CLEAN FUELS PROGRAM ADVISORY GROUP AGENDA  
FEBRUARY 10, 2022, 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 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.

<table>
<thead>
<tr>
<th>Welcome &amp; Overview - 9:00 – 10:30 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Welcome &amp; Introductions</td>
</tr>
<tr>
<td>(b) Goals for the day</td>
</tr>
<tr>
<td>(c) AB617 Background and Update</td>
</tr>
<tr>
<td>(d) Call for participation in District Advisory Council</td>
</tr>
<tr>
<td>(e) Feedback and Discussion</td>
</tr>
<tr>
<td>(f) Public Comment (2 minutes/person)</td>
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Areas of South Coast AQMD Focus

Fuel Cell Electric HD Trucks and Buses – Development and Demonstration  
10:30 AM – 12:30 PM

<table>
<thead>
<tr>
<th>Areas of South Coast AQMD Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Hydrogen Generation and Infrastructure</td>
</tr>
<tr>
<td>(b) Fuel Cell HD Truck Development Projects</td>
</tr>
<tr>
<td>(c) Shore to Store FCET Project</td>
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<tr>
<td>(d) Fuel Cell Transit Bus Project</td>
</tr>
<tr>
<td>(e) Feedback and Discussion</td>
</tr>
<tr>
<td>(f) Public Comment (2 minutes/person)</td>
</tr>
</tbody>
</table>
2. **Hydrogen Generation and Infrastructure Projects**
   
   (a) Fuel Cell Medium Duty Bus Project
       Sam Cao, Ph.D., Program Supervisor
   
   (b) Renewable Hydrogen Infrastructure Project
       Phil Barroca, Program Supervisor
   
   (c) Hydrogen Infrastructure for Heavy Duty Trucks
       Lisa Mirisola, Program Supervisor
   
   (d) Feedback and Discussion
       Advisors and Experts
   
   (e) Public Comment (2 minutes/person)

3. **Wrap-up – 3:00 PM – 4:00 PM**
   
   (a) 2022 CF Proposed Plan Update Discussion & Wrap-up
       Aaron Katzenstein, Ph.D., Assistant Deputy Executive Officer
   
   (b) Advisor and Expert Comments
       All
   
   (c) Public Comment (2 minutes/person)

**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.
AB 617 Background and Update

Clean Fuels Advisory Group – February 2022
Assembly Bill (AB) 617 Overview

• Signed into state law in 2017
• Focuses on emissions and exposure reductions in communities most impacted by air pollution

• Key elements of AB 617
  o Community driven action
  o Community Emissions Reduction Plans (CERPs)
  o Community Air Monitoring Plans (CAMPs)
  o Clean technology investments
  o Best emissions controls
  o Easier access to emissions data
AB 617 Communities

- CARB selected six communities recommended by the Governing Board

- 2018 communities
  - East Los Angeles, Boyle Heights, West Commerce
  - San Bernardino, Muscoy
  - Wilmington, Carson, West Long Beach

- 2019 communities
  - Eastern Coachella Valley
  - Southeast Los Angeles

- 2020 community
  - South Los Angeles
Community Emissions Reduction Plans (CERPs) – 2018 Communities

**East Los Angeles, Boyle Heights, West Commerce**

- **Air Quality Priorities**
  - Neighborhood and Freeway Truck Traffic
  - Railyards
  - Metal Processing Facilities
  - Rendering Facilities
  - Autobody Shops
  - Schools, Childcare Centers, Libraries and Public Housing

**San Bernardino, Muscoy**

- **Air Quality Priorities**
  - Neighborhood Truck Traffic
  - Railyards
  - Warehouses
  - OmniTrans Bus Yard
  - Concrete Batch Plants
  - Schools, Childcare Centers, and Community Centers

**Wilmington, Carson, West Long Beach**

- **Air Quality Priorities**
  - Neighborhood Truck Traffic
  - Railyards
  - Ports
  - Oil Drilling and Production
  - Concrete Batch Plants
  - Schools, Childcare Centers, and Community Centers

- **July 2019**, staff finalized CAMPs and **September 2019**, CERPs adopted by the Governing Board
- **September 2020**, CARB approved the CERPs
Community Emissions Reduction Plans (CERPs) – 2019 Communities

**Eastern Coachella Valley**

- **Air Quality Priorities**
  - Salton Sea
  - Pesticides
  - Diesel Mobile Sources
  - Greenleaf Power Plant
  - Fugitive Road Dust and Off-Roading
  - Open Burning and Illegal Dumping

  - **December 2020**, CAMP finalized
  - **June 2021**, CERP adopted by Governing Board (amendment)
  - **September 2021**, CERP approved by CARB

**Southeast Los Angeles**

- **Air Quality Priorities**
  - Rendering Facilities
  - Green Spaces
  - Metals
  - General Industrial Facilities
  - Truck Traffic and Freeways
  - Railyards and Locomotives

  - **December 2020**, CERP adopted by Governing Board and CAMP finalized
  - **May 2021**, CERP approved by CARB
Community Emissions Reduction Plan – 2020 Community

• Community includes Compton, Lynwood, Willowbrook, and parts of Inglewood and Los Angeles

• Co-leadership model to develop CERP and CAMP

• Air quality priorities
  - Mobile Sources
  - General Industrial
  - Oil and Gas Industry
  - Auto Body Shops
  - Metals

• Plan adoption anticipated in June 2022
## CERP Implementation – Highlights

### Truck Targeted Sweeps (All Communities)
- 37 sweeps, **1,066 trucks inspected** across first 5 communities

### Oil Well Monitoring & Enforcement (WCWLB)
- **194 inspections with FLIR surveillance**, 8 facilities identified by monitoring for elevated emissions, and **responded to 377 oil well related complaints** *

### Monitoring (ELABHWC)
- Ongoing **mobile air monitoring measurements** conducted since June 2019; additional mobile air monitoring is being conducted by Aclima Inc.

