CLEAN FUELS PROGRAM ADVISORY GROUP AGENDA
FEBRUARY 2, 2023, 9:00 AM – 3:45 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 Assembly Bill 361,
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 two (2) minutes each.

	Welcome & Overview **9:00 – 10:15 AM**	
(a)	Welcome & Introductions	Aaron Katzenstein, Ph.D., Deputy Executive Officer *
(b)	Goals for the Day	Maryam Hajbabaei, Ph.D., Program Supervisor*
(c)	Off-Road Projects and Recent Grant Proposals	Mei Wang, Manager* (slide 12 corrected after meeting)
(d)	Feedback and Discussion	Advisors and Experts
(e)	Public Comment (2 minutes/person)	
1.	**Zero Emission Infrastructure** **10:15 AM – 12:30 PM**	
(a)	BEV Beachhead	Bret Stevens, Daimler Trucks North America
(b)	Accelerate the Shift towards Zero Emissions	Keith Brandis, Volvo Group North America
(c)	Charging Infrastructure Planning, Execution, and Operation	Jordan Smith, Southern California Edison
(d)	Hydrogen is Now	Carey Mendes, Nikola Corporation
(e)	Heavy-Duty Hydrogen Fueling and R&D	Sam Sprik, National Renewable Energy Laboratory
(f)	Feedback and Discussion	Advisors and Experts
(g)	Public Comment (2 minutes/person)	
	Lunch **12:30 PM – 1:30 PM**	

2.	Zero Emission Infrastructure and Emissions 1:30 PM – 3:00 PM	
(a)	SoCalGas RD&D Program Overview	Jeffrey Chase, SoCalGas
(b)	Non-Exhaust PM Emissions Research	Seungju Yoon, Ph.D., P.E, California Air Resources Board
(c)	Hydrogen Microgrid Projects	Seungbum Ha, Ph.D., Program Supervisor*
(d)	Feedback and Discussion	Advisors and Experts
(e)	Public Comment (2 minutes/person)	
3.	**Wrap-up 3:00 PM – 3:45 PM**	
(a)	2022 CF Annual Report/2023 CF Plan Update & Wrap-up	Aaron Katzenstein, Ph.D., Deputy Executive Officer*
(b)	Advisor and Expert Comments	All
(c)	Public Comment (2 minutes/person)	

*: South Coast AQMD Technology Advancement Office Staff

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

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

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.

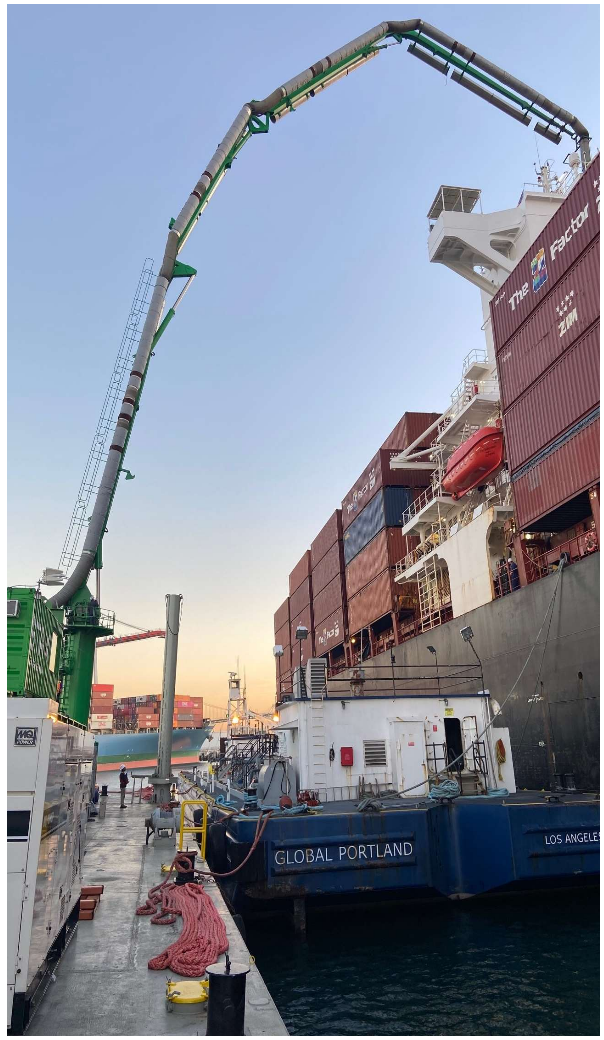
Directions for TELEPHONE line only:

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

Off-Road Projects and Recent Grant Proposals

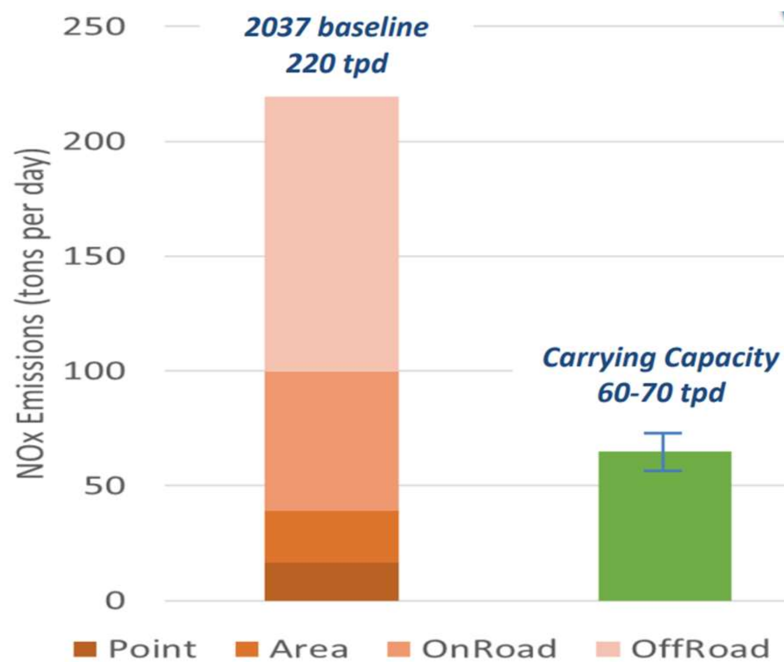
Mei Wang

Technology Implementation Manager

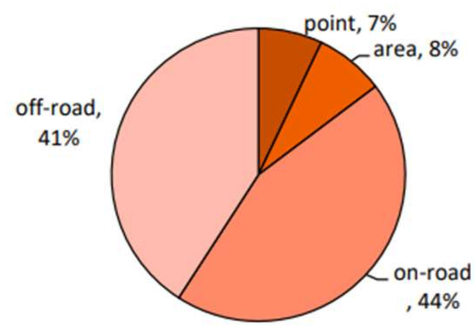


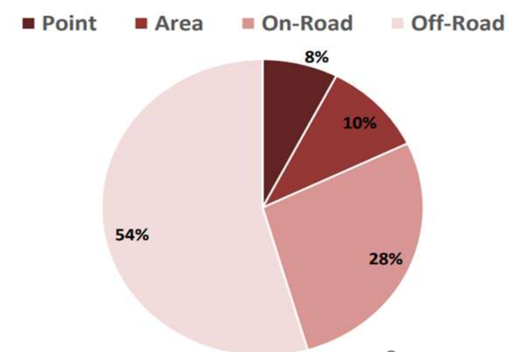
Background

- NOx reduction is the only path to achieving ozone standard
- 70% NOx reduction is needed
- Emission would decrease with the implementation of control strategies
- Remaining emissions mostly from locomotives and ocean-going vessel
- Majority of NOx emissions are from State and federally-regulated mobile sources beyond the South Coast AQMD's control

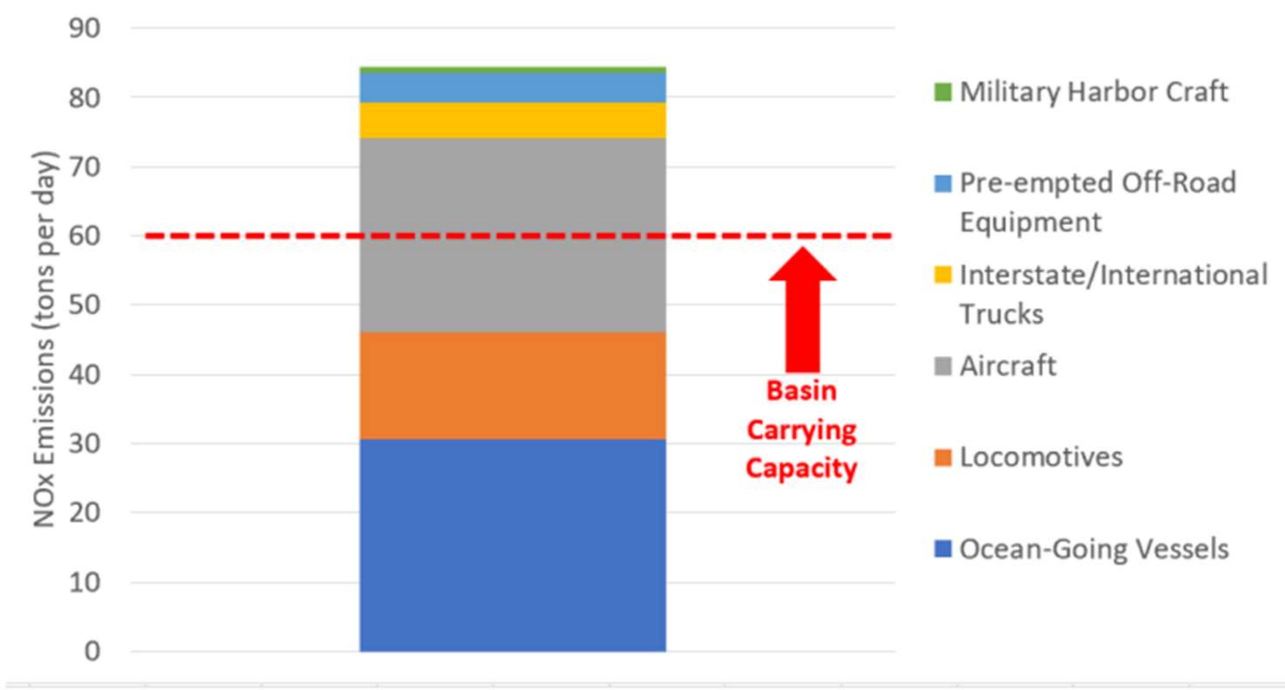


NOx Emissions in 2018 and 2037

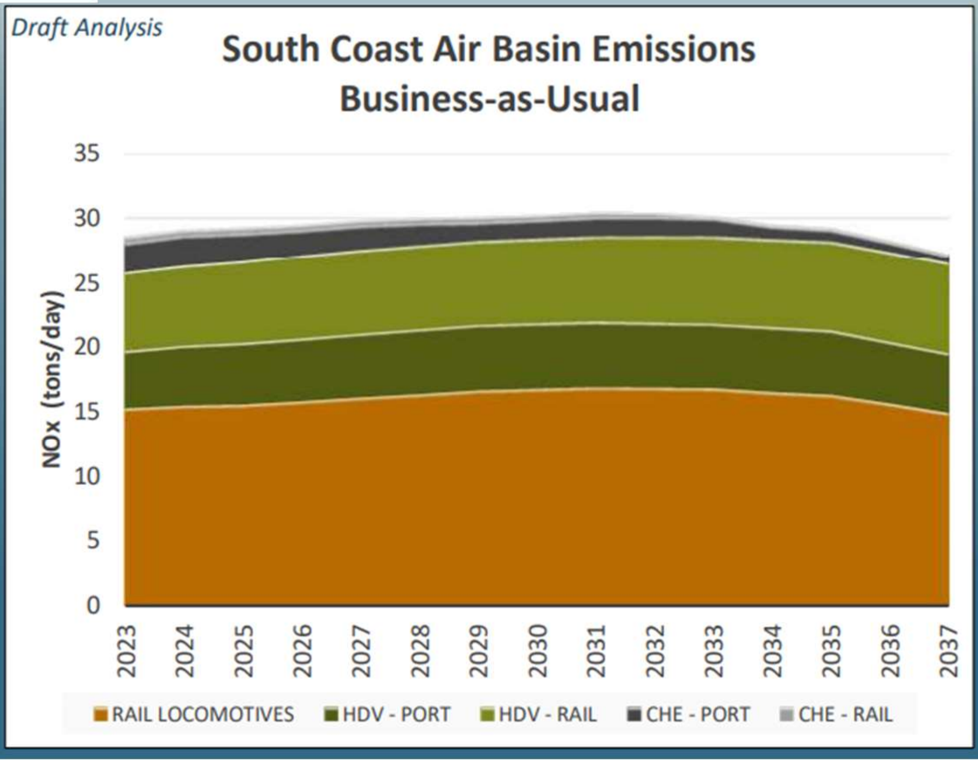


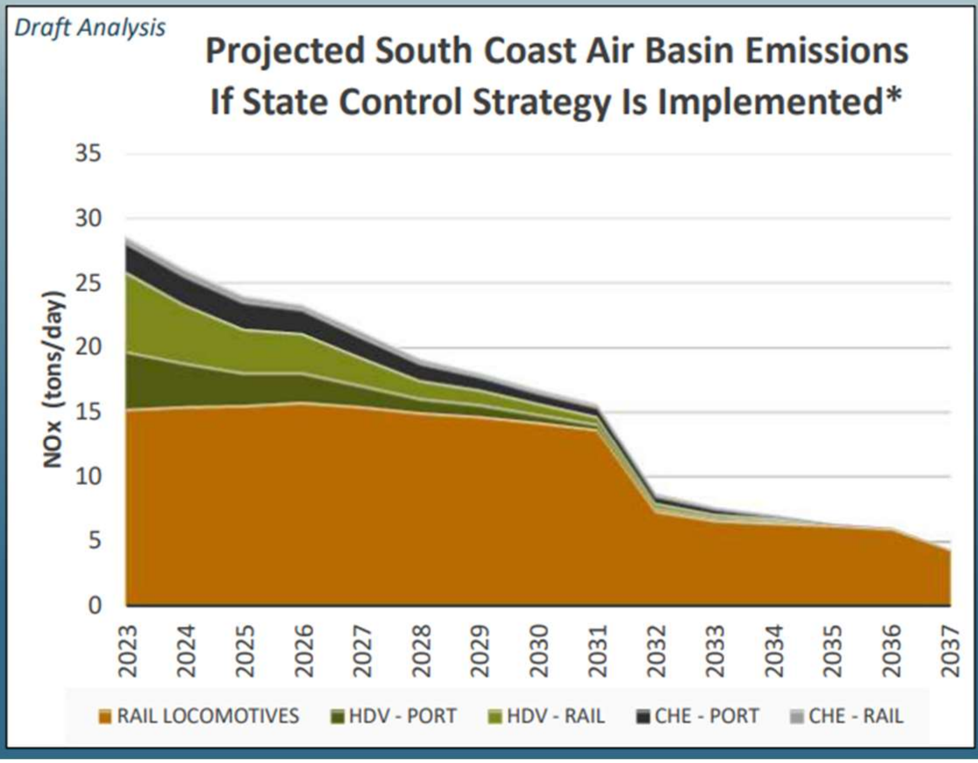


NOx Emissions in 2037 from Sources under Federal and International Authorities



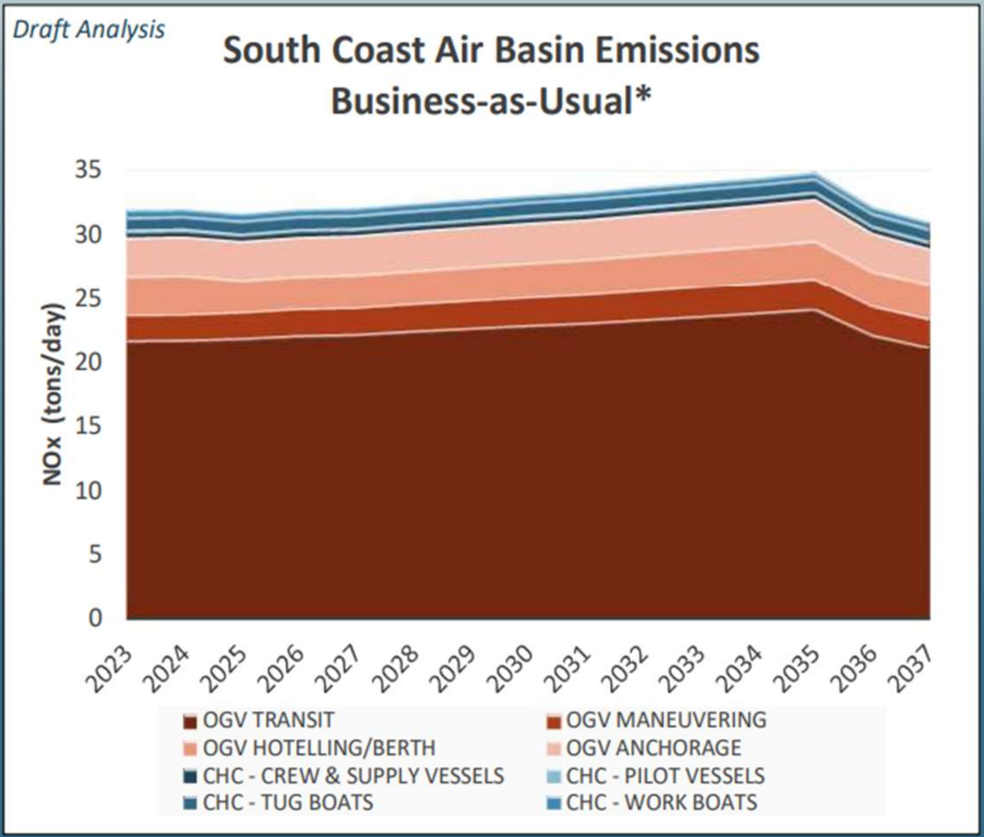
LANDSIDE EMISSION REDUCTION OPPORTUNITIES

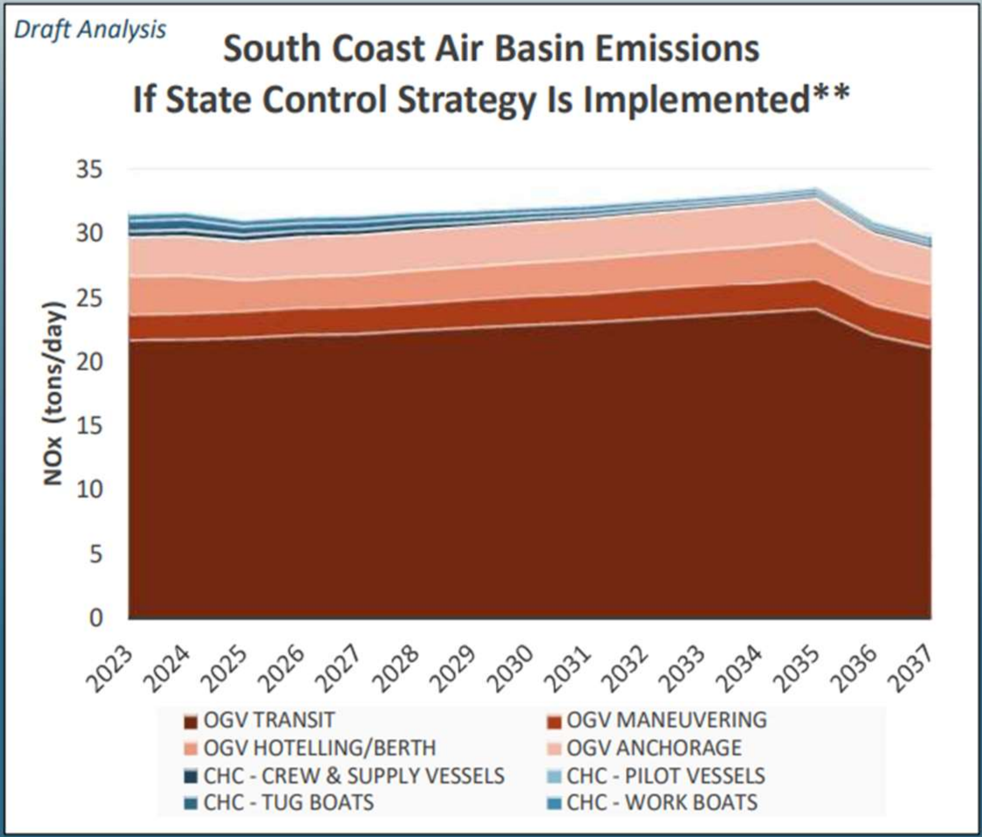




*Depending on implantation of CARB regulations, projected emission reductions may not necessarily occur within the South Coast Air Basin

OCEANSIDE EMISSION REDUCTION OPPORTUNITIES





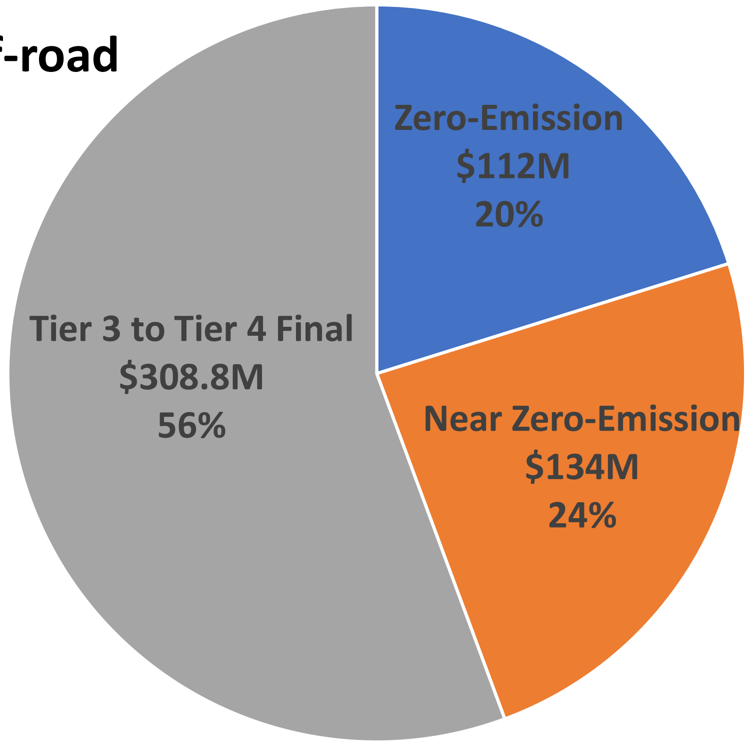
*Staff working with CARB to finalize projected emission reductions from At-Berth amendment

**State Control Strategy includes adopted Commercial Harbor Craft Amendments; 2022 SIP federal action for OGVs and ports Green Shipping Corridors not included

Incentive Funding Allocation Since 2017

- **56% of incentive funding for Tier 3 to 4 are off-road engines**
- **Experience in developing on-road engine technologies can be transferred to the off-road sector**

Main Incentive Programs
• Carl Moyer Program • Proposition 1B Goods Movement • Lower School Bus Program • Replace Your Ride



Off-Road Demonstration Projects

Awarded Projects

- OGV Water-in-Fuel (WiF) Retrofit
- Polar Bear Pilot Vessel(OGV multi-fuel conversion)
- OGV LPEGR retrofit
- Capture and Control System for Oil Tankers
- Battery Electric Line-Haul
- Battery Electric Top Handlers
- Battery Electric Yard Tractors
- Hybrid RTGs

Proposed Projects

- OGV Methanol Conversion
- Plug-in Hybrid Tugboat with Hydrogen Fuel Cell powered charging system
- Hydrogen Fuel Cell Short Line Locomotive for Cargo Transport

South Coast AQMD

OGV WiF Retrofit

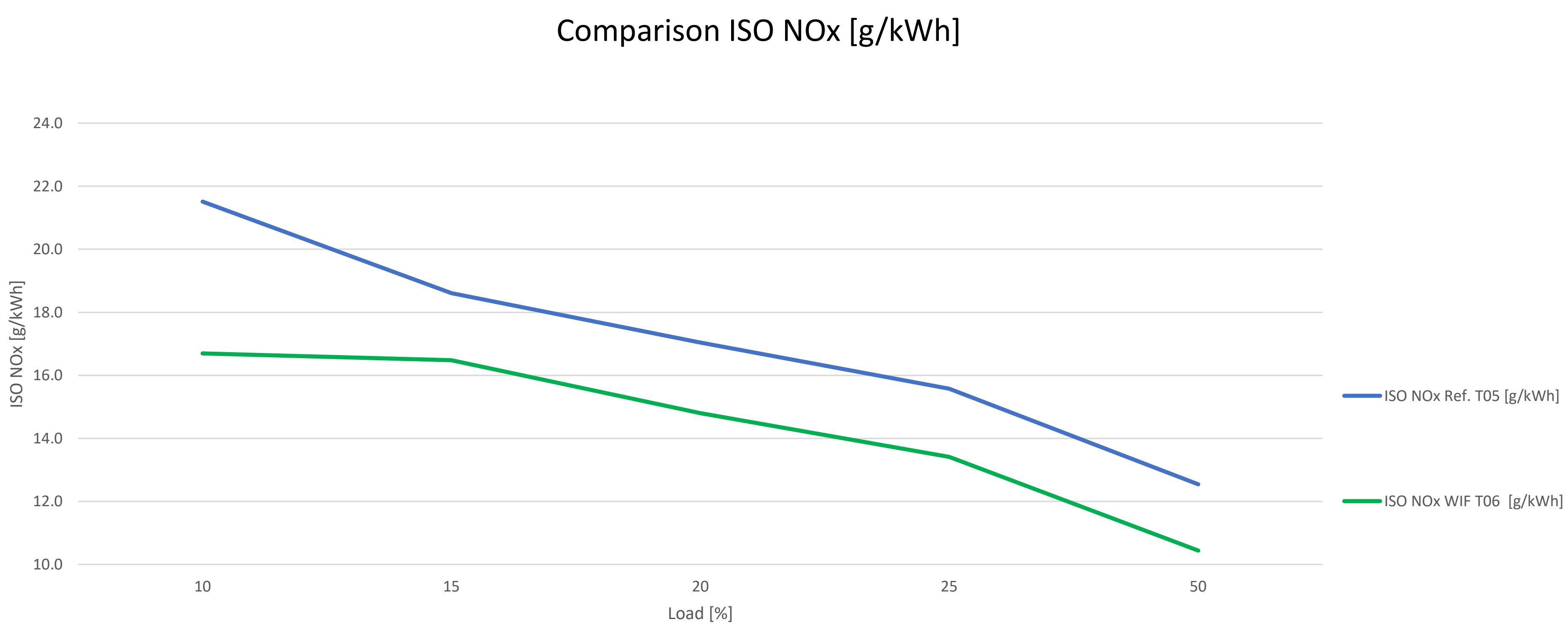
- Project cost: 3.2M
- Funded by SCAQMD, POLA and POLB
- Partnered with MAN Energy Solutions and Mediterranean Shipping Company (MSC)
- Project Period:
  - August 2020 to August 2022
- NOx reduction technology in Coastal operation
- Quick installation without a dry dock
- Re-designed WiF System

OGV WiF Retrofit

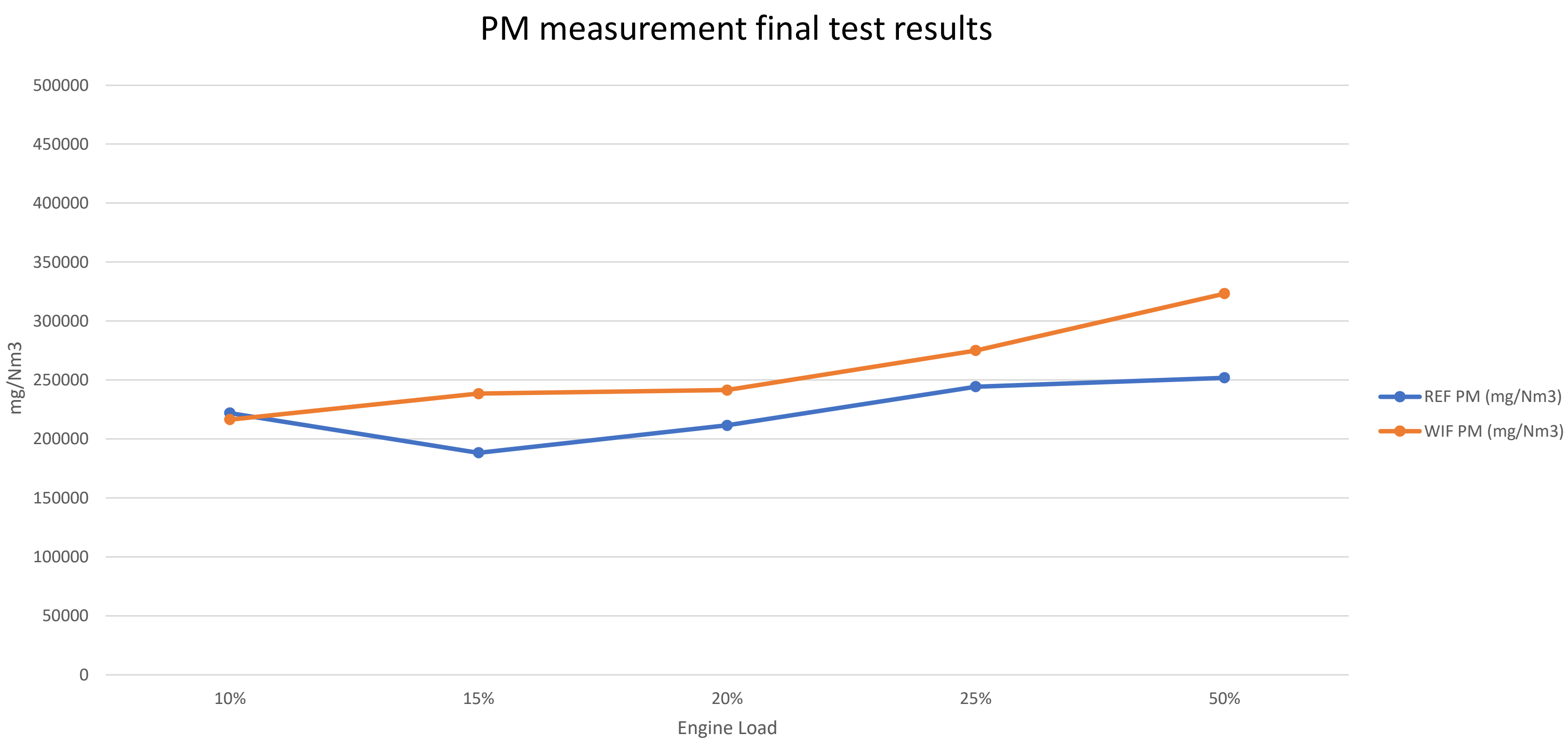
- Vessel:
  - MSC ANZU
  - IMO Tier II, built in 2015
  - 9000TEU container vessel
  - MAN 9S90ME 2-stroke main engine, 52,000kW and 4 auxiliary engines
- Commissioning tested in March/April 2022
  - <50% engine load
  - 140NM
  - Marine Diesel Oil (MDO) with 0.1% Sulphur
  - Maximum 41% water content
  - Three sea trails and over 40 performance tests

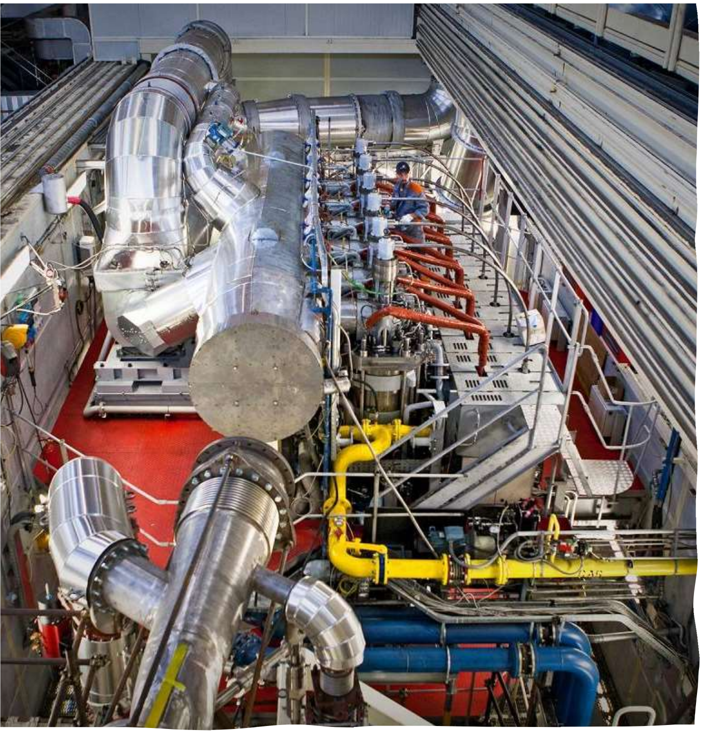
South Coast AQMD

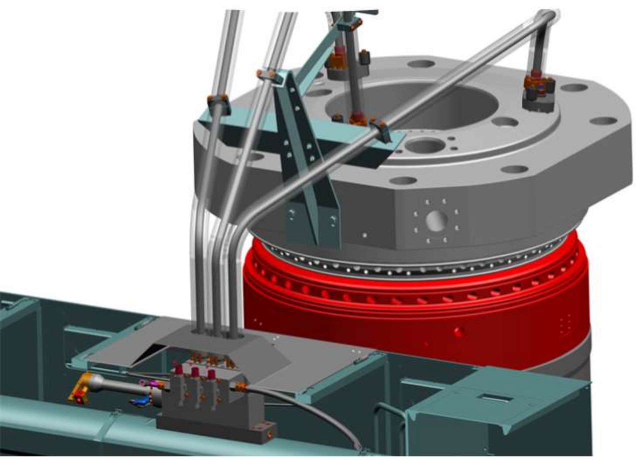
OGV WiF Retrofit



OGV WiF Project





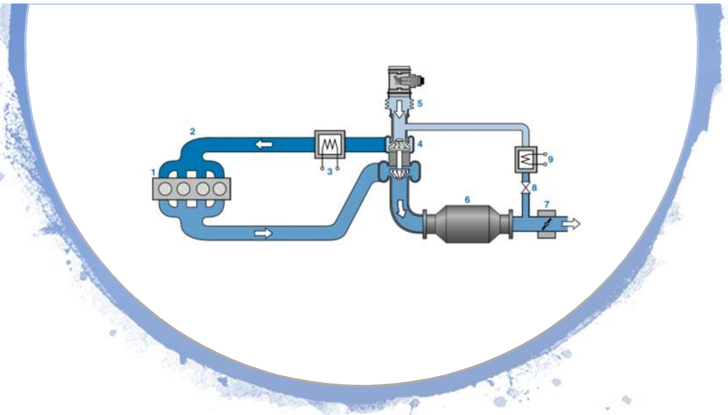


OGV Muti-Fuel Conversion

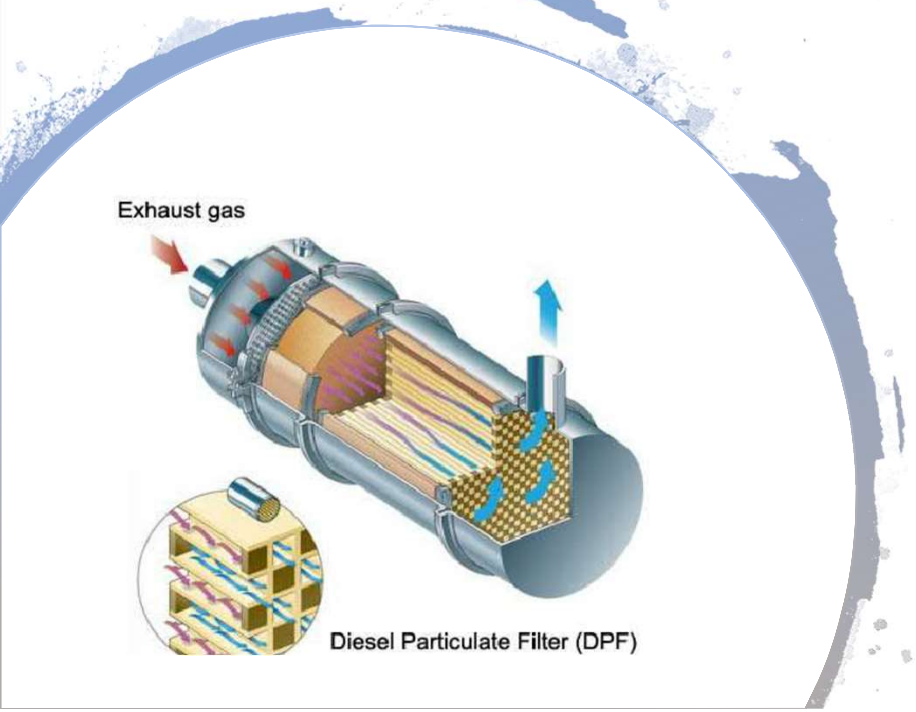
- EPA Year 20 Targeted Airshed Grant (TAG) Award: $7.5M
  - Total project cost: $17M
  - Cost-share by MSC, POLA, POLB, and SCAQMD
- Retrofit with a multiple fuel flexible injection platform and gas supply system
- Negligible methane slip
- Boil-off gas genset unit
- Initially operate on diesel, LNG and ammonia
- Develop off-the-shelf conversion kit
- Expect 70% NOx and PM and 25% CO_2 reduction from a Tier II OGV
- Project completion: 12/31/2025

*Pictures are not from the actual project

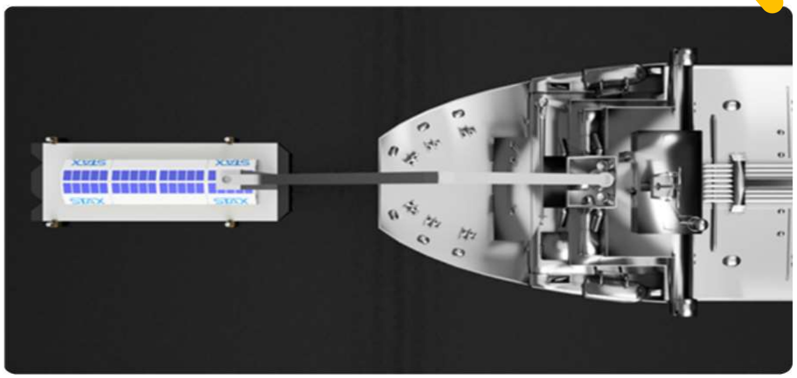
South Coast AQMD



OGV Low-Pressure Exhaust Gas Recirculation (LP-EGR) Retrofit



- EPA Year20 TAG Award: $3.9M
  - Total project cost: $4M
  - Cost-share by POLA, POLB, and SCAQMD
- Retrofit with small footprint LP-EGR system
- Add-on patent-pending particulate filter
- 90% PM reduction and 75% NOx reduction from a Tier II OGV
- System to operate in a wide range of engine loads, including 10% load
- Project completion: 12/31/2025



