CLEAN FUELS PROGRAM ADVISORY GROUP AGENDA
SEPTEMBER 15, 9:00 AM – 4:00 PM
South Coast AQMD - Remote Meeting

INSTRUCTIONS FOR ELECTRONIC PARTICIPATION
Join Zoom Webinar Meeting - from PC or Laptop
https://scaqmd.zoom.us/j/91964955642
Zoom Webinar ID: 919 6495 5642 (applies to all)
Teleconference Dial In +1 669 900 6833
One tap mobile +16699006833, 91964955642#

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

Pursuant to Governor Newsom's Executive Orders N-25-20 (March 12, 2020) and N-29-20 (March 17, 2020), the South Coast AQMD Clean Fuels Program Advisory Group meeting will only be conducted via video conferencing and by telephone. Please follow the instructions below to join the meeting remotely.
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 three (3) minutes each.

	Welcome & Overview - 9:00 – 10:30 AM	
(a)	Welcome & Introductions	Matt Miyasato, Ph.D., Deputy Executive Officer
(b)	Overview of Emission Reduction Goals & Strategy	Aaron Katzenstein, Ph.D., Assistant Deputy Executive Officer
(c)	Grid Impacts and Solutions for Battery Electric Drayage Fleets	Mark Duvall, Ph.D., Director, Electrification and Customer Solutions, EPRI
(d)	Goals for the day	Joseph Impullitti, Technology Demonstration Manager
(e)	Feedback and Discussion	All
1.	**Areas of South Coast AQMD Focus** **Zero Emission HD Trucks - Demonstration to Commercialization** **10:30 AM – 12:30 PM**	
(a)	Volvo Electric Truck Development Projects	Seungbum Ha, PhD, Program Supervisor
(b)	Daimler Electric Truck Development Projects	Phil Barroca, Program Supervisor
(c)	Drayage Truck Pilot Project	Patricia Kwon, Program Supervisor
(d)	Feedback and Discussion	All
2.	**Lunch 12:30 PM – 1:30 PM** **Zero and Near Zero Emission Development and Deployment Projects** **1:30 PM – 3:30 PM**	
(a)	Fuel Cell Truck Development Projects	Seungbum Ha, Ph.D., Program Supervisor
(b)	Hydrogen Infrastructure for Heavy Duty Trucks	Lisa Mirisola, Program Supervisor
(c)	Near Zero Engine Development & NZE Deployment Projects	Joseph Lopat, Program Supervisor
(d)	200 Vehicle In-Use Emission Study	Sam Cao, Ph.D., Air Quality Specialist

3.	Wrap-up – 3:30 PM – 4:00 PM	
(a)	2022 CF Proposed Plan Update Discussion & Wrap-up	Joseph Impullitti
(b)	Advisor and Expert Comments	All

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 three (3) minutes each.

Document Availability
All documents (1) 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 by contacting 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.

Americans with Disabilities Act
Disability 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 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.

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.

Overview of Emission Reduction Goals & Strategy

Clean Fuels Retreat
September 15th, 2021

Aaron Katzenstein, Ph.D
Assistant Deputy Executive Officer
Technology Advancement Office

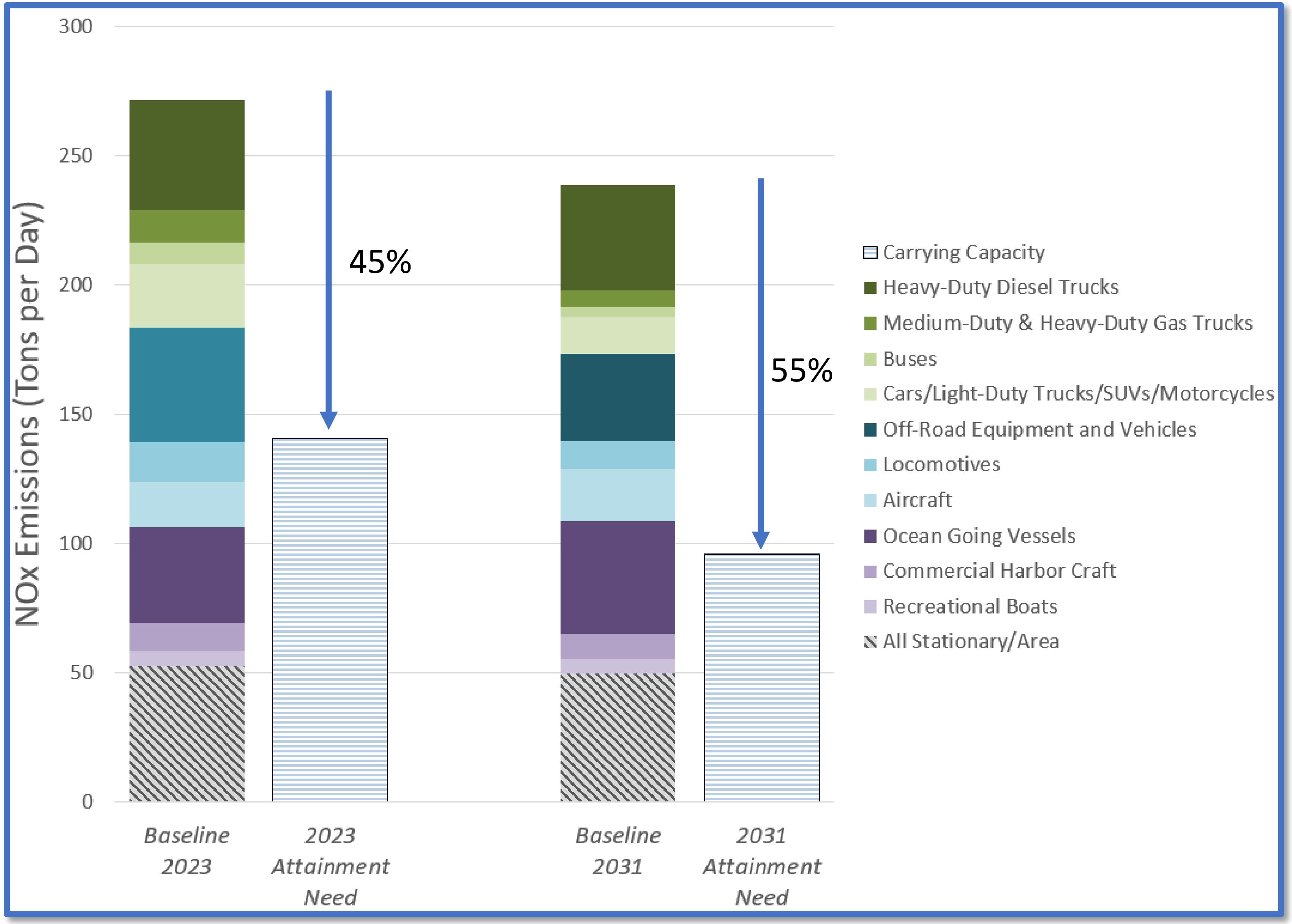
Overview

- ➢ Update & overview of ozone attainment challenges
  - 2022 AQMP
  - MATES Study
  - Warehouse Indirect Source Rule

- ➢ Federal/State Actions

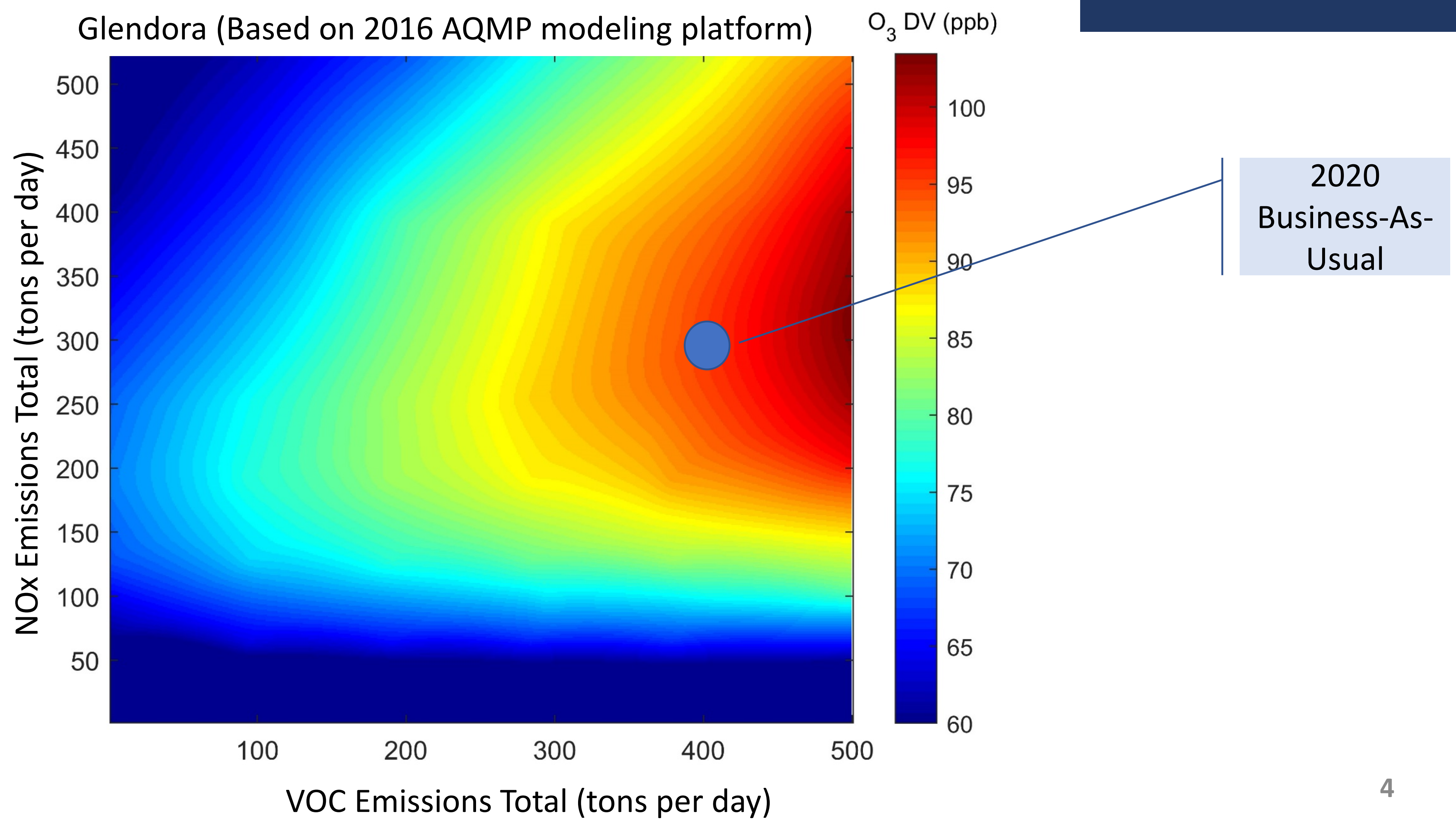
- ➢ Infrastructure – Governor's Emergency Proclamation

Ozone Attainment Challenges



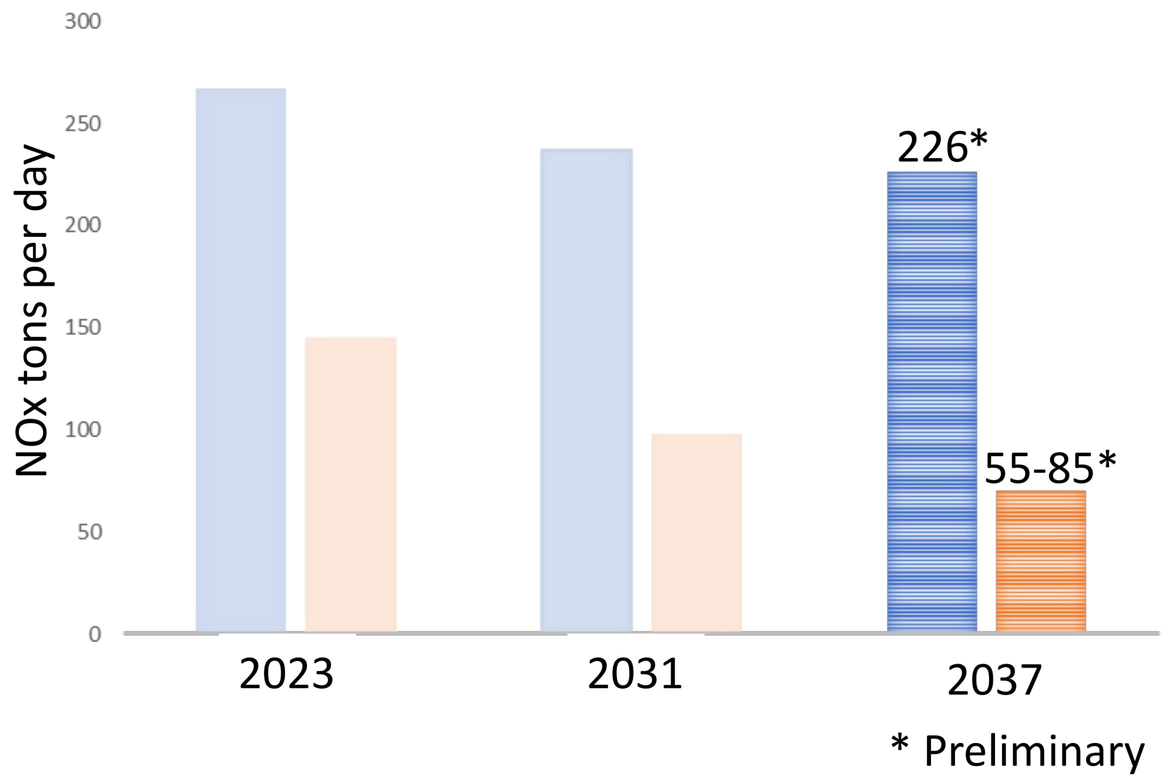
Mobile Sources >80% of NOx inventory for 2023

Ozone Concentrations Relative to NOx & VOC



South Coast AQMD
2022 Air Quality Management Plan

- 2015 8hr ozone standard (70ppb)
- Attainment deadline 2038
- Control Approach
  - Transition to near zero and zero
  - Cleanest available if NZE/ZE not feasible
  - Regulatory measures
  - Incentives (new & existing)
  - Seek legislative authority where applicable



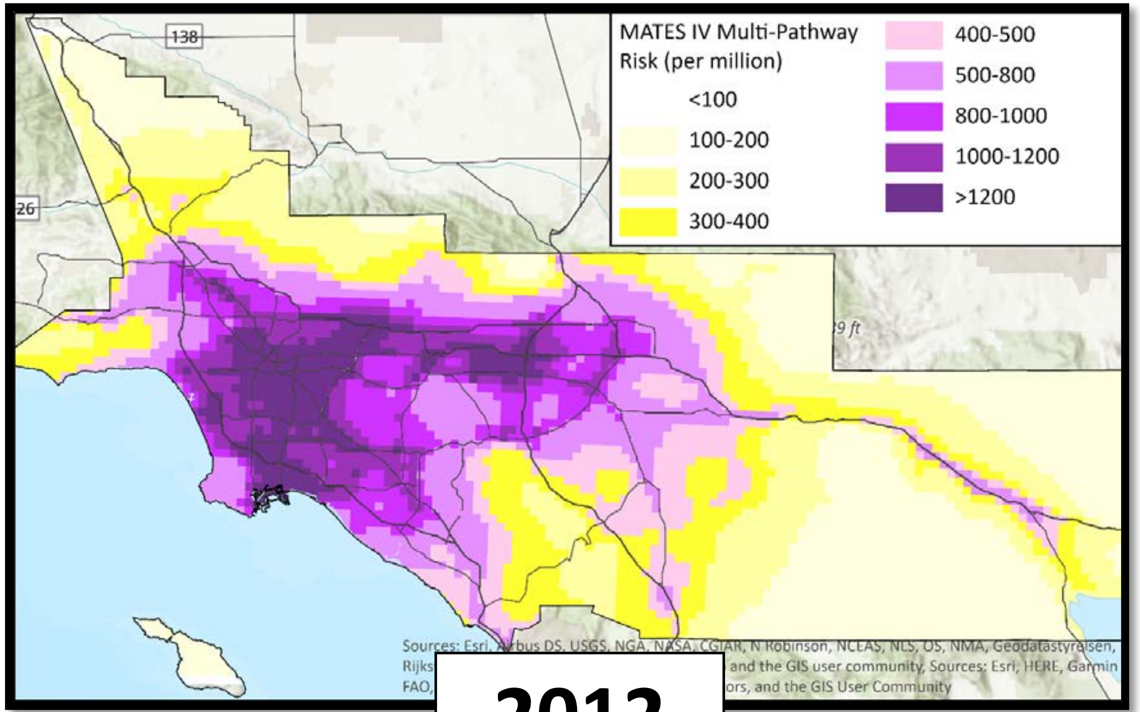
Multiple Air Toxics Exposure Study (MATES V)

- Time period:
  - May 1, 2018-April 30, 2019
- Monitoring stations:
  - 10 fixed sites
  - >100 pollutants measured

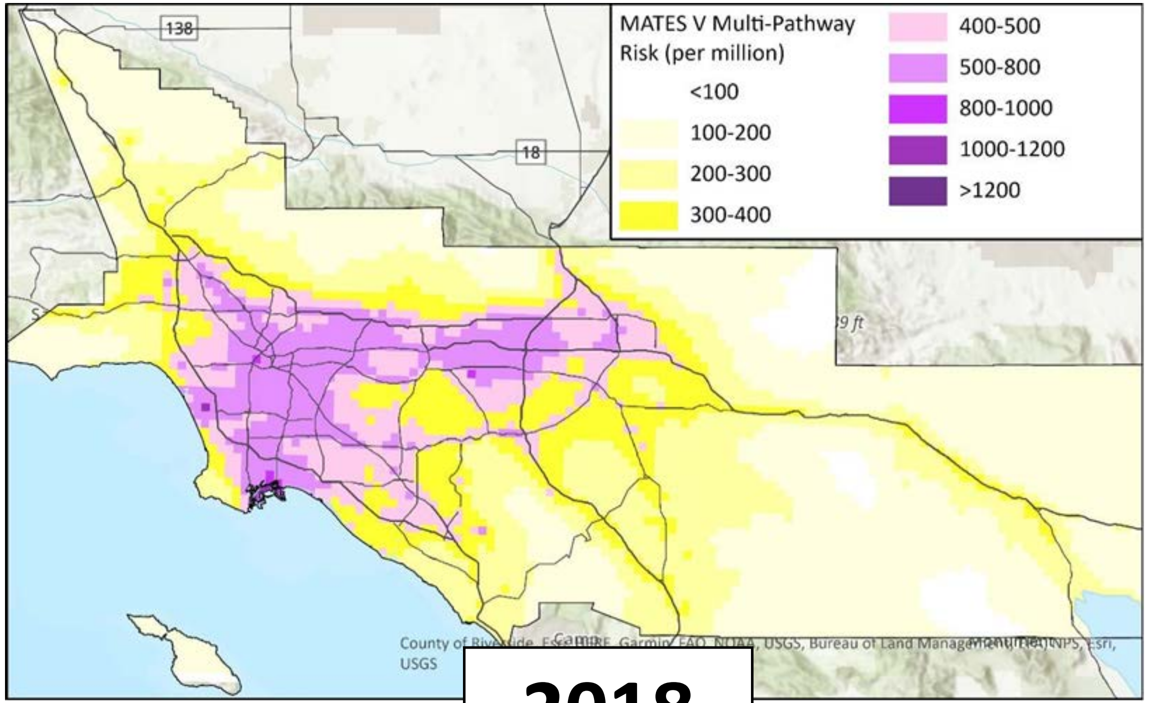
Air Toxic Cancer Risk – Modeling Data

MATES IV (population-weighted):
South Coast Air Basin: **997-in-a-million**
Coachella Valley: **357-in-a-million**

MATES V (population-weighted):
South Coast Air Basin: **455-in-a-million**
Coachella Valley: **250-in-a-million**

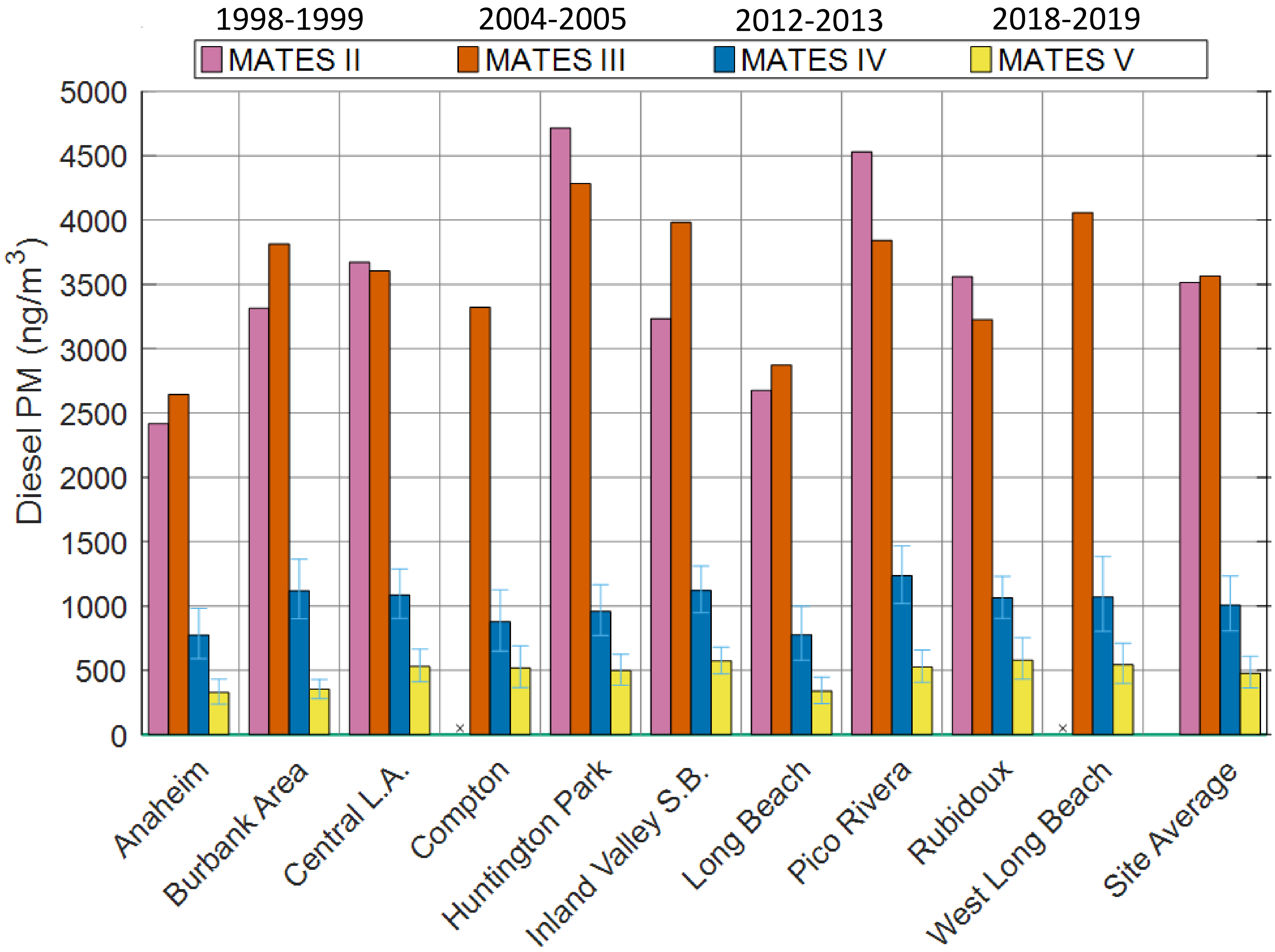


2012



2018

Diesel Particulate Matter Trends



MATES V Data Visualization Tool & Air Monitoring Dashboard

South Coast AQMD
Rule 2305 – Warehouse Indirect Source Rule

- Adopted May 7, 2021
- Applicable to warehouse owners and operators ≥ 100,000 sq. ft
- Phased in approach based on warehouse size

Year	Warehouse Size
2022	≥ 250,000 sq. ft
2023	≥ 150,000 – 249,999 sq. ft
2024	≥ 100,000 – 149,999 sq. ft

- Warehouse owners must report warehouse size, location, details.
- Warehouse operators responsible for compliance
  - Based on Weighted Annual Truck Trips (WATTS)
  - Use WATTS to determine WAIRE Points Compliance Obligation

Federal/State Actions

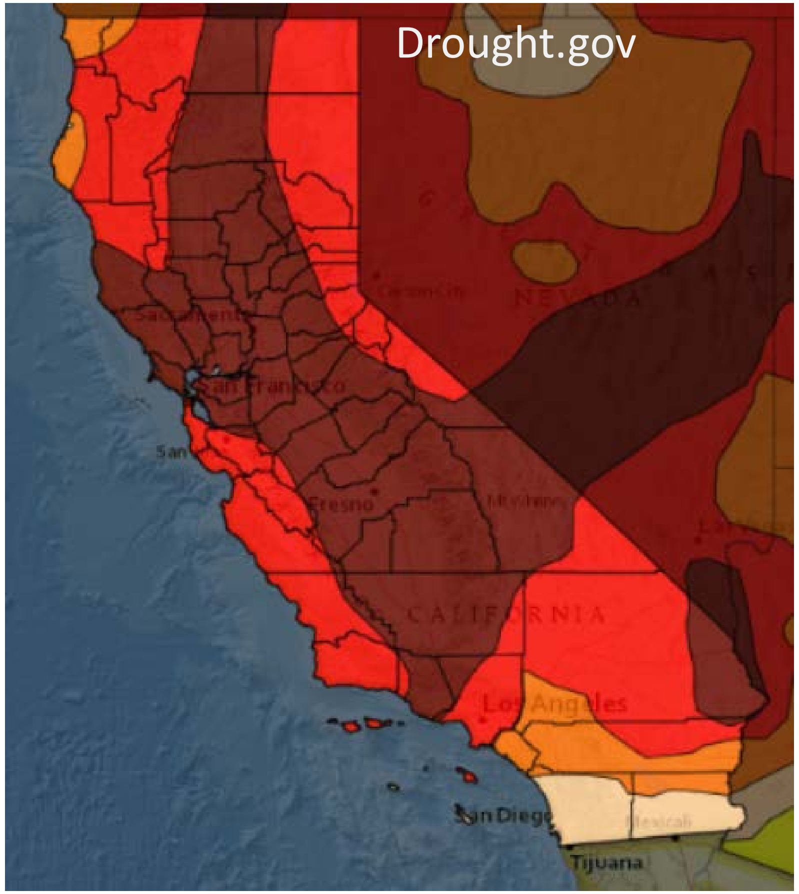
EPA

- Funding
- Clean Trucks Initiative

CARB

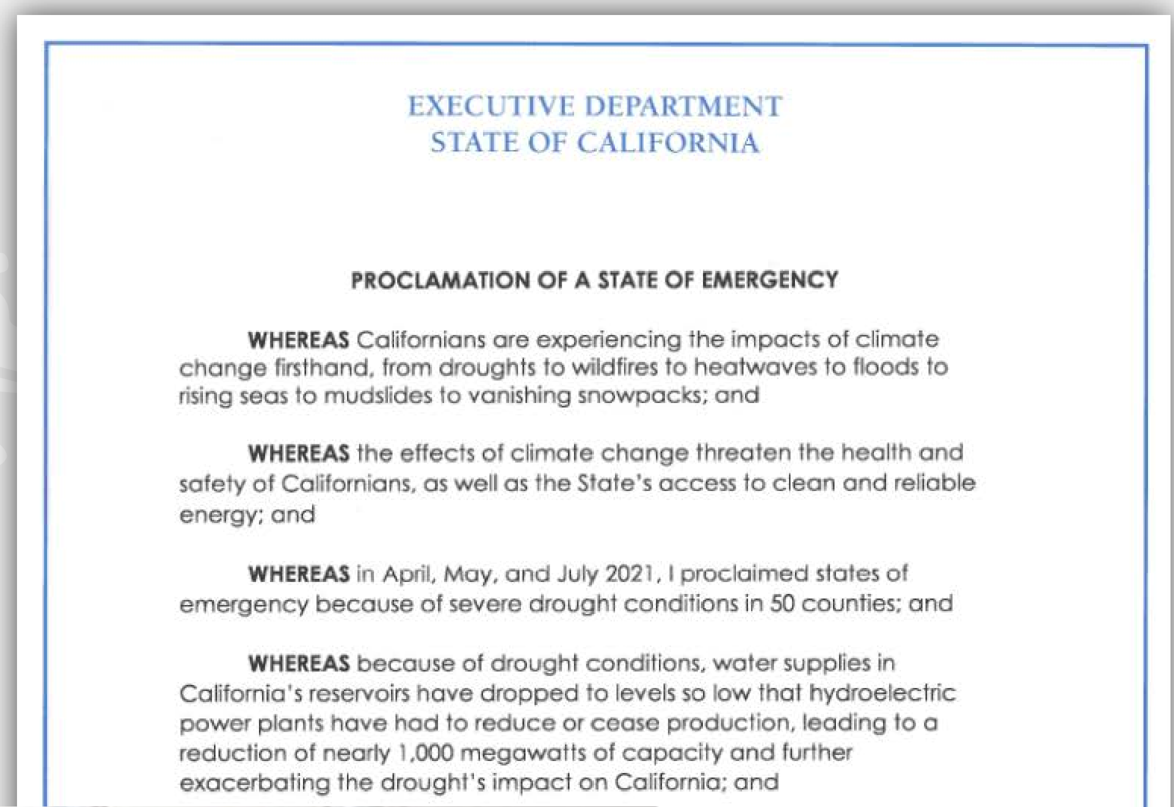
- Advanced Clean Fleets
- Transport Refrigeration Unit

Infrastructure



Infrastructure

- ➢ Governor's State of Emergency Proclamation
  - July 30th
- ➢ Estimated 3,500 MW generation shortfall during afternoon peak
  - 5,000MW anticipated next summer
- ➢ Allows IOUs to incentivize:
  - Reduced demand
  - Use of backup generators



EXECUTIVE DEPARTMENT
STATE OF CALIFORNIA

PROCLAMATION OF A STATE OF EMERGENCY

WHEREAS Californians are experiencing the impacts of climate change firsthand, from droughts to wildfires to heatwaves to floods to rising seas to mudslides to vanishing snowpacks; and

WHEREAS the effects of climate change threaten the health and safety of Californians, as well as the State's access to clean and reliable energy; and

WHEREAS in April, May, and July 2021, I proclaimed states of emergency because of severe drought conditions in 50 counties; and

WHEREAS because of drought conditions, water supplies in California's reservoirs have dropped to levels so low that hydroelectric power plants have had to reduce or cease production, leading to a reduction of nearly 1,000 megawatts of capacity and further exacerbating the drought's impact on California; and

...med states of emergency ...nts that hit California and ...and and putting significant ... and

...21 Extreme Heat Event, the ...ened the California-Oregon ...Northwest into California, ...y almost 4,000 megawatts;

...re located in high fire ...ates on which California ...e impacting California's ... season; and

...and compounding effects of continuing wildfires, ongoing drought, and extreme heat conditions

Links

CARB

- Advanced Clean Fleets https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets
- TRU Rulemaking https://ww2.arb.ca.gov/our-work/programs/transport-refrigeration-unit
- Mobile Source Strategy https://ww2.arb.ca.gov/our-work/programs/transport-refrigeration-unit

EPA

- Clean Trucks Plan https://www.epa.gov/system/files/documents/2021-08/420f21057.pdf

South Coast AQMD

MATES V http://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-v

AQMP http://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan

Warehouse ISR:

Governor's State of Emergency Proclamation: www.gov.ca.gov/wp-content/uploads/2021/07/Energy-Emergency-Proc-7-30-21.pdf

Infrastructure for Medium and Heavy-Duty Electric Vehicles

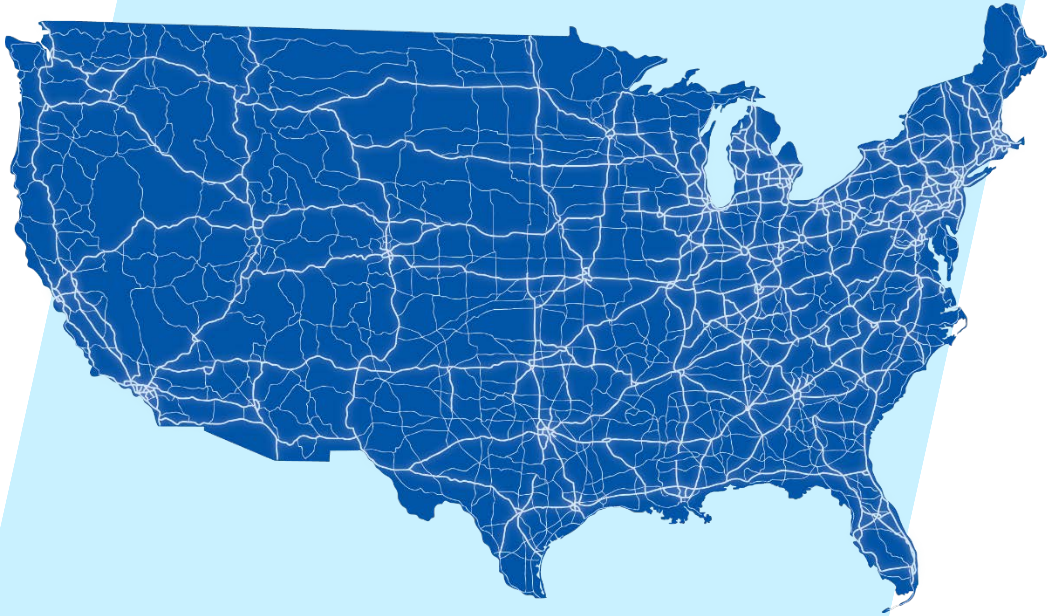
Electric service and charging requirements for fleets.

Mark Duvall
Director, Electrification and Customer Solutions
Electric Power Research Institute

September 15, 2021

Truck Classifications

Class 1	*6,000 lbs or less*	MINIVAN	CARGO VAN	SUV	PICKUP TRUCK
Class 2	*6,001 lbs to 10,000 lbs*	MINIVAN	CARGO VAN	FULL-SIZED PICKUP	STEP VAN
Class 3	*10,001 lbs to 14,000 lbs*	WALK-IN	BOX TRUCK	CITY DELIVERY	HEAVY-DUTY PICKUP
Class 4	*14,001 lbs to 16,000 lbs*	LARGE WALK-IN	BOX TRUCK	CITY DELIVERY	
Class 5	*16,001 lbs to 19,500 lbs*	BUCKET TRUCK	LARGE WALK-IN	CITY DELIVERY	
Class 6	*19,501 lbs to 26,000 lbs*	BEVERAGE TRUCK	SINGLE-AXLE	SCHOOL BUS	RACK TRUCK
Class 7	*16,001 lbs to 33,000 lbs*	REFUSE	FURNITURE	CITY TRANSIT BUS	TRUCK TRACTOR
Class 8	*33,001 lbs Up*	CEMENT TRUCK	TRUCK TRACTOR	DUMP TRUCK	SLEEPER CAB



EPRI with Co-lead CALSTART Receiving CEC Funding for Research Hub for Electric Technologies in Truck Applications (RHETTA)

Focused on the development, advancement, and deployment of innovative medium- and heavy-duty (MDHD) high-power charging infrastructure along key freight corridors that promote the adoption of Class 7 and 8 battery electric zero-emission (ZE) trucks.

- **CEC Funding:** $23M ($13M phase 1, $10M phase 2)
- **Timing:** Phase 1 – Through Q1 2025, Phase 2 – Through Q2 2028

Research Hub for Electric Technologies in Truck Applications (RHETTA)

Funding (anticipated – won and in negotiation): $21.1M total ($13M from CEC to EPRI, $2.8M in-kind partners, $5.3M internal EPRI sources). Phase 2 funding available: $10M.

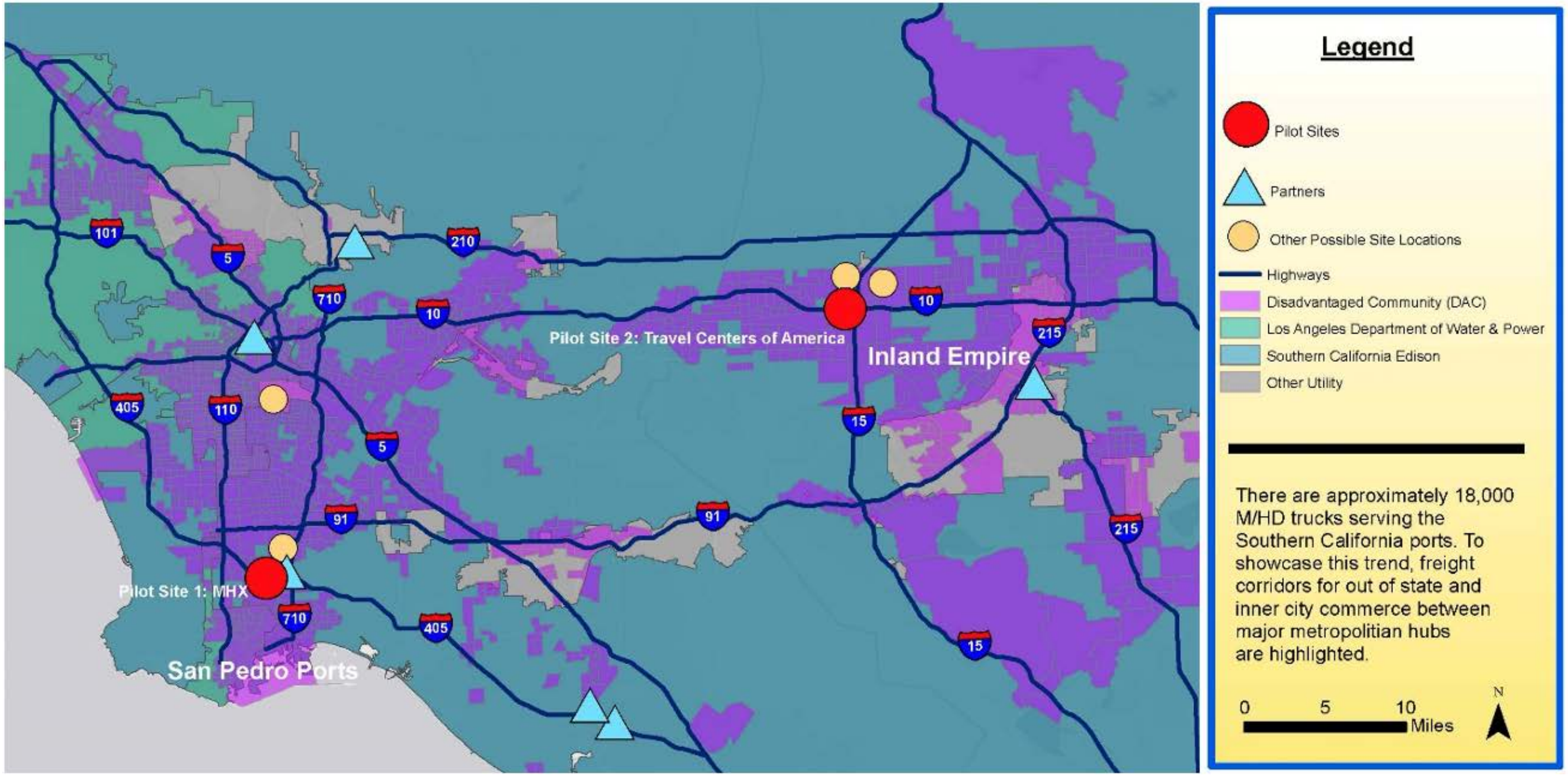
Objective: Fleet Electrification. Through RD&D, create a Research Hub for Electric Technologies in Truck Applications. The research hub will engage broad stakeholders including pollution burdened and impacted communities, truck fleets, charging equipment and service providers, electric utilities, and planning agencies to advance high power charging components systems, and to plan, design, and deploy innovative public corridor charging strategies that extend the range and increase the operational flexibility of battery electric trucks.

Team members: EPRI (prime), CalSTART, Burns & McDonnell, Southern California Edison, Orbcomm, Cambridge Systematics, Southern California Association of Governments, Momentum, Lawrence Berkeley National Lab, GRID Alternatives and UC Riverside.

