Wi-Fi
SSID: NCTCOG Guest Secured
Password: rangers!

AGENDA

North Central Texas Council of Governments
Hydrogen Stakeholder's Meeting

January 16, 2020; 9:00 am – 11:00 am
616 Six Flags Dr. Centerpoint II Arlington, Tx 76011
Transportation Council Room

Call-in information:
1-888-809-4354
Passcode: 4580507
Access WebEx here

Objective: Continue building a network of stakeholders focused on implementation of hydrogen-fueled transportation projects in Texas. Today's meeting will focus on continuing to build a working knowledge across the group by sharing information about current projects and state-of-the-industry.

1. Welcome/Introductions ..... Lori Clark, NCTCOG
2. Hydrogen Funding and Commercially Available Vehicles ..... Bethany Hyatt, NCTCOG
3. Hydrogen Overview ..... Larry Irvine, Plug Power
4. Hydrogen Supply in Texas ..... Jordan Truitt, AirLiquide
5. Texas Project Updates .....
   - I-45 ZEV Corridor Updates ..... Lori Clark, NCTCOG
   - H2@Scale Update ..... Mike Lewis, UT Austin
6. Closing Remarks ..... Lori Clark, NCTCOG
   - Next Meeting Date ..... All
   - Future Presentation Topics ..... All

North Central Texas Council of Governments

www.dfwcleancites.org
cleancities@nctcog.org
Text **DFWCLEANCITIES** to **22828** to join our mailing list**!**

Dallas-Fort Worth CLEAN CITIES

Commercially Available Hydrogen Vehicles and Funding Opportunities

Hydrogen Stakeholder's Meeting

January 16, 2020

Bethany Hyatt

Air Quality Planner

Dallas-Fort Worth CLEAN CITIES

North Central Texas Council of Governments

Hydrogen Fueled Commercially-Available Light-Duty Vehicles

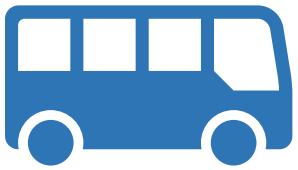
2019/2020 Hyundai Nexo
Alternative Fuel Economy: 57 MPGe Combined
Engine: 120 kW electric motor

2019/2020 Hyundai Nexo Blue
Alternative Fuel Economy: 61 MPGe Combined
Engine: 120 kW electric motor

2019 Toyota Mirai
Alternative Fuel Economy: 67 MPGe Combined
Engine: 113 kW electric motor

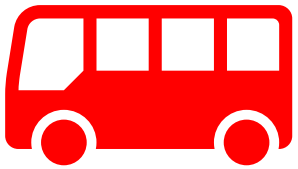
2019 Honda Clarity
Alternative Fuel Economy: 68 MPGe Combined
Engine: 130 kW electric motor

Hydrogen Fueled Commercially-Available Transit Vehicles



ENC AXESS
Maximum Seating: 43
Transmission: BAE
Hydrogen Capacity: 50 Kg

US Hybrid H2Ride 30
Maximum Seating: 25
Power Source: Hydrogenics HD30 PEM fuel cell
Note: Eldorado Aero Elite 29 (F550) chassis; 125 miles total range (15 electric-only)



US Hybrid H2Ride 32
Maximum Seating: 29
Power Source: Hydrogenics HD30 PEM fuel cell
Note: Eldorado Aero Elite 29 (F550) chassis; 200 miles total range (15 electric-only)

Van Hool A300L
Maximum Seating: 34
Transmission: Van Hool
Hydrogen Capacity: 40 kg

More information on U.S. fleets using hydrogen fuel cell transit vehicles: https://www.nrel.gov/docs/fy19osti/72208.pdf

Hydrogen Fueled Commercially-Available Heavy-Duty Vehicles

US Hybrid H2Cargo
Power Source: Hydrogenics HD PEM fuel cell
Note: 113 kW electric motor

US Hybrid H2 Truck Drayage
Power Source: US FuelCell PC80 PEM fuel cell
Note: International, ProStar Day Cab Chassis

Hydrogen Fueling Funding Opportunities:

Texas Volkswagen Environmental Mitigation Plan

Statewide Light-Duty ZEV Supply Equipment Funding (Coming Summer 2020)

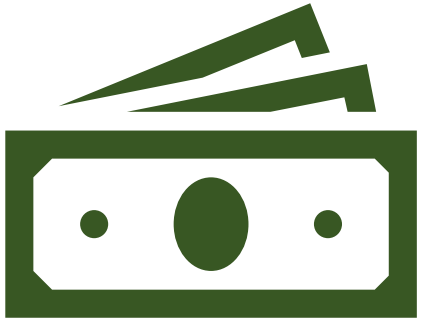
Funding for electric vehicle charging stations
Funding for hydrogen fueling facilities for light-duty hydrogen fuel-cell vehicles

VW ZEV Infrastructure Funding	
Electric Chargers	50%
Hydrogen Supply (250 kg/day)	33%
Hydrogen Supply (100 kg/day	25%

Texas Emissions Reduction Act (TERP) Alternative Fueling Facilities Program

Statewide Alternative Fueling Facilities Funding

50% funding for electric vehicle charging stations and hydrogen fueling facilities
Max of $600,000
First Come-First Served
Deadline: March 18, 2020



For More Information and to Apply: www.nctcog.org/aqfunding

Other Hydrogen Funding Opportunities

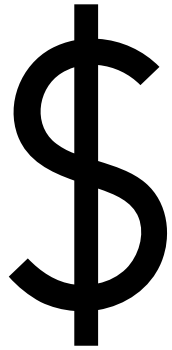
2020 Clean Diesel Call for Partners

Replace Diesel Vehicles with Hydrogen Fuel Cell Vehicles

45% funding for a zero-emission vehicle replacement of an old diesel vehicle NCTCOG anticipates submitting a grant application on behalf of the region

Deadline to Apply: **January 31, 2020**

Department of Energy Notice of Intent



H2@Scale New Markets FOA Areas of Interest:

1. Electrolyzer Manufacturing R&D
2. Advanced Carbon Fiber for Compressed Hydrogen and Natural Gas Storage Tanks
3. Fuel Cell R&D for Heavy-Duty Applications
4. H2@Scale New Markets R&D– HySteel
5. H2@Scale New Markets Demonstrations

Fiscal Year 2020 Advanced Vehicle Technologies Funding Opportunity Announcement (FOA) Area of Interest

11. Gaseous Fuels Technology Demonstration Projects

Receive Email updates on latest funding opportunities here

For More Information

Bethany Hyatt

Air Quality Planner

(817) 704 5663

Bhyatt@nctcog.org

Lori Clark

Program Manager and

DFW Clean Cities Coordinator

(817) 695-9232

Lclark@nctcog.org

www.nctcog.org/aqfunding

Path to Clean Cities and Energy Autonomy

Agenda

OVERVIEW OF TECHNOLOGY

POWERING FLEETS WITH CLEAN ENERGY

Ray Gwin & Larry Irvine

Managing Directors, SPARK Fuel Cells USA

Horizon Fuel Cell Technologies


60
MINUTES
II

Clean, Reliable, Resilient Transit and Stationary Power Operations –

- Clean Air
  - Statutory and Regulatory Issues
  - Societal/Employee Welfare
- Efficiency – Competitiveness
- Energy Autonomy
- Resiliency and Redundancy
- Risk Reduction

Pathway to ZEV Mobility - Hydrogen Eco-System

Create

- **Multi-stakeholder market-specific H2 approach**
- H2 electrification strategy to meet energy, urban and mobility planning objectives
- Ensure city, regional, state, and national policies support and reinforce each other

Prioritize

- **High-use vehicles, captive fleets**
- Focus on H2 electrification of public transport and heavy-duty commercial applications -
- Prioritize energy-efficient hydrogen generation hubs with grid edge technologies

Deploy

spark

Global Challenge

Houston made the **top 10** list for **most polluted cities** in the country for ozone, according to the 2019 American Lung Association “State of the Air” report.