Capture and Control System for Oil Tankers

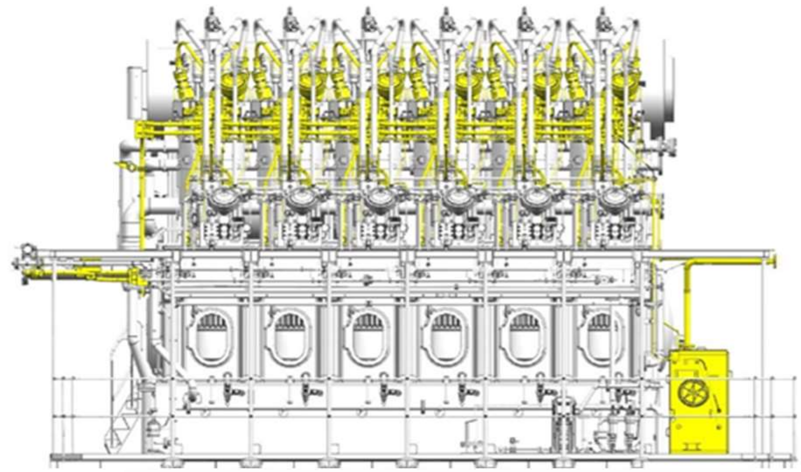
- CARB award of $10M
  - Total project cost $13M
  - Cost shared by SCAQMD and STAX Engineering
- Self-propelled Spud Barge
  - Powered by renewable diesel and fuel cell
  - Solar and battery storage
- Exhaust capture system and purification units
- Carbon-capture
- At least 90% reduction of NOx, PM2.5 and ROG from both auxiliary engines and boilers
- Obtain CARB executive order
- Demonstration partner: Tesoro Logistics, located in POLB
- Project completion: 8/31/2024

Capture and Control System for Oil Tankers

Project Status

- Two tanker safety assessments conducted
- CARB emission test plan approved
- One of two exhaust treatment systems complete
- Exhaust capture arm installed
- Barge power system installed
- Barge completed over 2,000 hours of operation

OGV Methanol Conversion (Proposed)

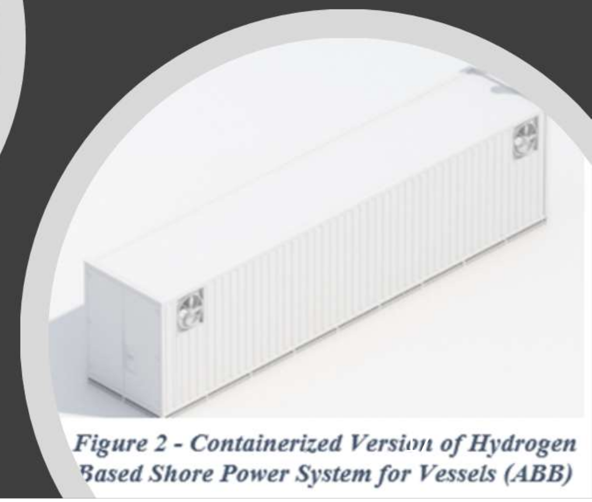


MAN Energy Solutions

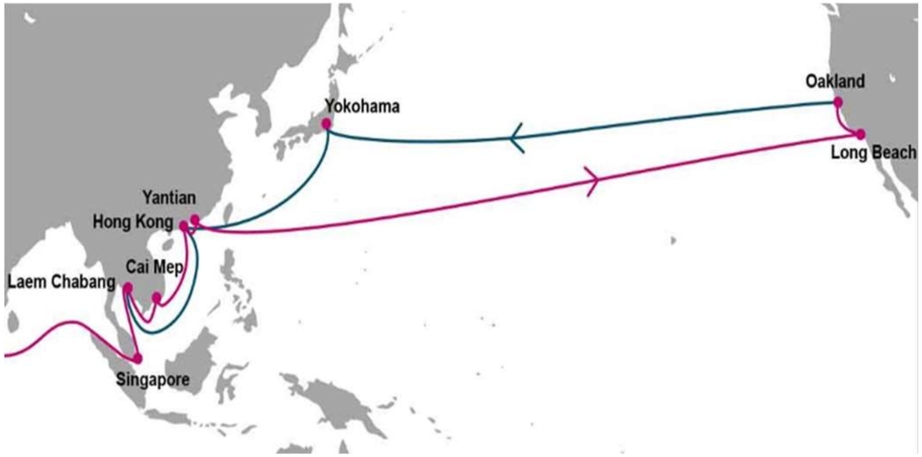
- Proposal submitted in December 2022 under EPA 2022 TAG
- Project cost $33M, requested $10M
- Design and develop a full-scale 2-stroke methanol engine for one of the largest OGV engine
- Convert a CMA CGM Tier II vessel to run on methanol
- Partnership with MAN Energy Solutions and CMA CGM
- Expect emission reduction of 30-50% NOx, 95% SOX and 10% PM
- 90% CO2 reduction when using renewable methanol fuel

Plug-in Hybrid-Tugboat Project with Innovative Supporting Charging Infrastructure Powered by Hydrogen Fuel Cells (Proposed)

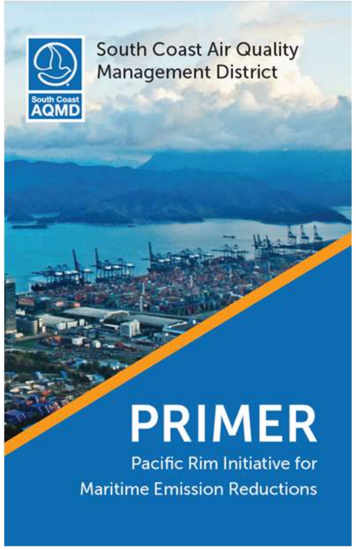
- Proposal submitted in December 2022 under EPA 2022 TAG
- Project cost $43.5M, requested $10M
- Design and build a 90-ton bollard pull plug-in hybrid tugboat that tow OGVs in the San Pedro Bay Ports
- Capable for zero emission with adequate charging infrastructure
- Innovative stand-alone charging system with batteries and hydrogen fuel cell power generation



Pacific Rim Initiative for Maritime Emission Reductions (PRIMER)



- Trans-Pacific partnerships of multiple port regions around the Pacific Rim
  - Engagement with Asia
  - Develop policy paper
  - Industry partnerships
- Efforts to incentivize cleaner ocean-going vessels
  - Develop and coordinate programs to attract cleaner OGVs on shared routes
  - Voluntary incentive-based programs



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Battery Electric Line-Haul Locomotive with Charging Infrastructure

- EPA Year 21 Targeted Airshed Award: $4.2M
  - Total project cost: $8.9M
  - Cost-share by BNSF, Progress Rail, and SCAQMD
- Replace a BNSF Tier 1+ freight line-haul with an 8 MWh battery-powered zero-emission locomotive
- Two 1.4MW chargers with at Barstow and Watson
- Project completion: 12/31/2025

Battery Electric Line-Haul Locomotive with Charging Infrastructure

Project Status

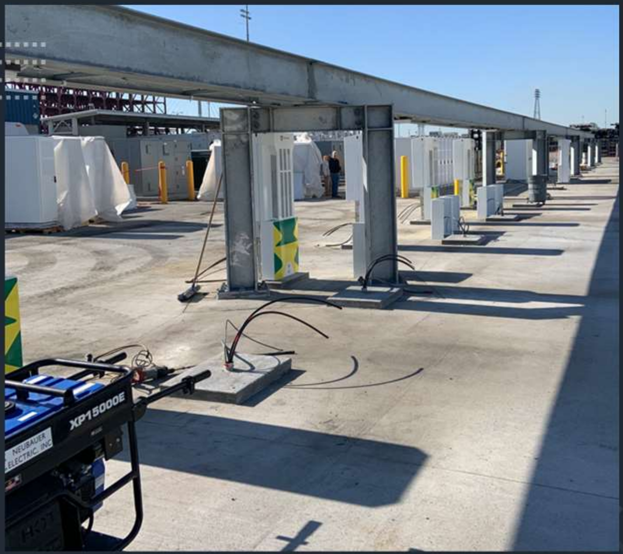
- Progress Rail Initiated locomotive model design and built detail engineering schedule
- BNSF review and commented the mechanical, operating practices and safety
- Route modeling initiated
- Submitted applications for both charging site to SCE and a project manager was assigned
    - Capacity study and site survey is underway
- Purchase order placed for charging infrastructure engineering consultant to design and install the chargers

South Coast AQMD

Hydrogen Fuel Cell Short Line Locomotive for Cargo Transport (Proposed)

- Proposal submitted in January 2023 to California State Transportation Agency (CalSTA)
- Project cost $42M, requested $35M
- Design and develop a short-line hydrogen fuel cell locomotive operating around Southern California to support cargo movement in San Pedro Bay Ports
- Improve haulage ability and increase throughput
- Develop a best practice to fuel large quantity of H2 for each fueling event safely
- Durability assessment after a 12-month demonstration and improve it for a longer route as phase 2 project (not part of the proposal)

Wabtec CORPORATION



Battery Electric and Hybrid Cargo Handling Equipment

Deployment and demonstration of 16 battery-electric yard tractors

- Total project cost (equipment only) :$5.3M
- Infrastructure was funded by CEC
- EPA Year 16 Targeted Airshed Grant, POLA, POLB and CARB(ZANZEFF)
- 10 BYD yard tractors at West Basin Container Terminal with wireless chargers
- 6 Dina/Meritor yard tractors at SSA Terminals with mechanized charging connections

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Battery Electric and Hybrid Cargo Handling Equipment

- Deployment and demonstration of a Hyster-Yale battery-electric top-handler with wireless charger at APM Terminals
  - Project award: 3.7M
  - Funded by CEC and SCAQMD

- Installation and demonstration of six hybrid RTGs at SSA Terminals
  - Project cost: $2.7M
  - Funded by SCAQMD

South Coast AQMD

Questions

SCAQMD – Clean Fuels Program - BEV Beachhead

EMG eConsulting / 2.2.2023

Pilot Projects help us to co-create this new technology with our customers

Today

GAINING KNOWLEDGE

ELECTRIC INNOVATION FLEET

Co-creation of Innovation Fleet

20 eCascadia

10 eM2

South Coast AQMD

PUTTING CUSTOMER READINESS TO THE TEST

CX FLEET

Customer Experience (CX) Fleet

6 eCascadia

2 eM2

South Coast AQMD

Bay Area Air Quality Management District

SERIES PRODUCTION

eCASCADIA

eM2

Freightliner Electric Trucks at scale out of our established Portland Truck Manufacturing Plant

SOP 2022/23

2023 PORTFOLIO EXPANSION

ADDITIONAL OPTIONS, FEATURES AND APPLICATIONS

SCAQMD has been a critical partner in deploying Commercial BEVs

Program	Year	Trucks	Product
SCAQMD Mitigation Funds	2018	20	Innovation Fleet
SCAQMD Tech Advancement Office Discretionary funding	2019	6	Innovation Fleet
EPA Targeted Air Shed Grant & CARB HVIP Funding	2019	35	Gen2
Joint Electric Truck Scaling Initiative	2021	80	Gen2

What is the problem needing to be solved

What the future might hold

Vehicle Technology

- Future products to meet additional use cases where feasible
- Integrating new technologies and efficiencies based on market readiness and commercialization

Cost Parity

- Assumption of cost efficiencies based on production scale
- Raw material increases and supply chain requirements
- Uncertainty around critical component and infrastructure cost.

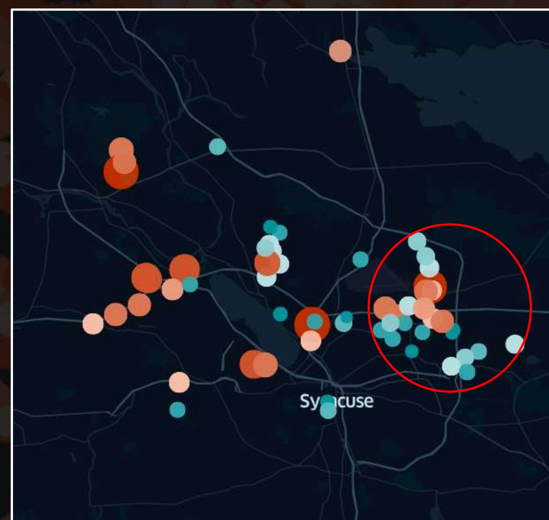
Daimler Truck collaborates with utilities to support infrastructure development

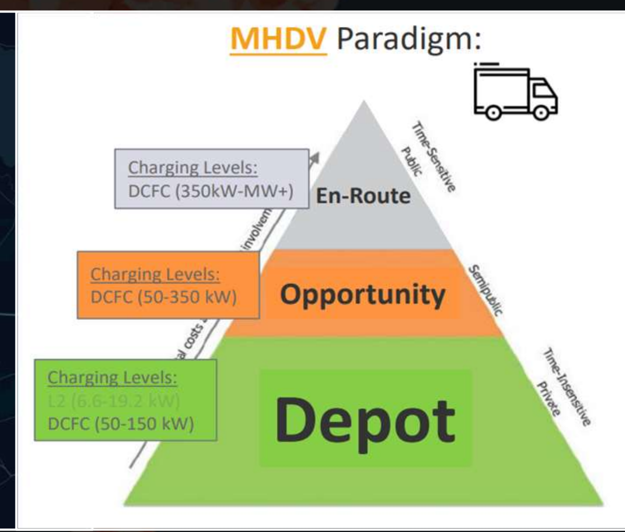
Daimler Truck offer to utilities

- Daimler Truck can engage with utilities to share insights on Vehicle Telematics Data
- Utilities can leverage data to build the grid capacity necessary to support commercial EV charging
  - Critical in states that adopted ACT rule or areas that perceive distribution inadequacies
- Offer open to utilities to have reoccurring access to the data

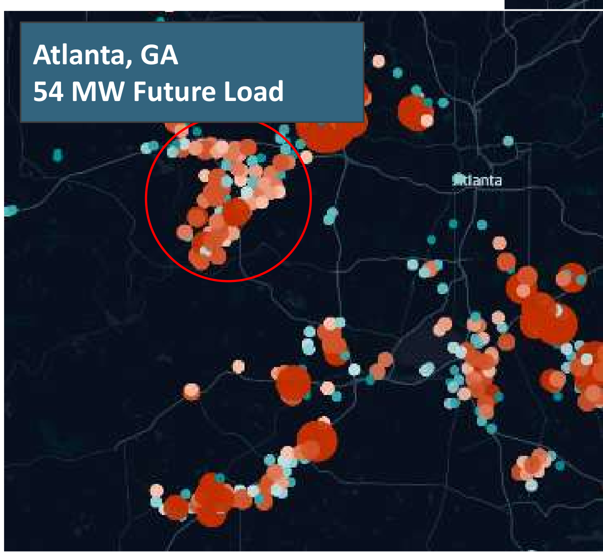
Data insights

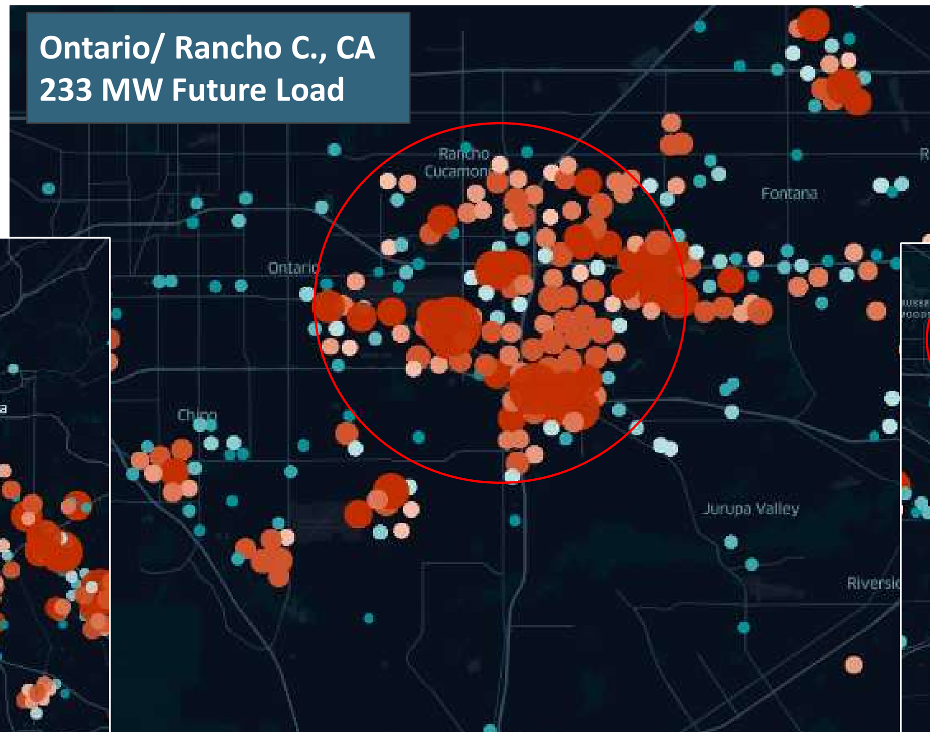
- Detailed location on future MW load
- Example: **4.5 MW highlighted area Syracuse, NY**

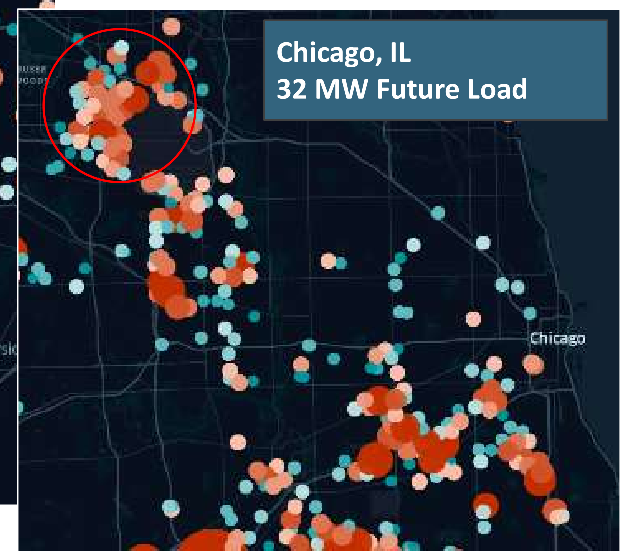




Additional Examples







Forecasted upgrades to meet ZEV mandate

5 years average of new registrations in California (from Polk Database)

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Table A-1. ZEV Sales Percentage Schedule

Model Year	Class 2b-3 Group	Class 4-8 Group	Class 7-8 Tractors Group
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035 and beyond	55%	75%	40%

ACT Rule

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Estimated California Simultaneous Power Demand (MW)- Per Class										
Use Case	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Distribution Truck Cl. 6	15	18	21	33	49	65	82	90	98	106
Distribution Truck Cl. 7	15	18	21	33	50	66	83	91	99	107
Distribution Truck Cl. 8	25	30	36	55	82	110	137	151	164	178
Walk in Van	23	28	33	52	77	103	129	142	155	167
Daycab Distribution	27	37	54	80	107	134	161	187	214	214
Class 2/3 Trucks	13	19	27	40	54	67	81	94	108	121
Total MW in CA	**118**	**151**	**192**	**293**	**419**	**545**	**672**	**755**	**838**	**895**

Based on projected volumes, product mixes, and expected power consumption needs, infrastructure needs to support California's proposed adoption of the ACT rule can be projected. Compared to today, by 2033, California would need to add:

$3.3B
Funding for charging equipment & installation

~5 gigawatt
Simultaneous additional connected electrical power

$1.8B – 3.9B
Funding for grid upgrades

Fleets are facing increased complexity with increased risk

Legacy

Consistent, predictable, linear

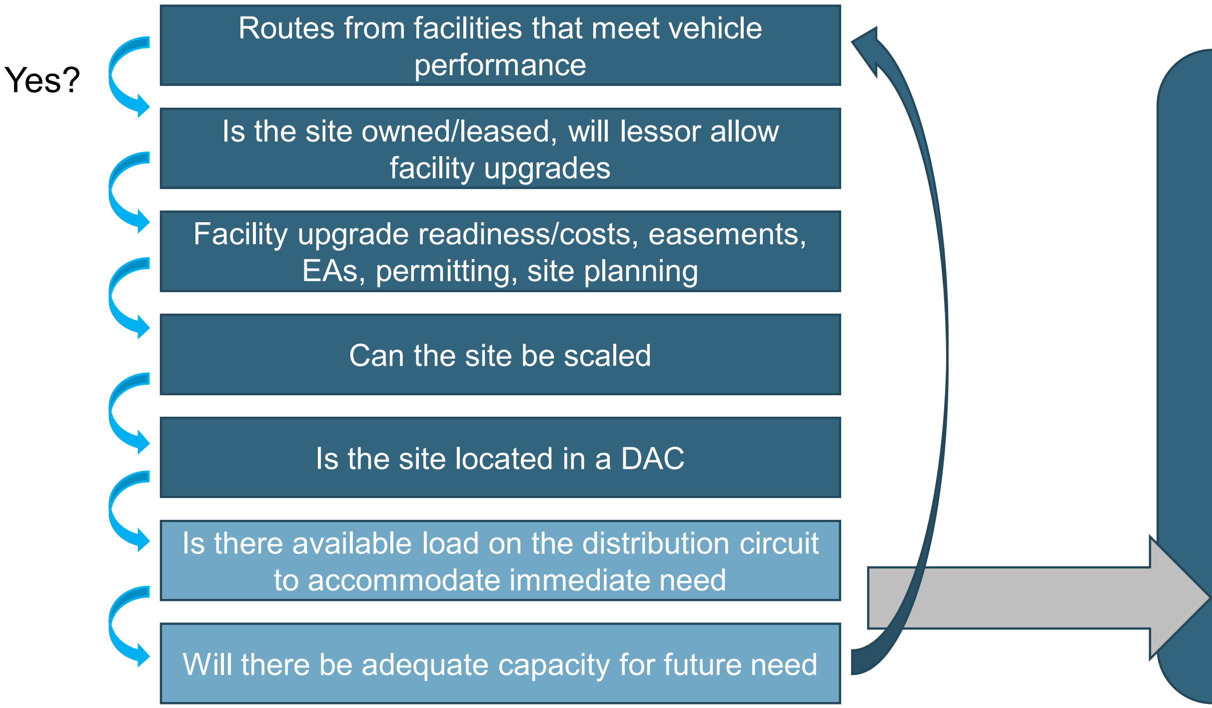
1. Truck to retire
2. Order Replacement
3. Place into service
4. Operate
5. Repeat

Battery Electric

More Complex, more planning, more pitfalls, more risk

- Interest TCO/ESG/ Regulation
- Utility Prep Work
- Civil Work
- Cost Analysis
- Utility Prelim Work
- Incentive Funding
- ESVE Order
- Competitive Analysis
- Board Approval
- EVSE Install
- Permitting
- Easements
- Opps Review
- Vehicle Scrapping
- Landlord/ Tenant
- Vehicle Order
- Route Analysis
- Power Availability
- Utility Capacity timeline
- Reporting Requirement
- EVSE sizing

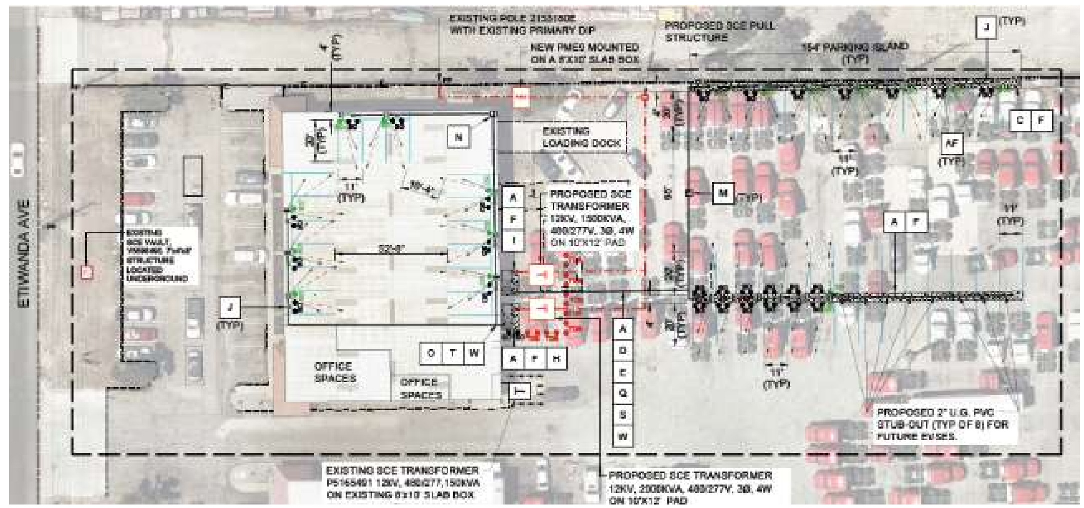
Site determination can be a challenge with many disqualifiers



Key Insights

- Not every site is created equal.
- If one critical component is not met, it can be 'back to the drawing board'
- Fleets are learning as they go due to the nascency of the technology and eco-system
- **A site-by-site approach will not support scaling and rapid adoption**

Fleet Site Example



- ✓ Drayage routes within vehicle range
- ✓ Site is owned
- ✓ Eligible for DAC and EngergIIZE Jump Start
- ✓ Currently adequate capacity on circuit

- ❑ Limited opportunity to scale (8 more chargers)
- ❑ Distribution Circuit listed as “Red” on SCE DRPEP tool
- ❑ Significant operational challenges to be addressed

We all want to avoid temporary charging

We have completed trucks on "Customer Hold" until their infrastructure is ready.

THANK YOU.

FREIGHTLINER®
Run Smart™

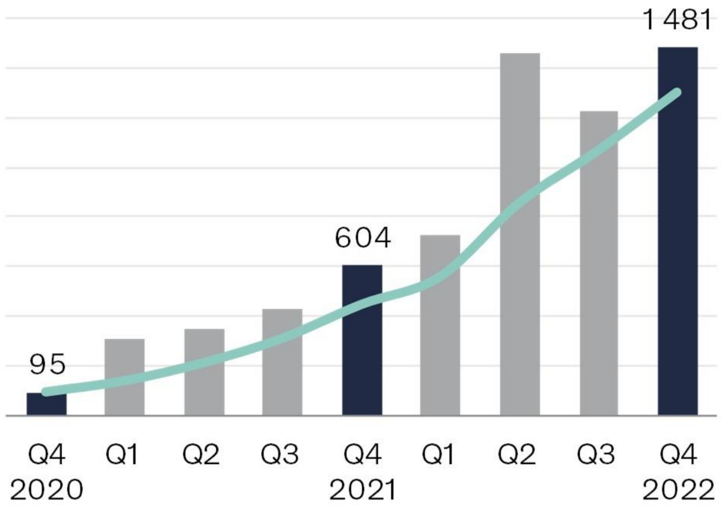
Accelerate the shift towards zero emissions

Volvo Group

Electrification progress*

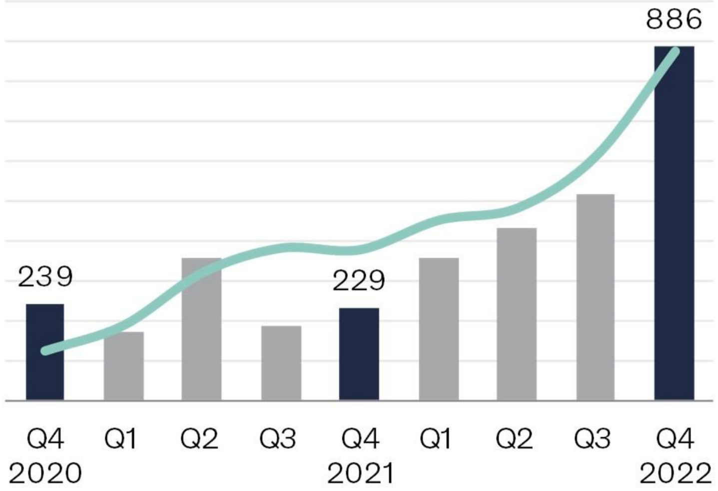
ORDER INTAKE, FULLY ELECTRIC VEHICLES

12 months 4,892 units

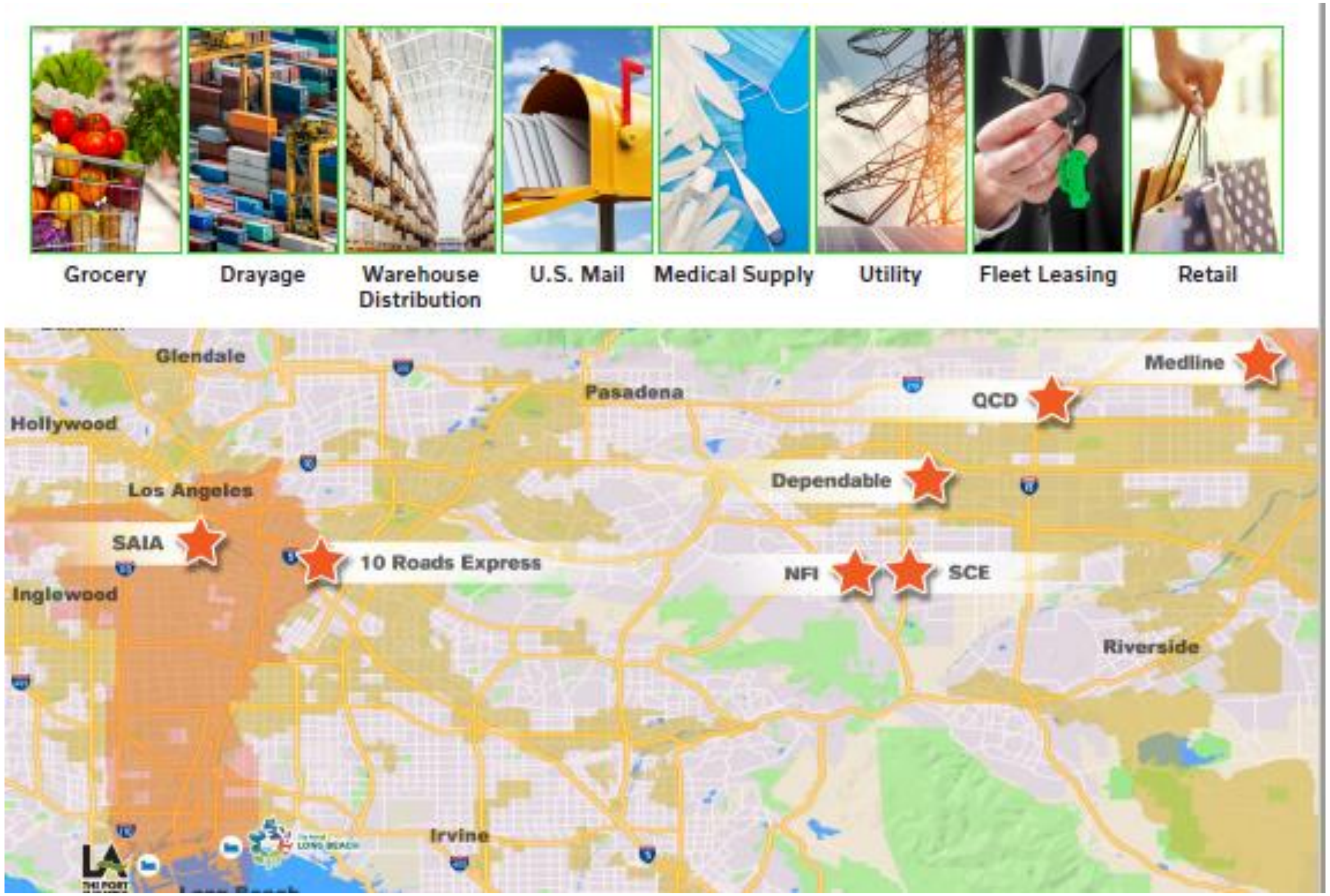


DELIVERIES, FULLY ELECTRIC VEHICLES

12 months 2,194 units



**Including Designwerk and Nova Bus*



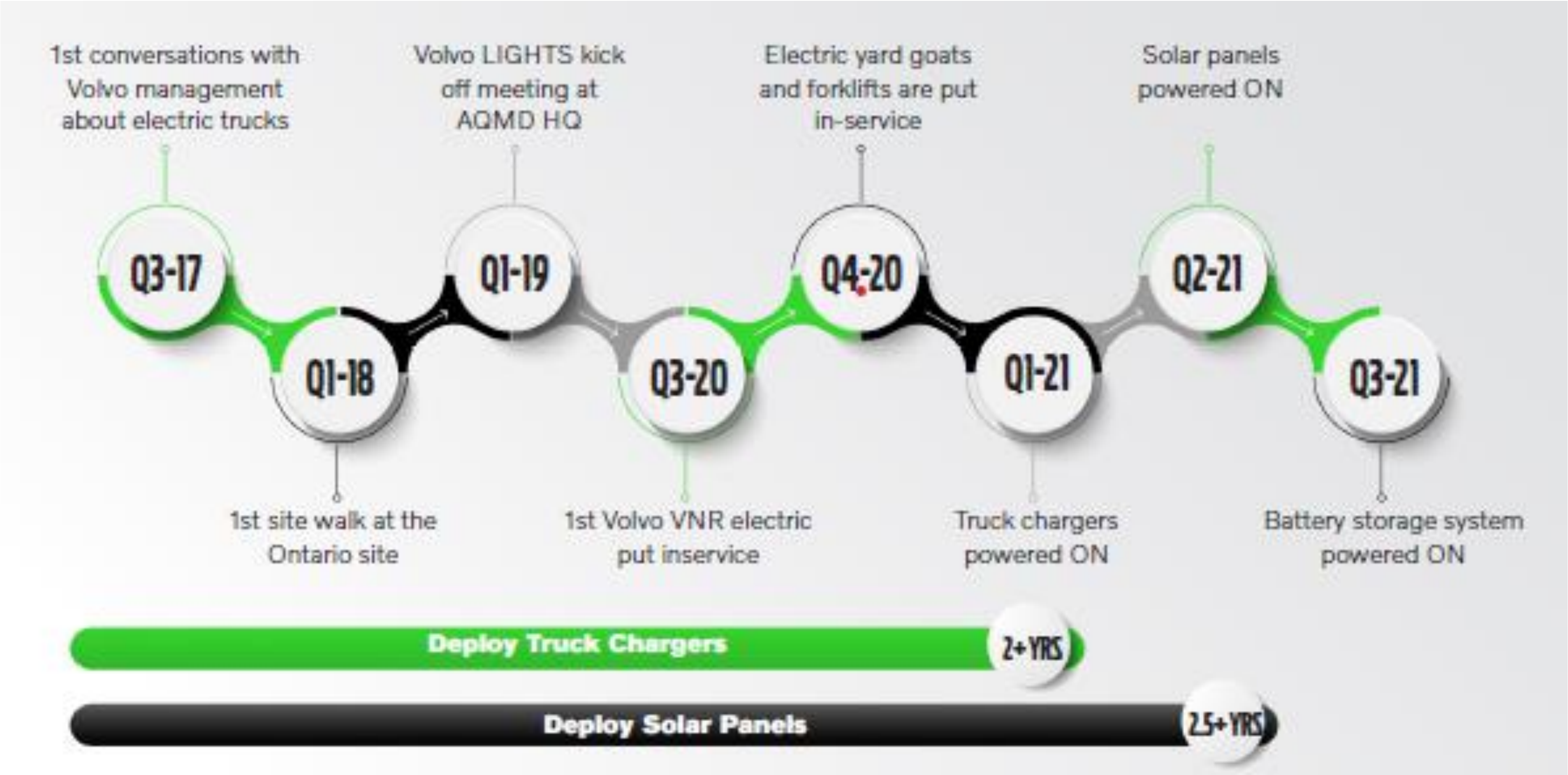
VOLVO LIGHTS Project 2019-2022

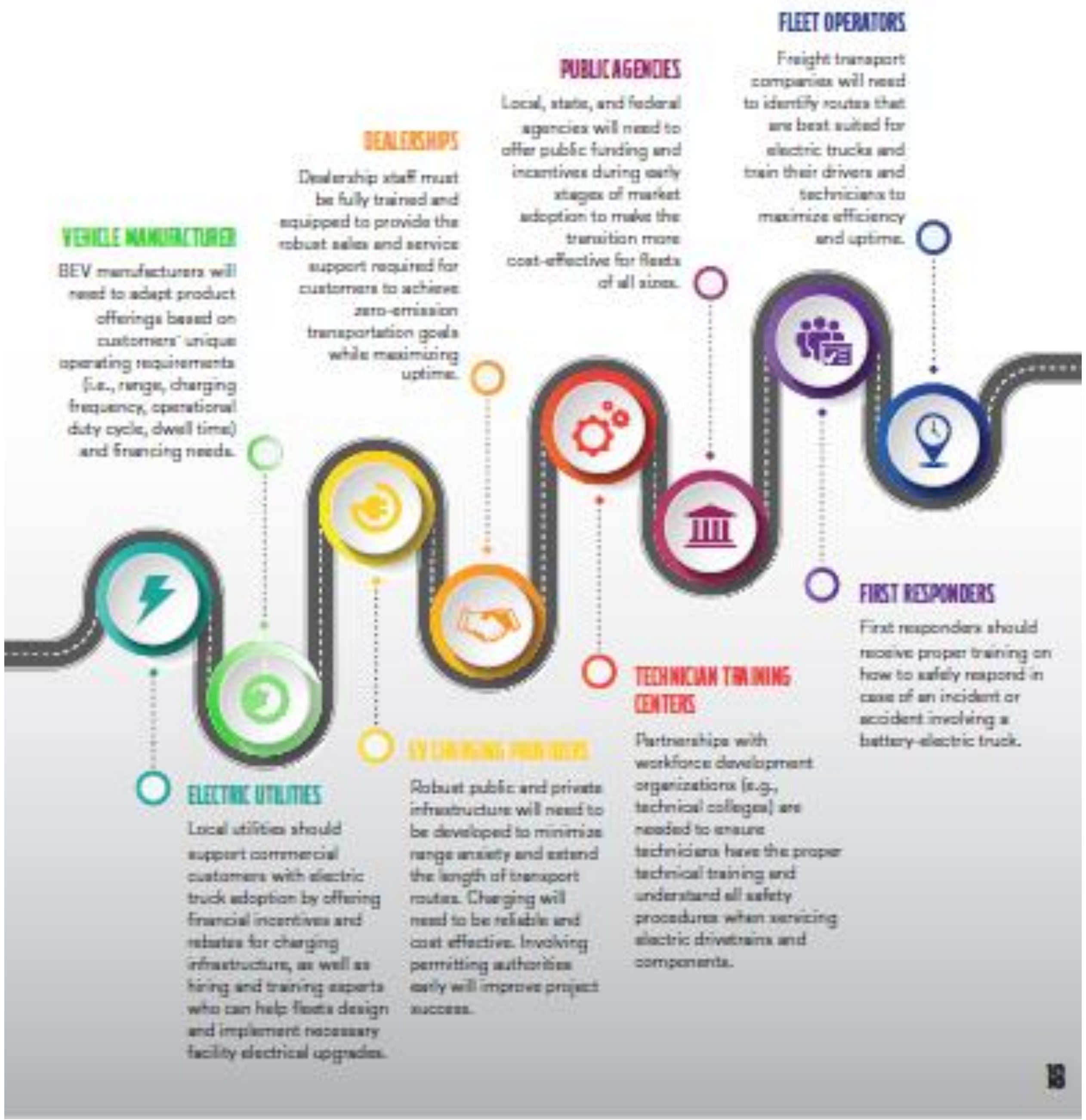
VOLVO LIGHTS PROJECT PARTNERS:

Lessons Learned:

- Use a **holistic, eco-system approach** to electrification of transportation at individual sites
- **Hire the right consultants** (EV equipment, charging, energy, financial, engineering, and assistance with voucher / grants)
- **Appoint a project team** and site manager
- **Perform a site walk-around** with the entire team (especially your local electric utility company)
- **Prepare for unexpected delays:**
  - Supply chain constraints with electrical components and systems
  - Construction permitting, crew scheduling, power-on approval, etc.
- **Optimize EV routes** to match available range, opportunity charging and maximum payload

Plan for longer lead-times
Example:





VEHICLE MANUFACTURER

BEV manufacturers will need to adapt product offerings based on customers' unique operating requirements (i.e., range, charging frequency, operational duty cycle, dwell time) and financing needs.