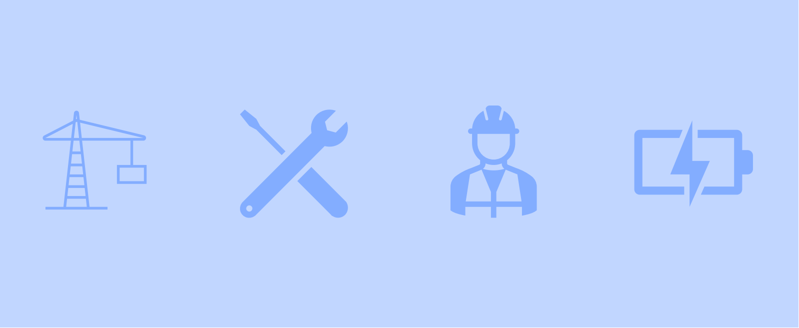
Key Activities

- Community Engagement and Workforce Development
- Fleet Needs and Technology Maturity Assessment
- Advanced High-Powered Charger System R&D
- Phase 1 Pilot Deployment
- Plan for Phase 2 Public Corridor Network
- Phase 2 Implementation
- Technology/Knowledge Transfer Activities

Fleet Needs Assessment & Travel Data



Expansion of SCE's Laboratory Facilities

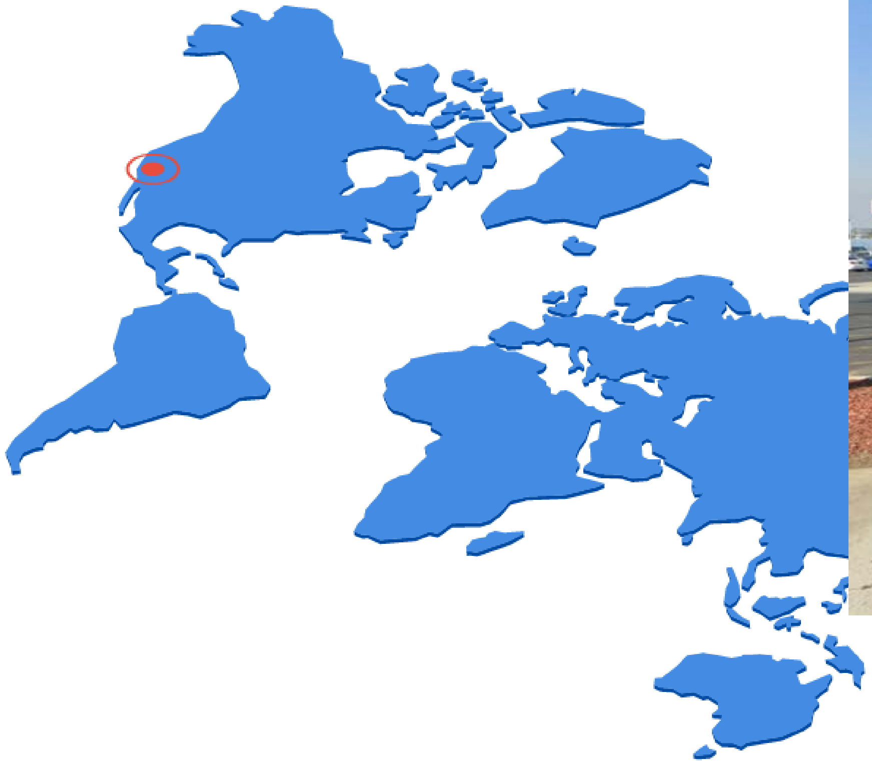


R&D for High-Power Charging

Targeted Level of Performance

- Capable of providing 100 miles of range for a HD BEV drayage truck in less than 10 minutes;
- Uses only open standards for connectors and communications to increase interoperability across different vehicles and control systems;
- Modular design that can be scaled up with future BEV truck deployment;
- Delivered at a total cost below 500 $/kW.

Pilot Site – Ontario, California



The Issue

Objectives of Fleet Planning Tools

The Process of Balancing The Unique Fleet Power Requirements With Available Capacity on the Distribution Grid

Fleet operator choices influence the power requirements:

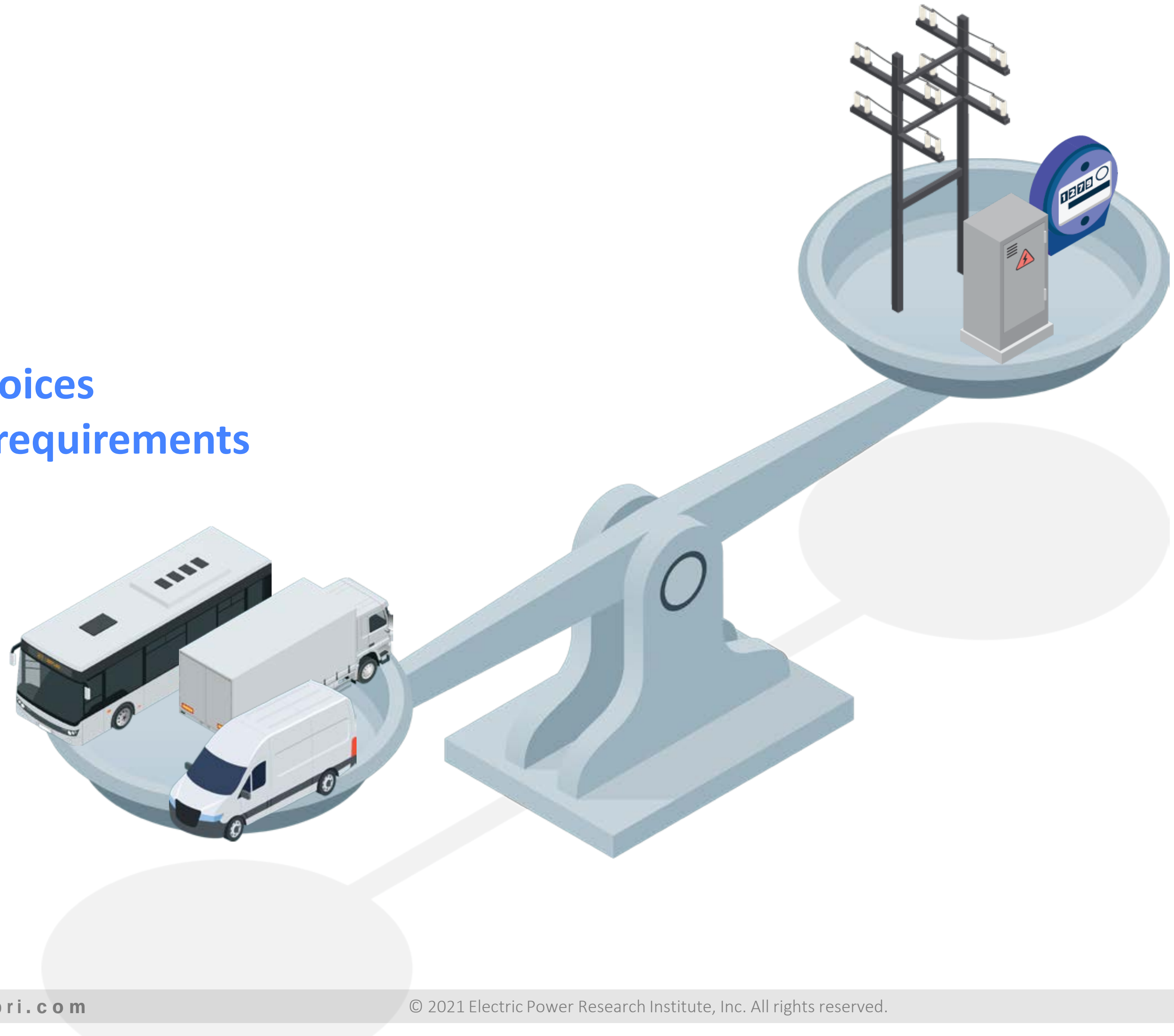
- Number of vehicles
- Fleet vehicle choices
- Fleet route choices
- Fleet operating practices
- Charger power levels
- Charge management strategies
- Onsite Resources

Distribution system capabilities are unique at each location:

- Distribution primary voltage
- Rating of distribution feeder equipment
- Pre-existing power loads / sources
- Ease of line extension or upgrades
- Substation capacity

Fleet Planning Tools Help Inform Balancing Power Requirements With Capacity

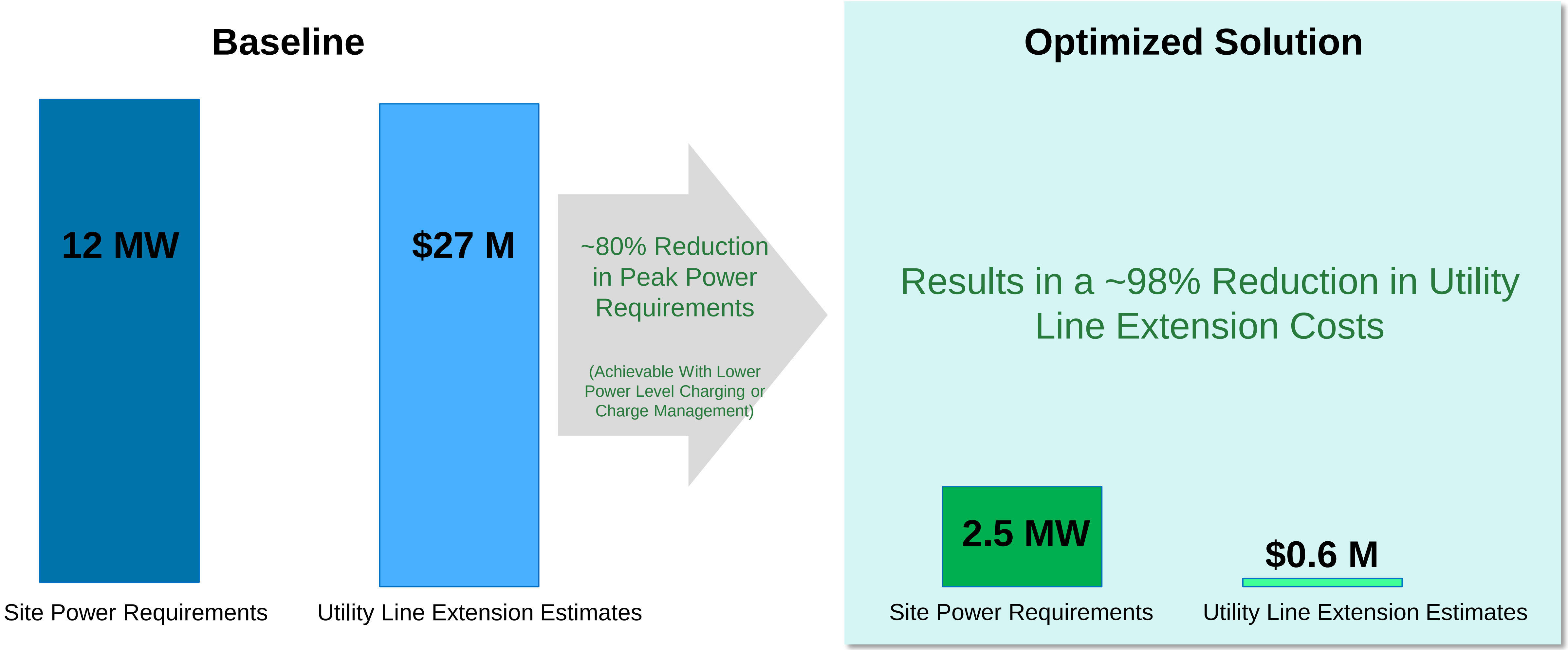
Fleet operator choices influence power requirements



Distribution system capabilities are unique at each location

Developing Tools Which Enable Informed Decision Making

Co–Optimization: 100 Bus Transit Depot Example



Baseline data from : http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/8525797c00471adb8525842000559bff?OpenDocument

Infrastructure Enables Adoption…*Research Needs*

Fast Charging and Energy Storage

- Technology
- Design
- DC as a Service
- Energy Storage Integration
- Value Assessment

Fleet Electrification

- Data Analytics
- Design
- Economics
- Charging Infrastructure Integration
- Coordination with Fleet Operators

Planning and Operations

- Advanced Planning Tools and Methods
- Models for EV Charging Systems
- DERMS Requirements
- Non-wires Alternatives
- Flexibility

Interoperability

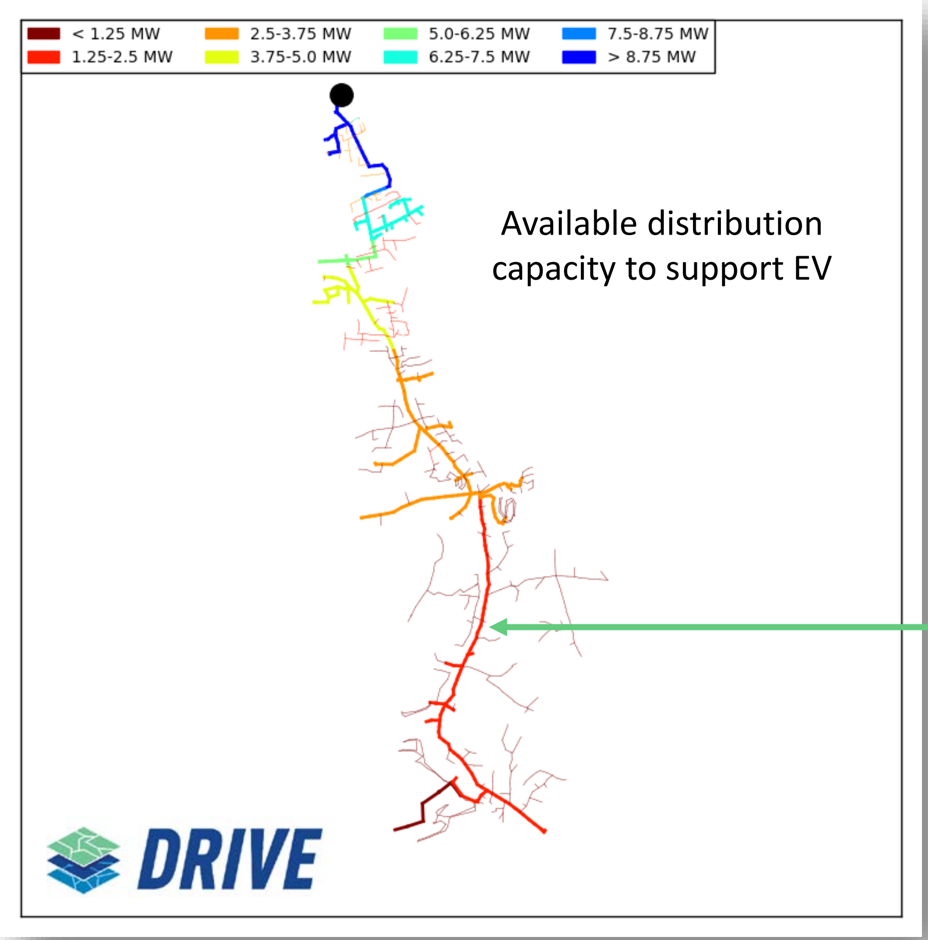
- Infrastructure
- Between Charging Systems (Customer)
- Charging System/Grid
- Vehicle/Grid

Resiliency

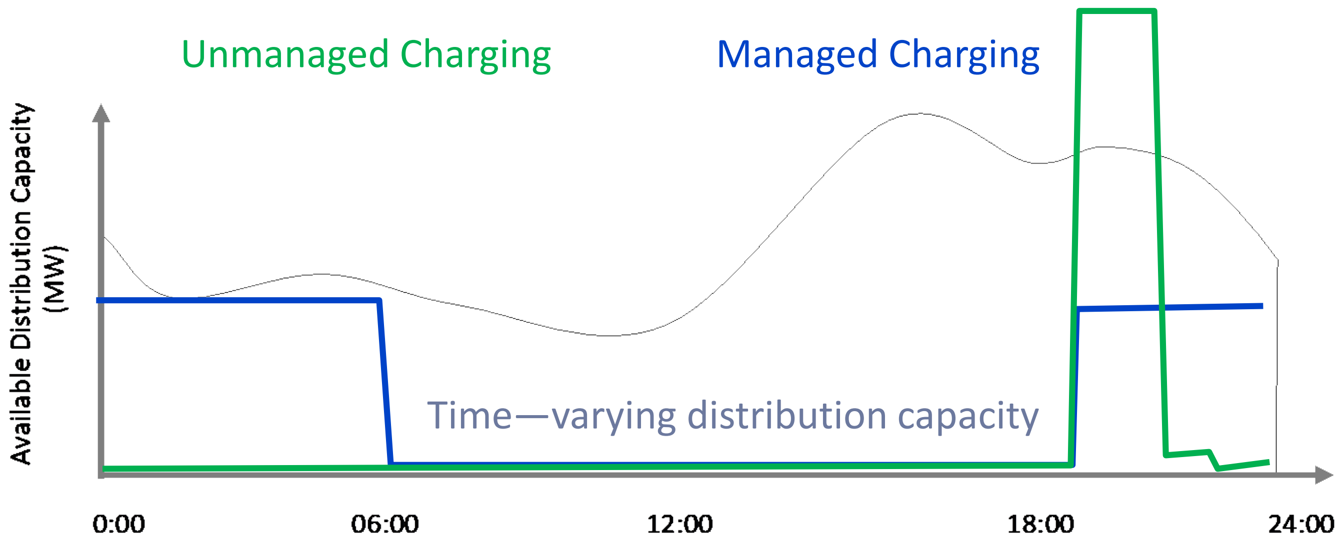
- Environmental solutions to support resiliency strategies

Customer Perspective is Crucial

Integrating Fleet Calculator with Distribution Planning Tools



Output from the Fleet Calculator can be layered into distribution capacity profiles

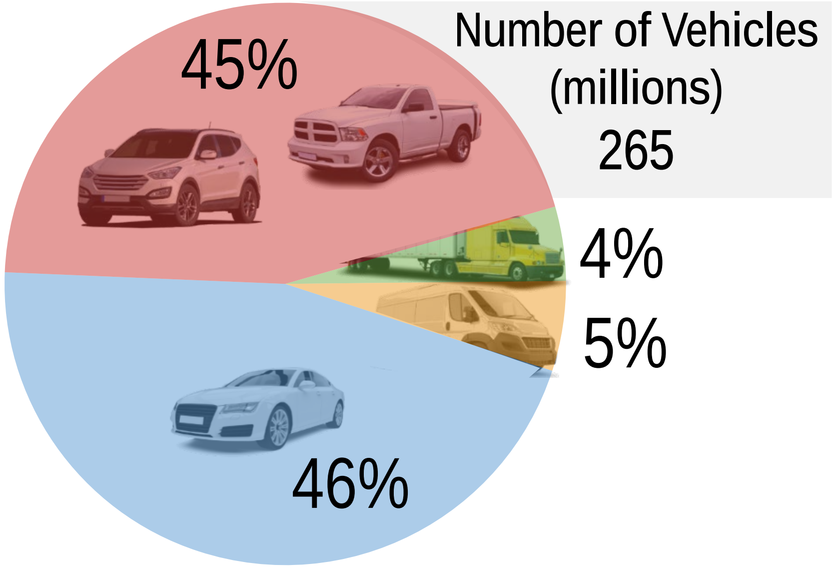


Distribution Planning Tools Also Inform Fleet Planning and Charging Approach

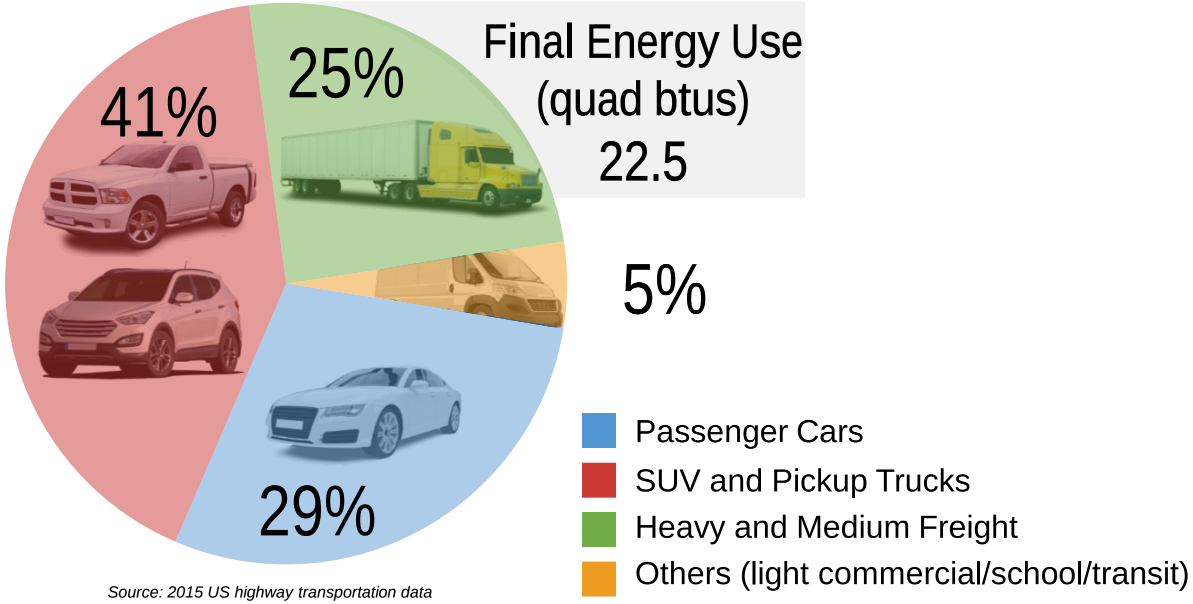
Projected Energy Requirements for MD/HD are High

Electric Transportation Market

Number of vehicles



Energy Market



Source: 2015 US highway transportation data

Fleet Segments

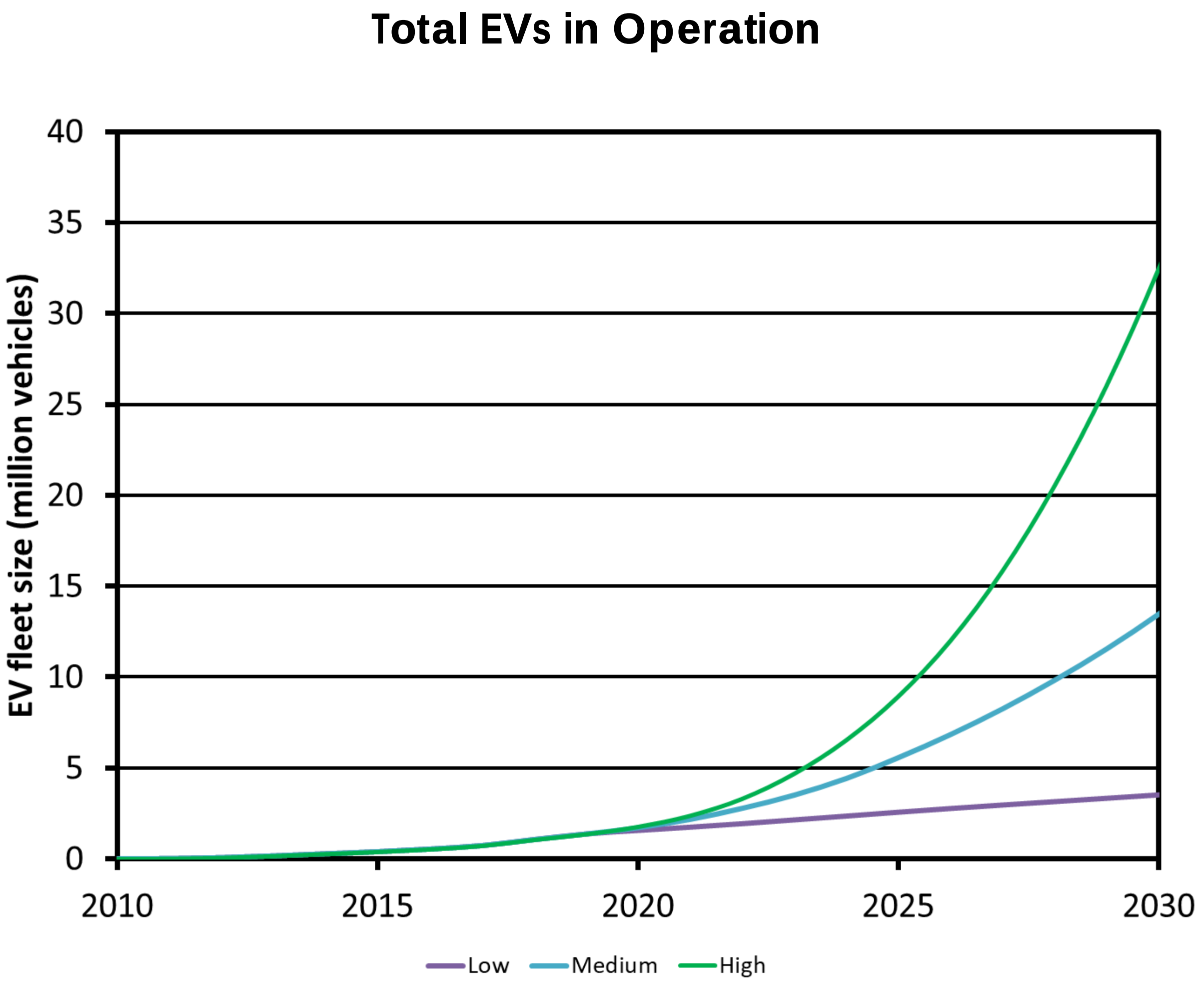
- School buses
- Transit buses
- Delivery vehicles
- Garbage trucks
- Ferries
- Mining equipment
- Construction equipment
- Aviation
- Etc.

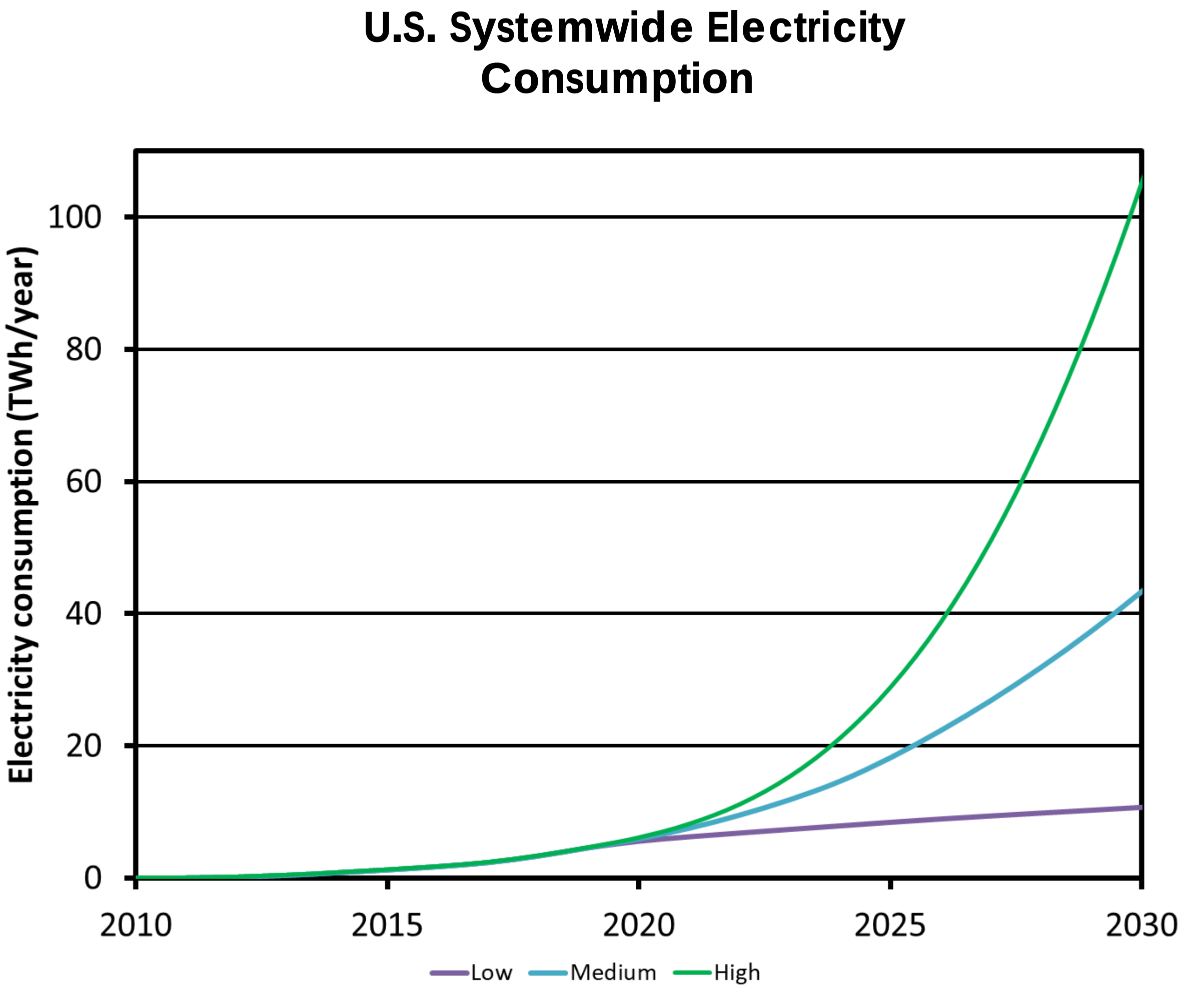




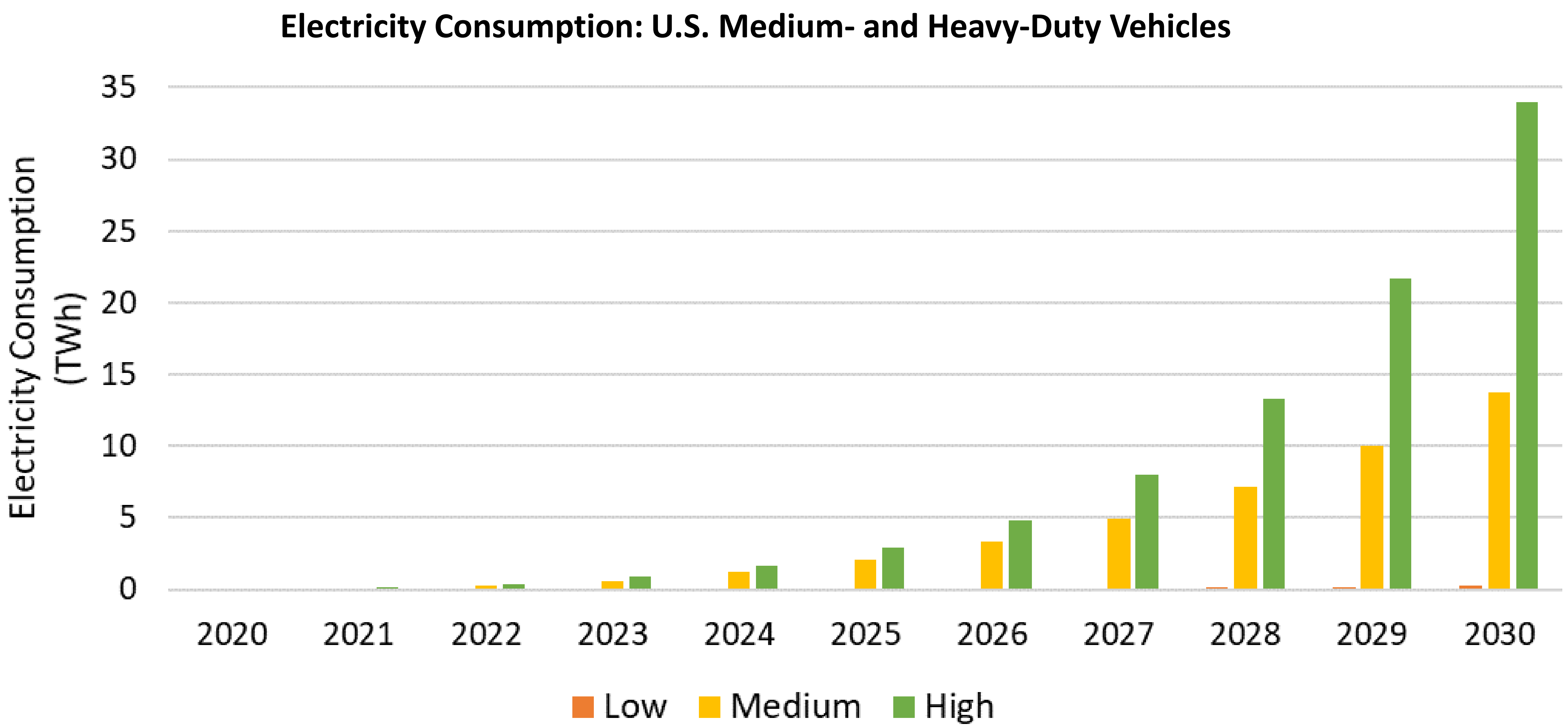

What is the U.S. market size (TWh) for light-duty EVs?

Depends on rate of adoption





What is the U.S. market size (TWh) for large EVs?



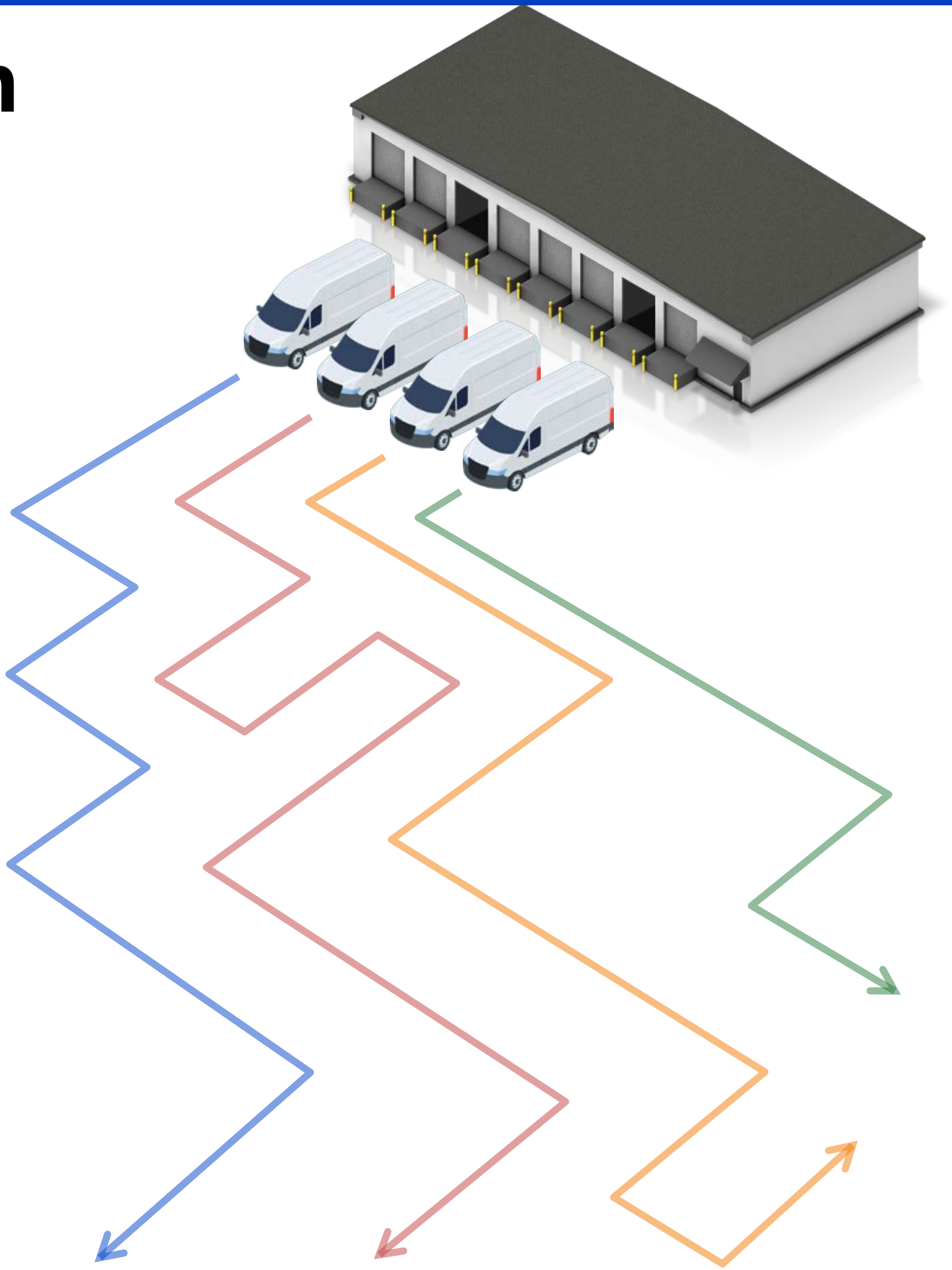
Fleet Electrification Characterization

Fleet Electrification Characterization

Fleet Operation and Needs Assessment

Challenges / Needs:

- Each fleet segment will have different types of vehicles (efficiency, range, etc.)
- Fleets operation can vary based on its industry (driving time, driving distance, frequency of stops, payload, etc.)



Approach:

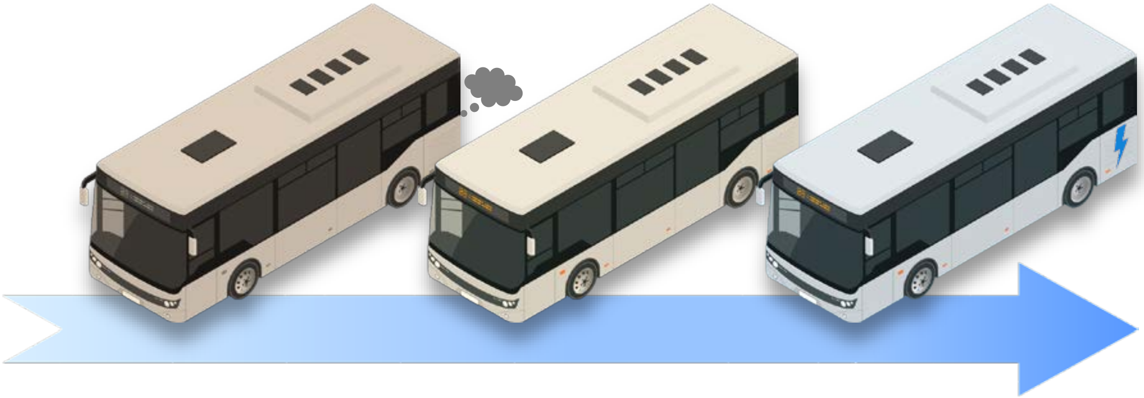
- Assessing fleet characteristics / operation for each fleet segments:
  - Travel patterns (distance, duration, etc.),
  - Vehicle types,
  - Quantities, etc.

Fleet Electrification Characterization

Technology Maturity Assessment

Challenges / Needs:

- What is the state of the market?
- What technologies are already available vs coming soon?
- Are fast chargers currently available for fleets?



Approach:

- Assess the state of the market for:
  - Electric vehicle technology
  - High-power charging equipment
  - Required supporting infrastructure

Fleet Electrification Characterization

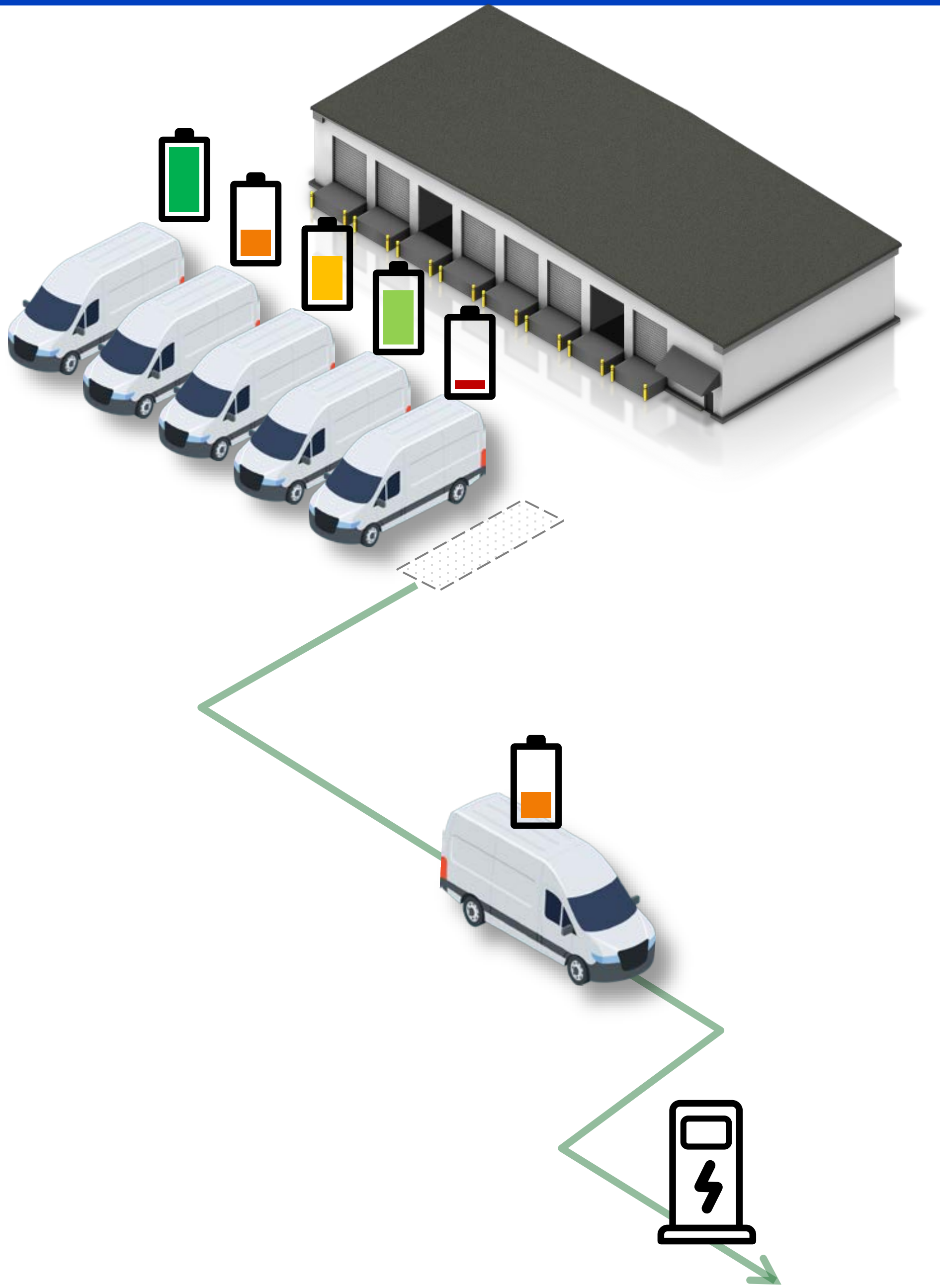
Charging Strategies and Applications

Challenges / Needs:

- What type of charging strategies exist?
- How do different incentives / programs affect the charge schedule?
- Does certain fleet segments have specific charging strategies?