### Incentive Outreach (SELA)
- Worked with the CSC to identify approximately 10 local fleets and small businesses to provide **information on incentive funding for zero-emission technology**

### Warehouse ISR (ELABHWC, SBM, SELA, WCWLB)
- **Adopted Warehouse Indirect Source Rule (ISR)** – Warehouse Actions and Investments to Reduce Emissions (WAIRE) Program

### Collaboration (ECV)
- Initiated partnerships with CARB, DPR, OEHHA, and the Riverside County Agricultural Commissioner to address CSC concerns related to pesticides

*Based on data from 4th quarter of 2021*
Community Engagement – CERP Implementation & Development

• CERP Implementation – 2018 and 2019 Communities
  o Quarterly Community Steering Committee (CSC) meetings
  o Participatory budgeting
  o Collaborations with community-based organizations
  o Technical Advisory Group Meetings
  o Over 100 meetings with community members

• CERP Development – 2020 Community (South Los Angeles)
  o 14 community meetings (CSC and subcommittee meetings)
  o Virtual joint Air Quality Conference with PSR-LA
  o Weekly co-lead meetings to discuss CSC charter, meeting topics, approach, and plan development
  o Co-lead meetings for contracts, charter, and public engagement coordination
CERP Implementation – School and Residential Air Filtration

• Work with communities to prioritize:
  o Funding for residential and school air filtration (e.g., participatory budgeting)
  o School sites and residences to receive air filtration

• Key funding considerations are:
  o Accessibility
  o Costs
  o Maintenance

• Develop a project plan to fund air filtration systems under the Community Air Protection Guidelines

• Implement Residential and School Air Filtration Program
  o Conduct community outreach
  o Evaluate and approve applications
  o Install filtration units at schools and deliver home units
CERP Implementation – Truck Incentives

• AB 617 communities identified emissions from trucks as an air quality concern

• Four communities allocated $14.5 million toward cleaner trucks, including:
  o East Los Angeles, Boyle Heights, West Commerce ($1.8 million)
  o Southeast Los Angeles ($5 million)
  o San Bernardino, Muscoy ($5 million)
  o Wilmington, Carson, West Long Beach ($2.7 million)

• CSCs expressed interest in prioritizing funds for zero-emission trucks

• Staff is holding a series of community workshops to develop a truck incentives program for AB 617 communities
CERP Implementation – Truck Incentives (continued)

• Input from community workshops will guide development of an AB 617 Truck Incentives Program

• Community support for an electric-truck loaner concept
  o Opportunity for short-term trial
  o Builds awareness of electric truck options
  o Minimizes financial risks

• Work with communities and other stakeholders to address key challenges
  o Identifying participants
  o Identifying truck types and host locations
  o Loan terms (e.g., duration of loan, insurance requirements, and training)
  o Program outreach
Questions
Hydrogen Production and Infrastructure

Clean Fuels Advisory Group 10 February 2022

Jeffrey Reed
Production

- Power-to-Gas on Campus Microgrid
- Power-to-Gas Design -- Five Points
- GridH2 – Optimal Use of Excess Renewables

Transport and Storage

- Hydrogen injection and blending
- System impacts (leakage and embrittlement)
- RH2 and RNG for renewables firming
- Gas grid H2 carrying capacity
- Optimal pathways for deep decarbonization of the gas system

End Use

- Hydrogen tolerance of burners
- Emissions/AQ impacts
- Performance validation
CCUS was out of RH2 Roadmap scope.
Technology Forecasting Methodology

- Technology forecasting methods
  - Expert elicitation (researchers, equipment vendors)
  - Progress or learning rate analysis / trend analysis (X% reduction per unit time or per doubling of global cumulative production)
  - Bottom-up analyzes based on design, bill-of-materials and production scale
  - Analogy or proxy analysis
700 to 1,200 PJ/yr. At $60 to $100 per dry ton.

Map Source: California Department of Fire Protection 2015
Cost Evolution for Full Production Cost of Renewable Hydrogen

Cost per kg RH2

Year of Commercial Operation

Year of Commercial Operation

- Electrolytic
- Thermochemical
- Anaerobic Digestion
Cost evolution of zero-carbon gaseous fuel pathways

- Electrolytic-RNG
- Electrolytic-RH2
- Bio-RNG
- Bio-RH2
- CCUS -- Air Capture
- Power Generation
- Industrial
- Post-Comb CCUS

Year of Initial Operation

Cost $/GJ
Hydrogen is the least cost option among renewable fuels.
• Future supply chain may include pipeline transport, at-station production via electrolysis or reformation and new transport and storage media such as hydrogen-carrying liquids
Increased station network utilization and station economies of scale are the biggest contributors to cost reduction

<table>
<thead>
<tr>
<th>Input Assumptions</th>
<th>Current</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Size Kg/d</td>
<td>300</td>
<td>600</td>
<td>1200</td>
<td>1500</td>
</tr>
<tr>
<td>Utilization</td>
<td>40%</td>
<td>70%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Production Volume</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Source: UCI APEP using HDSAM 3.1
Conclusion -- RH2 Sector Can Be Self-Sustaining Before 2030

Price range for fuel-economy-adjusted parity with gasoline at 2.5x fuel economy ratio
Figure 5: Average Daily Hydrogen Dispensing
Infrastructure needs to be considered in light of all sources of demand.
Pipeline transport is potentially least cost = order of $0.30 per kilogram
• Hydrogen backbone roughly $5B
• Throughput for transportation applications could reach roughly 500 Petajoules per year in 2050 (this is about 3.5 billion kg)
• Assuming an annual charge rate of 20% for the pipeline, transport cost would be under $0.30/kg
• Rollout strategy needs further assessment (initial utilization modest but growing rapidly post 2030)
Initial assessment is that transitioning the natural gas system to hydrogen could be cost effective and would enhance the economics of the backbone.