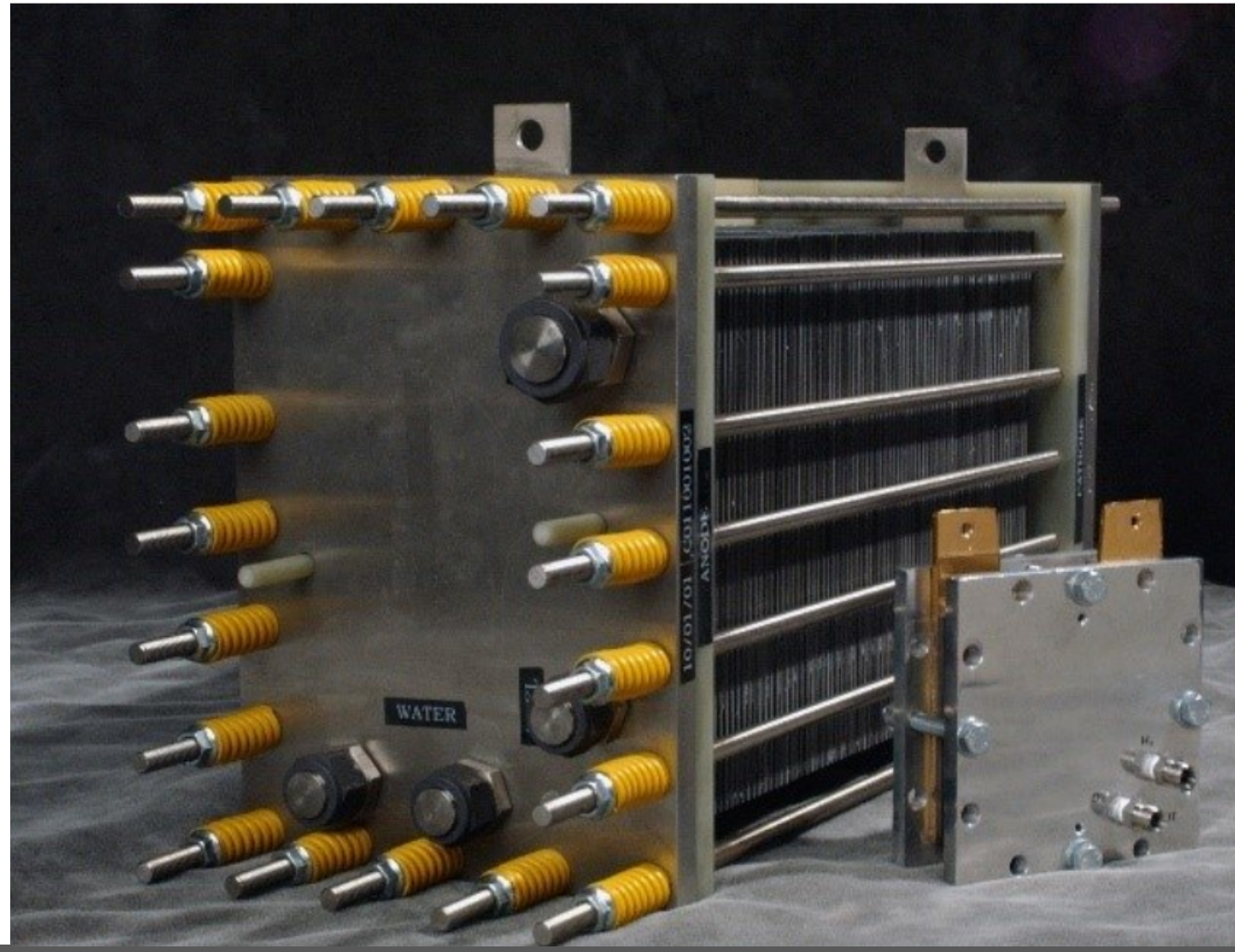
”a 10 ppb decrease in ozone concentrations increases worker productivity by 5.5 percent” (Graff Zivin & Neidel, 2012).

n.b. California is looking to reduce ozone concentration by 20ppb.

Photo: Melissa Phillip, Staff / Houston Chronicle

Experience

Electrochemical Proces
Generates Electricity
Zero Emission



Big Equipment – Larger Positive Impact

Fuel Cells Come of Age

High Utilization Heavy Vehicles and Equipment Depend on Hydrogen for Decarbonization

PEM Fuel Cells provide continuos power and

Equipment Utilization and Facilities Efficiency

Powering your possibilities

- Electrification of transportation is growing
  - Global Urban projects driven by Zero Emission Agreements and initiatives
  - Battery-based systems have performance limitations
  - Benefits go beyond clean air initiatives; greater resiliency is key

- Major players adapting existing equipment to electric platforms
  - Hydrogen Fuel Cell technology offers compelling operational advantages
  - Most compelling use case is high utilization equipment

Powering Fleets of Heavy Vehicles to Clean Air

Transit Fleet Projects

- China, USA, Europe, Japan, Korea, Australia
- Buses, trucks, delivery vans are the current focus
- Strong experience in converting systems over to Fuel Cell Electric operations

Global Agreement

Mobility Electricfication

- Policy Makers
- Industry Leaders
- Investment Leaders

(*Jaakko Kooroshy, Goldman Sachs, Feb 2018).*

"Goldman Sachs believes that a healthy environment is necessary for the well-being of society, our people and our business, and is the foundation for a sustainable and strong economy", "It is imperative we get behind, ahead and lead this transformation"