Approach:

- Assessing charging strategies and applications:
  - Charging behavior for each fleet segments
  - En-route vs depot-based charging
  - Charge management strategies
  - Market-based vs incentive-based operations



Framework

FRAMEWORK: Forecasting fleet electrification

Q#1: Fleet Locations

- Where are existing fleet depots?
- Where are new depots being considered?
- …

Q#2: Fleet characteristics

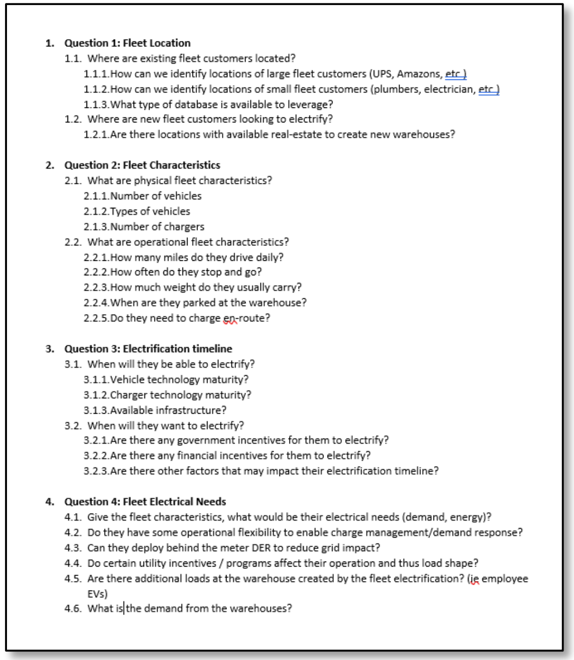
- How many vehicles are at the location?
- What type of vehicles are parked at the location?
- How large is the warehouse/depot/distribution center?
- How many miles do they drive each day?
- When are they parked at the warehouse?
- …

Q#3: Electrification timeline

- When will they electrify?
- Is the technology mature?
- Is the infrastructure ready?
- …

Q#4: Fleet Electrical Demand

- What is the peak demand, load shape, energy needs?
- Can charge management reduce the impact?
- Can customer-sided solutions provide help?
- …



1. **Question 1: Fleet Location**
   1.1. Where are existing fleet customers located?
      1.1.1. How can we identify locations of large fleet customers (UPS, Amazons, etc.)
      1.1.2. How can we identify locations of small fleet customers (plumbers, electrician, etc.)
      1.1.3. What type of database is available to leverage?
   1.2. Where are new fleet customers looking to electrify?
      1.2.1. Are there locations with available real-estate to create new warehouses?

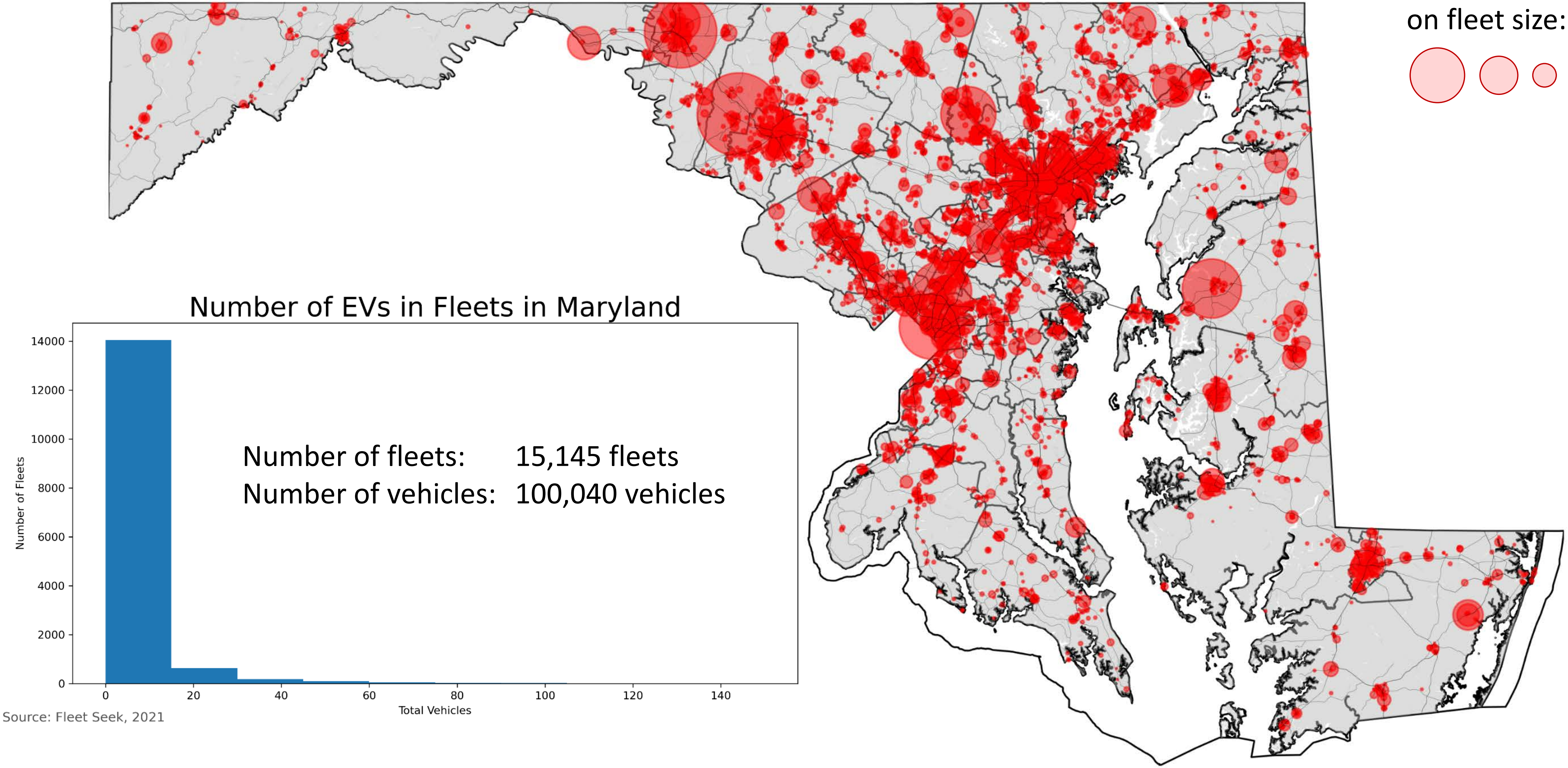
2. **Question 2: Fleet Characteristics**
   2.1. What are physical fleet characteristics?
      2.1.1. Number of vehicles
      2.1.2. Types of vehicles
      2.1.3. Number of chargers
   2.2. What are operational fleet characteristics?
      2.2.1. How many miles do they drive daily?
      2.2.2. How often do they stop and go?
      2.2.3. How much weight do they usually carry?
      2.2.4. When are they parked at the warehouse?
      2.2.5. Do they need to charge en-route?

3. **Question 3: Electrification timeline**
   3.1. When will they be able to electrify?
      3.1.1. Vehicle technology maturity?
      3.1.2. Charger technology maturity?
      3.1.3. Available infrastructure?
   3.2. When will they want to electrify?
      3.2.1. Are there any government incentives for them to electrify?
      3.2.2. Are there any financial incentives for them to electrify?
      3.2.3. Are there other factors that may impact their electrification timeline?

4. **Question 4: Fleet Electrical Needs**
   4.1. Give the fleet characteristics, what would be their electrical needs (demand, energy)?
   4.2. Do they have some operational flexibility to enable charge management/demand response?
   4.3. Can they deploy behind the meter DER to reduce grid impact?
   4.4. Do certain utility incentives / programs affect their operation and thus load shape?
   4.5. Are there additional loads at the warehouse created by the fleet electrification? (ie employee EVs)
   4.6. What is the demand from the warehouses?

Fleet location state-wide (Maryland)

Circle based on fleet size:

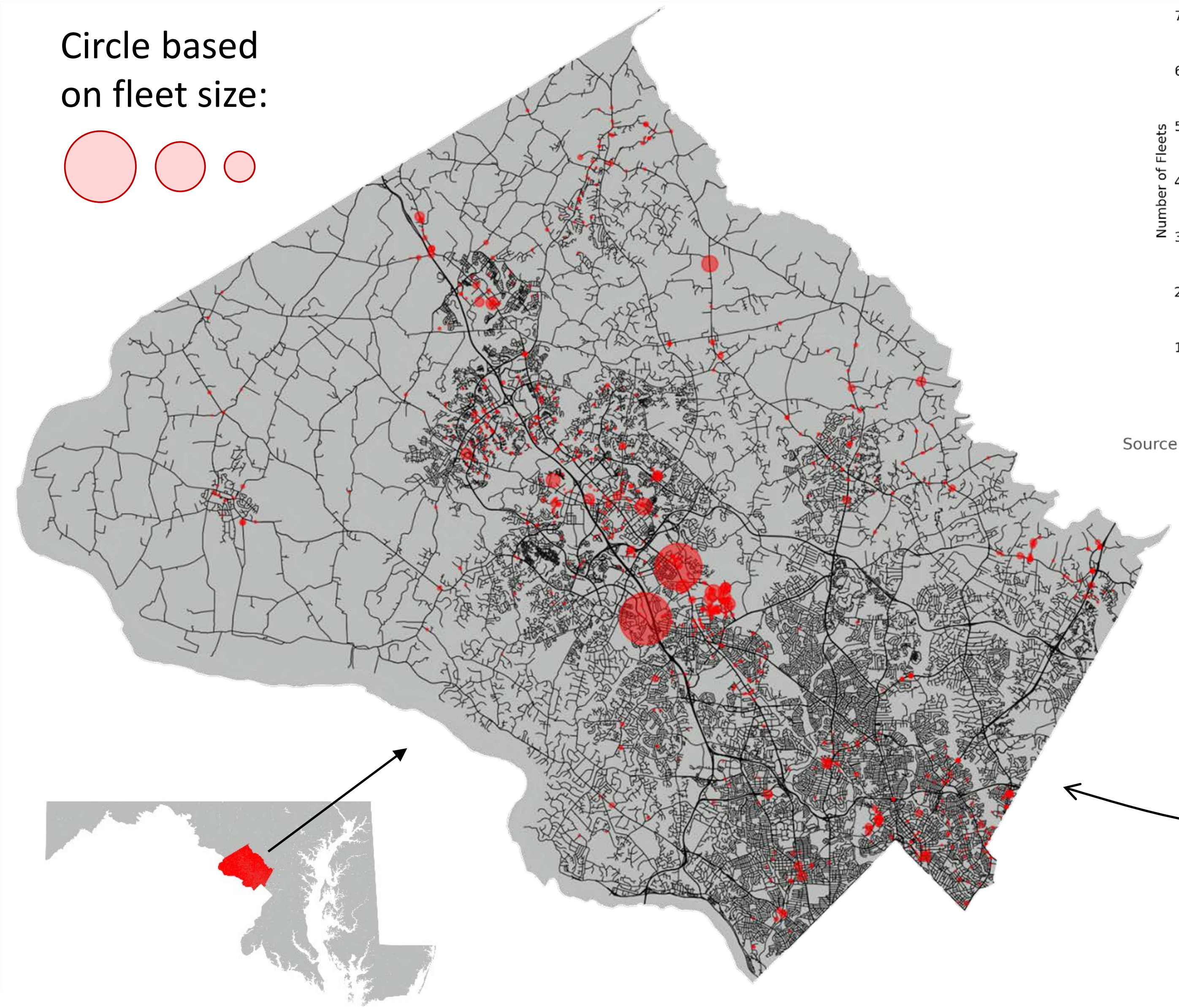


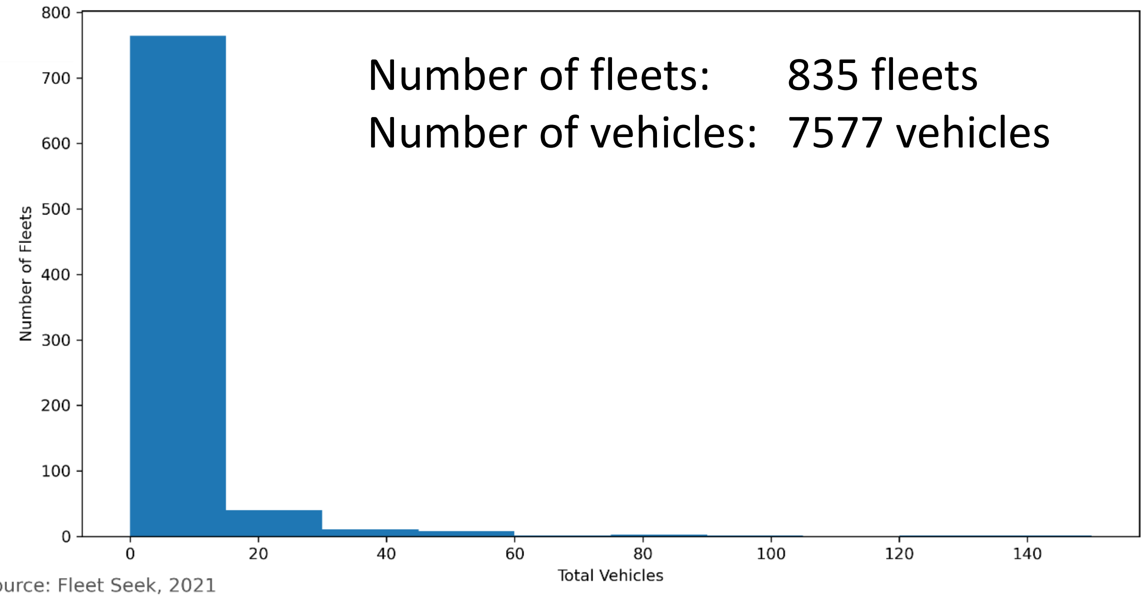
Source: Fleet Seek, 2021

Caveat: This is for illustrative purposes, FleetSeek only provides company headquarters, not exact location of warehouse.

City-level fleet location

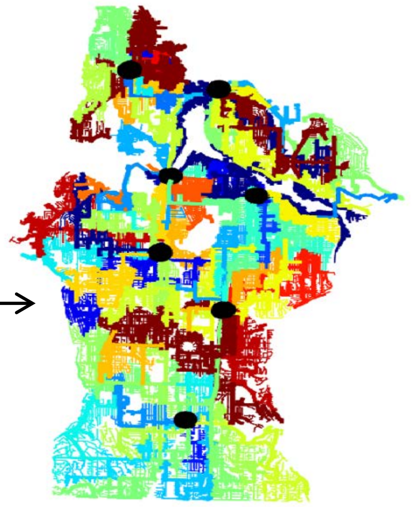
Circle based on fleet size:





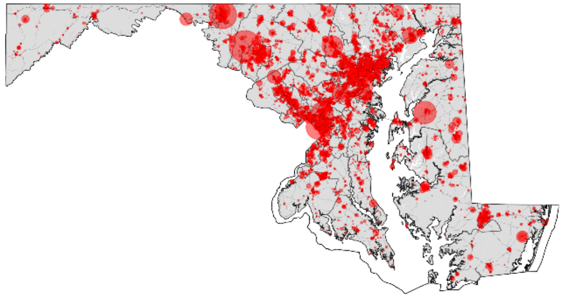
Source: Fleet Seek, 2021

Objective:
Comparing fleet location with grid capacity

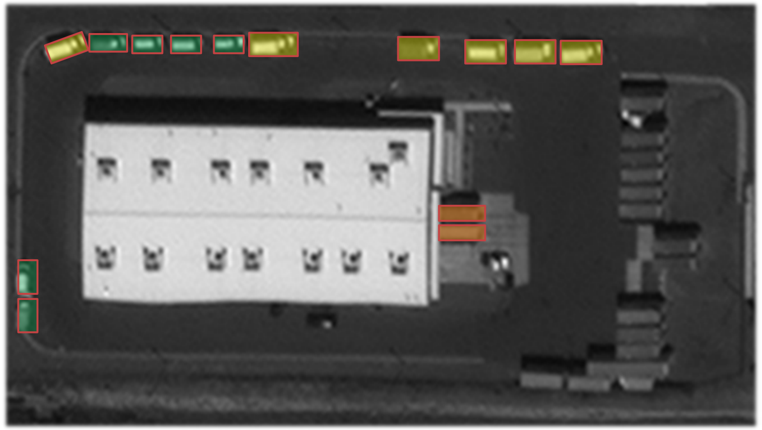


FRAMEWORK: Forecasting fleet electrification

Q#1: Fleet Locations



FleetForecaster



Q#2: Fleet characteristics

Fleet **Physical** Characteristics

Fleet **Operational** Characteristics

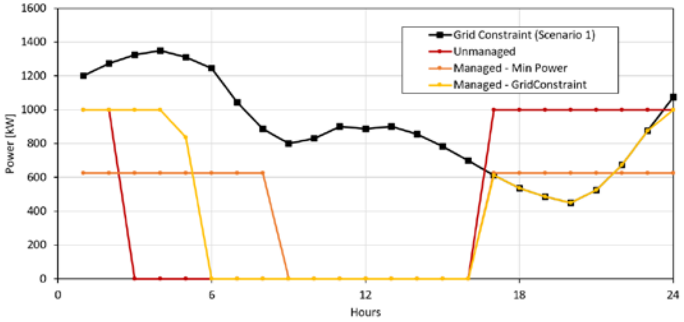
?

Q#3: Electrification timeline

?

Q#4: Fleet Electrical Demand

FleetCalc



Grid Planning for Fleet Electrification

Grid Planning for Fleet Electrification

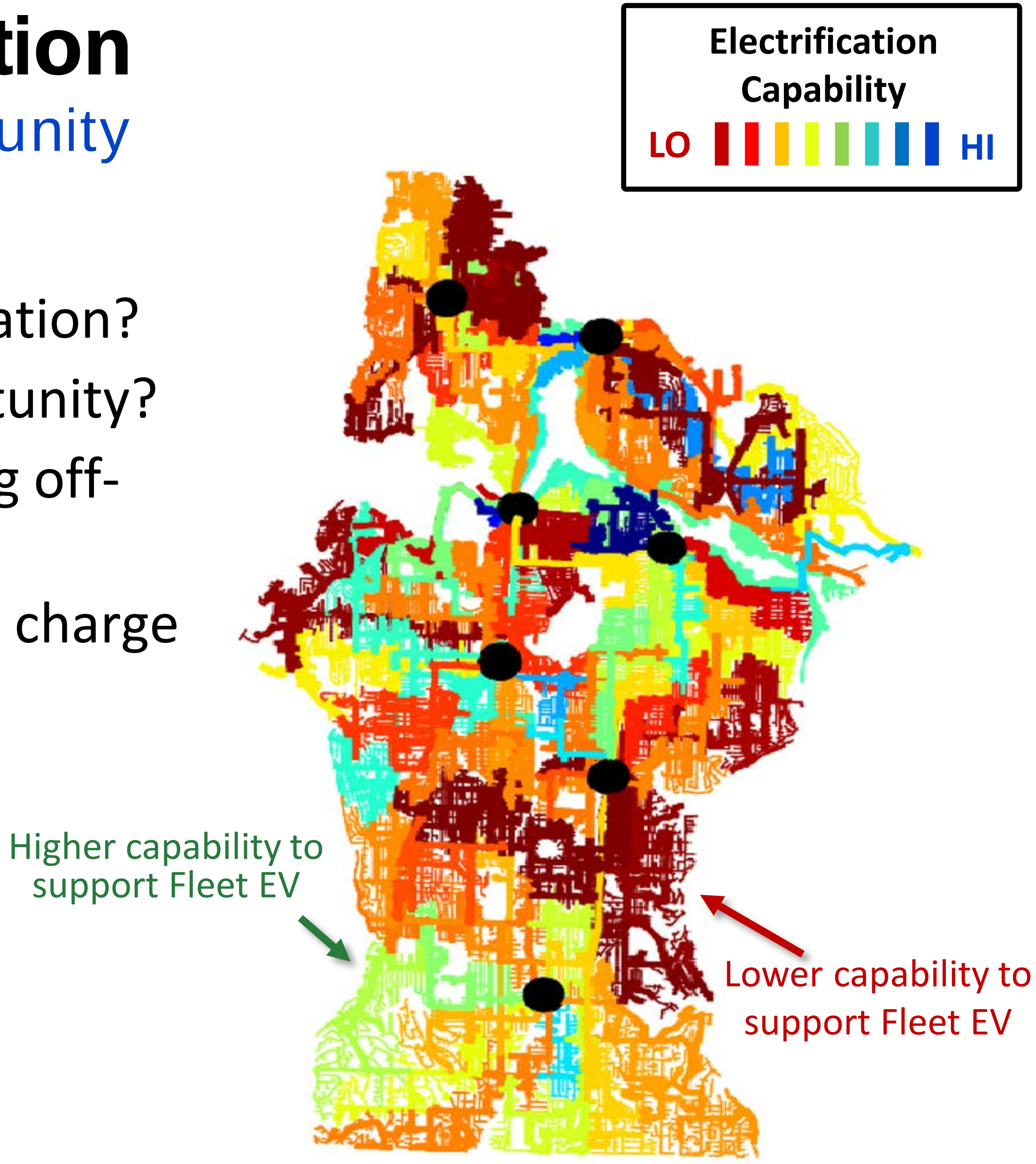
Assess wide-area grid electrification opportunity

Challenges / Needs:

- Which feeders should be prioritized for electrification?
- Which feeders have limited electrification opportunity?
- How much capacity and energy is available during off-peak hours for fleet electrification?
- How much additional fleets could be hosted with charge management?

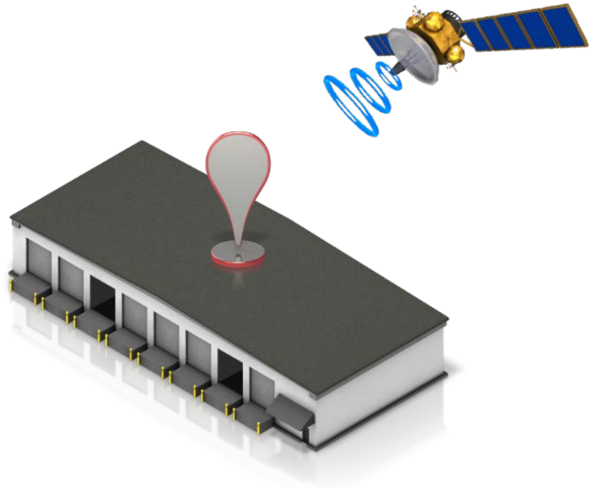
Approach:

- Identify existing capabilities across a wide-area
- Identify areas with under-/ over-utilized assets
- Prioritize grid investments for areas with limited capabilities



Grid Planning for Fleet Electrification

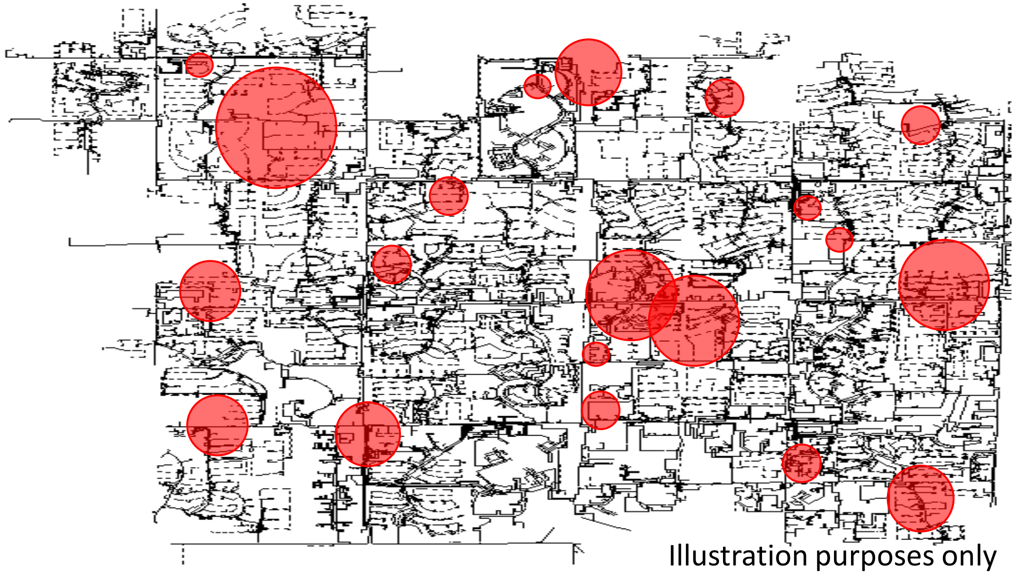
Future Fleet Electrification Assessment



Challenges / Needs:

- With limited information available from the customer, how can we estimate a site's future fleet electrification?
- How many vehicles are there?
- What type of vehicles would operate at that location?
- How does that translate into demand profiles?

Potential Future Fleet EV Loads



EV Fleet demand/energy

Smaller — Larger

Approach:

- Identify potential fleet vehicles sites
- Estimate the number and type of vehicles using aerial imagery and additional data streams
- Estimate demand / energy needs at up to 10 locations

 www.epri.com

Grid Planning for Fleet Electrification

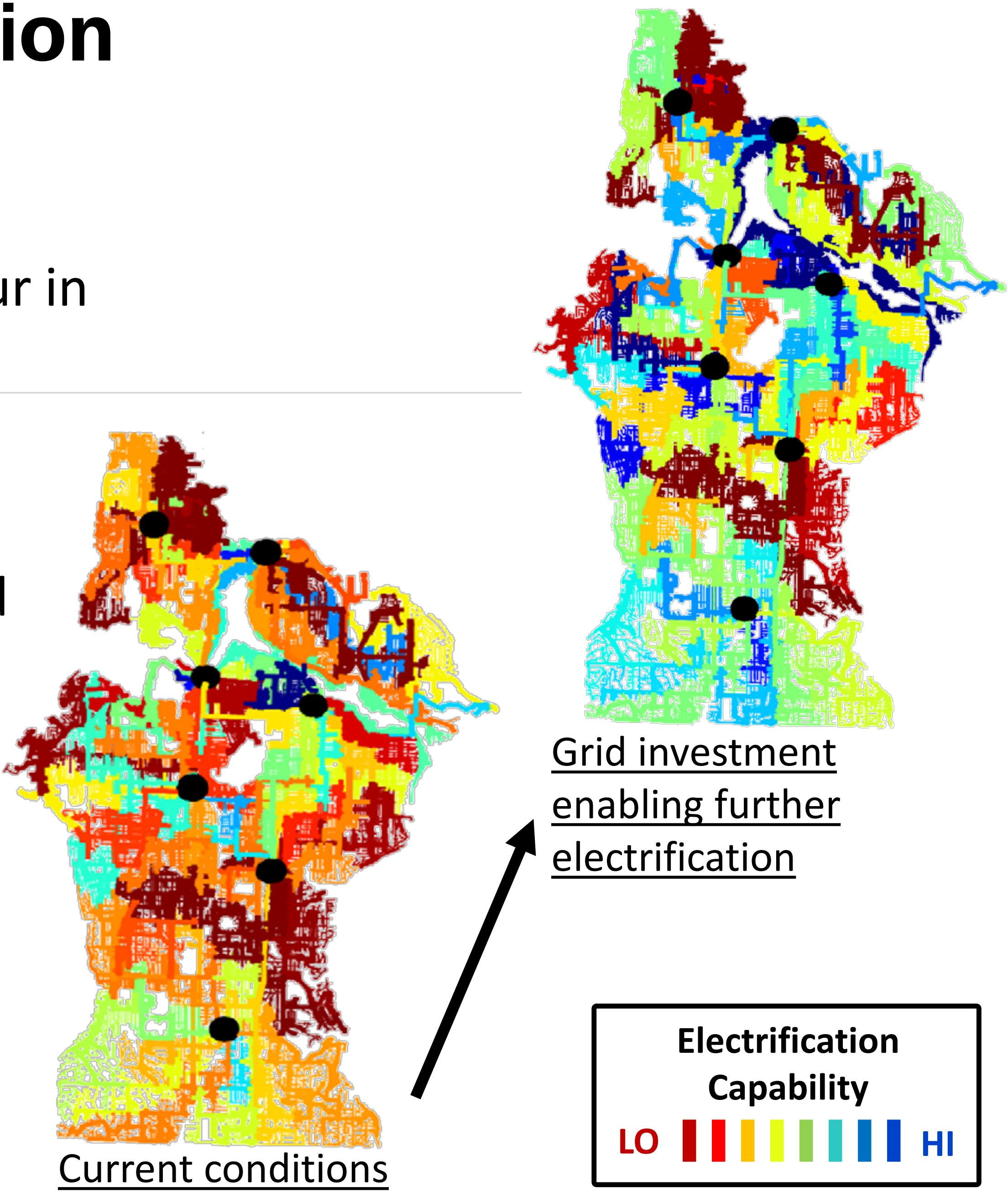
Grid Readiness and Integration Assessment

Challenges / Needs:

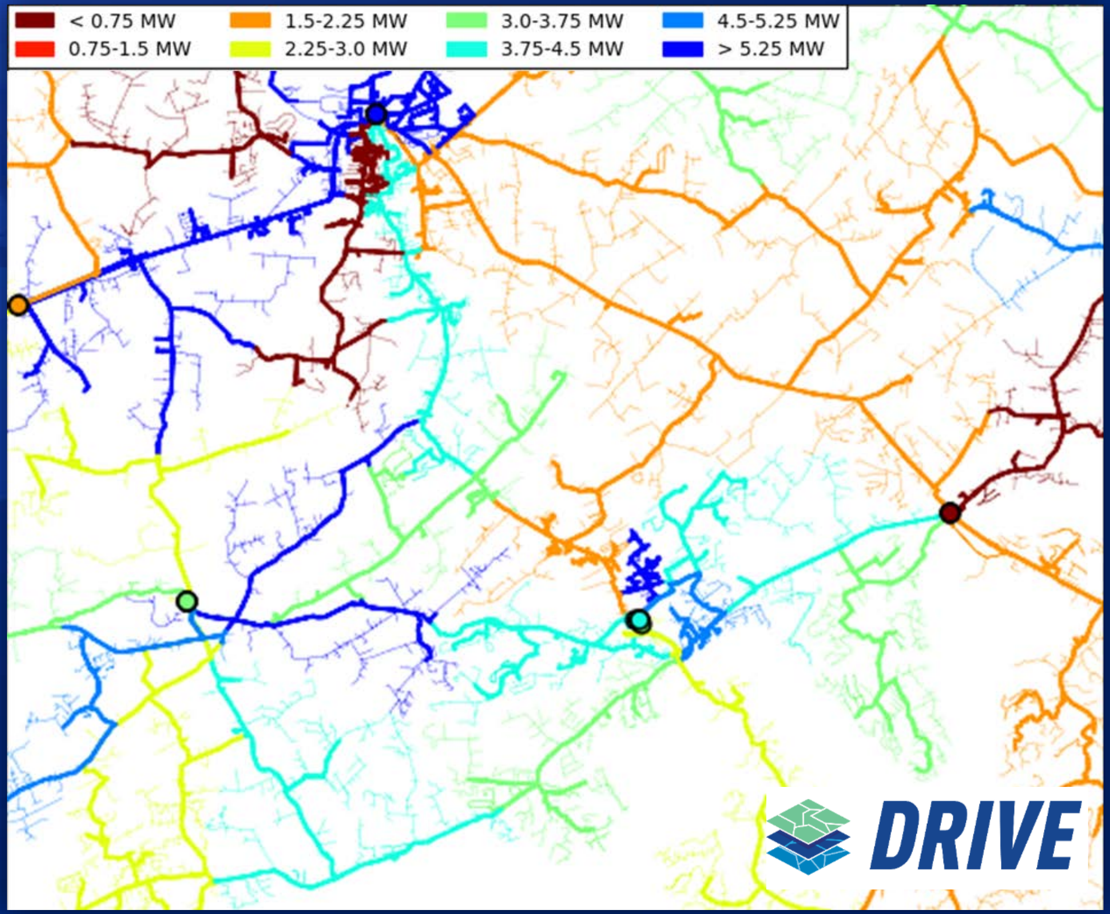
- Grid capacity and fleet electrification may not occur in the same area on the feeder
- Grid constraints can vary from feeder to feeder and can occur at different times of the day
- Charge management from the fleet operator could avoid infrastructure investment

Approach:

- Merging future fleet forecast parameters with system-wide grid assessment
- High-level assessment of grid investment options and integration costs



Determining Grid Impacts

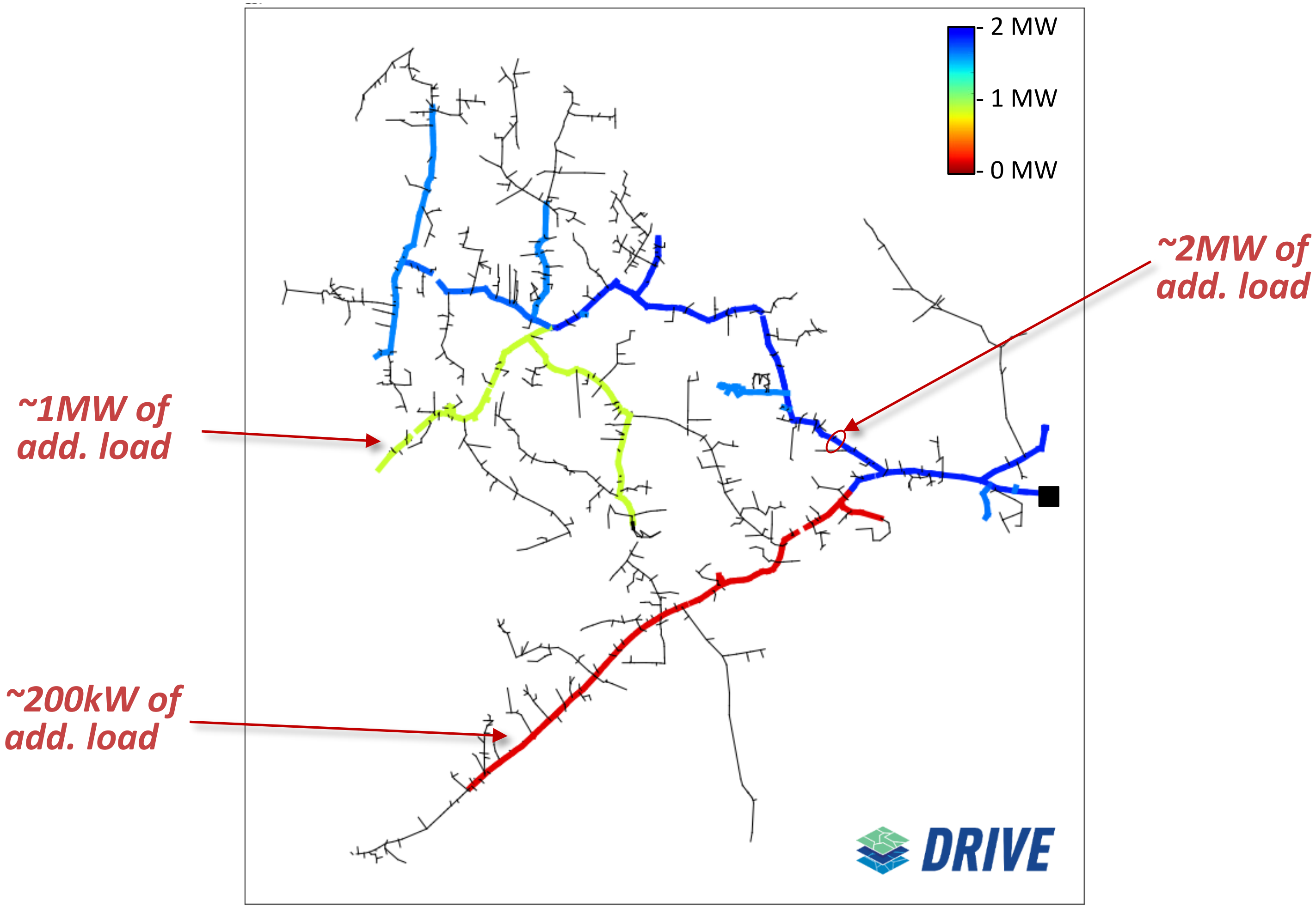


Fleet EV Hosting Capacity is Location Dependent

Factors that affect the grids ability to support Fleet EV

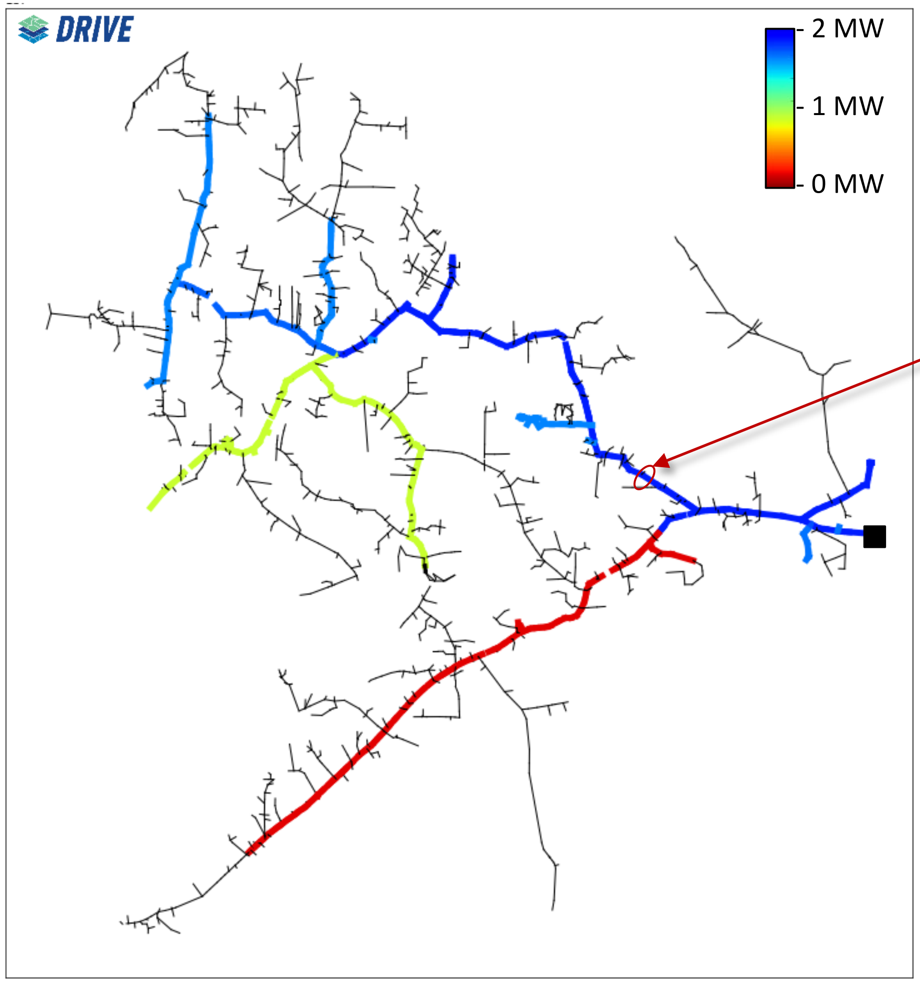
- Grid topology
- Equipment ratings
- Feeder configuration
- Existing + forecasted load
- DER
- Etc.