DEALERSHIPS

Dealership staff must be fully trained and equipped to provide the robust sales and service support required for customers to achieve zero-emission transportation goals while maximizing uptime.

PUBLIC AGENCIES

Local, state, and federal agencies will need to offer public funding and incentives during early stages of market adoption to make the transition more cost-effective for fleets of all sizes.

FLEET OPERATORS

Freight transport companies will need to identify routes that are best suited for electric trucks and train their drivers and technicians to maximize efficiency and uptime.

ELECTRIC UTILITIES

Local utilities should support commercial customers with electric truck adoption by offering financial incentives and rebates for charging infrastructure, as well as hiring and training experts who can help fleets design and implement necessary facility electrical upgrades.

Robust public and private infrastructure will need to be developed to minimize range anxiety and extend the length of transport routes. Charging will need to be reliable and cost effective. Involving permitting authorities early will improve project success.

TECHNICIAN TRAINING CENTERS

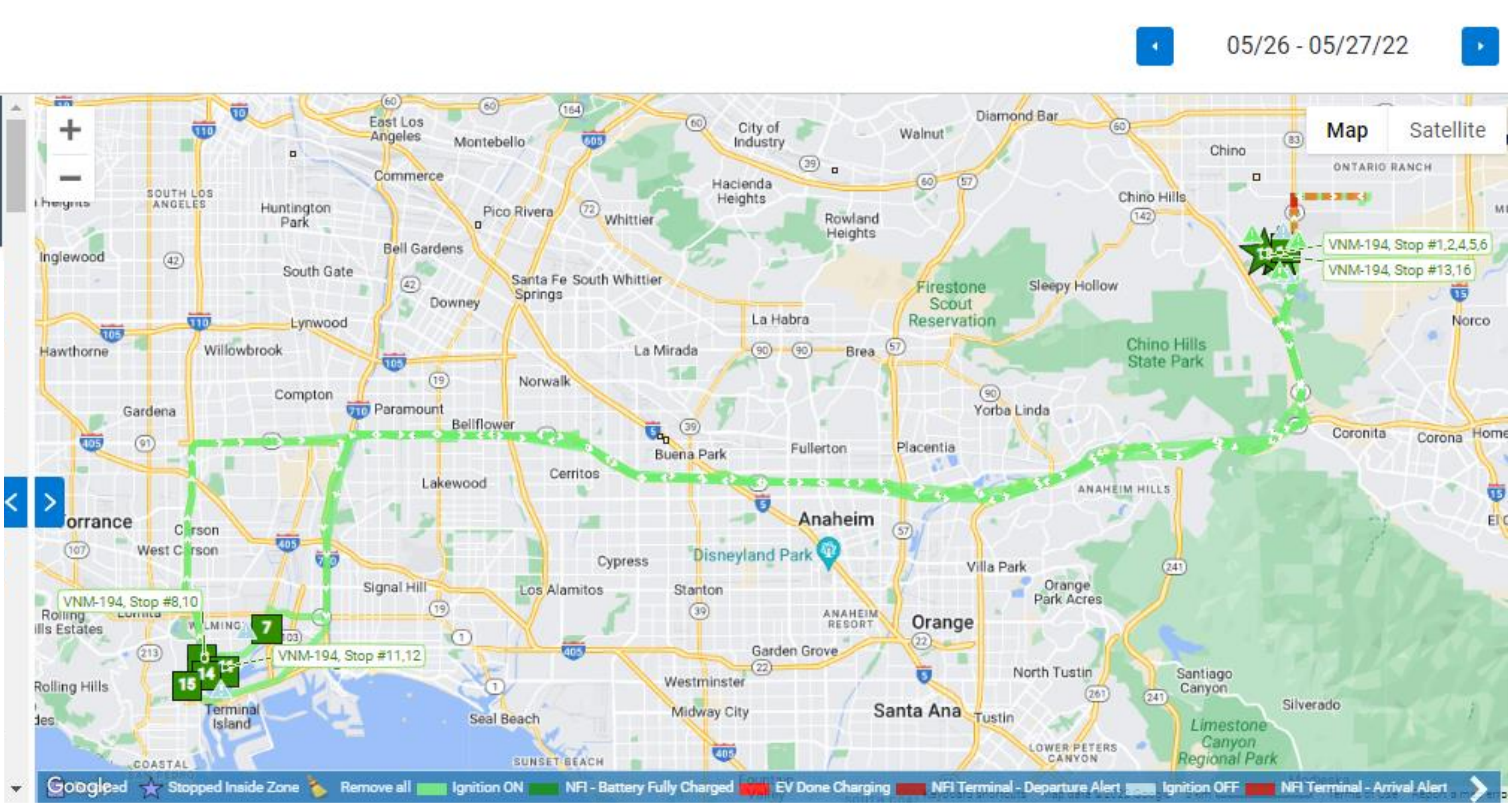
Partnerships with workforce development organizations (e.g., technical colleges) are needed to ensure technicians have the proper technical training and understand all safety procedures when servicing electric drivetrains and components.

FIRST RESPONDERS

First responders should receive proper training on how to safely respond in case of an incident or accident involving a battery-electric truck.

18

Lessons Learned: Use data analytics



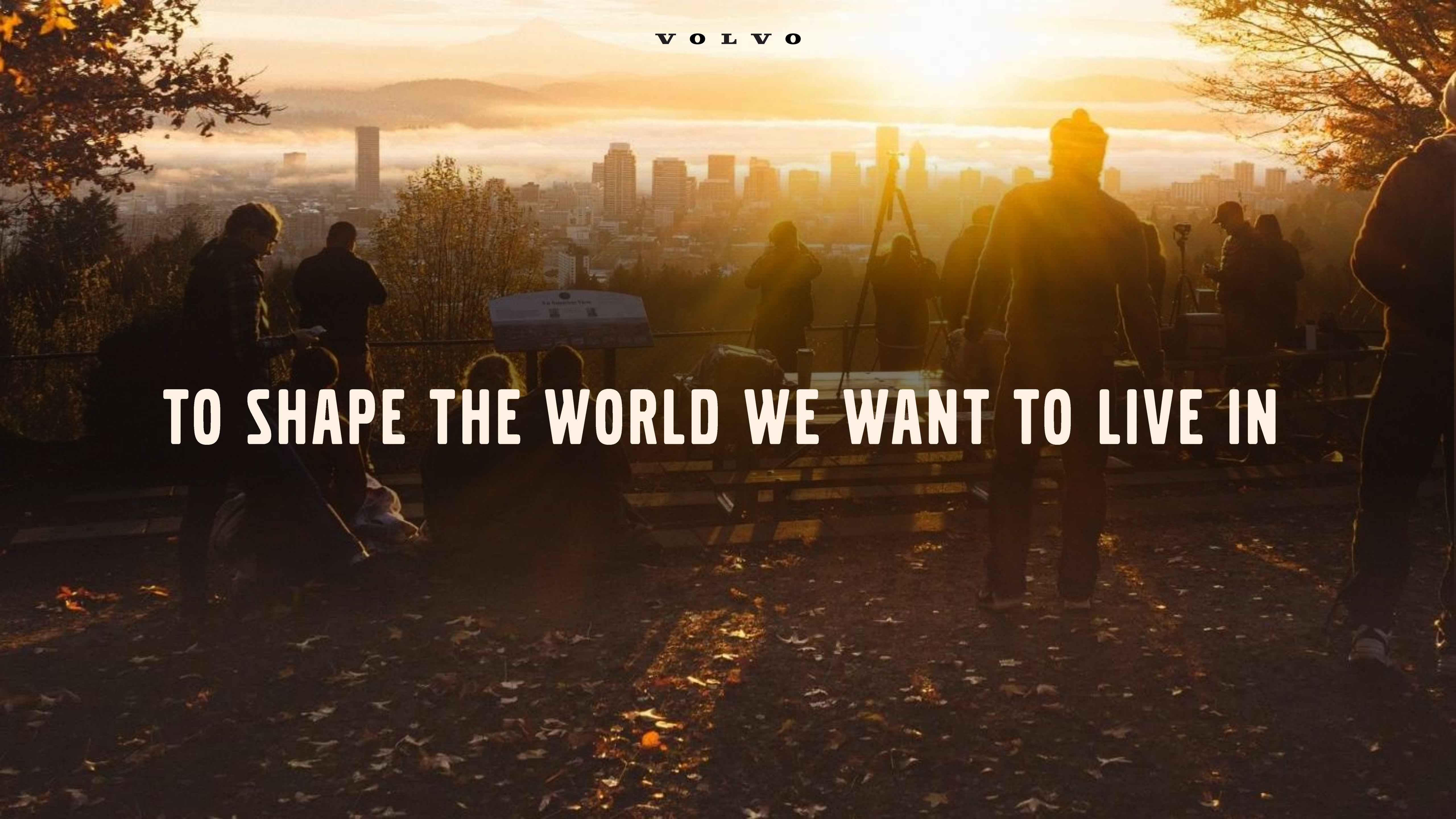
- Total Trip mileage
- Total daily mileage
- Number of stops
- Average state of charge
- Opportunity charging sessions
- Ending state of charge
  - Total energy used
- Vehicle speeds / efficiency

Truck Charging Demands

- All Volvo and MACK Truck Dealers must be EV certified before customer contact
- Commercial grade, UL Listed, DC Fast charging is preferred for fixed infrastructure
  - 250 kWh
  - Interoperability tests required
- Direct ship from Volvo dealers:
  - 50kW Mobile DC Fast Charger (Single Port CCS1) or a 180kW Flex DC Fast Charger (up to three CCS-1 dispensers)

Coordination with Utilities

- On-site review must start first
  - Infrastructure incentive programs
- Available grid capacity
  - Growth plans
- Timing alignment with truck delivery plans
- Project requirements
  - Owned or leased
  - Easements
  - Permitting, inspection and approvals
  - Construction requirements

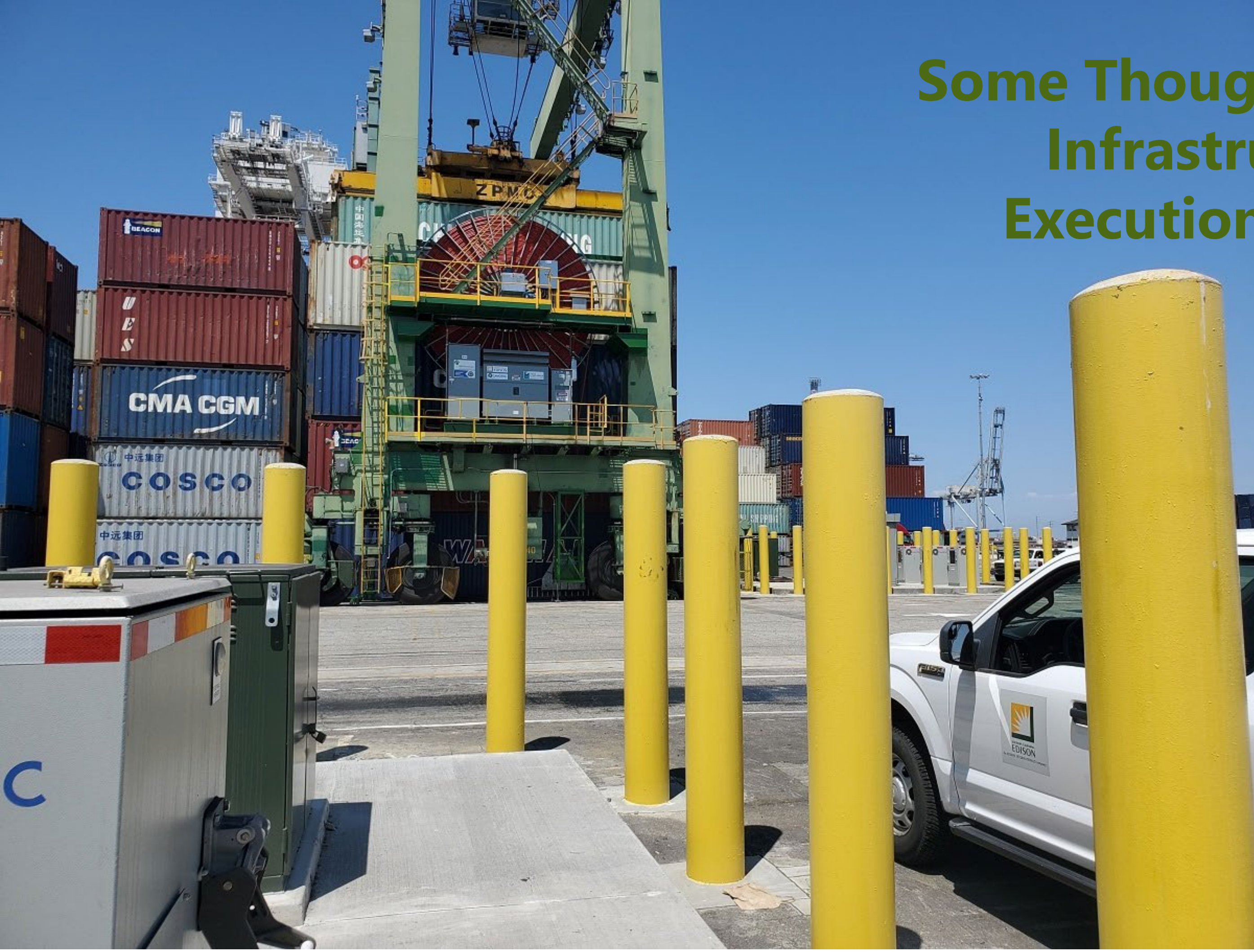

VOLVO
TO SHAPE THE WORLD WE WANT TO LIVE IN

Additional information at:

https://www.volvotrucks.us/

https://www.lightsproject.com/

Some Thoughts on Charging Infrastructure Planning, Execution, and Operation



Jordan Smith, P.E.

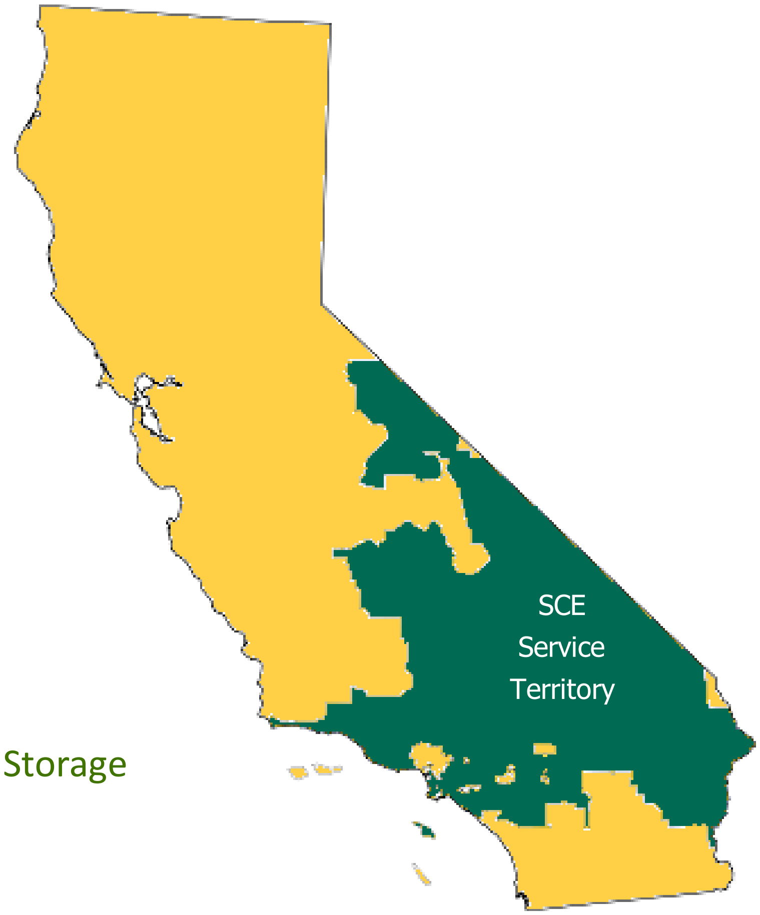
Grid Edge Innovation

2 February 2023

Clean Fuels Advisory Group
AQMD

Southern California Edison Overview

- 50,000 square-mile service area
- 5 million customer accounts
- 14 million residents
- Infrastructure
  - 1.4 million poles
  - 700,000 transformers
  - 103,000 miles of T&D lines
- Rate base growth driven by:
  - Safety and reliability
  - Distribution Resources Plan
  - Transmission growth, renewables
  - State environmental policy
  - Electric Vehicle charging and Energy Storage



SCE Grid Technology Innovation

- Demonstration projects that support long-term strategies
- Engagement with Universities, National Labs, Research Institutes to partner on demonstration projects and align industry with SCE strategy
- New innovation projects in support of SCE long term strategies
- Operate innovation labs to vet pre-commercial technologies to inform SCE strategies

SCE Pomona Labs – EV Technical Center

- Established in 1993
- Quality Management System
- Unique in utility history
- DOE QTS
- Energy storage in transportation and stationary fields
- Vehicle and power train testing and evaluation
- Charging infrastructure evaluation, standards
- Fleet support

Topics to Cover Today

- Introduction
- Setting the stage
- Overview of Clean Power Pathway, Pathway 2045, Reimagining the Grid
- SCE EV Charging Service Requests and SCE Charge Ready programs
- A short primer on grid planning and serving the EV charging needs of customers into the future
- EPIC Demonstration Projects, Lessons learned and assessment of truck fleet electrification grid impact studies, Volvo LIGHTS

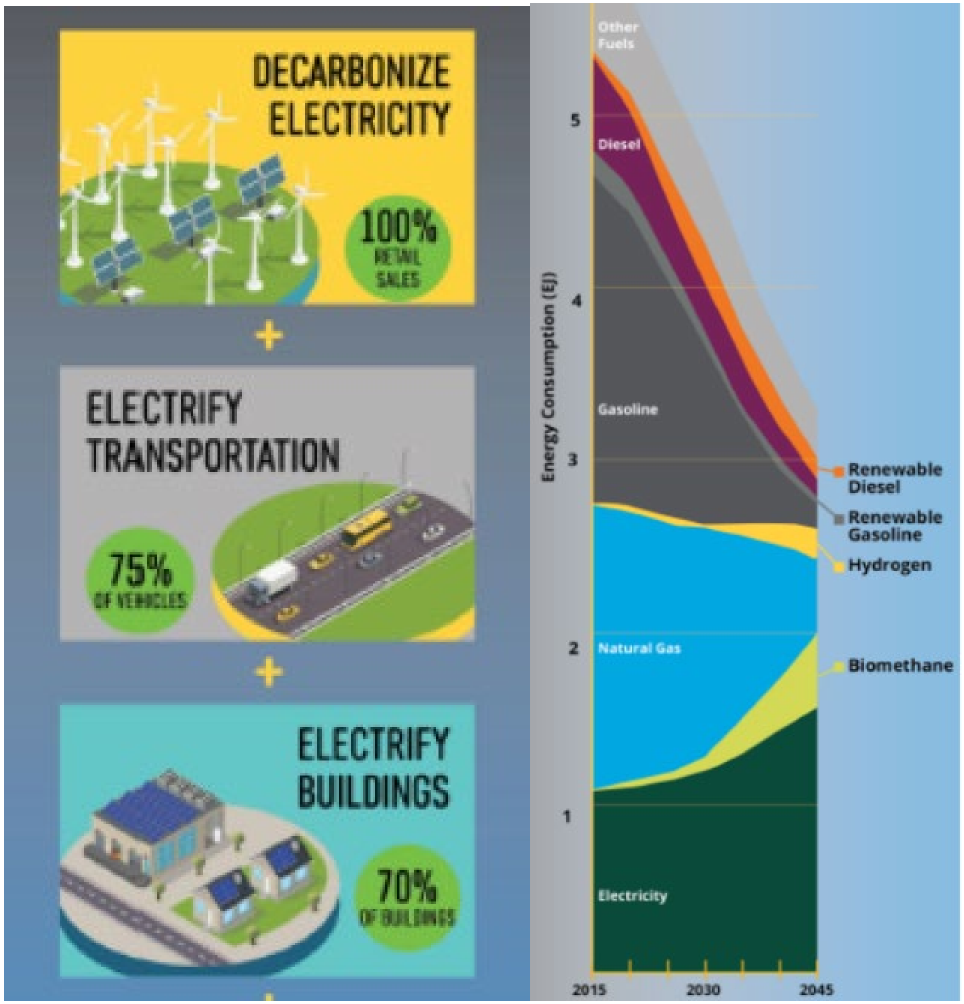
Pathway 2045 to Clean the Electric Grid and Reach Carbon Neutrality

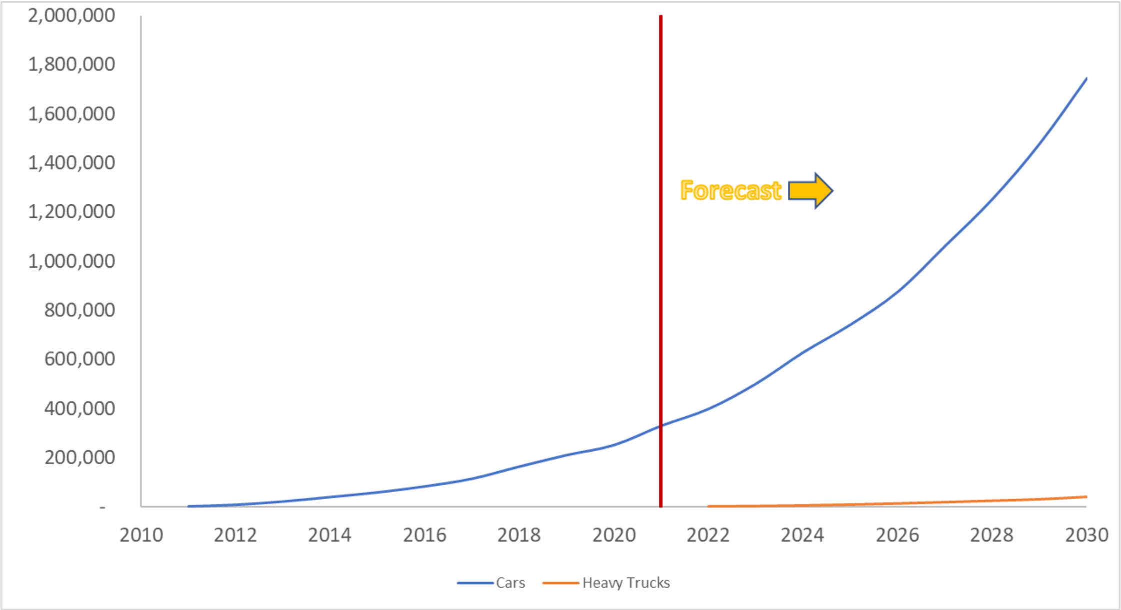
Generation

- 40% increase in peak load
- 80 GW of new generation
- 30 GW of new energy storage

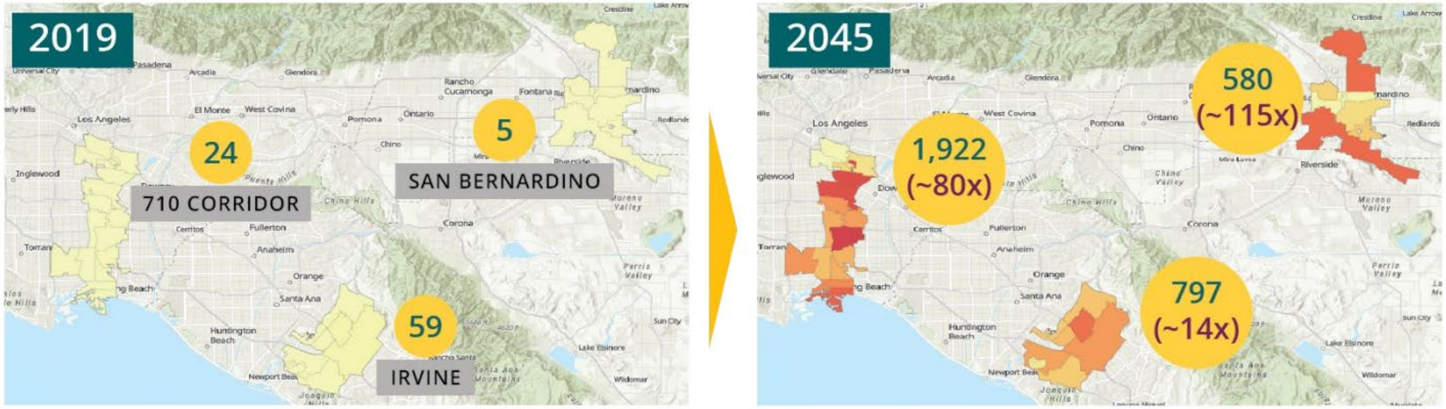
Transportation Electrification

- 75% of light vehicles
- Two thirds of medium-duty trucks
- One-third of heavy-duty trucks





Transportation Electrification Grid Impact



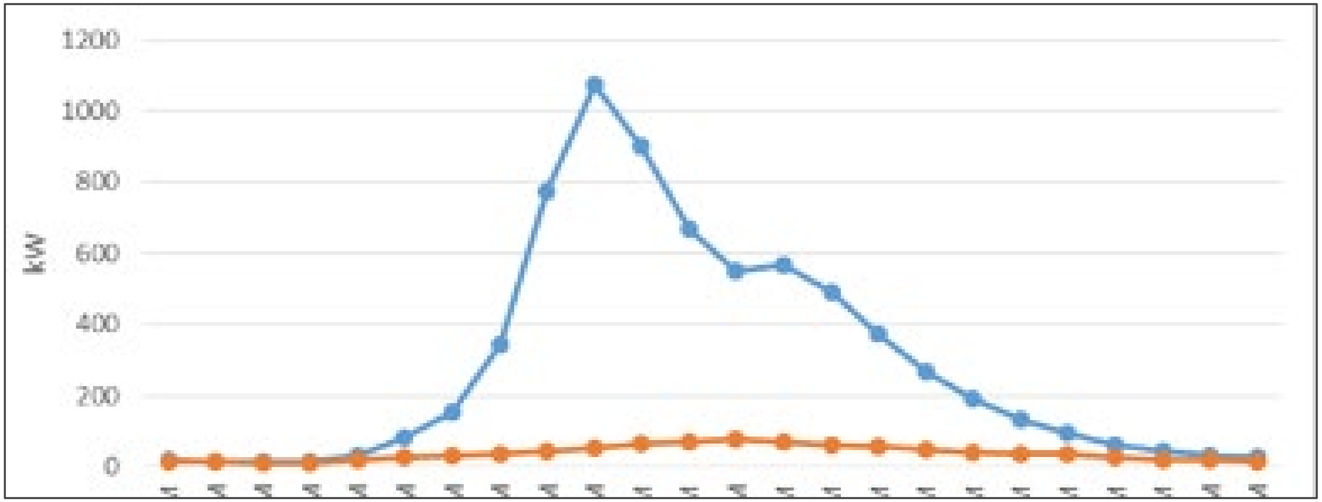
- By 2045, on average, **EV penetration will grow 34x** (GWh) from today in SCE service territory

>250 GWh
125 GWh
<0.004 GWh

XX Annual EV load in GWh

Load Management – Controlled vs. Uncontrolled

- Assessing Load Shapes
  - Behavioral
  - Tariff influenced
- Load management
  - Demand Response
  - Auto Functions
  - Directed Functions



Reimagining the Grid

Traditional Grid
to deliver safe, reliable, affordable power

- Separate transmission (network) vs distribution (radial) architectures
- Human operated electro-mechanical

Today's Grid
to support more reliability, resilience & DER integration

- Modernized distribution technologies but still separate architecture from transmission
- Rules-based, automated and hardware-centric
- Centralized control of grid services

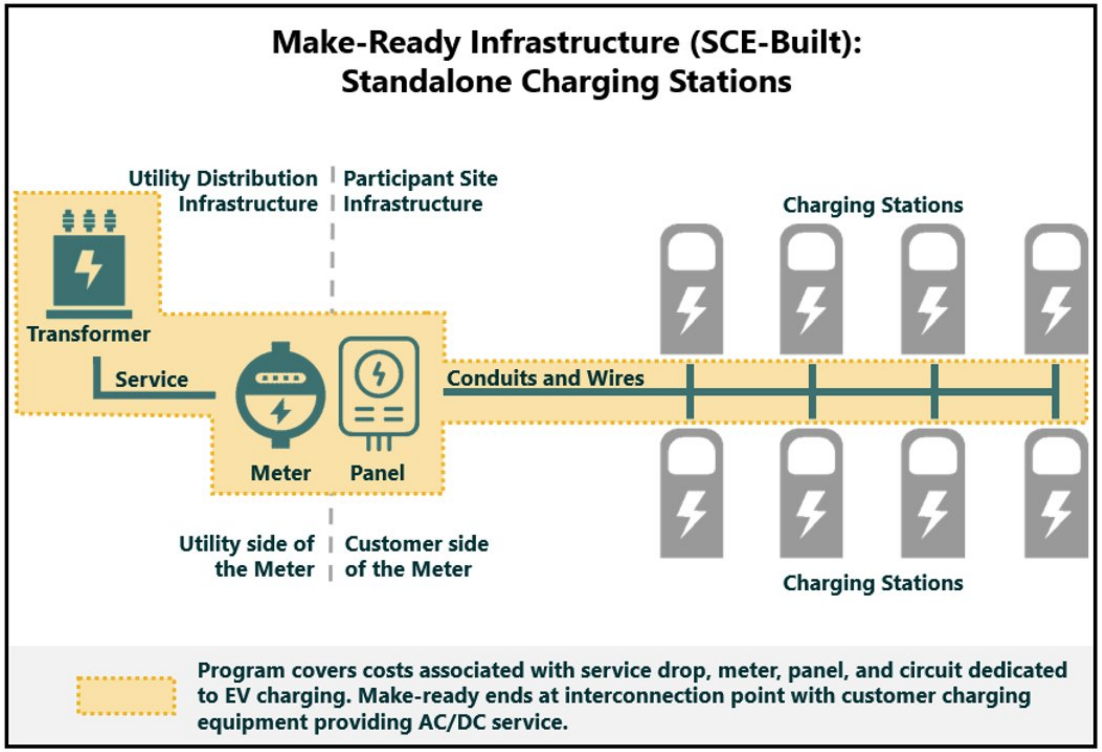
Reimagined Grid
to enable Pathway 2045 vision and meet location-specific needs

- Heterogenous architectures, integrated across transmission and distribution
- Partially autonomous, flexible and software/network-centric
- Decentralized control of grid services
- Advanced cybersecurity
- Common IT/OT platform deployed across the grid
- Tailored grid architectures with next-generation technologies deployed as needed for different regions

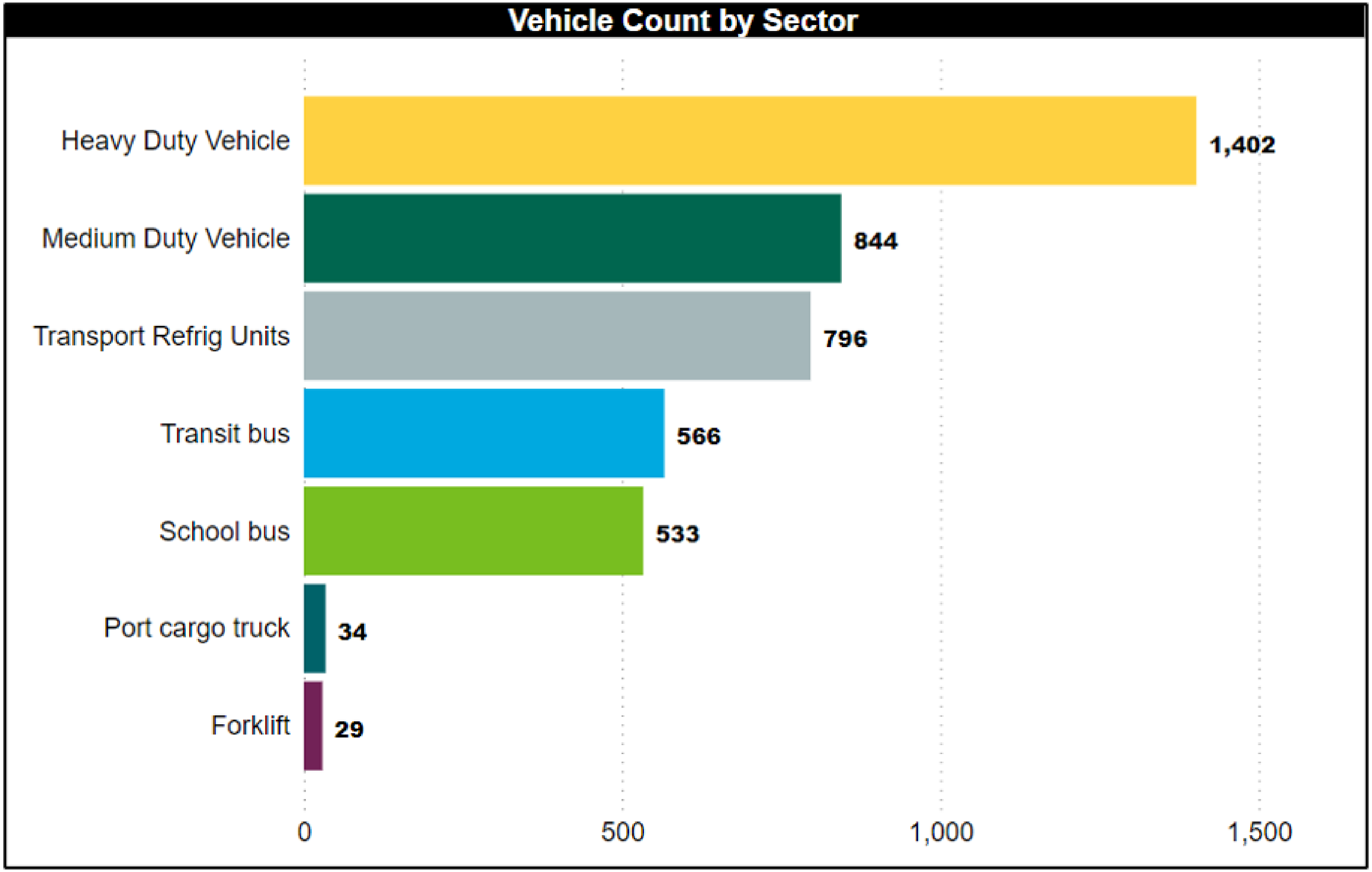
https://www.edison.com/our-perspective/reimagining-the-grid

EV Charging Service – Ready to Serve

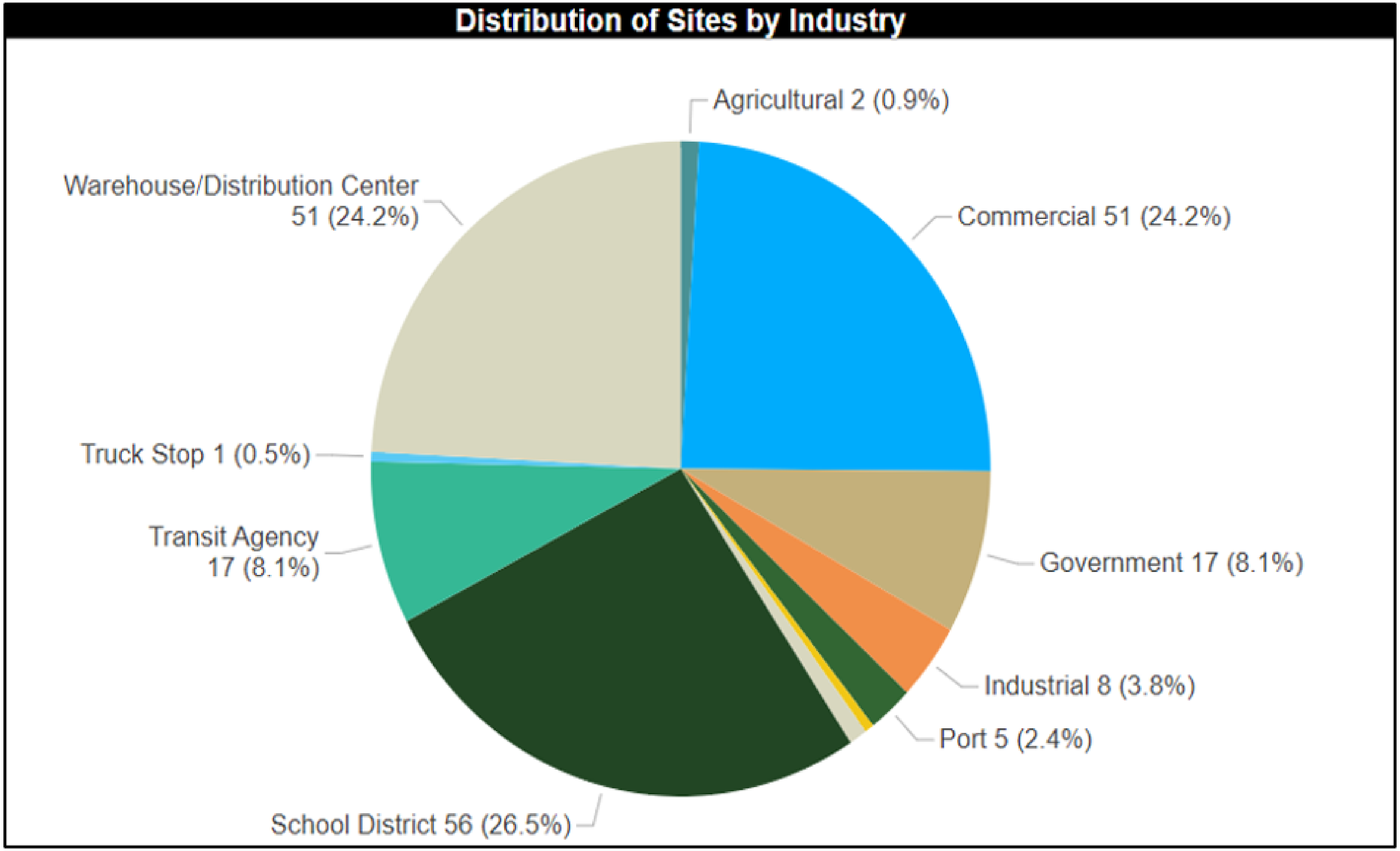
- Charge Ready Programs
  - Transport – MD and HD, Trucks, Buses
  - Charge Ready – LD, passenger
  - SCE build and build it yourself + rebate options
- Standard Service Requests – Utility Side Only



Charge Ready Transport Snapshot



Charge Ready Transport Snapshot



Grid System Planning

- The utility and energy system has evolved to serve Californians' needs throughout modern history – and will continue to do so
- SCE performs annual system evaluation to address the changing power needs throughout its service territory
- System upgrade plans are described in a 10-year forecast based on engineering assessment, information provided by customers and load forecasting
- Accurate and timely customer information is crucial – not speculation
- Forecasting: Top down and bottom up
  - Official processes – IRP, State, Federal
    - Data Sources:
      - Customer data – meter data, historical usage, DER adoption
      - Demographics, socio-economics
      - Customer programs and surveys
      - Known project development and plans

New EV Charging Projects

- *Inform SCE as Soon as Possible – preferably at least 2 years before needing large power service*
- SCE will always provide the power our customers require to operate their business **but upgrades to grid may be required.** Partnering with SCE early will help ensure that the level of power required is delivered in both a timely – and safe – manner
- Be ready to discuss and review the scope of your project, including technical details around equipment, number, power levels, number of vehicles, types, as well as equipment and vehicle acquistition plans for phasing in power

Plan Ahead – Providing Energy Capacity

Did You Know? A new 12 kV circuit which provides about 10MW of power (roughly 12,000 amps @480 V) can take between 2 to 3 years to construct?