- Payback based fuel cost savings form transitioning gas system to hydrogen
- Economics of backbone only serving transportation and industrial loads also favorable
Fuel Cell Heavy-duty Truck Demonstration and Beyond

Technology Advancement Office
Program Supervisor

Seungbum Ha
Heavy-Duty Battery Electric Truck Project

Technology Readiness Level

<table>
<thead>
<tr>
<th>Technology Development</th>
<th>Technology Demonstration/Commissioning</th>
<th>Technology Deployment/Commercialization</th>
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<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
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<td>7</td>
<td>8</td>
<td>9</td>
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100mi
Early Demo
Tier 2 manufacturer developed EV technology

ZECT I
Battery Electric /CNG Hybrid
$10M($1.2M)

GGRF
Battery Electric /Hybrid
$40M($6M)

Daimler
Battery Electric
$31M($13M)

Volvo
Battery Electric
$90.4M($4M)

CARB/CEC Pilot
Battery Electric
$70.4M($5.6M)

* $ Total Project Cost(SCAQMD Cost-share)
CARB-CEC Pilot Project

- 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

<table>
<thead>
<tr>
<th>Daimler</th>
<th>Volvo</th>
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<tbody>
<tr>
<td>200 – 250-mile electric range</td>
<td>195 – 220-mile electric range</td>
</tr>
<tr>
<td>475 kWh lithium-ion battery pack</td>
<td>564 kWh lithium-ion battery pack</td>
</tr>
<tr>
<td>CCS1 connector for fast charging</td>
<td>CCS1 connector for fast charging</td>
</tr>
</tbody>
</table>

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

Advantages over conventional IC Engine

- Least commercialized option with fewest vehicles on the road
- High MSRP
- High fuel cost ($10-15/kg_H2)
- Fueling infrastructure not commonly available

- Slow charging times (at least 3-4 hours to fully charged)
  - Secondary charging infrastructure required
  - Ultra fast charging (over 1MW charger)
- Limited range currently up to 150-200 miles
- Installing charging infrastructure can be expensive, time consuming, and takes up space
- Heavy battery can lead to weight issues
- Battery recycling required at high volume deployment

- LOW INITIAL INFRASTRUCTURE COSTS
- ZERO EMISSIONS
- HIGH EFFICIENCY
- ELECTRIC DRIVE
- LOW NOISE
- LOW INFRASTRUCTURE COSTS AT SCALE
- FAST REFUELING
- FULL CARGO CAPACITY
- LONG RANGE
- EXTREME WEATHER TOLERANCE

- ~30mins
- >500 miles

>500 miles
~30mins
Cost comparison for charging/Hydrogen Infrastructure

- For drayage trucks, battery charging infrastructure is expected more than twice as costly as hydrogen fueling infrastructure for the medium- and high-volume cases.
  - Charging station: $58k/truck @Low volume $28k/truck @High volume
  - Hydrogen station: $62k/truck @Low volume $10k/truck @High volume

- Infrastructure costs per truck decline significantly as scale increases, with large cost declines from the first 100 trucks to the first 1,000 trucks and more moderate declines afterward.

https://theicct.org/sites/default/files/publications/ICCT_EV_HDVs_Infrastructure_20190809.pdf
Zero Emission Fuel Cell Vehicle Project

<table>
<thead>
<tr>
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Early Demo
Honda FCX

Data analysis
Toyota Highlander
Hyundai Tucson

ZECT II
Fuel Cell
/CNG Hybrid
$20M($2.5M)

CTE-OCTA
Fuel Cell Bus

ZANZEFF
Toyota-KW
Fuel Cell Truck

CEC ARFVTP
Cummins
Fuel Cell truck
$5M($0.6M)

Hyundai
Fuel Cell Truck

100mi

150mi

200mi

* $ Total Project Cost(SCAQMD Cost-share)
## ZECT II Fuel Cell trucks

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

- Up to 250 miles range
- 700 bar H2 tank

**ZANZEFF**
*Toyota-KW Fuel cell Truck*

**CEC ARFVTP**
*Cummins Fuel cell Truck*
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
Fuel Cell-dominant vs. Battery-dominant

150 miles

- Battery-dominant: 60kW Fuel Cell stack, 120kWh Battery
- Fuel Cell-dominant: 100kW Fuel Cell stack, 80kWh Battery

500 miles

- Battery-dominant: 100kW Fuel Cell stack, 400kWh Battery
- Fuel Cell-dominant: 180kW Fuel Cell stack, 75kWh Battery

Not-to-scale
CEC ARFVTP – Cummins Fuel Cell Drayage Truck

- 4 Fuel Cell Class 8 drayage trucks (200+ mile ZE range)
- Complete and deliver vehicles in 2022 with 12 month demonstration

### 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

![Image of Kenworth T680 Day Cab](image-url)
CEC ARFVTP – Cummins Fuel Cell Drayage Truck

- Vehicle development progress
  - Truck #1: completed by Apr. 2022
  - Truck #2,3,4: completed by Q2 2022