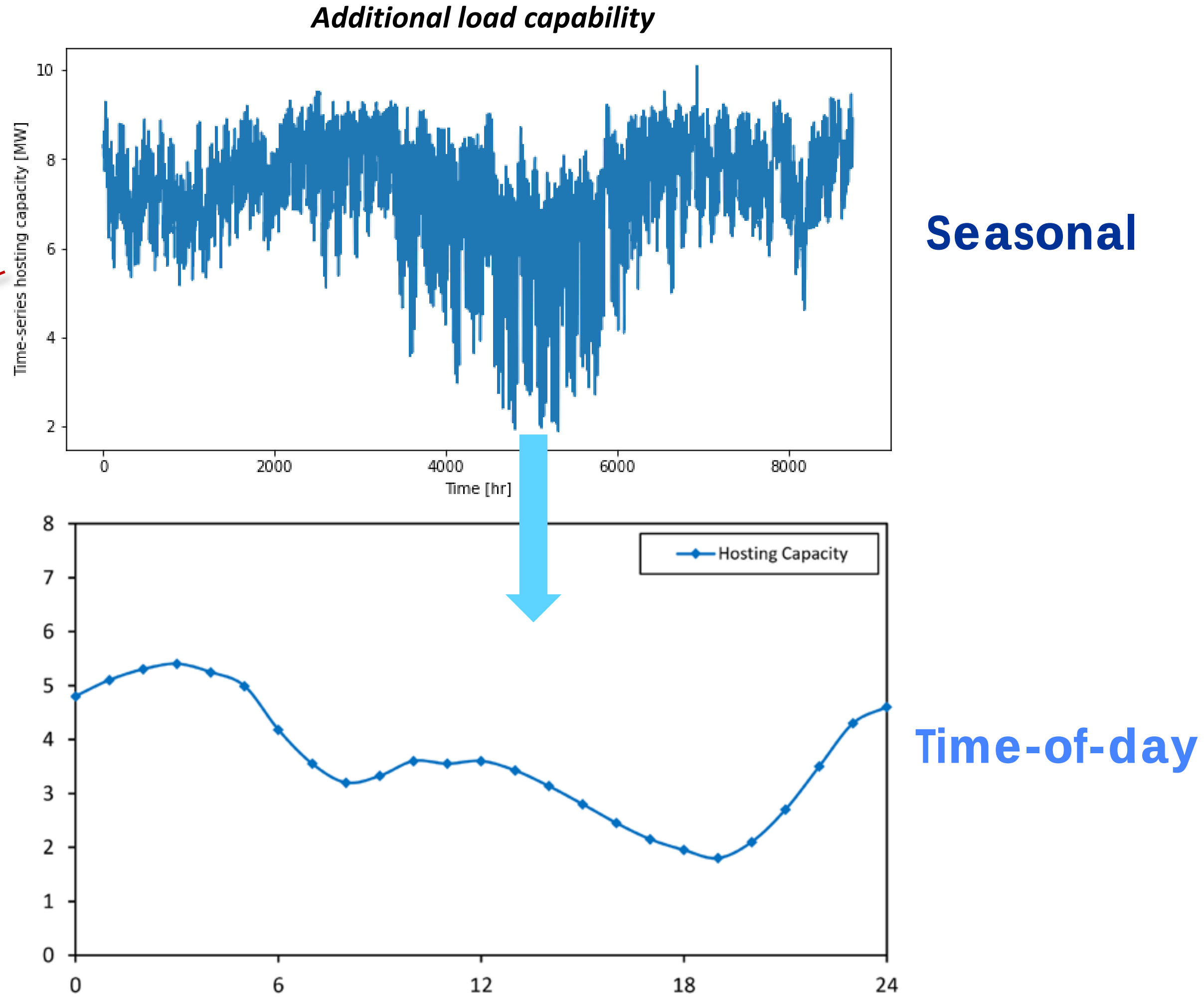
Fleet EV Hosting capacity



Fleet EV Hosting Capacity Is also Time Dependent

Hosting capability will vary based on the season and time-of-the-day

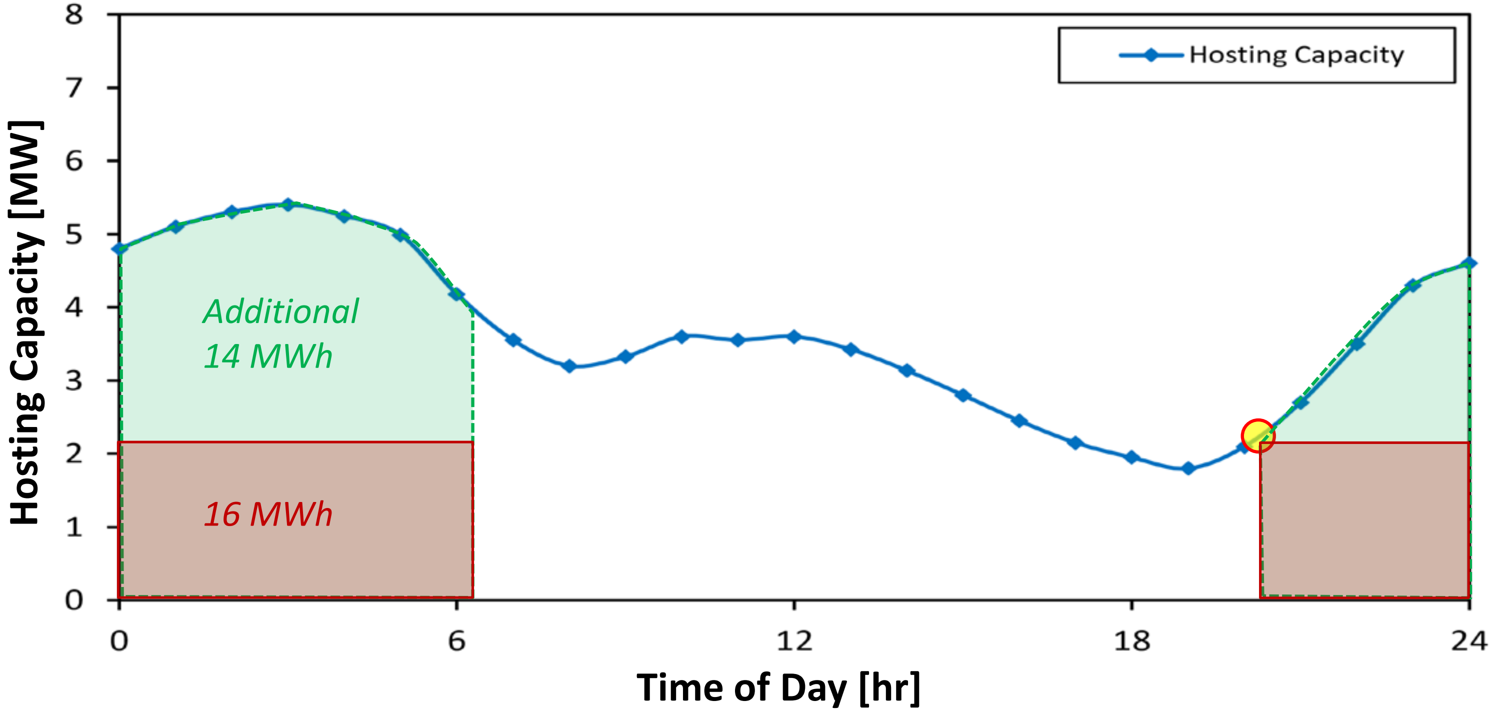




Supporting Fleet EV Charging

Unmanaged charging:
Fleet can charge up to a fixed demand level

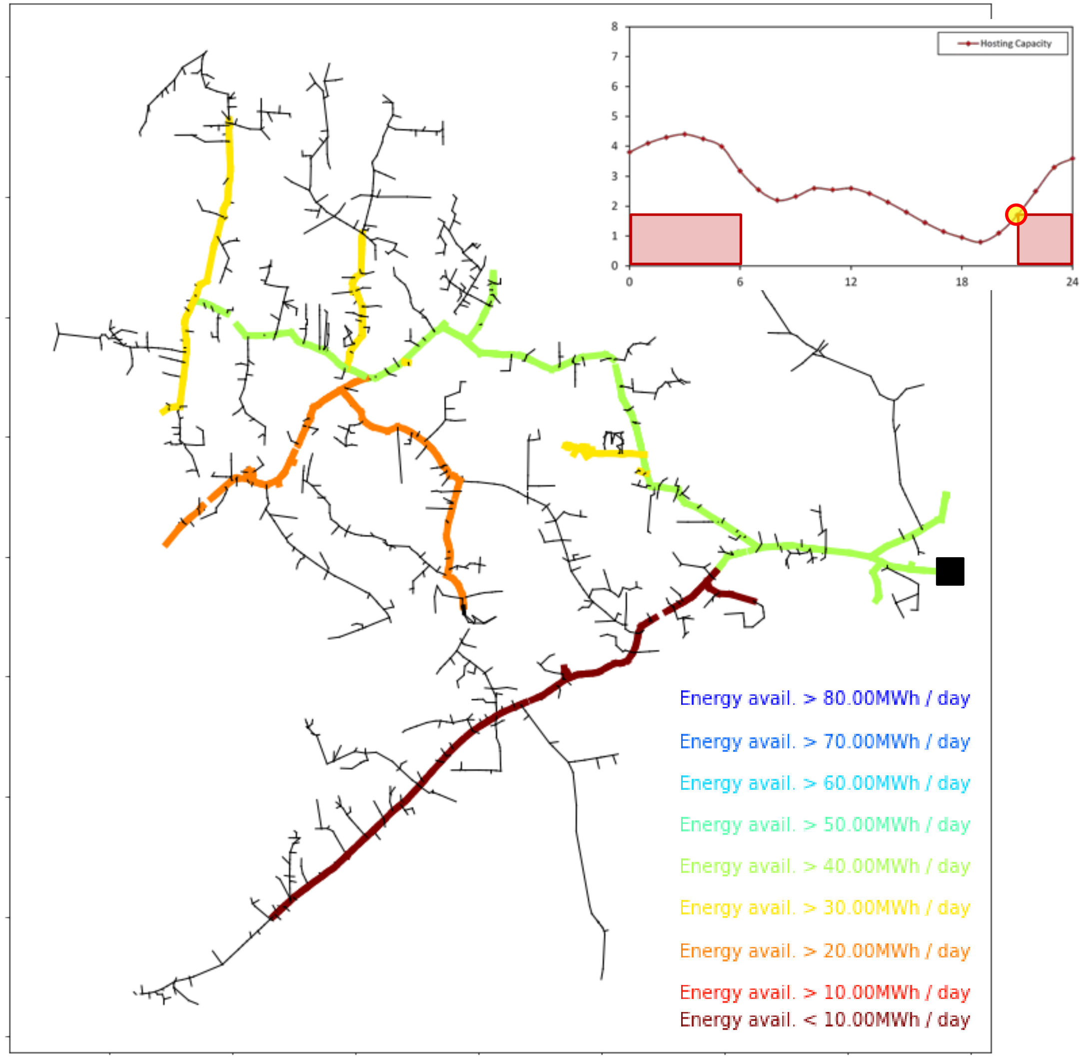
Managed charging:
Fleet can charge up to the operational limits of the grid if managed (dispatched)



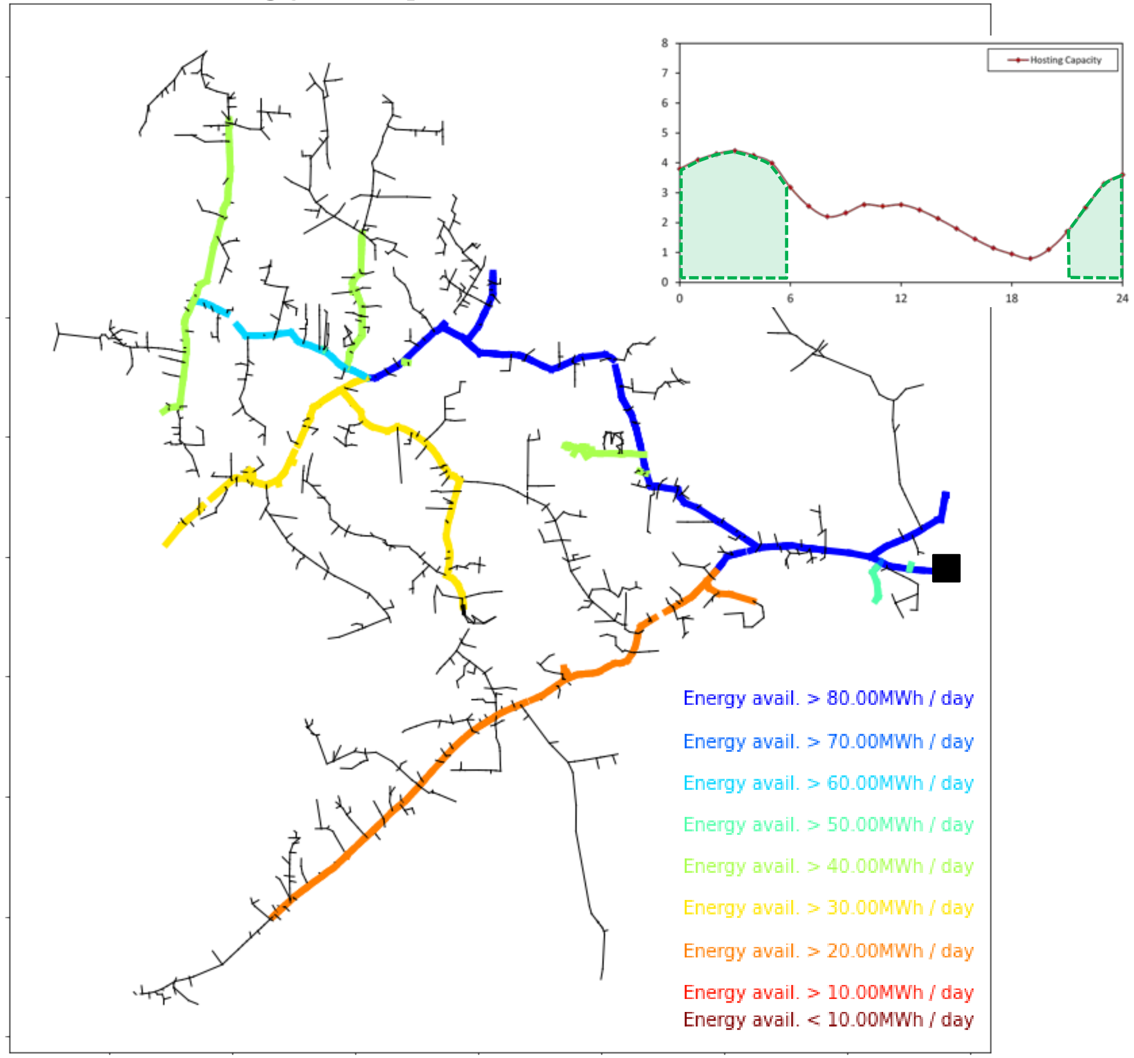
The amount of energy available for fleet charging will depend on the charging behaviour

Fleet EV Charging – Grid's Energy Availability Maps

Energy Map – **Unmanaged** charging

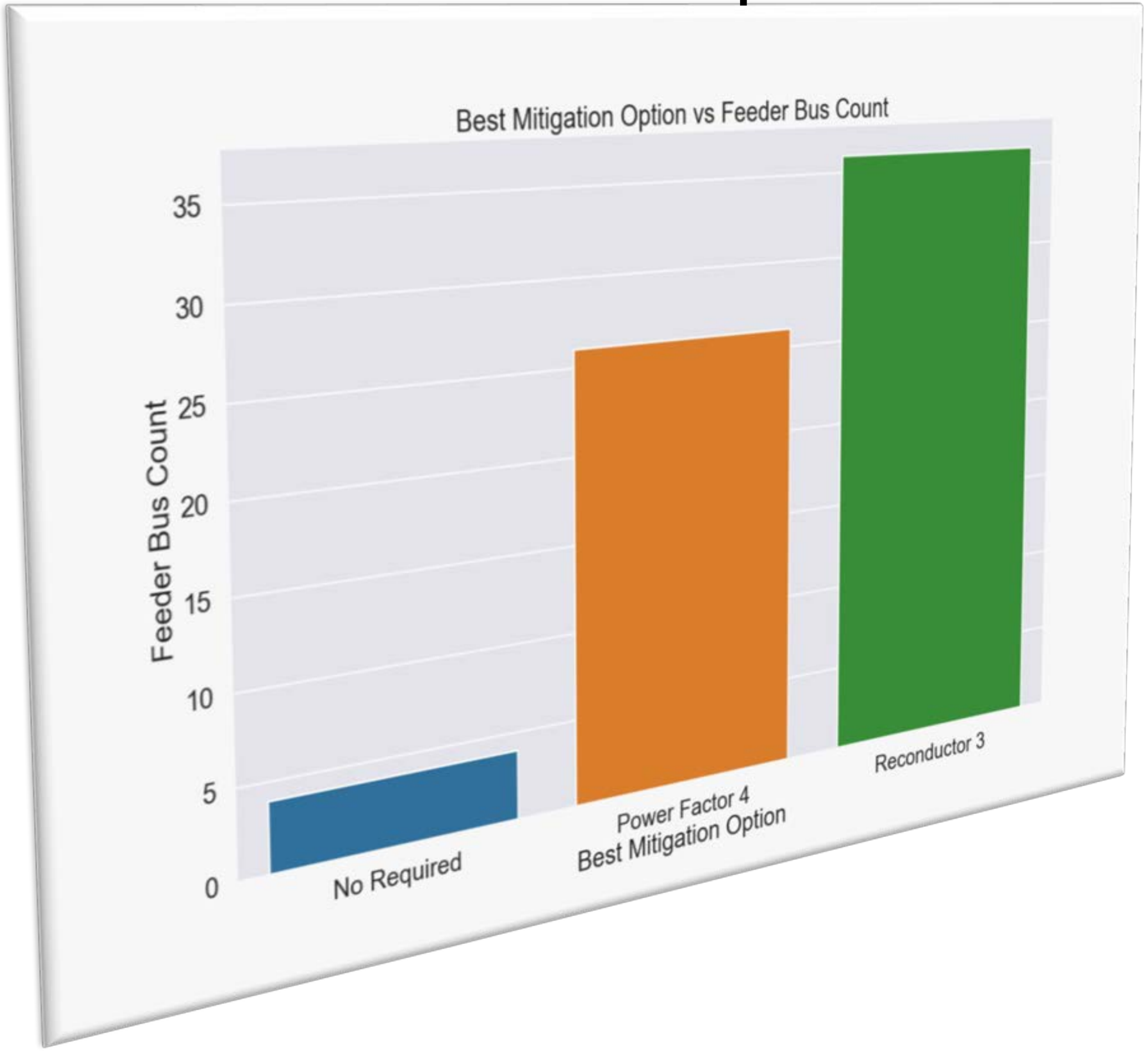


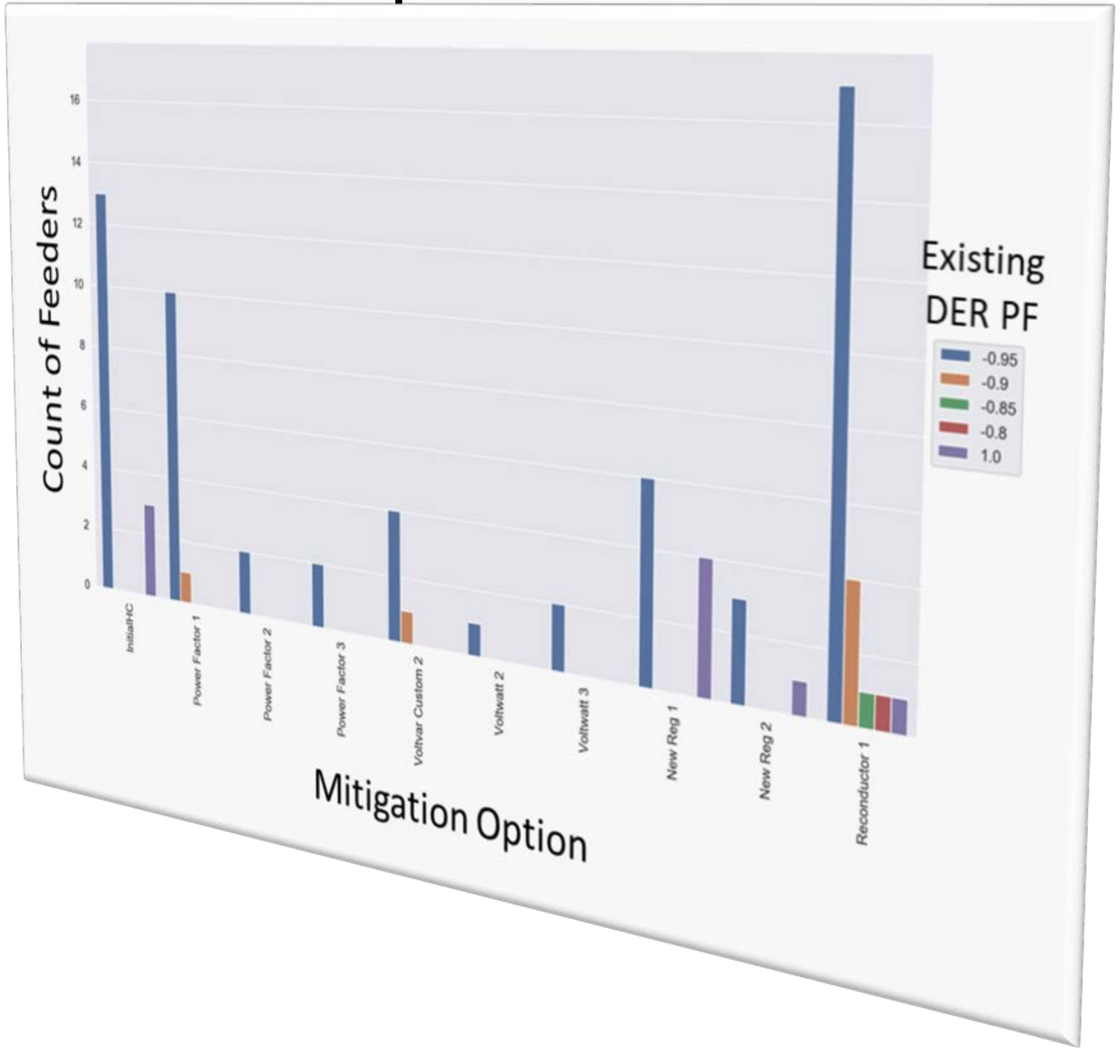
Energy Map – **Managed** charging



New analytical capabilities being developed in DRIVE

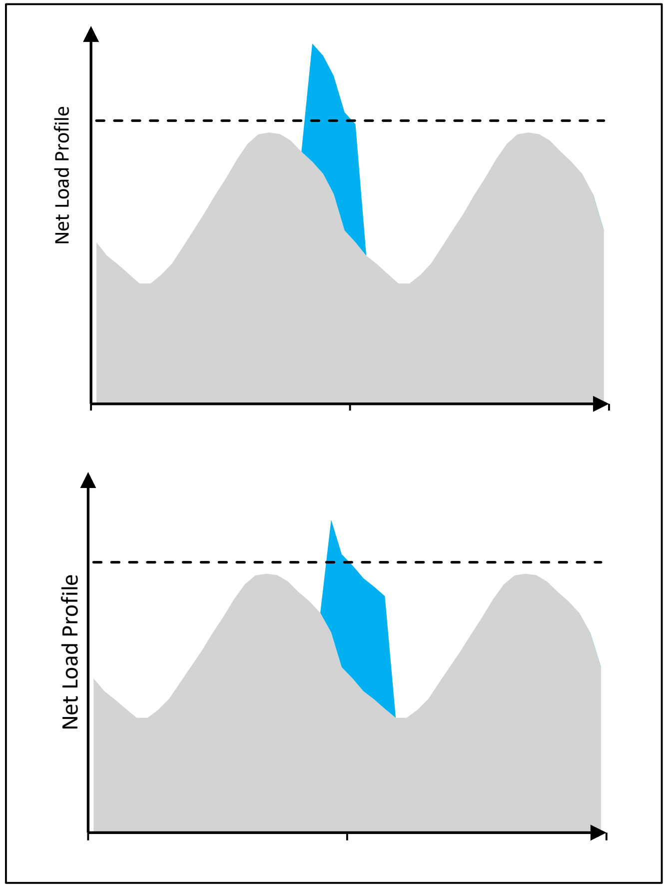
Planning Use Case:
Identifying common low-cost mitigation to integrate Load or Generation at multiple buses or across multiple feeders



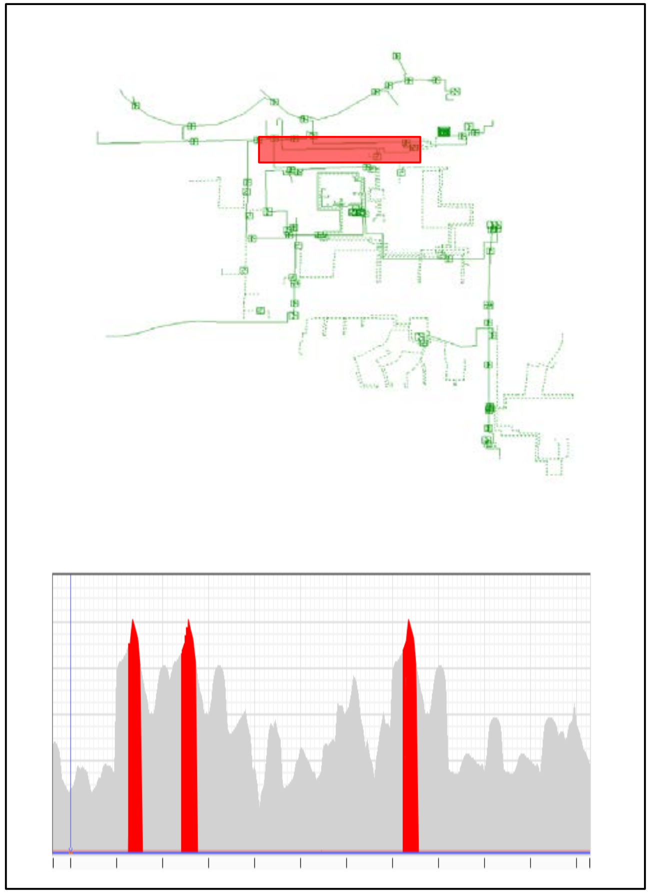


Mitigation Scenario Evaluation using ADAPT

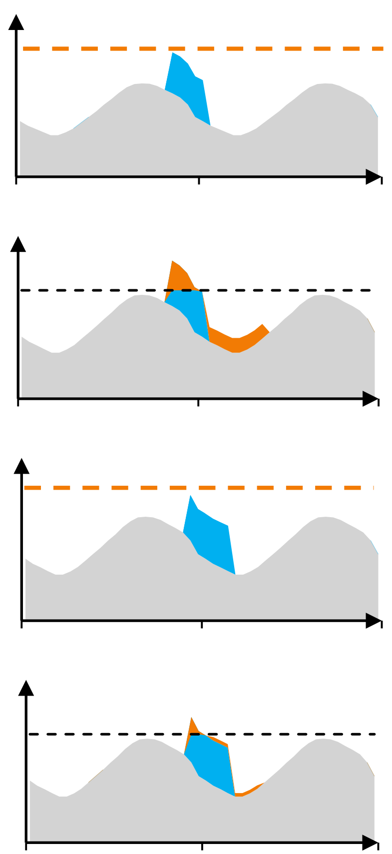
1 Charging cases derived from Fleet-VET



2 System constraint severity analysis

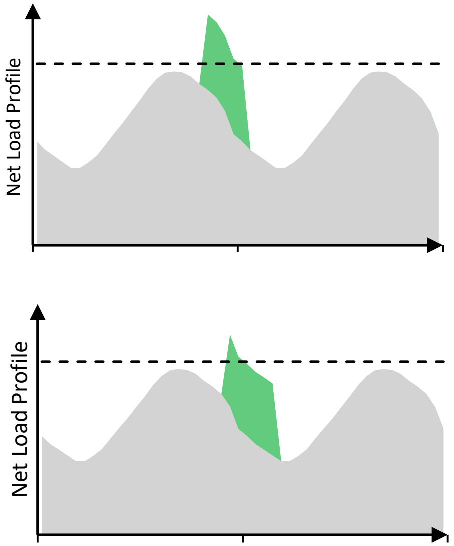


3 Automated wires & non-wire alternative design and evaluation

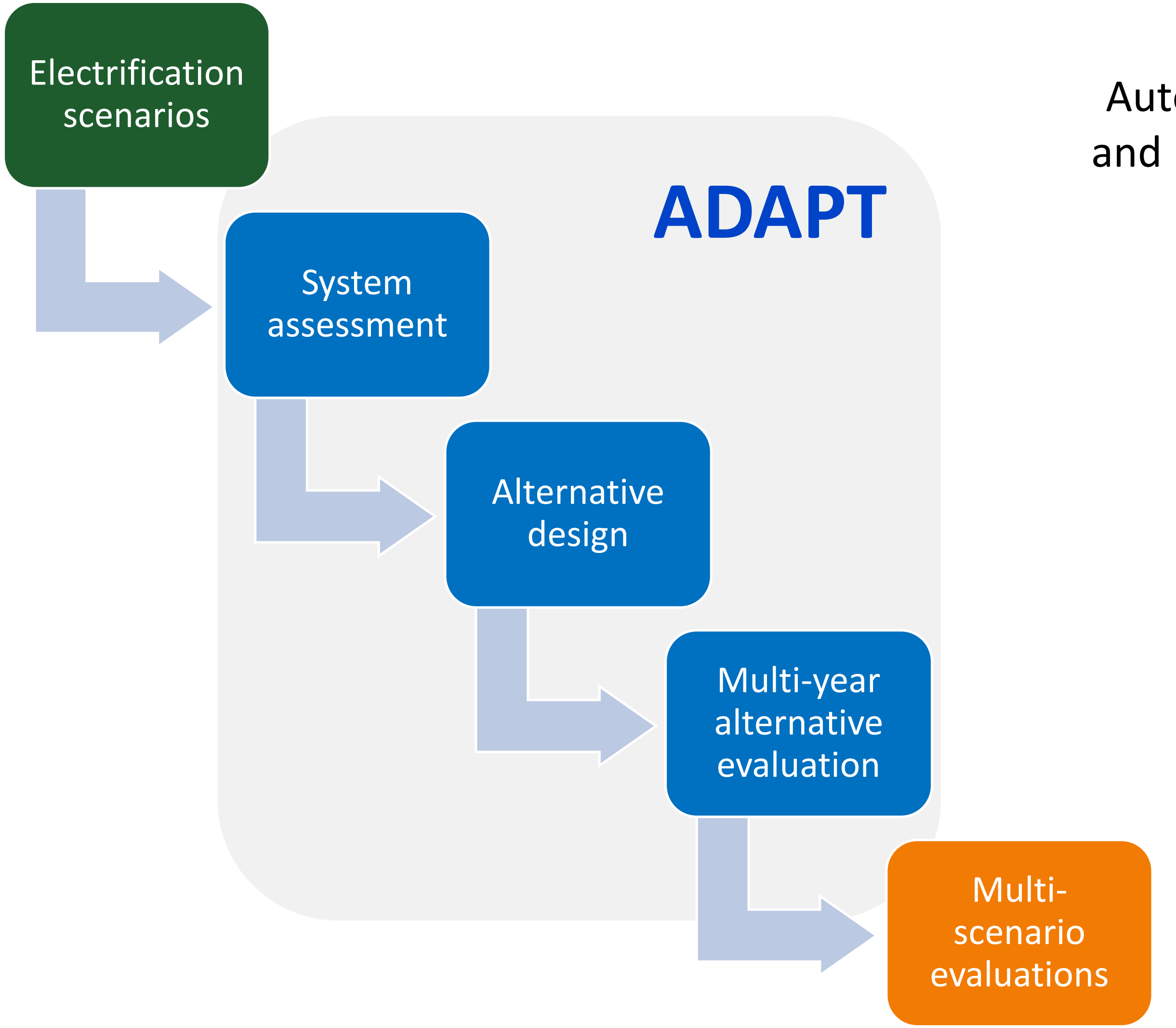


Determine and rank solutions by total behind the meter & system solution costs

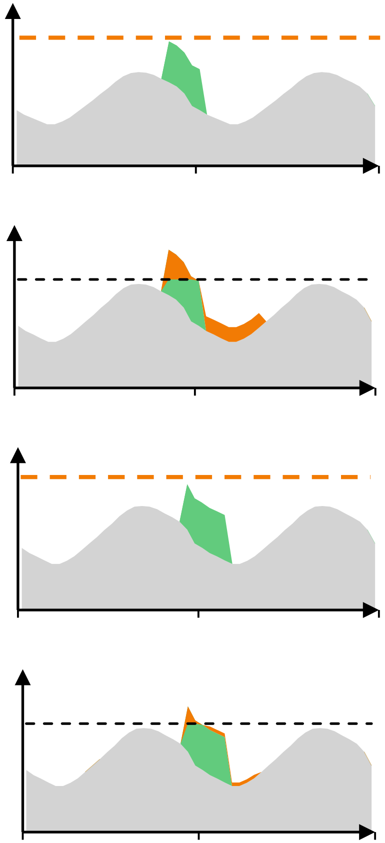
Application of the ADAPT Toolset



Quickly assess different electric fleet charging cases



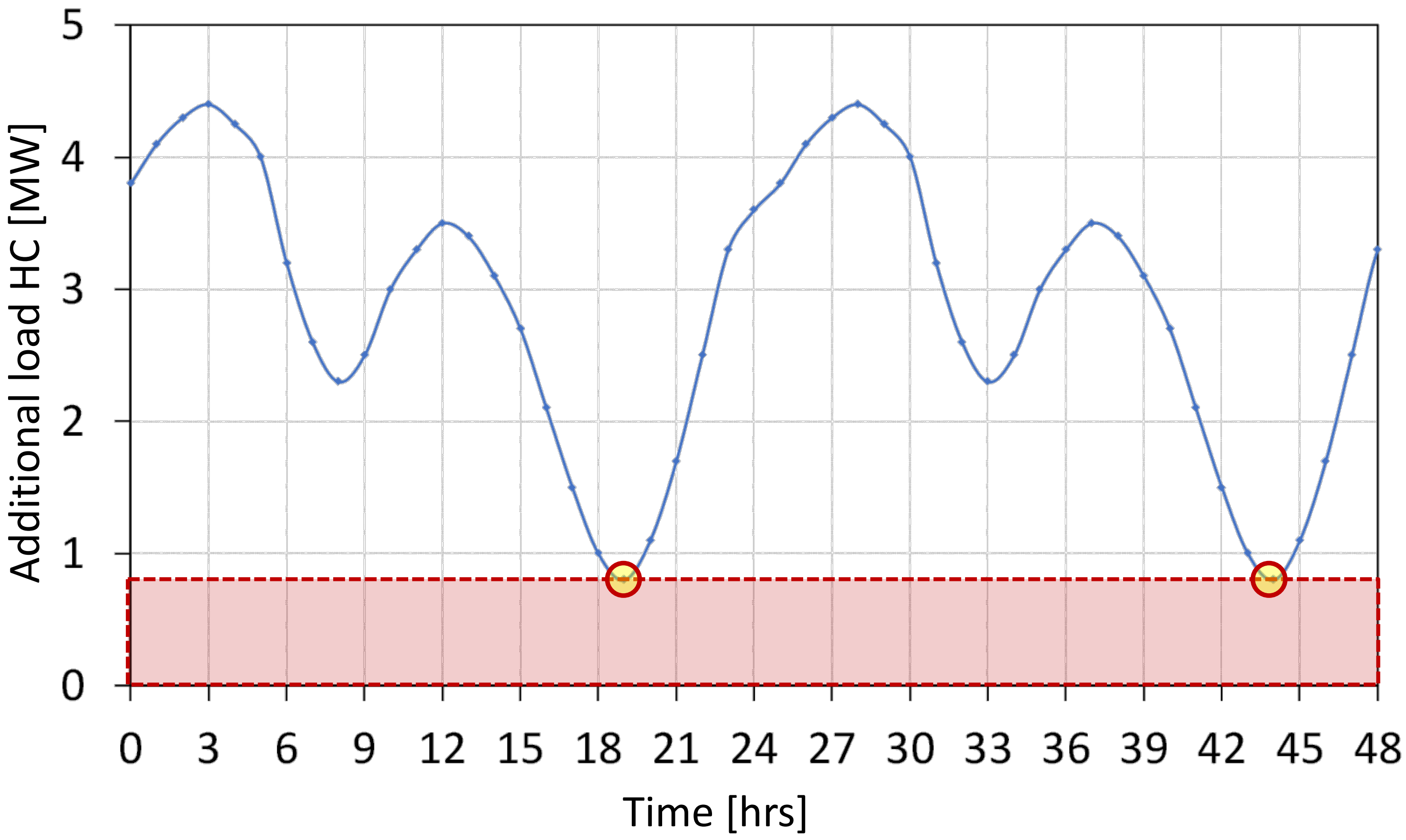
Automated evaluation of traditional and non-wires mitigation options and costs



 www.epri.com

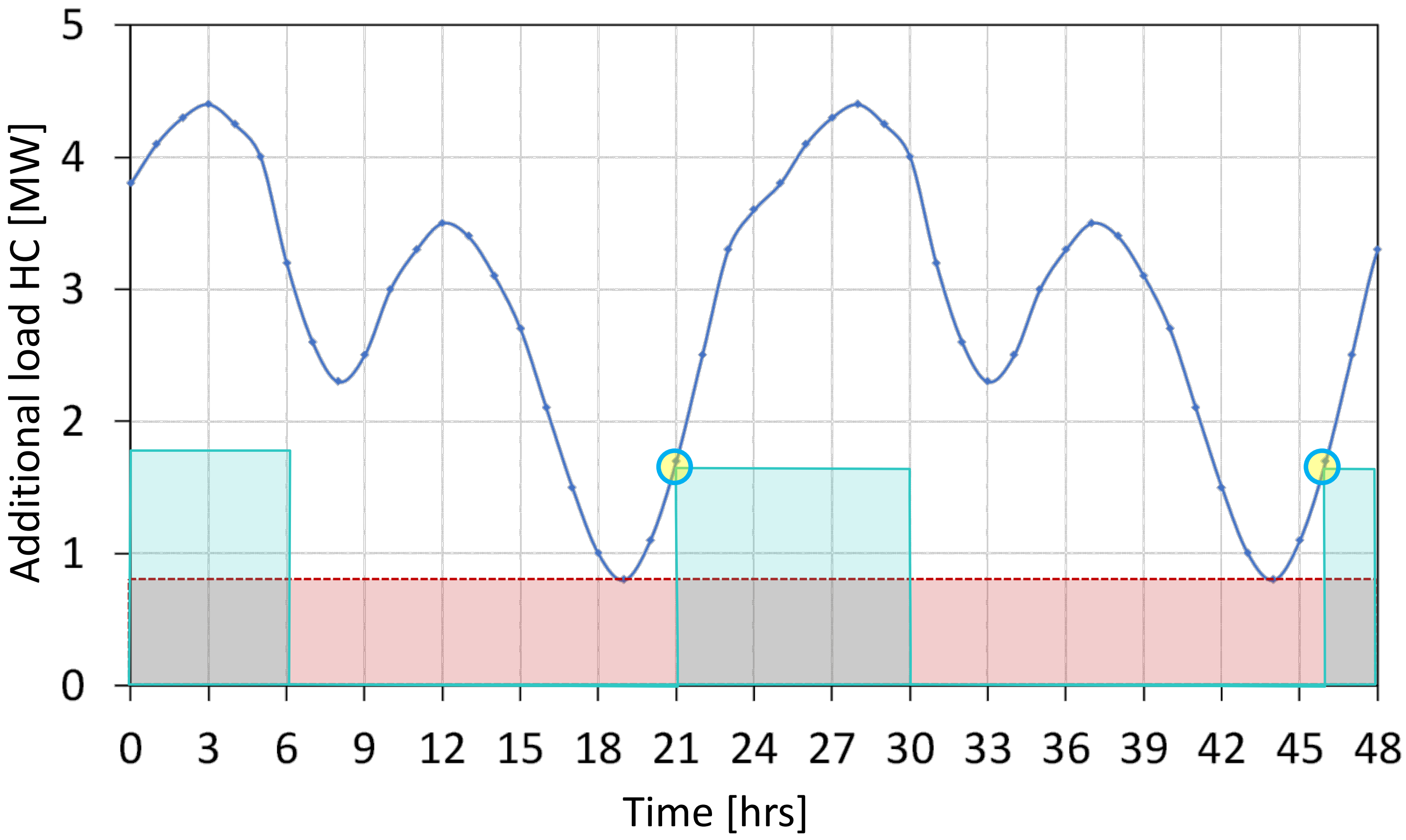
Grid electrification capability depends on charging behavior:

- **Unconstrained charging**: Charging station can operate at any time of the day as long as the demand remains below a certain power level.



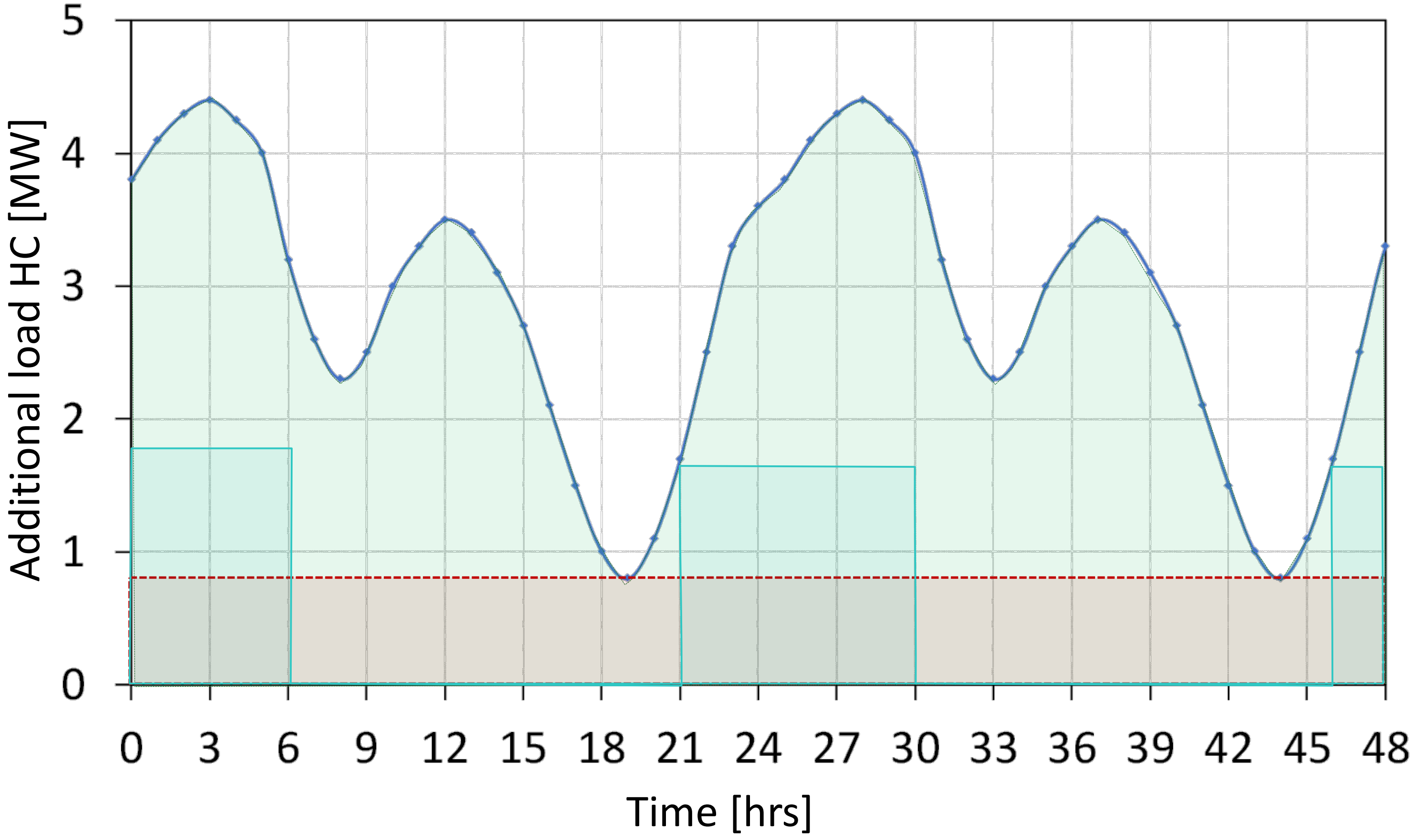
Grid electrification capability depends on charging behavior:

- **Unconstrained charging**: Charging station can operate at any time of the day as long as the demand remains below a certain power level.
- **Scheduled-based charging**: Charging would occur during some hours allowing additional vehicles to simultaneously charge during that period (compared to the unconstrained charging).