Did you Know? A new customer-owned substation can take between 3 to 5 years to construct?

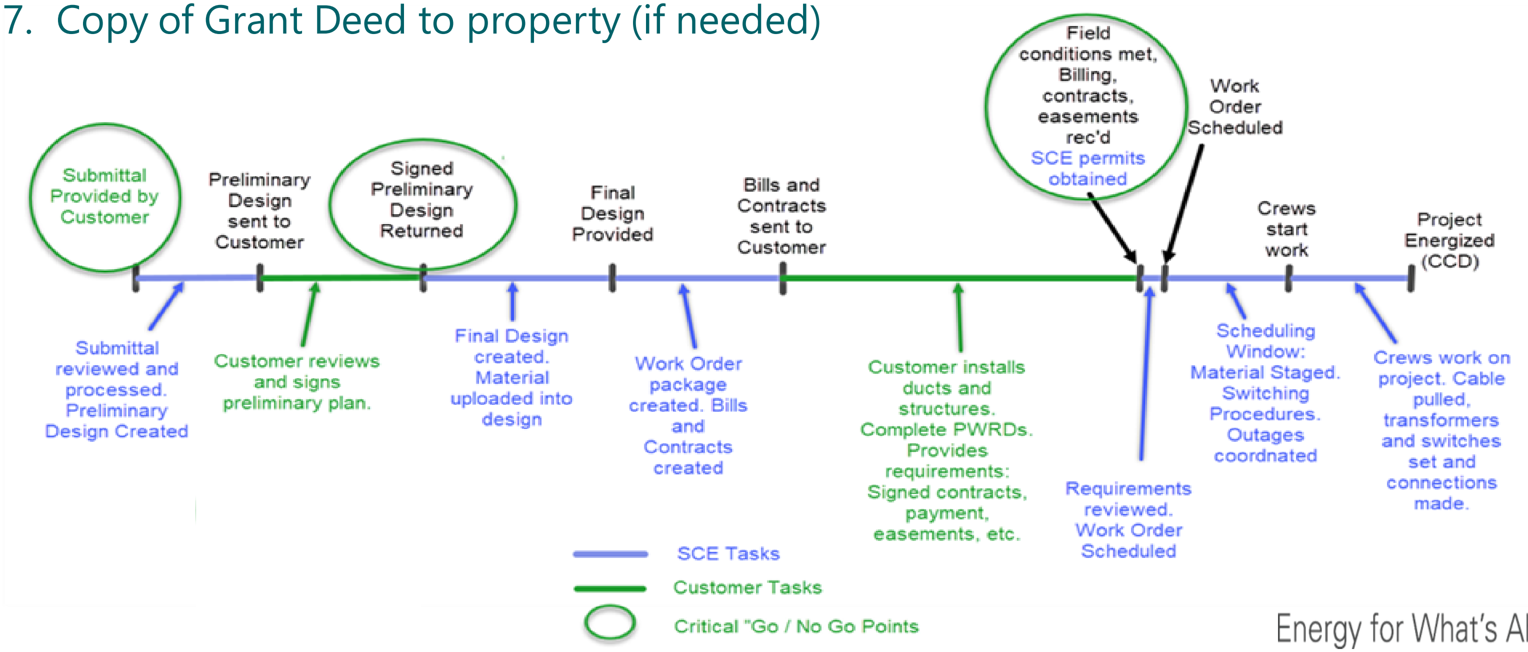
Sample Process Overview – Service Request for New Development

Submittals:

1. Completed Customer Project Information Sheet (CPIS)
2. TPM Supplemental Form
3. Design Option Letter (DOL)
4. Relevant Plans (Site, street Improvement, Electrical, Grading etc..) (PDF and CAD)
5. Detailed Load Schedule & Single Line Diagram
6. Project Phasing Plan
7. Copy of Grant Deed to property (if needed)

Good to be aware of division of responsibilities

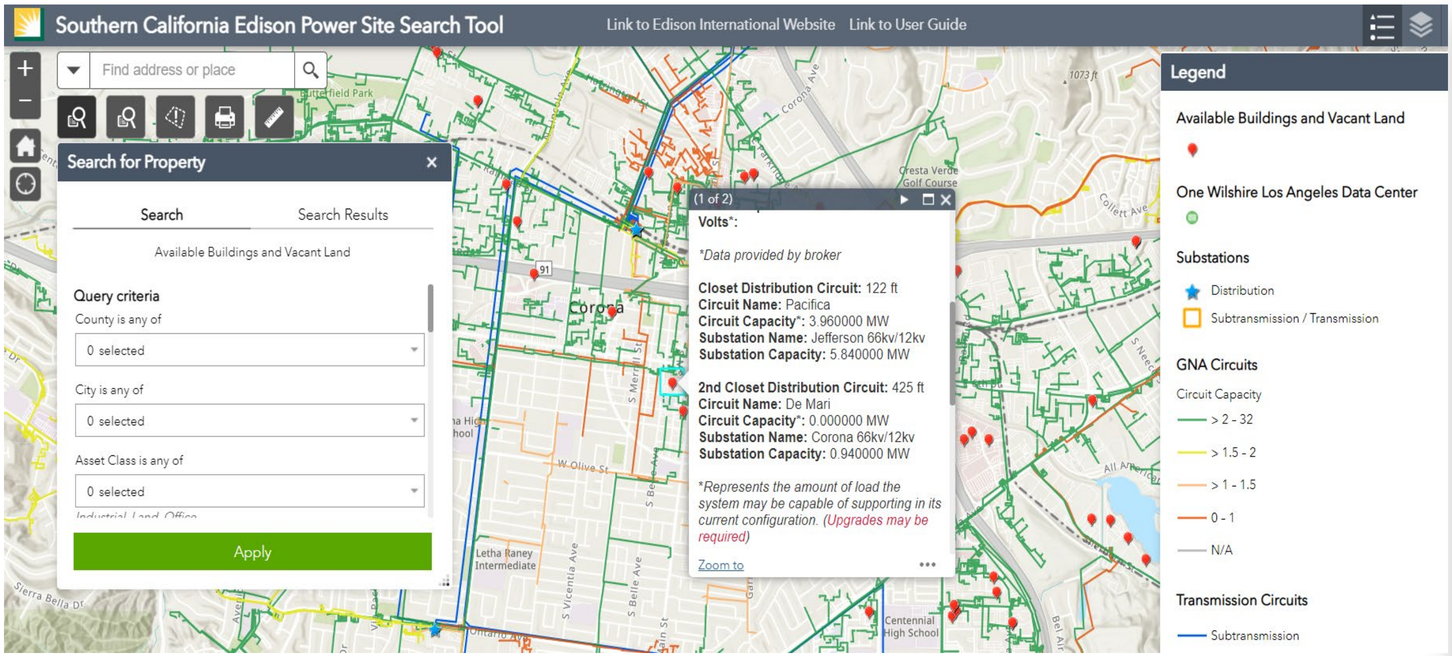
- SCE tasks
- Customer tasks

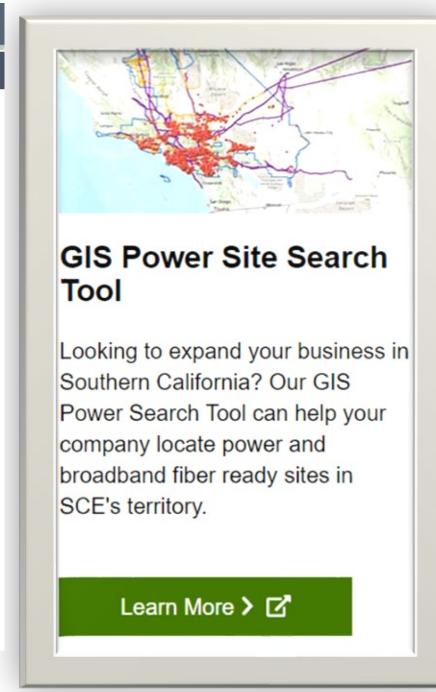


SCE's GIS Power Site Search Tool

SCE Circuit Capacity & Infrastructure

www.sce.com/economicdevelopment





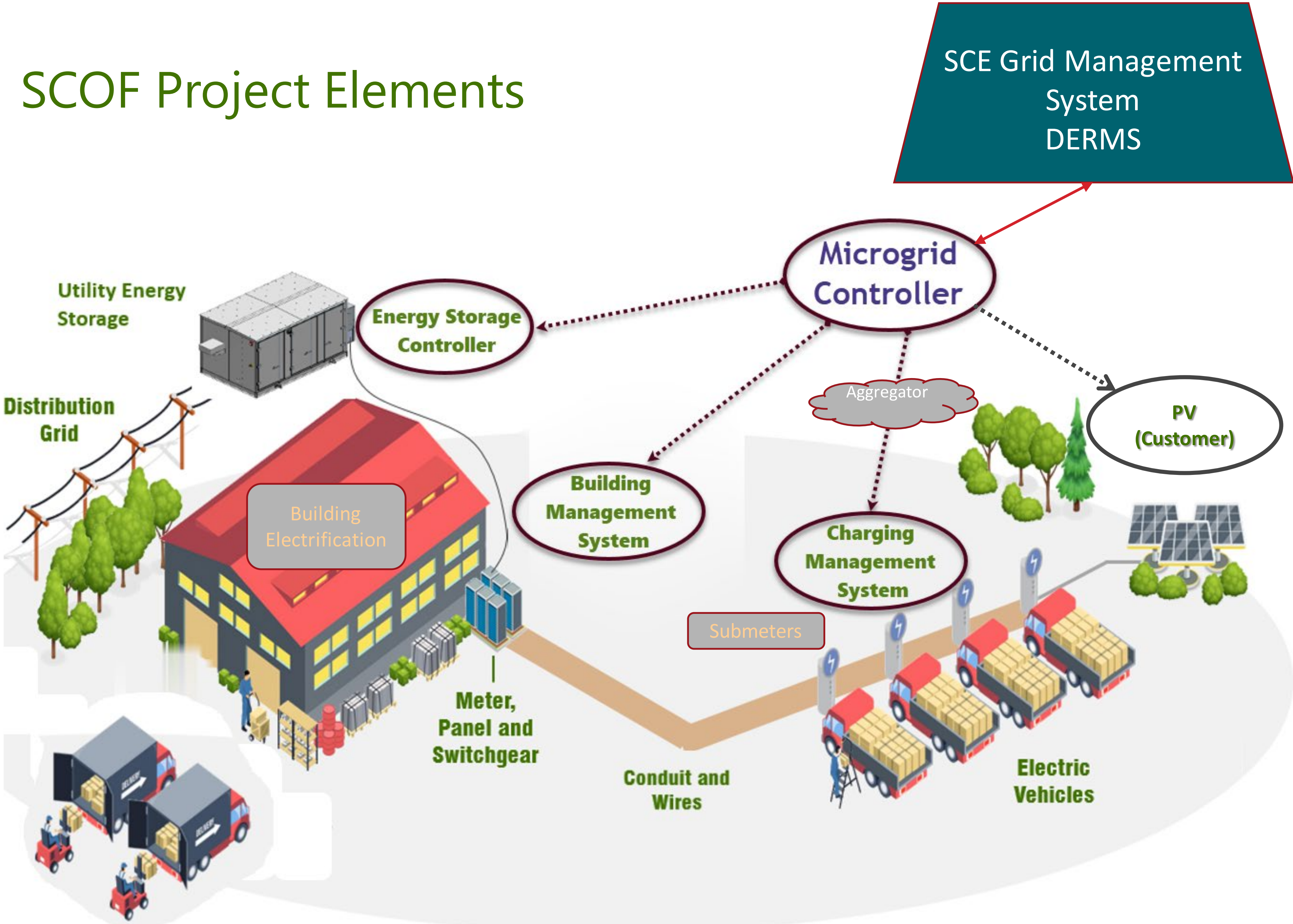
An additional resource for capacity information is the Distribution Resource Plan External Portal (DRPEP) search tool. DRPEP is an interactive web portal that provides public access to general locations of SCE distribution circuits and substations, including electrical load and Distributed Energy Resources (DERs) hosting capacity by circuit. Visit: **https://drpep.sce.com/drpep**

Current SCE EPIC Transportation Electrification Projects

Three current *Electric Program Investment Charge* demonstration projects involve transportation electrification with technical implementation of various use cases

1. **Service Center of the Future**
   - **Fleet and building electrification at facility level, storage, PV, FMS, GMS, DERMS**
2. Vehicle to Grid Integration – V2G, light duty, heavy duty
3. Distributed Charging Resources
   - Batteries connected with fast chargers, EV Energy Management Systems

SCOF Project Elements



Objectives and Use Cases

Demand Response

- Microgrid control system (MCS) to communicate and manage demand response (DR) events
- Building management system (BMS) to optimize building energy usage
- Charging management system (CMS) to contain EV peak demand

Grid Support

- MCS to support over/under voltage conditions using ESS and controls
- MCS to charge/discharge ESS to support grid capacity needs

Resiliency

- MCS to manage island formations
- MCS to manage grid re-synchronization

EV Charging Management

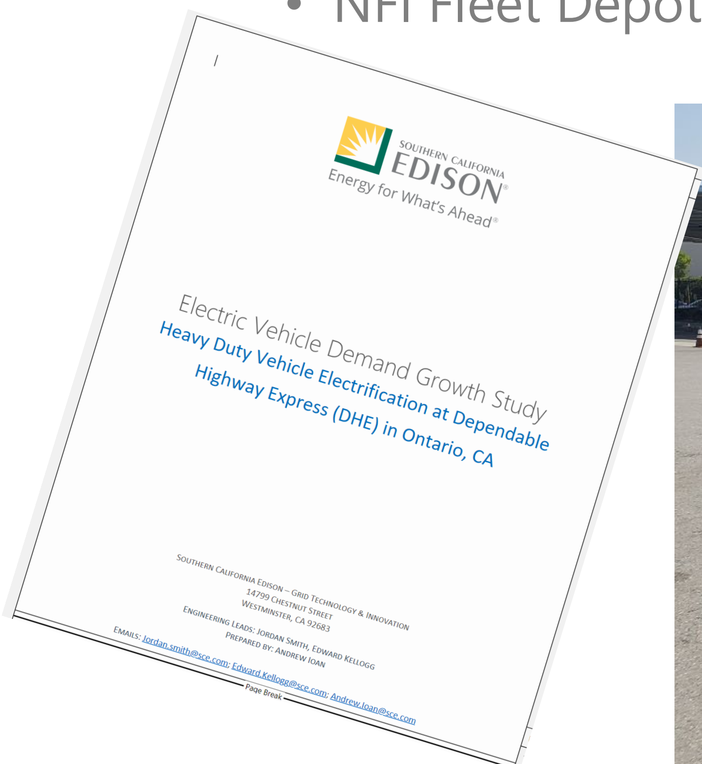
- CMS to optimize EV charging schedule, satisfying requirements of fleet operation while minimizing electric fuel cost

Challenges and Value Delivered

- Demonstrate alternative service option and real/controlled capacity needs
- Integration of fleet operational control strategy with site and grid energy management systems
- Secure communication between microgrid and third-party DERs
- Interconnection of storage system and battery management functions (grid side, customer side, generation, distribution)
- Siting of storage and infrastructure components on customer property and consideration of operational needs, configuration, switching
- Outage resiliency with energy storage
- Demonstrate advanced metering options and back office systems
- Learnings to enable further deployment of such technology and lower the cost and time required for large-scale fleet electrification

Some Learnings – Volvo LIGHTS

- Completed Engineering Grid Impact Study
  - Using customer load characteristics and grid modeling tools
    - DHE Fleet Depot
    - NFI Fleet Depot



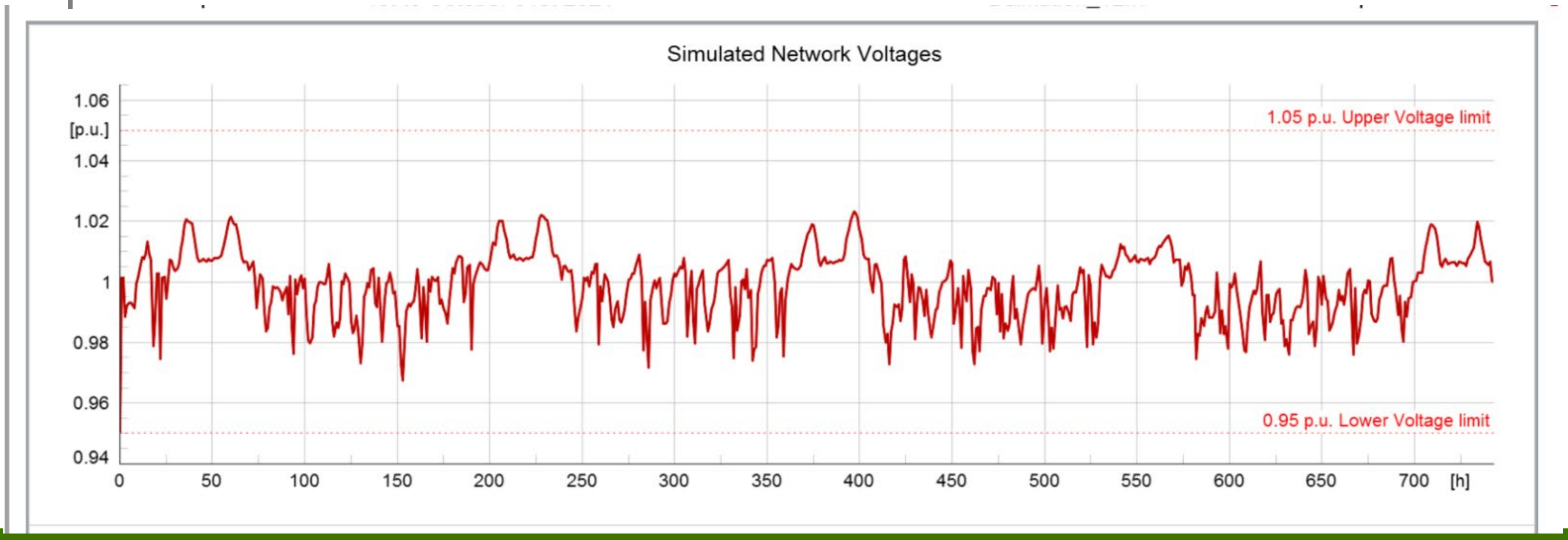
Southern California Edison
Energy for What's Ahead®

Electric Vehicle Demand Growth Study
Heavy Duty Vehicle Electrification at Dependable Highway Express (DHE) in Ontario, CA

Southern California Edison – Grid Technology & Innovation
14799 Chestnut Street
Westminster, CA 92683
Engineering Leads: Jordan Smith, Edward Kellogg
Prepared by: Andrew Ioan
Emails: Jordan.smith@sce.com; Edward.Kellogg@sce.com; Andrew.Ioan@sce.com
Page Break

Sample Results

- Modeled increase in charging loads up to current service size
  - Can accommodate with no impact on feeder
- Modeled further increase in loads up to next step in service level
  - Feeder upgrade
- Results used to inform planning and prepare for additional fleet depot EV charging service
- Model layered controls (SCOF) for alternative reduced impact options



Thank You

jordan.smith@sce.com

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PRESIDENT, ENERGY
NIKOLA CORPORATION

PIONEERING SOLUTIONS FOR A ZERO-EMISSIONS WORLD.

NIKOLA

ELECTRIC
CLASS 8 TRUCKS

+

ENERGY
SOLUTIONS

COMING SOON

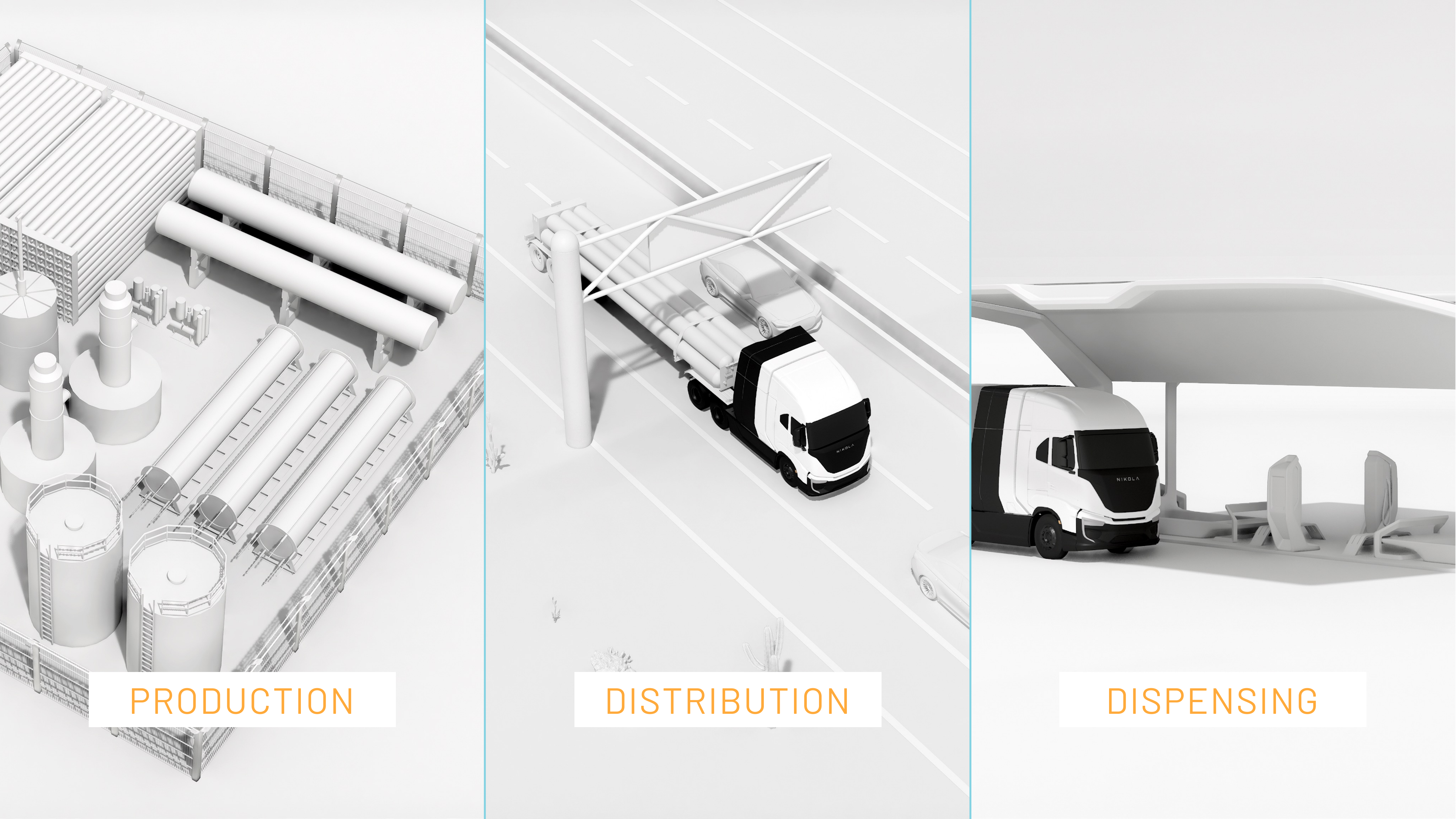
UP TO
500 mi
RANGE*

REFUEL TIME
20 min
OR LESS **

0
TAILPIPE
EMISSIONS

* Range estimate was calculated using data obtained from Nikola proving grounds testing, real-world vehicle operation, and computational-based engineering and validation tools. Actual range will vary based on several factors including use case, vehicle characteristics, driver behavior, and environmental conditions.
** Estimate based on projected technology improvements


HYLA™


PRODUCTION
DISTRIBUTION
DISPENSING

HYLA

ENERGY SUPPLY
AND TRADING

HYDROGEN FUELING
STATIONS AND LOGISTICS

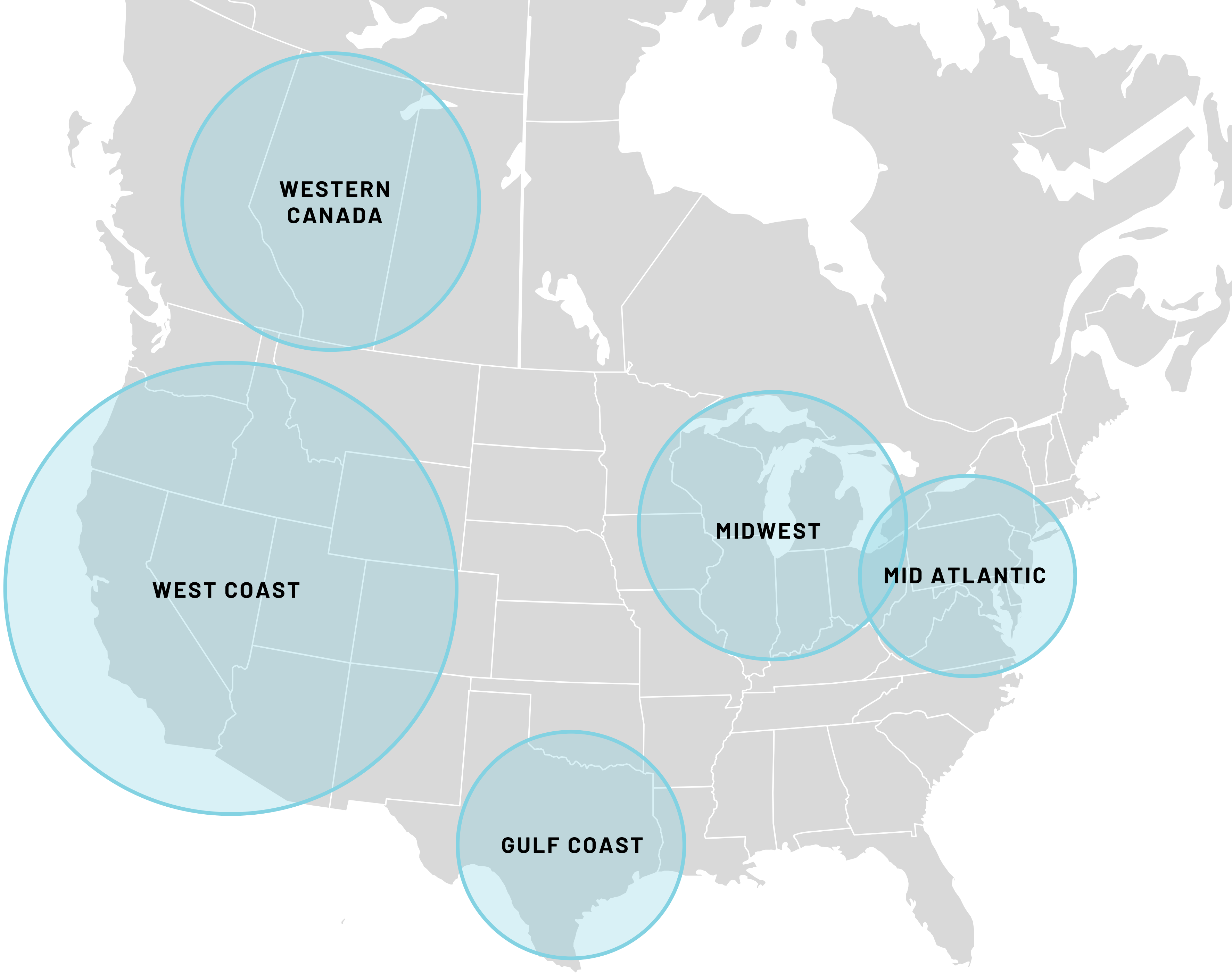
ENERGY INFRASTRUCTURE
AND OPERATIONS

TECHNOLOGY
AND ENGINEERING

REGULATORY
INCENTIVES

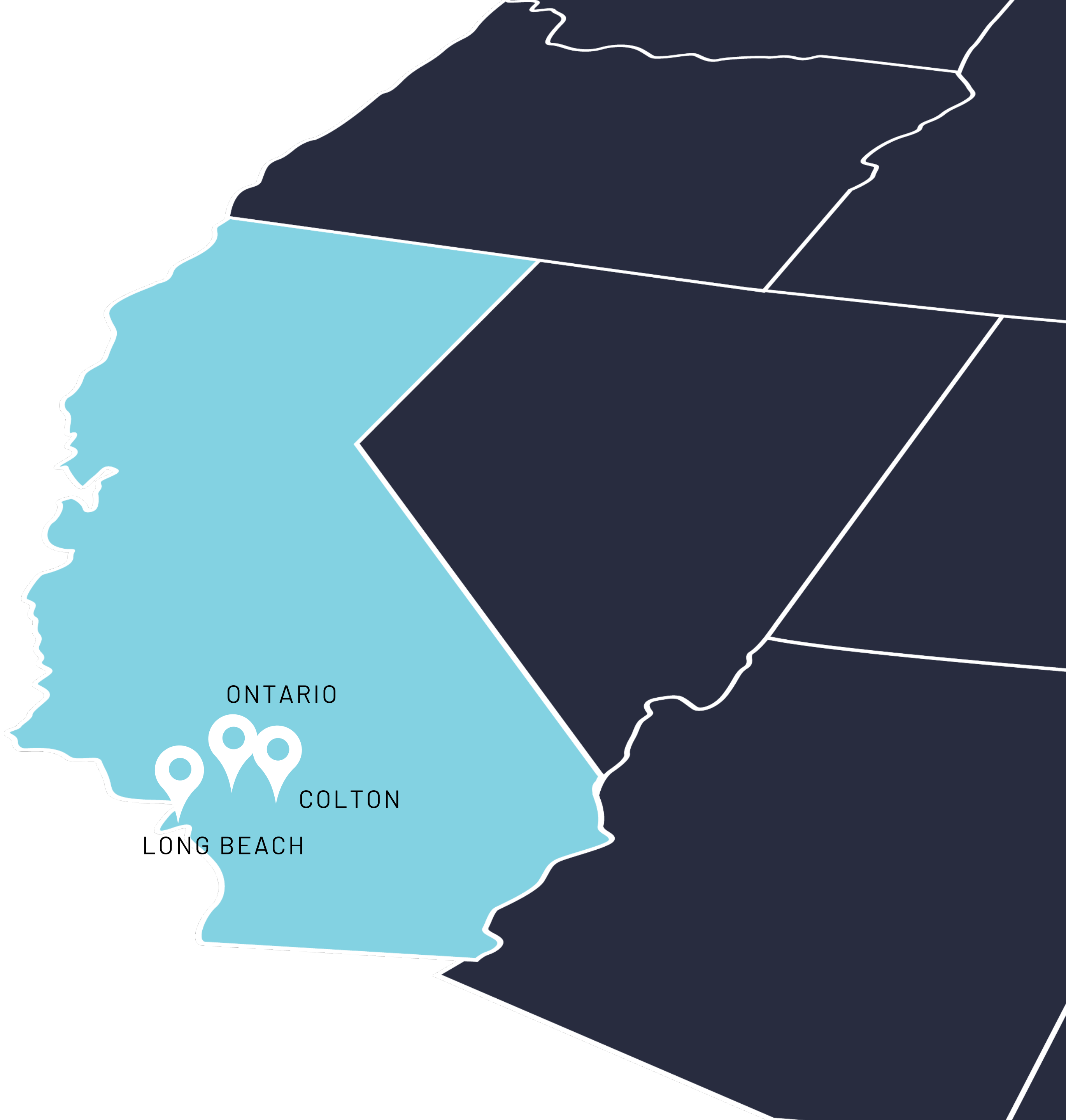
FINANCE
AND ANALYTICS

HYDROGEN PRODUCTION & SUPPLY STRATEGY



THREE HYDROGEN STATIONS ANNOUNCED

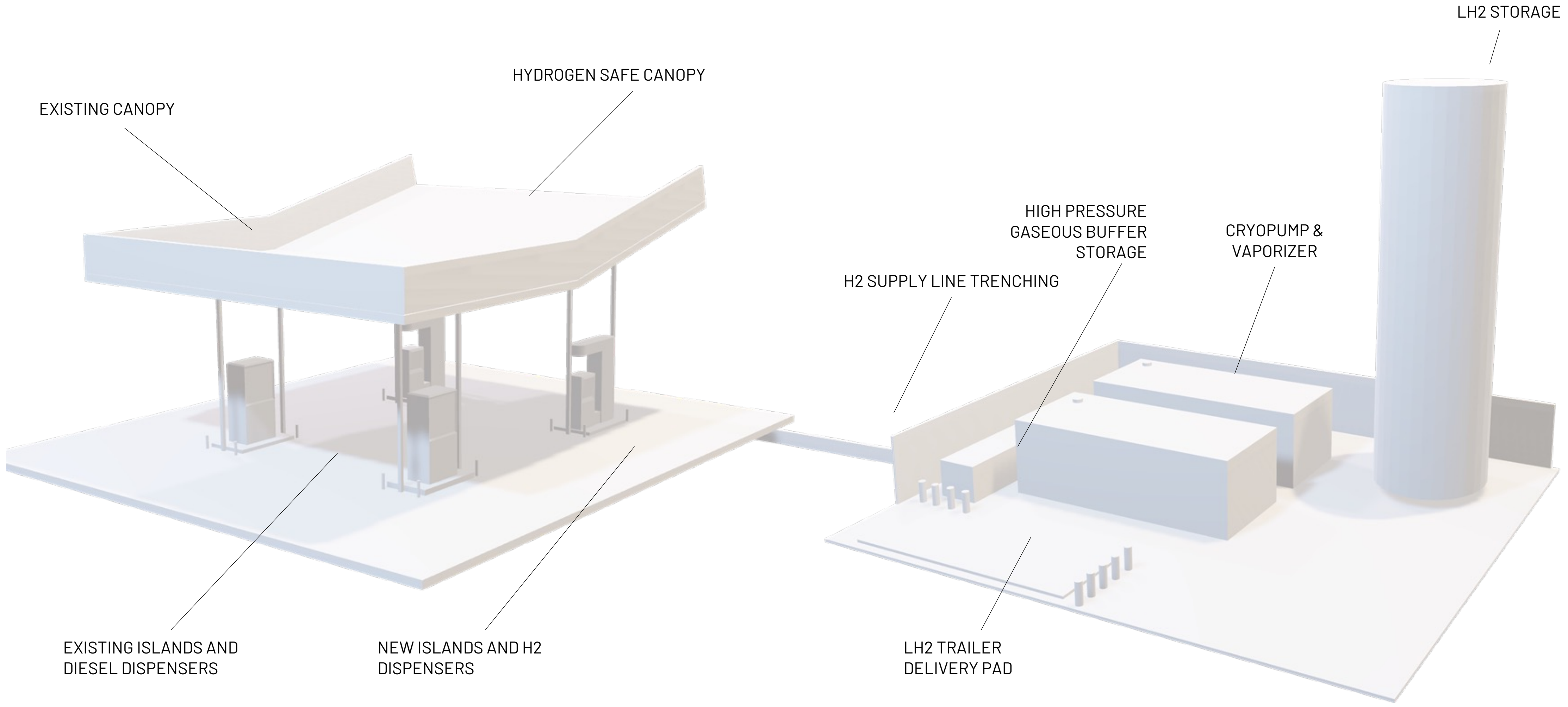
MORE TO COME
IN 2024 AND 2025



OWNED STATIONS

PARTNERED STATIONS

PUBLIC FUELING INFRASTRUCTURE



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HYLA HYDROGEN MOBILE FUELERS

PROVIDING TRANSITIONAL FUELING IN ADVANCE OF PERMANENT INFRASTRUCTURE

The HYLA Mobile Hydrogen Fueler offers solutions to help fleets rapidly transition from combustion engines to zero emissions. Our mobile fuelers provide flexible pre-station fueling options to help meet your demand and offers early access to dispensing hydrogen without the long wait time of permanent infrastructure.

