Hydrogen and Regional Air Quality

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Aaron Katzenstein, Ph.D.
Assistant Deputy Executive Officer
## Air Quality Who Does What

### U.S. Environmental Protection Agency (EPA)
- Adopts Health-Based National Air Quality Standards
- Regulates Interstate Sources (Trucks, Trains, etc.)
- Oversees State Clean Air Plans
- Federal GHG Programs

### California Air Resources Board (CARB)
- Adopts Health-Based State Air Quality Standards
- Regulates Cars, Trucks, Fuels, Consumer Products
- Approves Local Air District Clean Air Plans
- AB32 – GHG Programs and Regulations

### Local Air Districts (SCAQMD)
- Monitor Air Quality; Issue Health Alerts
- Prepare Clean Air Plans
- Regulate over 28,000 Stationary Sources
- Issue over 10,000 permits annually
South Coast Air Basin

17 Million People

67% of CA EJ population lives in South Coast

28,000 permitted sources

One-third of all U.S. containerized cargo
### 25 Cities Most Polluted by Ozone

<table>
<thead>
<tr>
<th>Rank</th>
<th>City</th>
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<tbody>
<tr>
<td>1</td>
<td>Los Angeles-Long Beach, CA</td>
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<tr>
<td>2</td>
<td>Bakersfield, CA</td>
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<td>3</td>
<td>Visalia, CA</td>
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<td>4</td>
<td>Fresno-Madera-Hanford, CA</td>
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<td>5</td>
<td>Phoenix-Mesa, AZ</td>
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<td>6</td>
<td>Sacramento-Roseville, CA</td>
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<td>7</td>
<td>San Diego-Chula Vista-Carlsbad, CA</td>
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<tr>
<td>8</td>
<td>Denver-Aurora, CO</td>
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<tr>
<td>9</td>
<td>Salt Lake City-Provo-Orem, UT</td>
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<tr>
<td>10</td>
<td>San Jose-San Francisco-Oakland, CA</td>
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<td>11</td>
<td>Houston-The Woodlands, TX</td>
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<td>12</td>
<td>Las Vegas-Henderson, NV</td>
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<tr>
<td>13</td>
<td>El Paso-Las Cruces, TX-NM</td>
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<tr>
<td>14</td>
<td>New York-Newark, NY-NJ-CT-PA</td>
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<tr>
<td>15</td>
<td>El Centro, CA</td>
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<tr>
<td>16</td>
<td>Chicago-Naperville, IL-IN-WI</td>
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<td>17</td>
<td>Dallas-Fort Worth, TX-OK</td>
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<td>18</td>
<td>Fort Collins, CO</td>
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<td>19</td>
<td>Chico, CA</td>
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<td>20</td>
<td>Redding-Red Bluff, CA</td>
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<td>21</td>
<td>Philadelphia-Reading-Camden, PA-NJ-DE-MD</td>
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<tr>
<td>22</td>
<td>Washington-Baltimore-Arlington, DC-MD-VA-WV-PA</td>
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<td>23</td>
<td>Sheboygan, WI</td>
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<tr>
<td>24</td>
<td>Milwaukee-Racine-Waukesha, WI</td>
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<tr>
<td></td>
<td>Hartford-East Hartford, CT</td>
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**American Lung Association: State of the Air**
Ozone Formation

Hydrocarbons (VOCs) + NOx → Ozone
Ozone Concentrations Relative to NOx & VOC

Glendora (Based on 2016 AQMP modeling platform)

2020 Business-As-Usual
Ozone Attainment Challenges NOx Reductions Needed

Mobile Sources >80% of NOx inventory for 2023
Multiple Air Toxics Exposure Study (MATES) Air Toxics Cancer Risk

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

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

Maps showing the risk distribution for 2012 and 2018.
Ports Area

MATES V Risk (per million)

- <100
- 100-200
- 200-300
- 300-400
- 400-500
- 500-800
- 800-1000
- 1000-1200
- >1200

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GERCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Diesel Particulate Matter Trends
Clean Fuels Program Fund

- Established in 1988
- $1 fee on DMV registrations ($~13M/yr)
- Leverage funds with grants and other project partners
- Research, develop, demonstrate, and deploy clean technologies
Zero Emission Fuel Cell Vehicle Projects

* $ Total Project Cost (SCAQMD Cost-share)

ZECT II: Zero Emission Cargo Transport II
ARFVTP: Alternative and Renewable Fuels and Vehicle Technology Program
ZANZEFF: Zero- and Near Zero-Emission Freight Facilities
U.S DOE – Zero Emission Cargo Transport
ZECT II

First large-scale fuel cell drayage truck demo in California

- 6 Fuel Cell Trucks and 1 CNG Truck
  - 24 month demonstration prototypes
- Operated drayage at Ports of Long Beach & Los Angeles
  - Operated 710, I10 and 60 freeways
  - In use analysis
  - Total cost of ownership
US DOE ZECT II: First FCEV Drayage Truck Demo in California

Fuel cell trucks performed at higher efficiency

- Us DOE ZECT II: First FCEV Drayage Truck Demo in California

<table>
<thead>
<tr>
<th>Developer</th>
<th>BAE/Kenworth</th>
<th>Cummins</th>
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<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>100 kWh</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 250miles range
- 700bar H2 tank
- Higher FC stack Power

ZANZEFF
Toyota-KW
Fuel cell Truck

CEC ARFVTP
Cummins
Fuel cell Truck
In 2019, Cummins acquired EDI and Hydrogenics

4 Fuel Cell Class 8 drayage trucks (200+ mile ZE range)

Deliver vehicles in early 2022
Hyundai Fuel Cell Drayage Truck

- Fuel-cell technology: Attractive solution for regional and long-haul services
- Demonstration: 12 months in regional and long-haul routes to fully utilize up to 500-mile range
- Infrastructure: FirstElement Fuel
OCTA