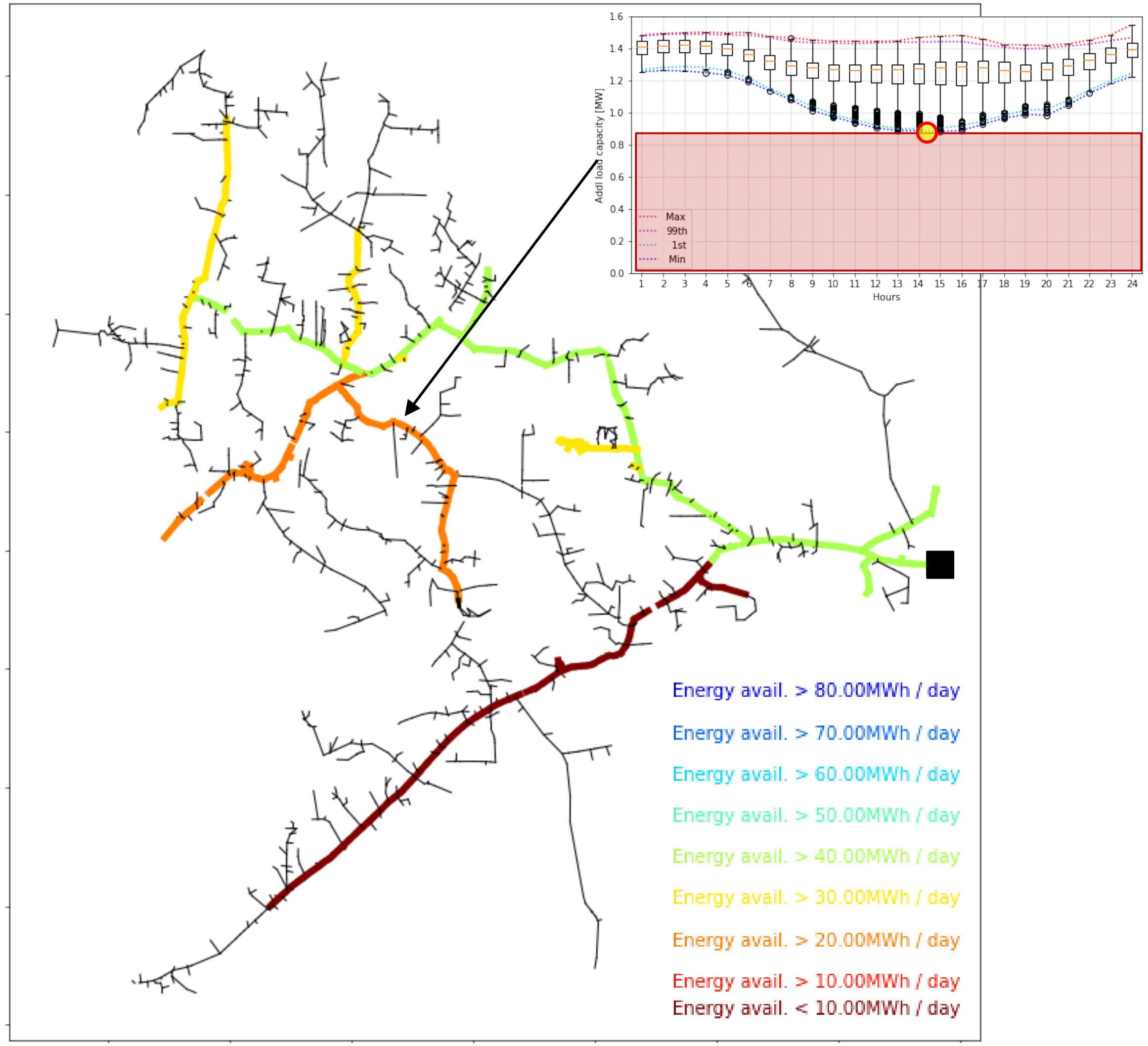
Grid electrification capability depends on charging behavior:

- **Unconstrained charging**: Charging station can operate at any time of the day as long as the demand remains below a certain power level.
- **Scheduled-based charging**: Charging would occur during some hours allowing additional vehicles to simultaneously charge during that period (compared to the unconstrained charging).
- **Constraint-based charging**: Charging station can charge within the operational limits of the system but available energy would depend on the feeder load condition.



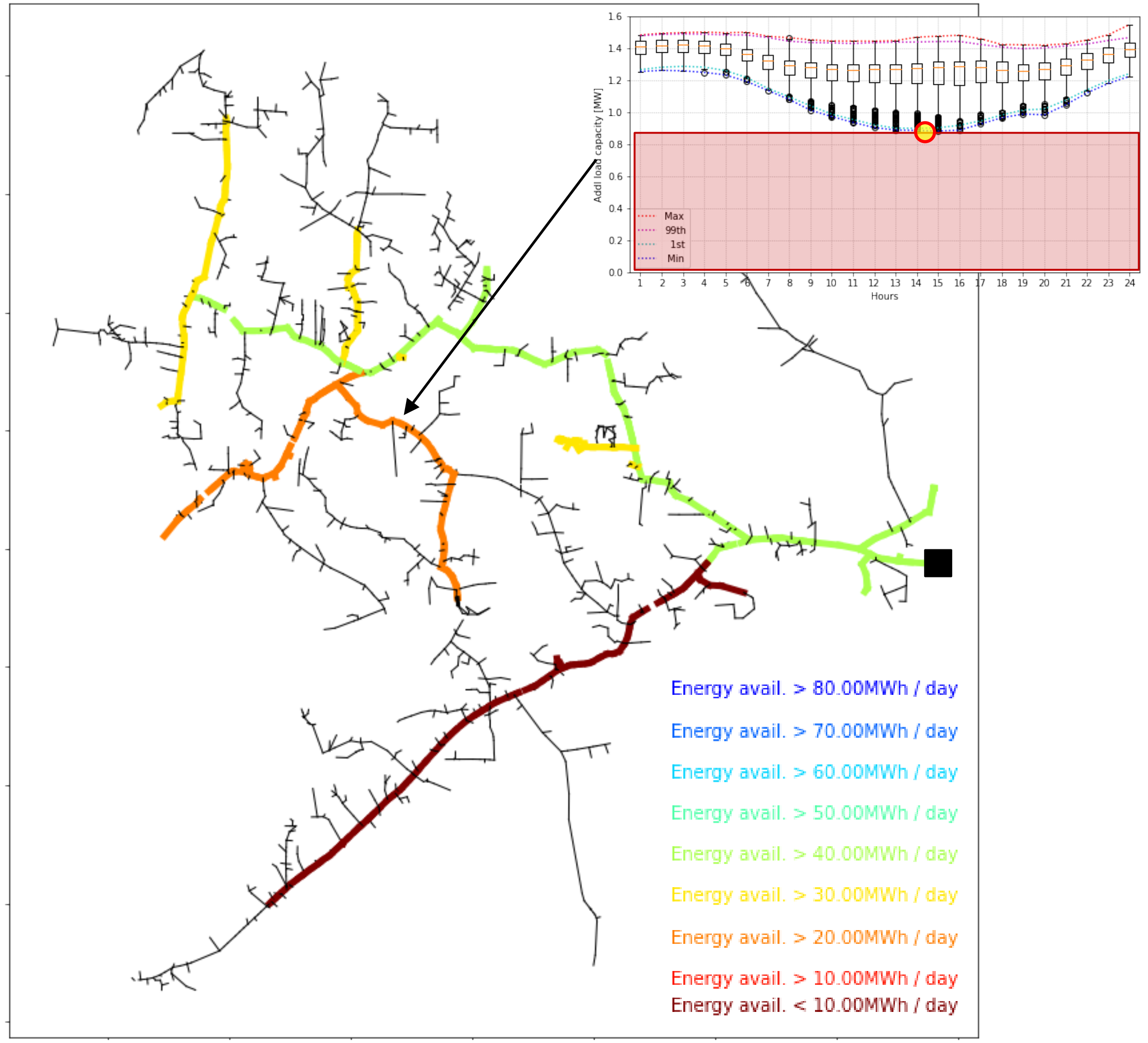
Energy availability maps

Energy Map – **Unconstrained** charging

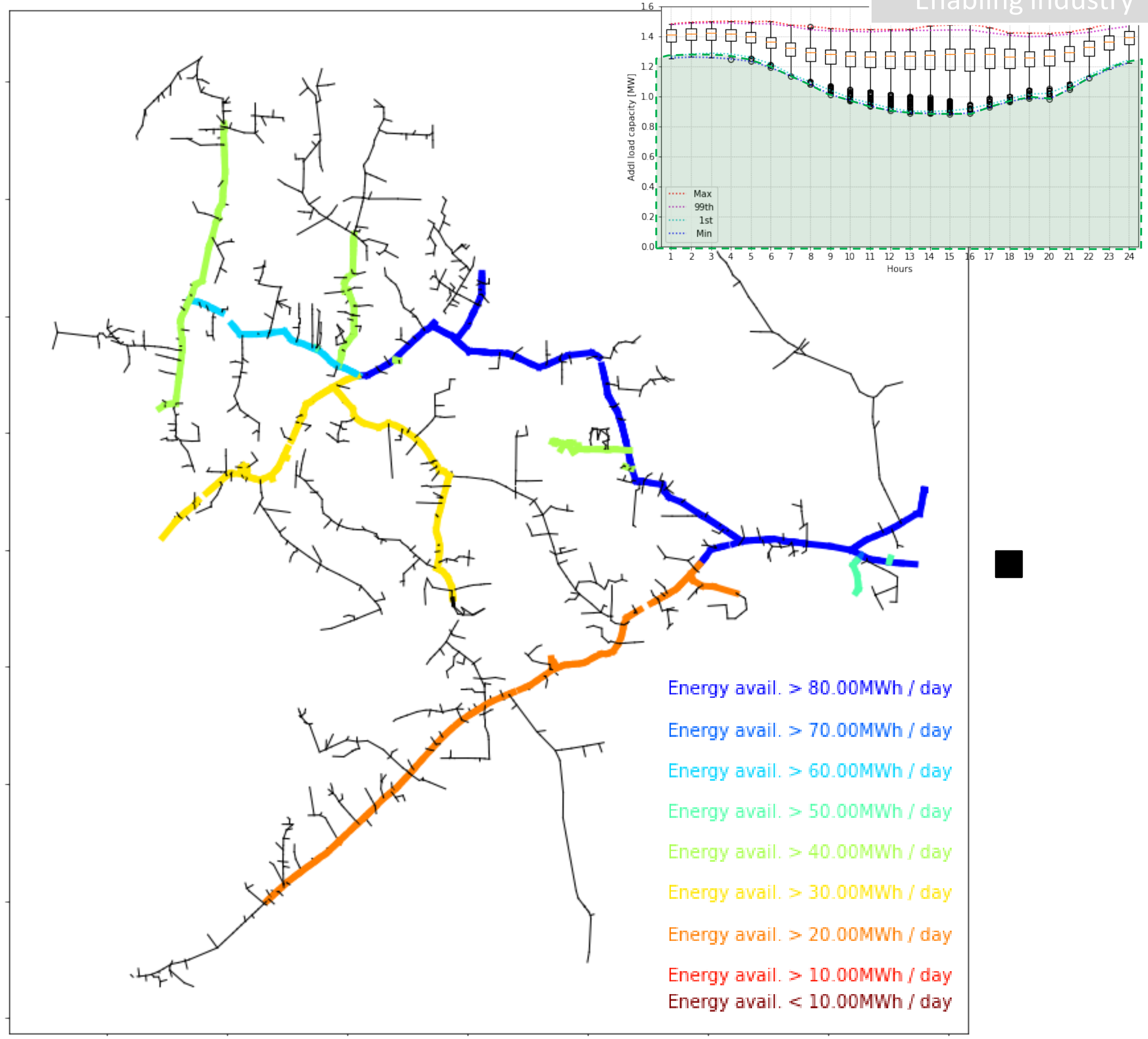


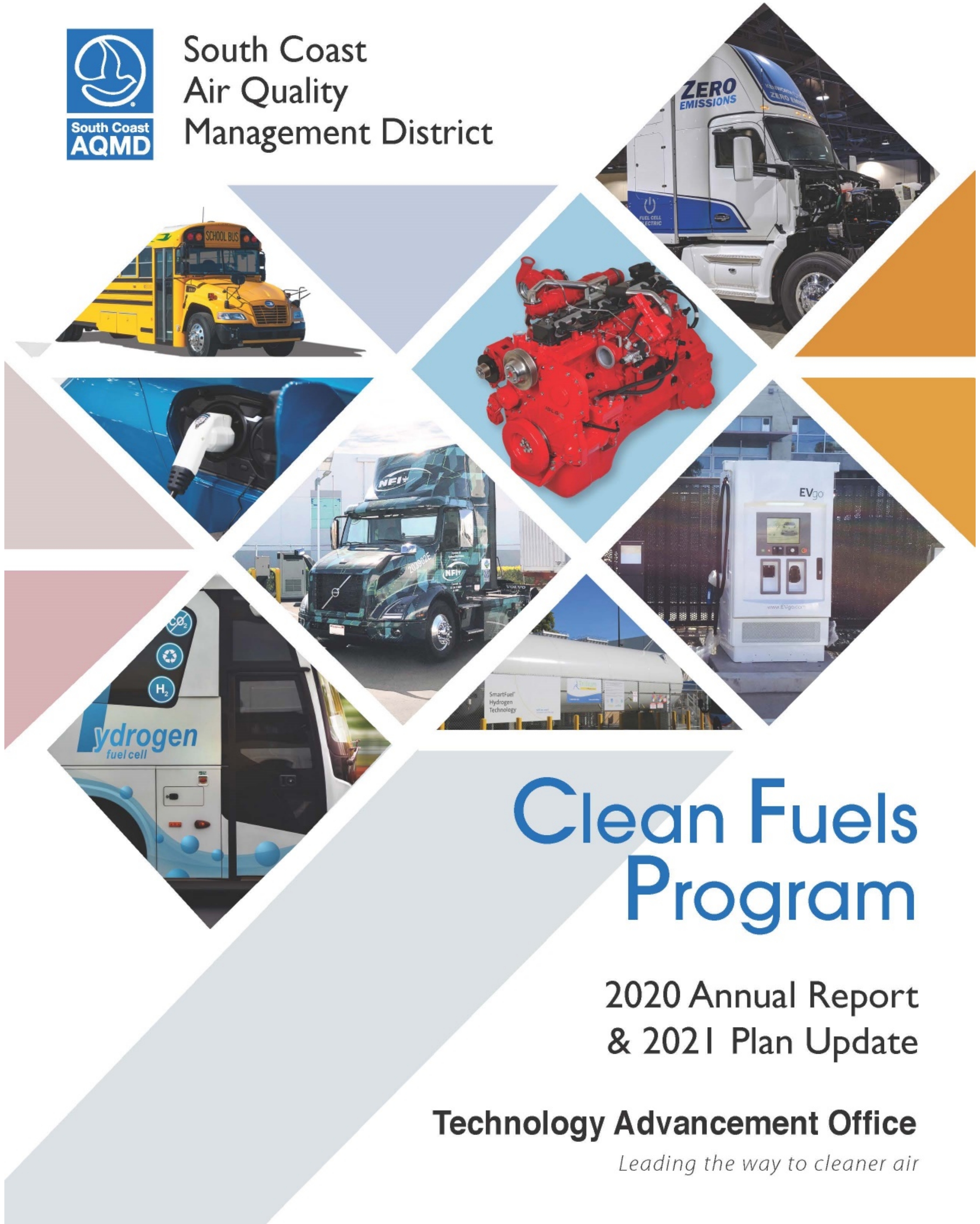
Energy availability maps

Energy Map – **Unconstrained** charging



Energy Map – **Constraint-based** charging





Clean Fuels Program Advisory Group Meeting

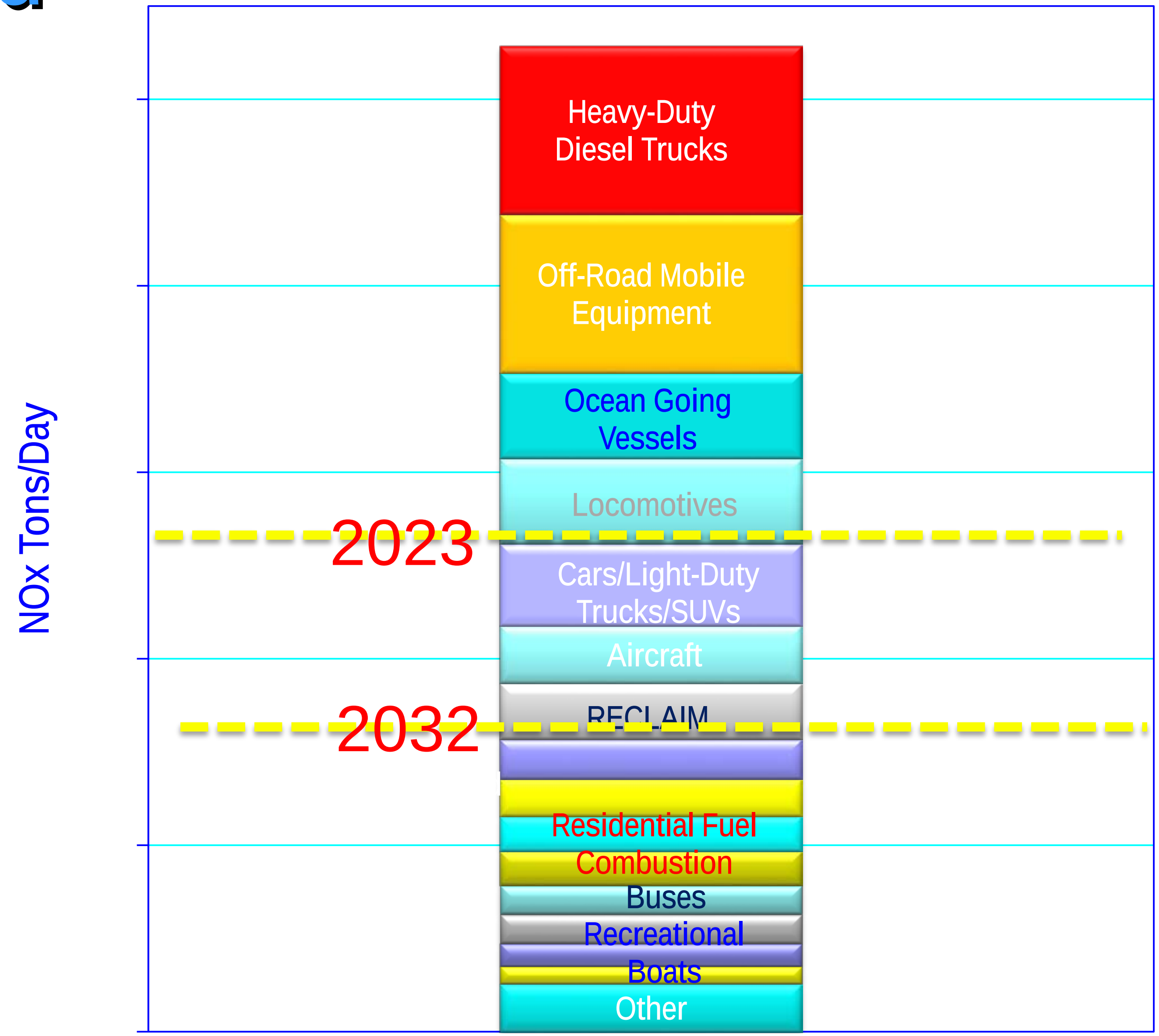
September 15, 2021

Joseph Impullitti,
Technology Demonstration Manager

The War on Southern California Smog

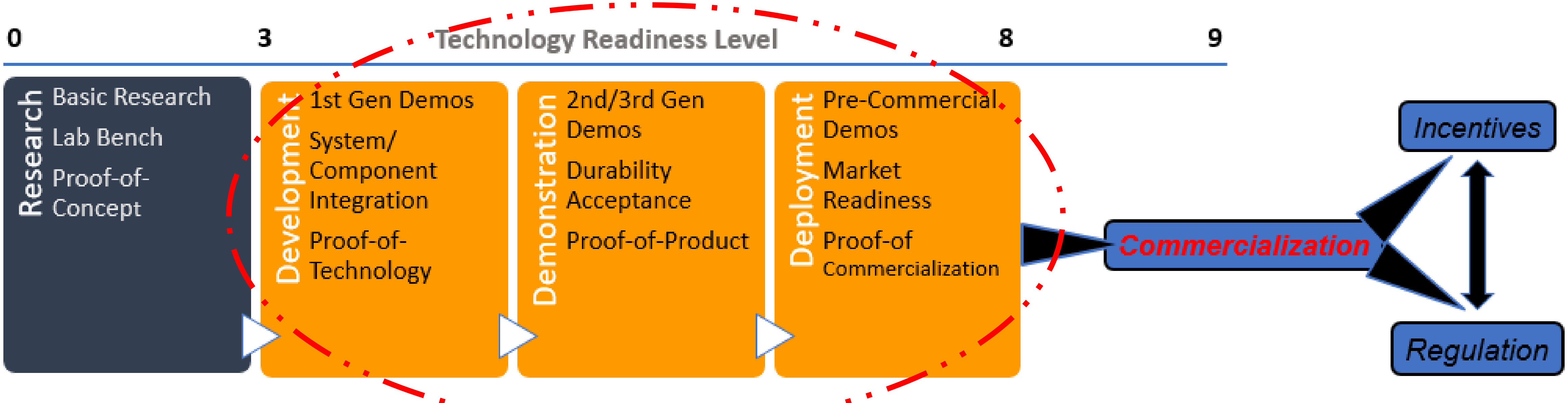
NOx Reductions Needed

45-55%



Clean Fuels Fund Program

- Established in 1988
- $1 fee on DMV registrations ($~12M/yr)
- Stationary source fee (~$400k/yr)
- Research, develop, demonstrate, and deploy clean technologies



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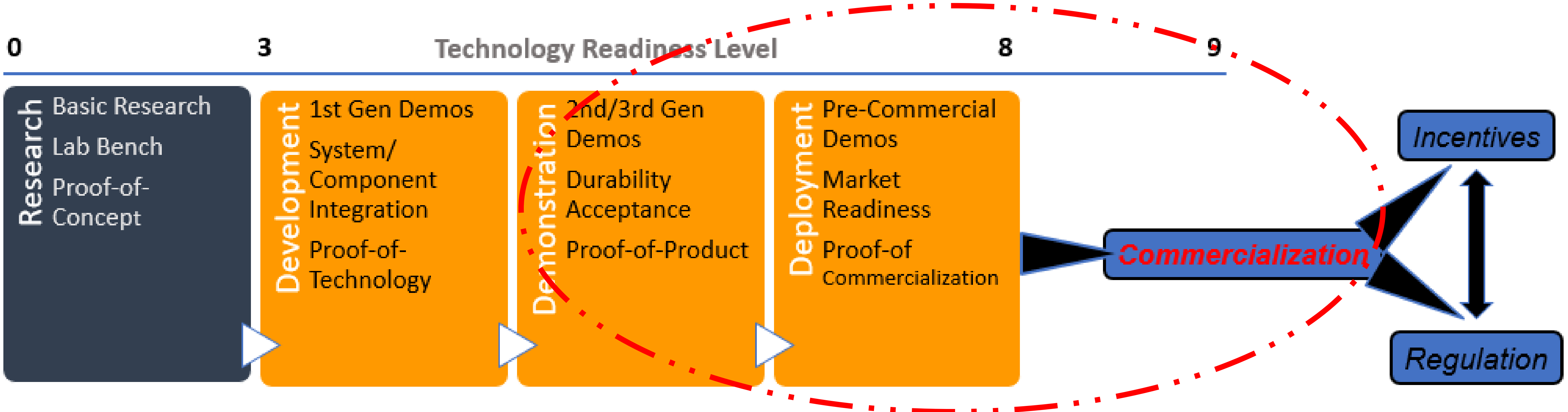


2021 Key Funding Partners

Total = $40.9M

Targeted Airshed – CATI - DERA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CALIFORNIA AIR RESOURCES BOARD

CALIFORNIA CLIMATE INVESTMENTS

THE PORT OF LOS ANGELES

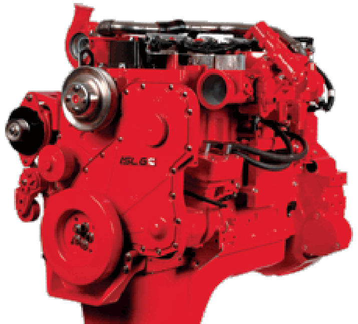
Port of LONG BEACH The Green Port

SoCalGas A Sempra Energy utility

STATE OF CALIFORNIA ENERGY COMMISSION

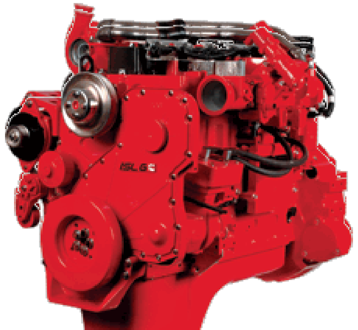
Draft 2022 Plan Update
(Key Technical Areas)

- Focus priorities on large demonstrations of zero emissions drayage trucks to test and validate OEM readiness and infrastructure viability
- Defining technology pathways via special projects - the Ultra-Low Emissions Engine Program
- Near-zero emission (gaseous and liquid fuel) engine systems, with a focus on high HP HD engine technology
- Long range fuel cell electric truck development and demonstration
- Hydrogen production, dispensing and mobile refueling
- Maintain other areas of emphasis

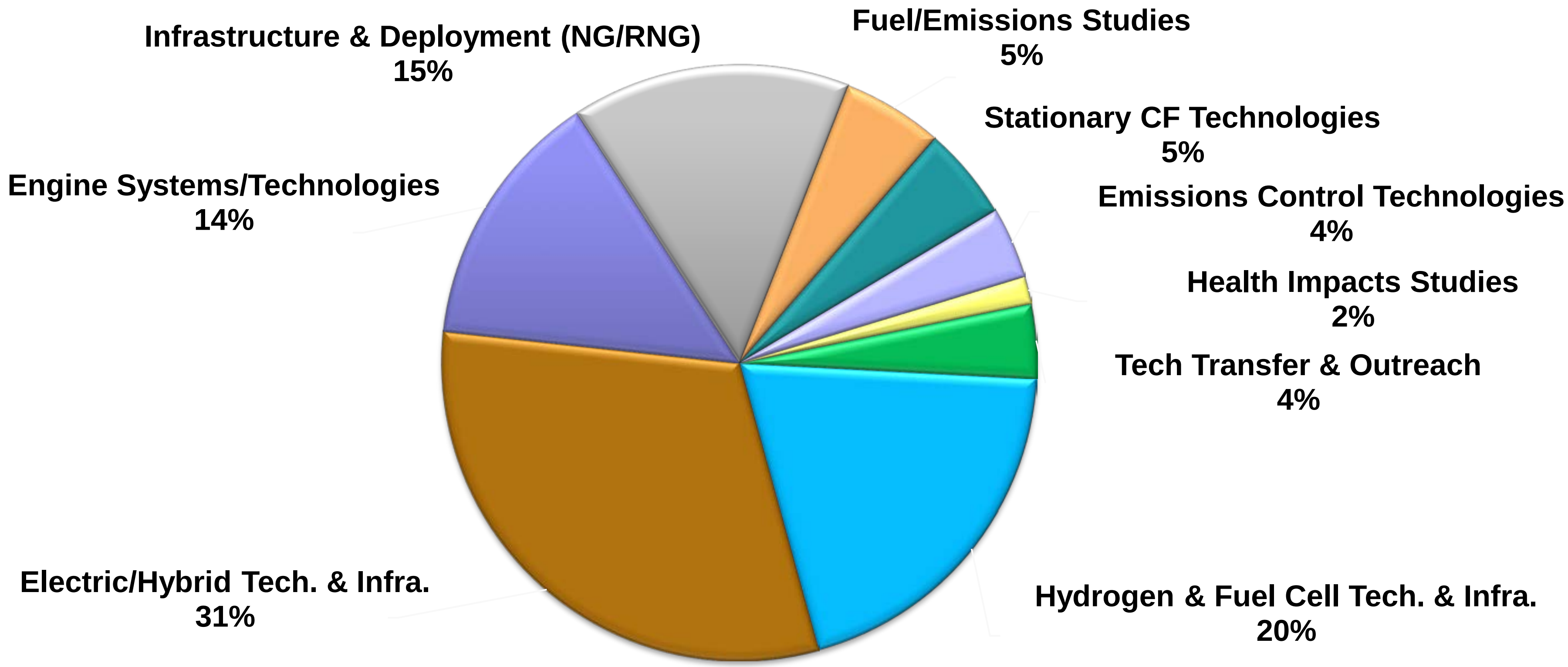



Draft 2022 Plan Update
Proposed Projects

- Large deployment projects of HD zero emission battery electric trucks and infrastructure
- Continue microgrid demonstrations to support large HD truck deployment projects
- Support advanced high power quick charge infrastructure to support HD BET's
- Development and demonstration for long range fuel cell electric trucks
- Develop pathways and demonstrate green hydrogen production
- Heavy-duty diesel truck replacements with near-zero emissions natural gas trucks
- Engine System Technologies:
  - Development and demonstration of 15L HD Low-Nox engine
  - On-road demonstration of Low Nox diesel engine
  - Ethanol/H2 combustion studies

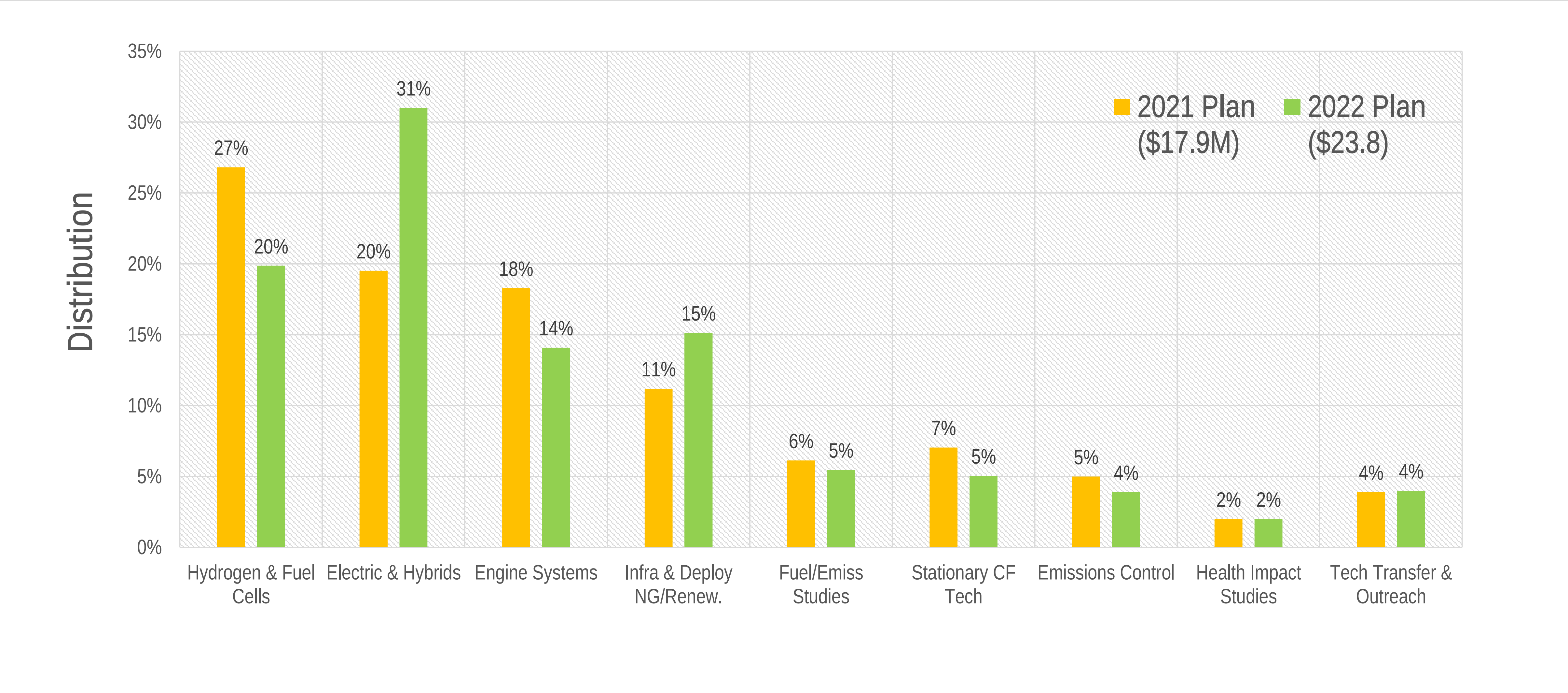


Proposed 2022 Plan Distribution



$23.8M

Plan Update Comparison



Proposed Distribution

	2021 Plan	Draft 2022 Plan
Hydrogen & Fuel Cell Tech. & Infra.	27%	↓ 20%
Engine Systems/Technologies	18%	↓ 14%
Electric/Hybrid Tech. & Infra.	20%	↑ 31%
Infrastructure & Deployment (NG/RNG)	11%	↑ 15%
Stationary CF Technologies	7%	↓ 5%
Fuel/Emissions Studies	6%	↓ 5%
Emissions Control Technologies	5%	↓ 4%
Tech Transfer & Outreach	4%	4%
Health Impacts Studies	2%	2%
	100%	100%

Feedback

Email

Aaron Katzenstein
akatzenstein@aqmd.gov
or
Joseph Impullitti
jimpullitti@aqmd.gov

Volvo LIGHTS

Technology Advancement Office
Program Supervisor

Seungbum Ha

Volvo LIGHTS
- Heavy-Duty Battery Electric Trucks & Infrastructure

- Volvo LIGHTS (Low Impact Green Heavy Transport Solutions)
- 23 battery electric trucks, 29 off-road equipment, solar for zero emission freight handling
- Funding: $44.8M CARB/CCI, $4M South Coast AQMD, $41.6M Volvo & Partners – Total: $90.4M
- Battery electric forklifts, yard tractors at fleets

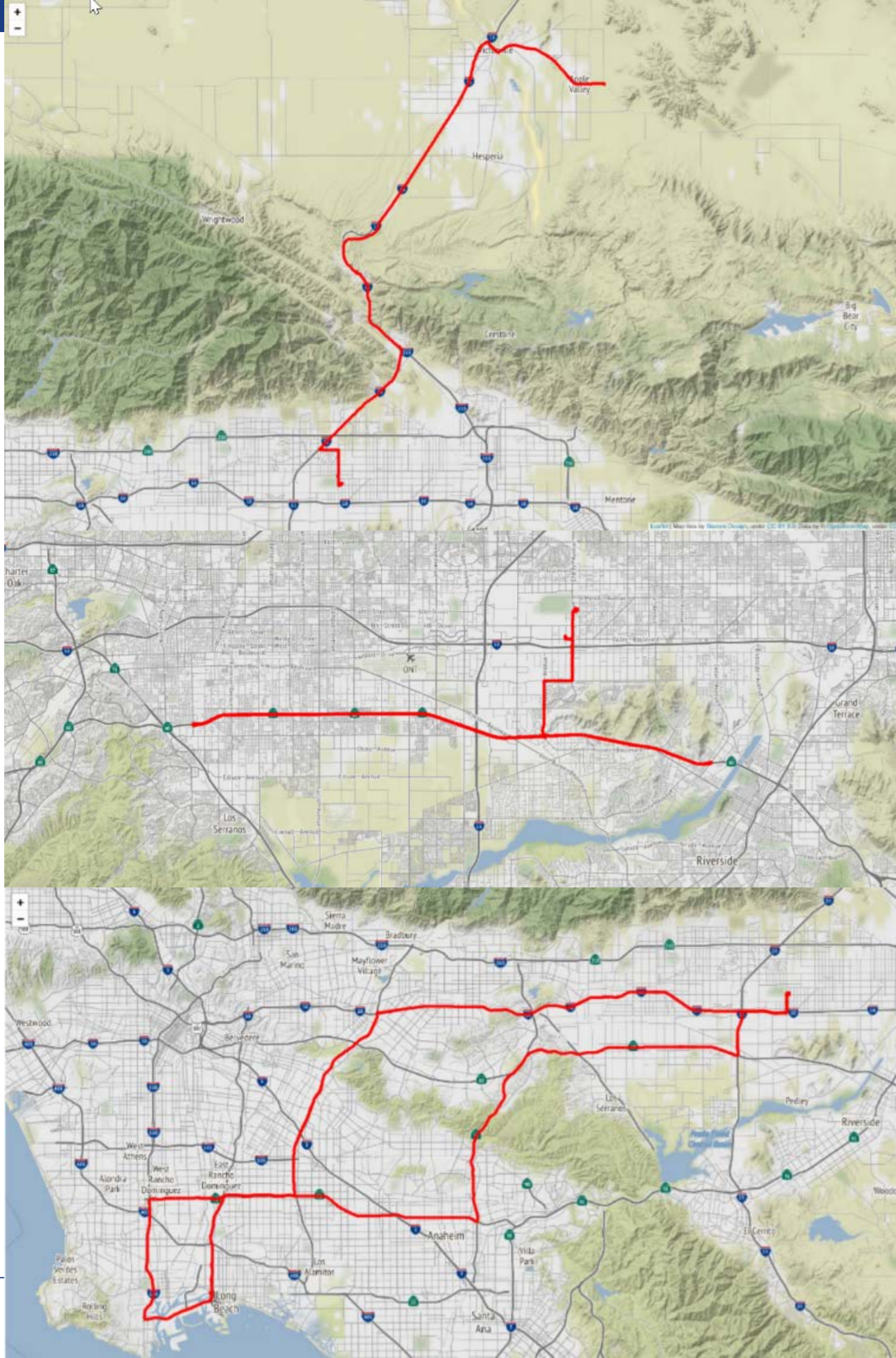
Volvo LIGHTS
- Heavy-Duty Battery Electric Trucks & Infrastructure

- 5 Trucks under operation (TEC, NFI, DHE)
- Chargers installed at fleets, SCE Charge Ready Transport
  - 7.2 kW, 15 kW for EVs, forklifts
  - 22 kW AC, 50 kW DCFC for yard tractors
  - 150 kW DCFC for trucks
- Solar installed at DHE
- Completed additional 15 trucks