Discover how the portfolio of innovative fueling solutions can help businesses accelerate access to support the transition to hydrogen fueling.

AGILE HYDROGEN SOLUTIONS


HYLA™

Heavy Duty Hydrogen Fueling and R&D

SCAQMD – Clean Fuels Retreat
February 2, 2023
Sam Sprik
National Renewable Energy Laboratory

NREL's H_2 & FC R&D Strategy

NREL's efforts will improve the economic viability of transforming, transporting, and storing hydrogen technologies in conjunction with key government and industry partners who will accelerate their adoption

Make

- Electrochemical
- Photoelectrochemical
- Biological
- Thermochemical
- Grid integration
- Power electronics
- Direct connect renewable integration

Move

- Pressure
- Form
- Quantity
- Mode

Store

- On-board
- Carriers
- Bulk

Use

- Fuel cells
- Electrons to Molecules
- Fuel upgrading
- Combustion
- Metal reductant

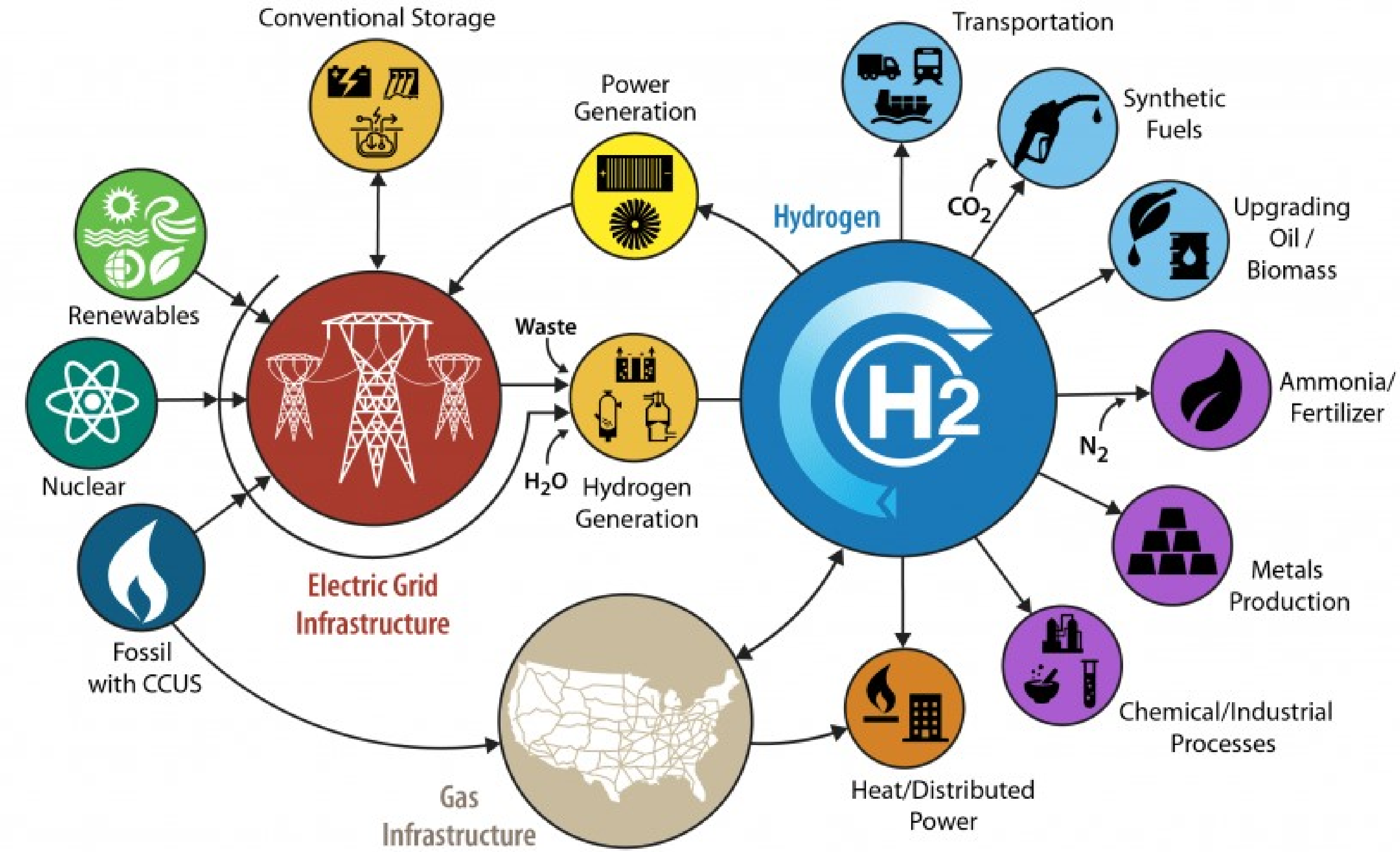
Crosscuts

- Foundational decision science
- Manufacturing
- Safety
- People

Vision: *Hydrogen will be a ubiquitous means of transporting, storing, and transforming energy at the scale necessary to enable a clean and vibrant economy*

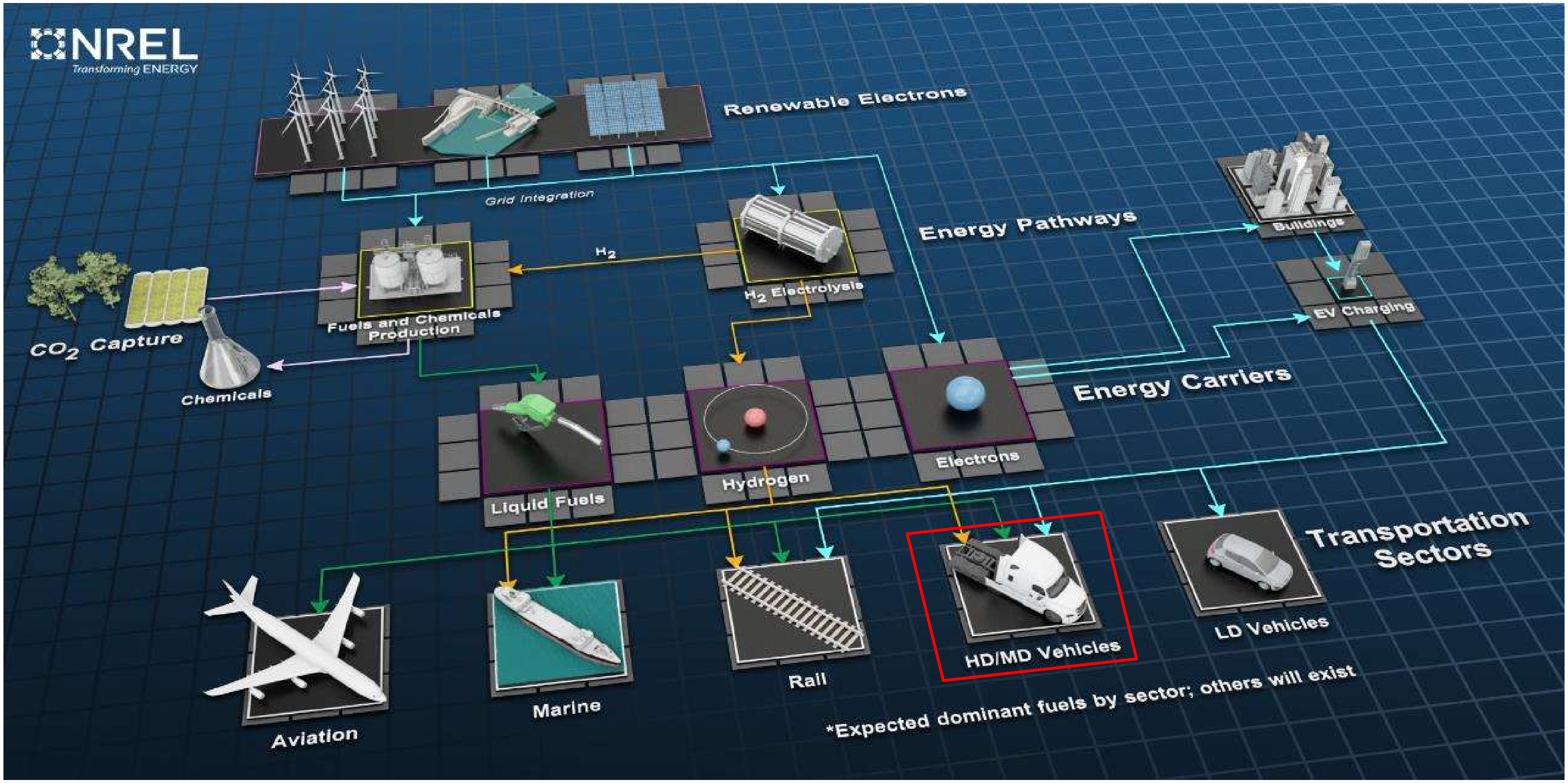
DOE's H2@Scale

H2 Integrated

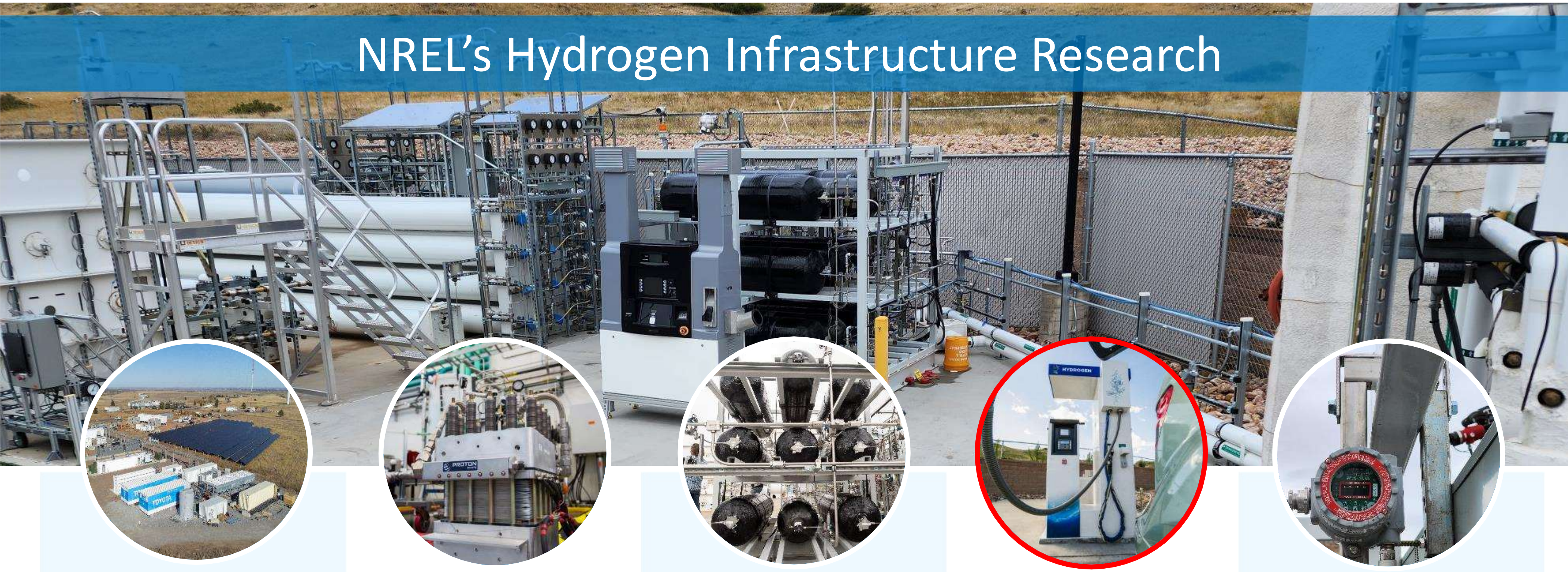


Focus: Hard to Decarbonize Sectors and Renewables

Decarbonization and Criteria Pollutants Reduction for the Transportation Sector



NREL's Hydrogen Infrastructure Research



Grid and Renewables Coupling

Electrolyzers as dispatchable loads in power systems, dynamic operations and integration with renewable production

Hydrogen Production

Full stack scale electrolyzer and BOP performance, system optimization when coupled to grid/renewables and end uses

Distribution and Storage

System scale distribution and storage challenges, vehicle and ground storage performance and modeling

End Use Applications

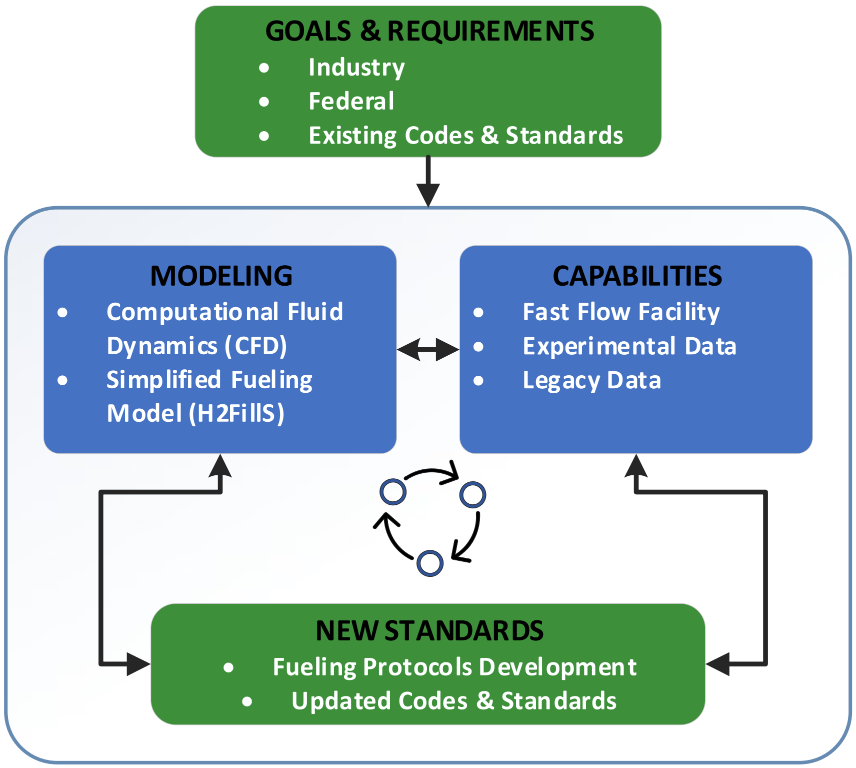
Transportation applications, industrial applications, natural gas blending, renewable synthetic molecules

Safety and Sensors

Development and evaluation of safety and sensor systems, component failure characterization

Fast Flow Hydrogen Fueling R&D

NREL's approach to fast flow hydrogen fueling R&D centered on:



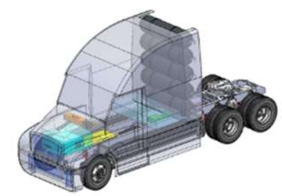


Table 1. Technical System Targets: Class 8 Long-Haul Tractor-Trailers (updated 10/31/19)

Characteristic	Units	Targets for Class 8 Tractor-Trailers	
		Interim (2030)	Ultimate[9]
Fuel Cell System Lifetime[1,2]	hours	**25,000**	**30,000**
Fuel Cell System Cost[1,3,4]	\$/kW	**80**	**60**
Fuel Cell Efficiency (peak)	%	**68**	**72**
Hydrogen Fill Rate	kg H_2/min	**8**	**10**
Storage System Cycle Life[5]	cycles	**5,000**	**5,000**
Pressurized Storage System Cycle Life[6]	cycles	**11,000**	**11,000**
Hydrogen Storage System Cost[4,7,8]	\$/kWh (\$/kg H_2 stored)	**9 (300)**	**8 (266)**

Source: https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

Heavy-Duty Hydrogen Fast Flow Facility

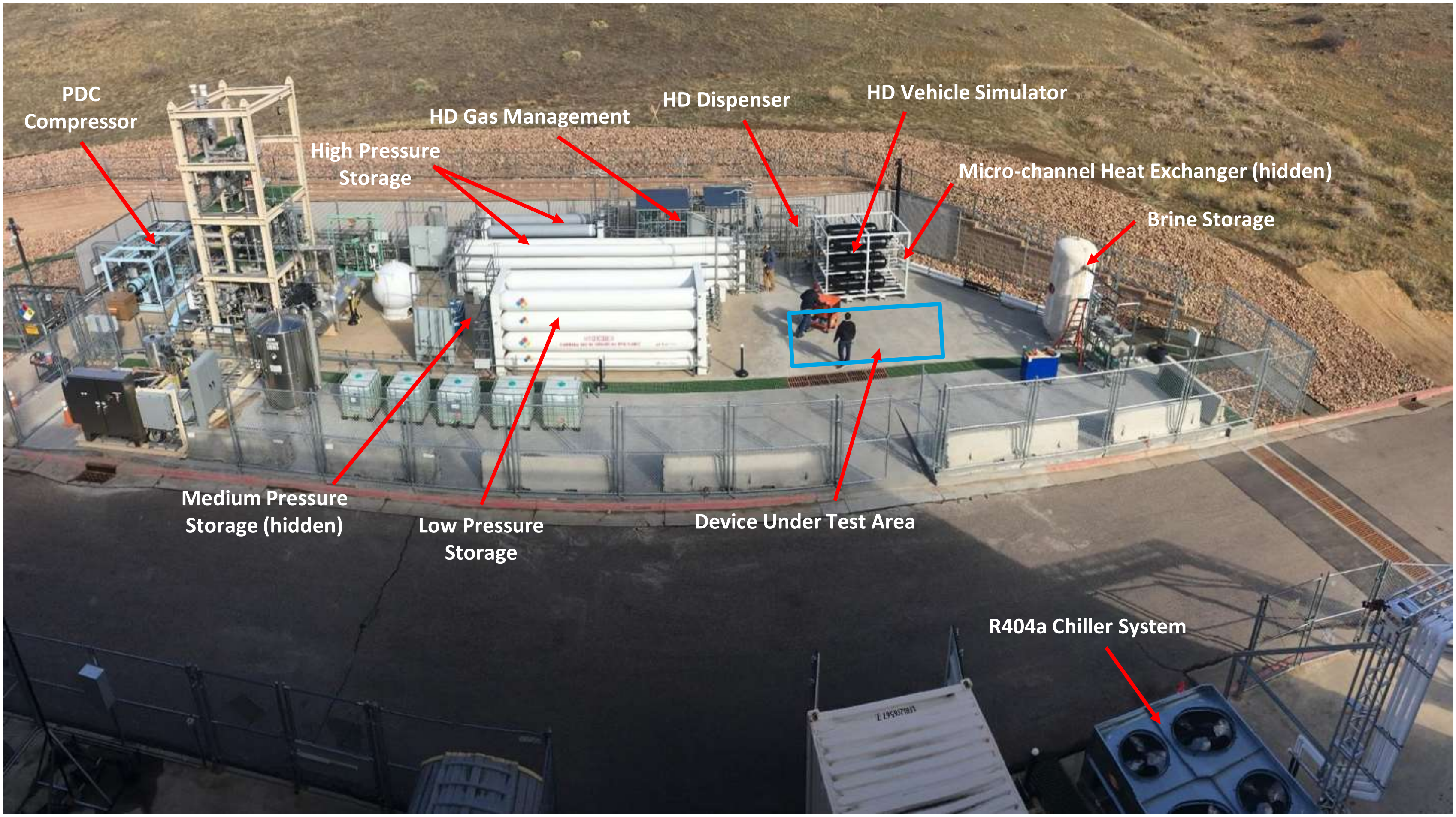
First-of-its-kind, experimental research capability for medium and heavy-duty fueling R&D

- Located: Energy Systems Integration Facility (ESIF)
  - Golden, Colorado, USA
- Leverages legacy light-duty station capabilities
- Fueling capability (gaseous): 70 MPa, -40°C precooling, 10 kg/min average (20 kg/min peak), and 80+ kg fill mass into a heavy-duty vehicle simulator.
- Operational: July 2022
- ~650 kg bulk gas storage (L, M, HP)
- Limited back-to-back fueling capability

✓ Enables HD fueling protocols, components, and hardware evaluations

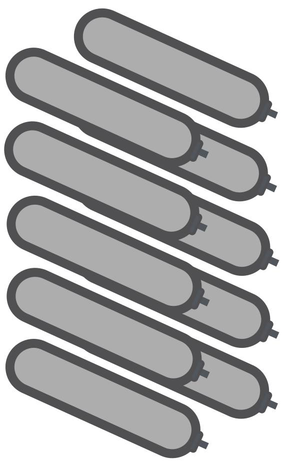
✓ Publicly available modeling tools and data for hydrogen infrastructure stakeholders

Heavy-Duty Hydrogen Fast Flow Facility



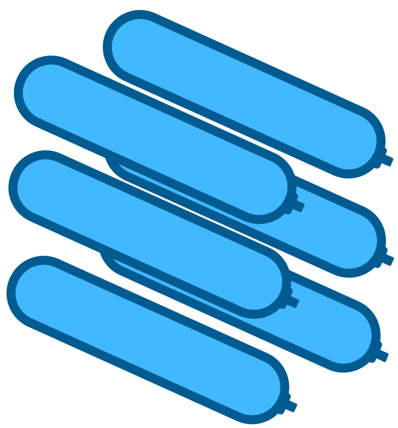
Pressurized Ground Storage for HD Fills

Low Pressure Storage



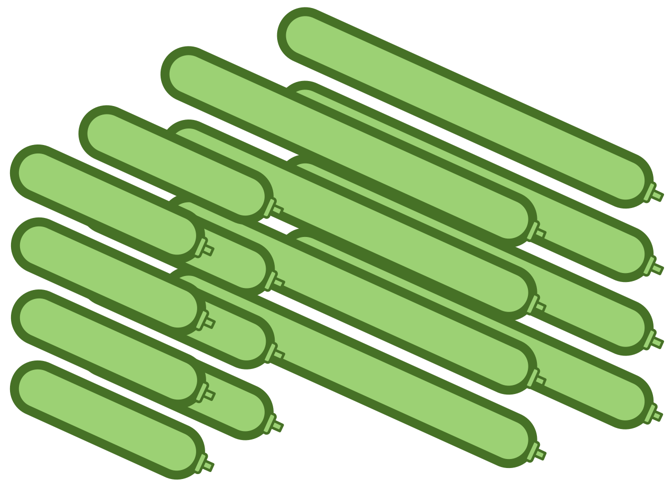
10X - 18 kg/tank
Type I
Total: 180 kgs

Medium Pressure Storage



6X - 13.5 kg/tank
Type I
Total: 81 kgs

High Pressure Storage



8X - 16 kg/tank
Type II
Total: 128 kgs

8X - 32 kg/tank
Type I
Total: 256 kgs

~650 kg total storage

Cascade approach:
- Low: 20.7 MPa (3,000 psig)
- Medium: 41.4 MPa (6,000 psig)
- High: 93 MPa (13,500 psig)

Demonstrated:

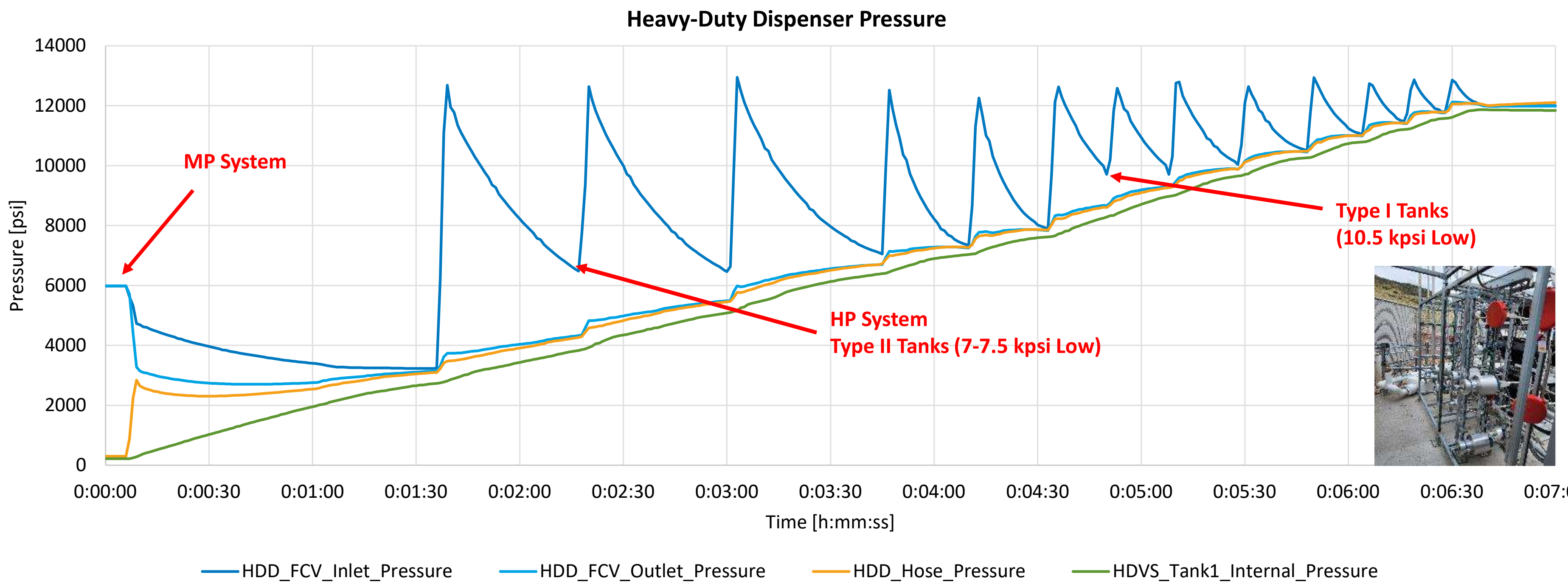
~80 kgs transfer using MP and HP storage (all HDVS tanks)

~60 kgs transfer using only HP into 7 Type IV tanks on HDVS

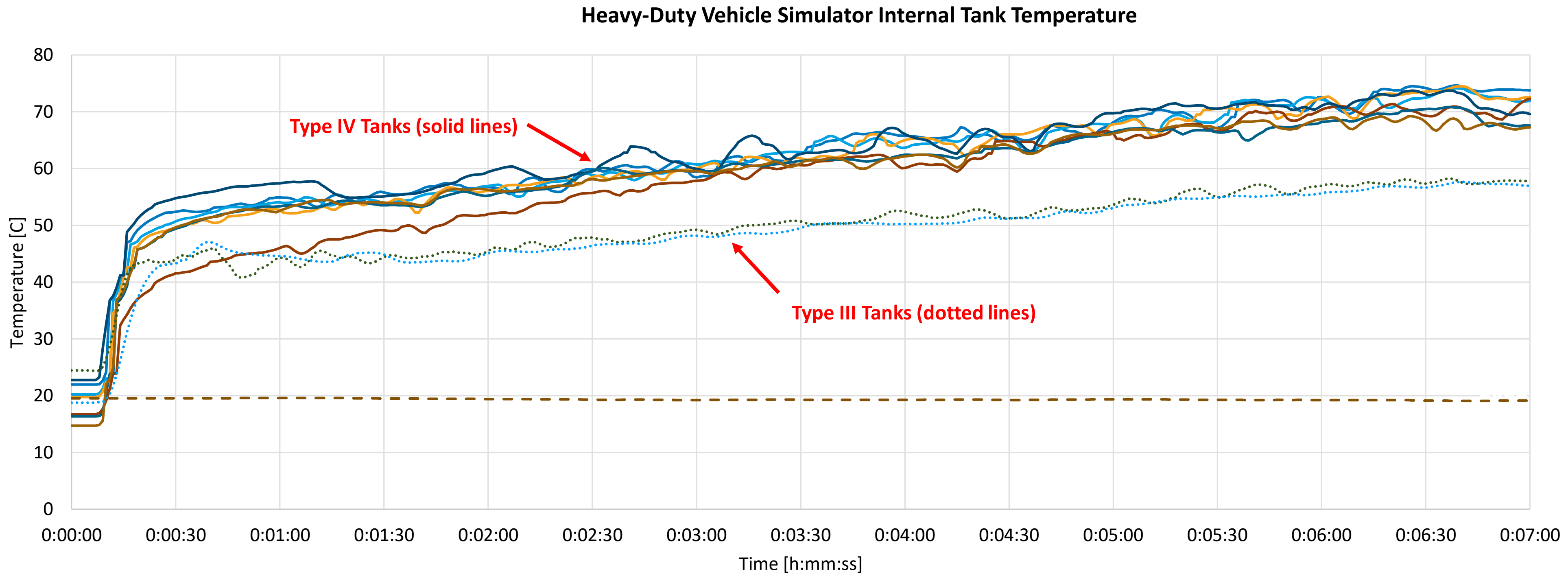
82.3 kg Flow Test – Experimental Results

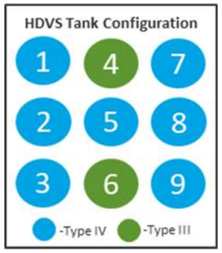
Date: 10/6/2022
Mass Transfer: 82.3
Time: 6 minutes 33 seconds (<10 minute target)
Average Mass Flow Rate: 12.57 kg/min (10 kg/min target)
Peak Mass Flow Rate: 23 kg/min (20 kg/min target)

Configuration: 9 tanks - Type IV and III
Starting/Ending Pressure : 1.52 MPa (220 psig)/ 83.4 MPa (12,100 psig)
APRR: 12.3 MPa/min (1,778 psig/min)
HDVS SOC: 100%
Ambient Temperature: 19°C

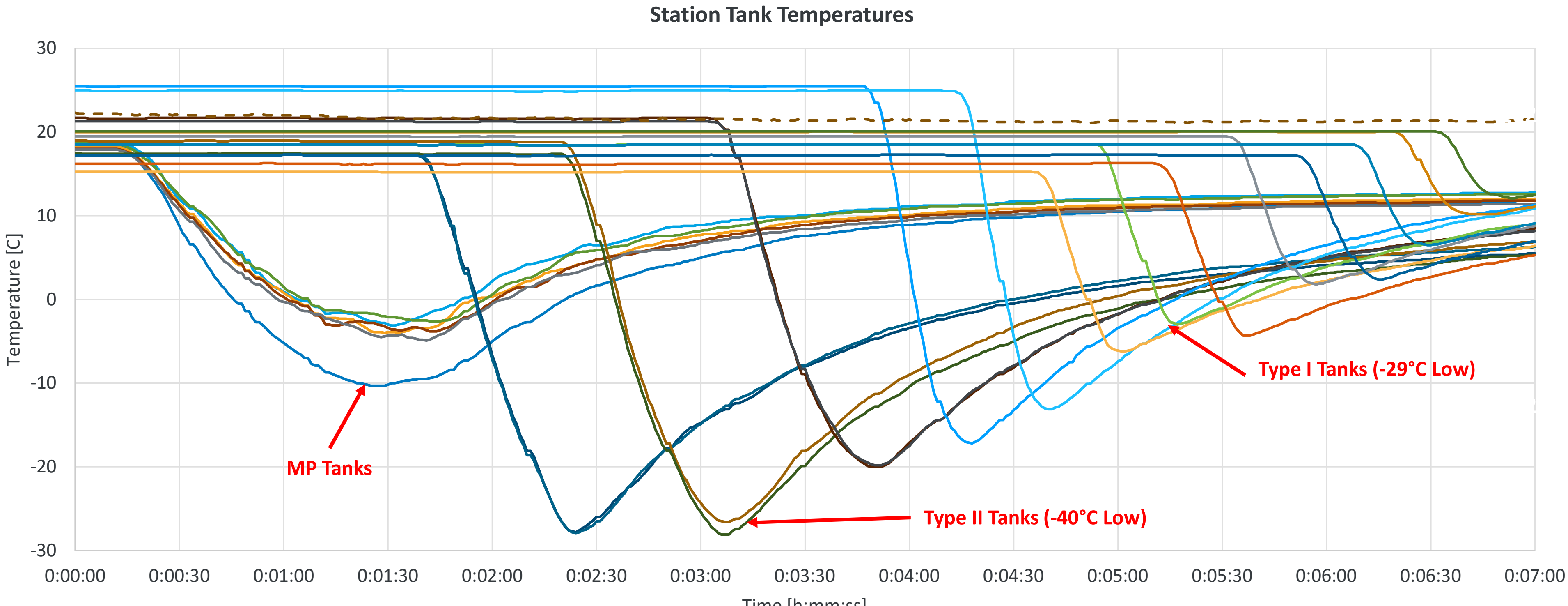


Heavy-Duty Vehicle Simulator Internal Tanks Temperatures



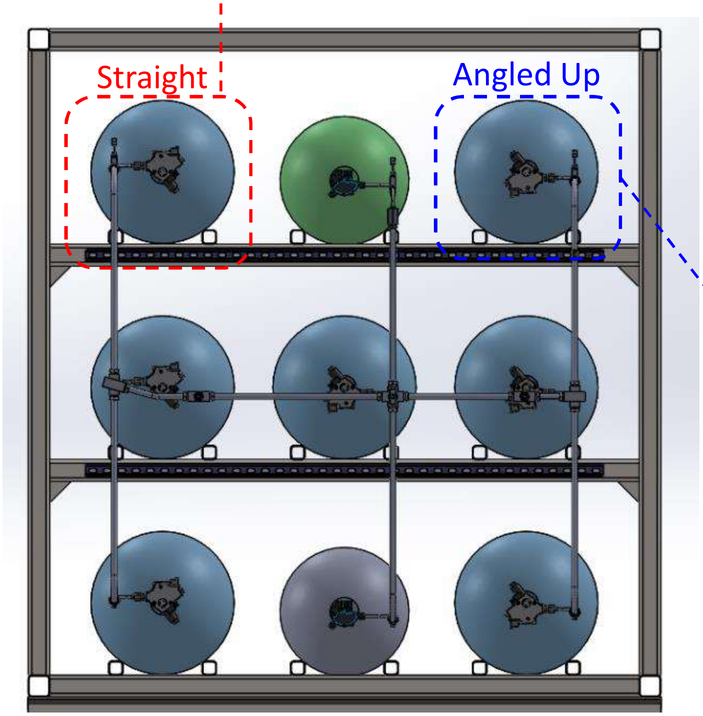


Hydrogen Station Storage Tank Temperatures



CFD Modeling Work

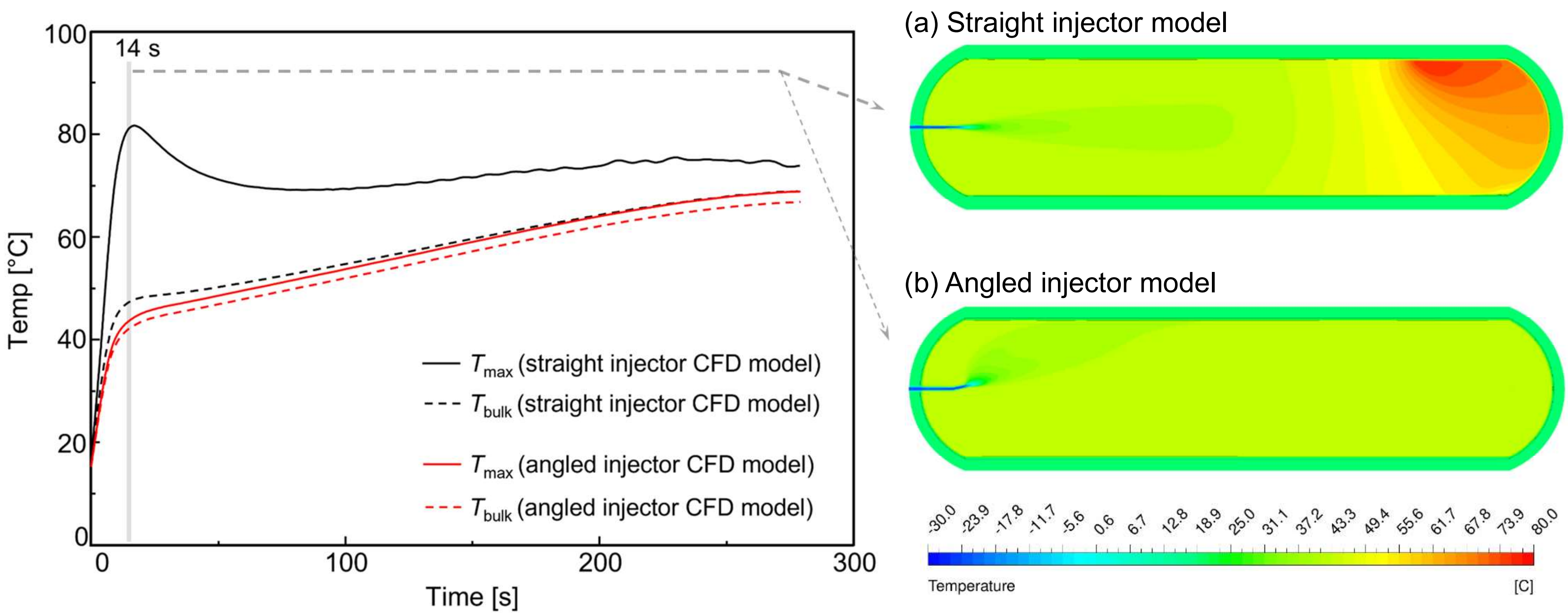
- Ran fast-fill CFD simulations with 9.8 kg type IV tanks that are installed in NREL's HDVS
  - The injector shapes in the two tanks are different, so the NREL team evaluated the impact of the injector shapes on the hydrogen temperatures.



(a) Straight injector model
- Inner diameter: 5.4 mm

(B) Angled injector model
- Inner diameter: 5.4 mm
- Angle: 12 deg.

Maximum and Bulk Average Gas Temperatures



- The straight injector causes a large difference in the maximum and bulk average gas temperatures.
- The angled injector mixes the hydrogen well; therefore, the difference in the maximum and bulk average gas temperatures is small.

