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
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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 – 10:30 AM	
(a)	Welcome & Introductions	Matt Miyasato, Ph.D., Deputy Executive Officer
(b)	Goals for the day	Aaron Katzenstein, Ph.D., Assistant Deputy Executive Officer
(c)	AB617 Background and Update	Dan Garcia, Planning & Rules Manager
(d)	Call for participation in District Advisory Council	Ian MacMillan, Assistant Deputy Executive Officer
(e)	Feedback and Discussion	Advisors and Experts
(f)	Public Comment (2 minutes/person)	
1.	**Areas of South Coast AQMD Focus** **Fuel Cell Electric HD Trucks and Buses – Development and Demonstration** **10:30 AM – 12:30 PM**	
(a)	Hydrogen Generation and Infrastructure	Jeff Reed, Ph.D., Chief Scientist, Advanced Power and Energy Program, UCI
(b)	Fuel Cell HD Truck Development Projects	Seungbum Ha, Ph.D., Program Supervisor
(c)	Shore to Store FCET Project	Lisa Mirisola, Program Supervisor
(d)	Fuel Cell Transit Bus Project	Maryam Hajbabaei, Ph.D., Program Supervisor
(e)	Feedback and Discussion	Advisors and Experts
(f)	Public Comment (2 minutes/person)	

	Lunch 12:30 PM – 1:30 PM	
2.	**Hydrogen Generation and Infrastructure Projects 1:30 PM – 3:00 PM**	
(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:

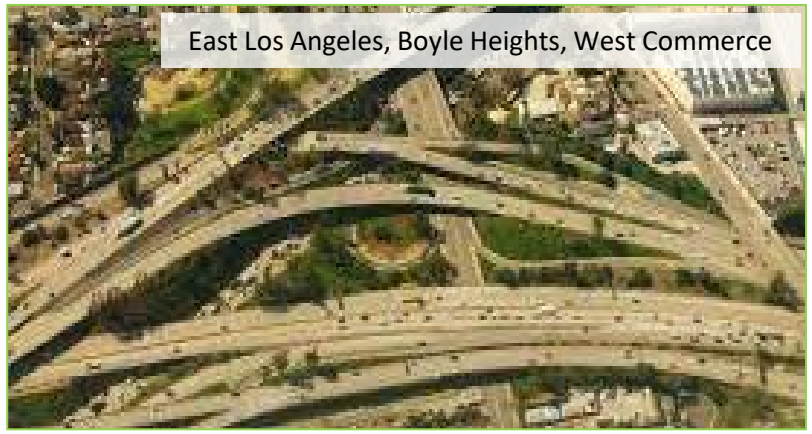
- If you would like to make a public comment, please click on the **"Raise Hand"** button on the bottom of the screen.
- This will signal to the host that you would like to provide a public comment and you will be added to the list.

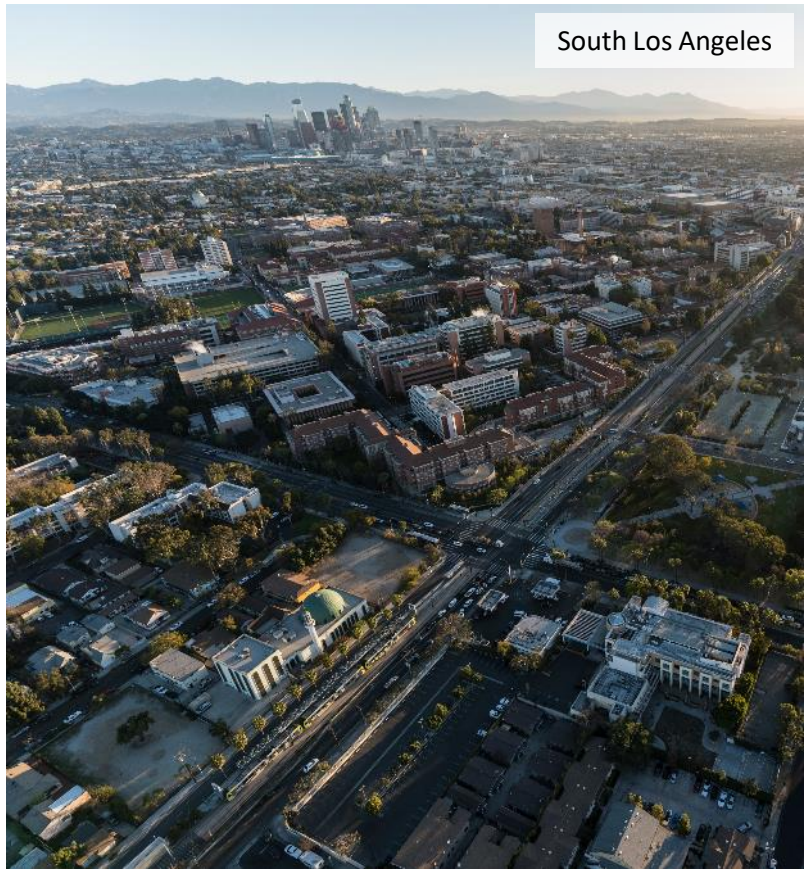
Directions for Video Zoom on a SMARTPHONE:

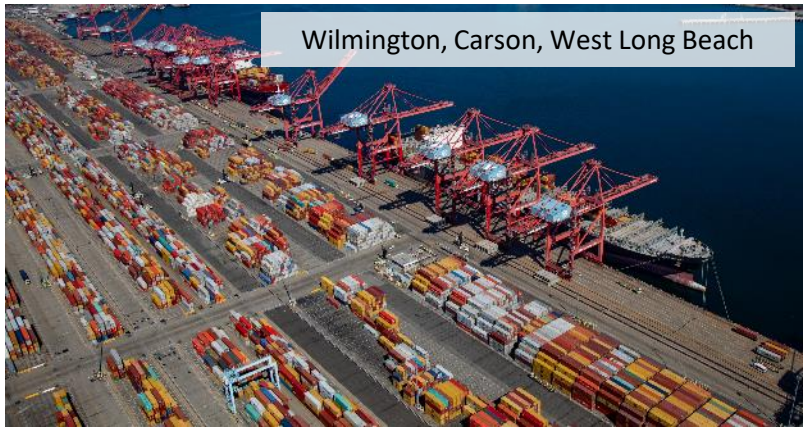
- If you would like to make a public comment, please click on the **"Raise Hand"** button on the bottom of your screen.
- This will signal to the host that you would like to provide a public comment and you will be added to the list.

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.





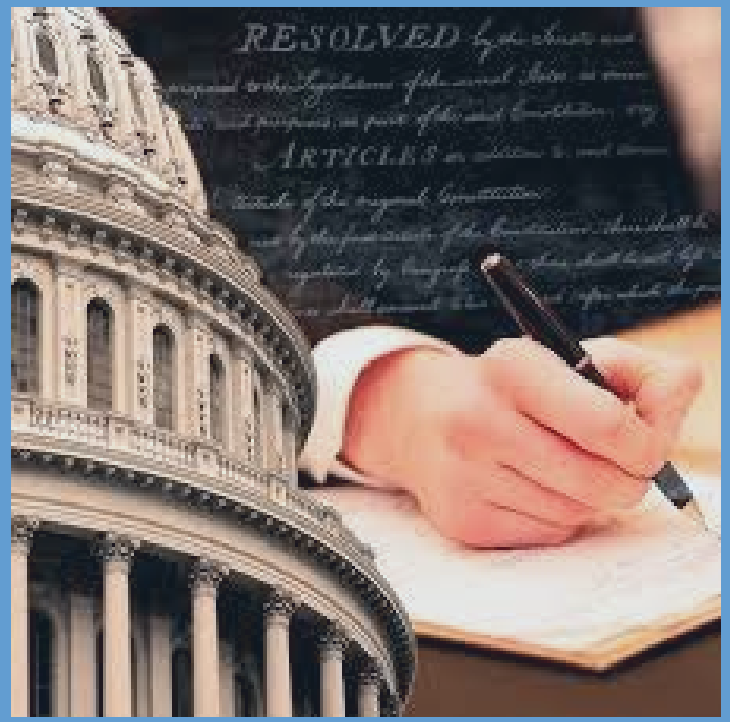


AB 617 Background and Update

Clean Fuels Advisory Group – February 2022

South Coast AQMD

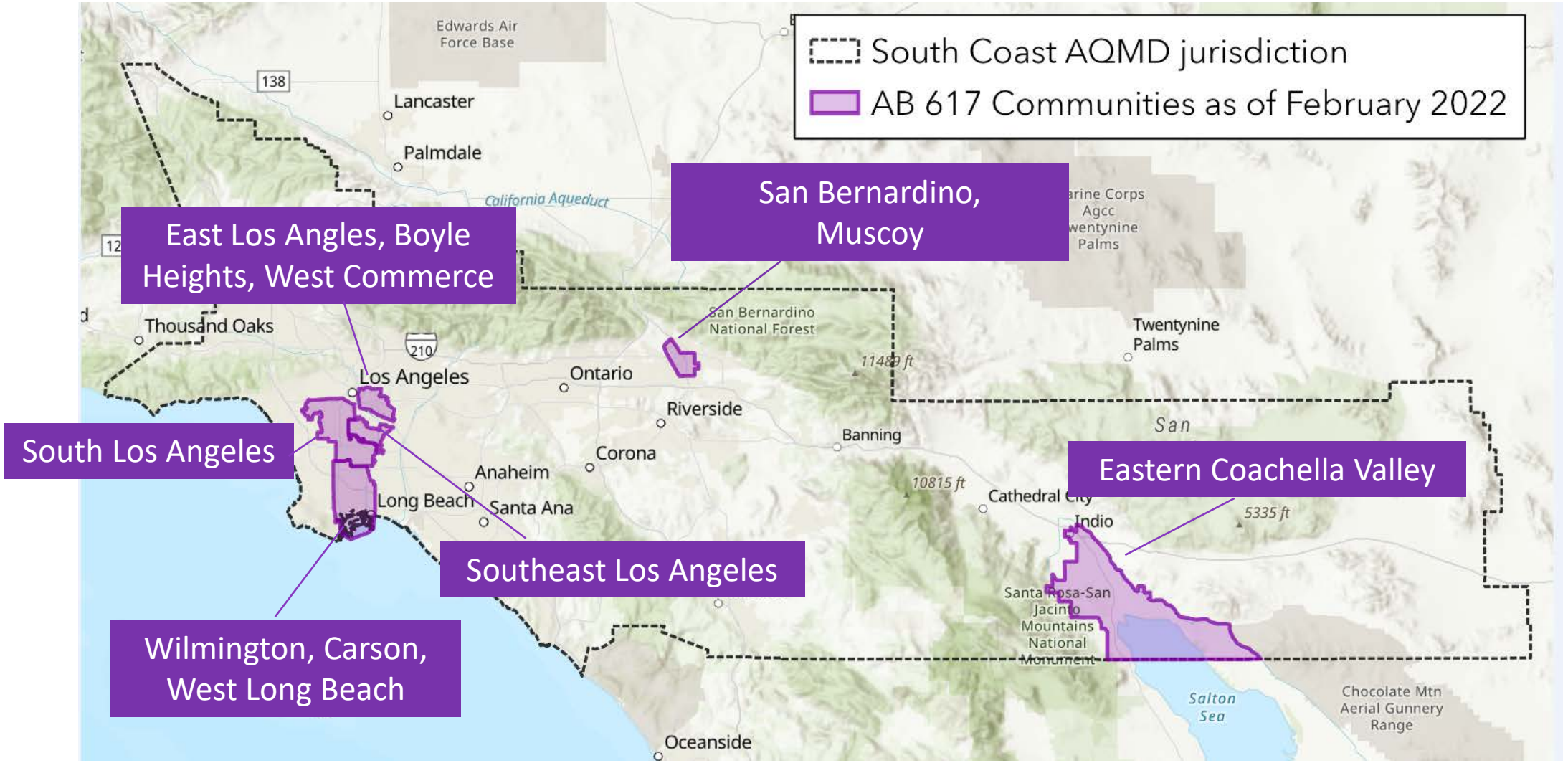
Assembly Bill (AB) 617 Overview



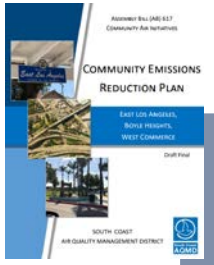
- Signed into state law in 2017
- Focuses on emissions and exposure reductions in communities most impacted by air pollution
- Key elements of AB 617
  - Community driven action
  - Community Emissions Reduction Plans (CERPs)
  - Community Air Monitoring Plans (CAMPs)
  - Clean technology investments
  - Best emissions controls
  - 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*


South Coast AQMD jurisdiction
AB 617 Communities as of February 2022
East Los Angles, Boyle Heights, West Commerce
San Bernardino, Muscoy
South Los Angeles
Eastern Coachella Valley
Southeast Los Angeles
Wilmington, Carson, West Long Beach
Edwards Air Force Base
Lancaster
Palmdale
California Aqueduct
Thousand Oaks
Los Angeles
Ontario
Riverside
Corona
Anaheim
Long Beach
Santa Ana
San Bernardino National Forest
Banning
Twentynine Palms
Cathedral City
Indio
Santa Rosa-San Jacinto Mountains National Monument
Salton Sea
Chocolate Mtn Aerial Gunnery Range
Oceanside
138
210

Community Emissions Reduction Plans (CERPs) – 2018 Communities

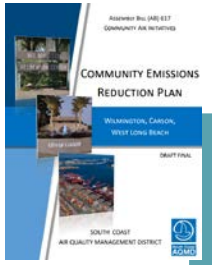


East Los Angeles, Boyle Heights, West Commerce

- **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

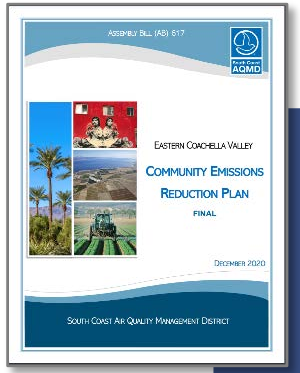


Wilmington, Carson, West Long Beach

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

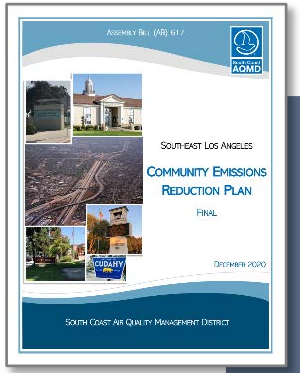
- **July 2019**, staff finalized CAMPs and **September 2019,** CERPs adopted by the Governing Board
- **September 2020**, CARB approved the CERPs

Community Emissions Reduction Plans (CERPs) – 2019 Communities



Eastern Coachella Valley

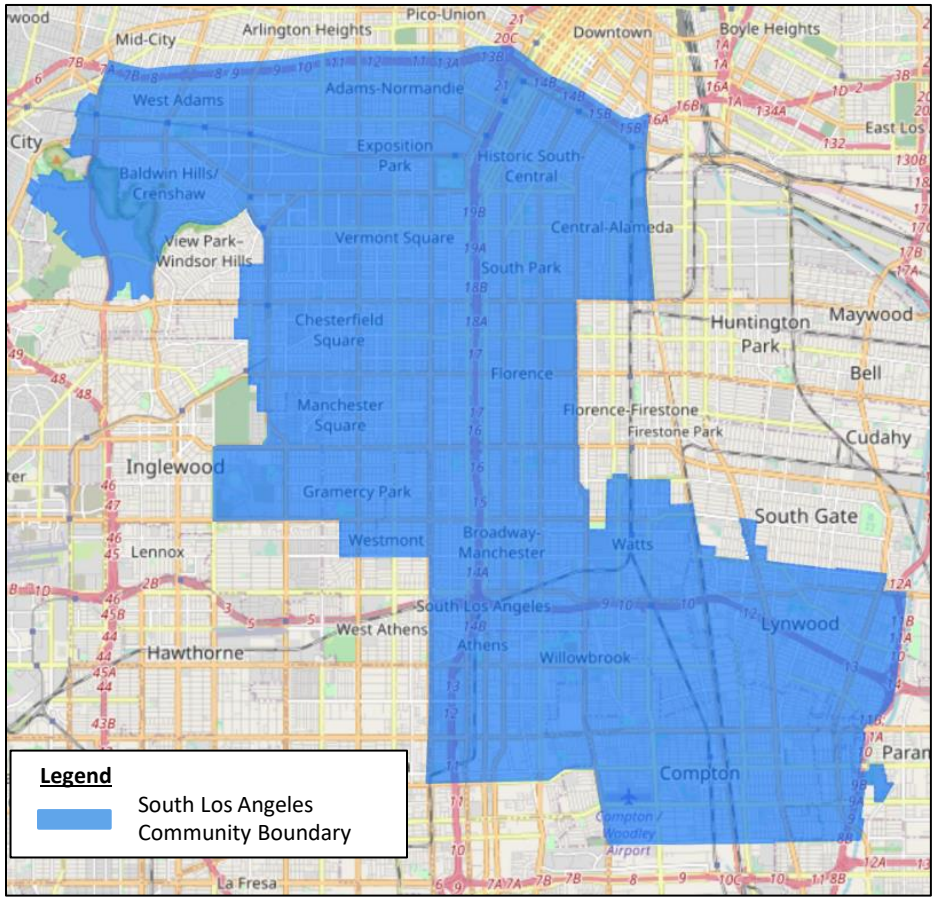
- **Air Quality Priorities**
  - Salton Sea
  - Pesticides
  - Diesel Mobile Sources
  - Greenleaf Power Plant
  - Fugitive Road Dust and Off-Roading
  - Open Burning and Illegal Dumping
- **December 2020**, CAMP finalized
- **June 2021**, CERP adopted by Governing Board (amendment)
- **September 2021**, 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

PSR LA Physicians for Social Responsibility Los Angeles

SCOPE STRATEGIC COMMUNITY AGENDA

WATTS CLEAN AIR & ENERGY COMMITTEE

- Air quality priorities
  - Mobile Sources
  - General Industrial
  - Oil and Gas Industry
  - Auto Body Shops
  - Metals
- Plan adoption anticipated in June 2022

South Coast AQMD

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

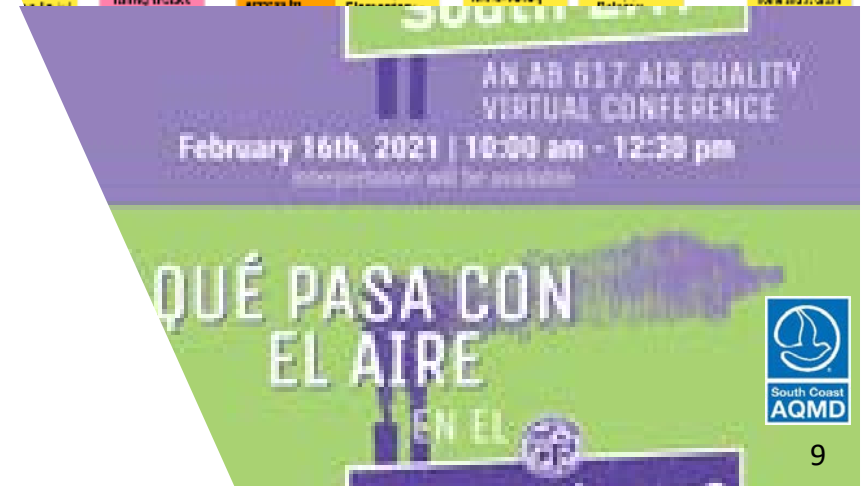
Collaboration (ECV)