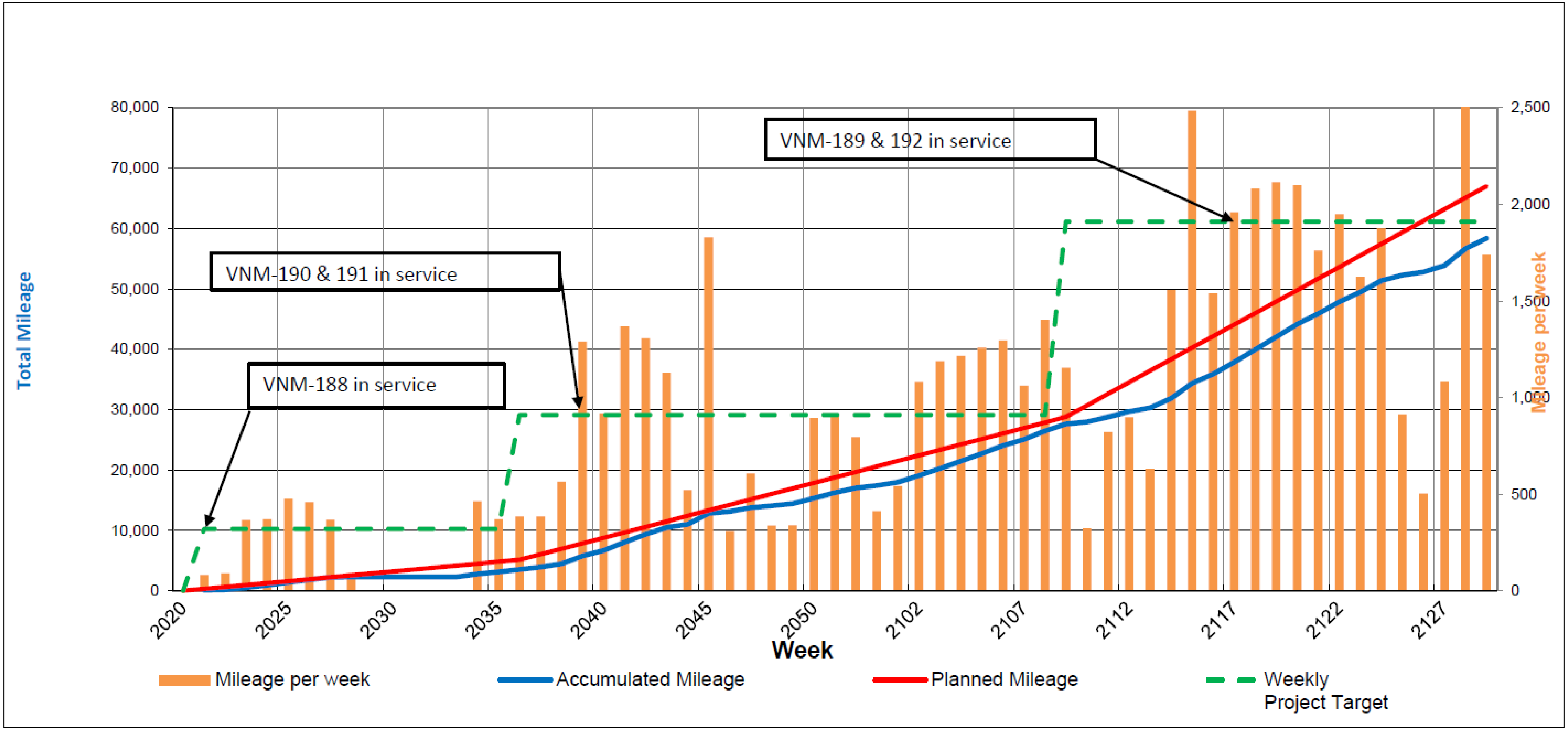
Truck Demo Data

Total Mileage: 128,427

Customer	Route
TEC	TEC Fontana – TEC La Mirada 90 miles, mostly flat
NFI	NFI Chino – Ports 102 miles, mostly flat (170m)
DHE	DHE – mixed drop off locations 80 miles, mostly flat
DHE	DHE – mixed drop off locations including Apple Valley 110 miles, big mountain climb (600m)
NFI	NFI Chino – Ports 102 miles, mostly flat



Accumulated Mileage



Charging Energy Summary

Fleet

Fleet	Total Sessions	Total Energy(kWh)	Avg Energy/Session
A	191	12,333.9	64.6
B	187	11,512.0	61.6
C	42	2,368.4	56.4

Vehicle

Total Sessions	Avg Sessions per Day	Total kWh charged	Avg kWh per day
26	1.13	2,377.9	103.4
32	1.07	2,689.5	89.7
31	1.03	2,254.4	75.1

Charging schedule

Start Time	End Time	Energy(kWh)	Duration (H:M:S)
2021-08-03 09:50:46	2021-08-03 10:45:50	127.6	00h 55m 04s
2021-08-05 09:35:41	2021-08-05 10:13:19	83.2	00h 37m 38s
2021-08-05 19:49:39	2021-08-05 20:25:42	47.0	00h 36m 03s

Volvo LIGHTS Update

- Volvo Class 8 eVNR trucks certified by CARB, EPA
- Eligible for sale in California
- Delivering parts full-time at TEC Fontana
- Online and/or socially distanced BET classes
- Approved baseline testing plans, UCR installed data loggers at DHE, collecting PEMS data
- CALSTART collecting charging data from fleets

Project Partners

- OEM
- Government
- Utilities
- Fleets
- Education/Training
- Ports
- Dealership
- Outreach
- Charging Infrastructure

Microgrid - On-Site Solar + Storage

- BEV fleet owners to maximize their investment while reducing their energy costs.
- As grid-independent energy resources, solar + storage systems enhance resiliency
- Pairing an energy storage device, such as a second-life battery, with a solar system enables a fleet to access carbon-free power

Next phase of Volvo LIGHTS: EPA Switch-On

- CARB certified commercial trucks
- Largest single commercial truck deployment
- Additional performance data in drayage/freight applications
- U.S. EPA Targeted Airshed grant
- Volvo and fleets provide in-kind and cash cost share
- Deploy 70 Class 8 battery electric trucks

Next phase of Volvo LIGHTS: CARB-CEC Pilot

- CARB and CEC awarded South Coast AQMD $16M and $11M respectively to deploy up to 100 Daimler and Volvo Class 8 BETs and infrastructure at two fleets in DACs

- Daimler and Volvo will manufacture trucks certified by U.S. EPA and CARB

Daimler	Volvo
200 – 250-mile electric range	195 – 220-mile electric range
475 kWh lithium-ion battery pack	564 kWh lithium-ion battery pack
CCS1 connector for fast charging	CCS1 connector for fast charging

- Data Collection
  - Ricardo—data collection/analysis on BETs
  - CALSTART—charger pricing analysis, fleet case studies
  - EPRI—charger performance analysis, fleet reliability uptime dashboard

Daimler eCascadia


Volvo VNR Electric

Daimler/Freightliner
Battery Electric Transport Demonstration to Deployment

South Coast AQMD

Clean Fuels Technical Advisory Meeting

South Coast AQMD

September 15, 2021

Phil Barroca, Program Supervisor,
Technology Demonstration
Technology Advancement Office

Innovation
DTNA / SCAQMD/ EPA / POLA / POLB

Pre-commercial Class 8 (eCascadia) and Class 6 (eM2)
DC Fast Charging distributed in Air Basin
Energy Storage System (Time-of-Usage study)
Penske Truck Leasing and Logistics and NFI Logistics

Q4-2018 | Vehicles & EVSE | Q2-2022

CX
DTNA / SCAQMD / BAAQMD / SCE

Expanded demonstration of pre-commercial EVs
DC Fast Charging using portable DCFC from ChargePoint CPE250
2-9 months of “hands-on” with 10 major fleet operators

Q3-2020 | Q4-2022

DTNA Commercial
DTNA / EPA / CARB / SCE

Commercial ready eCascadia and eM2
Customer installed/paid DCFC
US Foods; JB Hunt ; Ryder Truck ; Schneider

Q2-2019 | EVSE | Vehicles | Q2-2025

Innovation
DTNA / SCAQMD/ EPA / POLA / POLB

Vehicles & EVSE first deployed in Q3 2019

Demonstration through Q2 2022

Q4-2018

Agility® fuel solutions

Objectives –

- Develop and demonstrate on-road heavy-duty battery-electric trucks
- Meet performance objectives
- Meet or exceed all safety standards, EPA and CARB certifications
- Install DC Fast Charge Infrastructure
- High visibility, well-positioned demonstration partners

Project Cost: $31 MM

- DTNA, SCAQMD ($12.5 MM)
- POLA, POLB, EPA ($1MM ea)

LOGISTICS • TRANSPORTATION • DISTRIBUTION NFI

PENSKE

Innovation Fleet – Vehicle Specs

Innovation Fleet

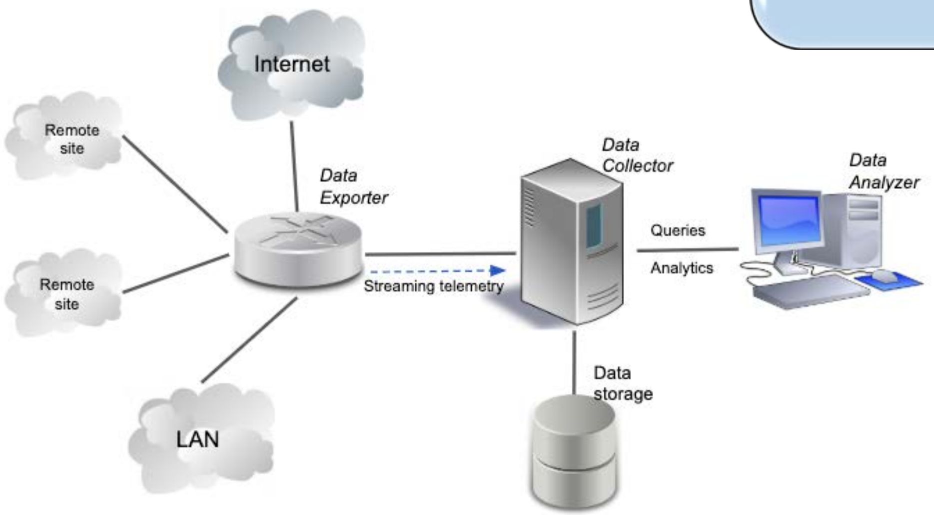
- *Class 8*
  - 23,500 lbs. (curb weight)
  - 80,000-lb GVWR
  - 670 peak h.p.
  - 1430 lb-ft. torque
  - 400 kWh battery (useable)
  - 160 mile full load range
  - <3 hours full recharge @150kW
- *Class 6*
  - 17,500 lbs. (curb weight)
  - 26,000-lb GVWR
  - 333 peak h.p.
  - 737 lb-ft. torque
  - 220 kWh battery (190 kW useable)
  - 150 mile full load range
  - 2 hours full recharge @150kW

Anti-lock Braking System (ABS)
Electronic Stability Control (ESC)
Traction Control System (TCS or ASR)
Advanced Driver Assist System (ADAS)
Adaptive Cruise Control (ACC)
Automatic Emergency Braking (ABA)

Innovation Fleet

Data Collection

- Shift duration
- Miles driven per day
- Location of operation
- Total energy consumed per day
- Charge duration per day
- Driving efficiency per day
- Vehicle regenerative energy per day
- Auxiliary load and energy per day
- Driver behavior
- Thermal system performance
- Battery & cell temperature; battery health



Innovation Fleet

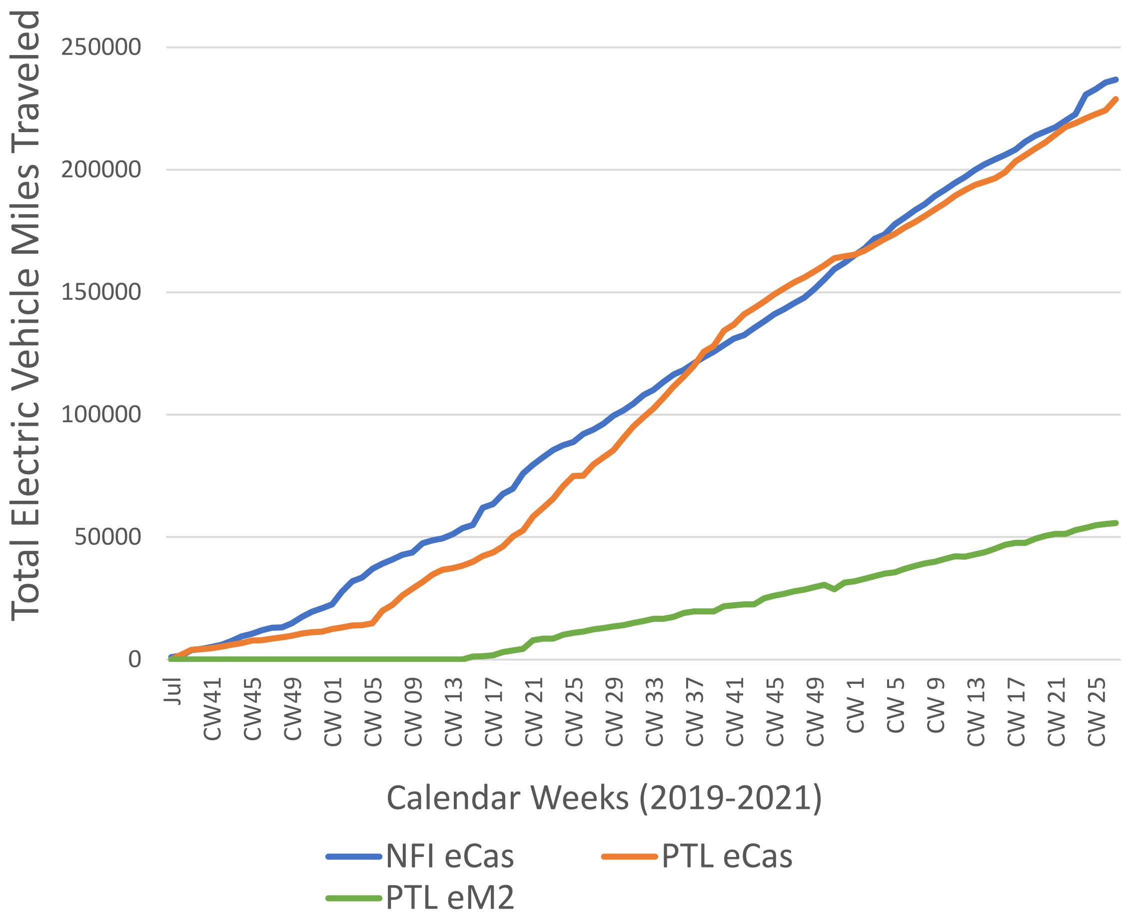
Innovation Fleet - Metrics to Date

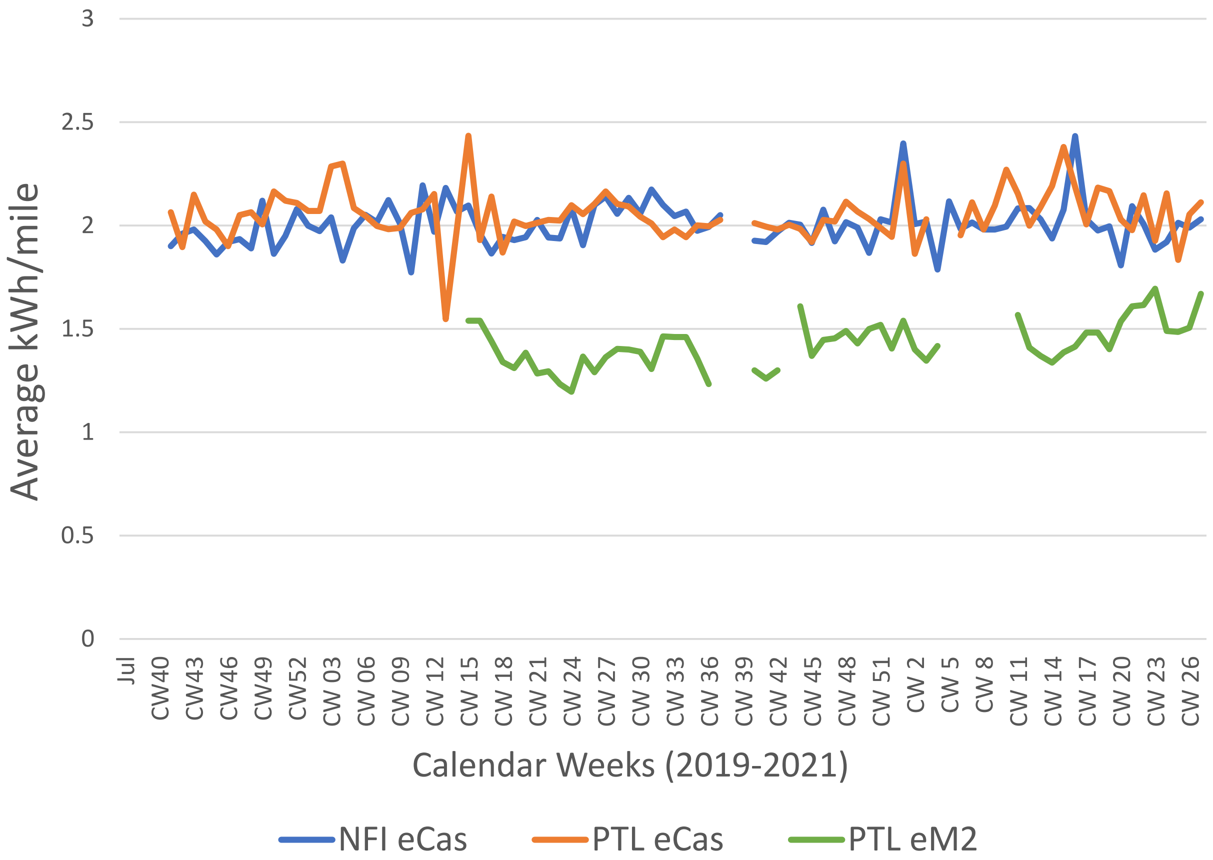
- Total miles accrued all vehicles: > 525,000 miles thru August 2021
- eCascadia: 470,000+ miles; 2.03 kWh/mile (avg)
  - NFI: (avg/max)
    - Miles: 150 / 246
    - Hours per day: 7.5 hrs / 11.6
    - Loads (lbs): 24,000 / 53,000
  - Penske Logistics: (avg/max)
    - Miles: 102 miles / 196
    - Hours: 5.5 hrs / 11.1
    - Loads (lbs): 40,000 / 60,000
  - Charging hours: 3 - 4

- eM2: 55,000+ miles; 1.35 kWh/mile (avg)
  - Penske Logistics: (avg/max)
    - Miles: 86 miles / 135
    - Hours: 1.42 / 12.5
    - Loads (lbs): 2,500 / 6,000
  - Charging hours: 2-3

Miles and Efficiencies

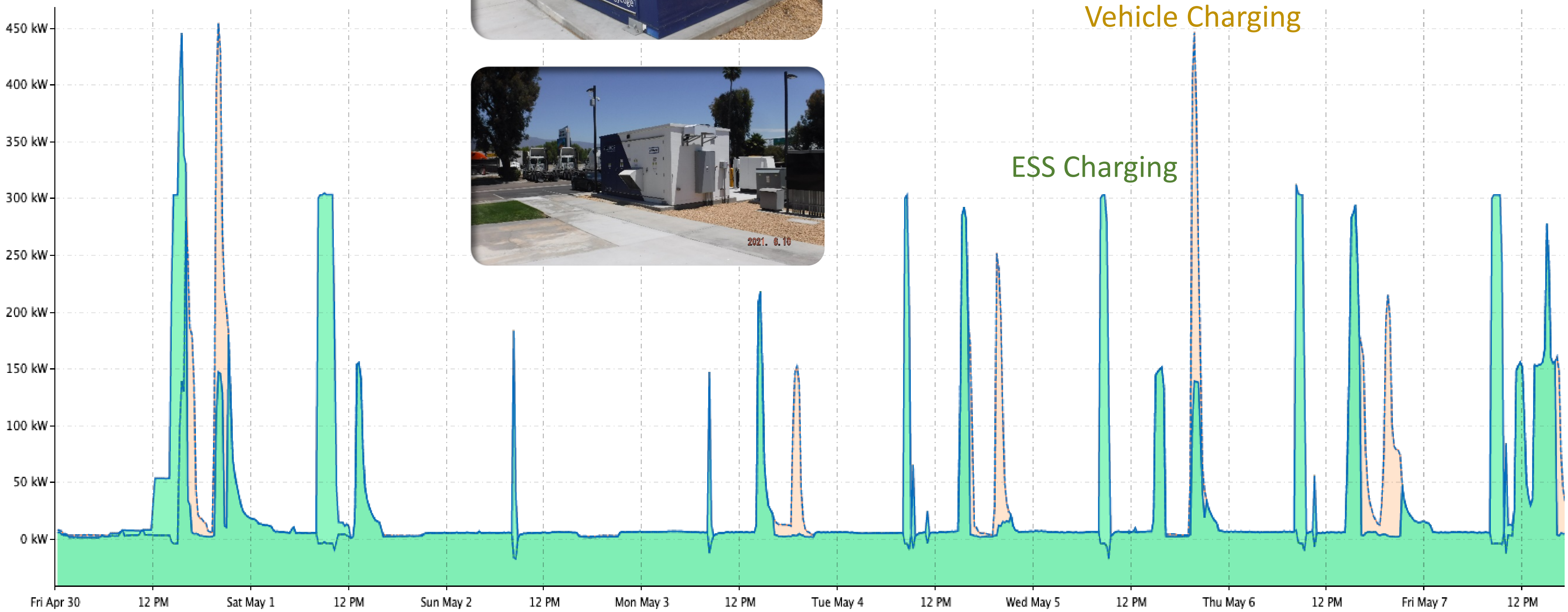
Innovation Fleet





ESS Profile

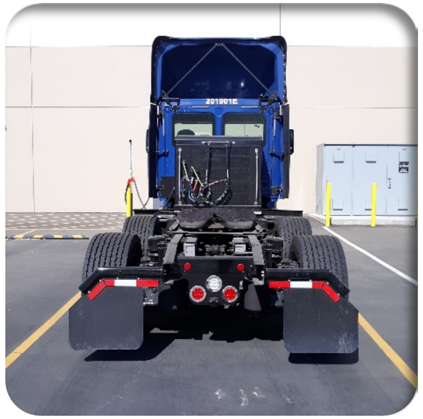
Innovation Fleet



Innovation Fleet – Problems/Resolutions

Innovation Fleet

- Concerns
  - Turning radius is larger
  - Back-of-Cab radiator obstructs view of fifth wheel
  - Accelerated tire wear
- Problems:
  - High Voltage Batteries
  - eAxle Bearing failures
  - Software
  - AC Compressor issue
  - COVID delays




CX

DTNA / SCAQMD/ BAAQMD / SCE

Vehicles & EVSE first deployed in Q3 2020

Demonstration through Q4 2022

Q2-2020

"Customer Experience"

Objectives –

- Expand vehicle demonstration to multiple fleets / outreach
- Provide introduction to DCFC
- 2 – 9 months of demonstration
- Stimulate consumer interest and education
- Gain additional insights on fleet operations and challenges

Demonstration Partners

Kroger, US Foods, Pepsi, Schneider, Sysco, J.B. Hunt, Ryder, Knight Transportation, Swift Transportation

Project Cost: $ 6.742 MM

- DTNA, SCAQMD ($1 MM), BAAQMD, SCE

CX Fleet

Data Collection

- Data loggers captures include:
  - Driver behavior (vehicle controls)
  - Location of operation
  - Recuperation demand
  - Thermal system performance
  - Battery & cell temperature; battery health
  - Charging rate; state of charge and kWh used
  - Power/torque
  - Auxiliary load demand
  - Issues

CX Fleet - Metrics to Date

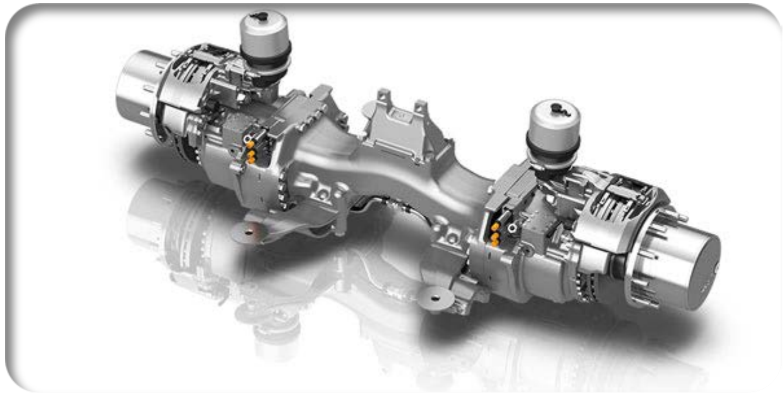
CX Fleet

- Total miles accrued all vehicles: ~ 71,000 miles thru August 2021
- eCascadias : (10 fleets)
  - 64,000 miles
  - 2 kWh/mile (avg.)
  - 5.3 hours / day (avg.)
- eM2's (2 Fleets)
  - 7,000 miles
  - 1.34 kWh/mile (avg.)
  - 5.7 hours / day (avg.)

CX Fleet – Problems / Resolutions

CX Fleet

- Comparable Issue to Innovation Fleet
- Pre-emptive Steps taken on Main Issues
    - eAxle Bearings replaced with ceramic bearings
    - HV Batteries - circuit board isolation issues addressed



- DMV Registration issues
    - CARB certified / not experimental
    - Sales tax on each transfer
    - IRP taxed out of state

CX – Customer Surveys/Outreach

CX
Fleet

Vehicle Performance	
Ease of use and maneuverability	75%
Range	75%
Acceleration	95%
Torque Availability	100%
Power	90%
Regenerative braking - performance	90%
Regenerative braking - ease of use	95%
Uptime	95%
Instrument Cluster & HMI	100%

Charging	
Overall ease of use	100%
Functionality	90%
Uptime	100%
Vehicle Integration	85%
Network Services	65%

Overall Scoring	
Performance	91%
Charging	88%
Total	90%

J.B. HUNT

Kroger FRESH FOR EVERYONE

SOUTHERN CALIFORNIA EDISON Energy for What's Ahead

SCHNEIDER

ACT Expo: Aug. 31, 2021

Schneider: 50 eCascadias

Press Releases:

Q2 2021 : HUB Group

Q4 2020 : SCE

Q3 2020 : Knight Swift, J.B. Hunt

DTNA Commercial

DTNA / EPA / CARB / SCE

Q2-2019		EVSE	Vehicles		

Q2-2025

Objectives -

Commercial Roll-out of eCascadia and eM2

Four Fleets ; 20 eCascadia's ; 15 eM2's

Infrastructure install assistance / SCE funds

Project Cost: $12.5 million

- DTNA ($3.3 MM), EPA TAG ($4.2 MM)
- HVIP/SCE/DTNA ($5.3 MM)

US. FOODS SCHNEIDER J.B. HUNT Ryder Ever better.

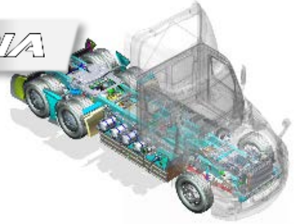
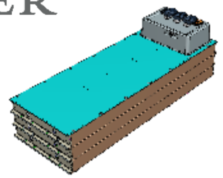
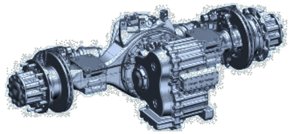
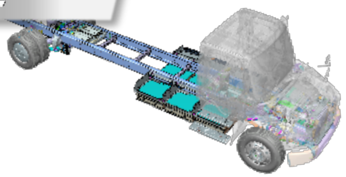
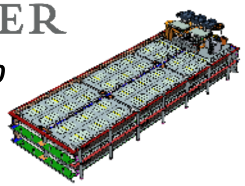
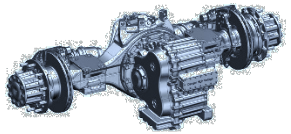
eCascadia
Functional Product Requirements

DTNA Commercial
DTNA / EPA / CARB / SCE

- Range capability: 250 miles per day
  - Achieve 2.0 kWh/mile
  - Redesign 500-550 kWh battery back system
  - Ultra-efficient integrated e-axles
  - Reduce curb weight to ~20,000lbs
  - Lighter battery packaging
- Enhance motor design, software, telematics, weatherization and diagnostic systems custom designed for electric trucks
- Provide a life-cycle cost-effective and zero-emission freight movement solution for more than 70% of use cases

Prototype to Commercial Changes
Drivetrain and Batteries

DTNA Commercial
DTNA / EPA / CARB / SCE

	Vehicle	E/E Platform	Battery	eAxle
ELECTRIC INNOVATION FLEET	eCASCADIA 	Current Cascadia	Agility® ROMEO POWER™	ZF 
	eM2 	Current M2	XALT Energy; Cummins + EFFICIENT DRIVETRAINS; Agility® ROMEO POWER™	MERITOR.  AXLETECH ELECTRIC VEHICLE SYSTEMS 
Series Production	eCASCADIA 	ACTROS GEN2 CEEA+ 	DAIMLER *EVA2/ CB401* 	DAIMLER *Re440* 
	eM2 		DAIMLER *EVA2/ CB400* 	DAIMLER *Re440L* 

eCascadia

Infrastructure

DTNA Commercial
DTNA / EPA / CARB / SCE

US Foods (La Mirada)

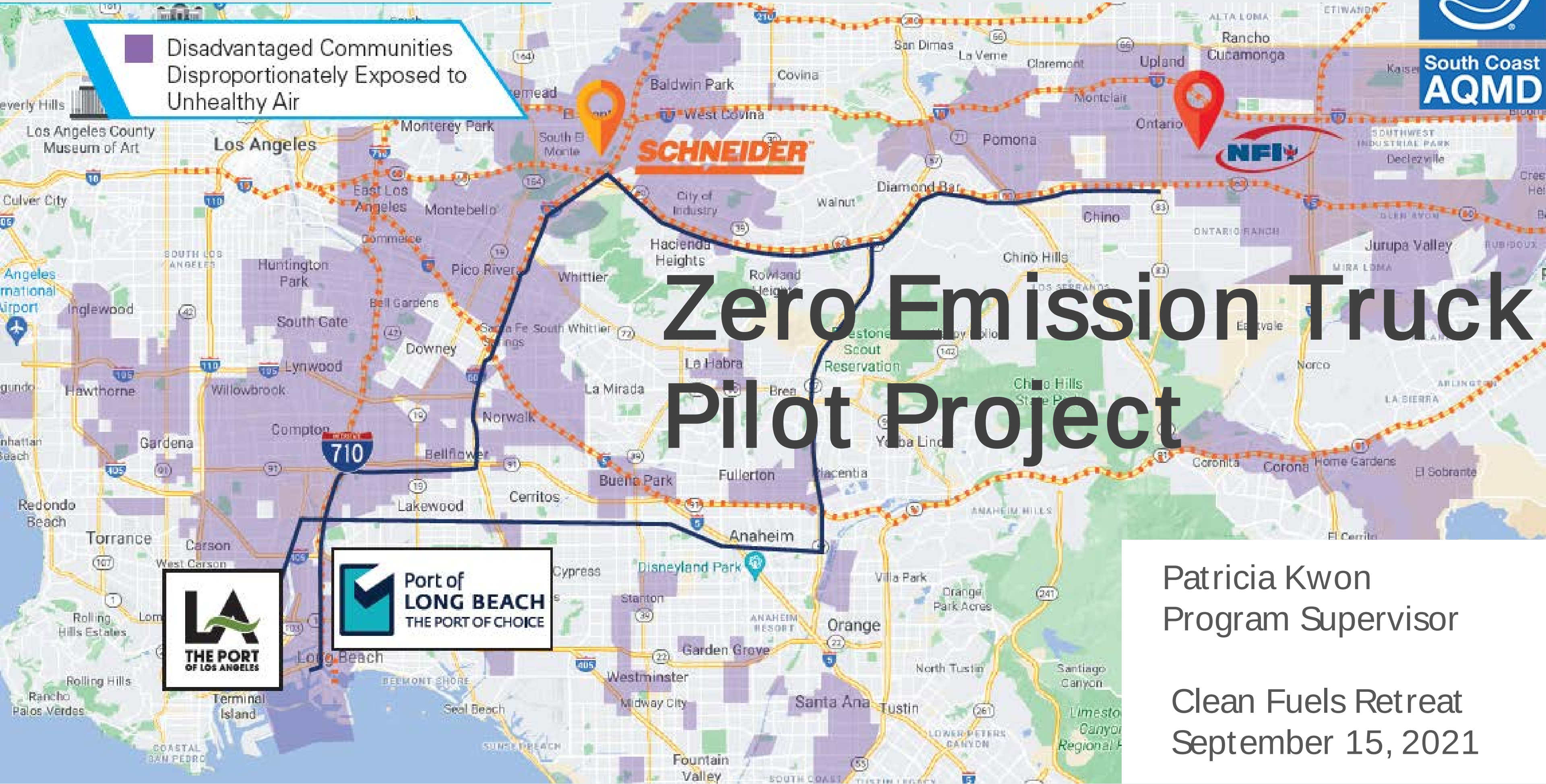
- Site preparations underway
- Trenching options being explored
- EVSE three-part Phase-in through 2024:
  - three power modules;
  - 50 charging dispensers
  - 3.6-4.5 MW
- First vehicles expected in Q2 2022

Daimlers' "Electric Island"
in Portland, OR

"The site is built to immediately provide charging for EVs of all shapes and sizes, and will serve as an innovation center, allowing both PGE and DTNA to study energy management, charger use and performance, and, in the case of DTNA, its own vehicles' charging performance."

Thank You

Zero Emission Truck Pilot Project



South Coast AQMD

Patricia Kwon
Program Supervisor

Clean Fuels Retreat
September 15, 2021

Project Overview

CALIFORNIA
JOINT ELECTRIC TRUCK SCALING INITIATIVE

South Coast AQMD awarded $27M from CARB and CEC to deploy 100 commercial Class 8 BETs and EVSE

- 50 trucks per fleet (Ontario, South El Monte)
- Fleets heavily utilize I-710 freight corridor
- Located and operate in DACs
  - Drayage & regional short haul
  - Leverage past & on-going demonstrations
  - ZEV workforce plan & training courses
  - Community and stakeholder outreach
  - Data collection, analysis, fleet tools

	NFI	Schneider
Duty Cycle	Drayage	Drayage & Regional Haul
Number of Trucks	50*	50*
Number of Chargers	34	16
Solar	1 MW	
Battery Storage	5 MWh	
Truck Deployment	10 BETs Q2 22 40 BETs Q1 23	10 BETs Q4 22 40 BETs Q2 23
Fleet Location	Ontario	South El Monte

*Volvo and Daimler Class 8 battery electric trucks are CARB and EPA certified

Project Goals

CEC/ CARB project goals

- Advance Class 8 BET technology
- Assess feasibility of 50 trucks each at fleets
- Support economies of scale for OEMs
- Achieve criteria and GHG emission reductions
- Compliance with CARB regulations
- Address concerns of residents in DACs

South Coast AQMD and partner project goals

- NOx reductions towards attainment
- Compliance with ISR regulations
- Transition to zero emission at Ports and fleets
- Analyze infrastructure and grid impacts

Project Benefits	NFI	Schneider
NOx, ROG, PM10 Weighted Reductions (tpy)	2.45	2.55
CO_2 reductions (MT/ year)	3,823	3,984
Jobs Created/ Retained	70	30
Solar CO_2 reductions (MT/ year)	440	--

*Emission reductions based on current fleet truck age and VMT

Deployment at NFI

NFI will deploy in Ontario (drayage)

- 50 Daimler and Volvo BETs
- 34 175 kW and 350 kW DC fast chargers
- 1 MW solar
- 5 MWh battery energy storage

ABB chargers at NFI

Solar/ storage

Volvo and Daimler BETs

Deployment at Schneider

Schneider will deploy in South El Monte (regional haul)

- 50 Daimler BETs
- 16 175 kW and 350 kW DC fast chargers

Power Electronics NB Station at Schneider

Daimler BETs

Project Costs by Fleet

Task	NFI	Schneider	Subtotal
Class 8 battery electric trucks	$21.7M	$19.2M	$40.9M
Chargers	$6.9	$7.3	$14.2
Solar	$2.0	--	$2.0
Energy Storage	$2.0	--	$2.0
Maintenance Facility	$2.0	--	$2.0
Project Total	**$34.6M**	**$26.5M**	**$61.1M**

Project Funding

	Amount	Percent
CARB	$16.0M	24%
CEC	$11.0M	16%
NFI	$9.5M	14%
Schneider/ DTNA	$8.7M	13%
MSRC	$8.0M	12%
South Coast AQMD	$5.4M	8%
SCE	$5.0M	7%
POLA	$1.5M	2%
POLB	$1.5M	2%
Project Total	**$66.6M**	**100%**

Other Project Partners

- Daimler/ Volvo: BET OEMs
- Black & Veatch, Electrify Commercial, Power Electronics: EVSE partners
- Ricardo: data collection on trucks, fleet analysis
- CALSTART: charger pricing, fleet case studies
- EPRI: charger performance, fleet uptime dashboard
- UCR CE-CERT: BET eco-routing
- GNA: media/ communications, ZEV workforce plan, EVSE support
- LACI: ZEV workforce plan, workforce performance metrics, stakeholder outreach
- CCA: DAC outreach
- Rio Hondo and San Bernardino Valley College: BET education and training partners

Timeline

CALIFORNIA
JOINT ELECTRIC TRUCK SCALING INITIATIVE

Trucks

EVSE
DER

Data Collection

DAC Outreach

Stakeholder Outreach

Final Report

BET Eco-Routing
Charger Pricing
Charger Performance
Fleet Case Studies
Fleet Uptime Dashboard

ZEV
Workforce
Plan

Media & Communications

2021 | 2022 | 2023 | 2024 | 2025

South Coast AQMD

Project Benefits

- Demonstrate feasibility of large BET deployments
- Better understand fleet needs
- Develop fleet tools for transition to BETs
- Drive technology improvements in electric range and fast charging
- Address equity and scale priorities in DACs near Ports and goods movement

5 Weighted Tons

of criteria pollutants will be avoided each year by displacing diesel

8,200 Metric Tons

of greenhouse gas emissions (GHGs) will be reduced each year

5.5 Million DGEs

of diesel fuel will be displaced over the eight-year project

239 Long-Term Jobs

sustained, including drivers and service technicians

$16.8+ Million

in regional economic activity as result of site construction

Next Steps

- Kick-off meeting Sept 2021
- Execute remaining contracts
- Develop data collection plans on BETs, EVSE, specialized studies
- Refine infrastructure deployment at fleets
- Update BET deployment at fleets
- Work on stakeholder and DAC outreach plans
- Finetune workforce training between colleges, fleets, OEM partners
- Develop outline and metrics for ZEV workforce plan

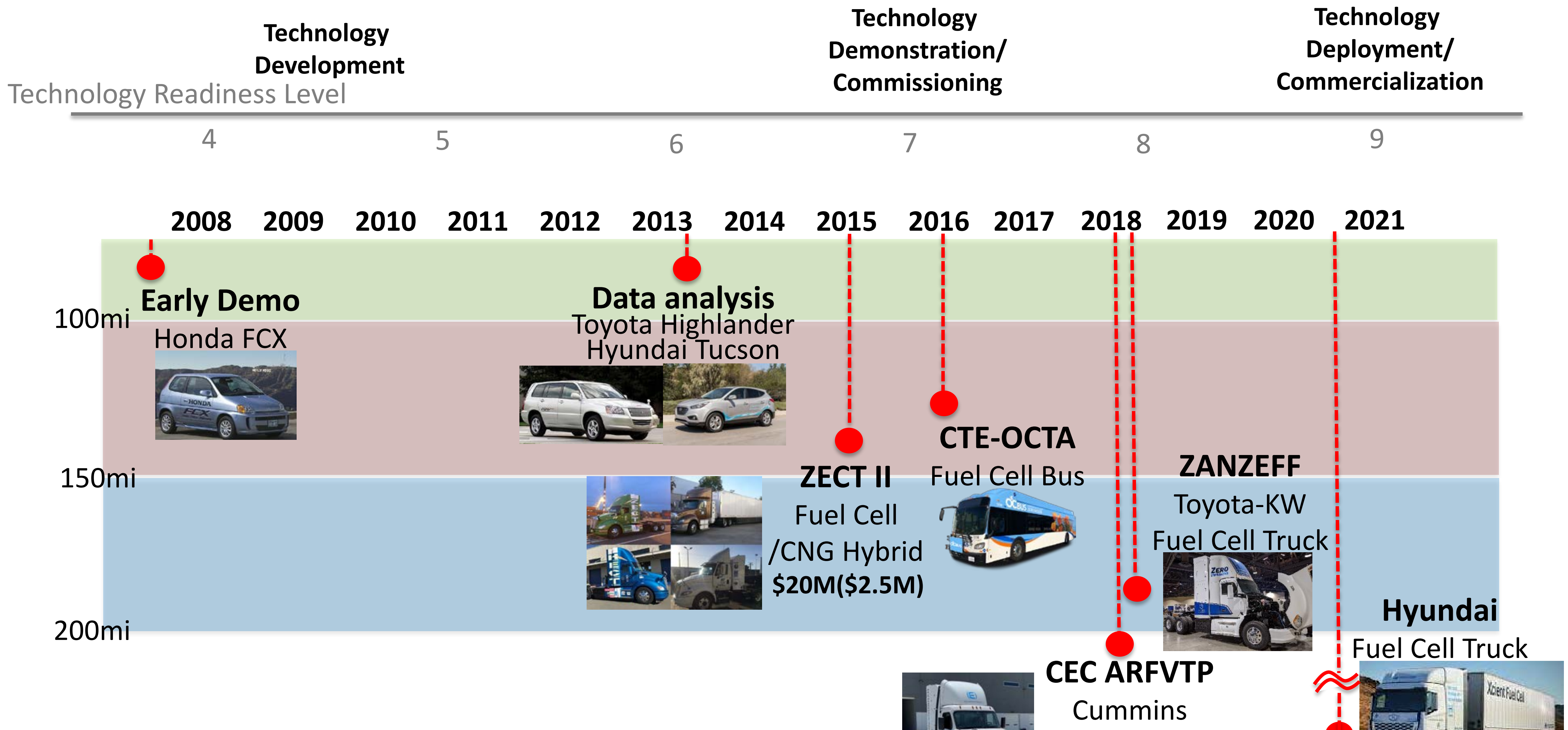
Fuel Cell Heavy-duty Truck Demonstration and Beyond