HD Dispenser & Nozzle Assembly Project

Heavy-Duty Dispenser and Nozzle Assembly Development

- Develop retail focused HD dispenser and nozzle assembly (nozzle, receptacle, hose, and breakaway) capable of fueling heavy-duty (HD) vehicles.
- Test and demonstration of the system at NREL's HD R&D facility under real-world conditions.
- Targeting ≤100 kg fueling in 10 minutes at a nominal pressure of 70 MPa .
    - Utilizes SAE J2601 category D or other advanced HD fueling protocol.
    - IRdA communications

Project Partners

- Electricore Inc.
- Bennett Pump Company
- WEH Technologies Inc.
- Quong & Associates Inc.

Images: 2022 DOE AMR Electricore Slides

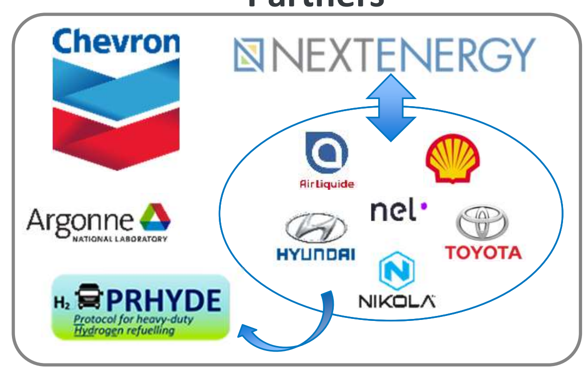
HD Fueling Methods Research Project

Industry lead assessment of HD fueling protocols (70 MPa), HD station architectures, functional safety requirements, and the implications of these on the total cost of station ownership (TCO).

- Provide industry stakeholders with key supporting information for selection and implementation of iterations of HD fueling protocols.
  - Leverage NREL's new HD research station capabilities.
- HD fueling components testing and evaluation.
- Techno-economic assessments (TEA) and Total Cost of Ownership (TCO) of HD fueling infrastructure and industry selected strategies.
  - Leverage existing models and tools for the development of the TEA and TCO methods.
- Explore advanced communications strategies (beyond IRdA).

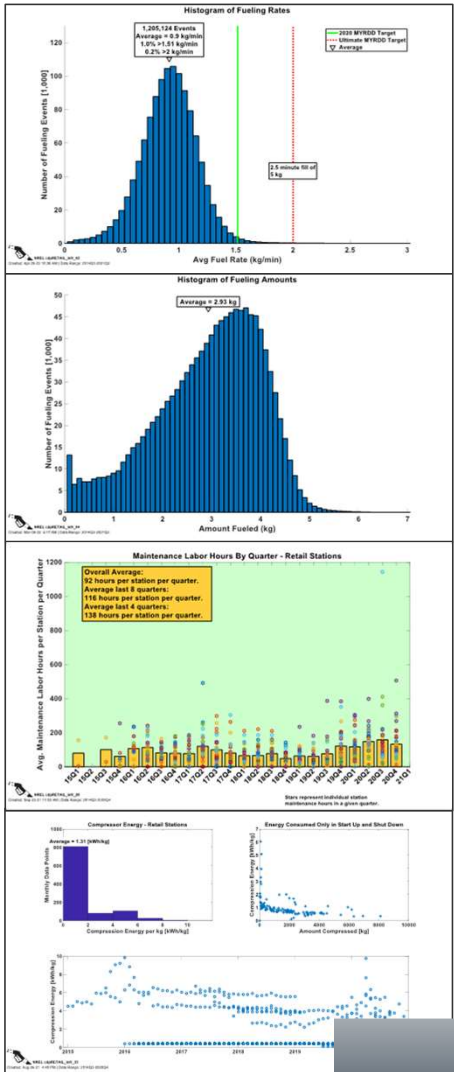
HD Refueling Hardware

Partners



Light Duty H2 Stations Data (CEC/DOE effort)
Sampling of Results

HD



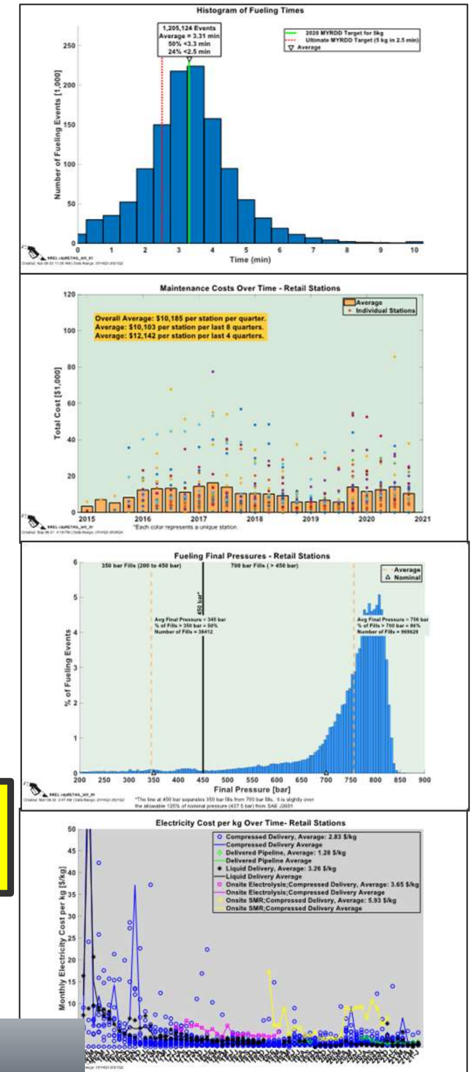
Fueling Rate Average	0.9 kg/min
Fueling Amount Average	2.93 kg
Fueling Time Average	3.31 min
Compressor Energy Average	1.29 kWh/kg
Total Hydrogen Dispensed (42 Stations)	3,715,067 kg 2,751,081 kg - 19Q3
Maintenance Cost per Station per Quarter Average	$10,185 per station-quarter $10,103 (last 8 quarters)
Maintenance Hours Average	92 hours/Quarter 116 hrs/Qtr (last 8 quarters)
Fueling Final Pressure Average	756 bar
Average Electricity Cost by Delivery Type 2020Q2	$2.83/kg – Compressed $3.26/kg – Liquid $3.65/kg –Electrolysis

10+

50+

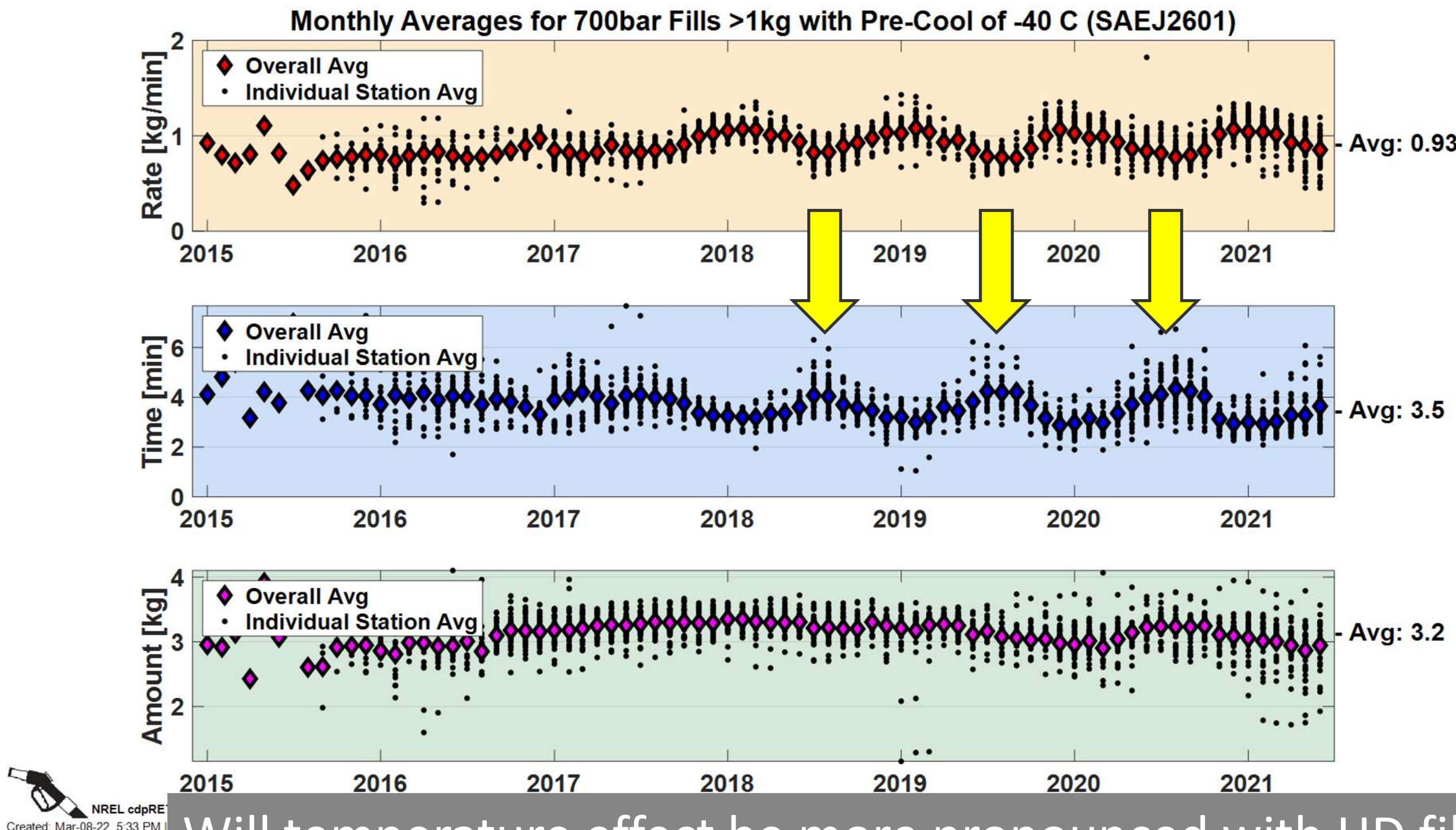
<10

Liquid? 350?



102 Composite Data Products in 8 topic areas publicly available
https://www.nrel.gov/hydrogen/hydrogen-infrastructure-analysis.html

Light Duty Filling Rates Affected by Ambient Temperature (SAE J2601)
Seasonal: Takes Longer to Fill in the Summer

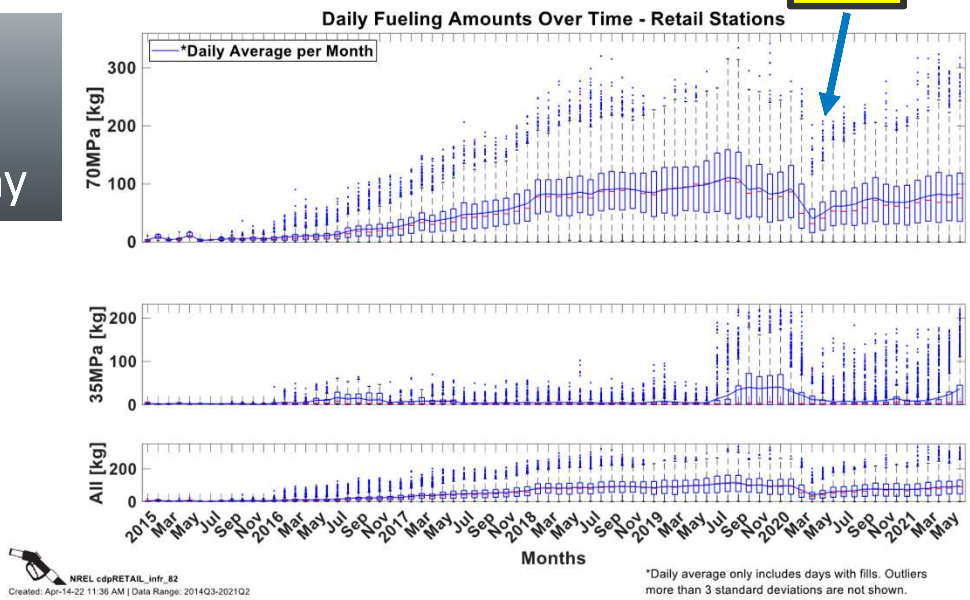


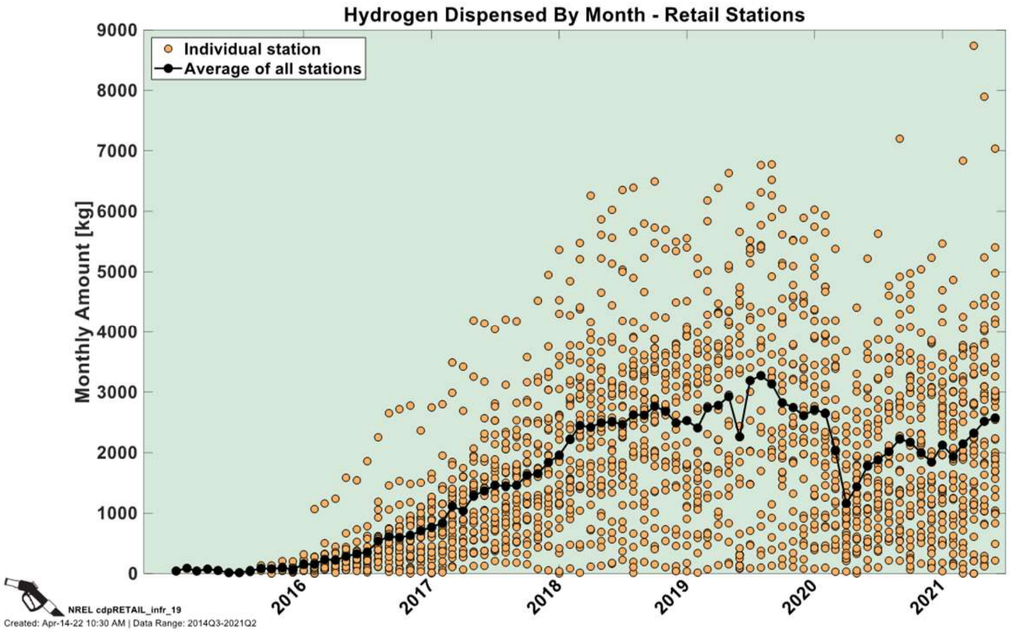
Will temperature effect be more pronounced with HD fills?

Light Duty H2 Demand

- Daily fueling amounts near 100 kg H2/day on average after dip in 2020
- Some stations are reaching 300+ kg H2/day

2020



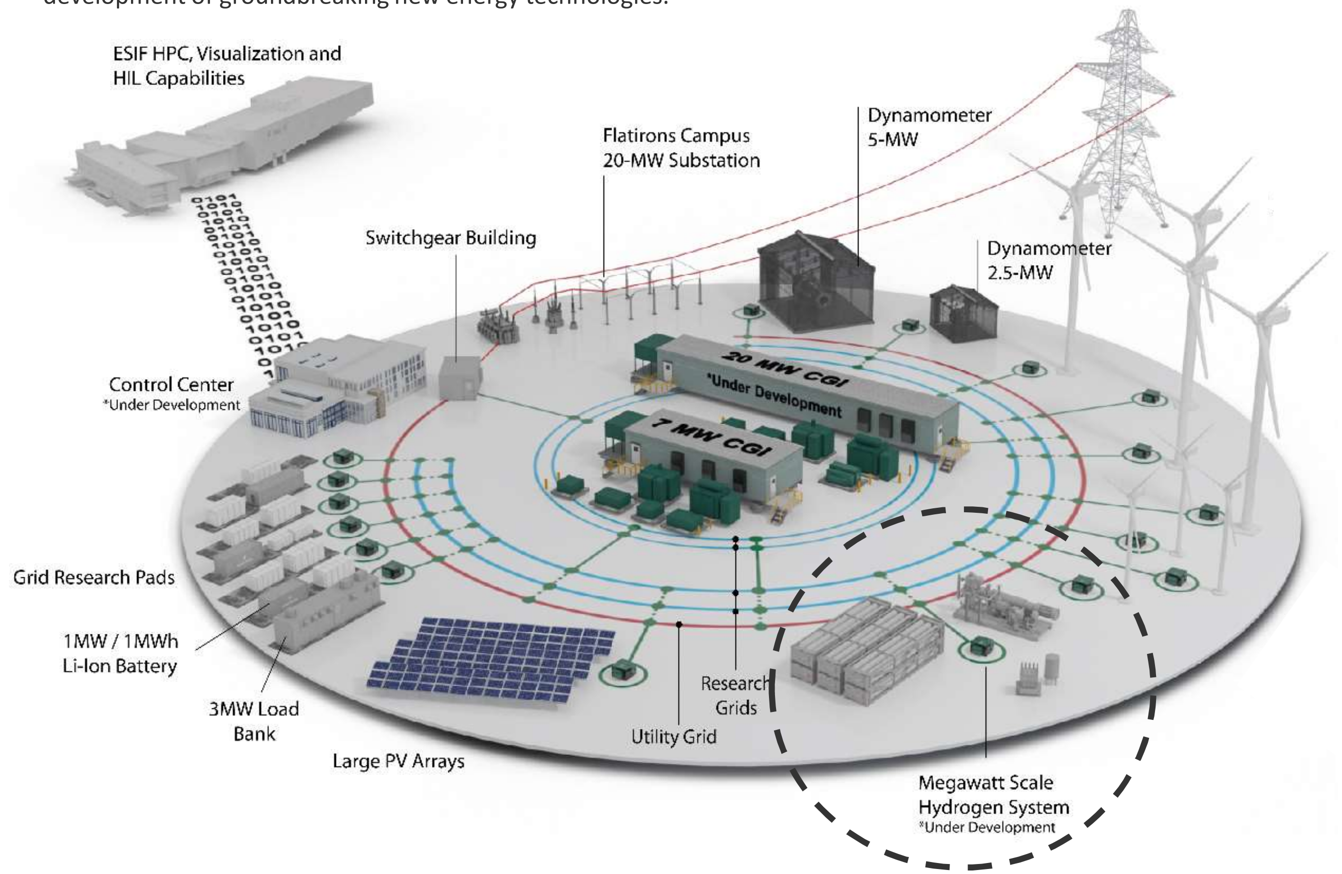


- What is the daily amount for HD?
- Will it be more consistent?

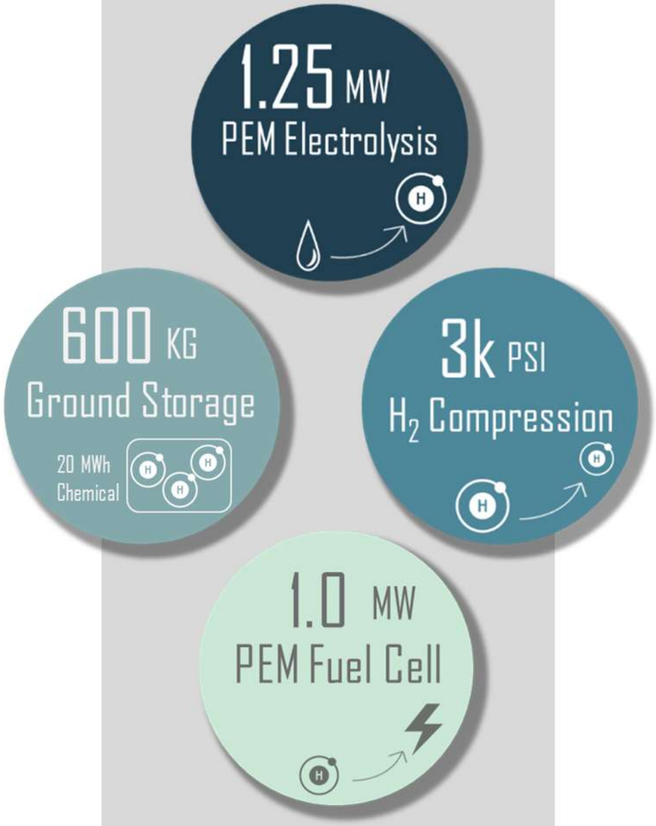
Advanced Research on Integrated Energy Systems (ARIES)

Science of Scaling Hydrogen Systems

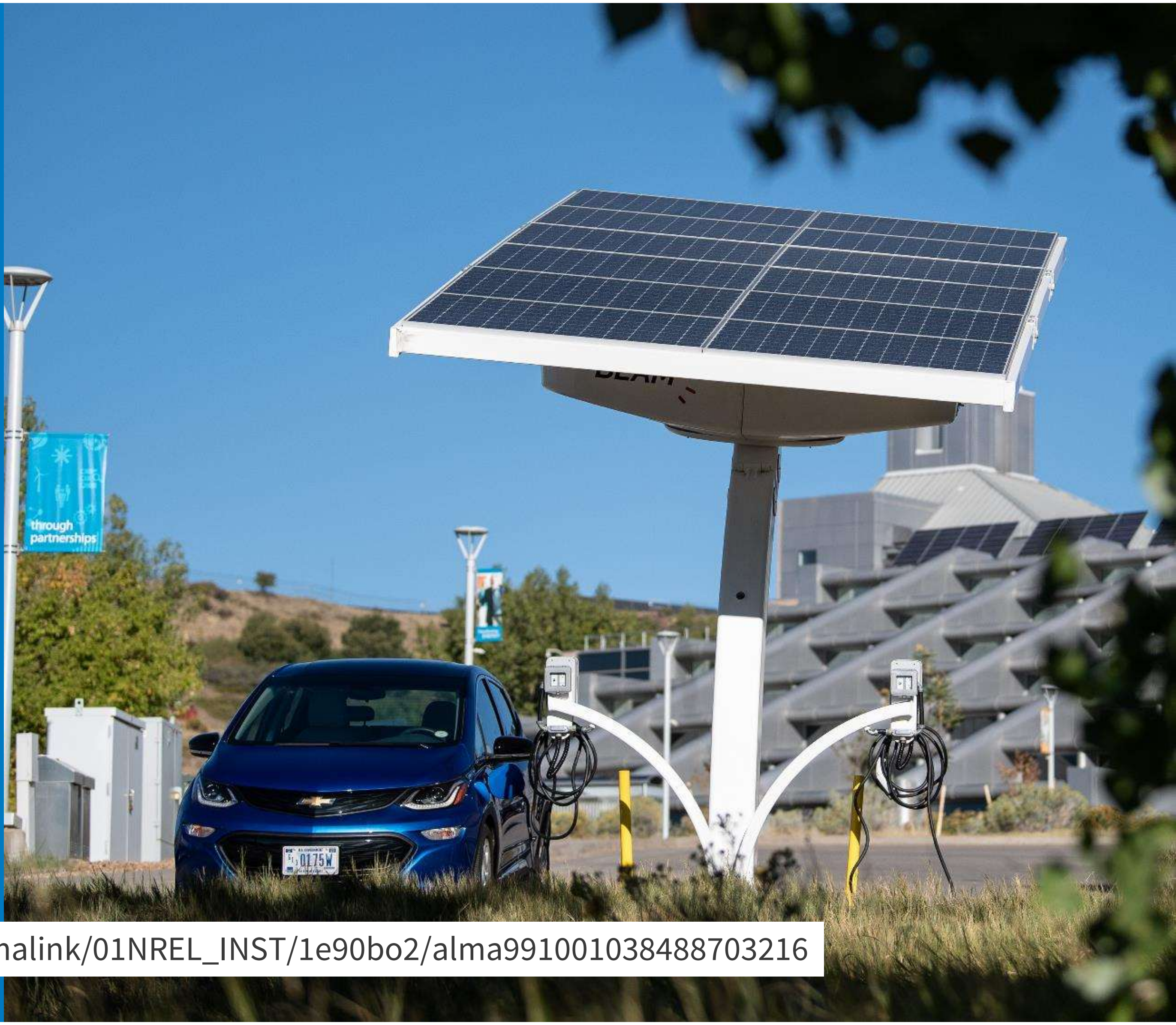
- Research platform that can match the complexity of the modern energy system and conduct integrated research to support the development of groundbreaking new energy technologies.



Integrated Megawatt Scale Hydrogen System

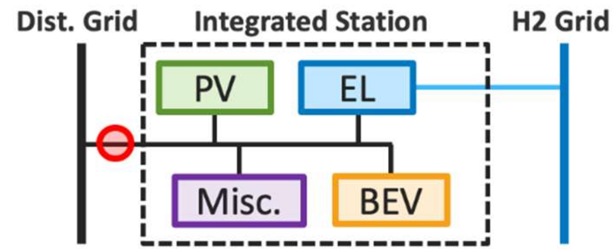


Integrated Electrolysis and Fast Charge Station



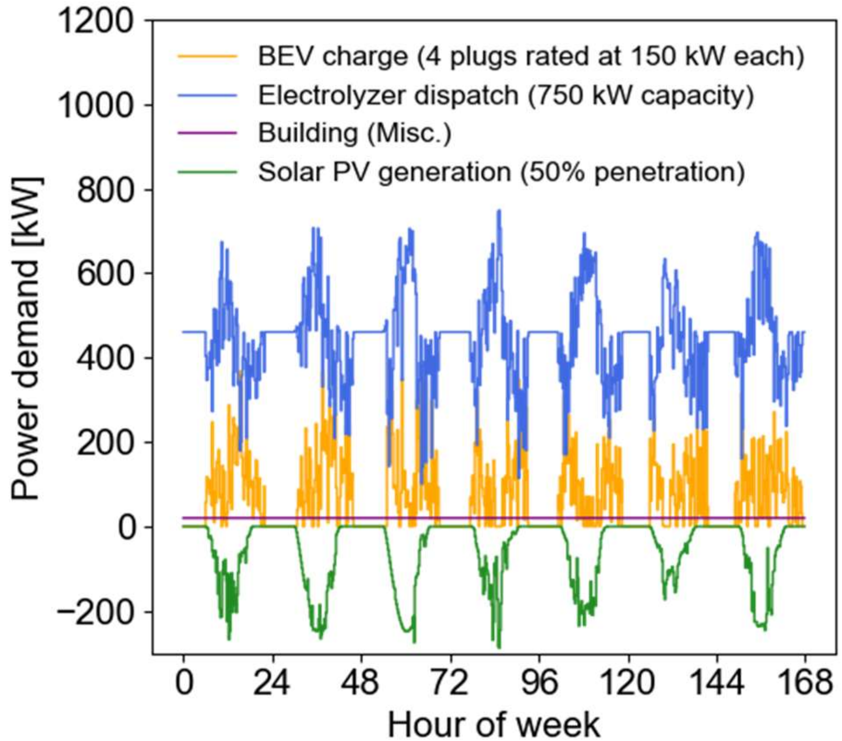
https://nrel.primo.exlibrisgroup.com/permalink/01NREL_INST/1e90bo2/alma991001038488703216

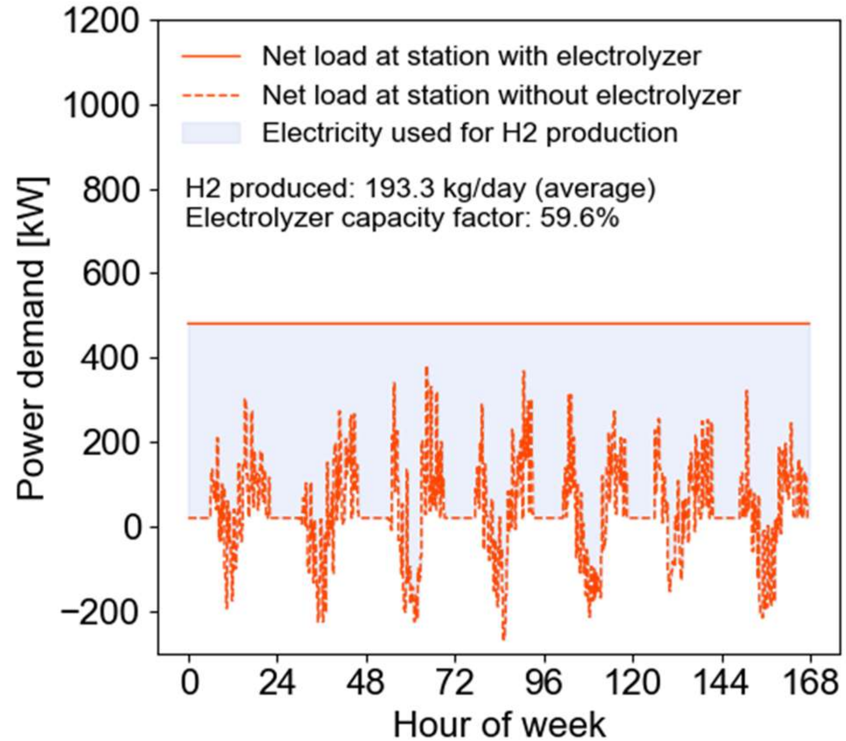
Effect of Electrolzyer Control on Net Load



The integrated station with the electrolyzer stabilizes demand fluctuations while producing valuable hydrogen, and the utility just sees the constant power demand.

Simplified scenario (constant net load).





Hydrogen Filling Simulation (H2FillS)

https://www.nrel.gov/hydrogen/h2fills.html

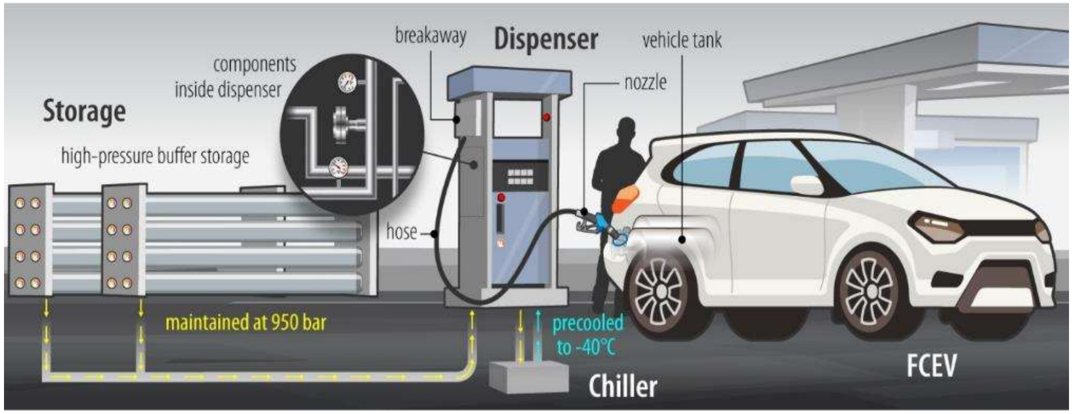


Fig. Hydrogen fueling station

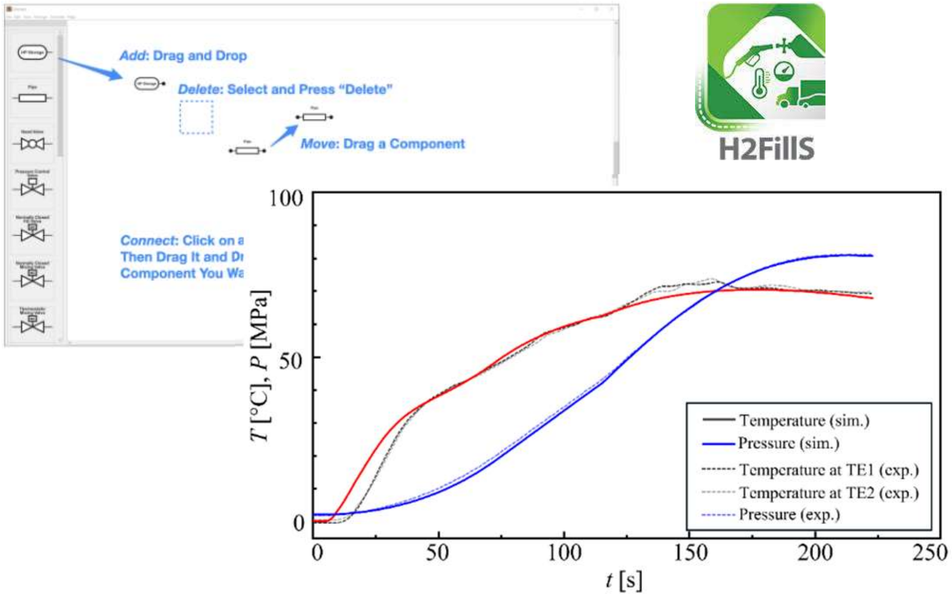


Fig. H2FillS' GUI and simulation result

- H2FillS simulates the real-world fueling process from the station to the vehicle storage.

- Enables station and vehicle design through individual component's influence on fueling performance (i.e. change in temperature and pressure, and pre-cooling system impacts on vehicle CHSS).
- Current version is for light-duty. Upgraded H2FillS for heavy-duty fueling (HD-H2FillS) will be available to the public early this year.

H2@Scale HD CRADA Project: CA Research Consortium
Title: Reference Station, Fueling Performance Test Device, Station Capacity Model

Tasks

- Station Capacity Model for HD Stations
  - NREL led
  - HyCap tool running H2FillS in background. Will be web based.
  - 1st draft near completion. Public version end of year.
- HD Reference Station Designs
  - SNL led
  - 1st Report to be completed in next few months.
- Design Concepts for HD Station Performance Test Device
  - NREL led
  - Kicking off task this quarter.

https://www.hydrogen.energy.gov/pdfs/review22/h2041_sprik_2022_p.pdf

Partners

- National Renewable Energy Laboratory (**NREL**): Sam Sprik (PI), Taichi Kuroki, Kazunori Nagasawa, Jacob Thorson
- Sandia National Laboratories (**SNL**): Ethan Hecht (Co-PI), Qi Guo, Brian Ehrhart
- Argonne National Laboratory (**ANL**): Amgad Elgowainy
- California Governor's Office of Business and Economic Development (**GO-Biz**): Gia Vacin
- California Air Resources Board (**CARB**): Andrew Martinez
- California Energy Commission (**CEC**): Esther Odufuwa
- South Coast Air Quality Management District (**South Coast AQMD**): Maryam Hajbabaei

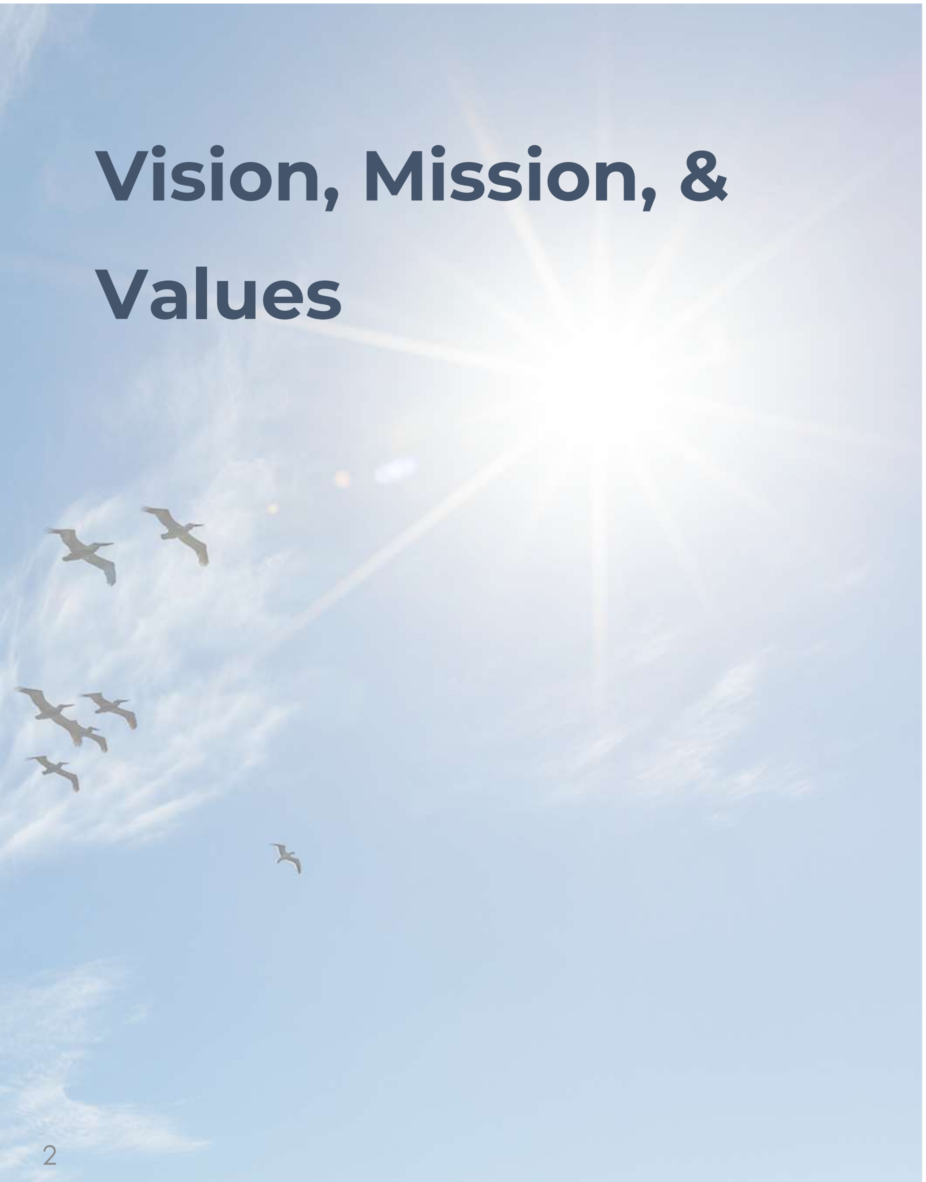
Thank you

www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

SoCalGas RD&D Overview

January 31, 2023



Vision, Mission, & Values

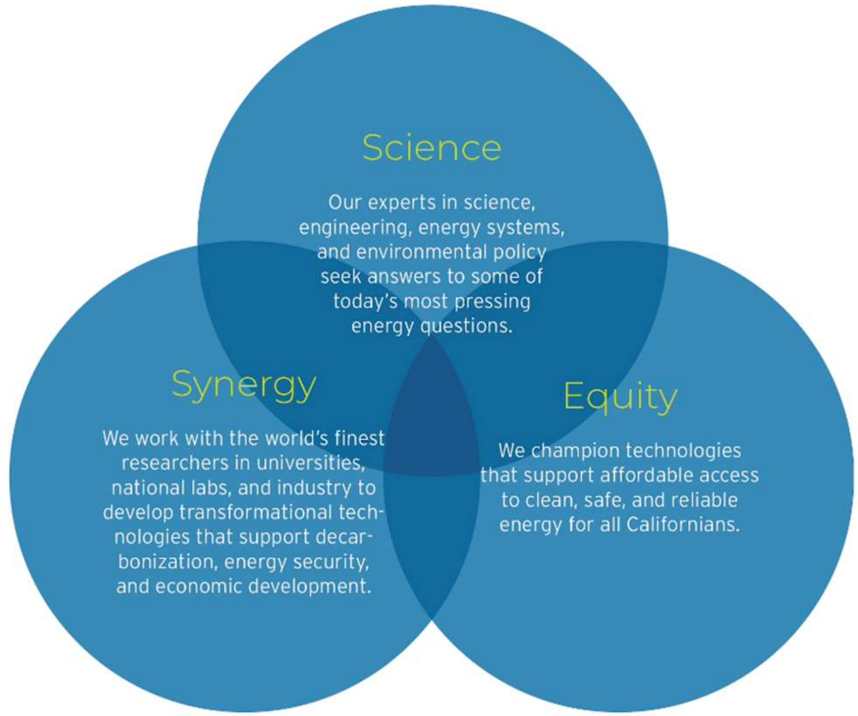
OUR VISION

Advancing innovative technologies for safer, cleaner, and more reliable energy.