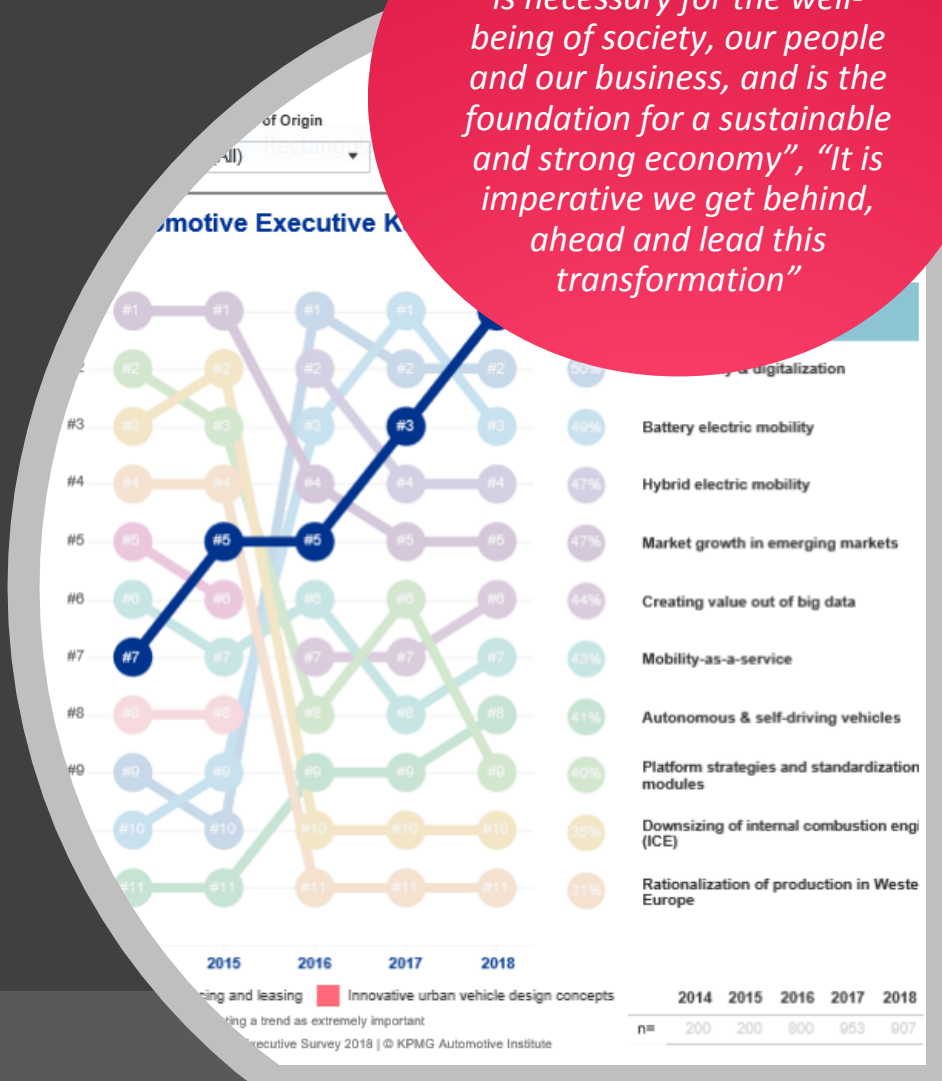
KPMG 2018 Global Auto Executive Survey

1,000+ Global Auto Industry

Senior Executives 80%+ respondents agree:

"fuel cell mobility is the most important (#1) trend through 2025"

https://gaes.kpmg.de/



Mobilization and Distributed Energy

January 2020

Texas Opportunities

Scaled Solutions

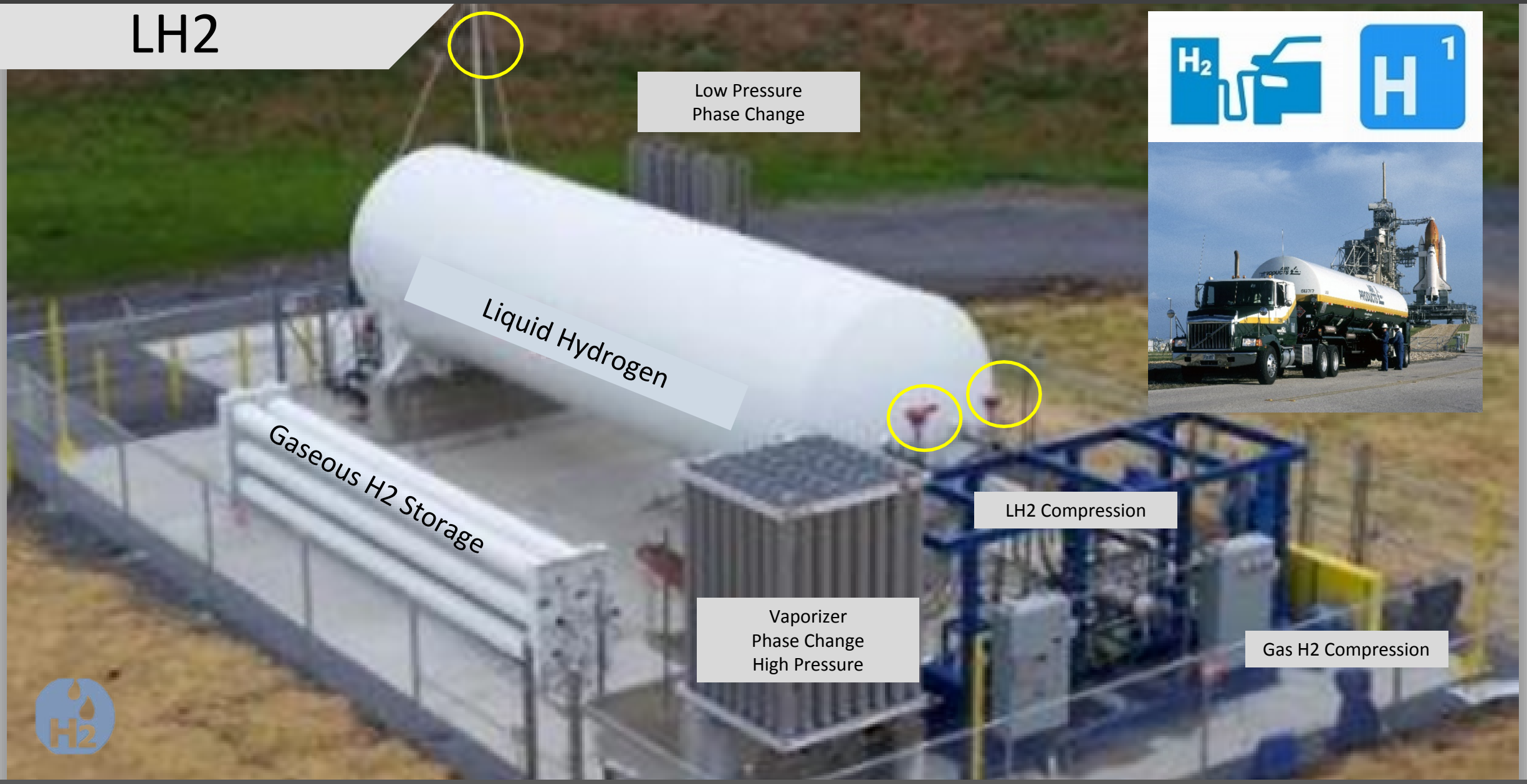
- Fueling station is compatible with all hydrogen fuel cell vehicles in operation
- Hydrogen fuel can be supplied from many sources:

Renewable and Traditional Sources		
Refinery waste streams	Conventional natural gas reforming	Waste to Syngas
Industrial gas companies	Biofuel reforming	Off-Process
Hydroelectric	Solar	Wind
Excess Electricity	Nuclear	Algae

