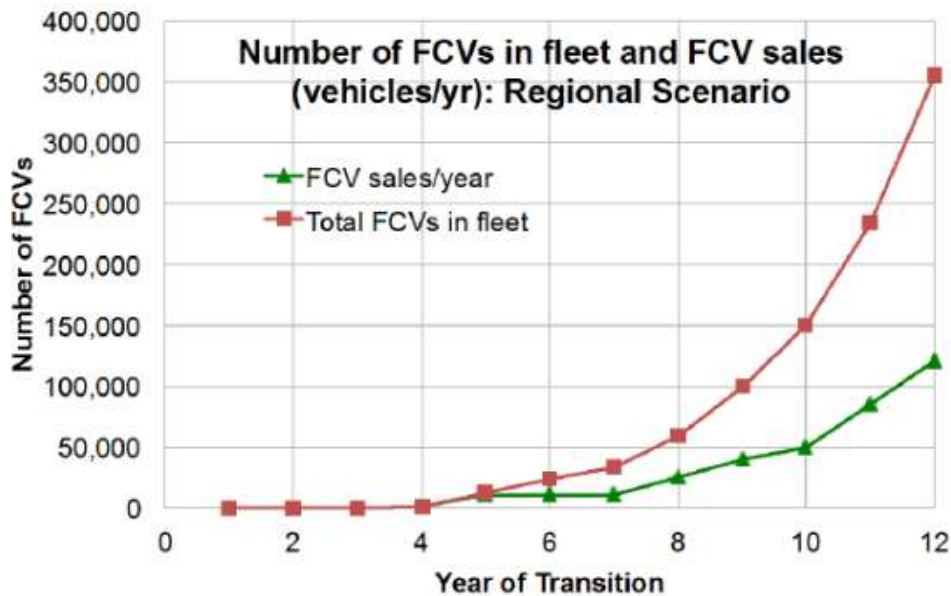


8,000
retail gas stations



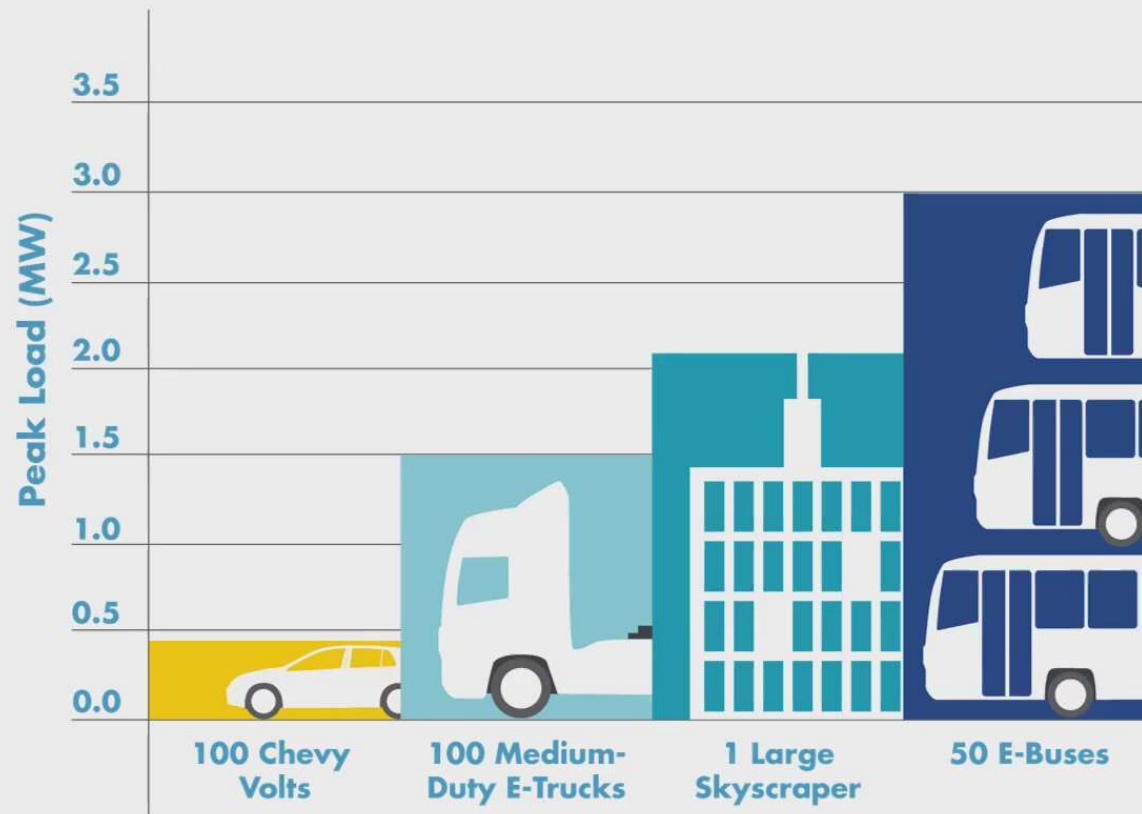
1,000
retail H2 stations

Scale Creates Cost-Competitiveness & Consumer Adoption



Joan Ogden, UC Davis – Transitioning to Electric Drive Vehicles

Why FCEV for HD? Infrastructure, Scaling, and Power Demand of EVs



- The peak load at the substation level is challenged by a B-EV fleet
- Larger scale means FC is better able to handle fueling with a lower TCO
- Volt charge rate 3.3 kw, truck 15 kw, bus 60kw (4-6 hours to full charge for bus)

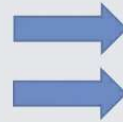


Key Heavy Duty Projects

ZANZEFF Project

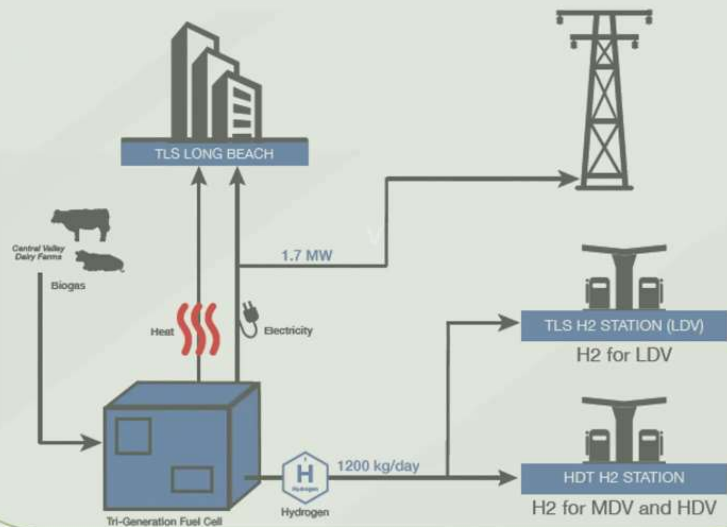


\$41MM
Grant



10 Class 8 FC Trucks
2 H2 stations to support HDTs

Tri-Generation



HD Fueling Development



Large demonstration projects support development for trucks, infrastructure, and renewable H2

Infrastructure Challenges



- Cost
- Supply Chain:
H2 Production, distribution, parts
(need multiple suppliers)
Scale, skilled labor
- CEQA/Permits
- Need higher capacity stations, with refined HD fueling protocols to become “Recommended Practice”
- Short-term network fragility