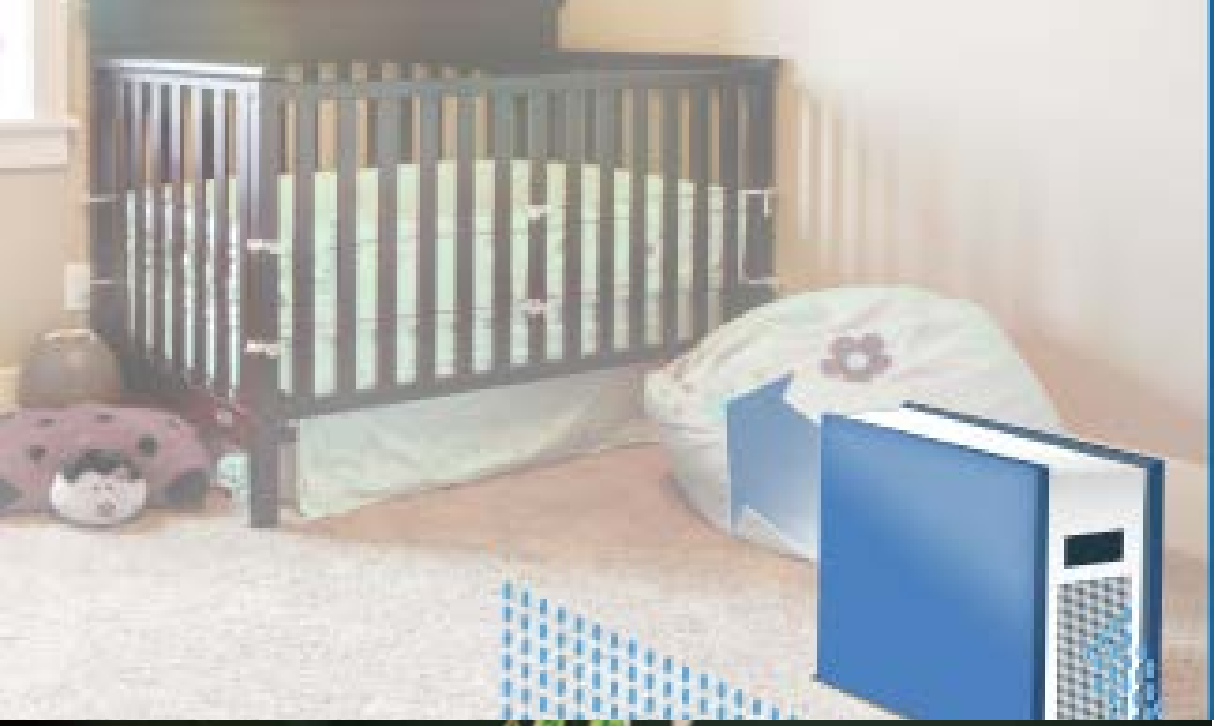
- Initiated **partnerships** with **CARB, DPR, OEHHA**, and the **Riverside County Agricultural Commissioner** to address CSC concerns related to pesticides

**Based on data from 4th quarter of 2021*

Community Engagement – CERP Implementation & Development

- CERP Implementation – 2018 and 2019 Communities
  - Quarterly Community Steering Committee (CSC) meetings
  - Participatory budgeting
  - Collaborations with community-based organizations
  - Technical Advisory Group Meetings
  - Over 100 meetings with community members
- CERP Development – 2020 Community (South Los Angeles)
  - 14 community meetings (CSC and subcommittee meetings)
  - Virtual joint Air Quality Conference with PSR-LA
  - Weekly co-lead meetings to discuss CSC charter, meeting topics, approach, and plan development
  - Co-lead meetings for contracts, charter, and public engagement coordination





CERP Implementation – School and Residential Air Filtration

- Work with communities to prioritize:
  - Funding for residential and school air filtration (e.g., participatory budgeting)
  - School sites and residences to receive air filtration
- Key funding considerations are:
  - Accessibility
  - Costs
  - Maintenance
- Develop a project plan to fund air filtration systems under the Community Air Protection Guidelines
- Implement Residential and School Air Filtration Program
  - Conduct community outreach
  - Evaluate and approve applications
  - 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:
  - East Los Angeles, Boyle Heights, West Commerce ($1.8 million)
  - Southeast Los Angeles ($5 million)
  - San Bernardino, Muscoy ($5 million)
  - 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
  - Opportunity for short-term trial
  - Builds awareness of electric truck options
  - Minimizes financial risks
- Work with communities and other stakeholders to address key challenges
  - Identifying participants
  - Identifying truck types and host locations
  - Loan terms (e.g., duration of loan, insurance requirements, and training)
  - Program outreach

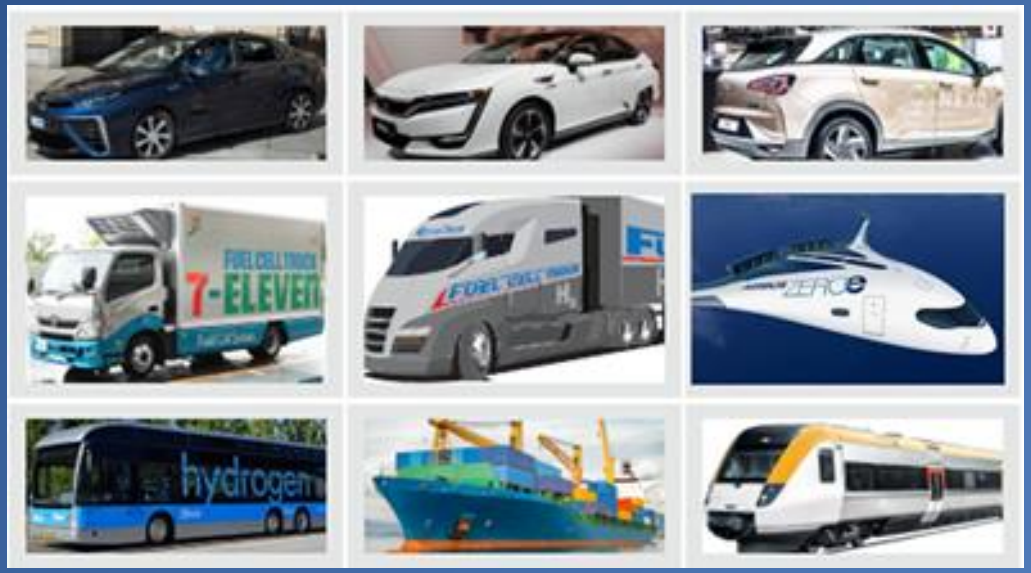
Questions

UCI

Advanced Power and Energy Program

Hydrogen Production and Infrastructure

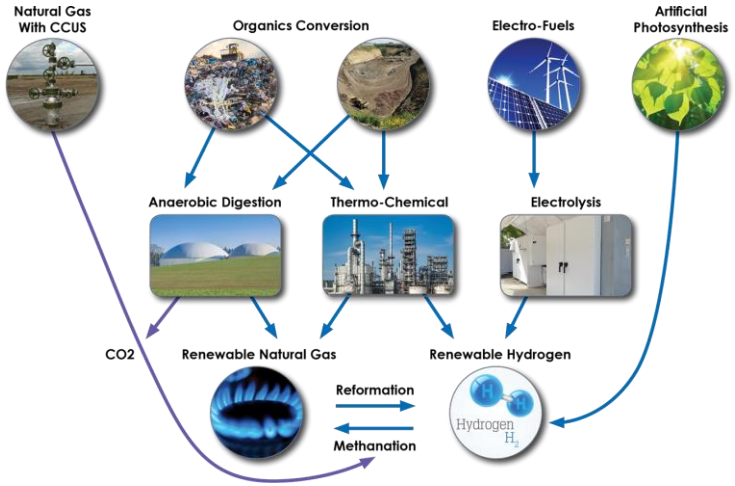
Clean Fuels Advisory Group 10 February 2022



Jeffrey Reed

APEP Hydrogen Research

Production

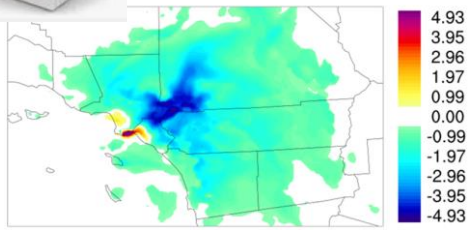


- Power-to-Gas on Campus Microgrid
- Power-to-Gas Design -- Five Points
- GridH2 – Optimal Use of Excess Renewables