- Mix of sources to optimize
  - Reliability
  - Cost
  - Environmental Impact

Energy Storage – Multi Purpose - Space Saving

LH2



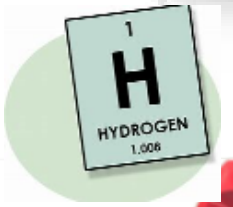
Horizon Fuel Cell Technologies

Material Handling – Trucks, Forklifts, Bus, Transit Applications

Captive Fleets

$55 Billion Hydrogen Fuel Cells Markets - Global Outlook to 2026

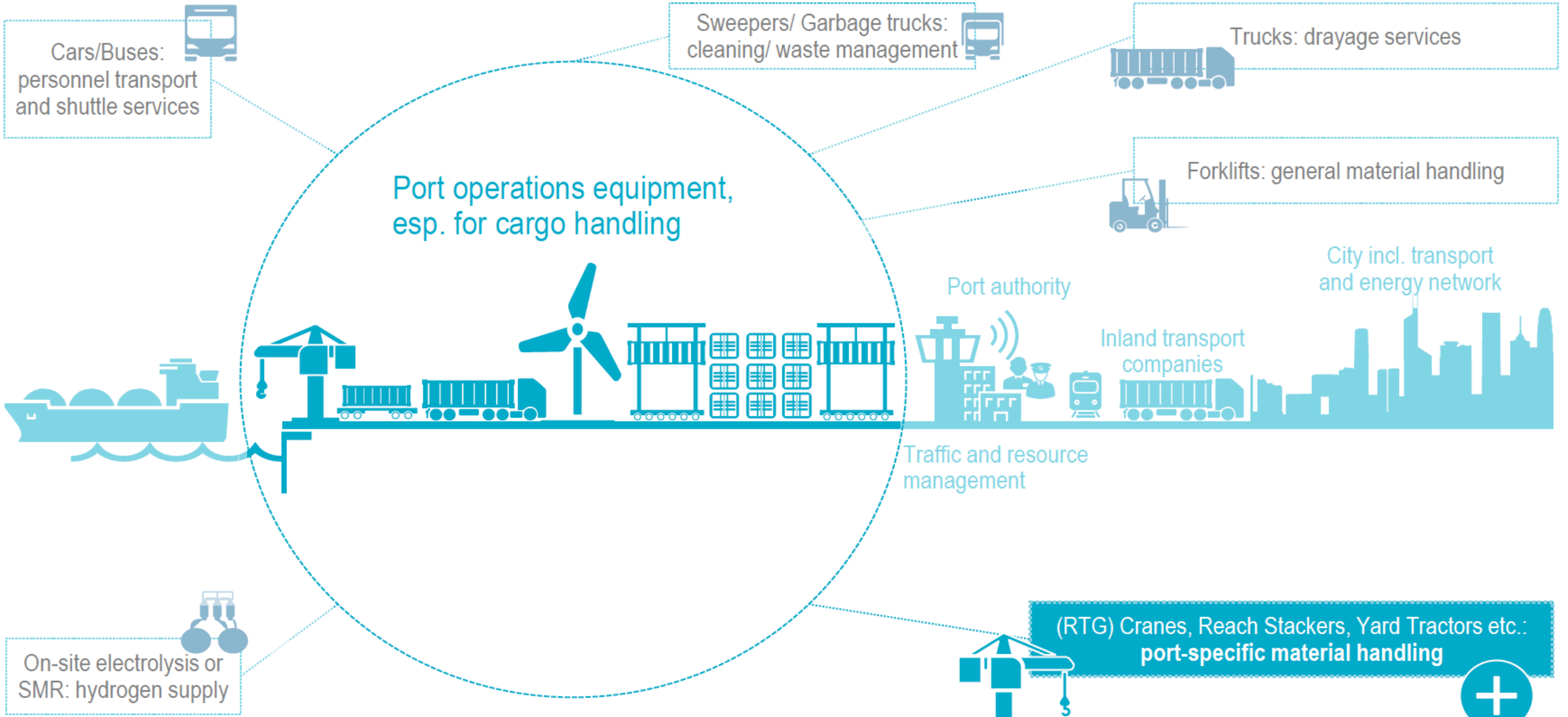
Global sectors: passenger buses and small delivery trucks, heavy duty trucks, light duty vehicles



Horizon Materials Handling

Where Can Fuel Cells Deliver Benefits in Texas Fleet Operations?

Ecosystem Advantage



Sustainable Mobility

Let’s work together for clean efficient smart cities

Presented:
Larry Irvine
Ray Gwin


Air Liquide
H2 Energy
At the heart
of the energy transition

Launching of the “Hydrogen Council”
January 17, 2017 | Davos

13 companies and their CEO’s joined forces to voice the vision and ambitions of the hydrogen industry with a commitment of investing **$1.9Bn/year**

Benoit Potier, AL CEO

Membership Growth
September 7, 2017 | Brussels

The Hydrogen Council welcomes **four** new steering members: **Audi, Iwatani, Plastic Omnium** and **Statoil**.

Mitsui & Co., Plug Power, Faber Industries, Faurecia, First Element Fuel, Fore and Toyota Tsusho have joined as our first Supporting Members.

Air Liquide · ALSTOM · AngloAmerican · Audi · BMW GROUP · DAIMLER · ENGIE · HONDA · HYUNDAI · Iwatani · Kawasaki · Plastic Omnium · Shell · THE LINDE GROUP · TOTAL · TOYOTA

Hydrogen Energy at Air Liquide

Mobility for Professionals
US+EUROPE
9 HRS

Mobility for Consumers
US North-East
10 HRS
+ Supply chain

Mobility for Consumers
California
3 HRS

Mobility for Consumers
Japan
6 HRS

Mobility for Consumers
Dubai
1 HRS

Mobility for Consumers
Korea
1 HRS

Power to Gas
Denmark
5 HRS
+ 1 Electrolyzer

Mobility for Consumers
Germany
12 HRS

Mobility for Consumers
Paris, Brussels and Rotterdam
5 HRS

3, 500 mTPD

1, 150 miles H_2 pipelines

46 large H_2/CO plants

40 electrolyzers in operation

$2.3B in sales

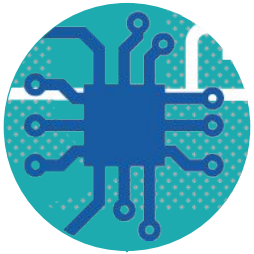
100+ Hydrogen refueling stations (HRS) installed by Air Liquide in the world in which 40 directly invested and operated by Air Liquide

Hydrogen Energy World Business Line

Five Main roles of the Hydrogen WBL (based in Paris)

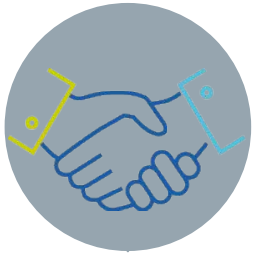
Strategy

Marketing



Technology

Industrial Management



Engagement

California network

Anaheim H_2 station

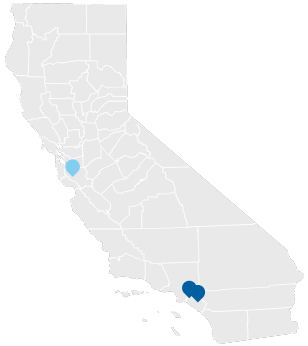
Dispensed 300+ kg/day in July 2019

First HRS installed in Anaheim, reached +10,000 fills milestone in March 2018;
2 other stations at Los Angeles Airport and Palo Alto

Long Beach

Air Liquide has built and operates a hydrogen station designed for the Toyota fuel cell semi-truck.

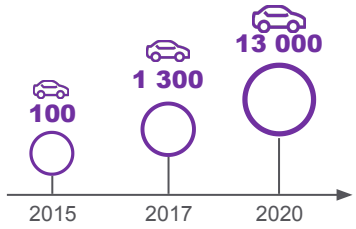
The Portal project in partnership with Toyota Air Liquide has built in 2017 and operates a hydrogen station designed for the Toyota fuel semi-truck.