Technology Advancement Office
Program Supervisor

Seungbum Ha

Clean Fuels Fund Advisory Retreat
Sep. 2021

Zero Emission Fuel Cell Vehicle Project



** $ Total Project Cost(SCAQMD Cost-share)*

US DOE ZECT II

ZECT II Fuel Cell trucks

Developer	BAE/Kenworth	Cummins
Platform	1	Freightliner
Fuel Cell Power	85kW	60kW
Fuel Cell stack	Ballard	Hydrogenics
Battery Capacity	100 kWh	100kWh
Range (per fueling)	120 miles	150 miles
Fuel Cap.: H2 (kg)	30 kg @350 bar	30 kg @350 bar

- Up to 250miles range
- 700bar H2 tank

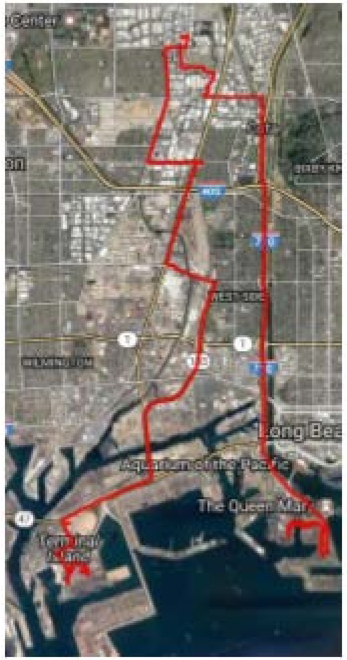
ZANZEFF
Toyota-KW
Fuel cell Truck

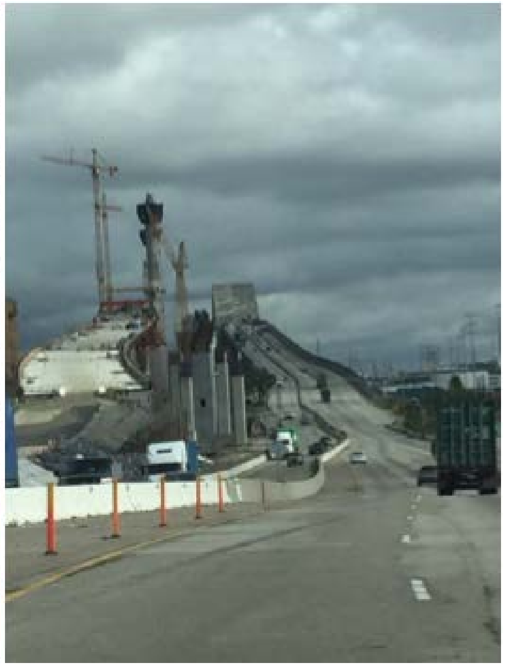
CEC ARFVTP
Cummins
Fuel cell Truck

US DOE ZECT II - Specification

System Design

- Two electric motors with 270 kW combined power output - comparable to a current Class 8 truck engine's power output.
- 100 kWh Li-ion batteries,
- 85 kW (net) fuel cell system
- Hydrogen storage capacity is 30 kg (25 kg usable)





Target Performance

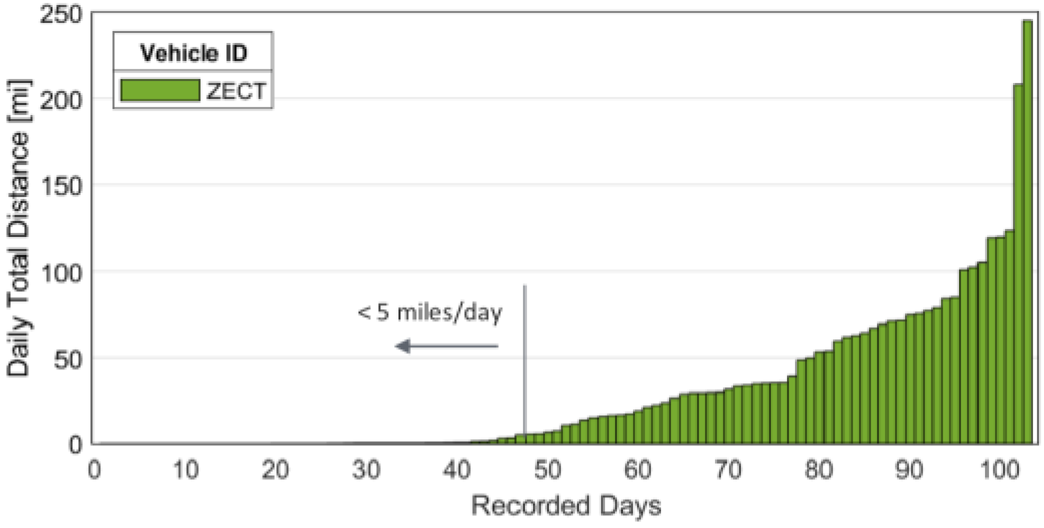
Performance Parameters	Expected Performance*
Fuel Economy	4.5 to 6.0 mi/kg
Hydrogen Storage	30 kg storage and 25 kg usable
Range	112 miles
Gradeability and Start-ability	6.5% grade at 35 mph 5.0% grade at 40 mph 15 second start-ability at 30% grade
Top Speed	70 mph
Operating Temperature	-4 F (-20 C) to 115 F (46 C)

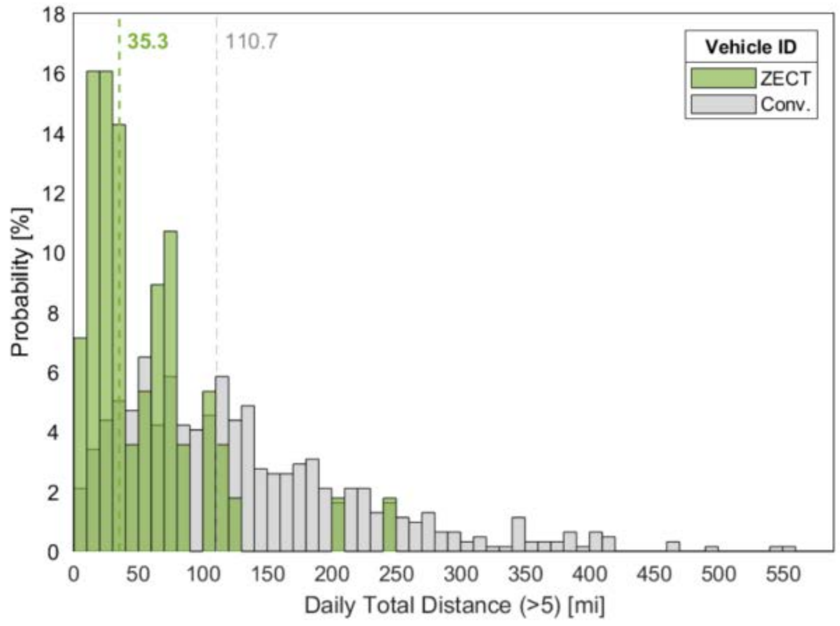
* Note: All performance parameters tested with a vehicle GVW of 65,0000 lbs.

US DOE ZECT II - Demonstration

Vehicle In-service Operation

- Over a 24-month demonstration on regularly scheduled routes, I-710 freeway in the ports and I-10/CA-60 corridor in Los Angeles
- NREL - Detecting overall trends and spotting days of service, more specific to the operator, TTSI





South Coast AQMD

US DOE ZECT II

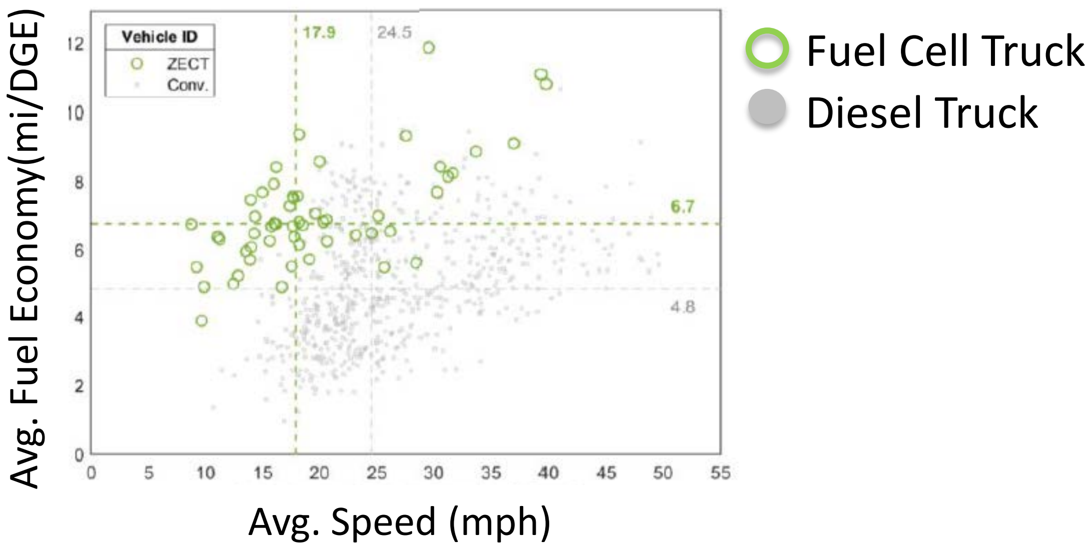
- **Fuel cell truck performed a higher efficiency compared to the baseline vehicles**

Metric	Units	Baseline* Conventional	Kenworth ZECT
Date range		2014–2015	6/13/2019 – 1/15/2021
Number of total days recorded	#	557	103
In-service days with >5 miles	#	—	56
Max daily distance	mi	—	245.2
Avg daily distance	mi	127.9	53.9
Avg operating time (key-on)	hr	10.1	6.9
Avg driving time	hr	4.5	2.6
Avg speed	mph	14	8.4
Avg driving speed (speed>0)	mph	26.5	20.0
Kinetic intensity	1/mi	0.64	1.1
Avg stops/day	#/day	124.9	176.1
Avg stops/mi	#/mile	1.38	4.7
Median stop duration	sec	40.8	7.4
Avg daily fuel use (H_2)	kg	—	8.4
Avg daily fuel use (diesel equiv.)	gal	23.7	7.4
Avg fuel economy (diesel equiv.)	mi/gal	5.7	6.5
Avg fuel cell efficiency	%	—	52.1%

ZECT II milestone report: Baseline Vehicle Data Collection and Analysis Report – Port Drayage

More Stop-n-Go

Higher fuel economy



US DOE ZECT II - Conclusion

- The largest strides in Technology Readiness Level (TRL) on the overall vehicle design and architecture.

- Improvements to packaging and vehicle control strategies to increase efficiency

- Challenges
  - ✓ Lack of standardization in componentry
  - ✓ Improving reliability across the system
  - ✓ Deploying a larger numbers of vehicles
  - ✓ Reliable H2 fuel supply

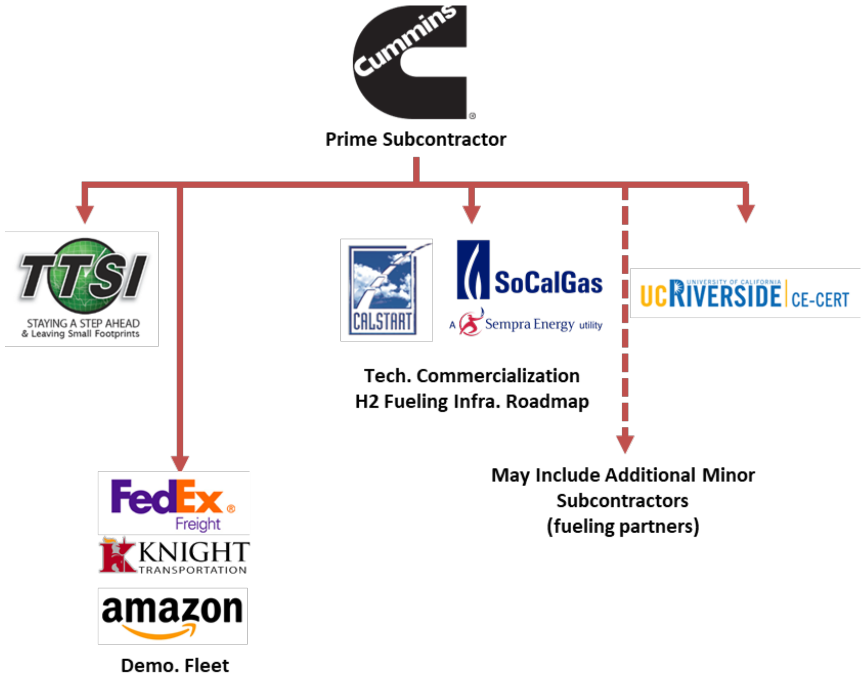
South Coast AQMD

CEC ARFVTP – Cummins Fuel Cell Drayage Truck

- In 2019, Cummins acquired EDI and Hydrogenics
- 4 Fuel Cell Class 8 drayage trucks (200+ mile ZE range)
- Complete and deliver vehicles in 2021 with 12 month demonstration

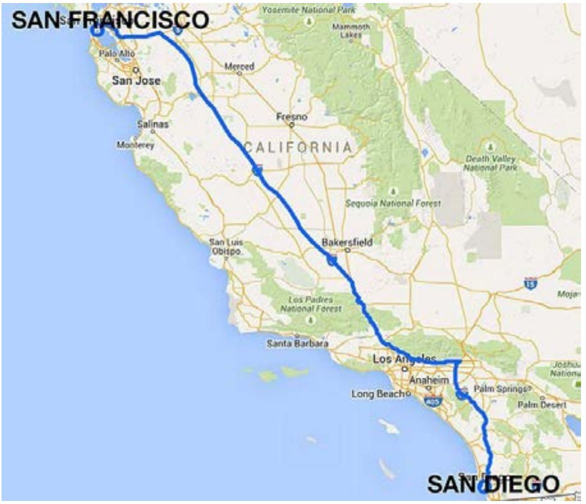
Announcing:
Cummins Acquires Efficient Drivetrains

MY2020 Kenworth T680 Day Cab
82,000 lbs. (Class 8)
Hydrogenics 2 x HyPM HD90 180 kW
Cummins Motor/Inverter w/ 4-speed Trans.
Agility 23.5 kg @ 350 bar
10-15 minutes
150-200 mi. depending on duty cycle
Pilot / pre-production. Commercialization planned in 2022-2023.



Hyundai Fuel Cell Drayage Truck

- Fuel-cell technology is an attractive solution for regional and long-haul services
- The trucks will be demonstrated for 12 months in regional and long-haul routes to fully utilize up to 500-mile range
- South Coast AQMD has been awarded $500,000 from U.S. EPA FY21 Clean Air Technology Initiative Program



Comparison of Technologies

	Pros	Cons
Diesel	• The most common fuel type for decades, so capital costs are low and fueling locations are common • Range only limited by driver's 10 hour driving limit	• Biggest polluter of particulate matter and greenhouse gases • Loud and odorous operation • Relatively high maintenance costs • Being phased out by California and port regulations
CNG	• Less emissions than diesel • Quick refill like diesel • ~ 300 mile range • Fueling infrastructure relatively common • Fuel slightly less expensive than diesel • Quieter operations	• Not zero-emission • Although highly commercialized now, gained a reputation for not being reliable when first entering the market • Emits about 75% as much CO_2 and 10% as much NO_x as diesel trucks
Hydrogen Fuel Cell	• Zero tailpipe emissions • Quick refueling (10 minutes) • Expected 300+ mile range • Quiet operations • Reduced maintenance costs • Possibility for extended range with 700 bar fueling • Torque / acceleration	• **Least commercialized option with fewest vehicles on the road** • **High MSRP** • **High fuel cost** • **Fueling infrastructure not commonly available**

- Hydrogen infrastructure
  - Assessment of feasible pathway for hydrogen fueling in near and long term
  - Renewable hydrogen station
- TCO analysis and commercialization roadmap

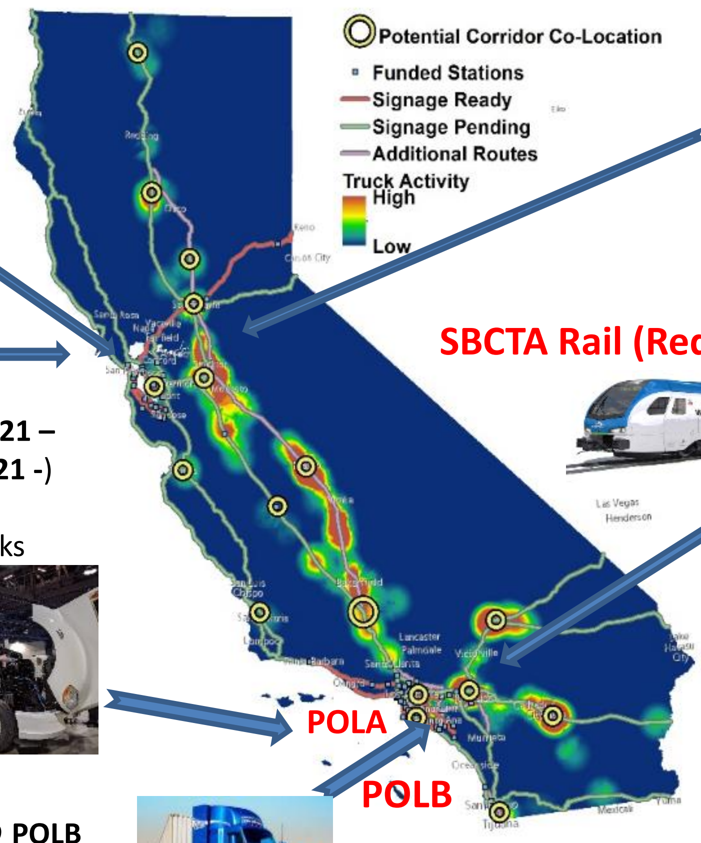
Clean Fuels Advisory Group Meeting
September 15, 2021

Hydrogen Infrastructure for Heavy-Duty Vehicles

Lisa Mirisola
Program Supervisor
Science and Technology Advancement
South Coast AQMD

CA Heavy Duty Hydrogen Stations

HD Truck Infrastructure CaFCP 2030 Vision



A.C. Transit

CEC NOPA 20-606 NorCal Pilot
CTE – First Element, Hyundai
700 bar, 3000 kg/day
2 dispensers, 30 Hyundai CL8 FCT

POLA ZANZEFF
Equilon (**Ontario: August 2021 – Wilmington: September 2021** -)
350 & 700 Bar, 1000 kg/day
10 Kenworth Class 8 FC Trucks

US EPA – SCAQMD
2 Hyundai Cl8 FCT

CEC ARFVTP
Cummins
Fuel Cell truck

US DOE ZECT1, ZECT 2,

CEC NOPA 17-603
Equilon, Toyota @ **POLB**
July 2021 -
350 & 700 bar, 1000 kg/day

(Photo: Toyota Red=Alpha & Blue = Beta)

CEC NOPA 20-604 H2RAM
GTI – Equilon, FCT &
Sierra Northern H2 Locomotive

SBCTA Rail (Redlands Arrow route) MSRC$ 2024+

Nel H2 – Proton
2020 + (est 2002)
350 bar, 900 kg/day
2 dispensers

SunLine Transit*

UC Irvine
Upgrade to LH2 delivery
2022+ (est. 2005)
800 kg/day, 700 bar LD,
350 bar FC Bus (at night)

OCTA
Trillium, APCI LH2 delivery
February 2020 -
350 bar, 1600 kg/day
10 New Flyer, 36 kg/bus

A Vision for Freight Movement in California – *and Beyond*

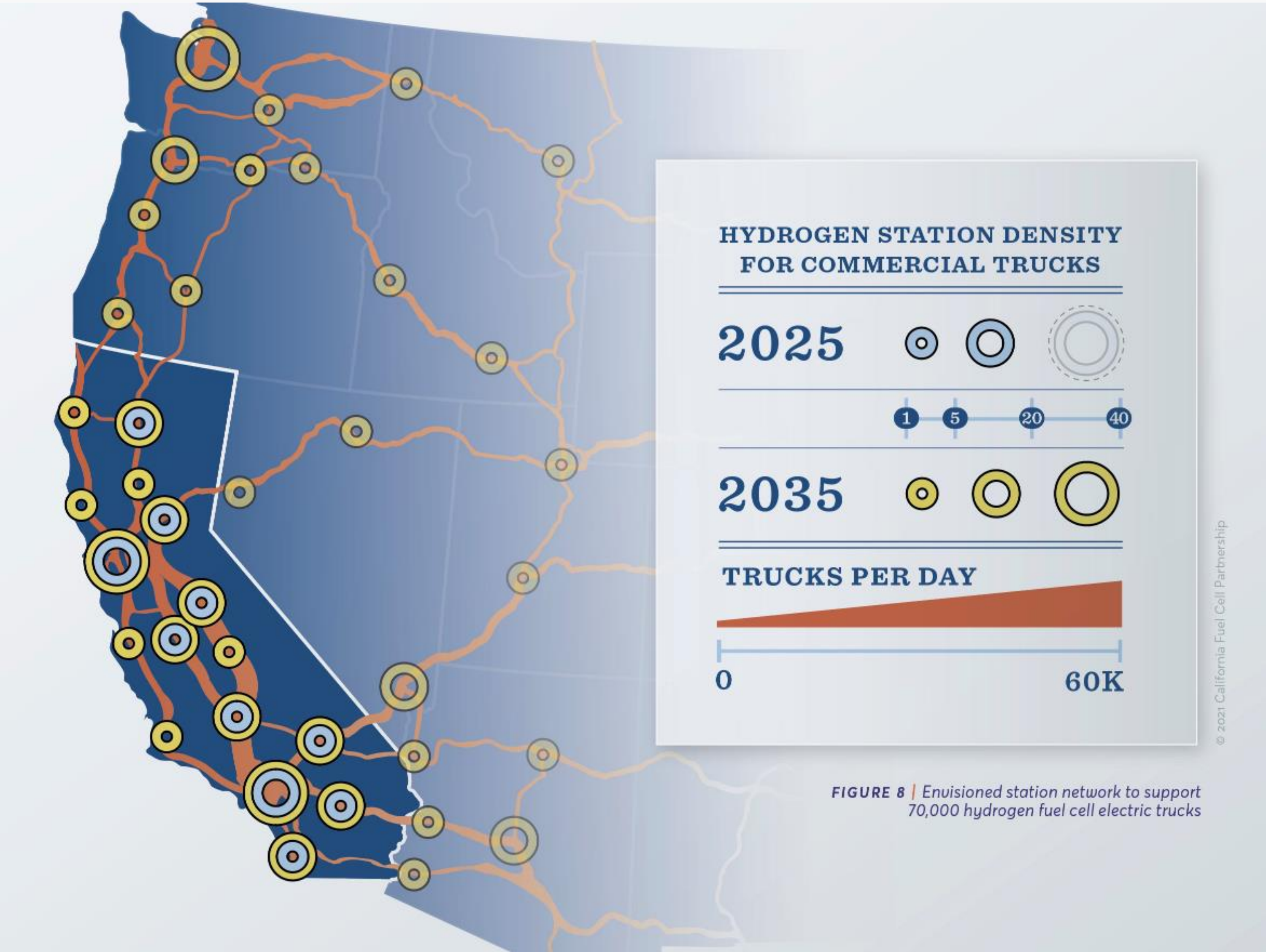


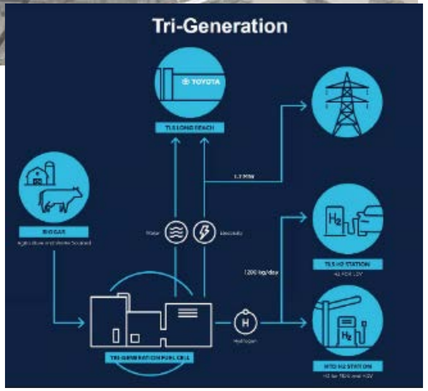
FIGURE 8 | Envisioned station network to support 70,000 hydrogen fuel cell electric trucks

H2Freight Project at POLB

- CEC GFO-17-603 - Advanced Freight Vehicle and Infrastructure Deployment:
- CONTRACTOR: Equilon (dba Shell)
  Station at POLB (property leased to Toyota)
- 1,000 kg/day truck refueling with multiple fueling positions at 700 bar
- SCAQMD cost-share to refuel heavy-duty vehicles at 350 bar for demonstration by multiple operators
- **Commissioned & Open July 2021**
- Evaluate fueling protocols, dispenser design, station throughput/reliability, etc.







Zero Emissions Freight "Shore to Store"

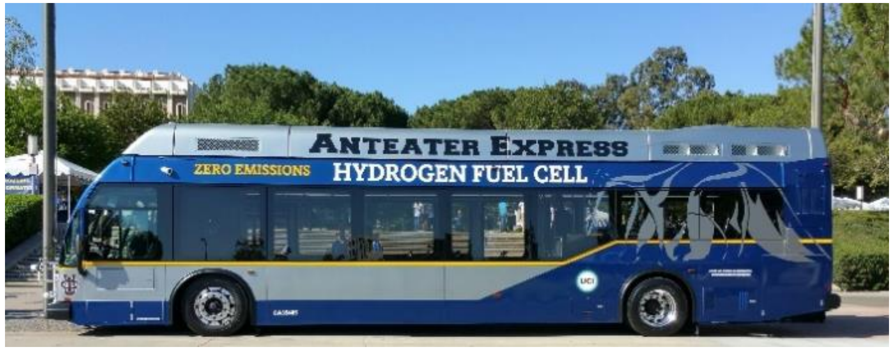
- Contractor: POLA
- Total $82.5M ZANZEFF
- Develop and demonstrate ten fuel cell trucks (Class 8 Kenworth T680 with Toyota fuel cells)
- H2 stations in **Ontario** & Wilmington (Shell Equilon)
- **All 10 FCET in revenue service (August 2021)**
  United Parcel Services (3),
  Total Transportation Services Inc (2),
  Southern Counties Express (1),
  Toyota Logistics Services (4)

UC Irvine Hydrogen Station Expansion

South Coast AQMD

Clean Transportation Funding from the MSRC

- Expansion to 800 kg/day with liquid delivery, increased storage, and four fueling positions
- Public access will continue 24/7, with bus refueling at night
- Co-funding approved & contracts executed
  - MSRC for up to $1M (PON 2018-02)
  - CEC $400k (ARFVTP)
  - SCAQMD $400k (Clean Fuels)
- Equipment will be moved to new location on UCI property (at UCI expense), then upgraded



California HD Hydrogen Infrastructure Research

- U.S. DOE H2@Scale program with national labs, CA GO-Biz, CEC, CARB and SCAQMD
- Joint agreement led by NREL to continue hydrogen infrastructure research efforts 2021 – 2022
- Priorities

  H2 Contaminant Detector
  Heavy duty reference station design
  Heavy duty station test device design
  Heavy duty station capacity

California High Flow Bus Fueling Protocol

- U.S. DOE H2@Scale program with national labs and project partners to apply MC fueling protocol developed for light-duty vehicles to heavy duty vehicles (H35HF)
- Frontier Energy agreement led by NREL
- Project tasks (2021 – 2022)
  - Bus Fueling Protocol Modeling & Simulation
  - Protocol Test & Validation @ NREL
  - In-use demonstration @ Sunline Transit

Hydrogen Systems Analysis

- UC Davis
- Co-Sponsors including, but not limited to Aramco, CEC, GM, Honda, Hyundai, Leighty Foundation, Shell, So Cal Gas and Toyota.
- Project tasks (2021 – 2022)
  - Analyze and model hydrogen's role in a carbon-neutral system of transportation, industry and energy storage through 2050 in California and beyond;
  - Assess existing policies to identify gaps over the next 5-10 years; and
  - Study the role of hydrogen and other storage including vehicle-to-grid (V2G) and power-to-gas (P2G) in grid serving both fuel cell and battery electric vehicles.

SBCTA Rail

[San Bernardino County agency orders its first zero-emission train for Redlands rail service](https://www.gosbcta.com/project/redlands-passenger-rail-project-arrow/)
BY STEVE SCAUZILLO
November 15, 2019 at 4:07 pm

- Michigan State University (MSU) feasibility study
- Approved the hydrogen fuel cell-battery hybrid alternative propulsion technology for implementation as part of the future Arrow Service
- **Potential site of joint use hydrogen station,** west of 215 fwy, between 10 & 210 fwys
- 2024 Zero Emission in-service goal
- **MSRC awarded $1,662,000 co-funding under PON 2018-02 (June 2021)**

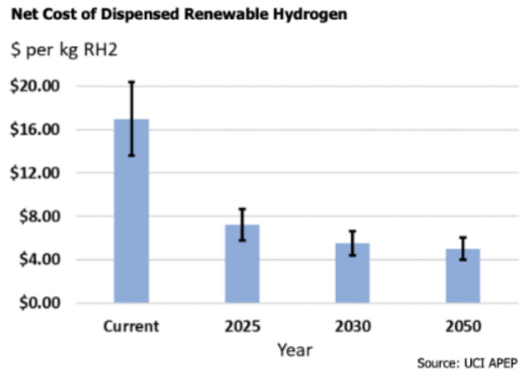
https://www.gosbcta.com/project/redlands-passenger-rail-project-arrow/

Hydrogen Shot Summit

Goal: 80% Cost Reduction of Clean Hydrogen
($1 per kg in 1 decade)

DOE Hydrogen Shot Summit 2021 Topics

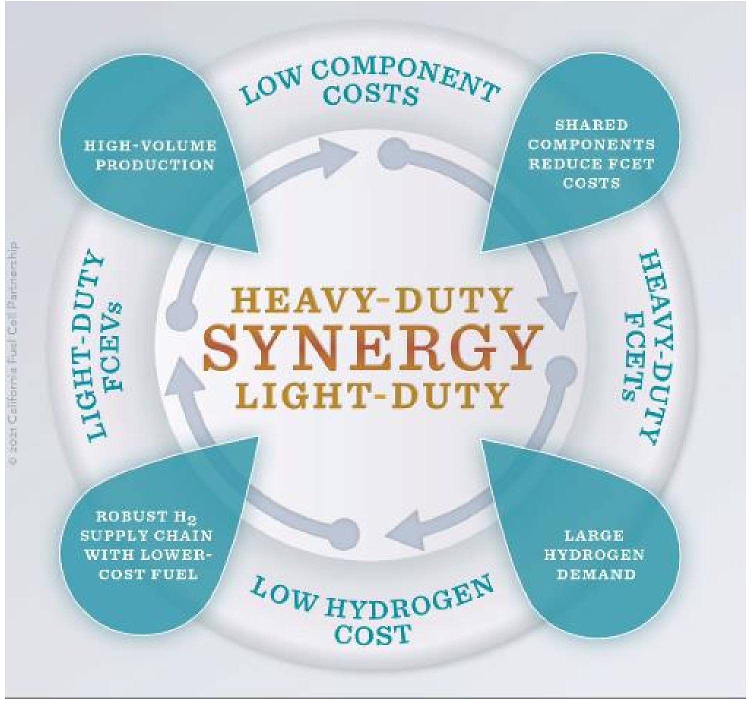
- Electrolysis
- Thermal Conversion with Carbon Capture and Storage
- Advanced Pathways
- Deployment and Financing



https://www.energy.gov/eere/fuelcells/hydrogen-shot-summit

Infrastructure Challenges & Opportunities

- Policy & funding predictability
  Coordination across all gov levels
- Supply Chain: H2 Production,
  distribution, parts, materials,
  Need multiple suppliers & scale
- Skilled labor, workforce training
- Focus on safety always; codes & standards
- CEQA/Permits
- Site specific development & operational issues
- Increasing capacity stations are starting to reduce dispensed cost; working on refined HD fueling protocols to become "Recommended Practice"
- Address short-term H2 network fragility
- Increase renewable H2 production dedicated to transportation



CaFCP: 2021 HD Vision

Heavy-Duty Engine Development and Beyond

NOx Target ≤ 0.02 g/bhp-hr

Joseph Lopat

September 15, 2021

South Coast AQMD

Achates Opposed Piston Engine

- Increased TRL diesel engine development
- 0.02 NOx results with less complicated aftertreatment
- Integrated into Peterbilt chassis.

South Coast AQMD

Achates Demonstration

- Beginning Demonstration
- Walmart revenue service
- In-use emissions testing

Low NOx Diesel Projects

Project	Expected end date	Expected Results	Funding agency
Low NOx conventional diesel	2022	0.02 NOx	South Coast AQMD, CARB, US EPA, MECA
Final Aftertreatment Selection	2021	800,000 miles aged at near 0.02 NOx	CARB, US EPA
Low NOx hardware studies	2022	Supporting low NOx	CARB, US EPA
Final assessment and testing	2022	Determination of new standards for emissions	CARB, US EPA
Demonstration of near-zero NOx engine in class 8 truck	2022-2023	In-use testing at 0.02 Nox	Potentially South Coast AQMD, CARB, MECA, Peterbilt?

South Coast AQMD

Continuous Development Toward Lowering NOx (2021-2022)

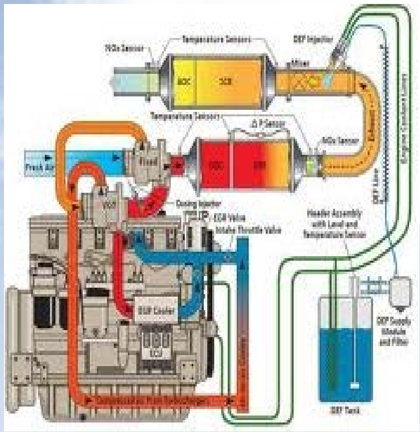
- Cummins Cylinder Deactivation 15L ISX
  - ➢ 0.02 NOx results
  - ➢ Final selected aftertreatment configuration
  - ➢ Aftertreatment durability

  Tested to maintain near 0.02 NOx at 800,000 miles useful life

South Coast AQMD

Low NOx Hardware Studies (2021-2022)

Target is any engine and/or exhaust after treatment development that has the potential to attain a NOx emissions of 0.02 g/bhp-hr or lower.



- Exhaust Gas recirculation
- Turbo and supercharger advancement
- Cold ambient air and wind speed testing
- Expectation in-use 2021-2035 0.04 NOx

South Coast AQMD

Low NOx Engine Demonstration in class 8 truck(2022)

- Final data collection in September 2022
- Down selected hardware and engine for chassis integration
- Demonstrate low NOx diesel technology
- Renewable Diesel
- 0.05 NOx capable diesel technology for market 2027
- 0.02 NOx capable diesel technology for market 2030

South Coast AQMD

Potential Natural Gas Future Projects

- Certified 0.02 NOx
- 12-liter class 8 drayage trucks
- 9-liter for refuse haulers and buses
- On-going class 6-7 projects Ford 7.3
- 15-liter development
- RNG
- Infrastructure

South Coast AQMD

Market Acceleration Program

- Launched in July 2020
- Port trucks only
- 40 class 8 CNG powered trucks ordered
- Award amount $100,000/truck
- 40 2014 and older diesel trucks scrapped
- Streamlined process
- $4 million funding available
- 2021-2022 truck delivery

South Coast AQMD

Trade Down Pilot Program

- Launched in Fall of 2020
- 50 CNG replacements expected - Port trucks only
- Fleet 1 - EMY 2014 or newer diesel traded in
- Fleet 1 - Award amount $100,000 + $25k for trade-in to purchase low NOx truck
- Fleet 2 – EMY 2009 or older for scrapping
- Fleet 2 – Purchases the trade-in for $30k
- Dealership matches fleets/packages application
- $5 million funding available from EPA and MSCRC

South Coast AQMD

Questions

200 Vehicle In-Use Emissions Testing Program Update

Clean Fuels Advisory Group | Sam Cao - Air Quality Specialist | September 2021

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), Propane 0.02 (2), CNG 0.02 (34), CNG 0.2 (84), Non SCR Diesel (7), Diesel 0.2 (70), Diesel-Hybrid (6), BEV (10), FCEV (1), HDPI (4), RD (12)

Testing Phase Update

Testing Phase	Assigned	Recruited	Completed
Portable Activity Monitoring System (PAMS)	200	219	206 (Complete)
Portable Emissions Measurement System (PEMS)	100	100	98
Chassis Dynamometer	60	62	60 (Complete)
Real-World In-Use Trailer	10	10	8

- Analysis & reporting in progress
- Target testing completion - 3Q2021
- Target report completion - early 2022

Testing Elements of This Study

This Update

New Chassis Test Cycle

Route Information

PAMS
Activity, Average Speed, VMT, Idle, Starts

PEMS
Real-World Data, NTE/WBW, Start/Running Emissions

Chassis
Lab Grade Data, Real-Word Cycles Start/Running Emissions

On-Road
Real-World Lab Grade Data, NTE/WBW Start/Running Emissions

Emission Inventory

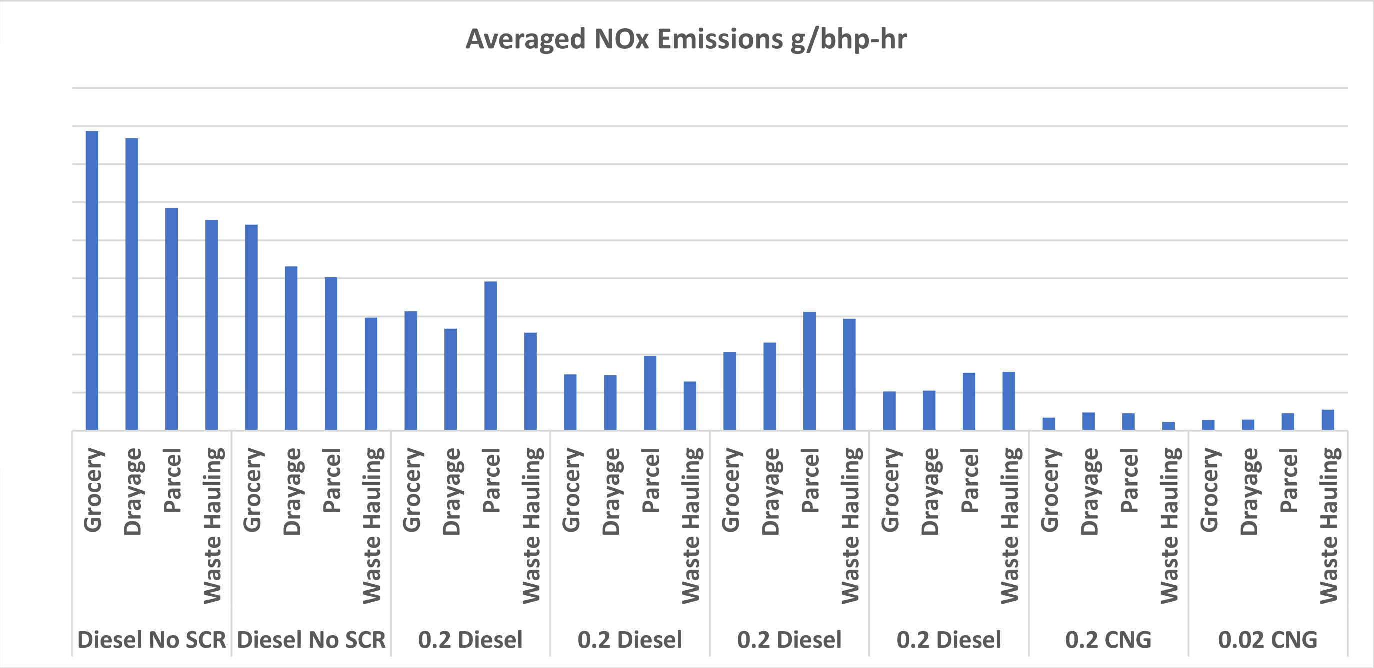
On-Road Testing Matrix

- Test cycle generated from on-road telemetry data (PAMS) w/actual segments and statically representative cycle similar to chassis cycles (Markov method)
- 10 vehicles, equally shared between WVU and UCR
- On-road tests: repeatable duty-cycle, lab-grade equipment but limited to class 7/8 tractors only, GVWR 65,000 – 68,000 lbs

Technology	Grocery	Drayage	Parcel	Waste
No SCR Diesel (2)	x	x	x	x
0.2 Diesel (4)	x	x	x	x
0.2 CNG (1)	x	x	x	x
0.02 CNG (3*)	x	x	x	x

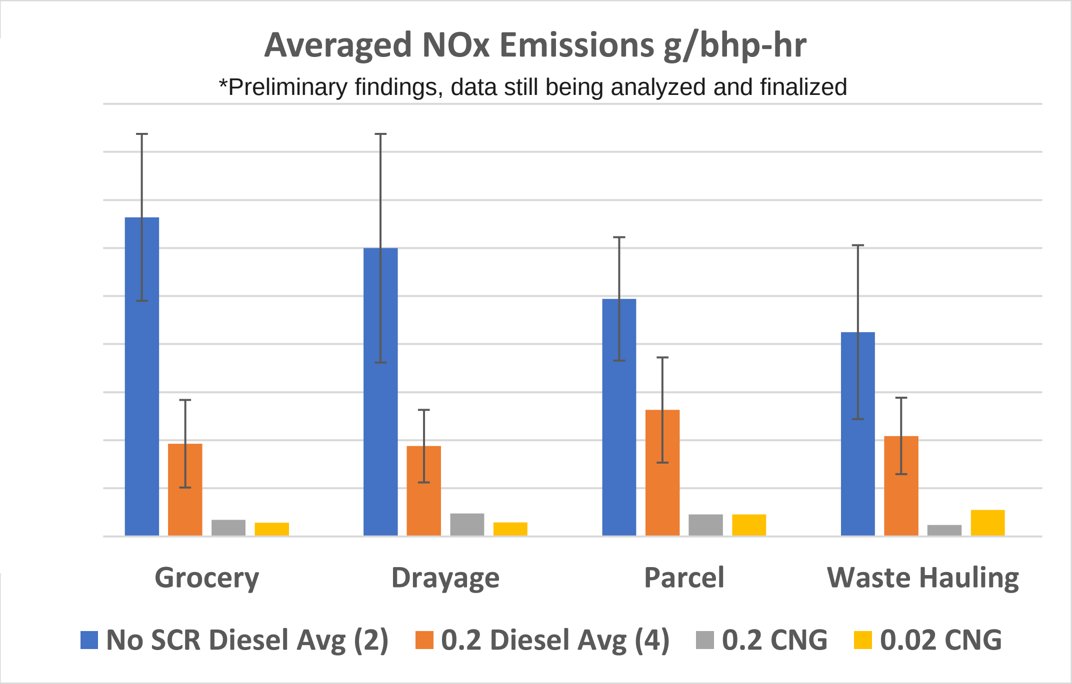
Overall Preliminary Findings

- 8 trucks, NOx emission averaged over the entire route, each route 4-9 hours long
- Is comparing to the standard best way to assess emissions?