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

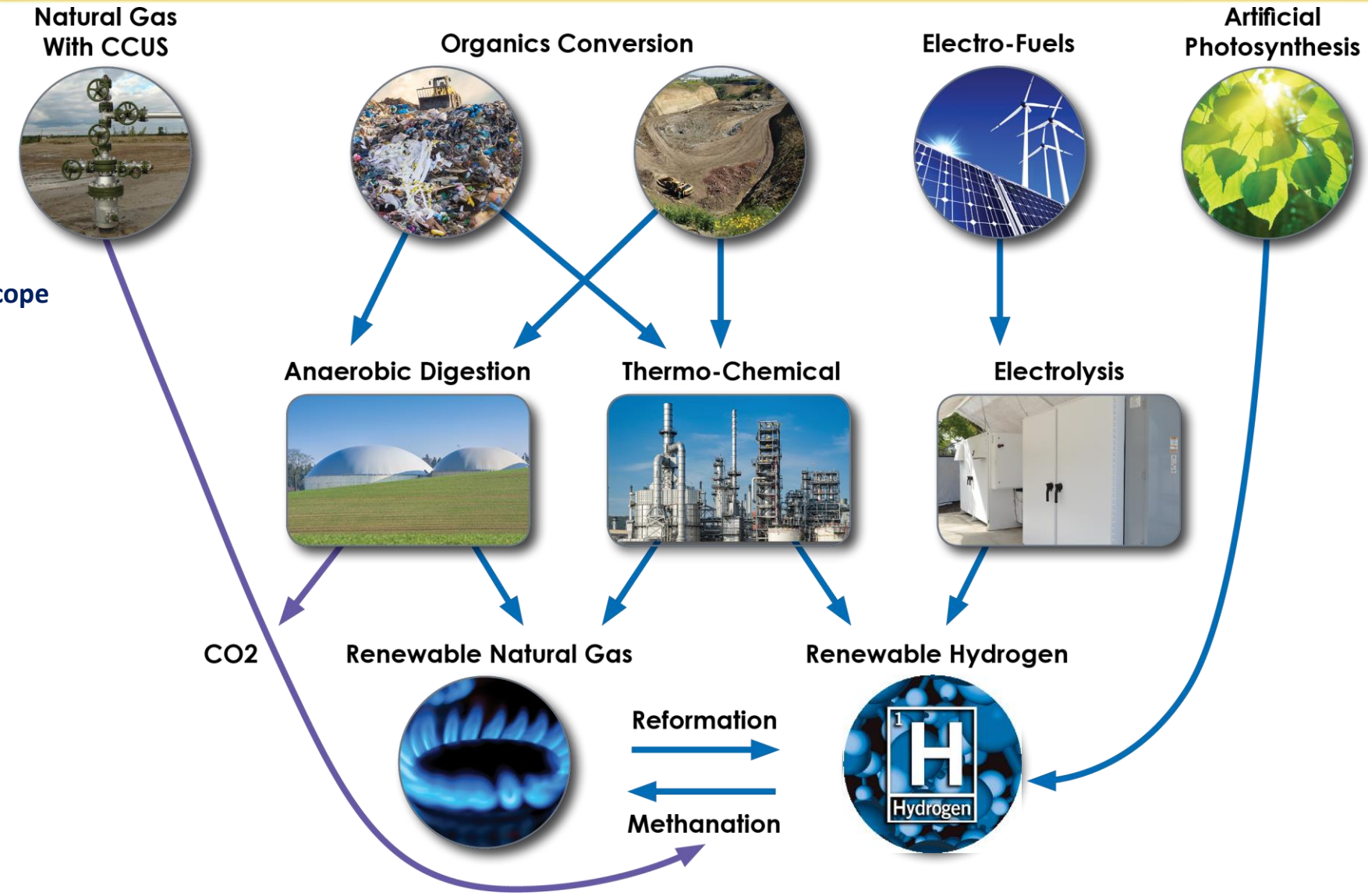
End Use



- Hydrogen tolerance of burners
- Emissions/AQ impacts
- Performance validation

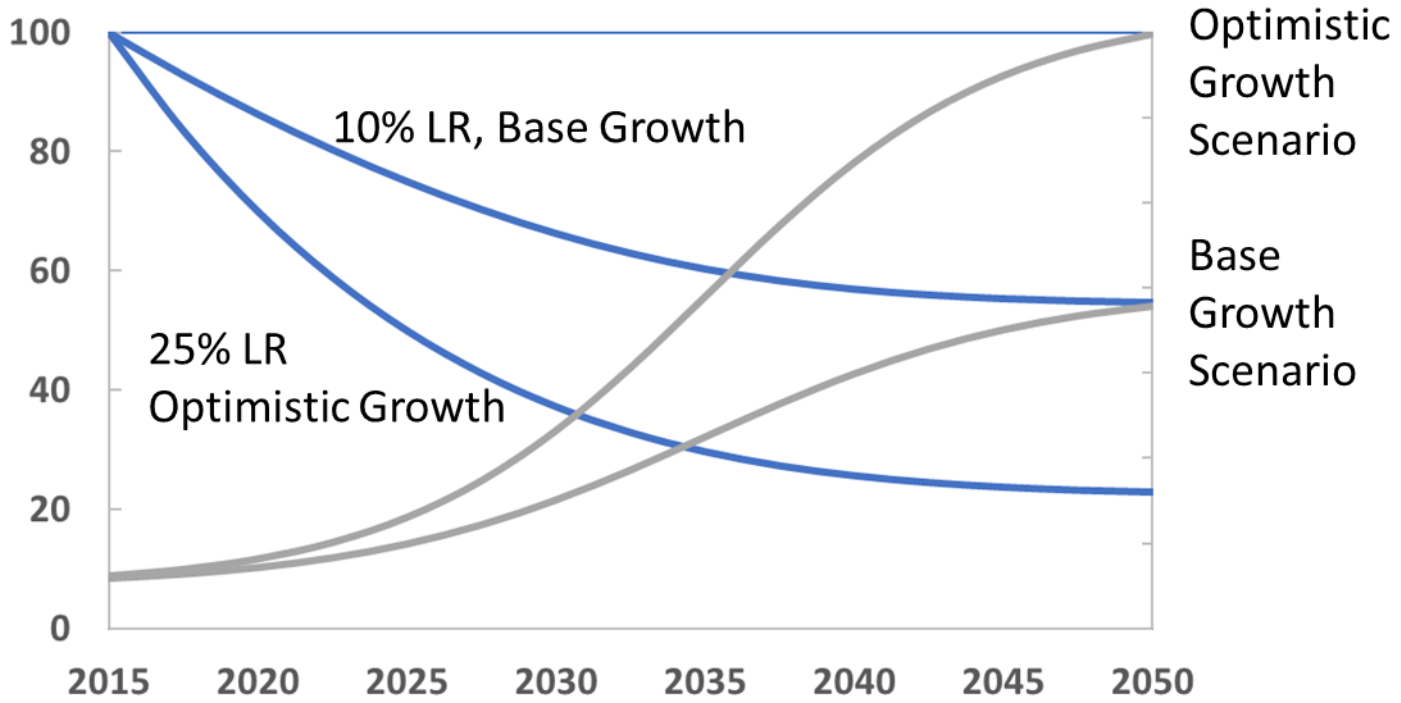
Renewable Hydrogen Pathways

CCUS was out of RH2 Roadmap scope

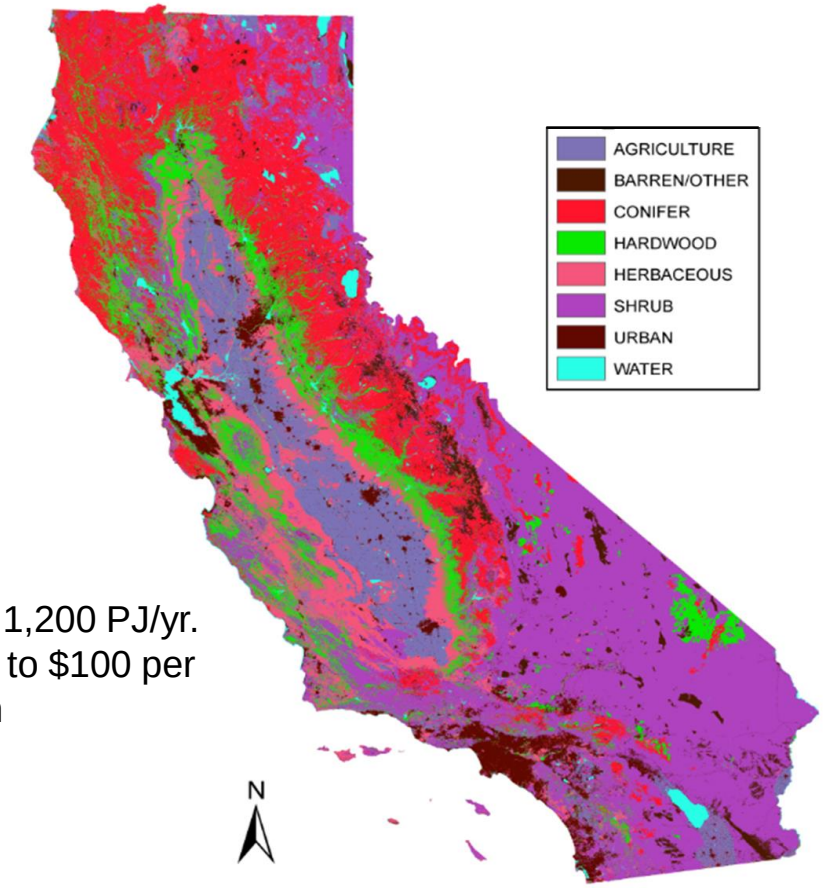


Technology Forecasting Methodology

- 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

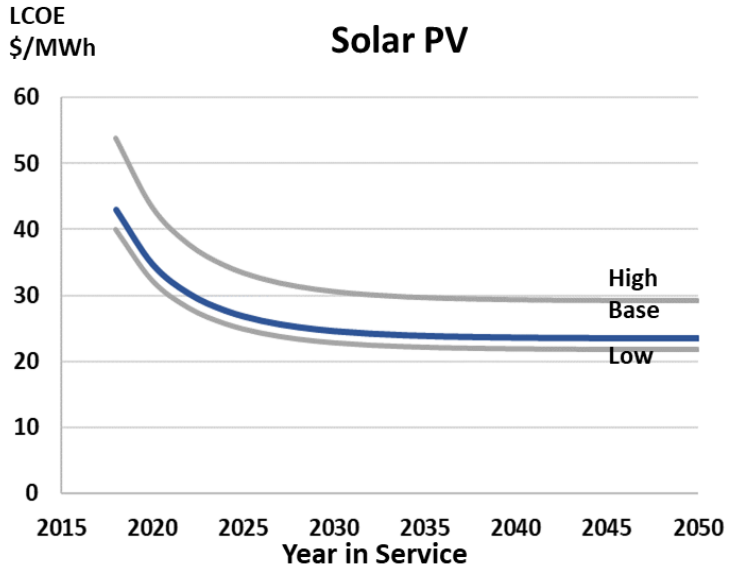


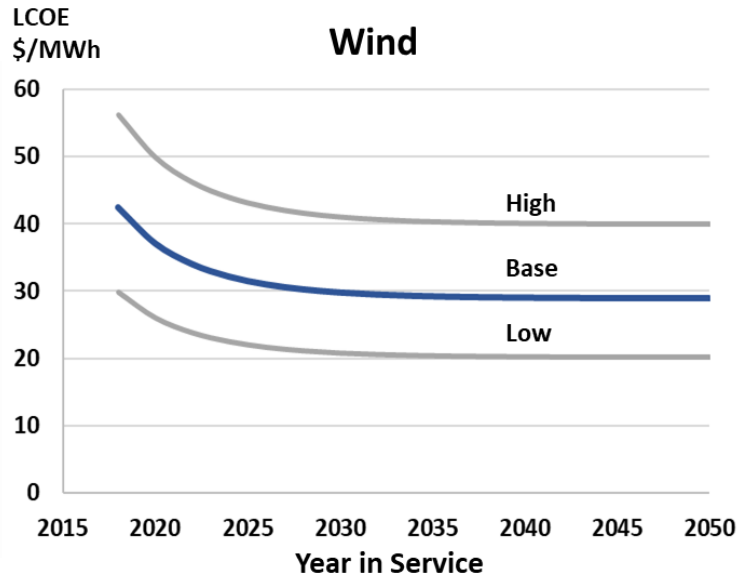
Feedstock Supply and Cost



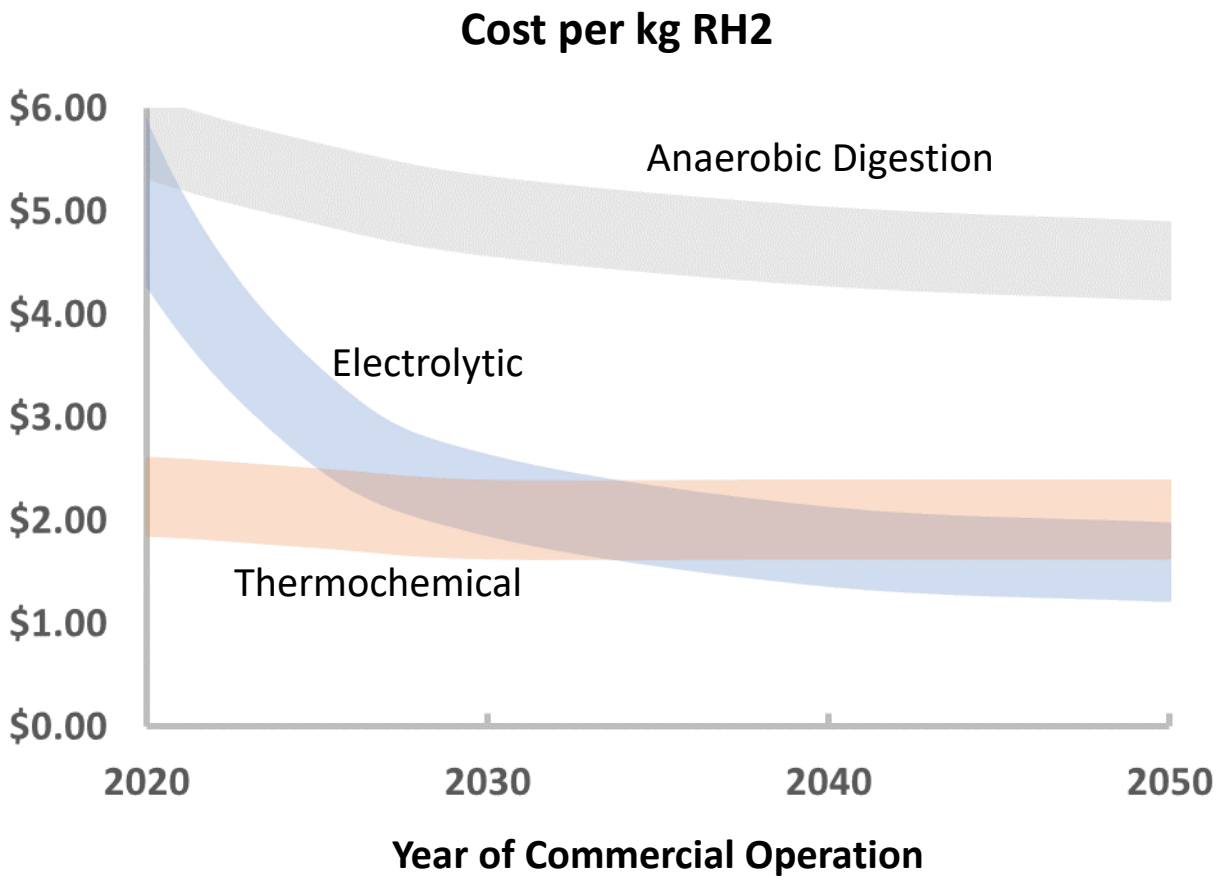
700 to 1,200 PJ/yr.
At $60 to $100 per dry ton

Map Source: California Department of Fire Protection 2015

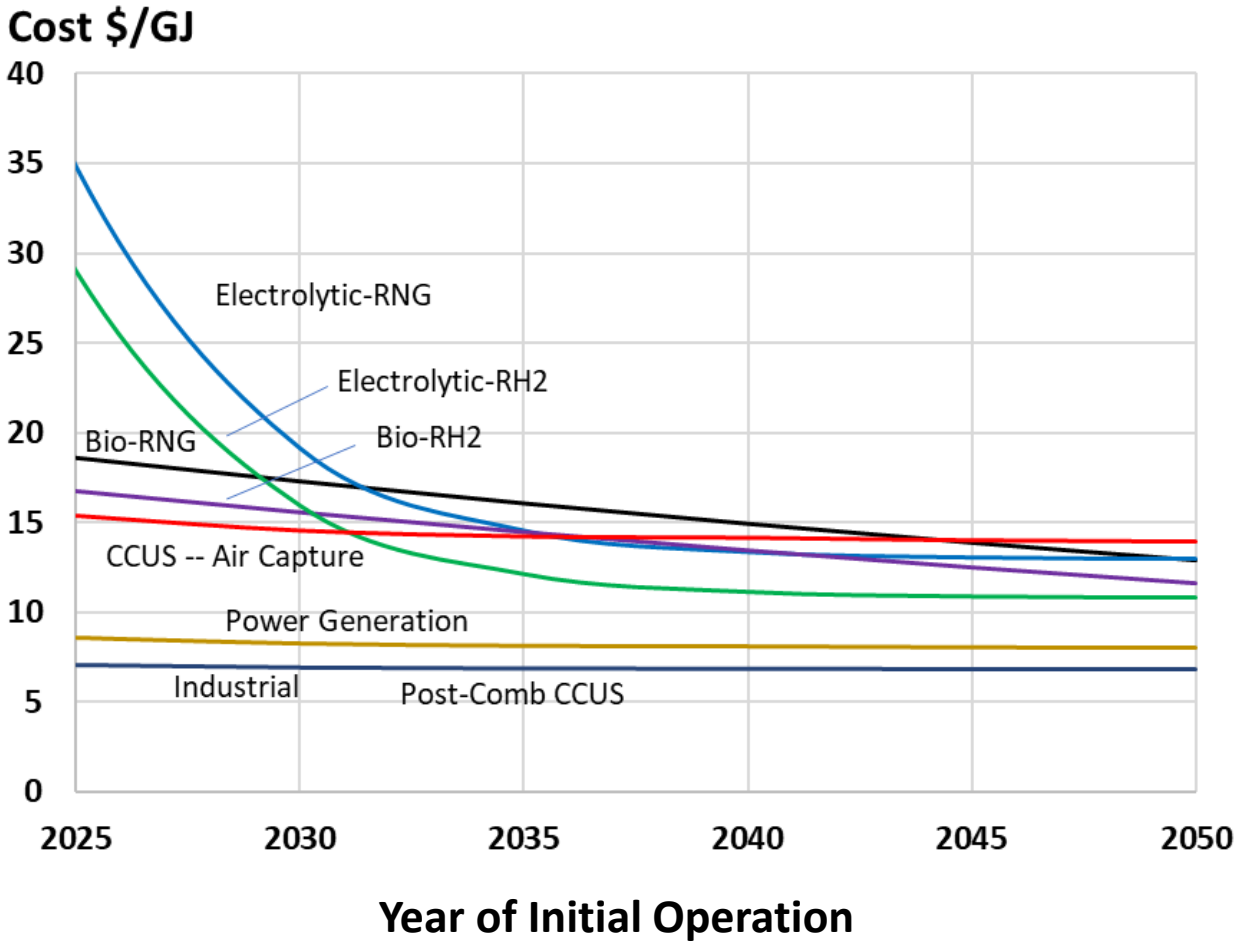




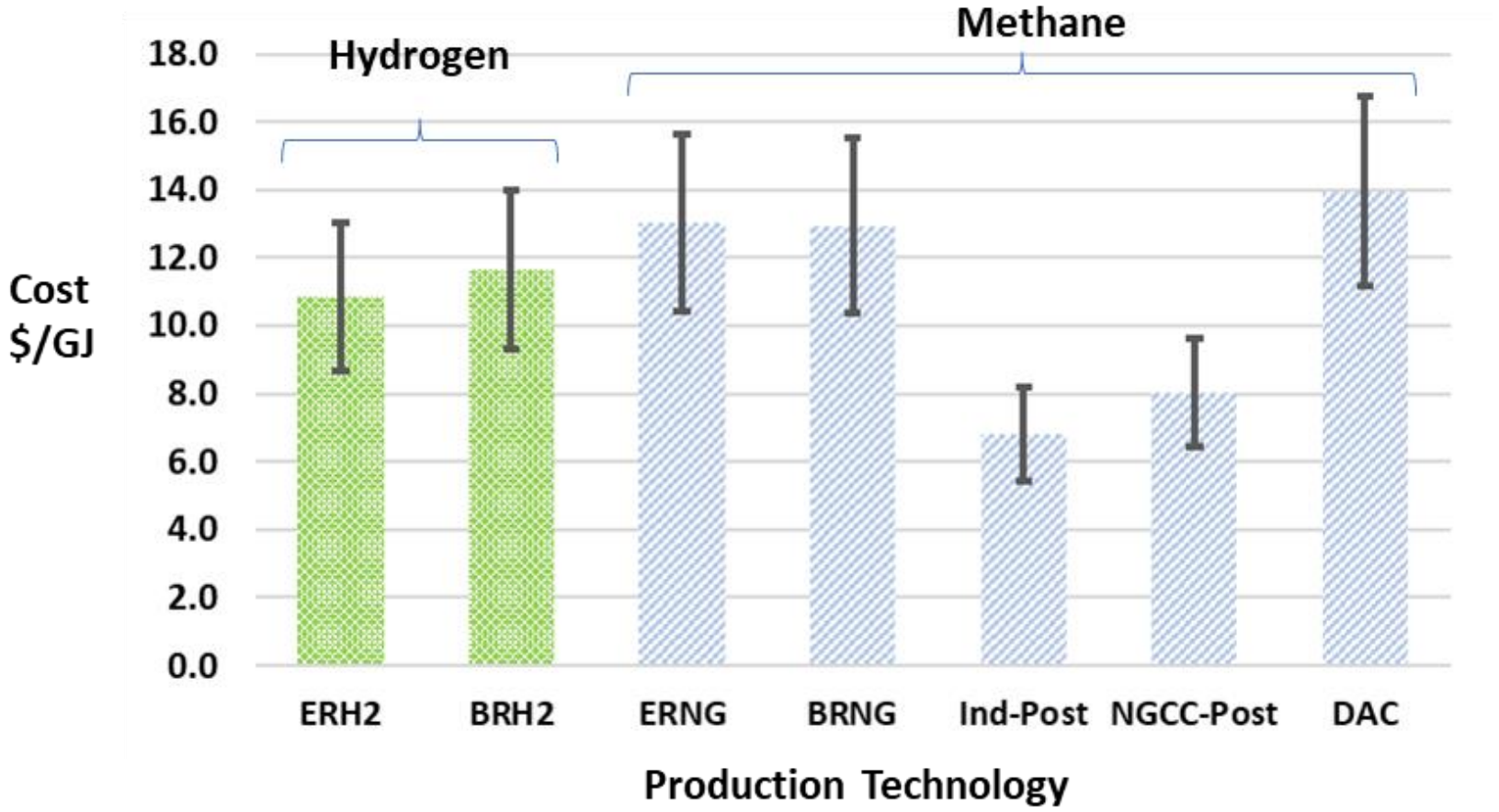
Cost Evolution for Full Production Cost of Renewable Hydrogen



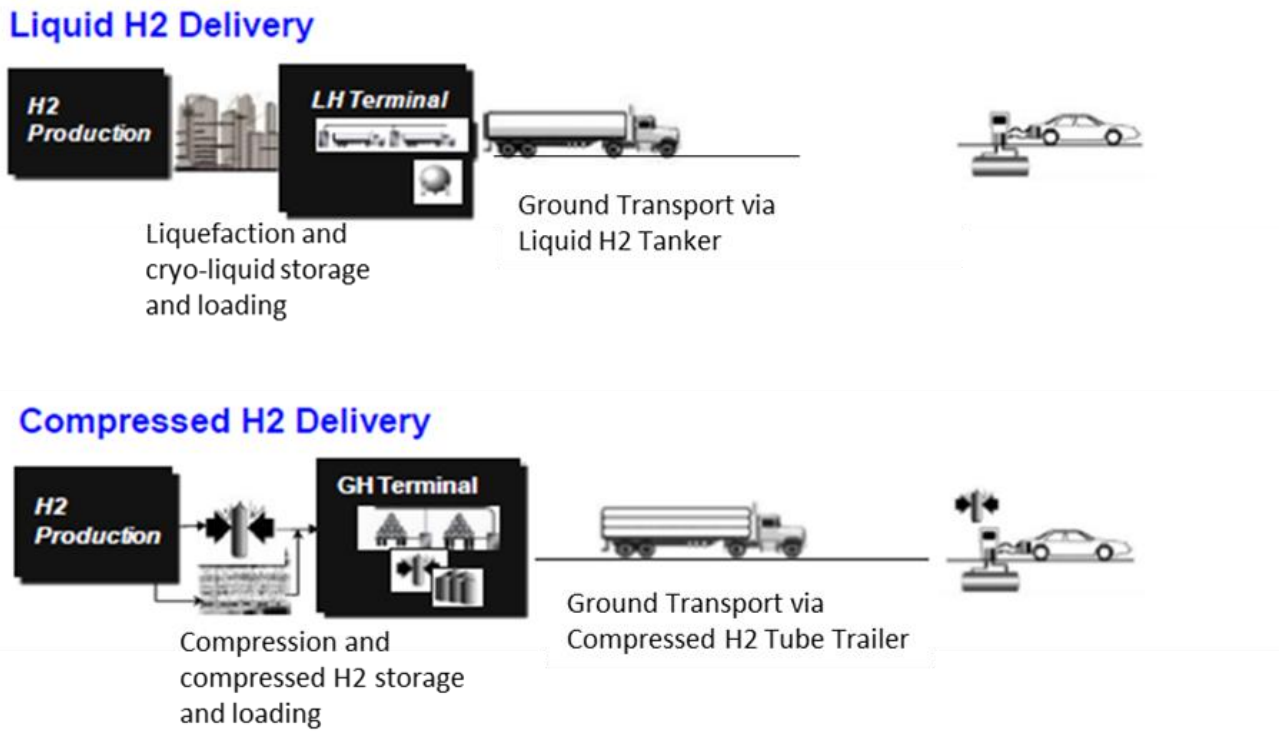
Cost evolution of zero-carbon gaseous fuel pathways



Hydrogen is the least cost option among renewable fuels



Plant-Gate-to-Dispenser

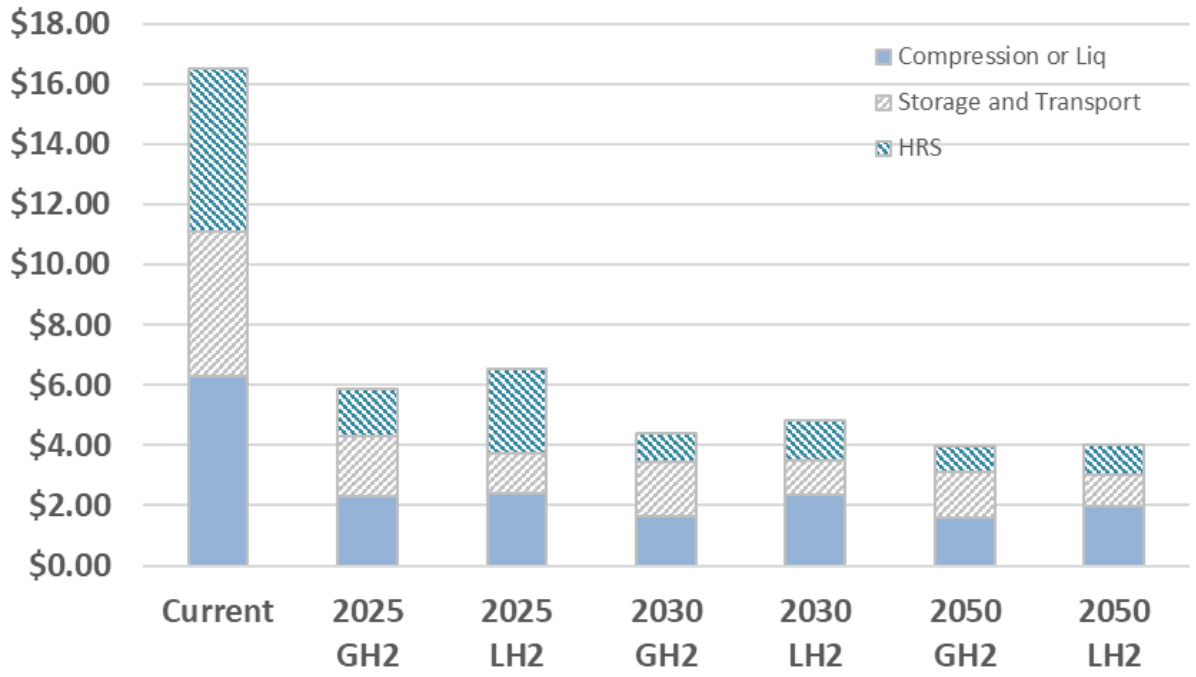


Source: UCI APEP adapted from DOE H2A Delivery Scenario Analysis Model Version 3.0 (HDSAM 3.0) User's Manual