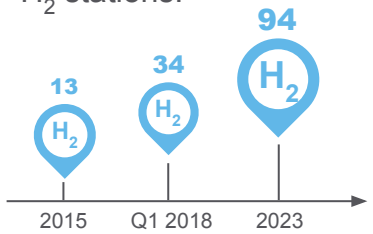
AL Stations in placet
- ➔ Anaheim
- ➔ LAX
- ➔ Palo Alto

Overall deployment figures in CA

FCEV's:



H_2 stations:

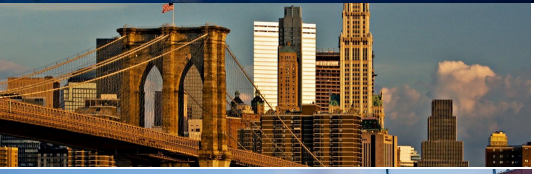


Northeast network

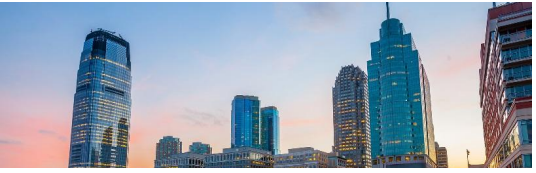
Massachusetts

Connecticut

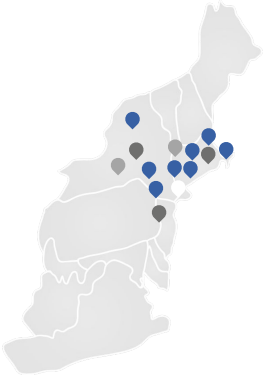
Rhode Island



New York



New Jersey



- Air Liquide is building a network of NE HRS
  First openings in 2018
- Network of 10 stations under development
- Fully operational from 2020
- Dedicated H2 supply chain by Air Liquide creative oxygen
- Project in collaboration with TOYOTA

Hydrogen Production - General Overview

Inputs

Outputs

End-Consumer

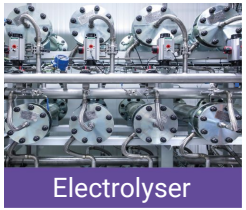
Bio-Methane

Methane (Nat. Gas) & Electricity

Electricity & Water

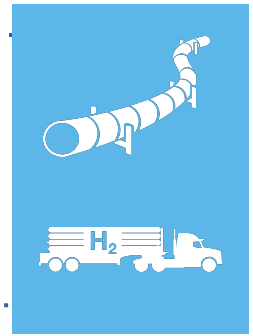
Renewable energy

Reformer



Electrolyser

GH2 or LH2



Hydrogen – Modes of Supply

LH2 → **Liquid trailer**

GH2

→ **Off site production** → **200 – 450 bar tube trailer**

→ **Pipeline**

→ **On site production**

→ **SMR**

→ **Electrolyser**

Typical LH2 Installation

TEXAS HYDROGEN

AIR LIQUIDE

"Made in Texas & Future Opportunities"

17 GW Installed Wind

Salt caverns and reservoirs
500-700 billion SCF of storage

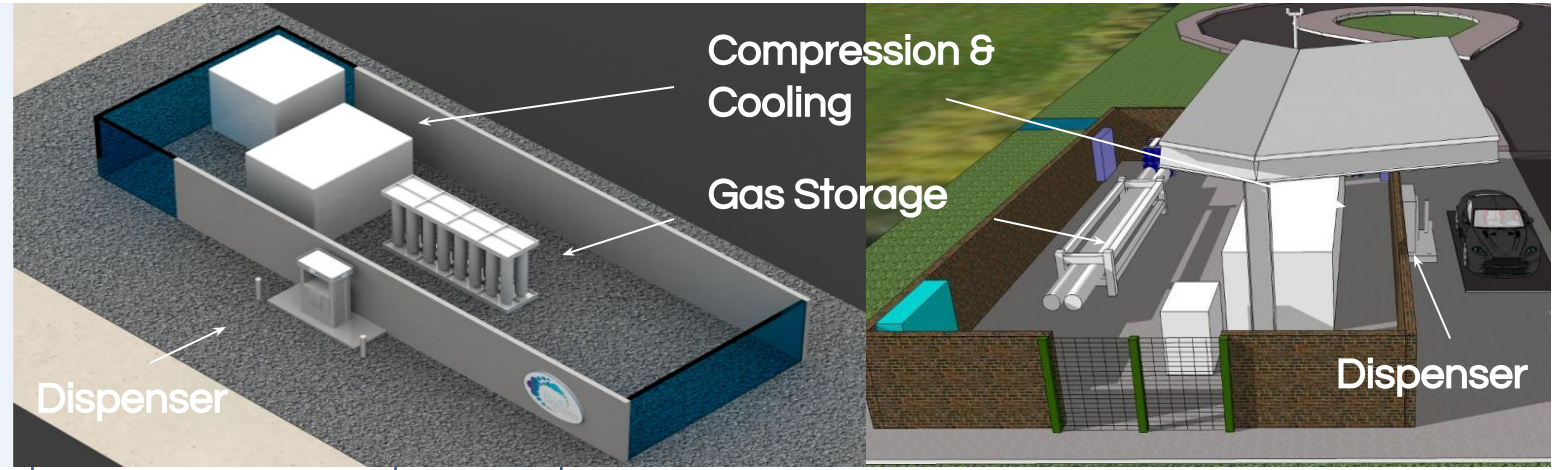
N
W
E
S

3.5 Billion SCFD
total pipeline volume

ıdustry and Health.