- Technology Commercialization Roadmap:
  - Potential FCET market size model based on the results of the hydrogen fueling and production capacity constraints.
  - Commercialization of trucks with particular focus on financial incentives and increasing fuel cell manufacturing
  - Total cost of ownership comparison model
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
Hyundai Fuel Cell Xcient Roadshow

Vehicle arrival: 11/11-12
Vehicle check: 11/12-11/28

**WEEK 1**
- Anaheim Stadium
- 29 Nov - 2 Dec (4 days)

**WEEK 2**
- Diamond Bar SCAQMD
- 6-7 Dec (2 days)
- Apple Valley Walmart
- 9-10 Dec (2 days)

**WEEK 3**
- Oakland
- 14 Dec (1 day)
- Sacramento
- 16 Dec (1 day)

**Locations**
- Sacramento
- Oakland
- Apple Valley
- Diamond Bar
- Anaheim
- Walmart

**Organizations**
- CARB California Air Resources Board
- CEC California Energy Commission
- California Fuel Cell Partnership

**Districts**
- BAAQMD Bay Area Air Quality Management District
- SCAQMD South Coast Air Quality Management District
- Alameda County Transportation Commission
- CTE cte
A Vision for Freight Movement in California – and Beyond

Figure 8: Envisioned station network to support 70,000 hydrogen fuel cell electric trucks.
Background

H2Freight “Project Portal” at POLB

- CONTRACTOR: Equilon (dba Shell)
  Station at POLB (property leased to Toyota)

- CEC GFO-17-603 - Advanced Freight Vehicle and Infrastructure Deployment (Total $12M)

- 1,000 kg/day truck refueling with multiple fueling positions at 700 bar

- Clean Fuels cost-share $1.2M to refuel heavy-duty vehicles at 350 bar for demonstration by multiple operators

- First Heavy-duty station Commissioned & Open July 2021

- Evaluate fueling protocols, dispenser design, station throughput/reliability, etc.
Zero Emissions Freight “Shore to Store”

- Contractor: POLA (Clean Fuels $1M)
- Total $82.5M ($41M CARB ZANZEFF)
- Develop and demonstrate ten fuel cell trucks (Class 8 Kenworth T680 with Toyota fuel cells)
- H2 stations in Ontario & Wilmington (Shell Equilon)
- 5 FCET in revenue service (August 2021)
  All 10 in revenue service (November 2021)
United Parcel Services (3),
Total Transportation Services Inc (2),
Southern Counties Express (1),
Toyota Logistics Services (4)
## Port of Los Angeles

### Shore to Store Project Funding

<table>
<thead>
<tr>
<th>Partner</th>
<th>Funding</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARB</td>
<td>$41,122,260</td>
<td>49.8</td>
</tr>
<tr>
<td>CEC (Project Portal match)</td>
<td>$25,999,331</td>
<td>31.5</td>
</tr>
<tr>
<td>Toyota</td>
<td>$9,740,000</td>
<td>11.8</td>
</tr>
<tr>
<td>Kenworth, Shell, Southern Counties Express, Total Transportation Services, Port of Hueneme, UPS</td>
<td>$4,685,433</td>
<td>5.7</td>
</tr>
<tr>
<td>South Coast AQMD</td>
<td>$1,000,000</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$82,547,024</strong></td>
<td><strong>100.0</strong></td>
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## Project Tasks & Progress

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen station design, build, commissioning</td>
<td>Ontario commissioned &amp; operating, Wilmington in commissioning</td>
</tr>
<tr>
<td>Class 8 FCET design, build, validation</td>
<td>10 trucks completed &amp; in fleet operations</td>
</tr>
<tr>
<td>Technology Demonstrations</td>
<td>12-month demonstration started May 2021</td>
</tr>
<tr>
<td>Data Collection, Analysis</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Reporting</td>
<td>Monthly progress meetings</td>
</tr>
</tbody>
</table>
Data Collection & Analysis Ongoing

Analysis by NREL

Statistics as of January 10, 2022

- 48k miles accumulated
- 21k miles in service

Analysis parameters (Daily average, Distance weighted average)

- Fuel efficiency
- H2 consumption
- Comparisons to fleet baselines, payloads, maintenance
- H2 fueling throughput, number of fills

Wilmington H2
Ocean Truck Map Plots
Project Benefits

- Demonstrate feasibility of fuel cell electric truck (FCET) deployments
- Better understand fleet needs
- Drive technology improvements in FCETs
- Support hydrogen fueling infrastructure development for heavy-duty demonstration
- Collect and analyze data about FCETs and heavy-duty hydrogen fueling
- Address equity in communities near ports impacted by goods movement
Fuel Cell Transit Bus Project

MARYAM HAJBABAEE
CLEAN FUEL PROGRAM ADVISORY GROUP – FEBRUARY 2022
Transit Buses Current Regulations + Incentives

California Innovative Clean Transit
• Reduce NOx and GHG emissions
• Focus on transit-dependent and disadvantage communities
• Public transit agencies to gradually transition to a 100% ZEB fleet
• 100% of new purchases must be ZEBs starting 2029 with a goal for full transition by 2040

2016 AQMP Control Measure
• Transition to zero and near-zero emission technologies
• Secure funding for incentives for early deployment and commercialization of zero and near-zero technologies

Available Incentive Programs
Hybrid and Zero-Emission Truck and Bus Voucher (HVIP)
VW Mitigation Funds for California
Carl Moyer Program
Examples of Zero Emission Transit Agencies

- **Orange County Transit Authority (OCTA)**
  Currently operates 10 fuel cell buses and plans to add 20 additional fuel cell buses by 2029