- 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

Cost Progression for Hydrogen Supply Chain

Increased station network utilization and station economies of scale are the biggest contributors to cost reduction

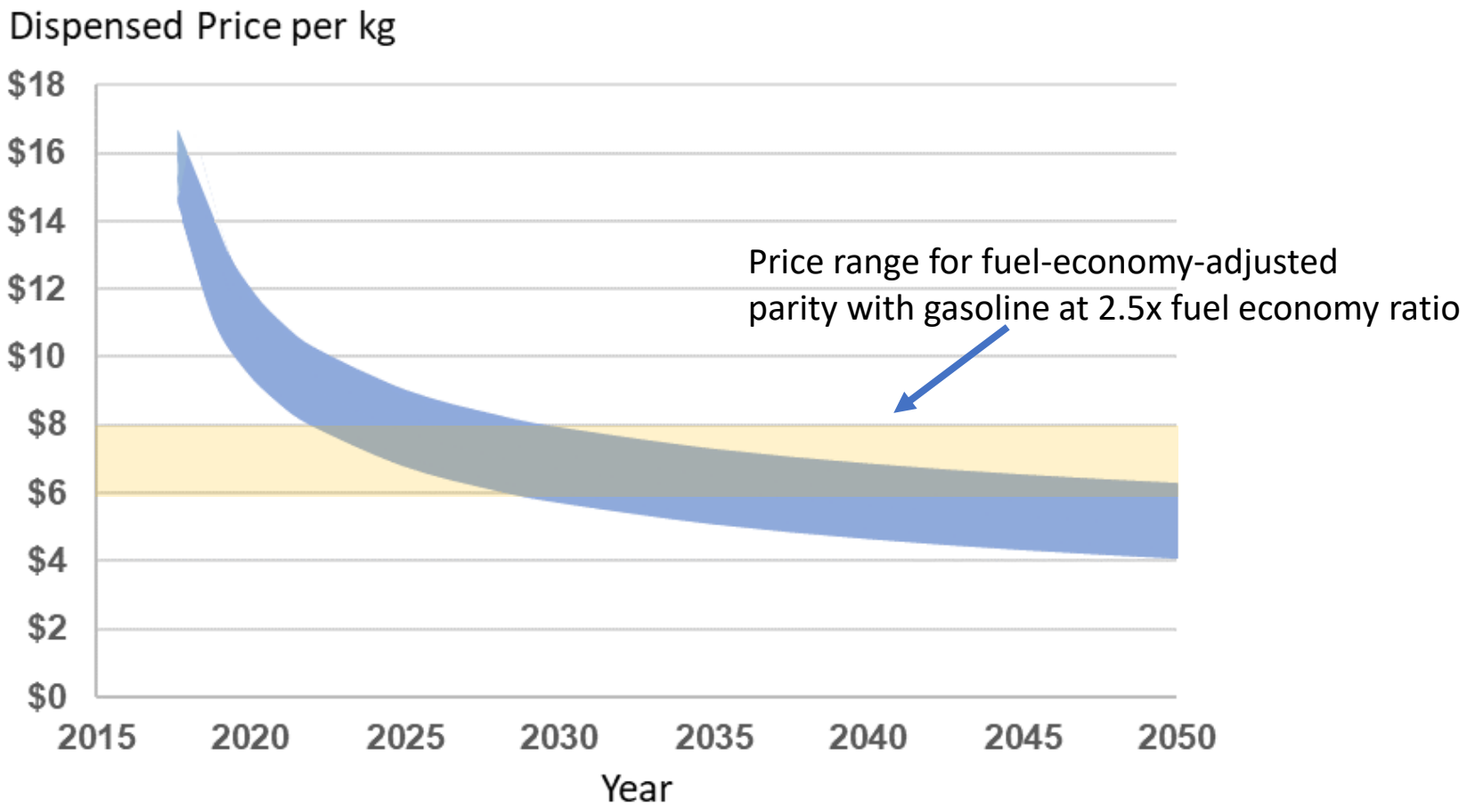


Input Assumptions

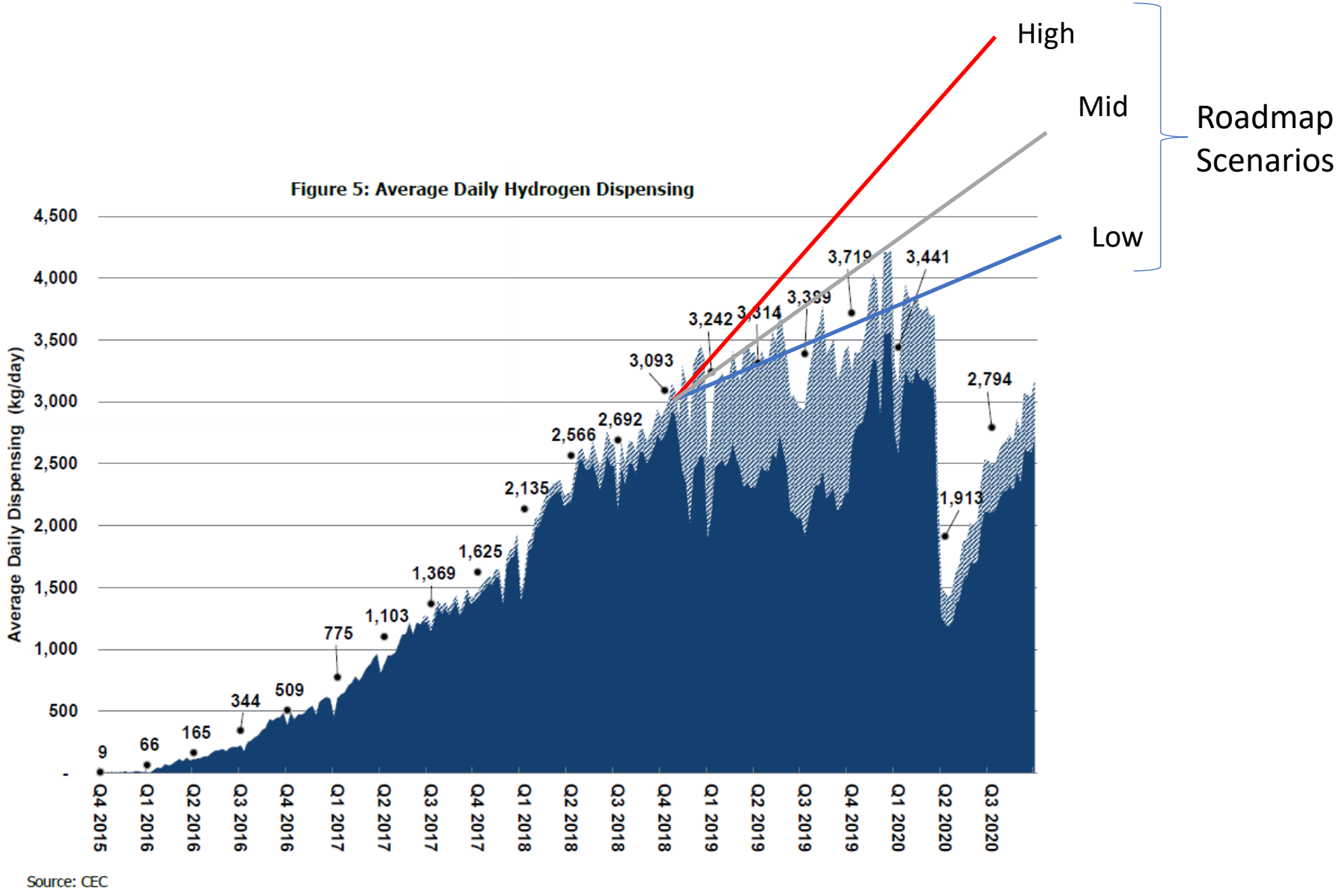
	Current	2025	2030	2050
Station Size Kg/d	300	600	1200	1500
Utilization	40%	70%	80%	80%
Production Volume	Low	Medium	High	High

Source: UCI APEP using HDSAM 3.1

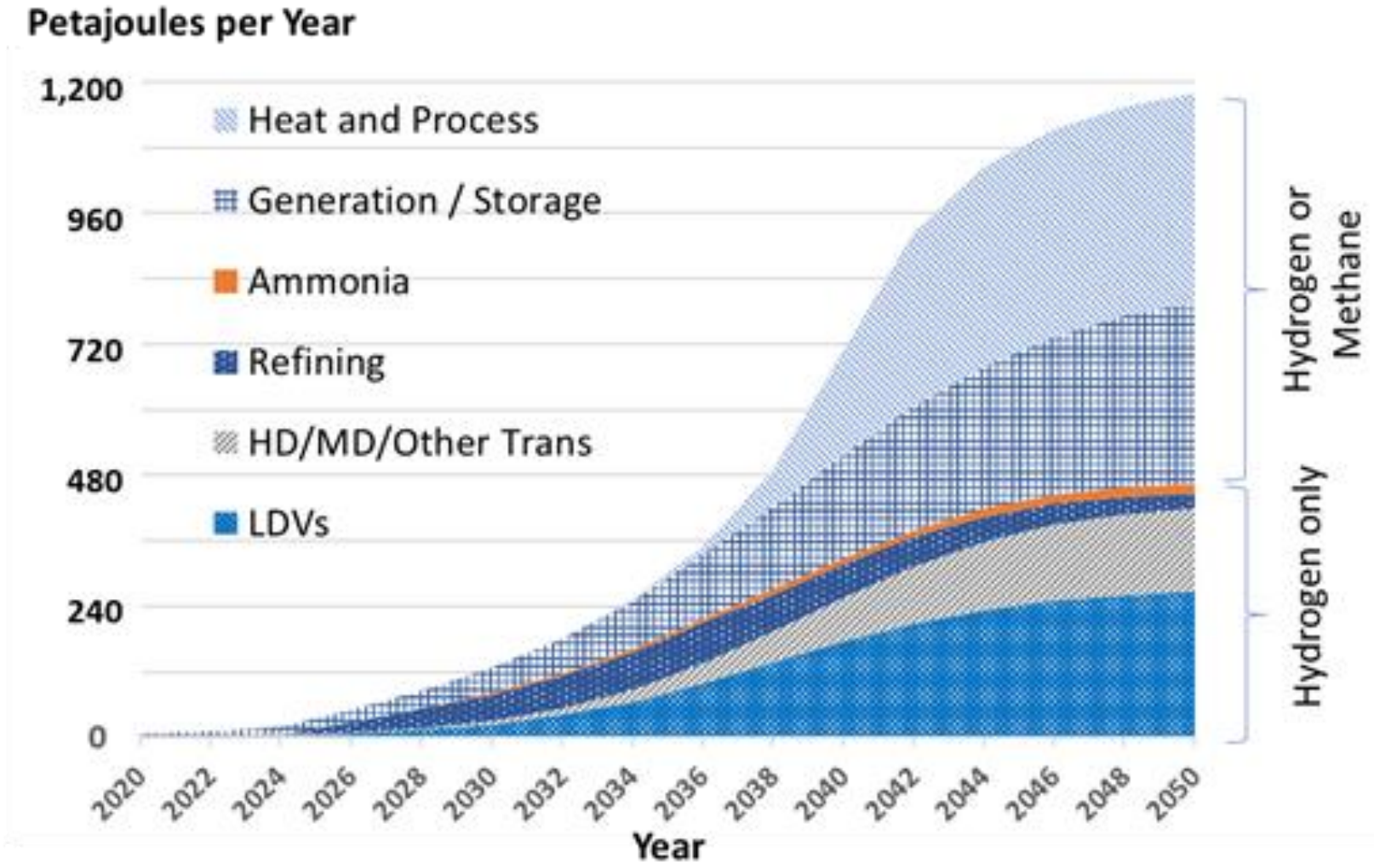
Conclusion -- RH2 Sector Can Be Self-Sustaining Before 2030



RH2 Roadmap Demand Overlay on Report Actuals



Infrastructure needs to be considered in light of all sources of demand

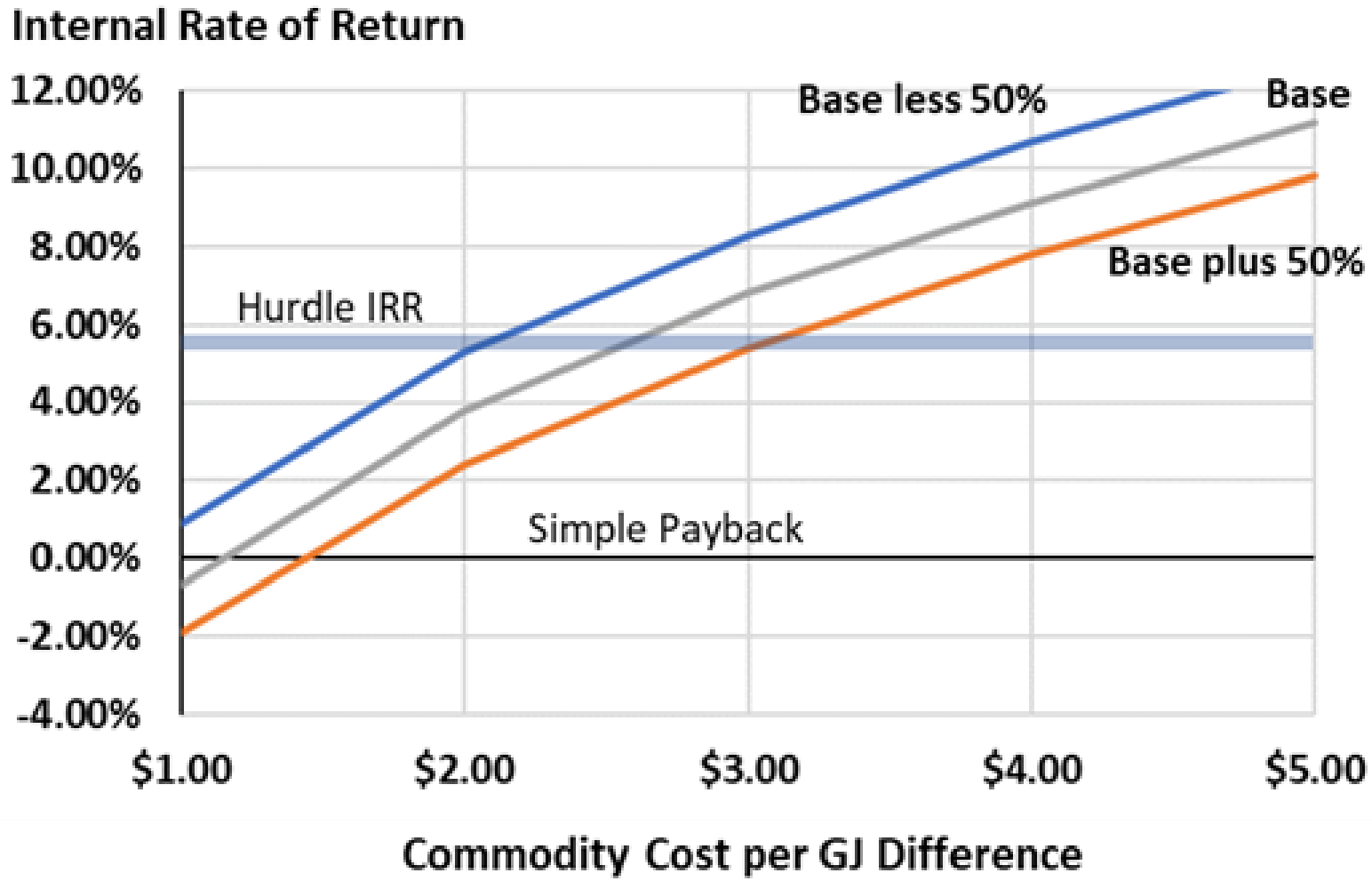


Pipeline transport is potentially least cost = order of $0.30 per kilogram

Potential economics attractive

- 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

Thank You

#RH2@APEP

RENEWABLE HYDROGEN

UCI ADVANCED POWER AND ENERGY PROGRAM

jgreed@uci.edu

Fuel Cell Heavy-duty Truck Demonstration and Beyond

Technology Advancement Office
Program Supervisor

Seungbum Ha

Heavy-Duty Battery Electric Truck Project

Technology Development | **Technology Demonstration/ Commissioning** | **Technology Deployment/ Commercialization**

Technology Readiness Level

4 5 6 7 8 9

2008 **2009** **2010** **2011** **2012** **2013** **2014** **2015** **2016** **2017** **2018** **2019** **2020** **2021**

100mi

150mi

200mi

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 **$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

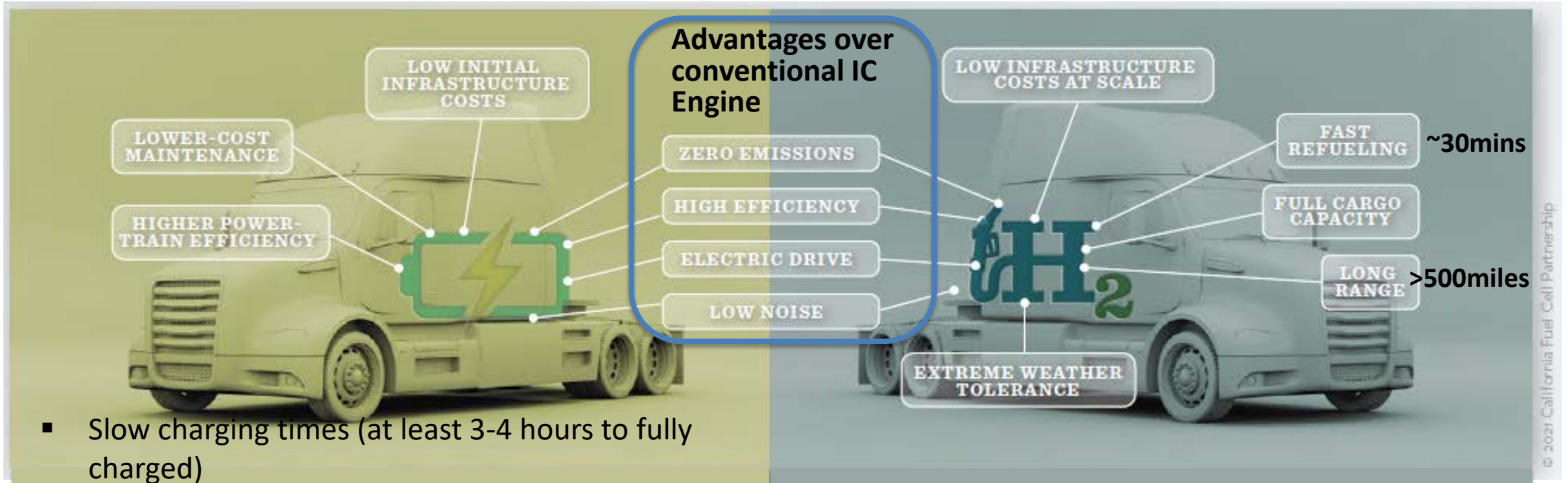
Daimler	Volvo
200 – 250-mile electric range	195 – 220-mile electric range
475 kWh lithium-ion battery pack	564 kWh lithium-ion battery pack
CCS1 connector for fast charging	CCS1 connector for fast charging

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

Daimler eCascadia

Volvo VNR Electric

Battery Electric / Fuel Cell



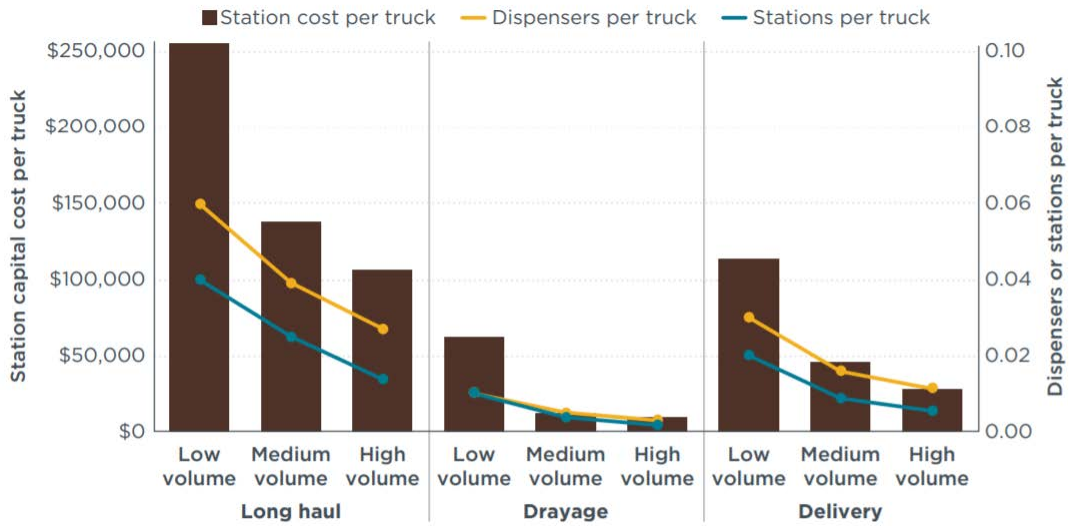
- Slow charging times (at least 3-4 hours to fully charged)
  - Secondary charging infrastructure required
  - Ultra fast charging (over 1MW charger)
- Limited range currently up to 150-200 miles
- Installing charging infrastructure can be expensive, time consuming, and takes up space
- Heavy battery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

- Least commercialized option with fewest vehicles on the road
- High MSRP
- High fuel cost ($10-15/$kg_{H2}$)
- Fueling infrastructure not commonly available

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.