OUR MISSION

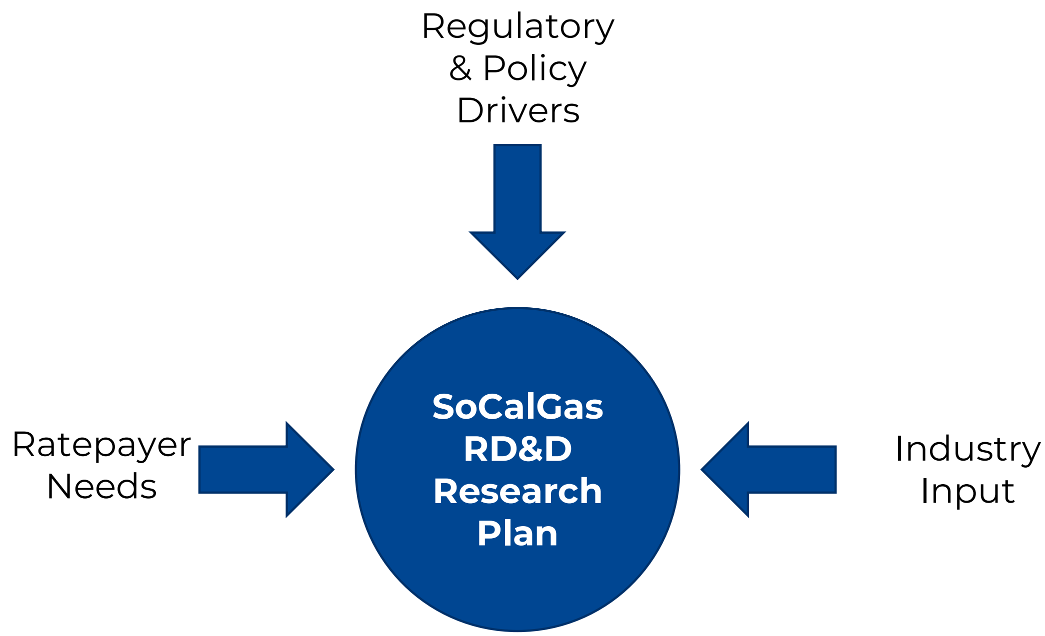
Identify transformational energy solutions. Build them. Share them with the world.

OUR VALUES



Research Planning

To build the RD&D Research Plan, program staff consider multiple factors, including:



RD&D Supports Hundreds of Projects

TOTAL **ACTIVE PROJECTS** IN 2021

379

TOTAL **PROJECTS COMPLETED** IN 2021

114

TOTAL **PROJECTS INITIATED** IN 2021

72

Customer Benefits

RELIABILITY 203

OPERATIONAL EFFICIENCY 144

REDUCED GHG EMISSIONS 211

IMPROVED AFFORDABILITY 107

IMPROVED AIR QUALITY 167

SAFETY 177

RD&D Structure

Low Carbon Resources

Carbon Capture, Utilization, and Storage

Renewable Gas Production

Gas Operations

Environmental & Safety

Operations Technology

System Design & Materials

System Inspection & Monitoring

Clean Transportation

Off-Road

Onboard Storage

On-Road

Refueling Stations

Clean Generation

Distributed Generation

Integration & Controls

Customer End-Use Applications

Advanced Innovation

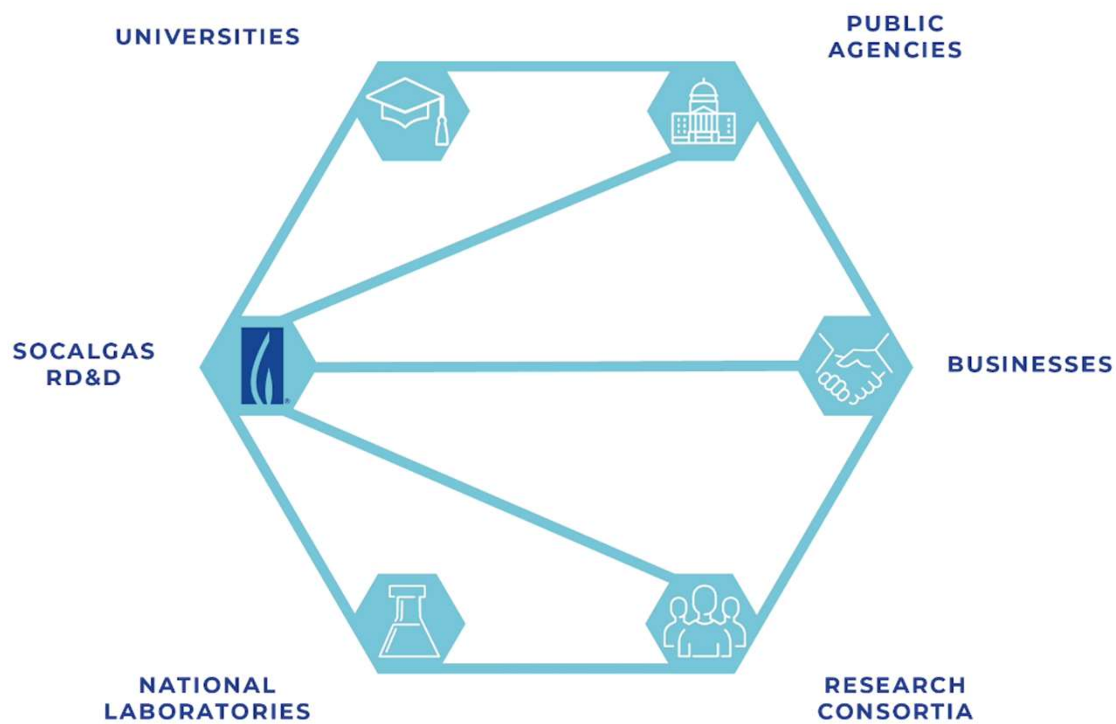
Commercial Applications

Commercial Food Service

Industrial Process Heat

Residential Appliances

Synergy
Collaboration Ecosystem



Collaboration Ecosystem

BERKELEY LAB

CARB

JPL Jet Propulsion Laboratory

UCLA

NYSEARCH

OAK RIDGE National Laboratory

STATE OF CALIFORNIA ENERGY COMMISSION

PUBLIC UTILITIES COMMISSION EUREKA STATE OF CALIFORNIA

Pacific Northwest NATIONAL LABORATORY

UTD Utilization Technology Development

Lawrence Livermore National Laboratory

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

GTI ENERGY solutions that transform

PRCI Pipeline Research Council International LEADING PIPELINE RESEARCH

NREL Transforming ENERGY

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

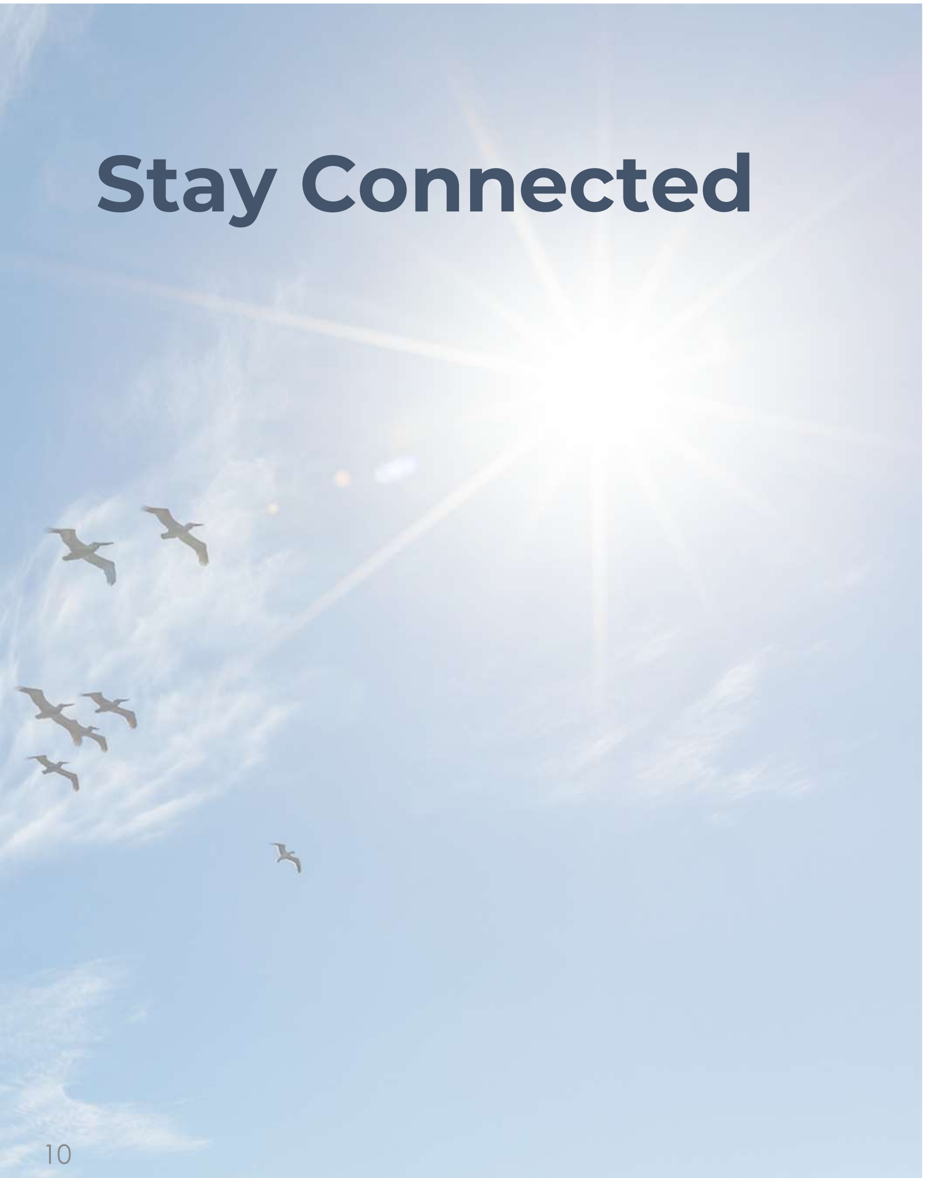
South Coast AQMD

OTD Operations Technology Development

UC Irvine

Clean Transportation Program

Off-Road	Zero emission off-road transportation solutions.
On-Road	Zero emission medium- and heavy-duty on-road vehicles.
Onboard Storage	Technologies and systems that improve onboard storage of transportation fuels.
Refueling Stations	Technologies and systems that support refueling for alternative fuels, including gaseous and liquid hydrogen.



Stay Connected

RD&D Webpage and Email

https://www.socalgas.com/clean-energy/research-and-development

RDDInfo@socalgas.com

LinkedIn

https://www.linkedin.com/showcase/socalgas-research-development-&-demonstration-rd&d-

CEC's Empower Innovation Platform

https://www.empowerinnovation.net/en/custom/organization/view/6477

Thank You

Jeff Chase

jchase@socalgas.com

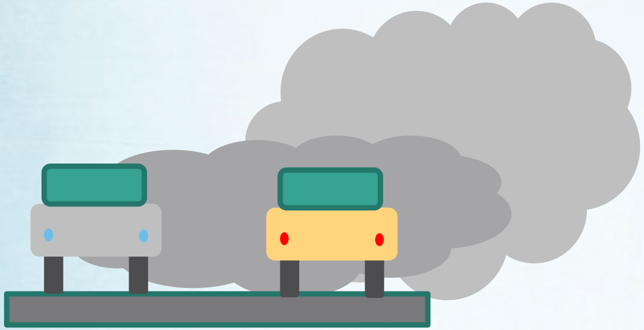
Non-Exhaust PM Emissions Research

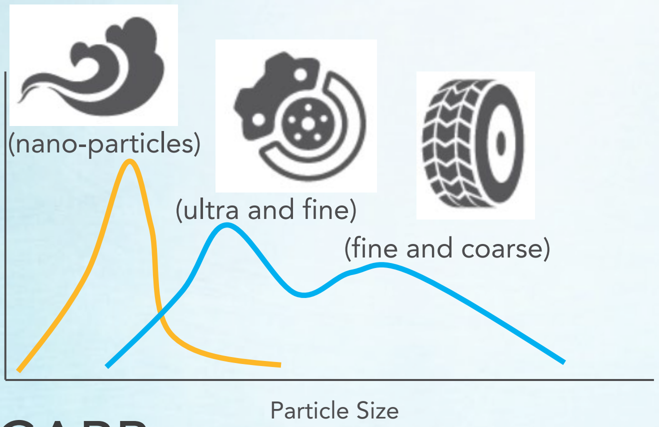
Seungju Yoon, Qi Yao, and Jorn D. Herner

February 2, 2023

Prepared for South Coast AQMD Clean Fuels Program Advisory Group Meeting

What are non-exhaust PM emissions?

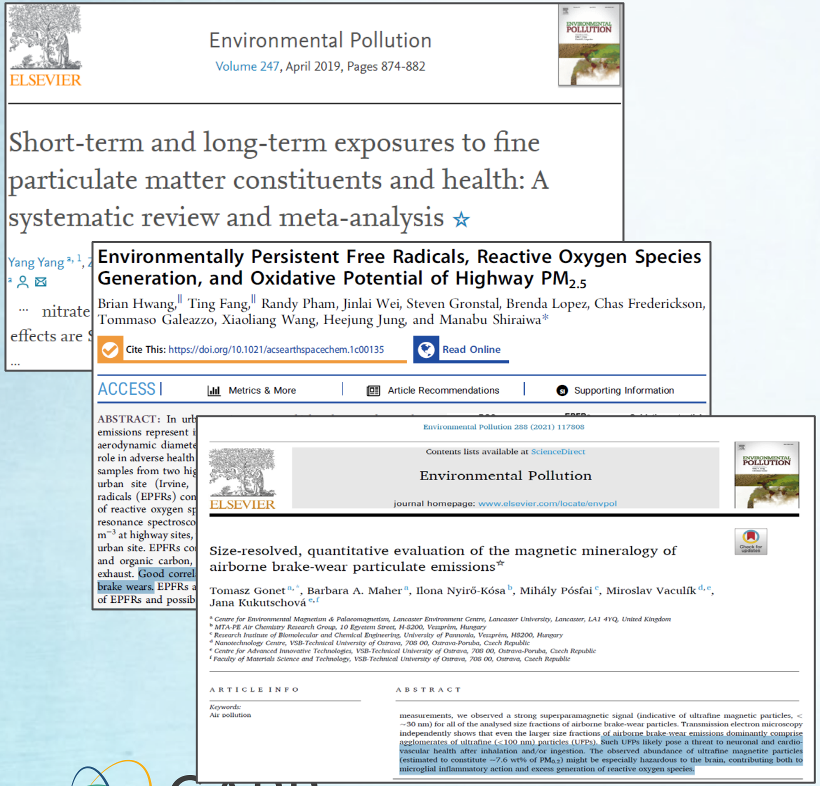




- Brake-wear PM
  - Less than PM2.5
  - Ultra-fine (<0.1 µm) and Fine particles
  - High metal content: Cu, Fe, Zn, Ti, and others
- Tire-wear PM
  - Less than PM10
  - Fine and coarse particles
  - High micro-plastic and metal content: Alkanes, NR, SBR, SBR, Zn, Si, Al, Ca, Ti, and others

CARB

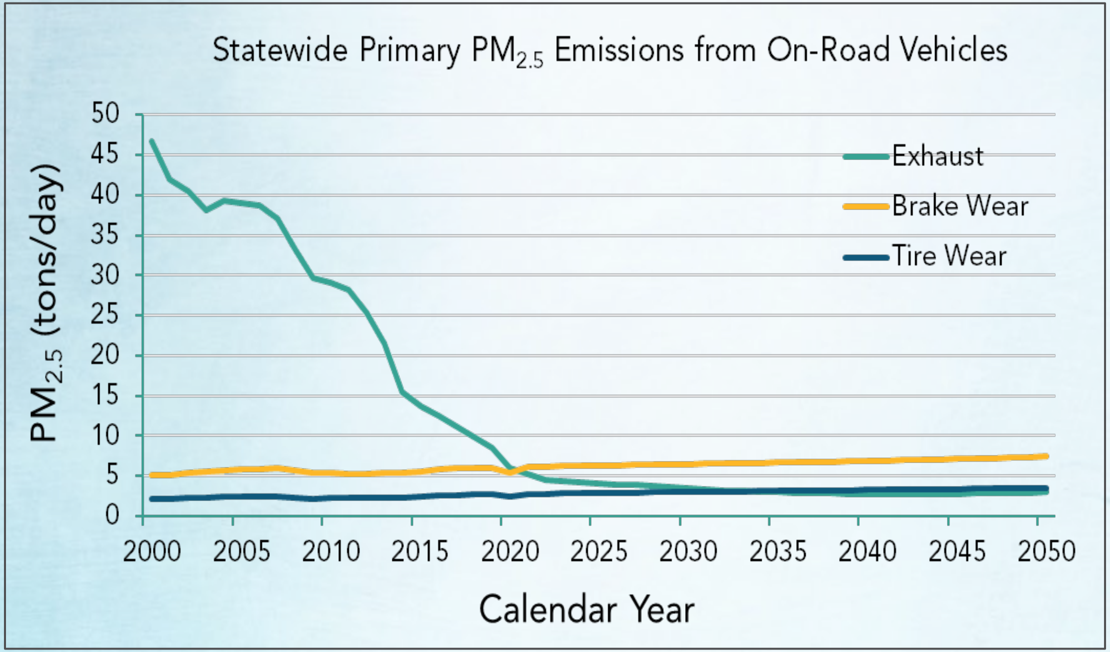
What are reported potential adverse health effects of brake- and tire-wear PM?



- Potential adverse health effects
  - Respiratory issues
  - Cardiovascular disease
  - Developmental and reproductive effects
  - Cancer
- Still being studied and more research is needed to fully understand the extent of their impact on human health

CARB

Projected Brake- and Tire-wear PM – EMFAC2021



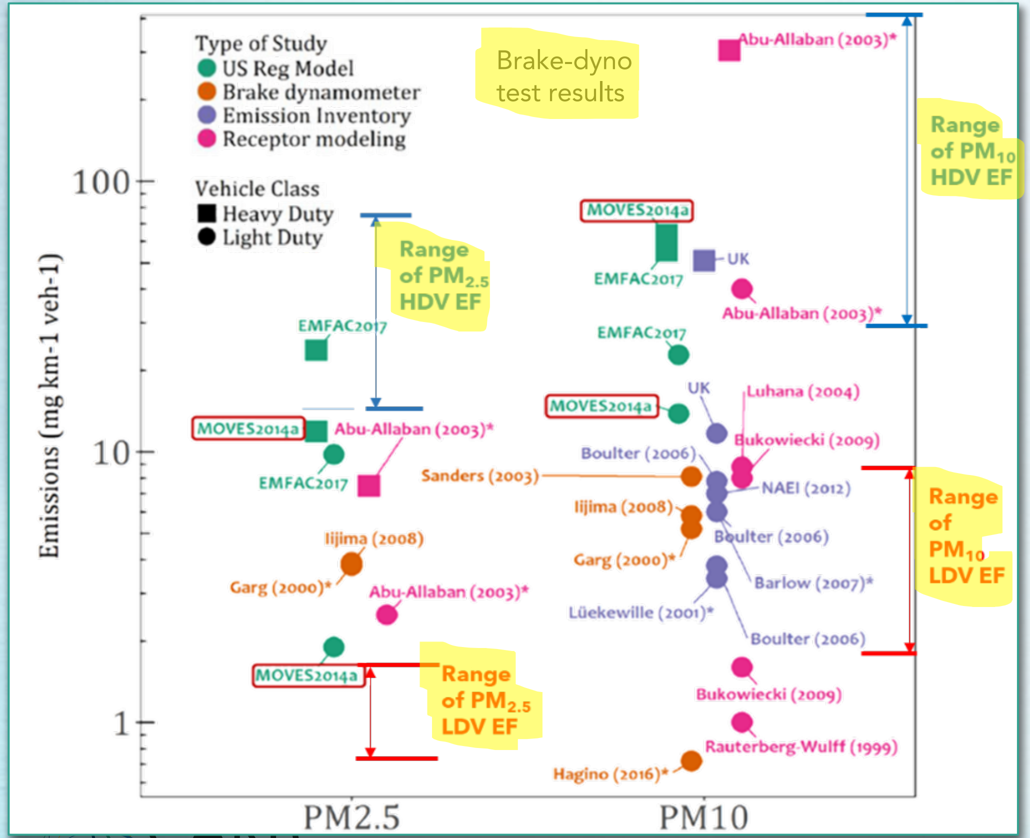
- Brake-wear PM is currently equivalent to vehicular exhaust PM emissions.
- Tire-wear PM is projected to surpass the exhaust PM by 2035.
- Brake- and tire-wear PM emissions projected in 2050 are still 75 percent below 2010 levels and 85 percent below 2000 levels of direct PM exhaust emissions.

CARB

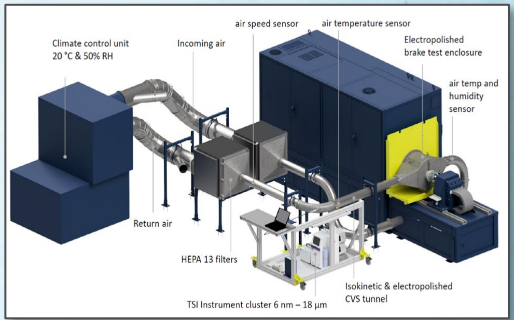
Research Questions

- What are the best methods for measuring/monitoring brake- and tire-wear PM?
- What are the near-road community exposure and health effects of brake- and tire-wear PM?
- What are the real-world emissions associated with brake- and tire-wear PM emissions?
- What are potential reduction opportunities of brake- and tire-wear PM?

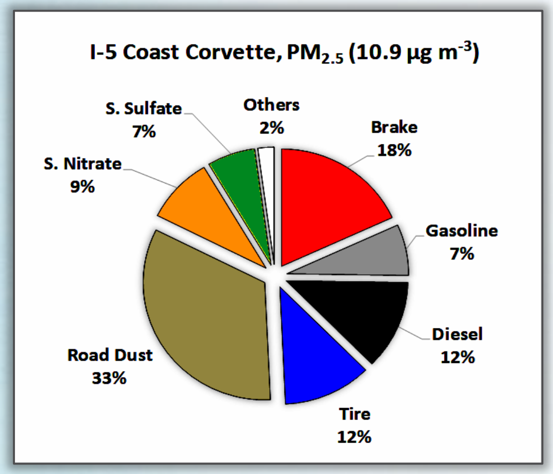
Completed: Brake-Dyno Testing Projects



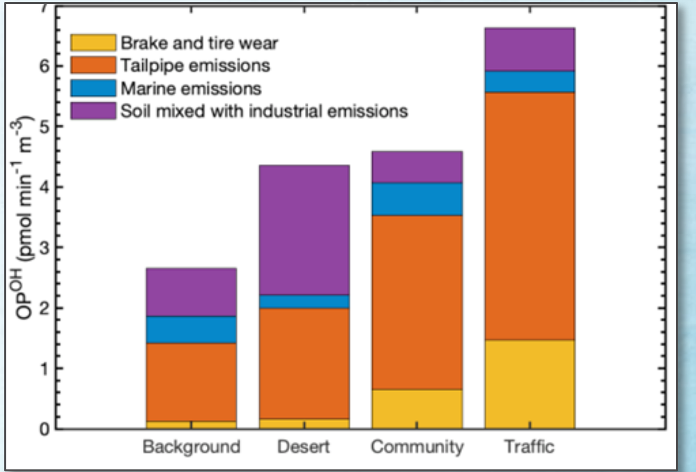
- Funded brake-dynamometer laboratory testing projects jointly with Caltrans and U.S. EPA
- Derived speed-dependent LDV and HDV emission factors
- Updated PM2.5 and PM10 EFs are used for EMFAC2021



Completed: Near-Road PM Measurement and Regional Health Impact Assessment



- Oxidative potential(OP^{OH}), a respiratory health impact indicator, placental health and birth outcomes in women living in Los Angeles were strongly associated with tracers of brake- and tire-wear emissions



- Brake- and tire-wear PM contributions:
  - For PM2.5, were greater than gasoline and diesel PM
  - For PM10, were 2 – 3 times the exhaust contributions

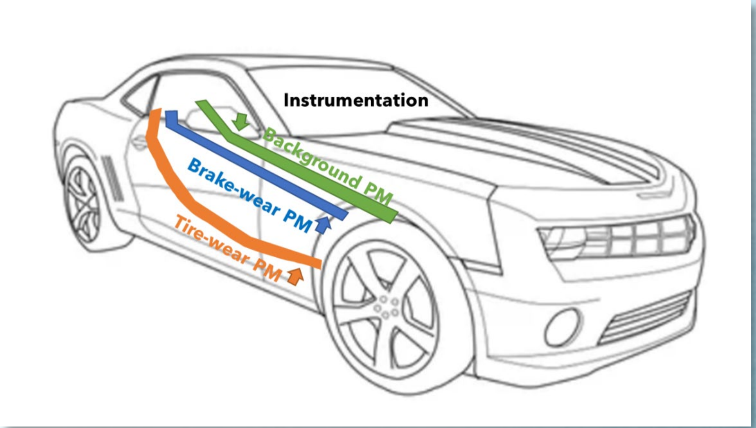
CARB

Planned: On-road Vehicle Testing for Brake- and Tire-wear PM Measurement

- Design an on-road brake- and tire-wear sampling method
- Measure brake- and tire-wear PM in consideration of factors potentially influence PM samples and their characteristics

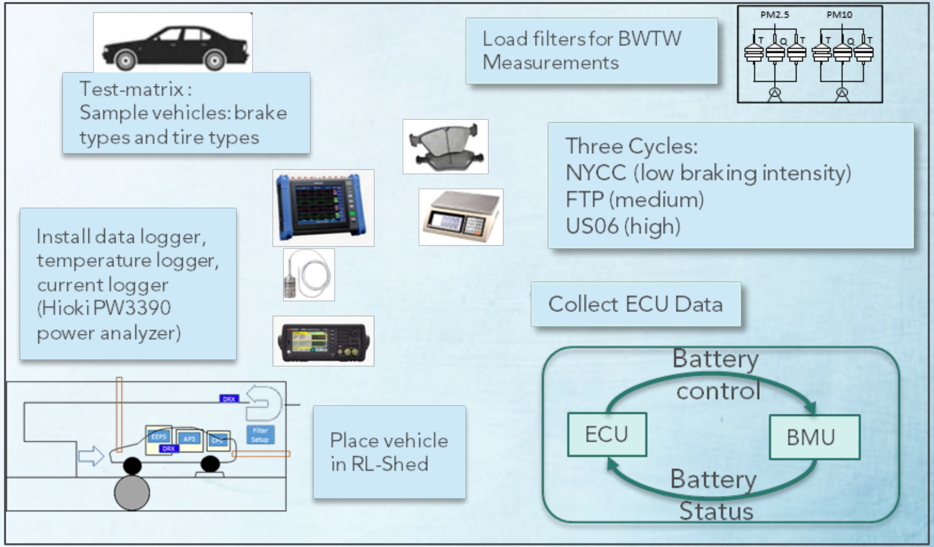
Factors

- Brake and tire types
- Road types and Geometry
- Vehicle types (LDVs and HDVs)
- Traffic and environmental conditions



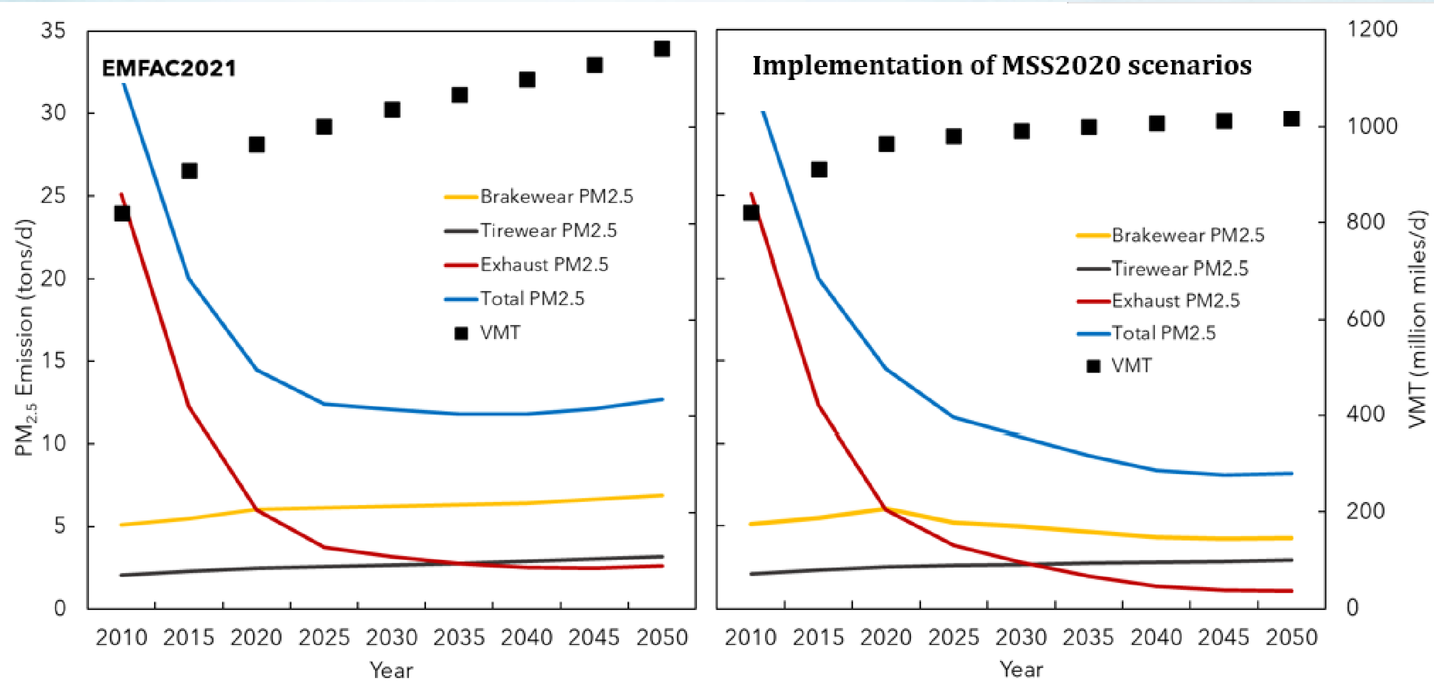
Planned: Measuring Non-Exhaust PM and EV Energy Recovery during Running Loss Shed (RLS) Testing

- Characterize non-exhaust PM emission behavior inside RLS compared to brake-dynamometer measurements
- Measure energy recovered by EV regenerative braking and evaluate the potential reductions of non-exhaust PM emissions



Potential Reduction Opportunities (1)

- Implementation of MSS2020 scenarios such as low carbon transportation incentives, ACCII, ACT, ACF, ICT, and others



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Potential Reduction Opportunities (2)

- Implementation of CEC's replacement tire efficiency program

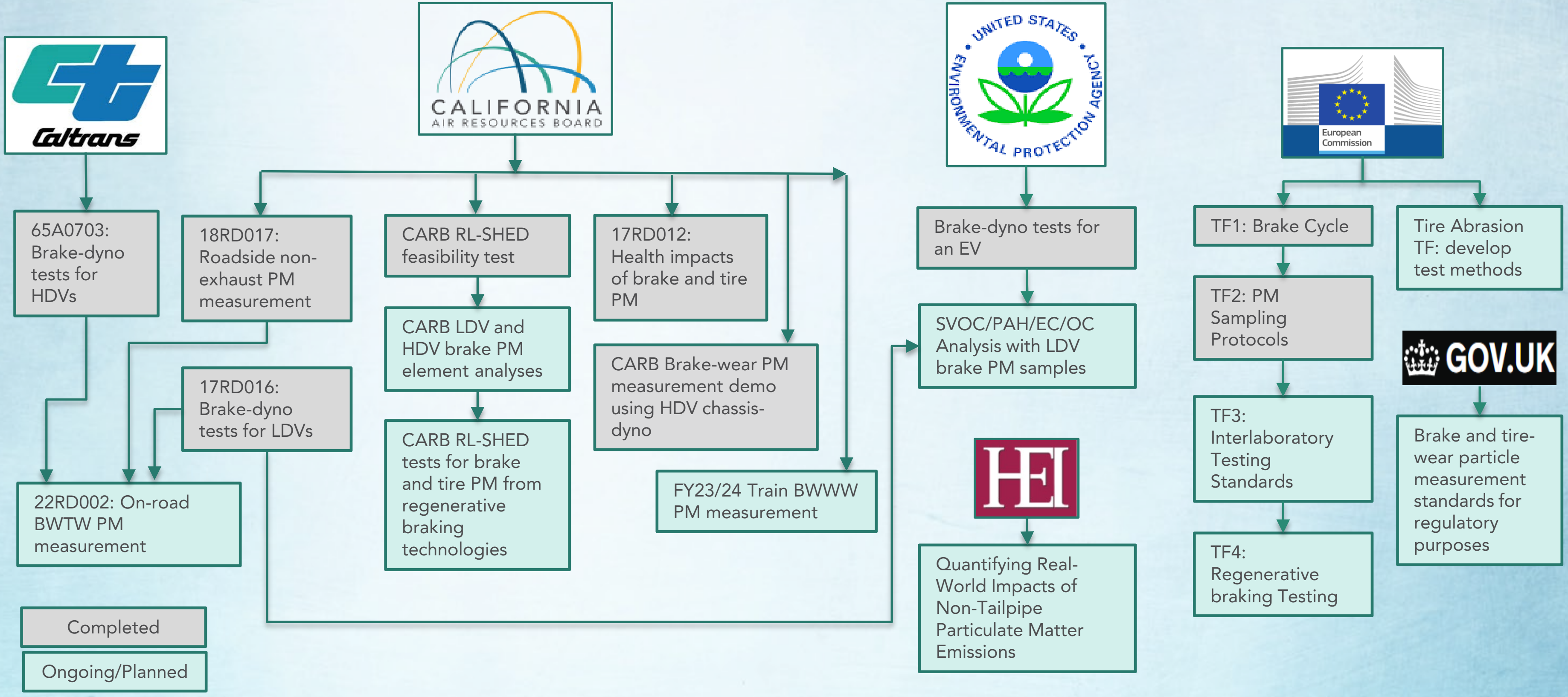
- Adoption of emerging technologies such as regenerative braking, low-rolling resistance tires, reformulated tires for electric vehicle, higher energy density and lighter batteries

CARB

Remaining Research Areas

- Develop standardized PM measurement methods for CA fleets
  - EU proposes a standardized method to measure brake-wear PM emissions from LDVs in the laboratory that will be used as part of the Euro 7 legislation.
  - EU investigates in developing a tire-wear measurement standard that will be used as part of the Euro 7 legislation.
- Examine potential discrepancies between laboratory and real-world brake-wear PM
  - Brake-dyno vs. on-road testing
- Characterize the impact of new technologies on the PM
  - Regenerative braking technologies
  - Low rolling resistance tires
  - Reformulated tires for electric vehicles
  - Heavier weight of electric vehicles
- Assess near-road community exposure and health effects
  - Real-world exposure levels
  - Cardiovascular and carcinogenic effects

Research Collaborations and Communications



Contact for more information:

CALIFORNIA AIR RESOURCES BOARD

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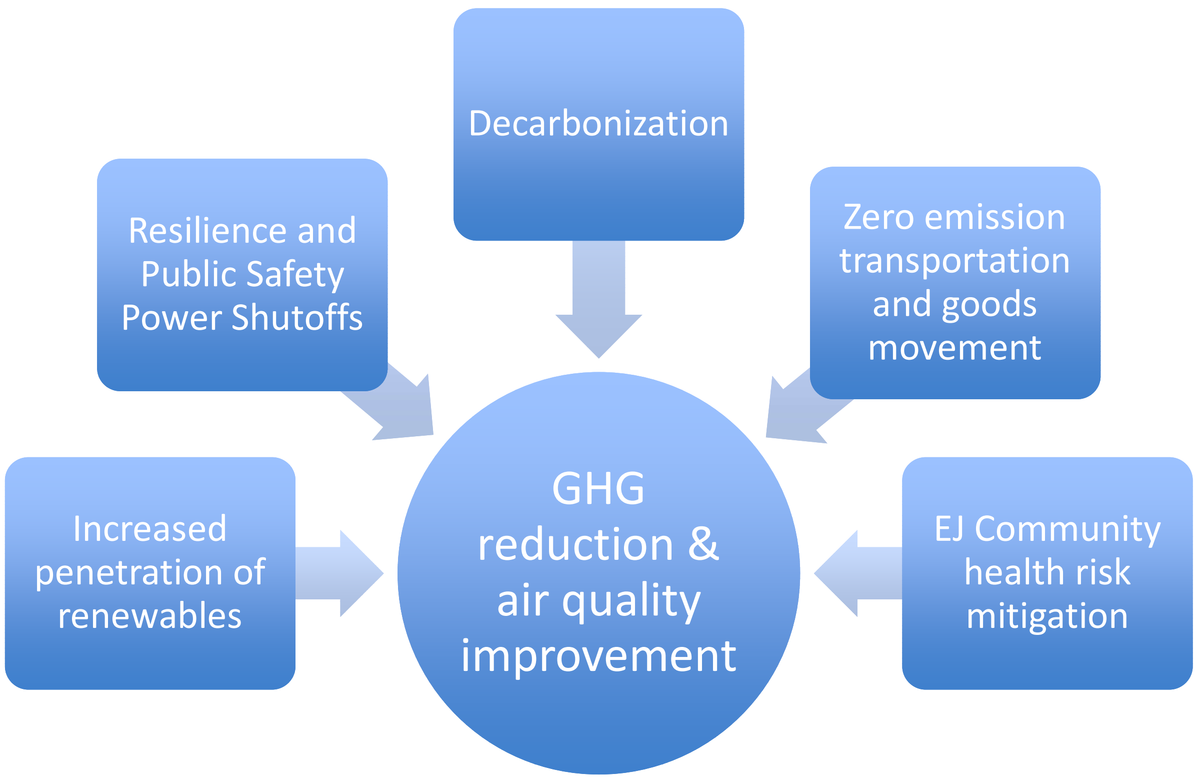
Hydrogen Microgrid Projects

Technology Advancement Office
Program Supervisor

Seungbum Ha, PhD

Clean Fuels Fund Advisory Retreat
Feb. 2, 2023

South Coast & California Policy Priorities



Microgrid for Heavy-Duty Vehicle Deployment

Charging 100 Electric drayage trucks (30MWh):

- 50kW * 100 trucks = 5MW & 6hours continuous charging (300kWh/truck)
- 150kW * 100 trucks = 15MW & 2hours continuous charging

Fueling 100 Hydrogen drayage trucks:

- 30kg * 100 trucks = 3ton of hydrogen

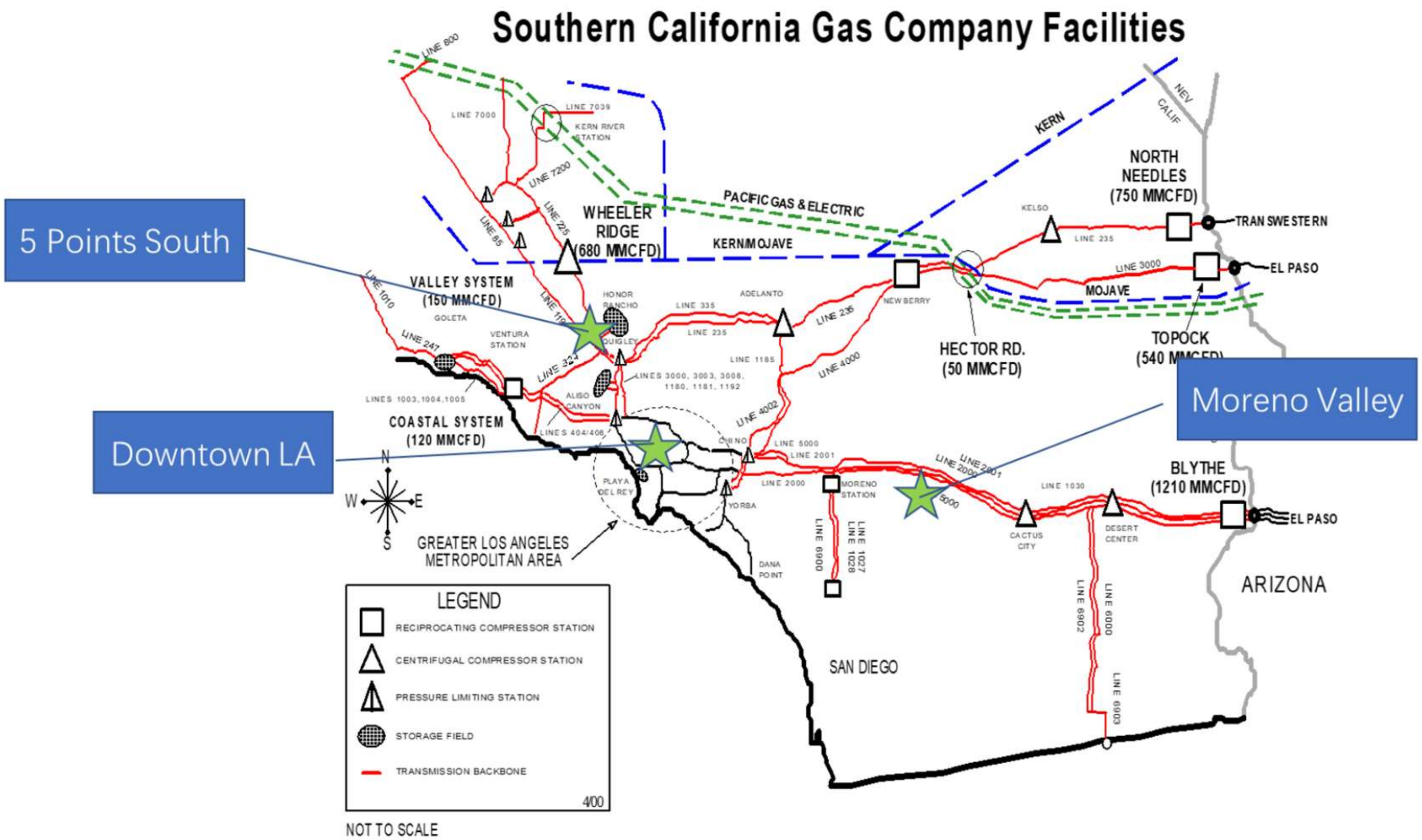
Grid or hydrogen station can support cost-effectively?