- **Foothill Transit Agency**
  Currently operate 35 standard and double-deck electric buses and plans to add 30 additional zero emission buses by 2022

- **SunLine Transit Agency**
  Currently operates 21 fuel cell and 4 battery electric buses and plans to add 25 additional zero emission buses by 2025
SunLine Transit Bus Project

- Deployment of 5 Fuel Cell Electric Buses at Sunline Transit Agency
  Replacing 5 2008 CNG buses

- Total Project Budget: $6.9 M
  EPA (Targeted Airshed Grant) : $5.9 M
  South Coast AQMD (Clean Fuel Program) : $205K
  Sunline Transit Agency : $806K
New Flyer Xcelsior XHE40
40’ Transit Bus powered by Ballard Fuel Cell

<table>
<thead>
<tr>
<th>New Flyer</th>
<th></th>
</tr>
</thead>
</table>
| PROPULSION SYSTEM  | Siemens - E-Drive All Electric Propulsion System  
Includes PEM 1DB2016, 160 KW Traction Drive Motor, Inverters, E-drive Controls and related components |
| FUEL CELL RANGE EXTENDER | Ballard FCveloCity HD85 – 85 kW                                                   |
| FUEL SYSTEM       | H2 – 5 Hexagon Lincoln ACF tanks - total capacity of 37.5 kg                       |
| RANGE             | Up to 350 miles                                                                     |
| BATTERY ENERGY STORAGE | 80 kWh battery pack Li-FePo4                                                        |
| SERVICE LIFETIME  | >25,000 miles                                                                       |
SunLine Transit Agency

- Existing fleet of 21 fuel cell and 4 battery electric buses
- Operations in Coachella Valley area
- Non-attainment area for Ozone/ AB617 Community
- Newly upgraded 900 kg/day hydrogen station
- Capacity for fueling 30 buses
- The $5.9 M US EPA Targeted Air Shed Grant & South Coast AQMD Clean Fuel Fund add another 5 fuel cell buses to this agency fleet
- New buses operates on variety routes through disadvantage communities
- Bus operation - 12-year lifetime
Fuel Cell Bus Deployment Project
EPA, Sunline, and South Coast AQMD

Project Kicked off in August 2021
SunLine is in the process of ordering the buses

Procurement, delivery, and commissioning of the buses within a 5-year period

A minimum of 1 year of data collection

Project will conclude in 2025
SunLine New Mobile Refueling Station in Indio

- Developed by NICE American Research
- Mobile refueling station allows hydrogen refueling without a permanent station structure
- Mobile refueling station has the capacity for fueling up to 10 buses
- Every third day, liquid hydrogen is transported to the Indio facility from Ontario
- In the mobile station the liquid hydrogen compresses into hydrogen gas that enters the bus through a pump
Hydrogen Fuel Cell Medium-Duty Buses

Clean Fuels Advisory Group | Sam Cao – Program Supervisor | February 2022
Medium-Duty Buses Serves Diverse Applications

- Various zero-emission mandates adopted on medium-duty (MD) buses
- Innovative Clean Transit Regulation (ICT)
- Zero-Emission Airport Shuttle Regulation
- Advanced Clean Trucks (ACT) Regulation
Today’s ZE MD Buses Almost All Battery-Electric

- CALSTART White Paper reported ~98% ZEBs today are BEBs
- HD FCEBs already beyond TRL 9
- TRL for MD FCEBs currently far behind HD FCEBs and HD & MD BEBs
- FCEBs nonexistence for some applications
- CARB ICT allows late phase-in (after 1/1/2026) for less common buses (cutaway, double decker, articulated buses)

<table>
<thead>
<tr>
<th>HVIP List (as of Feb 2022)</th>
<th>Battery Electric Buses (BEBs)</th>
<th>Fuel Cell Electric Buses (FCEBs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD Buses (Class 8)</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>MD Buses</td>
<td>19</td>
<td>0*</td>
</tr>
</tbody>
</table>

Source: Appendix D CARB 21-22 Long-Term Heavy-Duty Investment Strategy
Some Industries Prefers MD FCEBs

- Battery electric buses fits majority of urban, lower use, shorter route buses applications
- Demanding duty cycles will require longer range and faster fueling option
- Certain ADA applications requires lower floor buses

<table>
<thead>
<tr>
<th>Applications</th>
<th>Special Duty-Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel (Airport) Shuttles</td>
<td>24/7 operations</td>
</tr>
<tr>
<td>City/Muni Transportation Services</td>
<td>Current CNG customers with daily routes between 180 miles – 350 miles (15+ hr day)</td>
</tr>
<tr>
<td>Transit Systems</td>
<td>Rural routes over 200 miles</td>
</tr>
</tbody>
</table>
Strong Market Demand for MD FCEBs Transit Buses

- CALSTART analyzed ICT roll out plans
- 40% of transit agencies will operate cutaway (MD) buses, ~10% of total fleet
- 47% FCEBs for cutaway (MD) buses, but only ~15% FCEBs for all buses

“Will consider switching to FCEBs if battery range does not increase soon enough.” – LA Metro

“BEBs for shorter routes, FCEBs for longer routes” – Fresno Express

“Views FCEBs as most comparable to CNG buses in a “business as usual” scenario” – OCTA

Source: CALSTART White Paper, CALIFORNIA TRANSIT AGENCIES CHART A COURSE TO ZERO EMISSIONS, June 2021
Infrastructure Considerations/Grid Impacts