Capital costs for hydrogen station per truck

https://theicct.org/sites/default/files/publications/ICCT_EV_HDVs_Infrastructure_20190809.pdf

Zero Emission Fuel Cell Vehicle Project

Technology Readiness Level

Technology Development

Technology Demonstration/ Commissioning

Technology Deployment/ Commercialization

4 5 6 7 8 9

2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

100mi

150mi

200mi

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

Hyundai
Fuel Cell Truck

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

(500mi)

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

US DOE ZECT II

ZECT II Fuel Cell trucks

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

- Up to 250miles range
- 700bar H2 tank

ZANZEFF
Toyota-KW
Fuel cell Truck

CEC ARFVTP
Cummins
Fuel cell Truck

US DOE ZECT II - Conclusion

More Stop-n-Go

Higher fuel economy

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

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

- The largest strides in Technology Readiness Level (TRL) on the overall vehicle design and architecture.
- Improvements to packaging and vehicle control strategies to increase efficiency
- Challenges
  - ✓ Lack of standardization in componentry
  - ✓ Improving reliability across the system
  - ✓ Deploying a larger numbers of vehicles
  - ✓ Reliable H2 fuel supply

South Coast AQMD

Fuel Cell-dominant vs. Battery-dominant

150miles

60kW Fuel Cell stack

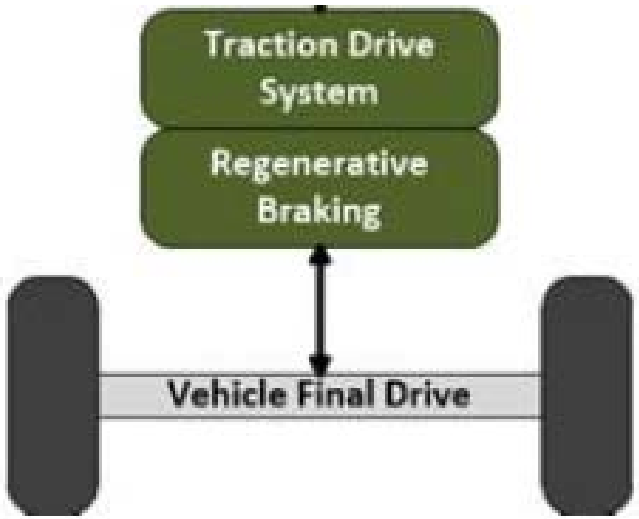
120kWh Battery

Battery-dominant

100kW Fuel Cell stack

80kWh Battery

Fuel Cell-dominant



500miles

100kW Fuel Cell stack

400kWh Battery

Battery-dominant

180kW Fuel Cell stack

75kWh Battery

Fuel Cell-dominant

Not-to-scale

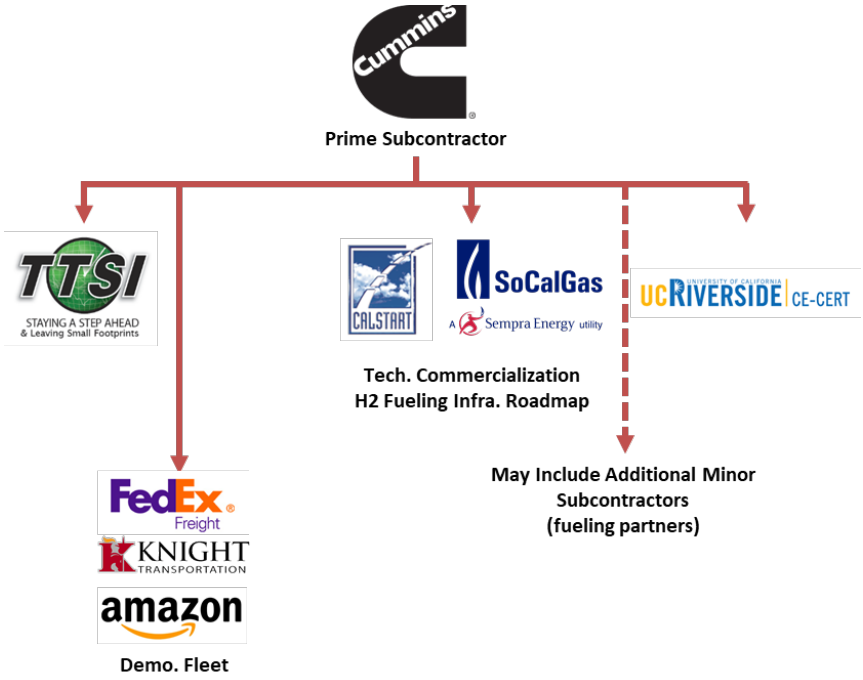
CEC ARFVTP – Cummins Fuel Cell Drayage Truck

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

Announcing:
Cummins Acquires Efficient Drivetrains

Cummins + EFFICIENT DRIVETRAINS

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



CEC ARFVTP – Cummins Fuel Cell Drayage Truck

- Vehicle development progress

  - Truck #1: completed by Apr. 2022

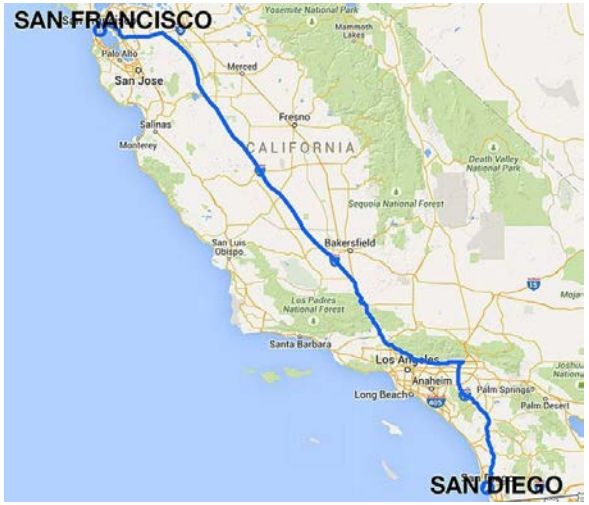
  - Truck #2,3,4: completed by Q2 2022

- 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

Hyundai Fuel Cell Drayage Truck

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



Hyundai Fuel Cell Xcient Roadshow

	WEEK1		WEEK 2		WEEK 3	
Vehicle arrival	Vehicle check	Anaheim	Diamond Bar	Apple Valley	Oakland	Sacramento
	HATCI	Stadium	SCAQMD	Walmart		
11/11~12	11/12~11/28	29 Nov ~ 2 Dec (4days)	6~7 Dec (2days)	9~10 Dec (2days)	14 Dec (1day)	16 Dec (1day)

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

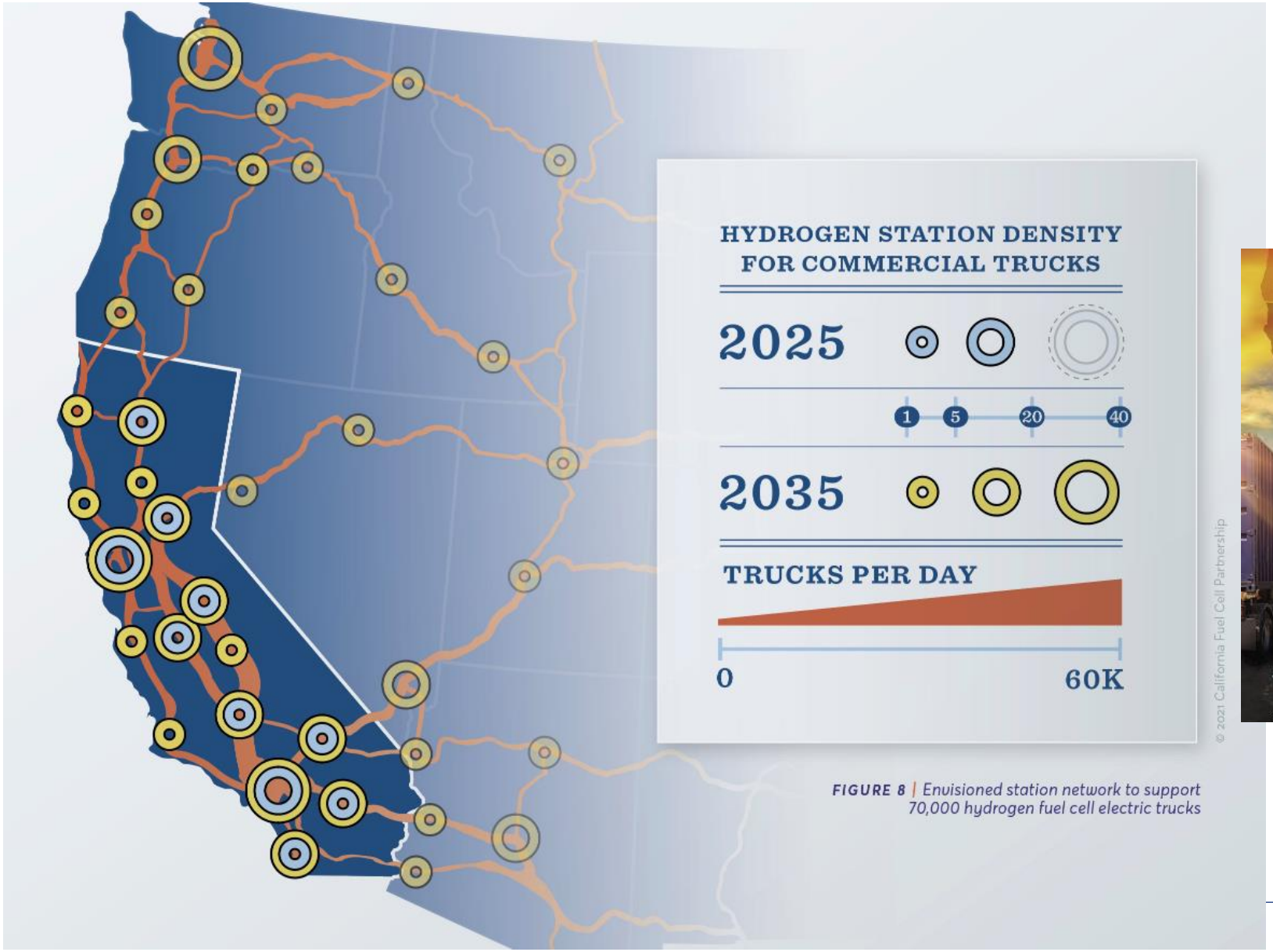


FIGURE 8 | *Envisioned station network to support 70,000 hydrogen fuel cell electric trucks*

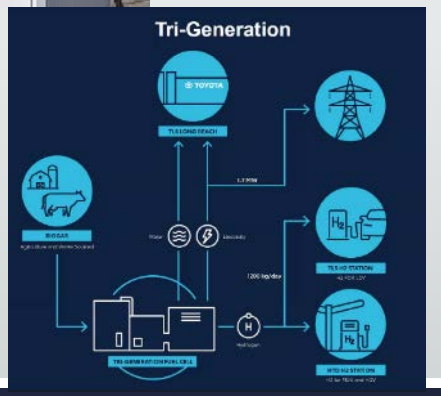
Shore to Store FCET

Lisa Mirisola | February 2022

South Coast AQMD

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)

Ontario H2

Port of Los Angeles

Shore to Store Project Funding

Partner	Funding	Percent
CARB	$41,122,260	49.8
CEC (Project Portal match)	$25,999,331	31.5
Toyota	$9,740,000	11.8
Kenworth, Shell, Southern Counties Express, Total Transportation Services, Port of Hueneme, UPS	$4,685,433	5.7
South Coast AQMD	$1,000,000	1.2
Total	$82,547,024	100.0

Ontario H2

Project Tasks & Progress

Tasks	Progress
Hydrogen station design, build, commissioning	Ontario commissioned & operating, Wilmington in commissioning
Class 8 FCET design, build, validation	10 trucks completed & in fleet operations
Technology Demonstrations	12-month demonstration started May 2021
Data Collection, Analysis	Ongoing
Reporting	Monthly progress meetings

Data Collection & Analysis Ongoing

Wilmington H2

Analysis by NREL

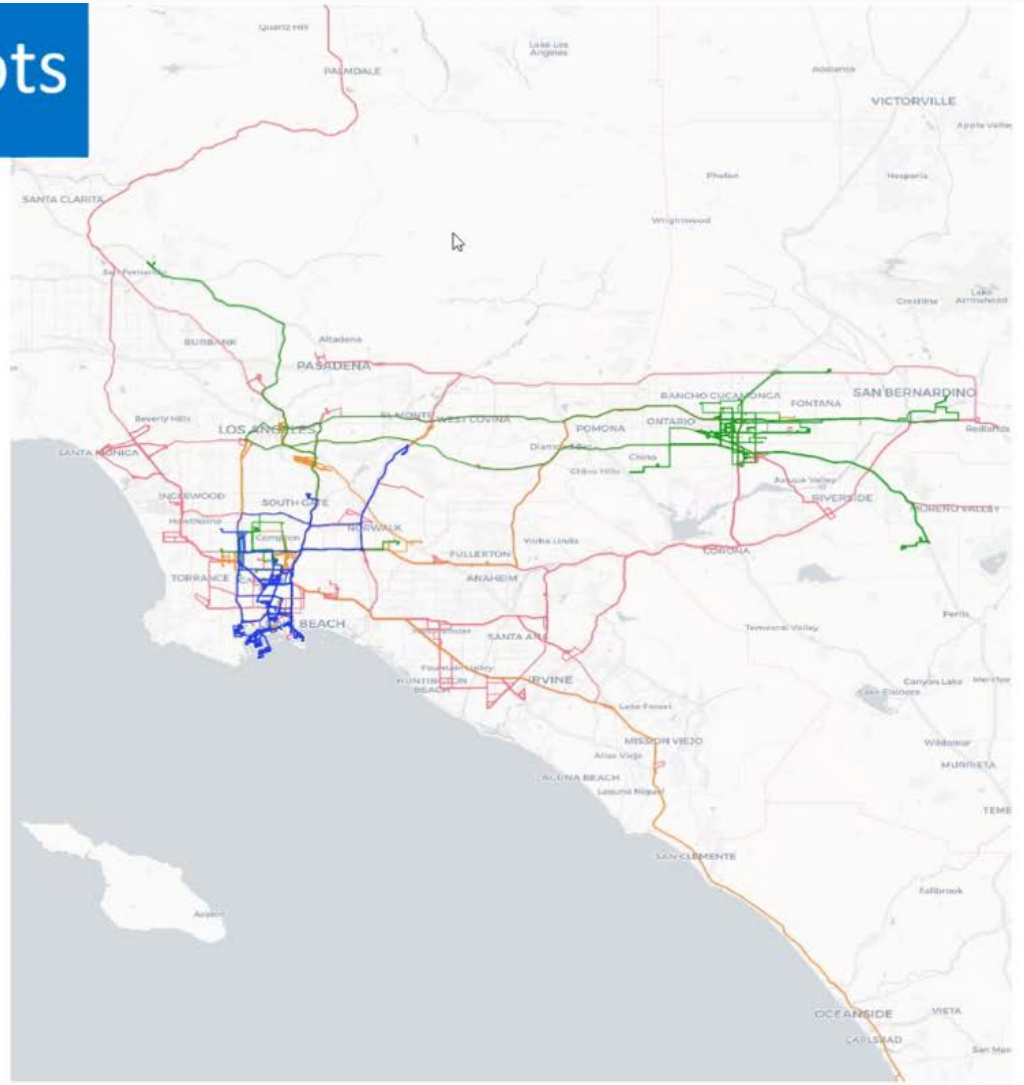
Statistics as of January 10, 2022

- 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

Ocean Truck Map Plots



https://www.capitoltreetracker.com/

Project Benefits

Credit: Toyota

- 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 HAJBABAEI

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

EPA

South Coast AQMD

SunLine TRANSIT AGENCY

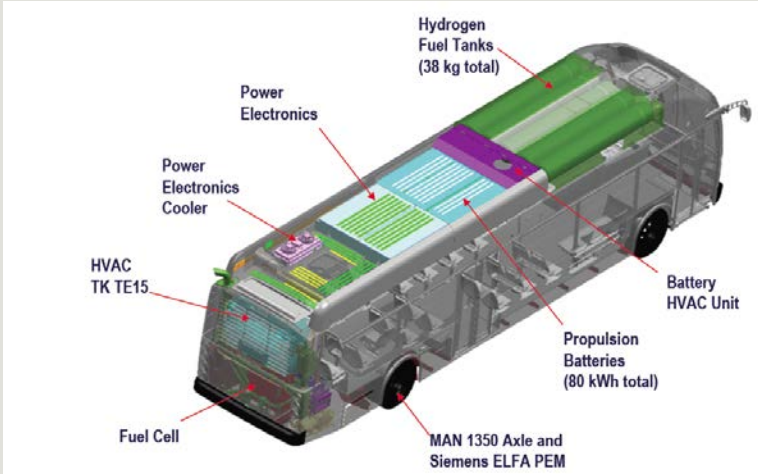
NEW FLYER

BALLARD® PUTTING FUEL CELLS TO WORK

New Flyer Xcelsior XHE40

40’ Transit Bus powered by Ballard Fuel Cell

New Flyer	
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

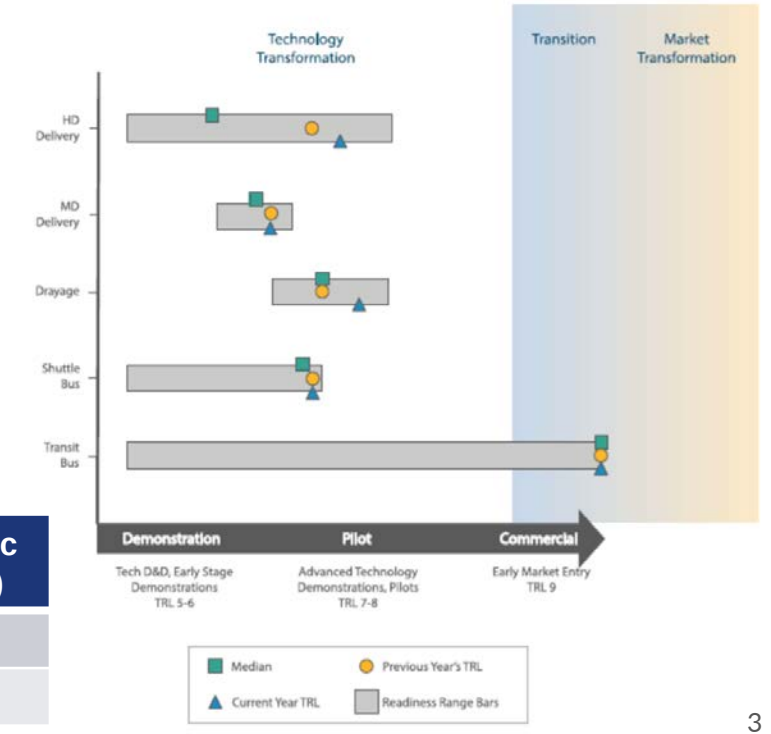
Today's ZE MD Buses Almost All Battery-Electric