Technology Comparison Show Lower NOx for CNGs

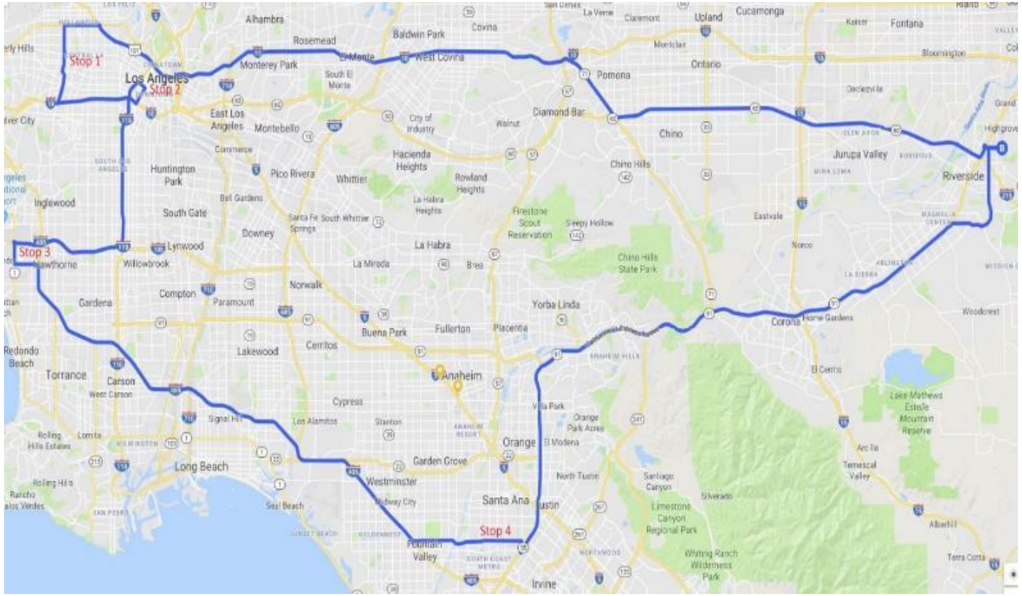
- CNGs significantly lower NOx compare to 0.2 diesel baseline
- 0.2 CNG very low NOx (<0.1 g/bhp-hr)
- 0.02 CNG higher NOx on parcel & CR&R route, data still being verified
- 2 additional 0.02 CNGs to be tested
- Segmented analysis later



Grocery Delivery Truck Route ("Ralphs" Route)

- Representing typical operation of grocery from IE warehouse to LA supermarkets, using telemetry data from 23 trucks

Parameter	Unit	Value
Duration	[hrs]	9.35
Distance	[miles]	185.6
Idle	[%]	37.4
Urban (≤31mph)	[%]	30.9
Rural (>31 & ≤46.6mph)	[%]	10.8
Highway (>46.6mph)	[%]	20.9



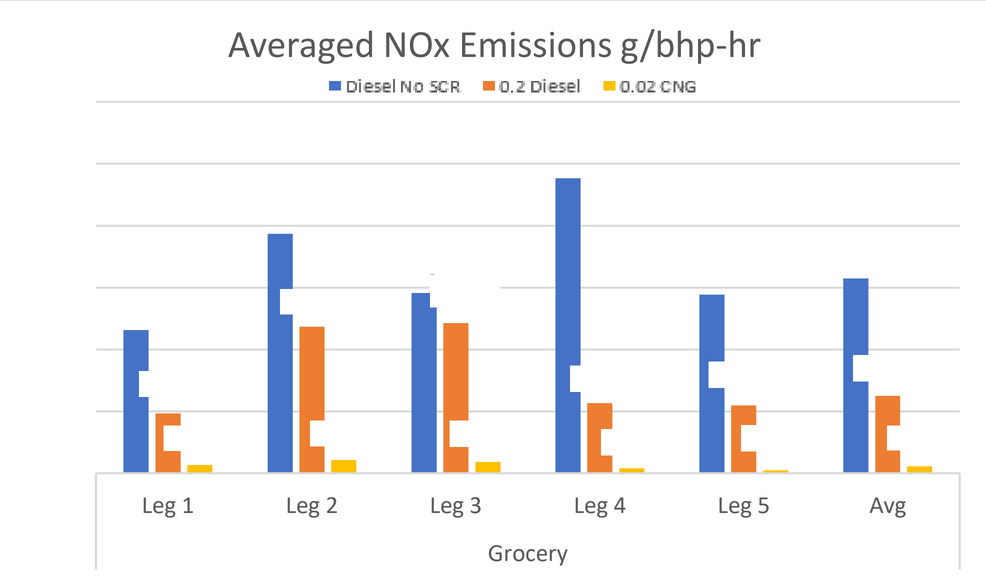
Grocery Delivery Truck Route ("Ralphs" Route)

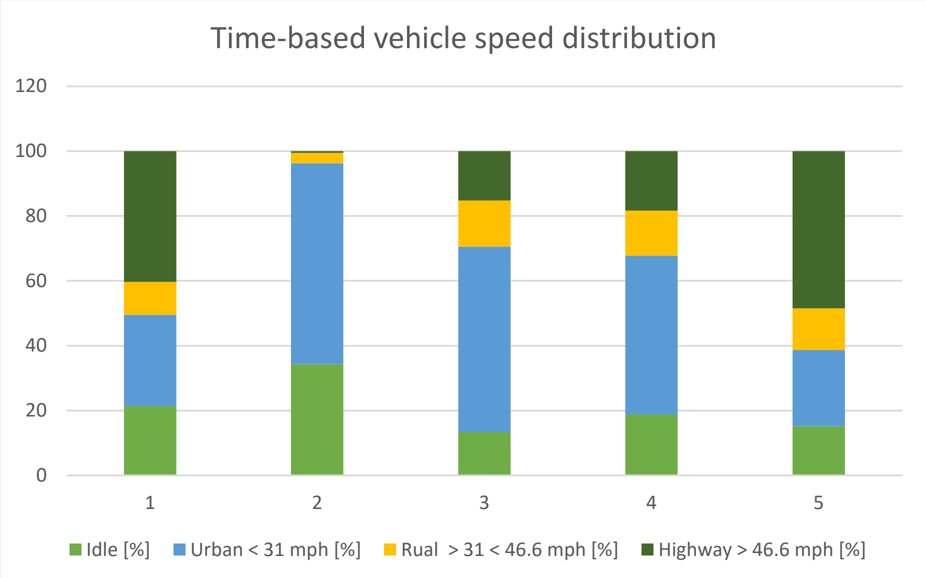
- Route has 4 stops (5 segments/"legs") at stores to unload goods, engine off events of about 30min duration

Segmented Emissions – Grocery Route

Idle	Vehicle Speed <= 1 mph
Urban	31 mph>Vehicle Speed > 1 mph
Rural	46.6 mph > Vehicle Speed > 31 mph
Highway	Vehicle Speed > 46.6 mph

- One truck from each technology
- Averaged NOx emissions over each segment/leg (e.g. Grocery Route "Leg 1" = IE to Stop 1 in DTLA)
- The duty cycle vary drastically from one segment to next (so as segmented averaged NOx emissions)



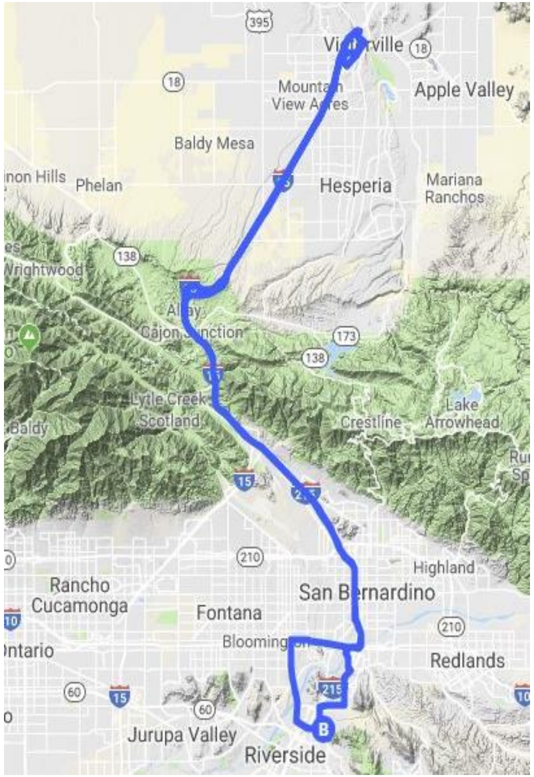


Parcel & Waste Hauling Routes

- Modified versions of "CARB Southern" Route
- Goods movement route with ~ 4,200 ft of elevation change ("UPS" route ~ 115 miles)
- Highway goods movement route ("CR&R" route ~ 179 miles)

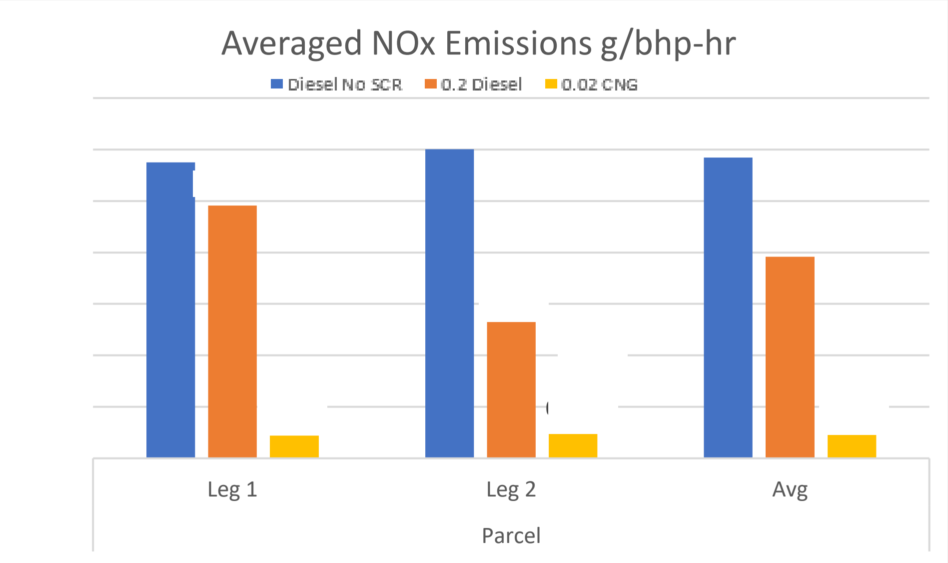
"CR&R" Route

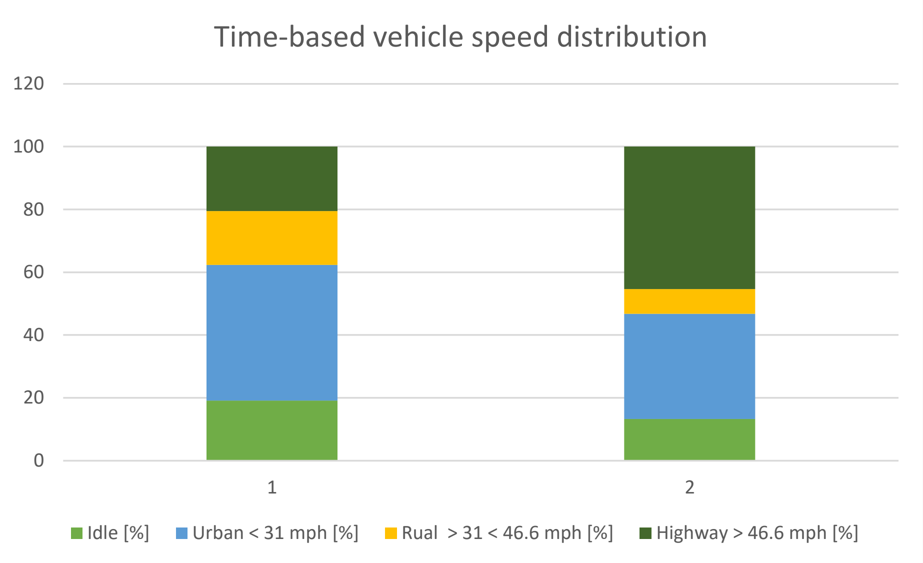
"UPS" Route



Segmented Emissions - Parcel

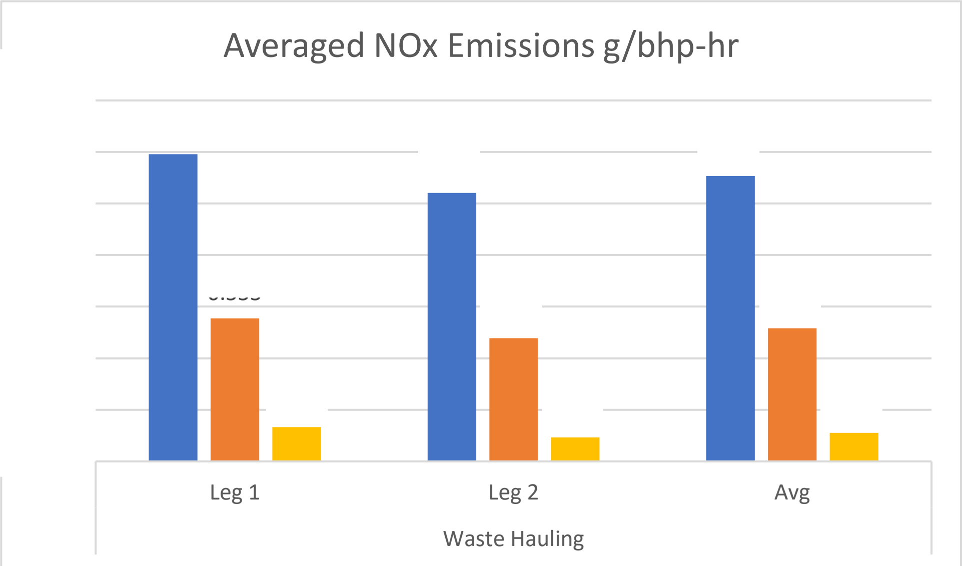
- Elevation change ~ 4,200 ft
- 0.2 diesel drastically different segmented NOx emissions between leg 1 (traffic or cool-off?) and leg 2
- 0.02 CNG + NO SCR Diesel did not show segmented dependency on NOx emissions
- Traffic conditions impacts NOx emissions even on same route

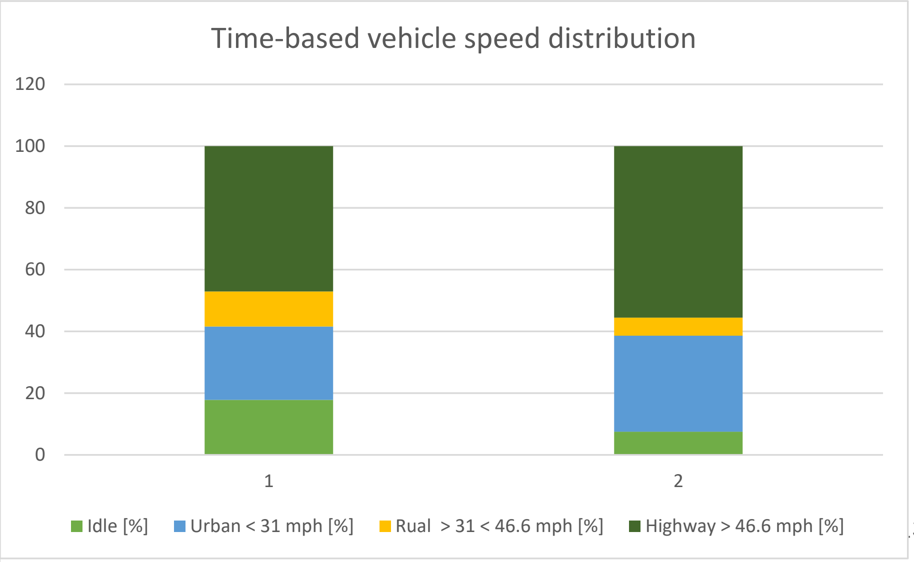




Segmented Emissions – Waste Hauling

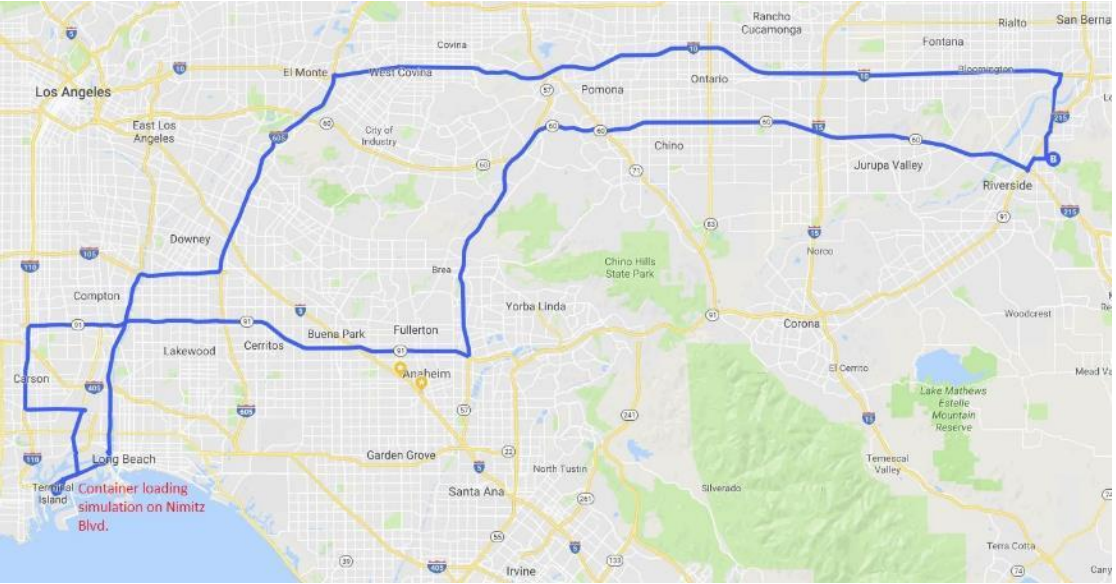
- Unlike Parcel route, waste hauling route does not show different NOX emissions between segments,
- High percentage of highway operation (> 50%)
- 0.02 CNG showed higher levels of NOx on Grocery route, data to be checked and verified
- Two additional 0.02 CNG trucks planned



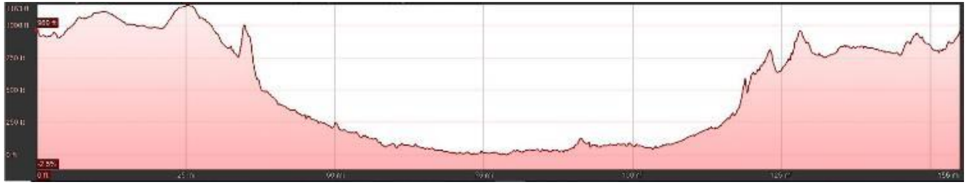


Drayage Truck Route ("TTSI" Route)

- Representing typical operation of drayage trucks between ports and regional IE warehouses, using telemetry data from 49 trucks

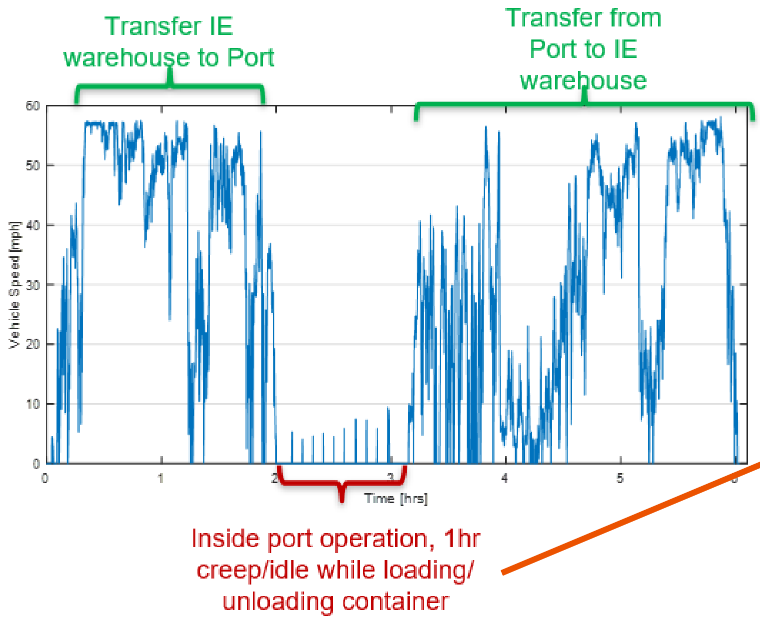


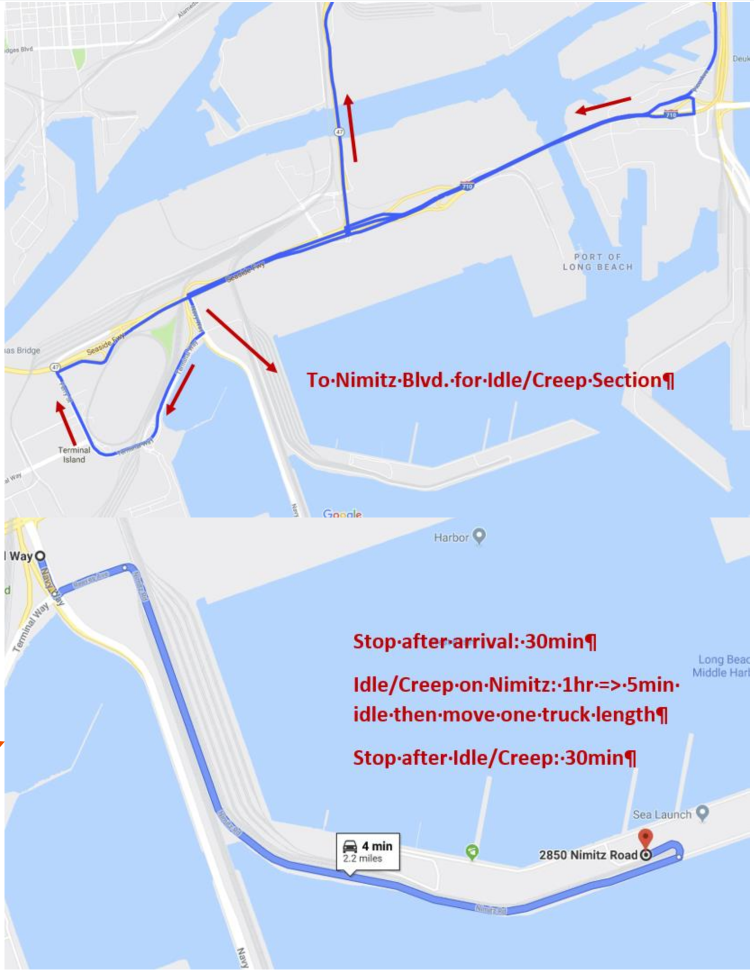
Parameter	Unit	Value
Duration	[hrs]	6.03
Distance	[miles]	161.5
Idle	[%]	23.3
Urban (≤31mph)	[%]	31.6
Rural (>31 & ≤46.6mph)	[%]	15.6
Highway (>46.6mph)	[%]	29.6



Drayage Truck Route

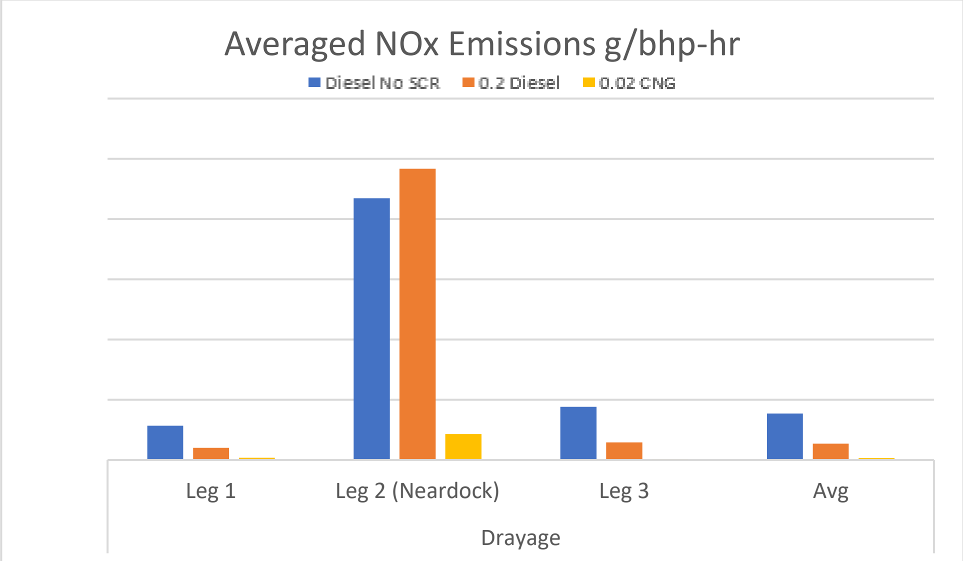
- Leg 1: Transfer of load from IE warehouse to port
- Leg 2: 1hr long creep/idle operation in port to unload/load
- Leg 3: Transfer of load to IE warehouse

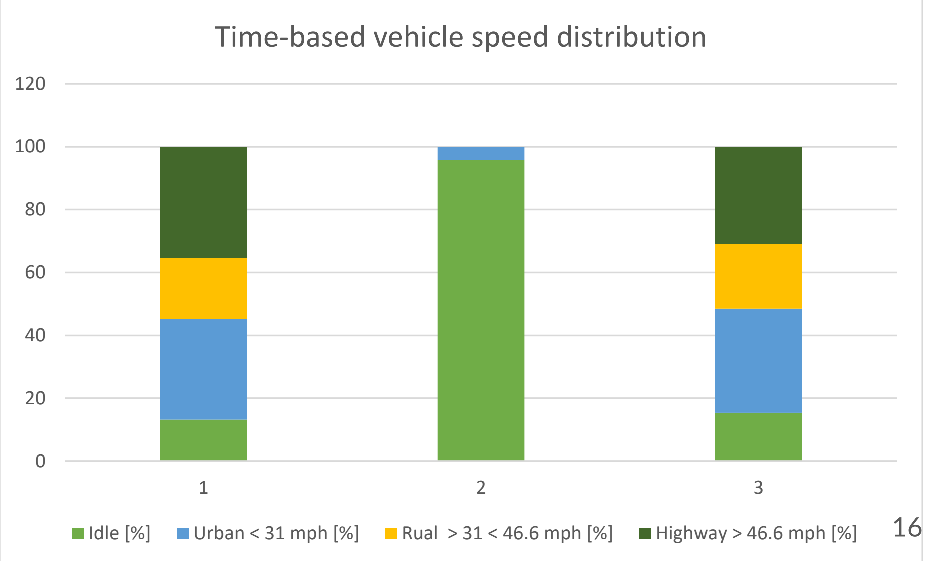




Segmented Emissions - Drayage

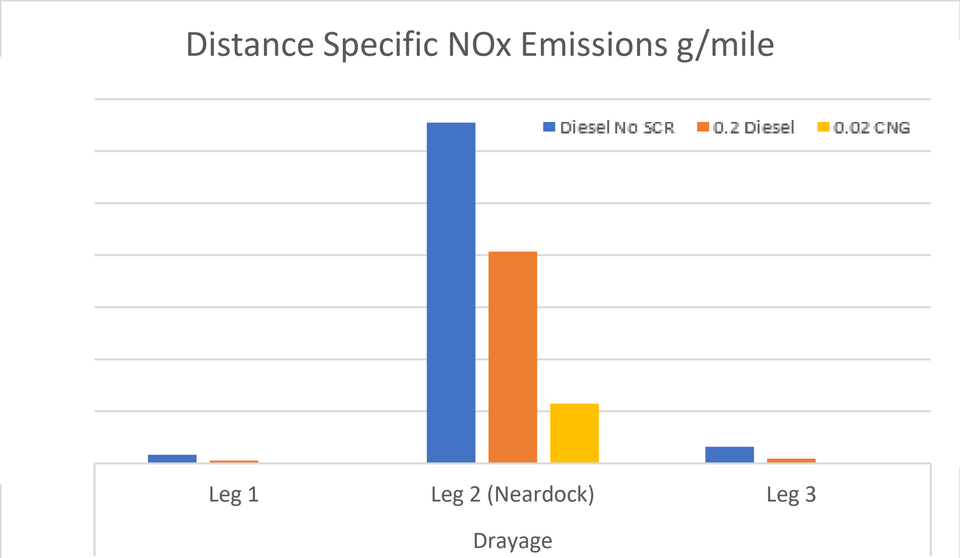
- Leg 2 (Neardock) cycle to simulate creep operation, < 90% idling
- Very little cycle work (~ 3.3 bhp-hr vs ~300 bhp-hr for leg 3)
- High brake-specific/distance-specific emissions due to duty-cycle and “math”
- 0.02 CNG showed lowest NOx emissions, as expected

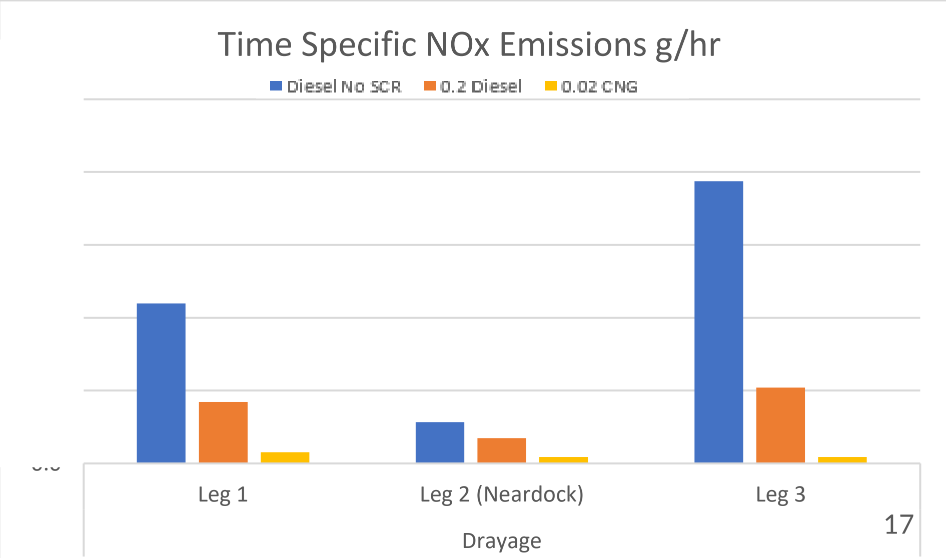




Metric are Important Considerations for Idle/Low-Load Conditions

- g/bhp-hr vs g/mile vs g/hr will affect the NOx emissions comparison
- Idle should use grams/hr for characterizing emissions (subsequent slides idle all in g/hr)
- Lower load duty-cycles emissions should also be treated differently
- Should consider for "where" and "when" the emissions are emitted

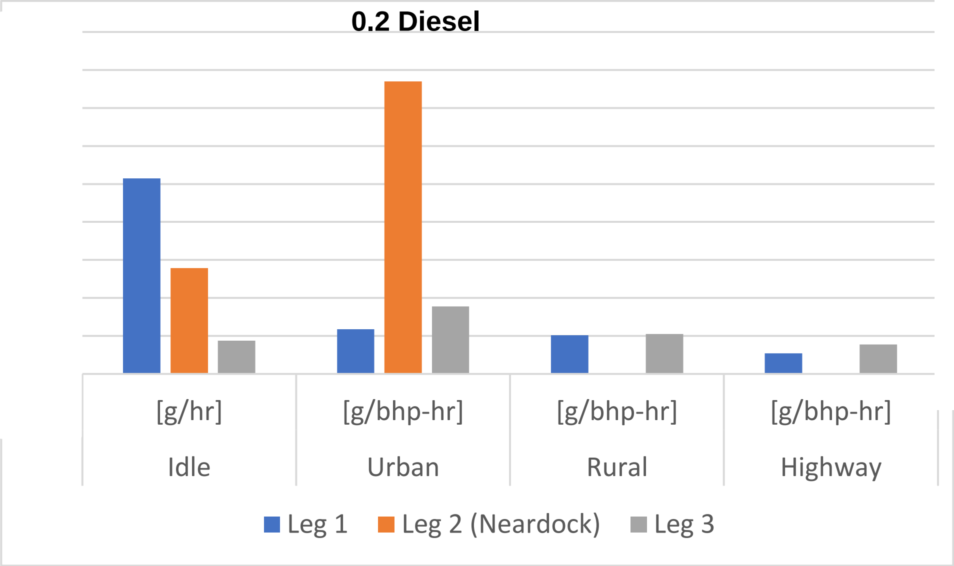


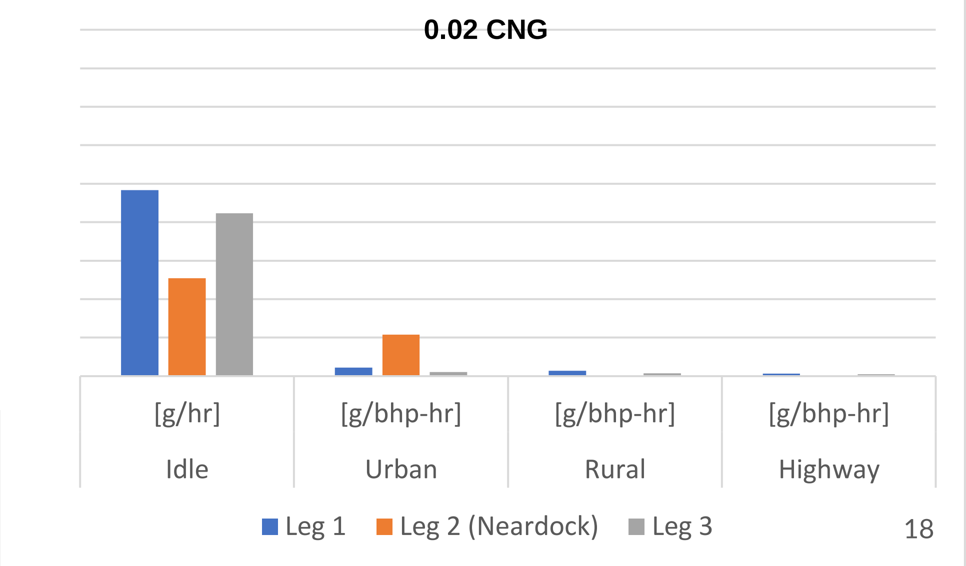


Better Way to Look at Emissions: Speed Binning

- Compare only two trucks for simplicity (0.2 diesel and 0.02 CNG)
- Idle in gram/hr (chart not to scale)
- Bin: 1 sec mini windows binned by vehicle speed
- Average NOx emission for all windows within each bin

Idle Bin	Vehicle Speed <= 1 mph
Urban Bin	31 mph>Vehicle Speed > 1 mph
Rural Bin	46.6 mph > Vehicle Speed > 31 mph
Highway Bin	Vehicle Speed > 46.6 mph





Future Regulations Will Account for Duty Cycle

- Omnibus and EPA CTI will dramatically change how emissions are regulated
- Different limit/metric for different duty cycles
- Conformity Factor (CF) added to account for measurement system variability under in-use conditions
- Future combustion technology are expected to be more robust emissions under various operating conditions

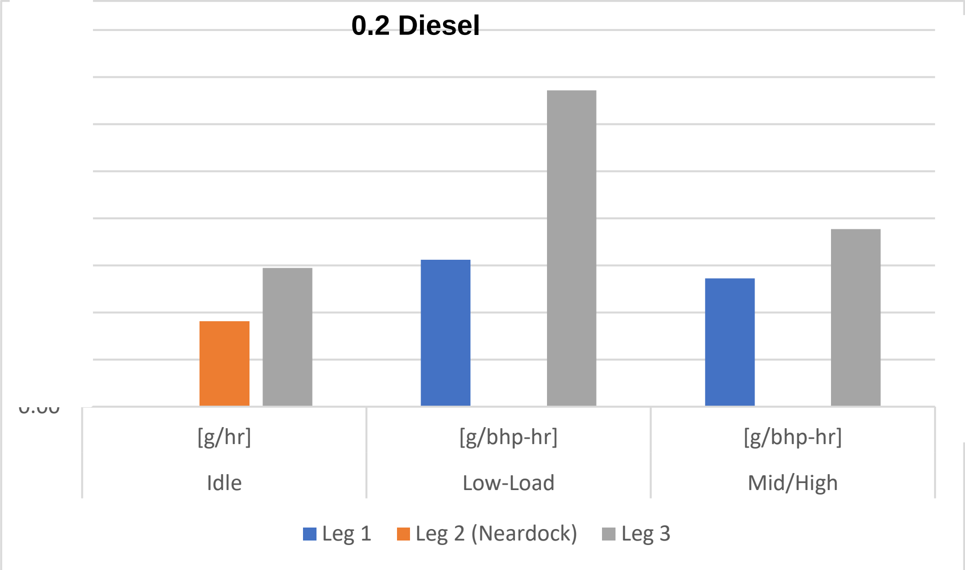
Bin	Duty-Cycle	2024 NOx Standard (CA Only)	2027 NOx Standard	CF	2024 In-Use Std W/ CF	2027 In-Use Std W/CF
Idle	< 6%	10 g/hr	5 g/hr	2.0 (1.5)	20 g/hr	10 g/hr
Low Load (LLC)	6% - 20%	0.20 g/bhp-hr	0.05 g/bhp-hr	2.0 (1.5)	0.40 g/bhp-hr	0.10 g/bhp-hr
Mid-High Load (FTP/RMC)	> 20%	0.05 g/bhp-hr	0.02 g/bhp-hr	2.0 (1.5)	0.10 g/bhp-hr	0.04 g/bhp-hr

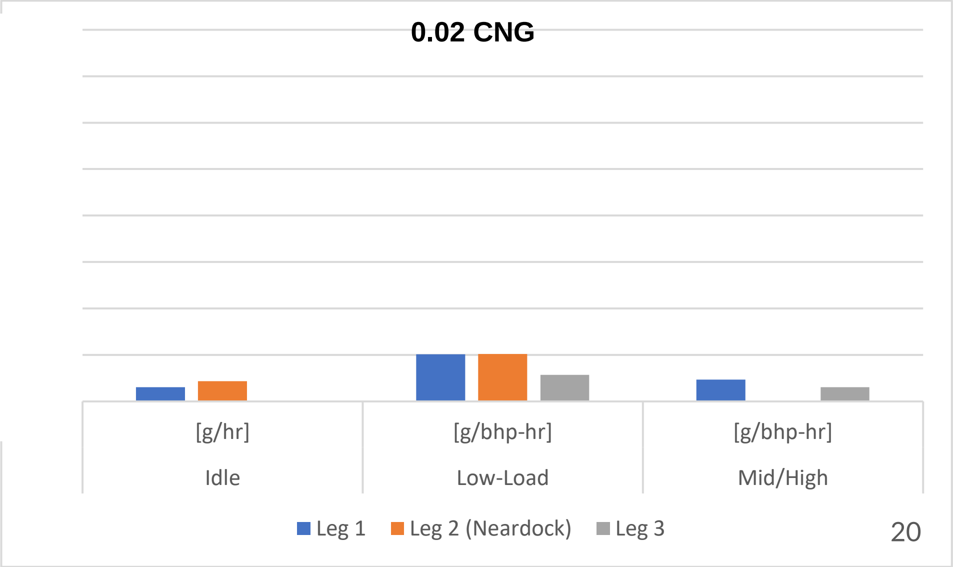
Source: CARB Omnibus Final Rule

3B-MAW Results

- Each window is 300 secs (MAW)
- As expected, 0.2 diesel performed well on Mid/High bin (similar to cert cycle) but poorly on Low-Load/Idle bin
- 0.02 CNG NOx level close to CARB 2027 standard

Bin	2024 In-Use Std W/ CF	2027 In-Use Std W/CF
Idle < 6%	20 g/hr	10 g/hr
Low Load (LLC) 6-20%	0.40 g/bhp-hr	0.10 g/bhp-hr
Mid-High Load (FTP/RMC) 20%	0.10 g/bhp-hr	0.04 g/bhp-hr





Team

Contractors: WVU, UCR/CE-CERT

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

South Coast AQMD

Thank you.