- ZEBs will require electricity to operate regardless of fuel type
- BEBs consumes electricity directly as fuel, FCEBs consumes electricity to produce, compress and dispense fuel
- FCEBs fleet ~1/5 of peak power demand of BEBs fleet
- Most fleets expected to operate both
- High capital cost for stations

"Favors FCEBs because they can negotiate hydrogen fuel prices, unlike electricity rates for BEBs" - SDMTS

## A-1 MD FCEBs Project

<table>
<thead>
<tr>
<th>Base Chassis</th>
<th>Ford F-53/-59 Stripped Chassis, Ford E-450 Shuttle Cutaway,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Types</td>
<td>1 low-floor F-53/59 1 standard E-450</td>
</tr>
<tr>
<td>GVWR</td>
<td>19,500-22,500 lbs/14,500 lbs</td>
</tr>
<tr>
<td>Range</td>
<td>200-300 miles</td>
</tr>
<tr>
<td>H2 Fuel Capacity</td>
<td>19.6 kg/16.4 kg</td>
</tr>
<tr>
<td>FC Power Level/Battery Capacity</td>
<td>TBD via simulation as project deliverable</td>
</tr>
<tr>
<td>Payload</td>
<td>5,000 lbs /4,000 lbs</td>
</tr>
<tr>
<td>Fuel Storage</td>
<td>Roof mount/in-body</td>
</tr>
</tbody>
</table>
A-1 Project to Commercialize Two MD FCEBs

- Approved August 2021, kick-off 1Q2022
- Partnering with SoCalGas
- Plug Power Inc. and SEA Electric LLC to develop hydrogen fuel cell and chassis electrification components
- Turtle Top, Hometown Manufacturing, Inc. and Luxfer Gas Cylinders to provide shuttle bus bodies and hydrogen storage systems
- A-1 to perform the final integration and (Turtle Top, HM and A-1) to get CARB & Altoona certifications
- Up to 12 months in-service demonstration with Sunline Transit
### Project Timeline/Cost

*Tentative Timeline*

<table>
<thead>
<tr>
<th>Project Partners</th>
<th>Cost-Share Cash/In-Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>SoCalGas</td>
<td>$531,116</td>
</tr>
<tr>
<td>SCAQMD</td>
<td>$531,116</td>
</tr>
<tr>
<td>Plug Power Inc.</td>
<td>$258,000</td>
</tr>
<tr>
<td>SEA Electric LLC</td>
<td>$250,000</td>
</tr>
<tr>
<td>Sunline Transit Agency</td>
<td>$160,608</td>
</tr>
<tr>
<td>A-1</td>
<td>$132,668</td>
</tr>
<tr>
<td>Hometown Manufacturing, Inc</td>
<td>$110,000</td>
</tr>
<tr>
<td>Turtle Top</td>
<td>$85,000</td>
</tr>
<tr>
<td>Luxfer Gas Cylinders</td>
<td>$28,000</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$2,086,608</strong></td>
</tr>
</tbody>
</table>
Biomass to Renewable Fuels

Kore Infrastructure
High Temperature Pyrolysis

South Coast Air Quality Management District
February 10, 2022

Phil Barroca
Program Supervisor, Technology Demonstration
Technology Advancement Office
Waste-to-Fuel

- Renewable Transportation Fuels
  - Fuel NZE and ZE vehicles
  - CI Biomass based Renewable Hydrogen < CI fossil steam methane reformation

- Benefits:
  - Landfill and biowaste diversion, reduce petroleum dependency, increase energy security, reduce GHGs and short-lived climate pollutants (SLCP)
  - Generate Carbon Offsets through California LCFS and federal RIN credits which support lower cost fuel to consumer
### SCAQMD Co-Sponsored Renewable Fuel Production Projects

<table>
<thead>
<tr>
<th>Project/Location</th>
<th>Technology</th>
<th>Feedstock</th>
<th>Product</th>
<th>CI</th>
<th>Co-Sponsors</th>
<th>Pipeline Interconnect</th>
<th>Project Cost (est)</th>
<th>SCAQMD Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR&amp;R (Perris, CA)</td>
<td>Anaerobic Digestion (AD)</td>
<td>Green Waste</td>
<td>Renewable Natural Gas (RNG)</td>
<td>0.34</td>
<td>CEC, CalRecycle</td>
<td>X</td>
<td>$55,000,000</td>
<td>CFF $900,000</td>
</tr>
<tr>
<td>Kore (Los Angeles, CA)</td>
<td>High Temperature Pyrolysis</td>
<td>Low Moisture Biomass</td>
<td>Renewable Hydrogen (RH\textsubscript{2})/RNG</td>
<td>-100</td>
<td>SoCalGas</td>
<td></td>
<td>$6,050,000</td>
<td>$2,450,000</td>
</tr>
<tr>
<td>Rialto Bioenergy/Anaergia (Rialto, CA)</td>
<td>AD/Pyrolysis</td>
<td>Food Waste</td>
<td>RNG</td>
<td>-57 (est)</td>
<td>CEC</td>
<td>X</td>
<td>$77,873,000</td>
<td>$4,365,801</td>
</tr>
</tbody>
</table>
Carbon Intensities EER-Adjusted rel. to HD Diesel, gCO2eqv/MJ

- Diesel (Conventional)
- Gasoline
- Natural Gas (Fossil)
- Diesel (Renewable)
- Propane
- Biomass-based Diesel
- CNG or LNG Spark Ignition Engines
- CNG or LNG Compression Ignition Engines
- Electricity - BEV or PHEV Truck or Bus
- Electricity - Heavy Rail Fixed Guideway
- Electricity - Light Rail Fixed Guideway
- Electricity - Trolley, Cable Car, Streetcar
- Electricity - Forklifts
- Hydrogen - Fuel Cell Vehicle (FCV)
- Hydrogen - Forklifts (FCV)