- 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)

HVIP List (as of Feb 2022)	Battery Electric Buses (BEBs)	Fuel Cell Electric Buses (FCEBs)
HD Buses (Class 8)	27	4
MD Buses	19	0*

CARB Technology Status Updates

Figure 8: On-Road Fuel Cell Electric Vehicles Technology Status Snapshot



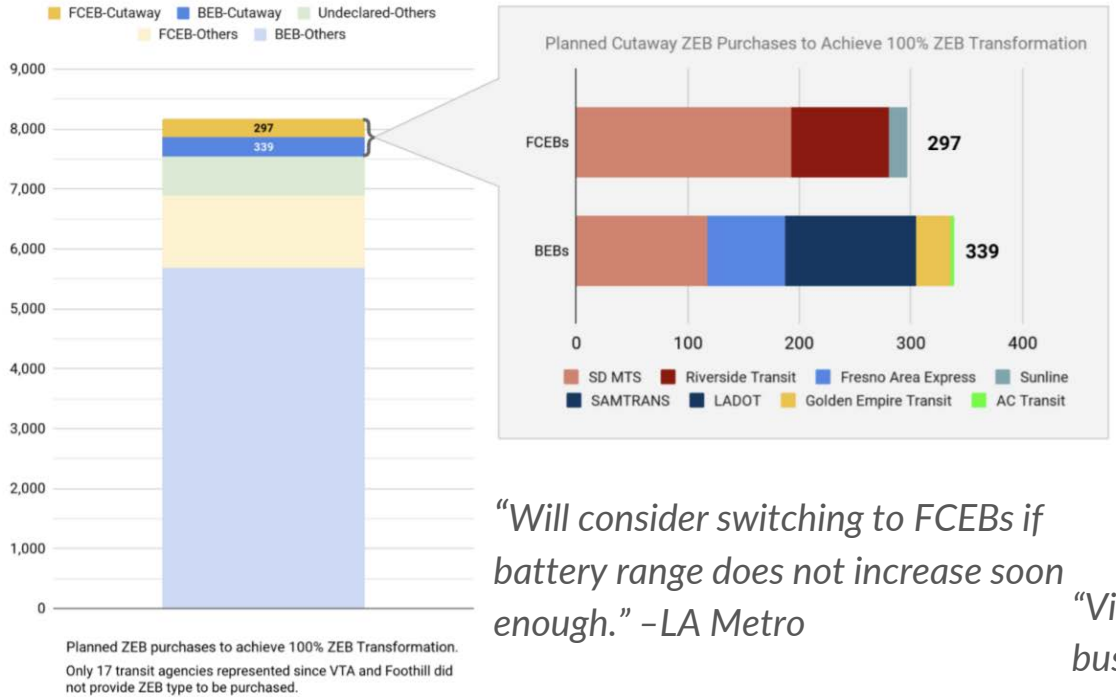
Source: Appendix D CARB 21-22 Long-Term Heavy-Duty Investment Strategy

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

Applications	Special Duty-Cycles
Hotel (Airport) Shuttles	24/7 operations
City/Muni Transportation Services	Current CNG customers with daily routes between 180 miles – 350 miles (15+ hr day)
Transit Systems	Rural routes over 200 miles

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

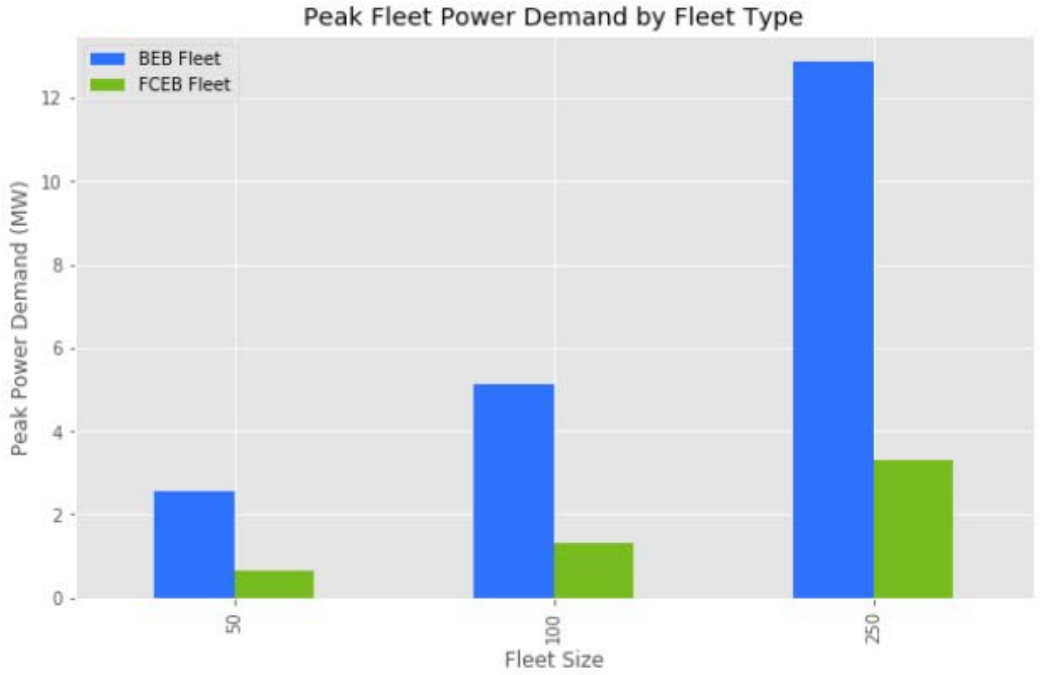
"BEBs for shorter routes, FCEBs for longer routes" –Fresno Express

"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

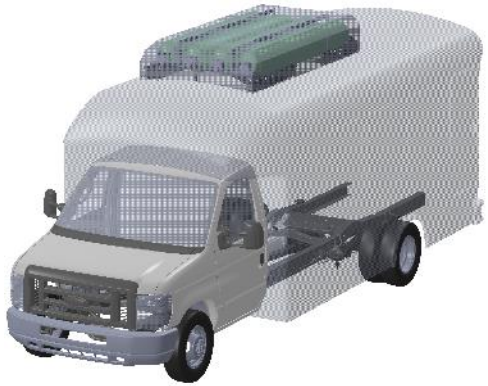


"Favors FCEBs because they can negotiate hydrogen fuel prices, unlike electricity rates for BEBs" - SDMTS

Source: CALSTART White Paper Zeroing in on ZEBs: 2020 Edition

A-1 MD FCEBs Project

Base Chassis	Ford F-53/-59 Stripped Chassis, Ford E-450 Shuttle Cutaway,
Bus Types	1 low-floor F-53/59 1 standard E-450
GVWR	19,500-22,500 lbs/14,500 lbs
Range	200-300 miles
H2 Fuel Capacity	19.6 kg/16.4 kg
FC Power Level/Battery Capacity	TBD via simulation as project deliverable
Payload	5,000 lbs /4,000 lbs
Fuel Storage	Roof mount/in-body



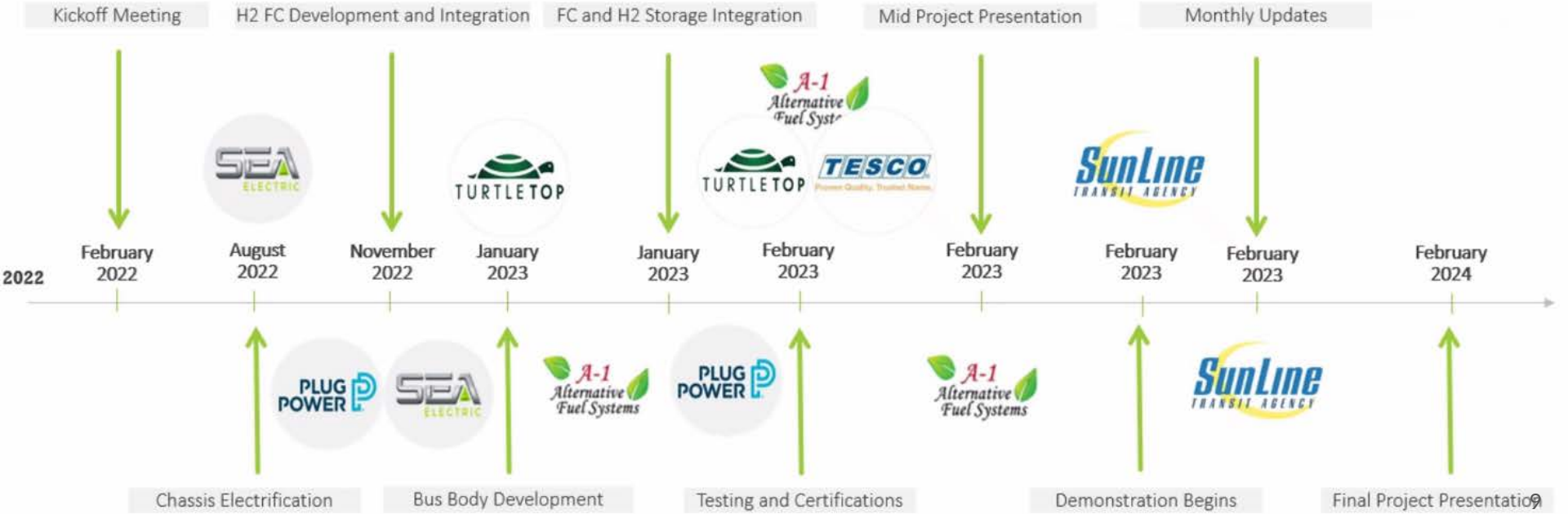
A-1 Project to Commercialize Two MD FCEBs

- 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

Project Partners	Cost-Share Cash/In-Kind
SoCalGas	$531,116
SCAQMD	$531,116
Plug Power Inc.	$258,000
SEA Electric LLC	$250,000
Sunline Transit Agency	$160,608
A-1	$132,668
Hometown Manufacturing, Inc	$110,000
Turtle Top	$85,000
Luxfer Gas Cylinders	$28,000
Total Cost	**$2,086,608**

*Tentative Timeline



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

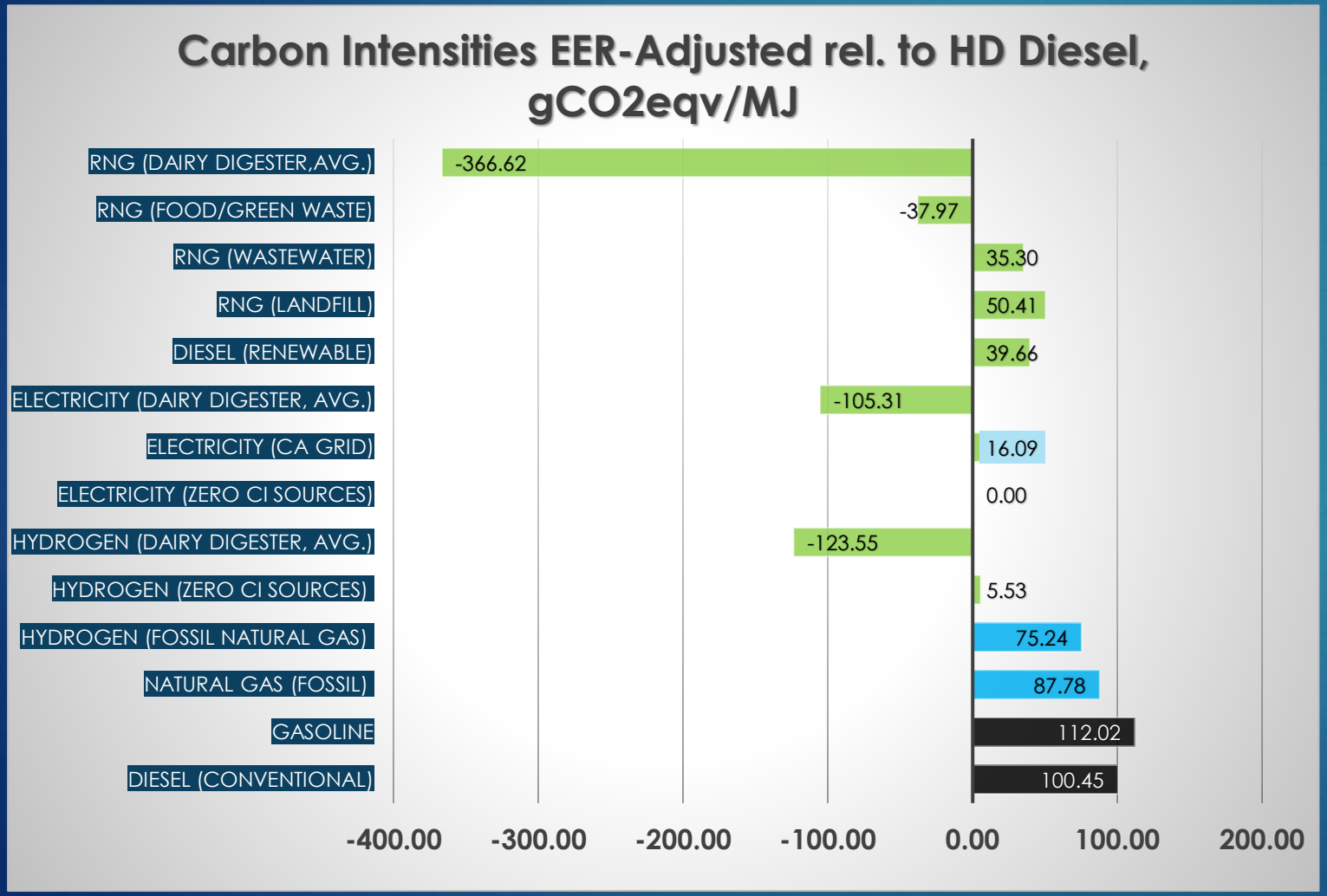
Waste-to-Fuel

- 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

Project/ Location	Technology	Feedstock	Product	CI	Co-Sponsors	Pipeline Inter-connect	Project Cost (est)	SCAQMD Funding
CR&R (Perris, CA)	**Anaerobic Digestion (AD)**	**Green Waste**	**Renewable Natural Gas (RNG)**	**0.34**	**CEC, CalRecycle**	**X**	**$55,000,000**	**CFF $900,000**
Kore (Los Angeles, CA)	**High Temperature Pyrolysis**	**Low Moisture Biomass**	**Renewable Hydrogen (RH_2)/RNG**	**-100 (est)**	**SoCalGas**		**$6,050,000**	**$2,450,000 CFF $1,000,000**
Rialto Bioenergy/ Anaergia (Rialto, CA)	**AD/Pyrolysis**	**Food Waste**	**RNG**	**-57 (est)**	**CEC**	**X**	**$77,873,000**	**$4,365,801 CFF - $0**

California LCFS – Carbon Intensity Scores



EER Heavy-Duty Applications - Replacing Diesel	
Fuel/Vehicle Combination	**EER**
Diesel	1
Biomass-based Diesel	1
CNG or LNG Spark Ignition Engines	0.9
CNG or LNG Compression Ignition Engines	1
Electricity - BEV or PHEV Truck or Bus	5
Electricity - Heavy Rail Fixed Guideway	4.6
Electricity - Light Rail Fixed Guideway	3.3
Electricity - Trolley, Cable Car, Streetcar	3.1
Electricity - Forklifts	3.8
Hydrogen - Fuel Cell Vehicle (FCV)	1.9
Hydrogen - Forklifts (FCV)	2.1
Propane	0.9

EER - Energy Economy Ratio

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)