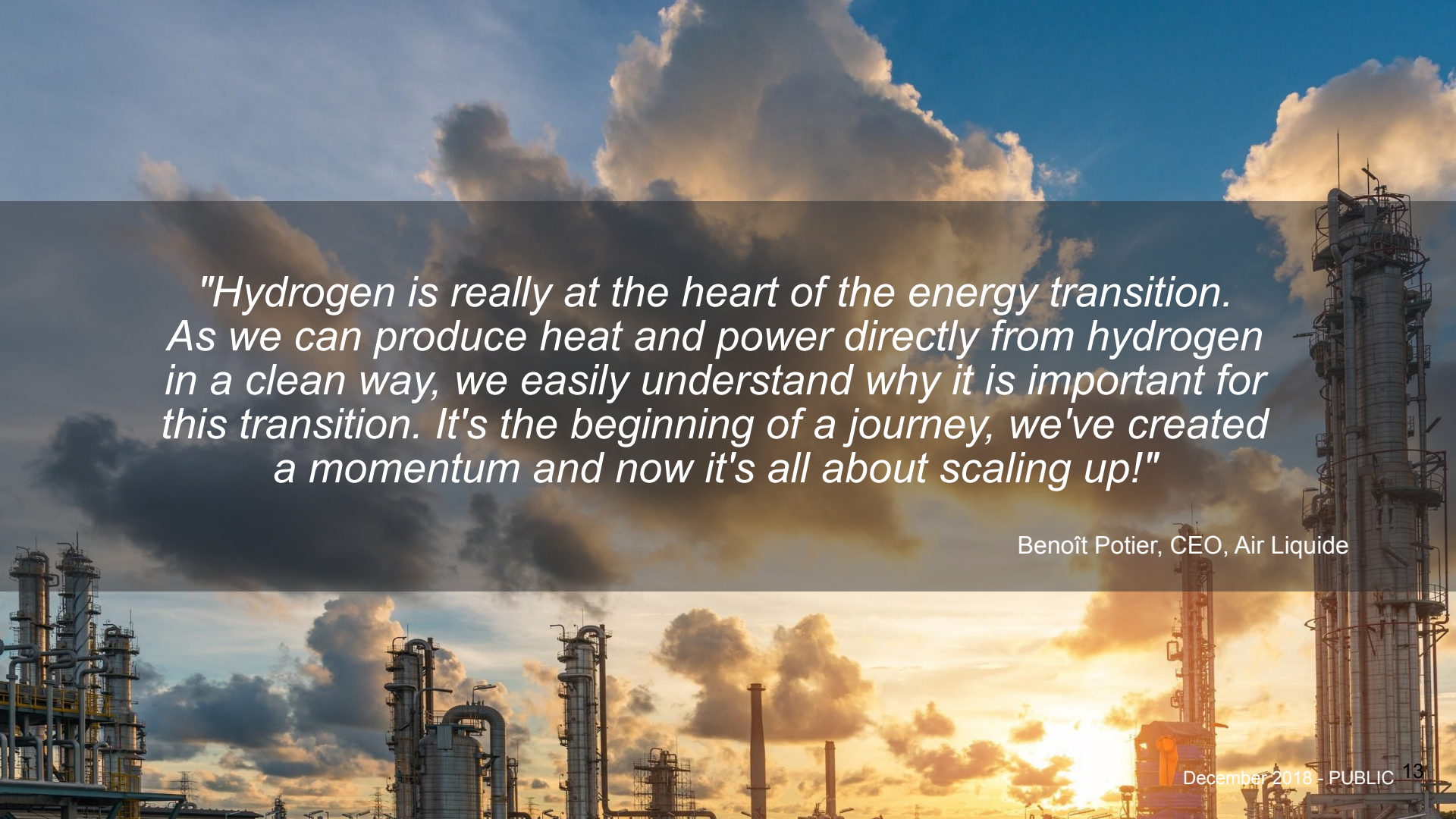
Station Design - LDV

- Small footprint 1500-2000 ft2
- All equipment modular, above ground and expandable
- Fueling time 3-5 minutes
- NFPA 2 and CGA compliant
- Digital - connected consumers.



Relative Infrastructure Costs, Supply Considerations

- Station designs and costs vary from supplier to supplier, and by target vehicle and end use:
  - **LDV** - 700 bar, pre-cooling, typically modular, can be relatively low capex ($2-$3MM GH2 for capacity 200 kg/day)
  - **MDV** - 350 bar, pre-cooling, typically modular and scalable, moderate capex as size scales up (50 bus TA, LH2 $4-$6MM for 1500kg/day)
  - **HDV** - 350 or 700 bar, pre-cooling, one-off designs to date (capex TBD), use typically 60-100kg/day per vehicle (2-4 miles/kg)
  - **Rail** - 350 bar, pre-cooling, one-off designs to date (capex TBD), use typically 200kg/day
- Supply considerations:
  - **Industrial Pipeline Network** - typically fed by large SMR's; high demand volumes (refinery, petrochemical) give rise to lower H2 unit cost, but pipeline connection is very capex intensive to install ($1MM/mile), and site specific.
  - **Onsite production** -
    - SMR - moderate capex, harder to operate, lower scalability (ramp up)
    - Electrolyzer - high capex, moderately difficult to operate, higher scalability (ramp up)
  - **Offsite production** - one unit (typically SMR or electrolyzer) can supply multiple users who benefit from lower unit production cost; required when customer does not have space for its own H2 plant, or does not want to operate its own production facility (usually a very different skill set, and carries its own risks)
    - GH2 transport - less efficient (carry smaller loads), so transport cost weighs heavily; not economic outside a limited distance
    - LH2 transport - higher production cost (liquefaction) balanced by more efficient transportation (larger loads), greater delivery range, and more product storage for the same space/volume



"Hydrogen is really at the heart of the energy transition. As we can produce heat and power directly from hydrogen in a clean way, we easily understand why it is important for this transition. It's the beginning of a journey, we've created a momentum and now it's all about scaling up!"

Benoît Potier, CEO, Air Liquide

Texas Project Updates

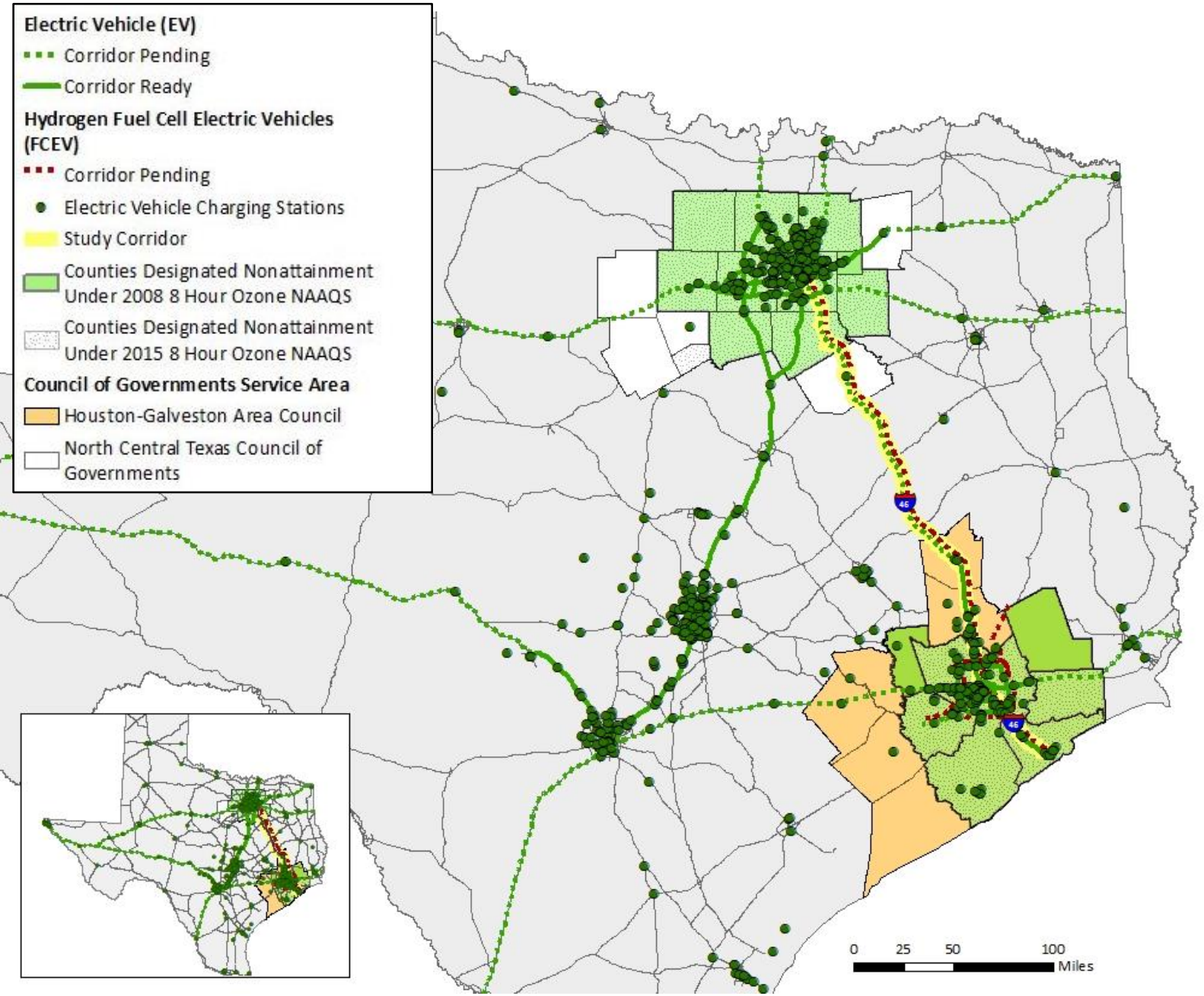
Hydrogen Stakeholder's Meeting
January 16, 2020