The Alternative Fuel’s (AF) CI value is divided by its EER to produce the EER-Adjusted CI value representing the emissions from the AF per MJ of conventional fuel (diesel) displaced.
High Temperature Pyrolysis (HTP)

- Thermochemical conversion of organic solids to Gas, in lean Oxygen environment using indirect heating
- Feedstocks: typically low moisture waste biomass
- Products: Syngas ($H_2$, $CH_4$, $CO_2$, CO) and sequestered carbon Solids (Biochar)

Diagram:
- Material Handling
- Drying
- Pyrolysis
- Gas Conversion

Feedstocks:
- Nut shells
- Biosolids
- Green waste
- Tree / Forest Debris

Products:
- Renewable Energy: Natural Gas (RNG), Hydrogen (H$_2$), Power
- By-Products: Water, Biochar
Pyrolysis Biomass Conversion
Gas/Liquid/Solid vs Temperature

Yield of Products (wt %)

Temperature (°C)
Pyrolysis Gas Composition vs Temp.
Other Pyrogases

- CO can be used to produce additional Hydrogen through a Water-Gas Shift reaction: \[ \text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + \text{H}_2 \]

- CO\(_2\) could be utilized to produce RNG through the Sabatier reaction at the expense of H\(_2\): \[ \text{CO}_2 + 4\text{H}_2 \rightleftharpoons \text{CH}_4 + 2\text{H}_2\text{O} \]

- CO\(_2\) produced in pyrolysis is considered “carbon neutral” because it derives from the biomass that absorbs CO\(_2\) from the atmosphere during photosynthesis - “no net increase”
Biochar and Carbon Sequestering

Process transfers atmospheric CO₂ to elemental C locked in soil
Approximately half of biomass carbon is sequestered in the soil
Kore Infrastructure – System Design

- Pyrolyzer is a Plug Flow Reactor
  - Indirect Heat using natural gas and “pyrogas”
  - Two screw auger conveyors are mounted in parallel and transport feed through the pyrolyzer reactor in a “U” shape to meet necessary residence time and minimize stress on auger shafts
- Multiple Knife gate valves help control air intrusion from feed entry and biochar exit
- Nitrogen (Inert) gas used to purge Oxygen primarily at feed to pyrolyzer
- Belt conveyor transports Feedstock from hopper
- Water cooled screw conveyor transports biochar from pyrolzer to collection bin
- Cyclone separates remaining solids in gas stream
- Heat exchangers to remove higher molecular weight condensables
- PSA to separate, recover and improve quality of hydrogen in pyrogas stream
- Cooling tower, Wastewater tank
- Flare for processing waste gases/emergencies
- Onsite NG Gensets for electrical power
- Utility Gas and Water lines, and electrical conduits
- Electrical panels, PLC and software to control system and operation
Kore site photos

Knife Gate valves

Heated pyro-gas recirculation
Kore site photos

Pyro Gas conveyance and processing

High temperature expansion joints
Testing and Expected Outcomes

- Testing to occur from February – May
- Various biomass feedstocks will be considered
  - Construction and demolition wood
  - Nut shells
  - Tree prunings
- Current Testing using uniform wood pellets
- Feed rate: 1 ton/hr
- Operating Temp.: 1000F - 1400F
- \( H_2 \) Production Rate (with PSA): 20-40 kg-\( H_2 \)/hr
- Gas Composition: 40% \( H_2 \), 20% ea.: \( CH_4 \), \( CO \), \( CO_2 \)
- Carbon sequestered Biochar
Kore Project – Next Steps

- Demonstrate and assess production from various Biomass
- Integrate Pressure Swing Absorption system to improve compound separation and fuel quality
- Continue to assess feed rate and feed delivery techniques
- Monitor, manage, and utilize auto thermal reactions
- Continue monitoring system to improve operations, efficiencies
- Continue to assess applications of biochar and other gas compounds
- Continue exploring new opportunities and applications for HTP
Thank You

Questions?
History

- Kore founded in 2008
- 2009 Five-year pilot study with LASAN District in City of Carson
- 2013 long-term performance-based contract with LASAN (subsequently halted?)
- 2015 City of Rialto issues permits for Kore to process biosolids to produce renewable diesel via Pyrolysis and Fischer Tropsch method
- 2016 Project changed to produce RNG from Biosolids with SCAQMD support: $1.5 million B.P. Arco Settlement Fund and $1 million Clean Fuels
- 2017 demonstration project with SoCalGas at Olympic Blvd. site to produce renewable fuels including RNG and RH2: $1.5 million SoCalGas and $1 million Clean Fuels; Project Cost estimate $6.05 million
- 2018 Rialto project discontinued; Clean Fuels monies returned to CF Fund
- 2022 “Olympic project” commencing field testing of biomass to produce renewable transportation fuels
Clean Fuels Advisory Group Meeting
February 10, 2022

Hydrogen Infrastructure for Heavy-Duty Trucks

Lisa Mirisola
Program Supervisor
Science and Technology Advancement
South Coast AQMD
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
  
  *Contracts executed & tasks ongoing*

- Priorities
  
  H2 Contaminant Detector *(CARB CRADA)*
  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 *In progress*
  - 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) ongoing
  – 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.
UC Irvine Hydrogen Station Expansion

• 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
  - likely needs to be rebid
UC Irvine  Light-duty and Bus fueling H2 expansion
- also relocated across campus

San Bernardino County Transportation Authority H2 for Passenger Rail

Air Products & Chemicals Heavy-duty truck and Light-duty H2
- World Energy, Paramount

Nikola Heavy-duty truck H2
- Travel Center of America, Ontario

Clean Energy Heavy-duty truck H2
- Co-located with RNG fueling, San Bernardino

What are the leading issues keeping hydrogen stations from successfully fueling FCEVs today?