- 10 New Flyer fuel cell buses in operation early 2020
  - 85 kW Ballard fuel cell and 80 kWh Li-FePO4 batteries
  - Each bus uses 37.5 kg/day to provide up to 350 miles range
  - >300k miles traveled

- OCTA hydrogen fueling station
  - Developed by Trillium and Air Products Liquid Hydrogen Delivery
  - 1600 kg/day @ 350 bar
  - Capacity for fueling 40-50 fuel cell buses
  - Fueling time 6 – 10 minutes per bus
  - 280 kg peak back-to-back fills
SunLine Transit Agency

- Existing fleet of 21 fuel cell* and 4 battery electric buses
  - Operations in Coachella Valley area
  - Non-attainment area for Ozone/ Year 2 - Community Air Protection Program
  - Bus operation - 12 year lifetime
- Newly upgraded 900 kg/day hydrogen station
  - Capacity for fueling 30 buses
- South Coast AQMD - Awarded $5.9 M US EPA Targeted Air Shed Grant - deploy 5 additional fuel cell buses

* Sunline is in the process of accepting 5 Fuel cell buses
A-1 Hydrogen Fuel Cell Medium-Duty Buses

- Plug Power Inc. and SEA Electric LLC to development hydrogen fuel cell and chassis electrification components
- A-1 to perform the final integration and CARB & Altoona certifications
- Sunline Transit will operate buses
# Challenges for Fuel Cell Trucks & Transit Buses

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Hydrogen Fuel Cell</td>
<td>Least commercialized option with fewest vehicles on the road</td>
</tr>
<tr>
<td>- Quick refueling (10 minutes)</td>
<td>- High MSRP</td>
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<tr>
<td>- Expected 300+ mile range</td>
<td>- High fuel cost</td>
</tr>
<tr>
<td>- Quiet operations</td>
<td>- Fueling infrastructure not commonly available</td>
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<tr>
<td>- Reduced maintenance costs</td>
<td></td>
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<tr>
<td>- Extended range with 700 bar fueling</td>
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<td>- Torque / acceleration</td>
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- Scale-up FC Truck Volume
- Infrastructure
California Fuel Cell Partnership

- The CaFCP was created in 1999
  “Promote fuel cell vehicle commercialization as a means of moving towards a sustainable energy future.”
- South Coast AQMD joined in 2000
- 23 Executive Board & Full Members (2021)
  - Automotive manufacturers (9)
  - Government agencies (5)
  - Industry stakeholders (9)
- 38 full & associate members
- Medium, Heavy-Duty Task Force Vision
A Vision for Freight Movement in California – and Beyond

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

The driest year in a century

Exceptionally low accumulation of rain and snow across the state is exacerbated by climate change, reviving fears of emergency measures.

LA Times Oct. 17, 2021
Governor’s State of Emergency Proclamation
- July 30th

Estimated 3,500 MW generation shortfall during afternoon peak
- 5,000MW anticipated next summer

Allows IOUs to incentivize:
- Reduced demand
- Use of backup generators

Allows ships to use auxiliary engines
Wind and solar curtailment totals by month

Source: Cal ISO
Develop Model for Connected Network of Microgrids (UCI)

- **Connected Network of Microgrids**: Most of the current research into microgrids has been focused on impacts of a single microgrid.

- **Evaluate four types of microgrids** - university campuses, ports, shopping centers and critical facilities.

- **Assess emission reduction** during both grid connected and islanded modes, including PSPS events.
Orange County Sanitation District
Tri-Gen Fuel Cell Demonstration

• Air Products - Developed and demonstrated 250KW Fuel Cell producing 100% renewable hydrogen from biogas
• H2 fueling station
• In partnership with UCI’s National Fuel Cell Research Center, US DoE, Air Products, Fuel Cell Energy and South Coast AQMD developed and demonstrated renewable H2 from biogas
• Project was completed in 2014 with a total project cost $8.7M
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

• Priorities
  • H2 Contaminant Detector
  • Heavy duty reference station design
  • Heavy duty station test device design
  • Heavy duty station capacity
UC Irvine Hydrogen Station Expansion

• Expansion to 800 kg/day with liquid delivery, increased storage, and four fueling positions

• Public use will continue 24/7, with buses scheduled to refuel at night

• Final design will incorporate state-of-the-art technology

• Co-funding approved & contracts executed: Total $1.8M expansion

• Equipment will be moved to new location on UCI property (at UCI expense), then upgraded
Infrastructure Challenges & Opportunities

- Policy & funding predictability
  Coordination across all gov levels

- Supply Chain: H2 Production, distribution, parts, materials
  - Need multiple suppliers & scale

- Skilled labor, workforce training

- Focus on safety: codes & standards

- CEQA/Permits

- Site specific development & operational issues

- Increasing capacity stations are starting to reduce dispensed cost; working on refined HD fueling protocols to become “Recommended Practice”

- Address short-term H2 network fragility

- Increase renewable H2 production dedicated to transportation

CaFCP: 2021 HD Vision
Summary

• Mobile sources are biggest contributor to air quality in Southern California

• Need rapid turnover of old diesel technologies to Zero and Near-Zero Emissions
  • Scale-up of hydrogen dispensing and trucks

• Infrastructure support – hydrogen storage, microgrids
Thank You!

Aaron Katzenstein

Akatzenstein@aqmd.gov