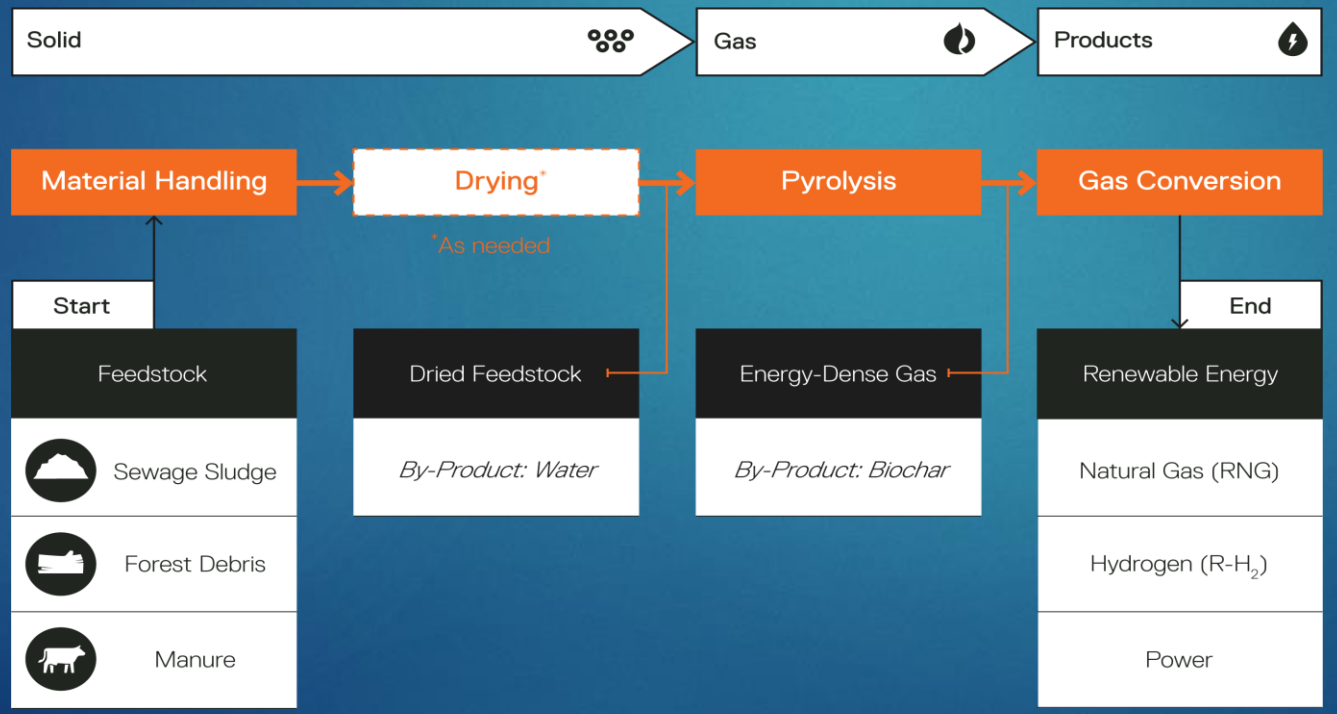
- Thermochemical conversion of organic solids to Gas, in lean Oxygen environment using indirect heating
- Feedstocks: typically low moisture waste biomass
- Products: Syngas (H_2, CH_4, CO_2, CO) and sequestered carbon Solids (Biochar)


Biosolids

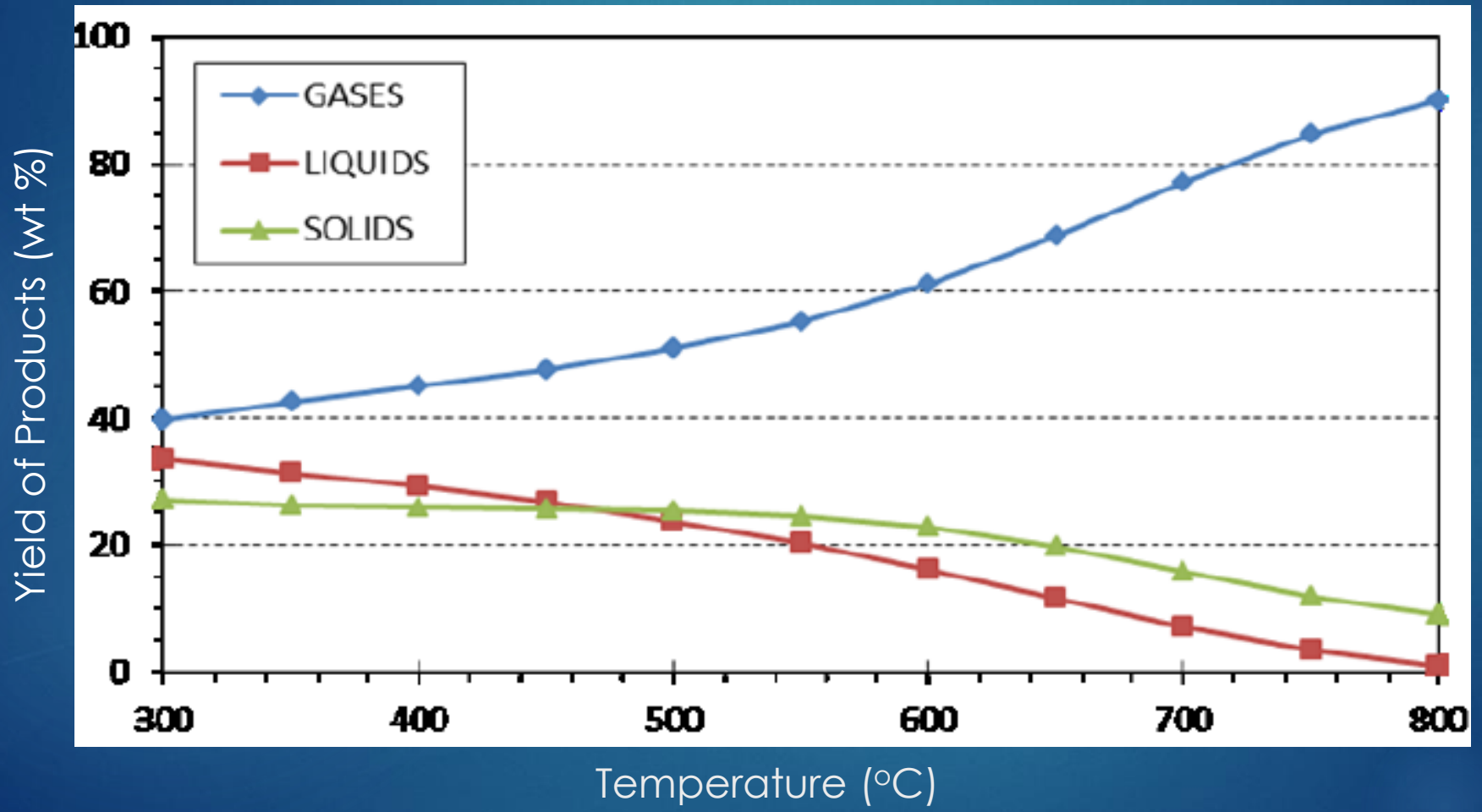

Nut shells


Green waste

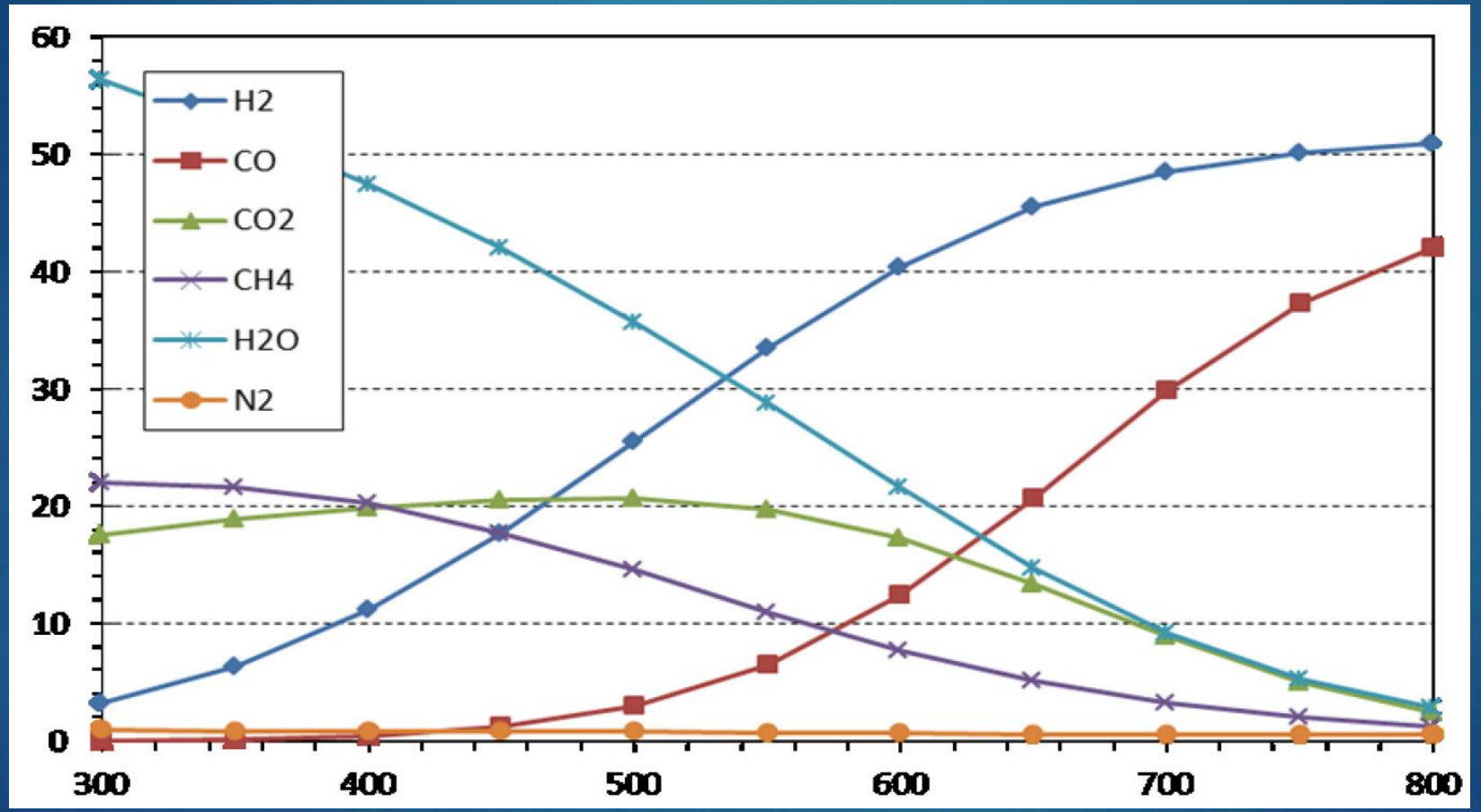

Tree /Forest Debris



Pyrolysis Biomass Conversion Gas/Liquid/Solid vs Temperature

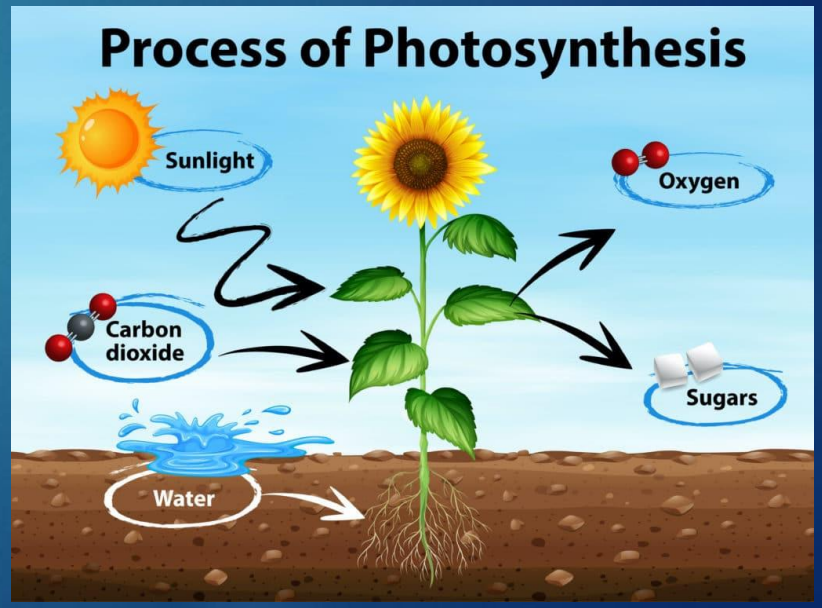


Pyrolysis Gas Composition vs Temp.

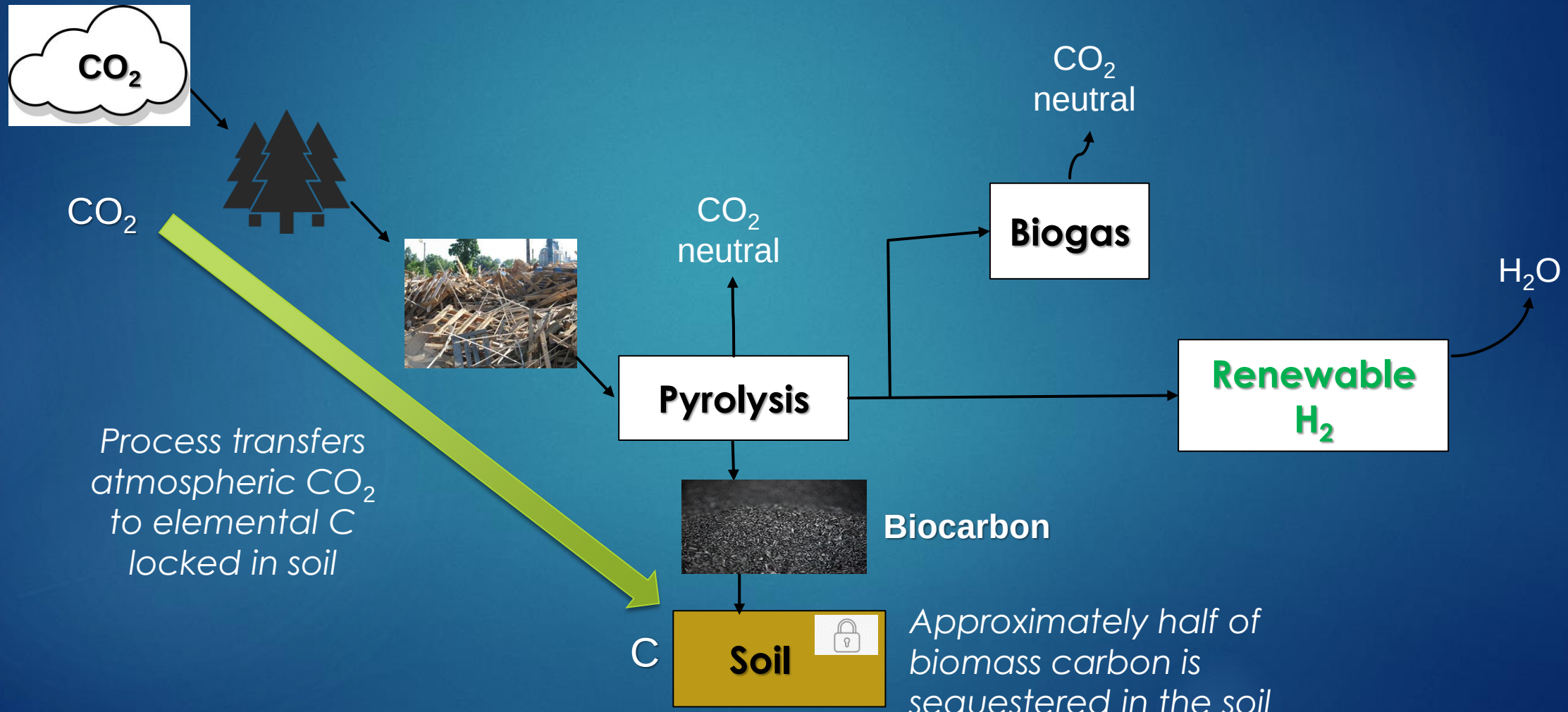


Other Pyrogases

- CO can be used to produce additional Hydrogen through a Water-Gas Shift reaction $CO + H_2O \rightleftharpoons CO_2 + H_2$
- CO_2 could be utilized to produce RNG through the Sabatier reaction at the expense of H_2 $CO_2 + 4H_2 \rightleftharpoons CH_4 + 2H_2O$
- 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"



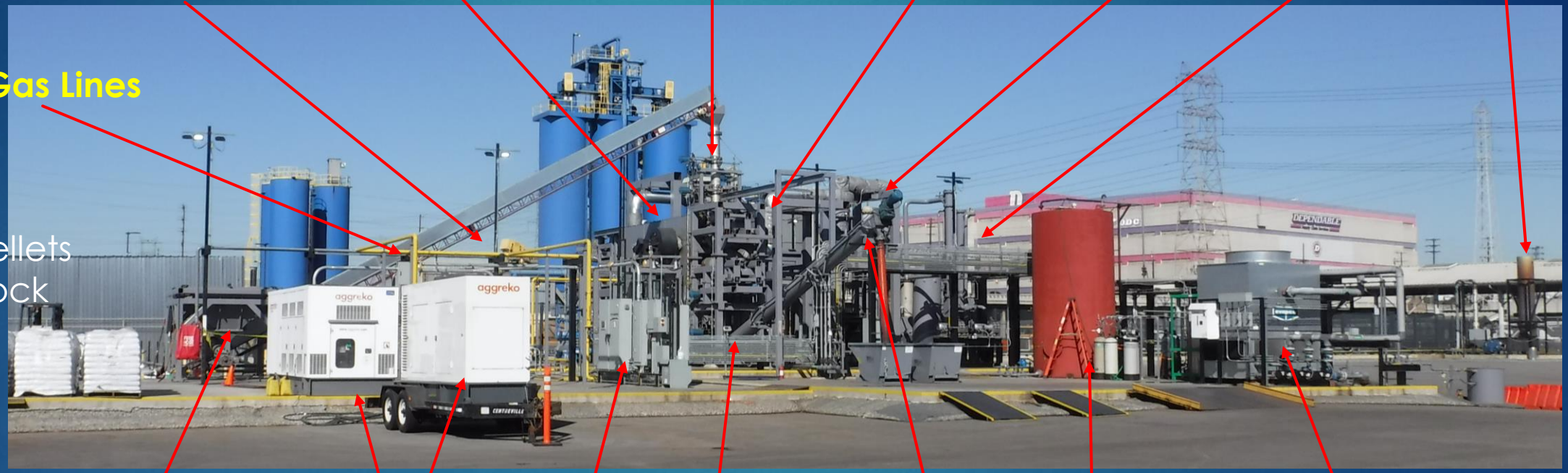
Biochar and Carbon Sequestering



Kore Infrastructure – System Design

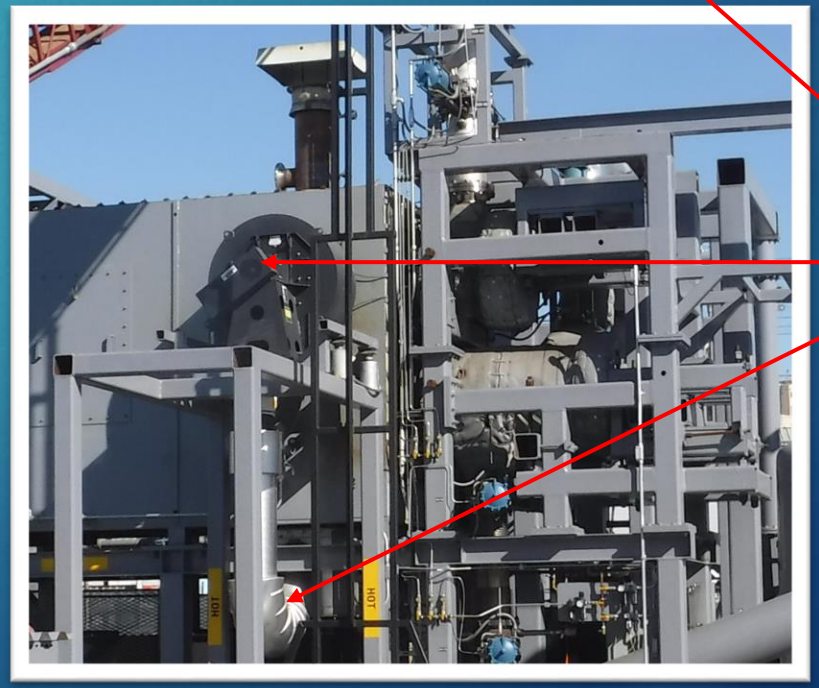
- Pyrolyzer is a Plug Flow Reactor
  - Indirect Heat using natural gas and "pyrogas"
  - Two screw auger conveyors are mounted in parallel and transport feed through the pyrolyzer reactor in a "U" shape to meet necessary residence time and minimize stress on auger shafts
- Multiple Knife gate valves 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 – Olympic Site