CaFCP July 2021: Envisions 200 HD H2 stations in CA to support 70,000 FCET traveling beyond CA
Project Highlights 2001 - 2021
Plan Update

Aaron Katzenstein, Ph.D.
Background

2021 Annual Report and 2022 Plan Update

• Annual Report on Clean Fuels Program (HSC 40448.5.1)
• Technology Advancement Plan (Update) (HSC 40448.5)
• 2022 Plan Update (draft) submitted to Technology Committee November 19, 2021
• Annual public hearing to approve Annual Report and adopt (final) Plan Update
• Submit to Legislature by March 31 every year
Input and Feedback

• Advisory group meetings
  ▪ September 2021 and February 2022
  ▪ Technology Advancement/Clean Fuels
  ▪ Invited Technical Experts

• Meetings - agencies, industry groups, technology providers and other stakeholders

• Symposia and conferences
  ▪ ACT Conference Expo (August 2021)
  ▪ ICEPAG Hydrogen: Fueling the Sustainable Future (September 2021)
  ▪ DOE Annual Merit Reviews (June 2021)

• Clean tech partnerships
  ▪ CNGVP
  ▪ CaFCP
Clean Fuels Program - Overview

- Research
  - Basic Research
  - Lab Bench
  - Proof-of-Concept

- Development
  - 1st Gen Demos
  - System/Component Integration
  - Proof-of-Technology

- Demonstration
  - 2nd/3rd Gen Demos
  - Durability
  - Acceptance
  - Proof-of-Product

- Deployment
  - Pre-Commercial Demos
  - Market Readiness
  - Proof-of-Commercialization

Technology Readiness Level

0 3 8 9

Incentives
Regulation

Commercialization
### Emissions Benefit from Technology Development

<table>
<thead>
<tr>
<th>South Coast AQMD Incentive Programs</th>
<th>NZE (# of Trucks)</th>
<th>ZE (# of Trucks)</th>
<th>NOx Reductions (tpy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW</td>
<td>47</td>
<td>93</td>
<td>28</td>
</tr>
<tr>
<td>Lower Emission School Bus</td>
<td>280</td>
<td>95</td>
<td>70</td>
</tr>
<tr>
<td>Proposition 1B</td>
<td>925</td>
<td>112</td>
<td>444</td>
</tr>
<tr>
<td>Carl Moyer</td>
<td>255</td>
<td>10</td>
<td>109</td>
</tr>
<tr>
<td>Total</td>
<td>1,507</td>
<td>310</td>
<td>651</td>
</tr>
</tbody>
</table>
Clean Fuels Program-Core Technologies

- Hydrogen/Fuel Cell Technologies and Infrastructure
- Engine Systems/Technologies (ultra-low emission NG HDVs)
- Electric/Hybrid Technologies and Infrastructure
- Infrastructure and Deployment
- Stationary Clean Fuel Technologies
- Fuels/Emissions Studies
- Emission Control Technologies
- Health Impacts Studies
- Technology Assessment/Transfer and Outreach
2021 – Key Funding Partners

Total = $53M
CY 2021 Accomplishments

• Clean Fuels Program executed 19 new projects or studies and modified 5 continuing contracts
  • Sponsored research, development, demonstration and deployment (RD³) projects
    ▪ Technology assessment and transfer contracts for alternative and clean fuel technologies
  • Funded $10.6M, with total project costs of $253M
    ▪ $253M includes coordinated funding from other governmental agencies, private sector, academia and research institutions
    ▪ The $10.6M includes approximately $4.3M recognized into the Clean Fuels Fund to facilitate project administration by the Clean Fuels Program
2021 Key Contracts Executed

- POLB START Zero Emissions Operations
- POLA Shore 2 Store Zero Emission Freight
- SunLine Fuel Cell Transit Buses
- Volvo Switch-On Battery Electric Vehicles
- DTNA Zero Emission Electric Delivery Trucks
- UCR Study of E15 Gasoline Fuel Effects
2021 Key Projects Completed

• Electric/Hybrid Technologies
  ▪ Zero Emission Fuel Cell Electric Buses

• Hydrogen/Fuel Cell Technologies and Infrastructure
  ▪ Installation of 8 Hydrogen Stations
  ▪ ZECT II – Fuel Cell Range Extended Drayage Truck
  ▪ Renewable Electrolytic Fuel (H2) Production

• Fuel/Emissions Studies
  ▪ Alternative Diesel Blends in Off-Road Engines
Proposed 2022 Plan Distribution

- Electric/Hybrid Tech. & Infra.: 31%
- Hydrogen & Fuel Cell Tech. & Infra.: 20%
- Engine Systems/Technologies: 14%
- Infrastructure & Deployment (NG/RNG): 15%
- Fuel/Emissions Studies: 5%
- Stationary CF Technologies: 5%
- Emissions Control Technologies: 4%
- Health Impacts Studies: 2%
- Tech Transfer & Outreach: 4%

Total: $23.8M
Development Schedule

- Technology Committee: November 19, 2021 (Draft 2022 Plan Update)
- Advisory Group Review: September 15, 2021
- Technology Committee: February 10, 2022
- Board Approval: February 18, 2022
- Due to State Legislature: March 4, 2022
- Due to State Legislature: March 31, 2022