Lori Clark
Program Manager & DFW Clean Cities Coordinator

Mike Lewis
University of Texas at Austin

North Central Texas Council of Governments

Dallas-Fort Worth CLEAN CITIES



FHWA Solicitation for Alternative Fuels Corridor Deployment Plans

Goals:

- Develop an Infrastructure Deployment Plan
- Transition Corridors from "Pending" to "Ready"
- Identify Public-Private Partnerships

NCTCOG Proposal:

- Develop Electric and Hydrogen corridor along I-45
- Emphasis on Freight Vehicles

Key Dates:

- Funding Notification Received: October 10, 2019
- Projects Due: November 30, 2020

August 2019 - NCTCOG

Data Downloaded from FHWA Website and AFDC Station Locator

The University of Texas at Austin
Center for Electromechanics

HYDROGEN @ SCALE IN TEXAS

DOE H2@SCALE DEMONSTRATION PROJECT AT UT

JANUARY 2020

Presenter:
Michael Lewis
mclewis@cem.utexas.edu

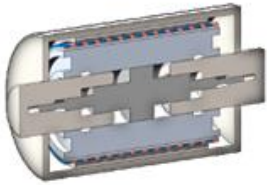
Hydrogen R&D at CEM

Fuel Cell Parcel Delivery Van

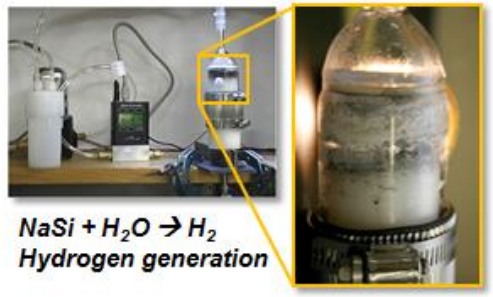
UT-CEM Hydrogen Station

22 ft Fuel Cell Hybrid Bus

Conformable storage vessels



H_2 Compressors



$NaSi + H_2O \rightarrow H_2$
Hydrogen generation

Hydrogen Utility Vehicle

FRONTIER energy

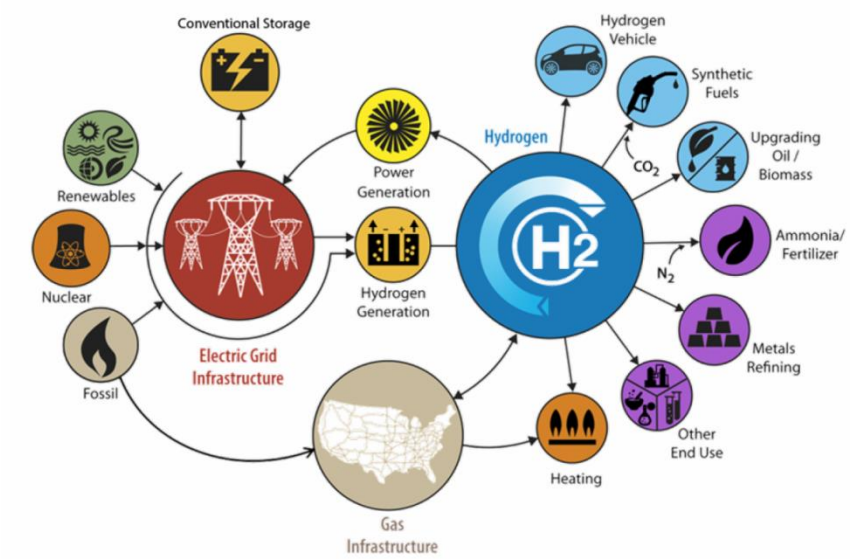
The University of Texas at Austin
Center for Electromechanics

gti

Hydrogen at Scale Vision

Hydrogen can Fuel a Sustainable Energy Transition by enabling U.S. energy security, resiliency and decarbonize the energy sector

- Hydrogen can be produced from diverse domestic resources for use in multiple sectors, or for export.
- Hydrogen has the highest energy content by weight of all known fuels – 3X higher than gasoline - and is a critical feedstock for the entire chemicals industry, including liquid fuels.
- Hydrogen and fuel cells can enable zero or near zero emissions in transportation, stationary or remote power, and portable power applications.
- Hydrogen can be used as a “responsive load” on the grid to enable grid stability and gigawatt-hour energy storage, and increase utilization of power generators, including nuclear, coal, natural gas, and renewables.
- Hydrogen can enable innovations in domestic industries (such as steel manufacturing and energy storage) and in transportation (e.g. in vehicles, rail, aviation, and marine applications) and iron making.



https://www.energy.gov/eere/fuelcells/h2scale

FRONTIER energy

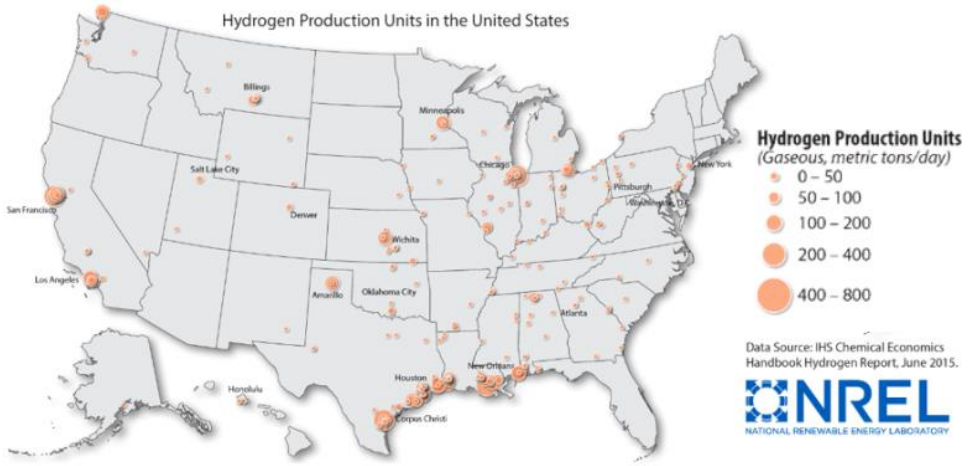
The University of Texas at Austin
Center for Electromechanics

gti

Hydrogen at Scale in Texas

Texas is ideally situated to be a leader in producing hydrogen for a sustainable energy system

- Texas is the largest producer in the nation of hydrogen
- Texas also has excellent resources of natural gas — the main feedstock for manufacturing hydrogen — and of solar and wind, which can be used to produce renewable hydrogen by electrolyzing water.
- Major industry leaders on the Hydrogen Council have a significant presence in Texas – Toyota, Shell, and Air Liquide.