Kore site photos

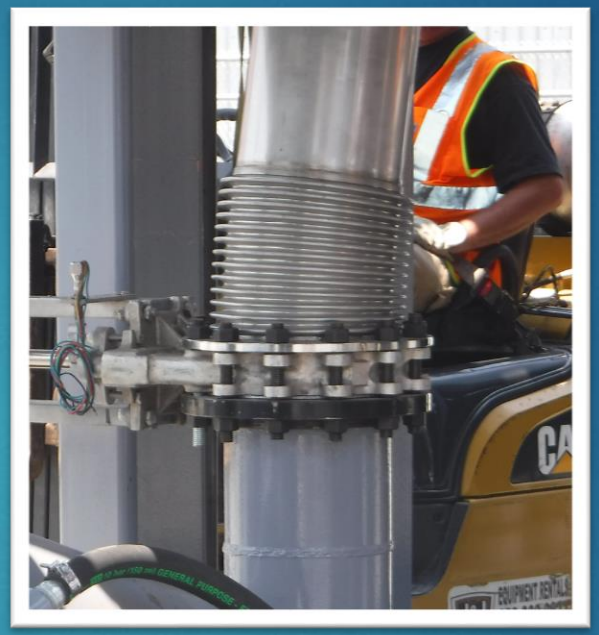
Knife Gate valves



Heated pyro-gas recirculation

Kore site photos

Pyro Gas conveyance and processing

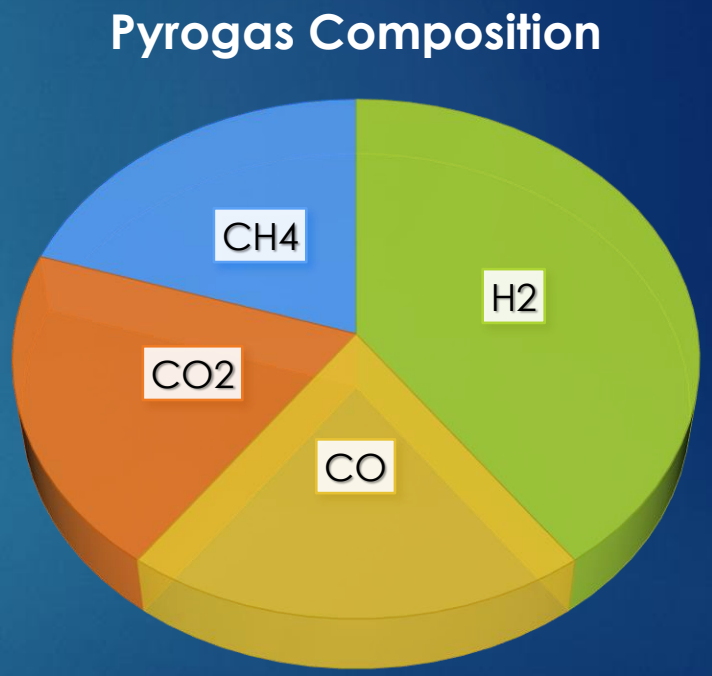


High temperature expansion joints

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

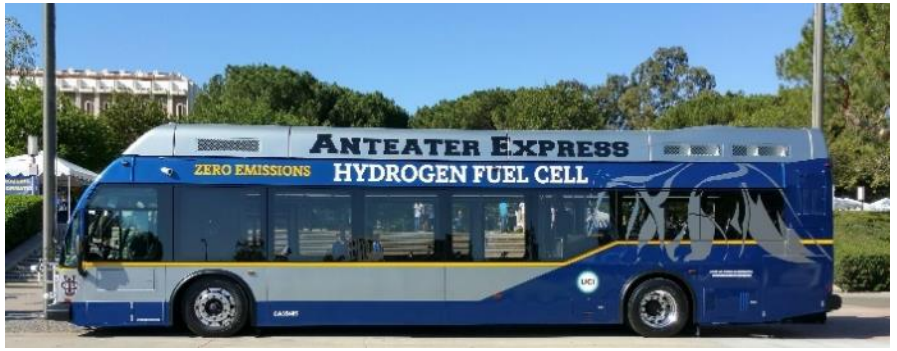
Hydrogen Systems Analysis

- 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

Clean Transportation Funding from the MSRC



Hydrogen Infrastructure Partnership Program
Mobile Source Air Pollution Reduction Committee

UC Irvine Light-duty and Bus fueling H2 expansion

- also relocated across campus

San Bernardino County Transportation Authority H2 for Passenger Rail

- 2024 Zero Emission in-service goal https://www.gosbcta.com/project/redlands-passenger-rail-project-arrow/

Air Products & Chemicals Heavy-duty truck and Light-duty H2

- World Energy, Paramount

Nikola Heavy-duty truck H2

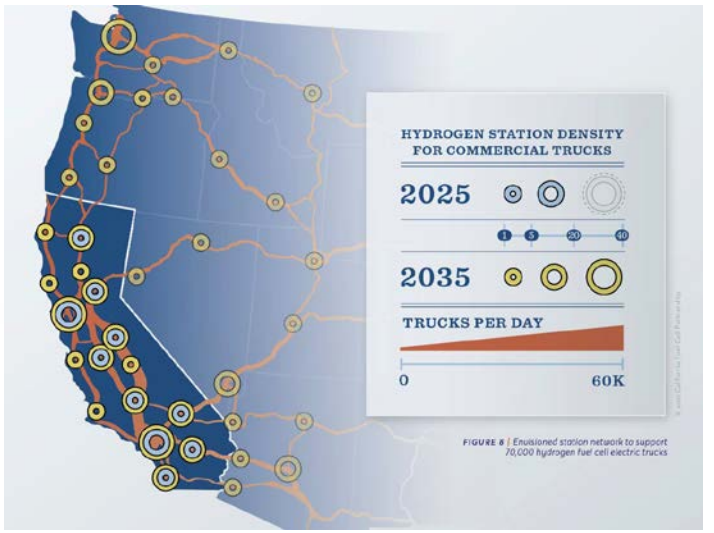
- Travel Center of America, Ontario

Clean Energy Heavy-duty truck H2

- Co-located with RNG fueling, San Bernardino

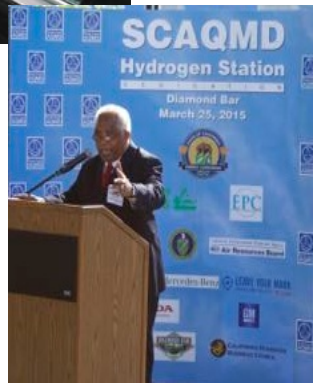
http://www.cleantransportationfunding.org/sites/default/files/agendas/2021-10/Oct_2021_MSRC_Retreat_Agenda_for_Web.pdf

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



South Coast
Air Quality
Management District

Clean Fuels Program

2021 Annual Report
& 2022 Plan Update

Technology Advancement Office

Leading the way to cleaner air

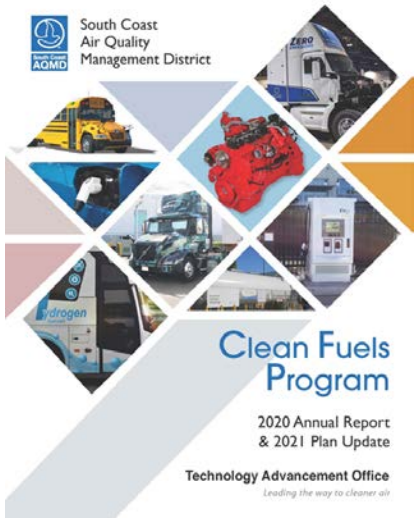
Plan Update

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



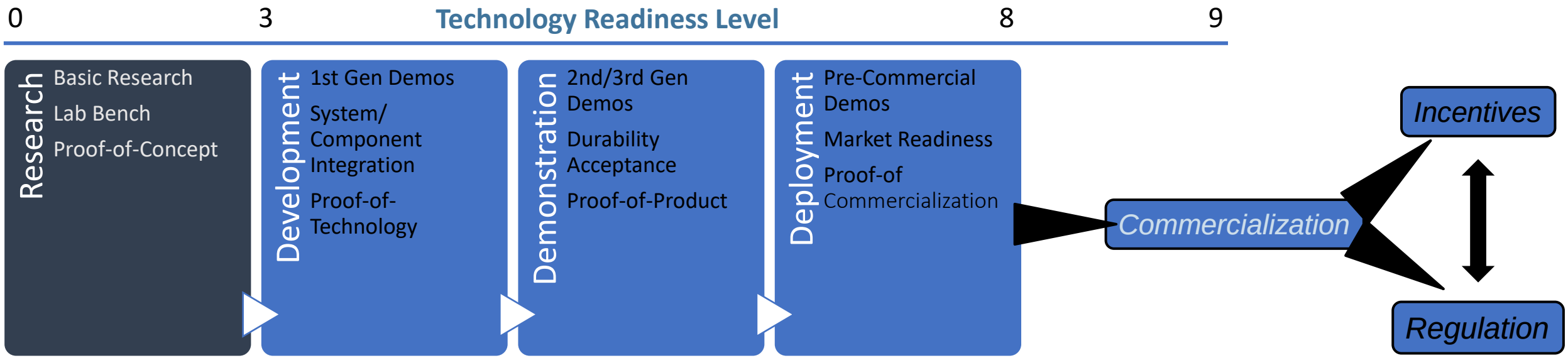
Input and Feedback

- Advisory group meetings
  - September 2021 and February 2022
  - Technology Advancement/Clean Fuels
  - Invited Technical Experts
- Meetings - agencies, industry groups, technology providers and other stakeholders
- Symposiums 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

California FUEL CELL PARTNERSHIP
DRIVING FOR THE FUTURE

California Natural Gas Vehicle Partnership

Clean Fuels Program - Overview



Emissions Benefit from Technology Development

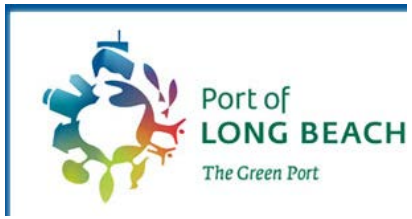
South Coast AQMD Incentive Programs	NZE (# of Trucks)	ZE (# of Trucks)	NOx Reductions (tpy)
VW	47	93	28
Lower Emission School Bus	280	95	70
Proposition 1B	925	112	444
Carl Moyer	255	10	109
Total	1,507	310	651

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

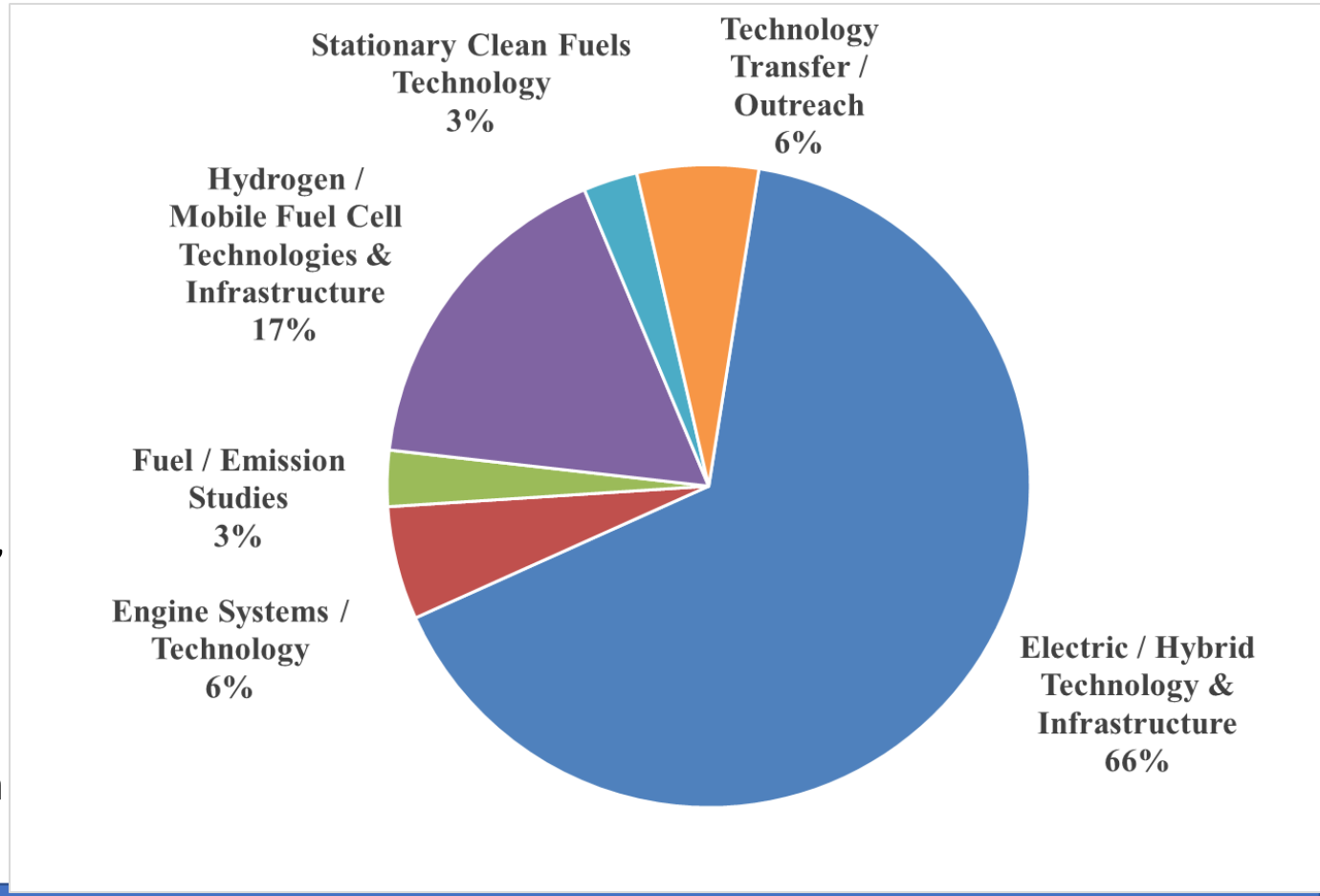
Total = $53M



CY 2021 Accomplishments

- Clean Fuels Program executed 19 new projects or studies and modified 5 continuing contracts
- Sponsored research, development, demonstration and deployment (RD^3) 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

Distribution of Executed Contracts



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

FCET Fueling @ H2 Station

SunLine Fuel Cell Buses

Volvo VNR Electric Truck

2021 Key Projects Completed

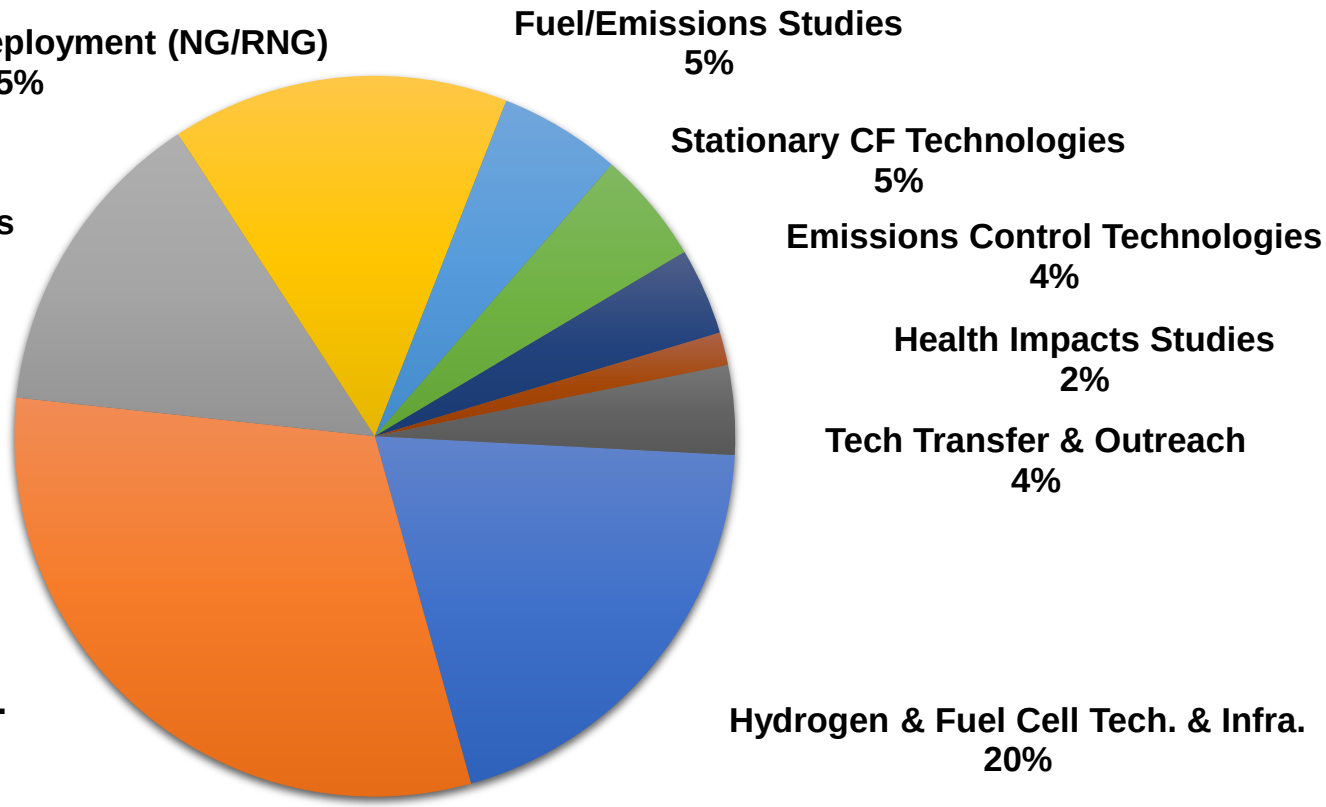
- Electric/Hybrid Technologies
  - Zero Emission Fuel Cell Electric Buses
- Hydrogen/Fuel Cell Technologies and Infrastructure
  - Installation of 8 Hydrogen Stations
  - ZECT II – Fuel Cell Range Extended Drayage Truck
  - Renewable Electrolytic Fuel (H2) Production
- Fuel/Emissions Studies
  - Alternative Diesel Blends in Off-Road Engines

Fuel Cell Bus

Range Extended Fuel Cell Truck


La Canada H2 Station

Proposed 2022 Plan Distribution



$23.8M

Development Schedule

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