How to add resiliency to avoid grid interruptions?

Renewable energy?

Duck curve?

Electrolyzer Operational Optimization



Review the potential to produce hydrogen in the target cost range of $2/kg injected onto the gas grid using combinations of self-generated and grid delivered energy

Electrolyzer Operational Optimization

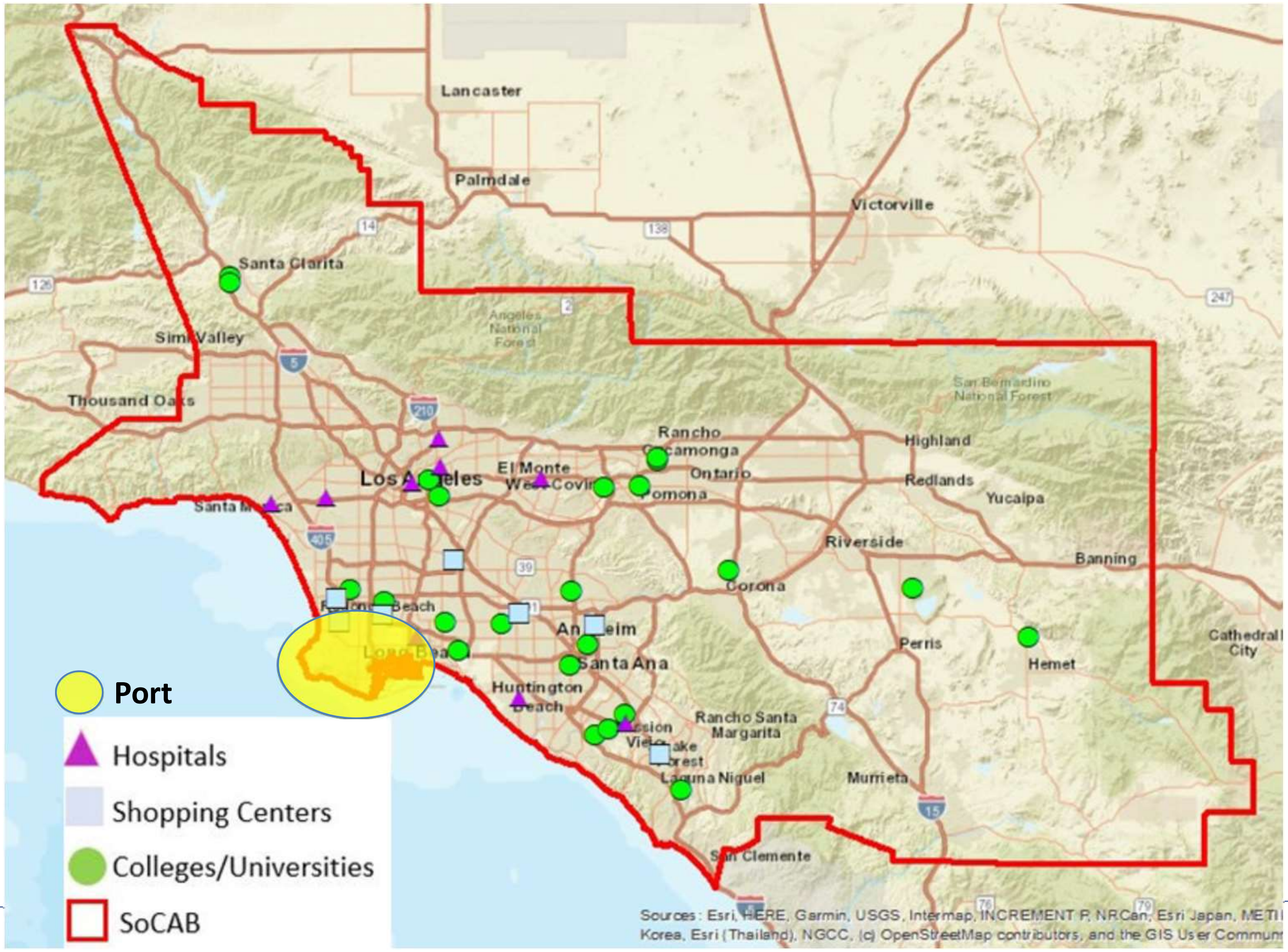
- Device sizing and cost parameters

Category	Property	Moreno Valley MV-1	Moreno Valley MV-2	Downtown LA (LA1)	Five Points (5PT)
Hydrogen	Electrolyzer size (MW)	15	50	2	30
	Electrolyzer capital cost ($/kW)	400-800	400-800	400-800	400-800
	Electrolyzer fixed operation and maintenance cost ($/kW-yr)	53	53	53	53
	Hydrogen storage cost ($/kg)	822 [3]	822 [3]	822 [3]	822 [3]
	Hydrogen compressor cost ($/kg)	See footnote [3]	See footnote [3]	See footnote [3]	See footnote [3]
Renewable	Renewable size (MW)	5	50	0	30
	2020 Annual Technology Baseline Price info	2030 - Solar - moderate	2030 - Solar - moderate	NA	2030 - Solar - moderate
	Renewable capital cost ($/kW)	687.8	687.8	NA	687.8
	Renewable fixed operation and maintenance cost ($/kW-yr)	8.055	8.055	NA	8.055

Electrolyzer Operational Optimization
- Key Lessons-Learned

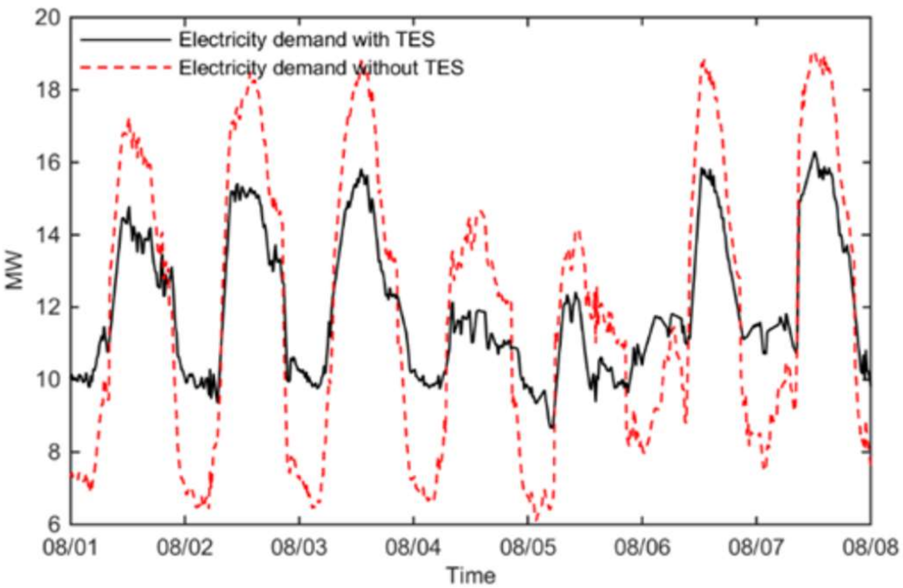
- **Higher electrolyzer capacity →lower hydrogen production cost.**
- **Amount of renewable sources available (Co-location with solar PV facilities helps to reduce hydrogen breakeven cost by increasing the utilization of the electrolyzer.)**
- **Location Moreno Valley (2) (the largest electrolyzer used in this study, e.g., 50 MW) , highest availability of renewable …has the lowest hydrogen breakeven cost ($0.62/kg).**
- **Market mechanism such as LCFS significantly reduces hydrogen B.E. cost (Decrease of ~$1.3 per kg for an increase of $40 per LCFS credit for MV2).**

Connected Network of Microgrids



Connected Network of Microgrids

- Energy mix for total load of various facilities



Hospitals

- 60% Fuel Cell with CHP system
- 25% Solar
- 15% battery energy storage system (BESS)
- up to 30,000 Ton-Hour thermal energy storage (TES), vary based on total load

Shopping Centers

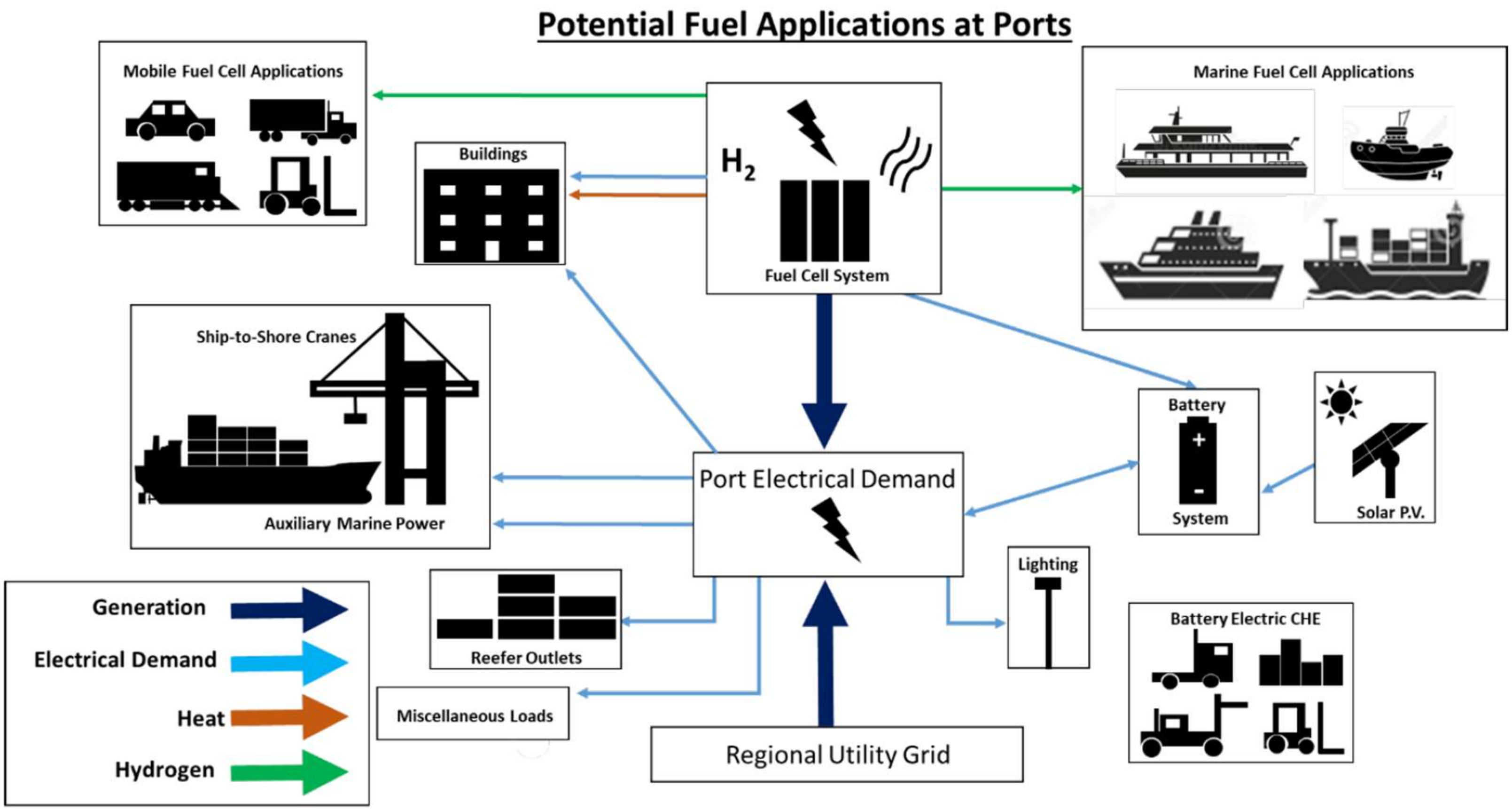
- 40% Fuel Cell
- 35% Solar
- 25% BESS

Universities

- 50% Fuel Cell with CHP system
- 30% Solar
- 20% BESS
- up to 20,000 Ton-Hour TES, vary based on total load

Connected Network of Microgrids

- Hydrogen Ecosystem at the Port



Connected Network of Microgrids

- Future Work

- **Improve the hypothetical analysis using real data**

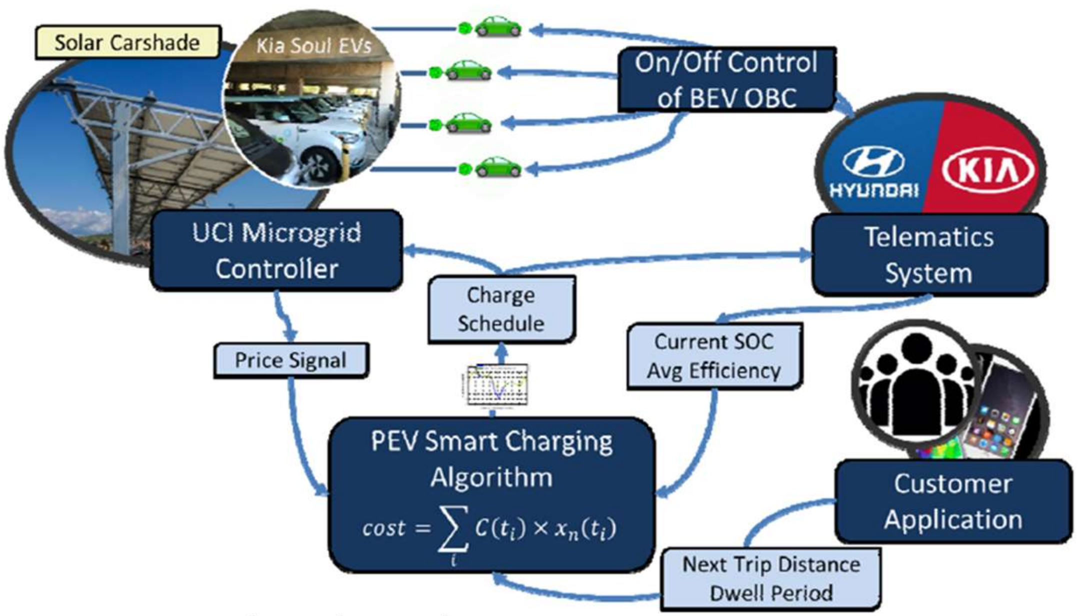
University of California Irvine Medical Center	University of California Irvine (UCI)	Stonewood Center
o 6 MW SOFC Generator o 2.5 MW Solar o 1.5 MW/1.5 MWh BESS o 30,000 Ton-Hour TES	o 10 MW SOFC Generator o 6 MW Solar PV o 4 MW/4MWh BESS o 60,000 Ton-Hour TES	o 1.3 MW SOFC Generator o 900 kW- 1MW Solar o 500 kWh BESS

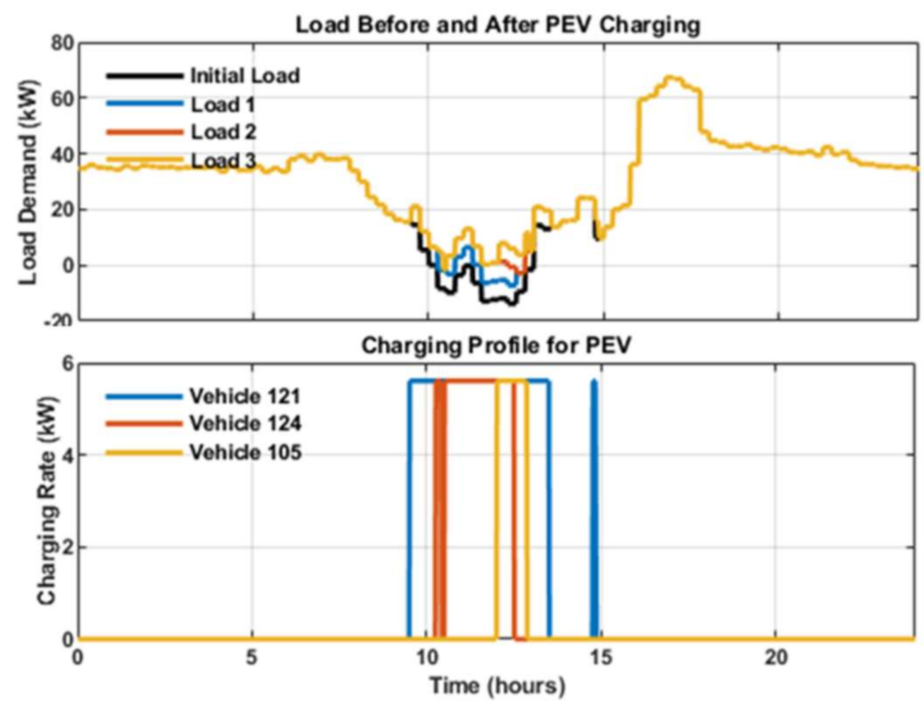
- **Develop the model connecting the zero-emission heavy-duty vehicles' data from CF demo project to microgrid systems**
- **Complete the connected microgrid model to understand synergy impact of mass deployment of microgrid systems**

Q & A

Thank you

Back-up: Plug-in Electric Vehicle Smart Charging





Clean Fuels Program Advisory Group Meeting

ANNUAL REPORT & PLAN UPDATE

2022 Annual Report & 2023 Plan Update

Aaron Katzenstein, Ph.D.
Deputy Executive Officer

February 2, 2023

Background

2022 Annual Report and 2023 Plan Update

- Annual Report on Clean Fuels Program (HSC 40448.5.1)
- Technology Advancement Plan (Update) (HSC 40448.5)
- 2023 Plan Update (draft) submitted to Technology Committee October 21, 2022
- Annual public hearing to approve Annual Report and adopt (final) Plan Update
- Submit to Legislature by March 31 every year

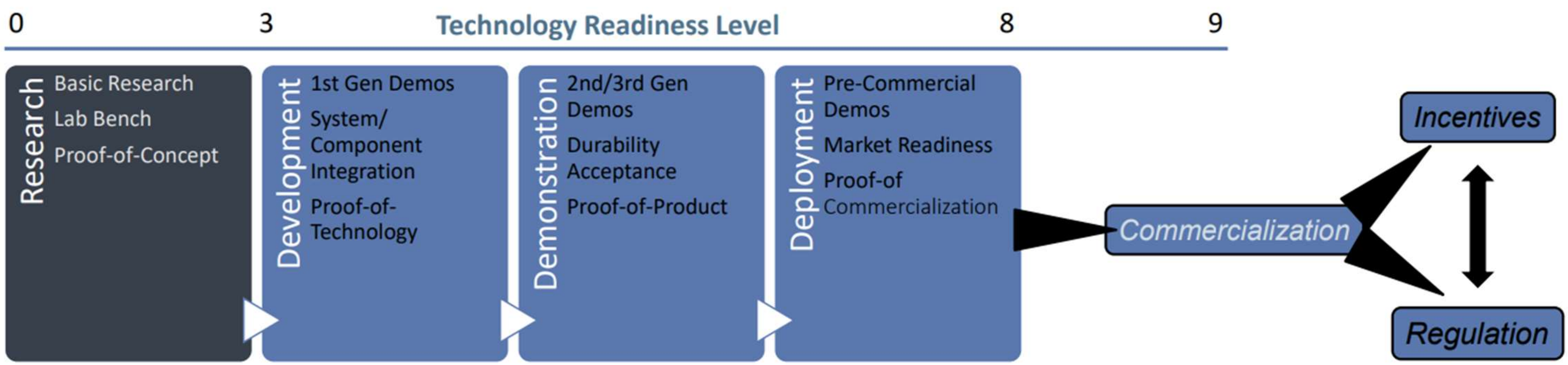
Reports: https://www.aqmd.gov/home/technology/reports

Input and Feedback

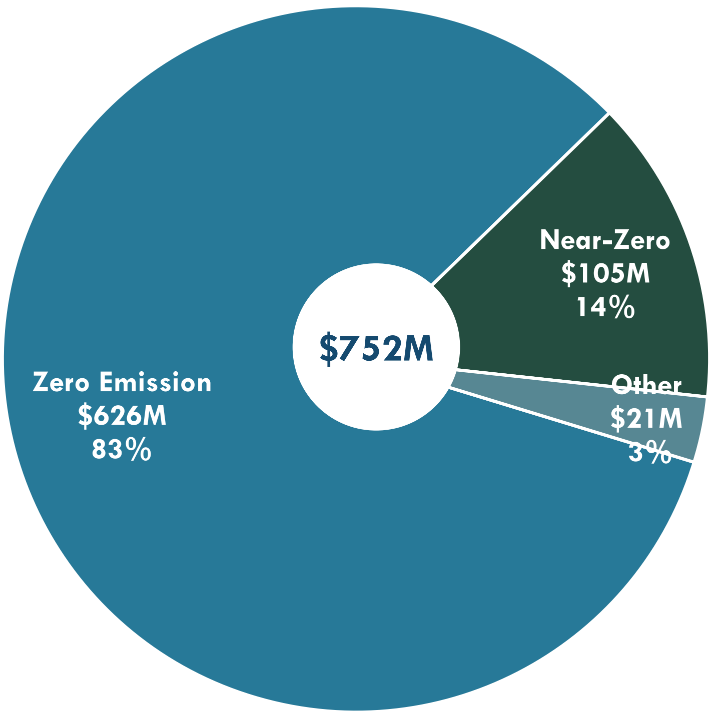
- Advisory group meetings
  - September 2022 and February 2023
  - Technology Advancement/Clean Fuels
  - Invited Technical Experts
- Meetings - agencies, industry groups, technology providers and other stakeholders

- Symposiums and conferences
  - PEMS Conference (04/2022)
  - CE-CERT's 30th Anniversary Event (04/2022)
  - SCAQMD Tech Show Case (05/2022)
  - ACT Conference and Expo (05/2022)
  - California Hydrogen Leadership Summit (06/2022)
  - AltCar Expo & Conference (10/2022)
  - ICEPAG (12/2022)
- Clean tech partnerships
  - Veloz
  - CNGVP
  - CALSTART
  - Hydrogen Fuel Cell Partnership

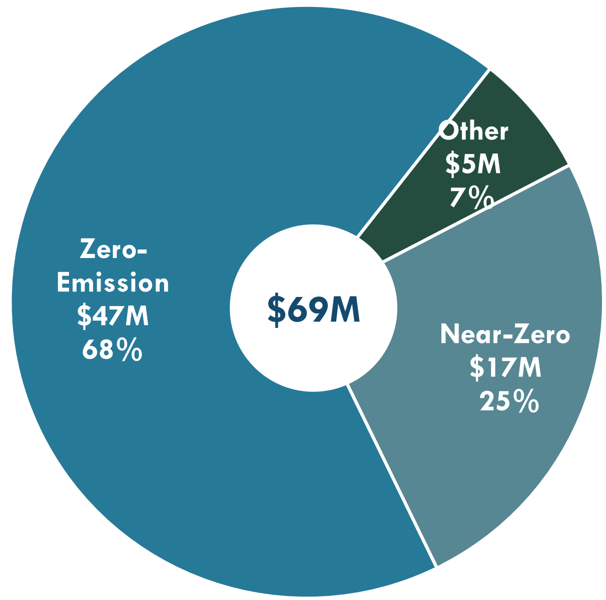
Clean Fuels Program – Overview



Clean Fuels Funding Allocation since 2017



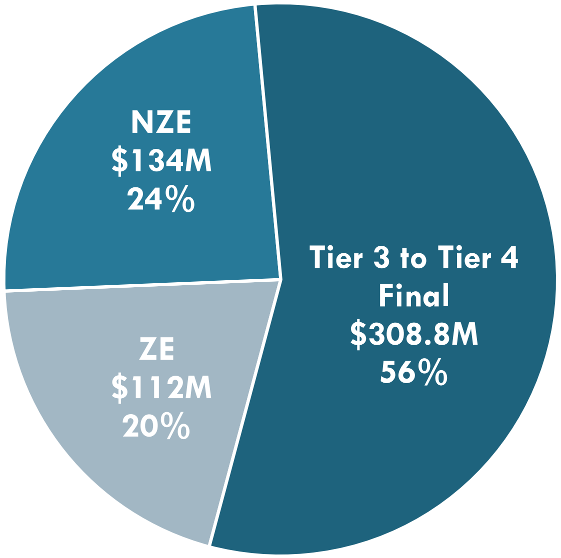
Total Project Cost



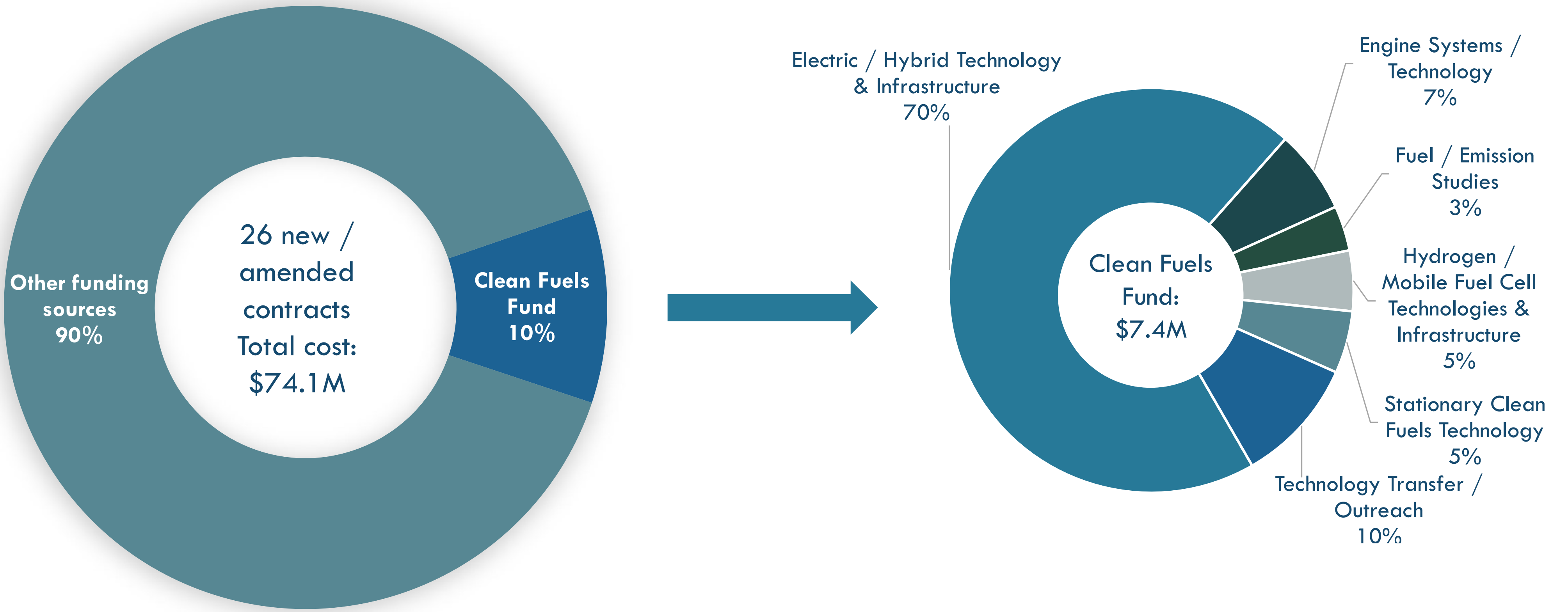
Clean Fuels Fund Cost Share

Emissions Benefit from Incentive Programs since 2017

South Coast AQMD Incentive Programs	NZE (# of vehicles)	ZE (# of vehicles)	Annual NOx Reductions (tons)
Carl Moyer Proposition 1B VW Mitigation Trust	1,445	180	711
Lower Emission School Bus	281	144	85
Total	1,726	324	797



2022 Executed Clean Fuels Projects



Major Funding Partners in 2022

Research Funding Organizations

- United States Environmental Protection Agency
- State of California Energy Commission
- California Air Resources Board
- Department of Energy, United States of America
- NREL – National Renewable Energy Laboratory

Major Manufacturers/ Technology Providers

- Daimler Truck North America
- Volvo
- SunLine Transit Agency

Local Entities

- Clean Transportation Funding from the MSRC – Mobile Source Air Pollution Reduction Review Committee
- Southern California Edison – Energy for What's Ahead[SM]
- LA – The Port of Los Angeles
- Port of Long Beach – The Green Port
- SoCalGas

Fleet Providers

- NFI
- Schneider

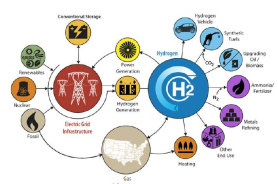
2022 Key Contracts Executed

JETSI NFI Deployment of Volvo and Daimler Class 8 Battery Electric Trucks, Charging Infrastructure and Distributed Energy Resource Technologies

JETSI Schneider Deployment of Daimler Class 8 Battery Electric Trucks and Charging Infrastructure

A-1 Alternative Fuel Systems to Develop and Demonstrate Hydrogen Fuel Cell Medium-Duty Buses

Frontier Energy High Flow Bus Fueling Protocol Development



UCI Study of Fuel Cell Microgrids for Backup Power and Transit

2022 Key Projects Completed

57 completed

Volvo Battery Electric Excavator and Wheel Loader Development and Demonstration Project

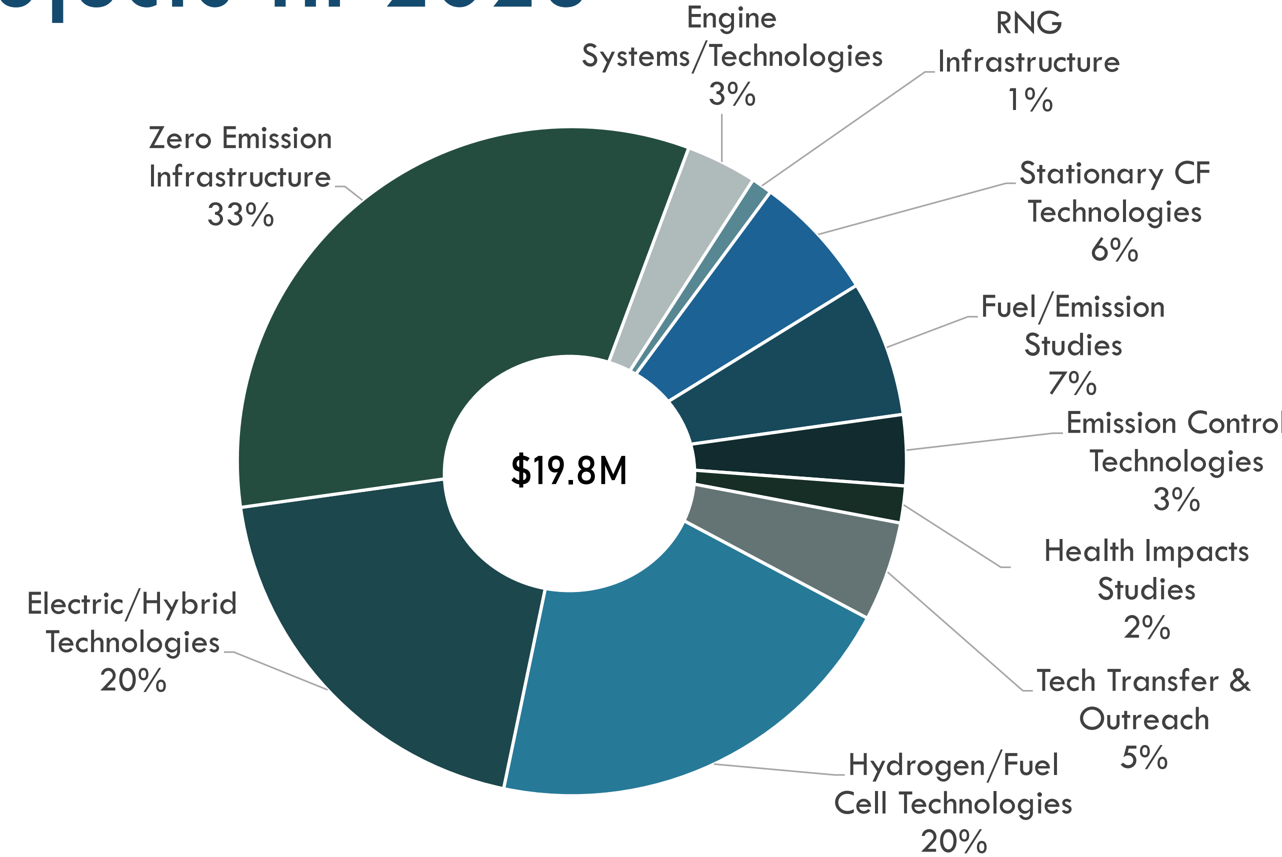
Daimler Zero Emission Truck Innovation Fleet Project

Volvo Low Impact Green Heavy Transport Solutions (LIGHTS)

200 Truck In-Use Emissions Testing and Fuel Usage Profile of On-Road Heavy-Duty Vehicles

GGRF Zero Emission Drayage Truck Demonstration Project

Potential Funding Distribution for Projects in 2023



Proposed Advisor Group Members

Technology Advancement Advisory Group (14 MEMBERS):

Elizabeth John, CEC

Rosalie Barinas, SCE

Clean Fuels Advisory Group (13 Members):

Marcus Alexander, EPRI

David Park, HFCP

Development Schedule

Technology Committee	October 21, 2022 (Draft 2023 Plan Update)
Advisory Group Review	September 8, 2022 February 2, 2023
Technology Committee	February 17, 2023
Board Approval	March 3, 2023
Due to State Legislature	March 31, 2023