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DOE Award for H2@Scale in Texas

Two unique RD&D tracks to understand the potential of integrating hydrogen with multiple co-located platforms and existing resources

- Demonstration of multiple renewable H_2 generation options, co-located with vehicle fueling and a large base load consumer to enable cost-effective hydrogen energy solutions

- Develop a framework for actionable H2@Scale pilot plans in Texas and the Port Houston and Gulf Coast region

Project Duration: 3 years, beginning early 2020

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Demonstration Activities at UT

Renewable hydrogen generation

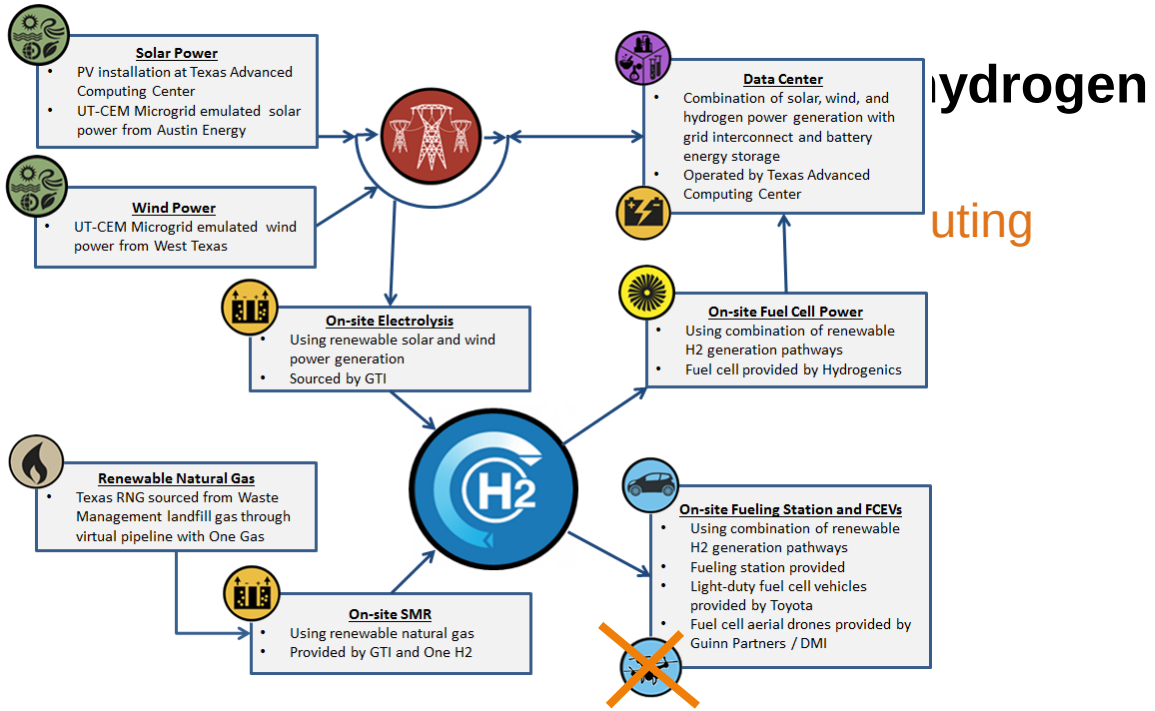
- Steam methane reformation using renewable natural gas
- Electrolysis using wind and solar power

Large scale, industry user
gas

- Fuel cell powering Texas
  Center

Vehicle refueling

- ~~Unmanned Aerial Vehicles~~
- Light-duty Vehicles



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Port Houston Framework for Hydrogen

- Identify key stakeholders and existing hydrogen infrastructure and business in Port Houston area
- Identify policy and regulation barriers
- Define use and implementation plans leveraging existing industry resources
- Develop actionable plan for H2@Scale demonstration and roll out of fuel cell vehicles in Port Houston

Current Project Status

- Award announcement in August 2019
  - Award amount was less than proposed
- Budget and Scope revised and submitted to DOE in December 2019
  - Pending feedback from DOE
  - Anticipated start date TBD (Maybe March to May timeframe)
- Updated Scope
  - Maintains hydrogen generation and fuel cell power for computing center
  - FCEVs are maintained but with a reduced scale fueling station
    - Toyota Mirai's maintained but fuel cell drone demonstration is pending
  - Port Houston still a part of the project
- Additional Partner
  - SoCal Gas is now a contributing partner
  - In conversations with others for additional in-kind or financial contributions
  - Seeking others to participate in Port Houston study

Thank You!

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January Hydrogen Stakeholders Meeting

Thursday, January 16, 2020

9:00 am- 11:00 am

Discussion:

In what ways can Hydrogen be generated?

- Excess wind
- Solar
- Nuclear
- Methane gas
- Algae
- Excess electricity
- Biofuel reforming

Two main pathways of producing Hydrogen:

- Electrolysis
- Methane Capture

What kind of fueling capacity is needed for different applications?

- Light Duty Vehicles are fueled with H2 fuel that is compressed at 700 bar pressure (10,000 psi) and use about 1 kg of hydrogen/day.
- Medium Duty Vehicles are fueled with H2 fuel that is compressed at 350 bar pressure (5,076 psi) and use about 12-20 kg of hydrogen/day. Hydrogen Transit buses use around 25-30 kg of hydrogen/day. A 40-foot hydrogen transit bus cost about $1.2 million. Whereas, 40-foot battery electric buses are around $850,000 and 40-foot Diesel buses are around $500,000-650,000. Incentives are very important.
- Heavy Duty trucks are fueled with H2 fuel that is compressed at 350 or 700 bar pressure and use about 35 kg of hydrogen/day.
- Rail is fueled with H2 fuel that is compressed at 350 bar pressure.

Transporting Hydrogen:

- The cost of transporting hydrogen usually ranges from $2-5 per mile
- Australia is conducting a case study of transporting Ammonia and converting it to Hydrogen at the source. We will hear more on this case study from one of our speakers at the March meeting.

Before building a hydrogen station:

- Notify Gas, Electric companies, and fire marshals as soon as possible. Get everyone involved, just in case.
- Find out the cost of power.
- Are you using onsite or offsite generation?
- How close to the source must you be for hydrogen station?
    - Liquid hydrogen must be within about 1000 miles of the source
    - Gaseous hydrogen must be within about 100 miles of the source
- Are you storing hydrogen on-site?
- Do you want to Buy or Lease the station(s)?

Key takeaways:

- Incentives/funding opportunities are important for both infrastructure and vehicles.
- Texas has plenty of supply with one of the largest capacities for wind and solar in the U.S.
- Type of hydrogen Station and supply really depends on application, fleet utilization, and fleet mobilization.

Next Steps & Action Items

NCTCOG will:

- Continue to add additional relevant stakeholders to interested parties list for future meetings.
- Reach out to individuals to contribute content in our I-45 Zero Emissions Vehicle Deployment Plan.
- Place stakeholders into working groups:
    - Infrastructure Development
    - Vehicle Availability
    - Customer identification
    - Policy/Incentives
    - Any other topics stakeholders recommend