ZEV Infrastructure

> Speaking: IEPR Presenter

Hydrogen Refueling Infrastructure

- Assembly Bill 8 (2013)
 - \$20 million annual allocation
 - Target: 100 publicly available stations
- Executive Order B-48-18
 - Target: 200 publicly available stations by 2025
- Funded to Date
 - 39 hydrogen refueling stations are open today
 - 12 are located in disadvantaged communities
 - Capacity of up to 17,000 kg/day (equivalent to 24,000 FCEVs)



Potential LCFS Credit Revenue for Hydrogen

| Fuel Production Technology | Feedstock | Example Carbon Intensity | Fuel Displacement Multiplier | Potential LCFS Credit Revenue |
|----------------------------|------------------------------------|------------------------------|------------------------------|-------------------------------|
| Steam Methane Reformation | Fossil natural gas | 117.67 gCO ₂ e/MJ | 1.9 | \$1.57/DGE |
| | Biomethane from landfills | 99.48 gCO ₂ e/MJ | 1.9 | \$2.03/DGE |
| | Biomethane from dairy/swine manure | -300 gCO ₂ e/MJ | 1.9 | \$12.24/DGE |
| Electrolysis | CA grid electricity | 164.46 gCO ₂ e/MJ | 1.9 | \$0.37/DGE |
| | Zero-CI electricity | 10.51 gCO ₂ e/MJ | 1.9 | \$4.30/DGE |